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Salmon Scale Wiki—an Interactive Online Protocol for Estimation of Chinook Salmon (*Oncorhynchus tshawytscha*) Scale Ages

by

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Abstract

As part of a project to examine consistency in age estimates of Chinook salmon scales within Alaska, we created Salmon Scale Wiki, an interactive website designed to help standardize methods and to facilitate interaction and learning among scale readers. Scale readers throughout the state estimated age of 10,000 digital images of Chinook salmon scales using an online application. Participants subsequently attended a workshop in Anchorage, Alaska to review project results and develop guidelines for estimating Chinook salmon scale ages from growth patterns. These guidelines were then incorporated into Salmon Scale Wiki, where scale readers can access information about Chinook salmon scales and stocks within Alaska. This website includes pages where readers learn about scale age estimation protocols, acquire training techniques, and explore images from a variety Alaskan Chinook salmon stocks. In addition, viewers learn how to develop quality control and quality assurance methods and improve data collection. The Wiki provides a glossary to encourage standardization of terms used to describe and explain the scale aging process.

Background and Need

Chinook salmon are important to subsistence, commercial, and sport users across the Pacific. However, productivity and abundance of these salmon have declined throughout Alaska, causing social and economic hardships in many communities (ADF&G Chinook Salmon Research Team 2013, JTC. 2006, Lewis et al. 2015, Schindler et al. 2013). Unfortunately, the causes of these declines remain poorly understood.

Chinook salmon scales are used to estimate fish age and play a key role in salmon management throughout the Pacific rim. Within Alaska, these estimated ages are used to construct brood tables, estimate total return, examine productivity, and set escapement goals (Munro 2018). Despite the pivotal role of scale ages in management, there are no statewide protocols or training (Agler and Wilson 2015, Agler et al. 2018). Currently, regional and area offices perform their own training, and few regional protocols for scale age estimation of Chinook salmon exist (Agler and Wilson 2015). Since Alaska's statehood in 1959, scale ages have been estimated by numerous personnel across the state. The large number of personnel who estimated ages over the years combined with a lack of standardized protocols and various difficulties in interpreting growth patterns suggest that there may be inconsistencies in Alaska's Chinook salmon scale age estimates, although the extent of this variability is unknown (Agler and Wilson 2015, Agler et al. 2018). Differences in age estimates can cause returns from a given brood year to appear either larger or smaller relative to the actual population size (Fournier and Archibald 1982). For example, a simulation of age reading errors for Baltic cod (*Gadus morhua*) found ages were biased towards older-aged fish, which caused fishing mortality to be underestimated. This bias led to less effective stock conservation and overly optimistic catch limits (Reeves 2003).

Only a few previous studies have examined consistency among age estimates. For example, a previous Alaska study (DuBois and Liller 2010) compared age estimates for Yukon River Chinook salmon among three labs for the same set of scales. The study found good percent

agreement among readers (freshwater age: average = 97.3%; saltwater age: average = 92.4%). Variation among readers occurred in freshwater age 2 and saltwater age 5 fish. McNicol and MacLellan 2010 examined the accuracy of using scales to age mixed-stock Chinook salmon of hatchery origin in Canada. They found that breadth of experience (number of systems previously examined) may be as important as years of experience in explaining variation in agreement among readers. Their results suggested that a reader should have experience examining samples from a wide variety of stocks of varying life history types.

The goal our project, supported by the Saltonstall-Kennedy grant program, was to improve the consistency of age estimates across Alaska. Reducing existing variability in age estimates would assist with improving estimates of productivity, harvest forecasts, and escapement goals. Consequently, the study was designed to: (1) quantify variability in Chinook salmon ages across Alaska stocks; (2) publish a protocol and develop a dynamic wiki (internet-accessible site) for estimating Chinook salmon ages from scales; and (3) examine the impacts of the observed variability on Chinook salmon escapement goals. Experienced Chinook salmon scale readers (n = 10) from Alaska estimated scale ages using an online data entry program containing 10,000 digital images of scales. We then examined the variability in age estimates among readers, ages, three time periods (1980–1992; 1993–2003; 2004–2015), and five geographically-distinct stocks (Karluk, Kuskokwim, Nushagak, Copper, and Stikine rivers).

During October 2018, participants attended a meeting in Anchorage, Alaska to review project results and facilitate interaction among readers. Participants jointly developed guidelines for estimating Chinook salmon scale growth patterns to ensure age estimates are as consistent and precise as possible among readers within ADF&G. In conjunction with an ADF&G biometrician, Tosehide Hamazaki, we developed simulations to examine the effects of reader variability on population models used to set escapement goals and harvest allocations.

Salmon Scale Wiki

A major outcome of this study was the development of guidelines for scale age estimates of Chinook salmon in Alaska. To facilitate this process, we created Salmon Scale Wiki (Figure 1; Table of Contents). The Wiki is an interactive website where scale readers can access information about Chinook salmon scales and stocks within Alaska. Scale readers can participate in expansion of the Wiki by adding or modifying content, thus, it is a living document that changes over time. This dynamic site includes pages where readers learn about the scale age estimation process (Figure 2), acquire training techniques and suggestions, study images of other Alaskan Chinook salmon stocks (Figure 3), and gain knowledge to improve their quality control and quality assurance methods. Salmon Scale Wiki also contains sections recommending methods to improve data collection, and there is a glossary and a section defining common terms. Salmon Scale Wiki includes descriptions of general and stock-specific considerations (Figure 3) for estimating age from Chinook salmon scales. There are also guidelines for estimating age from Chinook salmon scales (Figure 2), life-history traits affecting scale pattern interpretation, images of scales by stock, and sections describing scale characteristics of each stock.

Currently, Salmon Scale Wiki contains over 52 pages, and participants can add additional sections as the protocol develops. Thus, the publicly-available Salmon Scale Wiki will continue to evolve. We are also developing a concise, written protocol that will be accessible through the Wiki. We encourage researchers, biologists, and age readers to visit Salmon Scale Wiki and suggest additional sections to improve a reader's ability to learn to estimate the age of a Chinook salmon scale consistently over time.

https://www.admin.adfg.state.ak.us/confluence/display/ACSAS/Salmon+Scale+Wiki

Salmon Scale Wiki has the potential to continue to grow to include images and descriptions of how to estimate age for other species of salmon.

Acknowledgements

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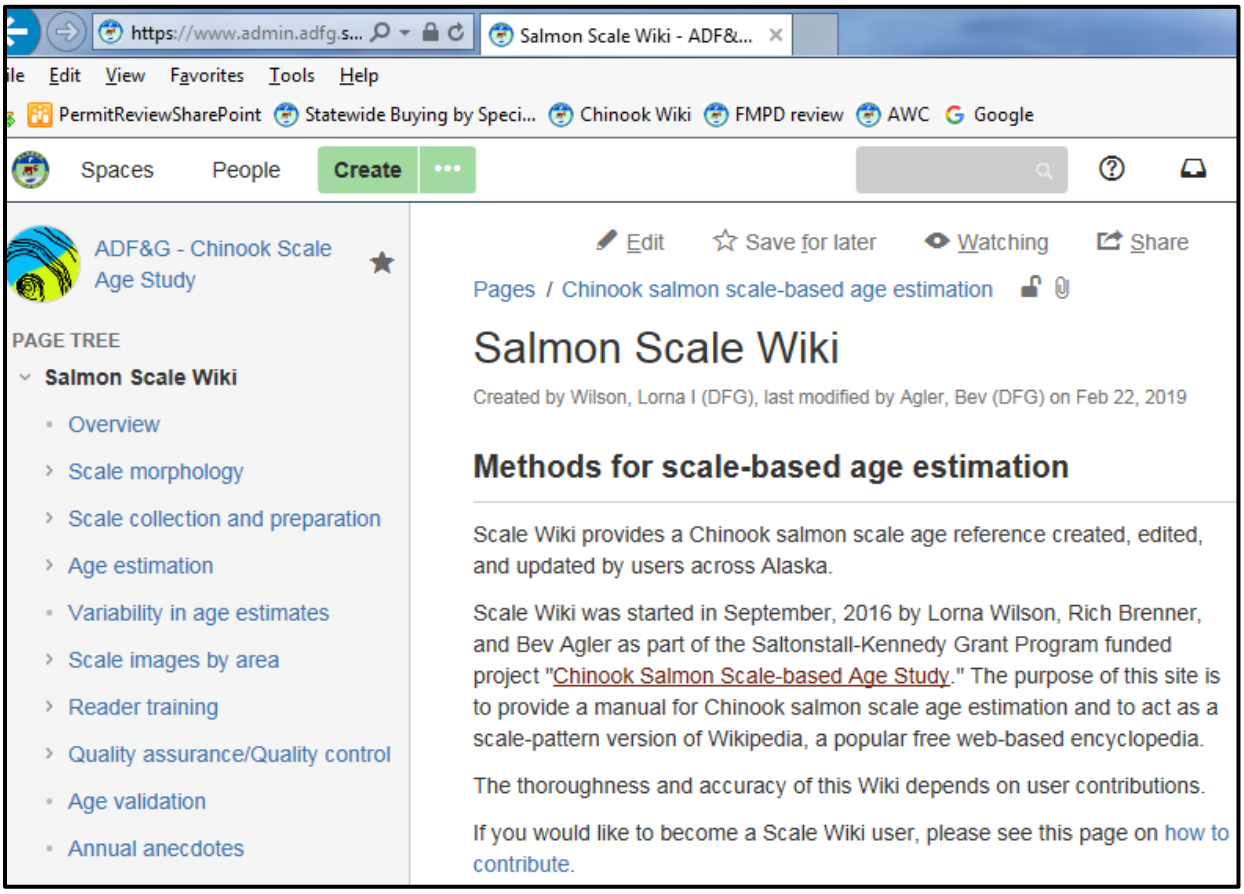

Figure 1. Screen shot of the first page of Salmon Scale Wiki, an interactive website designed for scale age readers to gain knowledge and share information about estimating age of Chinook salmon.

Age estimation

Created by Wilson, Lorna I (DFG), last modified just a moment ago

Scale patterns can be interpreted to estimate fish age because scales grow incrementally and have patterns of rings, called circuli, which reflect fish growth rates (Fisher and Pearcy 1990). During periods of fast summer growth, circuli spacing is wider, and during slow winter growth, circuli spacing is narrower. Annuli, distinguished by a pair of wide (summer) and narrow (winter) circuli, are counted to estimate fish age.

Salmon ages are recorded in European notation (Koo 1955; Mosher 1969) that includes the number of years spent in fresh water after emergence from the gravel, a point, and the number of years spent in the ocean. The total age of the fish is the sum of the number of years spent in freshwater and the number of years in the ocean plus one to account for the time spent developing in the gravel as an embryo.

Chinook salmon are the largest of the Pacific salmon, which are some of the largest and fastest growing fish species in the world and (Groot 2010). The large body size of Chinook salmon size is due to both rapid growth and prolonged life (Groot 2010). This fast growth is apparent year round, as growth rates as indicated by circuli spacing are not always different between summer and winter seasons (see examples in scale images by area), which can make identification of annuli for Chinook salmon particularly challenging.

On this page:

- Annuli
- Checks
- Freshwater growth
- Estuarine and ocean growth
- The final ocean annulus and "plus" growth
- References

See the following pages for auxiliary information used to help increase confidence and narrow down possible age estimates and scale deformities that can decrease confidence and widen possible age estimates:

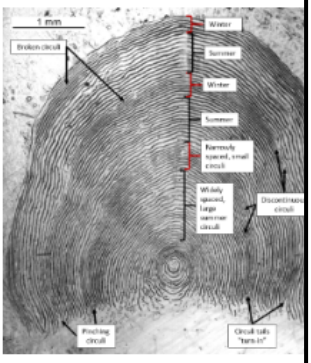

Figure 1. Example scale showing annulus features: circuli spacing and size, broken circuli, discontinuous circuli, circuli tails that "turn-in" at the base of the scale. This scale was collected from a male Chinook salmon in the Yukon River at the Middle Mouth test fishery using set gillnet gear o June 15, 2008. Fish was length 61 mm (mid-eye to fork of tail, MEF), and age estimate was 1.3.

Figure 2. Example of a page from Salmon Scale Wiki, an interactive website designed for age readers to gain knowledge and share information about estimating age of Chinook salmon scales. This page explains how to interpret scale patterns.

Taku River and tributaries

Created by Wilson, Lorna I (DFG), last modified on Jan 22, 2019

Scales collected from Chinook salmon in the Taku River and tributaries with matching coded wire tag (CWT) information. To find out more about the CWT data, enter the CWT tag code into the "Enter tag codes wanted" field of the Agency report.

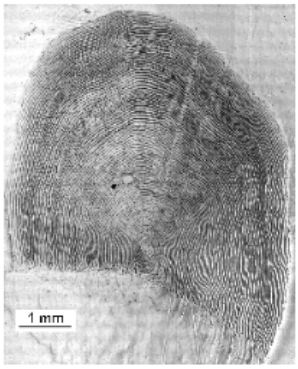

Figure 1. Scale collected from a 800 mm (mid-eye to fork of tail) male Chinook salmon sampled at the Canyon Island fishwheel, Taku River, on May 23, 2004. This fish was given strap tag 277420 and the 040353 CWT code was recovered that validates the marine age 4.

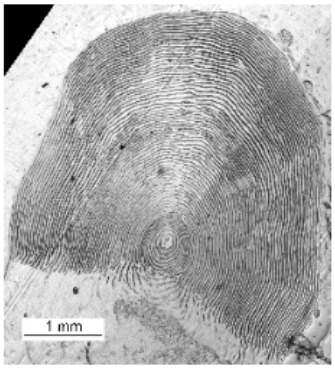

Figure 2. Scale collected from a 510 mm (mid-eye to fork of tail) male Chinook salmon sampled at the Canyon Island fishwheel, Taku River, on May 21, 2003. This fish was given strap tag 172934 and the 040354 CWT code was recovered that validates the marine age 2.

Figure 3. Example of a page from Salmon Scale Wiki, an interactive website designed for age readers to gain knowledge and share information about estimating age of Chinook salmon scales. This page is one of many showing scales patterns from individual stocks within Alaska.