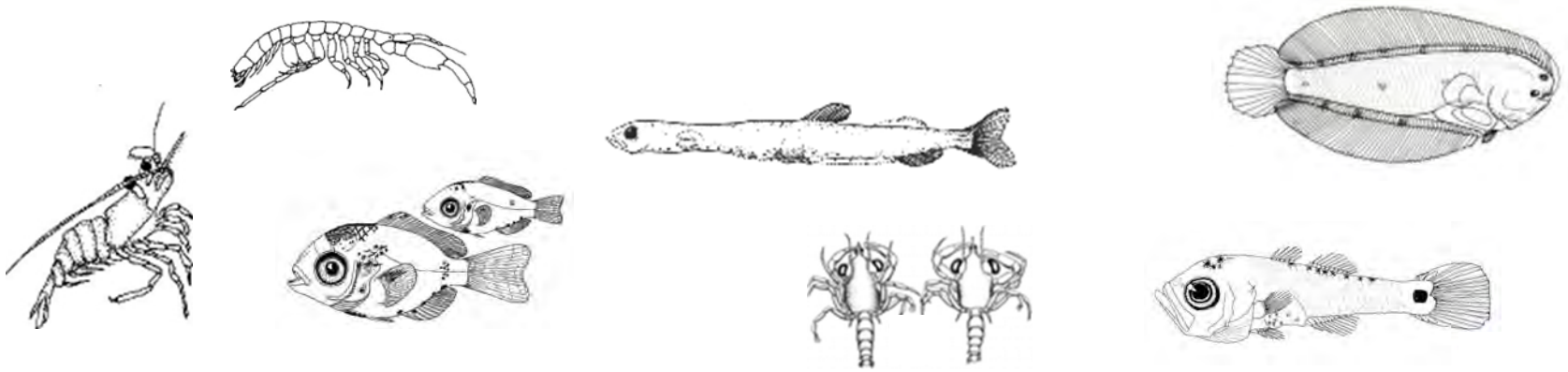
Seasonal variability in juvenile fish and invertebrate prey available to Columbia River salmon entering the ocean



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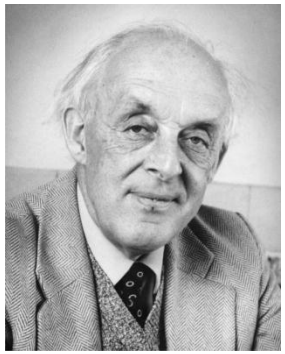
October 15, 2013

Match-Mismatch Hypothesis

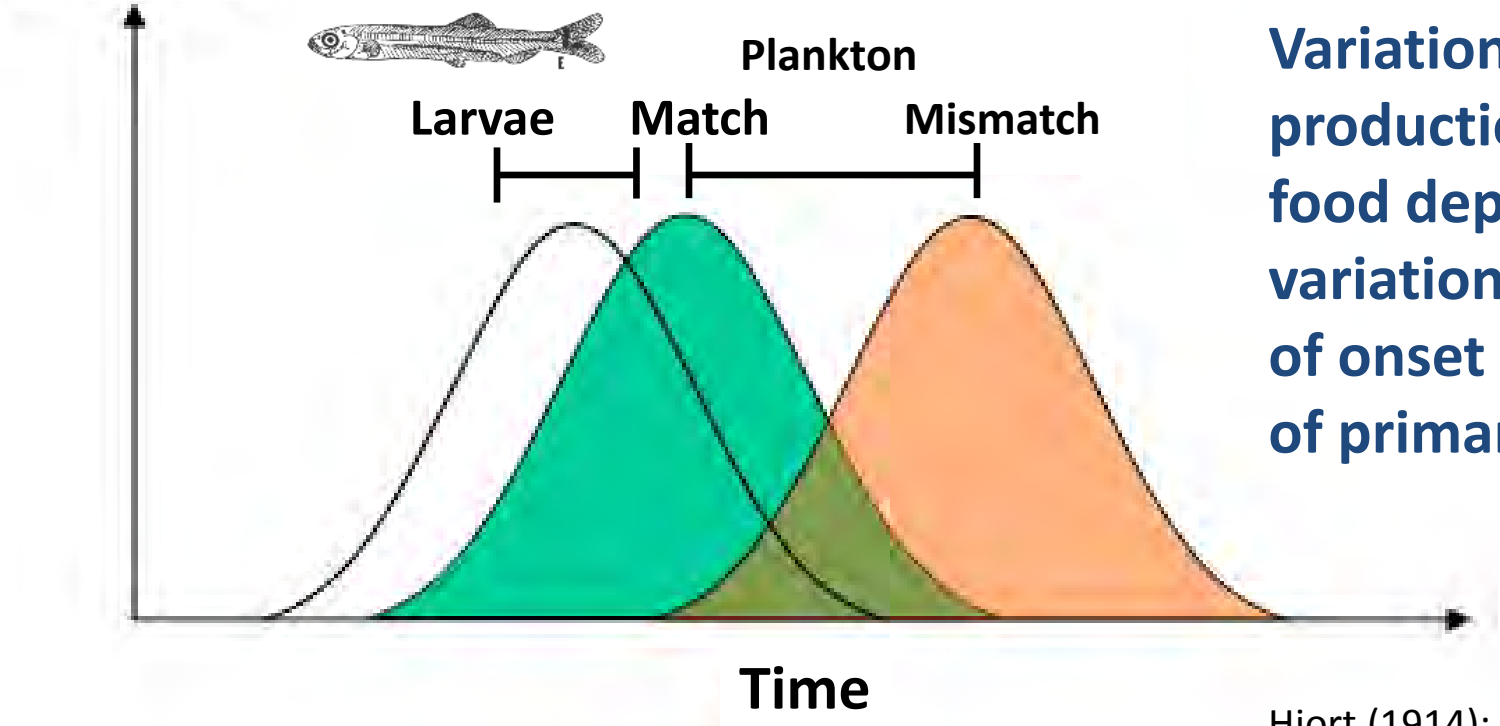
North Sea Herring

http://www.telegraph.co.uk

David Cushing



http://www.ioccg.org



Variation in production of larval food depends on the variation in the time of onset and duration of primary production

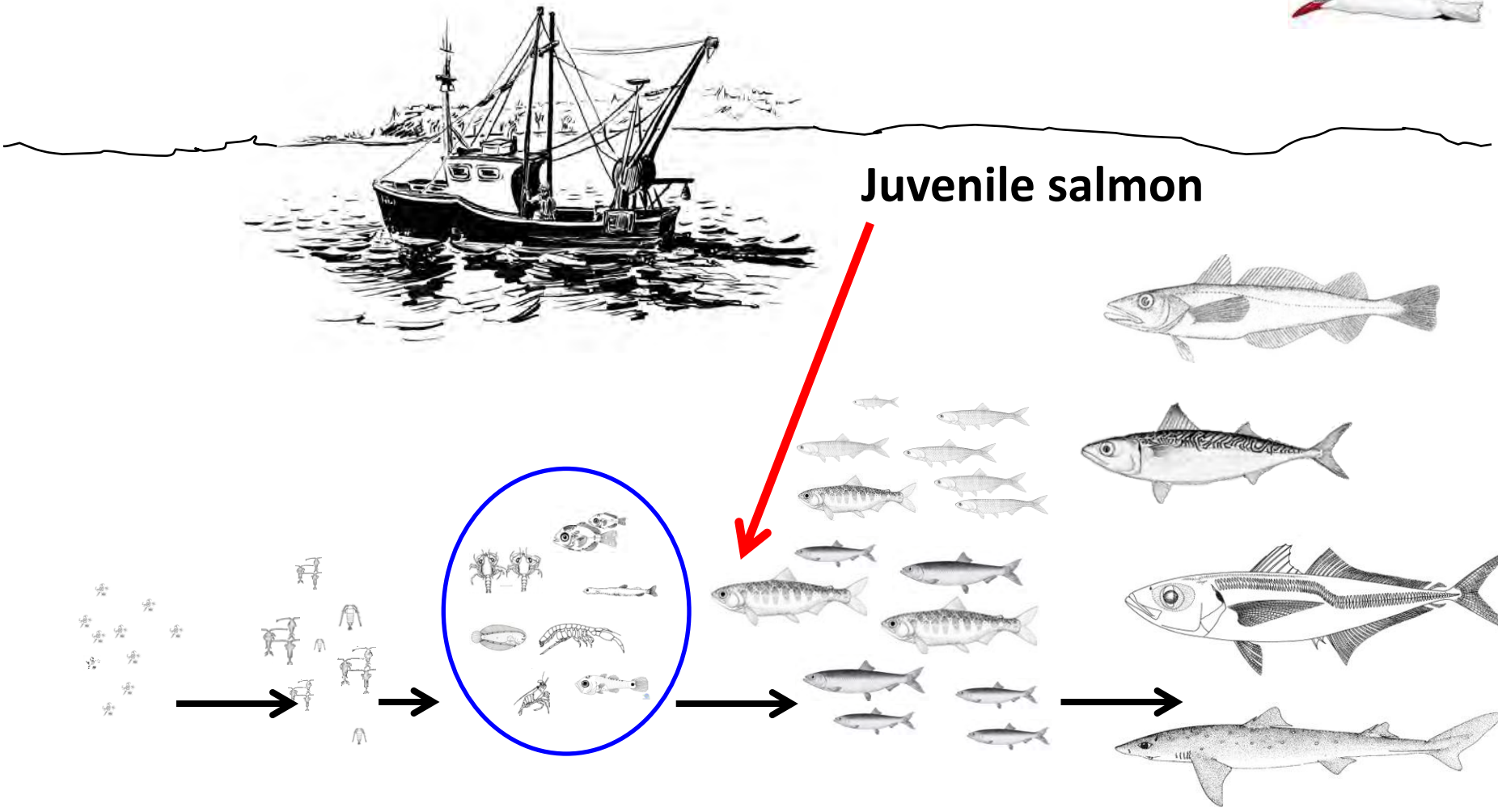
Hjort (1914); Cushing (1969; 1990)

Early ocean residence – a critical period?

- 13 out of 16 Columbia Basin salmon Evolutionary Significant Units (ESUs) are protected under the U.S. Endangered Species Act
- Mortality is variable and may exceed 90% in some years

http://www.nwd-wc.usace.army.mil/ Hartt and Dell (1986); Beamish and Mahnken (2001); Pearcy (1992); PFMC (2011)

Pelagic food chain including juvenile salmon micronekton prey

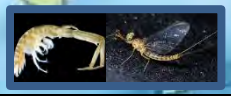


Salmon eat more fish as they enter the ocean

PACIFIC

OCEAN

Lower Columbia River

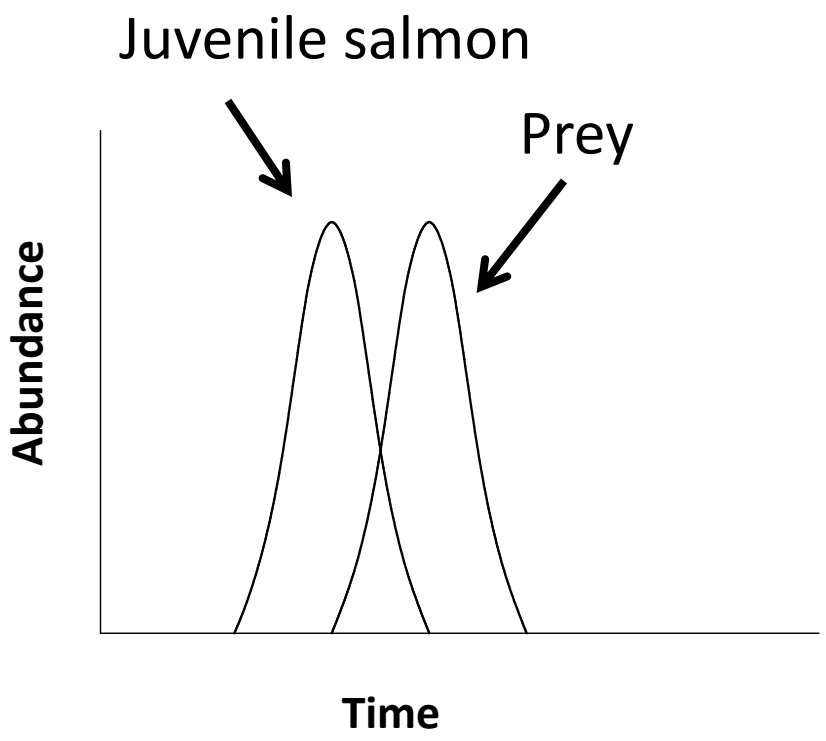


Peterson et al. (1982); Emmett et al. (1986); Brodeur et al. (1987 & 1990); Brodeur (1989 & 1991); Brodeur and Pearcy (1992); Keeley and Grant (2001); Schabetsberger et al. (2003); Daly et al. (2009)

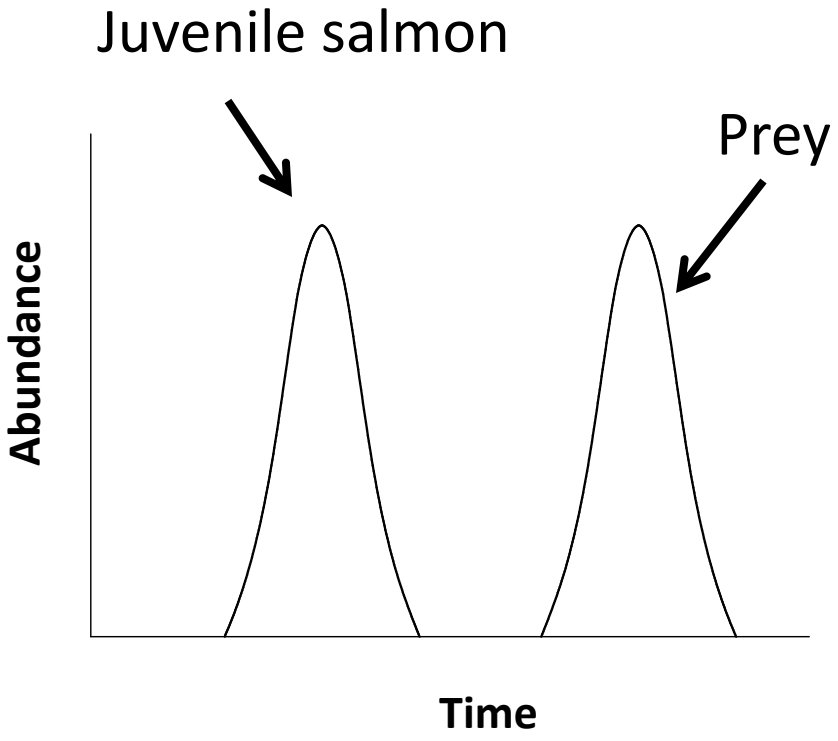
Estimating match/mismatch between juvenile salmon and prey resources

- Evaluate seasonal variability in prey community (2011 & 2012) in relation to environmental variables and timing of salmon ocean migration
- Compare prey biomass to salmon abundance
- Explore the relationship between prey availability and salmon condition

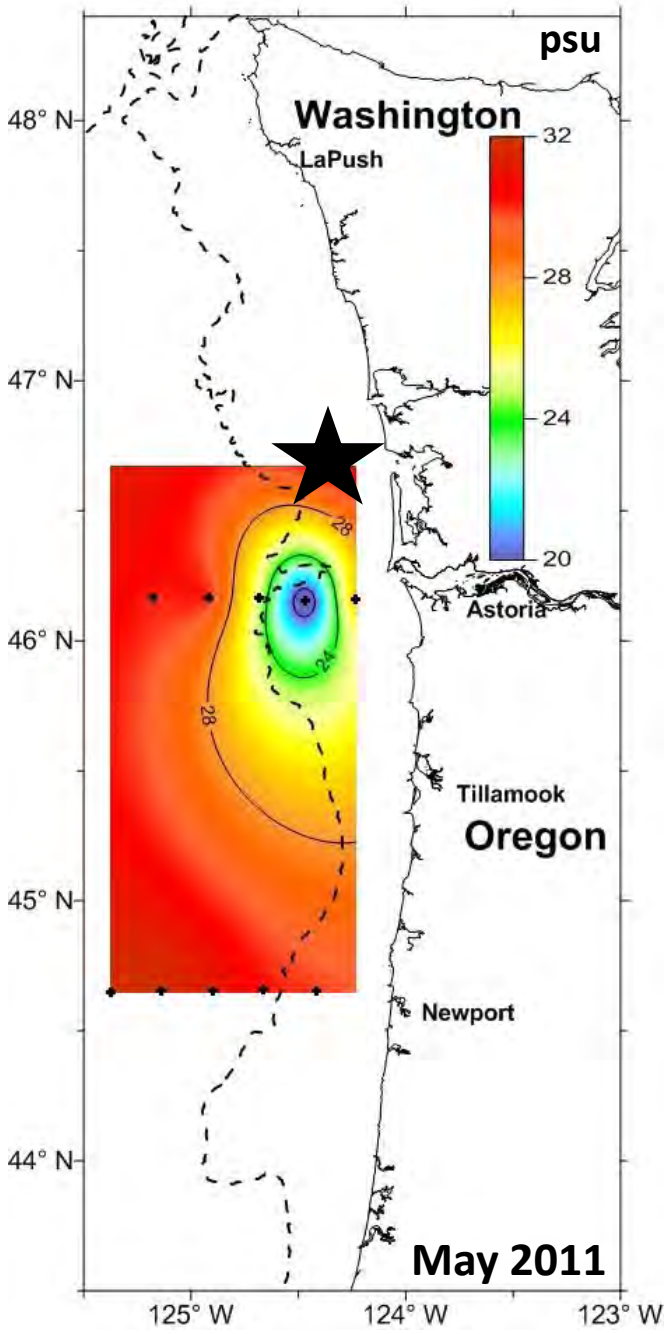
Predicted model of salmon and prey abundance



Match



Mismatch



Prey Field Sampling Stations

2011

5 cruises (May – September)

24 hauls + CTD casts

2012

4 cruises (May, July-September)

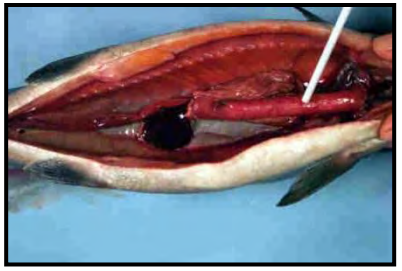
28 hauls + CTD casts

Sample collection and analysis

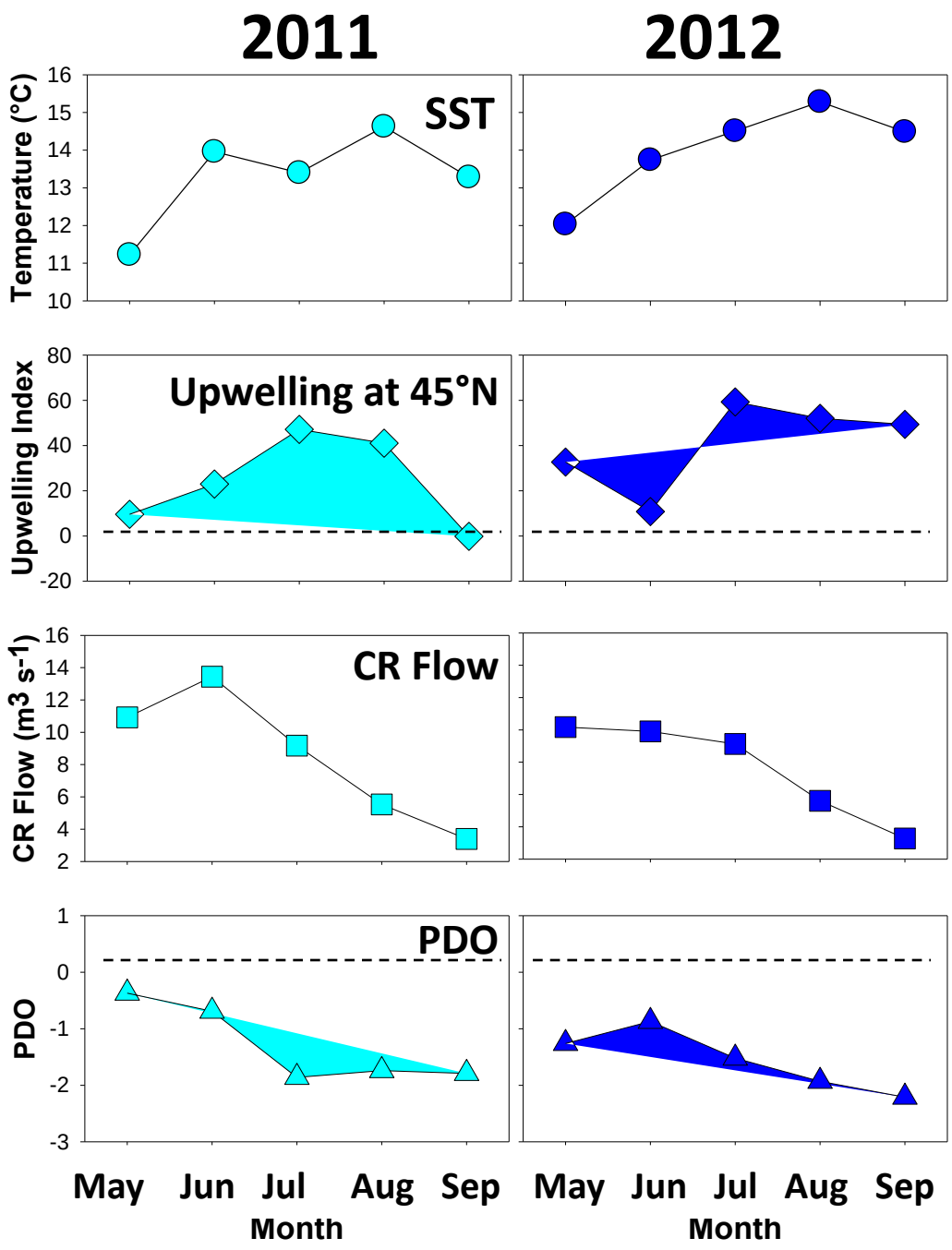
- **Prey** – ID, abundance, size (length, mass) measured in lab and converted to biomass

- **Genetics** – Fin clips from Chinook salmon (n=288) analyzed to determine genetic stock of origin

- **Salmon Diet** – Stomach contents from salmon evaluated



Seeb et al. (2007); Teel et al. (2009)



Ocean conditions were similar in both years

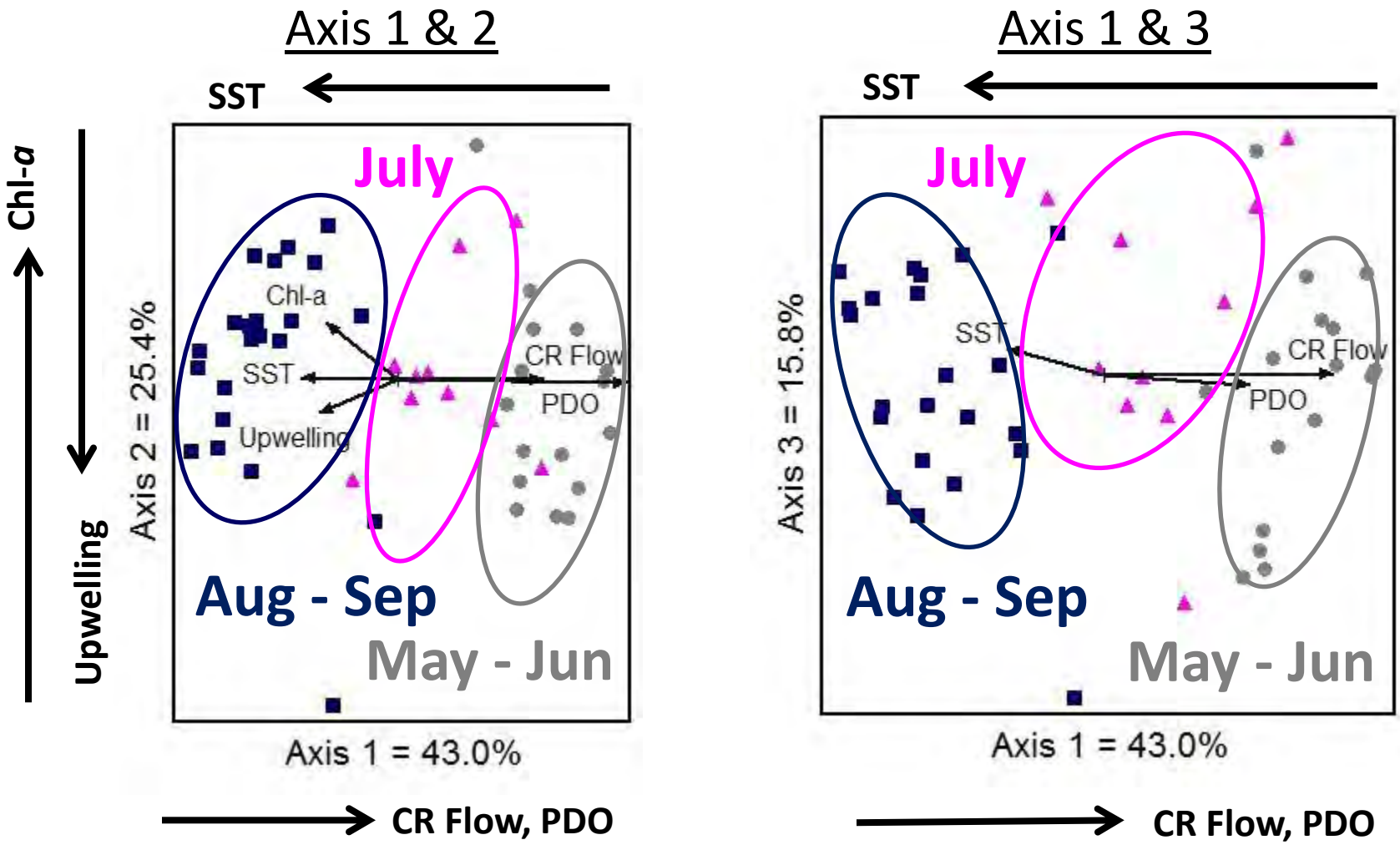
SST – Increased

Upwelling – Relaxation period during June 2012

Columbia River Flow – Highest flow in June 2011

PDO – Strongly negative in both years

NMS plots show 3 distinct communities of prey



Some species are more closely associated with a particular season

May-Jun

Limacina (sea snail)
T. spinifera (krill)
C. magister (crab megalope)
Osmeridae (smelt)
Pacific sand lance
Arrowtooth flounder
Pacific sand sole
Rock sole
Slender sole
Speckled sanddab

Flatfish YOY

July

Northern ronquil
C. productus/oregonensis
(crab megalope)

Aug-Sep

Northern anchovy

Indicator Species Analysis
Dufrêne and Legendre (1997)

Chinook genetics caught alongside prey

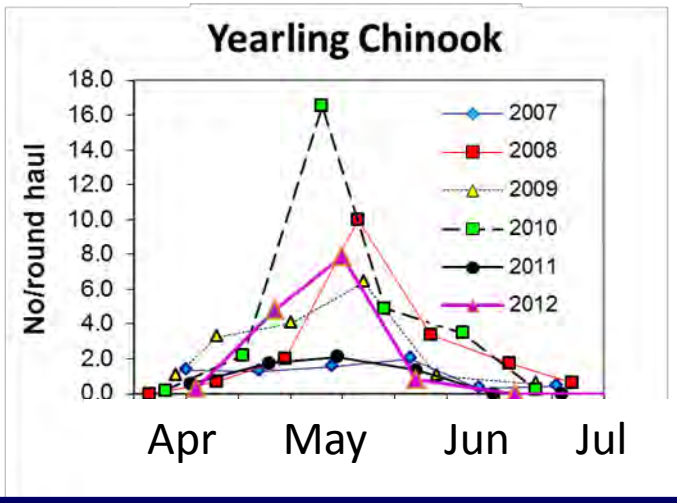
Month	May	Jun	Jul	Aug	Sep
2011	5	6	55	54	45
2012	12	-	84	4	23

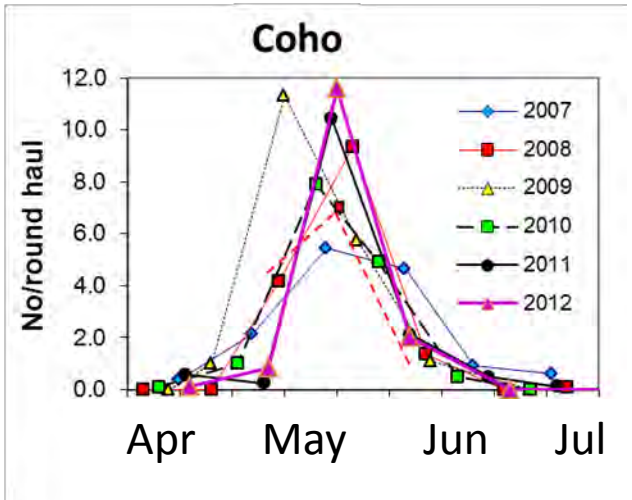
61% (175 of 288) of Chinook salmon from Upper Columbia River Summer/Fall genetic stock group
(mean probability for assignment = 0.89)

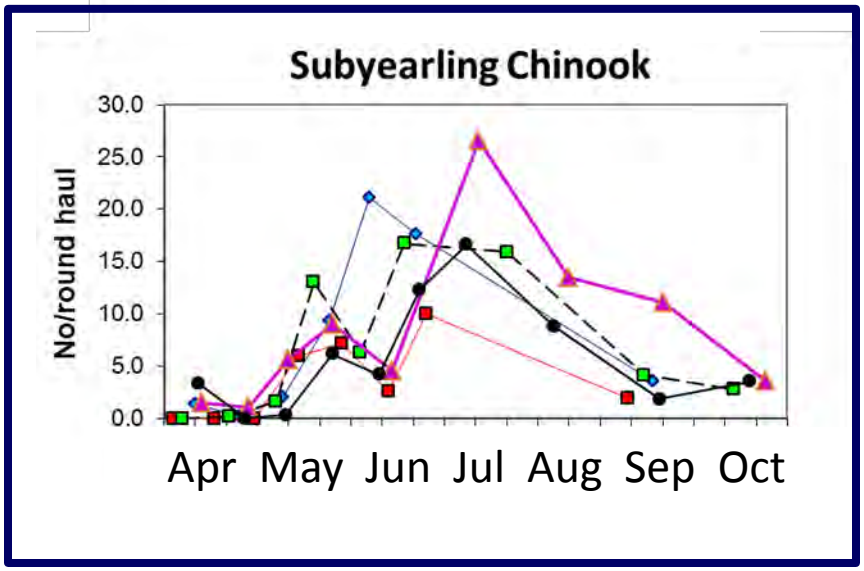
Coastal, OR/WA resident species

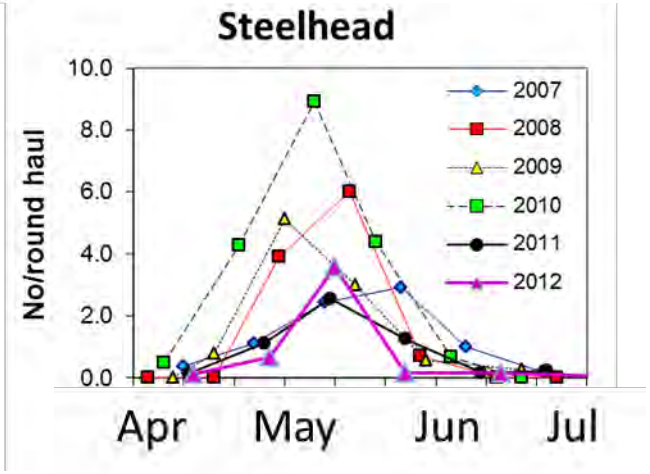
Seeb et al. (2007); Teel et al. (2009); Fisher et al. (2007)

Outmigration timing varies among salmon





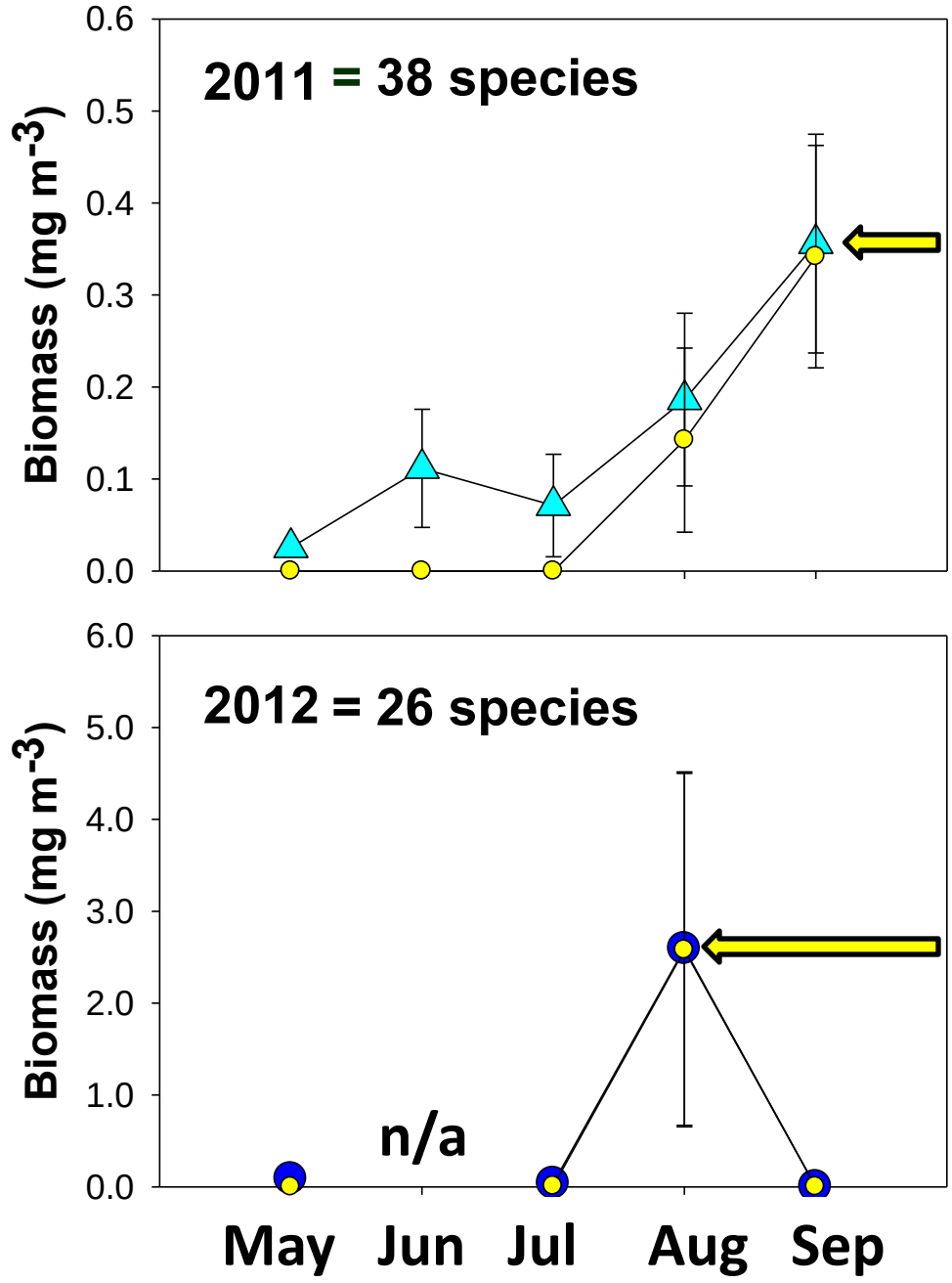




Weitkamp et al. (2012); Weitkamp et al. (in review)

Summary (so far)

- 3 distinct time periods for prey community: **May-June**, **July**, **August-September**
- Juvenile salmon migrate to sea at different times
- Most juvenile salmon (61%) caught were from a single genetic stock group (UCR Su/Fa), which will be the focus from here on….



Prey Biomass by Month

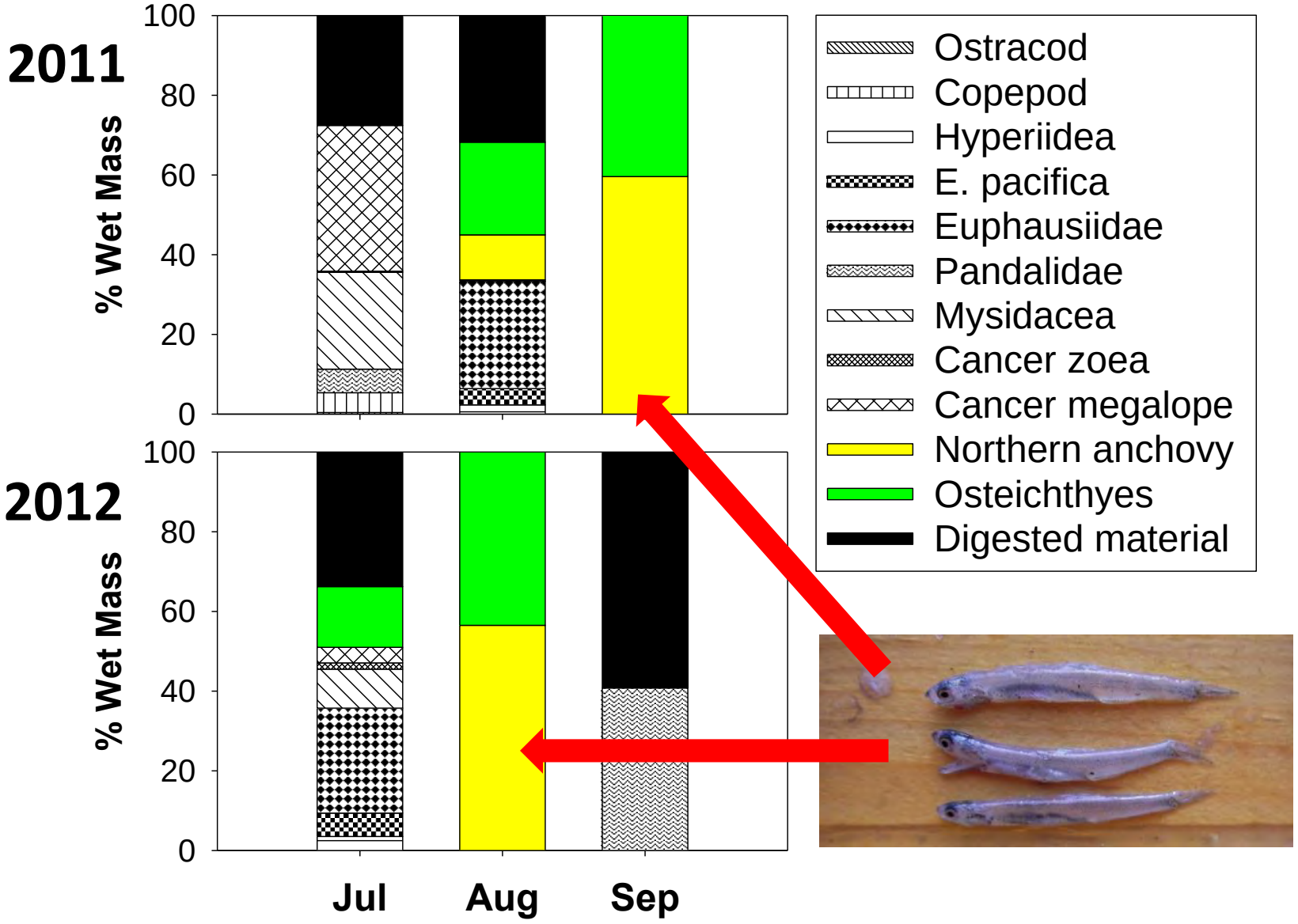
Highest biomass related to juvenile anchovy abundance

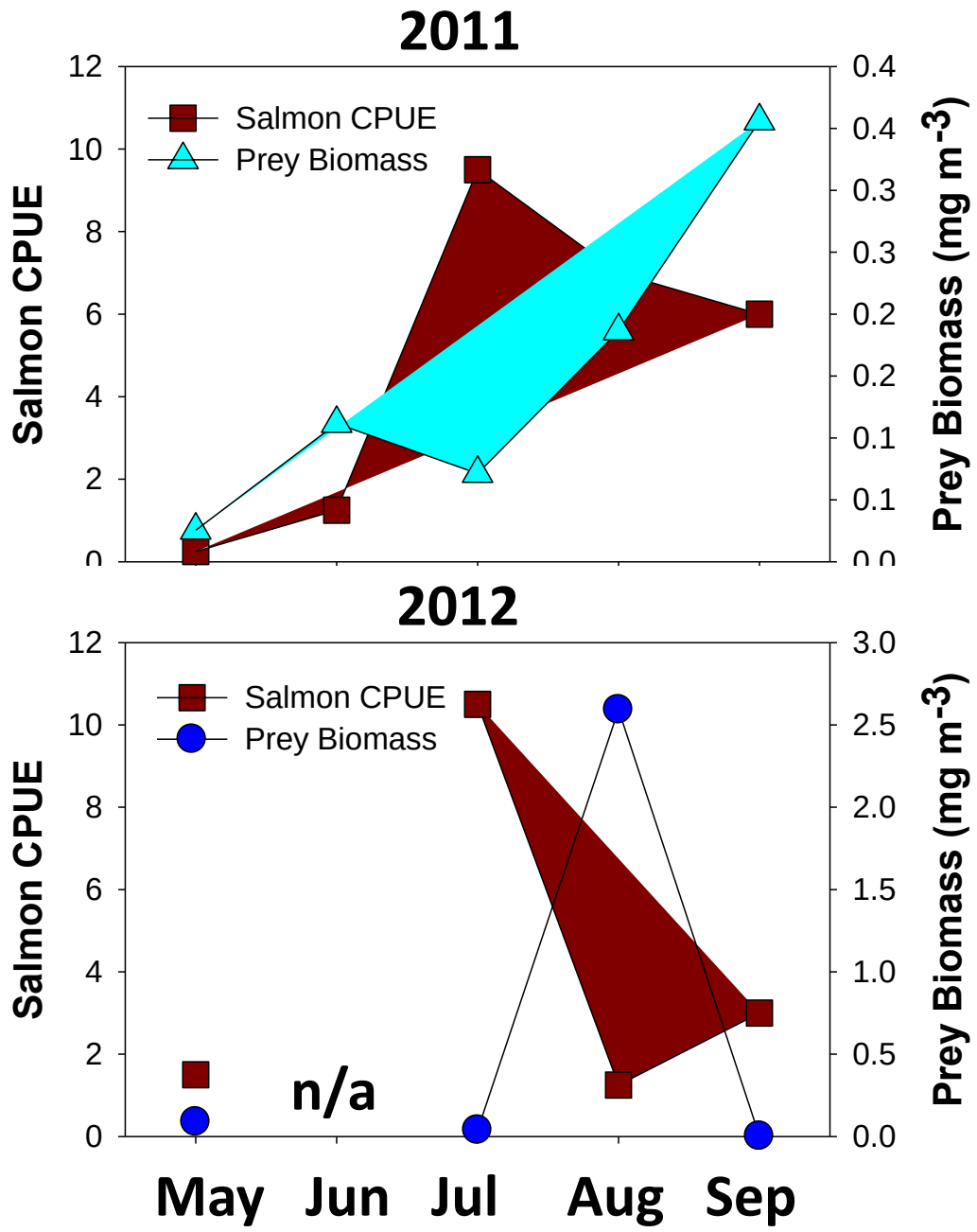
2011 = September

2012 = August

Northern anchovy (*Engraulis mordax*)

Salmon diets resembled the prey field





Match/Mismatch Hypothesis

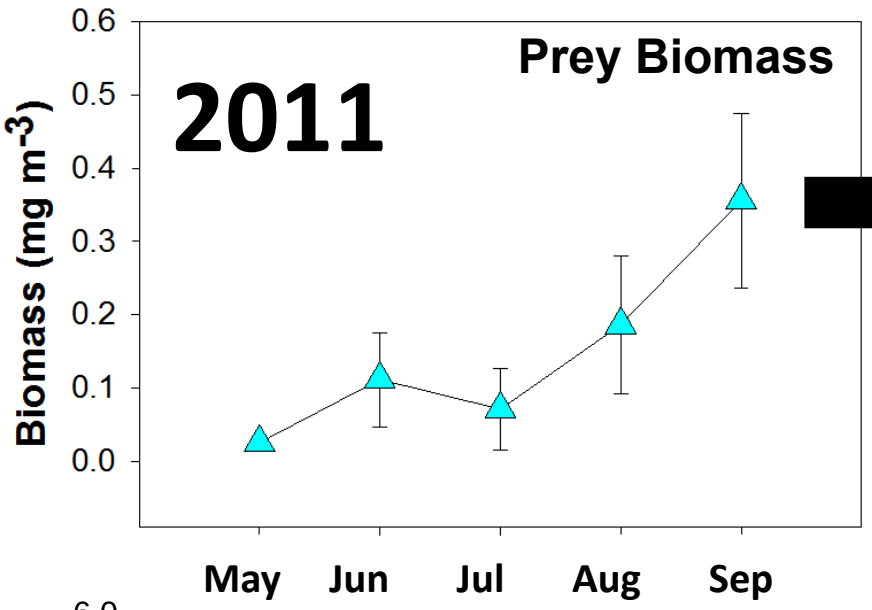
2011

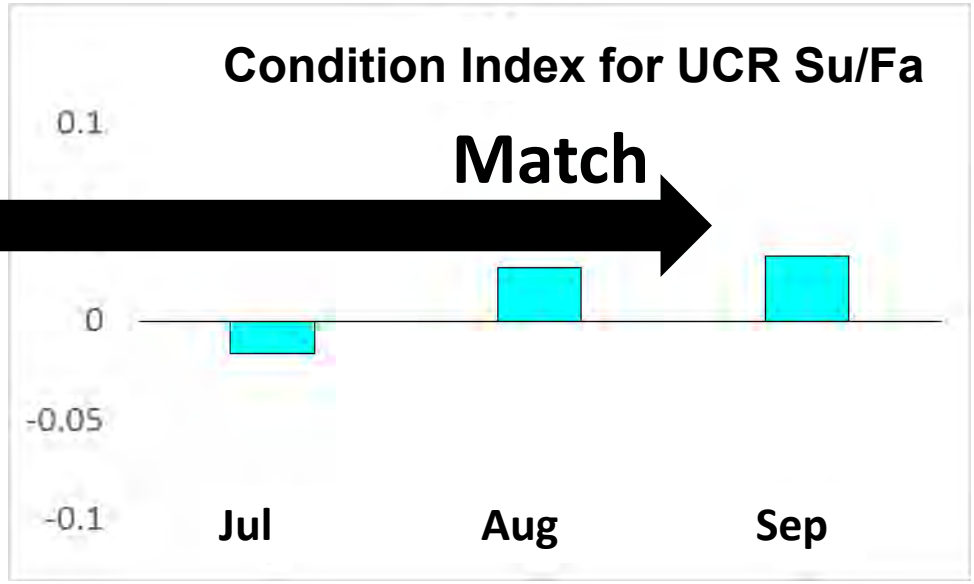
Match between peak prey biomass (anchovy) and juvenile salmon CPUE

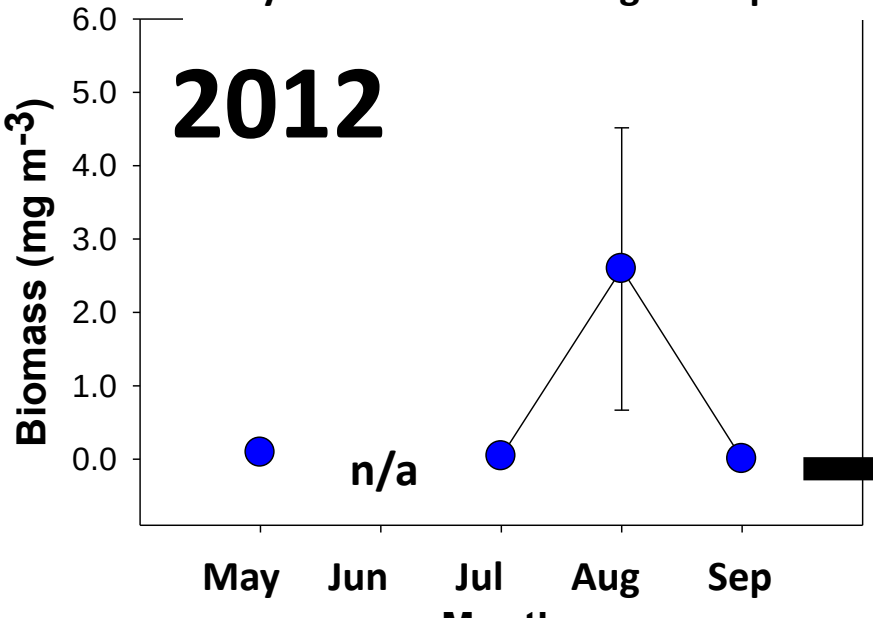
2012

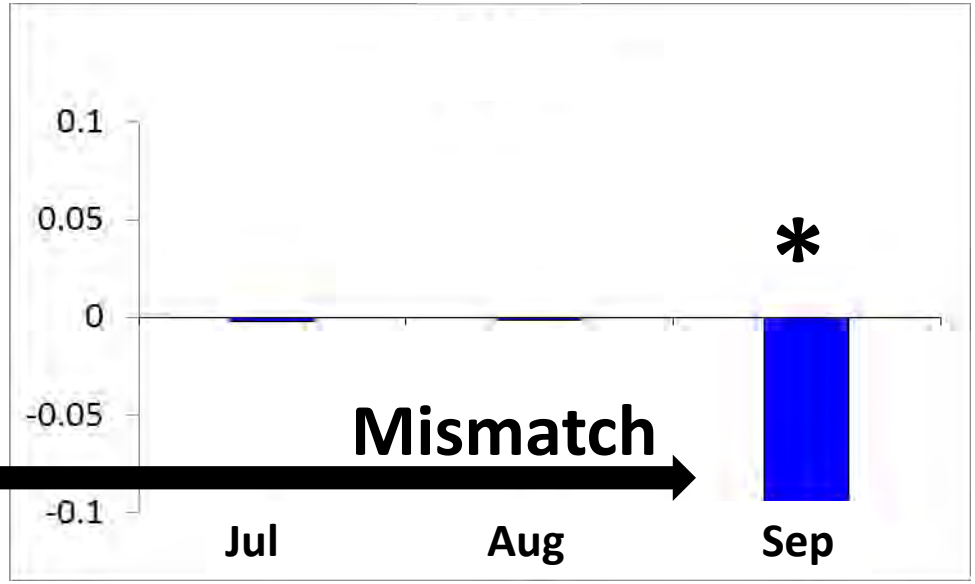
Mismatch between peak prey biomass (anchovy) and juvenile salmon CPUE

Prey biomass is also related to fish condition









Kruskal Wallis p > 0.001

Summary

- We identified three distinct prey communities:

  1. **May-June** = yearling migrants
  2. **July** = subyearling migrants
  3. **August-September** = critical period for subyearlings

- 61% of the juvenile salmon were subyearlings from a single genetic stock group (UCR Su/Fa)
- Diets of subyearling UCR Su/Fa salmon resembled the prey field (northern anchovy)
- In 2011, there was a **match** between prey biomass and salmon CPUE; in 2012, there appeared to be a **mismatch**
- Salmon condition index was more positive when anchovy biomass was highest

Acknowledgements

Laurie Weitkamp
David Kuligowski
Ric Brodeur
Elizabeth Daly
Toby Auth
Tristan Britt
Greg Hutchinson
Cheryl Morgan
Miller Lab
Hatfield Student Organization Travel Award
Mamie Markham Research Award
Bill Wick Marine Fisheries Award
Crew of the F/V Miss Sue