Interannual and spatial variability in the feeding ecology of juvenile Chinook salmon and effects on survival and growth

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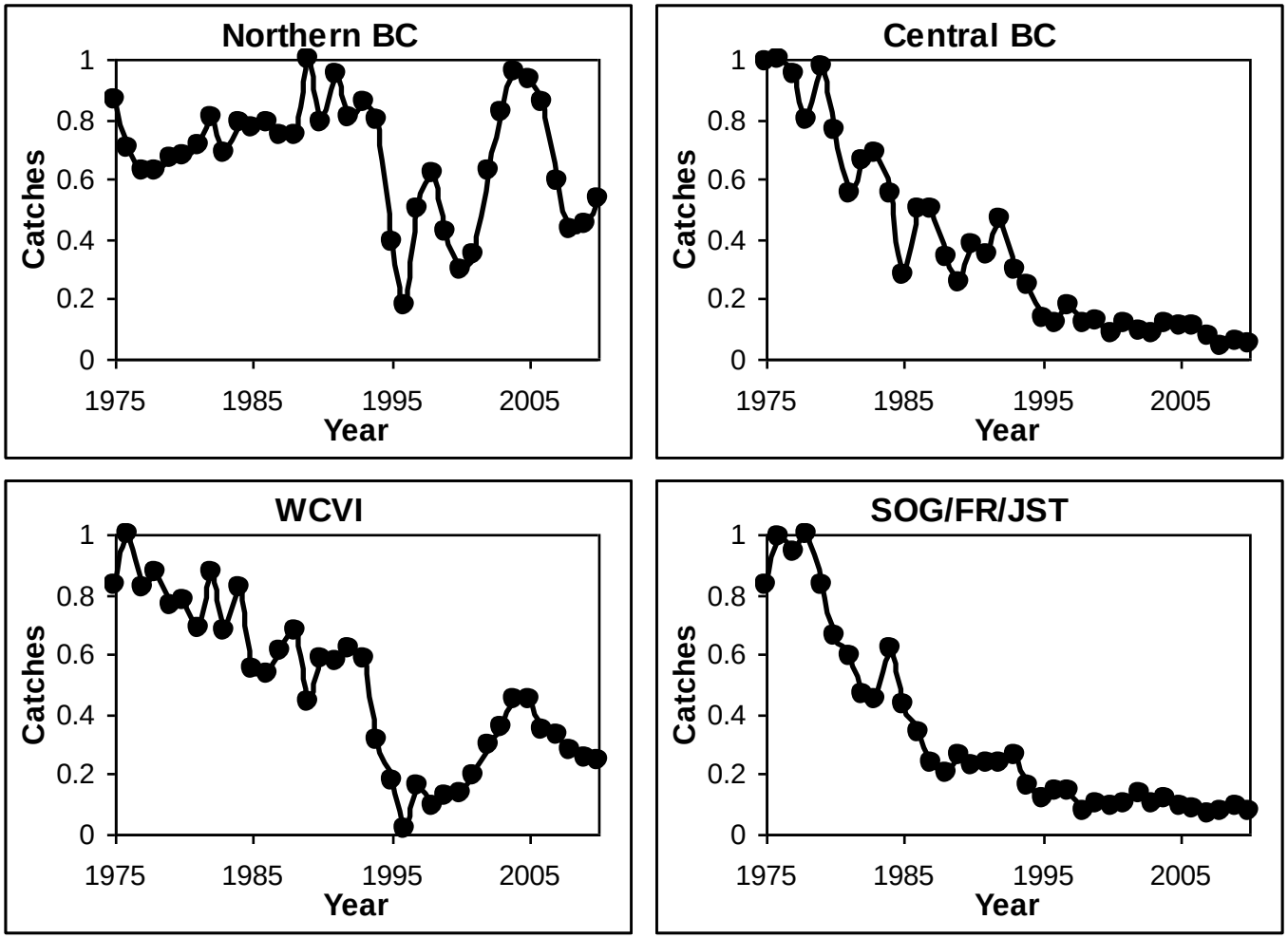
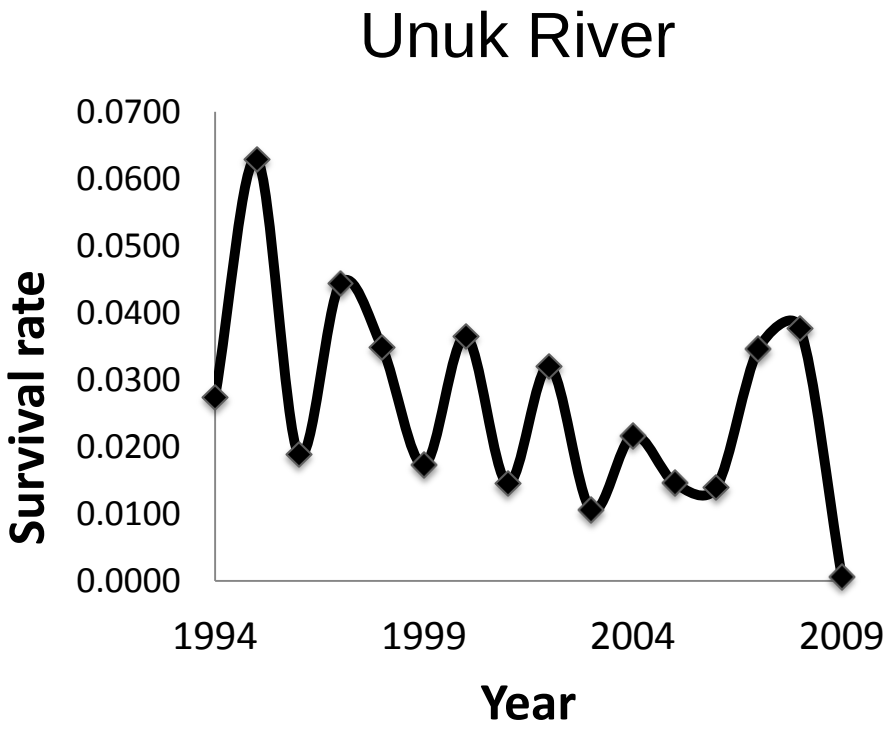
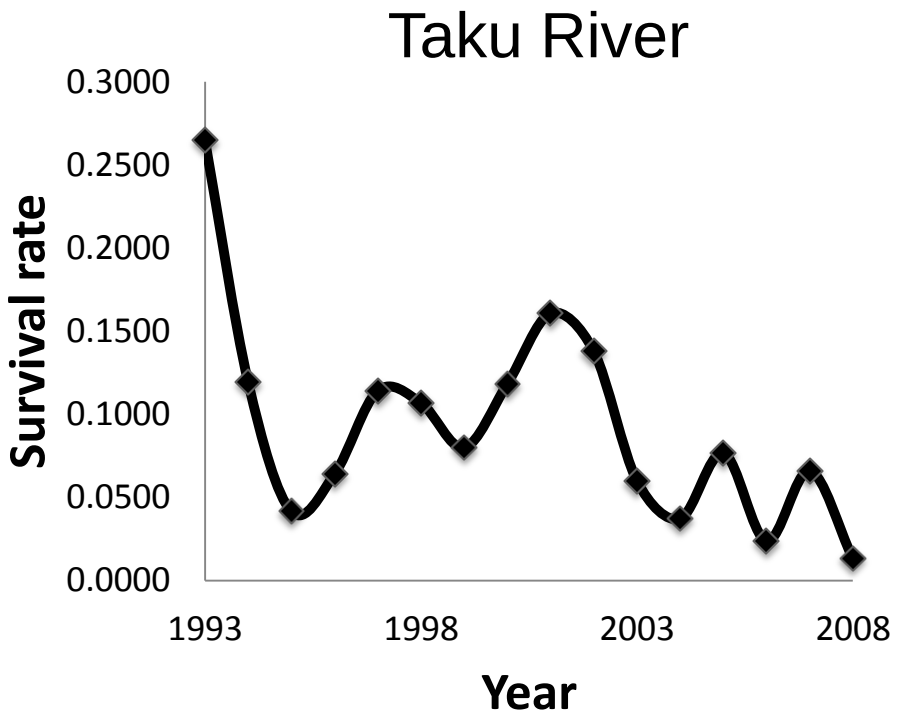
Status of Chinook stocks in B.C.



DFO, 2011

Status of SEAK Chinook





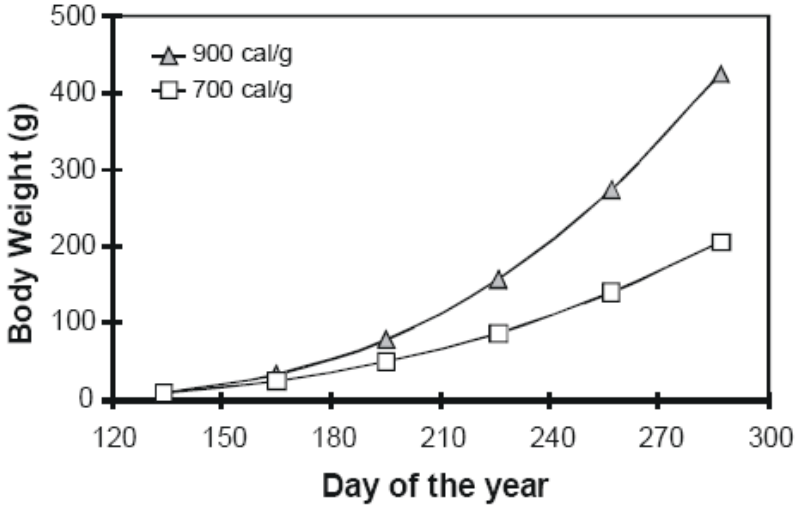
DFO and PSC, 2012

Critical period for salmon survival

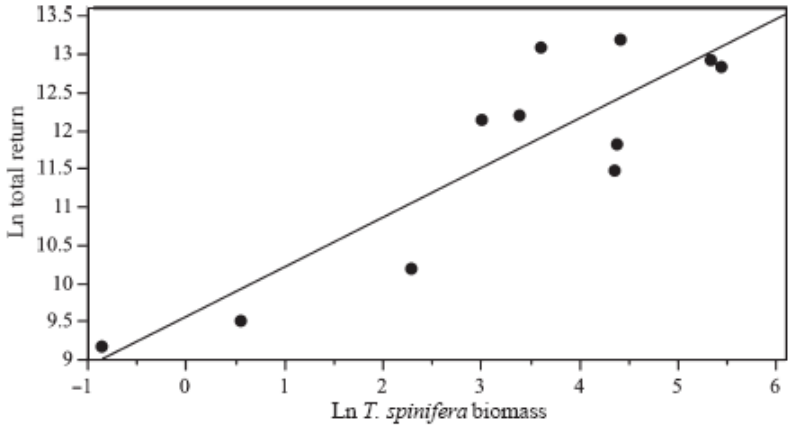
- Large and variable mortality rates during early marine life may define survival rates for salmon.
  - Mortality in early marine life tends to be size-selective.

Prey quality and quantity

- High quality vs. low quality prey affects growth (Trudel et al., 2002).



- Prey quantity can also affect salmon survival (Tanasichuk and Routledge, 2011).



Objective:

- To link the feeding ecology of juvenile salmon to growth and survival rates in order to provide a mechanistic link between oceanographic variables and adult returns.

Approach: stable isotope analysis

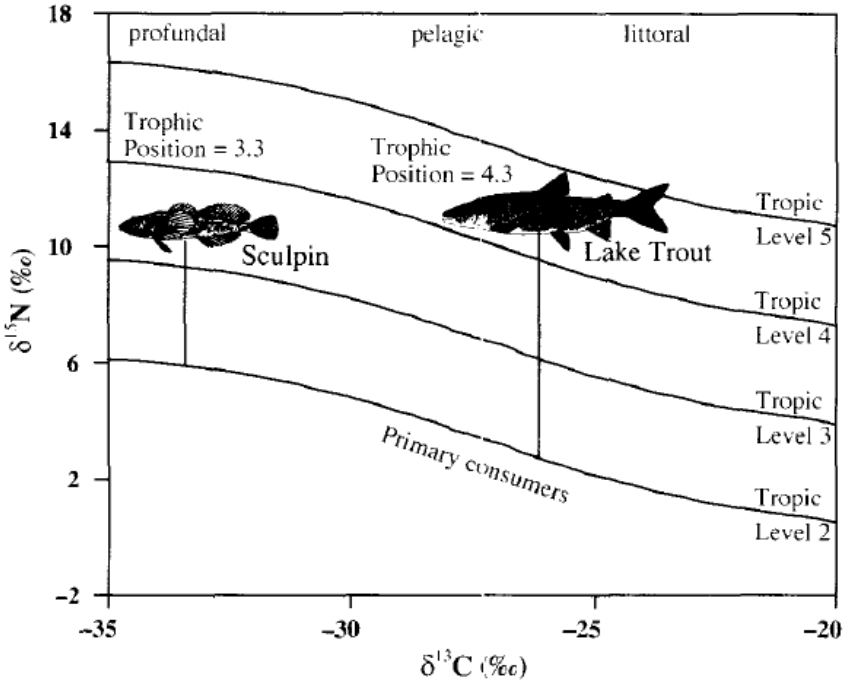
- Use stable isotope analysis to indicate feeding ecology and oceanographic processes.

$\delta^{15}N$

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

Trophic level

- Can use $\delta^{15}N$ to calculate trophic level.
- Assume zooplankton are at trophic level 2.
- $\delta^{15}N$ increases by ~ 3.4‰ / trophic level.
- So a juvenile salmon feeding only on zooplankton would be 3.4 ‰ above zooplankton and a trophic level of 3.



Vander Zanden and Rasmussem, 1999

- 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).

- **Hypothesis # 1: A higher $\delta^{15}N$ and trophic level will correlate with greater growth and survival of Chinook salmon stocks.**

$\delta^{13}C$

- There is generally an onshore / offshore gradient in $\delta^{13}C$ within years (Miller et al., 2008; Kline et al., 2008).
- But also may be interannual variability in $\delta^{13}C$ due to shifts in productivity.
- And: in CCS, shifts in currents can bring low quality offshore subtropical zooplankton onto shelf ecosystems (e.g Keister et al., 2011).

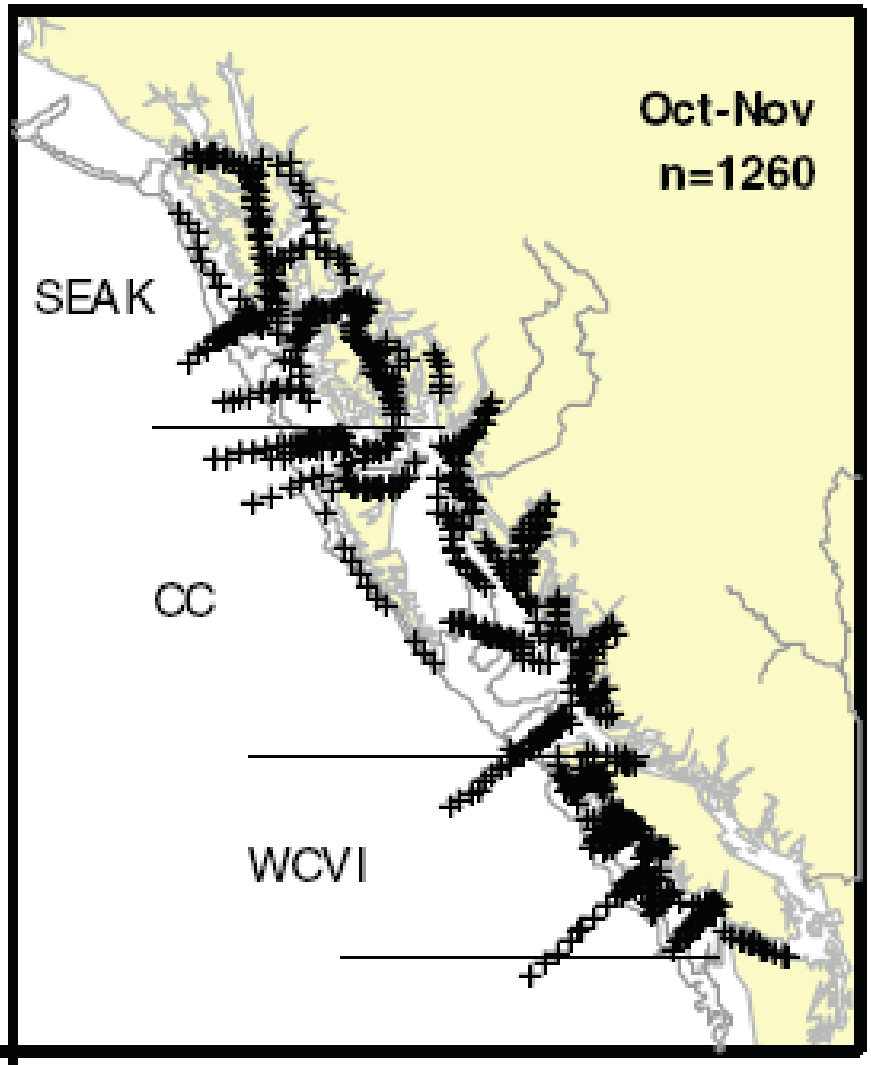
- **Hypothesis # 2. A higher $\delta^{13}C$ value will be linked to higher growth and survival.**

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.

- **Hypothesis # 3: Higher C:N ratios will correlate positively with growth and survival.**

Methods: study area and sampling



Tucker et al, 2011

WCVI Chinook

- Stocks on WCVI
- 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

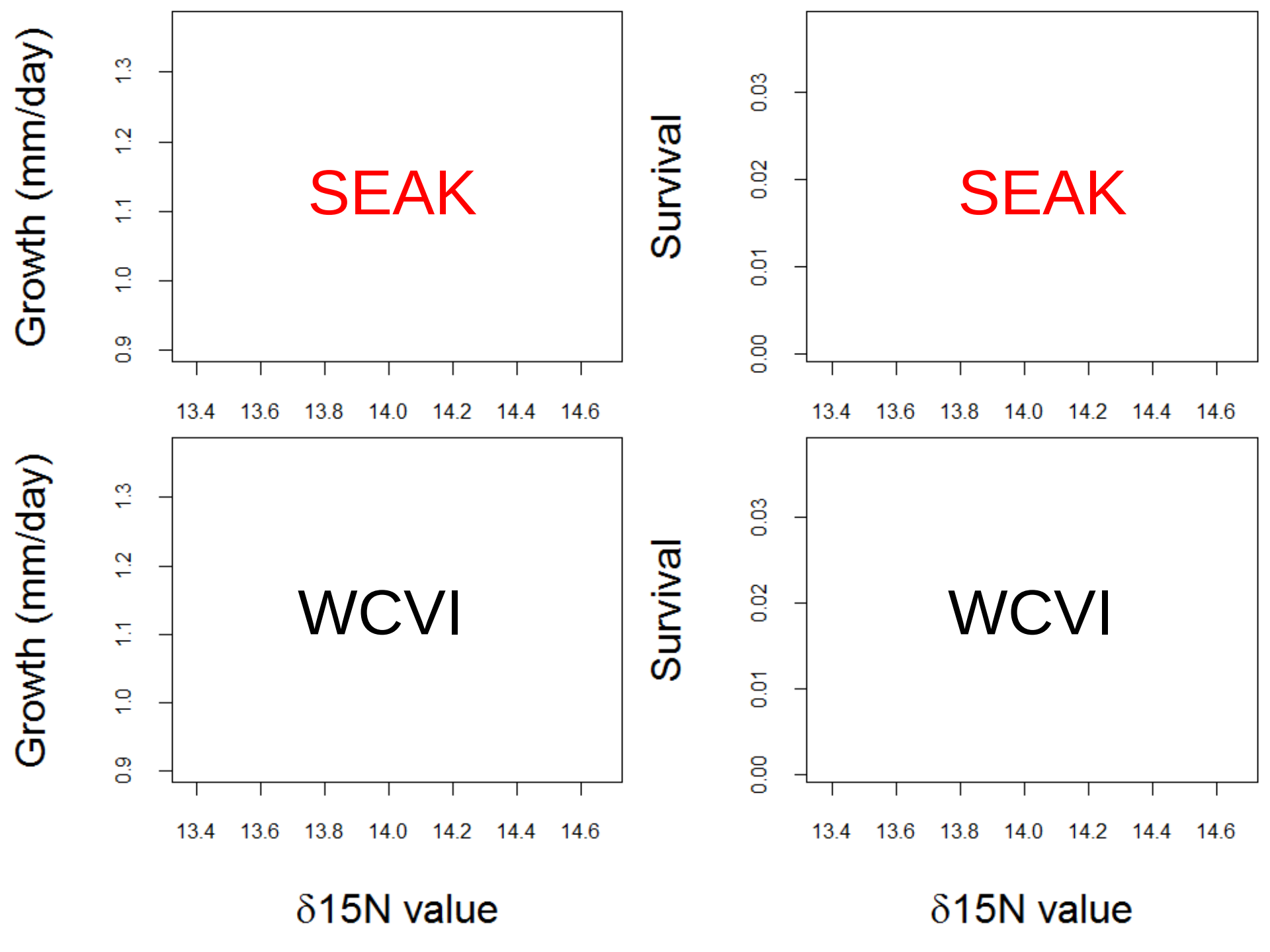
SEAK Chinook

- Stocks in SEAK
- 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

- Time series of stable isotope values of almost 900 juvenile Chinook salmon: 2000-2009.
- 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


Growth (mm/day)
0.9
1.0
1.1
1.2
1.3
SEAK
13.4
13.6
13.8
14.0
14.2
14.4
14.6
Survival
0.00
0.01
0.02
0.03
SEAK
13.4
13.6
13.8
14.0
14.2
14.4
14.6
Growth (mm/day)
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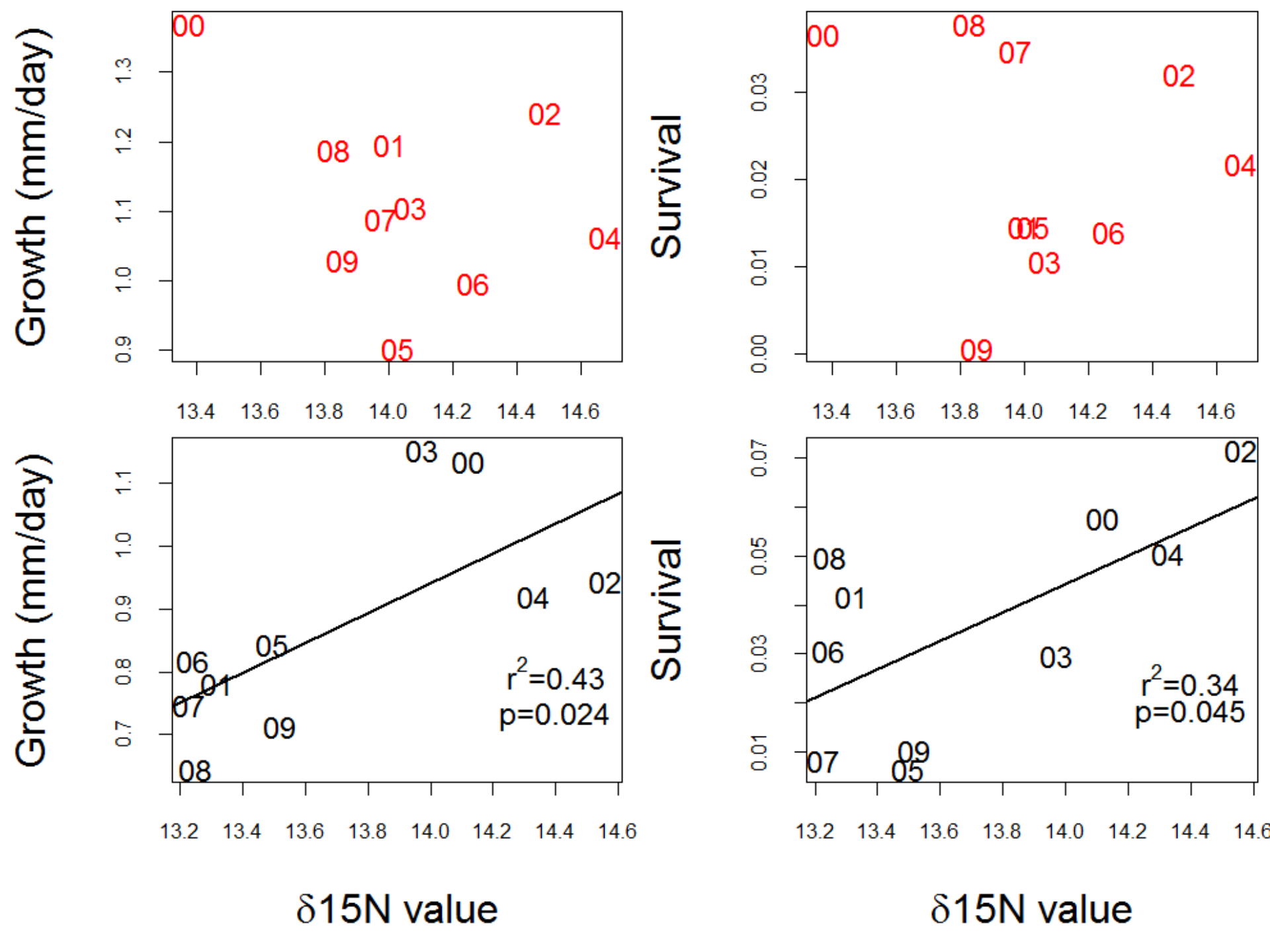
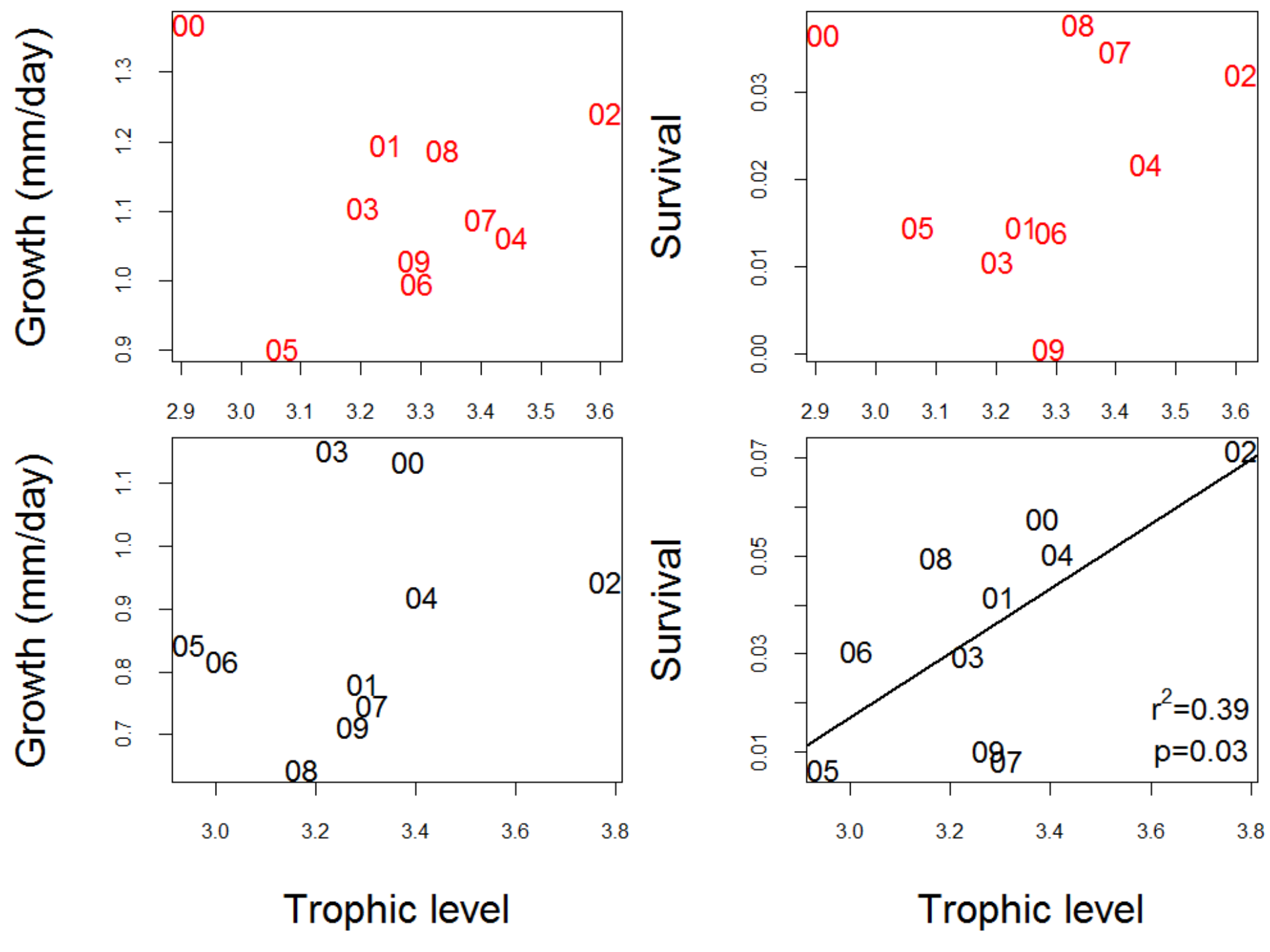
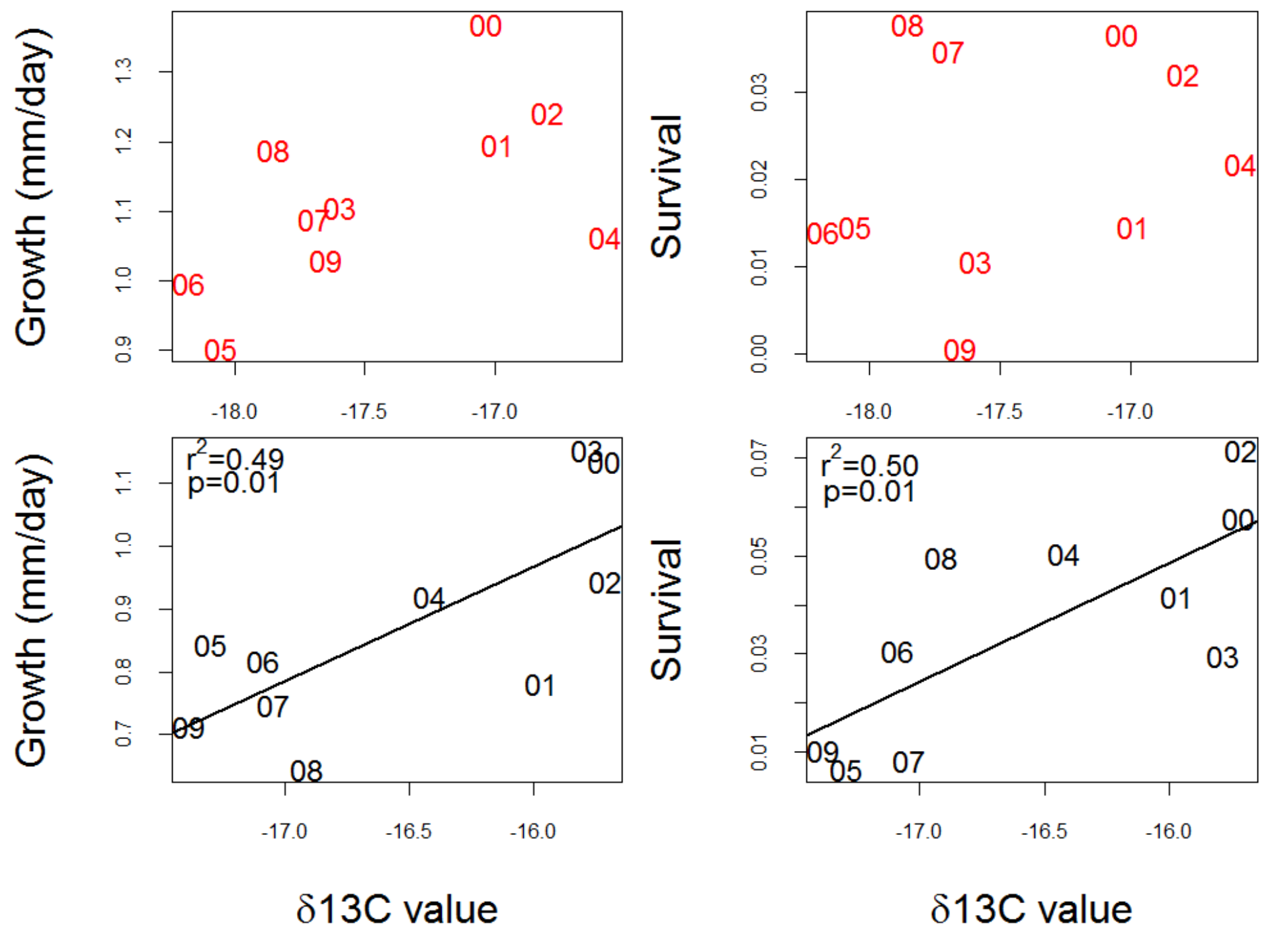
δ15N value
Survival
0.00
0.01
0.02
0.03
WCVI
13.4
13.6
13.8
14.0
14.2
14.4
14.6
δ15N value

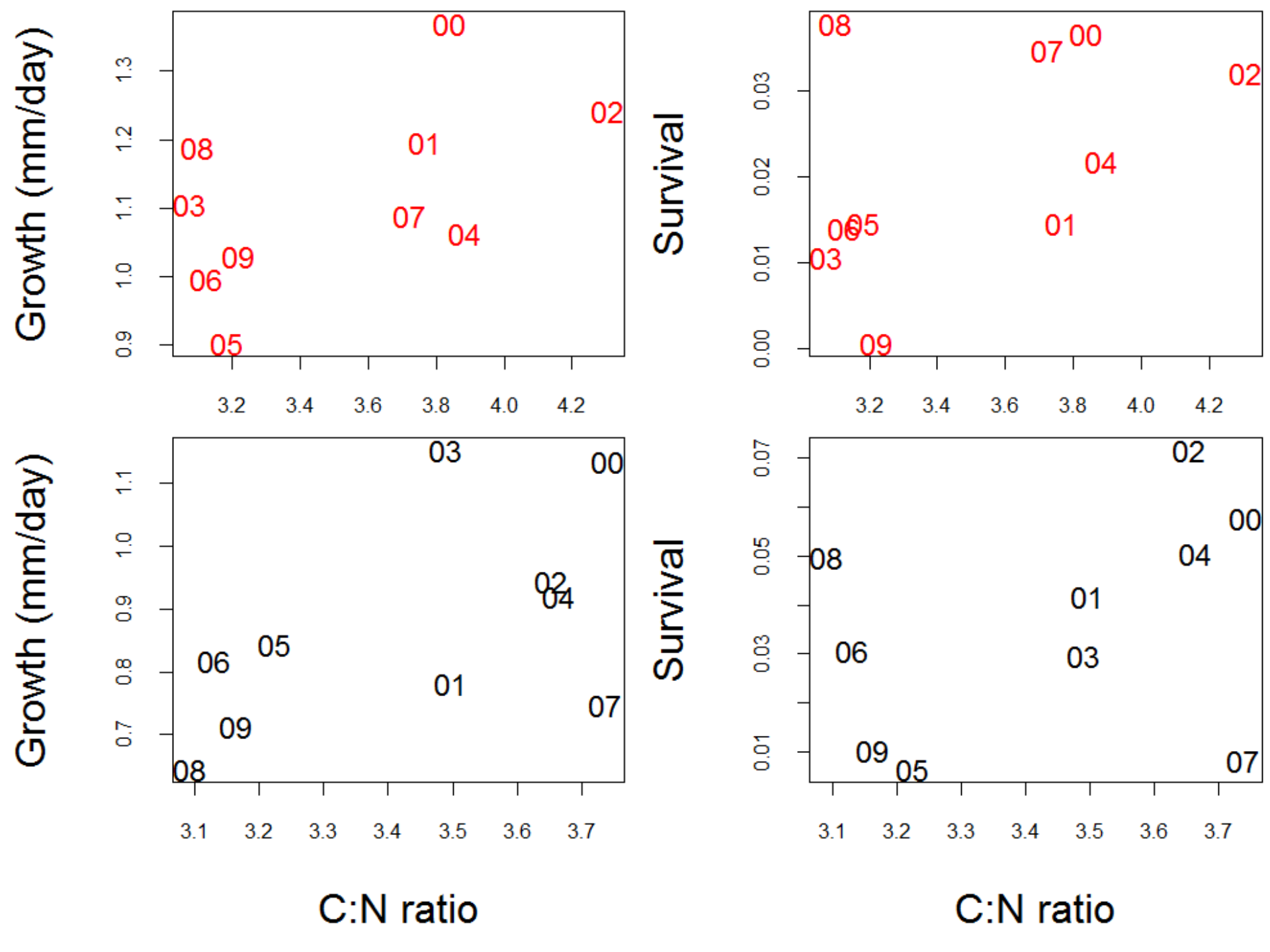

Growth (mm/day)
Survival
δ15N value
δ15N value
r2=0.43
p=0.024
r2=0.34
p=0.045


Growth (mm/day)
Survival
Growth (mm/day)
Survival
Trophic level
Trophic level
r2=0.39
p=0.03

- **Hypothesis # 1: A higher $\delta^{15}N$ and trophic level will correlate with greater growth and survival of Chinook salmon stocks.**
  - **Hypothesis #1 is supported for WCVI, but not for SEAK.**


Growth (mm/day)
Survival
Growth (mm/day)
Survival
r²=0.49
p=0.01
r²=0.50
p=0.01
δ13C value
δ13C value

- **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.**


Growth (mm/day)
Survival
C:N ratio
C:N ratio
00
01
02
03
04
05
06
07
08
09

- **Hypothesis # 3: Higher C:N ratios will correlate positively with growth and survival.**
- **No evidence for WCVI or SEAK.**

Conclusions

- Feeding ecology of SEAK fish not linked to survival or growth
  - Critical period of feeding may be earlier
  - Survival of these stocks may not be driven by bottom-up processes (LaCroix et al., 2009)
- Feeding ecology of WCVI Chinook linked to growth and survival
  - Higher $\delta^{15}N$ and trophic level correlated with greater growth and survival
    - Suggesting importance of ontogenetic niche shift to feeding on larger, higher quality prey
  - Higher $\delta^{13}C$ correlated with higher survival

Questions?

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