Growth Increment Formation Using Otoliths and Scales of Juvenile Chinook Salmon

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Project Synopsis

- How is growth recorded by juvenile Chinook salmon?
- Otolith and scale validation
- Wild comparison

Introduction

- Juvenile salmon survival is positively correlated with size.
  - Predation.
  - Territorial acquisition and defense.
  - Larger prey items.
  - Earlier smolting and migrate more quickly.

Photo from: http://mwigle.zenfolio.com/p1052286371/h6953D1F#h6953d1f

Introduction

- Size-selective mortality at sea
- Adult Recruitment

Photo from: http://www.alaska-in-pictures.com/smolt-silvers-1782-pictures.htm

Introduction

- Because freshwater growth is so important, managers have sought methods to examine past growth at age of salmon.

- Examples of these methods include:
  - Retrospective Otolith Analysis
  - Retrospective Scale Analysis

- Retrospective analysis, or back-calculation, is the extrapolation of body size at previous age based on the size of an otolith or scale at that age.

Introduction

- Back-Calculation models generally do not fit a species or stock perfectly.
- In order for a model to be accurately applied to a species or stock of fish, the model must be validated.

Introduction

- Validation – Four components
  - The mark radius is fixed
  - The timing of the mark is correct
  - The formula is accurate
  - Comparison
- Validation is critical – e.g., Bradford and Geen, 1987

Introduction

- The results of this study can be used by a number of entities across Alaska in studies of Chinook salmon.
- Many locations take scales from emigrating smolt every year and have archived scale samples.
- The findings of our study will be used by a concurrent study examining the role of freshwater growth in adult recruitment.

Objectives

- Validate the relationship between body size and growth and width between daily otolith growth increments and scale circuli in juvenile Chinook salmon.

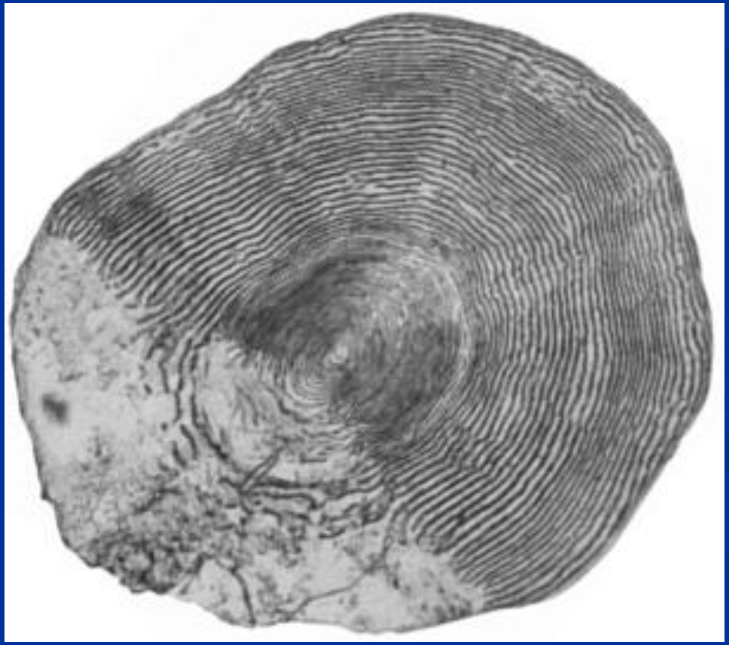
Otolith photo from: http://www.usgs.gov/indian/2001report/resources.html

Objective 1 - Hypotheses

- H_1: The width between hard structure increments in both otoliths and scales will reflect the growth rate of juvenile Chinook salmon.
- H_2: Otolith and scale circuli increments will be directly dependent on fish growth rate, with growth increments for each structure growing in a constant, measurable proportion to each other.
- H_3: Larger otolith and scale growth increments will be positively correlated with lower fish density and higher food ration.

Objectives

- Determine how growth is recorded on otoliths and scales of wild Chinook salmon relative to the same structures in laboratory-reared fish.



Scale photo from: http://www.nefsc.noaa.gov/salmon/Finalscalepatternanalyses2.html

Objective 2 - Hypotheses

- H_1: The width between hard structure increments in both otoliths and scales will reflect the growth rate of wild juvenile Chinook salmon.

- H_2: Proportional growth between otolith increments and scale circuli in wild Chinook salmon will be equal to proportional growth between increments of the same structures in laboratory-reared fish of the same species.

Methods - Facility

- A recirculating hatchery system was built in the newly remodeled wing of the Arctic Health Research Building (AHRB) on the West Ridge of the University of Alaska-Fairbanks during the summer of 2010.

- The system included 16 Heath hatching trays, 2 large circular tanks, and one raceway. An additional hatching system for whitefish was constructed in October, 2010.

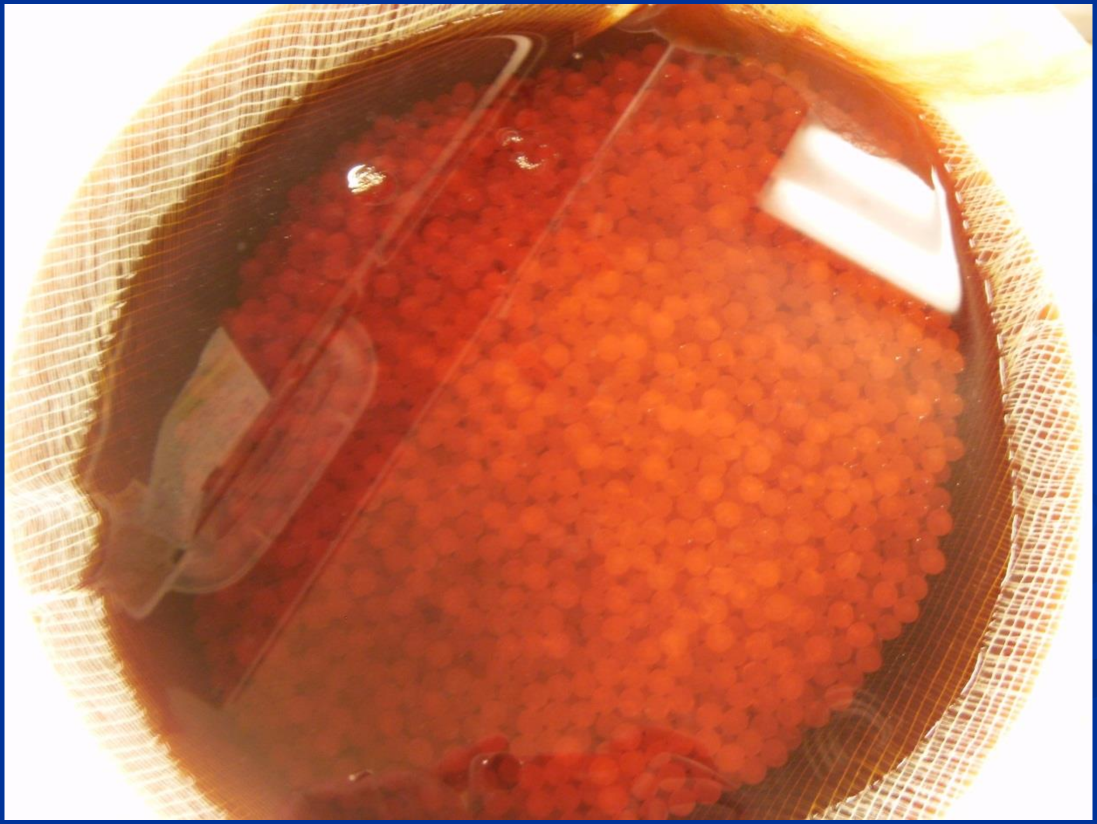
Methods - Facility

- A recirculating experimental system, composed of 24 110L aquaria, was also constructed in an adjoining laboratory to complement the hatchery system.

- Both systems operate completely independently of one another.

Methods

- About 600 eyed eggs were obtained from ADF&G on October 1, 2010. After being disinfected, they were placed in the Heath trays for incubation.



Methods

- Hatching began on October 8th, and was complete on or about October 15th.
- The alevins were reared in the Heath trays until about 2/3rds of their yolk sac had been used.

Methods

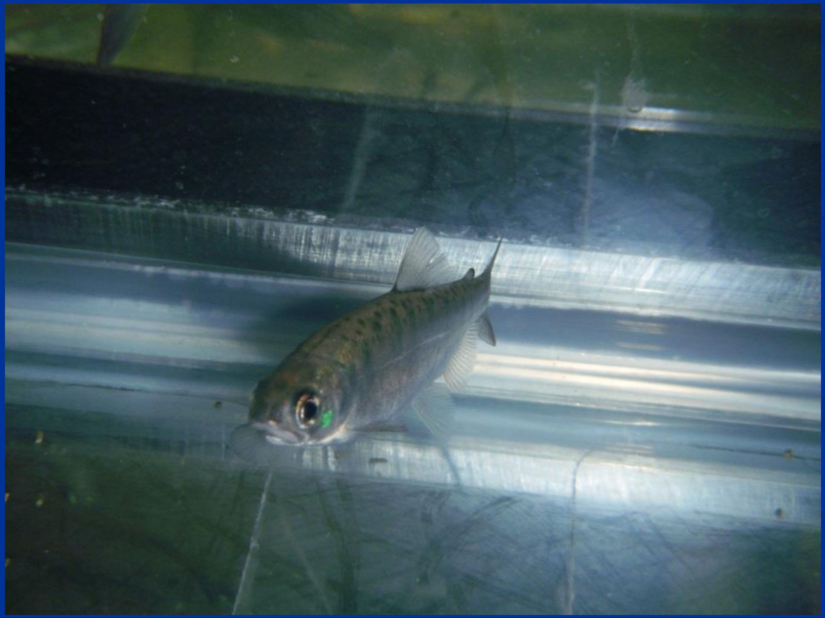
- The fry were stocked into one round tank on November 11th, where they were reared until they reached 60-80 mm in length.

Methods

- Three hundred-sixty (360) fish were marked, weighed (to nearest 0.1 g), measured for total length (to nearest 1 mm), and randomly assigned to the experimental aquaria on March 17th.

Methods

- Each fish* received one or more Visual Implant Elastomer tags to individually identify them from the others in the aquaria.
  - * - One fish in each aquaria was not marked
  - Marks were repeated among aquaria.



Methods

- Marks were applied to one or more of five body locations:
  - Adipose tissue behind right eye
  - Adipose tissue behind left eye
  - Base of dorsal fin
  - Base of anal fin
  - Base of caudal fin

Methods – Experimental Conditions

- Temperature
- Photoperiod
- Water Quality
  - Deionized water
  - Biofiltration

Methods

- 12 aquaria were stocked with 10 fish each. The remaining 12 aquaria received 20 fish each.

- Three feeding regimes were assigned:
  - A low growth ration at 1% of body weight
  - A maintenance ration at 2% of body weight
  - A high growth ration at 4% of body weight

- Density treatments and feeding regimes were randomly assigned among the aquaria.

Methods

- Every 30 days, each fish will be weighed and measured.
- Any mortalities when discovered will be weighed, measured, and frozen for subsequent analysis.

Methods

- All fish will be sacrificed at the end of the experiment (day 122). They will be weighed, measured, and frozen for later analysis.

Methods

- Sagittal and lapillar otoliths will be removed for analysis, as well as 10 – 15 scales.
- Sagittal otoliths will be mounted on microscope slides and prepared for reading by grinding.
- Scales will be mounted on microscope slides.

Methods

- Increments on each otolith and scale will be counted three times by a single reader.
  - No otolith or scale will be counted twice consecutively.
  - Counts will be averaged.

- Width between each increment on each otolith and scale will also be measured three times by a single reader.
  - No otolith or scale will be measured twice consecutively.

Methods

- A second reader will also count the increments on the otoliths and scales, and measure the width between increments.

Methods – Data Analysis

- A regression of otolith and scale increment counts as a function of known daily age will be calculated to determine the periodicity of increment formation.

- ANCOVA's will be conducted to:
  - Determine reader bias
  - Detect the effects of density and food ration on the periodicity of growth increment formation.

Methods – Data Analysis

- Least square means will be calculated for each treatment group

- Slope and intercept parameters will be calculated to allow for back-calculating fish lengths at previous daily ages.

Methods – Wild Comparison

- We are currently applying for a Fish Resource Permit with ADF&G to allow us to collect wild age-0 Chinook salmon this summer.

Methods – Wild Sampling Locations

- Age-0 Chinook salmon from the Salcha River
  - Direct cohort comparison
- Age-0 Chinook salmon from the Chena River
  - Comparison to a different stock

Methods – Wild Comparison

- Our goal is to build the growth history throughout the summer by measuring and weighing 50 fish at each of four sampling events (June, July, August, and September).

- 10 fish at each sampling event will be sacrificed and processed according to the same methods for the laboratory fish.

Methods – Wild Comparison

- A comparison of how growth is recorded in wild fish will be made with our laboratory findings.
- A back-calculation model will also be generated for the wild sample.
- Both models will be compared through ANCOVA to examine any differences between models.

Utility of Study Results

- Freshwater growth & adult recruitment
  - Justin Leon's project
- Threshold sizes and size-selective mortality
- Growth rates
- Validation of scale analysis

Questions?