The impacts of climate variability on local ecosystems of the Salish Sea

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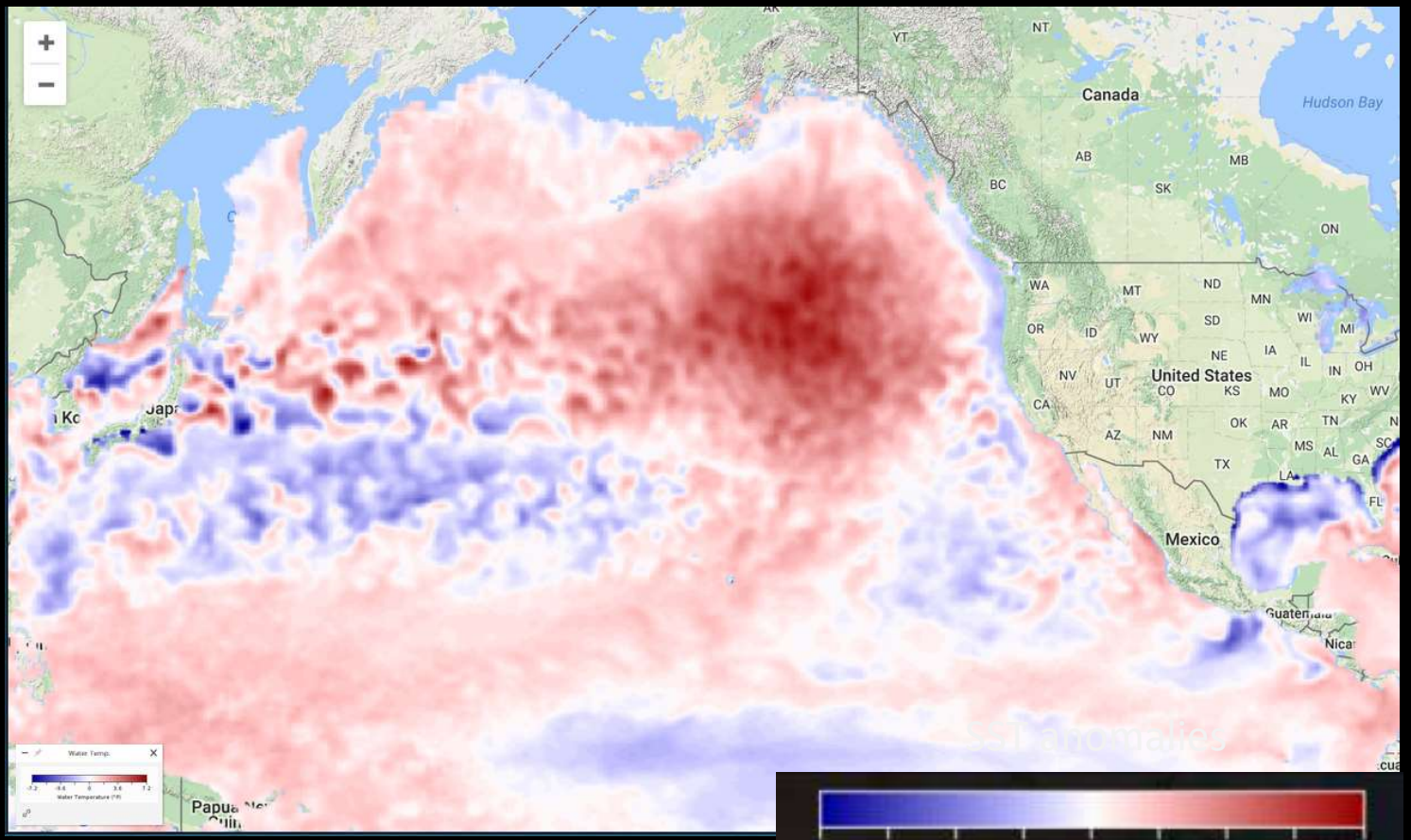
Record high temperatures occurred during the Pacific Warm Anomalies, a.k.a. “The Blob”

Develop during winter 2013-14

January 2014

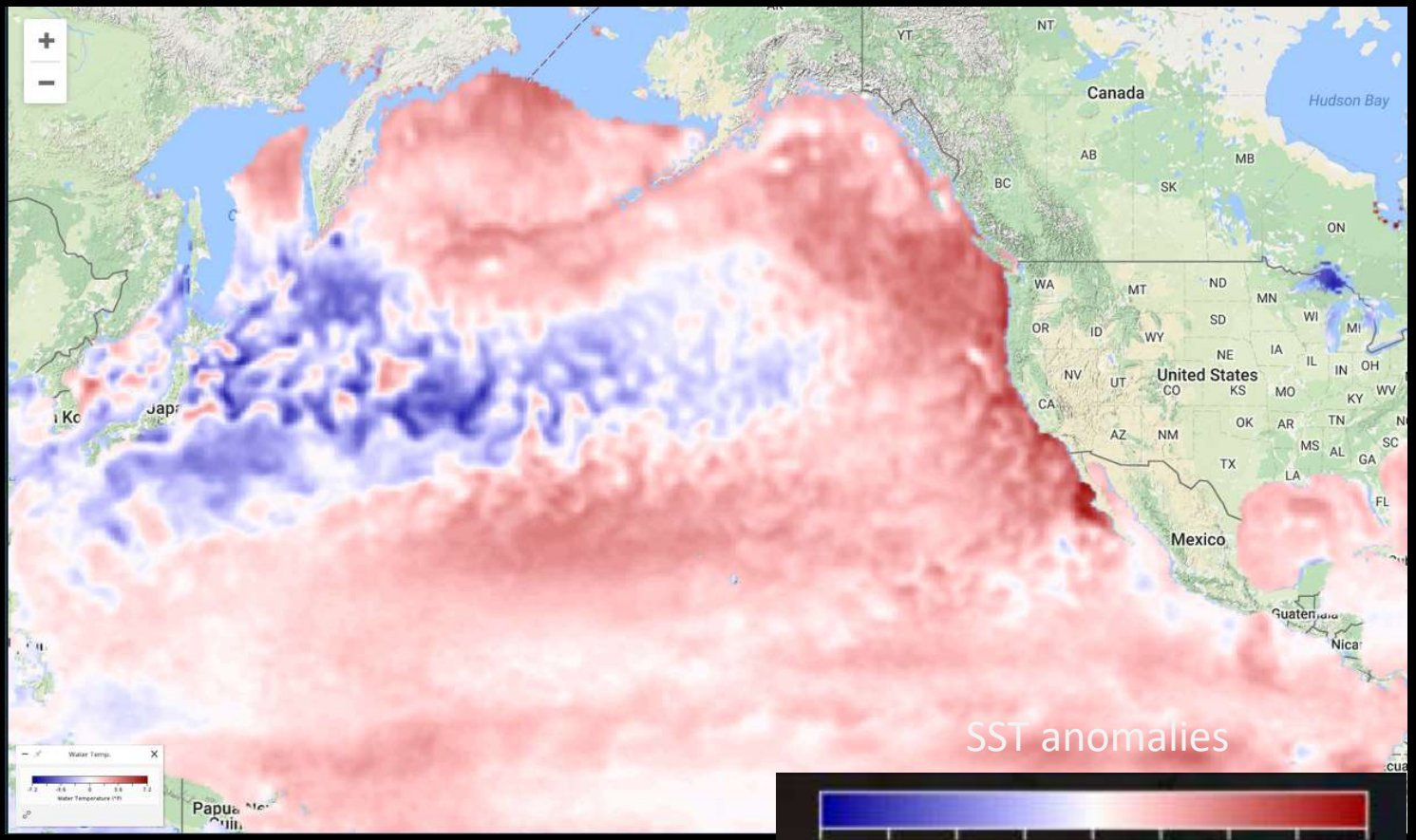


NANOOS Visualization System:
http://www.nanoos.org/

Autumn 2014 – Warm anomalies affect the coast

Moved onshore in fall 2014

October 2014



NANOOS Visualization System:
http://www.nanoos.org/

What effects were seen in local waters?

Temperature

↓

Chlorophyll

↓

Zooplankton

↓

Salmon and forage fish

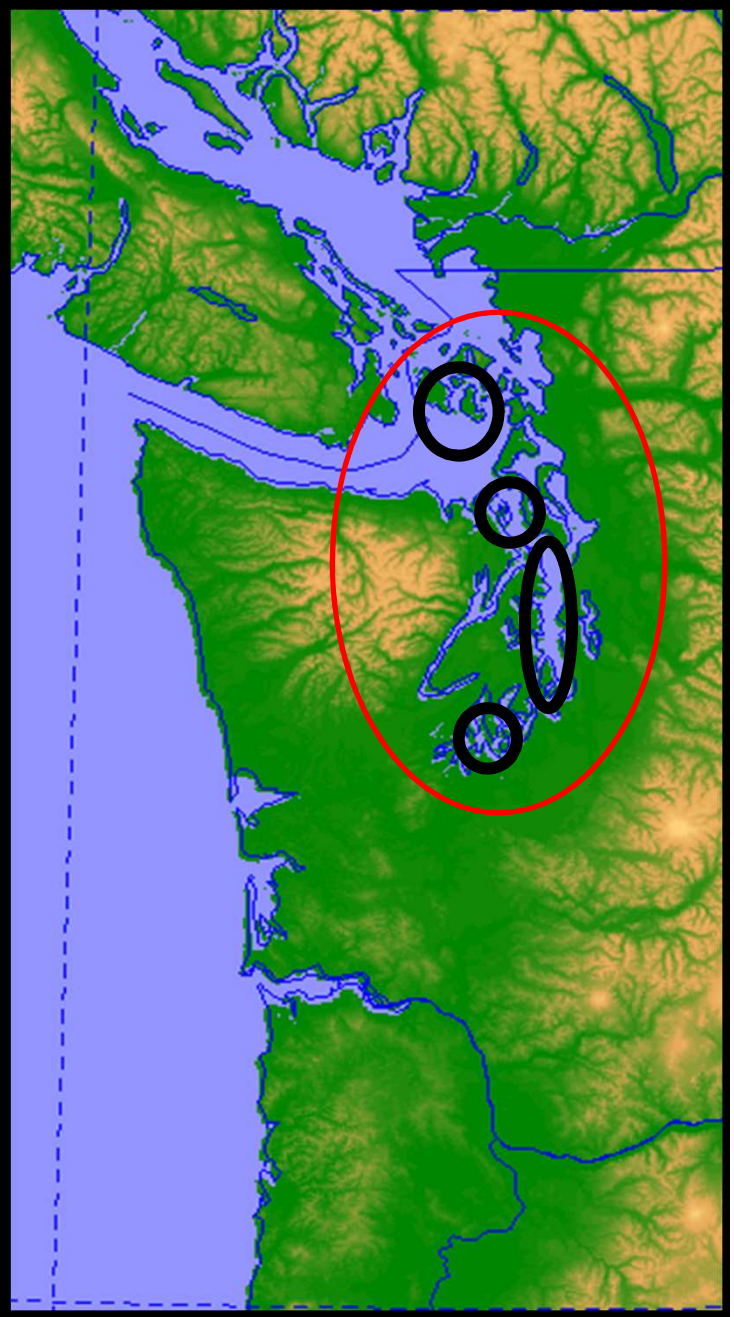
Time Series Data:

Hydrography and chlorophyll biomass:
1997-present, monthly
throughout Puget Sound
(WA Dept. of Ecology)

Zooplankton:
2014-present, bi-weekly
throughout Puget Sound
(SSMSP, J. Keister)

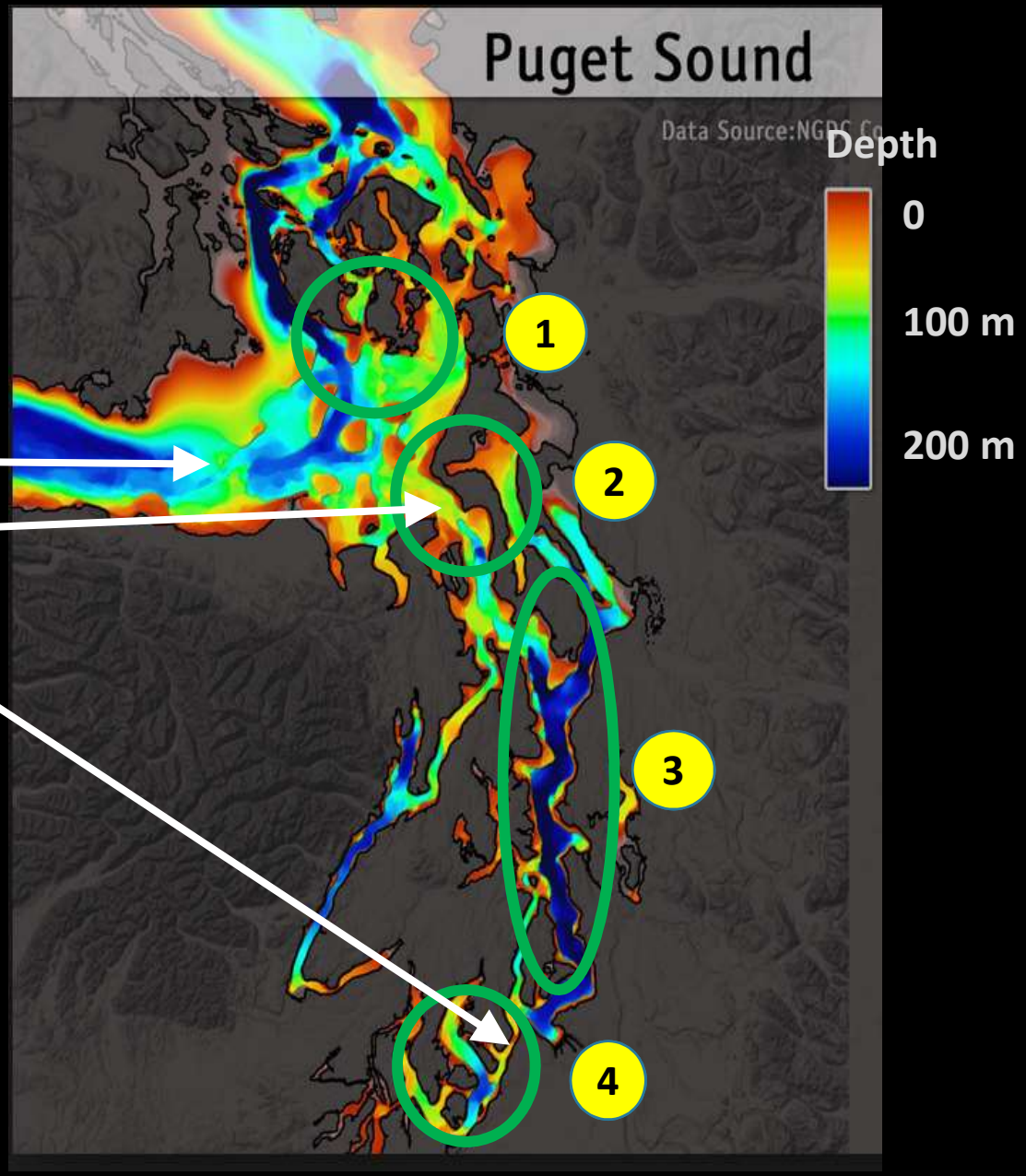
Salmon growth and survival:
multiple datasets, some since 1999
(Canada DFO, NOAA)

Herring spawning stock biomass
1990-present, weekly
(WDFW)



Salish Sea bathymetry

Series of shallow sills restrict water flow from the ocean.



Diverse, oceanic species assemblage

Copepods (>30 spp.):

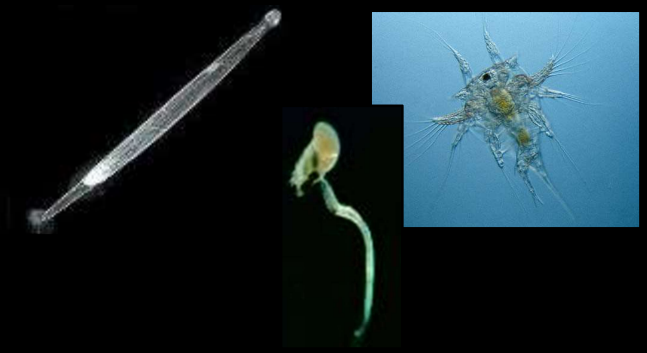
Euphausiids: 4 species

Decapods: 10+ species

Amphipods: 4+ species

Other species:

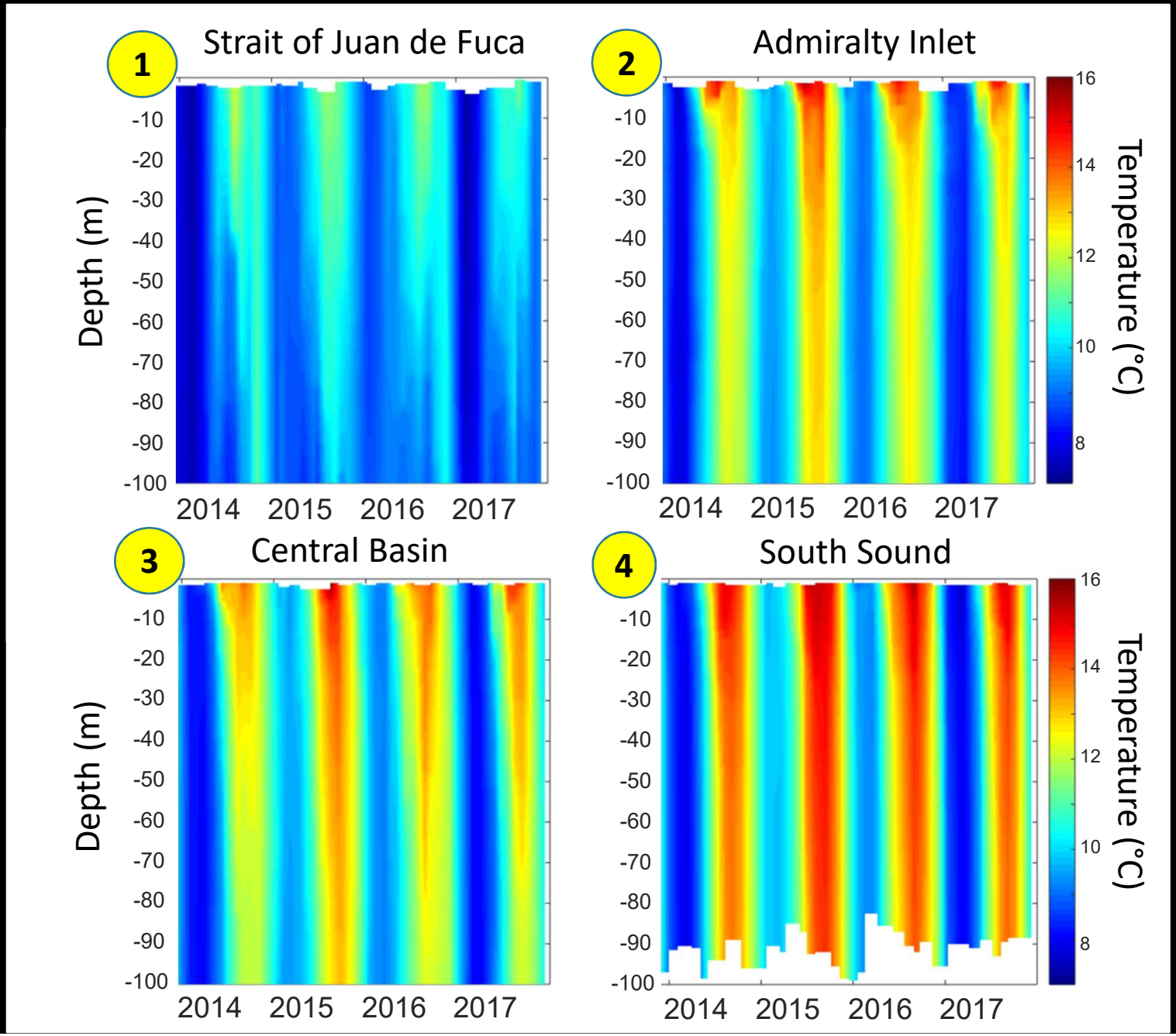
1 Chaetognath, 2 Larvaceans, 2 Cladocerans, numerous Bivalves, Gastropods, Echinoderms,Polychaetes, Barnacles …



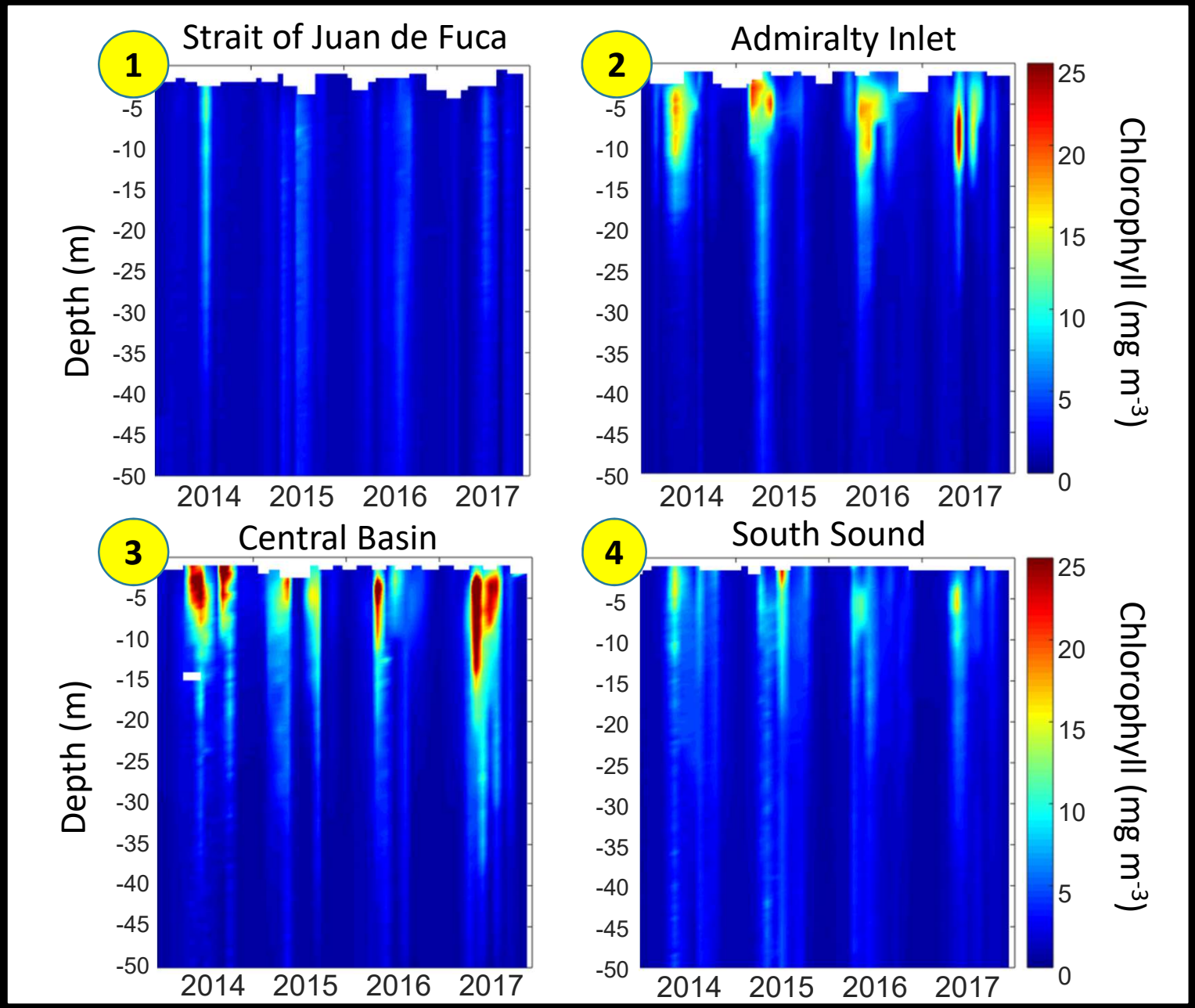
Pteropods: 3 species

Jellyfish: 12+ species

Temperatures from monthly CTD casts: 2014-2017

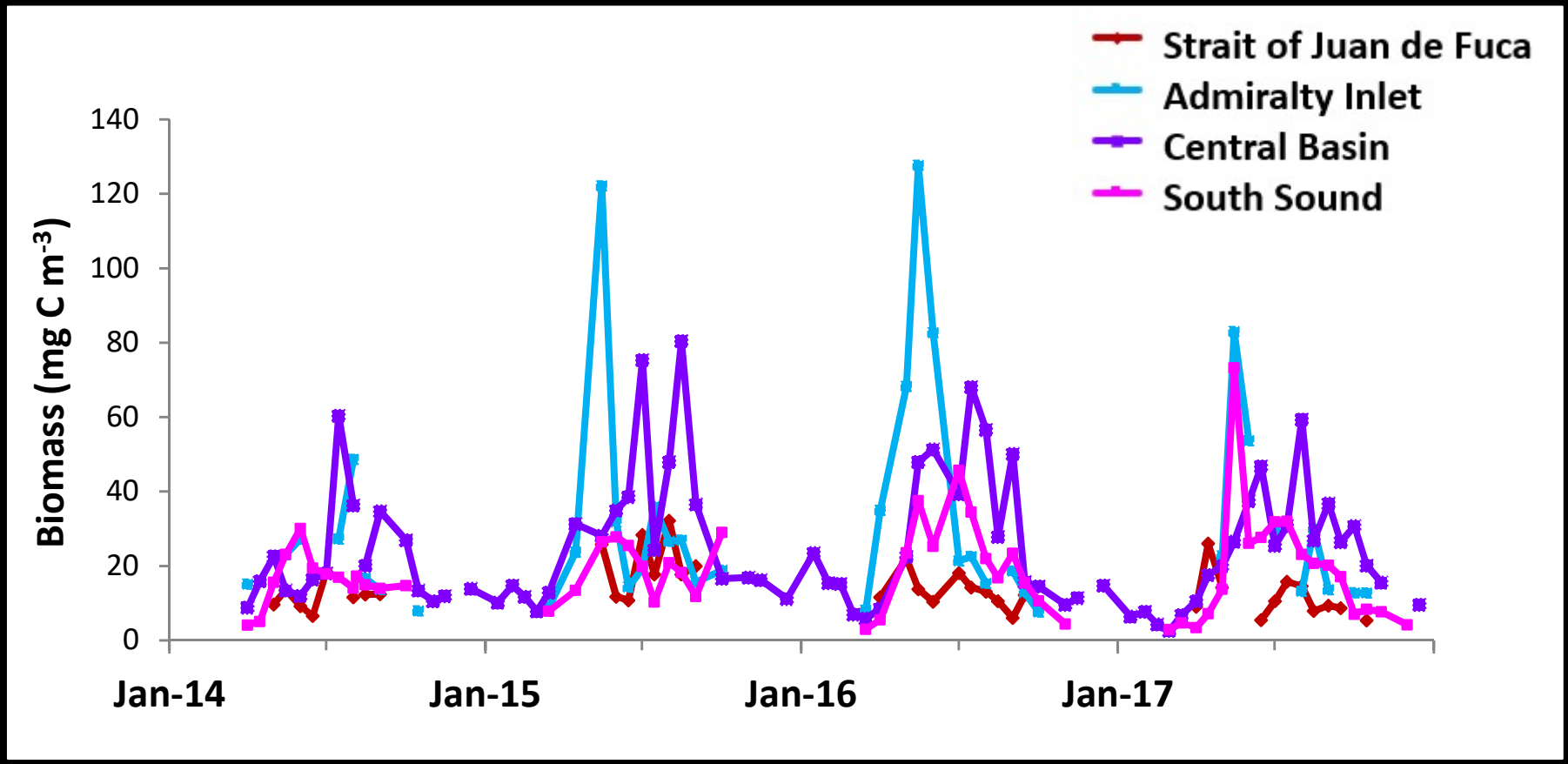


Chlorophyll biomass from monthly CTD casts



Total zooplankton biomass (vertical net tows):

Differences among regions and years



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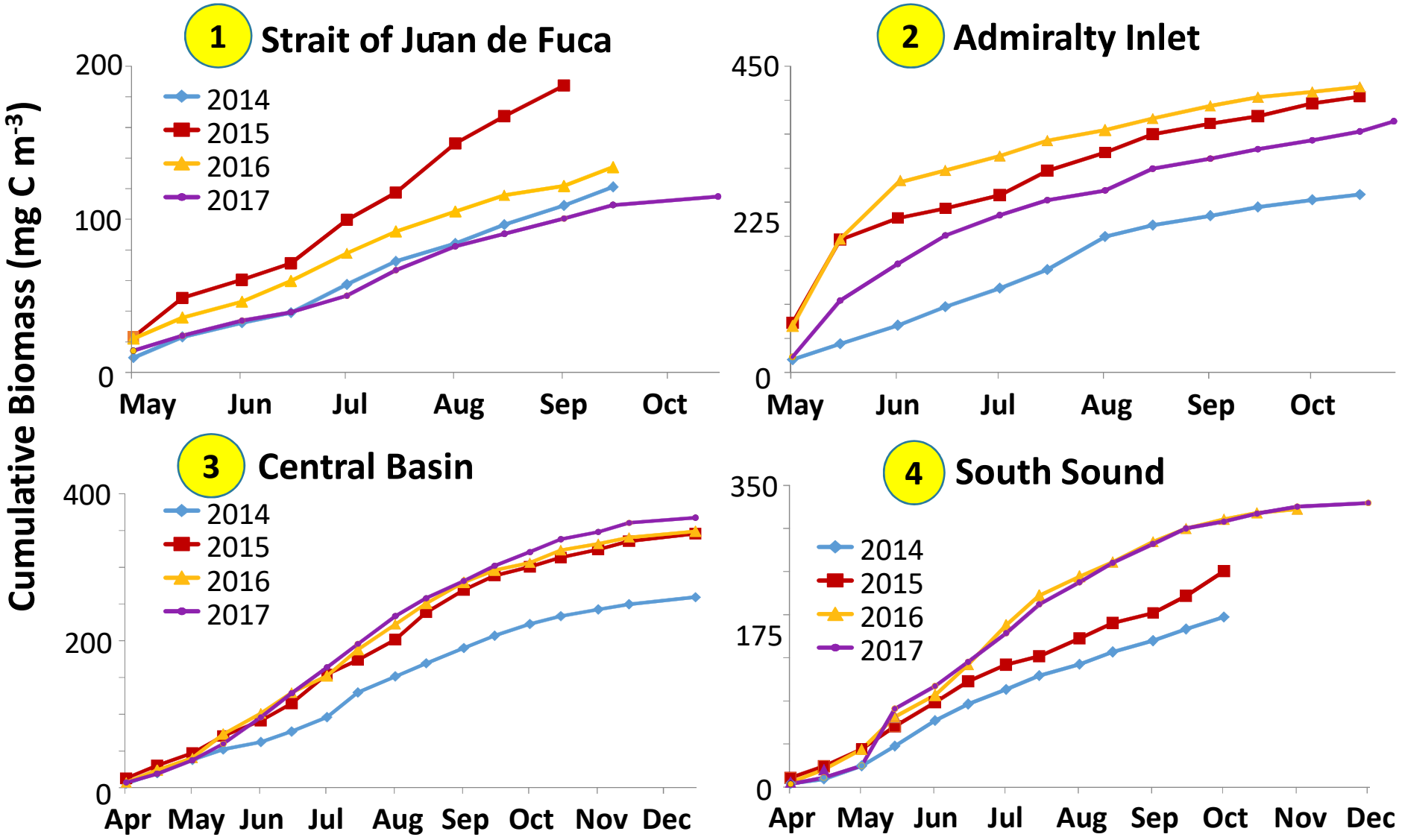
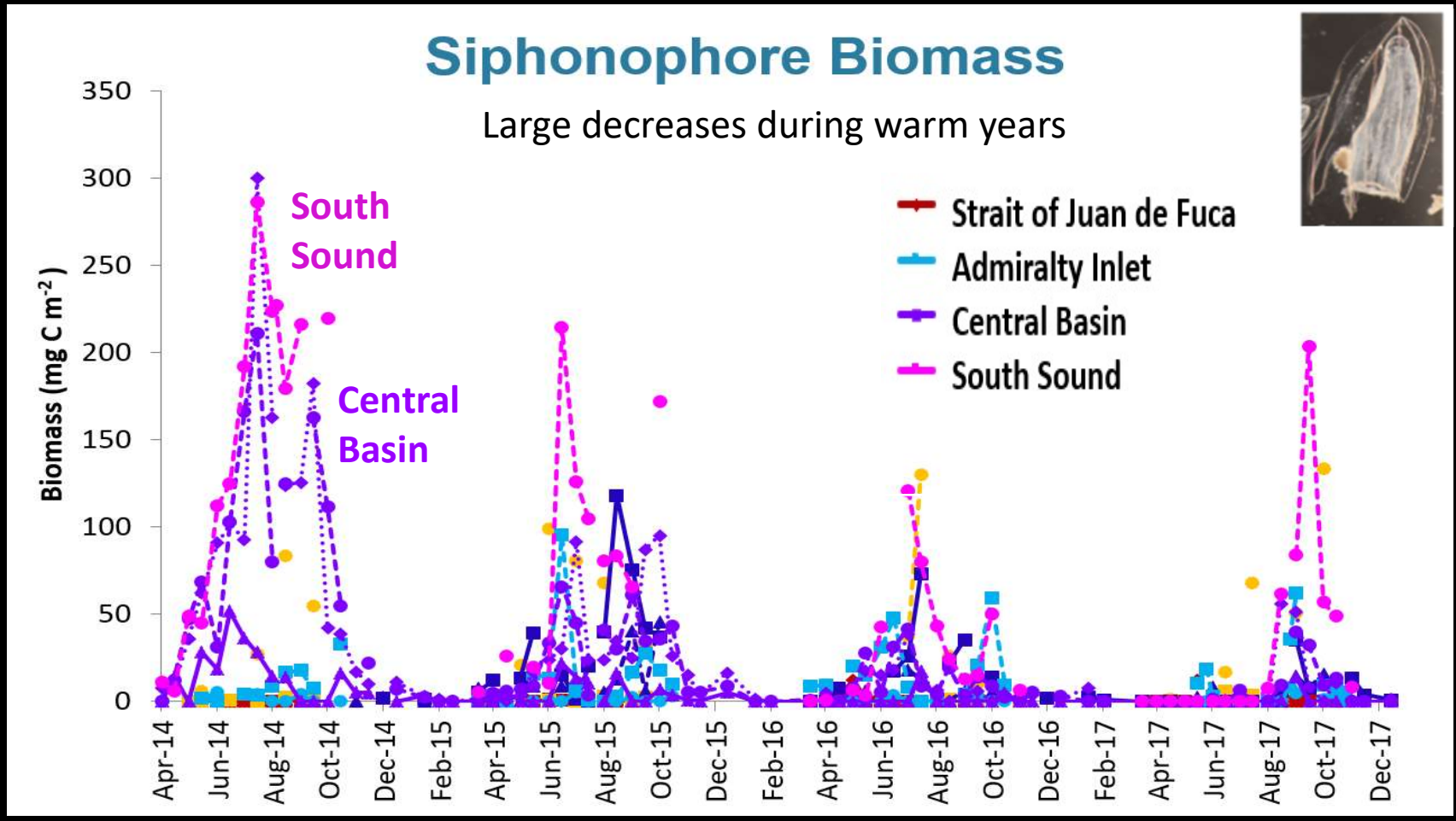
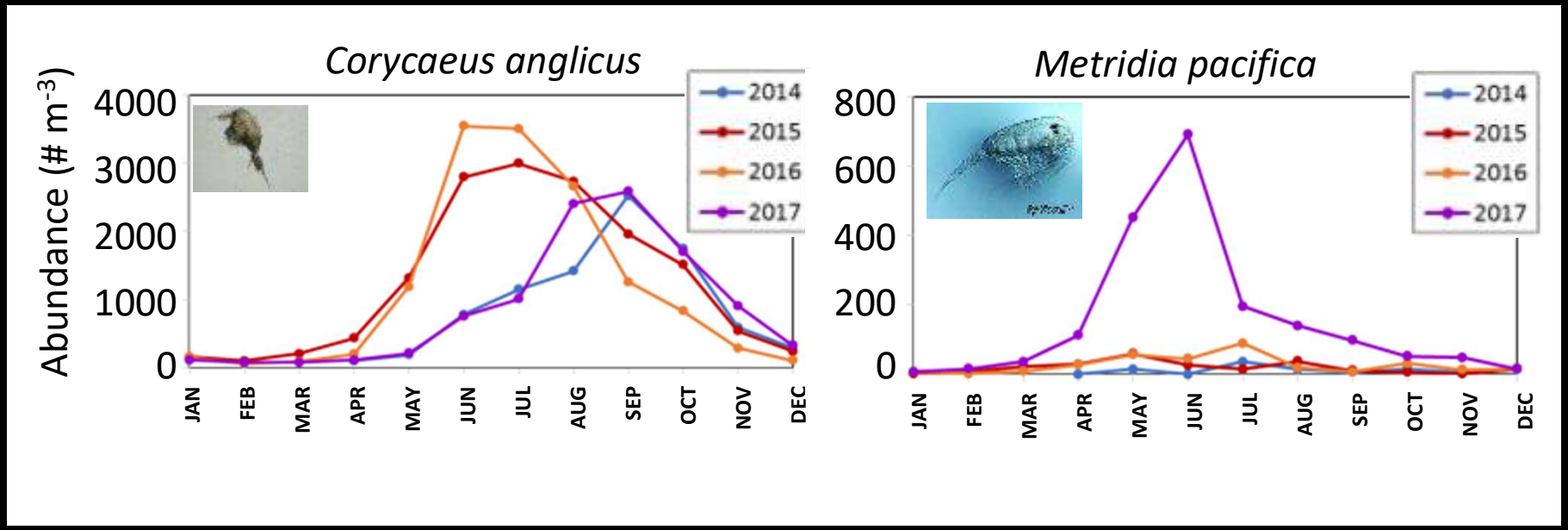


Changes in predation?



Some species showed huge phenology shifts during warm years:

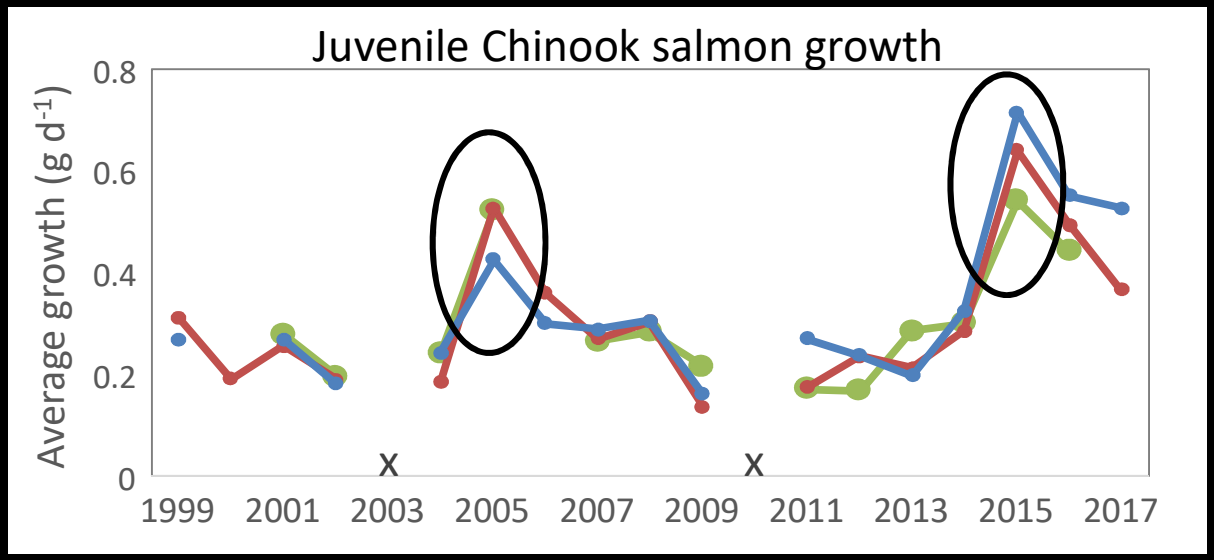
Some did not:

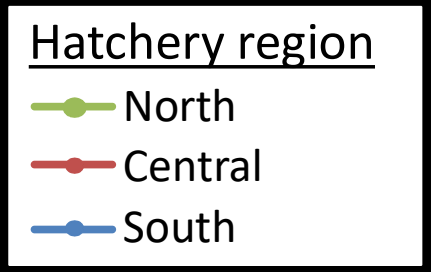


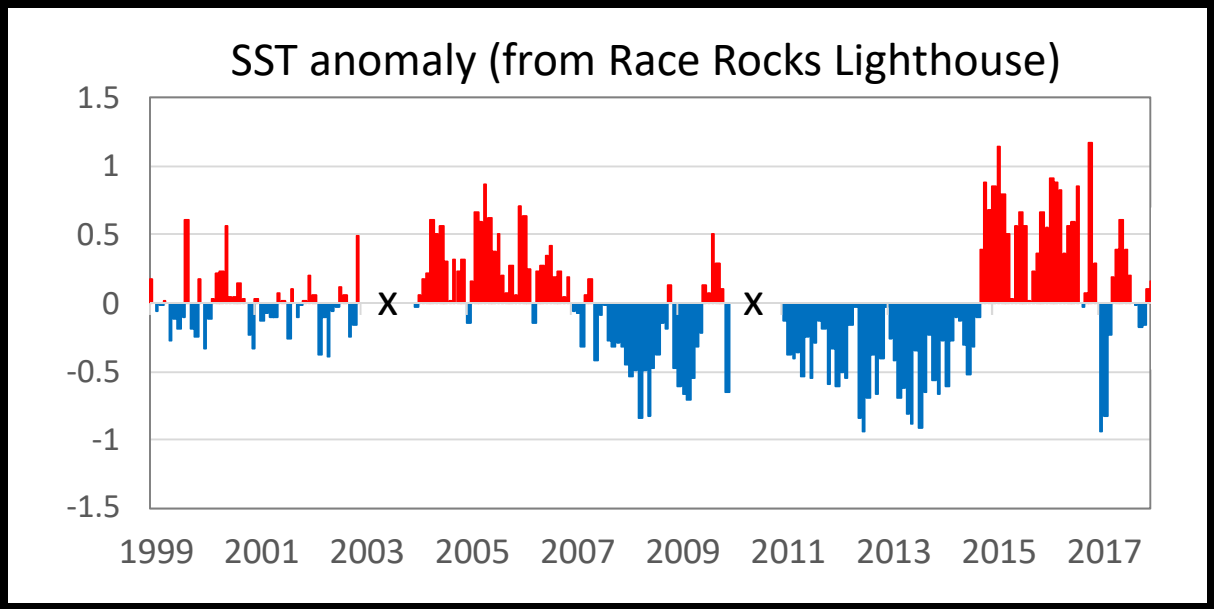
Juvenile salmon growth (hatchery Chinook)

Average weight gain per day from release to recapture

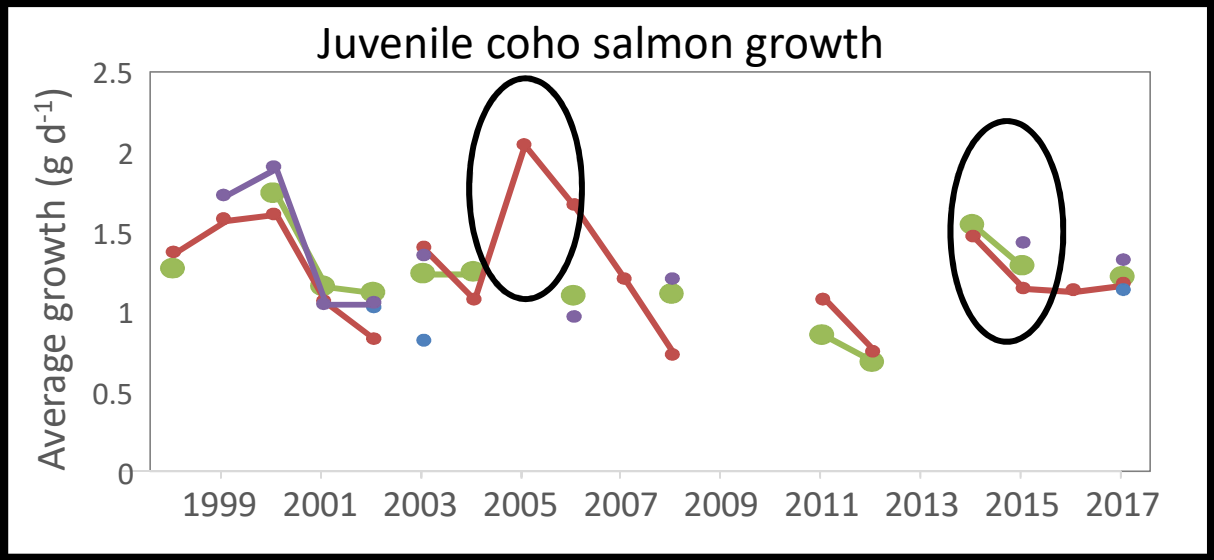
http://www.fpc.org

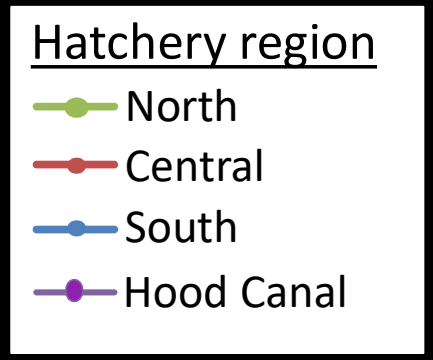


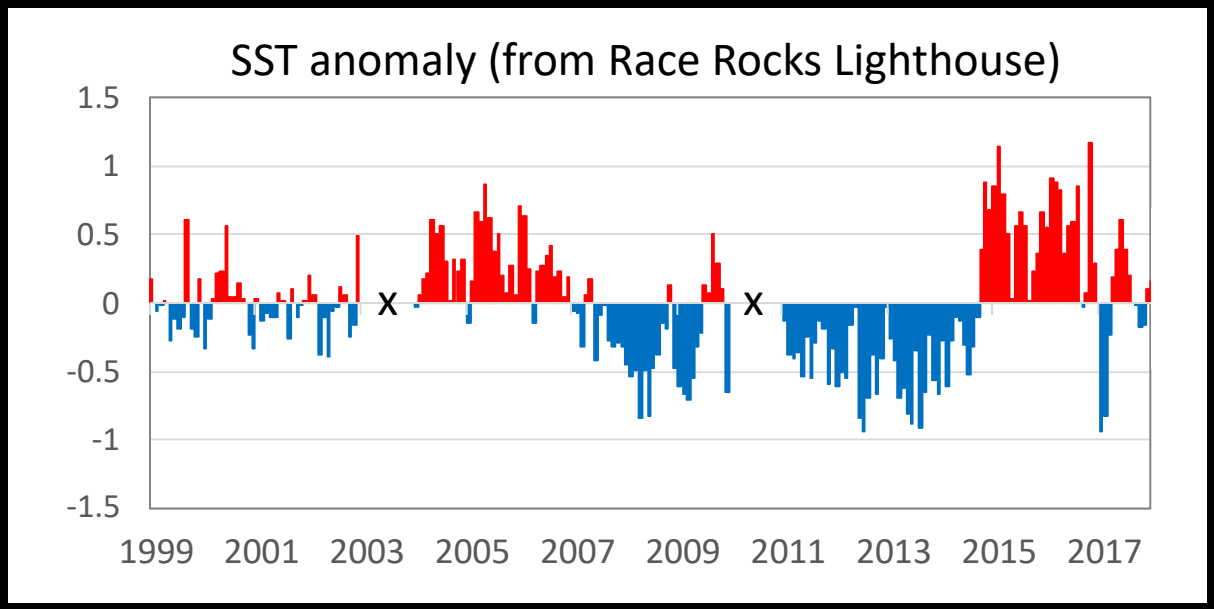




Not the same for juvenile coho salmon growth

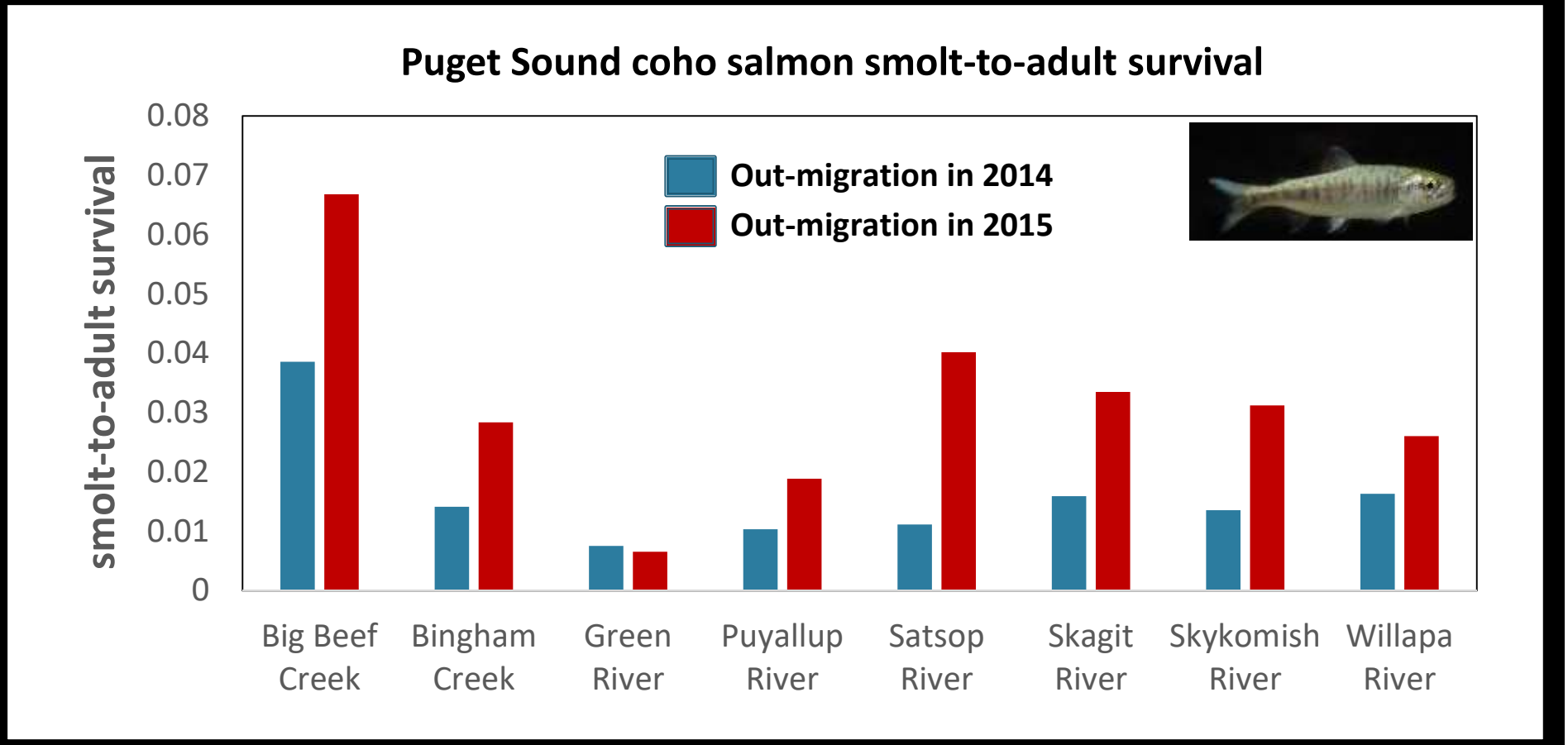




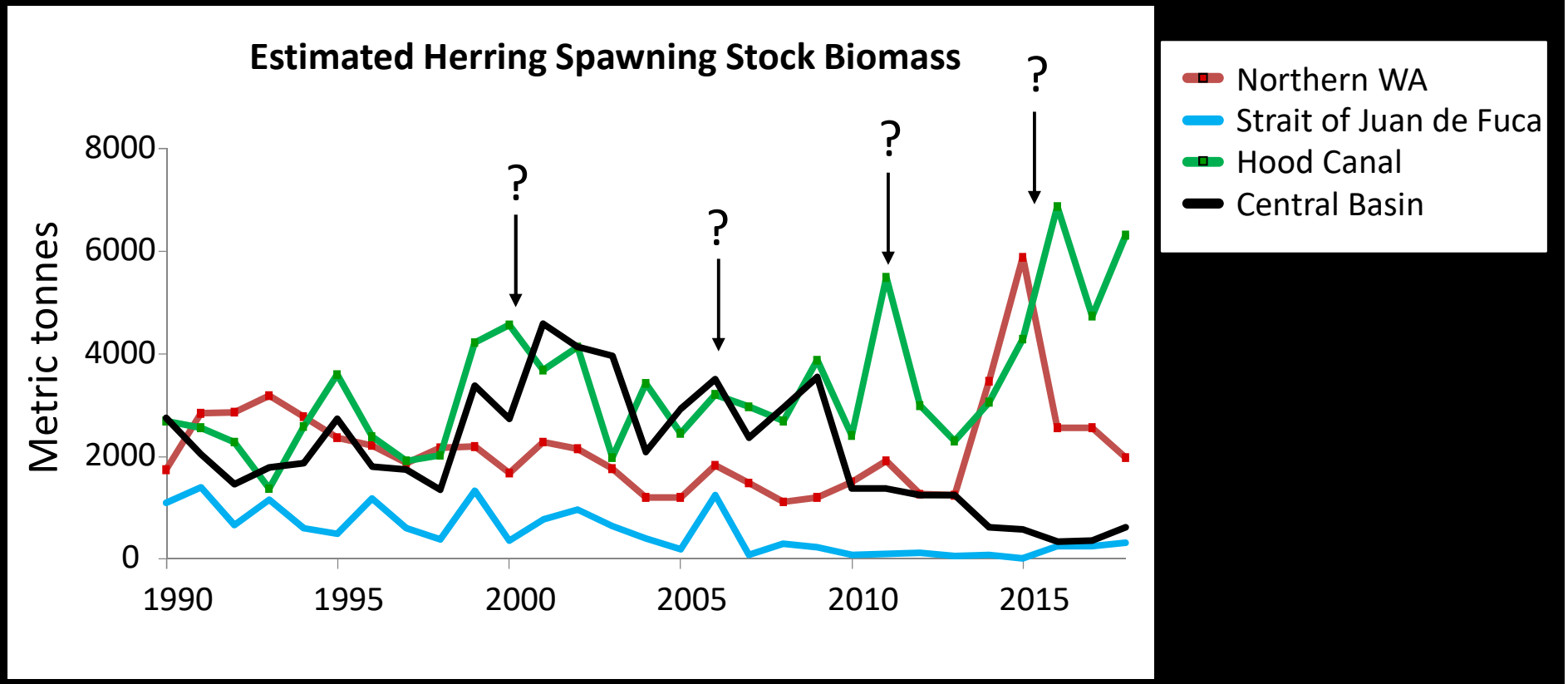


Coho salmon smolt-to-adult survival rate was higher for 2015 than 2014 out-migrants for many populations:

(No data yet for 2016 or 2017)

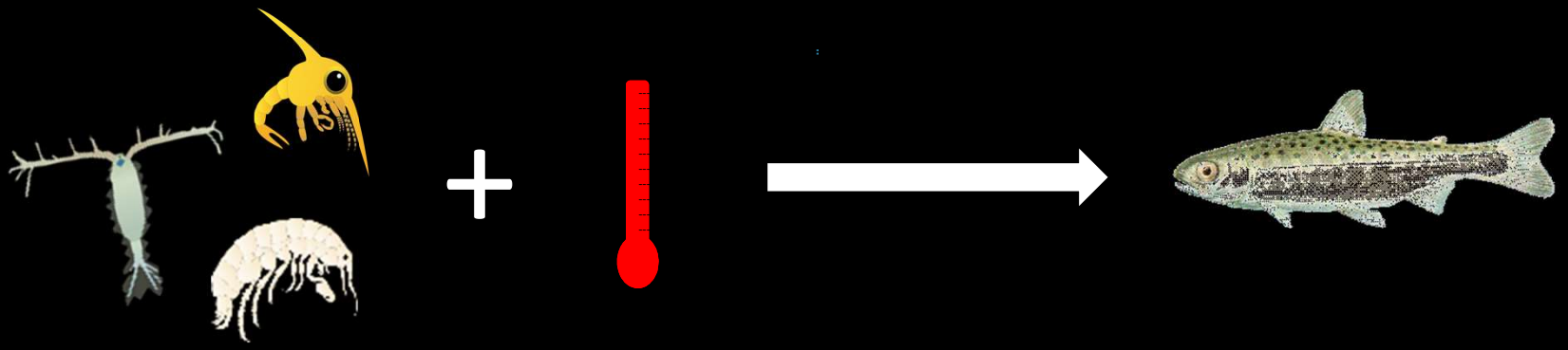


Herring spawning stock biomass (age 2+ years)



Next steps

- Model bioenergetic differences among years



Trudel et al. (2002) - Changes in growth driven more by prey composition and quality than SST-driven changes in salmon feeding and metabolic rates.

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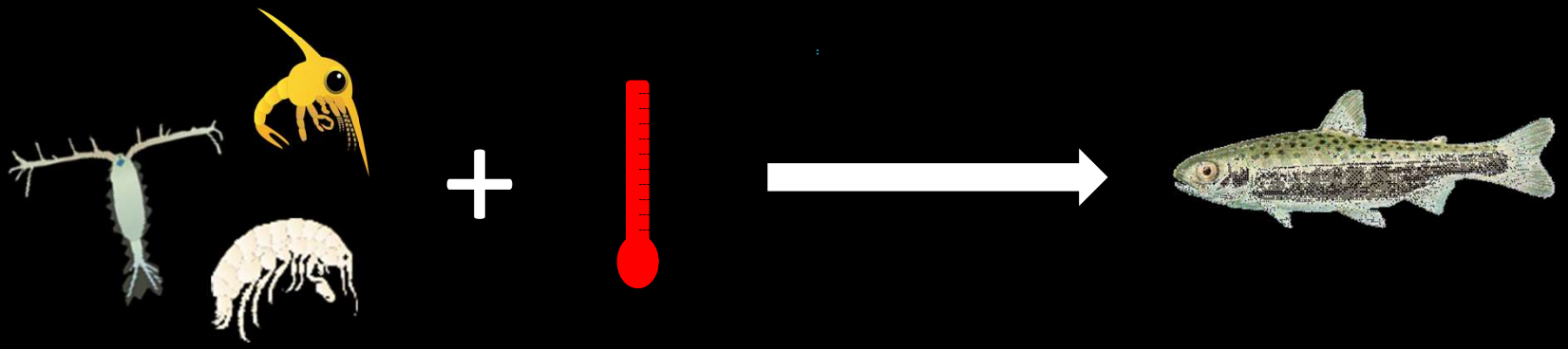


- Quantify relationships among “bottom-up” physical and biological variables

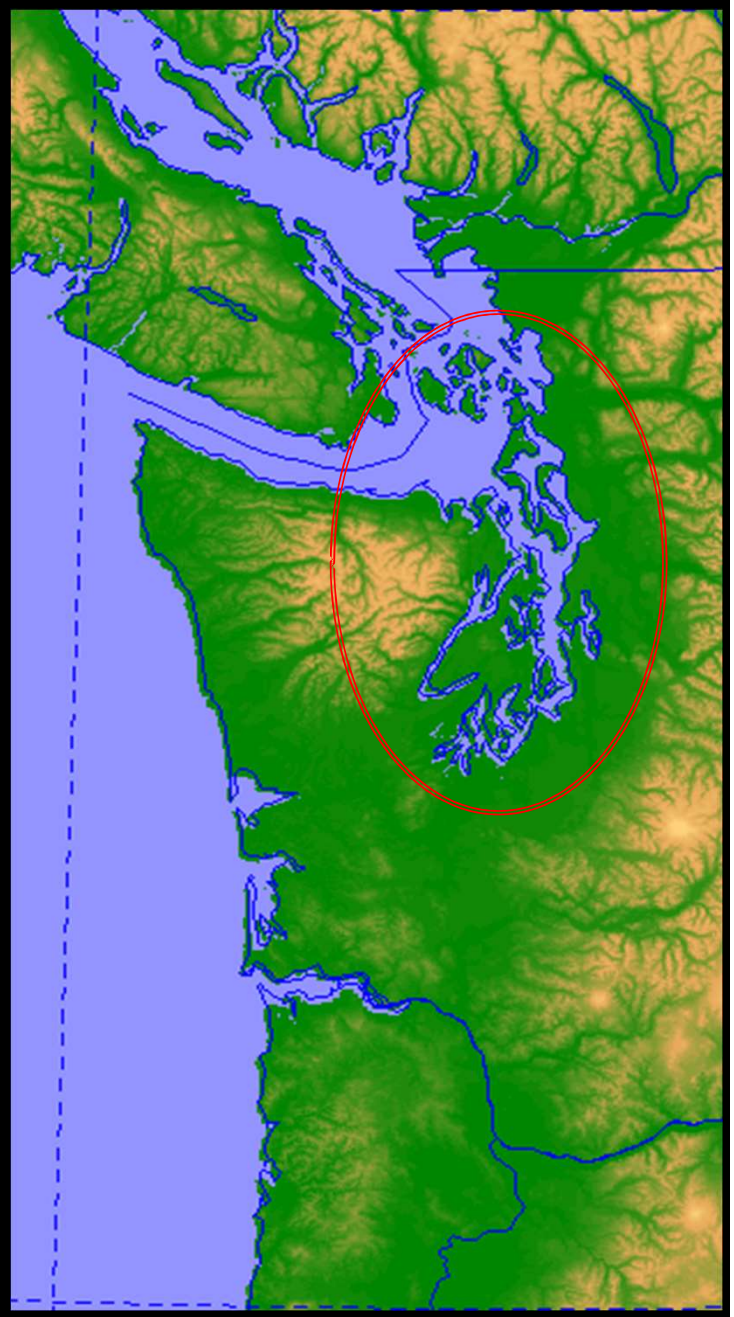
★ Continue diagnosing mechanisms of climate impacts on local ecosystem

In Puget Sound…

Changes in zooplankton biomass, phenology, composition

Possible changes in predation

→ Higher metabolism and growth across multiple trophic levels, supported by sufficient production.



Partnerships & Funding