Implications of the interannual variability in the feeding ecology of juvenile Chinook salmon

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• “Feeding is such a universal and commonplace business that we are inclined to forget its importance. The primary force of all animals is the necessity of finding the right kind of food and enough of it.” Elton, 1927
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Chinook salmon

• Largest of the Pacific salmon
• Either spend one full year in freshwater or a few months
• Tend to mature after 2-5 years in the ocean
• Stocks of interest from the West Coast of Vancouver Island (WCVI) and Southeast Alaska (SEAK)
Status of Chinook stocks in B.C.

Northern BC

Central BC

WCVI

SOG/FR/JST

DFO, 2011
Status of SEAK Chinook

Unuk River

Taku River

Survival rate

Year

DFO and PSC, 2012
Critical period for salmon survival

• Large and variable mortality rates during early marine life may define survival rates for salmon.
  – Mortality in early marine life tends to be size-selective.

Tomaro et al., 2012
Factors affecting early marine growth

• Temperature, prey quality, prey quantity

Beauchamp, 2009,
Objective:

• To determine whether feeding ecology of juvenile Chinook affects growth or survival in two contrasting stocks.
\( \delta^{15}\text{N} \)

- \( \delta^{15}\text{N} \) can indicate trophic level.
- Larger prey tend to have greater \( \delta^{15}\text{N} \).

\[ \delta^{15}\text{N} = 9\% \quad \delta^{15}\text{N} = 12\% \]
Trophic level

- Can use $\delta^{15}\text{N}$ to calculate trophic level.
- Assume zooplankton are at trophic level 2.
- $\delta^{15}\text{N}$ increases by $\sim 3.4\%$ / trophic level.
- So a juvenile salmon feeding only on zooplankton would be 3.4 \% above zooplankton and a trophic level of 3.
• Fish prey are generally more energy dense than zooplankton (Davis et al., 1998).
• Larger prey tend to be a more efficient prey choice than smaller prey (Kerr et al., 1971; Pazzia et al., 2002).
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• Hypothesis # 1: A higher δ^{15}N and trophic level will correlate with greater growth and survival of Chinook salmon stocks.
\( \delta^{13}C \)

- Onshore / offshore gradient in \( \delta^{13}C \) within years
- But also may be interannual variability in \( \delta^{13}C \) due to shifts in productivity.
• Hypothesis # 2. A higher $\delta^{13}C$ value will be linked to higher growth and survival.
C:N ratio

• Ratio of carbon to nitrogen isotopes can be an indicator of lipid content in aquatic systems.
• Higher C:N indicates higher lipid content.
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• Hypothesis # 3: Higher C:N ratios will correlate positively with growth and survival.
Methods: study area and sampling

Tucker et al, 2011
WCVI Chinook

- Ocean-type
- Hatchery and wild fish
- Average migration date: June 21st (Trudel et al., 2007)
- Survival rate of Robertson Creek (from DFO / PSC) a proxy for survival of all stocks

SEAK Chinook

- Stream-type
- Hatchery and wild fish
- Average migration date: May 24th (Trudel et al., 2007)
- Survival rate of Unuk River (from DFO / PSC) a proxy for survival of all stocks
Methods: other

• Genetic data from DFO to provide stock specificity.
• Growth data – change in fork length over time, with estimated ocean entry size and date (Trudel et al., 2007).
Results
Nitrogen and size

$\delta^{15}\text{N}$ value vs. Fork length (mm)

- Red dots: SEAK
- Black dots: WCVI
• Hypothesis # 1: A higher $\delta^{15}\text{N}$ and trophic level will correlate with greater growth and survival of Chinook salmon stocks.
  – Hypothesis #1 is supported for WCVI, but not for SEAK.
• Hypothesis #2. A higher $\delta^{13}C$ value will be linked to higher growth and survival.
  – Hypothesis #2 is supported for WCVI, but not for SEAK.
• Hypothesis # 3: Higher C:N ratios will correlate positively with growth and survival.
• No evidence for WCVI or SEAK.
WCVI

\[ \delta^{13}C \text{ value} \]

\[ \delta^{15}N \text{ value} \]

-\[21, -20, -19, -18, -17, -16, -15, -14\]

\[ p < 0.001 \]
\[ r^2 = 0.44 \]
2010 predictions (2013 returns)

![Graph showing survival rate against PC1 Score with an $r^2$ value of 0.49.](image)
## Stoplight Indicators for WCVI

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Environmental variables are scored from 1 (best for salmon) to 14 (worst for salmon)
Conclusions

• Feeding ecology of WCVI Chinook linked to growth and survival
  – Higher δ$^{15}$N and trophic level correlated with greater growth and survival
  – Higher δ$^{13}$C correlated with higher survival

• Feeding ecology of SEAK fish not linked to survival or growth
  – Critical period of feeding may be earlier
  – Top-down processes (LaCroix et al., 2009)?
Questions?

- Thanks to:
  - Funding agencies: NSERC Strategic Grant, Bonneville Power Administration, Genome BC
  - DFO for support with samples and data