2015 IPHC Research Report for TSC

Review of 2014 Projects and Proposals for 2015

International Pacific Halibut Commission Staff

Introduction

This report reviews research conducted by the IPHC staff in the past year as well as research proposed for the upcoming year. The report is divided into three sections: the first section briefly reviews staff changes over the past and upcoming year(s), the second section reviews the status of research conducted in 2014, and the third section presents the preliminary staff research proposals for 2015 and a summary of ongoing projects. This report does not include annual staff tasks such as data collection and processing that are necessary for the management of the fishery.

SECTION I:

Staffing Updates

In 2014 the IPHC hired Stephanie Hart (Administrative Assistant). Throughout 2014 and into 2015 efforts have been ongoing to fill the Biological and Ecosystem Science Program Head (Gregg Williams – ret'd) position. This is in addition to some standard turnover seen in both the port and sea sampling seasonal positions.

Stephen Kaimmer (Research Biologist) and Heather Gilroy (Fisheries Statistics Program Manager) are retiring from the Commission in May 2015. Claude Dykstra (current Survey Manager) was hired for the Research Biologist position and will transition into that role over the next few months. The Commission is in the process of hiring for the Survey Manager position. The Fisheries Statistics Program Manager will be filled in the interim as an acting role by Kirsten MacTavish.

The current contract for the Commission's Executive Director, Dr. Bruce Leaman, expires in early 2016. During 2015, the Commission will be searching for a new Executive Director to succeed Dr. Leaman.

SECTION II:

Review of 2014 - Project Summaries

This section provides a brief recap of projects conducted in 2014. Full reports on most projects can be found in the 2014 RARA.

Research is conducted within four areas of study which connect to the IPHC mission and support the assessment and management objectives of the Commission. These four areas are 1) assessment and stock identification; 2) management strategy; 3) biology; and 4) ecology.

Assessment and stock identification

Project 2014-02: Estimating hooking success for large halibut

Priority: Medium
Start: 2014
Anticipated Ending: 2014
Personnel: S. Kaimmer, I. Stewart

The study attempted to observe hook attacks by halibut in the 110 to 150+ cm range, i.e., 40-80 lb fish, to estimate hooking success. Previous camera studies (Kaimmer 1998) demonstrated an increasing hooking success with increasing size for halibut ranging from about 70 to 110 cm. Our Didson1 studies in 2006 and 2007 (Kaimmer and Wischniowski 2008 and 2009) used a much larger pool of observations to refine this curve. Although these investigations estimated an increasing relationship between hooking success and fish size, which would be indicative of an asymptotic cure, neither had enough observations of large fish (over 100 cm) to estimate whether this relationship might be dome shaped with a decreasing hooking success for very large fish. It was expected that observing an additional 50 attacks from halibut spread throughout the 110 to 150+ cm range would allow the estimation of the form of the relationship between hooking success and fish length for these larger fish. The form of this curve has very important implications for stock assessment assumptions (Clark and Kaimmer 2006).

A GoPro camera was used to observe hook attacks on a single baited hook off Afognak Island near Alaska's Kodiak Island. The number of large halibut observed was not enough to generate this parameter. However, large numbers of smaller halibut were observed which confirmed the earlier estimates of hooking success for halibut with fork lengths ranging between 60 to 100 cm and validated the technique for estimating hooking parameters.

Biology

Project 636.00: Evaluation of Pacific halibut macroscopic maturity stage assignments

Priority: High
Start: 2004
Anticipated Ending: Continuing
Personnel: K. MacTavish, other staff as needed

The staff believes it is necessary to re-evaluate our classification criteria for female gonad maturity stage. The method currently used on the assessment surveys is based on visual criteria established in the early 1990s and modified in 1995. These survey data combined with the age data are important components in the stock assessment model. Four maturity stages are presently assigned to female halibut; immature (F1), maturing (F2), spawning (F3) and resting (F4). Once a female halibut has spawned, the gonad transitions to a resting phase, back to maturing, and then to spawning again. Our criteria for classification also assume that the immature (F1) stage is only seen with immature fish but we are seeing anomalies during the survey that question this assumption. Gonad samples were collected in 2004 from which to base this study. In 2014, a sampling protocol was determined and histological slides were prepared from all the gonad

samples that were available. A technician was hired for 3 months to help with processing of the slides. The goal is to measure individual oocyte diameters from all the slides and to assign reproductive maturity stages from the slides to compare with those assigned in the field. Work on these goals will continue in 2015.

Project 621: Development of protocols for dockside monitoring of harvested sex ratios

Start Date: 2006
Anticipated ending: 2016
Personnel: T. Loher, I. Stewart, M. Woods, O. McCarthy, J. Marx; volunteer fleet members; L. Hauser, H. Galindo, and I. Jimenez-Hidalgo (UW-SAFS)

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. Sensitivity analyses suggest that variance in sex composition of landings may be the most influential source of uncertainty affecting current understanding of spawning stock biomass. 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 ratios translated into a roughly 50 million pound range in estimates of female spawning biomass (i.e., ~25% of the total estimated spawning biomass). Without direct observations of fishery sex ratio at age, there is no way to determine the magnitude of uncertainty and/or bias that exists in current assessment results due to this source. Unfortunately, there is currently no reliable way to determine the sex of commercially-harvest halibut at landing, because all individuals must be eviscerated at sea.

The current project represents a suite of integrated studies that are designed to obtain reliable sex data from eviscerated commercial landings. The project is composed of the following components: 1) comparison of the survey-based statistical method and genetic (microsatellite) sexing accuracy; 2) examination of methods to mark fish at sea, in a survey setting; 3) development of an unequivocal genetic sexing assay using single nucleotide polymorphisms (SNPs); 4) pilot testing of chosen marking methods in a commercial setting; 5) examination of spatial and temporal variance within and among the sex ratios of commercial landings, as determined via at-sea marking, and validated by genetic assays, and; 6) development of at-sea marking and genetic validation protocols that can provide fleet wide (by IPHC Regulatory Area and year) estimates of sex ratio for direct use in the stock assessment.

Components 1 and 2 represented summer internships conducted by Monica Woods and Orion McCarthy, respectively, and were completed in 2011 and 2014. Components 3 and 4 will be initiated this spring. The former will be executed via collaboration with the University of Washington (Dr. Lorenz Hauser, principal investigator), and is expected to produce by 2017 a SNP-based test of sex that can be conducted in-house, by the IPHC. Component 4 will rely upon collaboration with commercial IFQ holders landing their catch in Seward, Alaska. This will test a single method of sex-marking during six commercial fishing trips, in order to determine the marking method's feasibility from a fleet perspective, evaluate the additional workload that processing sex-marked catch is likely to have upon the IPHC's port sampling program, and

generate a small tissue archive that can be subjected to subsequent genetic analysis, as an element of Project Component 5. Components 5 and 6 are expected to occur from 2016-2018.

Project 621: Examining population connectivity between the southern Salish Sea and the outer continental shelf via Pop-up Archival Transmitting (PAT) tagging

Start Date: 2014
Anticipated ending: 2015
Personnel: T. Loher, survey team; B. Starkhouse (Lummi Nation), R. Svec and J. Peterson (Makah Fisheries Management Department), S. Bass (Point No Point Treaty Council)

A research paper published in the journal *Environmental Biology of Fishes* called into question whether Pacific halibut harvested from the inside waters of Area 2A (i.e., the southern Salish Sea) belong to the larger outer-coast population, or represent a unique inside-waters stock that should be managed independently. Thus, a tagging experiment was conducted during the summer of 2014 to examine whether halibut that reside in the US waters of the southern Salish Sea during the summer remain there or, alternatively, mix with spawning population(s) to the west and the north, thereby representing component(s) of a more broadly-ranging stock. The experiment will also assess interannual fidelity to summer feeding grounds by determining fish locations the summer after tagging, in addition to inferring potential spawning locations based on fish locations during the winter of 2014-2015.

Using refurbished satellite-transmitting archival tags, six halibut were tagged on May 27 and 28, 2014, during the IPHC's setline survey, and another six halibut tagged on October 11 and 12, during a dedicated charter. Six fish were tagged in each of two general regions: 1) north of the San Juan Islands, in the southern Strait of Georgia and Boundary Pass; 2) in the eastern Strait of Juan de Fuca, between Port Angeles and the San Juan Islands. All tagged fish were females, and ranged from 94-131mm in length. Eight tags were programmed to report final fish locations and environmental data (temperature, depth, and light-level; the latter used to infer at-liberty locations) on January 15, 2015; four tags were programmed to release and report between May 27 and June 1, 2015. To date, nine tags have detached and reported to passing satellites. Seven of those produced endpoint location data. Upon reporting, five fish were located near their deployment locations in the southern Salish Sea, on dates ranging from July 10, 2014 to March 20, 2015. The two remaining fish were located in Area 2B on their reporting dates (October 27, 2014 and January 15, 2015), at deep-water locations consistent with known halibut spawning grounds.

Project 650: Electronic archival tagging: preparation for coastwide deployment

Start Date: 2006
Anticipated ending: 2016
Personnel: T. Loher, J. Forsberg, T. Geernaert, R. Rensmeyer, S. Stephens, survey team; P. O'Flaherty (Lotek Wireless), J. Nielsen (UAF Juneau), F. Broell (Dalhousie University)

This project is composed of several components, first initiated in 2006 and expected to culminate in the deployment of electronic archival tags throughout the managed range of the eastern Pacific halibut stock. Electronic archival tags represent a powerful tool for studying fish migration, behavior, and physiology, at resolutions that cannot be achieved using conventional tags. Whereas conventional tagging produces, at best, two data points per fish –geographic location at deployment and recovery - archival tags can produce millions of data points per year, providing information not only on tagging and recovery locations, but also the potential for at-liberty position estimates using light data, geomagnetism, or tidal amplitude estimation; remote tag detection via a variety of telemetry methods; and depth, temperature, and acceleration data throughout deployment. The IPHC has been planning a large-scale deployment that will examine relationships between growth rates and water temperature, age- and sex-specific ontogenic migration, and seasonal migration patterns coastwide. However, advances in battery power and data storage capacity have increased the operable lifespan of modern archival tags to the point of allowing relatively fine-scale data collection (e.g., every 15-30 seconds) for periods in excess of five years. Such long tag life requires that new methods be developed that will optimize tag retention and recovery rates, in order to maximize data recovery from our deployments.

To this end, the IPHC has conducted two captive holding experiments to refine surgical implantation techniques and develop ultrasonic techniques for non-lethal sex identification (2006-2008), and develop external attachment protocols (2009-2015). Based largely upon these results, a suite of five at-sea tag deployments have been conducted, designed to test hard-on-body external attachment (2008), examine relative recovery rates of surgically-implanted versus hard-mount external tags (2009), identify potential fishery-specific deployment locations in the Aleutian Islands region (2010), field-test tags designed to record the earth's magnetic field strength (2011), and compare the effectiveness of three different external dart-and-tether designs (2013). At this juncture, we feel that sufficient information has been obtained from these experiments to allow tag deployments to begin during the summer of 2016. Given the scale of the currently-proposed deployment design (i.e., ~1,000 tags distributed among IPHC regulatory areas), we expect to conduct these deployments over a roughly 3-year window, using the IPHC survey as the primary deployment platform.

Project 664.11: Otolith increment study
Priority: High
Start Date: 2013
Anticipated ending: 2014
Personnel: B. Leaman, T. Loher, Ian Stewart, S. Martell, J. Forsberg

This research focuses on the decrease in size at age, and the desire to examine similar metrics in previous time periods of the halibut stock. The project is part of a broad-based study of changing size at age in halibut, involving food web and ecosystem drivers, bioenergetics, fisher effects, and analytic modeling. The study, in collaboration with NMFS, UW, and ADF&G, is partially funded by NPRB. Primary work by IPHC staff will include the use of the otolith archives to examine growth patterns and size at age in earlier time periods. Thus far, the IPHC staff has re-aged subsets of otoliths from each decade from the 1920s to the 1980s by both the surface and break-and-bake technique and compared original surface ages to the ages made in 2014 (surface and bake). Additionally, systematic subsamples of otoliths collected in 1992, 1993, and 1998 that were previously only surface-aged were re-aged by break-and-bake and included in this analysis. Results indicated that historical samples contained very few fish aged older than 15 years by either method. Based on simultaneous estimation of bias and imprecision for up to four unique ages per otolith, the properties of historical surface ageing methods were found to be very similar to current methods, becoming increasingly biased and imprecise beyond 15 years.
Otolith increment measurements were made on subsamples of 15-year-old halibut from birth years 1977 and 1992. Analyses of increment data indicate a decline in Pacific halibut size-at-age between 1977 and 1992, with larger Pacific halibut found in the eastern Aleutian Islands (4B) than west (3A) in both years.

We intend to extend this study by looking at samples by decade, back to the 1920s. Stomach and relative abundance samples for halibut and co-occurring groundfish species were also collected for the larger project during the 2013 NMFS Gulf of Alaska survey.

Project 665.11: Estimate of length/weight relationship and head/ice/slime adjustment
Priority: High
Start: 2013
Anticipated Ending: open ended
Personnel: R. Webster, L. Erikson, K. MacTavish, H. Gilroy

The purpose of this study is to reexamine the relationship between fork length and net weight, including the estimation of adjustments necessary to convert head-on weight to net weight. The current length-net weight relationship was estimated in 1926. Using 1989 data, Clark (1992) 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 always known that the relationship varies seasonally and likely regionally. If the relationship varies among regulatory areas, there may be systematic bias in regulatory area estimates of weight or WPUE derived from length measurements. Seasonal variation could affect weight estimates that are made from data collected during only a small part

of the year. Therefore, we are collecting data coastwide throughout the season in order to estimate spatial and seasonal variation in the length to weight relationship.

The current relationship used by IPHC between fork length and net weight also includes adjustments for the weight of the head, and of ice and slime: gross landed weight (gutted, with head, ice and slime) is assumed to include 12% head weight and 2% ice and slime, which combine to give a multiplier of 0.8624 to convert gross to net weight. However, the industry standard for head, ice and slime deduction is a total of 12%. Therefore 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. To achieve this, we plan to record multiple weights on at least a subsample of fish.

In 2013, a pilot phase of the project was implemented that tested the equipment and methods at a selection of ports (Bellingham, Port Hardy, Prince Rupert, Petersburg, Sitka, Juneau, and Homer). The need to carefully test potential scales prior to full implementation, and the fact that the scales we used were far more expensive than those considered within the 2013 project budget, meant that the scope of the project in 2013 was more limited than initially proposed. In 2014, scales were provided to most port samplers and thus length and weight data were collected in most staffed ports, except for Dutch Harbor, St. Paul, and Sand Point, Alaska. The data were collected throughout the entire length of the commercial fishing season to determine whether seasonal or area-specific L-W relationships are warranted. This project will continue in 2015.

Ecology

Project 610.13: Oceanographic monitoring of the north Pacific and Bering Sea continental shelf with water column profilers

Priority: Medium
Start date: 2009
Anticipated ending: Continuing
Personnel: L. Sadorus, P. Stabeno (NMFS PMEL)

The IPHC maintains one of the most extensive sampling platforms in the north Pacific. This platform provides enormous potential for collection of valuable oceanographic data. In particular, understanding the dynamics of the structure of the mixed layer depth – a major GLOBEC goal - requires *in situ* vertical profiling. Since 2001, IPHC has successfully deployed a SeaBird SBE-19 water column profiler during the annual stock assessment survey. A second profiler was added to the program in 2007. In 2009, a NOAA grant provided for the complete outfitting of all chartered survey vessels, resulting in a complete coastwide deployment. A total of 1,267 successful casts were made in 2014 out of a possible 1,394.

Project 642.00: Assessment of mercury and contaminants in Pacific halibut
Priority: Medium
Start Date: 2002
Anticipated ending: Continuing
Personnel: C. Dykstra, B. Gerlach (ADEC)

Our collaboration with the Alaska Department of Environmental Conservation (ADEC) continued in 2014, collecting halibut tissue samples for analysis of heavy metal and organic pollutant loading from the California, Puget Sound, Fairweather, and 4A Edge S charter regions. To date 2,284 samples have been tested by ADEC. The mean level of total mercury for these samples has been 0.311 ppm (for comparison the FDA limit of concern is based on methyl mercury (~85% of total mercury) levels of 1.000 ppm, the EPA and CFIA level of concern is 0.500 ppm) ranging from non-detectable to 2.0 ppm. Results from analysis of persistant organic pollutants (POP's - pesticides, selected PCB congeners, dioxins, and furans etc) found that in general these compounds are either undetectable in halibut or well below other marine fish species. This is a positive finding and is likely attributable to the lower fat content in halibut compared to these other species.

In 2014 the Alaska Section of Epidemiology (a division of the Alaska Department of Health and Social Services) issued new guidance for women of child bearing age (WCBA) and young children with regards to fish over 0.400 ppm methyl mercury. This guidance includes lingcod, yelloweye rockfish, salmon shark, spiny dogfish shark and halibut which are more than 40 lbs. This is not considered a concern for the commercial fishery where average weights coming out of the fishery are in the 25-26 lb range. Reporting in 2014 included joint analyses with ADEC staff in presentations at the International Flatfish Symposium and the 2014 EPA National Forum on Contaminants in Fish.

Project 661.11: *Ichthyophonus* prevalence in halibut
Priority: Medium
Start Date: 2012
Anticipated ending: ongoing
Personnel: C. Dykstra, J. Gregg (USGS), P. Hershberger (USGS)

Ichthyophonus is a protozoan parasite from the class Mesomycetozoea, a highly diverse group of organisms having characteristics of both animals and fungi. It has been identified in many marine fish, and is considered a causative agent in herring fishery collapses world-wide and there is concern over its effects on the success of salmon spawning on major rivers such as the Yukon.

During 2011-2014, samples were collected from halibut caught on the IPHC setline assessment survey over a broad geographic range, with a goal of describing the spatial and temporal distribution of *Ichthyophonus* prevalence. Limited sampling of small (<50 cm) halibut from the NMFS trawl survey recorded a very low prevalence rate of 2.4%, suggesting that infections establish after some ontogenetic shift in diet, habitat, or behavior. Sampling of larger, adult halibut have shown a wide range of rates, with Prince William Sound showing some of the highest observed in marine fish. The prevalence of infection is higher than that which has been observed in studies of other sympatric fish species, including other pleuronectids, suggesting that either susceptibility and/or infection pressures are higher in halibut. While *ichthyophoniasis* has

been shown to reduce growth rate, decrease swimming stamina, and cause mortality in other fish hosts, its effects on Pacific halibut are unknown. Results to date were presented, in conjunction with USGS co-authors, at the International Flatfish Symposium in the fall of 2014.

Other

Project 618.00: Undergraduate Internship

Start Date: 2002
Anticipated duration: Continuing
Personnel: L. Sadorus, other staff support as needed

The IPHC's 2014 summer intern, Orion McCarthy, worked on a pilot study to develop a marking technique that can be carried out by fishers and used by port samplers to identify commercially-landed halibut by sex (as gonads are not present upon arrival at port because halibut are dressed at sea). Successful marks must be cost effective, easily executed, identifiable, and not damaging to the fish. Distinct male and female knife cuts were developed, the female cut consisting of two incisions in the dorsal fin and the male cut consisting of an incision in the gill plate. The sex ratio of the catch marked by fishers and assessed by the port sampler did not differ significantly from the true biological sex ratio of the catch, indicating the marking method may be useful to represent the sex ratio of halibut stocks. Fisher participation is crucial if the IPHC truly wishes to gauge the sex ratio of commercial halibut stocks, and it is recommended a voluntary program be established before regulations are implemented. Future research should address the limitations of the current study, namely the small size of the offload, lack of repetition, limited geographical scope, and port sampler limitations.

Remote Data Entry Development

In 2014, the IPHC worked on developing software applications for data entry of commercial and survey data into tablets with the intent of replacing the pencil and paper method currently used in both programs. IPHC's programmers created and are still developing two applications: eLogs and eSurvey.

The eLogs application was finalized for testing in the field and tablets were deployed with port samplers in Alaskan ports at the start of the commercial halibut season (March 2014). Port samplers are using Panasonic Toughpads on which the eLog application was installed. Testing was ongoing throughout the season with fixes to the programming. Port samplers are still collecting paper logs until they pass a strict set of criteria, at which point, the samplers will enter the log data directly into the eLog application during the skipper interviews.

The eSurvey application was also developed to replace the paper data forms that are currently used on the survey. In 2014 the eSurvey application was pilot tested in the field on two different operations. Development continued throughout the fall, and a larger scale pilot project will occur in 2015, with the goal of full deployment cycle in 2016.

SECTION III:

Ongoing and Proposed for 2015

Research proposed by IPHC staff goes through an internal review process by a staff Science Board. This year, the Board met in mid-October to review staff proposals for 2015 research. For each proposal, the Board discussed the merits, objectives, design, and coherence with the Commission's research goals and objectives. The Principal Investigator (PI) subsequently joined the Board for a broad discussion of the project. Concerns, questions and need for refinements or revisions, if any, about the proposal were communicated to the PI at that time. Following a full review of all proposals, the Board assigned a priority rating to each project, based on the following criteria:

High – Research which has a direct bearing on the assessment or its inputs, harvest policy, or current management structure. Postponement of a high priority project would have a significant and immediate impact on management or IPHC operation.

Medium – Research which addresses an assessment issue or management question/need. Postponement will not have an immediate significant impact on fishery management or IPHC operation but may impact future analyses.

Low – Research which addresses current issues of any subject but is not considered having a timely need or being crucial to current IPHC management or operation.

For the past several years, two primary topics have been at the forefront of discussions about the halibut resource. The first has been the continuing decline in size at age, with the resulting effects and impacts on the harvest policy and stock status. The IPHC staff is continuing with an externally-funded (NPRB) project examining multiple influences on halibut size at age. Allied with this is the need to accurately estimate the removals from the stock through conversion of landed fish weight into the quantities required for the stock assessment. The second issue has been the migratory behavior of the stock, specifically seasonal and ontogenetic migration, including sex and age-specific differences in spawning migration timing and duration. Understanding migration patterns is the overarching goal of the archival tag program, which has several aspects examining tag type, location, tag shedding, and resolution of geomagnetic location data (projects 650.xx).

Research into both areas is of high priority for the Commission and staff. In the following section, studies for 2015 will be presented which address both topics. In addition, the staff proposes to undertake a genetic study designed to establish a validation procedure for estimating the sex ratio of the commercial catch. Sensitivity analyses have shown that the estimate of stock biomass is very sensitive to the estimated sex ratio.

Based on the Science Board discussions and the topics previously outlined, the following sections describe the upcoming work by IPHC staff and also provide descriptions of recommended research studies for funding in FY2015.

OBJECTIVE 1: STOCK IDENTIFICATION, MONITORING AND ASSESSMENT

Research in this area focuses on stock identification, monitoring, assessment, forecasting, and incorporation of uncertainty in both data and processes into management advice. The staff seeks to understand the underlying Pacific halibut stock structure and the influence of age, size, and sex on movement as they relate to stock components. Additionally, monitoring occurs through the IPHC Port Sampling program (fishery removals), standardized setline stock assessment survey (fishery-independent stock indices), and trawl surveys (pre-recruits).

The most significant work is the annual stock assessment, which produces estimates of abundance based on a comprehensive suite of fishery-dependent and -independent variables. The assessment also forecasts short-term trends in the stock to support the IPHC decision-making process. Assessment staff also works at determining and reducing the level of uncertainty associated with stock assessments through advanced analytical techniques. Where needed, improved data collection or other studies are recommended.

For 2015, in addition to the annual assessment, the staff is proposing studies to address the accurate determination of both the sex ratio of the catch, and the spawning biomass of the stock, as well as a cooperative project on hooking behaviour.

Funded research – Proposed

Project 2015-01: Genetic Sexing via Single Nucleotide Polymorhpisms (SNPs)
Priority: High
Start: 2015
Anticipated Ending: 2016
Personnel: T. Loher, L. Hauser (UW)

The work will allow for direct and reliable monitoring of sex ratios within the commercial catch in the face of potentially changing sex ratios due to decreasing size at age relative to the commercial minimum size limit (MSL). Proposals to reduce the MSL have also been advanced to reduce handling mortality on currently-sublegal fish, to theoretically bring a larger proportion of males into the exploited stock fraction, and to increase the economic efficiency of the harvest. At present, the sex composition of the catch is estimated from IPHC survey data but there is a critical need to directly monitor changes in sex composition of the catch should such actions be invoked.

The sequencing of Restriction site Associated DNA (RAD tags), has revolutionized genetics by allowing the discovery and genotype-calling of thousands of SNPs (Single Nucleotide Polymorphisms) in multiple individuals at relatively low cost. The technique takes advantage of the large number of sequences (millions of reads per run) produced by the Illumina HiSeq 2000 sequencer. Briefly, RAD tag sequencing focuses on sequencing the regions (tags) directly adjacent to specific restriction sites genome-wide. It is therefore possible to sequence a large and reproducible subsection of the genome in many individuals. Given the high success in sexing halibut with microsatellites, we expect to identify several dozens of sex specific SNPs that will allow the development of rapid assays for large samples. Once SNPs highly diagnostic for sex

have been identified, we will develop high-throughput assays to allow the screening of larger samples. We will identify about 20 SNPs and re-sequence them in additional individuals. We will optimize these SNPs for use with low quality DNA, allowing the elimination of costly and laborious DNA extraction methods in routine sex surveys. In addition, we will minimize the number of SNPs necessary for 100% sex identification by picking highly discriminatory SNPs from our panel.

Project 2015-02: Commercial Sex Marking Pilot
Priority: High
Start: 2015
Anticipated Ending: 2016
Personnel: T. Loher, I. Stewart, J. Marx

This project has three primary objectives: a) test a single method of sex-marking aboard a small sample of commercial fishing trips in order to determine its feasibility from a fleet perspective; b) evaluate the additional workload that processing sex-marked catch, and obtaining tissue samples for subsequent genetically-based QA/QC of the physical marking process, is likely to have upon the IPHC's port sampling program; c) generate a small tissue archive that can be subjected to subsequent genetic analysis, as an element of Project 2015-01, above. We plan to sample six offloads from Area 3A, equally distributed amongst spring, summer (during the survey period), and fall. The study will use volunteer vessel captains who are willing to mark fish during selected commercial trips, and we will also work with interested RAB members during the selection process. We will attempt to identify vessels and trips that plan relatively small landings (preferably in the 2000-3000-pound range), with an eye toward scaling the process upwards in the future. We expect that obtaining a broad temporal distribution of landings for each area may require collaboration from two, or even three, vessels in one or more areas.

Participating vessels will be briefed on the appropriate method for marking males and females during dressing, and asked to mark every fish retained during the designated fishing trip(s). The initial plan is to use the marks identified by McCarthy (2015), which consisted of two vertical cuts in the dorsal fin for females and one vertical cut in the white-side operculum for males. For each sampled offload, the port sampler will record the length and marked sex of each fish (including unmarked individuals) and collect and preserve a tissue sample. Analysis will include:

- A post-participation 'debrief' with each harvester regarding the marking process, time requirements, ideas for alternate marks and general willingness to participate again in the future.
- A comparison of the sex-ratio at age among the sampled trips with the sex-ratio at age among survey legs during the same year.
- Genetic samples will be stored, pending the development of SNIP assays when they can be assigned a sex and the accuracy of fishermen's marks can be tested directly following the approach used by McCarthy (2015).

Tissue samples will be archived until such time as a definitive genetically-based indicator of sex has been developed and is ready for use. When ready, the samples will be subjected to analysis and the resultant sex ratios compared to those obtained by at-sea catch-marking.

Project 2015-03: čibu·d hook research
Priority: Low
Start: 2015
Anticipated Ending: 2016
Personnel: E. Henry

In 2014, Makah Fisheries Management performed a study on the čibu·d, a traditional halibut hook used in the past by the Makah tribe. They were testing whether the traditional hooks could both fish effectively (maintain a similar catch-rate) and reduce the rate of non-halibut bycatch relative to commonly used circle hooks. Though it was shown from the Makah's original study that the čibu·d was not as effective at catching halibut in a commercial longline operation using circle hooks, there was a significant reduction in the observed rate of bycatch. A major uncertainty in the study was the actual fishing configuration and hooking process, which may have resulted in lower halibut catch rates. Although the mechanism of hooking can be inferred from the design of the čibu·d and location of the hook in captured fish, there are no recorded observations of halibut behavior when encountering the čibu·d, or of a halibut actually being hooked by one. Also, there is no information on the hooking success of čibu·d in comparison to circle hooks when deployed in a manner consistent with recreational rather than longline fisheries. The purpose of this study would be to record video of čibu·d hooking behavior, and to compare hooking behavior differences between čibu·d and circle hooks in a controlled aquarium setting. This could improve the understanding of the results already obtained by the Makah Fisheries Management program and help to better identify promising avenues for use of the čibu·d in future halibut fisheries.

This project has two primary goals: 1) establish the first video record of hooking behavior for halibut encountering metal čibu·d. This will include qualitative analysis of how the hook is attacked, where it becomes embedded in the jaw, and how many interactions are required for successful hooking, and 2) compare the rate of hooking success for metal čibu·d with modern 14/0 circle hooks.

OBJECTIVE 2: HARVEST POLICY AND MANAGEMENT

Work to support this objective involves annual evaluations of IPHC's harvest policy with regard to the current stock dynamics and management goals. The staff develops stock projection procedures which incorporate a realistic range of alternative hypotheses about stock behavior, environmental influences, and fishing effects on stock abundance and halibut characteristics. The staff also provides harvest management advice to the Commission and user groups in a form which allows the consideration of uncertainty in the assessment and forecasting processes.

In 2013 the Commission approved the formation of the MSAB to oversee the MSE process and to advise the Commission and Staff on the development and evaluation of candidate objectives and strategies for managing the fishery. The MSAB has been working with staff over the past 18 months to develop candidate management objectives, procedures to achieve these objectives, and performance metrics with which to measure success. The Board has developed five overarching objectives and a number of specific stock and fishery objectives. Progress and results of the Board's meetings are posted on the MSAB website (http://www.iphc.info/msab). The group is

currently working on a coastwide operating model of the halibut stock and in the future will develop more spatially explicit modelling.

OBJECTIVE 3: BIOLOGY, PHYSIOLOGY AND MIGRATION

Staff research within this objective seeks to collect and monitor primary biological characteristics of all sizes of halibut throughout the species' range. This includes directed studies but also involves incorporating studies monitoring the size at age of halibut within ongoing data programs wherever possible. IPHC also collaborates with other institutions and agencies to obtain biological and ecosystem information on halibut not otherwise available through IPHC programs and to incorporate that information into understanding and prediction of halibut population dynamics. Specific migration research objectives focus on the impacts of ontogenetic and seasonal movements on long-term yield, spatial distribution of spawning biomass, impact of fishing seasons on interceptions, and temporal variations in fish movement.
Research specific to halibut migration and movement was requested by the Commission in 2001 (Leaman et al., 2002). Dr. T. Loher of the IPHC staff has designed a tag study to provide information on seasonal migration of halibut that can provide input for discussing appropriate fishing seasons with four objectives. These objectives will be accomplished by quantifying, for the eastern Pacific halibut population, on regional bases:

1) the active spawning season for Pacific halibut, defined as the period over which eggs are released into the water column;

2) depth-specific spawning habitat, defined as the range of bottom depths over which halibut initiate active spawning behavior;

3) the fall and spring migratory periods, including estimates of the proportion of stock in a state of seasonal migration by date; and

4) where possible, timing of seasonal movement among regulatory areas, and the proportion of the spawning stock likely to be located out-of-area, by date.

Since 2009, the IPHC staff has been actively engaged in studies explicitly designed to establish protocols for the proposed work. This includes selection of appropriate tag type, tagging attachment and location protocols on the fish, and reliable, cost-effective tag technology. The ongoing studies outlined below support this work.

Also, in 2013 the IPHC embarked on an extensive set of studies to examine the recent decline in halibut size at age. The work encompasses several focused pieces of research, including those being conducted by IPHC staff and others in a collaborative study with the National Marine Fisheries Service (NMFS), the University of Washington (UW), and the Alaska Department of Fish and Game (ADF&G). Work will continue in 2015 as the decadal samples are identified and extracted from the archives, and aging/measuring of the growth increments begins.

The staff has also initiated a study of halibut movements within the southern Salish Sea (Puget Sound) in response to proposed hypotheses from Washington tribes about the nature of the population in that region. There has been a suggestion that the fish in this region are isolated and may require unique management. A demonstration of the movement of halibut from inside and outside waters will address the hypotheses.

Funded Research - Ongoing

Project 636.00: Evaluation of Pacific halibut macroscopic maturity stage assignments
Priority: High
Start: 2008
Anticipated Ending: 2016
Personnel: K. MacTavish, other staff as needed

The staff believes it is necessary to re-evaluate our classification criteria for female gonad maturity stage. The method currently used on the assessment surveys is based on visual criteria established in the early 1990s and modified in 1995. These survey data combined with the age data are important components in the stock assessment model. Four maturity stages are presently assigned to female halibut; immature (F1), maturing (F2), spawning (F3) and resting (F4). Once a female halibut has spawned, the gonad transitions to a resting phase, back to maturing, and then to spawning again. Our criteria for classification also assume that the immature (F1) stage is only seen with immature fish but we are seeing anomalies during the survey that question this assumption. Gonad samples were collected in 2004 from which to base this study. In 2015, research will include:

- Determining the maximum precision for oocyte diameter measurements by oocyte maturation stage.
- Conducting assessment of the prepared slides from the archived gonads using the sampling protocols developed in 2014.
- Developing the sampling plan required to characterize seasonal maturation, including determination of the value of current summer assessment of halibut maturity stages.

Project 650.13: Archival tags: mounting protocols (OCA)
Priority: High
Start Date: 2009
Anticipated ending: 2015
Personnel: T. Loher

For 2015, the staff intends to terminate the captive holding of halibut in tanks at the Oregon Coast Aquarium (OCA) in Newport, OR. Staff believes that we have obtained all the necessary information from this study with the finding that neither the dart-and-tether nor the surgical implantation methods show signs of shedding. This portion of the project will be terminated in late fall, although the fish may be used for project 2015-03 prior to sacrificing.

Project 650.16: Archival tags: Area 4B site selection
Priority: High
Start date: 2010
Anticipated ending: 2015
Personnel: T. Loher, J. Forsberg, survey team

In 2009, a total of 773 fish were tagged in Area 4B to evaluate tag recovery rates in preparation for a future release of archival tags in the area. Recovery rates of PIT tags released in the

Aleutians were quite low, without evidence of recovery hotspots. This suggested that if archival tags were deployed in the Aleutians, we would likely recover relatively few of those tags. This project deployed tags on four sites, and recoveries to date (41 with 70% from two sites) indicate that the two sites would provide suitable locations for subsequent recoveries. The requested budget for 2015 is to cover the rewards for the anticipated recoveries.

Project 650.18: Archival tags: tag attachment protocols
Priority: High
Start Date: 2013
Anticipated ending: 2017
Personnel: T. Loher

Recovery rates of archival tags affixed to halibut using four different external mounting protocols (three dart-and-tether configurations; one wired to the operculum) are being tested in a field release of "dummy" archival tags. During the summer of 2013, a total of 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 will be given for all tags recovered.

Project 665.11: Estimate of length/weight relationship and head/ice/slime adjustment
Priority: High
Start: 2013
Anticipated Ending: open ended
Personnel: R. Webster, L. Erikson, K. MacTavish, H. Gilroy

The purpose of this study is to reexamine the relationship between fork length and net weight, including the estimation of adjustments necessary to convert head-on weight to net weight. The current length-net weight relationship was estimated in 1926. If the relationship varies among regulatory areas, there may be systematic bias in regulatory area estimates of weight or WPUE derived from length measurements. Seasonal variation could affect weight estimates that are made from data collected during only a small part of the year. Therefore, we are collecting data coastwide throughout the season in order to estimate spatial and seasonal variation in the length to weight relationship. Data will be collected in 2015 from ports staffed with IPHC samplers throughout the fishing season. The goal is to determine whether seasonal or area-specific L-W relationships are warranted, or whether the effect of any variation can be incorporated via variation about the existing relationship.

The current relationship used by IPHC between fork length and net weight also includes adjustments for the weight of the head, and of ice and slime: gross landed weight (gutted, with head, ice and slime) is assumed to include 12% head weight and 2% ice and slime, which combine to give a multiplier of 0.8624 to convert gross to net weight. However, the industry standard for head, ice and slime deduction is a total of 12%. Therefore we are also collecting 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.

Project 646.13: Archival tags: Salish Sea PAT tags
Priority: Low
Start: 2014
Anticipated Ending: 2015
Personnel: T. Loher

This study is a test of several hypotheses regarding halibut movements within Area 2A. Specifically, that halibut found in the southern Salish Sea, i.e., Puget Sound, are an isolated stock component requiring management independent of the larger outer coast population. Six of the tags (at sites south of the San Juan Is.) were deployed in June from the IPHC survey platform. During July we attempted to formalize collaboration with a Lummi Nation vessel to deploy the remainder of the tags but this was unsuccessful and the six remaining tags were deployed from an alternate vessel in early October. The tags are programmed to pop up in January 2015 and June 2015.

Funded Research - Proposed

Project 2015-04: Length-weight relationship at sea
Priority: High
Start: 2015
Anticipated Ending: 2016
Personnel: E. Soderlund

This project integrates with the 665.11 port sampling project and obtains the two missing pieces of information on length-weight relationships: estimating shrinkage factors from fresh at-sea lengths and weights, to landed lengths and weights. It is particularly important for estimating removals from bycatch, recreational, and subsistence fisheries where no storage process occurs from capture to weight estimation.
The purpose of this study is to collect data on IPHC's SSA 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 samples from 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. If the relationship varies among regulatory areas, there may be systematic bias in regulatory area estimates of weight or 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. 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 to supplement data collected in project 665.11.

OBJECTIVE 4: ECOSYSTEM INTERACTIONS AND ENVIRONMENTAL INFLUENCES

Research on this objective seeks to advance the understanding of the ecological context for halibut, including predation and competition, as well as fishing and environmental effects on recruitment and distribution. This also includes understanding the relationship between environmental influences and halibut distribution and behavior. This is primarily accomplished with broad-scale monitoring programs, some of which can occur on IPHC research platforms. Additionally, IPHC seeks to share its environmental data set with other researchers and institutions. Collaborative research is sought out whenever possible.

IPHC is actively involved in a large-scale monitoring program from the setline assessment survey using water column profilers. The program is making environmental data available to other researchers through a public access portal with the Pacific Marine Environmental Laboratory (PMEL). Other monitoring is occurring from the survey platform, including an appraisal of contaminants in halibut and the prevalence of *Ichthyophonus*. These three programs are proposed to continue in 2015, and are discussed below.

Funded research – Ongoing

Project 610.13: Oceanographic monitoring of the north Pacifi c and Bering Sea continental shelf with water column profilers
Priority: Medium
Start date: 2009
Anticipated ending: Continuing
Personnel: L. Sadorus, J. Walker, P. Stabeno (NMFS PMEL)

The goal of this project is to measure oceanic properties in the waters over the Alaskan, B.C., and the U.S. west coast continental shelf that can be correlated to catch per unit effort (CPUE) of halibut as well as incidence of other groundfish species. The IPHC operates a survey that covers the area, and water column profilers that measure temperature, salinity, dissolved oxygen, pH, and florescence are deployed at each station. These data provide an annual snapshot of near shore oceanic conditions as well as valuable observational data for studying halibut distributions in relation to environment, addressing environmentally-related catchability in the survey, modeling and biological studies on recruitment and growth variability.

Since 2009, a NOAA grant has provided for the complete outfitting of all chartered survey vessels, resulting in a complete coastwide deployment. Annual costs are directed towards maintenance and calibration of the profilers, and data preparation necessary for submission to the National Ocean Data Center.

Funding in 2015 includes replacing one profiler, upgrading an older profiling unit to come into compliance with the newer units, the replacement of four profiler control/recording units, as well as maintenance and calibration of all units. An ancillary element of the proposal includes the construction of an environmental database, including the profiler and other data, at the IPHC for direct use by IPHC staff.

Project 642.00: Assessment of mercury and contaminants in Pacific halibut
Priority: Medium
Start Date: 2002
Anticipated ending: Continuing
Personnel: C. Dykstra, B. Gerlach (ADEC)

The staff proposes to continue IPHC's collaboration with the Alaska Department of Environmental Conservation (ADEC), collecting halibut tissue samples for analysis of heavy metal and organic pollutant loading. This work has been ongoing since 2002. In 2015 sampling will focus on the Shelikof, Adak, and St. Matthew charter regions, and will expand to include sub-legal halibut to better understand the accumulation dynamics over the animals' lifespan.

Project 661.11: *Ichthyophonus* prevalence in halibut
Priority: Low
Start Date: 2012
Anticipated ending: ongoing
Personnel: C. Dykstra, G. Williams, J. Gregg (USGS), P. Hershberger (USGS)

Ichthyophonus is a protozoan parasite from the class Mesomycetozoea, a highly diverse group of organisms having characteristics of both animals and fungi. It has been identified in many marine fish, and is considered a causative agent in herring fishery collapses world-wide, and there is concern over its effects on the success of salmon spawning on major rivers such as the Yukon.

Sampling of Pacific halibut aboard IPHC setline surveys has been ongoing since 2011. Results to date show that adult halibut have a wide range of infection rates, with Prince William Sound showing some of the highest observed in marine fish. Samples will continue to be collected in 2015 at three sentinel sites (OR, PWS, and northern Bering Sea) to monitor variability in prevalence and intensity of infections.

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