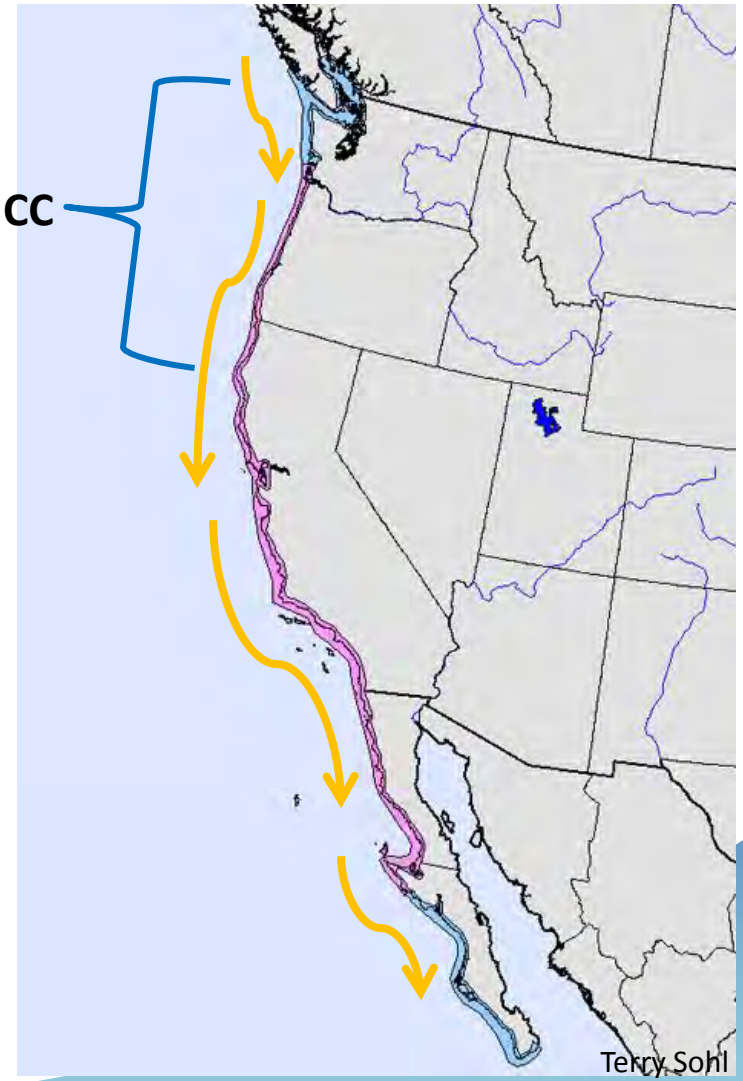
Climate Change Symposium
Washington, DC
June, 2018

Effects of recent warming ocean conditions on forage taxa in the northern California Current: an unprecedent ecosystem shift in progress?

Richard Brodeur and Mary Hunsicker
NOAA, Northwest Fisheries Science Center Newport, OR
Toby D. Auth
Pacific States Marine Fisheries Commission, Newport, OR
Elizabeth A. Daly
Cooperative Institute for Marine Resources Studies,
Oregon State University, Newport, OR

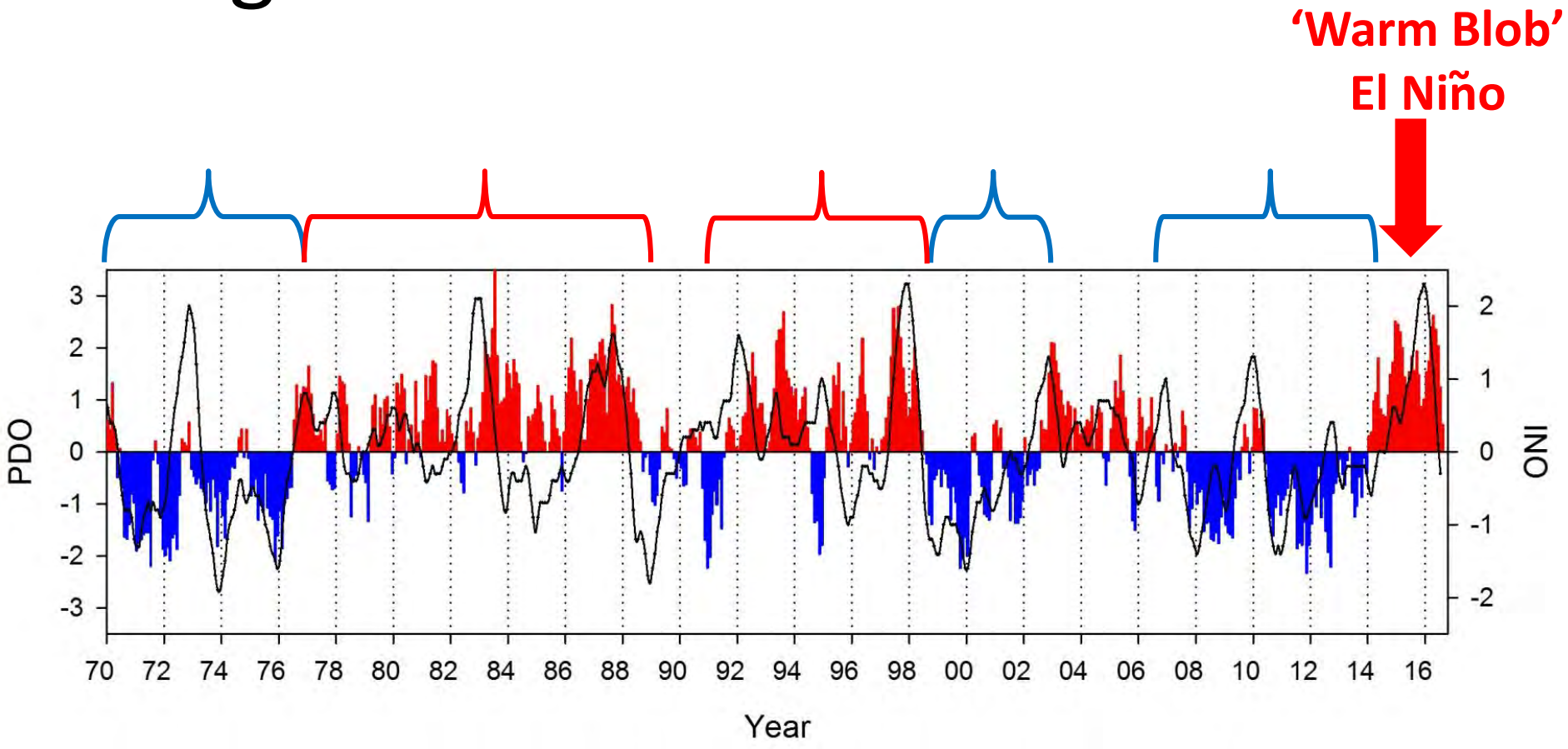
The Northern California Current

- Productive ecosystem dominated by strong seasonal upwelling periods
- Recently has undergone substantial interannual environmental variability



NOAA FISHERIES

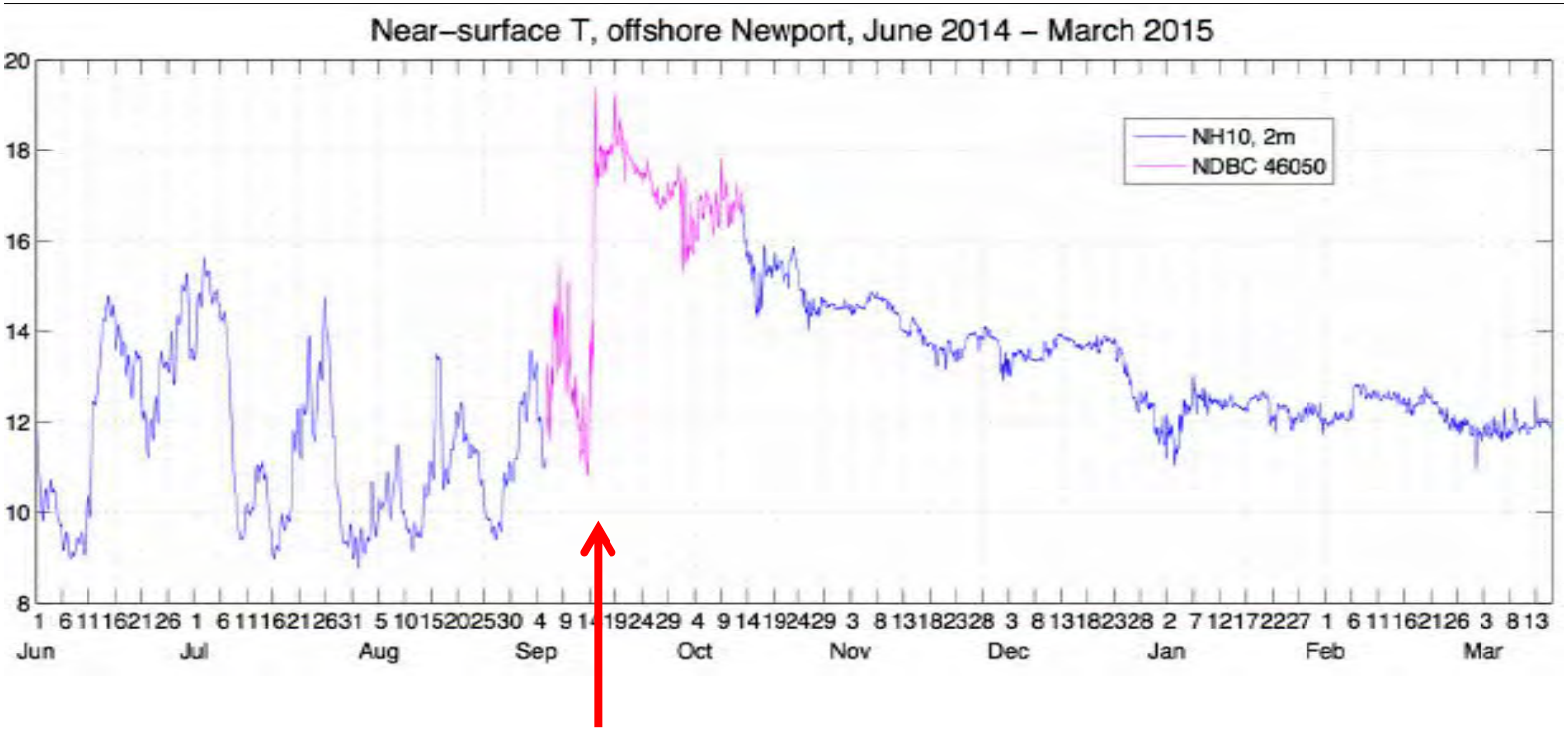
Large-scale Environmental Drivers



Bars = PDO (Pacific Decadal Oscillation Index)
Line = ONI (Oceanic Niño Index)

Auth et al. (2018) GCB

Near surface temperatures off Newport show appearance of ‘the Blob’

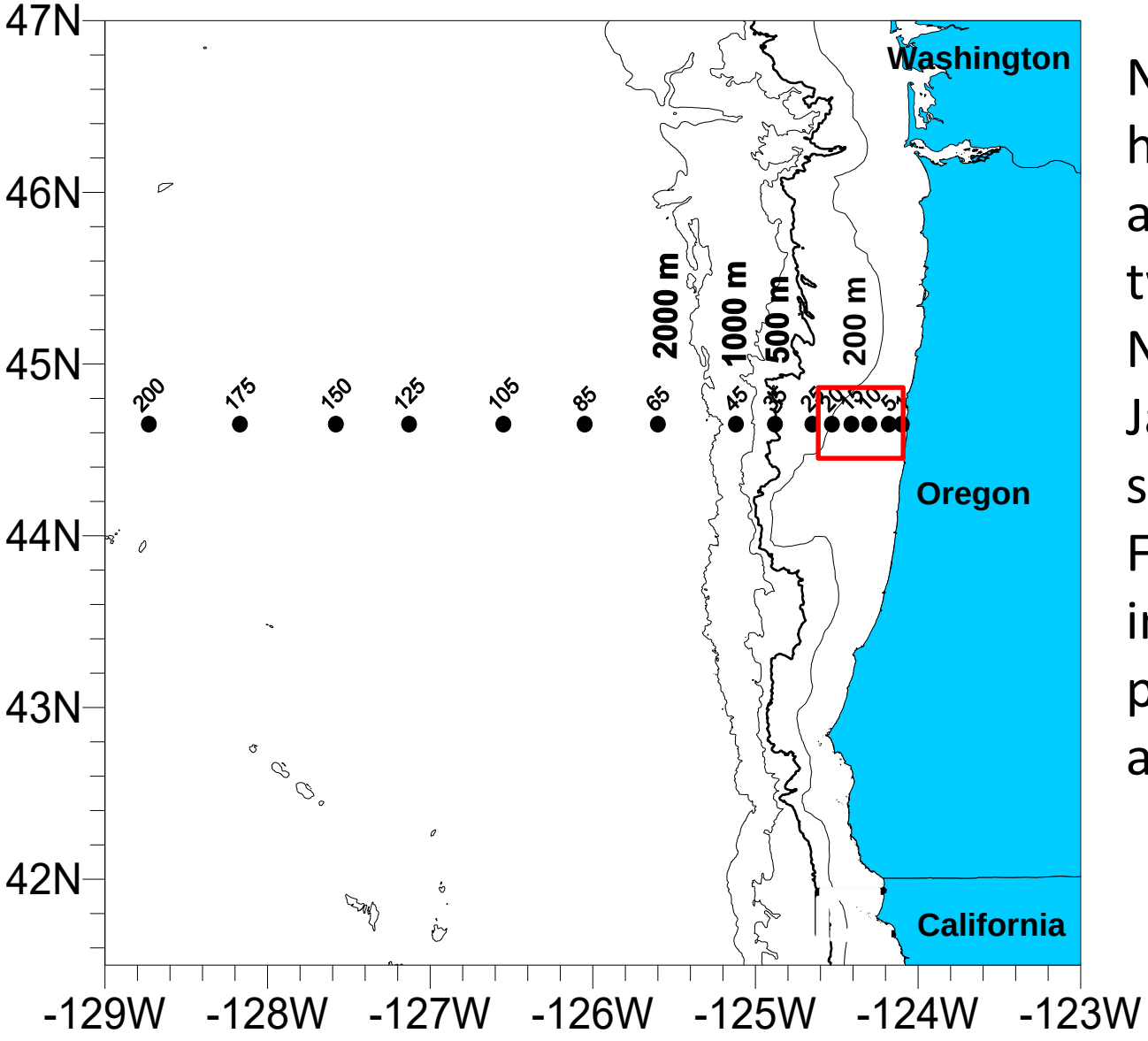


Sept. 14, 2014

Objectives

1. Examine changes in winter larval forage fish composition due to recent warm oceanographic conditions
2. Examine changes in species composition and diversity of forage micronekton over a broad geographic area
3. Examine forage fish dietary shifts between earlier cool and recent warm oceanographic periods

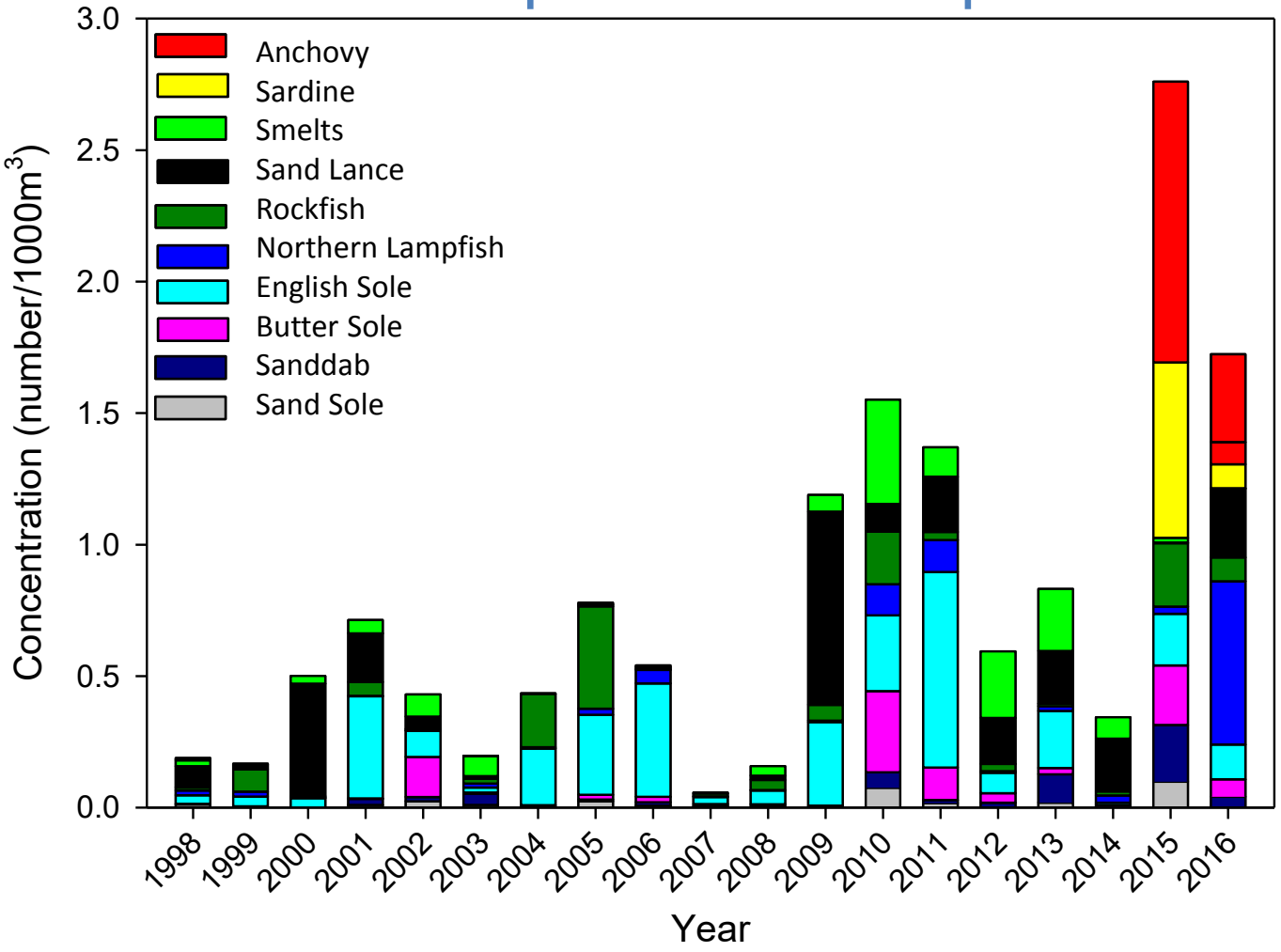
Winter Ichthyoplankton Composition



Night-time sampling has occurred approximately every two weeks along Newport Line from January to March, since 1998.

Fish larvae collected in bongo tows are preserved, identified and measured.

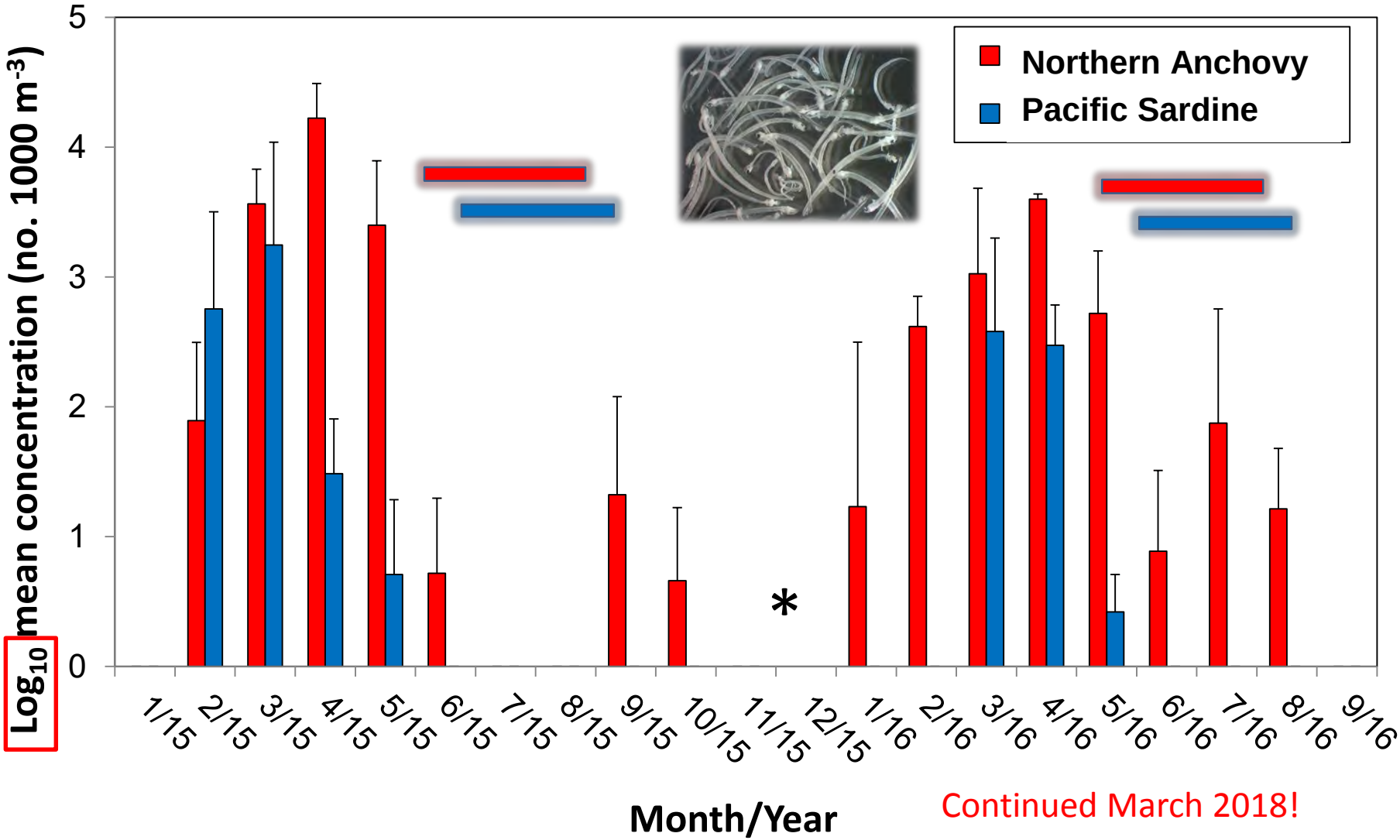
Winter (Jan. – March) Ichthyoplankton from Newport Line Samples



- Earliest (by three months) and most widespread spawning of anchovies and sardines in NCC
- Also found Pacific hake and jack mackerel eggs and larvae off Newport

Auth et al. (I2018.) GCB

Nearshore (NH 1-15) Density



Continued March 2018!

* No samples collected

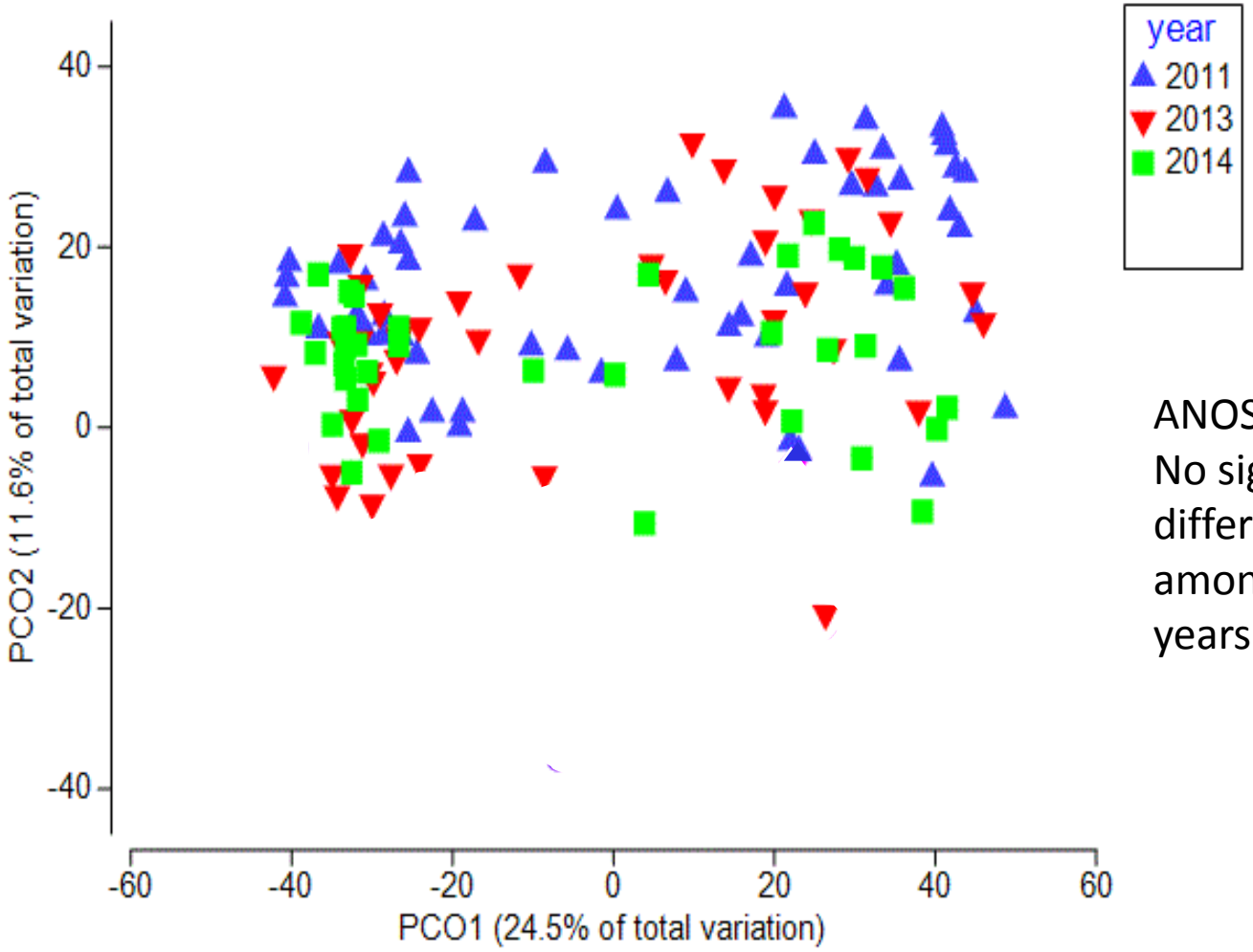
Objectives

1. Examine changes in winter larval forage fish composition due to recent warm oceanographic conditions
2. Examine changes in species composition and diversity of forage micronekton over a broad geographic area
3. Examine forage fish dietary shifts between earlier cool and recent warm oceanographic periods

Prerecruit surveys

- **Sampling dates:** June 2011, 2013-16
- **Net:** midwater trawl with a 26-m headrope and a 9.5-mm codend liner
- **Headrope depth:** 30 m
- Sampled 10 transects off Oregon and southern Washington

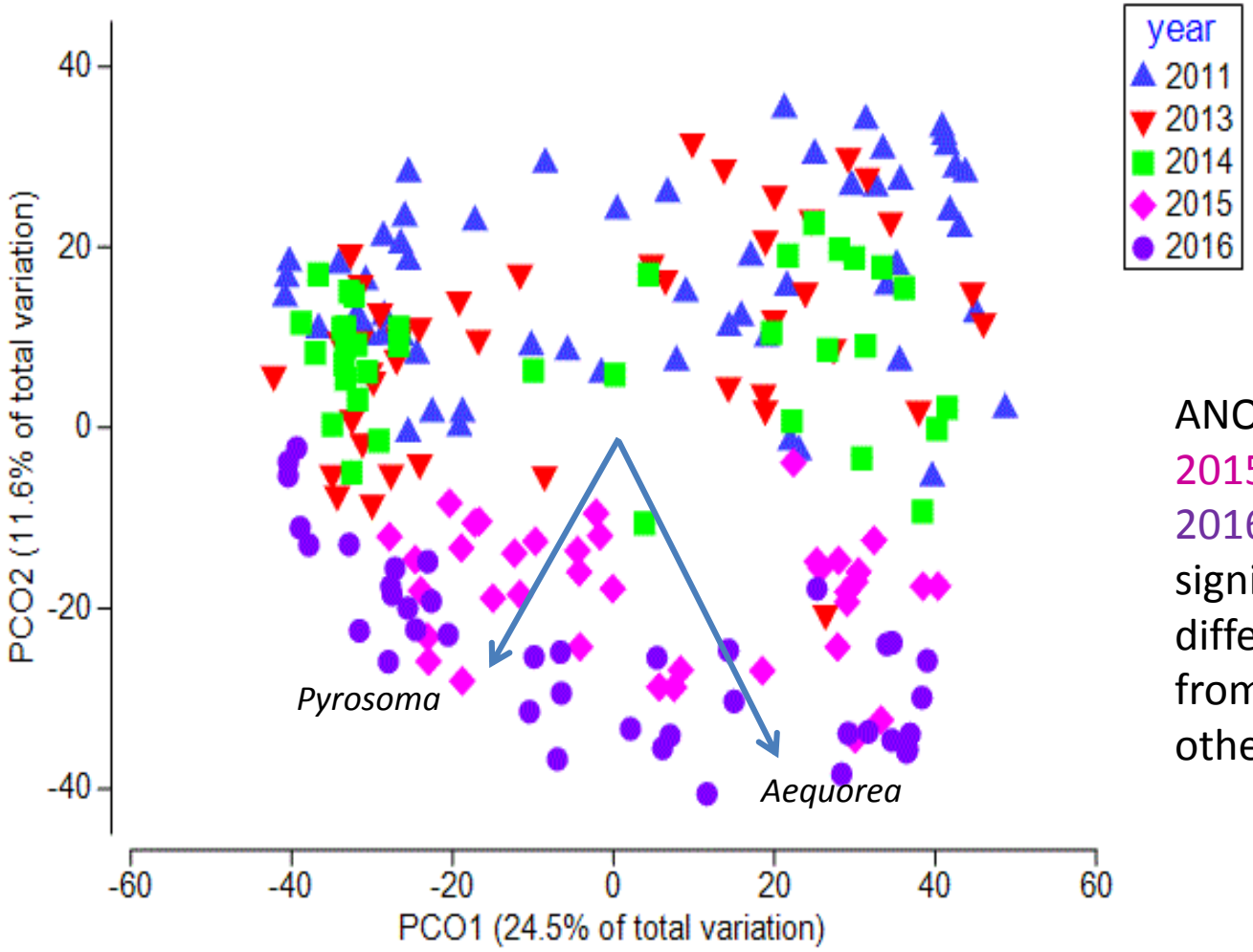
PCO by Year (Occ. > 10%)



ANOSIM
No significant differences among these years

Brodeur et al. (MS)

Community PCO by Year

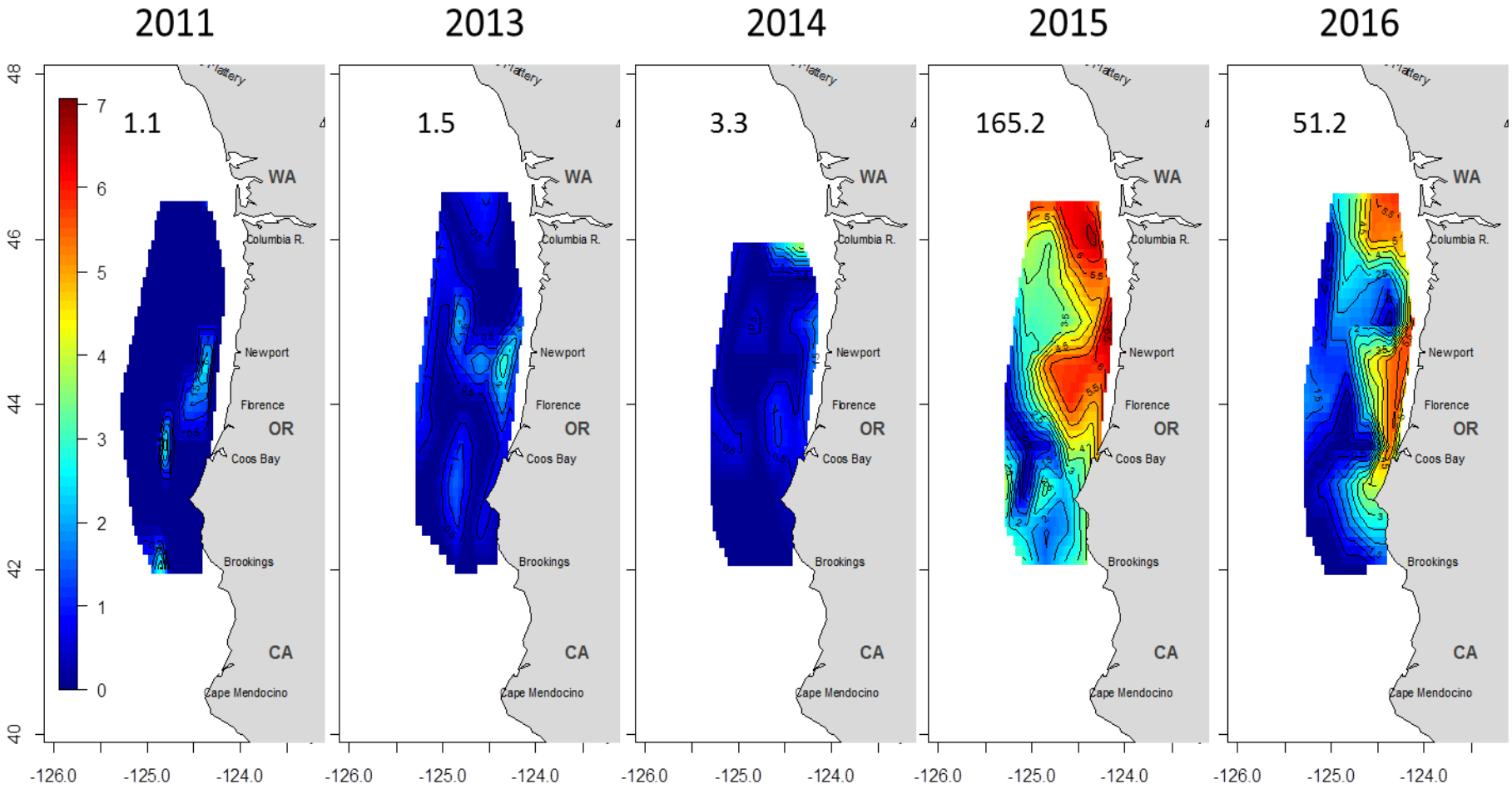


ANOSIM 2015 and 2016 were significantly different from all other years

Brodeur et al. (MS)

Water Jellies

Aequorea victoria

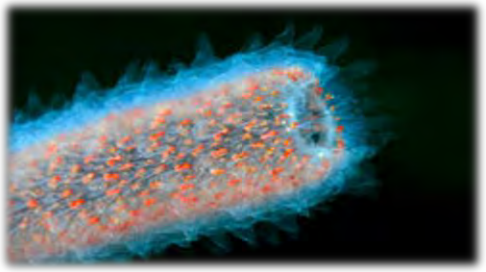


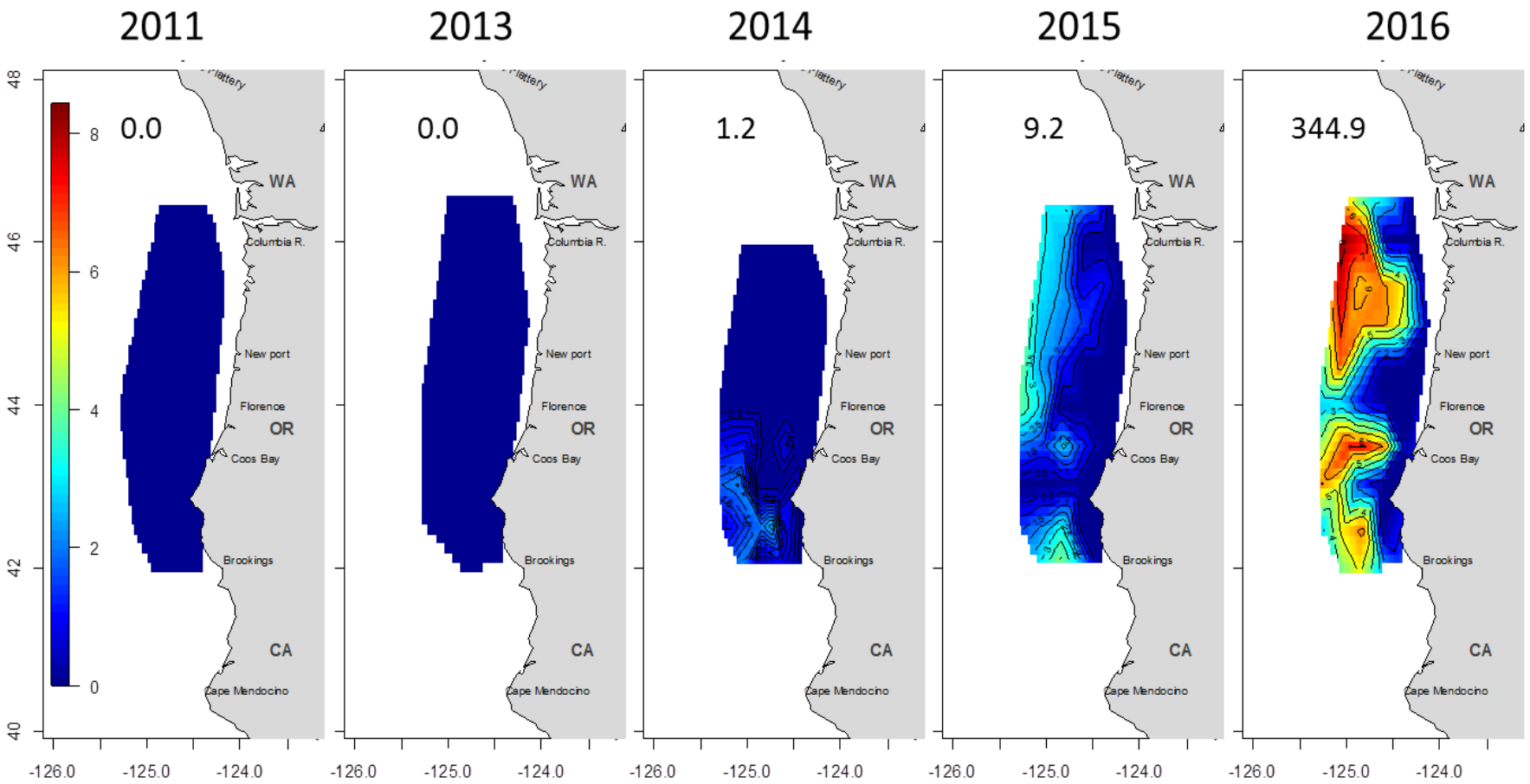
Scale bar = log (abundance)

Number = Geometric mean abundance

Brodeur et al. (MS)

Pyrosoma atlanticum





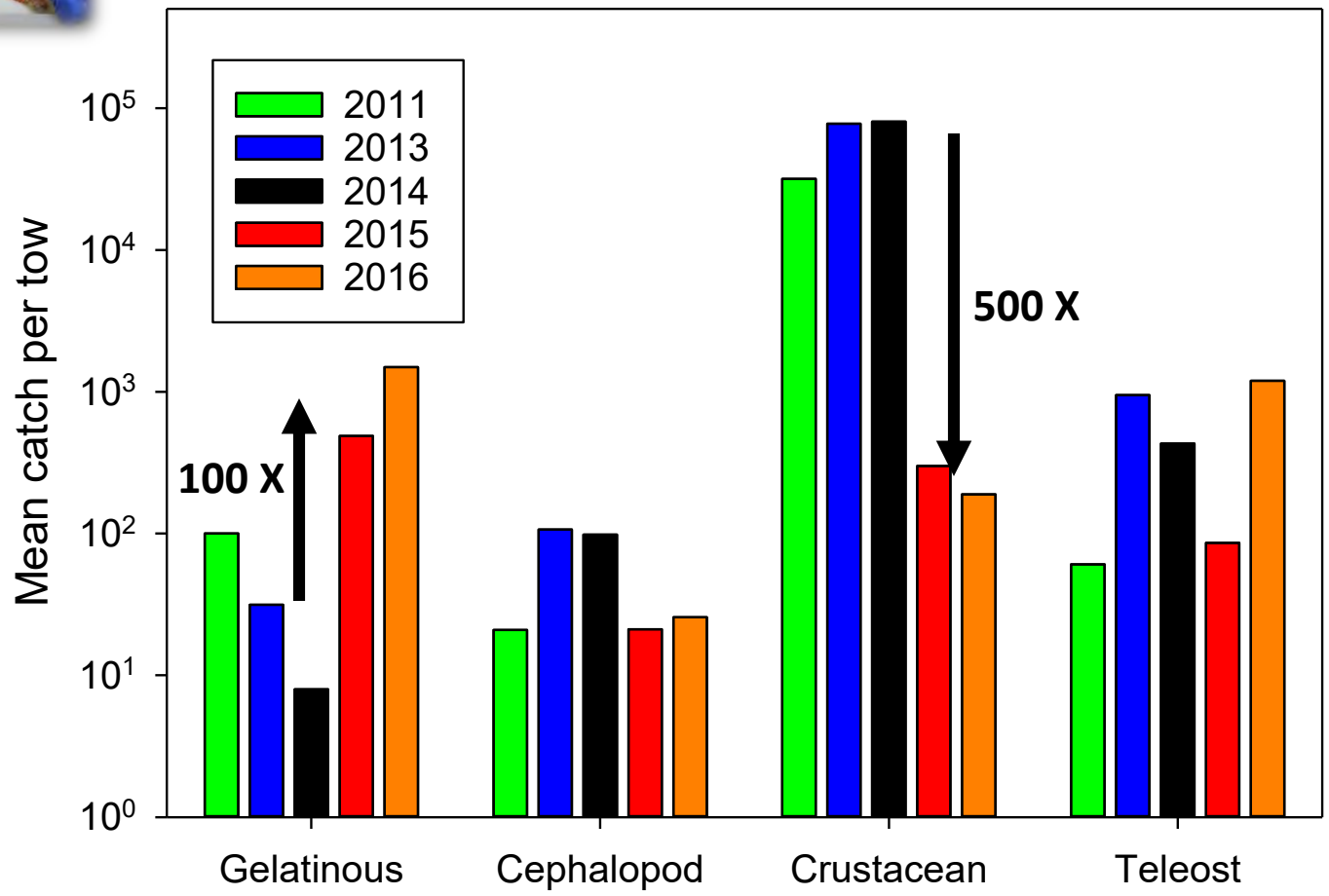
Scale bar = log (abundance)

Number = Geometric mean abundance

Brodeur et al. (MS)

2014

2015



Shift from crustacean-dominated to jellyfish-dominated ecosystem

Brodeur et al. (MS)

Objectives

1. Examine changes in winter larval forage fish composition due to recent warm oceanographic conditions
2. Examine changes in species composition and diversity of forage micronekton over a broad geographic area
3. Examine forage fish dietary shifts between earlier cool and recent warm oceanographic periods

Diet Shifts in Pelagic Forage Fishes

Analyze dominant small pelagic fish diets during warm anomaly and compare feeding habits to previous cooler periods in the California Current

NOAA FISHERIES

Dominant Forage Fish Species

Northern anchovy (*Engraulis mordax*)

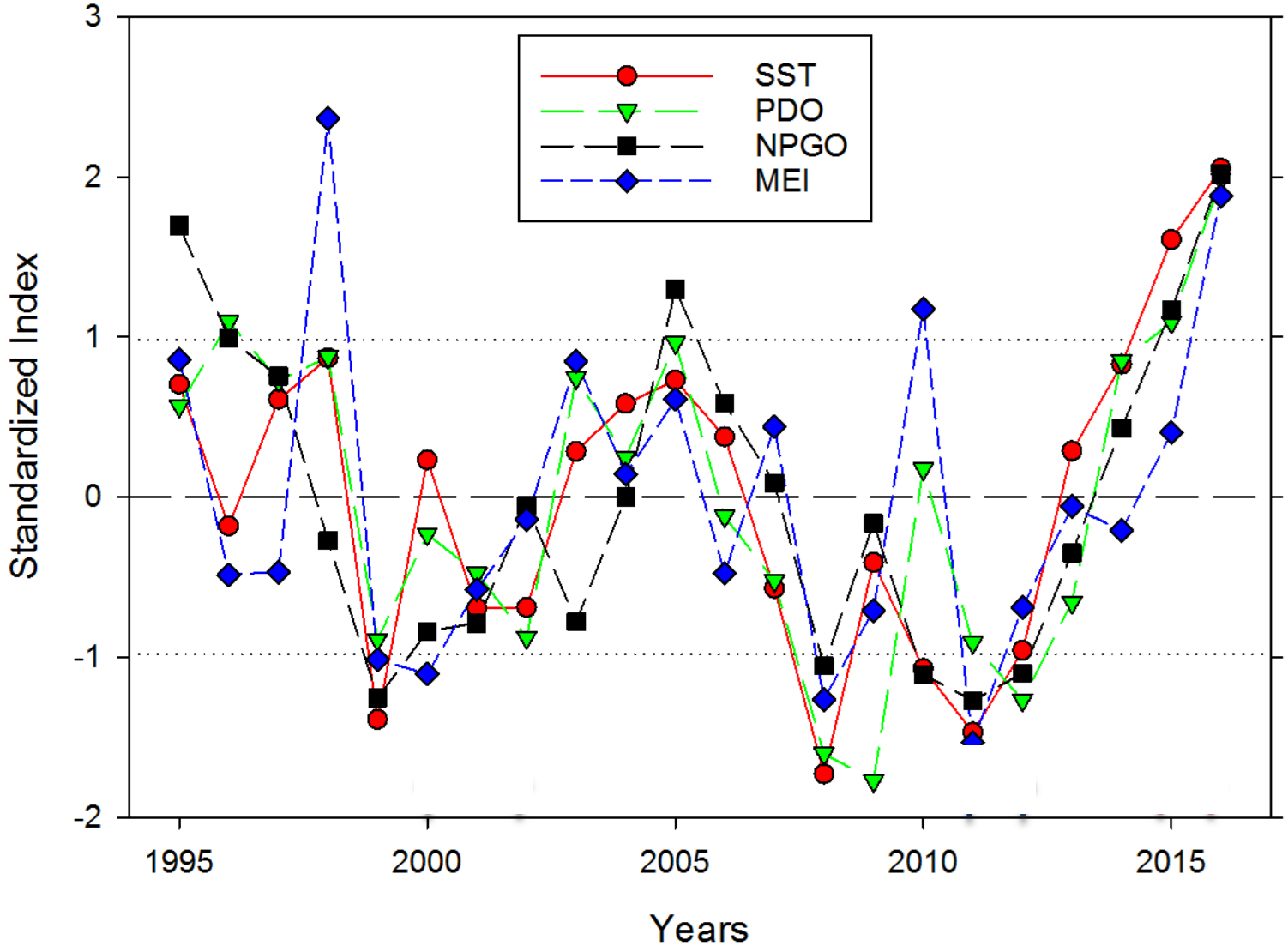
Pacific herring *(Clupea pallasii*)

Pacific sardine (*Sardinops sagax*)

Surf smelt (*Hypomesus pretiosus*)

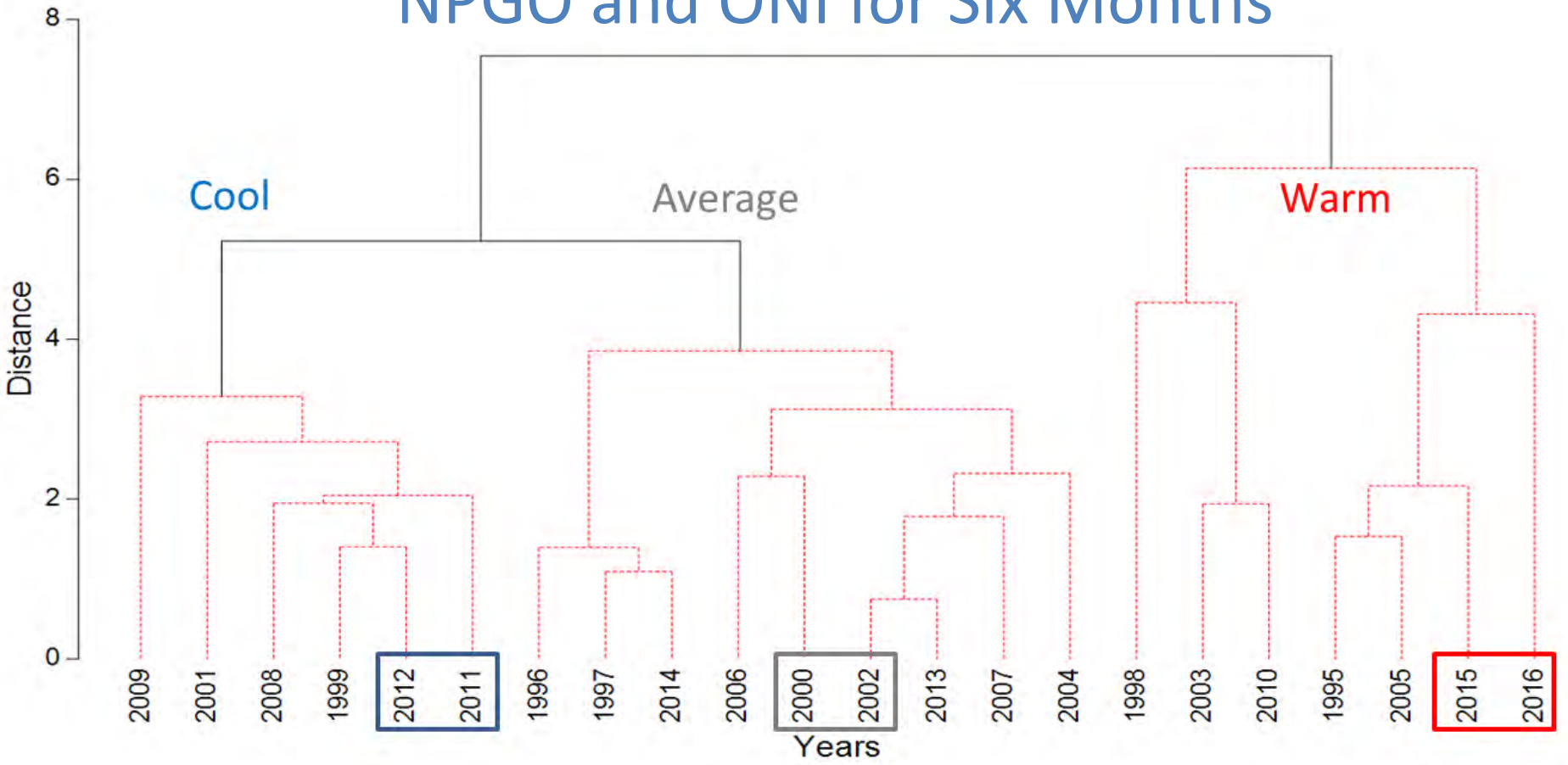
Jack mackerel (*Trachurus symmetricus*)

Whitebait smelt (*Allosmerus elongatus*)



Sign reversed for NPGO

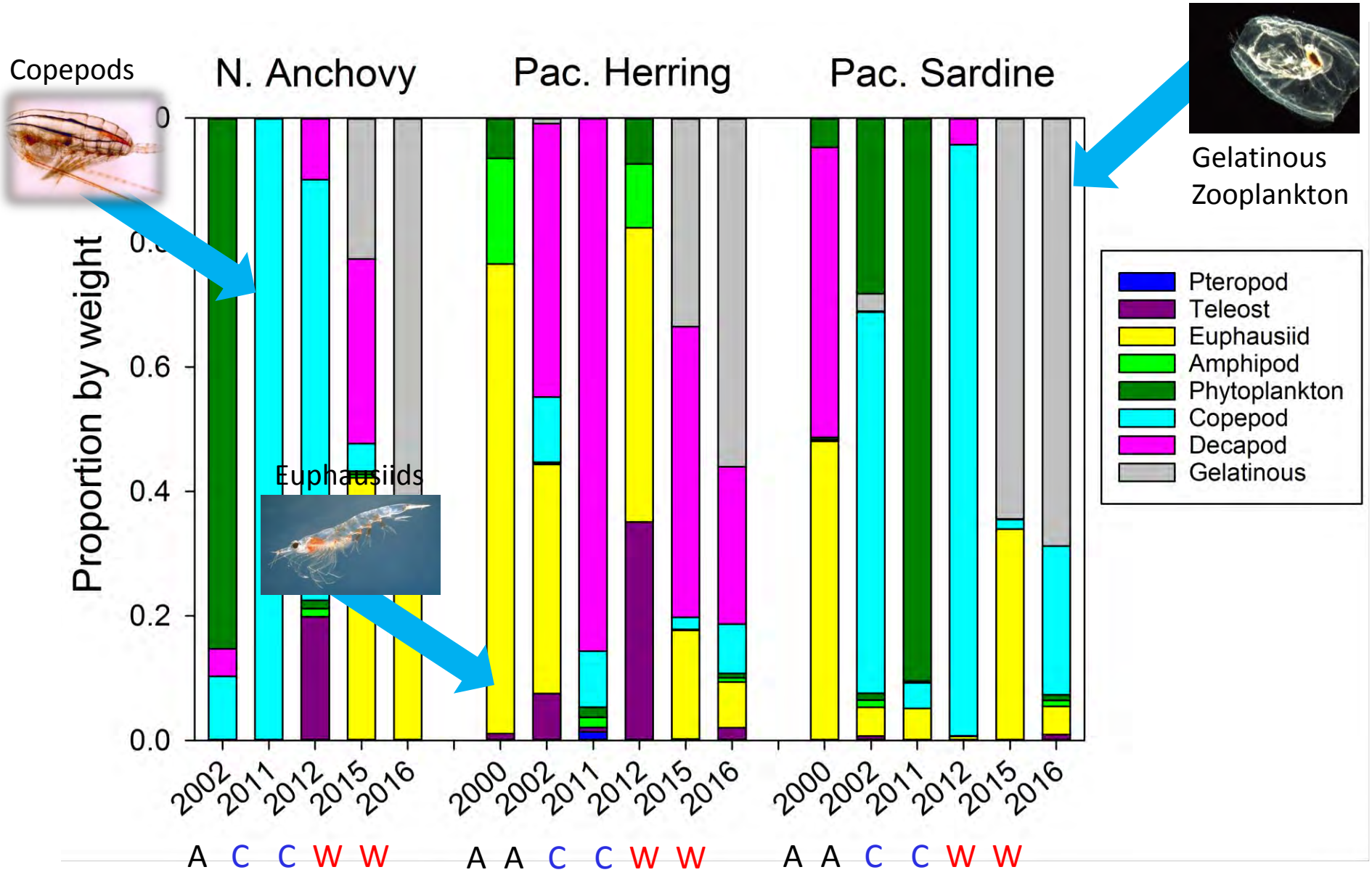
Cluster Based on Standardized Monthly Values of SST, PDO, NPGO and ONI for Six Months



Dashed lines not significantly different (SIMPROF, $p > 0.05$)

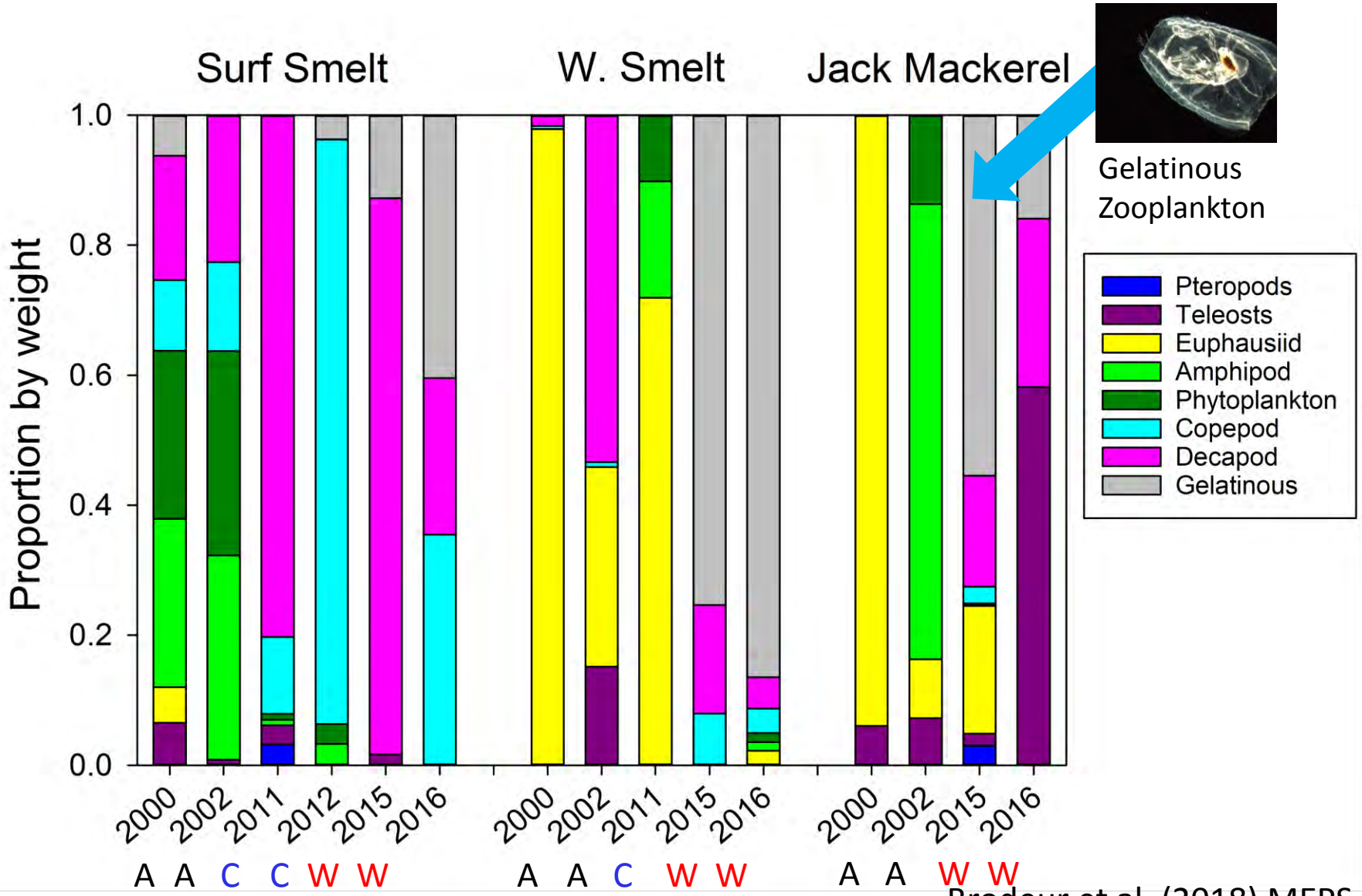
Brodeur et al. (2018) MEPS

Diet composition in June by weight



Brodeur et al. (2018) MEPS

Diet composition in June by weight



Brodeur et al. (2018) MEPS

Freq. of Occur. of Gelatinous Material in Stomachs (%)

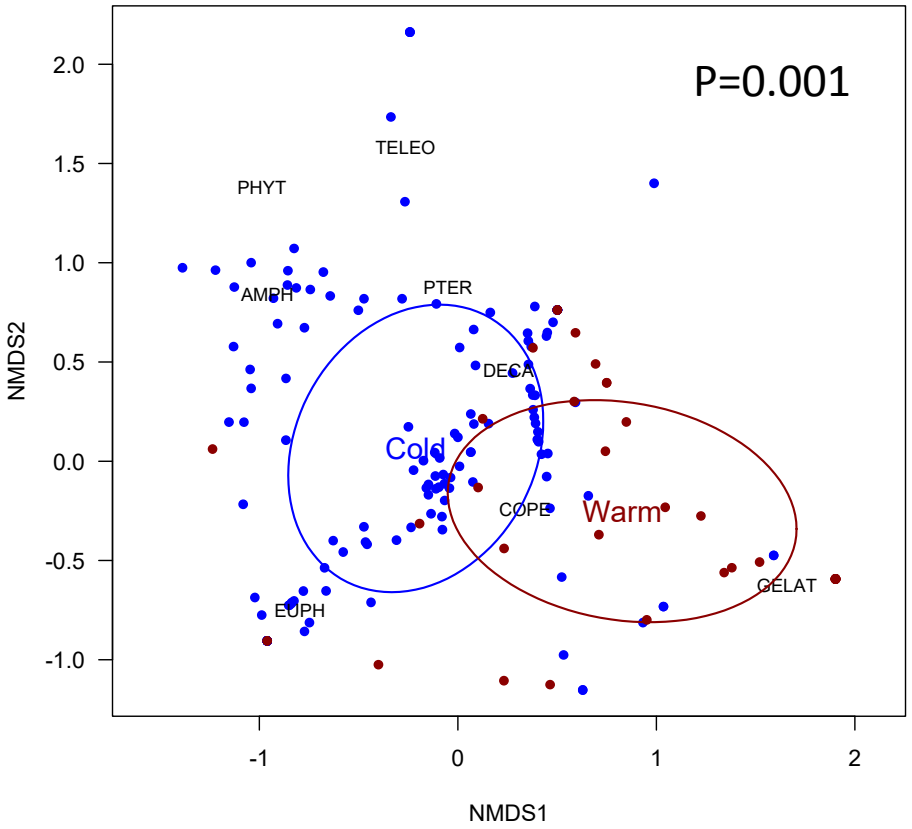
	2000	2002	2011	2012	2015	2016
Northern anchovy	0	0	0	5.3		
Pacific herring	0	12.0	0	0		
Pacific sardine	16.7	45.7	0	0		
Jack mackerel	0	0	---	---		
Whitebait smelt	0	0	0	---		
Surf smelt	40.6	71.7	0	66.7		
Regime	Average	Average	Cool	Cool		

Freq. of Occur. of Gelatinous Material in Stomachs (%)

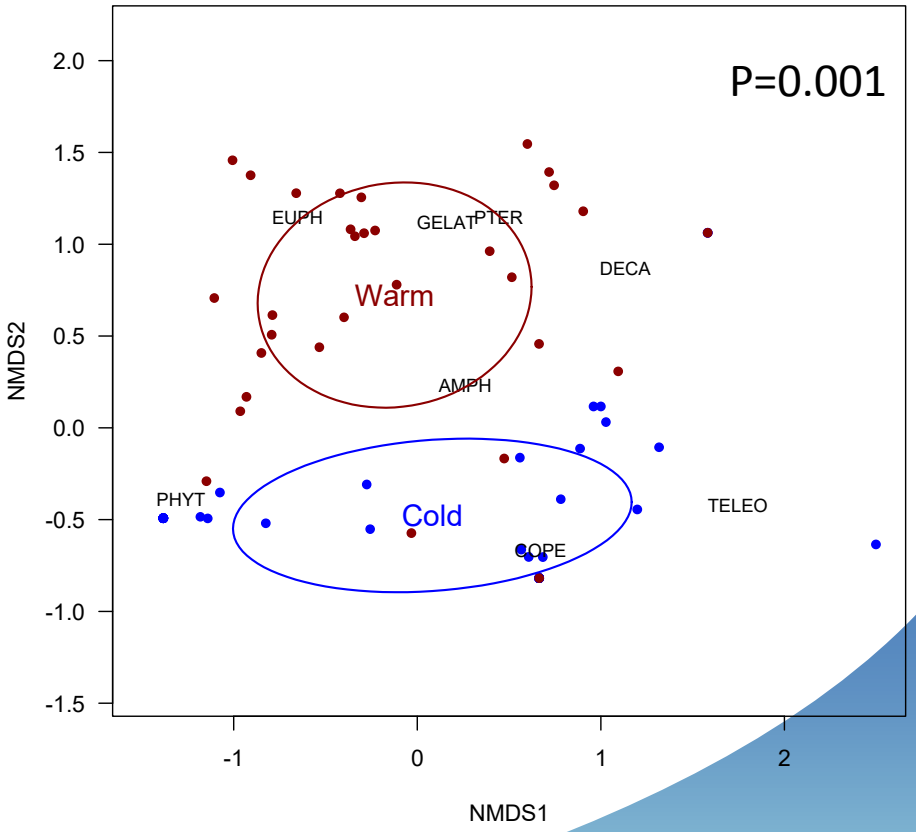
	2000	2002	2011	2012	2015	2016
Northern anchovy	0	0	0	5.3	60.1	78.4
Pacific herring	0	12.0	0	0	64.3	51.4
Pacific sardine	16.7	45.7	0	0	92.3	39.5
Jack mackerel	0	0	---	---	60.0	33.3
Whitebait smelt	0	0	0	---	---	92.6
Surf smelt	40.6	71.7	0	66.7	---	100.0
Regime	Average	Average	Cool	Cool	Warm	Warm

Diets are significantly different between warm and cold periods

Pacific Herring



Northern Anchovy



P-values based on Multi-Response Permutation Analysis

Dispersion ellipses show the standard deviation of the average spatial scores

NOAA FISHERIES

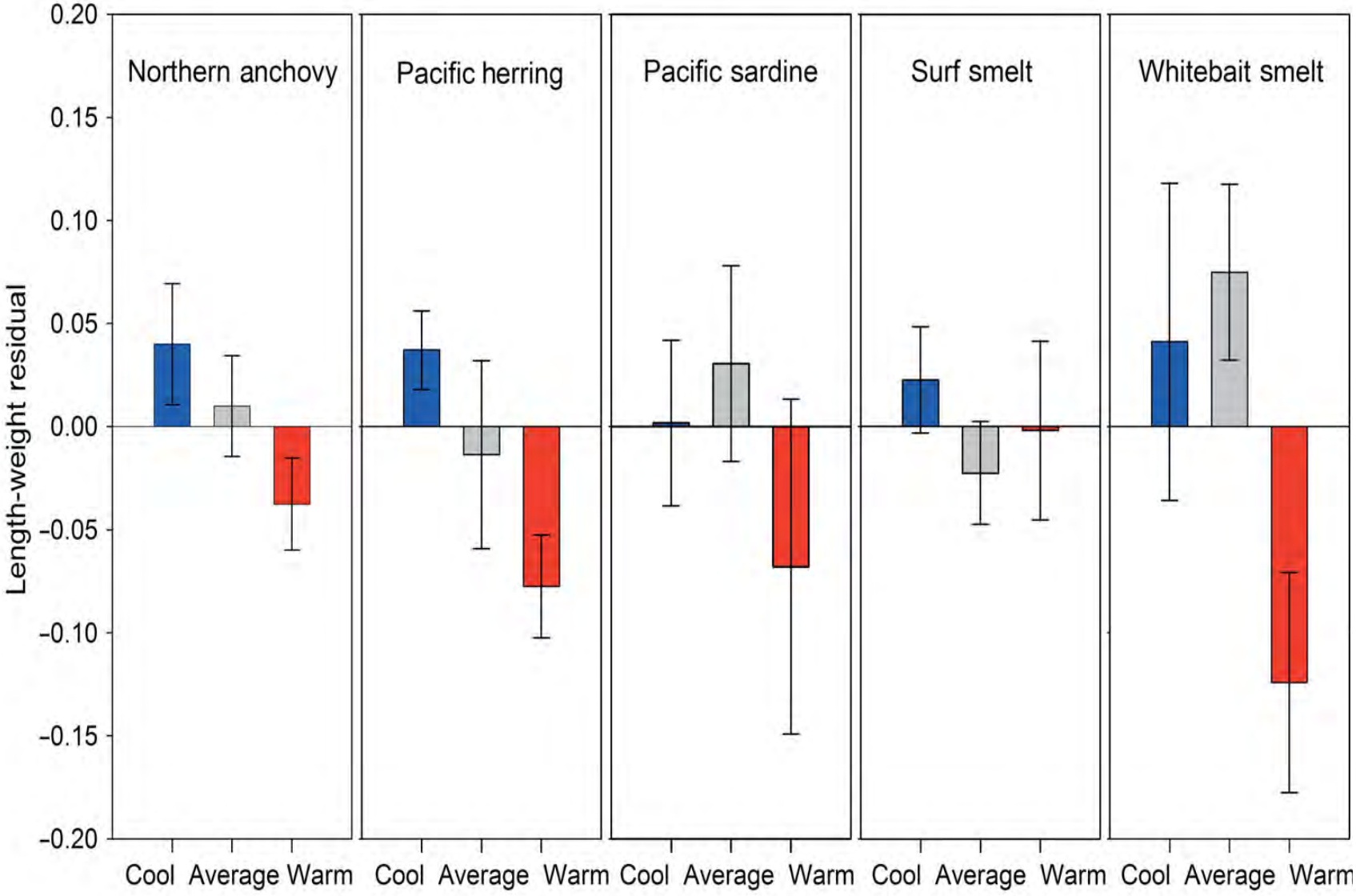
Brodeur et al. (2018) MEPS

Conclusions and Implications

- Pelagic forage fishes show major interannual changes in distribution and spawning phenology
- Recent shift to more gelatinous diets in many species related to changes in prey availability resulting from anomalous ocean conditions
- Uncertain how the switch a more gelatinous diet will affect growth and survival of these fish since these prey tend to be much less nutritious than crustacean or fish prey

NOAA FISHERIES

Relating changes in diets to changes in size and body condition



Brodeur et al. (2018) MEPS

Next steps…

- Continue diet analysis in future looking at more species in the NCC
- Relating changes in diets to changes in size and body condition
- Stable isotope ratios of carbon and nitrogen of predators and prey to compare to previous studies (Miller et al. 2010, MEPS)

NOAA FISHERIES

Acknowledgements

- Lab members (Todd Miller, Ashley Hann, Drew Hill)
- The crew and scientists of the NOAA Ship Bell M. Shimada, R/V Ocean Starr and F/V Frosti
- NOAA and Bonneville Power Administration for funding

NOAA FISHERIES