Migratory behavior and distribution of Pacific halibut

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PURPOSE

To provide the RAB with a description of the studies designed to improve our knowledge on distribution and migration of Pacific halibut in the northeast Pacific Ocean and eastern Bering Sea.

BACKGROUND

The IPHC is currently investigating Pacific halibut distribution and migration that encompasses all life stages via four different research projects.

U32 wire tagging

Of specific interest to the IPHC is the movement of juvenile Pacific halibut both within ocean basins (i.e., Gulf of Alaska and Bering Sea) and between them. The timing and distance traveled between nursery grounds to the adult feeding grounds varies over time and was last studied in the 1980s. Sampling platforms already being utilized for other investigations, the fishery-independent setline survey (FISS) and the NOAA-Fisheries (NMFS) trawl survey, are ideal vehicles for tagging and releasing U32 Pacific halibut during the summer months throughout their geographic range, and are currently the platforms for a spatially large-scale wire tagging effort.

Larval dispersal and connectivity

Unlike juvenile Pacific halibut which are demersal, larvae are pelagic for approximately the first six months of life and are distributed largely based on where they originated (i.e., where they were spawned) and where the currents carry them during their pelagic life stage. Of interest to the IPHC is the connectivity of larvae to nursery areas, particularly for larvae spawned in the Gulf of Alaska that settle in the Bering Sea, as well between the eastern and western sides of each basin, and the environmental drivers that may affect the magnitude of this connectivity. Also of interest are the geographic differences in larval dispersal and distribution of settled Pacific halibut related to environmental conditions. For example, note that it has been established that the counter-clockwise Alaska Coastal Current in the Gulf of Alaska flows into the Bering Sea via Aleutian Island passes, primarily Unimak Pass. The IPHC does not conduct larval surveys, but National Oceanic and Atmospheric Administration (NOAA) icthyoplankton (larval) surveys are conducted annually, and IPHC teamed with NOAA to examine these data spanning from 1972 to 2015 and model possible dispersal pathways, both at the larval and early demersal stages.

PAT tagging

The IPHC has conducted a series of pop-up archival transmitting (PAT) tag studies in the Bering Sea and Aleutian Islands (BSAI) region in order to identify winter spawning locations, determine the timing of seasonal movements, and investigate mixing of adult Pacific halibut within the BSAI

and between the Bering Sea and Gulf of Alaska. In 2018, the IPHC began a collaboration with Norton Sound Economic Development Corporation (NSEDC) and the University of Alaska, Fairbanks (UAF) to investigate dispersal of Pacific halibut in the far northeastern Bering Sea and potential connectivity between US and Russian waters. NSEDC provided tags, vessels, and logistical support for 2019 deployments. A UAF graduate student (Mr. Austin Flanigan) has been assigned to the project and will be supported at least through 2021 by a Rasmuson Fisheries Research Center (RFRC) Fellowship.

Coastwide deployment of fishery-recovery archival tags on U32 Pacific halibut

In 2018 the IPHC began a program in which electronic archival tags capable of recorded temperature, depth, and light levels for periods in excess of five years were deployed coastwide on U32 Pacific halibut. The data obtained from these tags will be used to relate rearing temperatures to growth rate and examine dispersal-at-age and -sex in Pacific halibut as they grow and recruit into the directed longline fishery.

DISCUSSION

U32 wire tagging

Each summer, IPHC deploys sea samplers on board the NMFS trawl surveys conducted in the Gulf of Alaska (biennially), Bering Sea (annually), and Aleutian Islands (biennially). The northern Bering Sea was surveyed in 2010, 2017, and 2019, and going forward has been added, at least temporarily, to the annual Bering Sea survey. Pacific halibut from 20 to 100 cm fork length are readily captured and sampled. In 2015, a pilot project was initiated on the trawl surveys to test the practicality of tagging and releasing a subsample of captured Pacific halibut with minimal impact to the regular sampling. The pilot project was considered a success and the program was fully implemented in 2016 going forward. Of the Pacific halibut captured, half are randomly selected as possible candidates for tagging. Within that subsample, a fish is tagged if it is U32 and viability is not assessed as “dead” using observer criteria. Table 1 lists project date to date.

Table 1. Release and recovery information of Pacific halibut tagged and released on board the NMFS trawl and IPHC fishery-independent setline surveys.

Wire tagging project	Years of tagging	Tags released	Tags recovered (as of 1/22/20)
Bering Sea trawl survey	2015, 2016, 2017, 2018, 2019	3,319	12
Gulf of Alaska trawl survey	2015, 2017, 2019	3,025	32
Aleutian Islands trawl survey	2016, 2018	318	2
IPHC FISS	2016, 2017, 2018, 2019	3,898	77
Total		10,560	123

In 2016, the IPHC investigated the practicality of adding U32 tagging to the FISS by conducting a pilot project in one Regulatory Area (Area 4D). The pilot project was successful and in 2017, the effort to tag and release U32 Pacific halibut was extended to the FISS in all areas where sampling rates for otoliths were less than 100 percent (i.e. Areas 2B, 2C, 3A, 3B, 4A, and 4B). U32 wire tagging will be continued on the FISS for the next several years. Area-specific tagging rates are set for all areas not sampled at 100% for otoliths, and a subsample of U32 fish not selected for otolith sampling are assessed using observer viability criteria and are subsequently tagged and released if not considered "dead". Additional information can be found in paper IPHC-2017-RARA27-R Chapters 2.5.1 and 2.5.4.

Larval dispersal and connectivity

The modeling portion of this work has concluded and the IPHC Secretariat is currently collaborating with NOAA co-authors in writing a manuscript to be published in a peer-reviewed journal later this year. Two models were utilized during this work: the first was a combination physical oceanography and larval recruitment model and the second was a spatio-temporal model. Results from the larval recruitment model indicated a large degree of larval connectivity between the Gulf of Alaska and the Bering Sea via Unimak Pass, especially from larvae originating from spawning grounds in the western Gulf and advecting to the eastern Bering Sea. There was also ample connectivity between the eastern and western Gulf of Alaska and the eastern and western Bering Sea to the Asiatic coast. The spatio-temporal model was used to examine Pacific halibut dispersal for fish aged 2-6 years using the NOAA Fisheries groundfish trawl survey data. Results indicated that at 2 years of age, young Pacific halibut are primarily in nearshore waters. By 4 years of age, a portion of the fish that originated in Bristol Bay have migrated to Unimak Pass, suggesting that they may be engaging in compensatory migration back through Unimak Pass, opposite to larval advection. By 6 years of age, halibut are widely dispersed across areas and depths. The study showed annual variations in dispersal, but there was no clear signal between warm and cold stanza years identified.

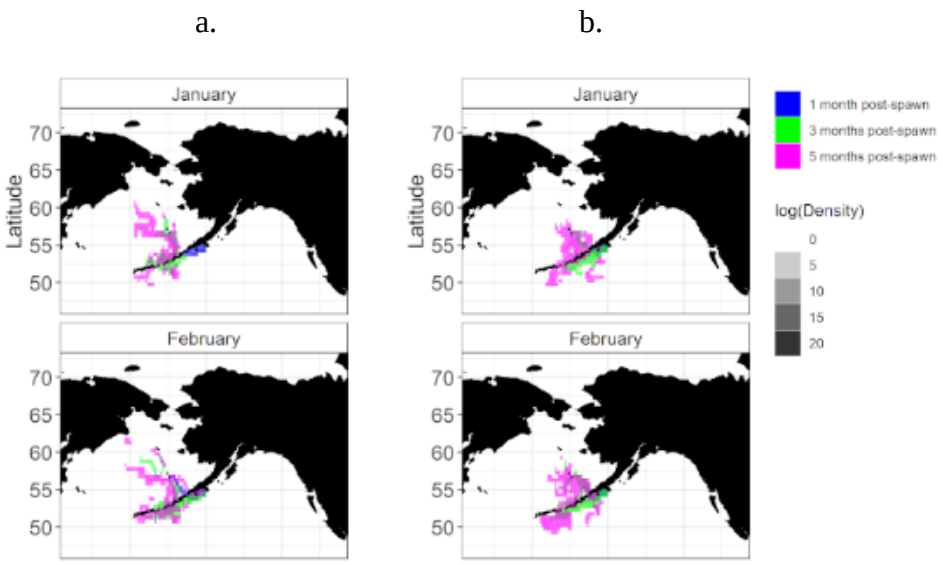

Figure 1. A sample of larval advection modelling results for Pacific halibut originating at a spawning ground in the western Gulf of Alaska during a) 2005 and b) 2009.

PAT tagging

A total of 44 Pacific halibut were tagged in 2020 with miniPAT tags (manufactured by Wildlife Computers, Redmond, Washington) in IPHC Regulatory Area 4E: in Norton Sound (n = 24), at St. Lawrence Island (Savoonga; n = 15), and during the National Marine Fisheries Service Northern Bering Sea trawl survey (n = 5). Tagging occurred 17-19 July in Norton Sound; 5-19 August at Savoonga; and 8-10 September aboard the NMFS trawl survey. The tags were programmed to release from their host fish and report their location and archived data during three periods: January 2020 (representing the spawning season); summer of 2020 (investigating summer feeding site fidelity versus emigration); and summer of 2021 (examining longer-term dispersal). Tags provided by the IPHC (n = 26) were used to tag relatively small fish (i.e., 71-93 cm fork length) while larger (97-141 cm) Pacific halibut were tagged using tags provided by NSEDC (n= 18). Deployments were designed to produce data that are comparable to the IPHC's prior PAT-tagging research that has been conducted to examine adult connectivity and spawning stock structure throughout the managed range, with the current effort being expanded to considerably broader stock demographics than any prior electronic archival tagging experiment. Of particular interest is anecdotal information that suggests that the northeastern Bering Sea Pacific halibut population may be composed of two functional groups: one that moves seasonally between this region and the continental shelf edge in US waters (e.g. Middle and Pervenets Canyons in IPHC Regulatory Area 4D), and another that may spawn in Russian waters (e.g., Navarin Canyon) and may be largely derived of individuals that were reared in Russian nurseries.

Collaborative tagging will continue in 2020. NSEDC will again provide staff and funding for vessel charters and logistical support, and has committed to the purchase 50 PAT tags to accompany 12 tags that were held over from 2019, having not been deployed due to a relative paucity of Pacific halibut encountered during the 2019 trawl survey. This year's work will include concurrent tagging of Pacific cod (*Gadus macrocephalus*) by researchers from the NMFS Alaska Fisheries

Science Center (Seattle). Both Pacific cod and Pacific halibut have been appearing in the Northern Bering Sea in increasing numbers, likely as a result of warming ocean conditions and the disappearance of winter sea ice, which may allow these species to reside in the region year-round. It is unknown to what degree migratory pathways and connectivity patterns may be similar between the two species. Analyses that consider both may have greater predictive power than attention to either species in isolation.

Coastwide deployment of fishery-recovery archival tags on U32 Pacific halibut

The coastwide U32 archival-tagging project that was initiated in 2018 continued with the deployment of 50 tags in the southeastern Bering Sea via the 2019 NMFS trawl survey platform. These tags have a long operating life (5-7 years) and will be used to study long-term ontogenetic dispersal as well as to relate the thermal conditions to which the fish are exposed to their growth. Temperature records from individual fish will be used to evaluate the degree to which fish that are reared in warm waters grow faster than those experiencing colder conditions on average. Temperature records will be related to stable isotope concentrations in collected otoliths so that this relationship can be used to reconstruct growth conditions for untagged fish and to examine temperature-dependent stock productivity patterns in time and space. Rewards will be offered for the recovery of these tags, where the reward amount will vary according to the amount of information provided to the IPHC: $300US if only the tag is returned; $400US if the tag is returned along with length and sex information and the fish's otoliths; $500US if the entire fish along with its tag is presented to an IPHC port sampler or equivalent agency biologist (e.g., fisheries observer) for sampling.

RECOMMENDATION

That the RAB:

1) **NOTE** paper IPHC-2020-RAB021-11, which described studies designed to improve our knowledge on Pacific halibut distribution and migration at all life stages.

REFERENCE

St-Pierre, G. 1984. Spawning locations and season for Pacific halibut. Int. Pac. Halibut Comm. Sci. Rep. 70. 46 p.