he changing North Pacific ecosystem and potential impacts to steelhead

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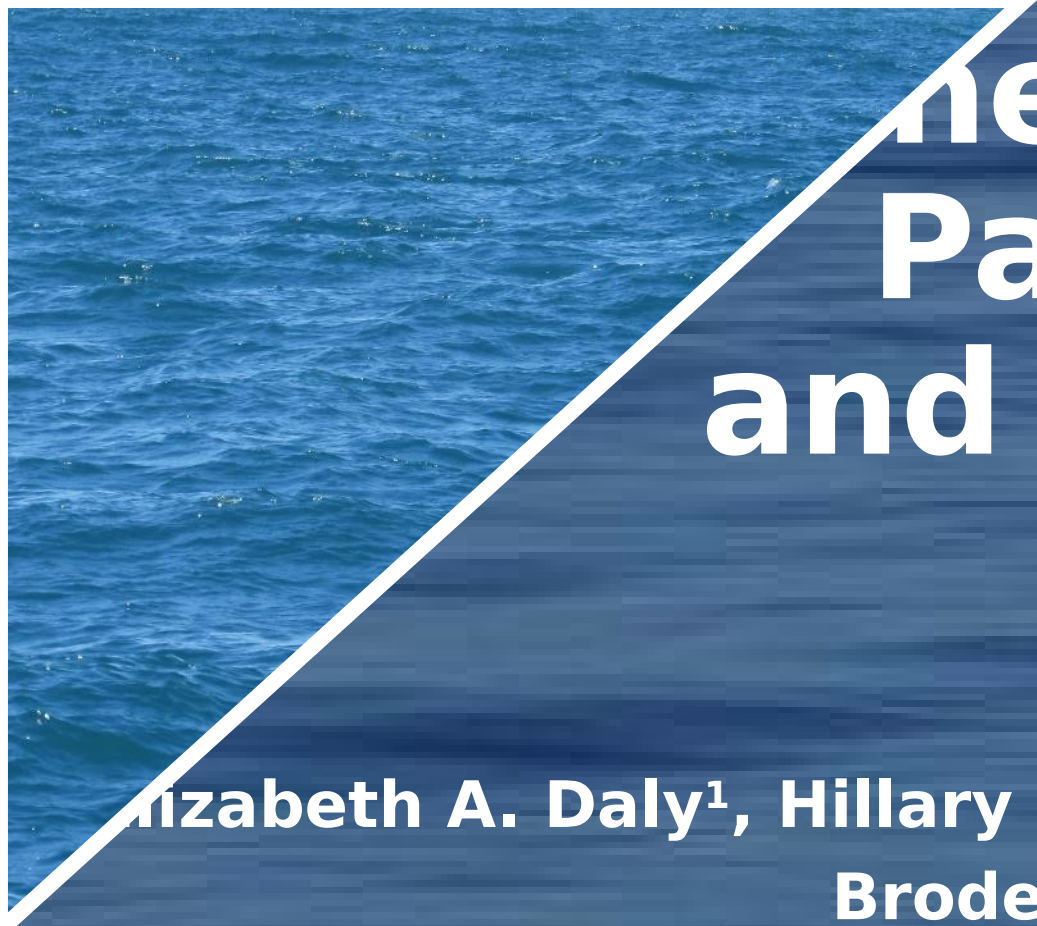


Juvenile steelhead peak timing of entry into seawater is mid-April to mid-May

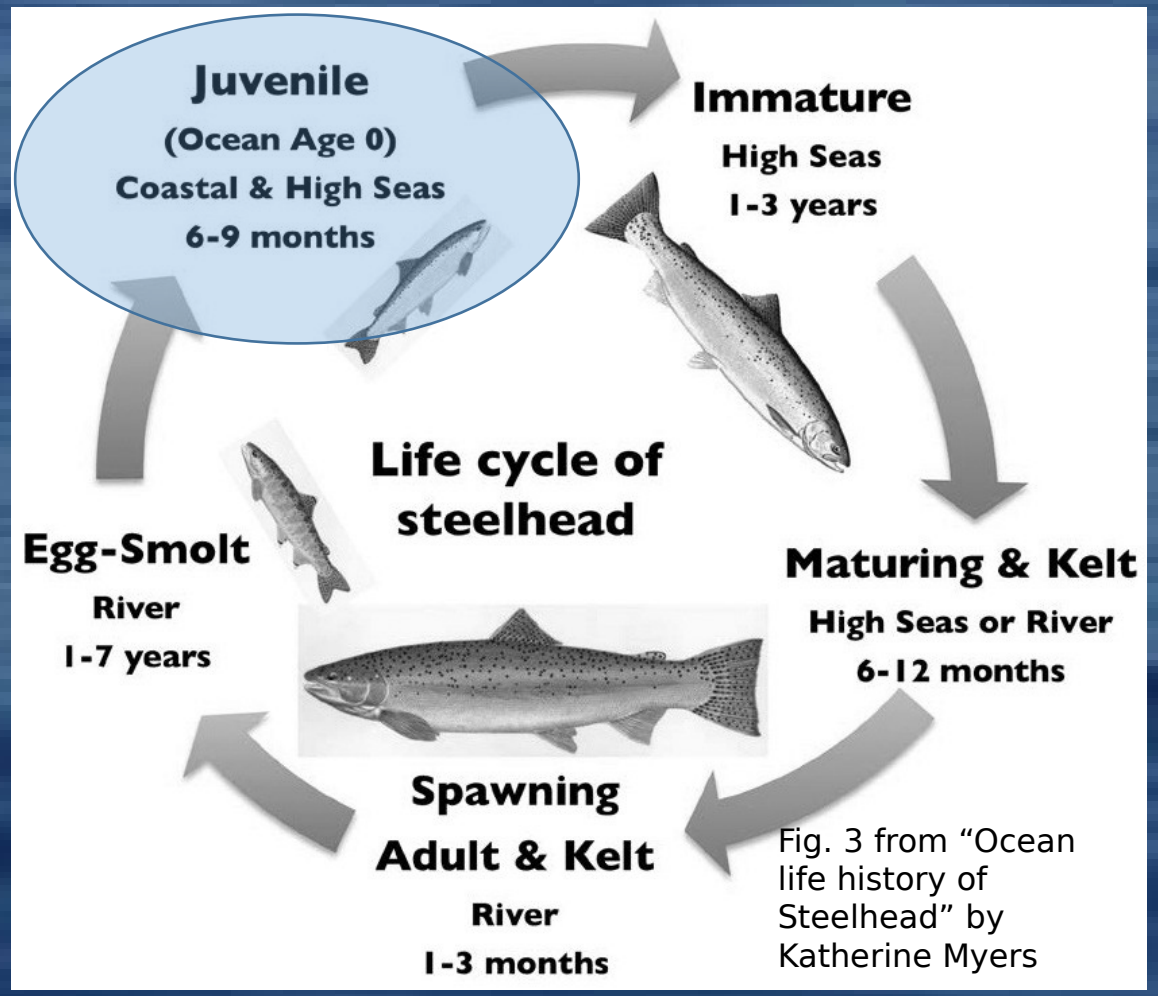
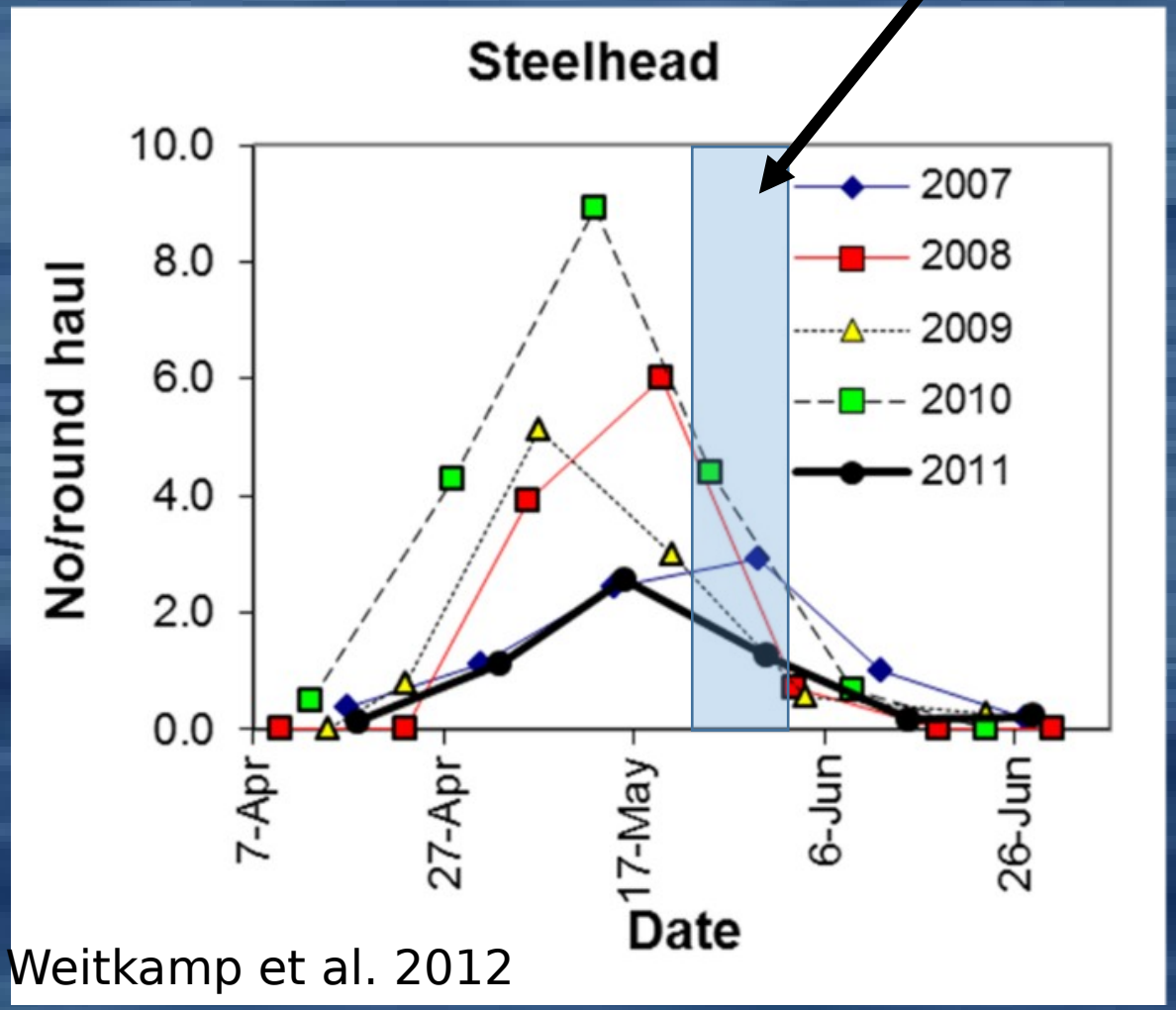


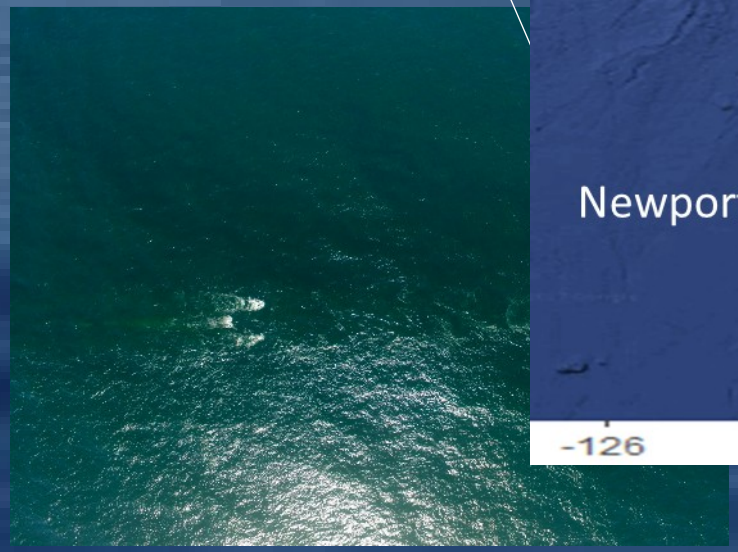
Fig. 3 from "Ocean life history of Steelhead" by Katherine Myers

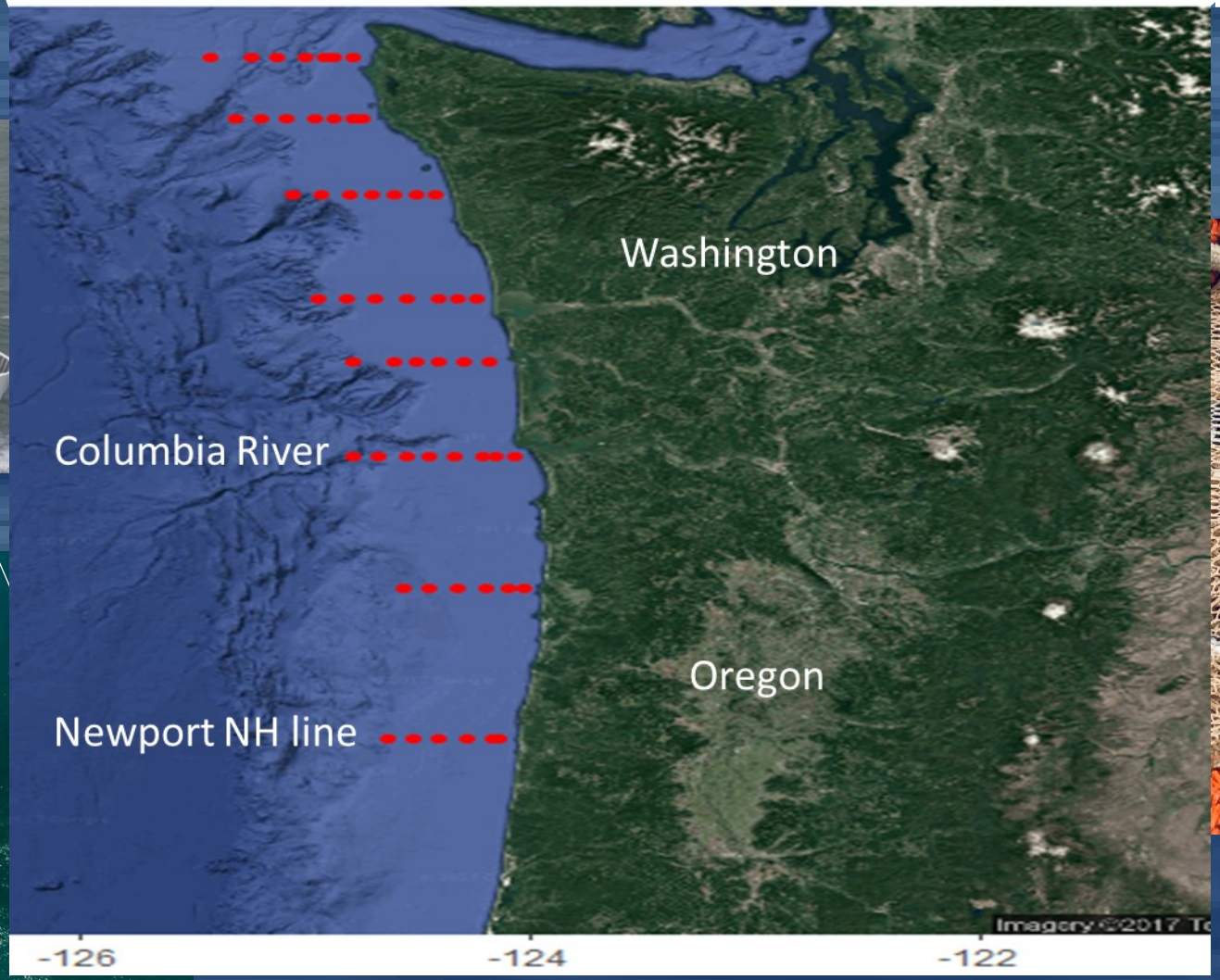
Ocean survey

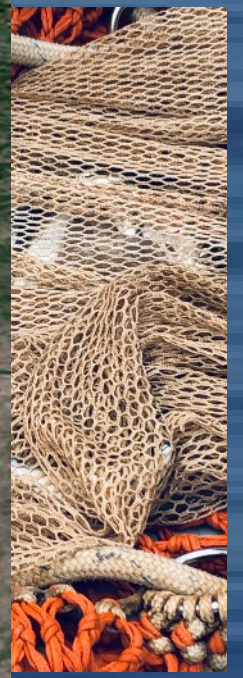


Weitkamp et al. 2012

Ocean sampling: Juvenile salmon ocean ecosystem survey (JSOES) May & June 1998-current

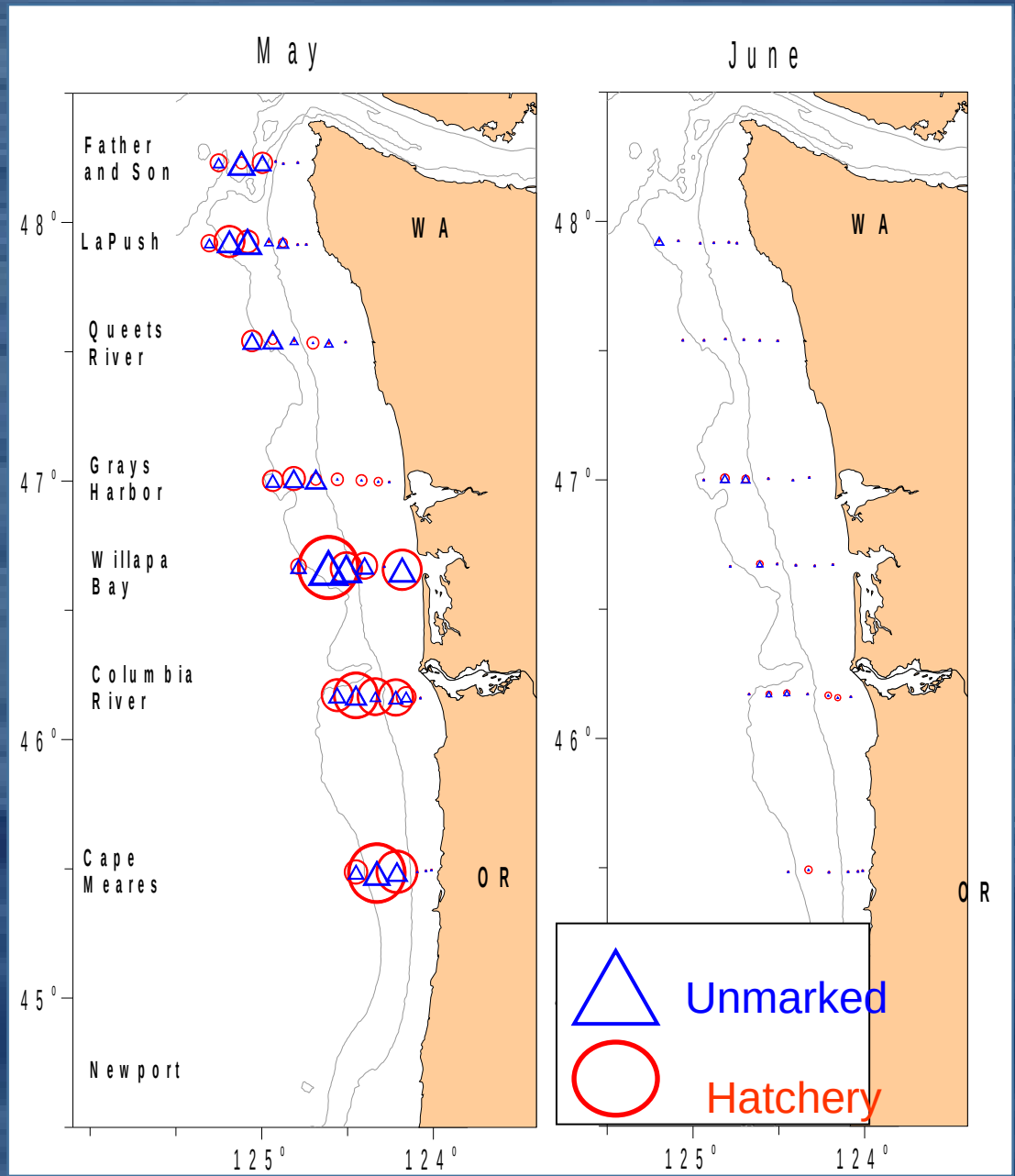






Juvenile steelhead catches in the ocean

- 97% of the steelhead were caught during the May ocean survey
- Steelhead are rarely caught and represent 2.6% of the juvenile salmon caught in May and June
- Juvenile steelhead were consistently caught at the most offshore stations (> 55 km)



Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/umcf20

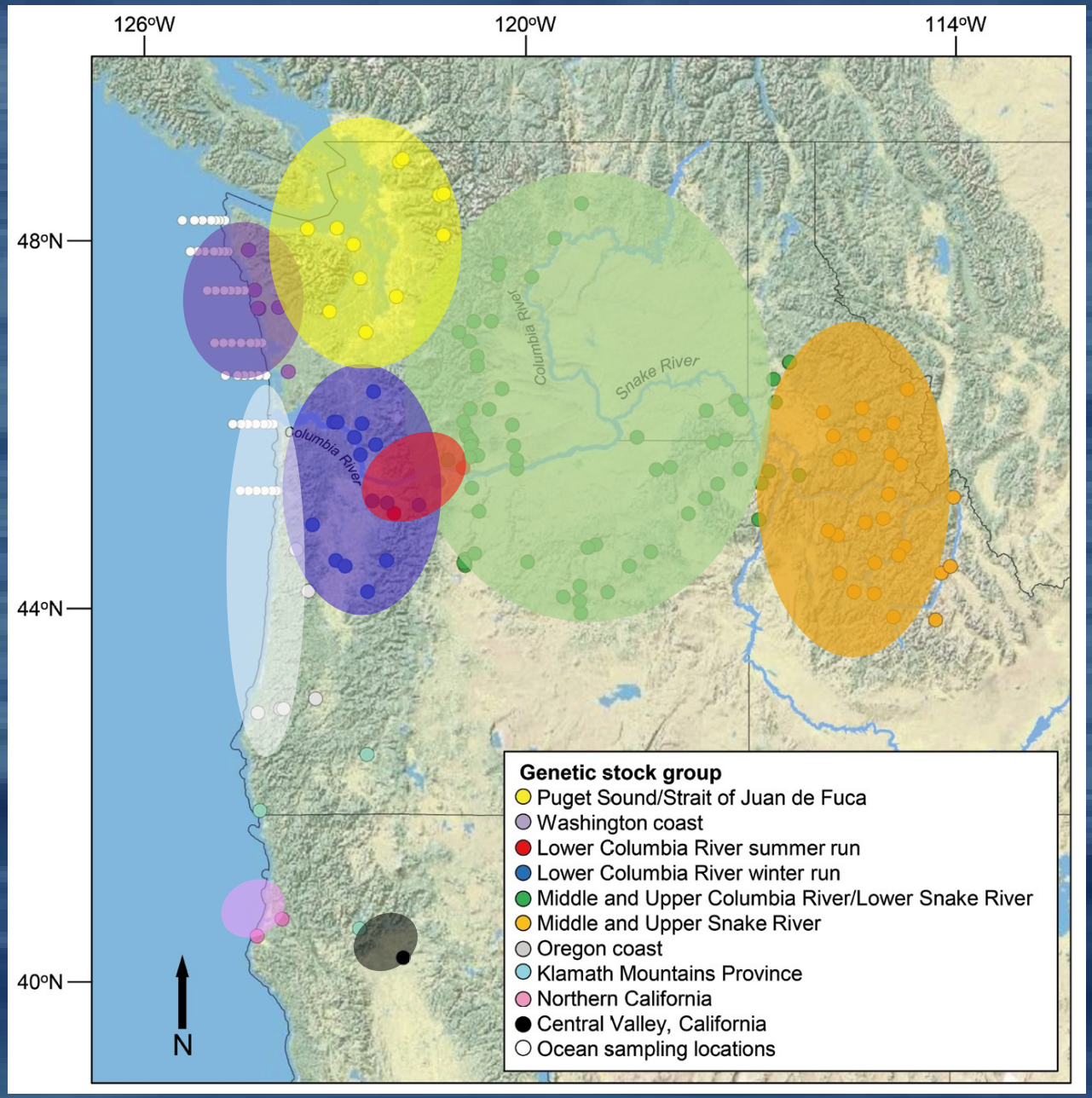
Juvenile Steelhead Distribution, Migration, Feeding, and Growth in the Columbia River Estuary, Plume, and Coastal Waters

Elizabeth A. Daly[a], Julie A. Scheurer[bc], Richard D. Brodeur[b], Laurie A. Weitkamp[b], Brian R. Beckman[c] & Jessica A. Miller[d]

Sites where steelhead genotypic data was collected for genetic baseline

Stock listed by highest ocean catches:

1. Mid & Upper Columbia R./Lower Snake R.
2. Snake R. basin
3. Lower Columbia R./Willamette R.
4. Washington coast
5. Puget Sound/Strait of Juan de Fuca
6. Oregon coast
7. CA Central Valley



Insights, from genetic analyses, into stock-specific distribution of juvenile steelhead (*Oncorhynchus mykiss*) from the Columbia River during early marine migration

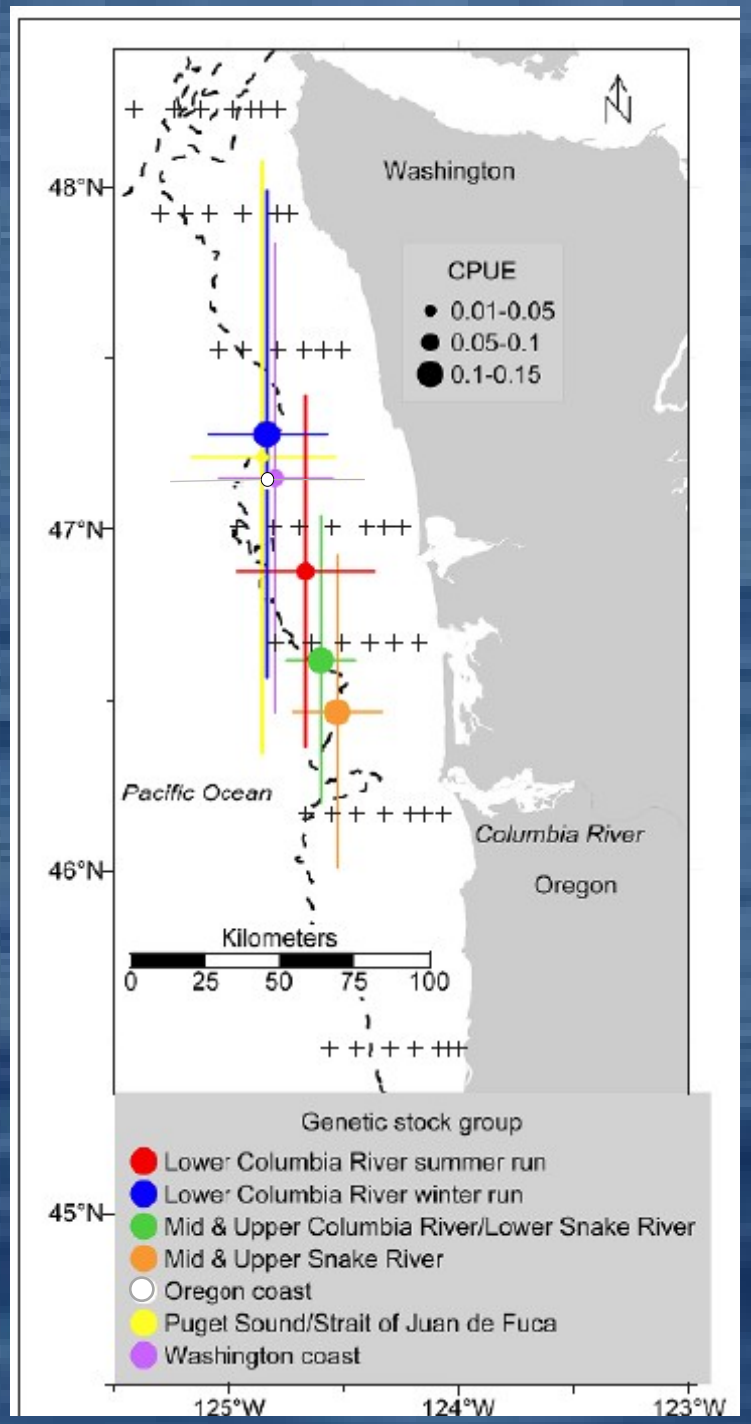
Donald M. Van Doornik (contact author)[1]
David R. Kuligowski[1]
Cheryl A. Morgan[2]
Brian J. Burke[3]
Todd R. Seamons[4]

Van Doornik et al. 2019

Location of juvenile steelhead by stock when caught in ocean

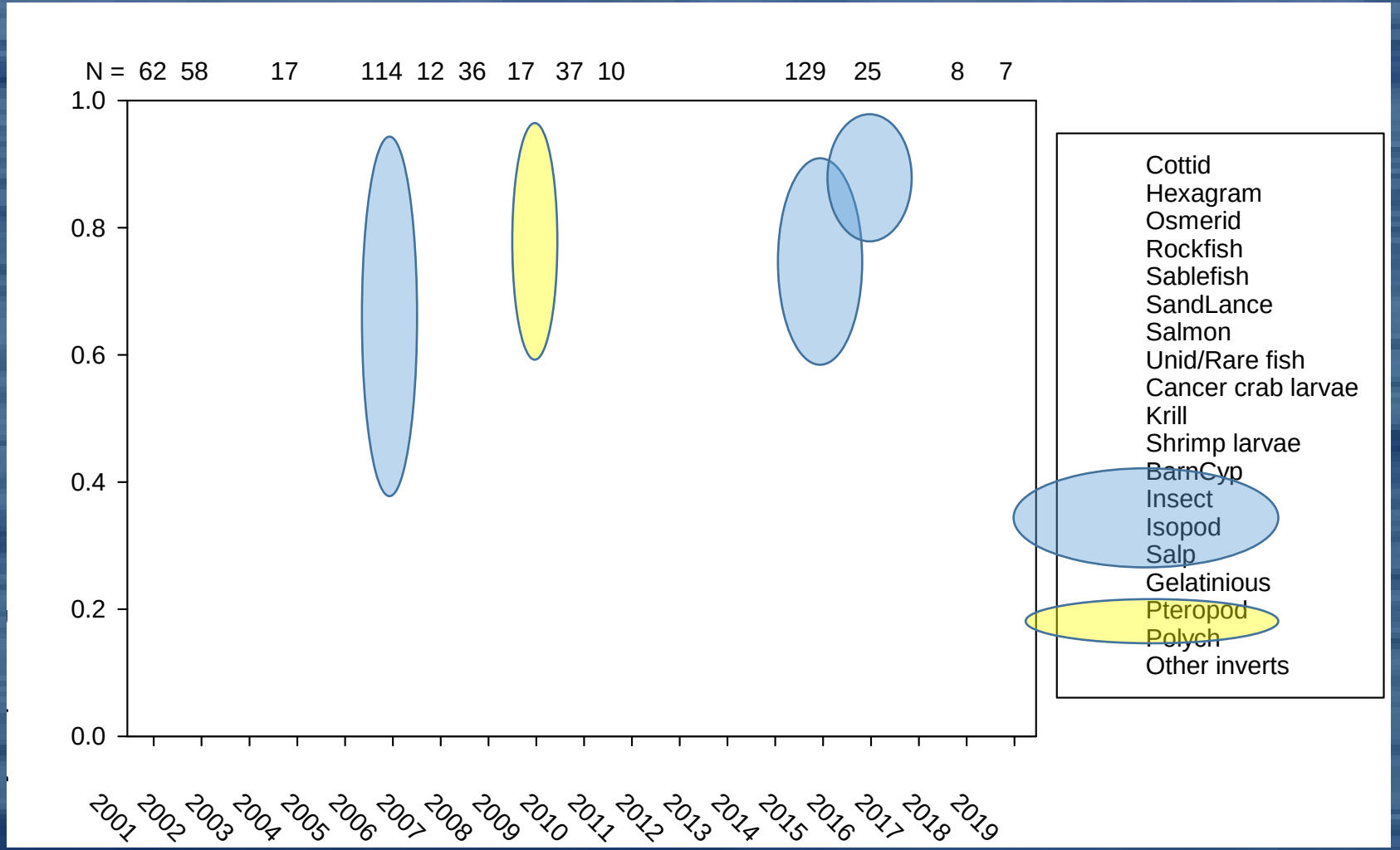
- Lower Columbia R.
- Puget Sound/Strait of Juan de Fuca
- Washington coast
- Oregon coast
- Willamette R.
- Mid & Upper Columbia R./Lower Snake R.
- Snake R. basin

Not present CA Central Valley



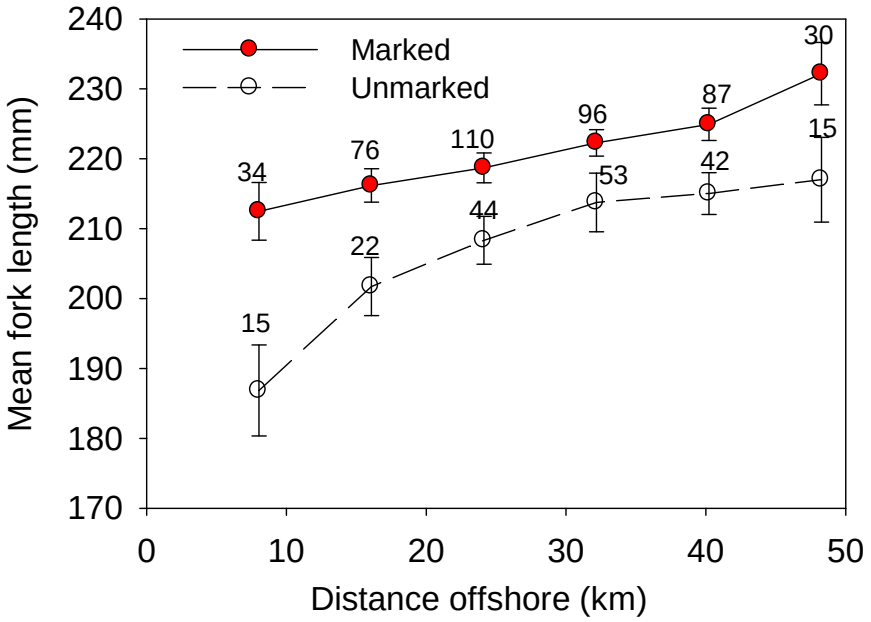
Marine feeding

- Juvenile steelhead primarily consume fish prey, *Cancer* crab megalopae, and adult krill (*Thysanessa spinifera)* (80.3 ± 14.3% of diet).



- In some years highly neustonic taxa like terrestrial insects (2015-16), barnacle larvae and isopods (2007), and pelagic worms (2009) were also eaten.
- Prey like juvenile rockfish and smelt were increasingly eaten during

Steelhead vs. Distance Offshore



Juvenile steelhead salmon quickly grow and move offshore, spending less than 10 days in our ocean sampling area-based on otoliths

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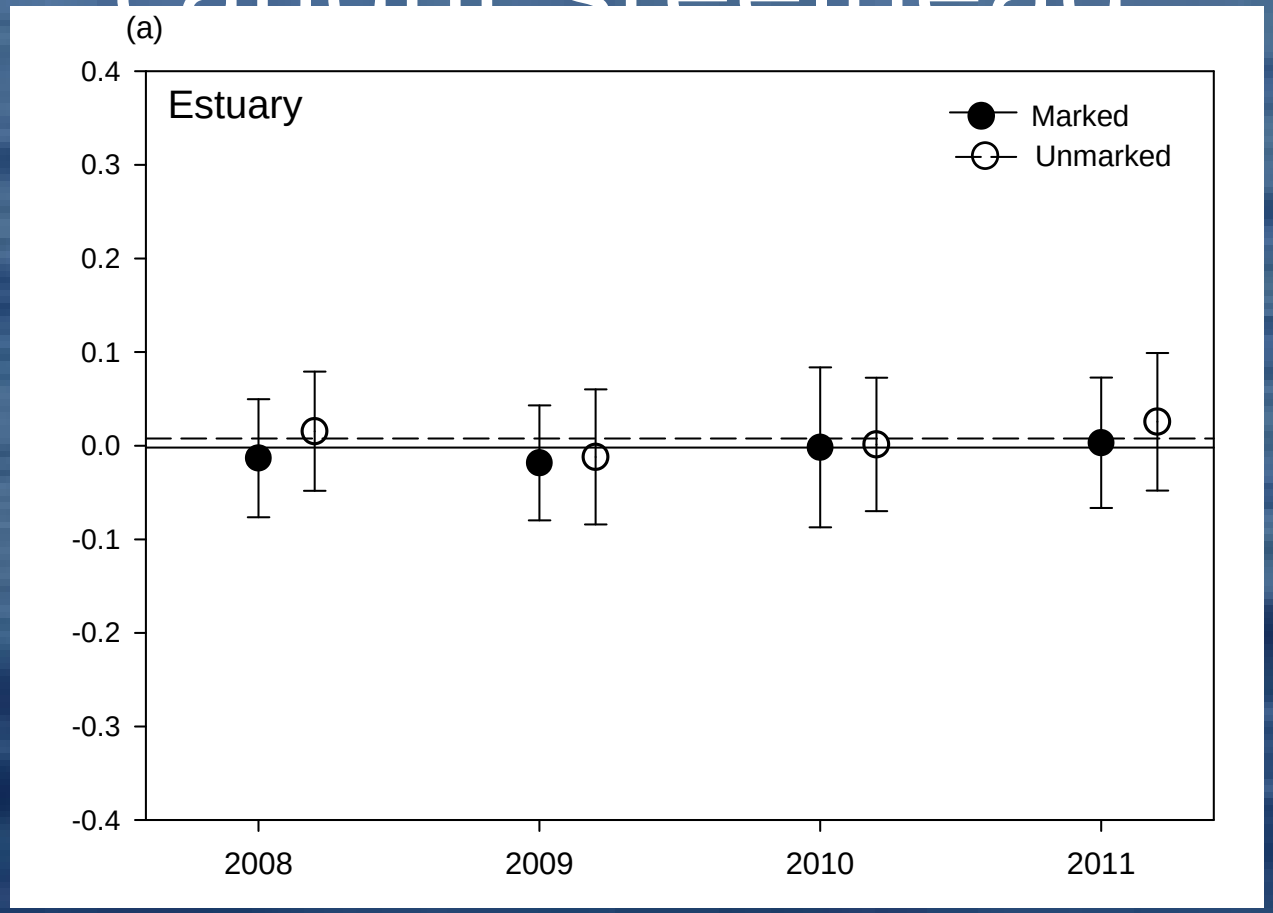
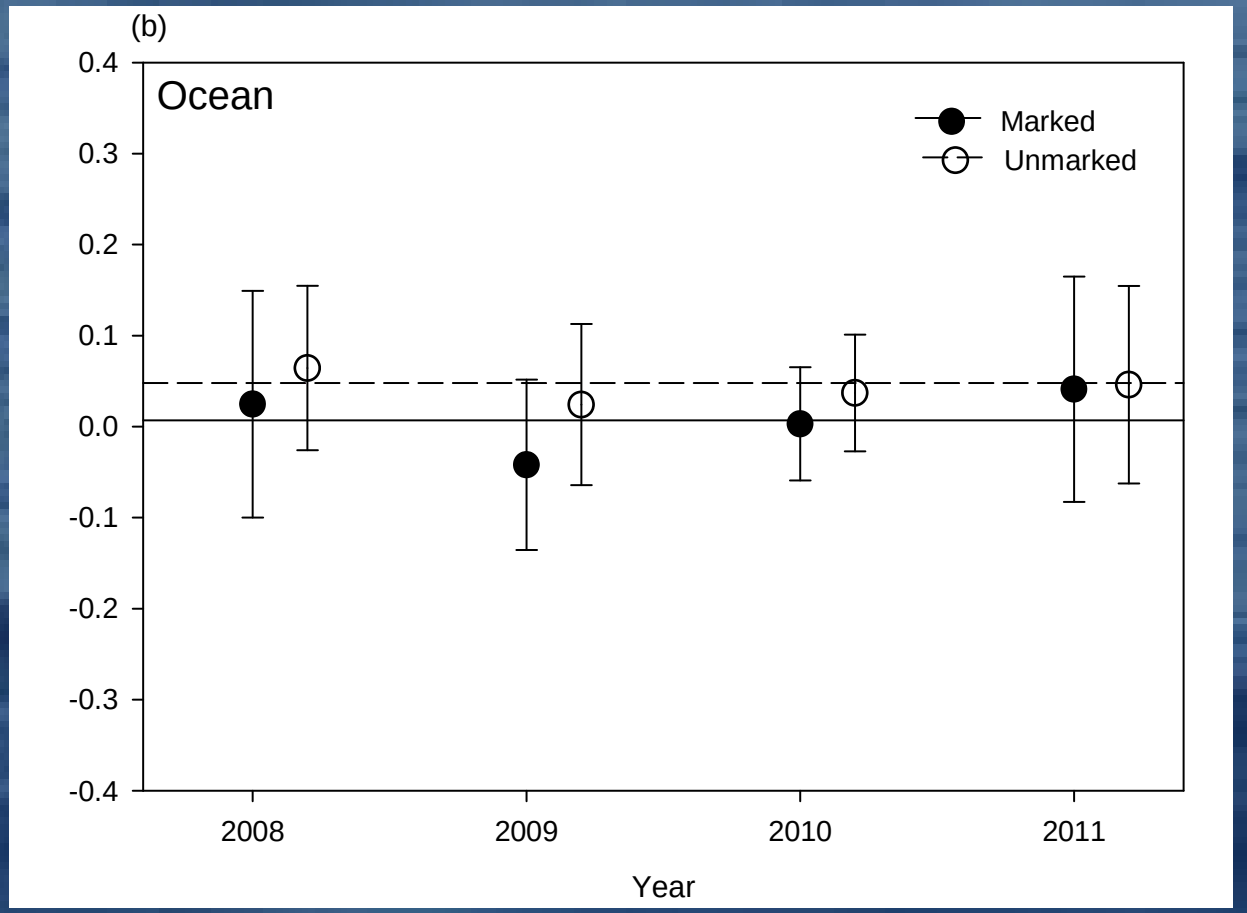
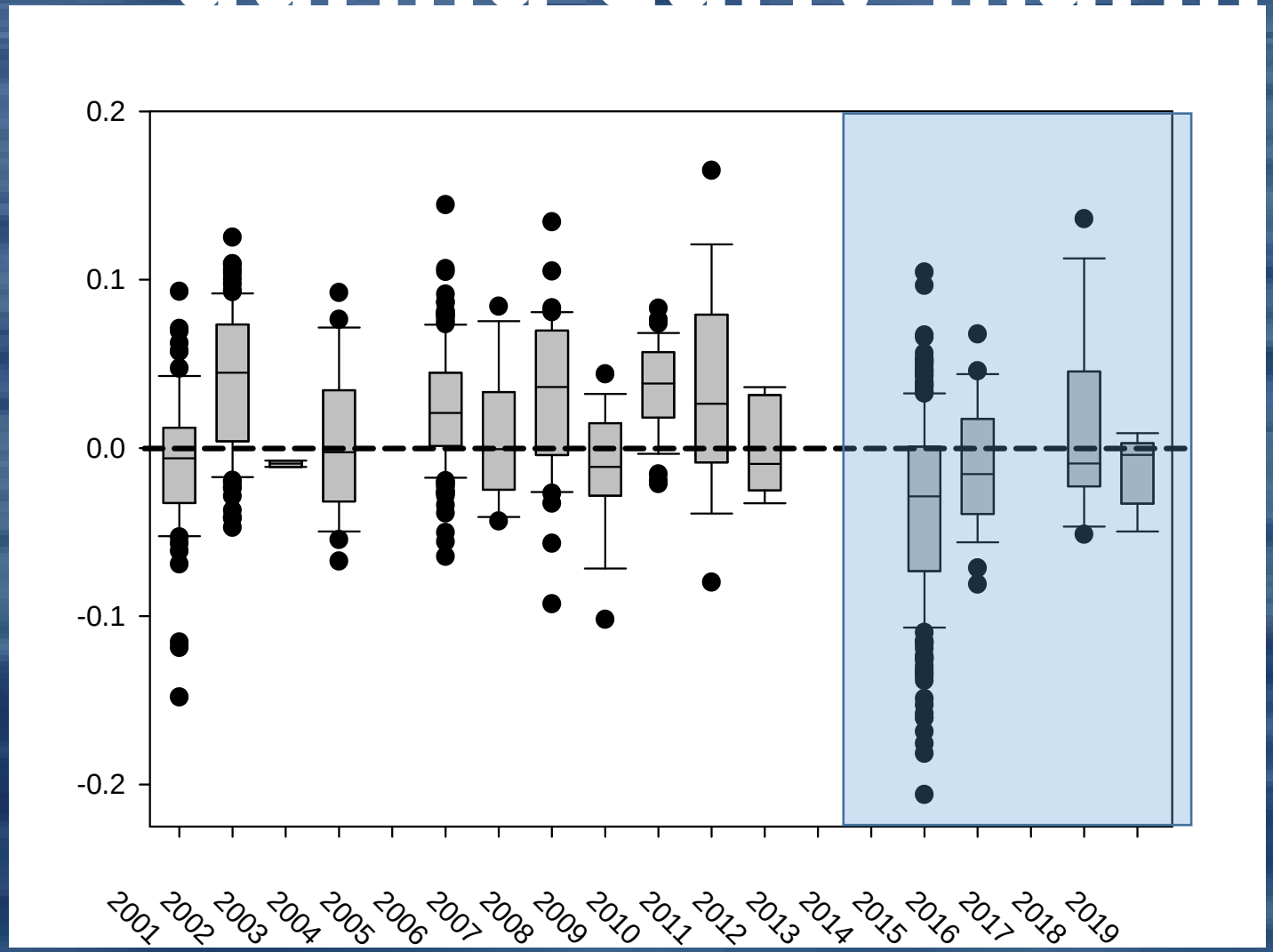
Marine growth can be observed quickly between estuary and ocean caught steelhead





Interannual changes in condition of juvenile steelhead during early marine period



Juvenile steelhead have been thin for their length 2015-2019

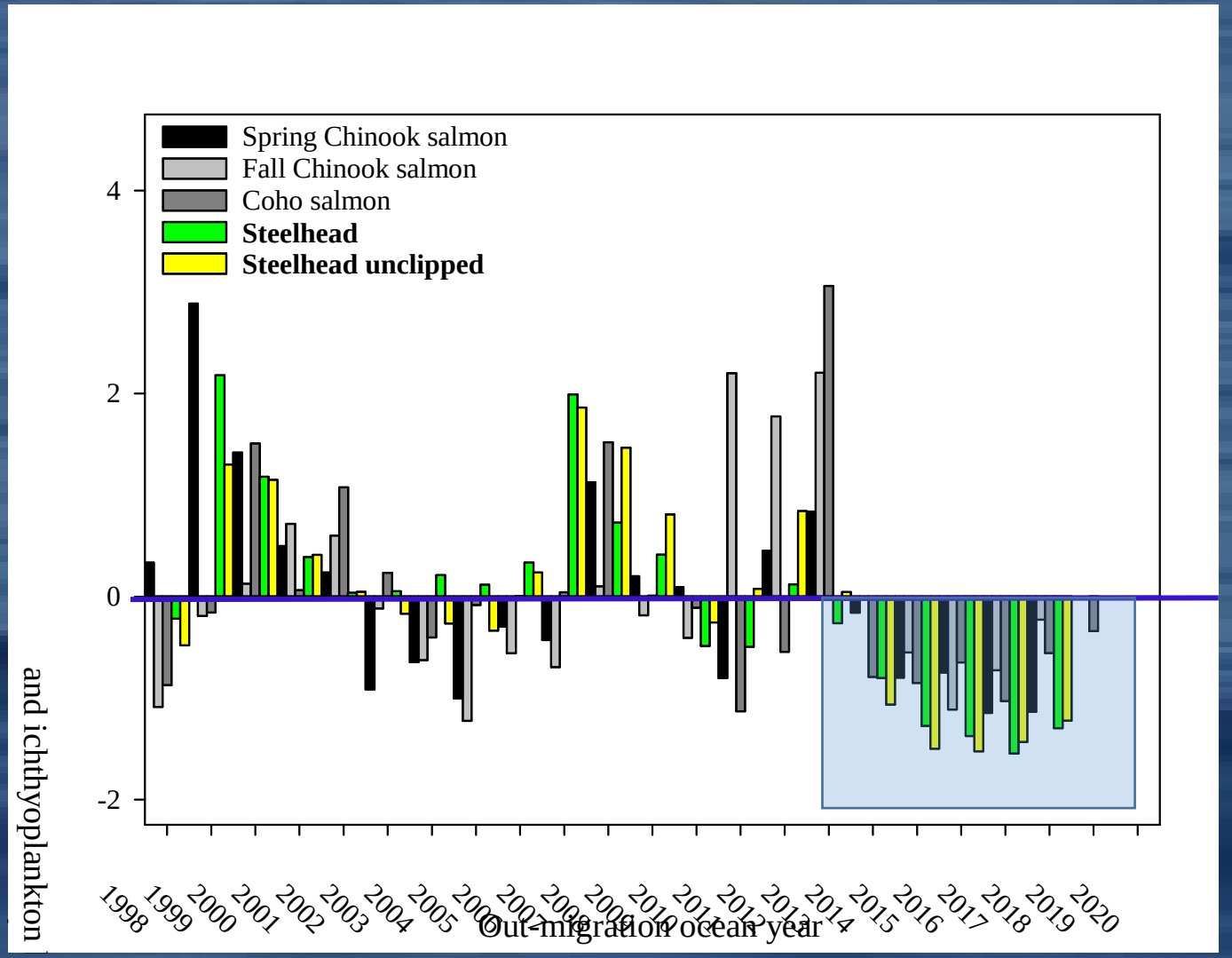
Recent returns of adult steelhead to the Columbia River have been some of the lowest seen in over 20 years

- 21-year average adult counts to Bonneville Dam:

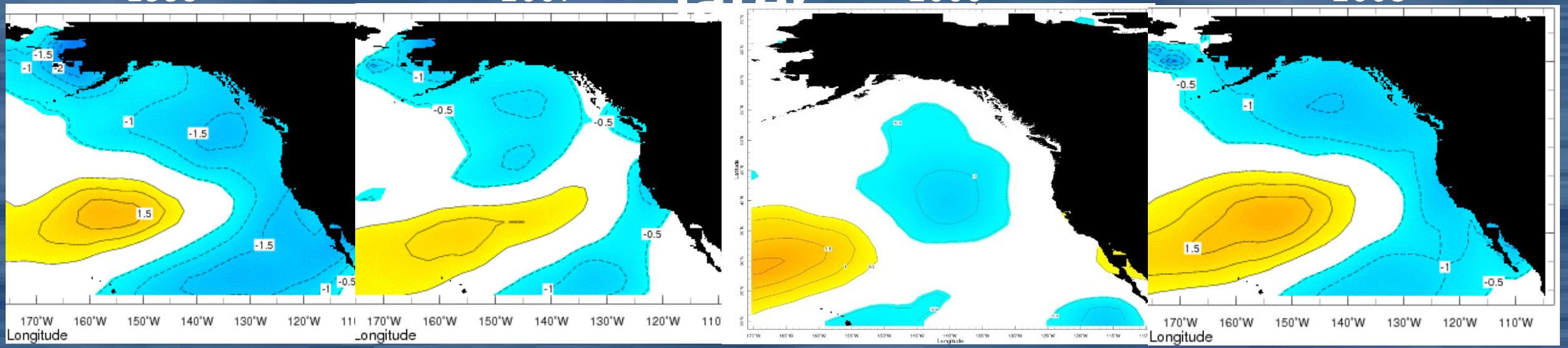
  403,807 ± 187,536

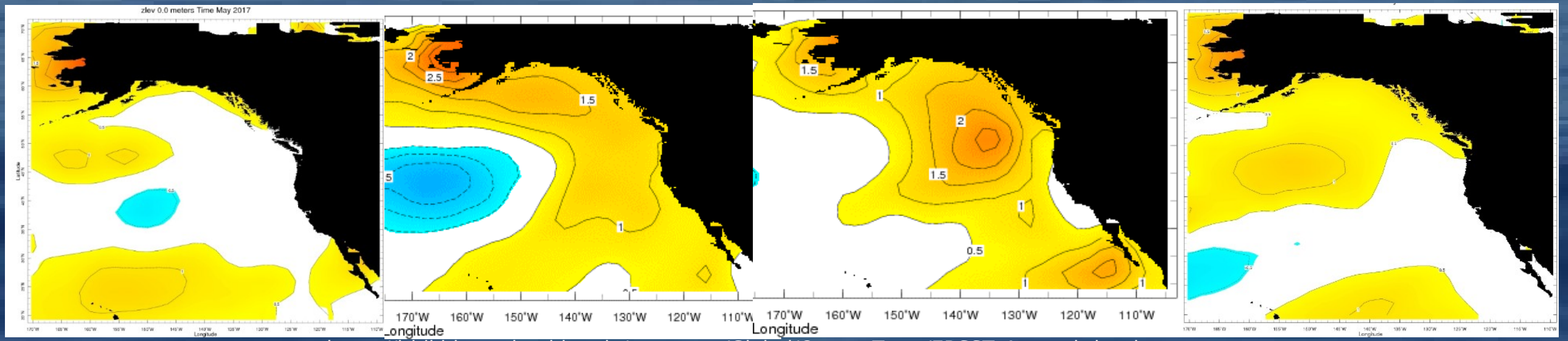
  (hatchery and unmarked)

- 8 out of the 9 most recent years have had the lowest returns of the last 21 years



Colder outmigration ocean conditions are correlated with higher adult returns 2 years later

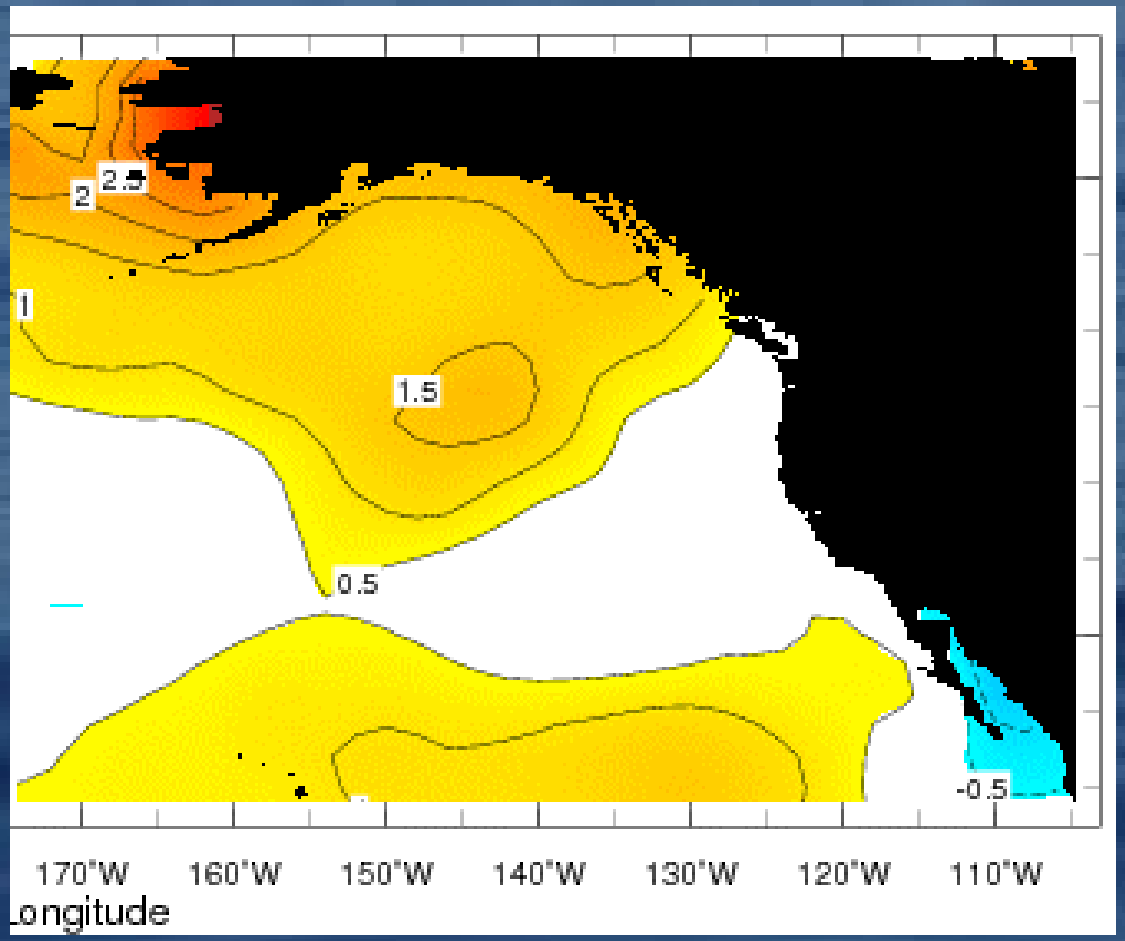




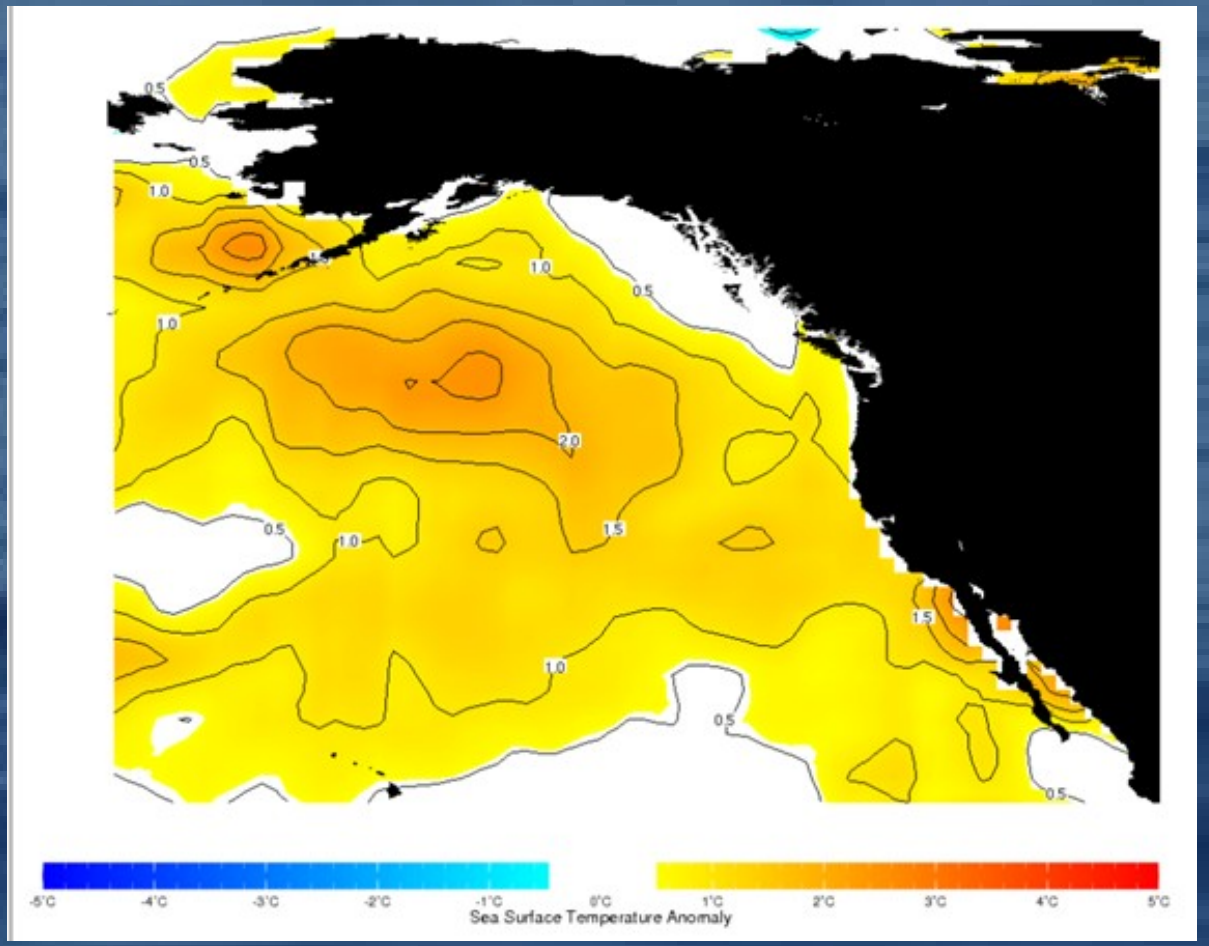
https://iridl.ldeo.columbia.edu/maproom/Global/Ocean_Temp/ERSST_Anomaly.html

Warm ocean condition in May 2019 and 2020 could be associated with lower adult returns 2021-23

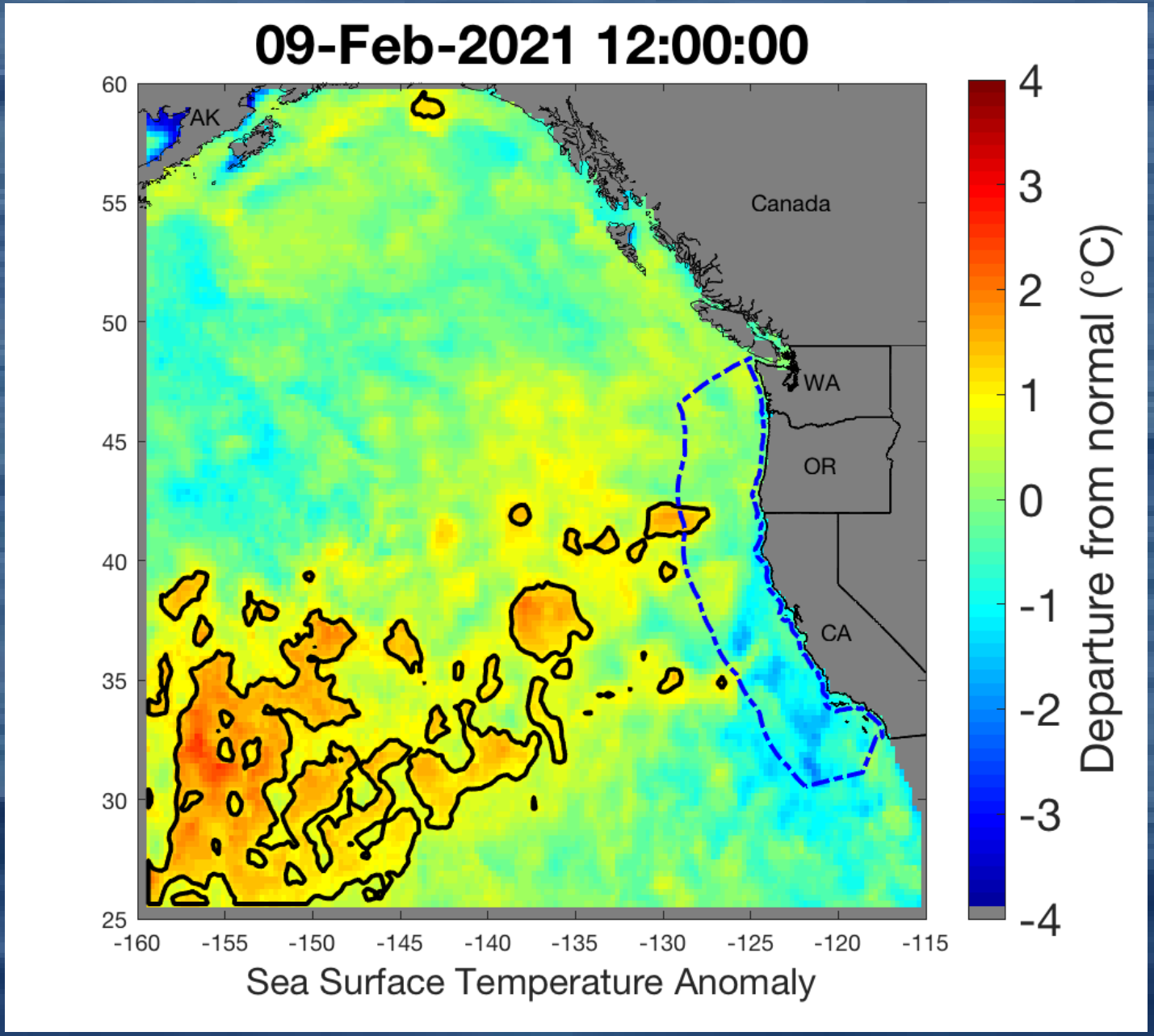
2019



2020

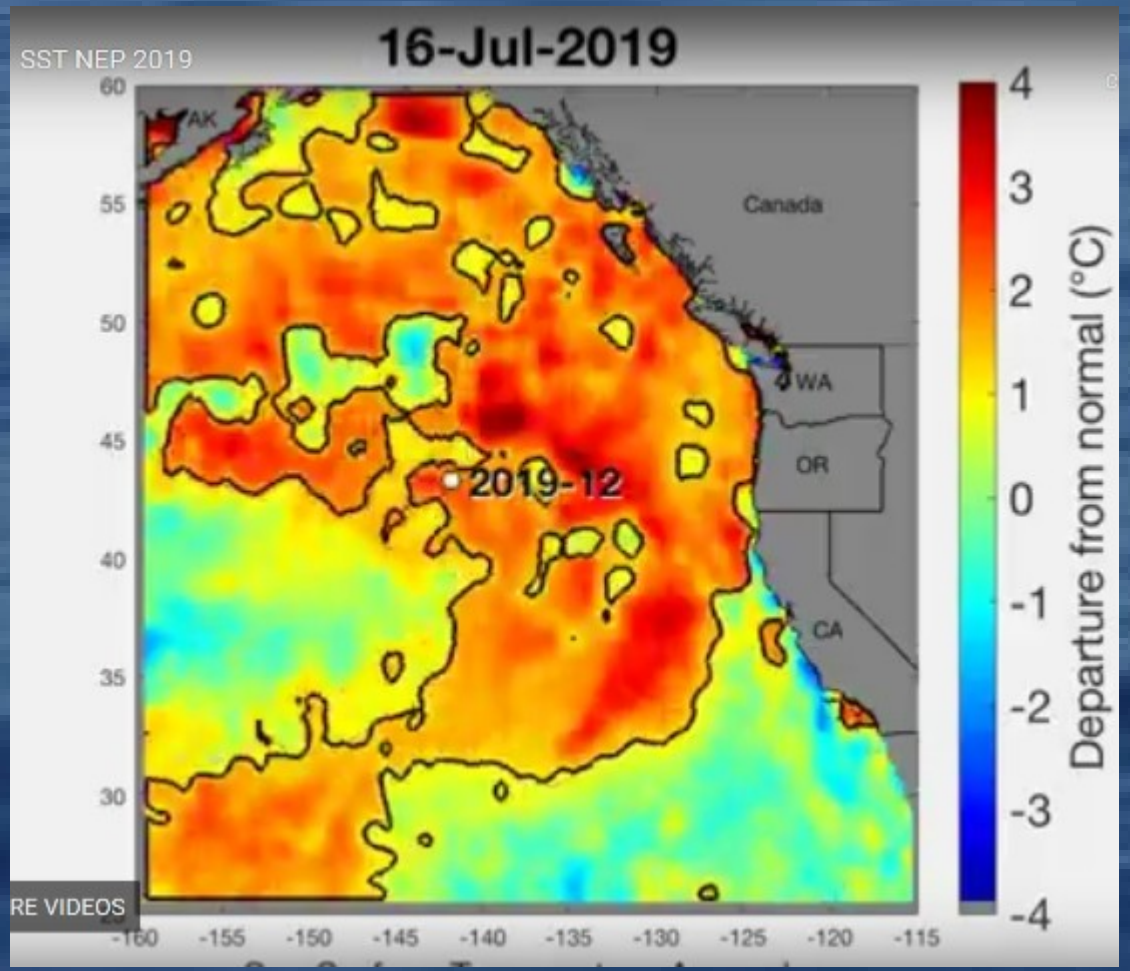


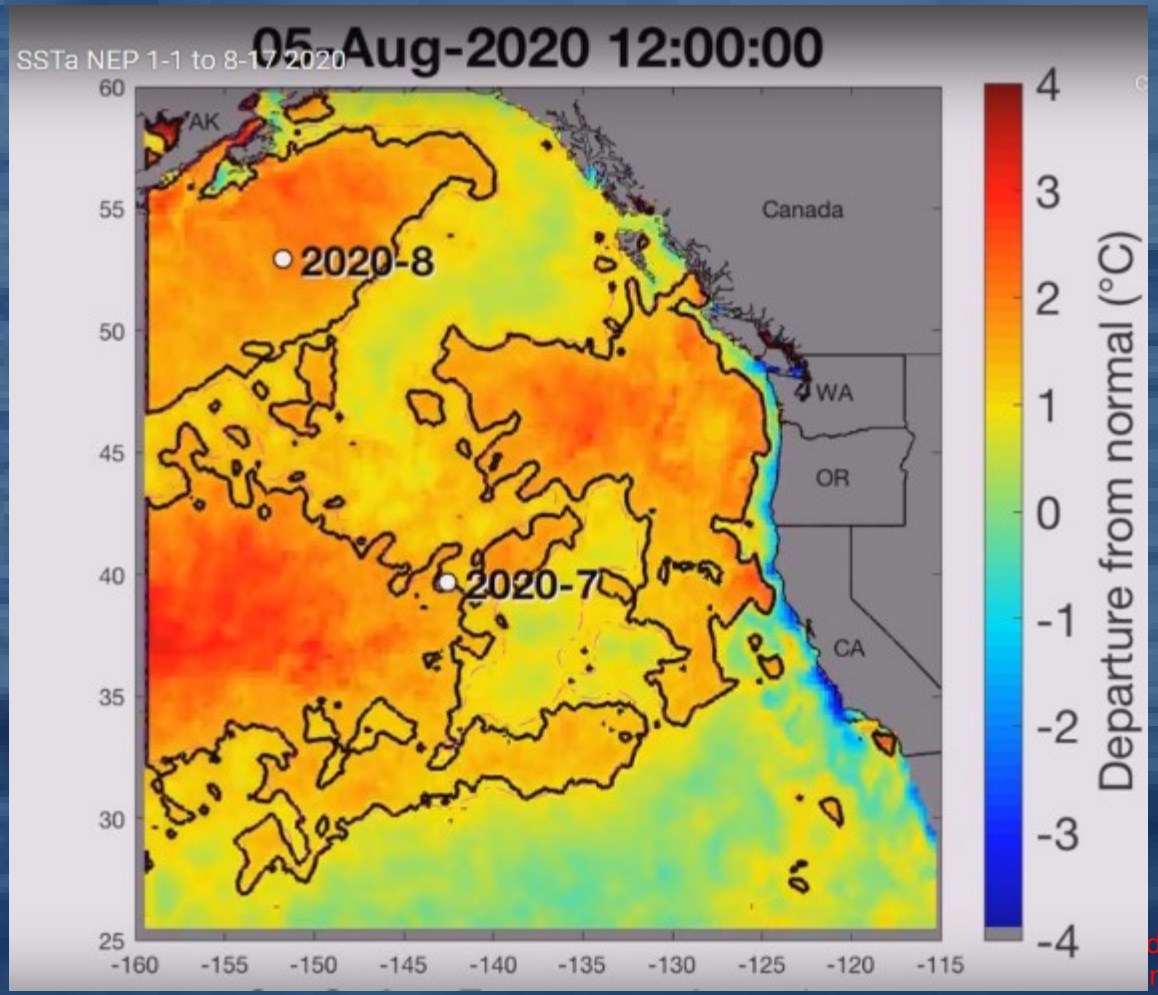
Current ocean conditions February 2021 Average to slightly above average SST and warmer offshore



https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-projects-blobtracker

Marine Heatwaves have developed most summers since 2014- including 2020





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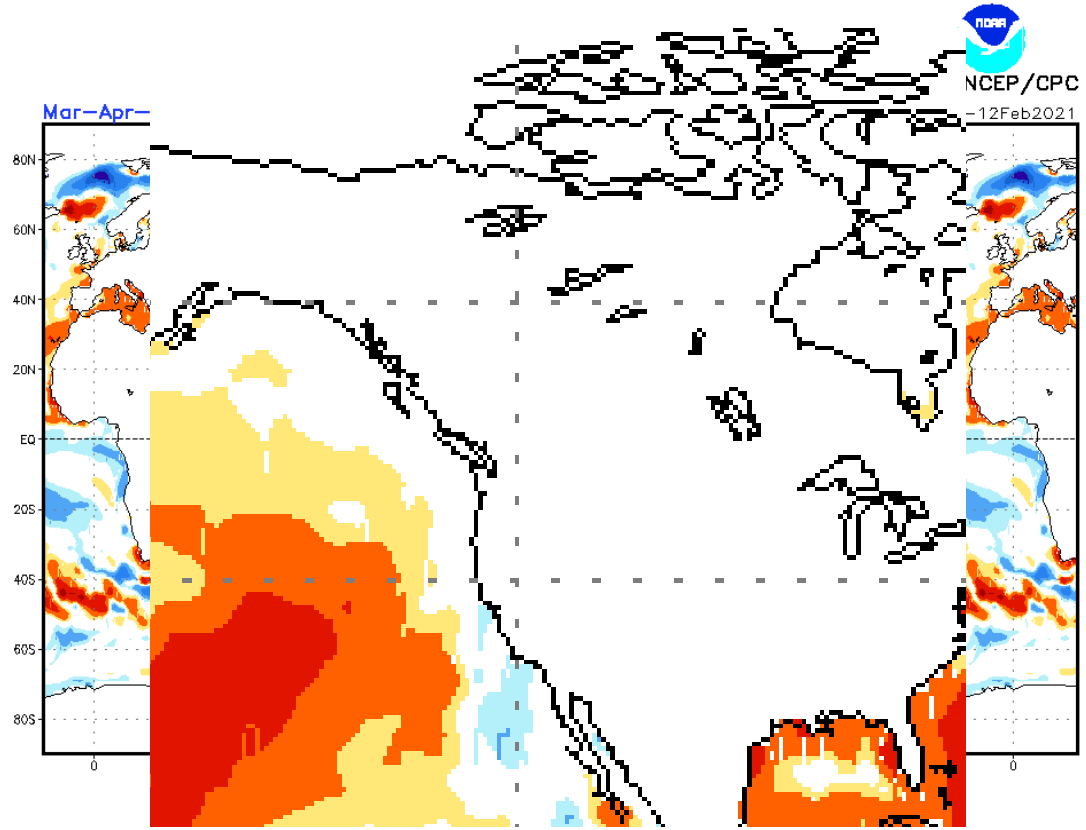
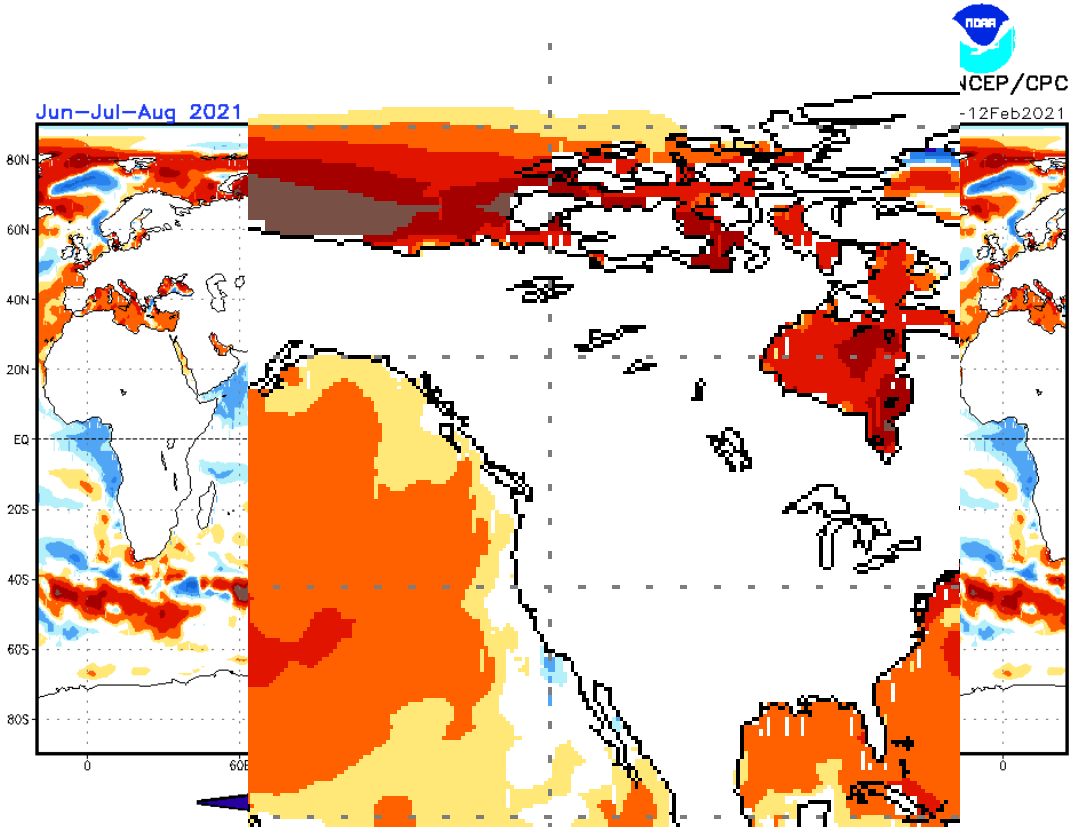
projects-blobtracker

Predicted ocean conditions for 2021: another MHW

Spring 2021



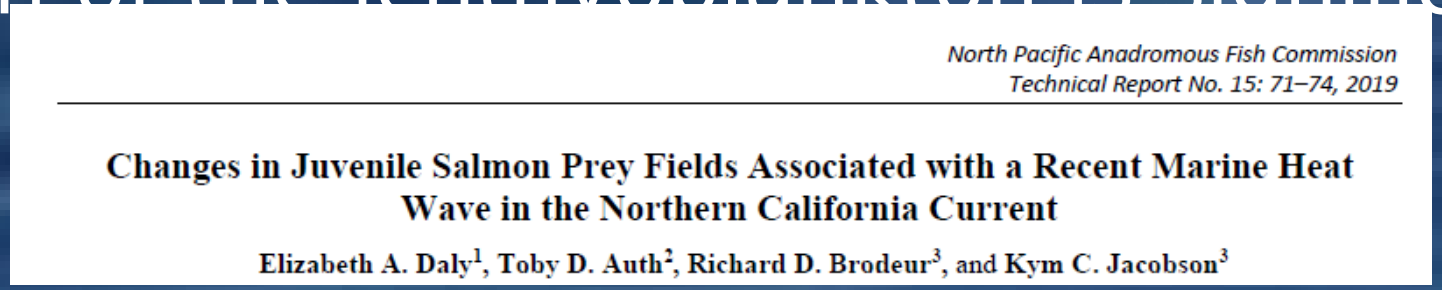
Summer 2021



https://www.cpc.ncep.noaa.gov/products/CFSv2/htmls/

Marine food conditions for juvenile steelhead change with ocean conditions

- The biomass of winter ichthyoplankton is an index of prey biomass for spring/summer out-migrating salmon.
- The biomass is *not* a significant predictor of juvenile steelhead food conditions- adding an index of winter spawned crab larvae and spring adult krill biomass data could be an improvement
- Food conditions for juvenile steelhead based on the composition of the ichthyoplankton is significantly related to steelhea



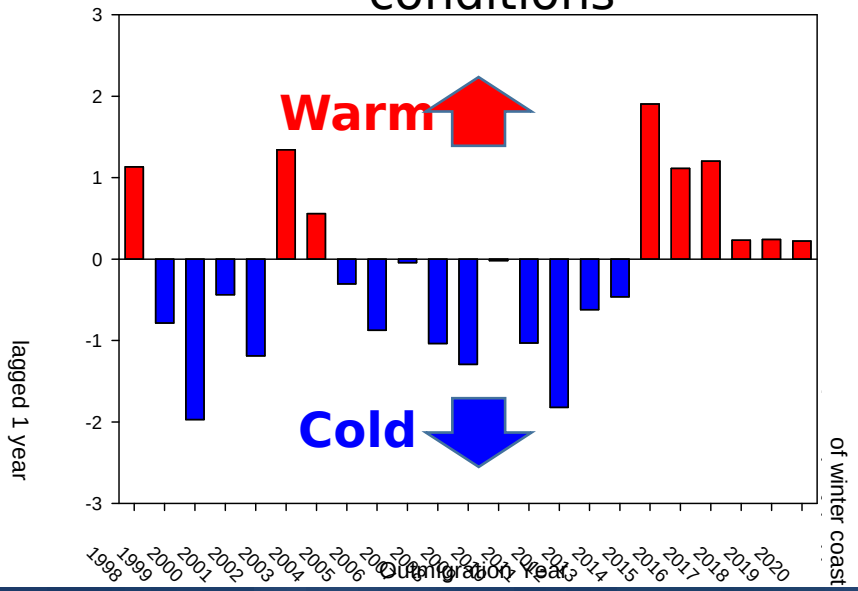
North Pacific Anadromous Fish Commission
Technical Report No. 15: 71–74, 2019

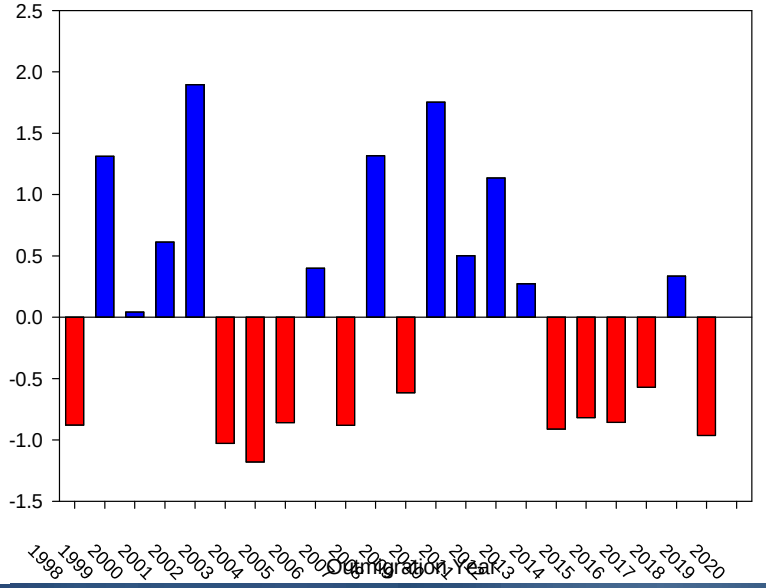
Changes in Juvenile Salmon Prey Fields Associated with a Recent Marine Heat Wave in the Northern California Current

Elizabeth A. Daly[1], Toby D. Auth[2], Richard D. Brodeur[3], and Kym C. Jacobson[3]

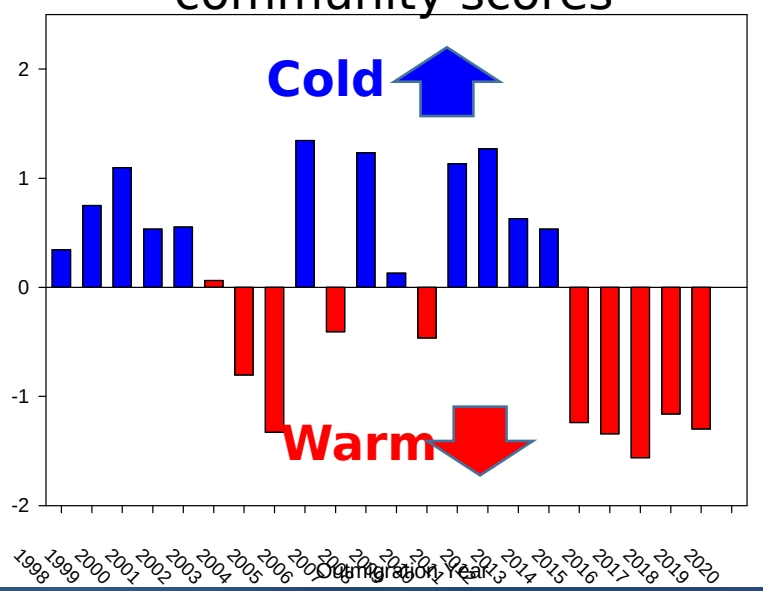
Ocean temperatures based on the Pacific Decadal Oscillation (PDO) in late fall/early winter predict food conditions for out-migrating salmon the following year

Prior year October-December P conditions



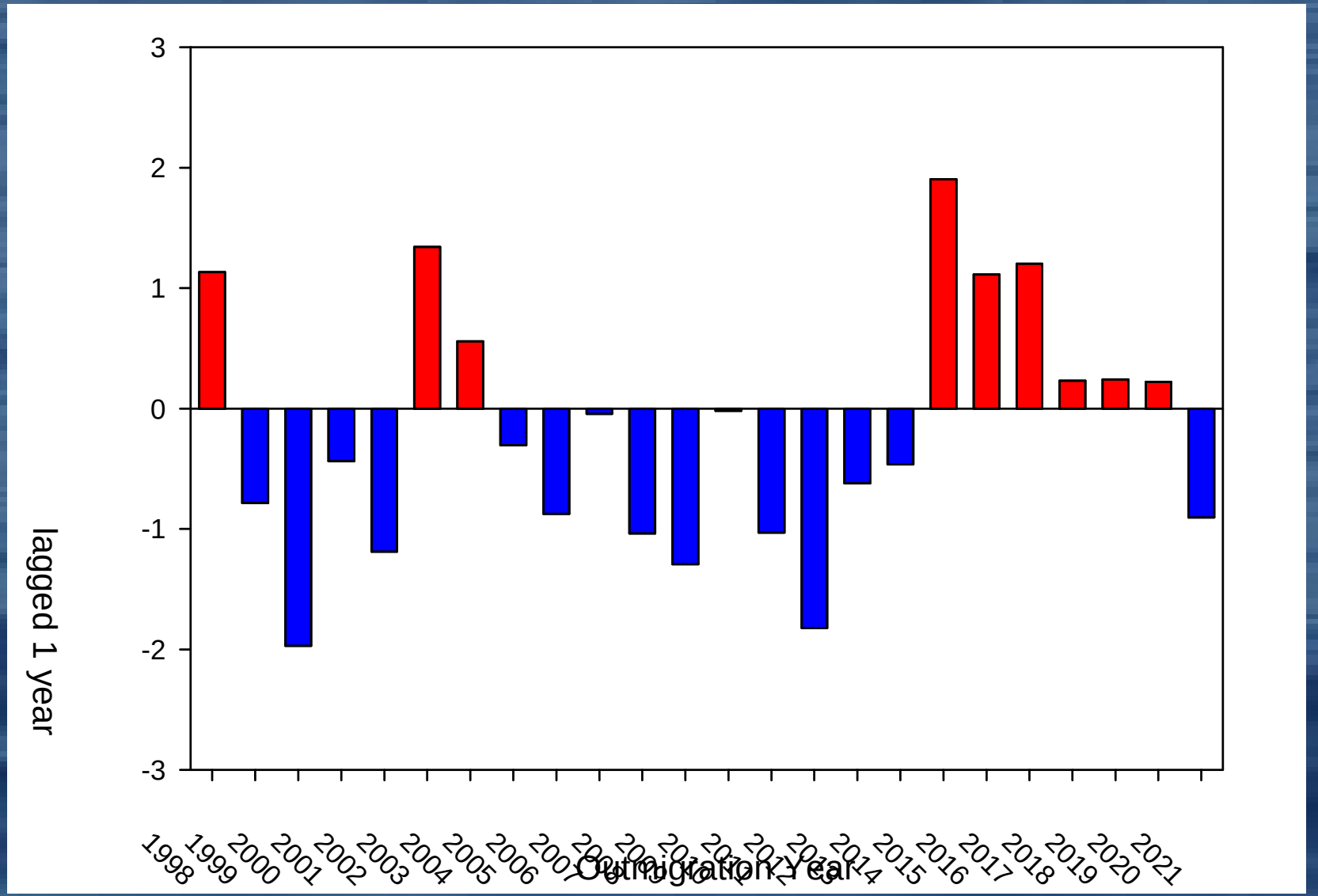


Winter ichthyoplankton community scores



2021 outmigration ocean conditions: Colder?

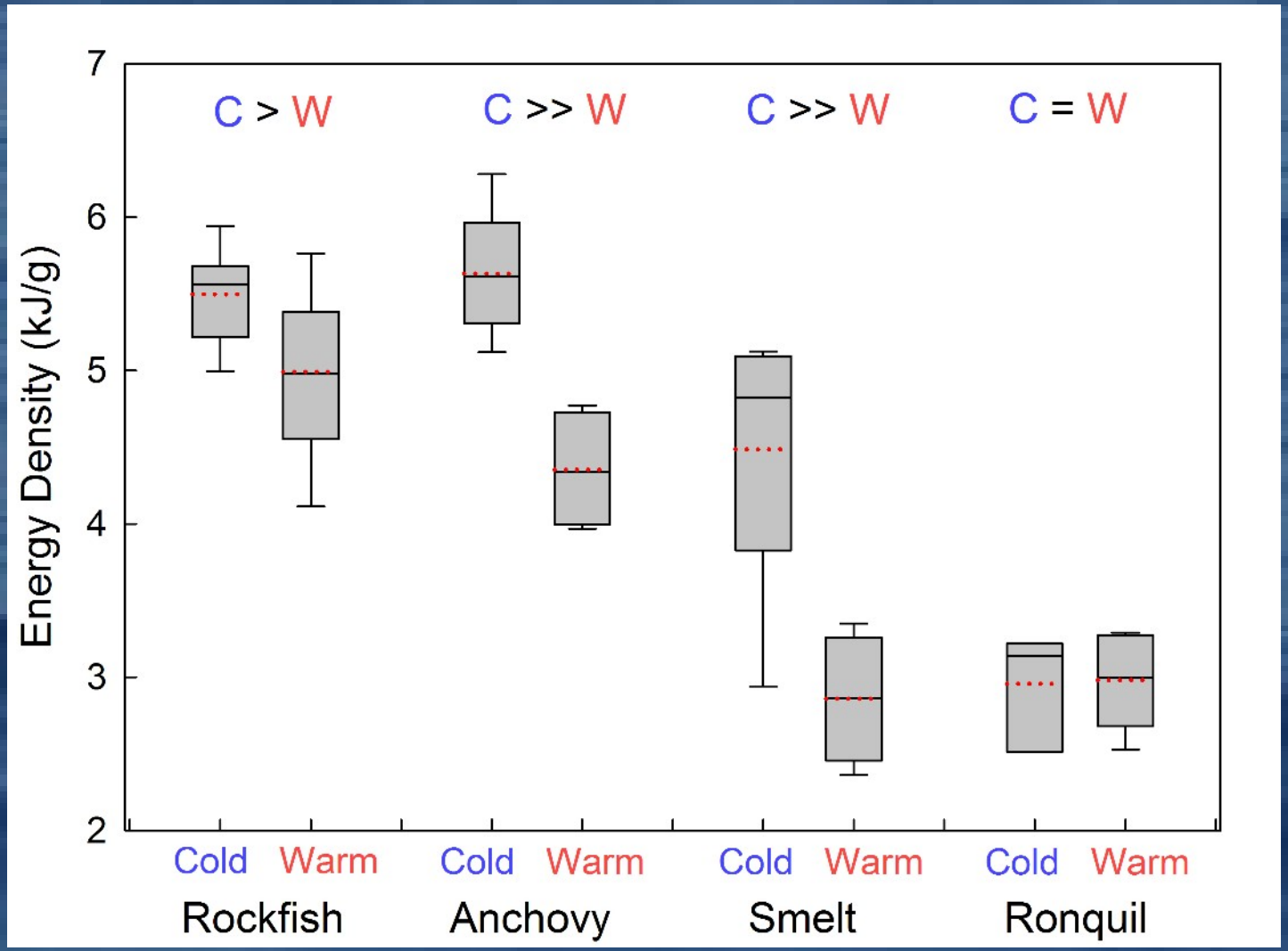
Oct-Dec 2020 ocean conditions were colder that it has been in years



Does salmon prey quality (energy density) change during different ocean conditions?

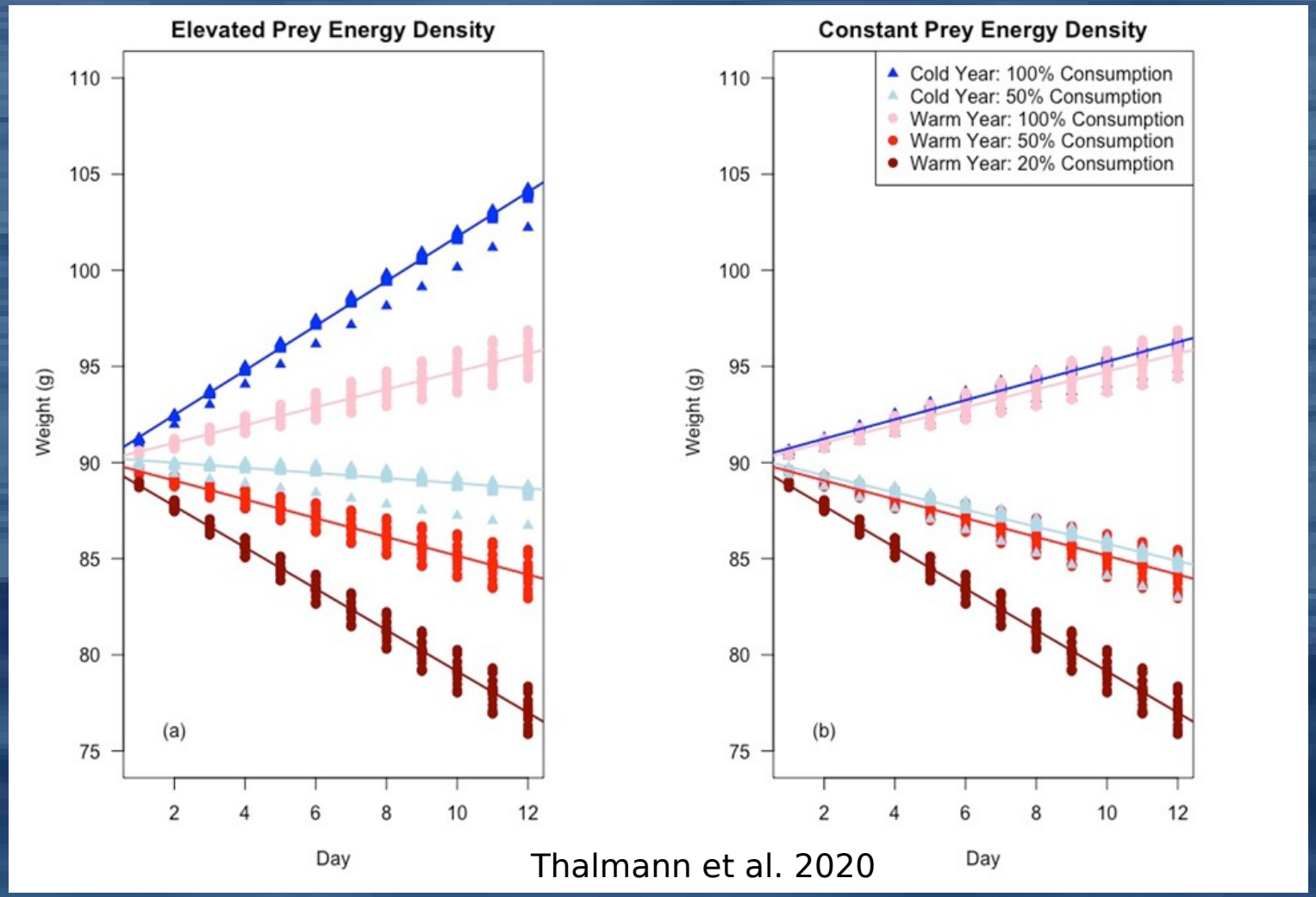
- 3 out of 4 juvenile salmon fish prey analyzed showed significant declines in energy density during warmer ocean conditions- (-30%)

In 2020 we purchased a Parr micro-bomb calorimeter



Bioenergetic models of steelhead growth during cold/warm ocean conditions

- When steelhead ate at maximum capacity during cold ocean conditions, growth was similar to warm ocean conditions (right panel)
- When prey energy density was decreased by 30% during warm ocean conditions (left panel), there were significant growth increases in the cold ocean condition relative to the warm by day 2



Thalmann et al. 2020

Conclusions and Acknowledg

- Juvenile steelhead spend a short period of time in the nearshore waters before migrating out of our sampling area
- Early marine growth of juvenile steelhead can be observed within days of ocean entry
- Ocean conditions have been warm and returns of ESA listed Columbia River adult steelhead have been below average for 8 of the last 9 years
- Ocean food conditions have been below average for the last 6 years yet the colder fall/winter ocean conditions may increase food conditions for out-migrating 2021 juvenile steelhead- hopefully the ocean will remain cool.

Funding and resources provided by:

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

We are indebted to the many people who assisted in collecting and sorting the samples, innumerable boat crews, and all those that assist the project in many different ways!


Question
s?