Otolith analysis reveals the importance of the delta for sustaining Chinook salmon in the Skagit River

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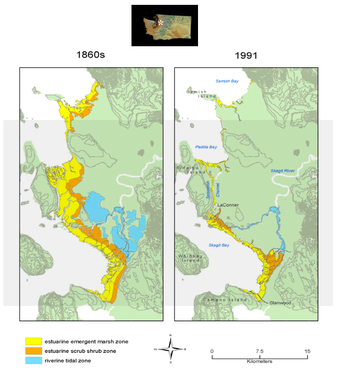
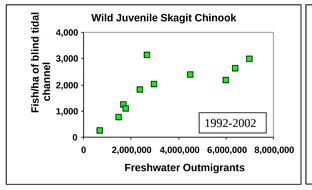
Background Information

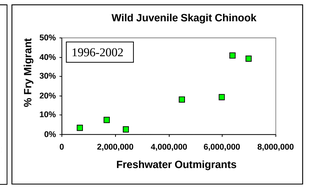
How has Skagit Delta Habitat Changed?

- Skagit tidal delta habitats are much smaller and more fragmented than historically.
- Rearing opportunity for Chinook salmon in the tidal delta has been greatly reduced (88% loss in habitat directly used by salmon).
- Restoration opportunities exist at historic delta sites. Some restoration projects are underway. Increasing habitat connectivity is a goal.



Indication of Density Dependence in the Delta





Freshwater Chinook smolt population estimates from Kinsel, C.G., Volkhardt, L. Kisimoto and P. Topping. 2007. 2006 Skagit River wild salmon production evaluation annual report. Report No. FPA 07-05. Washington Dept. of Fish and Wildlife, Olympia, WA

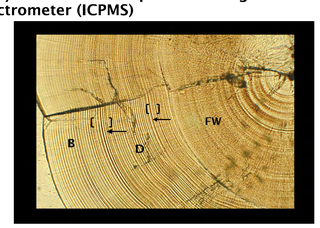
The number of Chinook per unit area within the delta levels-off as the total number of outmigrants increases.

The proportion of the total wild juvenile Chinook population in Skagit Bay bypassing delta habitat and migrating directly to Skagit Bay (defined as fry migrants) increases with outmigration levels above 2,500,000.

A further note not depicted here: The size of Chinook in delta habitat decreases as a function of outmigration up to populations of ~3,000,000.

Otoliths as a tool for identifying life histories

- Presence or absence of "checks" (disruption in a consistent microstructure pattern)
  - Identify checks associated with Chinook life history/habitat migration
- Changes in incremental patterns and width
  - Estimate residence (# of increments) and growth (mean incremental width) within habitat type
  - Estimate fork length at entrance to or exit from habitat type
- Changes in Sr/Ca ratio across otolith radius
  - Analyze chemical components using an Inductively Coupled Mass Spectrometer (ICPMS)



FW=freshwater growth
D=delta growth
B=Skagit Bay growth
Brackets=transition zone between habitats
Arrows="checks"

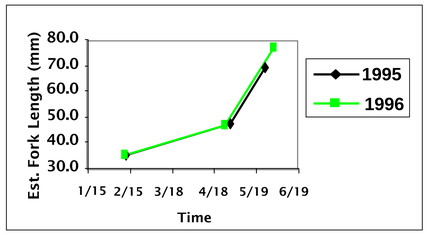
Previous Research

Identification of three life histories for Skagit River fall Chinook from otoliths

- Delta users - fry emerge and quickly migrate into the delta where they rear to ~70 mm fork length, then migrate to Skagit Bay. Subcategories of delta users also were identified
- Fry migrants (non-delta user) - fry emerge and quickly migrate into Skagit Bay, mimic pinks and some chum
- Parr migrants (non-delta user)- fry emerge and rear several months in freshwater to get up to size (~70 mm fork length), then migrate to Skagit Bay

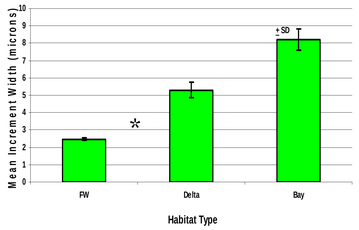
Importance of Delta Residence

- Delta users were the dominant life history type in both 1995 and 1996
- Length increased 22-30 mm and weight increased 4-5 times during delta residence
- Longer residence translates into greater growth (i.e. almost 10mm greater growth in 1996)



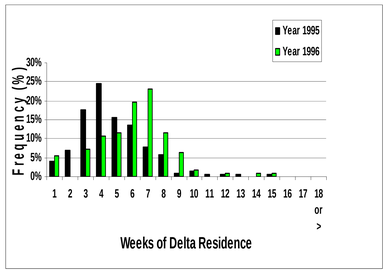
Relative growth varies among habitats

- Mean increment width doubles during lower delta residence and increases another 50% during near-shore residence
- Upper delta zones defined as slow growth region of delta, intermediate between FW and lower Delta (*)



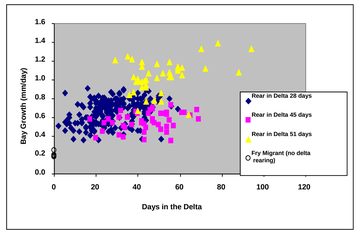
Duration of Delta Residence

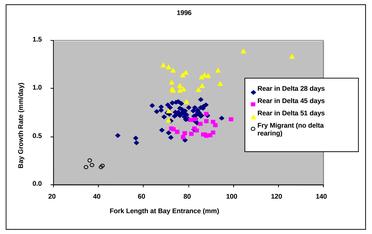
- At least 70% of all delta users utilize delta for a month or longer
- In higher density year (1995), residence time is shortened
- Residence time varies from year to year

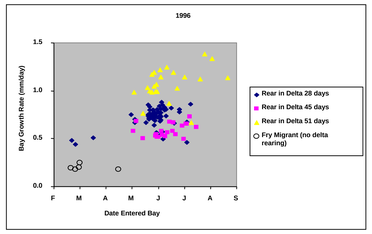


Importance of Delta Habitat for subsequent growth in Skagit Bay

- The longer wild sub-yearling Chinook spend in the delta, the better they grow in Skagit Bay.
- Fish size at bay entrance positively influenced growth rate in Skagit Bay.
- The later in the season fish entered the bay, the better they grew in Skagit Bay.





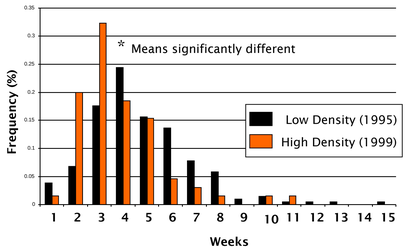


Future Research

This work is part of ongoing research funded by USGS-BRD base funds incorporating these methods for answering ecological questions related to salmon recovery. Our next priority is to analyze the otolith microstructure of juvenile Chinook from intermediate density outmigrant years and their returning adults to complete the picture. Otolith documentation of pocket estuary use by fry or parr migrants bypassing or displaced from the delta is another area of interest. Continued use of otolith microchemistry may be a necessary tool to help us answer some of these questions.

Current Research*

Duration of Delta Residence-Low v. High Density

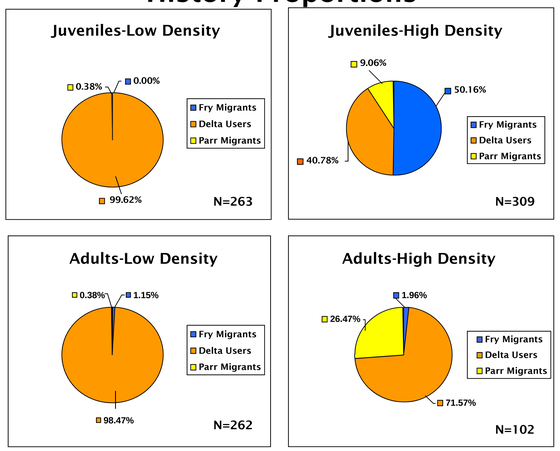


- Residence time was reduced by nearly a week under higher densities
- Low density residency mean=4.35 weeks
- High density residency mean=3.45 weeks

High Density Age-0 Outmigrant Summary

- Increase in number of fry migrants
- Increase in number of parr migrants
- Change in length of freshwater residence, outmigration timing and size of parr migrants
- Shortened delta residence
- Change in habitat usage within the delta; increased dependence on upper delta habitats

Comparison of Low/High Density Life History Proportions



- In the low density outmigrant year (1995) the majority of the juveniles used the delta for rearing before moving into Skagit Bay
- Chinook from the low density year returned as adults in about the same proportions as they outmigrated
- In the high density outmigrant year (1999), the majority (59%) of the juveniles bypassed the delta and moved directly into Skagit Bay, either as fry or after some freshwater rearing as parr
- Chinook from the high density year had differential survival. Very few fry migrants survived to adulthood while parr migrants and delta users returned in higher proportions
- Adult life history proportions were similar among 3-, 4-, and 5-year olds from the same broodyear

*Preliminary analysis