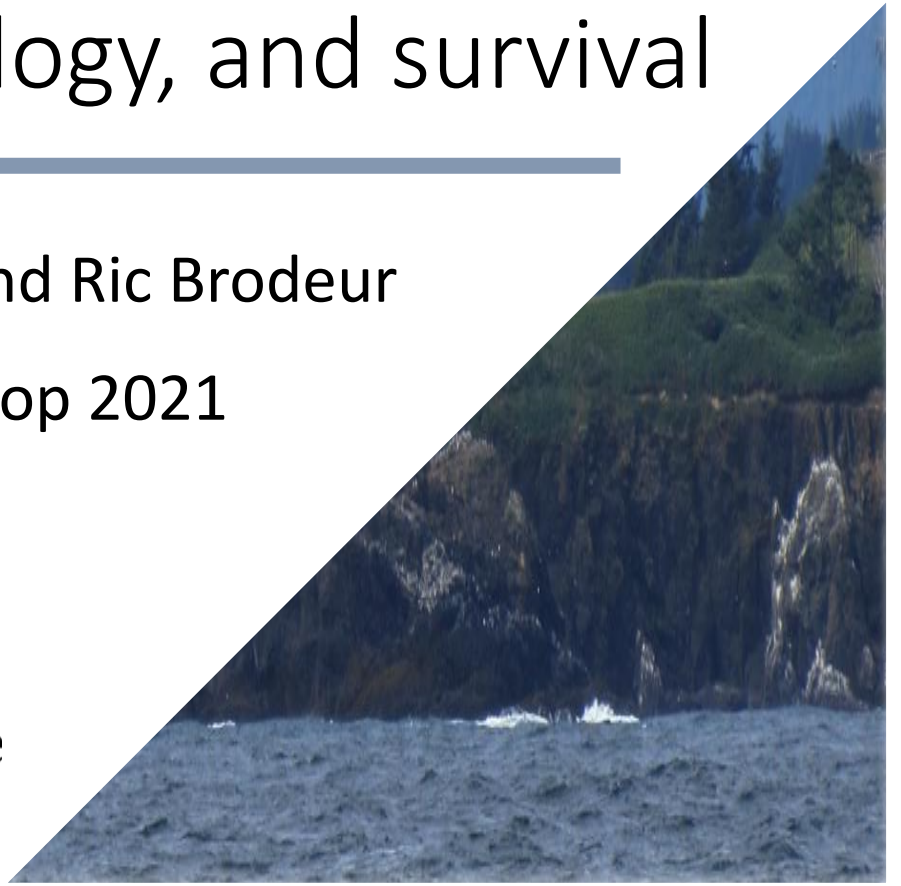
Two anomalously warm years in the Northern California Current:

impacts on early marine Steelhead diet composition, morphology, and survival

Hillary Thalmann, Elizabeth Daly, and Ric Brodeur

Fish without Borders Workshop 2021



Columbia River steelhead *(Oncorhynchus mykiss)* are an ESA-listed salmonid with a complex life history.

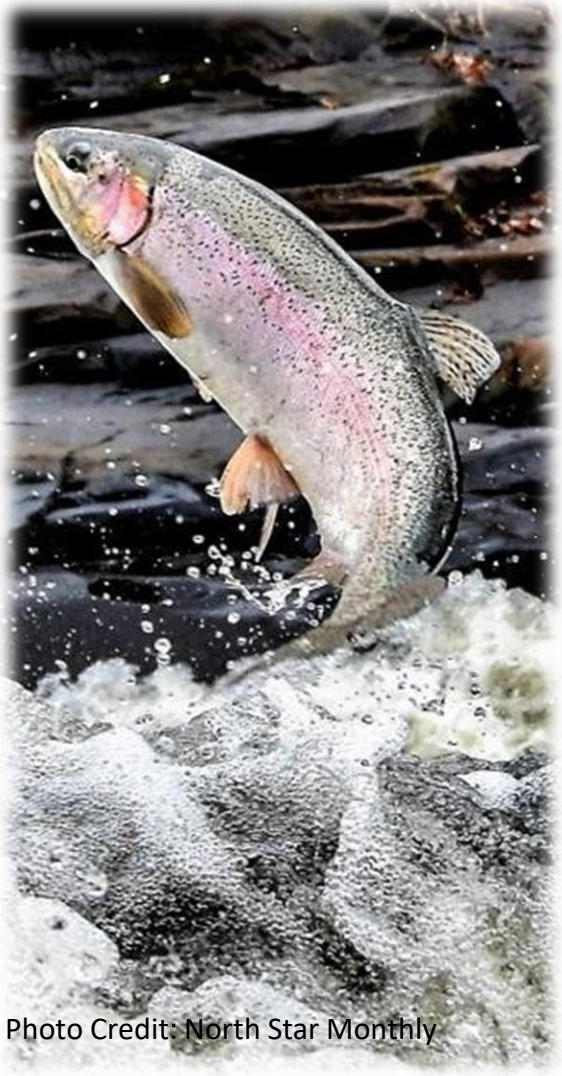


Photo Credit: North Star Monthly

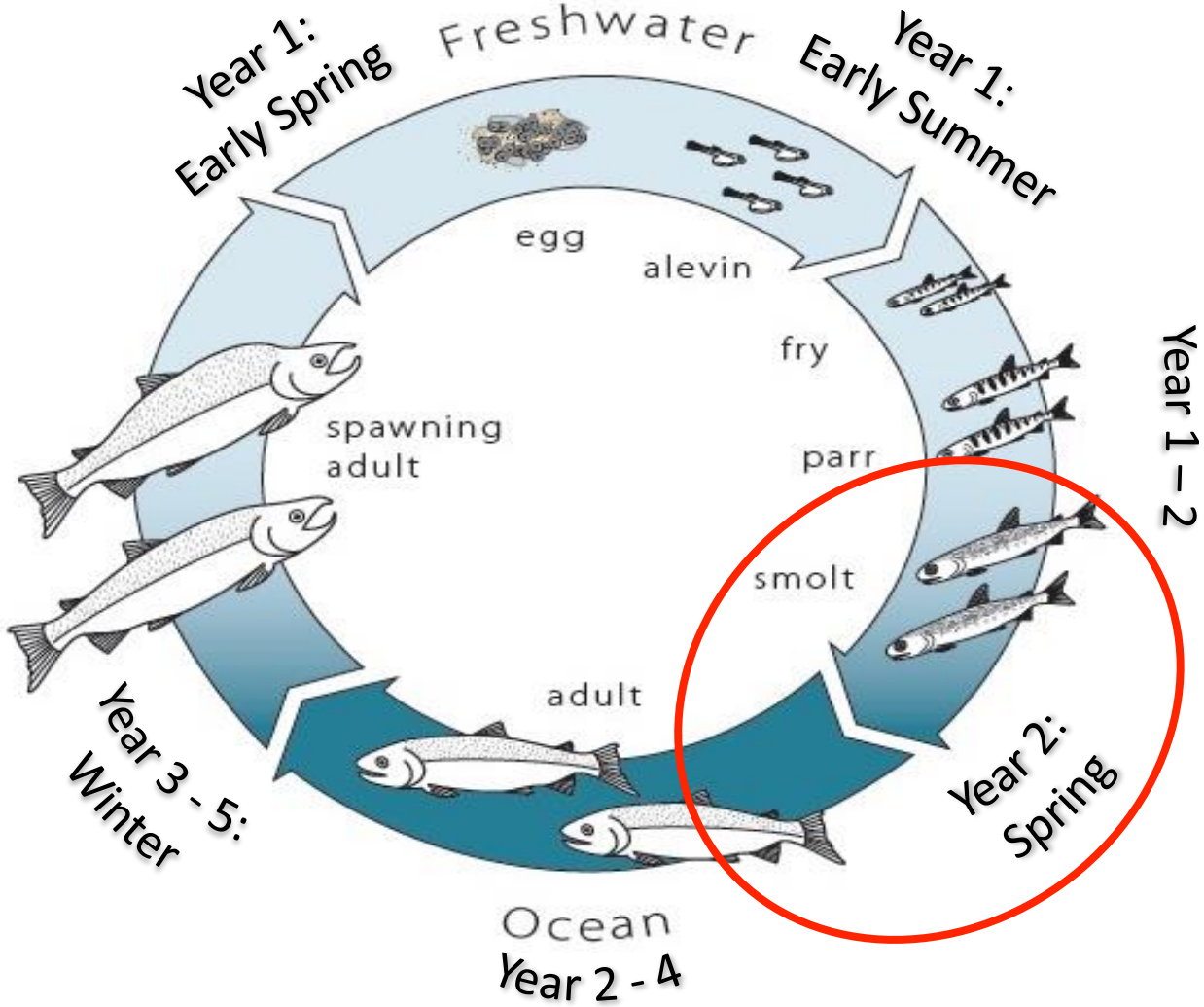
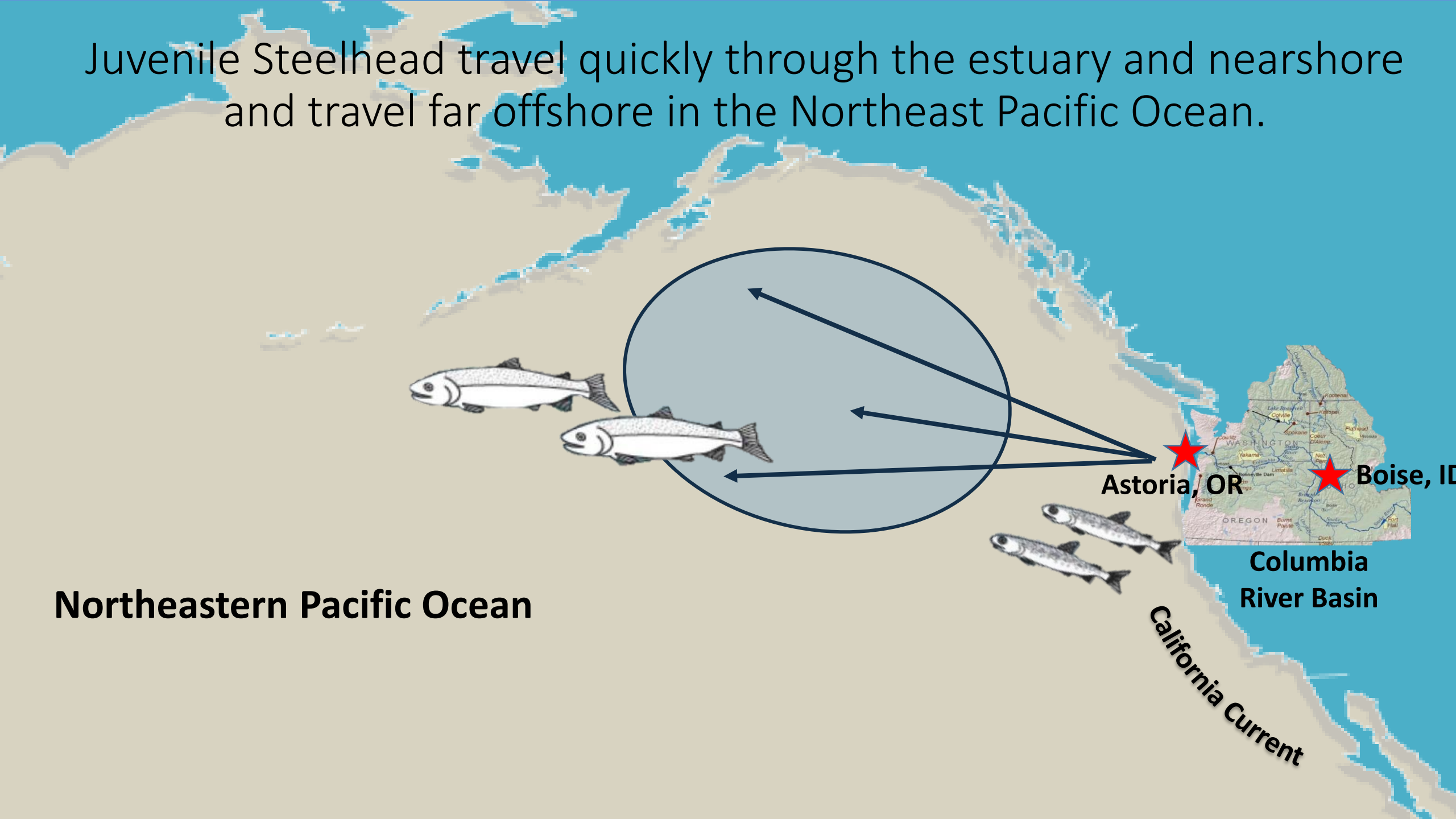
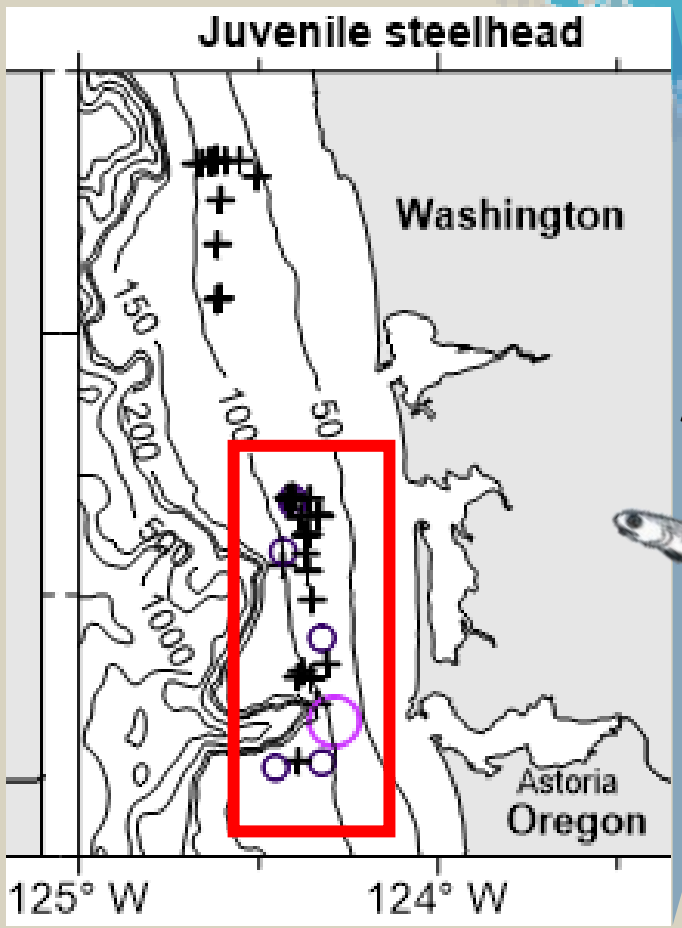


Photo Credit: Long Live the Kings

Juvenile Steelhead travel quickly through the estuary and nearshore and travel far offshore in the Northeast Pacific Ocean.



In our early marine Steelhead studies, we focus on their time nearshore, ~10 days after ocean entry.



Astoria, OR

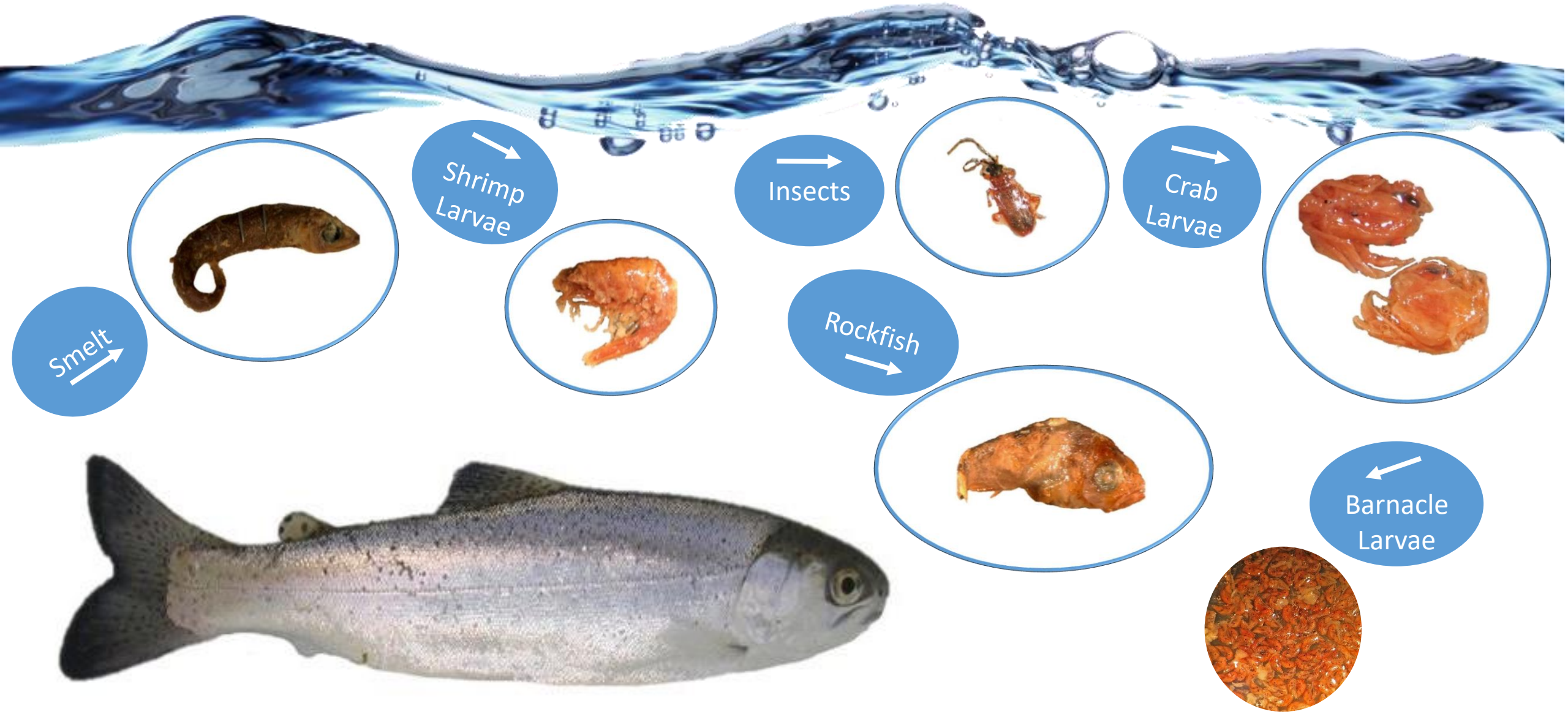
Boise, ID

Columbia River Basin

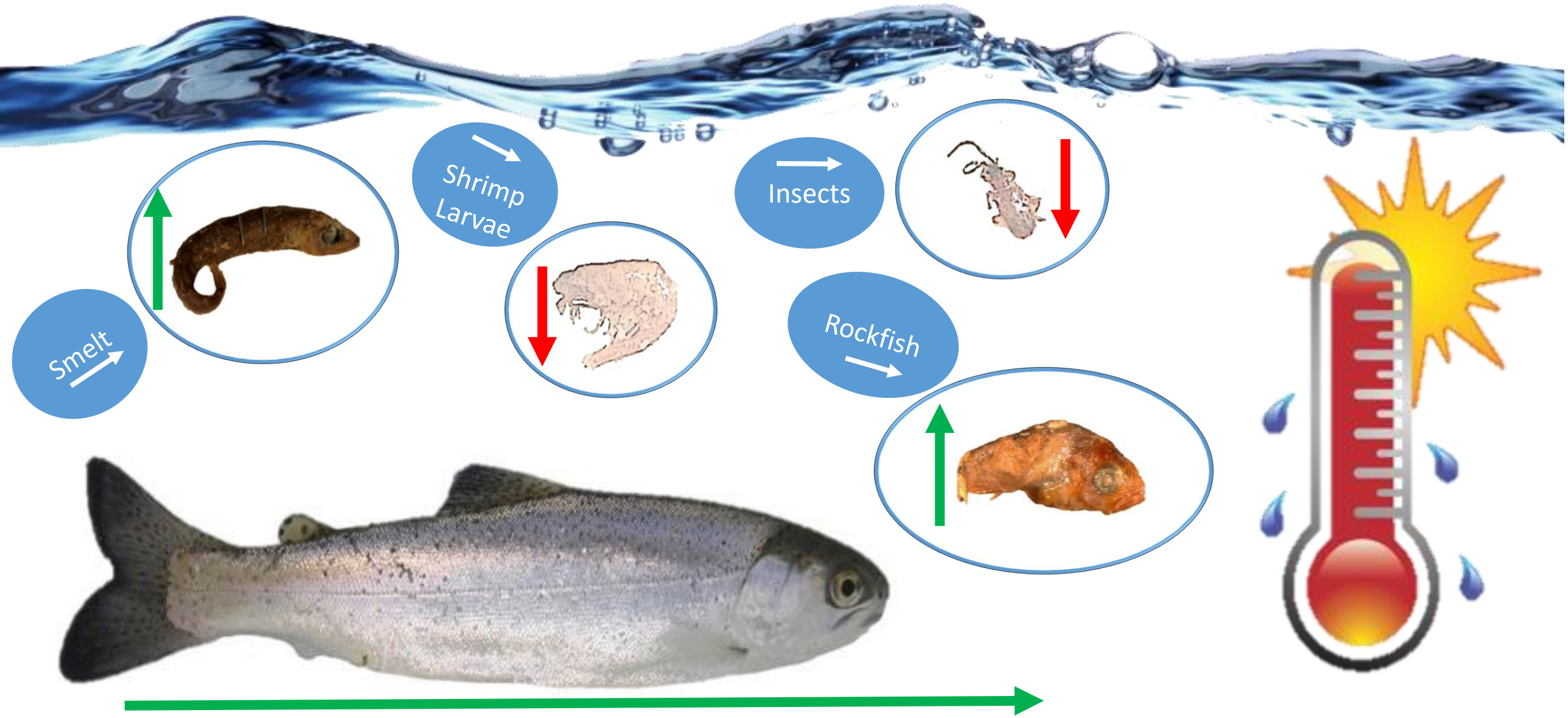
California Current

Northeastern Pacific Ocean

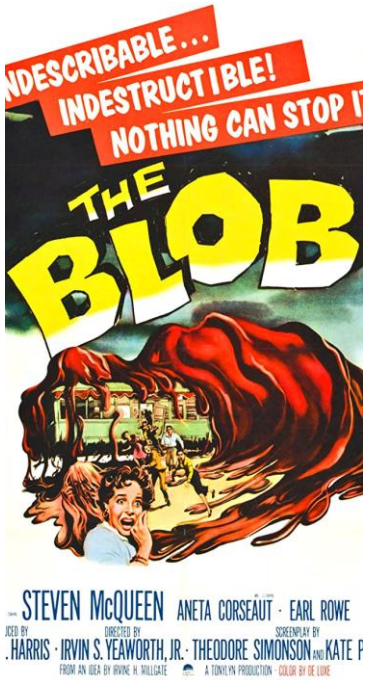
In the ocean, early marine steelhead feed on a variety of near-surface prey items.

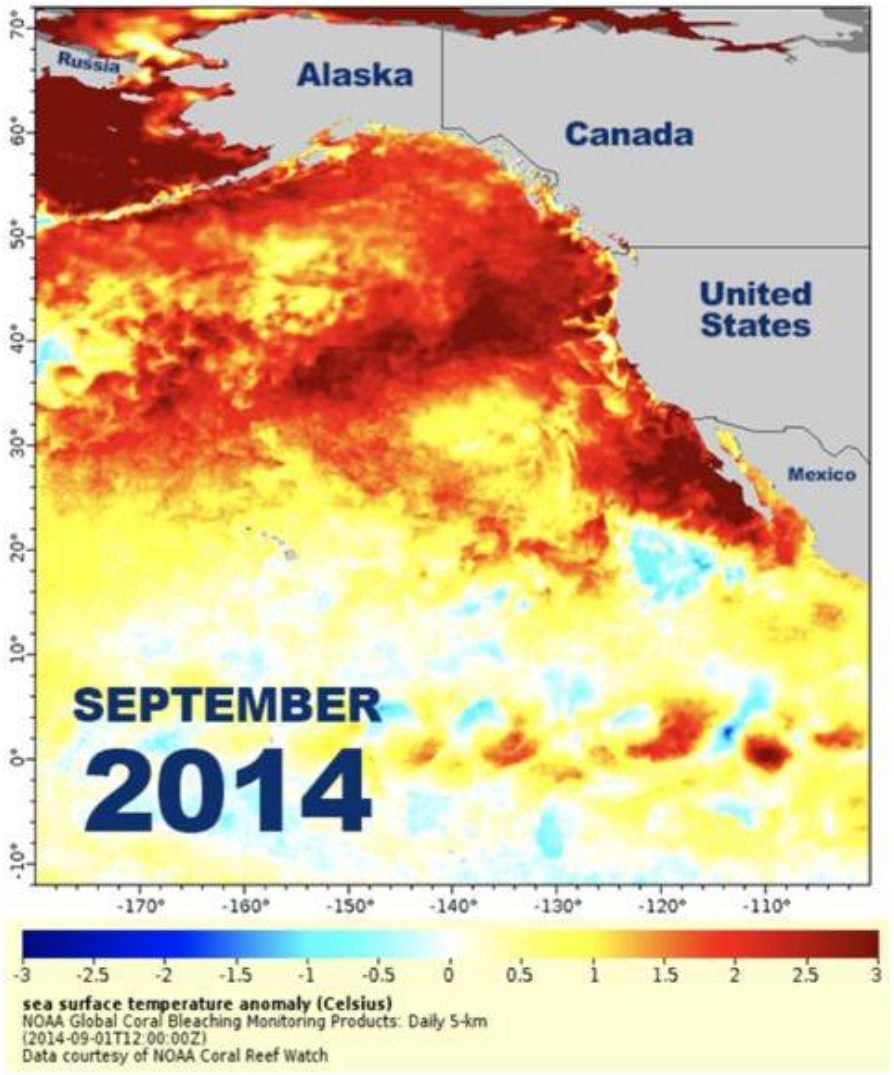


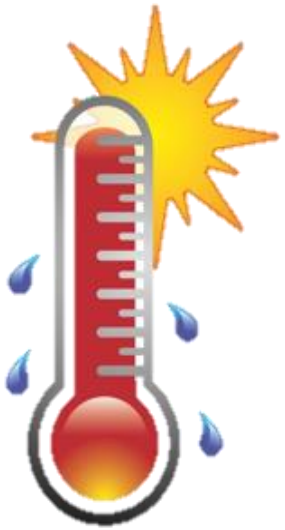
Early marine steelhead foraging and growth has the potential to change with temperature.



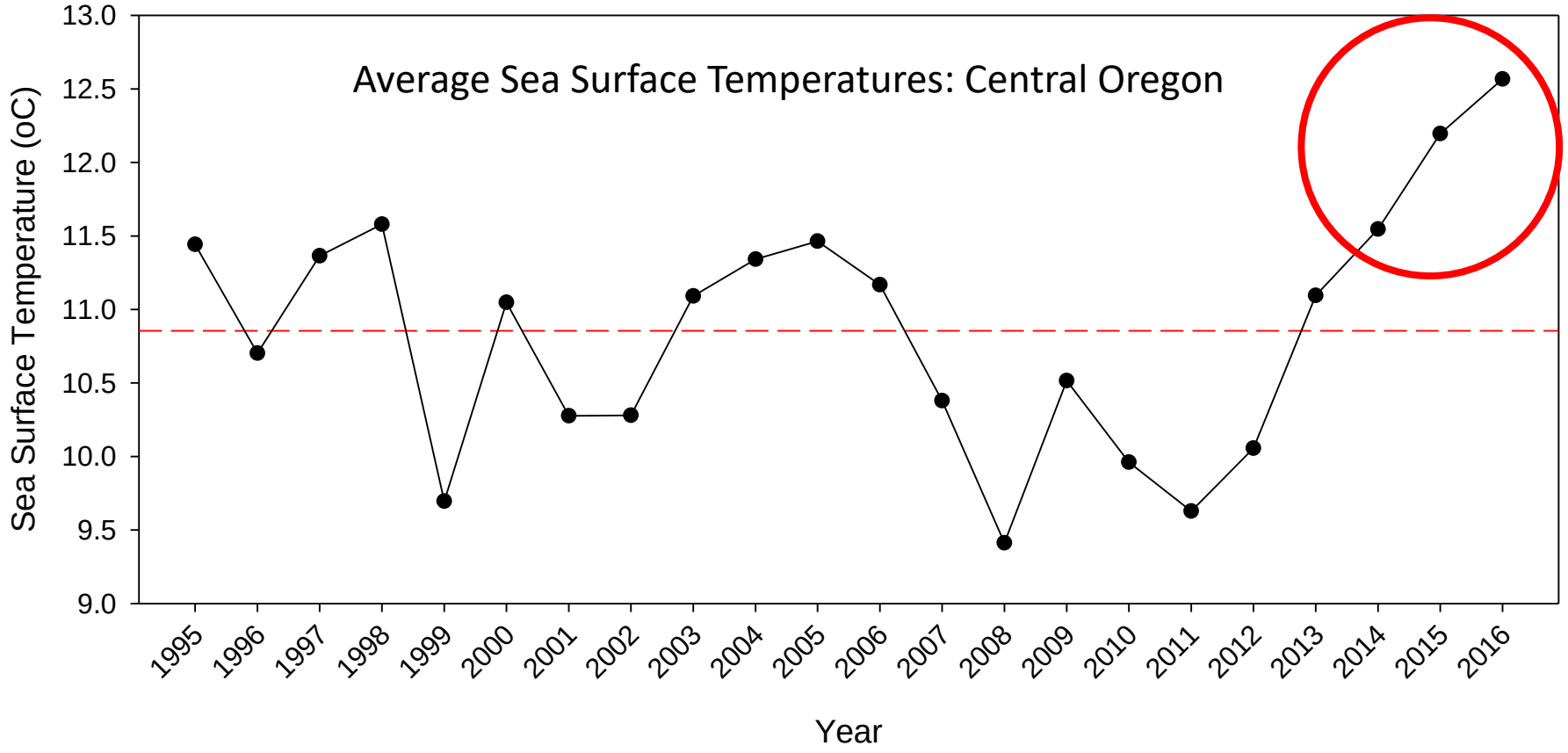
In 2014 - 2016, an anomalous marine heatwave occurred along the entire west coast, increasing ocean temperature by >2.5°C.







In 2014 - 2016, an anomalous marine heatwave occurred along the entire west coast, increasing ocean temperature by >2.5°C.



This marine heatwave event led to changes to biological communities throughout Northeastern Pacific.

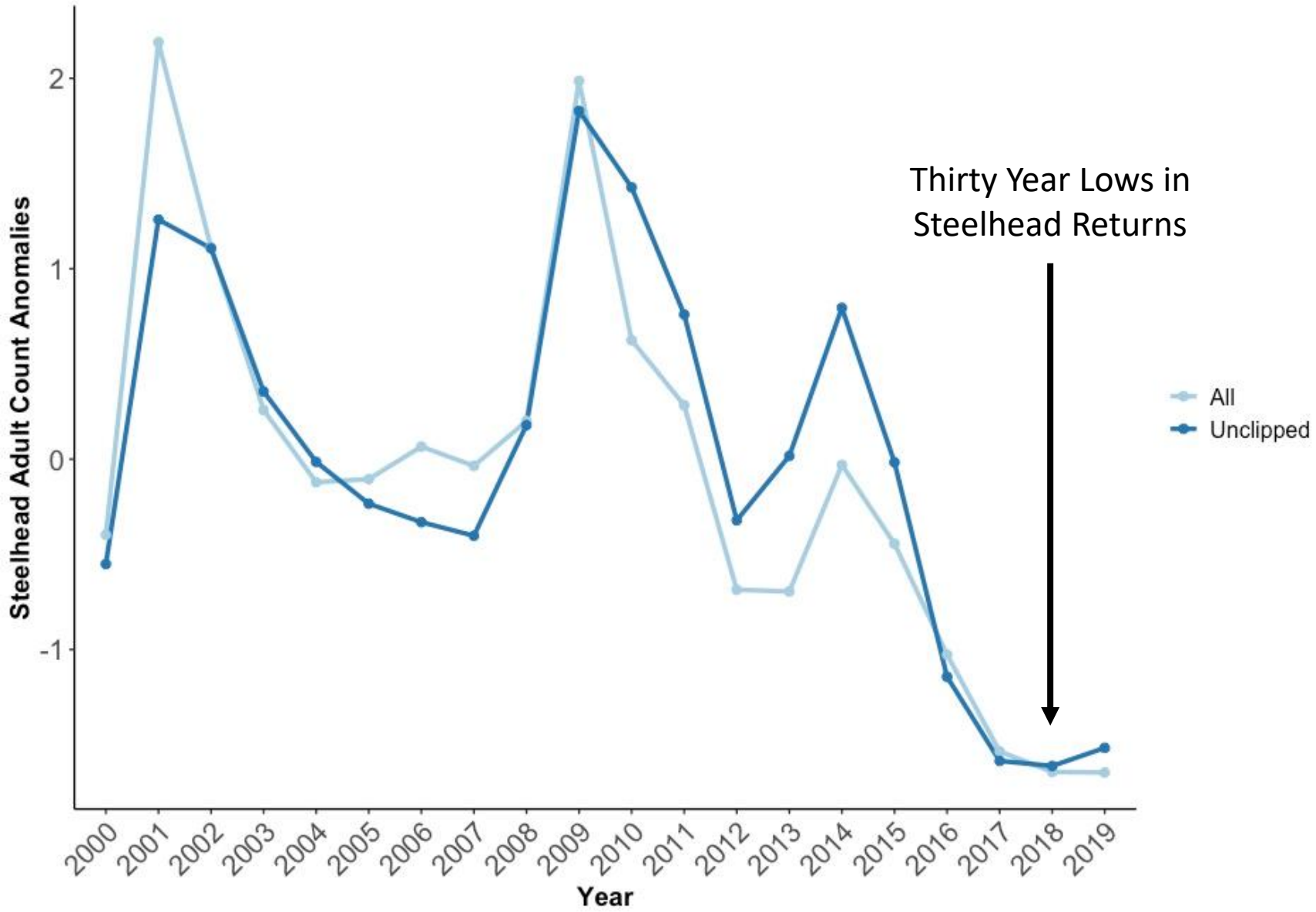
Seabird Mass Mortalities

Gray Whale Unusual Mortality Event

Increase in Harmful Algal Blooms

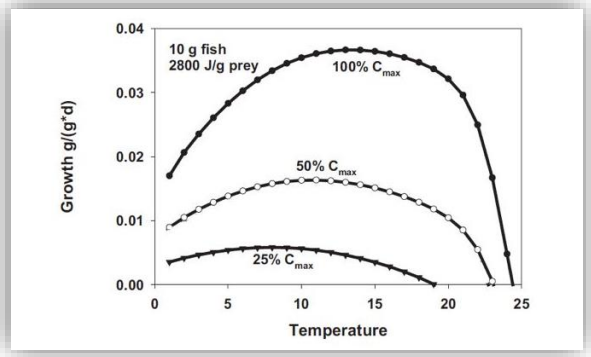
Shifting Copepod Communities

Steelhead that entered the ocean during the marine heatwave returned to the Columbia River as adults in record-low numbers.

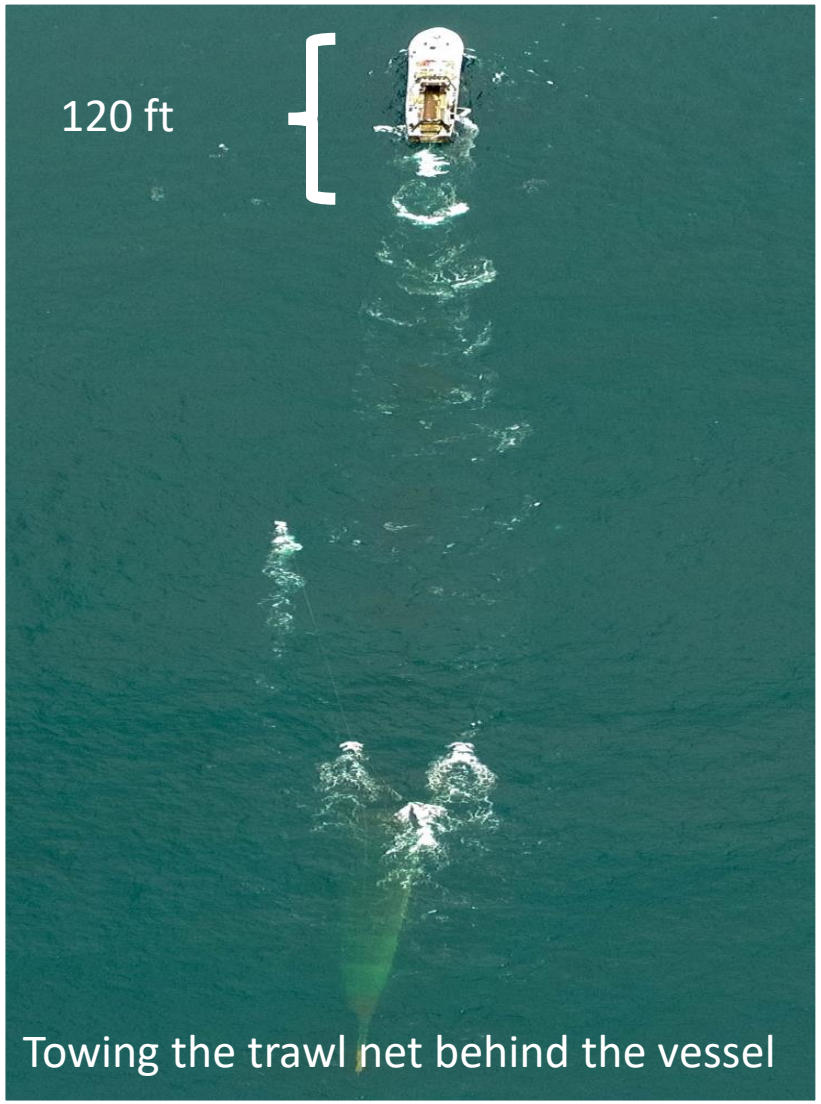


Objectives:

- Evaluate early marine Steelhead **diet composition** in warm ocean years compared to cooler or more average ocean conditions
- Assess Steelhead **size and body condition** in warm, cool, and average temperature ocean years
- Utilize **bioenergetics models** to predict **growth** in the early ocean residence under heatwave conditions



Juvenile Steelhead were collected and analyzed from sites near the Columbia River from 2001 to 2016.



Towing the trawl net behind the vessel


Hauling in the catch

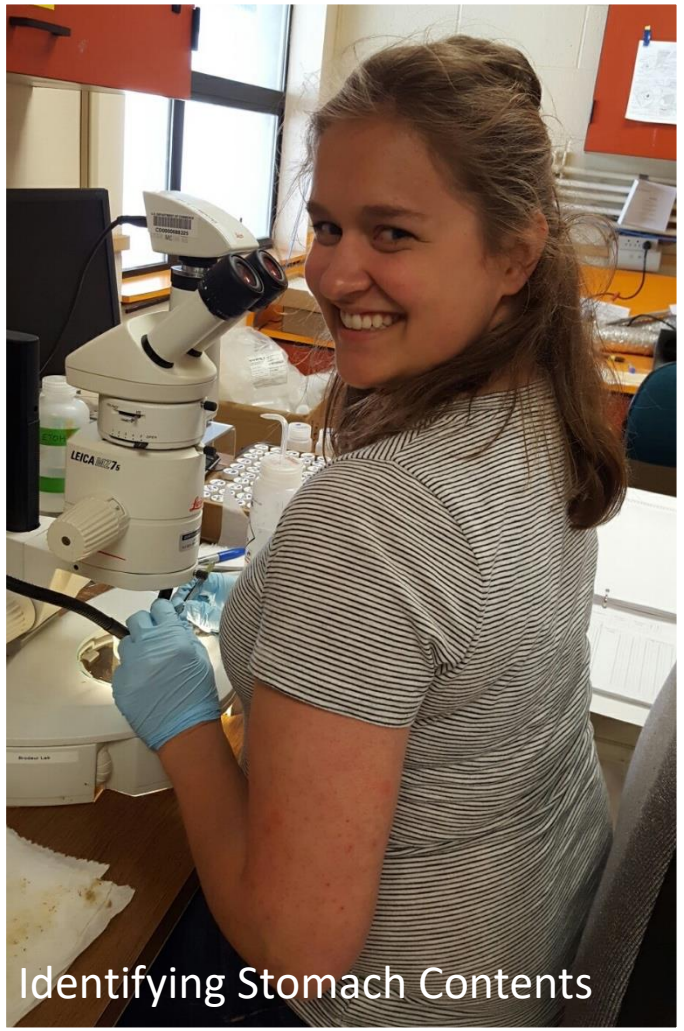

Sorting juvenile salmon

Steelhead stomachs were dissected to determine the amount and type of prey consumed.

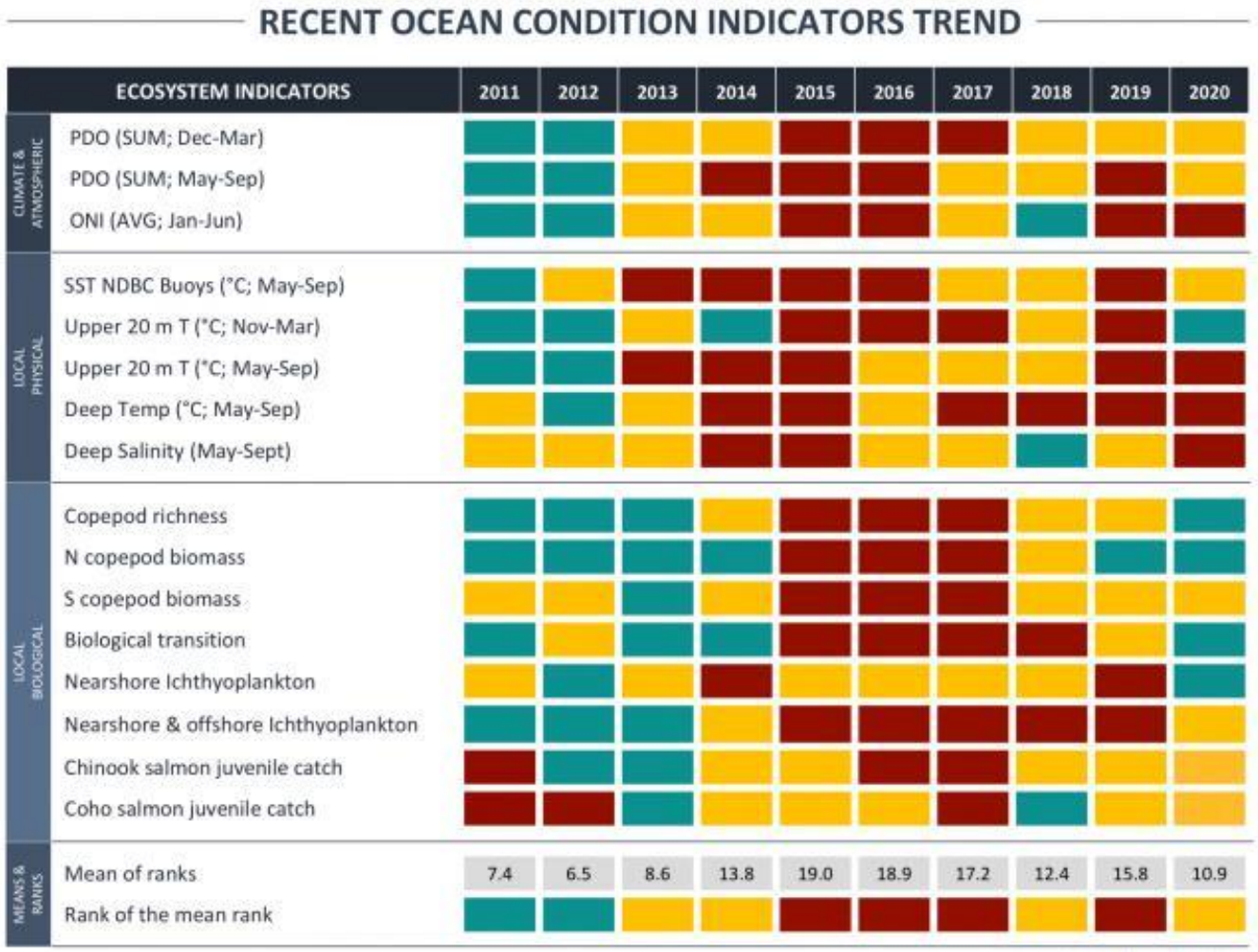
Dissecting Steelhead


Steelhead Stomach


Steelhead Prey


Identifying Stomach Contents

Steelhead were grouped into those collected in warm years, average years, and cool years based on the NOAA “Stoplight” Table.

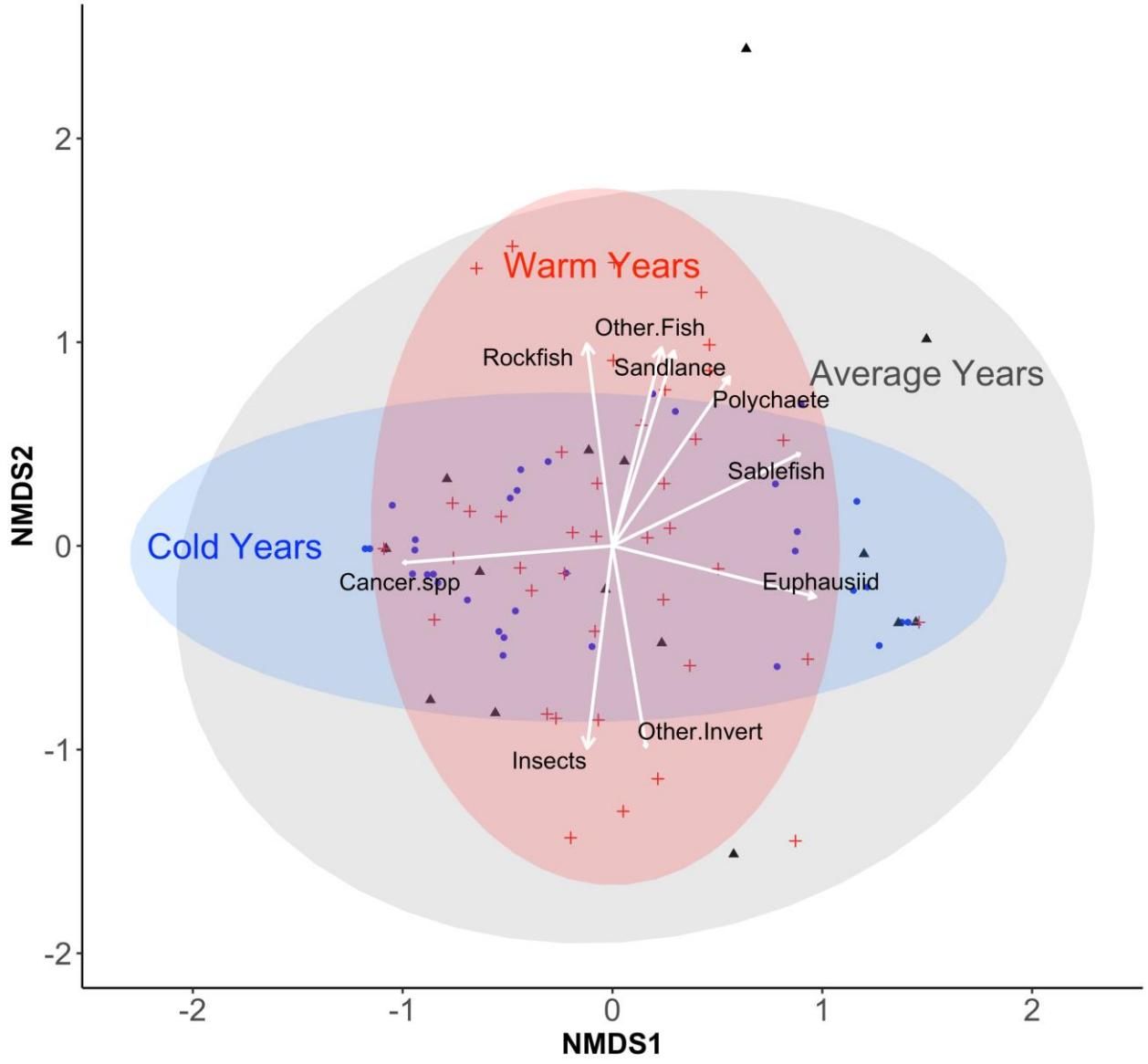


Poor Conditions

Fair Conditions

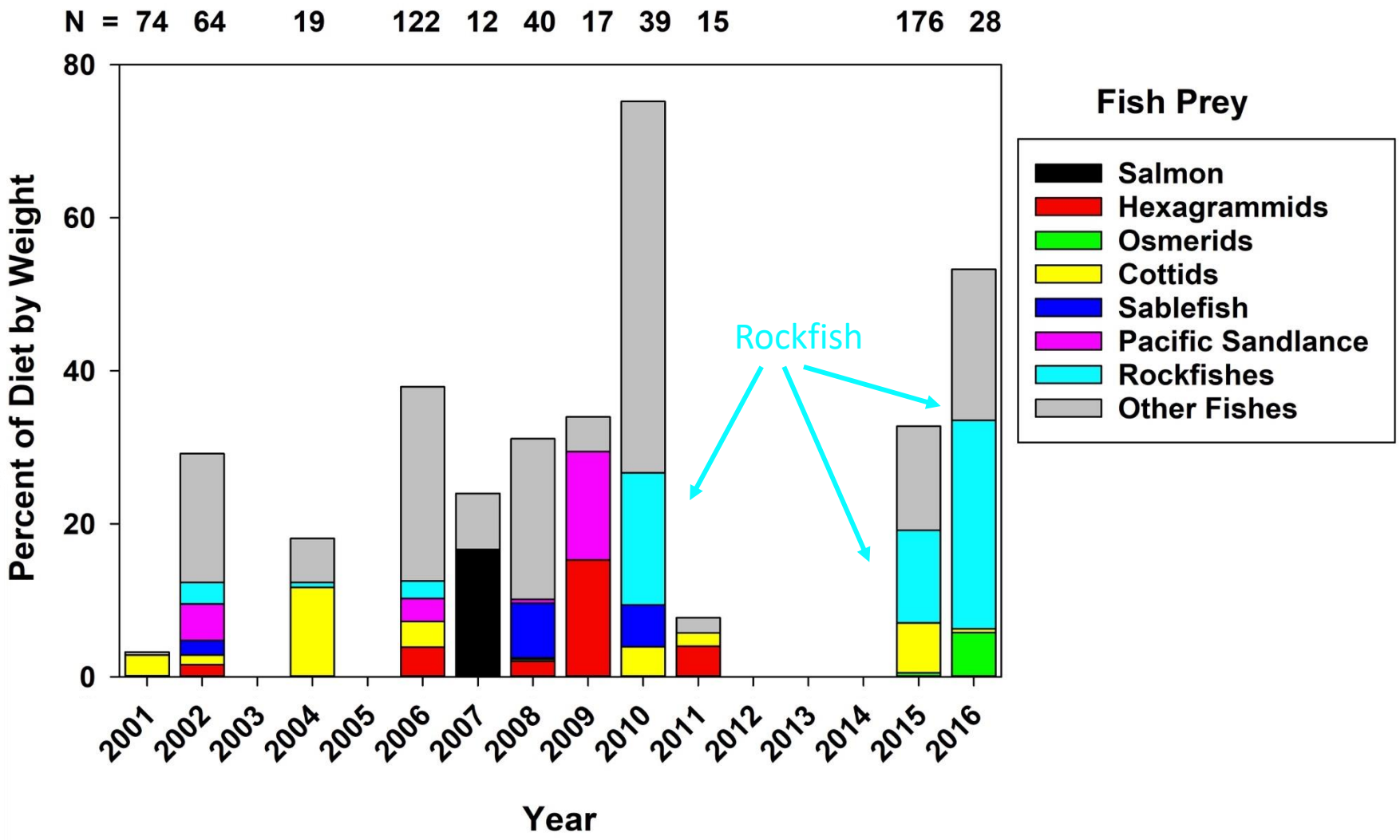
Good Conditions

Steelhead diet varied between warm and cold years and between warm and average temperature years.

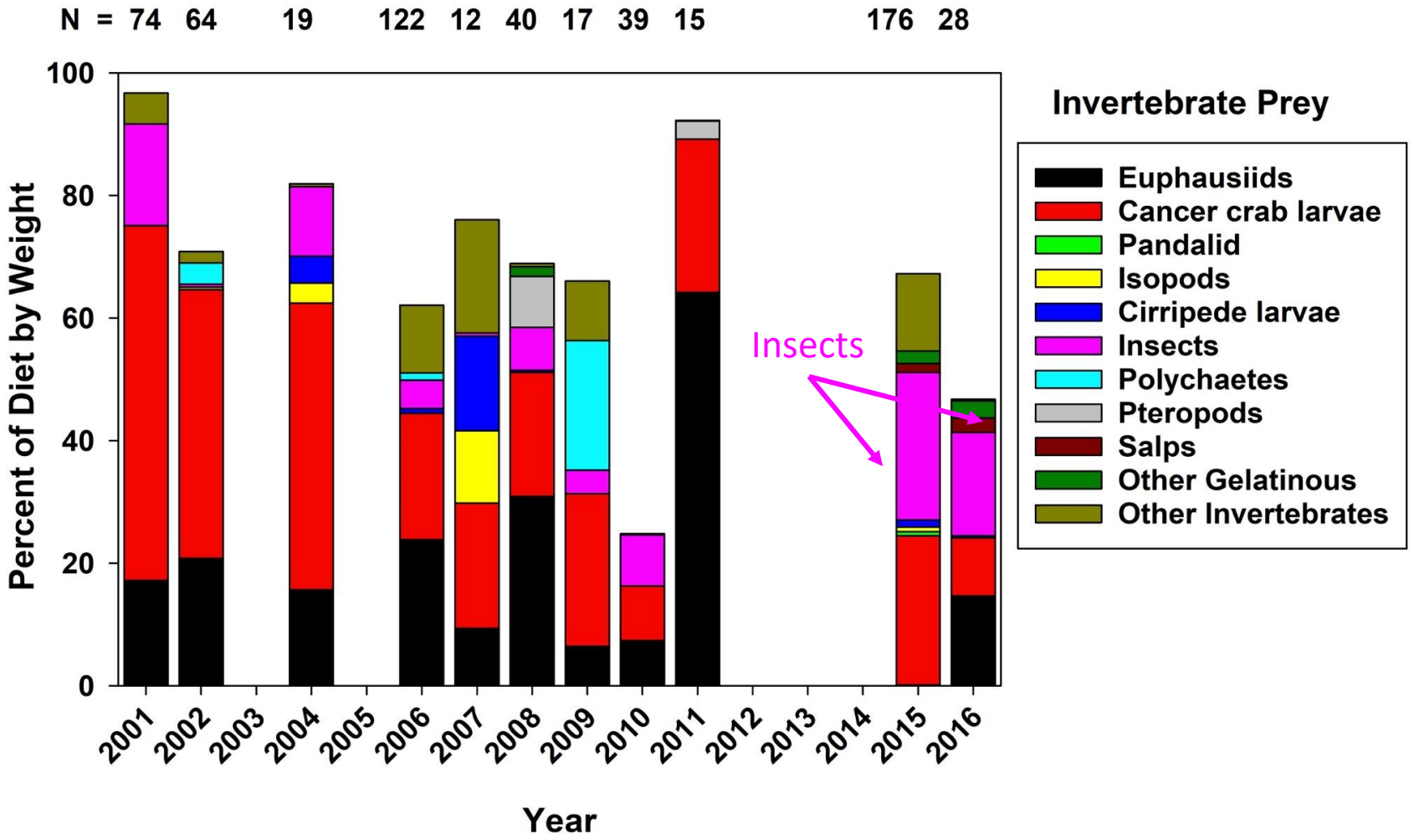


(MRPP, comparison of warm vs. cold years, $p < 0.001$, comparison of warm vs. average years, $p = 0.002$)

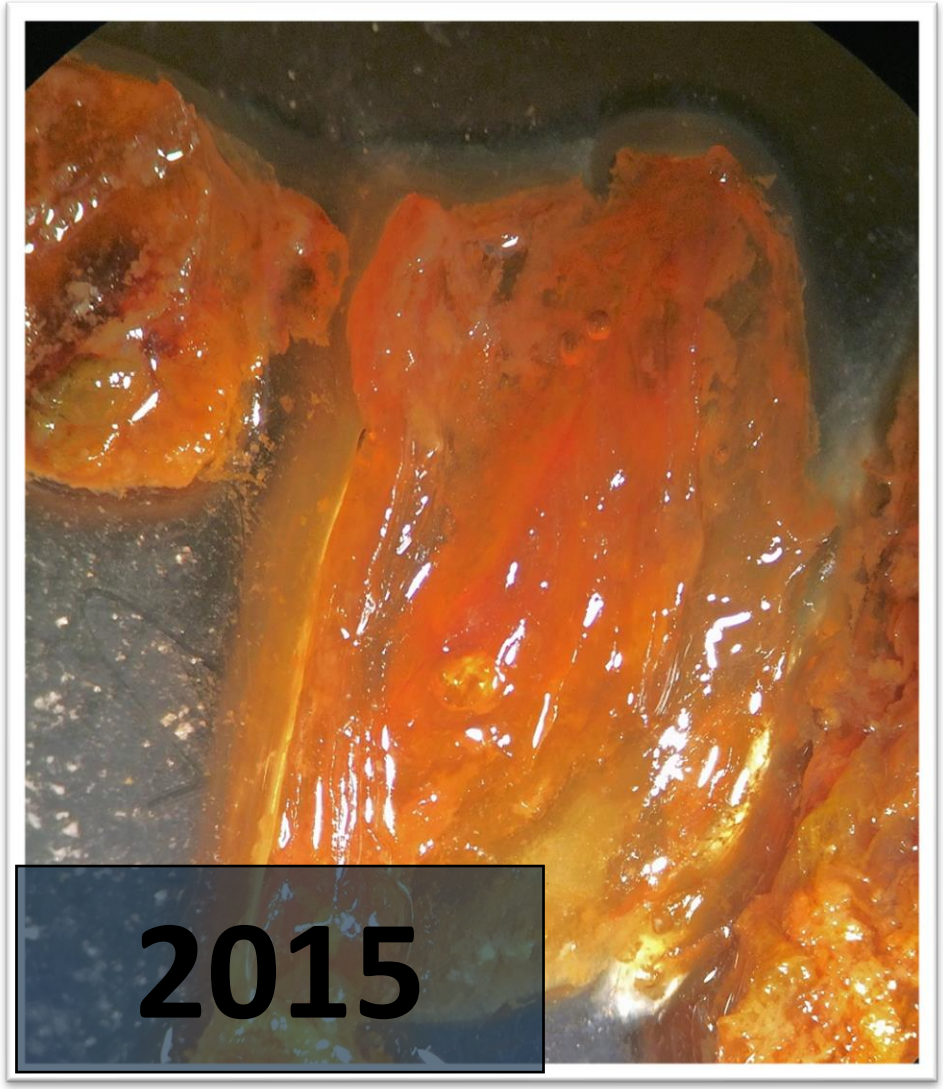
Juvenile Rockfish prey were more common in warm years than in any cool or average temperature years.



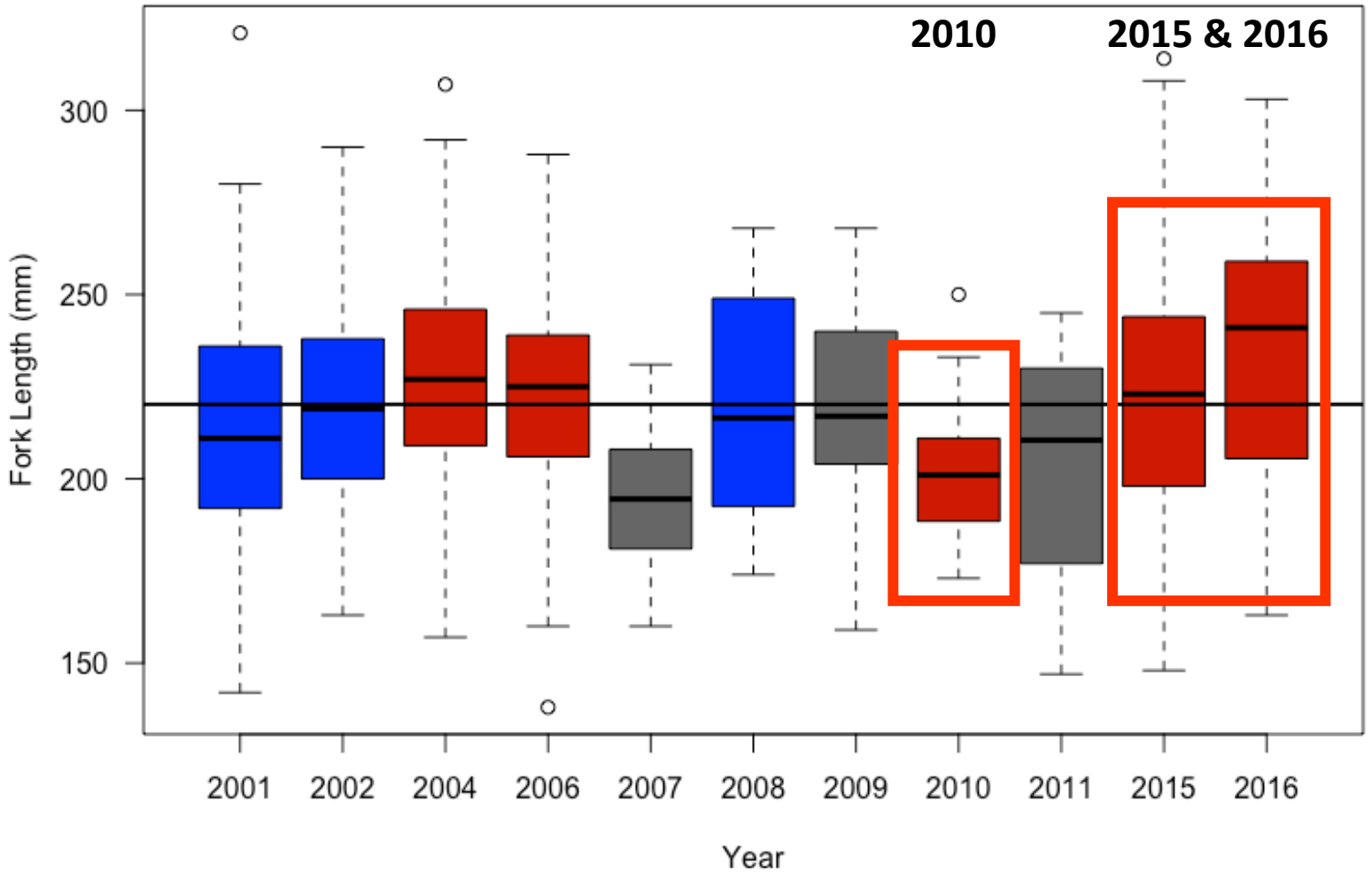
Insect prey were more common in warm years than in any cool or average temperature years.



Unusual taxa such as salps and smelt were consumed during heatwave-influenced years.

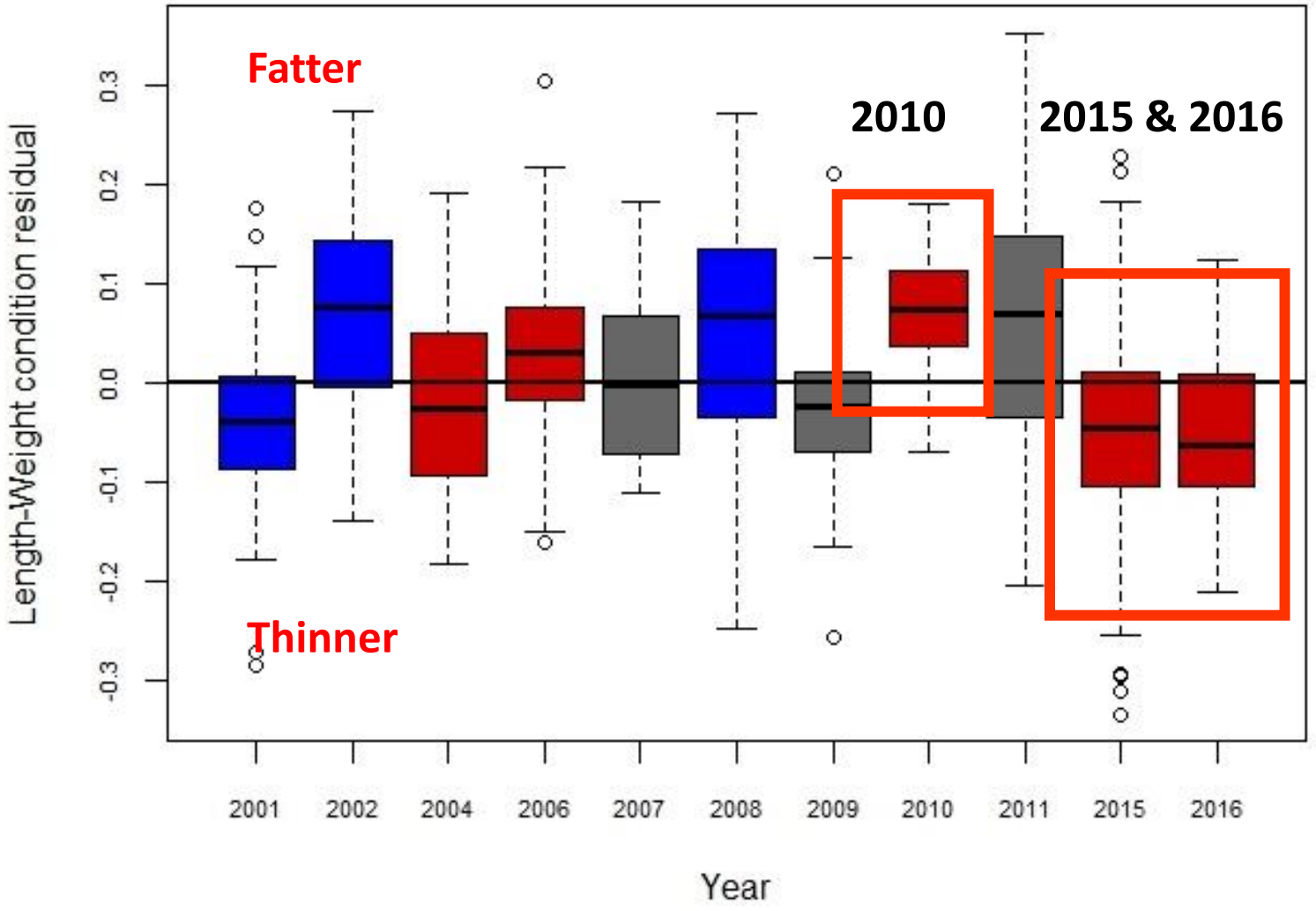


Steelhead tended to be larger in heatwave-influenced years, but this pattern was not consistent across all warm years.



(Bars represent 25th and 75th percentiles, Kruskal-Wallis Non Parametric Test, p = < 0.001)

Steelhead body condition was low during heatwave-influenced years, but this pattern was not consistent across all warm years.



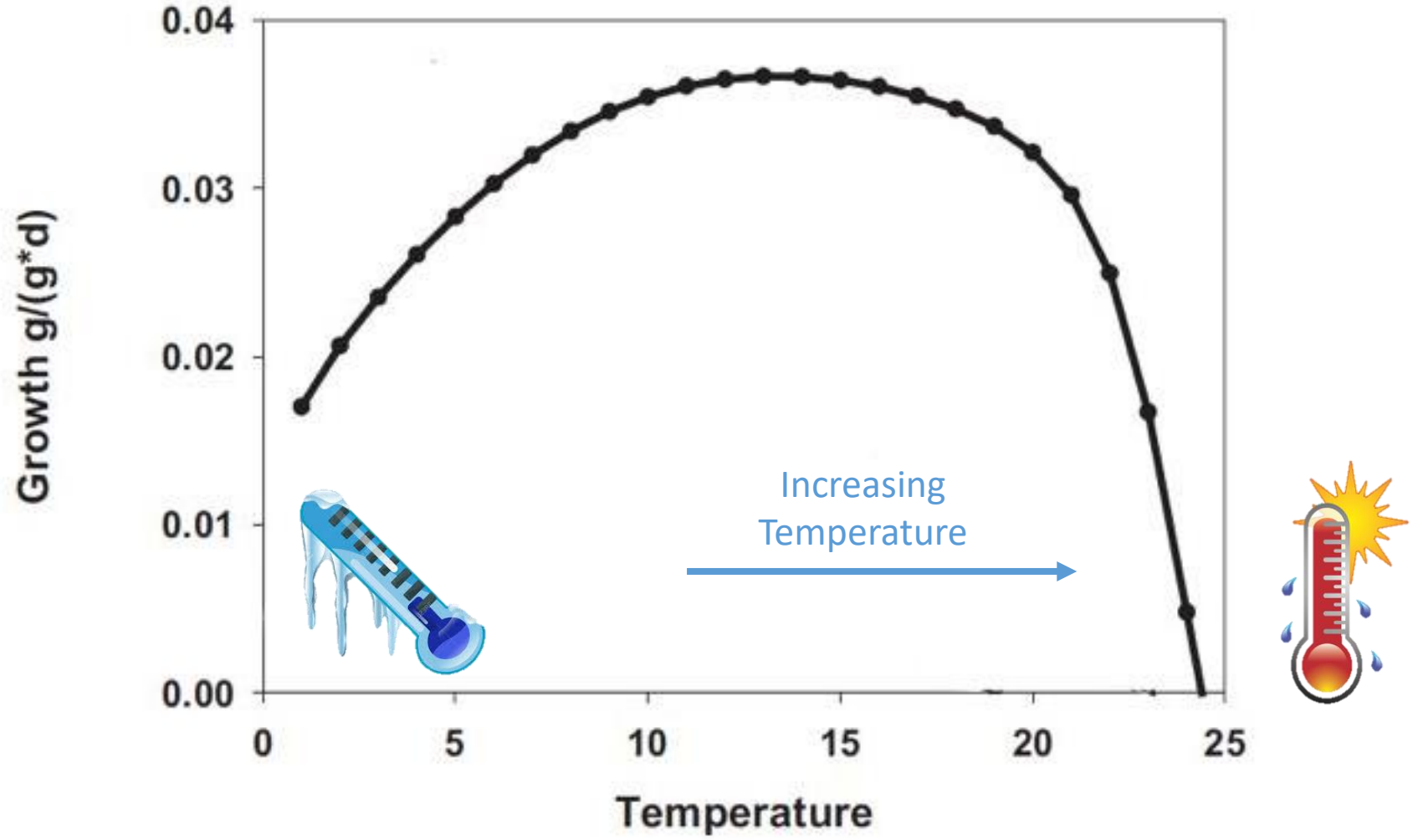
(Bars represent 25th and 75th percentiles, Kruskal-Wallis Non Parametric Test, p = < 0.001)

- Steelhead **diet composition shifts** in warm years
- Steelhead consume **more rockfish, insects, and unidentified fish** in warm ocean years
- Steelhead **size increases** but overall **condition decreases** in heatwave-influenced years

- Steelhead **diet composition shifts** in warm years
- Steelhead consume **more rockfish, insects, and unidentified fish** in warm ocean years
- Steelhead **size increases** but overall **condition decreases** in heatwave-influenced years

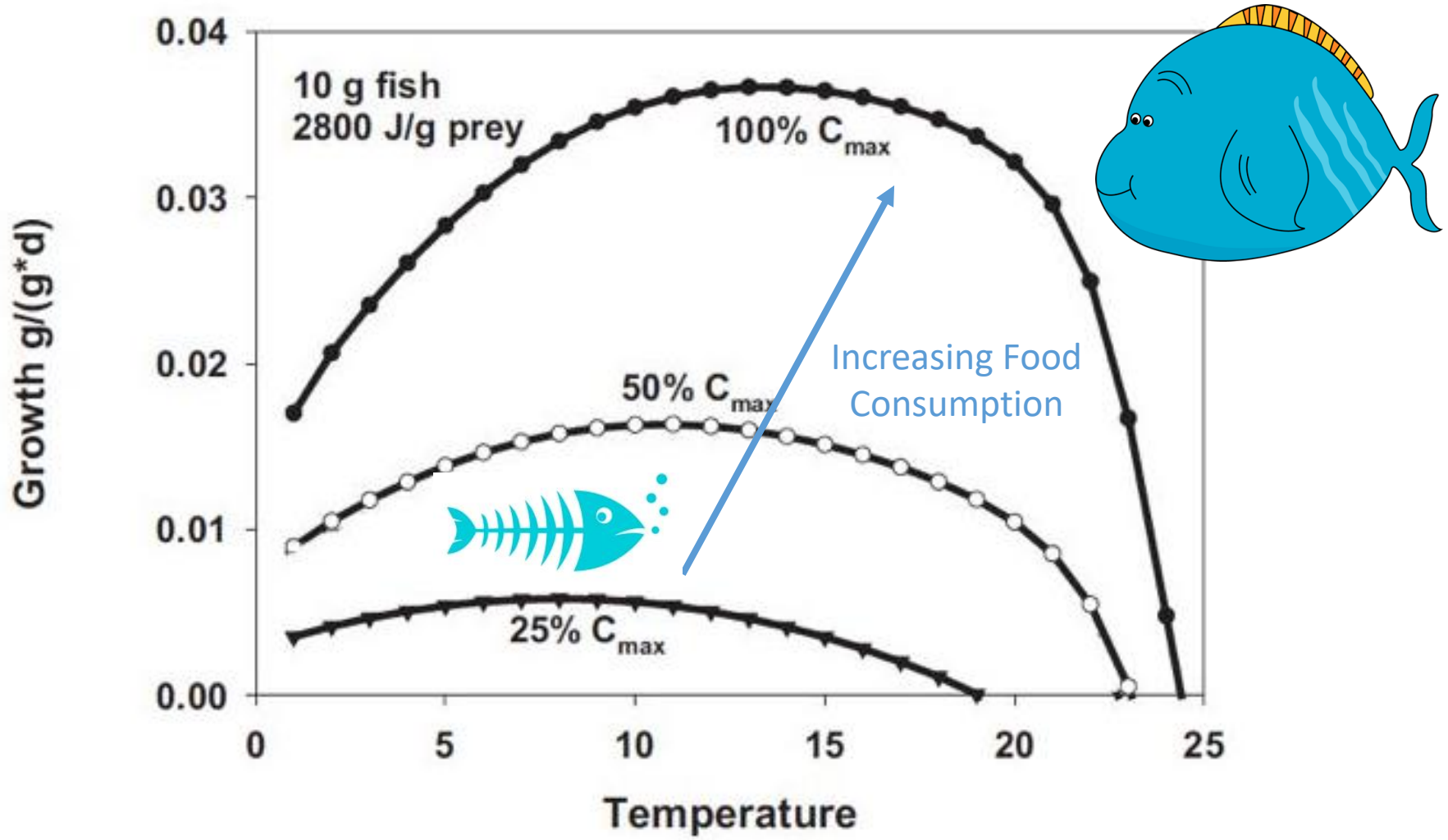
Can we use information about Steelhead diet and size to model predicted growth in warm ocean conditions?

Wisconsin Bioenergetics Models can infer fish growth at different water temperatures.



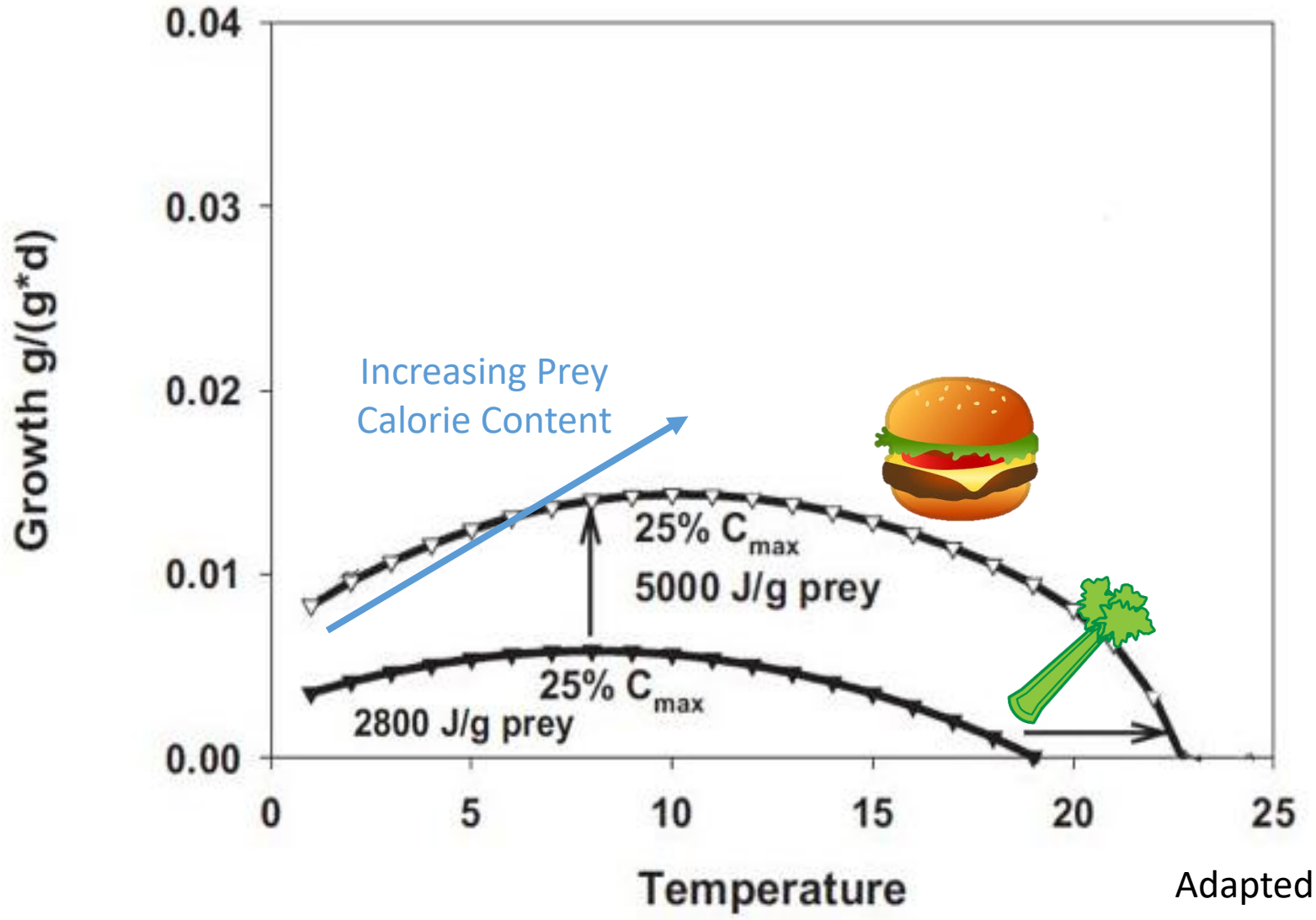
Adapted from Beauchamp 2009

Bioenergetics Models can also infer growth based on food consumption.



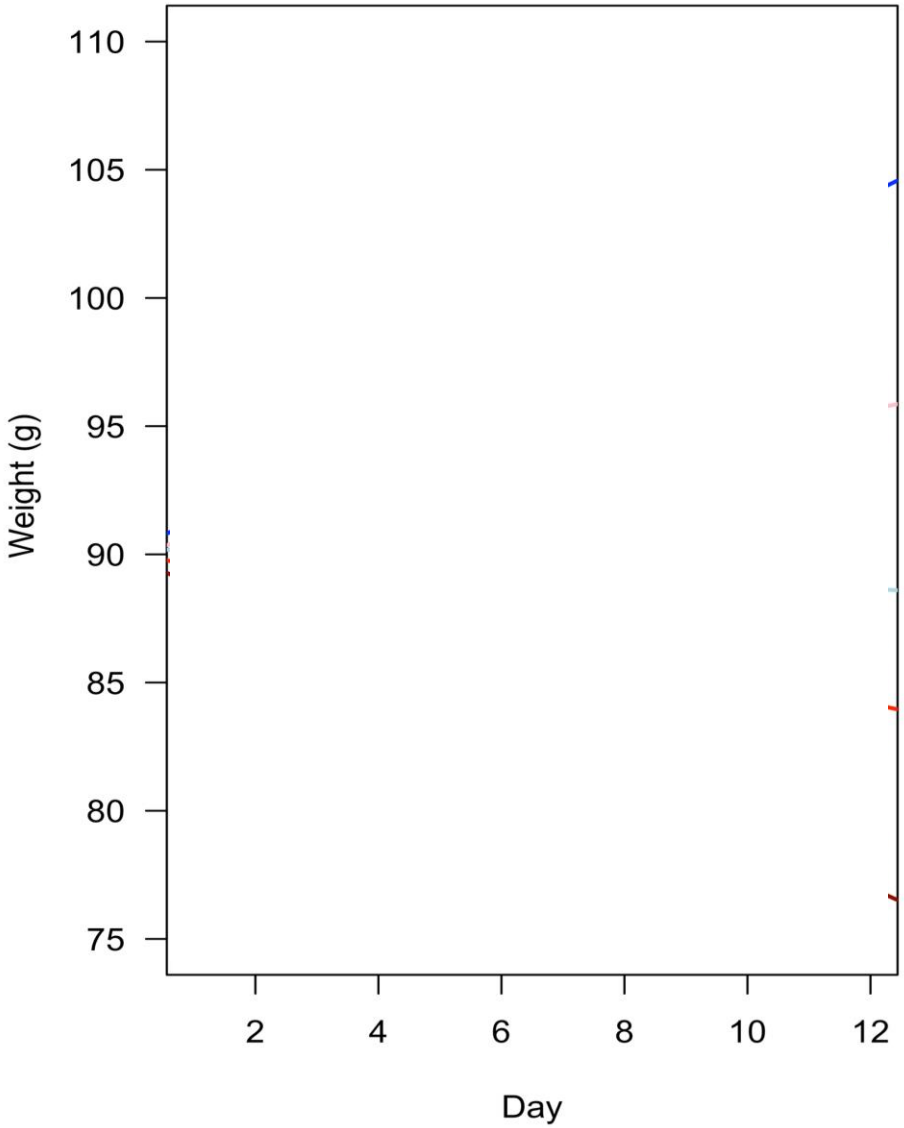
Adapted from Beauchamp 2009

Bioenergetics Models can also infer growth based on caloric content of food.



Adapted from Beauchamp 2009

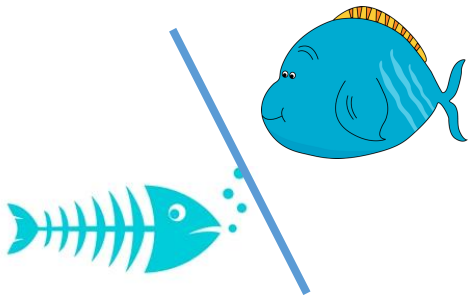
We manipulated Steelhead weight by day under different temperatures, consumption rates, and prey caloric contents.



Temperature

Warm Years: ~ 12ºC

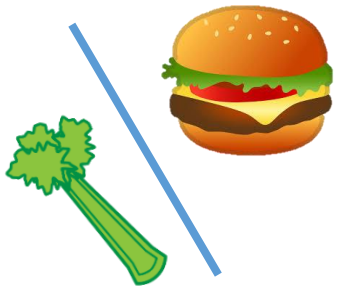
Cool Years: ~ 10 ºC



Consumption

Warm Years:
100%, 50%, 20%

Cool Years:
100%, 50%

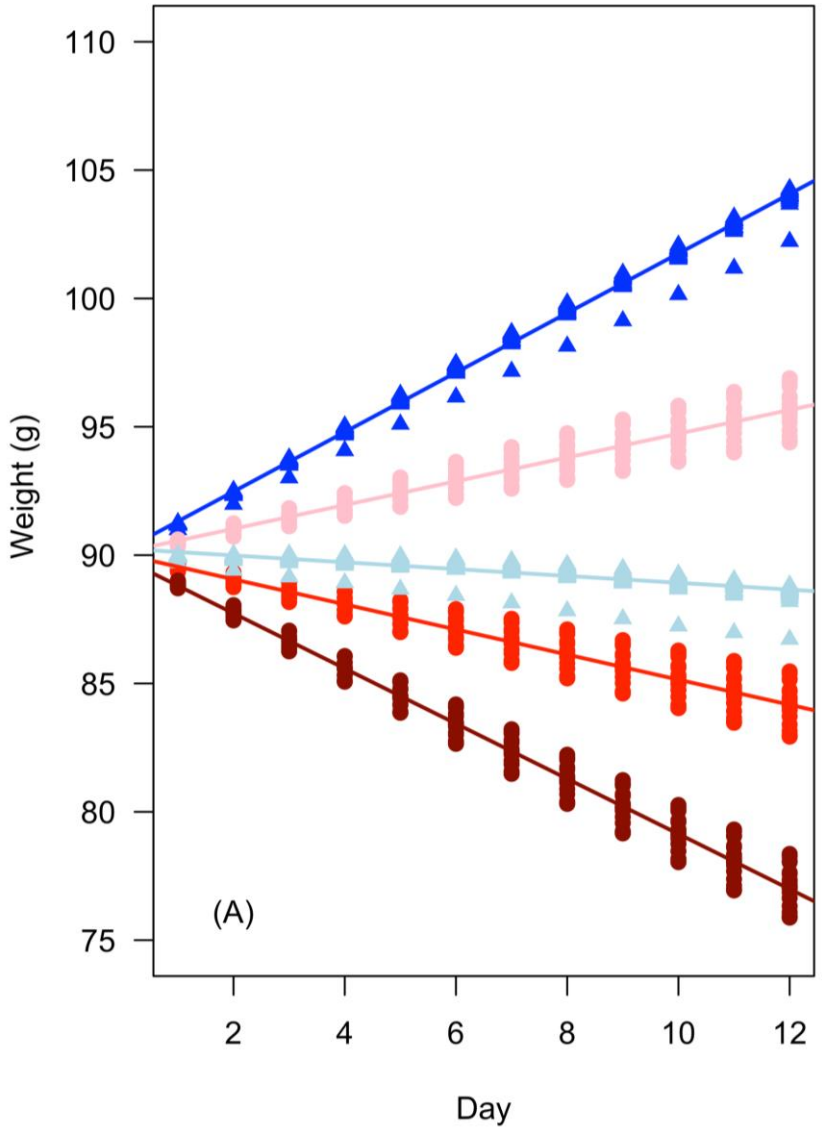


Prey Energy Density

Warm Years:
Depressed by 30%

Cool Years:
Normal

Under depressed food caloric content and warmer temperatures in heatwave years, juvenile Steelhead grew less quickly.



Cold Year, 100% Consumption, Elevated caloric content

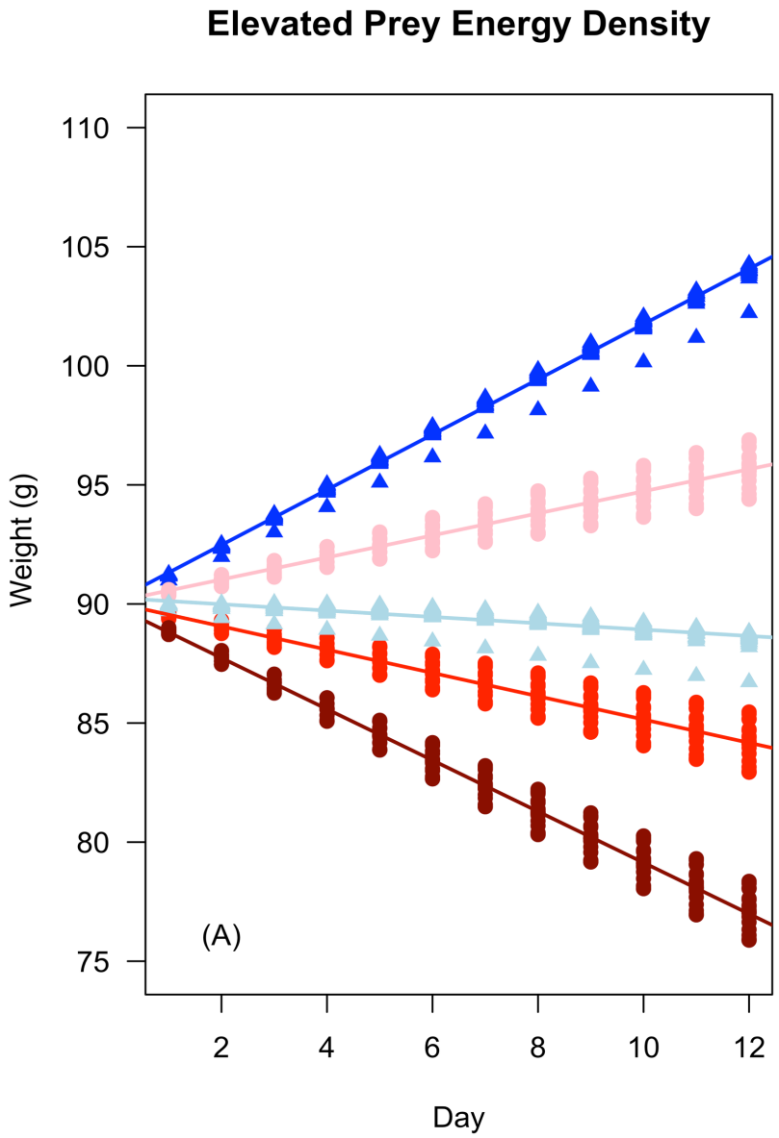
Warm Year, 100% Consumption, Depressed caloric content

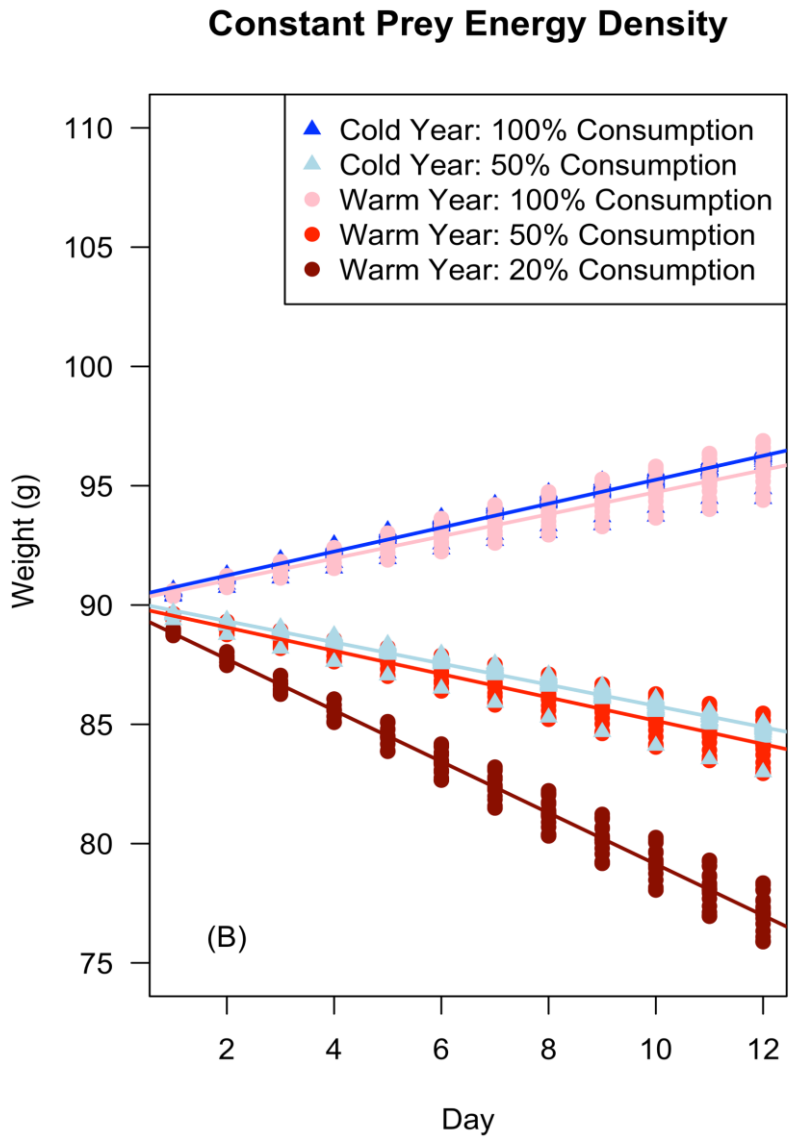
Cold Year, 50% Consumption, Elevated caloric content

Warm Year, 50% Consumption, Depressed caloric content

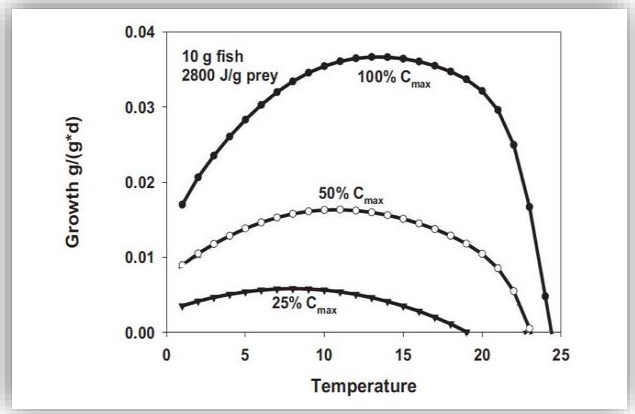
Warm Year, 20% Consumption, Depressed caloric content

Even under constant prey caloric content, juvenile Steelhead grow quickly during the first 12 days of ocean residence.





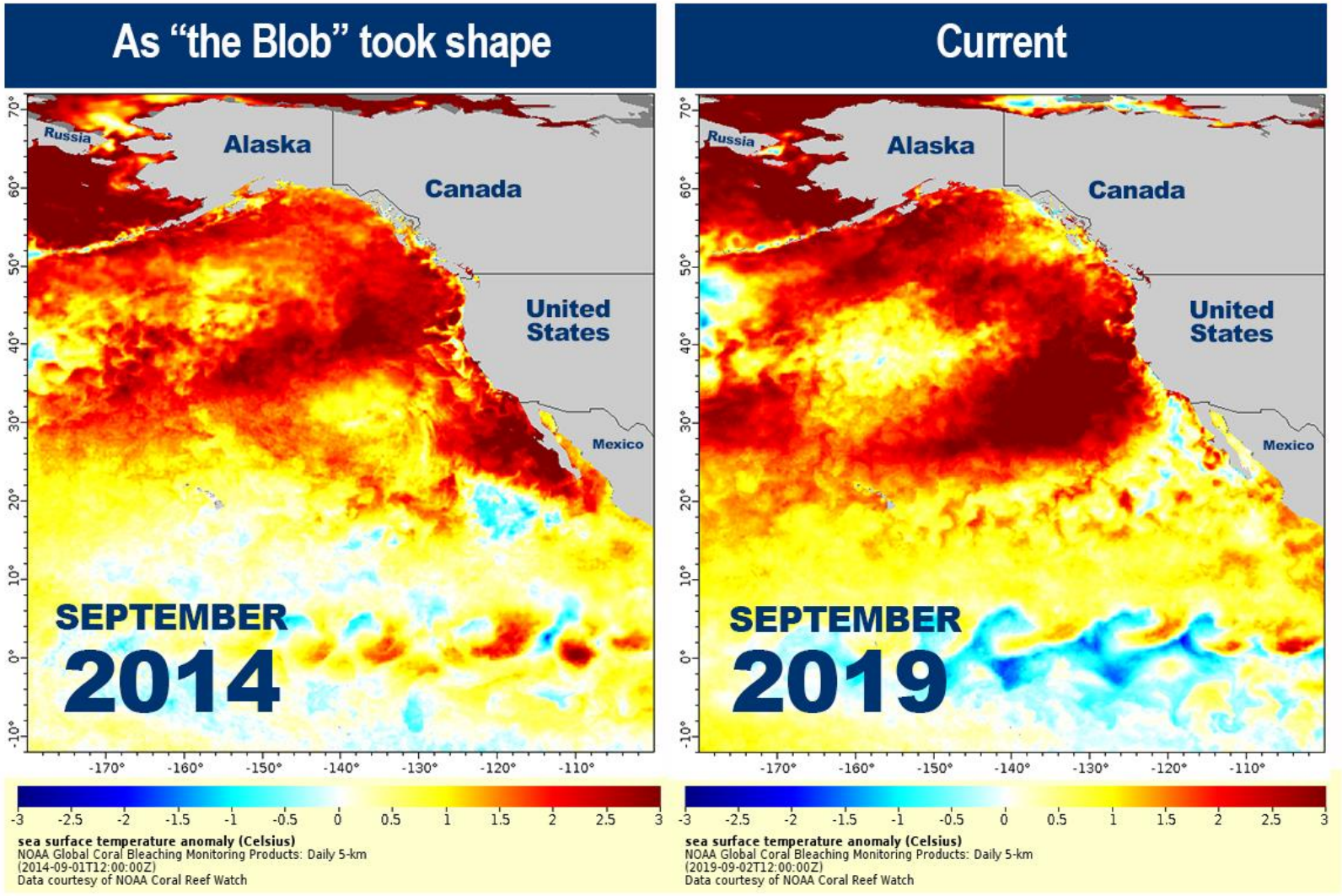
- Steelhead **diet composition shifts** in warm years
- Steelhead consume **more rockfish, insects, and unidentified fish** in warm ocean years
- Steelhead **size increases** but overall **condition decreases** in Blob-influenced years
- Steelhead put on **more weight more quickly** in cooler conditions and elevated prey caloric content



Environmental indicators in the North Pacific have shifted in recent years with a trend toward lower salmon abundance.

Indicator	2015	2016	2017	2018	2019	2020
PDO	Positive	Positive	Positive	Positive	Positive	Positive
Coastal surface temperature	Warm	Warm	Warm	Warm	Warm	Warm
Copepod community	Southern	Southern	Southern	Southern	Northern	Northern
Yearling salmon abundance	Low	Low	V. low	Low	Low	Low
Yearling salmon condition	Low	Low	Moderate	Moderate	Moderate	No Data
Salmon growth rates	Moderate	V. High	High	Moderate	Moderate	No Data
Coastal fish community	Offshore	Offshore	Offshore	Offshore	Offshore	Inshore & offshore
Juv. Rockfish abundance	Low	V. High	V. low	Low	High	No Data
Total seabird density off WA/OR	High	High	V. low	High	Moderate	No Data

Heatwave conditions re-established in 2019 across the Northeast Pacific, but were short-lived.

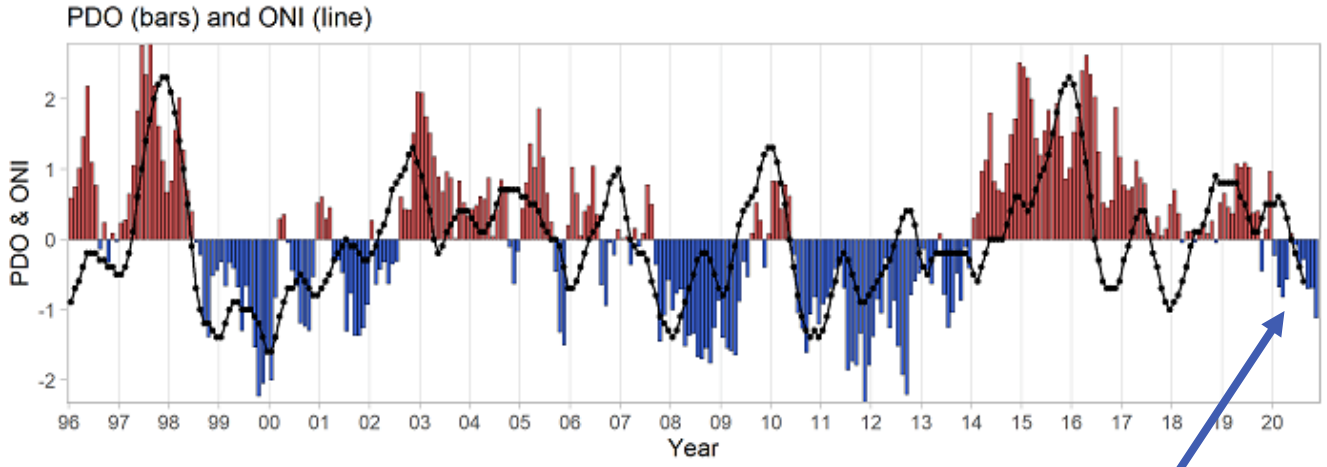


La Niña conditions developed in 2020, bringing cooler and more favorable conditions for salmon in the California Current.

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Home / News & Features

U.S. Winter Outlook: Cooler North, warmer South with ongoing La Nina



La Niña conditions and
Negative PDO index in 2020


NULLUM GRATUITUM PRANDIUM
THERE IS NO FREE LUNCH

Special Thanks To:

- Cheryl Morgan
- Samantha Zeman
- Don Van Doornik
- Brian Burke, Bill Pearcy, and Sean Hayes
- Bruce McCune
- Jessica Miller
- Olivia Blondheim and Bettyjo LaBare
- NOAA Ernest F. Hollings Scholarship Program
- NSF Graduate Research Fellowship Program

Questions??

Email: hillary.thalmann@oregonstate.edu

Twitter: @HillaryThalmann