Cryptic connections between zooplankton and juvenile salmon

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This is a story about an annually alternating, zig-zag, “see-saw”, pattern in coho salmon survival

... our efforts to understand it,

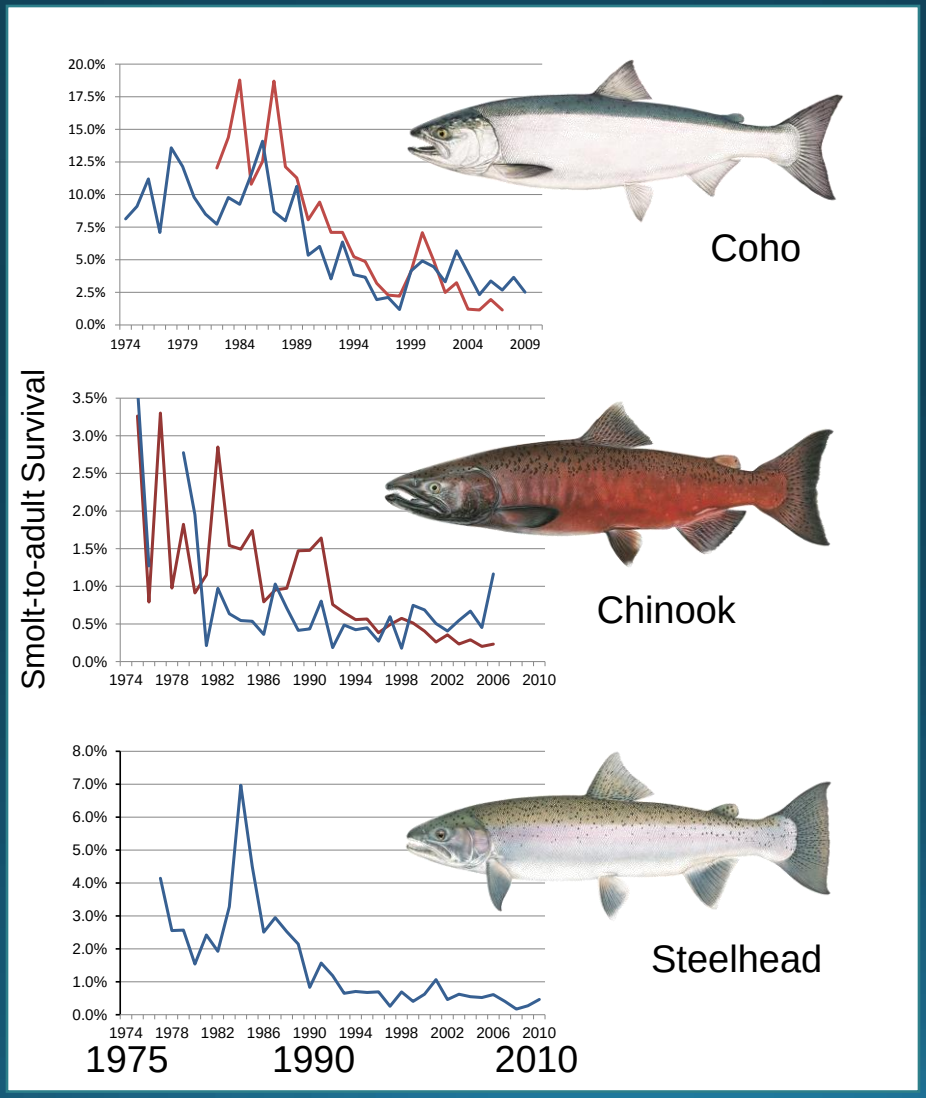
and its implications for ecosystem dynamics.


The Salish Sea
& Surrounding Basin
The Salish Sea extends from the north end of the Strait of Georgia to the south end of the Puget Sound and west to the mouth of the Strait of Juan de Fuca
Mt. Waddington
Monmouth Mountain
Strait of Georgia
Strait of Juan de Fuca
Puget Sound
Pacific Ocean
Olympic Peninsula
Vancouver Island
Fraser River
Mt. Baker
Glacier Peak
Mt. Rainier
N
0 50 100 km.
0 50 mi.
Data Sources:
SRTM (CGIAR-CSI), NOAA, Wa. DFW, Wa. DNR, BC Digital Atlas, ESRI
stefan freelan 2009

Declines in Salish Sea Marine Survival

Puget Sound

Strait of Georgia



http://marinesurvivalproject.com/

Are there zooplankton indicators of salmon survival?

Can they reveal a mechanism underlying the changes in salmon survival rates?

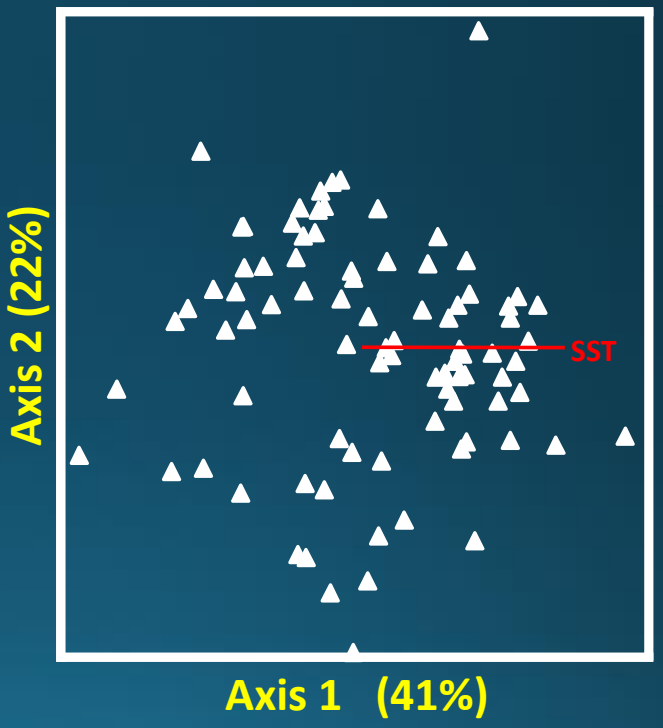
Monthly zooplankton time series:
2003-2016

- Zooplankton net tows
  - 75-cm diameter ring net
  - 150-µm mesh
  - Surface (0-40 m) vertical net tows
- CTD casts (T, S, D, DO)
- Bottle chlorophyll, nutrients, oxygen

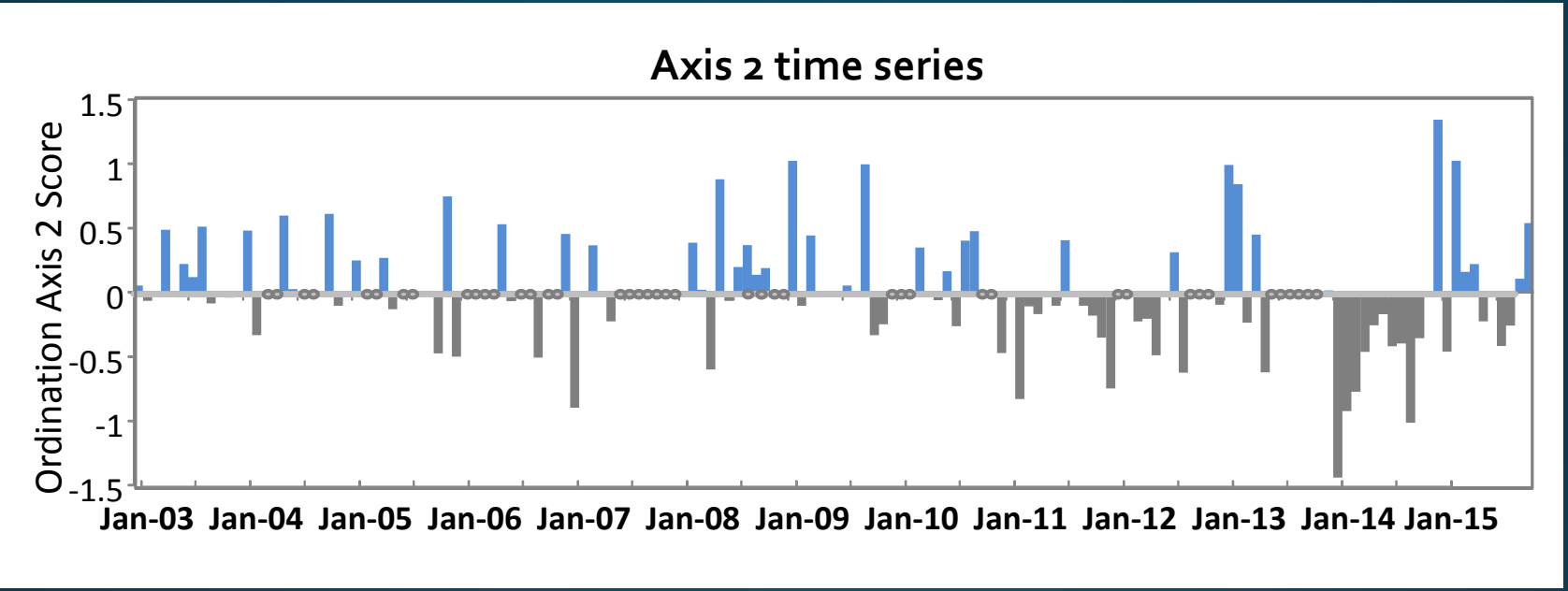
DEPARTMENT OF ECOLOGY
State of Washington

Data Analysis: Non-Metric Multidimensional Scaling (NMS) Ordination of copepod species composition

- **Relativized to species proportion in each sample**
- **3 axes explain 86% of total variance**
- **Axis 2 = best indicator of salmon survival**

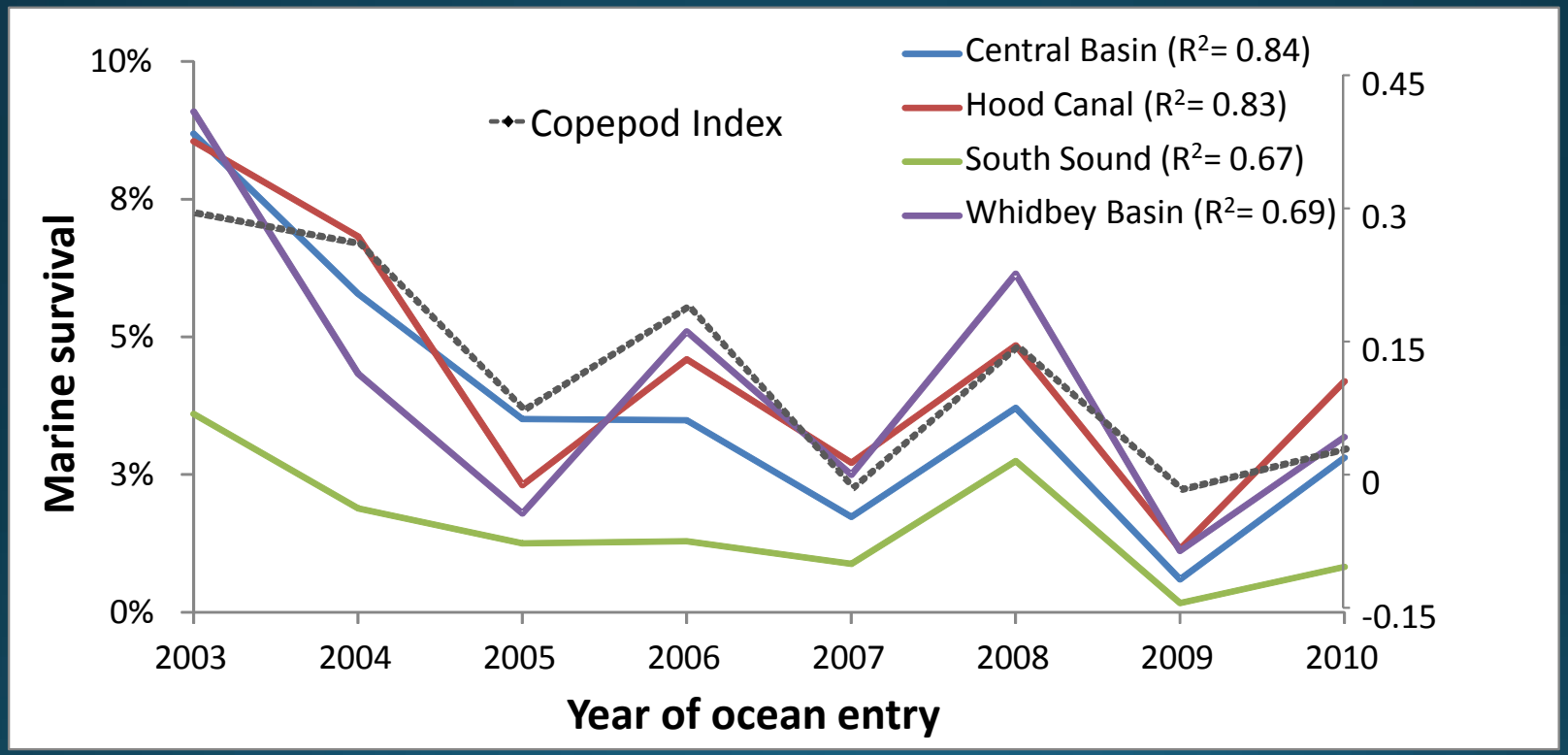


Copepod Community NMS Axis 2 scores:

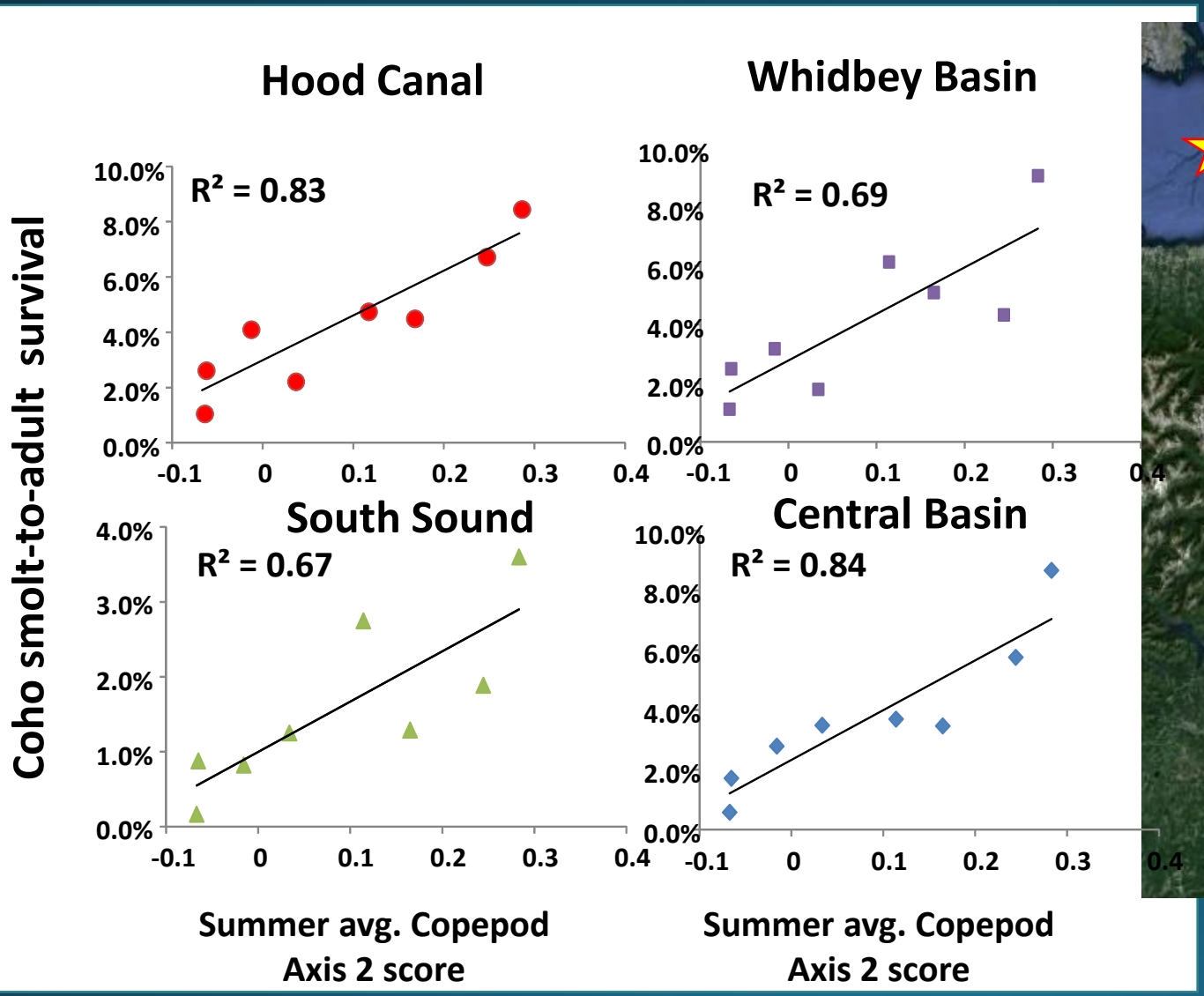


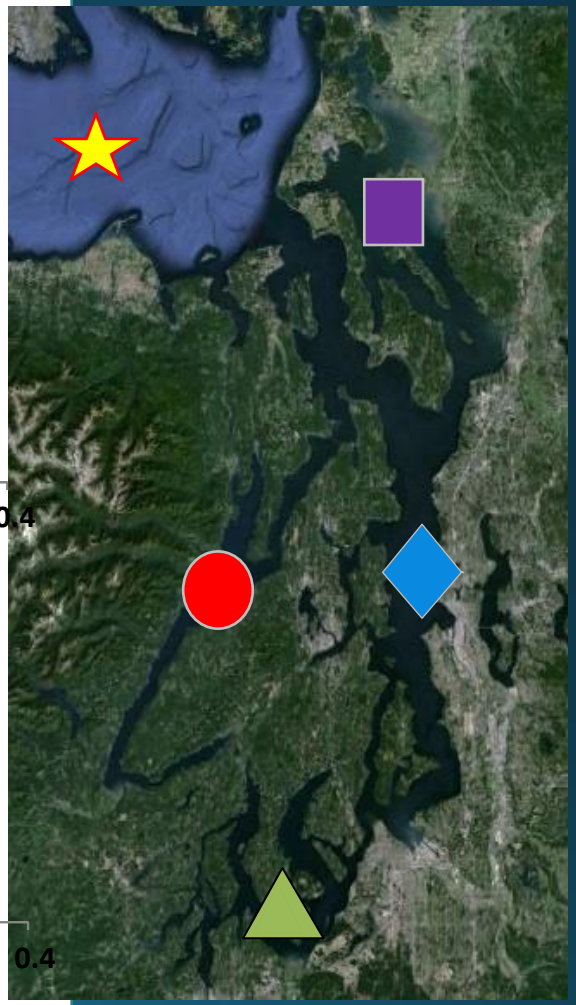
Create annual index to compare to salmon survival using summer (May-Sept) averages.

Coho salmon smolt-to-adult survival by marine entry year correlates with the Copepod Index:



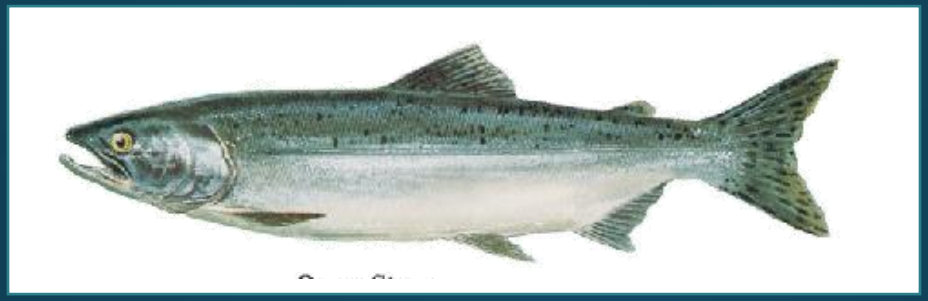
Coho – copepod index correlations:





What controls this alternate year cycling?

Adult pink salmon return only in odd years



>1 million adults return every-other year
(in odd years)

Even Years

20-40 million pink salmon smolts leave rivers (winter/spring)

Odd Years

No pink smolts

Puget Sound cycles (2003-2010):

Even Years

Pink salmon smolts leave rivers

Higher Coho salmon smolt survival

Increased Age-0 herring

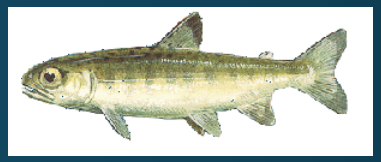
Higher Copepod Composition Index

(No adult pink returns)

Odd Years

(No pink smolts)

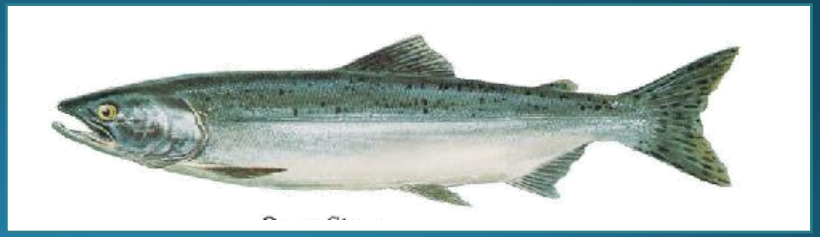
Lower Coho smolt survival



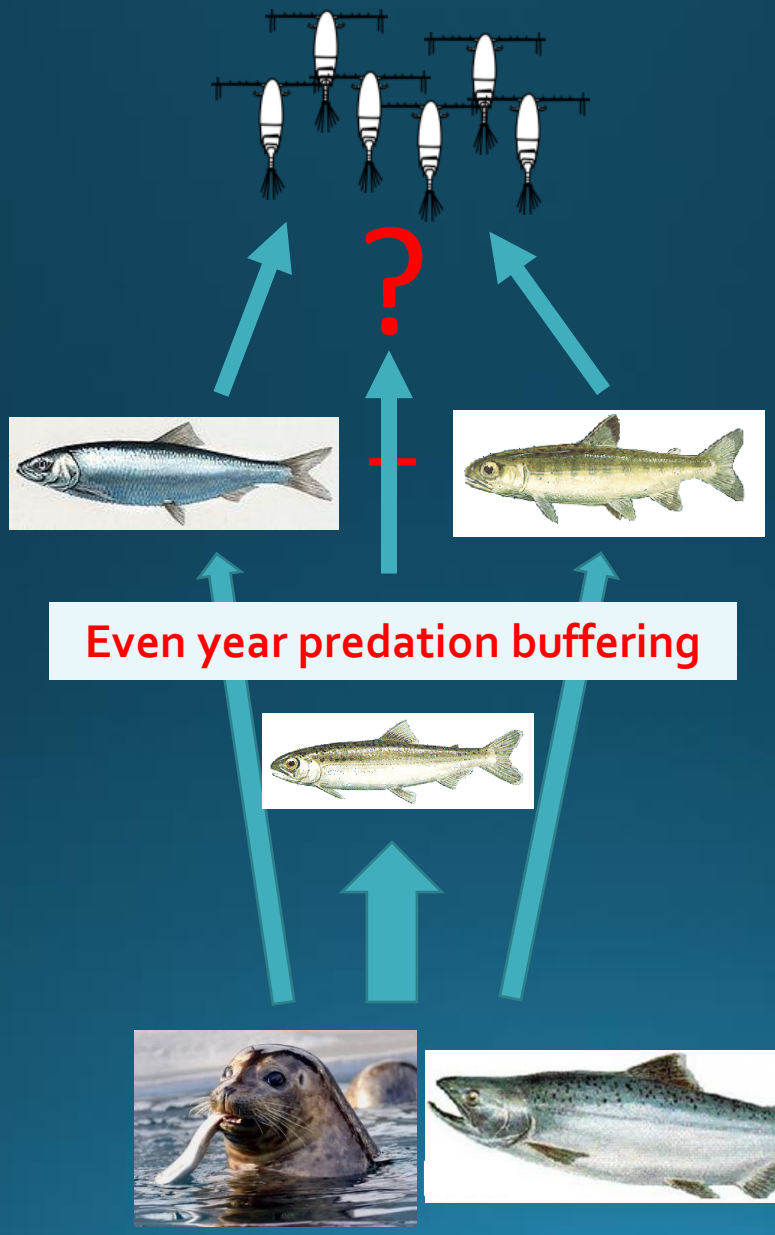
Lower Age-0 herring

Lower Copepod Index

Adult pink salmon return (late summer/fall)



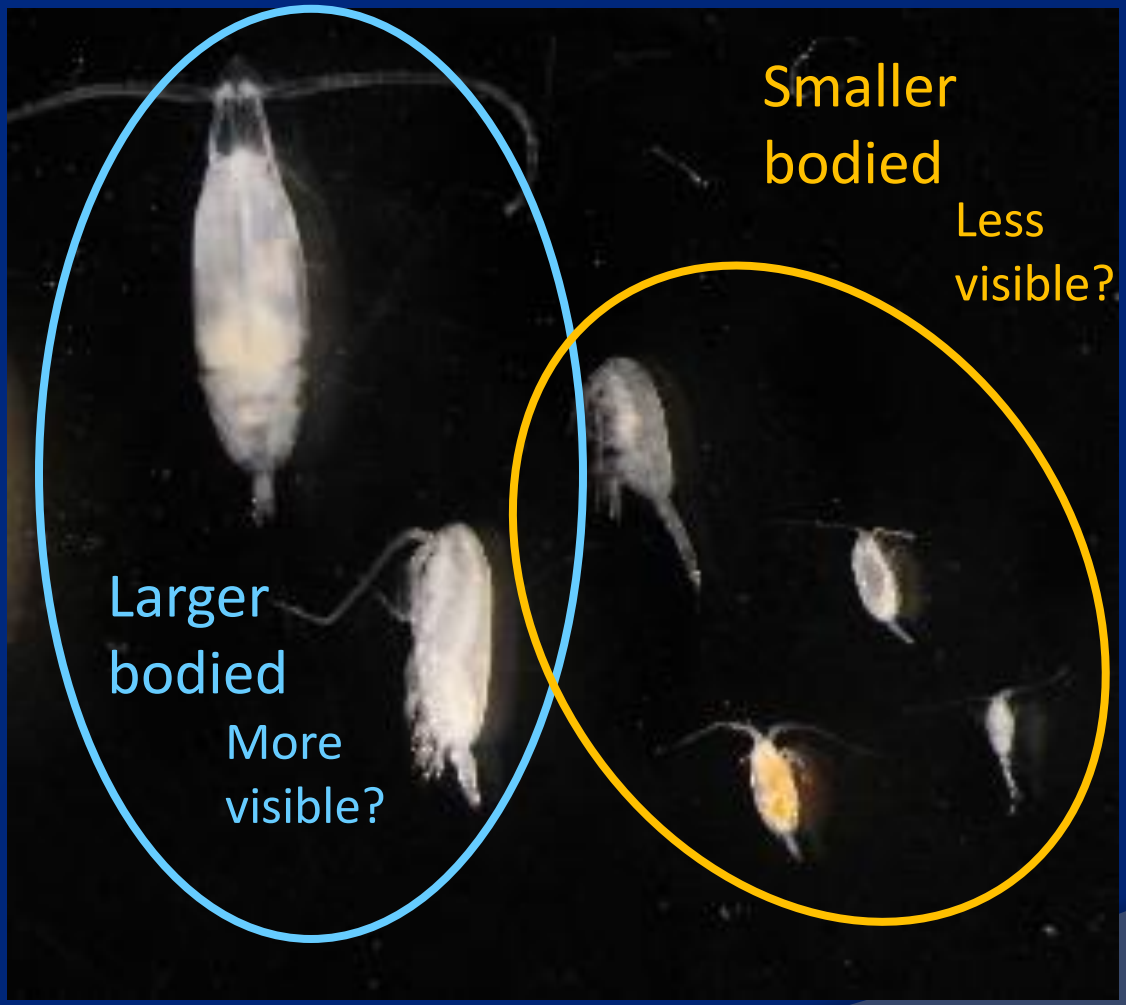
Hypothesis: Predation buffering (Ruggerone et al. 2004)



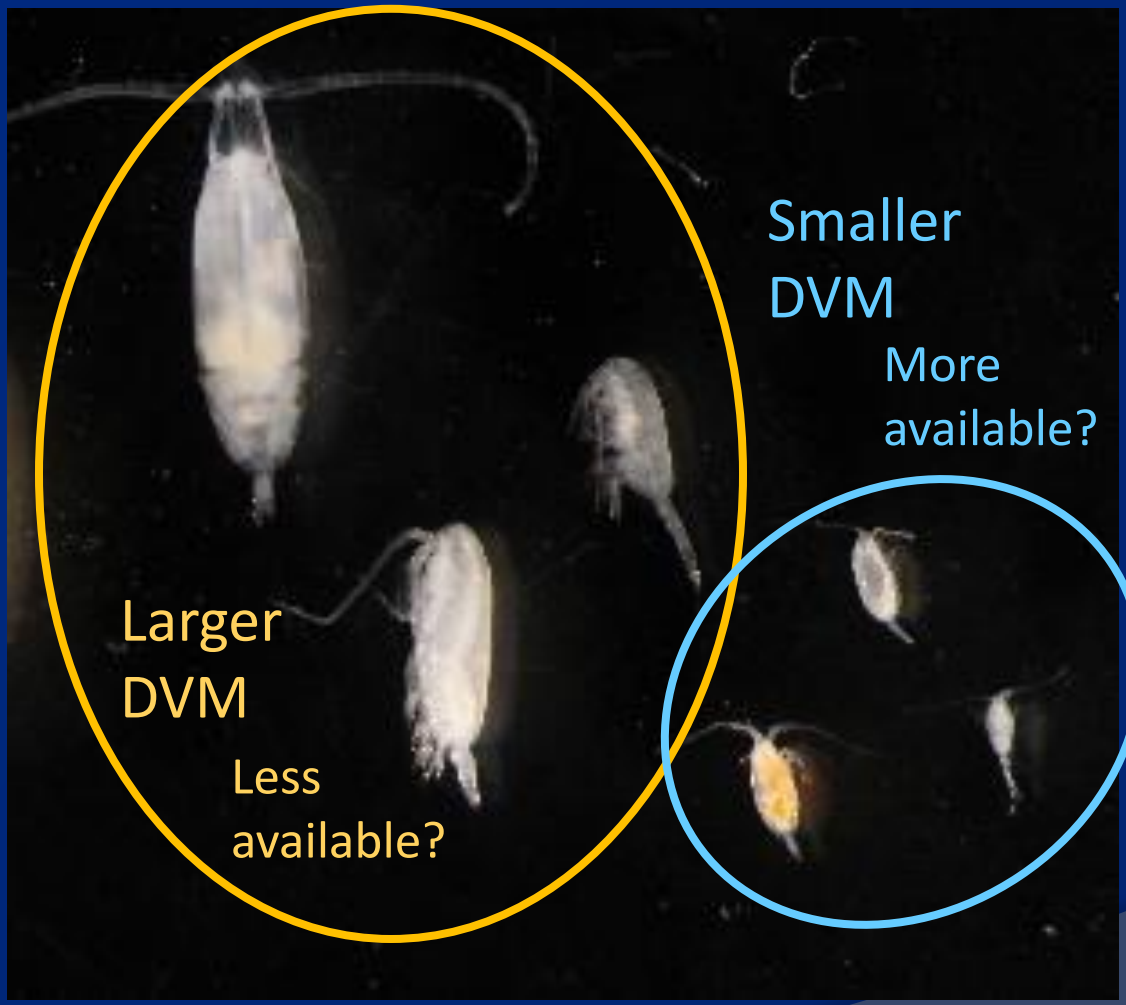
How does predation alter copepod species composition?

Huge differences among copepods:

Body size:

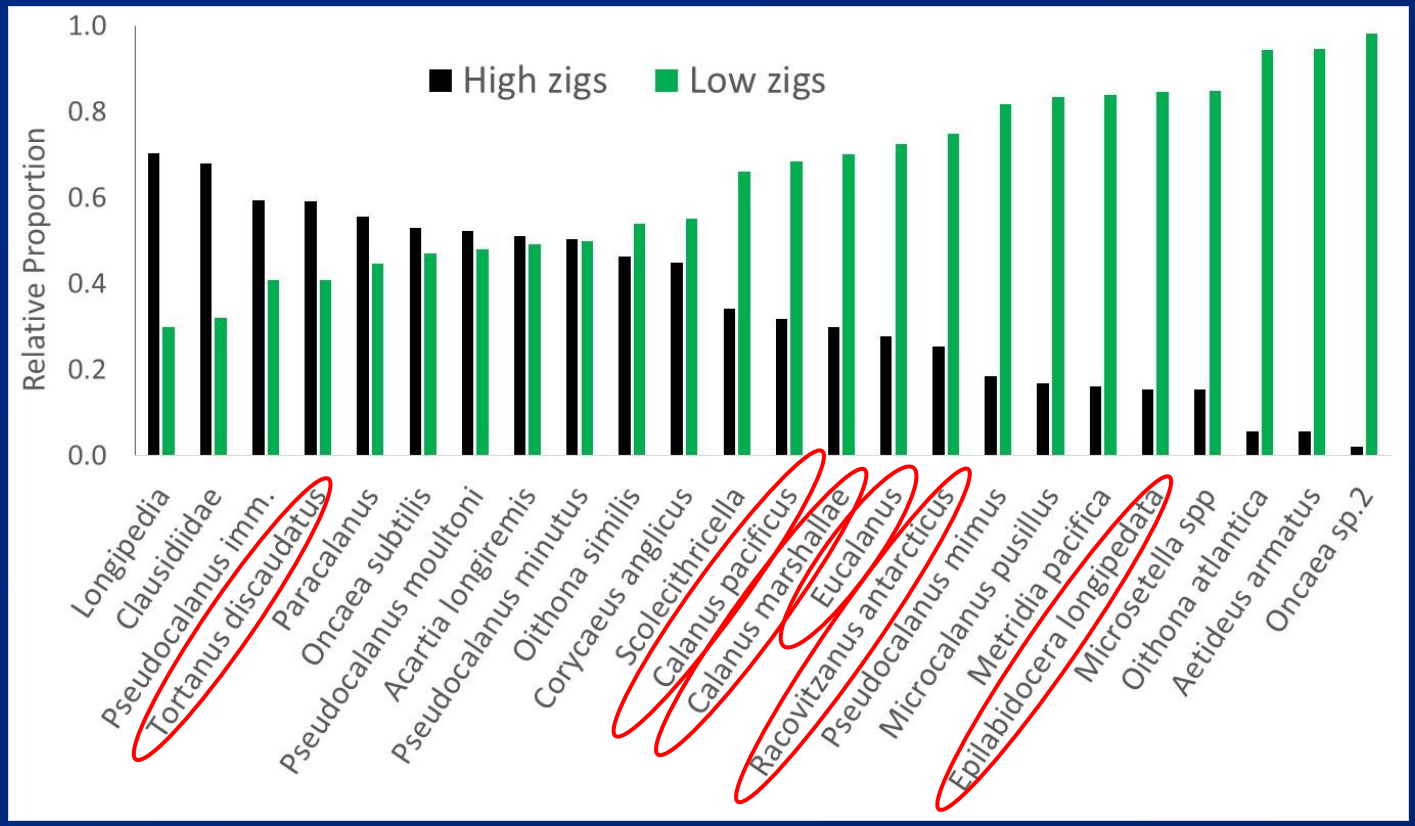


Vertical water column position:



There is diversity in diets, including multiple trophic levels within the copepods!

Copepod composition differs between even and odd years:



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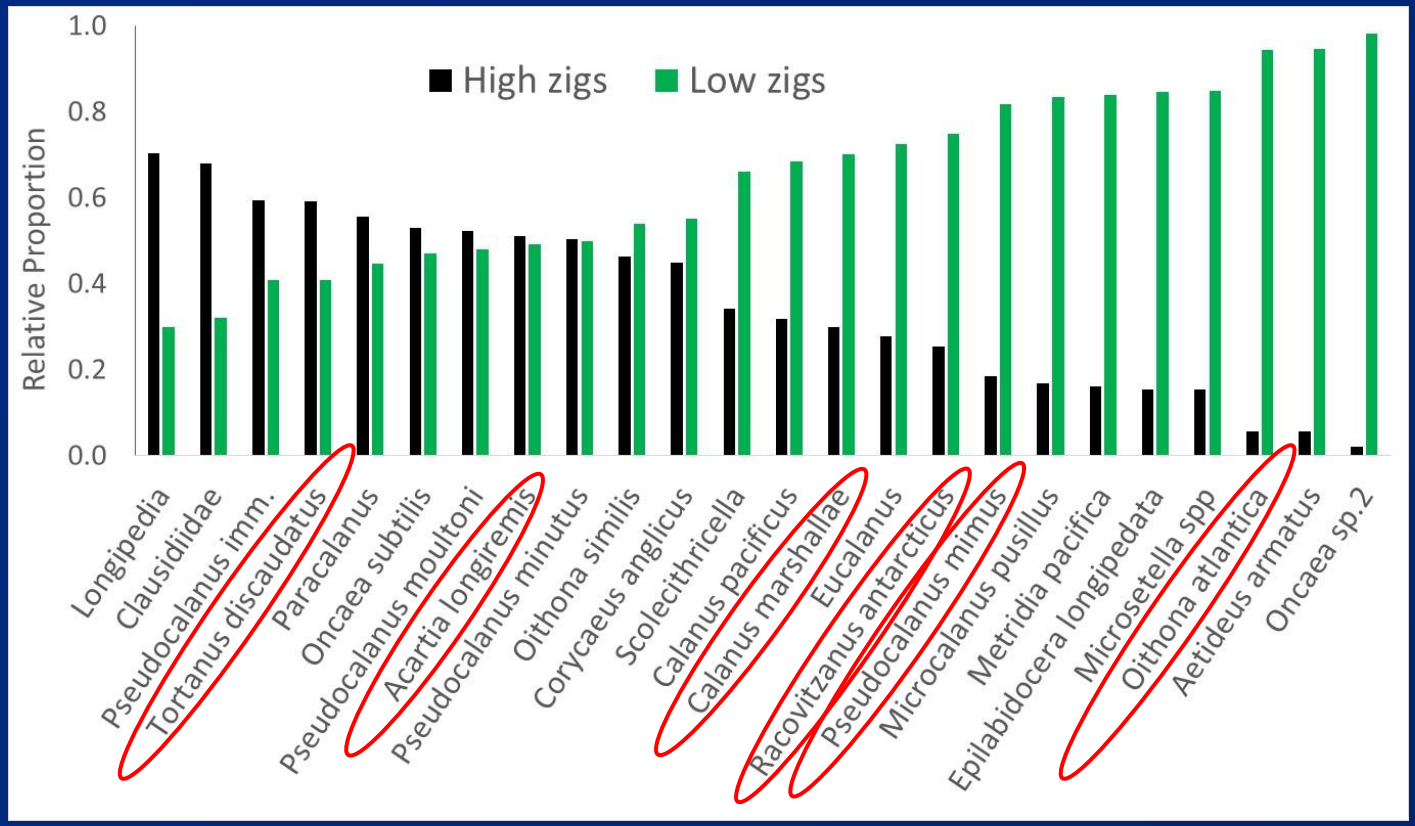

Which species are preferred prey of pink salmon, coho salmon, and herring?

Could selective predation be strong enough to cause the observed community shifts?

If so (or not), what do the copepod cycles mean to salmon cycles?

Partnerships & Funding