Effects of the warm ocean ‘blob’ on May & June 2015 juvenile salmon in the Northern California Current ecosystem

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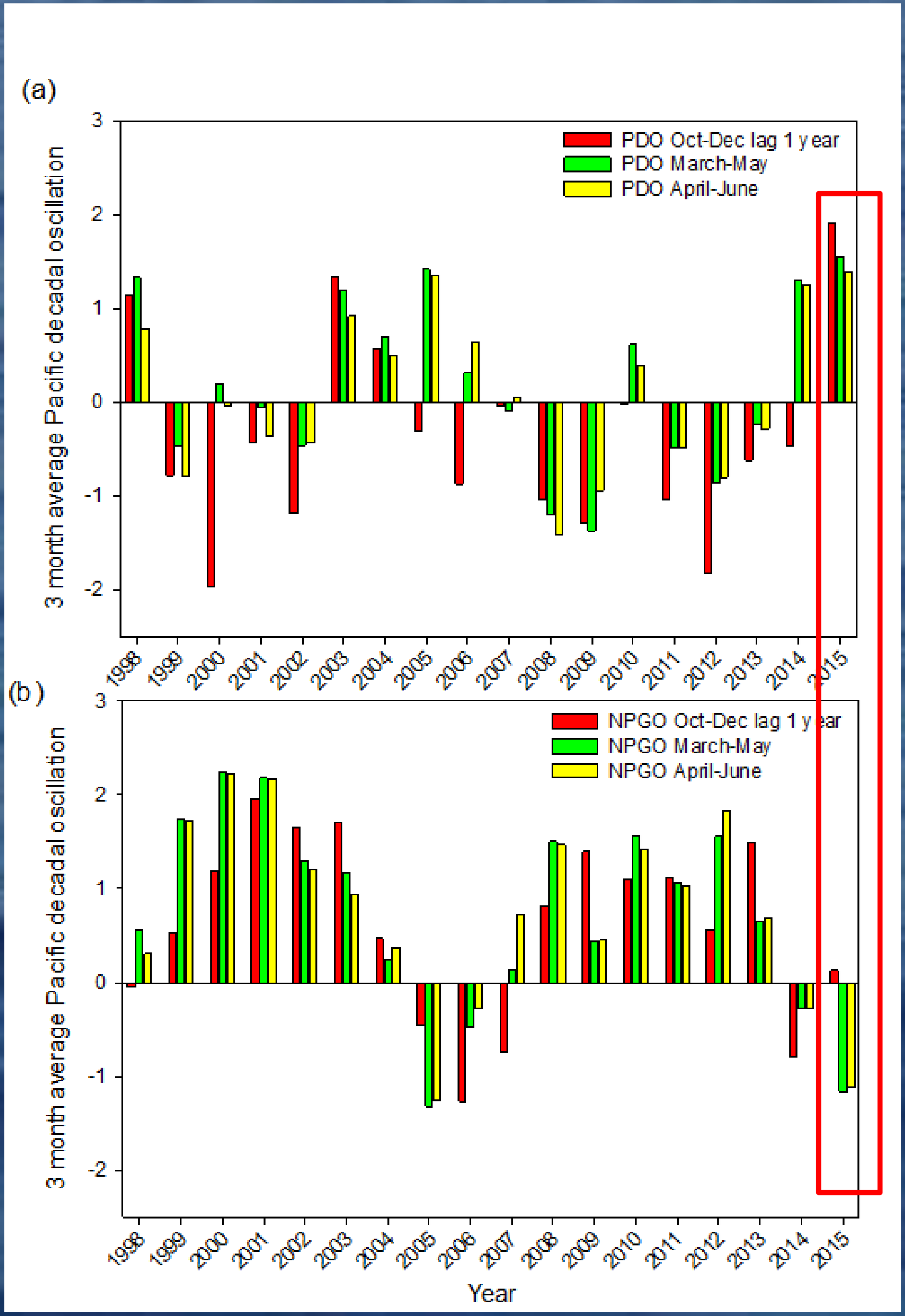
Purpose:

Did the anomalously warm ocean conditions in 2015 have on impact on juvenile salmon that entered the ocean that summer?

- Environmental conditions of 2015 based on the Pacific Decadal oscillation (PDO) and North Pacific Gyre Oscillation (NPGO)
- Fish prey biomass & type available to salmon
- What & how much was eaten- by juvenile Chinook salmon
- Condition factor of the juvenile salmon
- Predictions for returns of Spring Chinook and coho salmon from outmigration year 2015 relative to biological metrics

Environmental Conditions 2015

- Winter and spring 2015 were the 2nd, 7th and 11th most positive PDO since 1900.
- NPGO values were 8th most negative in 2015 since 1950. Winter NPGO was average.



Winter ichthyoplankton Biomass and composition: index of salmon prey

- Winter-spawned fish larvae develop into the juvenile fish prey that Coho and Chinook salmon rely upon for their principal food source during early summer ocean entry.

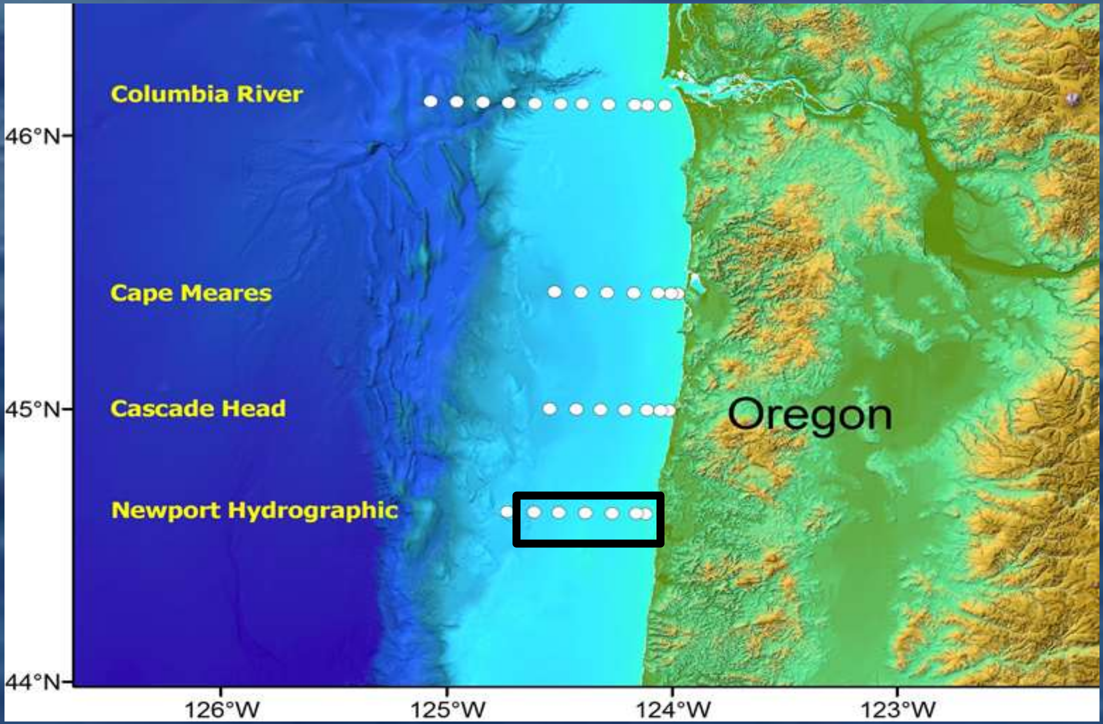
- The biomass* (amount) and composition (type) of ichthyoplankton from January-March is a predictor of food conditions for juvenile salmon which is correlated to salmon survival or return as adults several years latter.

- Index is available before salmon even enter the ocean

*Daly et al. 2013 MEPS

Winter ichthyoplankton Biomass and composition: index of salmon prey

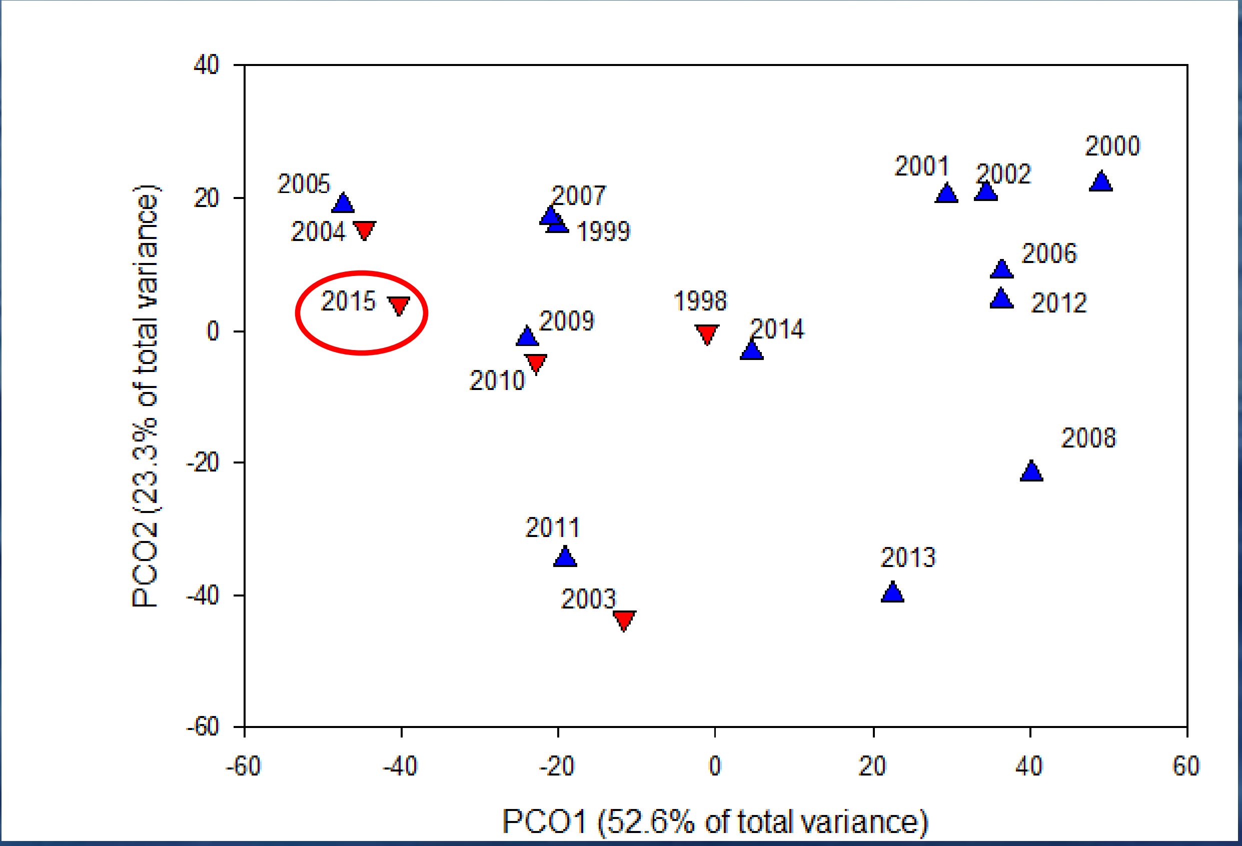
- Night time sampling has occurred approximately every two weeks from January to March, since 1998. Fish larvae are preserved, identified and measured then converted to biomass.



Food conditions for juvenile salmon

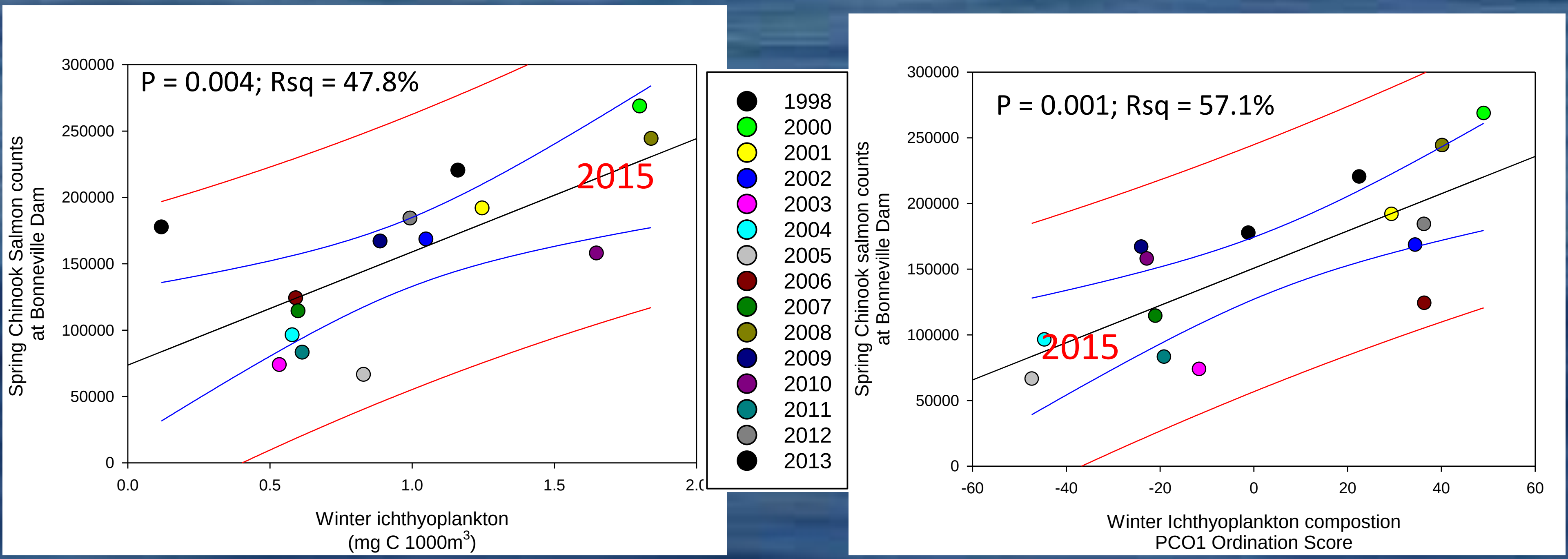
- The biomass of fish larvae in 2015 was above average (4th highest)
- The composition was primarily composed of warm ocean taxa such as larval rockfishes and northern anchovies (more on this latter)

Year	Rank	Salmon prey (mg C per 1000 m^3)
2008	1	69.3
2000	2	63.1
2010	3	44.5
2015	4	43.0
2016	5	29.8
2001	6	17.6
2013	7	14.5
2002	8	11.2
2012	9	9.8
1999	10	7.9
2009	11	7.7
2005	12	6.7
2011	13	4.1
2007	14	4.0
2006	15	3.9
2004	16	3.8
2003	17	3.4
2014	18	2.7
1998	19	1.3



Spring Chinook salmon returns and 2015 Winter ichthyoplankton

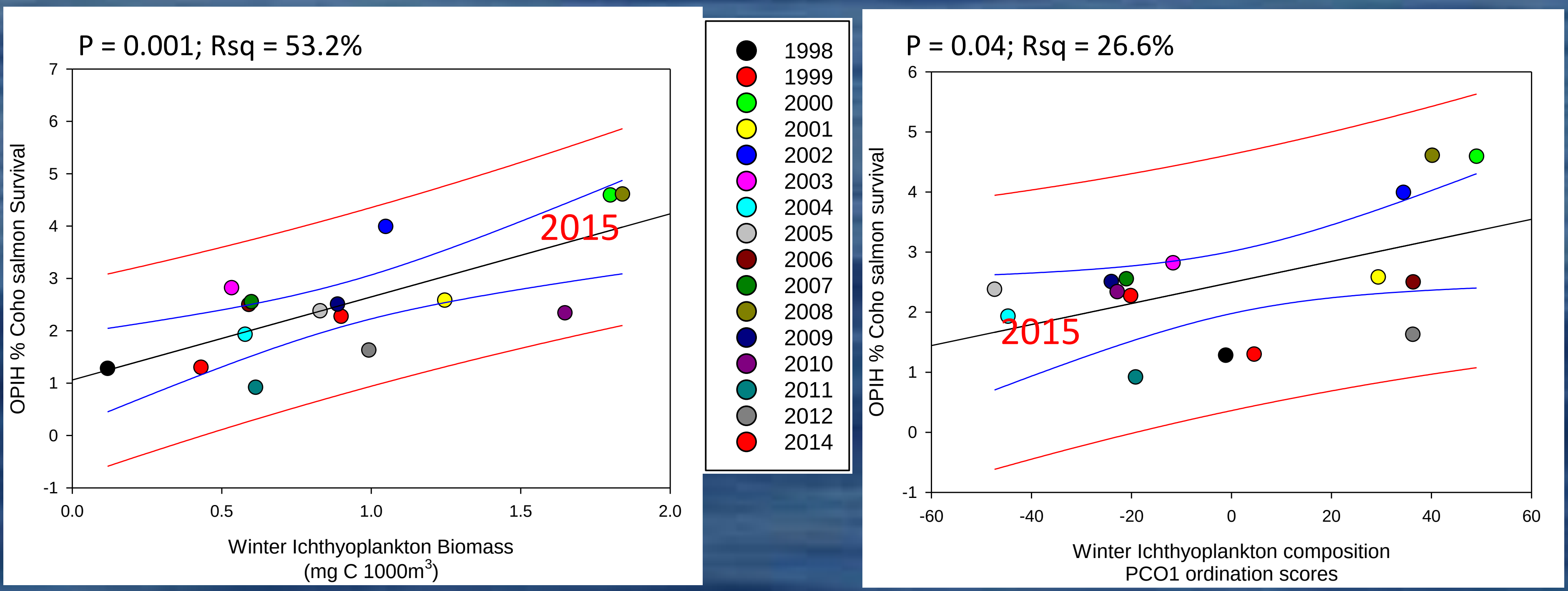
- Biomass predicts 213K adults returning in 2017
- Composition predicts 93K returning in 2017



*1999 removed as an outlier

Coho salmon returns and 2015 winter ichthyoplankton

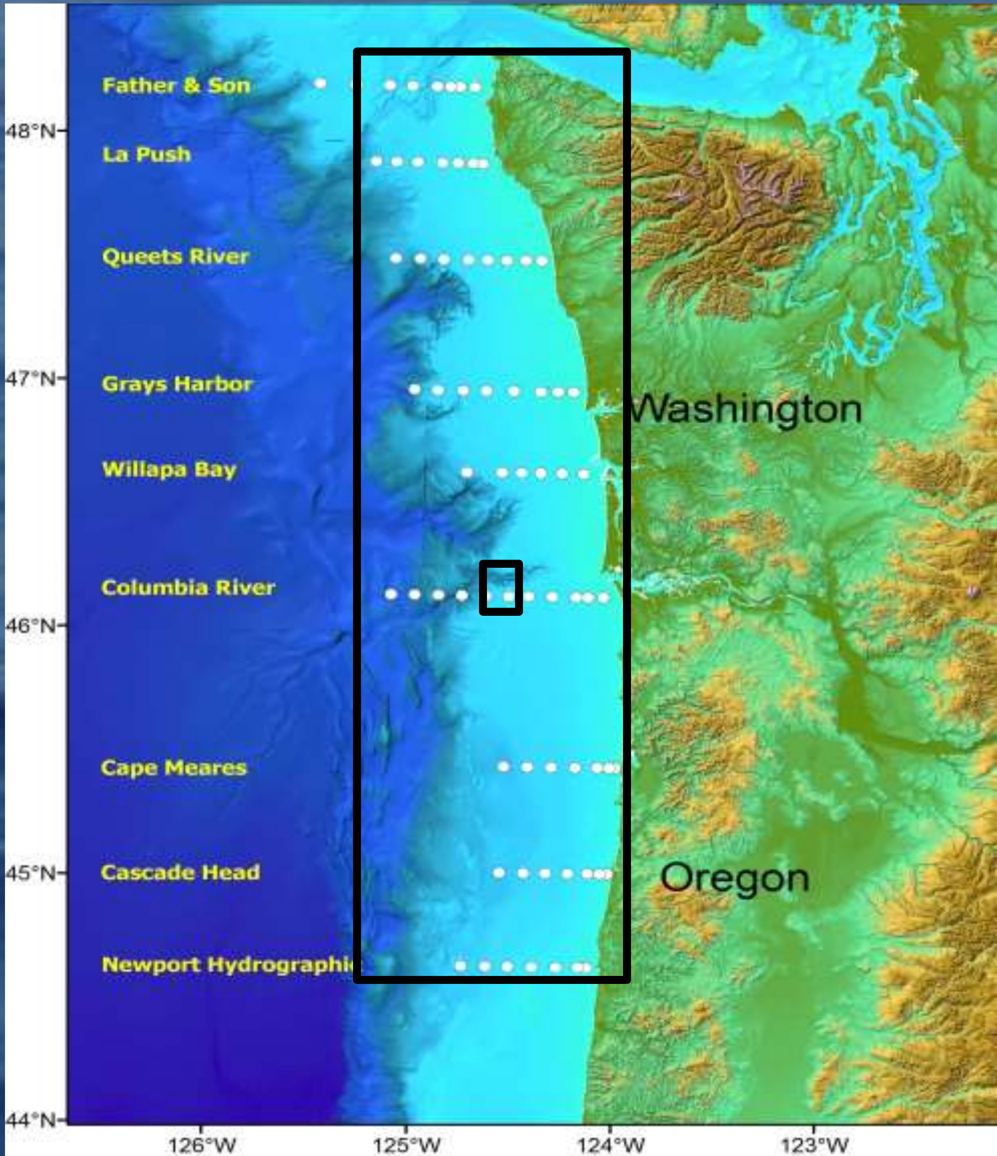
- Biomass predicts Coho salmon survival at 3.6% returning as adults in 2016
- Composition predicts Coho salmon survival at 1.8% returning as adults in 2016



*2013 removed as an outlier

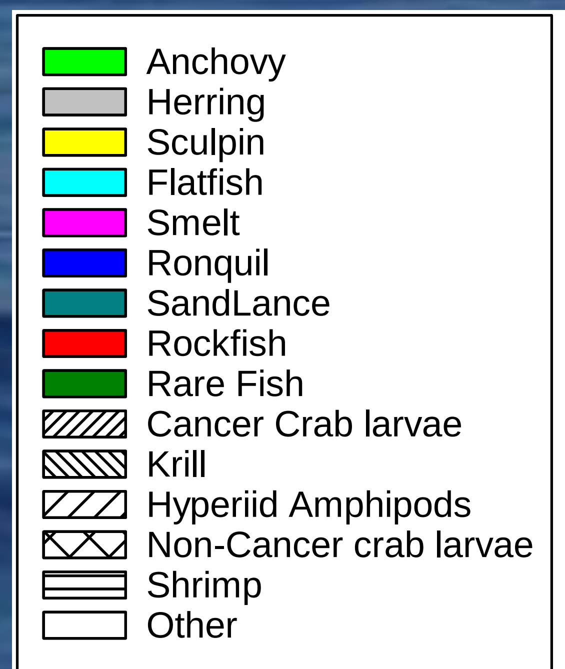
Methods for Sampling: Juvenile salmon Nordic trawl towed at surface

- May: 1999-2012; 2015
- May: no fish in 2005 in small area, no studies in 2013-14
- June: 1998-2015

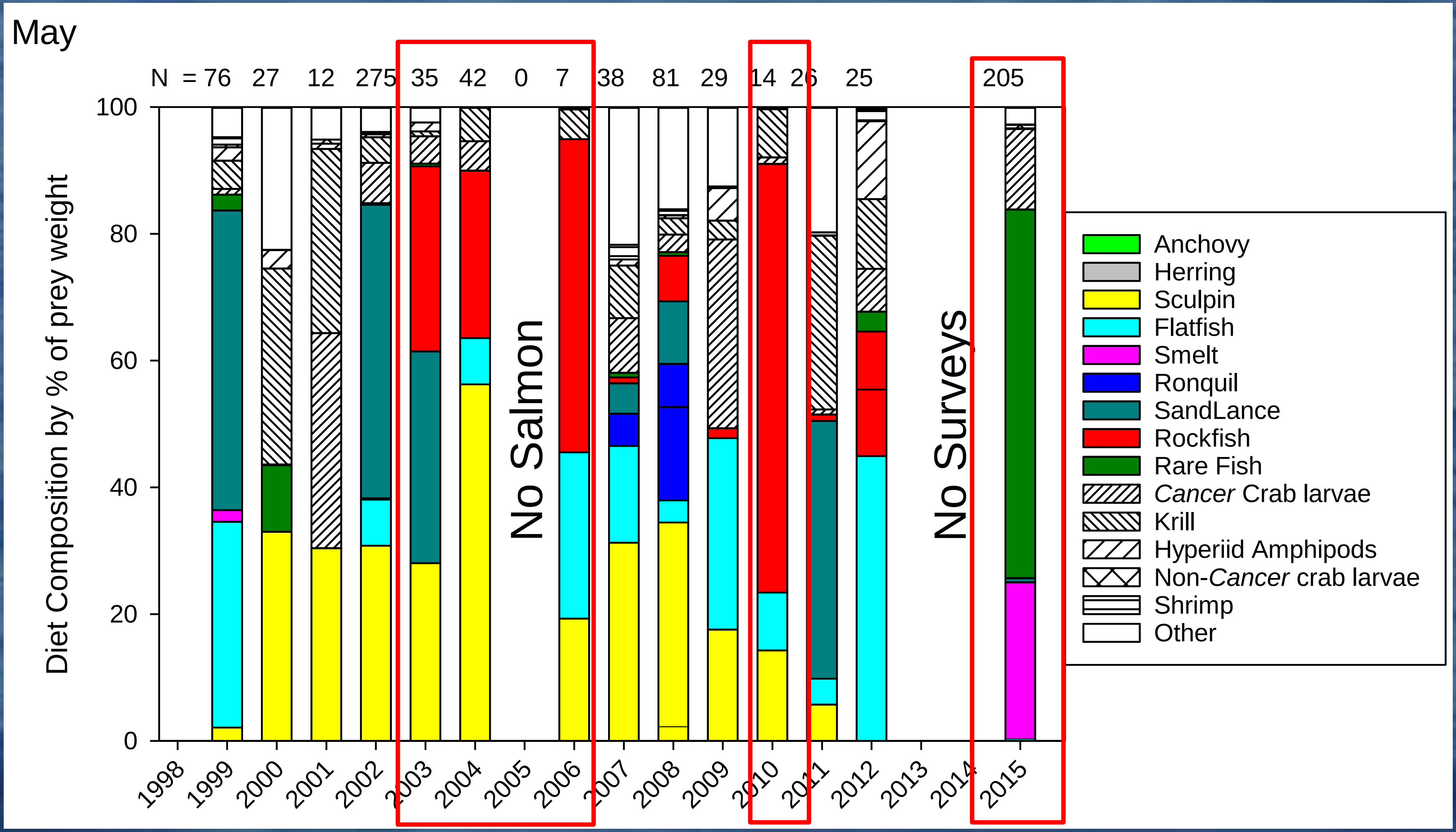


Salmon are frozen at sea, and in the lab they are measured and weighed, and stomachs removed and preserved

Prey analyzed to lowest possible taxonomic level and then grouped into 15 prey categories; Unidentified fish prey re-proportioned to known fish prey



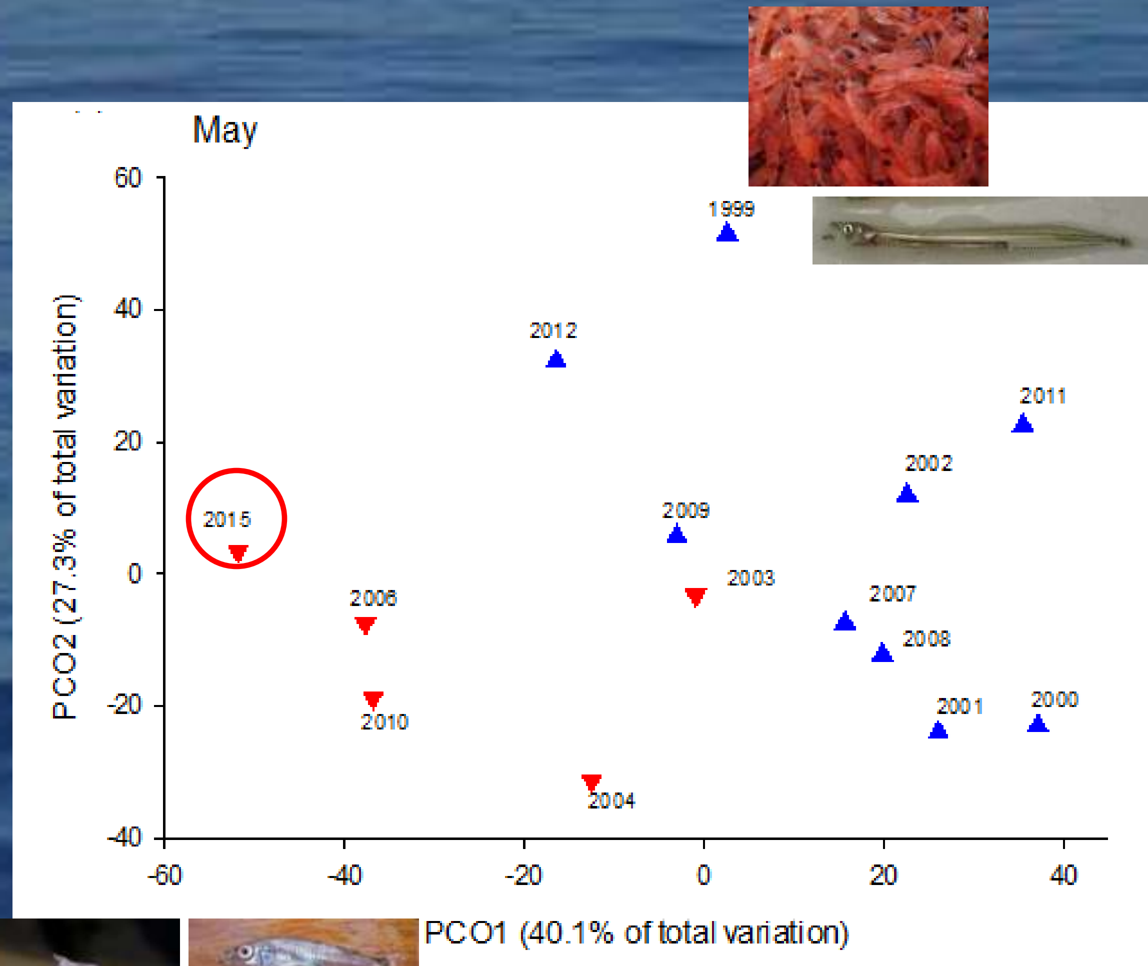
Results: May Diet composition yearling Chinook Salmon



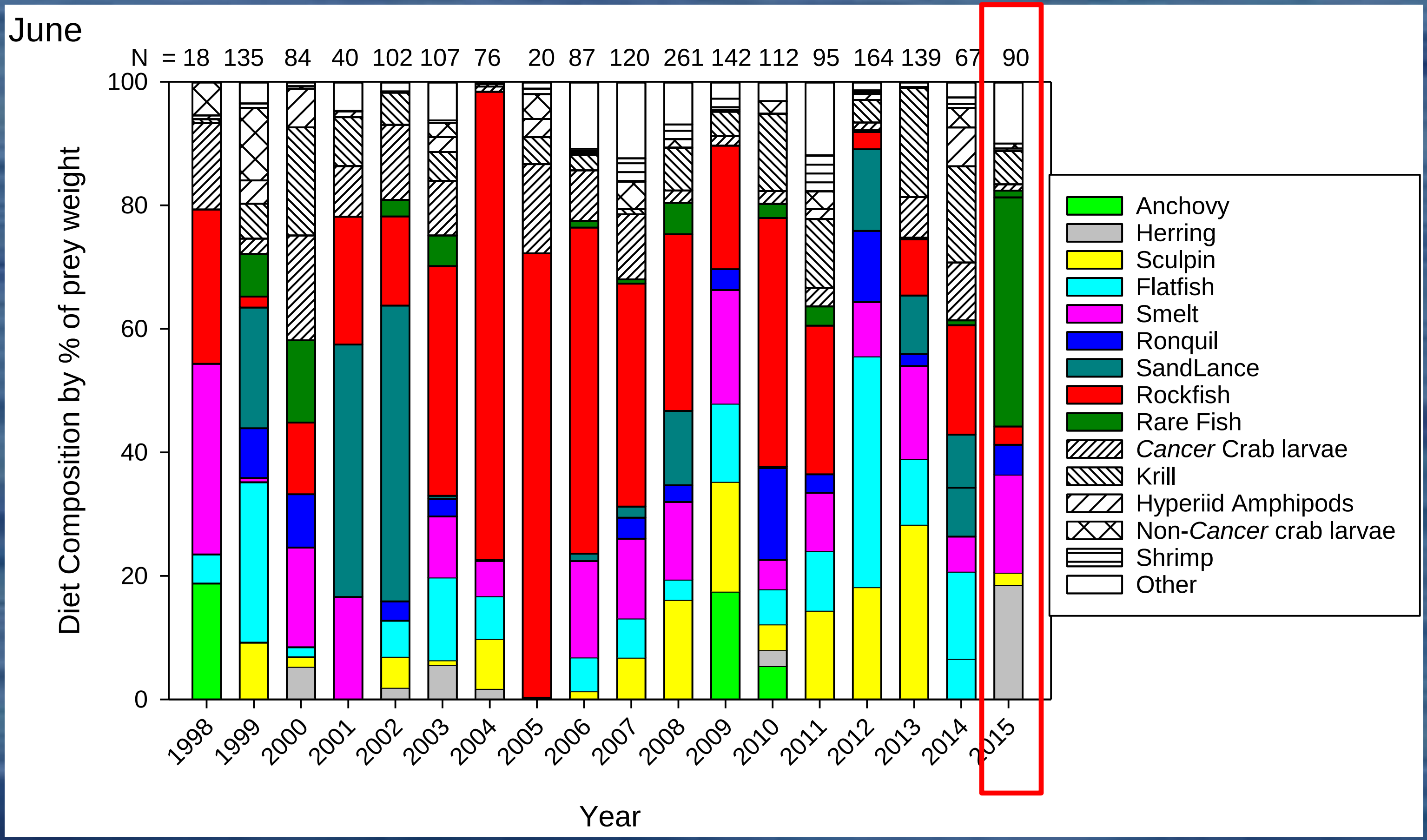
High amounts of juvenile rockfishes, flatfishes and *Cancer* spp. megalopae were eaten in 2015. Diets in 2015 were significantly different than all years except 2010.

Principal Coordinate Analysis of Chinook Salmon Diets (May 1999-2015)

- Significant positive relationship with diet composition predicted by Spring NPGO (p = 0.01; R-sq = 40.3%)



June Diet composition yearling Chinook Salmon

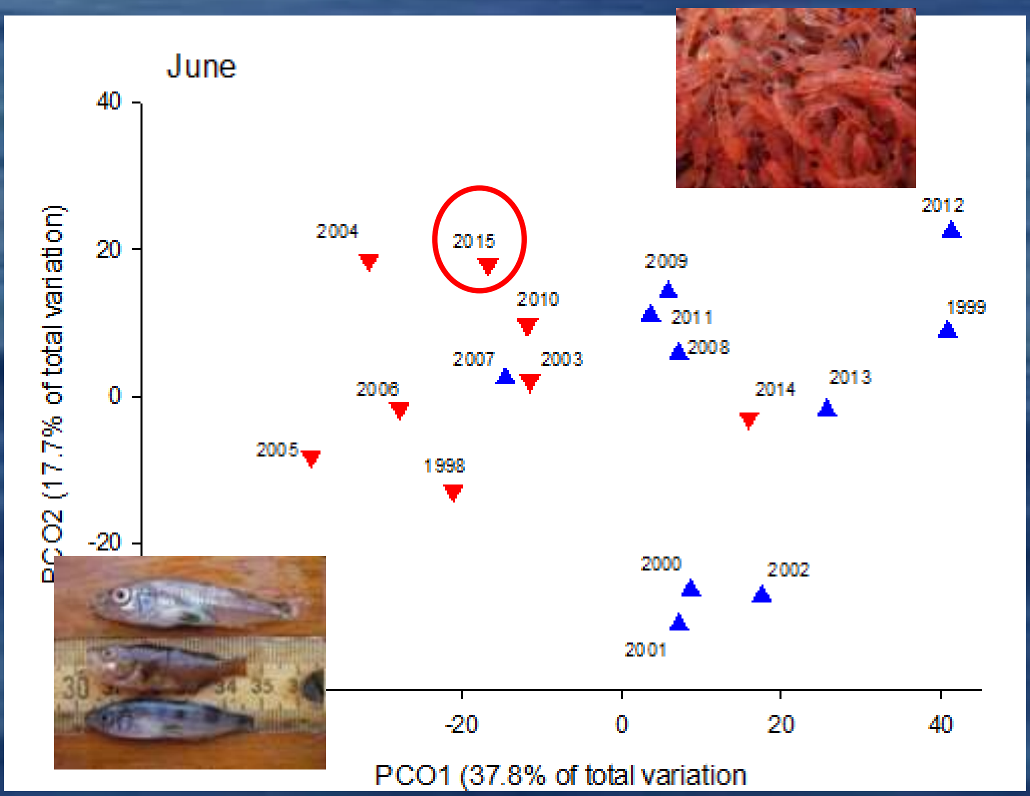


- Chinook salmon ate juvenile rockfishes, anchovies, and flatfishes in June 2015. Diets in 2015 significantly different than 14 other survey years.

Principal Coordinate Analysis of Chinook Salmon Diets (June 1998-2015)

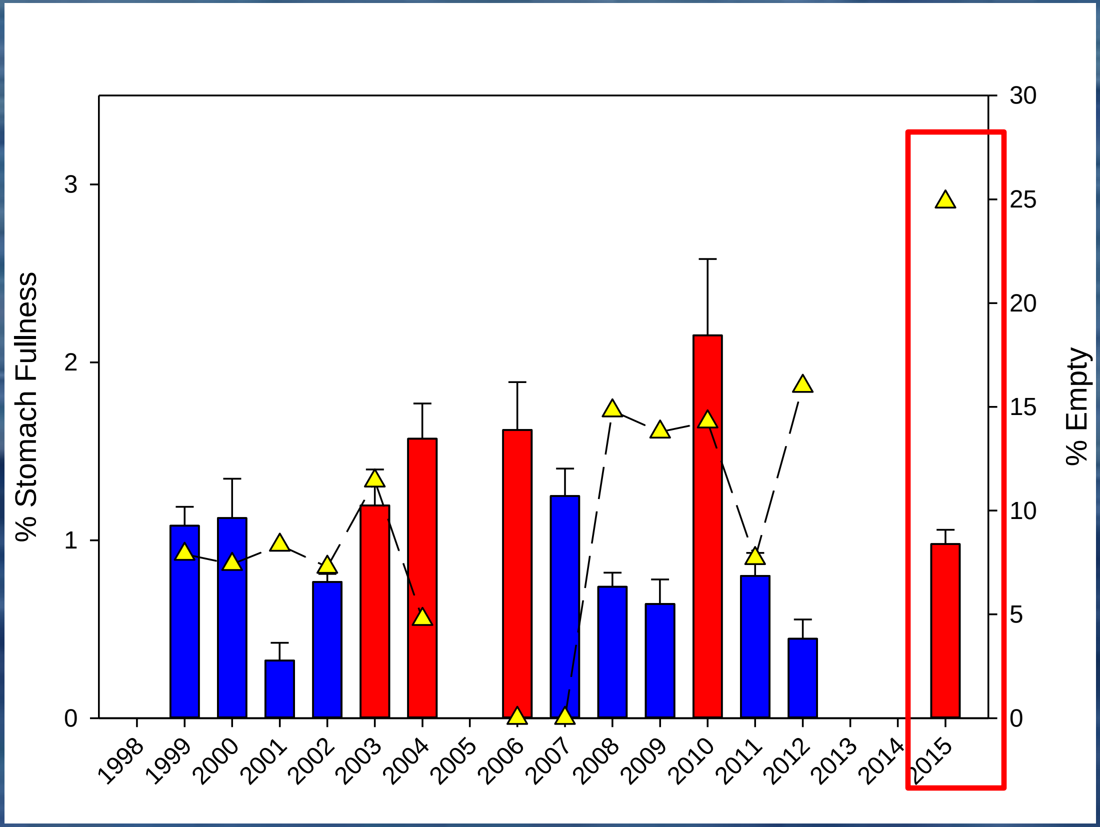
- PDO negatively related to diet ($p = 0.003$; r-sq = 44.0%)
- NPGO is positively related to diet ($p = 0.006$; r-sq = 38.0%)
- Diet composition is positively related to spring Chinook salmon adults returns 2 years later ($p = 0.01$; r-sq = 39.7%)

- Percent of juvenile rockfish in the diets is negatively related to adult returns ($p = 0.004$; r-sq = 47.9%)



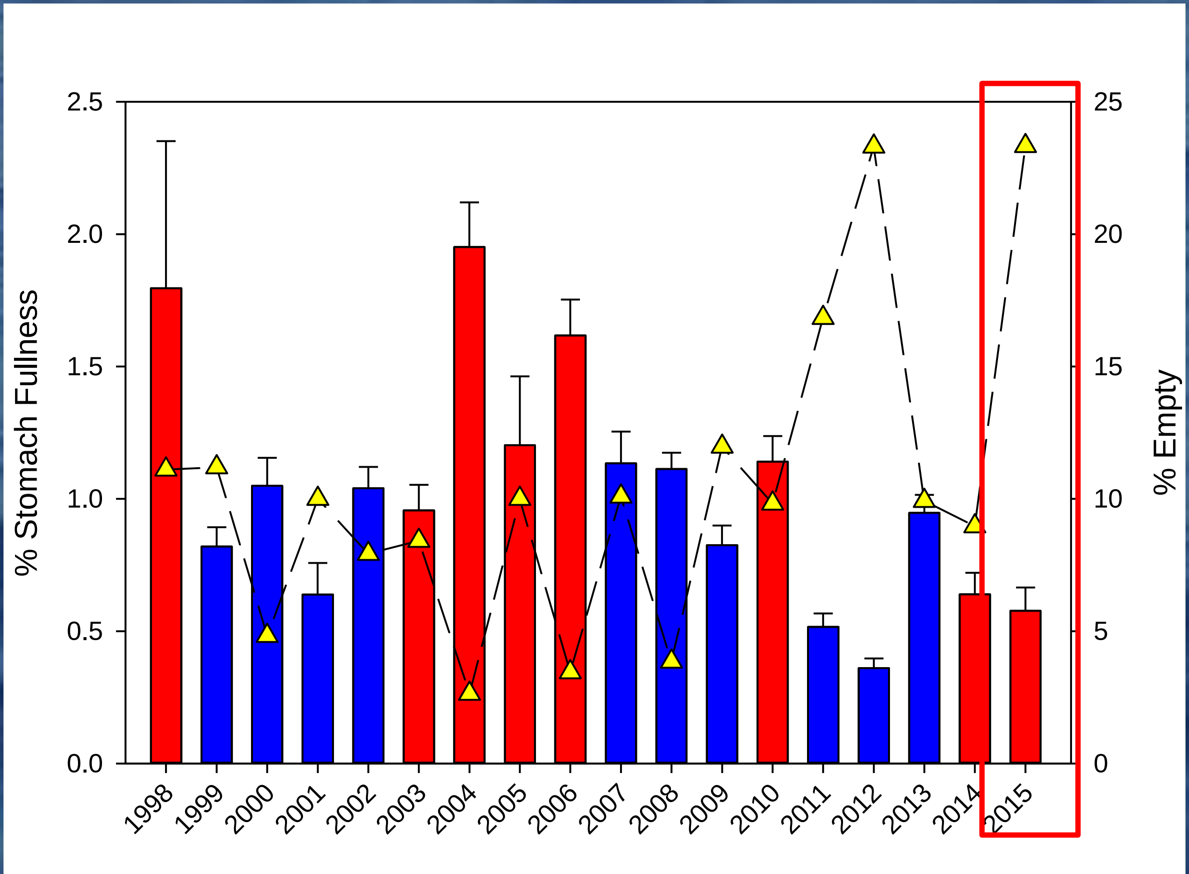
May Stomach Fullness and % Empty

- Stomach fullness average in 2015
- Significant positive relationship with stomach fullness and PDO ($p = 0.04$; R^2-sq = 30.0%)
- Salmon need more food with warmer ocean
- Percentage of empty stomachs in 2015 was highest of time series at 25% empty

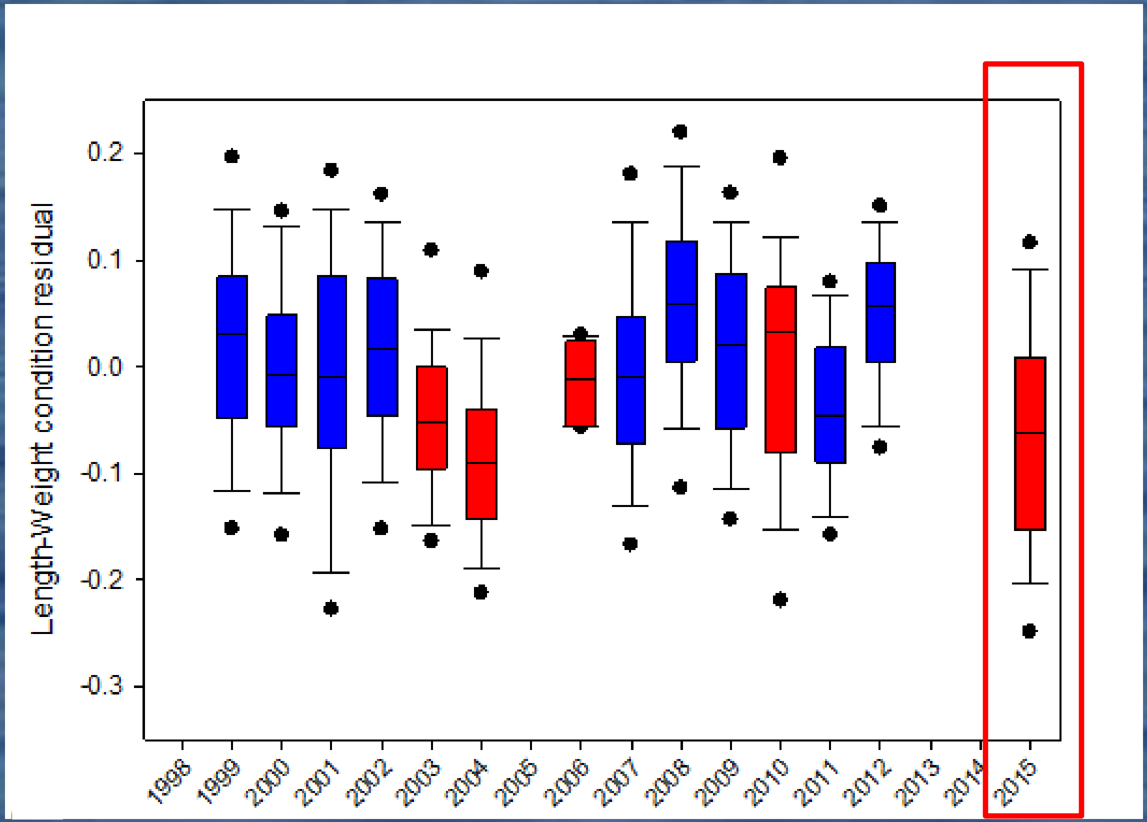


June Stomach Fullness and % Empty

- Average stomach fullness in 2015 was significantly lower than 10 other years
- Percentage of empty stomachs in 2015 was one of the highest of time series at 23% empty



Condition of May Chinook salmon (N = 2186)



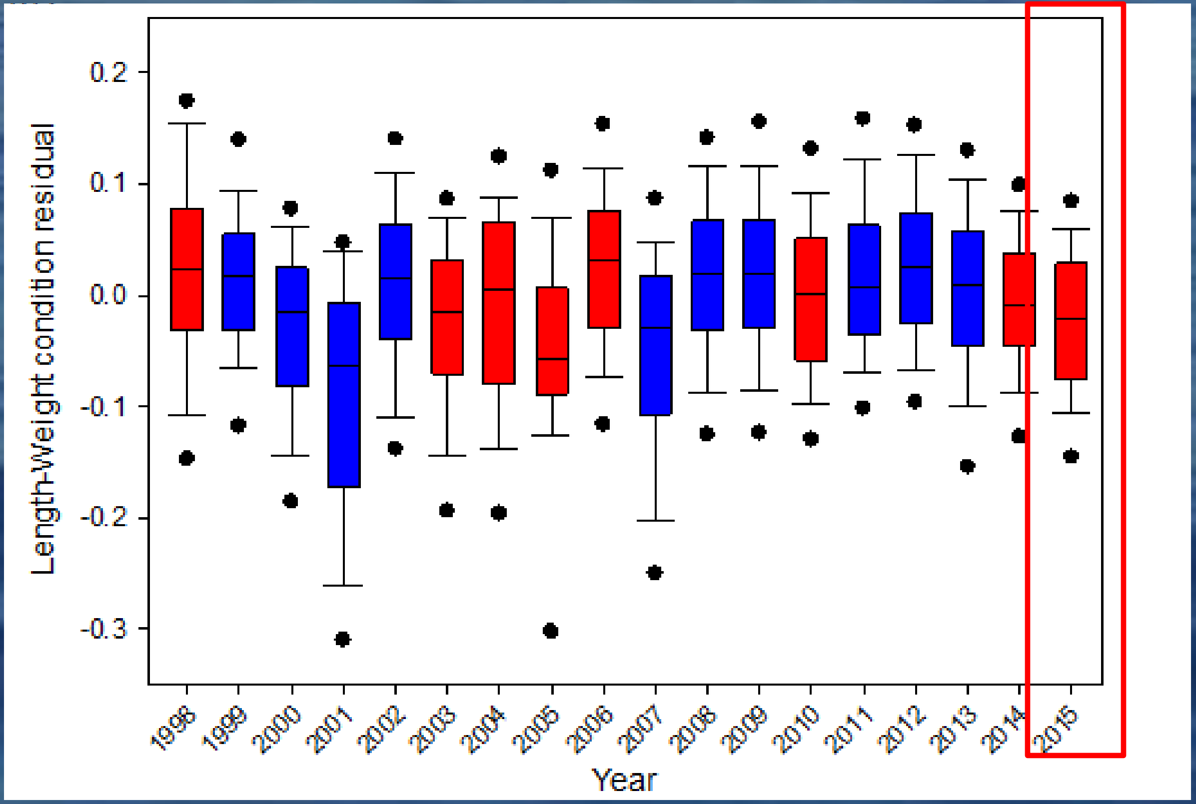
For fish of a narrow size range (148-152 mm), they weighed **17.6% less in 2015** than fish of that length in 2008

- Only fish in 2004 were significantly thinner than salmon in 2015
- Salmon are significantly thinner in May when PDO is positive (P = 0.001; Rsq = 61.0%)

Increased condition in May relates positively to return of adult Chinook salmon (P = 0.006; Rsq = 54.6%)

Chinook salmon Condition in June 2015

- 13th thinnest out of 18 years; only 2 years were significantly thinner (2001 &2007)
- All salmon were in poor condition: Chum, coho, Chinook- yearling & subyearling, and sockeye



High Biomass of northern anchovies in 2015: food for salmon?

- Presence of anchovy larvae in winter has occurred just two other times in 18 year time series; 1998 and 2003
- Biomass in 2015 was ca. 100x higher any other year
- Larvae and eggs present off Newport Feb-Oct 2015
- Growth of juvenile salmon can be higher with warmer temperatures if there are sufficient food resources, but this was not observed in 2015
- Salmon in May did not appear to eat anchovies, and low amounts were eaten in June 2015

Summary: 2015

- In 2015, the PDO was quite positive, and the NPGO was negative indicating ocean conditions that were warm and less productive
- There was a high biomass of ichthyoplankton, but of warm ocean taxa predicting both high and low returns of salmon
- Salmon diet composition was of warm ocean taxa predicting low returns
- High numbers of empty stomachs indicating low food conditions
- Salmon were thin in 2015 predicting low returns
- Salmon did not seem to take advantage of an early spawning of northern anchovies as a food source

Acknowledgments

Funding and resources provided by:

- Bonneville Power Administration (BPA)
- National Oceanic and Atmospheric Administration
- Cooperative Institute for Marine Resources Studies

We are indebted to past sorters, innumerable boat crews, and all those that assist the project in many different ways!

BONNEVILLE POWER ADMINISTRATION

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

Any questions or comments?

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