Snake River Fall Chinook salmon Age and Size at Return: Then and Now.

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This report investigates changes in age- and size-at-return of Snake River fall Chinook salmon over time. Historical data from Snake River fall Chinook salmon prior to the rapid decline in abundance is very limited. Initial estimates of size-and age-at return consisted of observation data of adult proportions determined from window counts at the dams. Additional data, including individual fish age and length data, was available from fish collected for broodstock following the initiation of the hatchery/egg bank program in 1976 and Lower Snake River Compensation Plan production at Lyons Ferry Hatchery in the mid 1980's (Bugert and Hopley, 1989). However, this short time series only represented a limited number of generations and did not include any natural-origin fall Chinook salmon adults. Consequently, data limitations severely constrained our abilities to fully explore changes from a historical perspective and only enabled some basic observations about the status of the Snake River fall Chinook salmon population related to size- and age-at-return.

We attempted to answer the following questions related to changes in size- and age-at-return: 1) has the size composition of natural-origin fall Chinook salmon changed over time, 2) has the adult hatchery-origin fall Chinook salmon length-at-age changed over time, and 3) has hatchery-origin fall Chinook salmon age-at-return changed over time?

Has the size composition of natural-origin fall Chinook salmon changed over time

Snake River fall Chinook salmon were mainly natural-origin prior to the start of hatchery program in 1980. Window counts at the lower Snake River dams categorized fish as adults or jacks based on observed total length estimated as they passed the counting window. This provided a rough estimate of size and age composition for early returns to the Snake River. We chose to analyze returns to Little Goose Dam (LGO) because it reduced the likelihood that non-Snake River fish were included in the analysis, as later data demonstrated a higher proportion of out of basin fish returned to Ice Harbor Dam (Mendel et al., 1997).

We compared the proportion of adult-sized fish ($\geq$57 centimeters) returning to LGO from 1970 – 1980 with a period from 2003 – 2012. Total abundance and proportion adults ($\geq$57 cm) for both periods is presented in Figure 1. Return of adults during the early period averaged 57.4% (S.D. = 18.5) compared to 67.6% (S.D. = 11.7). T-test revealed that the average proportions were not significantly different (P = 0.129). The first five years of the early period (1970 – 1974) was characterized by a higher proportion of adults in the period. After a rapid decline in abundance the percentage of large fish declined to be lower than that of jack returns (Figure 1). Results were based on visual window counts so sex or age a return data could not be determined.

These results demonstrated that size composition, as measured by the proportion of adults in the population, has not significantly changed over this time period. However, these results should be viewed with caution. Both the early and recent estimates that demonstrating higher adult proportions were very short time series representing less than one generation, so any proportional changes in size composition were likely not heritable. Exploitation rates in the ocean and lower Columbia River were significantly higher prior to Endangered Species Act listing in 1992 (Joint Chinook Technical Committee, 2011) and size-selective harvest methods likely impacted the proportion of adult-sized (> 57 cm FL) fish in the population. In addition, the recent time series was dominated by hatchery fish, including large returns from yearling smolt releases, which are known to return younger aged fish and higher proportions of jacks (Young et al. 2013). For these reasons, it is impossible to determine if the current size composition represented by adult:jack ratio has changed compared to historic levels.

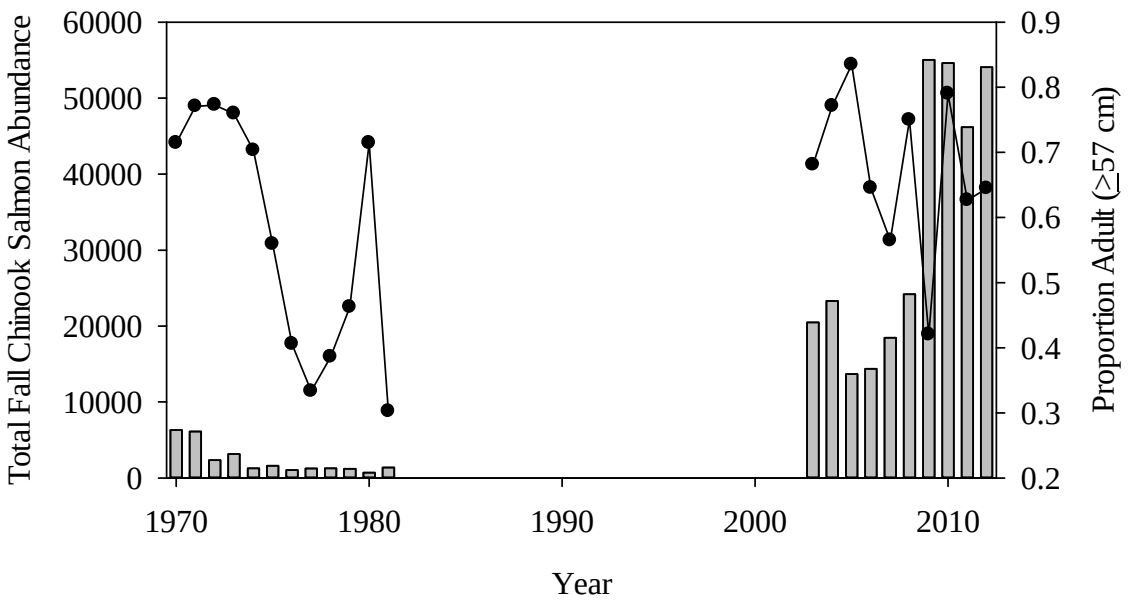


Figure 1. Snake River fall Chinook salmon abundance and proportion of large fish counted at Little Goose Dam from 1970 – 1981 and 2003 - 2012. Bars demonstrate total fall Chinook salmon abundance at Little Goose Dam and the line represents the proportion of large, adult-size (>57 centimeters fork length) fish in the run.

Sex and fork lengths (FL) were collected on fish trapped at LGO in 1976 and used in the study to profile the sizes of natural-origin fish prior to supplementation efforts. These data are some of the earliest on natural-origin Snake River fall Chinook salmon. In 1976 approximately 31% of the natural fall Chinook salmon return to LGO was captured, measured and spawned, representing the only historical data set available for analyzing past and present size composition. Scales were either not collected or lost, so age comparisons were not possible. Comparing length frequency histograms from 1976 with probable natural fall Chinook salmon collected from LGR in 2005 and 2006 revealed a similar length distribution for adult females, but a higher proportion of smaller adult males in the contemporary collections (Figure 2). Origin of the recent collections was determined by scale pattern analysis, which has been determined to be unreliable (Young et al. 2013) however, they were unmarked and likely had a high proportion of truly natural fish. As with the analysis above, this comparison should be viewed with caution because comparing historic data from a single year (1976) was a snapshot in time and did not represent the annual variation in length at return resulting from environmental variability or age composition changes over time. Based on these results, no clear evidence for a significant change in size composition from 1970 through present was observed.

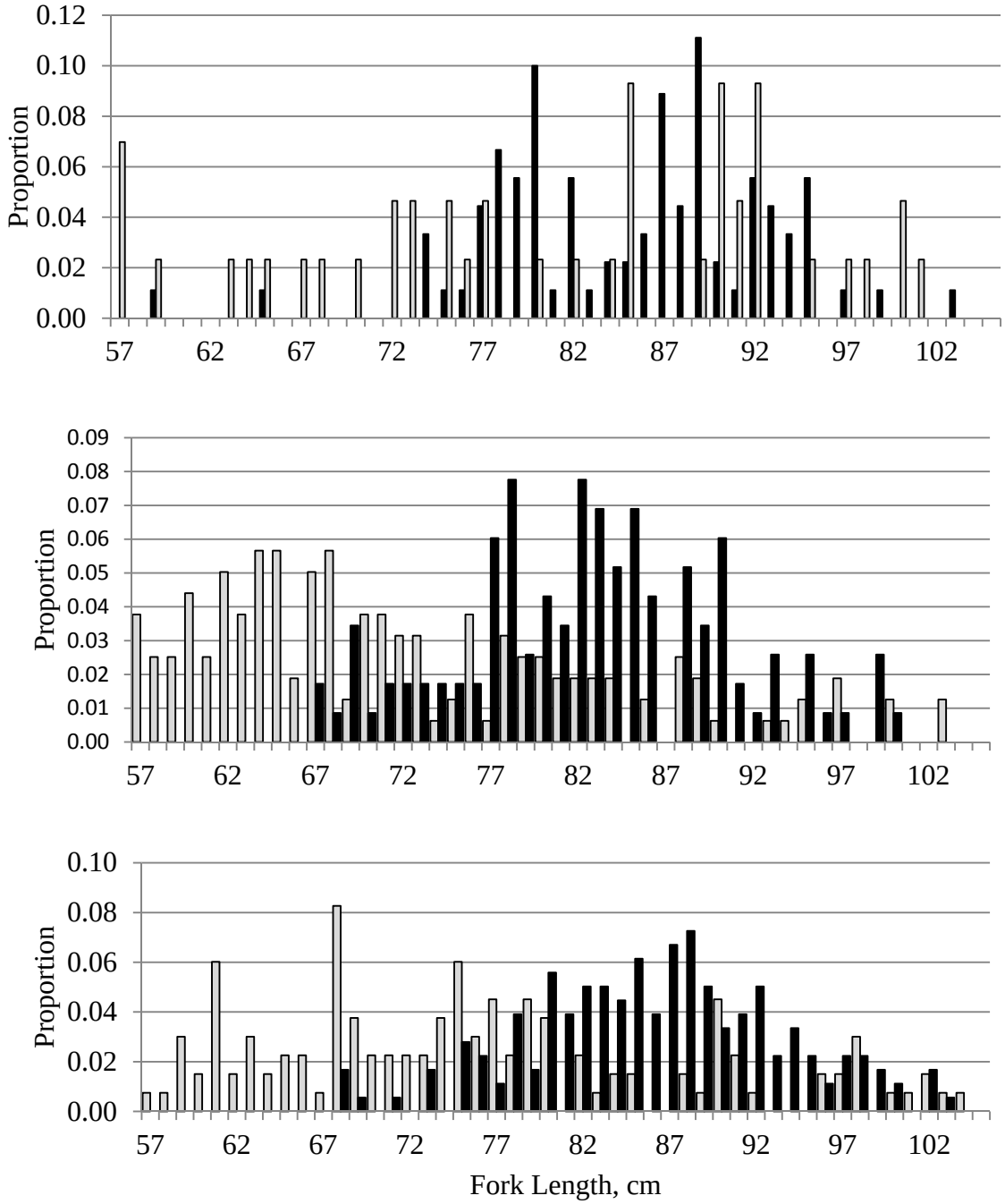


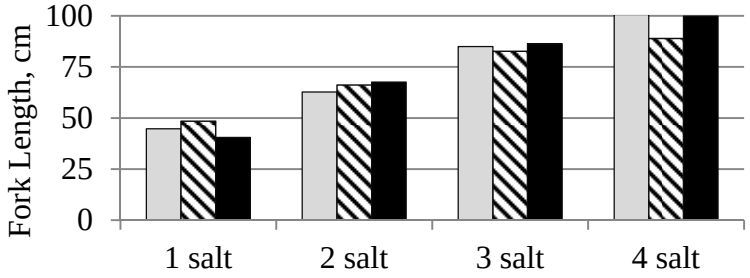
Figure 2. Length frequency histograms of natural-origin Snake River fall Chinook salmon adults (≥57 cm) returning to Little Goose Dam in 1976 (top) and returns to Lower Granite Dam in 2005 (middle) and 2006 (bottom). Males – gray; Females – black; cm - centimeters

Has the adult hatchery-origin fall Chinook salmon length-at-age changed over time?

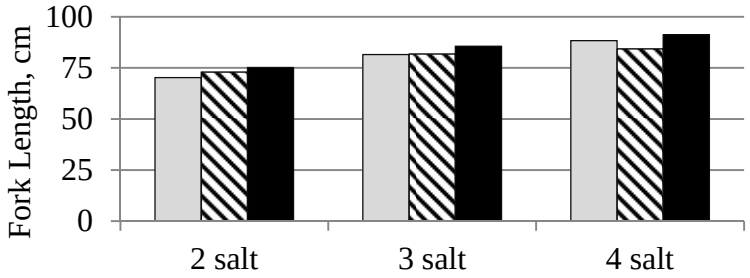
The earliest hatchery-origin fall Chinook salmon length-at-age data was from hatchery-origin broodstock collected from brood years 1984 – 1987. These data were compared to contemporary length-at-age data from groups of hatchery and natural fish captured in 2008 – 2010. Mean fork length comparisons were made for fish grouped by sex and subyearling and yearling freshwater life history types to account for age and size differences related to those factors.

Results demonstrated that although slight variations in size at ocean age were observed, overall sizes were similar for historical and contemporary hatchery fish, and both hatchery groups were similar to that observed for natural Chinook salmon (Figure 3). There were indications that contemporary natural-origin fish were larger and contemporary hatchery fish were smaller compared to historical hatchery fish, but these patterns were not consistent across all comparisons.

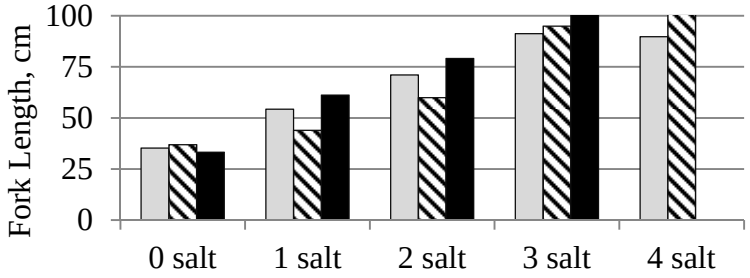
a. Subyearling males



b. Subyearling females



c. Yearling males



d. Yearling females

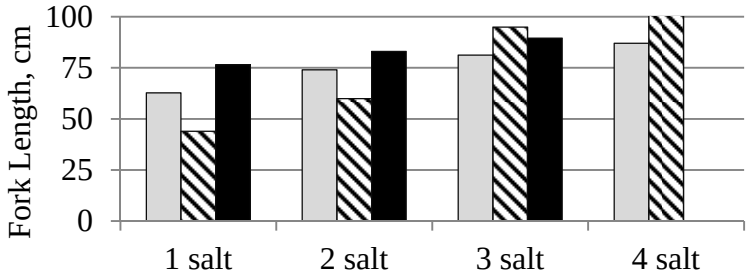
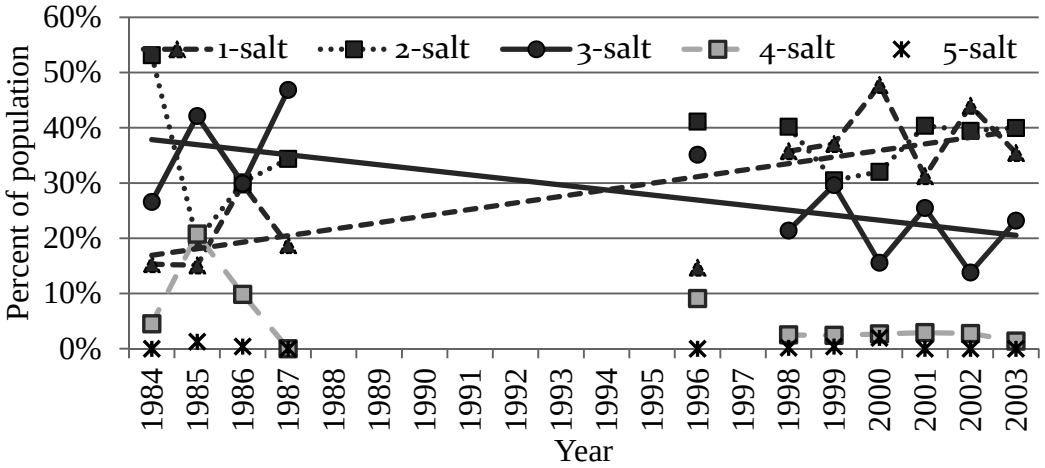


Figure 3. Average fork lengths by ocean age at return for subyearling males (a), subyearling females (b), yearling males (c) and yearling females (d). 1984 – 1987 hatchery – ; 2008 – 2010 hatchery – and; 2006 – 2008 natural – ; Centimeters – cm.

Has hatchery-origin fall Chinook salmon age-at-return changed over time?

Age composition data collected by the hatchery program provided information about trends over time in the hatchery population. Age composition from early broodstock collections in the mid 1980's were compared to those from 1996 – 2003. Brood year returns of both subyearling and yearling hatchery fish demonstrated trends toward younger age a return (Figure 4). Generally there was an increase in the proportion of 1 salt and a decrease in the proportion of 3 salt fish in the population for both subyearling and yearling returns. The proportion of 2 salt fish remained relatively stable, and older age fish (4 and 5 salt) remained a small portion of the return.

a.



b.

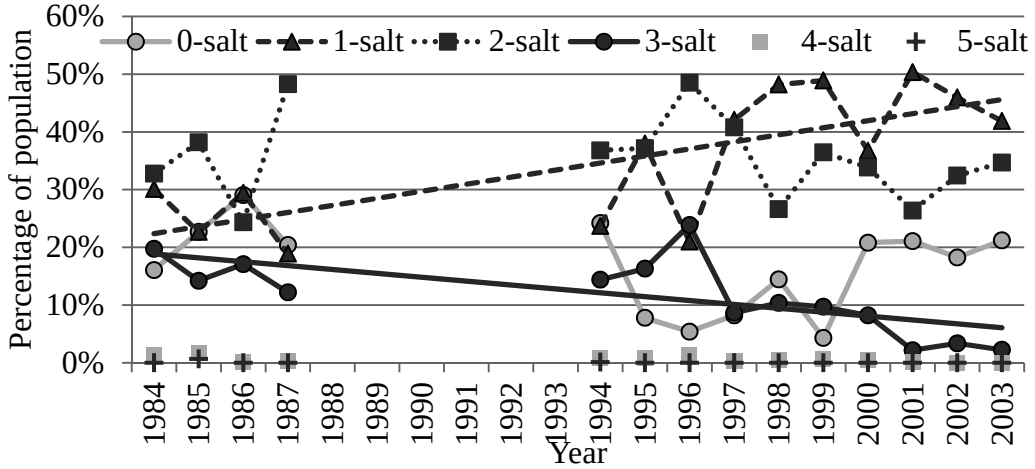


Figure 4. Percent of hatchery-origin Snake River fall Chinook salmon returning to Little Goose Dam by ocean age for subyearlings (a) and yearlings (b) for broodyears 1984 - 1987 and 1996 - 2003. Dashed and solid trend lines represent changes in the proportions of 1-salt and 3-salt fish, respectively.

Average ocean age demonstrated a similar pattern of decreasing ocean age over time for hatchery subyearling and yearling Snake River fall Chinook (Figure 5). These results suggested that the age at return has decreased for hatchery fish since the start of propagation. Unfortunately, data was not available to determine if similar changes occurred in the natural population.

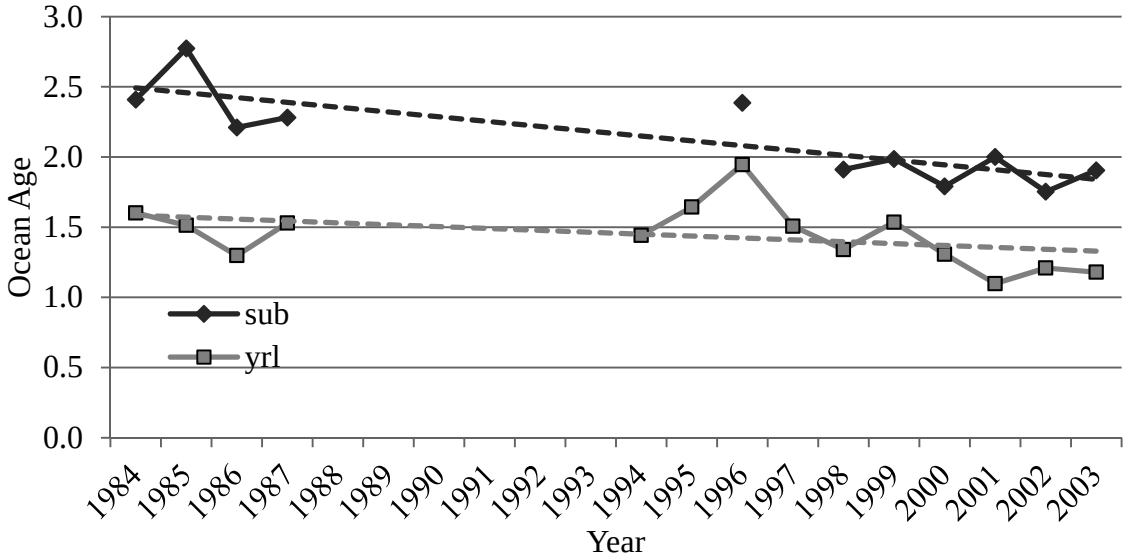


Figure 5. Trends in ocean age from broodyear 1984 – 1987 and 1994 - 2003 for Snake River hatchery fall Chinook salmon. Subyearling – black; yearling – gray.

Conclusions

The limited historic data restricted our ability to investigate long-term changes in size- and age-at-return for Snake River fall Chinook salmon, especially for natural-origin fish. Given the difficulties associated with measuring and deciphering age and size trends for Pacific salmon, especially related to data bias or long-term regime changes in the ocean environment (Quinn, 2005), larger data sets spanning a greater number of years would be required to fully understand the changes that have occurred in the Snake River population. Results suggested that a negative trend in average age-at-return in the hatchery population has occurred since the mid 1980's. However, the observed changes may have resulted from data biases, such as the presence of unique environmental conditions producing an abnormally high proportion of older age classes returning at the start of the time series. Comparing size- and age-at-return data from Snake River fall Chinook salmon with those of the Umatilla River or Hanford Reach populations could provide additional information related to expected size and age composition of Columbia River upriver bright fall Chinook salmon however, this still wouldn't determine if the characteristics of the historic Snake River population were maintained in the extant population.

Citations

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