IPHC 5-year Biological and Ecosystem Sciences Research Program: Update

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PURPOSE

To provide the Commission with a description of the new and continuing research projects proposed by the IPHC Secretariat and contemplated within the Five-Year Biological and Ecosystem Sciences Research Plan.

BACKGROUND

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

1) identify and assess critical knowledge gaps in the biology of the Pacific halibut;

2) understand the influence of environmental conditions; and

3) apply the resulting knowledge to reduce uncertainty in current stock assessment models.

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

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

DISCUSSION

For FY2019, five new projects are proposed that cover specific research needs (Appendix I).

Project 2019-01 ("***Integrating migration and genetics research to refine Pacific halibut population structure, distribution and movement***") proposes performing studies to improve our understanding of spawning site contributions to nursery areas in relation to year-class and

recruit survival and strength, as well as of the relationship between nursery origin and adult distribution and abundance over temporal and spatial scales through the application of genetic, approaches to address management-relevant questions on population structure, distribution and movement.

Project 2019-02 ("***Whale detection methods relevant for Pacific halibut***") proposes testing electronic monitoring-based methods to detect whale presence in the directed longline Pacific halibut fishery. This study will be performed in the framework a Bycatch Reduction Engineering Program (BREP-NOAA)-funded study led by the Alaska Longline Fishing Association in which IPHC is a collaborating partner (Appendix II).

Project 2019-03 ("***Adult Pacific halibut captive holding studies***") proposes performing studies on captive adult Pacific halibut to establish or validate measures or protocols required for other ongoing projects, such as (1) determining the permanence of individual tail markings for tracking individual movement rates, (2) calibrating measures of fat content for condition factor determinations and of stable isotope (C^{13} and N^{15}) ratios for inferring growth and dietary information, (3) calibrating O^{18} otolith signatures with environmental temperature and (4) producing larvae for behavioral studies.

Project 2019-04 ("***Use of LEDs to reduce Pacific halibut catches before trawl entrainment***") proposes evaluating if artificial illumination (e.g. LEDs) in trawl gear can reduce Pacific halibut bycatch before trawl entrainment in relation to the physiological condition of the fish. This study will be performed in the framework of a Bycatch Reduction Engineering Program (BREP-NOAA)-funded study led by Pacific States Marine Fisheries Commission in which IPHC is a collaborating partner (Appendix II).

Project 2019-05 ("***Improving the characterization of discard mortality of Pacific halibut in the recreational fisheries***") proposes determining mortality rates of discarded Pacific halibut in the Pacific halibut recreational fisheries. This study will be conducted with partial funding from a grant from the National Fish and Wildlife Foundation awarded to IPHC (Appendix II) in collaboration with academic and industry partners.

In addition to the new projects proposed, twelve continuing projects are proposed. These include the following:

- projects aimed at the development of tools for sex identification (**621.16**) and at producing accurate reproductive maturity estimations (**674.11**),
- project monitoring the Pacific halibut population for heavy metal and persistent organic pollutants (**642.00**),
- projects conducting migration-related research involving the use of satellite and wire tagging, estimating larval abundance and distribution over time and in relation to oceanographic and environmental conditions, and tail imaging recognition (**650.21, 650.22, 670.11, 675.11**),
- projects dealing with the identification of markers for growth-related studies (**673.14**) and on the relationship between temperature history and growth (**673.15**).
- projects investigating condition factor indices in wire-tagged fish (**672.12**) and characterizing the discard mortality rates in the longline fishery (**672.13**) and,
- project conducting work related to the sequencing of the Pacific halibut genome (**673.13**).

Projects are listed in Appendix I. An update on progress on continuing projects is provided below.

Project 621.16 ("***Development of genetic sexing techniques***") has as its main objective the identification of molecular markers for sex in order to provide a genetic method for sex identification in settings in which direct observations of sex cannot be obtained (i.e. fish at commercial offloads). In addition, this project was designed to provide genetic validation of the physical marking of sex at sea (Project 621.15, IPHC-2017-WM2017-10). Three single nucleotide polymorphisms (SNPs) were identified to be associated with sex and molecular assays were developed for two of the identified SNPs. These assays were estimated to have an accuracy of 97.5% in a comparison between assayed sex and visually-determined sex in a sample of 199 fish, based on an assumption that no process or recording errors existed within the visually-determined data (Drinan et al., 2018). The assay was subsequently used to evaluate the accuracy of commercial sex-marking at sea and is now being applied to provide sex information from biological samples (i.e. fin clips) collected from sampled fish from the 2017 commercial catch.

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

A total of four projects are continuing migration-related studies, two of which involve tagging. First, **Project 650.21:** ("***Investigation of Pacific halibut dispersal on Bowers Ridge via Pop-up Archival Transmitting (PAT) tags***") involved a study of the migratory behavior of O32 Pacific halibut residing in summer on Bowers Ridge in IPHC Regulatory Area 4B, at both seasonal and interannual time scales. The primary goal of the project is to evaluate relative connectivity between Bowers Ridge, the western Aleutian Islands, and the broader eastern Pacific Ocean. Results will be placed in the context of data obtained from prior satellite-tagging experiments in which more than 200 O32 Pacific halibut have been tagged in the eastern Bering Sea and Aleutian Islands region. A total of 22 fish (13 female; 8 male; 1 of unknown sex) were tagged during July of 2017 with pop-up archival transmitting (PAT) tags: 16 with tags programmed to detach and report in mid-January (i.e., during the spawning season) and 6 with tags programmed report in July (i.e., after 365 days at liberty) of 2018. Final locations were obtained for 18 of these fish (14 during winter and 4 in July). Seventeen of the reporting locations were on Bower's Ridge, with one tag reporting in winter from the eastern Bering Sea shelf break near St. Matthew Canyon. Analysis of the archived environmental data and generation of at-liberty position estimates is ongoing. Second, **Project 650.22** ("***Larval connectivity***") is aimed at investigating the movement and connectivity of Pacific halibut larvae primarily between the Gulf of Alaska and the Bering Sea, and also within each basin. Larval abundance and distribution, as well as that of 2-year old fish from the same cohort, are being modeled over time and over oceanographic and environmental conditions. Third, **Project 670.11:** "***Wire tagging of Pacific halibut on NMFS trawl and IPHC setline surveys***" involves the tagging of U32 Pacific halibut in order to further understand coastwide migratory and growth patterns of young Pacific halibut. In 2018, 916 Pacific halibut were tagged during the NMFS trawl survey (768 fish tagged in the Bering Sea and 148 fish tagged in the Aleutian Islands) and 1,747 Pacific halibut were wire-tagged on the IPHC's fishery-independent setline survey. Finally, **Project 675.11** ("***Tail pattern recognition***") is the continuation of a pilot study conducted in 2017 that investigated the

identification of individual fish to complement migratory studies by way of photographic recognition of tail patterns. Various pattern-recognition software packages have been used to examine uniqueness and longevity of patterns in tail coloration on both the blind and eyed side of the fish, showing relative promise for identifying the same individuals over time. Cameras were deployed on several vessels during the fisheries-independent setline survey in 2018 and over 744 tail images of wire tagged U32 fish were collected and are being used to create a database of tail images.

Project 672.12 ("***Condition Factors for Tagged U32 Fish***") continues the study of 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 performance. Fat level determinations, blood parameters and biometrical measures are being evaluated for a subset of tagged U32 fish.

Project 672.13 ("***Discard mortality rates and injury classification profile by release method***") is continuing to investigate the relationship between three hook release methods (careful shake, gangion cut and hook stripper) in the longline fishery and associated injuries with the physiological condition of fish and with post-release survival in order to update current estimates of discard mortality rates in the directed longline Pacific halibut fishery. Furthermore, this project is also conducting investigations on the applicability and accuracy of electronic monitoring in capturing release methods and fish condition in vessels without observer coverage. This project has received funding from a grant from the Saltonstall-Kennedy NOAA grant program under project number NA17NMF4270240 (Appendix II).

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

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

Project 673.15 ("***Influence of thermal history on growth***") is designed to study the thermal profile experienced by fish at sea as assessed by electronic archival tagging and otolith microchemistry in order to investigate the relationship between growth patterns (or productivity) and spatial and temporal variability in environmental conditions for growth. This study will allow us to relate temperature histories that are experienced by individual fish to the growth patterns

that they display, to examine spatial and temporal trends in rearing conditions and growth, and to extend thermal analyses to untagged Pacific halibut via otolith microchemical analyses. In addition, the data are expected to provide information regarding dispersal of U32 Pacific halibut, both seasonally and ontogenetically. During the 2018 FISS a total of 255 externally-attached electronic archival tags were deployed coast wide and 13 fish were tagged with PAT tags in the western Aleutian Islands. Additional tag releases are anticipated in 2019. Given that these fish are relatively small when tagged, and therefore only weakly selected to the target longline fishery, recapture rates are expected to be modest over their first 2-3 years post-release. One fish was recovered during 2018; the PAT tags are programmed to report during the summers of 2019 and 2020.

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

RECOMMENDATION/S

That the Commission:

1) **NOTE** paper IPHC-2019-AM095-14 which outlined the research projects proposed by the IPHC Secretariat and provided an overview of the Five-Year Biological and Ecosystem Sciences Research Plan.
2) **ENDORSE** the proposed new and continuing research projects.

APPENDICES

Appendix I: Summary of research projects proposed for FY2019.

Appendix II: Summary of current awarded research grants.

APPENDIX I

Summary of research projects proposed for FY2019

Project #	Project Name	Priority	Budget ($US)	External funding FY2019 ($US)	Management implications
New Projects					
2019-01	Migration and genetics	High	105,092	-	Population structure, distribution and movement
2019-02	Whale detection methods	High	7,511	7,511	Mortality estimation
2019-03	Adult captive holding studies	High-Medium	63,183	-	Changes in biomass/migration
Continuing Projects					
621.16	Development of genetic sexing techniques	High	18,000	-	Sex composition of commercial catch
642.00	Assessment of mercury and other contaminants	Medium	6,300	-	Environmental effects
650.21	Investigation of halibut dispersal in Area 4B	High	1,000	-	Spawning areas
650.22	Larval connectivity	High	-	-	Larval and juvenile distribution
670.11	Wire tagging of halibut on NMFS trawl survey and FISS	High	14,300	-	Juvenile and adult distribution
672.12	Condition factors for tagged U32 Fish	High	-	-	DMR estimates
672.13	Discard mortality rates and injury classification profile by release method	High	145,540	102,370	DMR estimates
673.13	Sequencing the Pacific halibut genome	High	39,500	-	Population changes
673.14	Identification and validation of markers for growth	High	111,914	102,839	Changes in biomass/size-at-age
673.15	Influence of thermal history on growth	High	115,319	-	Changes in biomass/size-at-age
674.11	Full characterization of the annual reproductive cycle	High	102,661	-	Maturity assessment
675.11	Tail pattern recognition	High-medium	3,900	-	Juvenile and adult distribution
	Total - New Projects ($US)		$175,786		
	Total - Continuing Projects ($US)		$558,434		
	Overall Total (all projects) ($US)		$734,220		
	External Funding (for FY2019) ($US)			$212,720	
	Net total ($US)		**$521,500**		

APPENDIX II

Summary of current awarded research grants

Project #	Grant agency	Project name	PI	Partners	IPHC Budget ($US)	Management implications	Grant period
1	**Saltonstall-Kennedy NOAA**	Improving discard mortality rate estimates in the Pacific halibut by integrating handling practices, physiological condition and post-release survival (Award No. NA17NMF4270240)	IPHC	Alaska Pacific University	$286,121	Bycatch estimates	September 2017 – August 2019
2	**North Pacific Research Board**	Somatic growth processes in the Pacific halibut (*Hippoglossus stenolepis*) and their response to temperature, density and stress manipulation effects (NPRB Award No. 1704)	IPHC	AFSC-NOAA-Newport, OR	$131,891	Changes in biomass/size-at-age	September 2017 – August 2019
3	**Bycatch Reduction Engineering Program - NOAA**	Adapting Towed Array Hydrophones to Support Information Sharing Networks to Reduce Interactions Between Sperm Whales and Longline Gear in Alaska	Alaska Longline Fishing Association	IPHC, University of Alaska Southeast, AFSC-NOAA	TBD	Whale Depredation	September 2018 – August 2019
4	**Bycatch Reduction Engineering Program - NOAA**	Use of LEDs to reduce Pacific halibut catches before trawl entrainment	Pacific States Marine Fisheries Commission	IPHC, NMFS	TBD	Bycatch reduction	September 2018 – August 2019
5	**National Fish & Wildlife Foundation**	Improving the characterization of discard mortality of Pacific halibut in the recreational fisheries	IPHC	Alaska Pacific University, U of A Fairbanks, charter industry	$98,902	Bycatch estimates	January 2019 – December 2019
				Total awarded ($)	**$516,914**		