Warming ocean conditions relate to changes in salmon prey field and juvenile salmon trophic requirements

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CIMRS

NOAA

Bonneville POWER ADMINISTRATION

We study the early marine growth period of juvenile salmon which has been shown to be critical for their survival to return as adults

- Juvenile salmon primarily out-migrate in spring-early summer and return several years later as adults

Figure updated from Weitkamp et al. 2012

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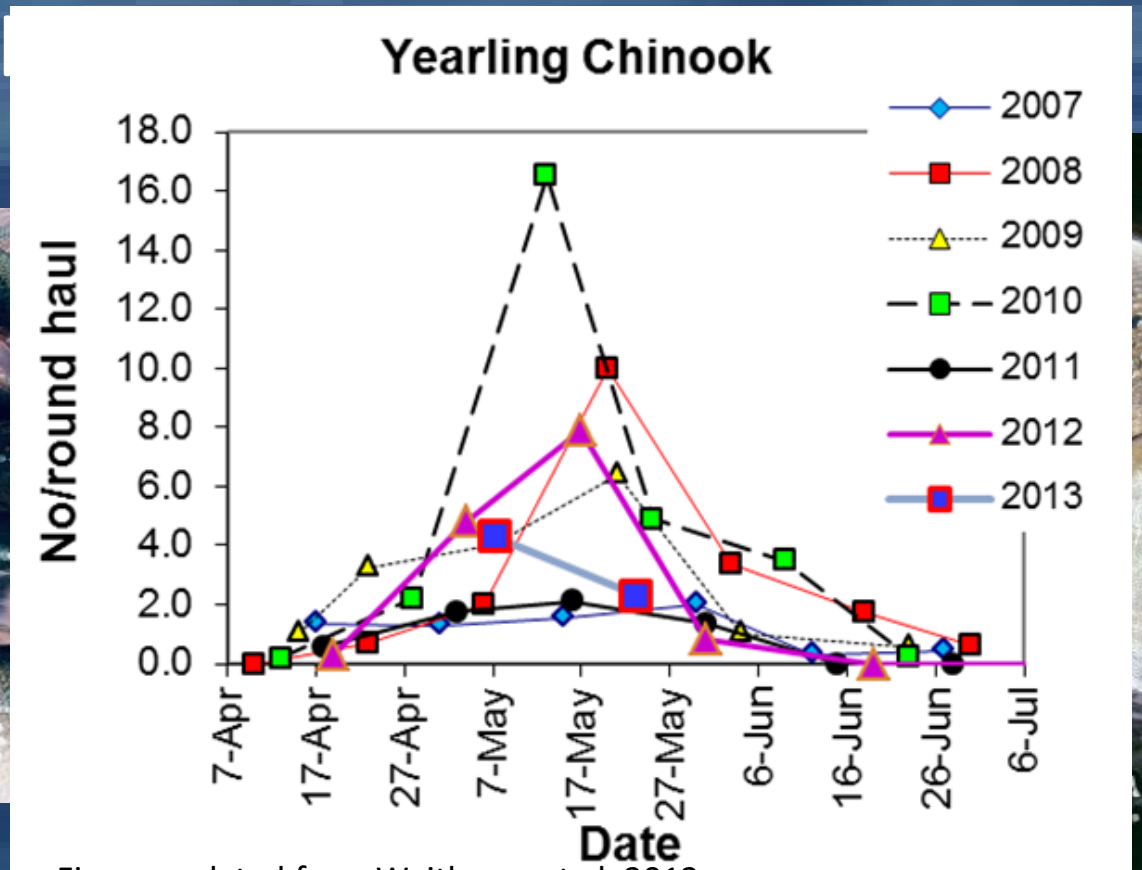

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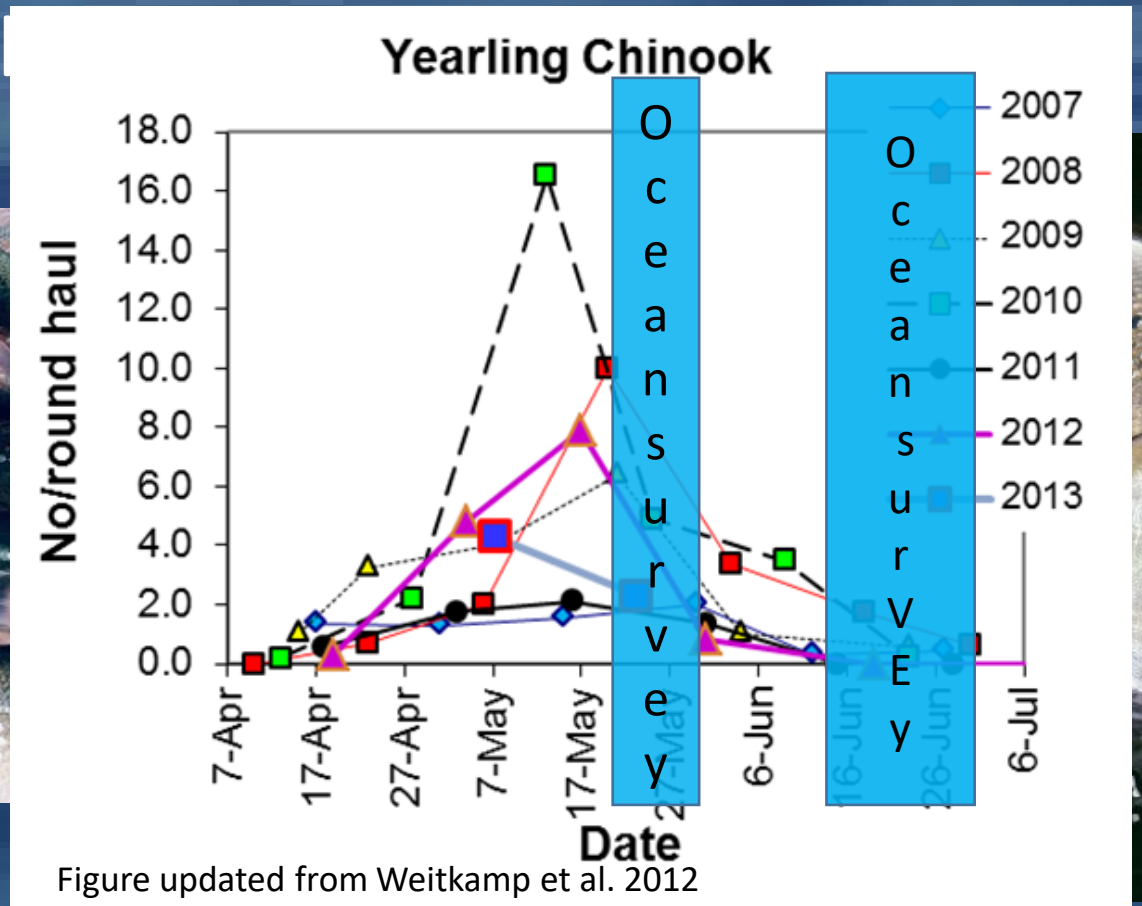

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Juvenile salmon ocean ecosystem survey (JSOES) 1998-current (23-yr time series)

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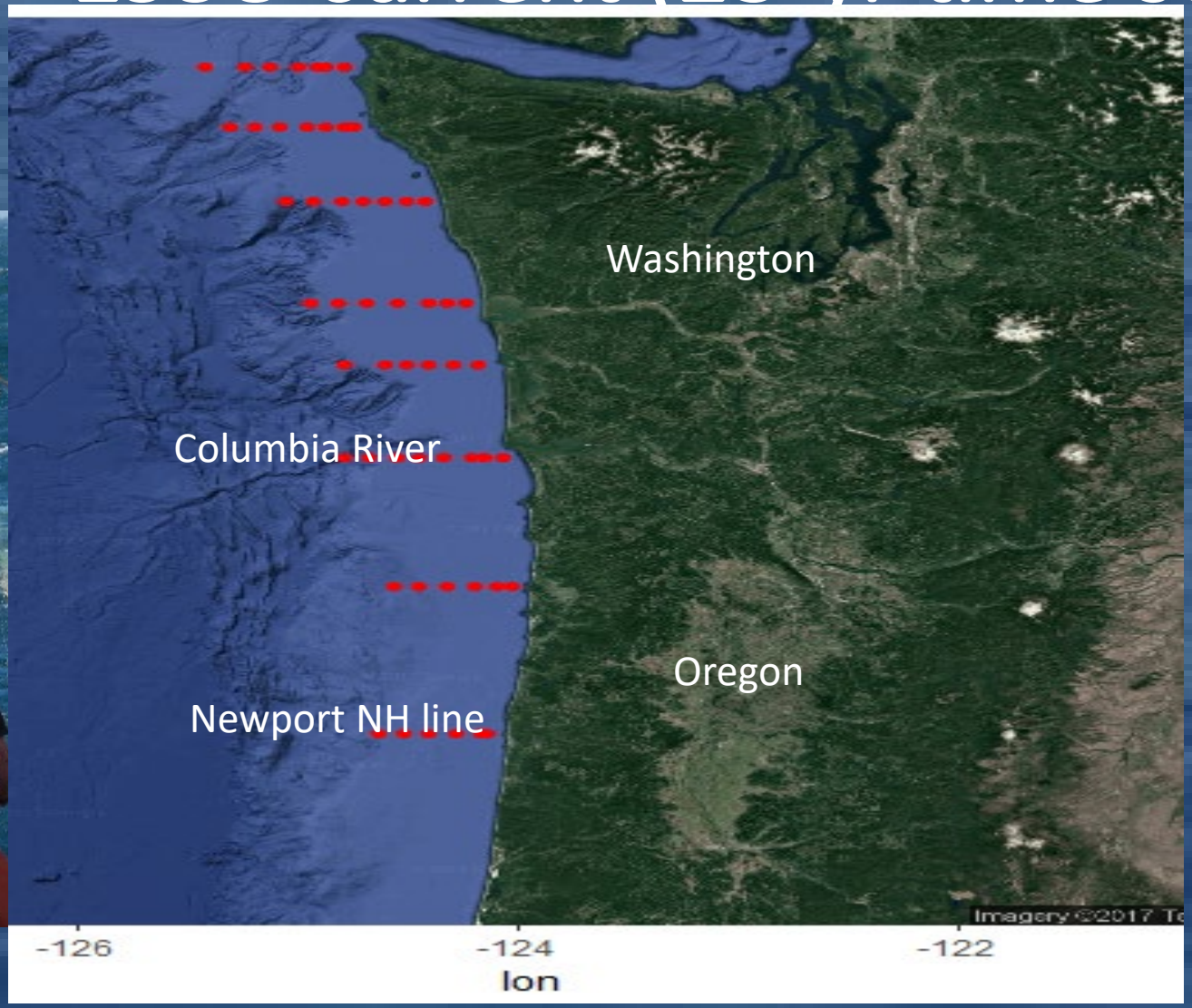
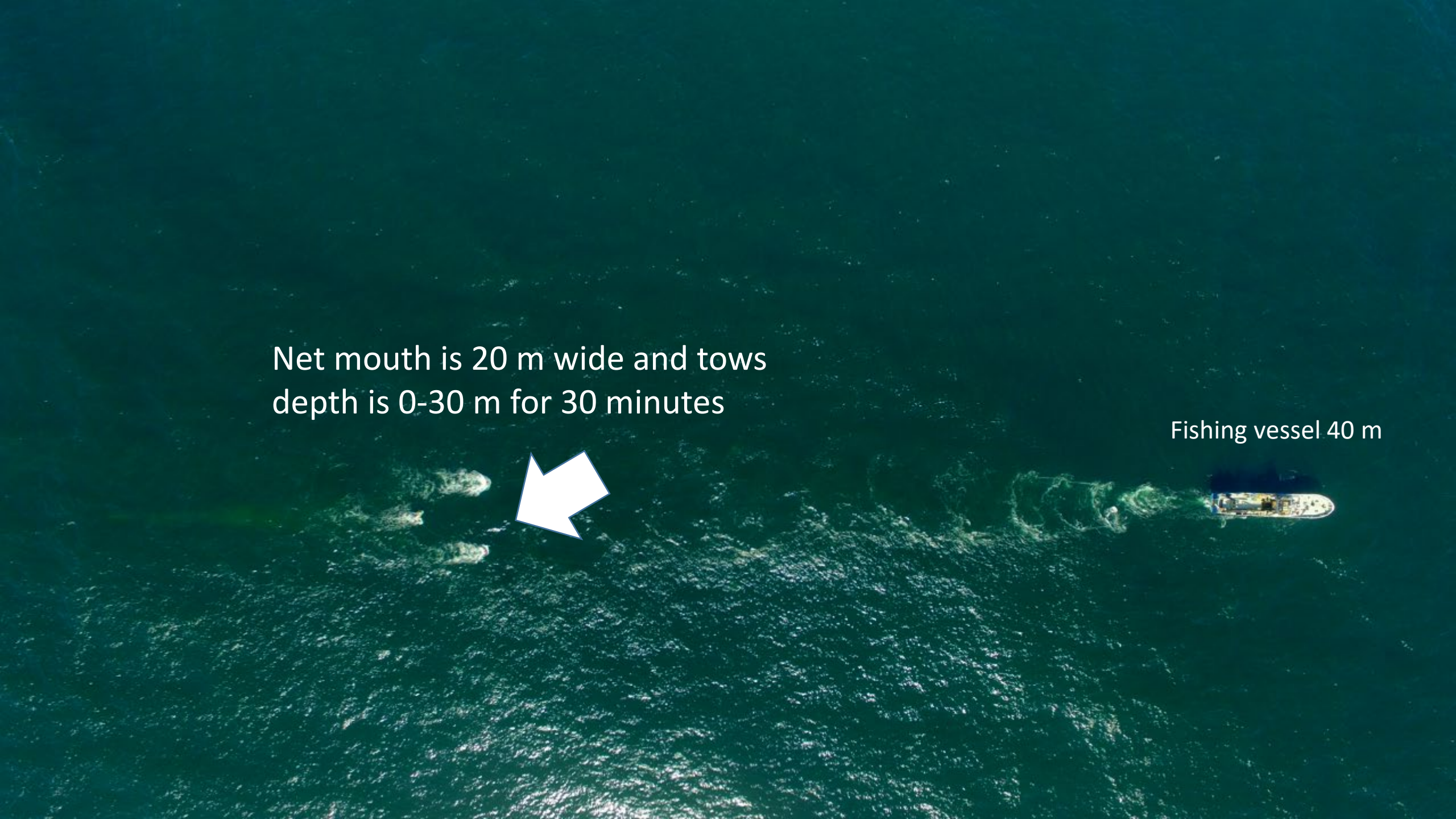



Net mouth is 20 m wide and tows
depth is 0-30 m for 30 minutes
Fishing vessel 40 m

Ne
de

Juvenile salmon are collected for:

- Diet and genetic analysis
- Size, marked/unmarked, distribution, prey, and growth metrics

Oceanographic conditions

All non-target catch is quantified (nekton, jellyfish, predatory fishes etc.)

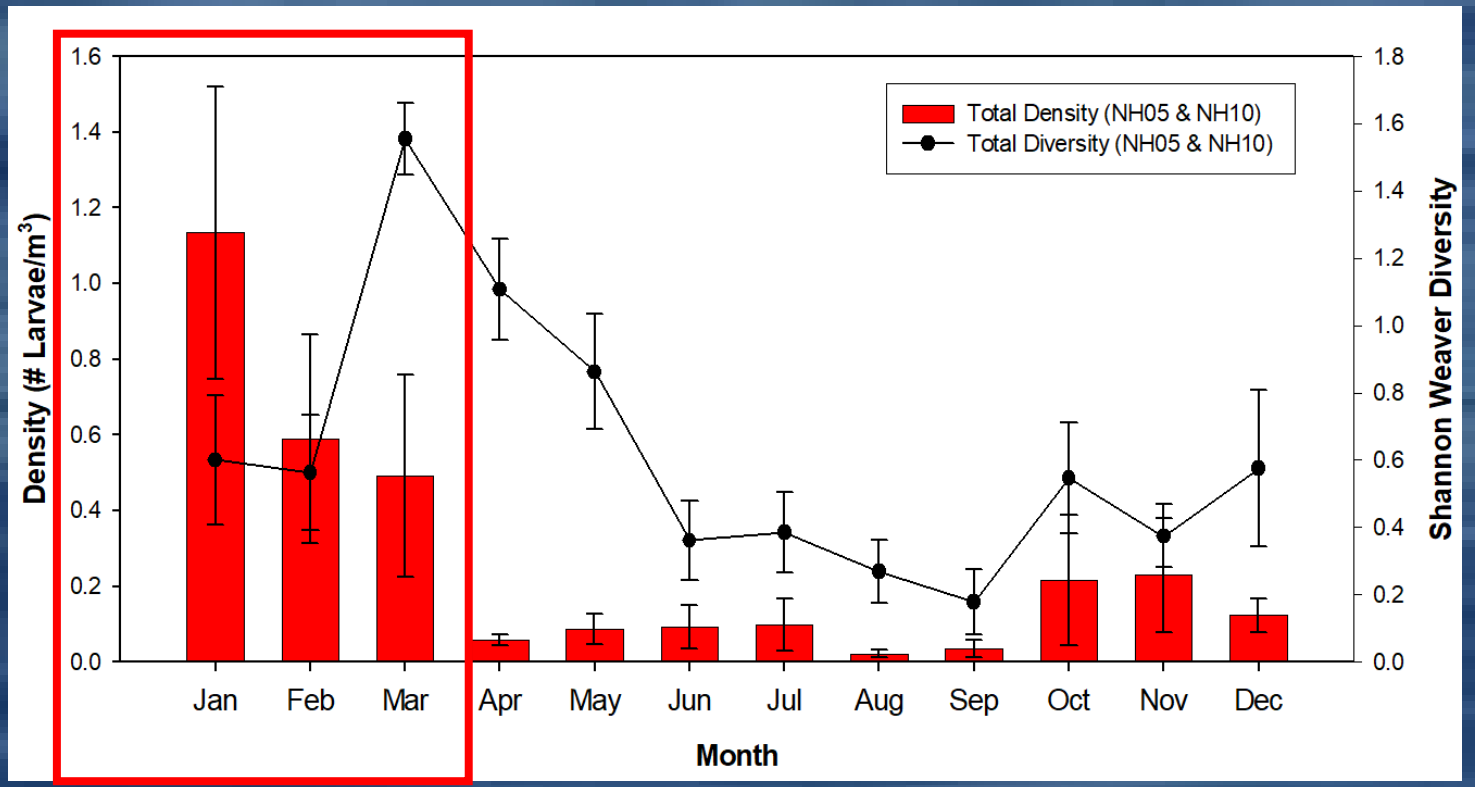
Visually survey quantifying sea birds and marine mammal

Fishing vessel 40 m

Marine prey of juvenile salmon

- Chinook and coho salmon and steelhead are highly piscivorous when they first enter the ocean
- Winter-spawned fish larvae grow to be the age-0 juvenile fish that are eaten by salmon (and various other marine fish and seabirds) during spring and summer.
- Direct sampling of age-0 juvenile fish prey is challenging

Winter-spawned fish larvae sampled from Newport Hydrographic line

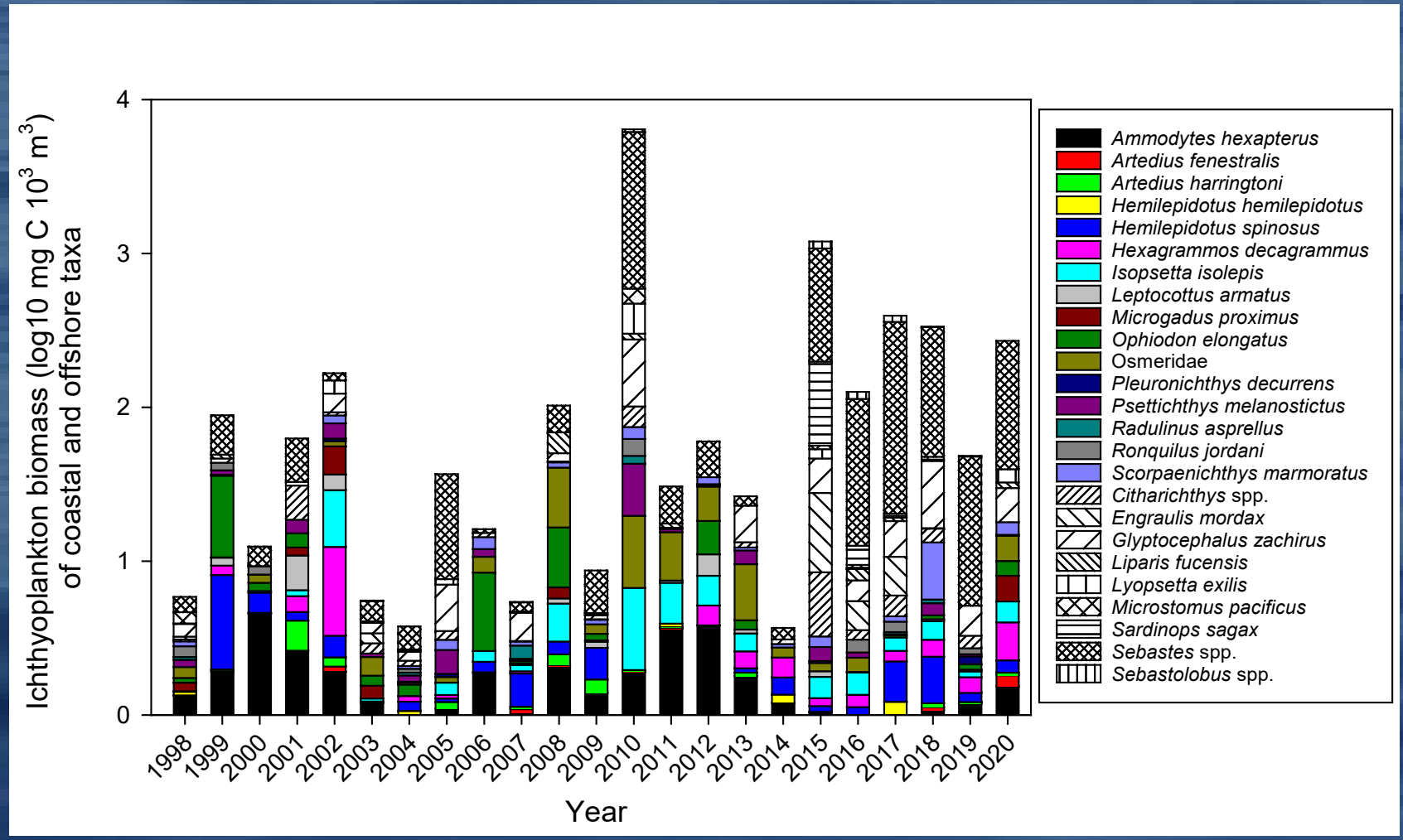


Smelt
Sandlance
Anchovy

Flatfish
Sculpins
Rockfish
Greenlings
Gadids
Ronquils

Brodeur et al. (2008) MEPS

Index of marine food conditions : Winter ichthyoplankton



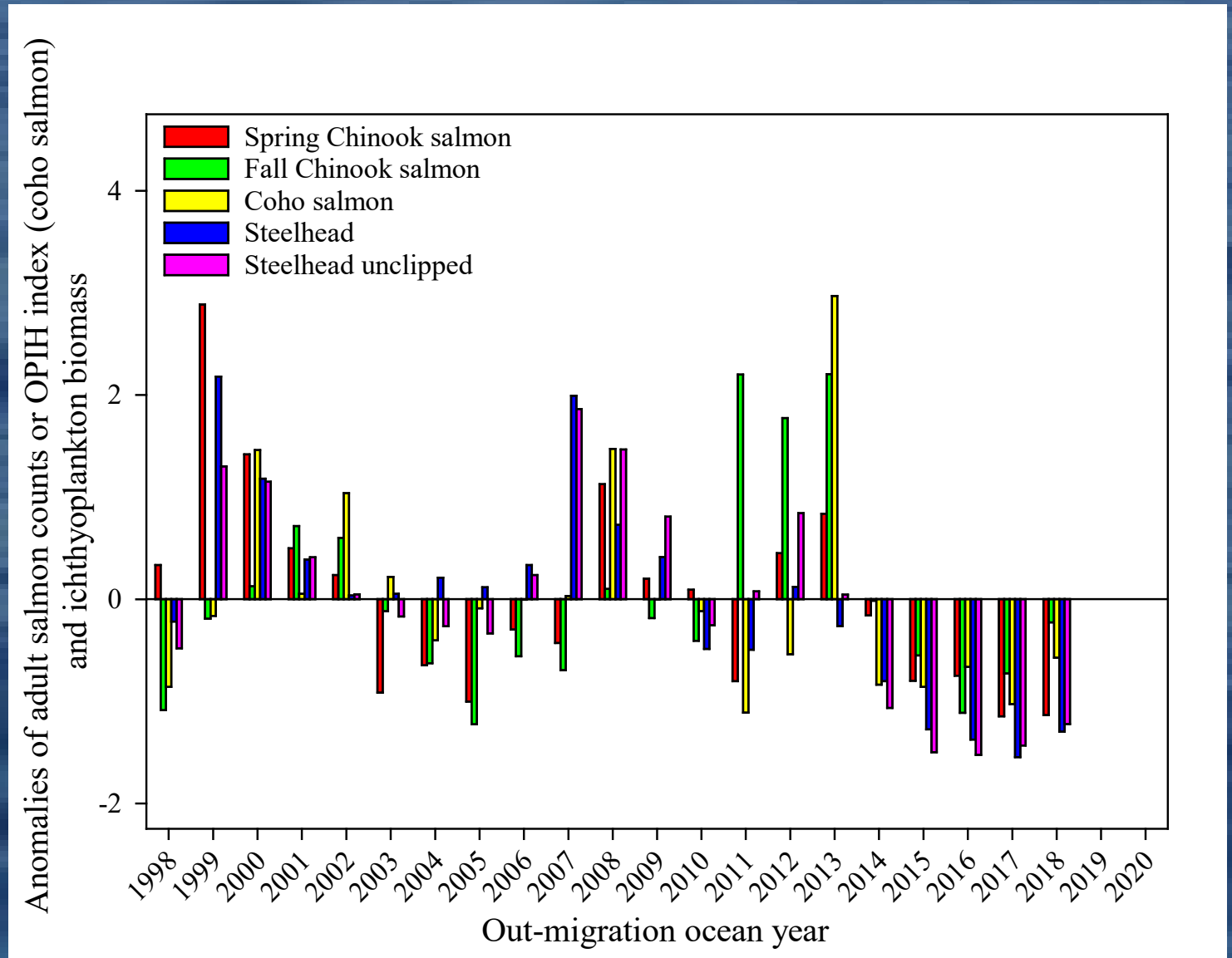
- Comprised of fish taxa that salmon are know to consume
- The coastal taxa make up the Index of Coastal Prey Biomass (ICPB): the taxa in filled color of bar plot
- The community composition of the winter ichthyoplankton also are important for salmon

Relating outmigration year ocean conditions to adult salmon returns at Bonneville Dam using lagged data

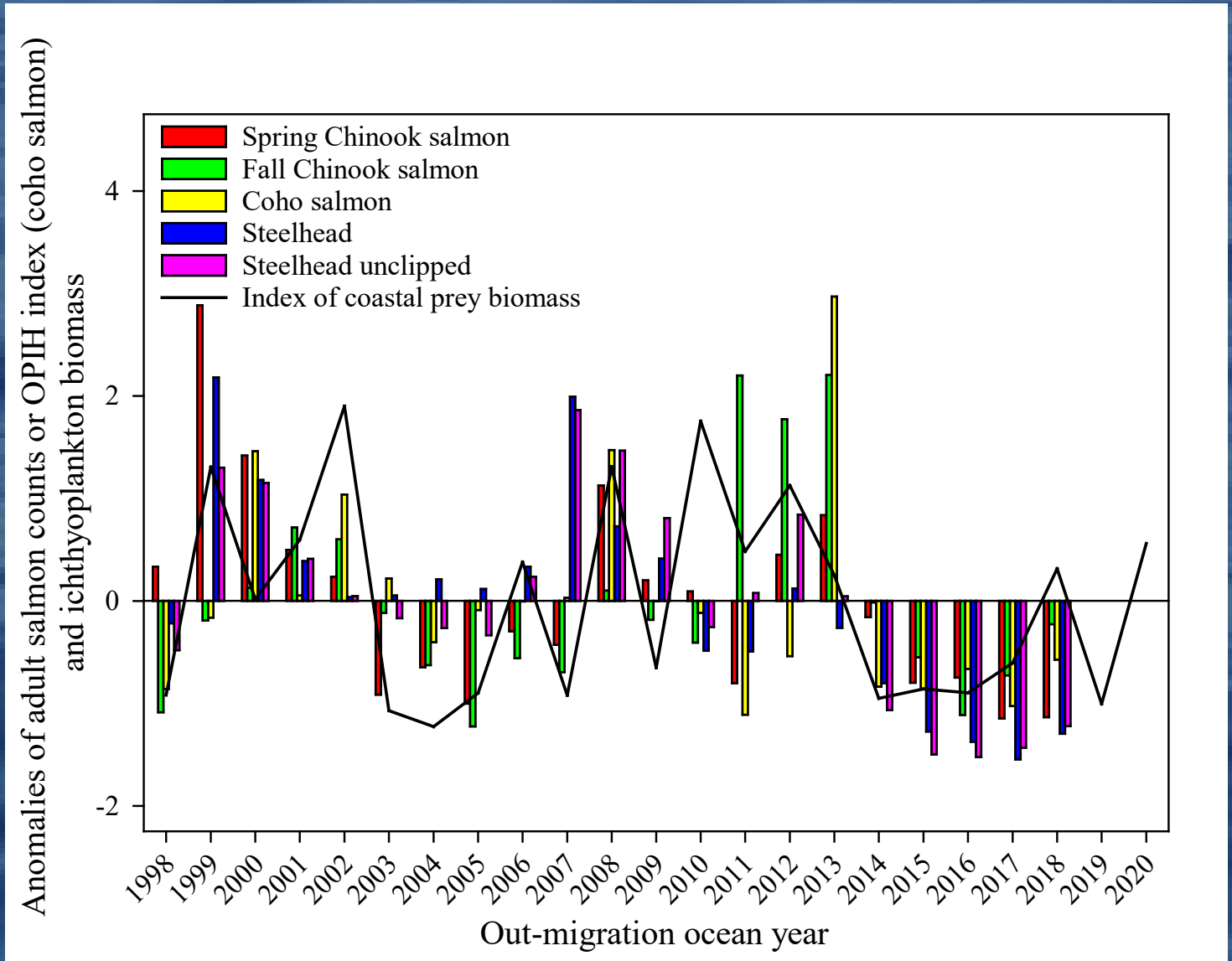
- Coho salmon return after 1 ocean year so return data is lagged by 1 year
- From CRITFC Technical Reports
  - Spring Chinook salmon adult counts are lagged 2 years
  - Fall Chinook salmon return roughly equally at year 2 or year 3 ocean year- adult counts lagged 2 years
  - Steelhead return roughly equally at year 1 or year 2 ocean year- adult counts lagged 2 years

Returns of adult salmon (lagged) have uniformly been poor since the 2014 ocean outmigration.

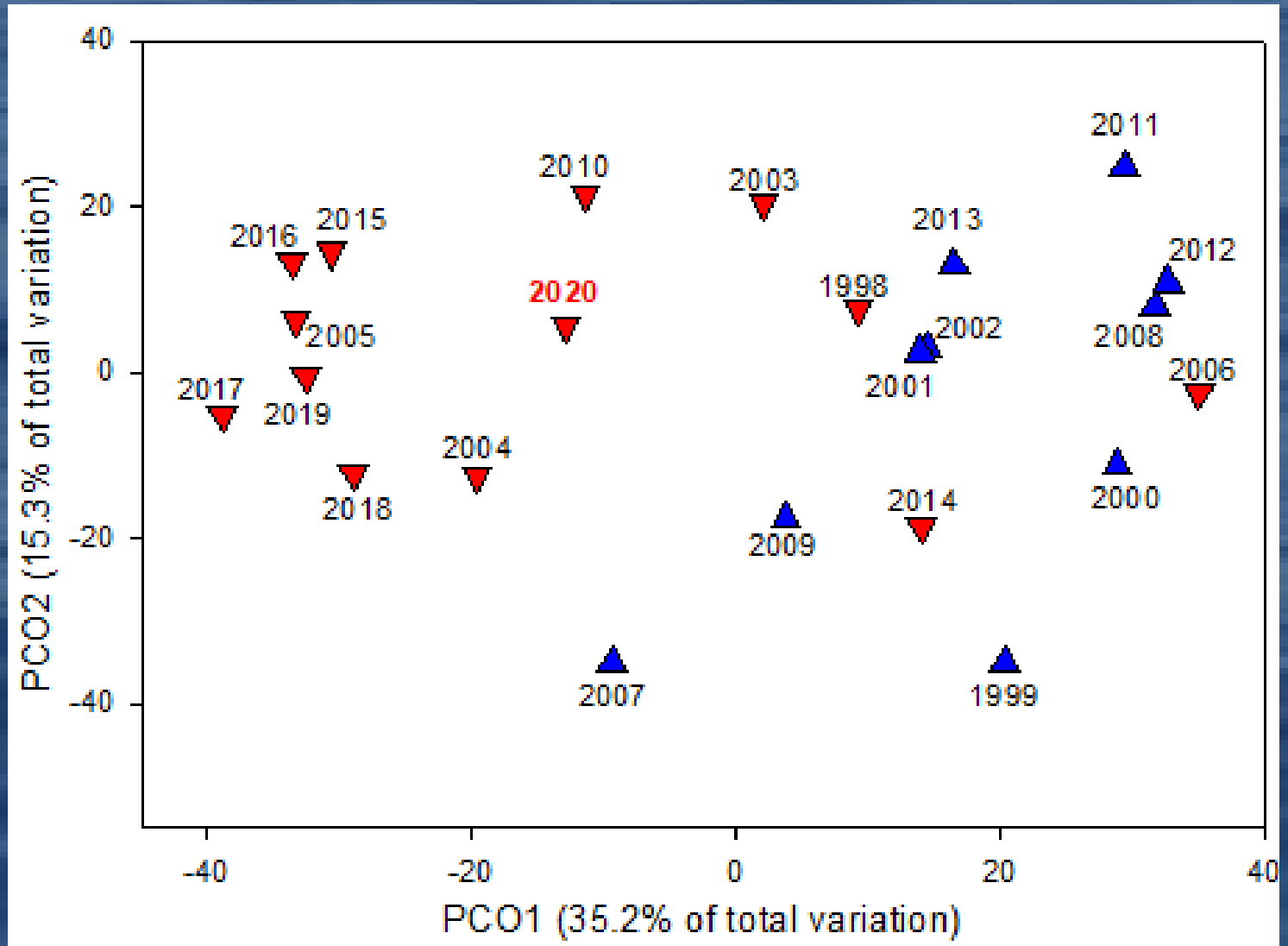
Anomaly plot



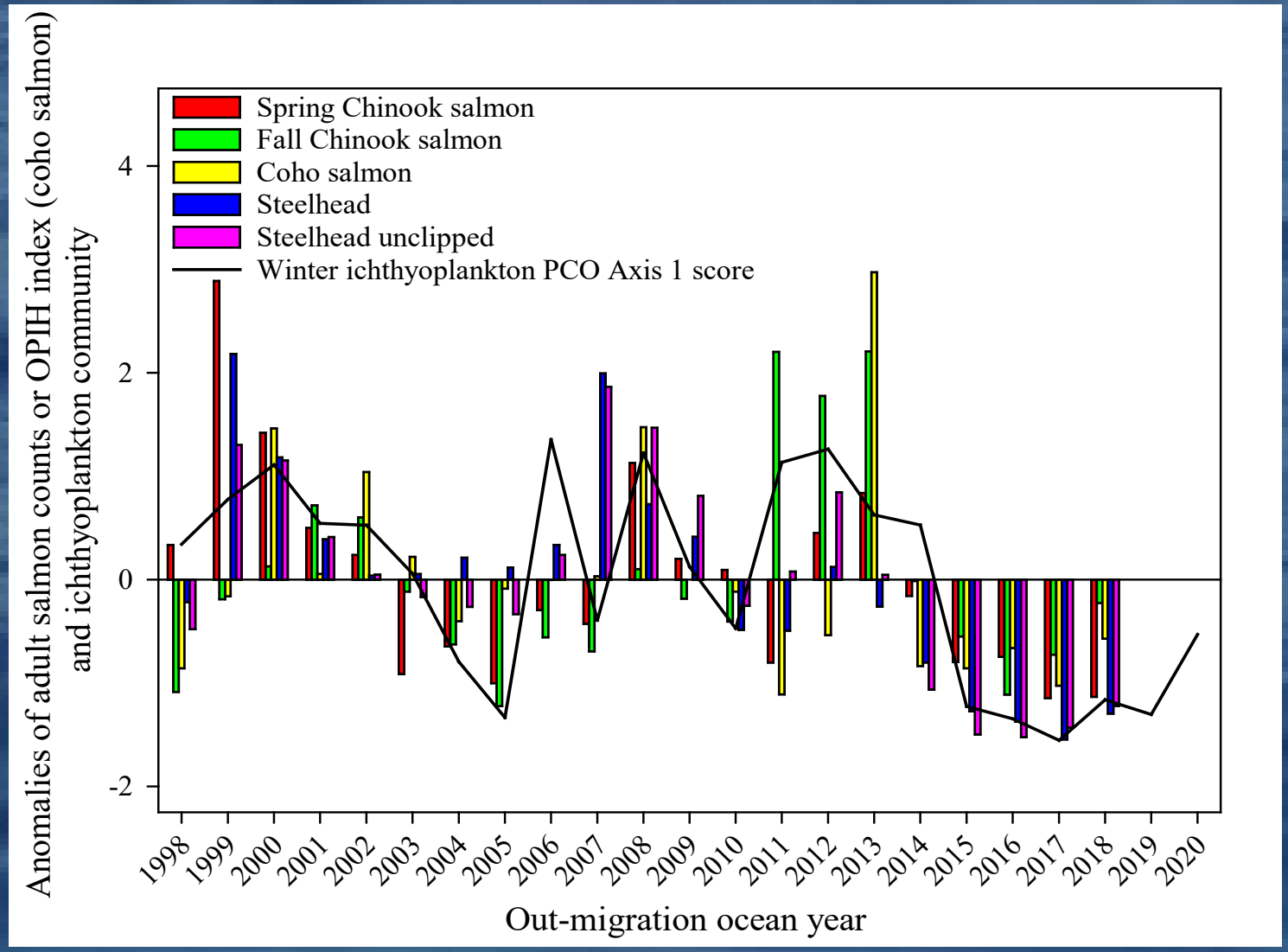
Lagged adult returns and amount of food biomass during early marine period



Food conditions for juvenile salmon: winter ichthyoplankton community composition

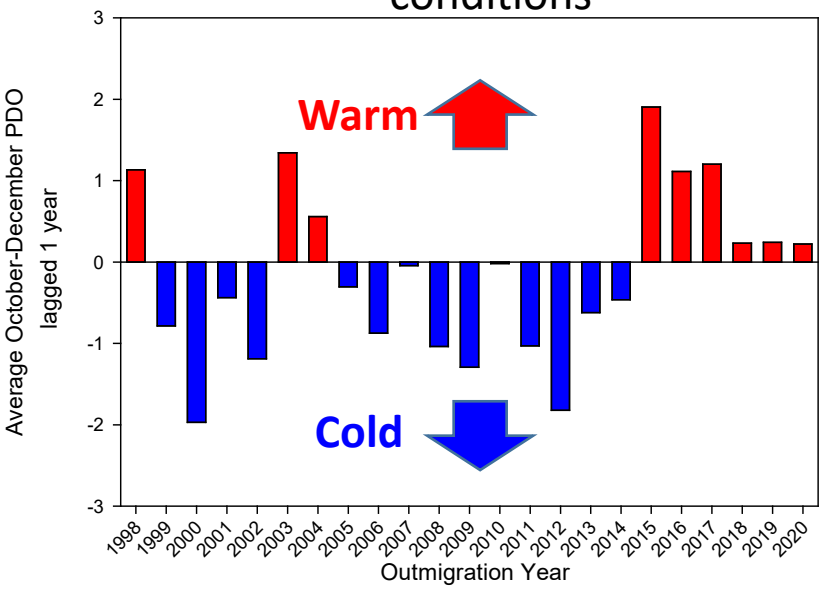


Lagged adult returns and ichthyoplankton community during early marine period

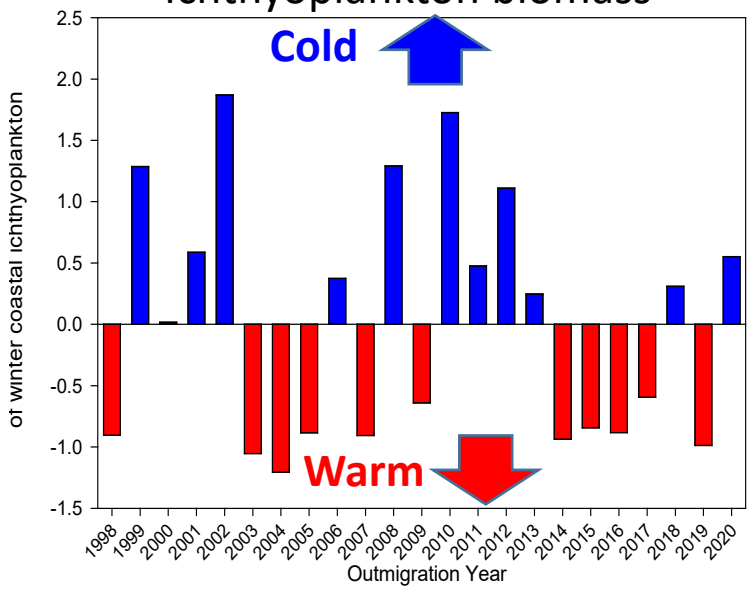


Winter ichthyoplankton biomass and community relate to ocean conditions in prior fall/winter of the outmigration year

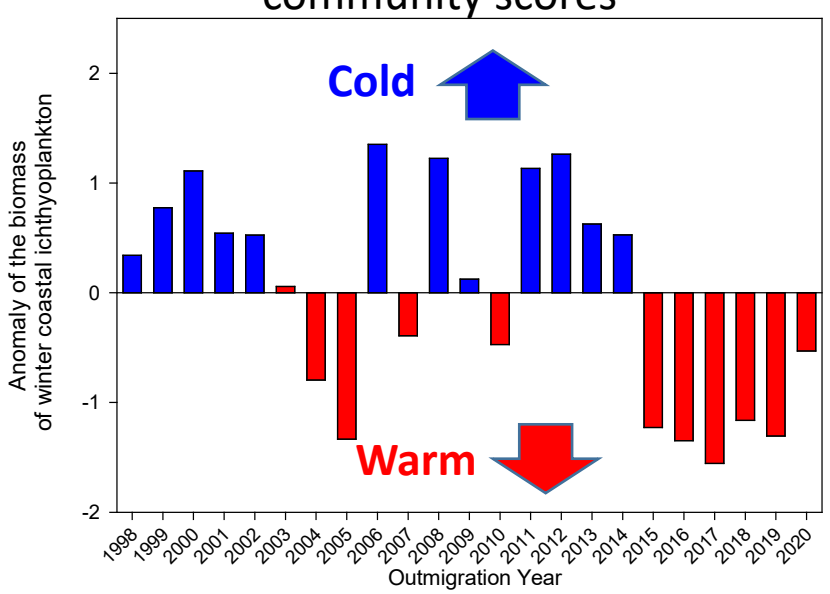
Prior year October-December PDO conditions



Winter coastal Ichthyoplankton biomass

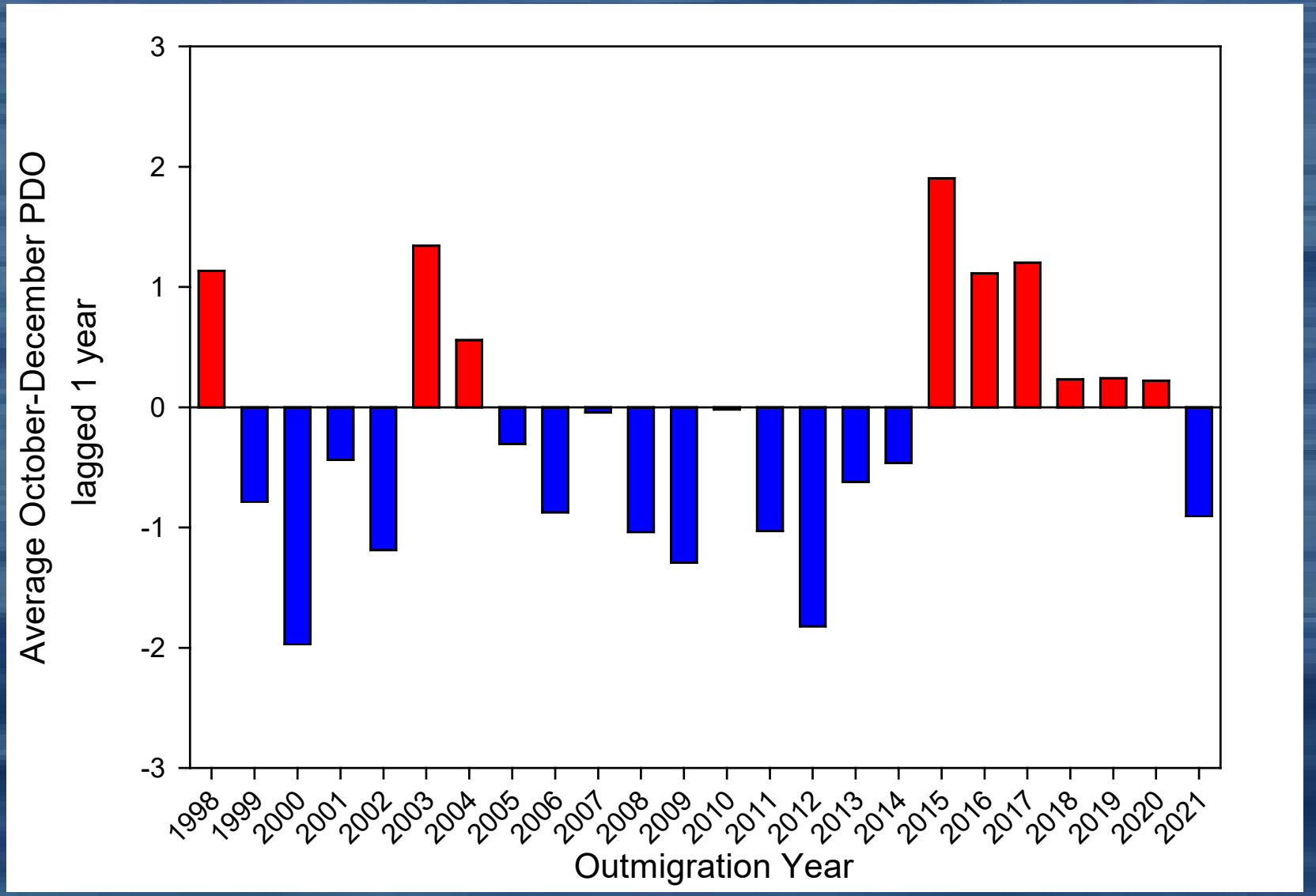


Winter ichthyoplankton community scores

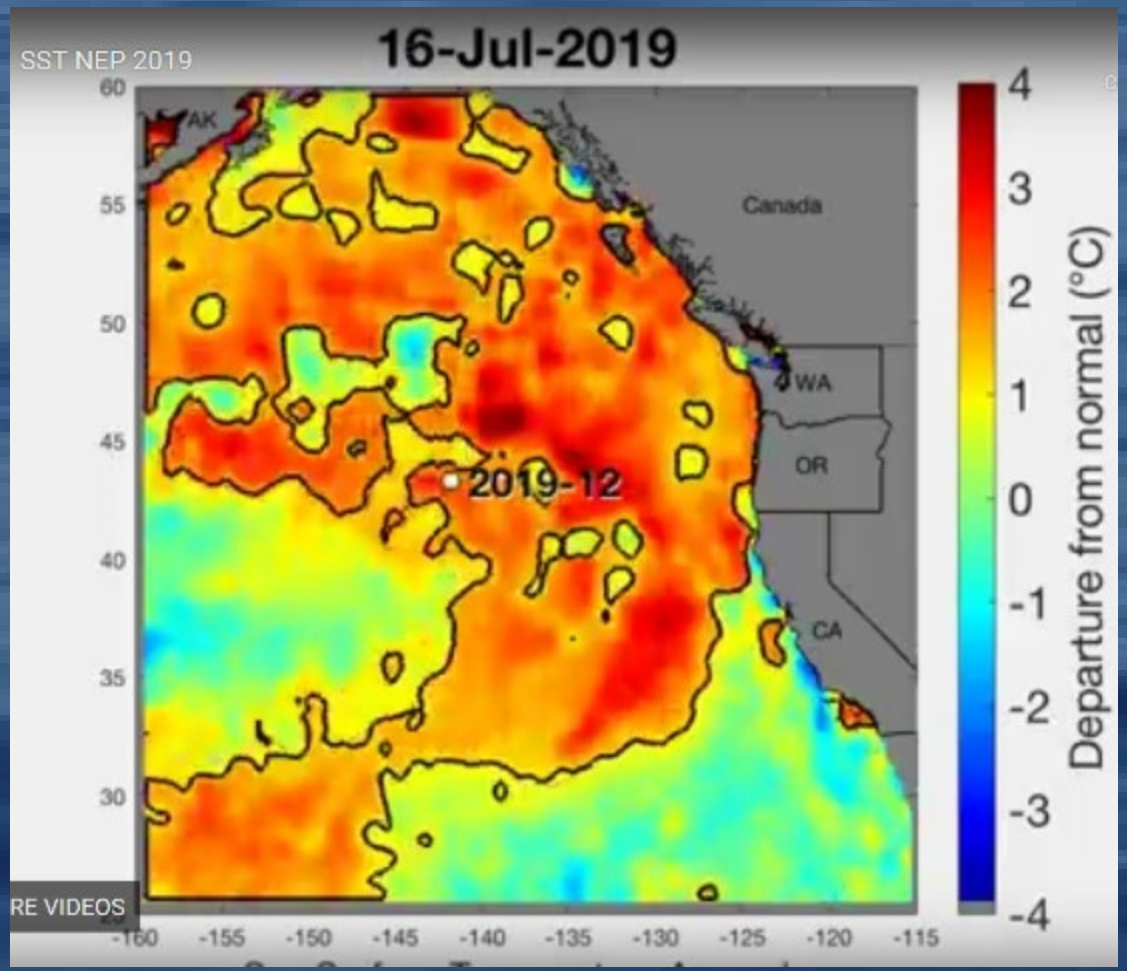


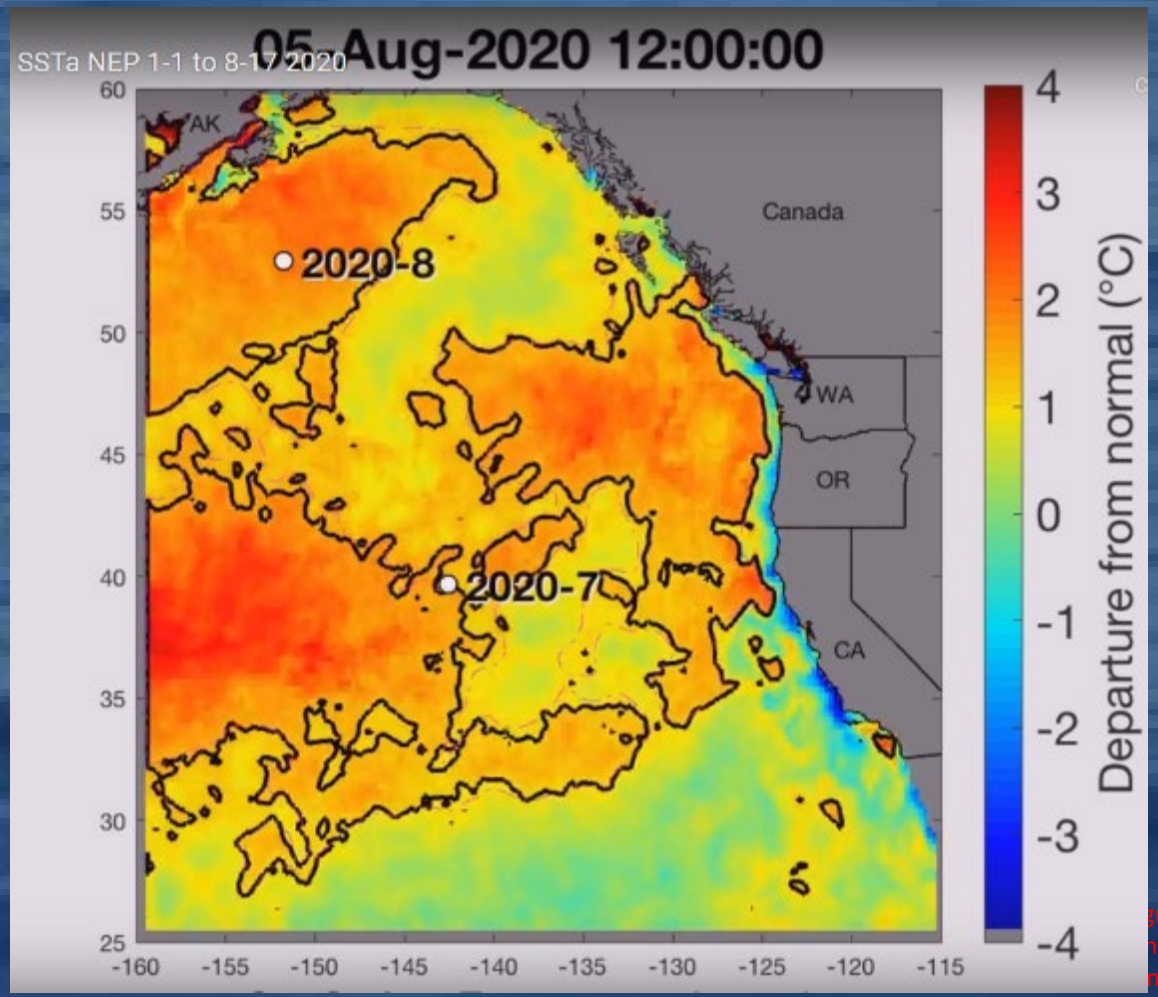
2021 outmigration ocean conditions: Colder?

Oct-Dec 2020 ocean conditions were colder that it has been in years-



Marine Heatwaves have developed each summer since 2014- including 2020





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During warmer ocean conditions juvenile Chinook salmon consume ~ 30% more food and are more piscivorous yet are smaller, thinner, and return as adults in lower numbers

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Anomalous ocean conditions in 2015: impacts on spring Chinook salmon and their prey field

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[1]Cooperative Institution for M
[2]Fish Ecology Division, Northw
[3]Pacific State

ABSTRACT: In the northe
tshawytscha that return as
natural-origin fish listed u
tions persisted in the Cali
period when fish prey reso
ocean. The biomass of icht
(1998–2015), predicting g
years later. The larval com
the warm-water taxa nort
composition of ichthyopla
poor returns of salmon. Ma
high proportions of juveni
bled those of other warm
sumed, predicting poor re
achs and were small and t
a cold year (2008). Lower
adult salmon. Overall, al
prospects for the 2015 oce

PLOS ONE

RESEARCH ARTICLE

Warming Ocean Conditions Relate to Increased Trophic Requirements of Threatened and Endangered Salmon

Elizabeth A. Daly[1]*, Richard D. Brodeur[2]

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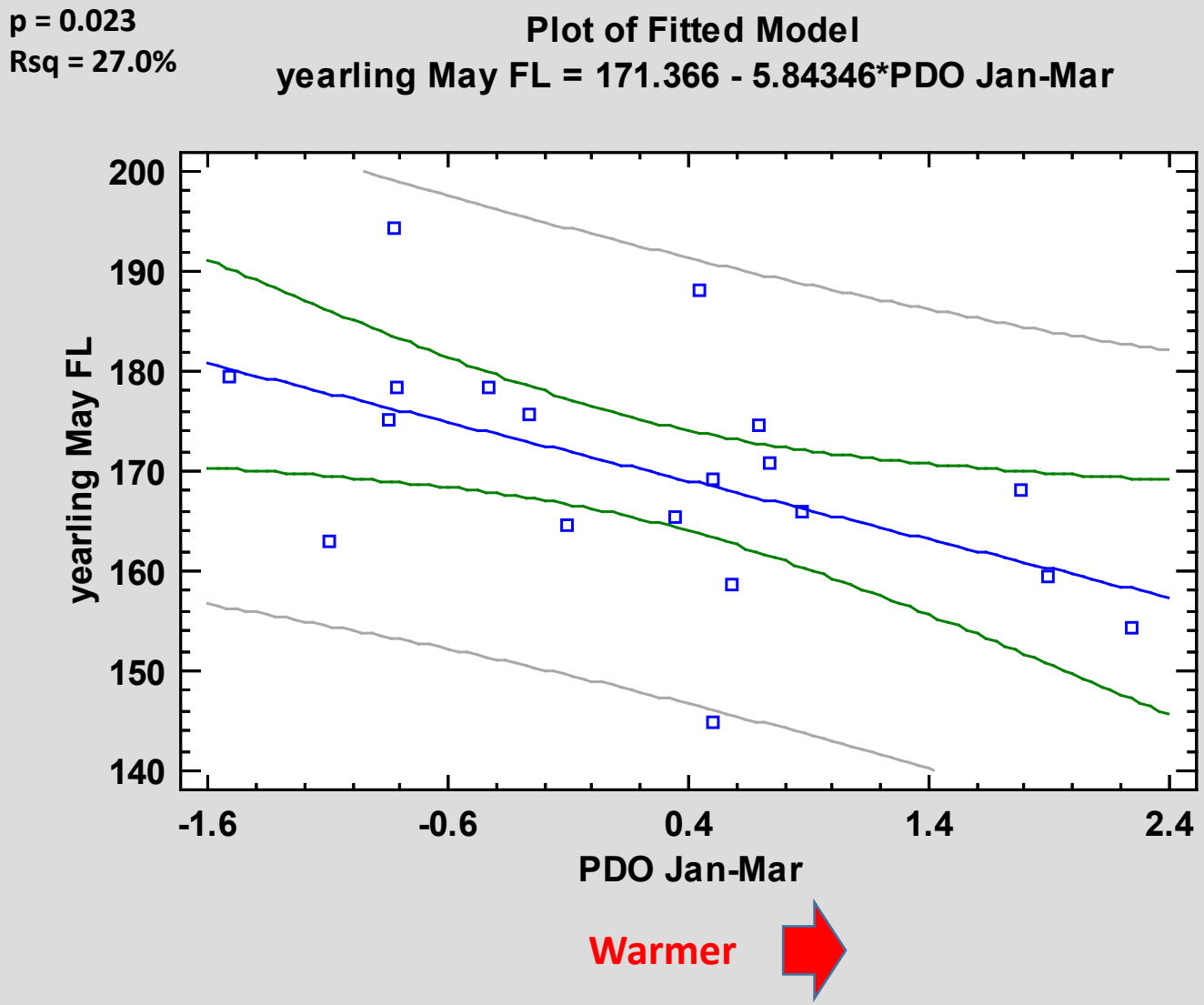
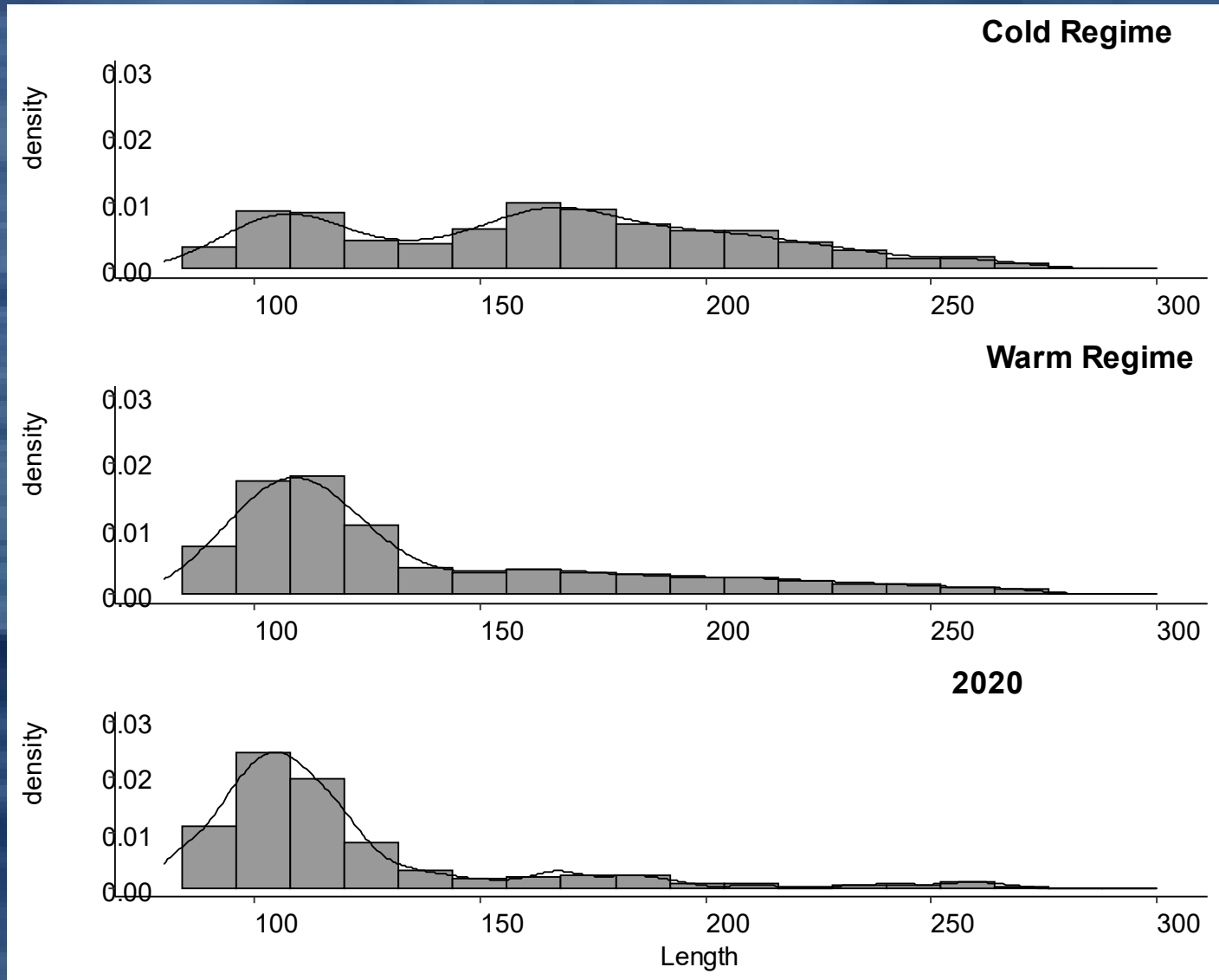
Shorter in fork length during warm ocean conditions

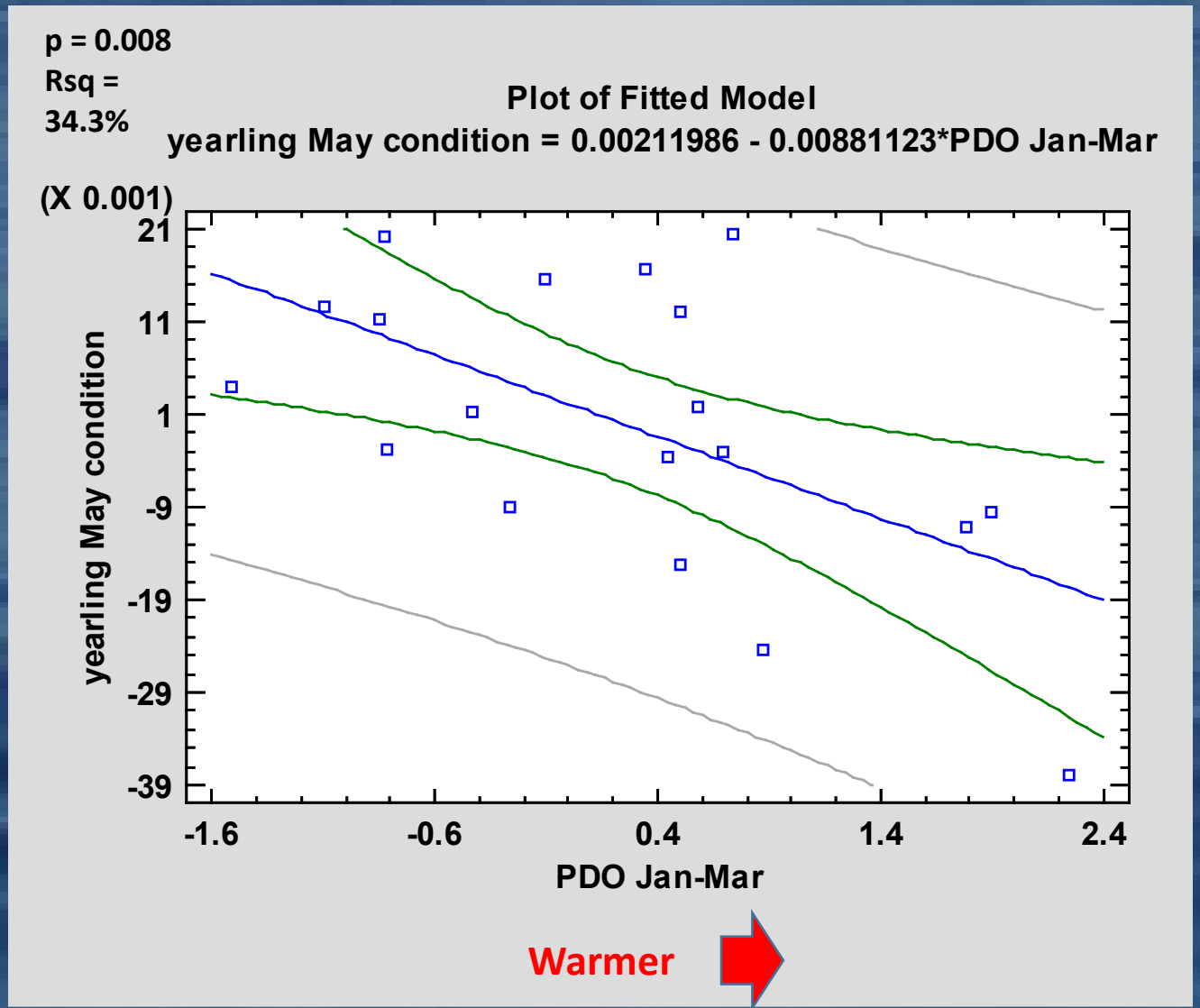


In June, the size and catch of Chinook salmon is reduced during warmer ocean conditions

- 2020 length frequency: the fish resemble the warmer ocean condition frequency plot
- 2020 CPUE was ranked 16th lowest out of 23 survey years

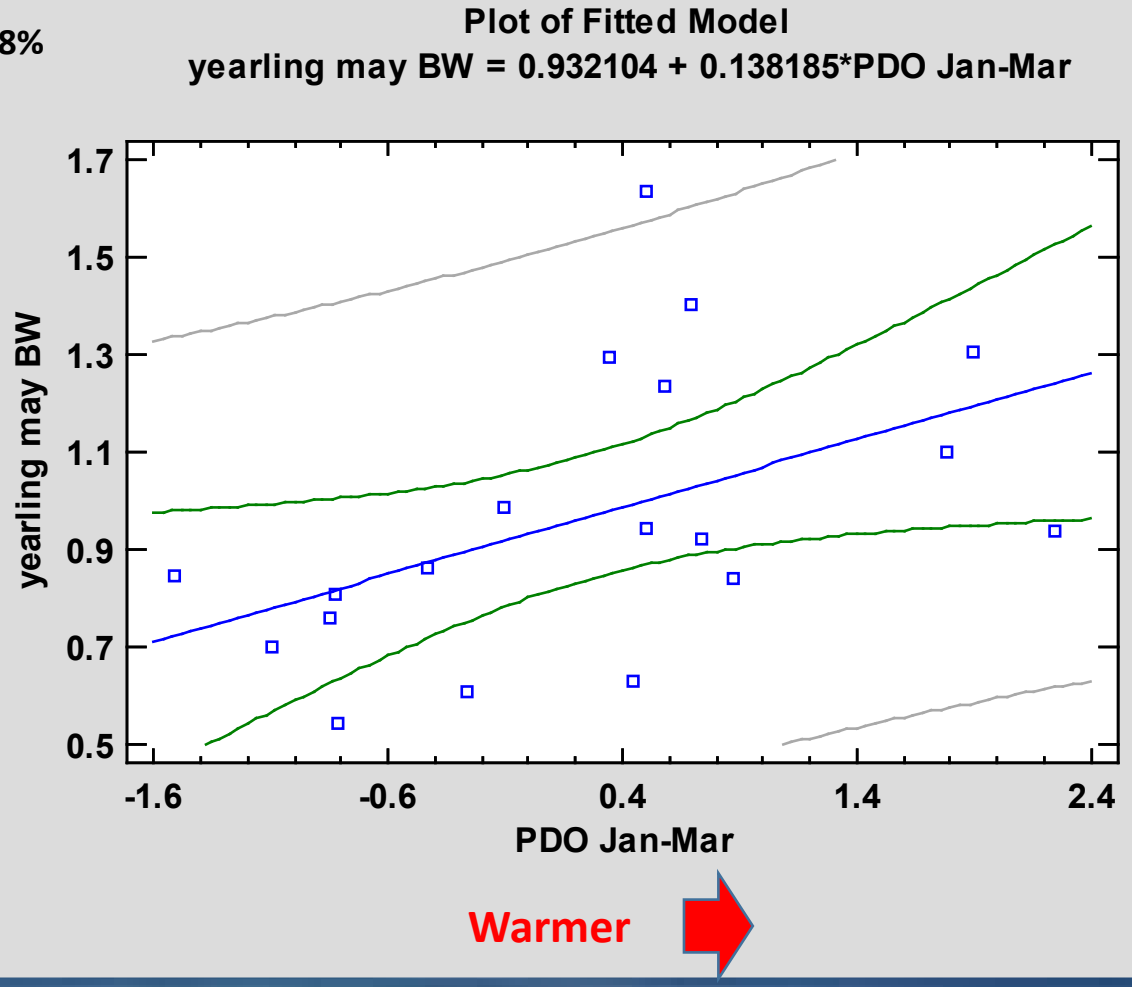


Thinner during warm ocean conditions (length-weight condition residuals)



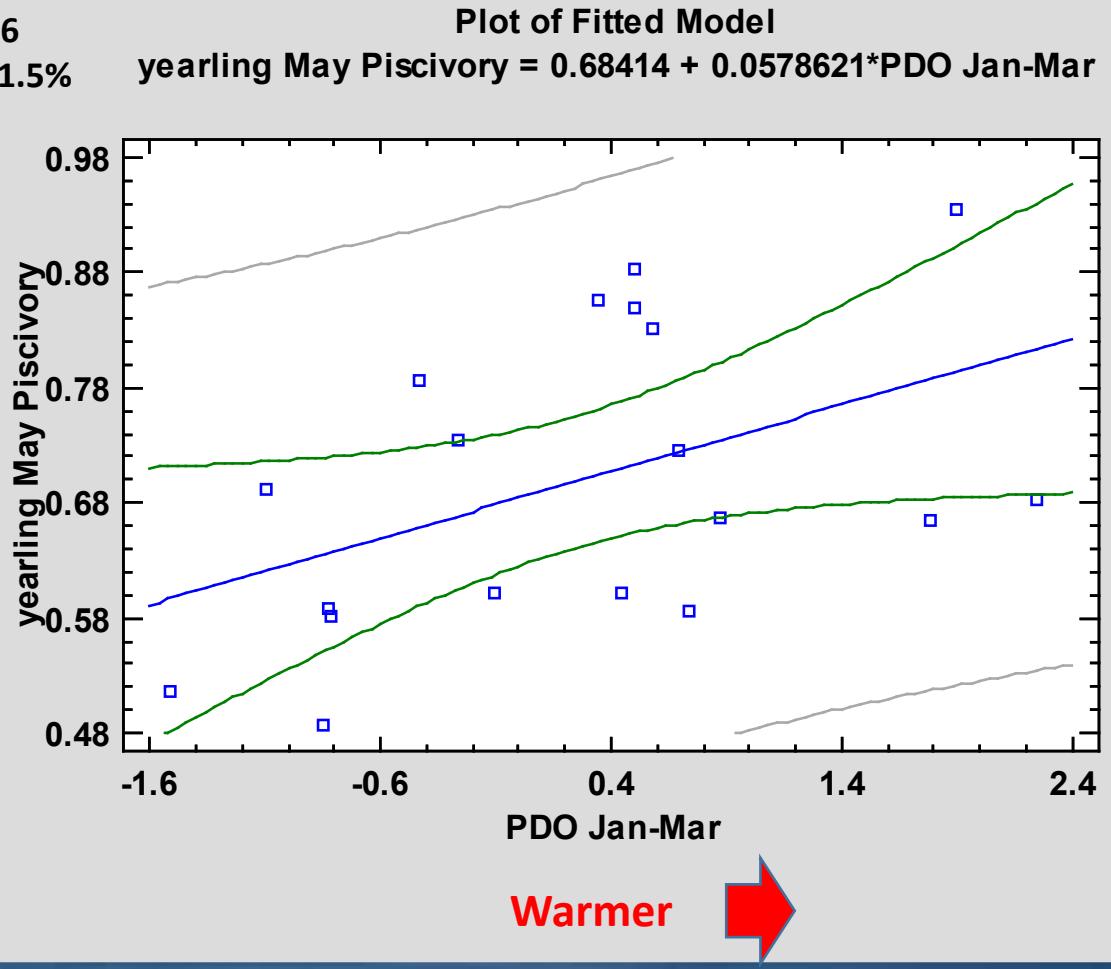
Ate more food during warmer ocean conditions (stomach fullness)

p = 0.034
Rsq = 23.8%



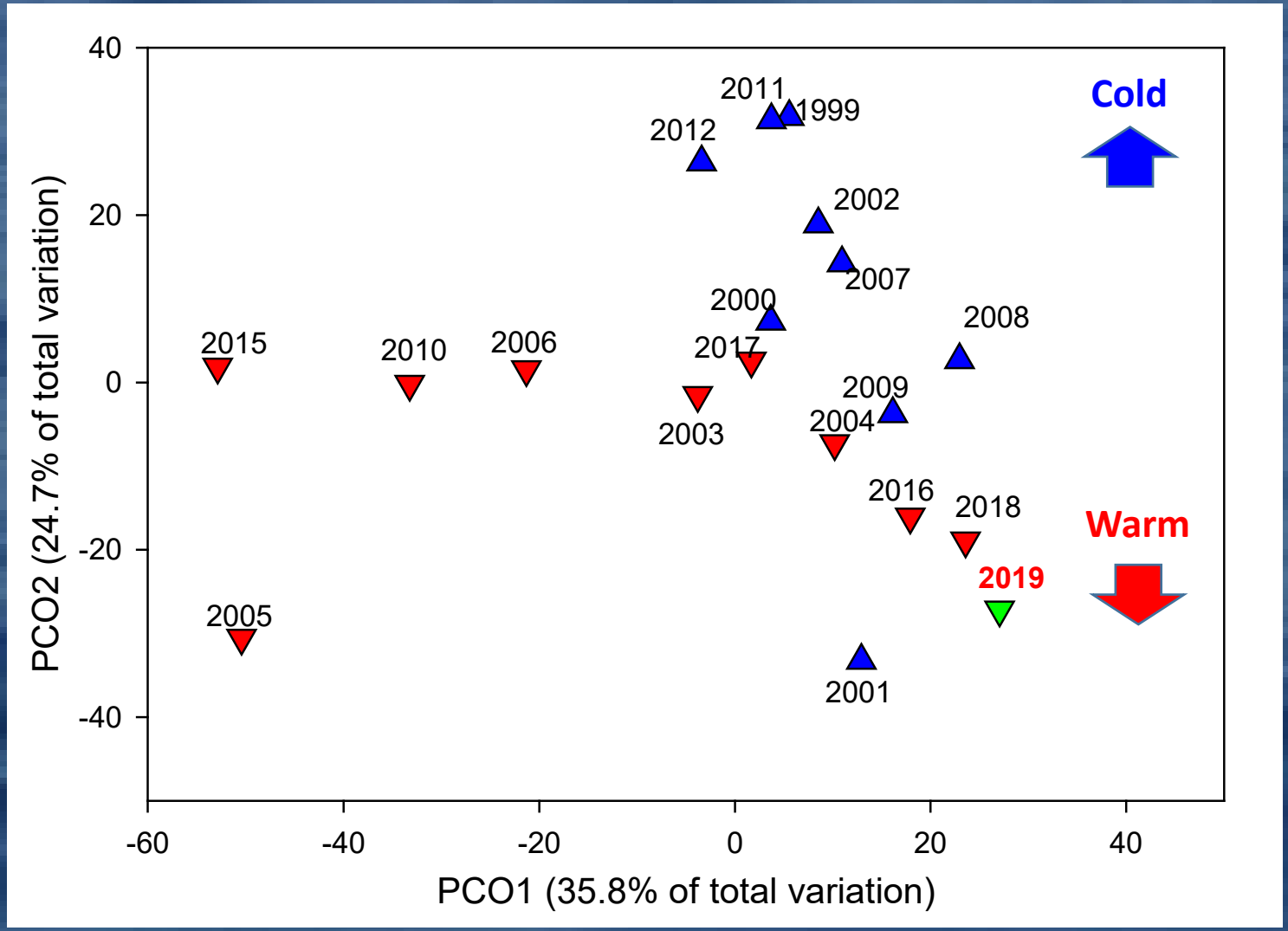
Are more piscivorous during warmer ocean conditions

p= 0.046
Rsq = 21.5%

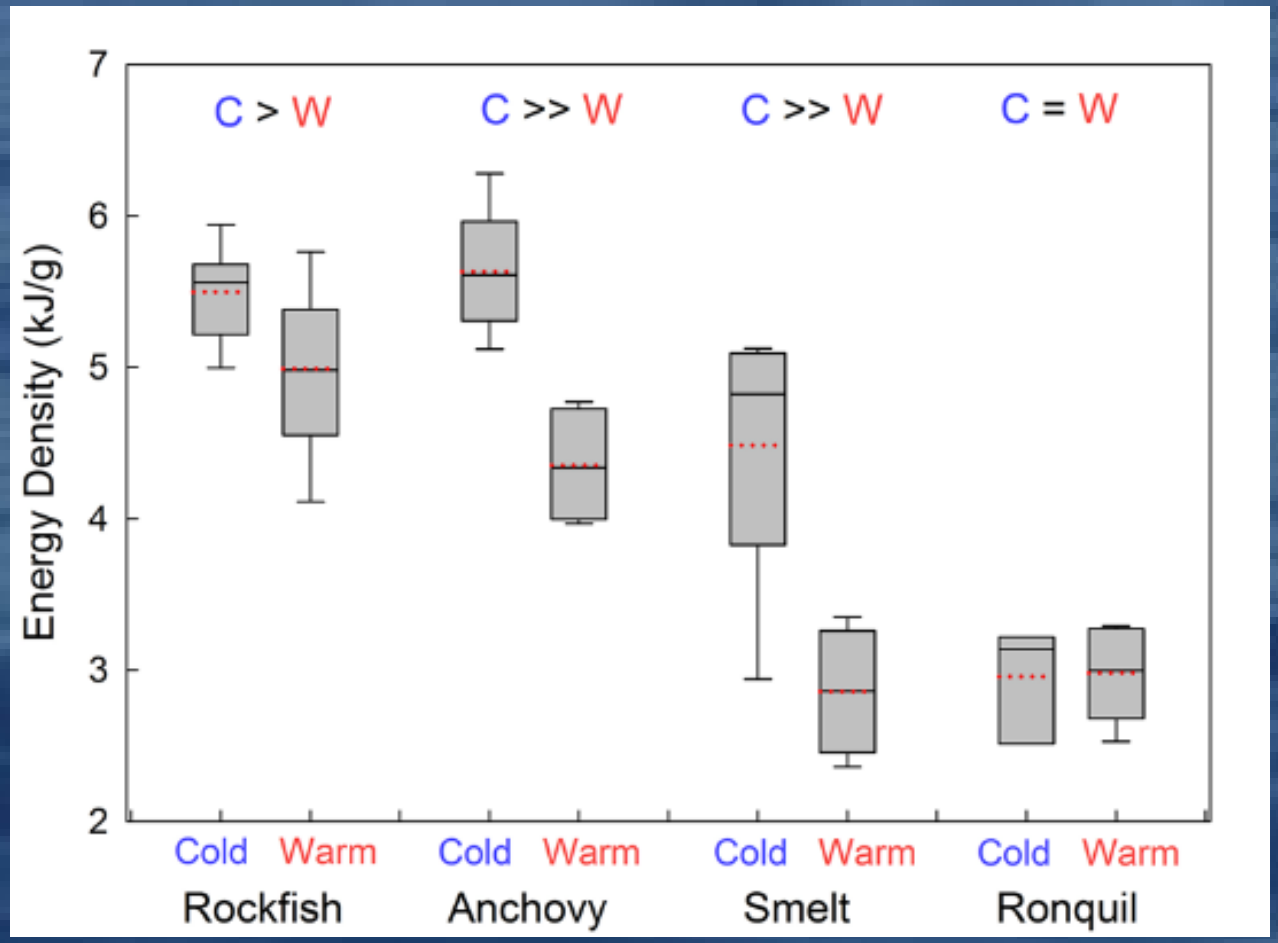


Diet composition changes during warmer ocean conditions

- Annual diet composition PCO2 axis scores relate to PDO conditions (p = 0.045) and PCO1 do not (p = 0.06)



How does salmon prey quality (energy density) change during warmer ocean conditions?



In 2020 we purchased a Parr micro-bomb calorimeter to try to answer this question- stay tuned!

Summary:

- Higher biomass of winter coastal ichthyoplankton taxa occurs during cooler ocean conditions.
- Winter ichthyoplankton community changes with ocean conditions.
- During warmer ocean conditions that salmon are smaller, thinner, eat more food, are more piscivorous, and their diet composition changes.
- Ocean conditions in 2019-2020 were warm and these juvenile salmon will be returning as adults this year and the next.
- However, 2021 is shaping up with colder ocean conditions, and the potential for better adult returns in 2022-2023.


Questions?