A PIT Tag Based Method for Investigating Survival of Juvenile Cowichan River Chinook during their First Year of Life

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Early marine survival is a critical factor driving the productivity of many salmonid stocks including Chinook salmon. Understanding the factors which control survival and how mortality is distributed across space and time is critical to identifying management actions which improve adult abundance. Despite a growing body of research much has yet to be discovered but with the application of new technologies the answers to long standing questions are in reach. In this project, we implemented Passive Integrated Transponder (PIT) tags to track four cohorts of natural and hatchery origin Cowichan River Chinook from juveniles to return. Uniquely coded tags allowed the fate of individuals to be tracked so that successful fish within a tag group could be compared to peers. Survival to return estimates were able to be created at four different points in time to reveal spatial and temporal variability at a resolution beyond current published research.

Methods

We implanted 12 mm PIT tags into the celomic cavity of juvenile fall run ocean type Cowichan River Chinook following guidelines set out by Fisheries and Oceans Canada¹ and the Columbia River PIT tag Steering Committee². Additional fish handling procedures were implemented during the tagging process including adding a water conditioner to reduce handling impacts on the mucous layer. Ice was used to maintain temperatures within two degrees and tagging activities halted when water temperatures exceeded 17.0°C. Tag ID’s were recorded electronically on hand-held scanners (HPR Lite³) while the last four digits were recorded manually for cross referencing with fork lengths. The scanners also associated a date time stamp with each tag to be included in the data base along with location, origin and other relevant data.

In the earliest stage, hatchery fish were held approximately three weeks after tagging to account for tag rejections and mortalities. Fish were measured, scanned and split into groups within five days of release. Wild fish were captured in-river by pole or beach seining moderate velocity runs and/or pools following methods in Pellett (2017) and Craig (2015). Origin was determined by the presence or absence of an adipose fin recognizing that 95–99% of production was clipped and some wild fish may be the progeny of hatchery Chinook reproducing in the natural environment. Fish were sorted by size and the threshold for tagging was set at 60 mm fork length. Following tagging, Chinook were held in an aerated recovery tank for a period of 5–20 minutes and released after displaying normalized behavior. Fish which failed to recover or that continued to display abnormal behavior after 20 minutes were removed from the tagging group.

Fish capture for later stages was conducted exclusively in the marine environment. In order to address the hypothesis that mortality occurs rapidly on marine entry two tag groups were created within Cowichan Bay. The first group (second stage) was captured by beach seining on the inner North side of the bay (Fig. 1). Two nets were employed for this activity ranging from 22 m to 38 m in length and 1.5 m to 2.5 m in depth. Panel size varied from 19.0 mm to 6.4 mm stretch mesh with 12.7 mm being the most common material. Nets were deployed from a 5.5 m aluminum boat (runabout style) while a team of 2–4 people pursed the net in from the shore. Approximately 5–10 sets were made per day depending on catch rates and processing time. Hatchery and wild fish were tagged in proportion to numbers encountered during the study.

For the third stage a 23 m commercial fishing vessel Ocean Venture was chartered to capture juvenile Chinook in Cowichan Bay. Efforts were focused in the central and inner portions of the bay but in deeper water compared to beach seining. The net was specially designed for juvenile sampling and was approximately 300 m x
20 m (Pellett and Damborg 2018). Once pursed in, crews sorted the bycatch (e.g., jellyfish, herring, squid, stickleback) from the main net, and using a small trailer, scoop juvenile salmonids into the large live wells. Further sorting would occur until only juvenile Chinook remained. Following tagging, fish were placed in a recovery tank prior to release with compromised fish removed from the tag group.

The final stage was focused predominantly in the Sansum Narrows area of the Gulf Islands (Fig. 2). Fish were captured by micro trolling (Duguid and Juanes 2017) using a series of 6 lure/attractor setups deployed from a downrigger on each side of a small sport fishing boat. A total of 12 lures were deployed at depths ranging from 6–24 m and retrieved at regular intervals not exceeding 10 minutes. Isolated compartments were created within an aerated holding tank on each boat in the event multiple fish were captured so that depth could be recorded. In addition to the standard data collected, a GPS waypoint was logged for each retrieval and DNA was retained for Genetic Stock Identification. This allowed Cowichan Chinook to be isolated within the tag groups later on. Scales were not collected from the majority of fish because the difference in size between age classes was ~100 mm. Instead, fish less than 300 mm fork length were assumed to be in their first ocean year.

A series of 12 PIT tag detection antennas were installed in the Cowichan River counting fence in May of 2016 in order to interrogate returning fish for tags as they migrated upstream to spawn (Fig. 3). Prior to this time, a single antenna was installed in the counting fence located at the same site (river km 7) while detection efficiency was estimated with a second antenna located in the Skutz Falls fishway 25 km upstream. In addition, brood stock were also scanned for tags as they were often removed from locations below the fence.

**Results**

A total of 56,145 Cowichan River Chinook were implanted with PIT tags between 2014 and 2017 (Fig. 4). Approximately equal numbers were marked in freshwater (27,078) and marine (29,067) habitats although a higher proportion of hatchery fish were tagged in freshwater (75% vs. 30%). Overall, 32,941 wild Chinook were tagged primarily due to a higher encounter rate in marine waters. Pursing accounted for the majority of marine captures at 20,494 followed by micro towing (3,760) and beach seining (3,392).
Through the end of fall 2018, a total of 594 PIT tagged Chinook returned to the Cowichan River (Fig. 5). Returns peaked in 2017 with 259 tags while purse seining has produced the largest tag return to date at 255 fish followed by 174 from the river, 99 from micro trolling and 70 from beach seining. The age structure of Cowichan Chinook is dominated by 3 and 4-year olds with < 5% of the population reaching age 5 (Baillie et al. 2015; Lister et al. 1981). For this reason, we expect data collection from the 2016 tag cohort to be essentially complete in fall 2019 and the study to finish in 2020.

Current analyses were limited to the 2015 tag cohort due to constraints in tag numbers (2014) or incomplete returns (2016 and 2017). A comparison of return rates was conducted based on observed tags in the river and expanded for detection efficiency (93.4% in 2016 and 100% in 2017/2018). Survival was found to increase with time and wild fish outperformed hatchery fish at every stage (Fig. 6). Exploitation rates for hatchery coded wire tagged Cowichan Chinook are approximately 50% (Tompkins et al. 2005) and were not accounted for in these estimates.

Survival data were transformed into a variation of a survivorship curve to illustrate how mortality is distributed by size (time). Curves were generated from 2015 data only and found to be similar for both hatchery and wild Chinook (Fig. 7). Data suggest there is approximately 78% mortality in hatchery fish and 80% in wild between mid-May and the end of September of their first year. However, mortality was found to be higher between October of their first year and return with estimates of 97% and 93%, respectively.
An investigation of survival by size was conducted on wild fish tagged during purse seining in 2015 (Fig. 8). Return rates varied between 1.5% and 4.3% with the highest survival observed in the 95 mm bin. However, this was driven mainly by age 2 fish (jacks) which returned at a rate of 2.7%. In general, the proportion of age 2 returns increased with size while older age classes were more common in smaller size bins. For the 2015 wild micro troll group, a scatterplot of Cowichan Chinook identified though GSI was overlaid with individual returns by age class (Fig. 9). Survivors were found to originate from a wide range of sizes and dates at a cursory level of analysis. Both tag applications and return rates of hatchery Chinook from both stages were too low to conduct further analyses at this time.

Preliminary data from this PIT tag-based survival study are encouraging and suggest this technique holds promise for gaining new insights into the mortality of Chinook in their first year of life. The striking difference in survival observed between hatchery and wild fish through the end of September suggests the mechanism responsible for the disparity occurs after this time. Despite relatively high mortality in the first few months our results suggest significant losses continue through the first marine winter. A more thorough investigation of size related effects on survival as well as a comparison between years will be conducted once data collection is complete in fall 2020.

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