Investigating seasonal migration of adult Pacific halibut (*Hippoglossus stenolepis*) along the Aleutian Chain using pop-up satellite transmitting archival tags

**Timothy Loher**  
International Pacific Halibut Commission

**Andy Seitz**  
U.S. Geological Survey/University of Alaska Fairbanks

**Abstract**

Pop-up Satellite-transmitting Archival Tags (PSATs) provide a novel technique for identifying the movement patterns and potential spawning sites of halibut. The tags record ambient temperature, depth, and light while attached to fish and are programmed to release from the fish on a predetermined date, float to the surface, and emit a satellite signal that indicates the tag location and uploads accumulated data to a passing satellite. In an attempt to better understand movement and behavior of halibut in the central and western Aleutian Islands, 25 adult halibut were tagged with PSATs during the 2004 IPHC summer setline survey. A total of twelve adult halibut were tagged in the Adak survey region, and thirteen fish in the Attu survey region. No tagged fish were returned by the targeted fishery prior to the end of the 2004 season, and all tags are programmed to release and transmit their data during February, 2005, during the winter spawning season.

**Background**

Present day, North American Pacific halibut fisheries harvest fish throughout the continental shelf of Canada and the US, on the species’ summer feeding grounds. During the winter months, most of these fish depart the relatively shallow waters of the shelf to aggregate and spawn in deeper waters along the shelf-edge, at spawning grounds that stretch from at least the Queen Charlotte Islands through to the southeast Bering Sea. A variety of surveys conducted during winter months from 1915-1981 have provided our basic knowledge regarding the location of major spawning areas (St. Pierre 1984). However, no similar research has been conducted in the last two decades and major information gaps still exist. In particular, the spawning surveys summarized by St. Pierre (1984) include only a single 1972 research trip in the central-western Aleutians (Area 4B), lasting only two days. As a result, we have very little understanding of potential spawning activity in the Aleutians, and St. Pierre (1984) suggested that no major spawning takes place west of the Bering Canyon (just north of Unimak Pass). However, early juveniles (age 1+ through 3+) are captured regularly in US National Marine Fisheries Service (NMFS) trawl surveys west of Atka Island.

During the last NMFS Aleutian survey in 2002, numerous early juveniles were captured at Tanaga and Buldir Islands, 600 km and 1000 km west (respectively) of the Bering Canyon. It is unlikely that Bering Canyon spawning could be the source of western Aleutian settlement because
prevailing currents are expected to advect larvae either north along the shelf-edge or east into Bristol Bay. In contrast, a persistent gyre bounded to its east by Bowers Ridge may provide a retention mechanism for larvae spawned in the western Aleutians, and if adults are faithful to spawning sites over time and their offspring recruit to the same general area, a distinct Aleutian sub-population may exist. Preliminary genetic analysis using nuclear microsatellites (Hauser et al., in review) suggests that central Aleutian halibut may be more isolated from the Gulf than are fish found in the southeast Bering Sea, a result that would be highly unlikely if spawning does not take place in the region.

It is clear that many questions remain concerning spawning population structure west of Unalaska, and until quite recently these were questions that would be difficult to answer without conducting midwinter charters in the Aleutians. Recent advances in tag technology are providing a tool that can be used to uncover some of these mysteries without the need for arduous winter work or reliance upon winter fisheries to recover conventional tags. Electronic Pop-up Satellite-transmitting Archival Tags (PSATs) record ambient temperature, depth, and light while attached to fish. The tags are programmed to release from the fish on a pre-determined date, float to the surface, and emit a satellite signal that indicates the tag location and uploads the temperature, depth and light data to the satellite. The result is a record of the fish’s spawning location, along with important environmental and behavioral data throughout the fish’s time at liberty, without the need for tag retrieval. PSATs provide a novel technique for identifying the movement patterns and potential spawning sites of halibut. Pop-up tags are the first fisheries-independent means of studying fish migration and have proven to be a feasible tool for studying halibut biology and ecology in the northern Gulf of Alaska (Seitz et al. 2002, Loher 2003). In the present study, fishery-independence is extremely important because no winter fishery is allowed for halibut, bycatch rates for halibut in other winter fisheries are typically low, and previous experience indicates that securing winter charter bids for Aleutian work is unlikely (Loher, this volume).

**General methods and progress**

PSATs (manufactured by Wildlife Computers, Redmond, WA) are very unique in appearance. The body of the tag is shaped much like a microphone, with a central diameter of approximately ¾” (2 cm), total body length of ~6 ½” (17 cm), and a 5” (12 cm) antenna made of plastic-coated 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 tag attaches to the fish by a 7” (18 cm) leader made of monofilament line covered in black shrink-tubing, secured to the fish using a titanium dart that is embedded through the pterygiophores, roughly 2.5 cm medially from the dorsal fin, on the eyed-side of the halibut where the body begins to taper towards the tail (Fig. 2). The leader is attached to the tag body via a thin metal wire, and on the programmed date, an electrical current is induced that causes the metal to rapidly corrode, the tag to release and float to the surface, and data transmissions to begin. Data are transmitted to the US National Oceanic and Atmospheric Administration’s (NOAA) polar-orbiting satellites, administered by the Advanced Research and Global Observation System (ARGOS). Histogram-summarized temperature and depth data, depth-temperature profiles and light-based geoposition estimates are broadcast. The tag’s endpoint position is determined from the Doppler shift of the transmitted radio frequency in successive uplinks received during one satellite pass (Keating, 1995). If the fish is 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 light level, temperature (0.1°C resolution), and depth (4 m resolution) every minute. However, detailed depth and temperature data will not be provided in satellite transmissions. Data will be transmitted as histogram summaries for consecutive 12-hour 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, 500.5-750.0 m, and 750.5-1000.0 m. Temperature bins were defined as: <1°C, 1.1-3.0°C, 3.1-5.0°C, 5.1-7.0°C, 7.1-9.0°C, 9.1-11.0°C, 11.1-13.0°C, 13.1-15.0°C, 15.1-17.0°C, 17.1-20.0°C, 20.1-30.0°C, and 30.1-60.0°C. Release was programmed for 00:00 hr Coordinated Universal Time (UTC) on February 15, 2005.

A total of 25 adult halibut were tagged by the second author (A. Seitz) during the 2004 IPHC summer setline survey, aboard the F/V Pacific Sun in the Adak survey region, and the F/V Heritage in the Attu survey region (Fig. 3). Tagged fish ranged in size (Fig. 4) from 110-176 cm forklength at Adak and 110-154 cm at Attu (Table 1). A total of twelve adult halibut were tagged in the Adak survey region, at four separate stations adjacent to Atka Island (Fig. 5, upper panel). Thirteen fish were tagged in the Attu survey region, at five stations southeast of Attu Island (Fig. 5, lower panel). No tagged fish were returned by the targeted fishery prior to the end of the 2004 season.

References


Table 1. Stations at which fish were tagged (refer also to Fig. 3), dates of deployment, and sizes of fish tagged.

<table>
<thead>
<tr>
<th>Survey region</th>
<th>Vessel</th>
<th>Station number</th>
<th>Date</th>
<th>Number tagged</th>
<th>Fish sizes (cm forklength)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adak</td>
<td>Pacific Sun</td>
<td>6093</td>
<td>7/13/04</td>
<td>1</td>
<td>127</td>
</tr>
<tr>
<td>Adak</td>
<td>Pacific Sun</td>
<td>6095</td>
<td>7/13/04</td>
<td>3</td>
<td>110, 117, 176</td>
</tr>
<tr>
<td>Adak</td>
<td>Pacific Sun</td>
<td>6105</td>
<td>7/13/04</td>
<td>4</td>
<td>128, 131, 133, 150</td>
</tr>
<tr>
<td>Adak</td>
<td>Pacific Sun</td>
<td>6099</td>
<td>7/13/04</td>
<td>4</td>
<td>111, 122, 143, 147</td>
</tr>
<tr>
<td>Attu</td>
<td>Heritage</td>
<td>6143</td>
<td>7/15/04</td>
<td>2</td>
<td>135, 142</td>
</tr>
<tr>
<td>Attu</td>
<td>Heritage</td>
<td>6149</td>
<td>7/15/04</td>
<td>3</td>
<td>129, 144, 144</td>
</tr>
<tr>
<td>Attu</td>
<td>Heritage</td>
<td>6147</td>
<td>7/15/04</td>
<td>4</td>
<td>111, 112, 115, 120</td>
</tr>
<tr>
<td>Attu</td>
<td>Heritage</td>
<td>6146</td>
<td>7/15/04</td>
<td>2</td>
<td>135, 146</td>
</tr>
<tr>
<td>Attu</td>
<td>Heritage</td>
<td>6145</td>
<td>7/15/04</td>
<td>2</td>
<td>110, 154</td>
</tr>
</tbody>
</table>
Figure 1. A leadered satellite tag. The tag’s antenna is on the left of the picture, the leader and dart are to the right.

Figure 2. IPHC sea sampler Kelly Attridge holding an adult halibut that has been tagged with a satellite tag during research conducted in 2002. The dart is inserted from the dark (eyed) side of the fish, just below the dorsal fin and a bit more than halfway, posterior, along the body (photo credit: Lynn Mattes).
Figure 3. General locations at which adult halibut were tagged.

Figure 4. Size-frequency distribution of all fish tagged during 2004, by 5 cm length categories. Refer to Table 1 for station-by-station detail.
Figure 5. Tagging locations in the Adak (upper panel) and Attu (lower panel) survey regions. Small dots with 4-digit numbers denote sampling stations visited during the IPHC standardized setline survey. Stations at which halibut were tagged are highlighted with a large circle; the large number above that circle indicates the number of adult halibut tagged at that station. Refer to Table 1 for an accounting of fish sizes tagged at each station.