

1.1 2017 IPHC Biological and Ecosystem Science Research Plan

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Abstract

Since its inception, the IPHC has had a long history of research activities devoted to describe and understand the biology of the Pacific halibut (*Hippoglossus stenolepis*). Currently, the main objectives of the Biological and Ecosystem Science Research Program at IPHC are to:

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

Traditionally, IPHC staff propose annually new projects designed to address key biological questions as well as the continuation of certain projects initiated the previous year, based on their own input as well as input from the Commissioners, stakeholders, and the IPHC Scientific Review Board (SRB) and the Research Advisory Board (RAB). Proposed research projects are evaluated internally by IPHC staff and presented to the Commission for feedback and subsequent approval. Importantly, biological research activities at IPHC are guided by a Five-Year Research Plan that identifies key research areas that follow Commission objectives. In this document, we present an outline of a new proposed Five-Year Research Plan for the period 2017-21 and an overview of the research projects proposed by IPHC staff for 2017.

IPHC Five-Year Research Plan

The new proposed Five-Year Research Plan for the period 2017-21 includes extensive studies covering five major research areas:

- 1) Reproduction (i.e., sex identification, maturity estimates),
- 2) Growth (i.e., decrease in size-at-age, temperature effects),
- 3) Discard mortality rates (i.e., physiological condition and survival post-release of by-catch),
- 4) Migration (i.e., larval dispersal, adult and reproductive migrations) and
- 5) Genetics and Genomics (i.e., genetic population structure, genome characterization).

These studies are intended to provide information on factors that influence the biomass of the Pacific halibut population (e.g., distribution and movement of fish among regulatory areas, growth patterns and environmental influences on growth in larval, juvenile and adult fish) and, specifically,

of the spawning (female) population (e.g., reproductive maturity, skipped spawning, reproductive migrations). Furthermore, these studies are also intended to provide information on the survival of bycatch and wastage fish and eventually refine current estimates of discard mortality rates. An overarching objective of the Five-Year Research Plan is to promote integration and synergies among the various research activities led by IPHC in order to significantly improve our knowledge of key biological inputs that are introduced into the stock assessment.

Overview of research projects for 2017

For 2017, seven new projects are proposed that cover specific research needs related to reproduction (Projects 2017-01, 2017-02), migration (Projects 2017-02, 2017-03, 2017-04), growth (Project 2017-05), viability assessment and survival post-capture (Projects 2017-04, 2017-06) and genetics (Project 2017-07). ([Table 1](#)) Project 2017-01 (“Full characterization of the annual reproductive cycle in adult female Pacific halibut”) proposes to study the annual reproductive cycle of Pacific halibut females in order to further our understanding of sexual maturation in this species and to improve maturity assessments and maturity-at-age estimates. Project 2017-02 (“Investigation of Pacific halibut dispersal on Bowers Ridge via Pop-up Archival Transmitting [PAT] tags”) proposes to study the migratory behavior of females prior to the spawning season in order to identify potential spawning areas in Regulatory Area 4B. Project 2017-03 (“Tail pattern recognition analysis in Pacific halibut”) is a pilot study that proposes to identify individual fish by ways of photographic recognition of tail patterns to complement migratory studies. Project 2017-04 (“Condition Factors for Tagged U32 Fish”) proposes to study the relationship between the physiological condition of fish and migratory performance as assessed by tagging in U32 fish in order to better understand the potential use of quantitative physiological indicators in predicting migratory (as well as other types of) performance. Project 2017-05 (“Identification and validation of markers for growth in Pacific halibut”) proposes to identify and validate molecular and biochemical profiles that are characteristic of specific growth patterns and that will be instrumental to describe different growth trajectories in the Pacific halibut population and evaluate potential effects of environmental influences. Project 2017-06 (“Discard mortality rates and injury classification profile by release method”) proposes to study the relationship between hook release methods in the longline fishery and associated injuries with the physiological condition of fish in order to improve our understanding of factors influencing post-release survival in the directed fishery. Project 2017-07 (“Sequencing of the Pacific halibut genome”) proposes to characterize for the first time the genome of the Pacific halibut and provide genomic resolution to genetic markers for sex, reproduction, and growth that are currently being investigated.

In addition to the new projects, eight continuing projects are proposed, including two projects dealing with sex identification (621.15, 621.16), two projects monitoring the Pacific halibut population for mercury and *Ichthyophonus* contamination (642.00, 661.11), three projects continuing migration-related research with the use of wire and satellite tagging (650.18, 650.20, 670.11) and one project finalizing work conducted on the reevaluation of the weight-length relationship (669.11). ([Table 1](#))

Summaries of each of the new and continuing projects are included in the following sections with indication of the principal investigator(s) (PIs). [Figure 1](#) presents a schematic diagram of new and continuing research projects, their interactions, and their relationship to the major research areas identified in the IPHC Five-Year Research Plan.

Following the discussion of new and continuing projects is a description of research proposals submitted in 2016 for external funding and a short description of other ongoing IPHC data collection projects that take place as part of the fishery-independent setline survey or as part of the commercial fishery data collection program.

New research projects for 2017

2017-01 Full characterization of the annual reproductive cycle in adult male and female Pacific halibut

PI: Josep Planas

In fisheries, understanding the reproductive biology of a species is important for estimating the reproductive potential and spawning biomass of the stock and, consequently, for optimizing the management of the species. The main purpose of this study is to improve our knowledge on basic aspects of the reproductive physiology of the Pacific halibut and to provide an updated and more comprehensive description of maturity in this species. The Pacific halibut is generally believed to reproduce following an annual cycle with spawning typically occurring in the winter. However, skipped spawning and biennial maturation cycles are not uncommon in temperate and subarctic species. Very large yet putatively immature female Pacific halibut are often observed in the setline survey and analyses of PAT tag data are consistent with the hypothesis that skipped spawning is common in Pacific halibut. Regional and temporal variation in maturation and spawning schedules can affect the relationship between estimates of mature biomass and effective female spawning stock. Additionally, seasonal changes in fish condition can affect stock productivity and the relative impact of any given volume of harvest over time. Given that reproduction is under the control of the endocrine system, knowledge on the reproductive hormones involved and their temporal pattern of production is essential for understanding the temporal progression of gonadal maturation. In Pacific halibut, a comprehensive characterization of the reproductive cycle has not been performed to date and no information on how reproductive hormones may control gonadal maturation is available. In the present study, we propose to describe the temporal changes in gonadal morphological characteristics as well as in the levels of reproductive hormones and physiological condition throughout an entire annual reproductive cycle in order to improve and update our estimation of maturity in this species.

2017-02 Investigation of Pacific halibut dispersal on Bowers Ridge via Pop-up Archival Transmitting (PAT) tags.

PI: Tim Loher

The IPHC has a history of conducting PAT tagging in the Bering Sea and Aleutian Islands (BSAI) in order to investigate both seasonal (2002-2007, 2016; Projects 622, 622.11.84, 622.14) and inter-annual (2008-2010, 2016; Projects 622.12, 622.14) dispersal. In total, (152) satellite tags have been deployed in the course of those experiments, covering the historically surveyed range of this stock component throughout Areas 4A, 4B, 4C, and the 4D Edge. These studies have been aimed at gaining greater understanding of the timing of movements within this stock component, identifying winter spawning locations, and investigating mixing among regulatory areas in a fishery-independent manner. The results of these experiments have complemented large-scale Passive Integrated Transponder (PIT) tagging and have jointly resulted in an understanding of population function that is generally consistent with the structure of the IPHC's current Area-as-Fleets stock

assessment model. However, notable gaps in spatial coverage of these tag deployments, relative to areas fished by BSAI fleet components, still exist: 1) Bowers Ridge (in 4B); 2) all of Area 4E. The IPHC extended its fishery-independent setline survey northward along the eastern Bering Sea continental shelf edge during 2016, providing for the first time demographic data and an opportunity to tag fish in southern Navarin Canyon, quite possibly the northern-most major spawning ground for this species. In 2017, the IPHC intends to extend its Area 4B survey northward along Bowers Ridge, presenting a unique opportunity to fill another gap in our understanding of Bering Sea stock structure. In particular, recent genetic analyses have indicated that Pacific halibut in western 4B are genetically distinct from the remainder of the stock (Drinan *et al.* 2016), raising questions regarding the relationship between Pacific halibut found along Bowers Ridge and the remainder of the Aleutian Islands region.

2017-03 Tail pattern recognition analysis in Pacific halibut

PIs: Claude Dykstra, Tracee Geernaert

The purpose of the study is to collect high resolution images of Pacific halibut tail patterns with the hypothesis that these patterns are unique to individual fish. Images will be combined with the 2017 U32 tagged fish allowing us to track growth/migration and re-image individuals when they are recaptured. By comparing images at tagging and recapture we can test the hypothesis that the tail morphology is unique and stable through growth. If a natural tag is discovered it could allow for large scale tracking of movement and as a potential control for other tagging experiments with the added benefit of shedding light on discard mortality rates.

The first step would be to determine if the patterns are unique and then the next step to determine if they are static or stable with growth.

2017-04 Condition Factors for Tagged U32 Fish

PI: Claude Dykstra

In this study we propose to collect condition factor information opportunistically on all fish under 32 inches in length (U32) that are tagged and released. This would need to be on a boat that was already carrying the scale for use in the weight-at-age project. In addition to the round weight of the tagged fish, this project would capture information on fat levels (utilizing the FatMeter device), and blood stress hormones. Over future years this would develop a deeper data set that could be related to some of the underlying physiology for tag recovery rates associated with different release injury and subsequent tag recoveries.

2017-05 Identification and validation of markers for growth in Pacific halibut

PI: Josep Planas

Growth is a physiological process that takes place throughout the lifetime of Pacific halibut and that results from the complex interaction among dietary or trophic influences, environmental conditions, genetic background, energy expenditure requirements, etc. Growth is intimately linked to fitness and performance, adaptive capabilities and reproductive potential and, therefore, is a key process determining the species' success in the ecosystem. From a fisheries perspective, growth at an individual and, ultimately, at a population level influences the amount of available biomass. In Pacific halibut, a significant decrease in size at age has been recorded over the last three decades. One of the various possible causes that have been attributed to this pattern, in addition to size-

selective fishing, harvest pressure or size-dependent migration, is a decrease in somatic growth. Unfortunately, little is known regarding the factors that influence growth in this species. In order to begin to understand how growth in Pacific halibut can be modulated under specific (biotic or abiotic) conditions, it is necessary to develop appropriate tools to monitor growth. In this study, we propose to identify and validate appropriate molecular markers for growth that can be used to identify the presence of distinct growth patterns in the Pacific halibut population and evaluate the influence of environmental conditions on somatic growth in this species.

2017-06 Discard mortality rates and injury classification profile by release method

PI: Claude Dykstra

Discard mortality rates (DMR) in the longline fishery are currently estimated from Pacific halibut injury or vitality data obtained on observed trips. The small vessel longline fleet (<57') is currently developing electronic monitoring (EM) capabilities to collect data normally collected by the observer program. Determining vitality codes requires handling of the animal (which includes looking at both sides of the fish, testing muscle tone and opercular responses), which is something that cannot be achieved with cameras. EM data analysts are able to collect information on Pacific halibut release techniques for close to 95% of events; however, the suite of injuries incurred by each release technique is unknown. This study proposes to begin developing an injury profile for different release techniques with associated physiological condition measures, which could then be used to calculate DMRs on vessels carrying EM systems rather than observers. Additionally, this project could be a platform to tag and release Pacific halibut to further refine DMRs by each release category. DMRs calculated based on this sort of effort would need to be understood to be in pristine condition as fisher would likely still try to release fish with minimal injury regardless of what treatment they would be randomly assigned.

2017-07 Sequencing the Pacific halibut genome

PI: Josep Planas

The genome of an organism is the collection of genes that are organized in chromosomes and that contain the genetic material necessary for its development, growth, and maintenance. The genome sequence therefore contains information on all the genes present in the genome, namely their DNA sequence and location in the genome. The purpose of this project is to generate a first draft of the genome of the Pacific halibut. Through the sequencing of the Pacific halibut's genome we will be able to identify genomic regions and genes that are responsible for temporal and spatial adaptive and phenotypic characteristics and better understand genetic and evolutionary changes that occur in response to environmental and fisheries-related influences. Therefore, the genome sequence will be essential for understanding possible changes in the genetic constitution of the Pacific halibut population. Importantly, the genome sequence will also allow us to understand the genetic basis of growth, reproductive performance, migratory behavior, etc. in this species. In the short term, the genome sequence will allow us to effectively map and capitalize information derived from all the identified single nucleotide polymorphisms (SNPs) associated with sex that are being derived through restriction-site associated DNA sequencing (RADseq) as well as the transcripts generated from our current RNA sequencing efforts.

Continuing research projects for 2017

621.15 Voluntary at-sea sex marking and portside sampling of commercial longline vessels

PIs: Tim Loher, Ian Stewart, Claude Dykstra, Lara Hutton, Jamie Goen – and relevant port samplers; Collaborators: Lorenz Hauser and Dan Drinan (UW)

The current IPHC stock assessment is sex-structured, but it is not based upon direct observations of sex in the landed catch. Historically, fishery sex ratio at age has been estimated on the basis of the sex ratios at size and age observed in IPHC survey catches, according to regulatory area. While this is statistically robust for some combinations of age and size (e.g., large young and small old fish), this procedure can be sensitive to small sample sizes and it ultimately provides an estimator of the properties of the survey catch, not fishery landings. In particular, the survey spans only ~40% of the commercial fishing period, and seasonal migration and the fishery's ability to target specific stock components and geographic areas have the potential to generate unknown degrees of variance between survey and fishery landings composition. In the absence of derived fishery sex-ratio data, the 2013 stock assessment was found to be very sensitive to the assumption that the relative selectivity at age of males and females is equivalent in the survey and fishery: a 20% range in fishery selectivity sex ratio translated into an ~50 million pound range in female spawning biomass estimates (i.e., ~25% of the total estimated value). Without direct observations of fishery sex ratio at age there is no way to determine the magnitude of the uncertainty and/or bias from this source that would be included in assessment results. The current study represents one component of a suite of integrated studies that are ultimately designed to obtain reliable sex data from eviscerated commercial landings.

621.16 Development of production-scale genetic sexing techniques for routine catch sampling of Pacific halibut

PI: Tim Loher. Collaborators: Dr. Lorenz Hauser, Dan Drinan (UW).

Declines in size at age of Pacific halibut, in concert with sexually dimorphic growth and a constant minimum commercial size limit, have led to the expectation that the sex composition of commercial catches should be increasingly female-biased. Given this likelihood, it is important to correctly estimate sex-specific fishing mortality rates in order to accurately predict stock trajectories for long-term policy analyses. Recent sensitivity analyses have indicated that uncertainty regarding sex ratios within commercial harvest may be the most influential factor affecting our understanding of female spawning stock biomass (SSB_f), with 10% variance in estimated sex ratios translating into a roughly 50 million pound range in estimates of SSB_f . Such uncertainty may be exacerbated if age-specific sex compositions vary in space and time, as recent studies have suggested that they do. However, there is no reliable way to determine sex at landing because all Pacific halibut are eviscerated at sea. The current work will develop genetic assays that will allow for the rapid and cost-effective sex identification of large samples from the commercial Pacific halibut fishery at relatively low cost.

642.00 Assessment of Mercury and other contaminants in Pacific Halibut

PI: Claude Dykstra; Collaborator: Bob Gerlach (ADEC)

Ongoing public concern over contaminants in seafood requires a better understanding of these levels in wild caught fish in different areas and by size of animal. We have been working with the Alaska Department of Environmental Conservation (ADEC) since 2002 to better characterize the levels of contaminants found in Alaska-caught Pacific halibut. The project is ongoing to further characterize, update and expand our understanding, and provide monitoring of contaminants encountered in wild-caught Pacific halibut from all regions of Alaska.

650.18 Archival tags: tag attachment protocols

PI: Tim Loher

Recovery rates of archival tags affixed to Pacific halibut using four different external mounting protocols (three dart-and-tether configurations; wired to the operculum) are being tested in a field release of “dummy” archival tags. During the summer of 2013, 900 fish were tagged off northern Kodiak Island (Area 3A), with an equal number of fish tagged with each tag attachment type. Fish carrying a dart-and-tether tag were also tagged with a bright pink cheek tag, and rewards of \$100 are being given for all tags recovered. Total tags recovered in FY2015 were 4); there were 32 in FY2016. We expect approximately 25 recoveries in FY2017.

650.20 Investigation of Pacific halibut dispersal on the far northern 4D Shelf Edge via Pop-up Archival Transmitting (PAT) tags

PI: Tim Loher

During the summer of 2016, 35 Pacific halibut were tagged with Lotek PSATs on northern Area 4D Edge survey stations. Of these tags, 32 were programmed to detach from their host fish and report to the Argos system during FY2017 (n=20 during January; 12 during June). The remaining three tags were scheduled to report in September 2016.

661.11 *Ichthyophonus* Incidence Monitoring

PI: Claude Dykstra

Ichthyophonus is an internal histozoic parasite that can be found in all visceral organs and the musculature of infected hosts. Over a six-year period, infections in Pacific halibut were detected at a relatively high prevalence compared to other host species. Between 2011 and 2016, the infection prevalence was 10.8 to 37.3% in the Bering Sea, 16.7 to 50% off the coast of Oregon, and with significantly higher infection prevalence ranging from 58.3 to 76.7% in Prince William Sound. Inter-annual infection prevalence has been relatively stable within geographic locations. While prevalence has been high for a marine species, infection intensity (i.e. number of schizonts in the liver or heart) has been extremely low to not detectable. Effects of infection vary greatly among individuals and host species, and can include reduced swimming performance, retarded growth, and acute mortality in other hosts; however, effects on Pacific halibut remain uninvestigated. The ongoing nature of the study is to monitor changes in infection prevalence at the three base sites (Bering Sea, inside Prince William Sound, Oregon) and more specifically in infection intensity. Sudden increases in infection intensity have been followed by large die off events in other species, and could then warrant a more intensive grow-out study.

669.11 At-sea Collection of Pacific Halibut Weight to Reevaluate Conversion Factors

PI: Eric Soderlund

Net weight is a fundamental concept that the IPHC uses for stock assessment, apportionment, and all facets of Pacific halibut management. However, individual net weight is not a strictly biological quantity; instead it is the result of natural variation as well as of one to several processing steps. The purpose of this study is to collect data on IPHC's fishery-independent setline survey for use in estimating the relationship between fork length and net weight, including the estimation of adjustments necessary to convert head-on weight to net weight, as well as estimation of shrinkage (potentially occurring in both length and weight) from time of capture to time of offload. This project will complement an ongoing project (665.11), in which portions of commercial deliveries are measured and weighed at the dock, by providing length-to-weight data that is not available at commercial offloads: from U32 fish, round fish, and freshly killed and dressed fish, as well as measurements of shrinkage from the time of capture to final weighing at the offload. The current length to net weight relationship was estimated in 1926. Using 1989 data, Clark (1991) re-estimated the relationship's parameters and found good agreement with the earlier curve. However, when Courcelles (2012) estimated the relationship data collected in 2011, she found significant differences between her estimated curve and that derived from the 1989 data, although inference was limited to a relatively small part of Area 3A and to the time of the setline survey. IPHC staff has also raised the issue of the relationship varying both regionally and seasonally (Courcelles, 2012). If the relationship varies among regulatory areas, there may be systematic bias in regulatory area estimates of weight or weight per unit effort (WPUE) derived from length measurements. The current relationship between fork length and net weight also includes adjustments for the weight of the head, and of ice and slime. As a secondary goal, we also plan to collect data to provide direct estimates of adjustment factors to compare with the currently assumed values, and to assess variability in the weight of heads and ice and slime.

670.11 Wire tagging of Pacific halibut on NMFS trawl and setline surveys

PIs: Joan Forsberg, Lauri Sadorus

In response to bycatch-related requests at the 2015 Annual Meeting to learn more about juvenile Pacific halibut distribution and movement, IPHC staff launched a pilot project during the 2015 survey season to test the practicability of wire tagging Pacific halibut aboard the NMFS trawl surveys. IPHC routinely participates in the NMFS groundfish trawl surveys in the Bering Sea (annual), Gulf of Alaska (biennial) and Aleutian Islands (biennial, alternate years from the GOA survey). Pacific halibut caught on the trawl survey range in size from about 20-100 cm fork length with most of the catch under 82 cm. The tagging effort was successful and the decision was made to continue the project into the foreseeable future on NMFS trawl surveys and to expand the tagging effort to small Pacific halibut captured on the IPHC setline survey. The IPHC setline survey tagging effort conducted in 2016 was limited to one regulatory area (4D) and to Pacific halibut less than 82 cm fork length that were not part of the otolith sample. In 2016, a total of 424 and 170 Pacific halibut were tagged and released in the Bering Sea and Aleutian Islands surveys, respectively. As of August 31, 2016, a total of eight tags from the NMFS trawl releases have been recovered and returned to IPHC: four tags from the 2015 Bering Sea and four tags from the 2015 Gulf of Alaska. A total of 169 Pacific halibut were tagged on the IPHC setline survey in Area 4D. No tags from the 2016 releases had been recovered as of August 31.

Research proposals submitted for external funding

Research proposals submitted for external funding are listed in [Table 2](#) and summarized below.

Title: Improving discard mortality rate estimates in the Pacific halibut by integrating handling practices, physiological condition and post-release survival

Lead PI: Josep V. Planas (IPHC)

Co-PIs IPHC: Claude Dykstra, Tim Loher, Ian Stewart, Allan Hicks.

Co-PIs Alaska Pacific University (APU): Nathan Wolf; Bradley Harris.

Funding agency: Saltonstall-Kennedy Competitive Research Program

The main objectives of this project are to address the important issue of DMRs of Pacific halibut in the directed and non-directed longline fisheries and to refine current estimates of post-release survival in incidentally caught Pacific halibut. In order to accomplish these objectives, the relationship between fish handling practices and fish physical and physiological condition and survival post-capture as assessed by tagging will be investigated.

The IPHC accounts for all mortalities or removals of Pacific halibut in its assessment of the stock, including bycatch as well as the incidental mortality from the commercial Pacific halibut fisheries (also known as wastage). Estimates of incidental mortality influence the output of the stock assessment and, consequently, the catch levels of the directed fishery. Prohibited Species Catch limits set by the North Pacific Fishery Management Council (NPFMC) requires that all Pacific halibut caught in non-directed fisheries must be discarded at sea, and these fisheries may be closed when Pacific halibut catch limits are reached. The NPFMC has identified DMRs in the Pacific halibut fishery as a research priority. The proposed project will directly address this recommendation by providing new scientific information to improve current estimates of DMRs.

The specific objectives of this project include (1) evaluation of the effects of fish handling practices on injury levels and their association with the physiological condition of captured Pacific halibut, (2) investigations on the effects of fish-handling methods and associated injury level and physiological condition on post-release survival, (3) application of electronic monitoring in associating fish handling methods to survival in vessels without observer coverage and (4) development of non-invasive methods for quantifying measurable physiological factors indicative of stress and physiological disturbance.

Title: Somatic growth processes in the Pacific halibut (*Hippoglossus stenolepis*) and their response to temperature, density and stress manipulation effects

Lead PI: Josep V. Planas (IPHC)

Co-PI: Thomas P. Hurst (AFSC – NOAA - NMFS)

IPHC Staff involved: Dana Rudy

Funding agency: North Pacific Research Board (NPRB)

Pacific halibut are distributed throughout the North Pacific Ocean and its fishery is one of the most important commercial fisheries in this region. The IPHC has been managing the Pacific halibut fishery since 1923 and throughout its history it has recorded changes in the size at age (SAA) of fish caught in the commercial fishery as well as independent IPHC research surveys. Importantly, a consistent decrease in SAA has been observed since the late 1990s that

has led to steady declines in the exploitable biomass of the Pacific halibut stocks. Although the decrease in SAA has been hypothesized as being attributed to several potential causes, including environmental effects such as temperature or food availability, as well as ecological or fishery effects, our knowledge on the actual factors that influence SAA of Pacific halibut is still scarce. This proposal aims at elucidating the drivers of somatic growth leading to the decline in SAA by investigating the physiological mechanisms that contribute to growth changes in the Pacific halibut. Specifically, we will investigate the effects of temperature, population density, social structure, and stress manipulations on biochemical and molecular indicators of this growth. Emphasis will be placed on the physiological responses to temperature, given the demonstrated importance of this environmental parameter in determining growth patterns in the Pacific halibut. This study will lead to a significant improvement in our understanding of the physiological mechanisms regulating growth in the Pacific halibut in response to environmental and ecological influences but also, importantly, to the identification of molecular and biochemical growth signatures characteristic of growth patterns that will be used to monitor growth patterns in the Pacific halibut population.

Title: Larval transport, supply, and connectivity of Pacific halibut (*Hippoglossus stenolepis*) between the Gulf of Alaska and the Bering Sea

**Lead PI: Esther Goldstein (AFSC - NOAA); Janet Duffy-Anderson (AFSC - NOAA),
IPHC Staff involved: Lauri Sadorus, Josep V. Planas, Ian Stewart**

Funding agency: North Pacific Research Board (NPRB)

Data suggest that the Gulf of Alaska and Bering Sea Pacific halibut populations may be interconnected during the early life stages. Determining variability in larval connectivity, identifying transport pathways, and assessing the conditions that affect larval transport and delivery across multiple years and climatic conditions will improve our understanding of the processes that influence Pacific halibut recruitment. Data from National Marine Fisheries Service (NMFS) ichthyoplankton surveys suggest that a significant number of eggs and larvae are transported through Unimak Pass from the Gulf of Alaska (GOA) to the Bering Sea (BS). The magnitude and variability of the larval transport, and the relative contribution of GOA-spawned Pacific halibut to the Bering Sea juvenile population will be examined. In 2016, historical larval survey data were summarized to establish a distribution baseline. In 2017, the synthesized data will be used to parameterize a biophysical model that incorporates a high resolution ocean circulation model to determine the influence of climate-mediated oceanographic variability on Pacific halibut source-sink dynamics, larval connectivity, and transport within and between the GOA and BS. There are also a total of 93 preserved samples of larval Pacific halibut caught from 2007-2014 which are available for genetic analysis. Additional samples may be collected in the future if deemed necessary.

Title: Validating biochemical markers of growth for habitat assessment in flatfishes

**Lead PI: Thomas P. Hurst (AFSC – NOAA - NMFS)
Co PI: Josep V. Planas (IPHC)**

Funding agency: Alaska Essential Fish Habitat Research Plan (EFH) - NOAA

This project complements and expands upon earlier work to identify essential nursery habitats of commercially important flatfishes and gadids using temperature-dependence of growth potential

in laboratory experiments and observed growth rates in the field. Specifically, this project will validate the use of biochemical molecular markers for growth in Pacific halibut and yellowfin sole using laboratory experiments. This will allow these markers to be applied to field-captured fish in the analysis of spatial variation in growth performance across the range of available habitats for these species. In other words, provide a tool for direct assessment of habitat value for two of the most important commercial flatfish species in the United States.

A 2016 EFH grant to Hurst et al., provided the necessary funds to collect yellowfin sole (*Limanda aspera*) and Alaska plaice (*Pleuronectes quadrituberculatus*) for laboratory experiments. As part of that collecting work, we were able to also collect juvenile Pacific halibut and longhead dab (*Limanda proboscidea*). The analyses proposed here will be conducted on yellowfin sole from the planned experiment and an additional experiment with Pacific halibut will be conducted for this project.

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 fishery-independent setline survey or as part of the commercial fishery data collection program. Ongoing data collection projects that are continuing in 2017 include the following.

IPHC fishery-independent setline survey

IPHC Survey Team – Tracee Geernaert, survey manager

The IPHC fishery-independent setline survey provides catch 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 (Henry et al. 2017).

Biological data collected on the surveys (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 survey 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 fishery-independent setline surveys in selected areas during most years since 1963. The majority of the current survey station design and sampling protocols have been consistent since 1998.

Environmental data collection aboard the IPHC setline survey using water column profilers

PIs: Lauri Sadorus, Jay Walker

The IPHC collects oceanographic data using water column profilers at each station during the IPHC fishery-independent setline survey. The profilers collect a suite of oceanographic data from surface to bottom, including pressure (depth), conductivity (salinity), temperature, dissolved oxygen, pH, and fluorescence (chlorophyll *a* concentration). The IPHC has operated profilers since 2000 on a limited basis, and coastwide since 2009 (Sadorus and Walker 2017).

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

PI: Lauri Sadorus

The National Marine Fisheries Service (NMFS) 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 (Sadorus et al. 2017a). The IPHC has participated in the NMFS Aleutian Islands trawl survey, which takes place every two years, since 2012 (Sadorus et al. 2017b). Alternating annually with the Aleutian Islands trawl survey is the NMFS Gulf of Alaska trawl survey, which IPHC has participated in since 1996 (Sadorus et al. 2016). The IPHC uses the NMFS trawl surveys to collect information on small Pacific halibut that are not yet vulnerable to the gear used for the IPHC fishery-independent setline survey 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 port sampling program

IPHC Port Team – Lara Erikson, port manager

The IPHC positions field staff to sample the commercial catch for Pacific halibut in Alaska, British Columbia, Washington, and Oregon. Commercial catch sampling involves collecting Pacific halibut otoliths, fork lengths, logbook information, and final landing weights (Erikson and Kong 2017).

The collected data are used in stock assessment and other research and the collected otoliths provide age composition. Lengths of sampled Pacific halibut provide the basis for estimates of mean weight and, in combination with age data, size-at-age analyses. 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.

References

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Table 1. List of new and continuing projects selected for internal (IPHC) funding

Project #	Project Name	Priority	Budget (US\$)	Principle Investigator	Management implications
New Projects					
2017-01	Full characterization of the annual reproductive cycle	High	91,098	Planas	Maturity assessment
2017-02	Investigation of Pacific halibut dispersal on Bowers Ridge	High-Medium	124,527	Loher	Spawning areas
2017-03	Tail pattern recognition analysis in Pacific halibut	High	2,370	Dykstra	Adult distribution
2017-04	Condition Factors for Tagged U32 Fish	High	13,000	Dykstra	DMR estimates
2017-05	Identification and validation of markers for growth	High	27,900	Planas	Changes in biomass/size-at-age
2017-06	Discard mortality rates and injury classification profile by release method	High-Medium	16,123	Dykstra	DMR estimates
2017-07	Sequencing the Pacific halibut genome	High	22,500	Planas	Population estimate
Continuing Projects					
621.15	Voluntary at-sea sex marking	High	18,120	Loher	Stock spawning biomass
621.16	Development of genetic sexing techniques	High	146,107	Loher	Sex composition of catch
642.00	Assessment of Mercury and other contaminants	Medium	8,400	Dykstra	Environmental effects
650.18	Archival tags: tag attachment protocols	High	2,800	Loher	Adult distribution
650.20	Investigation of Pacific halibut dispersal on the 4D Edge	High	5,500	Loher	Spawning areas
661.11	<i>Ichthyophonus</i> Incidence Monitoring	Medium	8,055	Dykstra	Environmental effects
669.11	At-sea Collection of Pacific Halibut Weight to Reevaluate Conversion Factors	High	1,500	Soderlund	Length-weight relationship
670.11	Wire tagging of Pacific halibut on NMFS trawl and setline surveys	High	12,000	Forsberg	Juvenile and adult distribution
	Total - New Projects		297,518		
	Total - Continuing Projects		202,482		
	Overall Total (all projects)		500,000		

Table 2. List of projects selected for external funding (submitted)

Grant agency	Project name	Partners	IPHC Budget (US\$)	PI	Management implications	Submission status
S-K NOAA	Improving discard mortality rate estimates in the Pacific halibut by integrating handling practices, physiological condition and post-release survival	Alaska Pacific University	223,220	Planas Dykstra Loher Stewart Hicks	Bycatch estimates	Submitted in December 2016
NPRB	Somatic growth processes in the Pacific halibut (<i>Hippoglossus stenolepis</i>) and their response to temperature, density and stress manipulation effects	AFSC-NOAA-Newport	122,264	Planas	Changes in biomass/size-at-age	Submitted in December 2016
NPRB	Larval transport, supply, and connectivity of Pacific halibut between the Gulf of Alaska and the Bering Sea	AFSC-NOAA-SandPoint-NWFSC	8,000	Sadorus Planas Stewart	Biomass distribution	Submitted in December 2016
EPH NOAA	Validating biochemical markers of growth for habitat assessment in flatfishes	AFSC-NOAA-Newport	35,000	Planas	Changes in biomass/recruitment	Submitted in November 2016
	Total requested		388,884			

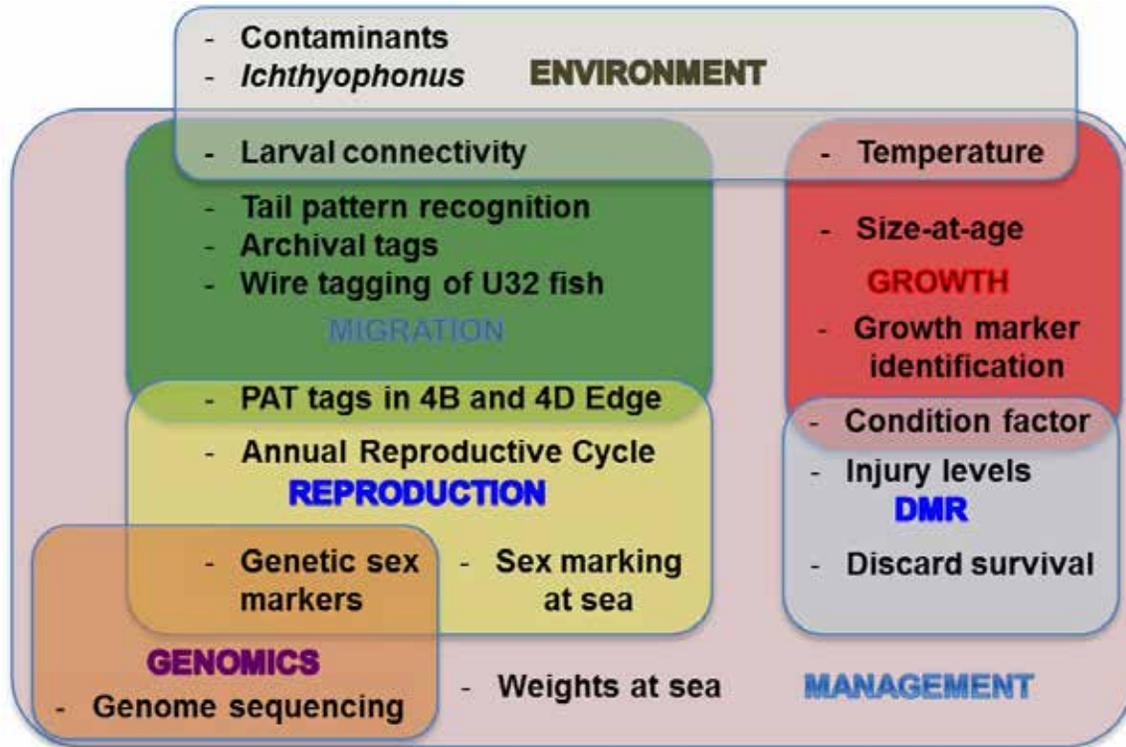


Figure 1. Schematic diagram of new and continuing research projects and their interactions.