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The Process of Developing Standardized Scale Age Estimation Protocols for Chinook Salmon

by

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Abstract

Sustainable fisheries management of salmon populations includes estimating the age of returning fish, and these ages are typically obtained from scale patterns. Although regional offices within the Alaska Department of Fish and Game (ADF&G) have developed scale age estimation methods, these procedures are often undocumented or not updated, which may lead to inconsistent age estimates and increased variability within and among regional offices. Because the amount of variability is unknown, this could have negative impacts on salmon management.

To improve the quality of scale age data, ADF&G, at the behest of the U.S. Chinook Technical Committee of the Pacific Salmon Commission, began comparing procedures used to estimate age of Chinook salmon in the Pacific Northwest and Alaska to determine whether they could be standardized. To accomplish this, ADF&G held a workshop to compare techniques for age estimation from scales, identify major challenges, and develop common terms. During this workshop, challenges to scale age estimation were documented, and participants concluded that procedures could be standardized over a broad geographic area.

As a result of the workshop, ADF&G began a comparison of the variability of Chinook salmon scale age estimates across Alaska. Once completed, these data will allow us to quantify the variability of age estimates and examine the effects of this variability on management parameters. Ultimately, these efforts will contribute to more consistent scale age estimates through the development a standardized protocol and image library. In addition, insights gained from these initiatives can be used to develop standardized scale age estimation protocols and to increase communication among readers around the Pacific Rim.

Introduction

Salmon are highly valued in subsistence, sport, and commercial fisheries across their range in the North Pacific. In Alaska, the Alaska Department of Fish and Game (ADF&G) manages salmon based on the sustained yield principle (Alaska Administrative Codes: AAC 5 39.222, 5 39.223) that stipulate the development and monitoring of sustainable spawning escapement goals as the primary management tool for major stocks of salmon.

Where feasible, ADF&G manages Chinook salmon stocks to achieve maximum sustainable yield (MSY). This requires reliable estimates of abundance and age compositions of spawning escapement and harvest. Because Chinook salmon spend variable amounts of time in both freshwater and marine environments — freshwater residence of 0–3 years, followed by a marine residence of 1–7 years (Healey 1991; Quinn 2005) — fish from a single brood year return to spawn across multiple years. Thus, to calculate the productivity (return per spawner) originating from a single brood year, fisheries biologists need information about the age composition of Chinook salmon present in harvests and escapement across years.

Age estimates of Chinook salmon are typically obtained from interpretation of scale patterns. 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. Annual growth, distinguished by pairs of wide and narrow circuli spacing zones, is counted to estimate fish age. Changes in temperature and food availability may contribute to differences in stock or geographic-specific growth patterns.

Although scale age estimates are a critical component of salmon stock assessments, few published manuals exist for age estimation from scale growth patterns for Chinook salmon, and these manuals are stock- or geographic-area specific (Koo 1967; Rowse et al. 1990; Yole 1989). Individuals who conduct scale age interpretation (readers) tend to work seasonally and do not have time to record methods in a manual. Thus, scale pattern knowledge is generally passed from reader to reader through apprenticeship. As experienced staff retire, historical knowledge is lost, and details of scale pattern knowledge remain undocumented. Additionally, there often is little communication among offices. With few protocols, no standard procedures, and little communication among areas, the possibility exists for inconsistencies in criteria to create variability in scale age estimates. The amount of variability associated with age composition estimates is currently unknown, and these are a critical component of assessing stock status and developing escapement goals.

Because of these concerns the U.S. Section of the Chinook Technical Committee (USCTC) of the Pacific Salmon Commission (PSC) encouraged us to propose a project to increase understanding of the challenges to scale age estimation of Chinook salmon within the Pacific Salmon Treaty area. This project consisted of a workshop attended by scale readers from the U.S. and British Columbia, Canada. At the workshop scale age estimation techniques were discussed, major challenges identified, and common terms were developed (Agler and Wilson 2015). As an outgrowth of the workshop, ADF&G proposed a second project to estimate the variability in scale age estimates and examine the effects of that variability on salmon management. Using results from these projects, we are working together with readers from across Alaska and the Pacific Northwest to develop protocols for scale age estimation for Chinook salmon.

Project Summaries

Chinook Salmon Scale Workshop

To compare age estimation procedures and explore the possibility of standardization among readers across the Pacific Northwest and Alaska, the USCTC funded a two-day meeting of Chinook scale readers from Alaska, British Columbia, Washington, Oregon, and Idaho (Table 1) to:

(1) Synthesize current Chinook salmon scale aging knowledge;
(2) Conduct a comparison of Chinook salmon scale aging methods;
(3) Discuss standardization of Chinook salmon scale aging methods; and
(4) Discuss formation of a committee to standardize and improve scale aging protocols for Chinook salmon.

During this workshop, we made progress towards all objectives. To address the second objective in detail, we received funding from the Saltonstall-Kennedy Grant Program to examine the variability of scale age estimates in Alaska (see below).

Prior to the workshop, participants provided protocols for scale data collection and age estimation in addition to annotated images of Chinook salmon scales (e.g., Figures 1 and 2). Participants presented procedures and challenges to scale age estimation. Many procedures were common among readers: most viewed scale impressions on a microfiche viewer, age data were mostly recorded in European notation (Koo 1962), and age was estimated by counting annual scale growth periods determined by from wide and narrow spacing of a scale's circuli. Some terms were area-specific, such as "ocean entrance," which was used by everyone except the readers from Alaska. Some challenges to scale age estimation were reported only by a single office. For example, one regional office in Alaska reported high rates of unreadable scales due to regeneration (a fish loses and then regrows a scale).

To establish a common language to use when discussing the estimation of fish age from scales, participants listed key terminology and developed definitions (Agler and Wilson 2015). Next, the challenges of scale age estimation from scales were discussed in detail, and the five most important topics were selected: (1) scale reading criteria and methods, (2) quality assurance and quality control, (3) age validation, (4) data management and database development, and (5) relationship with fisheries management. Participants identified issues within these broad topics, prioritized specific concerns related to each issue, suggested solutions, and then ranked their concerns. Below is a summary of the top-ranked challenge and solution for each topic. A complete list is available in the project report (Agler and Wilson 2015).

1) <u>Scale Reading Criteria and Methods</u>: Reabsorption along the scale margin was a major concern because it interfered with interpretation of saltwater and total age. Reabsorption caused growth at the edge of the scale to be missing or unreadable. Participants suggested that reviewing scale patterns from fish where the age and origin were known (i.e.; validation studies) would aid in determining whether age could be determined from a resorbed scale.

2) <u>Quality Assurance and Quality Control</u>: Participants were concerned with improving the accuracy and precision of age estimates, minimizing bias, and improving data quality. Participants agreed that experience ameliorated these issues and determined this could be rectified with development of training standards.

3) <u>Age Validation</u>: Concerns in this topic area include validation of total fish age and problems with interpreting growth patterns due to reabsorption. A missing annulus could cause a scale to be incorrectly aged. One solution is to mark salmon fry with coded wire tags (CWTs), small pieces of stainless steel wire etched with a decimal or binary code in a specific year. When a tag is recovered, release and recovery dates are known, allowing biologists to validate total age on the scale.

4) <u>Data Management and Database Development</u>: Participants identified a need for improved data access through centralized databases to facilitate data sharing. Data sharing allows data to be used more effectively by fisheries managers, research biologists, and other groups. Solutions to data accessibility included standardizing notation, formatting, and clarifying data collection and protocols.

5) <u>Relationship with Fisheries Management</u>: Participants suggested that communication with fishery managers needed improvement to ensure their needs were met. Participants suggested

requesting feedback from managers regarding data quality needs and timeliness of data availability.

One of the goals for this project was to determine whether methods for Chinook salmon age estimation from scales could be standardized across the Pacific Northwest and Alaska. This question was revisited throughout the workshop. Based on the similarities of protocols and terminology used, workshop participants agreed that methods used to estimate fish age from scales could be standardized. Additionally, project participants were interested in continuing to examine standardization of methods and forming a committee of scale experts for the Pacific Northwest and Alaska to guide, standardize, and improve scale age protocols for Chinook salmon. All meeting documents are available to the public:

http://mtalab.adfg.alaska.gov/OTO/ChinookScaleAgeMeeting.aspx

The next steps towards ensuring that the best age estimates are used in fishery management were identified as: 1) investigating the possible factors that contribute to variability of scale age estimates and 2) examining the effect of variability of scale age estimates on population model parameters and resultant fishery management. Thus, we proposed a two-year Chinook salmon scale age study, which was funded by the Saltonstall-Kennedy Grant Program.

Scale Age Study

Correct age data are critical to effective fishery management (Schnute and Richards 1995). The number of personnel who have estimated ages over years, the challenges of estimating Chinook salmon age from scales, and the paucity of protocols increase the likelihood that error and inconsistencies exist in age estimates. The variability in scale age estimates has been examined for older age Chinook salmon from the Yukon River (DuBois and Liller 2010). However, the extent of this error is unknown for Chinook salmon statewide.

With funding from the Saltonstall-Kennedy Grant Program, we are currently examining the consistency of scale age estimates of Chinook salmon in Alaska. To date, we have created an Internet-accessible data entry application accessing 10,000 images of Chinook salmon scales (Figure 3). Experienced readers from across Alaska are using this application to estimate age for scales from five geographically-separated Alaskan rivers and enter data into an Oracle database (Table 2). Data from this study allows us to quantify the variability among scale age estimates. We will use these data to quantify the variance: (1) among fish ages; (2) within and across stocks; and (3) among time periods. These results will improve our understanding of the sources of variation in scale age estimates for Alaska Chinook salmon, and we will examine the effect of this variance on fishery management, such as estimates of spawning escapement needed to produce MSY.

To discuss the development of a statewide protocol for estimating age of Chinook salmon from scales, we will convene a meeting during the fall of 2018. At this meeting we will share results of the age comparison study and discuss the development of statewide protocols. These protocols will contain stock-specific guidelines, QA/QC best practices, methods for addressing challenges of estimating fish age from scales, and descriptions of Chinook salmon scale growth patterns for Alaska. These protocols will be reported in a static document as well as a Wiki (a collaborative website allowing modification of content and structure; Wikipedia 2018).

Several outcomes of this project, such as a library of scale images and protocols, can be used into the future. The library of scale images will provide a visual reference of growth patterns for stocks across Alaska. The scale protocol can be used as a tool for training and improve consistency among readers. Improving our understanding of where variability occurs in scale age estimates from scales can help to focus efforts where needed (e.g., specific stocks or size classes). Improved consistency of scale age estimates among readers will lead to better stock assessments and assist with the sustainable management of Alaska Chinook salmon.

Future Plans

We will continue working towards standardizing procedures for estimating fish age from scales across Alaska and the Pacific Northwest, with the hopes of working with our colleagues within the North Pacific Anadromous Fish Commission to expand across the Pacific Rim. In the future, we plan to apply similar methods of examining variability in scale age estimates from scales for other salmon species. One recommendation is to form a committee of scale age readers. This committee could hold regular meetings to discuss standardization of methods, convey research results, and share novel techniques.

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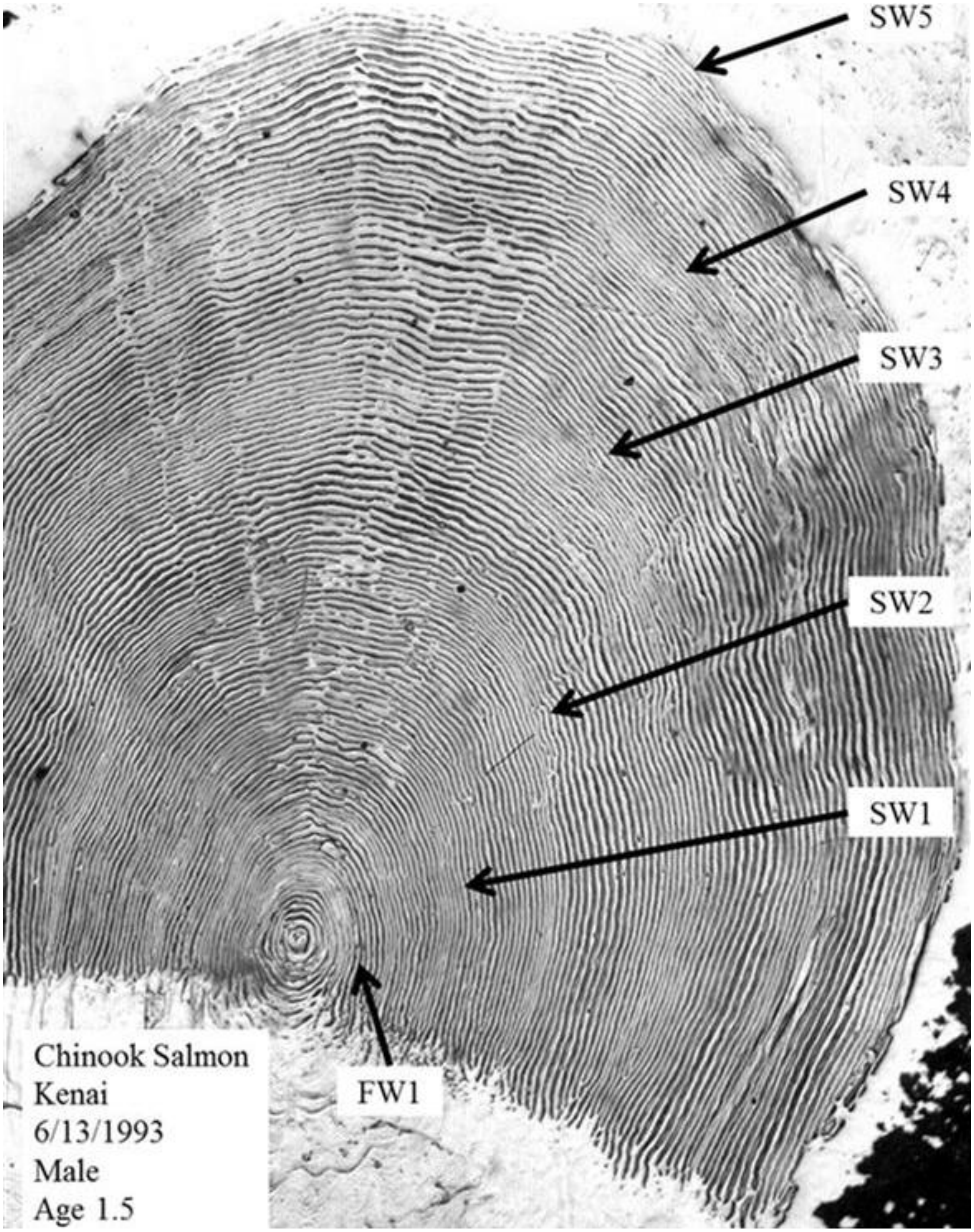

Figure 1. Chinook salmon scale sampled from the Kenai River, Alaska, USA. Arrows indicate the end of each annulus (e.g., FW1 – freshwater annulus, SW1 – first saltwater annulus, etc.). Scale age = 1.5 (European notation, one year in fresh water and five years in salt water). Sampling location, sample date, and sex noted on image. Similar images from several Chinook salmon stocks are published on the project website (http://mtalab.adfg.alaska.gov/OTO/ChinookScaleAgeMeeting.aspx).

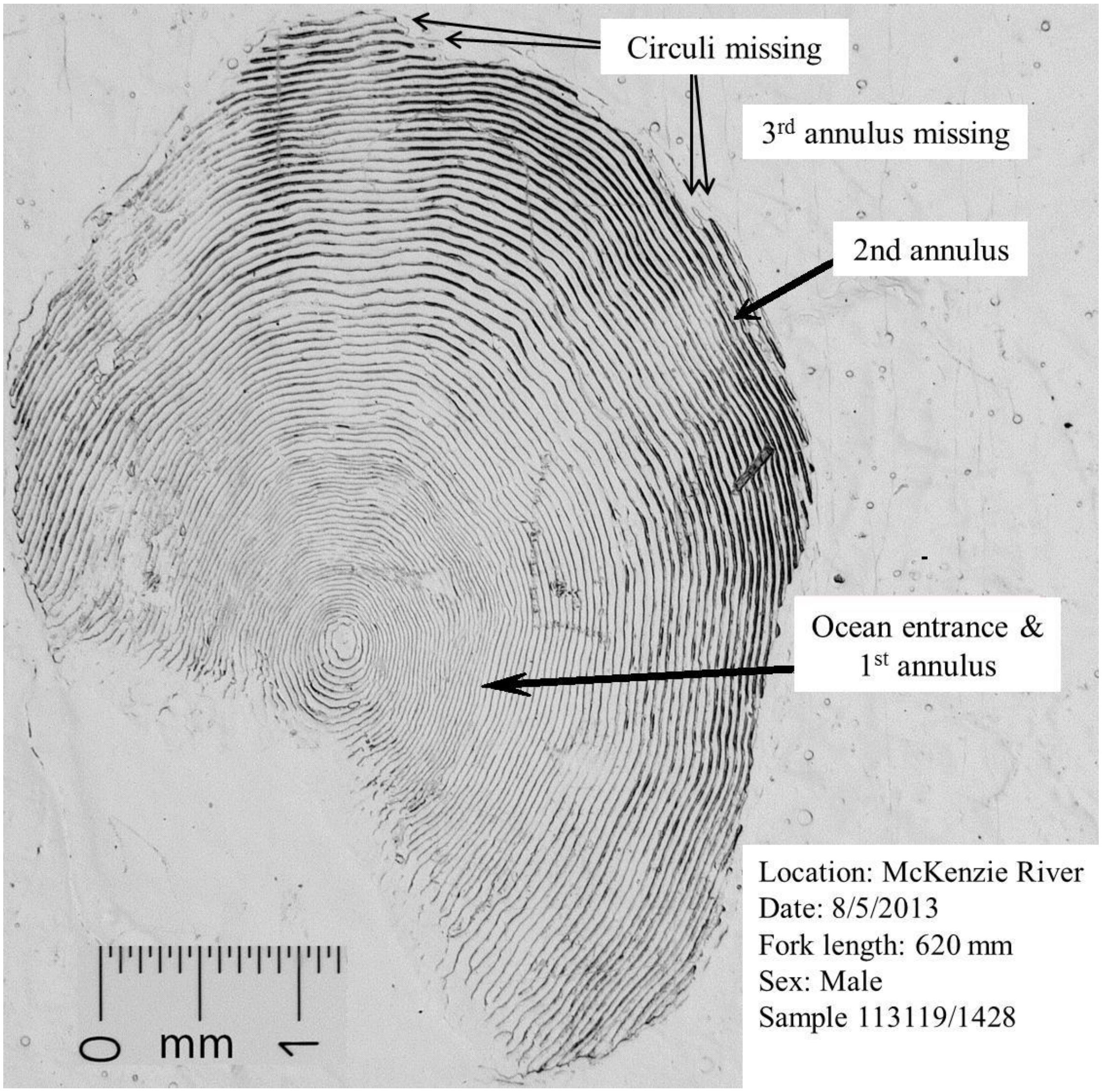

Figure 2. Chinook salmon scale from the McKenzie River, Oregon, USA. Arrows indicate ocean entrance and the end of the first and second saltwater annuli. Scale age = 1.2 (European notation, one year in fresh water and two years in salt water). Scale is reabsorbed along the margin, as indicated by missing and discontinuous circuli. Similar images from several Chinook salmon stocks are published on the project website (http:// mtalab.adfg.alaska.gov/OTO/ChinookScaleAgeMeeting.aspx).

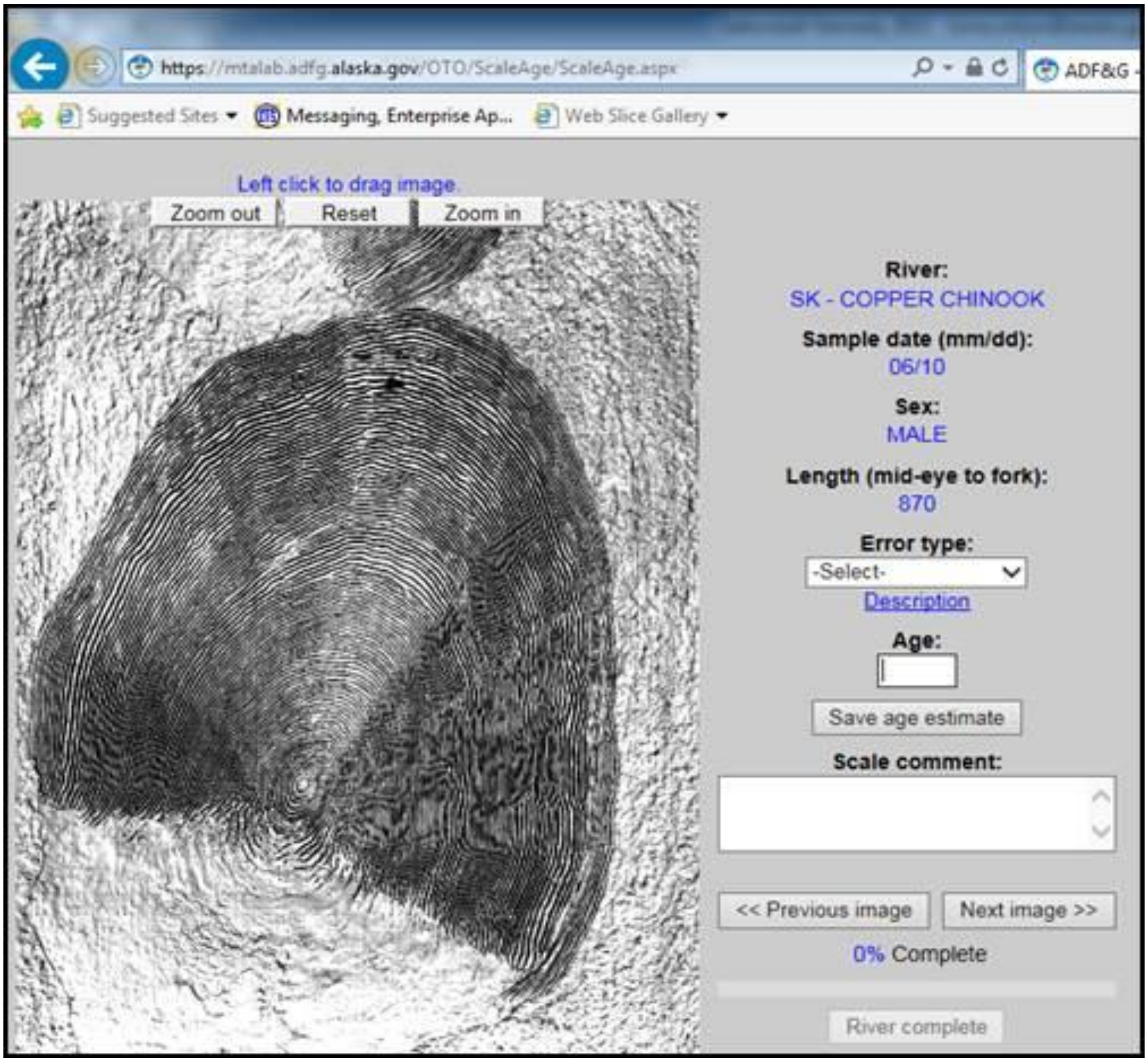

Figure 3. Screenshot of the Internet-accessible application developed by the ADF&G Mark, Tag, and Age Lab for experienced ADF&G scale readers to view scale growth patterns and enter age estimates. This is part of a study to examine variability among Chinook salmon scale age estimates across Alaska.

Table 1. Agency affiliations of participants attending a Chinook salmon scale workshop held 2–3 April 2014 in Juneau, Alaska.

Location	Agency affiliation
Anchorage, AK	ADF&G Division of Commercial Fisheries
Douglas, AK	ADF&G Division of Commercial Fisheries, Southeast
Juneau, AK	ADF&G Division of Commercial Fisheries MTA Lab
Anchorage, AK	ADF&G Division of Commercial Fisheries, AYK
Anchorage, AK	ADF&G Division of Commercial Fisheries, Bristol Bay
Cordova, AK	ADF&G Division of Commercial Fisheries, PWS
Soldotna, AK	ADF&G Division of Sport Fisheries, Cook Inlet
Kodiak, AK	ADF&G Division of Sport Fisheries, Kodiak/Alaska Peninsula
Douglas, AK	ADF&G Division of Sport Fisheries, Southeast
Portland, OR	Columbia River Inter-Tribal Fish Commission
Nanaimo, BC	DFO Sclerochronology Lab
Nampa, ID	IDFG/PSMFC Scale Aging Lab
Corvallis, OR	ODFW Fish Life History Analysis Project
Olympia, WA	WDF&W Fish Ageing Unit

Note: Acronyms listed in Agency affiliation: ADF&G = Alaska Department of Fish and Game; MTA Lab = Mark, Tag, and Age Laboratory; AYK = Arctic, Yukon, and Kuskokwim; PWS = Prince William Sound; DFO = Department of Fisheries and Oceans; IDFG = Idaho Department of Fish and Game; PSMFC = Pacific States Marine Fisheries Commission; ODFW = Oregon Department of Fish and Wildlife; WDFW = Washington Department of Fish and Wildlife.

Table 2. Number of readers by geographic area participating in a Chinook salmon scale age study. This project is funded by the Saltonstall-Kennedy Grant Program.

Geographic area	# readers
Statewide	3
Southeast	2
Southcentral	2
Bristol Bay	2
Arctic-Yukon-Kuskokwim	1
Kodiak Island and Aleutians	1
Total	11