

Reduced energy transfer through forage fish during the 2014-2016 North Pacific marine heatwave



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Acknowledgements

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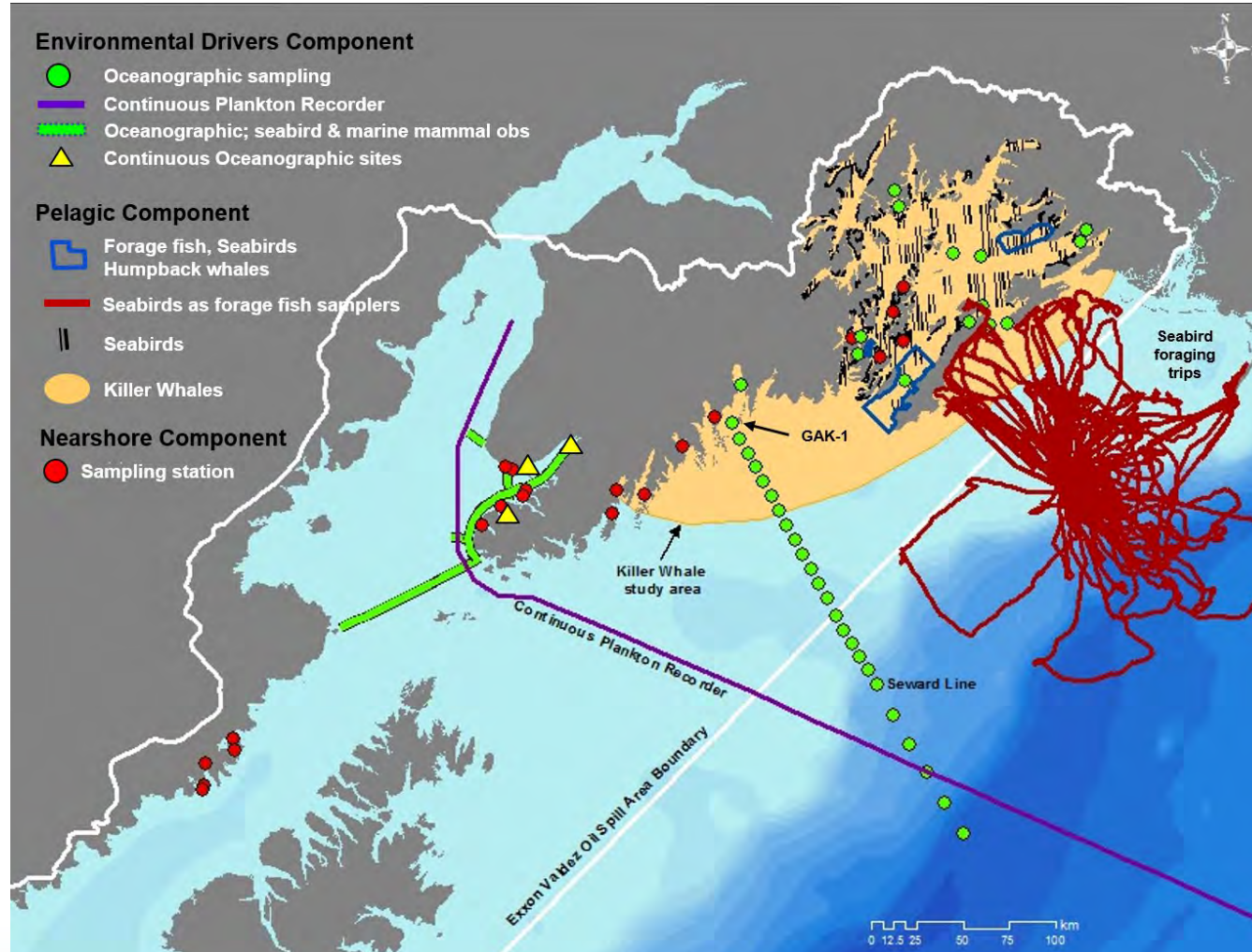
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Pole Star
Ecological Research LLC



Gulf Watch Alaska Long Term Monitoring Program

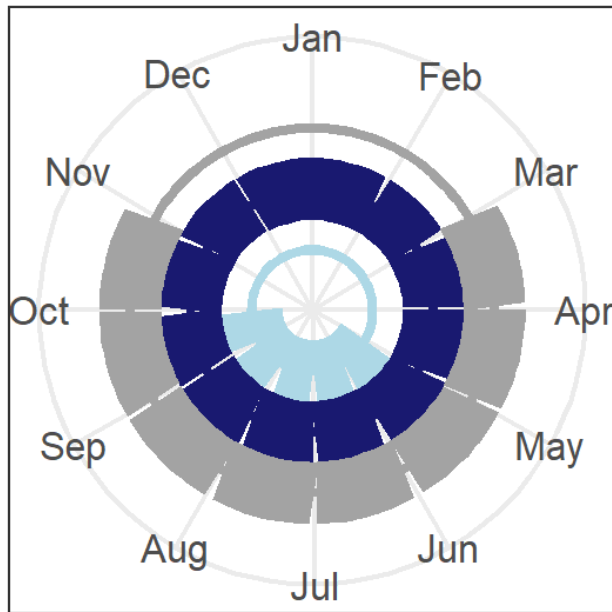


<https://gulfwatchalaska.org/>

Forage Fish

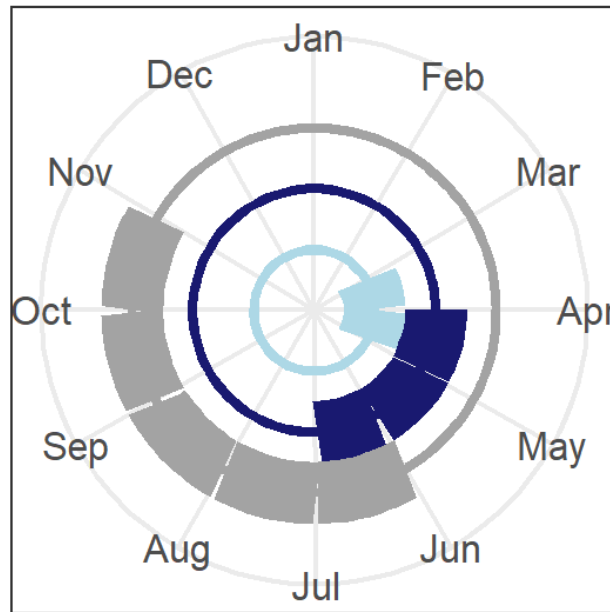
- transfer energy between plankton and predators
- diversity in life history strategies

Capelin



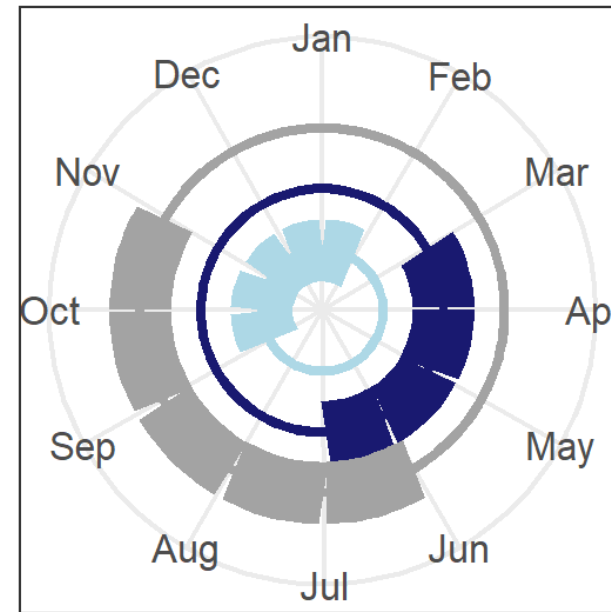
Summer spawning
Larvae overwinter

Herring



Spring spawning
Rapid development

Sand lance



Fall-winter spawning
Long incubation period



Doyle et al. 2019 DSR II

Objectives

1. Identify changes in key forage fish populations

- Survey-based abundance indices
- Trends in availability to predators

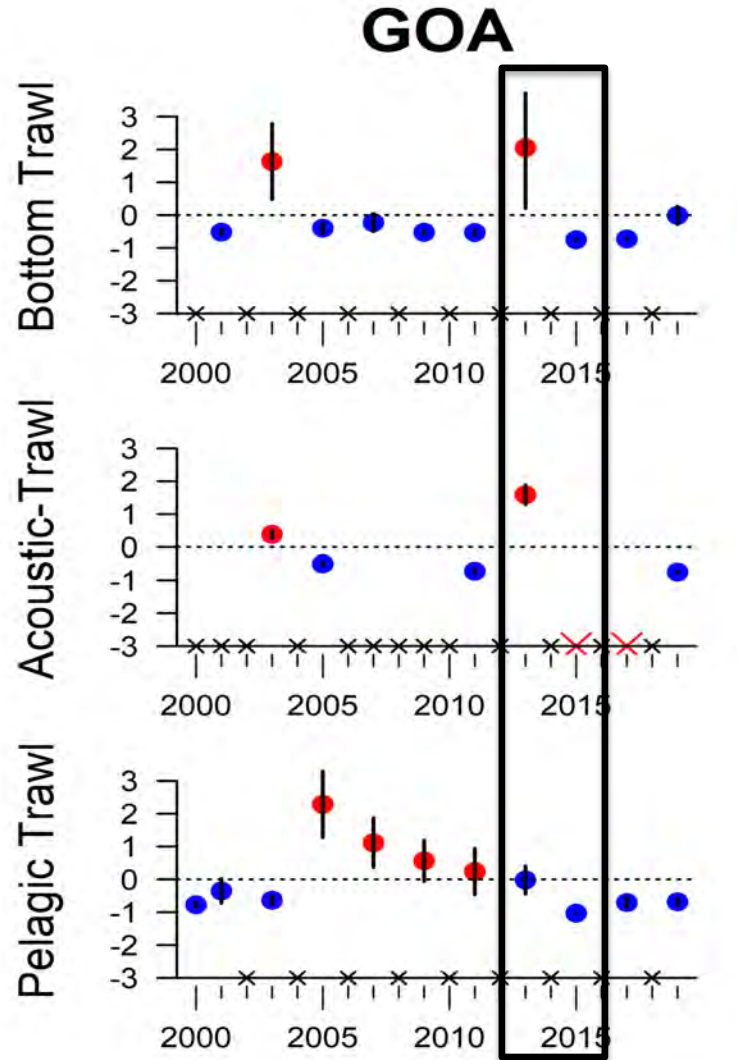
2. Identify changes in forage fish quality

- Age structure
- Energy content
- Growth

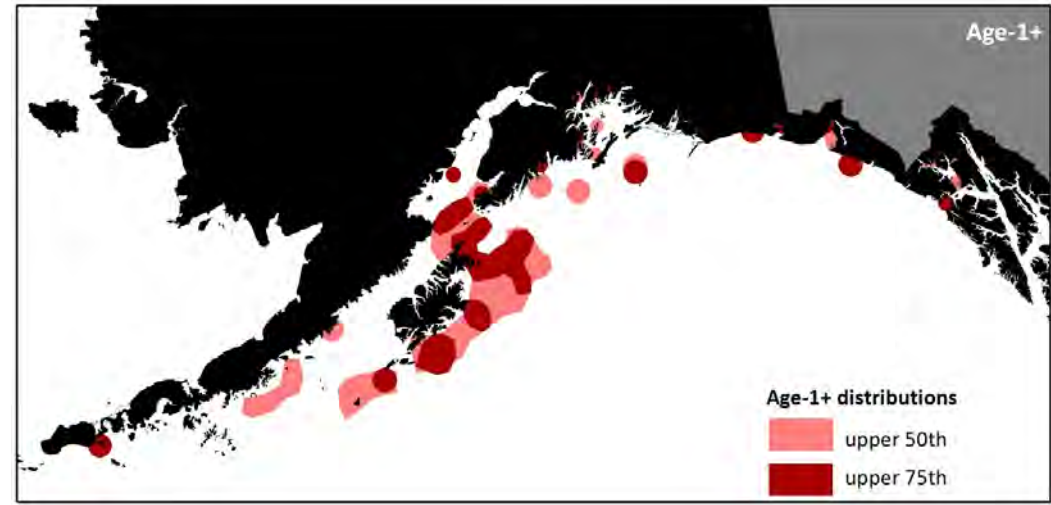
3. Do lower trophic level changes account for the disruption in the middle and upper trophic levels during the 2014-16 marine heatwave?



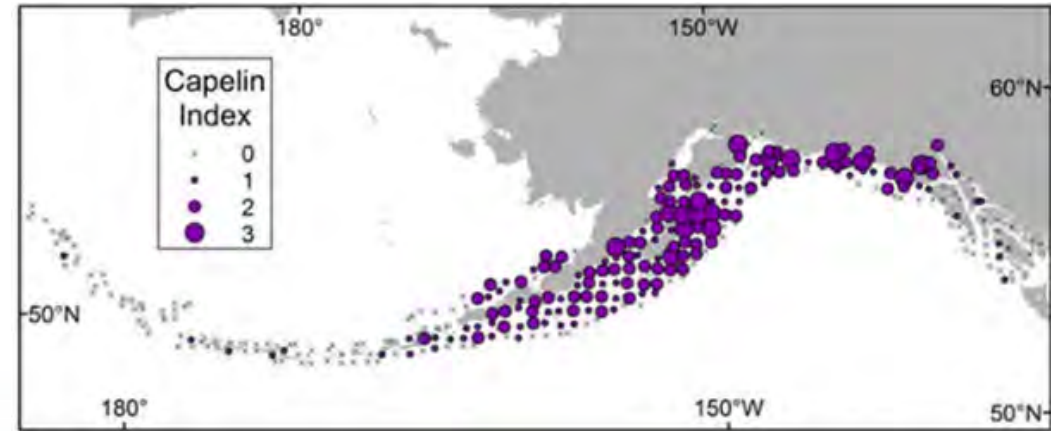
Abrupt Decline in Capelin Abundance by 2015



Data: NOAA AFSC, 2000 - 2019



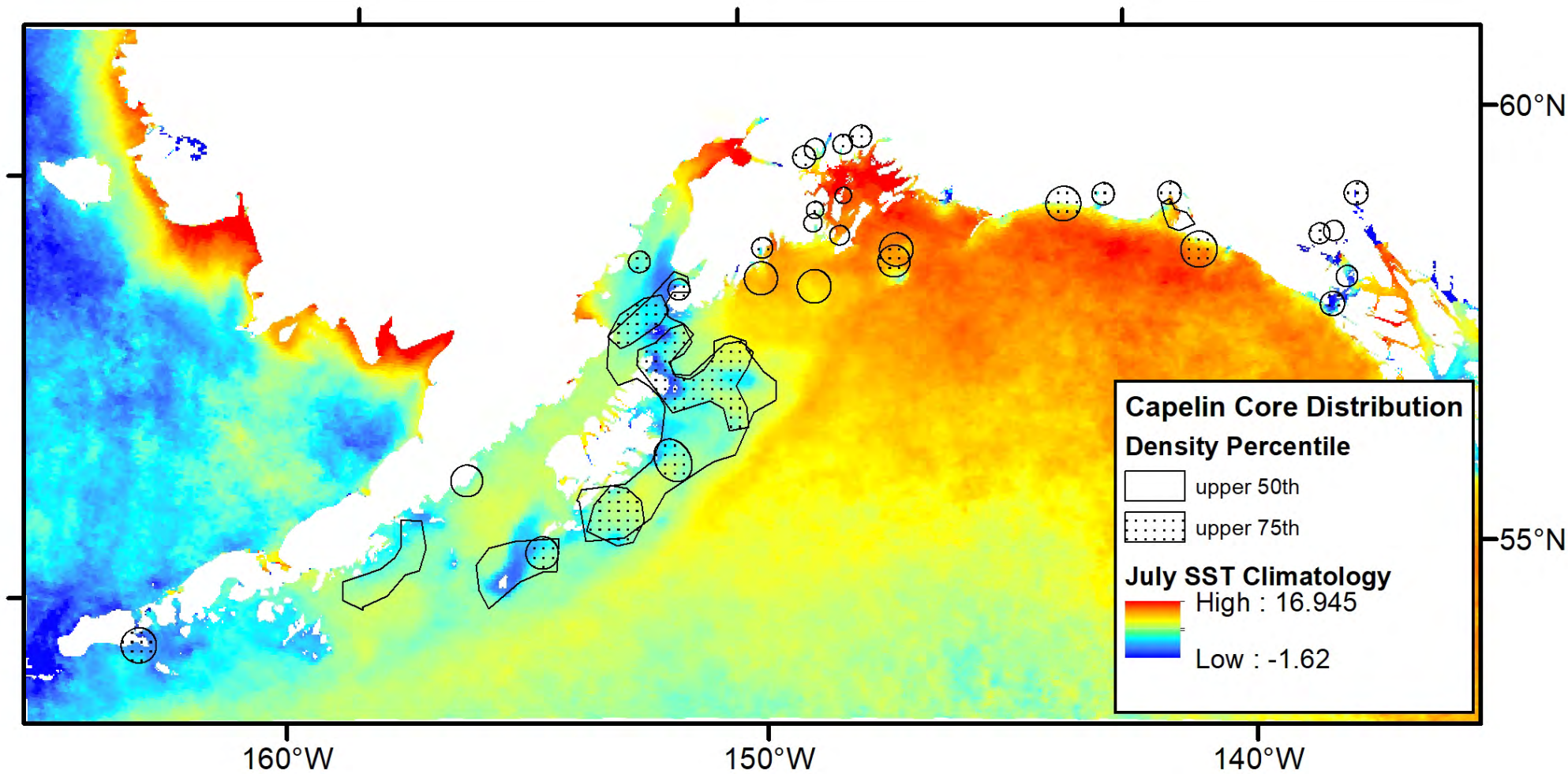
McGowan et al. In revision, MEPS



Piatt et al. 2018, FO

Capelin Core Distribution Northern Gulf of Alaska

July SST Climatology 2002-2018



Data: MODIS Aqua Satellite, NASA OceanColor

<https://oceandata.sci.gsfc.nasa.gov/>

Middleton Island Seabird Diets

Divers

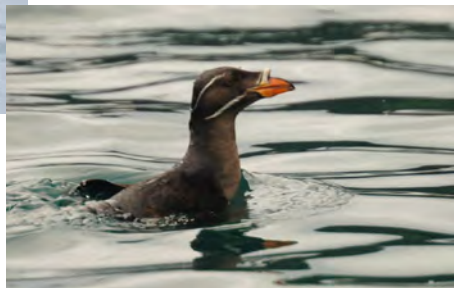
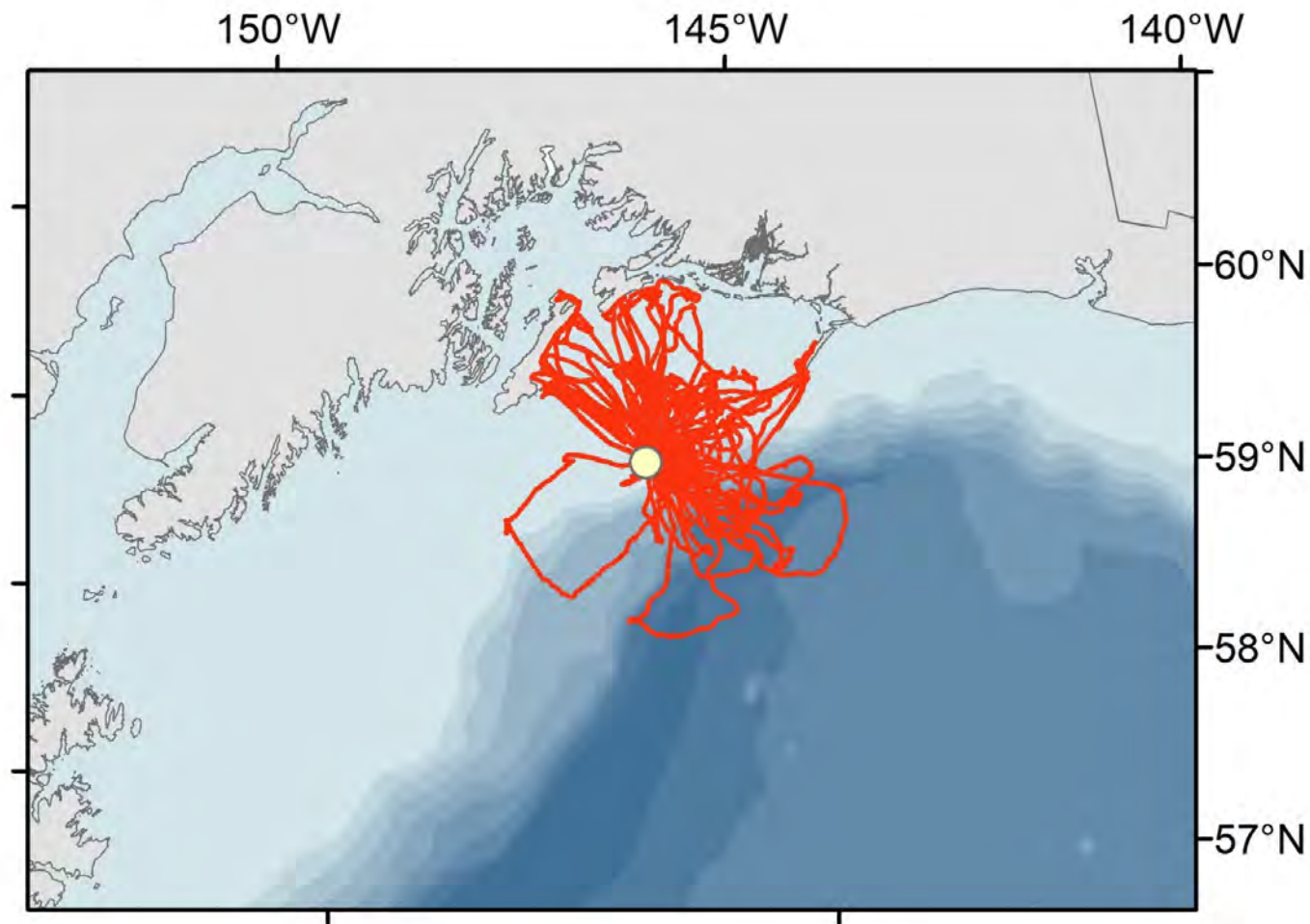


Photo: Marc Romano

Surface Feeders

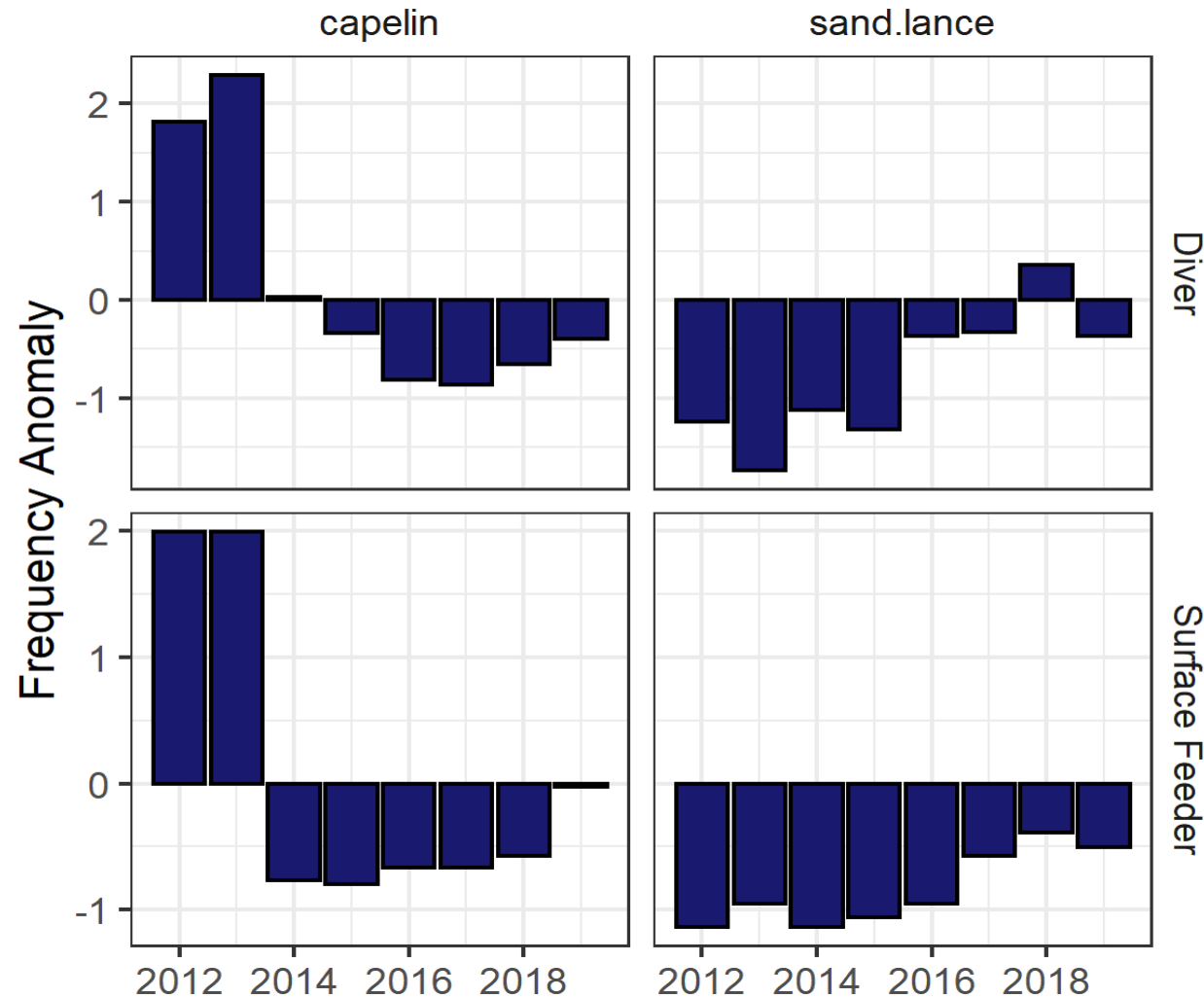


Photo: Sarah Schoen



Hatch 2013 MEPS

Capelin and Sand Lance Availability in Seabird Diets



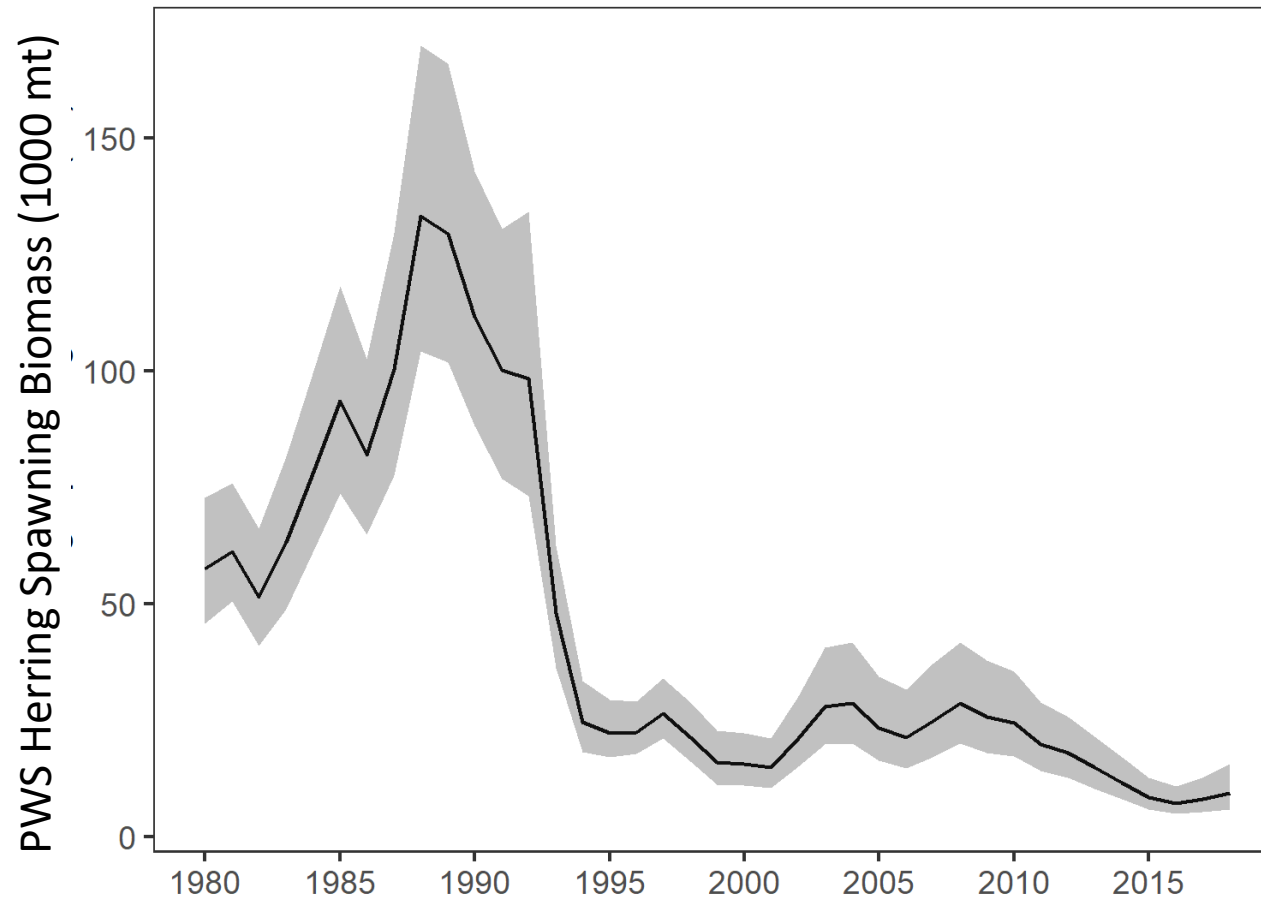
Low availability of capelin and sand lance after 2014

Capelin and sand lance indices alternated out of phase 1978-2012

Sydeman et al 2017, FO

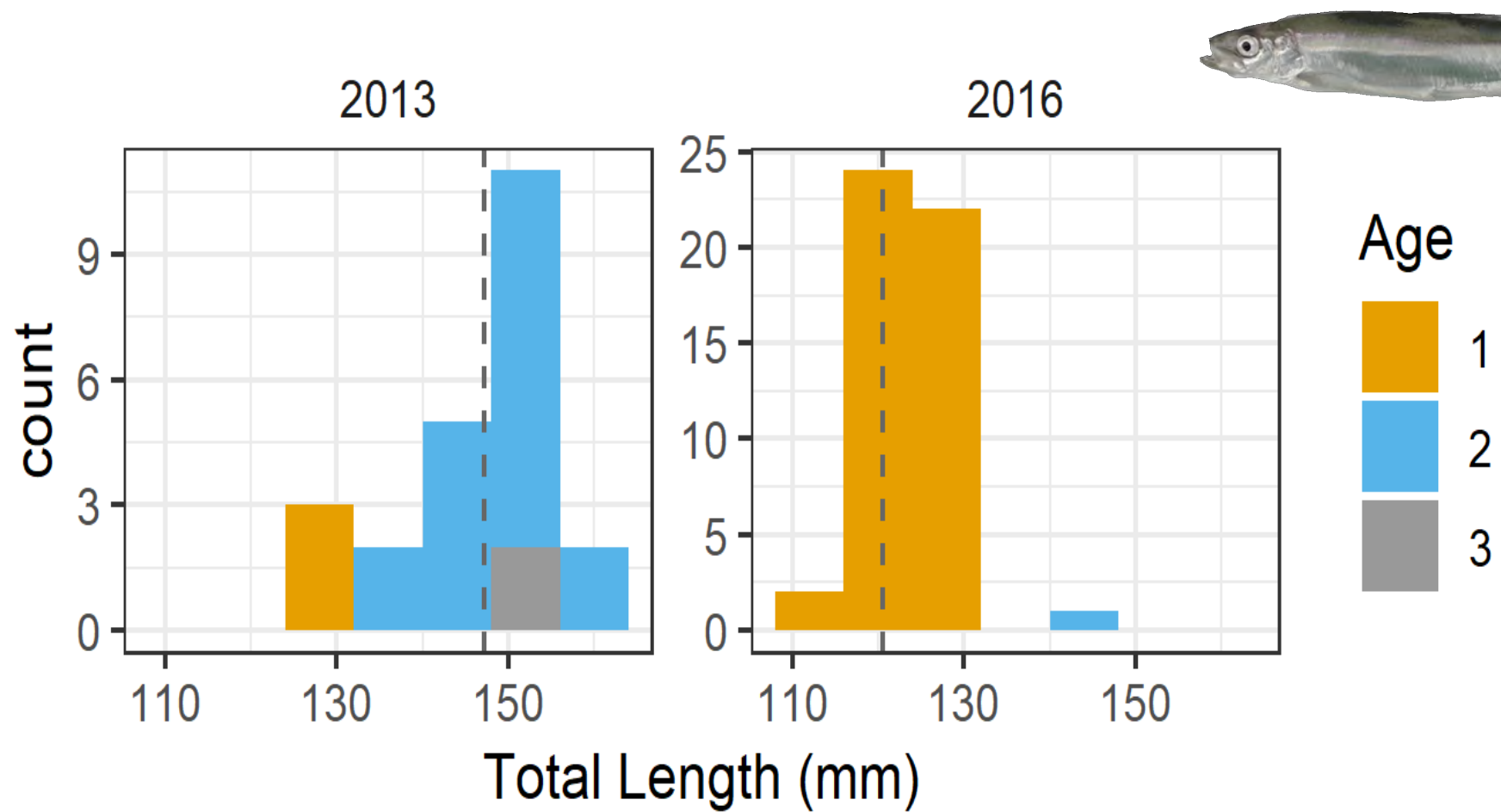
Data: Scott Hatch, ISRC 1993-2019

Prince William Sound Herring Biomass



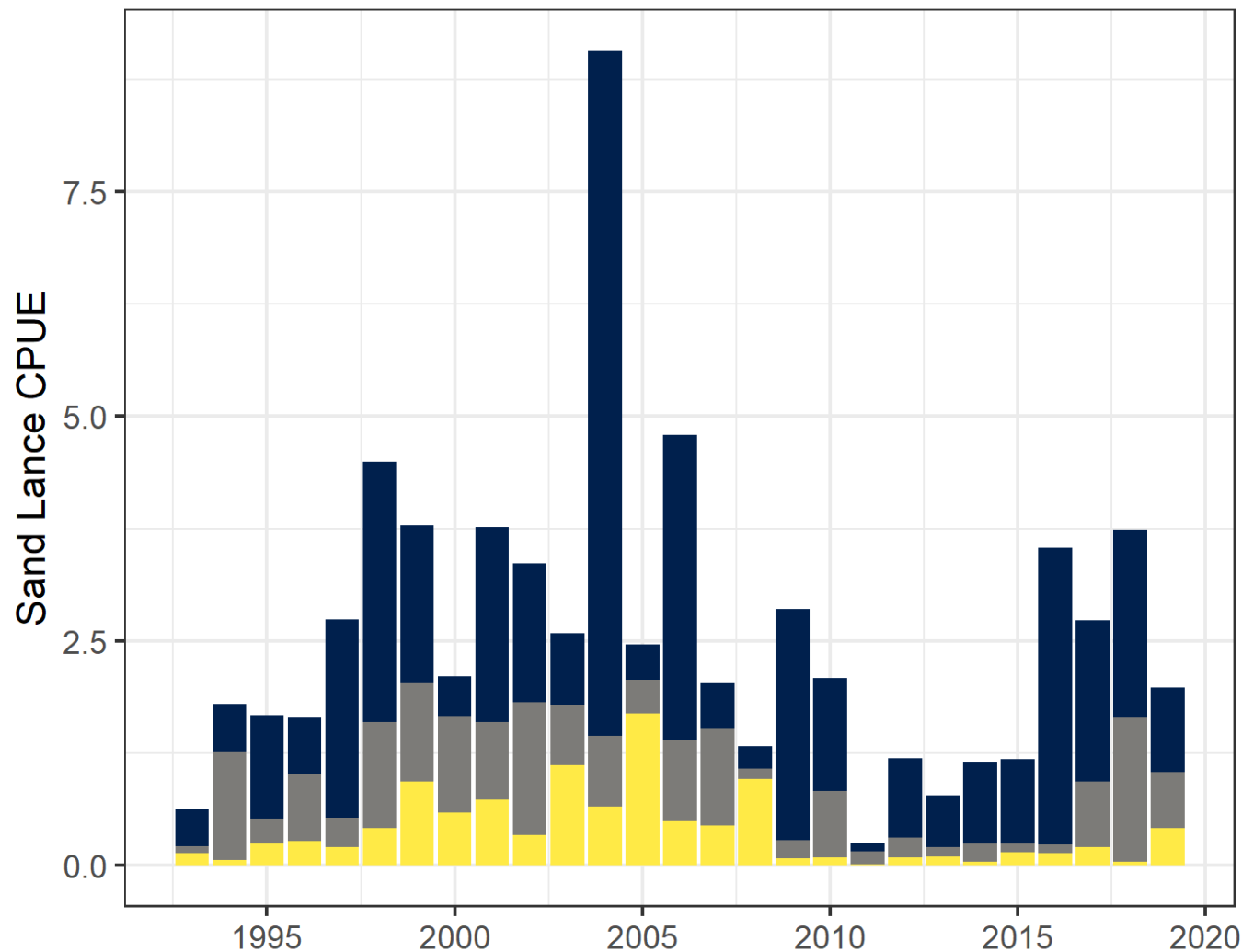
Source: Herring Research and Monitoring Program BASA

Prince William Sound Spawning Capelin Age Structure

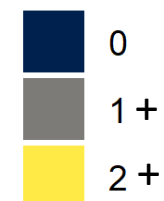


Spawning population was younger and smaller in 2016

Sand Lance Size Structure in Seabird Diets



Size Group

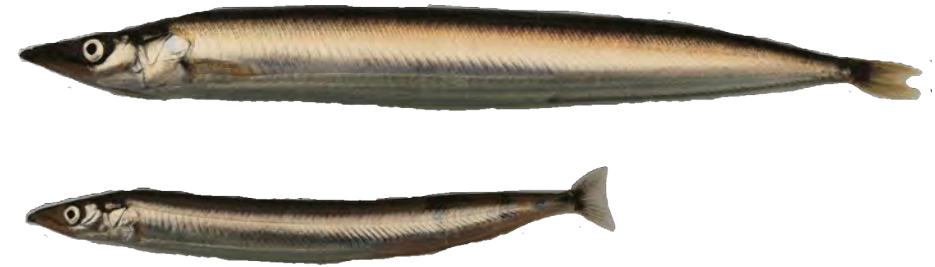
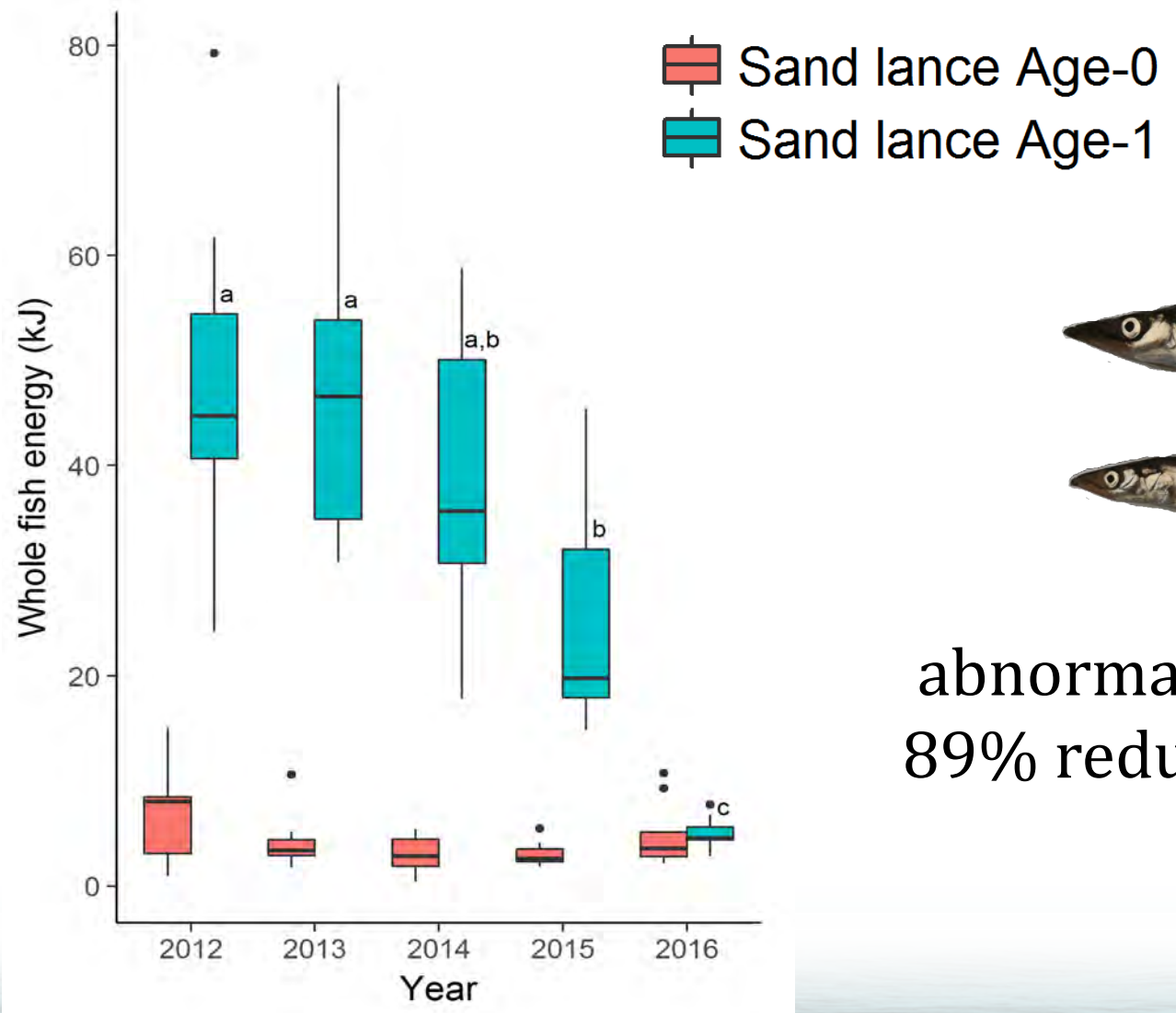


Lower proportion of larger size classes

Consisted of primarily age-0 fish in 2016

Data: Scott Hatch, ISRC

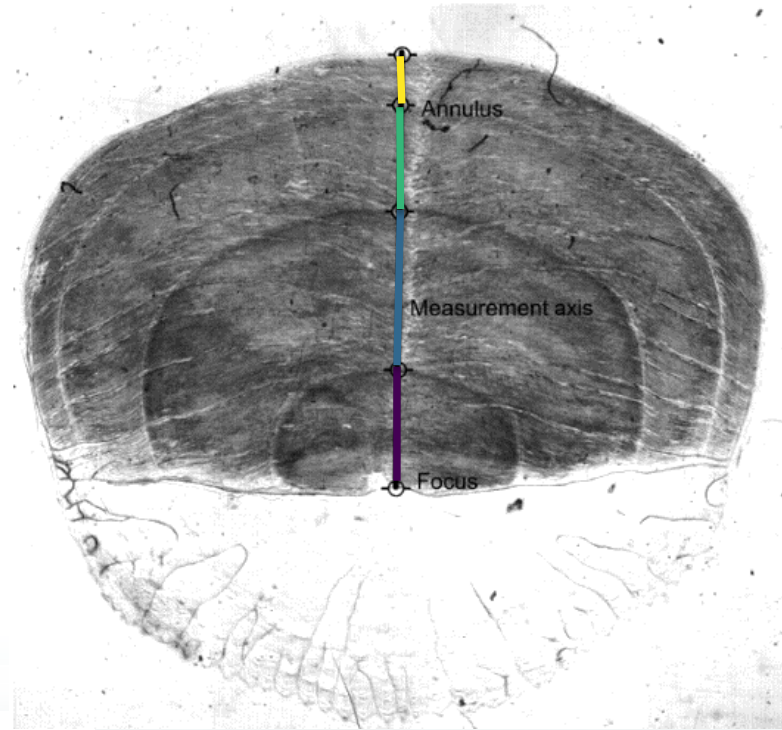
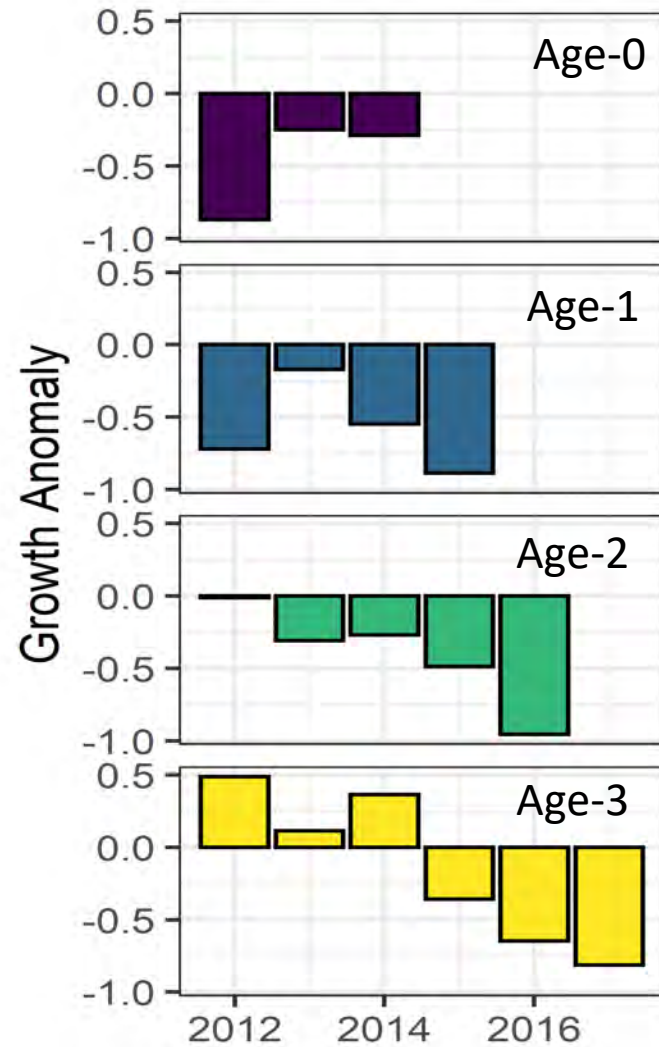
Prince William Sound Sand Lance Nutritional Quality



abnormally low growth in 2015-2016
89% reduction in energy content

von Biela et al. 2019 MEPS

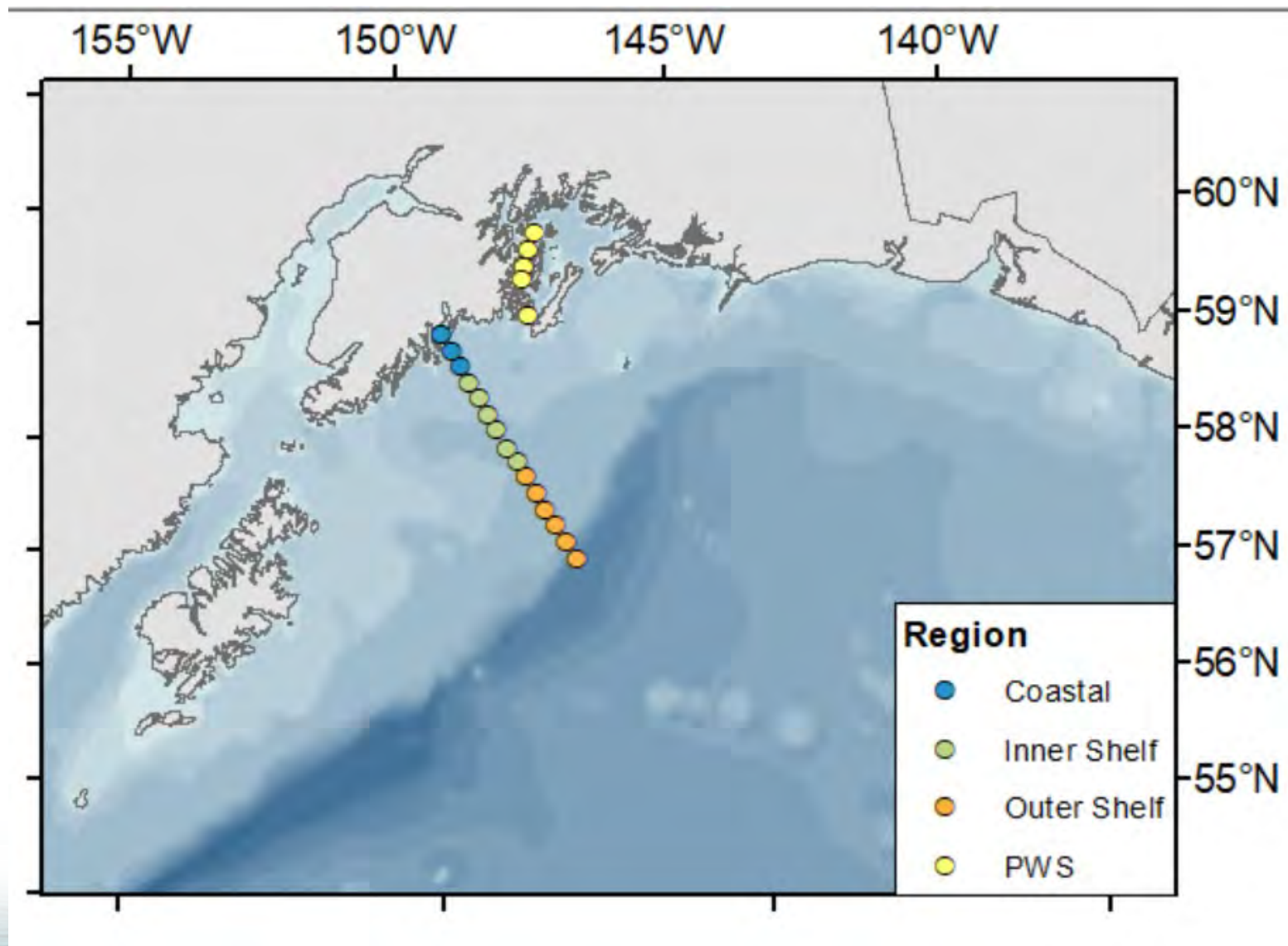
Prince William Sound Herring Growth Index



Data: Pegau (PWSSC) & Moffit (ADF&G) 1976-2017

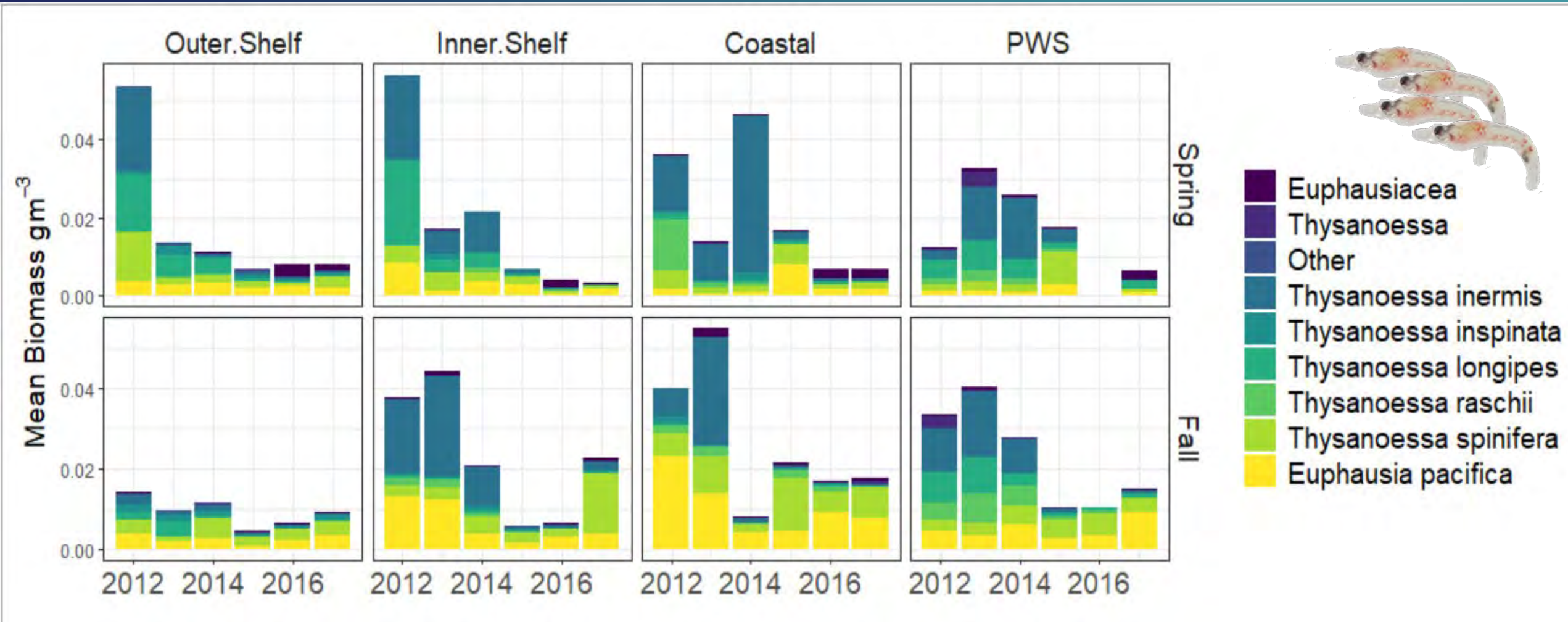
Batten et al. 2016 FO

Krill: The other forage “fish”?



<http://research.cfos.uaf.edu/sewardline/>

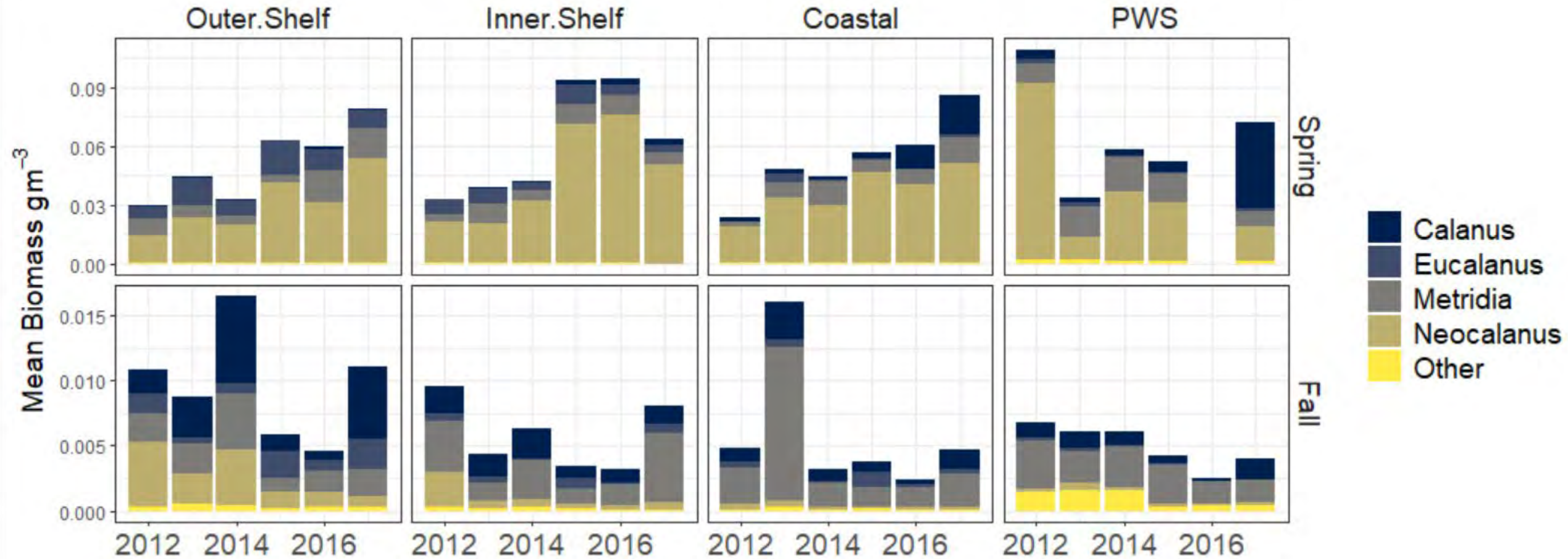
Seward Line Krill Biomass by Region



T. inermis densities declined by 2015

Data: Russ Hopcroft, UAF, 1997-2019

Seward Line Copepod Biomass by Region



Data: Russ Hopcroft, UAF, 1997-2019

Changes in copepods were not extreme enough to explain those observed at higher trophic levels

Summary

Availability and quality of key forage fish were reduced in the Northern Gulf of Alaska during the marine heat wave:

- Abrupt decline in capelin
- Sand lance and herring indices were also low
- Changes in forage fish size, age, growth
- Loss of diversity in krill community
- Changes in copepod biomass did not provide a bottom up mechanism

Reduced energy transfer by the middle trophic level disrupted the functioning of marine food webs in the Gulf of Alaska during 2014-2016
North Pacific Marine Heatwave