Deployment of Pop-up Archival Transmitting (PAT) tags to study interannual dispersal and seasonal migration timing in IPHC Regulatory Area 4

Timothy Loher and William G. Clark

Abstract

Since 2002, the IPHC has been using Pop-up Archival Transmitting (PAT) tags to study behavior and environmental conditions experienced by halibut in the eastern Pacific Ocean. During the 2008 IPHC summer setline survey, 115 halibut were tagged throughout the Bering Sea and Aleutian Islands (IPHC Regulatory Area 4) in order to examine interannual dispersal and seasonal migration timing. The study is comparable to tagging that was conducted in the Gulf of Alaska in 2005-06. All tags were programmed to release from their host fish and report location exactly 365 days after tagging, thereby generating fishery-independent information regarding the degree to which fish move away from their tagging sites after one year at liberty. At the same time, the tags will download accumulated behavioral and environmental data, providing information regarding onshore-offshore migration timing and seasonal habitat use. At time of writing, one tag had been recovered by the targeted fishery and another fourteen had released prematurely, leaving a total of 100 tags still in the water.

Background

In 2003, the IPHC tagged 43,999 halibut with Passive Integrated Transponder (PIT) tags and released them coastwide in proportion to surveyed abundance, by marking all the fish captured on three skates of standard setline survey gear at all IPHC survey stations (Kaimmer and Geernaert 2004). Through 2006, these marked fish had been recovered at approximately equal rates (2-3 tags per 10,000 fish scanned) within the central and western Gulf of Alaska (GOA; IPHC Regulatory Areas 3A and 3B) and at considerably higher rates (5-7 tags per 10,000 fish scanned) in the eastern GOA (Areas 2B and 2C). In contrast, recovery rates for fish tagged in the eastern Bering Sea (BS; Areas 4A and 4D) were <2 tags per 10,000 fish scanned, and <1 tag per 10,000 fish scanned for fish tagged along the Aleutian Islands chain (AI; Area 4B) (Webster and Clark 2007). Throughout the GOA, fishing mortality rates estimated from PIT tag recoveries are far below stock assessment estimates, but area-by-area relative magnitudes are similar to that estimated from the coastwide assessment. Fishing mortality rates estimated from PIT tag recoveries in the BS/AI are very low and would therefore result in biomass estimates an order of magnitude greater than assessment estimates (Clark 2006). Seeing as mark-recapture estimates are at odds with all other data on the relative distribution of biomass among areas, mark-recapture data have not been used to estimate area-specific commercial harvest rates of fully-selected halibut (Clark 2006).

In addition, it has been observed that of the halibut PIT-tagged in Area 4A and subsequently recovered in Areas 2 and 3, a total of 88% were tagged south of Unimak Pass and the Fox Islands, as opposed to within the Bering Sea proper. Total unadjusted rates of southeastward out-of-area recovery for PIT tags deployed in Area 4A have been three times greater for tags deployed north of the Aleutian Chain (23%; 6 of 26 recoveries) than south of it (69%; 42 of 61 recoveries). This suggests that a relative discontinuity in adult mixing may occur along the axis of the AI.

During the summer of 2008, a PAT-tagging project was initiated in order to investigate why so few PIT tags were recovered from tagging in the BS/AI region. One hypothesis for low recovery rates is potential movement of fish into areas where they would exhibit relatively low catchability, such as dispersing over the broad eastern Bering Sea shelf or moving into the Bristol Bay closed area. Of particular relevance to the present study is the fact that PAT tags do not need to be physically recaptured in order to generate accurate endpoint locations. On a pre-determined date, the tags release from the host fish, float to the surface, and emit signals; the Doppler shifts of the tags' broadcast signals are used to determine their location to within as little as 50 meters (Keating 1995) no matter where the fish are located at tag release. The result is recovery data free from spatial recapture biases arising from variance in fishery-based catchability, reporting, or tag detection. At the same time, the satellite uploads the accumulated depth and temperature data from the tags.

In addition to its relevance to analysis of PIT tagging results, the study is linked with genetic work (Hauser et al. 2006, 2007) and summer-to-winter PAT deployments (Seitz et al. in press) investigating the hypothesis that deep Aleutians passes serve to reduce east-west dispersal rates. According to this hypothesis, the Near and Rat island groups would be most isolated and most likely to support independently-operating subpopulations, with intermediate isolation in the Andreanof group relative to the remainder of the eastern Bering sea shelf. Furthermore, archived depth summaries broadcast by satellite can be used to assess when individual fish are resident on shallow summer feeding grounds and deepwater winter spawning grounds and determine the timing and duration of migratory phases between shallow and deep-water habitats, and detailed short-period depth data downloaded from physically-recovered tags can be used to define periods of putative spawning. This information may be useful for assessing match or mismatch between timing of commercial fishery season opening and closing dates relative to seasonal redistribution periods and the active spawning season and represents a geographic extension of prior studies conducted in the GOA and US Pacific Northwest (Loher 2008, Loher and Seitz 2008a, Loher and Seitz 2008b) and recent Area 2B archival tag deployments (Loher and Rensmeyer, this issue). While archival tag data from the GOA have begun to refine our understanding of seasonal processes within the halibut population, there is reason to believe that migration- and spawn-timing vary between ocean basins and along longitudinal gradients, as has been observed in the GOA for flathead sole (*Hippoglossoides elassodon*; Porter 2005).

The work represents a single coherent project, but will address four separate sub-questions within the BSAI: 1) the relative fates of Area 4 fish located north versus south of the AI Chain, 2) the fate of 4B fish, with emphasis on potential differences in dispersal between the Andreanof Island section and the Near-Rat islands section, 3) the fate of fish along the 4D Edge and the major island systems of the southeast Bering Sea shelf (i.e., St. Matthew and the Pribilof islands), 4) timing of onshore-offshore migration throughout the BS/AI region.

Progress in 2008

PAT tags (manufactured by Wildlife Computers, Redmond, WA) are unique in appearance. The body of the tag is shaped much like a microphone, with a central diameter of approximately 2 cm (¾"), total body length of 17 cm (6 ½"), and a 12 cm (5") antenna made of plastic-coated braided cable (Fig. 1). The body of the tag contains light, depth (pressure), and temperature sensors, as well as programming circuitry and a satellite transmitter. The tags were attached to the fish via an 18 cm (7") leader constructed of monofilament line covered in black adhesive-lined shrink-tubing, and were secured to the fish using a titanium dart embedded through the pterygiophores, roughly 4 cm (1 ½") medial to the dorsal fin, on the eyed-side of the halibut where the body begins to taper towards the tail (Fig. 1). The leader was attached to the tag body via a thin metal wire, and on the programmed date, an electrical current will be induced that causes the metal to rapidly corrode, the tag to release and float to the surface, and data transmissions to begin. Data will be transmitted to the US National Oceanic and Atmospheric Administration's (NOAA) polar-orbiting satellites, administered by the Advanced Research and Global Observation System (ARGOS). Summarized temperature and depth data, depth-temperature profiles and light-based geoposition estimates will be broadcast. The tag's endpoint position will be determined from the Doppler shift of the transmitted radio frequency in successive uplinks received during one satellite pass (Keating 1995). If fish are captured and the tag retrieved before the pop-up date, the full archival record can be accessed, from which highly detailed environmental data and daily geoposition estimates may be obtained.

The tags were programmed to record temperature (0.1° C resolution) and depth (4 m resolution) every 30 seconds and ambient light levels every minute. However, detailed depth and temperature data will not be provided in satellite transmissions. Data will be transmitted as summaries within consecutive 8-hr blocks, within user-defined depth and temperature intervals (i.e., bins) and as depth-temperature profiles. Complete data can be retrieved only if the tag is recovered. Depth bins were defined as follows: surface, 0-10.0 m, 10.5-50.0 m, 50.5-100.0 m, 100.5-150.0 m, 150.5-200.0 m, 200.5-250.0 m, 250.5-300.0 m, 300.5-400.0 m, 400.5-500.0 m, 500.5-600.0 m, 600.5-700.0 m, 700.5-800.0 m, and 800.5-1000.0 m. Temperature bins were defined as: <1° C, 1.1-2.0° C, 2.1-3.0° C, 3.1-4.0° C, 4.1-5.0° C, 5.1-6.0° C, 6.1-7.0° C, 7.1-8.0° C, 8.1-10.0° C, 10.1-12.0° C, 12.1-16.0° C, 16.1-20.0° C, and 20.1-60.0° C. Release was programmed for 01:00 hr Coordinated Universal Time (UTC), 365 days following the deployment date. Each tag's internal software should have begun a 365 day countdown as soon as the tag reached 10 m water depth.

A total of 115 adult halibut were tagged by IPHC sea samplers during the 2008 IPHC summer setline survey, aboard three survey vessels in four charter regions (Table 1; Fig. 2). A total of ten tags were obtained for deployment at St. Matthew Island, but low catch rates at the survey stations precluded deployment of all tags and survey specifications did not contain a provision to fish additional gear in order to complete the tagging. Thus, only five tags were deployed in 2008; the remaining tags were returned to Seattle and will be deployed in 2009. Unlike previous PAT tag studies, fish of all commercial sizes (≥82 cm FL) were tagged. Previously, only fish >105 cm (43.5 in) FL have been deemed appropriate for tagging based on the results of behavioral studies of captive halibut (A. Seitz, University of Alaska, Fairbanks, unpublished data) that suggested erratic behavior in smaller fish if the tag's antenna were allowed to make contact with the fish's tail when swimming. However, tagging and observation of an 86 cm FL captive halibut in 2006 (Loher, unpublished data) indicated that modifications to the tags' leader-length and attachment orientation could alleviate the size constraints and allow broader tag application. Halibut tagged in 2008 ranged in length from 82-171 cm (Fig. 3).

On July 31, one tag was recaptured by the commercial fishery at St. Matthew Island; the fish was recaptured approximately 8 km (5 mi) from its tagging location. In addition, a total of 14 tags have released prematurely from their host fish (see Table 1), leaving a total of 100 tags still in the water. To date there appears to be no relationship between fish size and tag retention: premature release has occurred on fish ranging from 84-139 cm FL.

References

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Table 1. Sites at which fish were tagged tagged during the 2008 IPHC setline survey (refer also to Fig. 3). One tag was recovered at St. Matthew Island by the commercial longline halibut fishery; an additional 14 have prematurely released from their host fish.

Survey region	Tag release site	Vessel	Number tagged	Number remaining
4D Edge	4D Edge	*Kema Sue*	18	18
St. Matthew	St. Matthew Island	*Kema Sue*	5	1
Pribilof Islands	St. Paul Island	*Kema Sue*	10	7
4A Edge	4A Edge	*Kema Sue*	18	15
Unalaska	South Unalaska	*Free to Wander*	18	17
Unalaska	North Fox Islands	*Free to Wander*	6	6
Adak	Andreanof Islands	*Pacific Sun*	18	16
Adak	Petrel Bank	*Pacific Sun*	4	4
Attu	Near-Rat Islands	*Pacific Sun*	18	17

Figure 1. ***Upper panel*: A PAT tag bearing the leader and dart assembly. The tag body possesses sensors that record temperature, depth, and light, as well as a release mecahnism that jettisons the body from the leader on a pre-programmed date. The tag then floats to the surface and broadcasts the accumulated data to passing satellites, which in turn use the tag's signal to calculate its position. *Lower panel*: An IPHC sampler holds a large halibut bearing a PAT tag.**

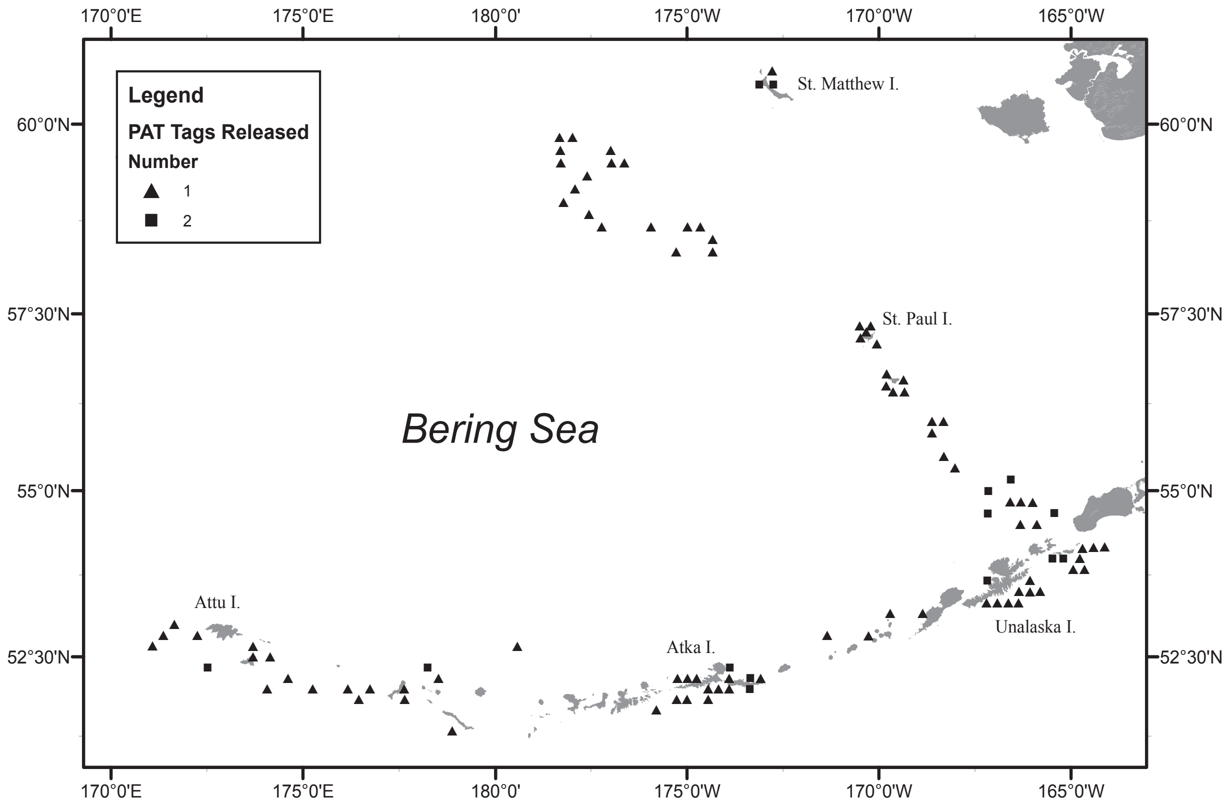

Figure 2. Deployment locations for PAT tags deployed during the 2008 IPHC standardized stock assessment survey. Either one or two tags was deployed at each location; larger symbols indicate two tags deployed.

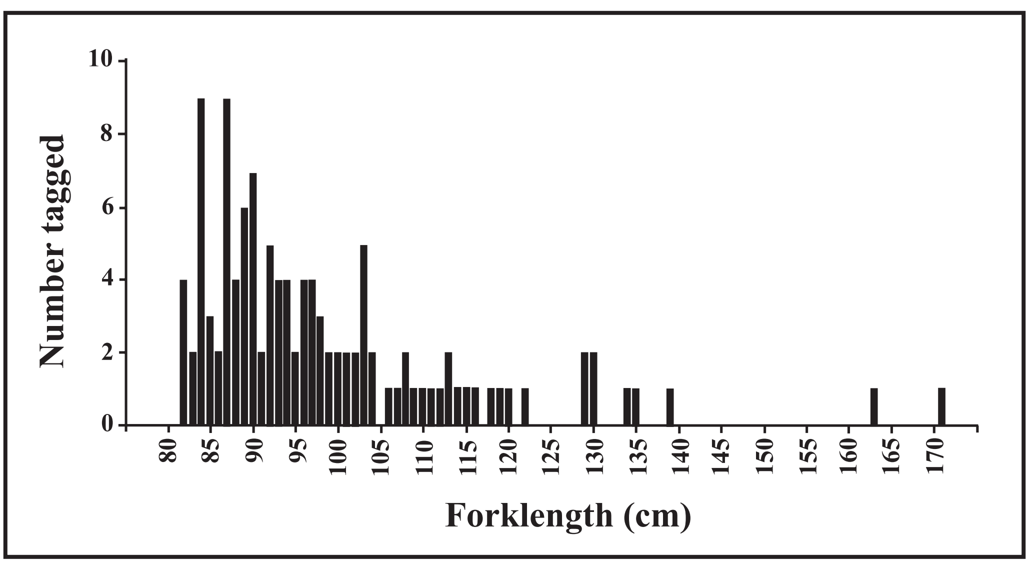

Figure 3. Size-distribution of halibut tagged with PAT tags during the 2008 IPHC standardized stock assessment survey.