Evaluating Minijack Rates in Spring Chinook: Comparing minijack rates based on spring plasma 11-ketotestosterone levels with rates based on fall gonadosomatic index

Lea R. Medeiros*, Andrew Pierce*,[2], Curt Knudsen[3], Chad Stockton[4], Bill Bosch[5], Peter Galbreath[2]

* Department of Biological Sciences, University of Idaho, 875 Perimeter Dr, Moscow, ID 83844, lmedeiros@uidaho.edu;[2] Columbia River Inter-Tribal Fish Commission, 700 Northeast Multnomah Street, Suite 1200, Portland, OR 97232;[3] Oncorh Consulting, 2623 Galloway St SE, Olympia, WA 98501; [4] Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501; [5] Yakama Nation, PO Box 151, Toppenish, WA 98948

Introduction

High rates of precocious male maturation of spring Chinook salmon *Oncorhynchus tshawytscha* as two-year old minijacks have been observed in Columbia River Basin conservation and supplementation hatchery programs. Minijacks are observed in the wild, with rates believed to be between 2-5%, whereas minijack rates measured in hatchery programs range from approximately 8 to 71%. This difference contrasts with the goal of a supplementation program to rebuild depressed fish populations with fish whose physical and behavioral characteristics mimic those of the wild population.

Previously, minijack rates have been assessed by lethal blood sampling of age 1+ juveniles, just prior to smolt release in the spring, and assay of plasma levels of 11-ketotestosterone (11-KT), the major androgen in salmonids. However, to our knowledge, no studies have provided confirmation that individual males with elevated springtime plasma 11-KT levels in the spring do in fact complete maturation and are prepared to spawn the next fall.

As part of a study to assess the effect of parent age on minijack rate, we PIT tagged and non-lethally blood sampled a portion of spring Chinook smolts in April, and reared these fish to the subsequent spawning season in September. We also evaluated growth and morphometric characteristics to determine whether the growth trajectories of minijacks and immature males differ.

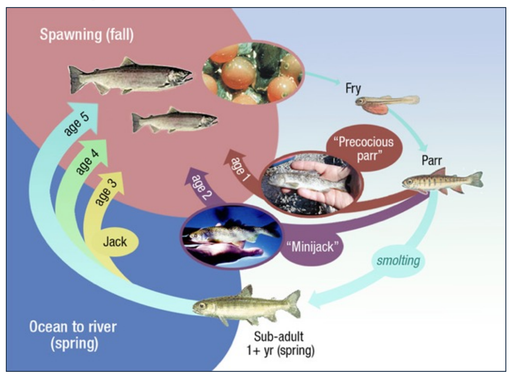

Figure 1. Life history strategies in Columbia River Basin spring Chinook Salmon
Diagram credit to NWFSC

Materials & Methods

In April of 2016, 1254 broodyear 2014 (BY2014) phenotypically male juvenile Chinook were lethally sampled. Length and weight were recorded and a blood sample and fin clip were taken from each fish. In addition, 459 fish were non-lethally sampled, PIT tagged, and returned to the tanks for continued rearing. In September of 2016, the surviving fish were lethally sampled. Length, total body weight, and testes weight (if male) were recorded and a blood sample taken from each fish.

Blood samples were centrifuged, and the plasma decanted and stored at -80C. An ethyl ether extraction was performed for each plasma sample, and the non-polar fraction retained. Extracted plasma samples were run using an 11-KT enzyme-linked immunosorbent assay (Cayman Chemical). Gonadosomatic Index (GSI) was calculated using the following formula:

$$\left[\frac{Gonad\ Weight}{Total\ Body\ Weight}\right] \times 100 = GSI\ (\%)$$

Plasma 11-KT and growth curve analyses were performed using Prism (GraphPad Software, Inc.) or Systat (Systat Software, Inc.). Determining the cutoff was performed in R Studio (Rstudio) using custom codes to determine the value with a 50/50 chance of being from either bimodal distribution (as produced by the histogram of plasma 11-KT values).

Results

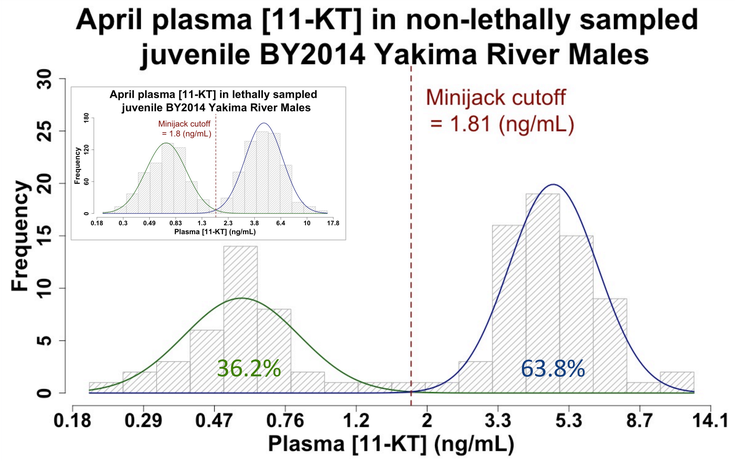

Figure 2. Histogram of April plasma 11-KT values from all non-lethally (main) and lethally (inset) sampled fish. As expected, analyses revealed statistically significant bimodal distributions, which was not observed at an earlier sampling time point (February, data not shown). From this, a cutoff 11-KT value was determined as the value with a 50% chance of being in each mode.

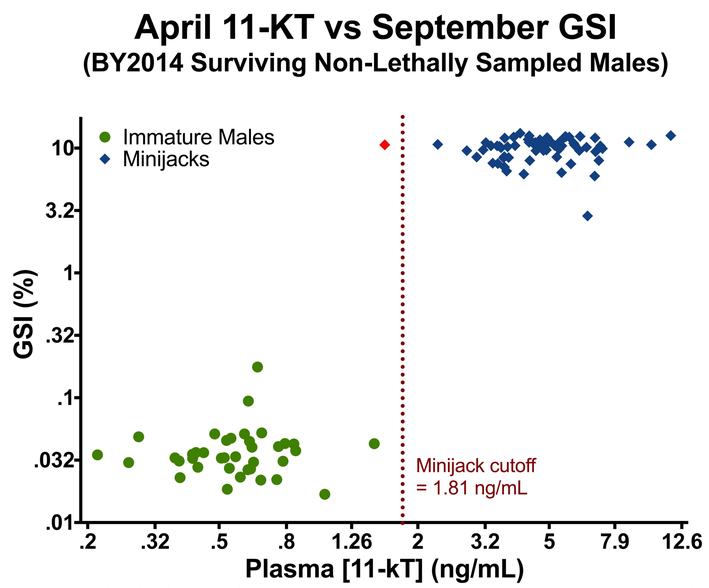

Figure 3. Individual April plasma 11-KT concentrations versus GSI (measured in September). 104 of 105 fish were classified correctly based on April 11-KT concentrations. The single exception is indicated by the red diamond.

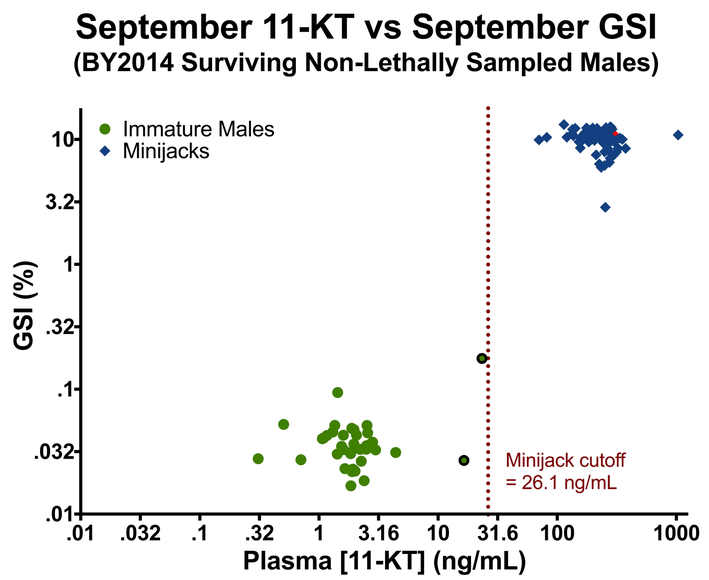

Figure 4. Individual September plasma 11-KT concentrations versus GSI, with the cutoff concentration determined from the September plasma 11-KT histogram analysis (data not shown). Points with black outlines may be initiating maturation for the following year.

Results

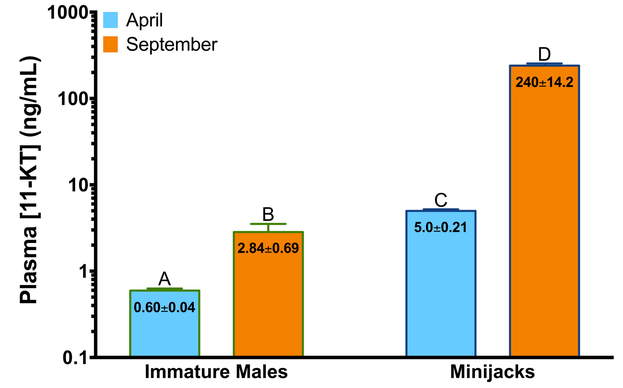

Figure 5. Average plasma 11-KT values for April and September, grouped by maturation status. Different letters represent a significant difference between values ($P < 0.0001$)

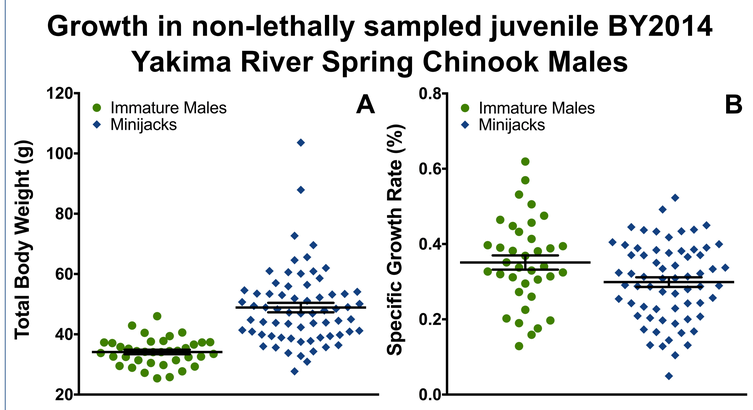

Figure 6. In April, total body weight (panel A) for minijacks and immature males was significantly ($P < 0.0001$) different. However, between April and September, the specific growth rate for weight (panel B) was significantly ($P < 0.05$) lower in minijacks. Bars are means ± SEM.

Conclusions

- Male plasma 11-KT levels were bimodally distributed in April with very little overlap
- Elevated springtime plasma 11-KT predicted completion of maturation as a minijack in almost all fish
  - Results support previous work that spring plasma 11-KT levels are a good predictor of fall maturation status
  - No evidence was found for arrested maturation
- Plasma 11-KT levels increased from April to September in both immature males and minijacks
  - Immature males with highly elevated plasma 11-KT levels in September may be initiating maturation as jacks
- Minijacks were heavier than immature males in April, but grew slower than immature males after April, consistent with stimulation of growth during the early stages of maturation and then diversion of energy from growth to reproduction

Future Work

- Explore physiological mechanisms behind maturation process to further refine estimates of when reproductive decisions are made
- Develop a quick, non-lethal test for detecting minijacks

Acknowledgements

We would like to thank the Yakama Nation and WDFW staff at the Cle Elum Hatchery for providing fish care throughout the experiment as well as the CRITFC technicians and University of Idaho undergraduates for help in collection and processing of the samples. This study was supported with funding from the Bonneville Power Administration under Project 2009-009-00.