Climate-related variability in assemblage and size-structure of euphausiids in coastal waters off northern California

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Objectives

Assess patterns in:

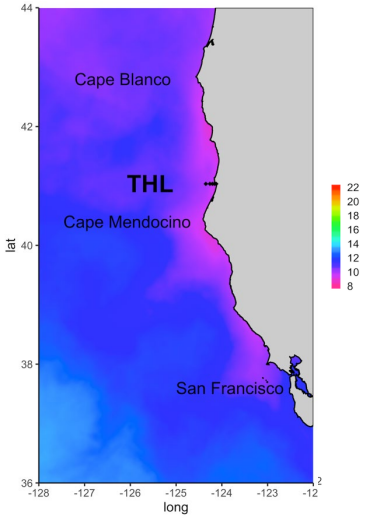
euphausiid assemblage structure

and

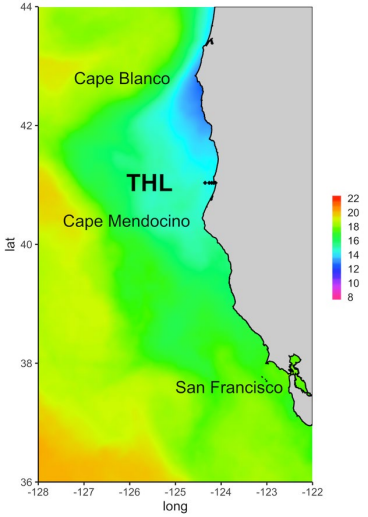
size structure of *Euphausia pacifica*

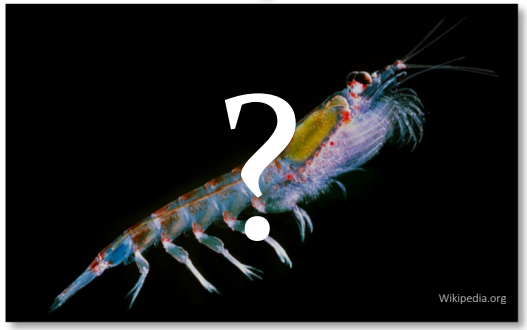
in coastal waters off northern California in the context of ocean conditions and climate forcing.

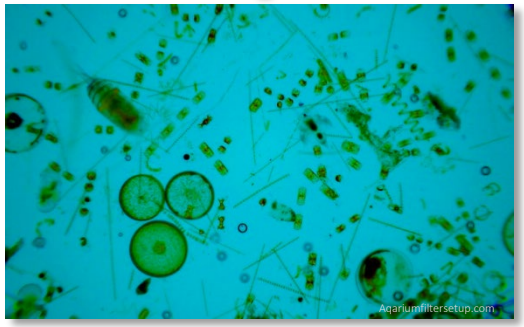
April 2013



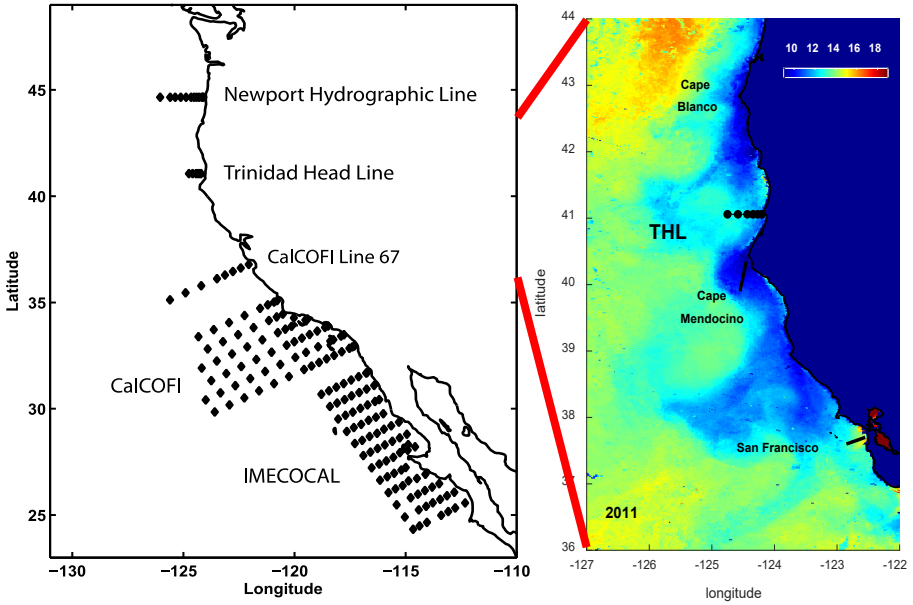
September 2014

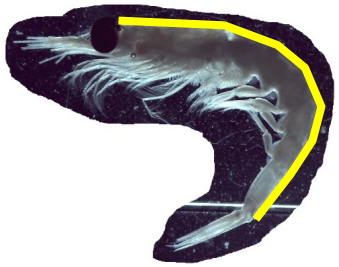






Trinidad Head Line (THL)





"Monthly" since late 2007:

125+ cruises, ~11 years

5 stations: 3 on shelf (afternoon)

2 offshore (night)

CTD: T, S, DO, pH, water samples

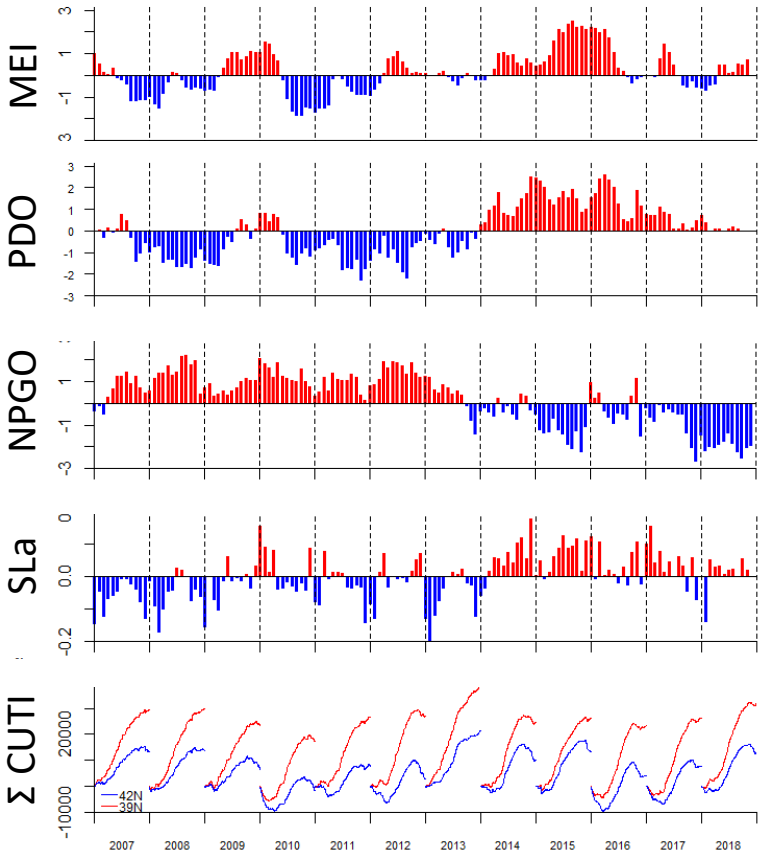
Zooplankton sampling (upper 100 m)

Ring net (202 µm)

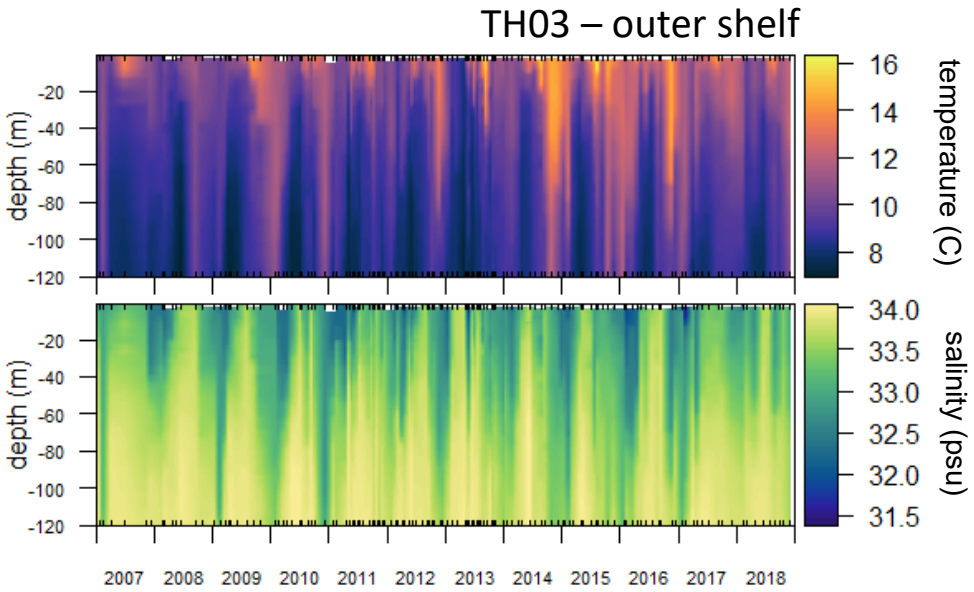
Bongo net (**505** & 333 µm)

Euphausiids are identified to species and life history stage (morphology), and measured (rostral-dorsal length)

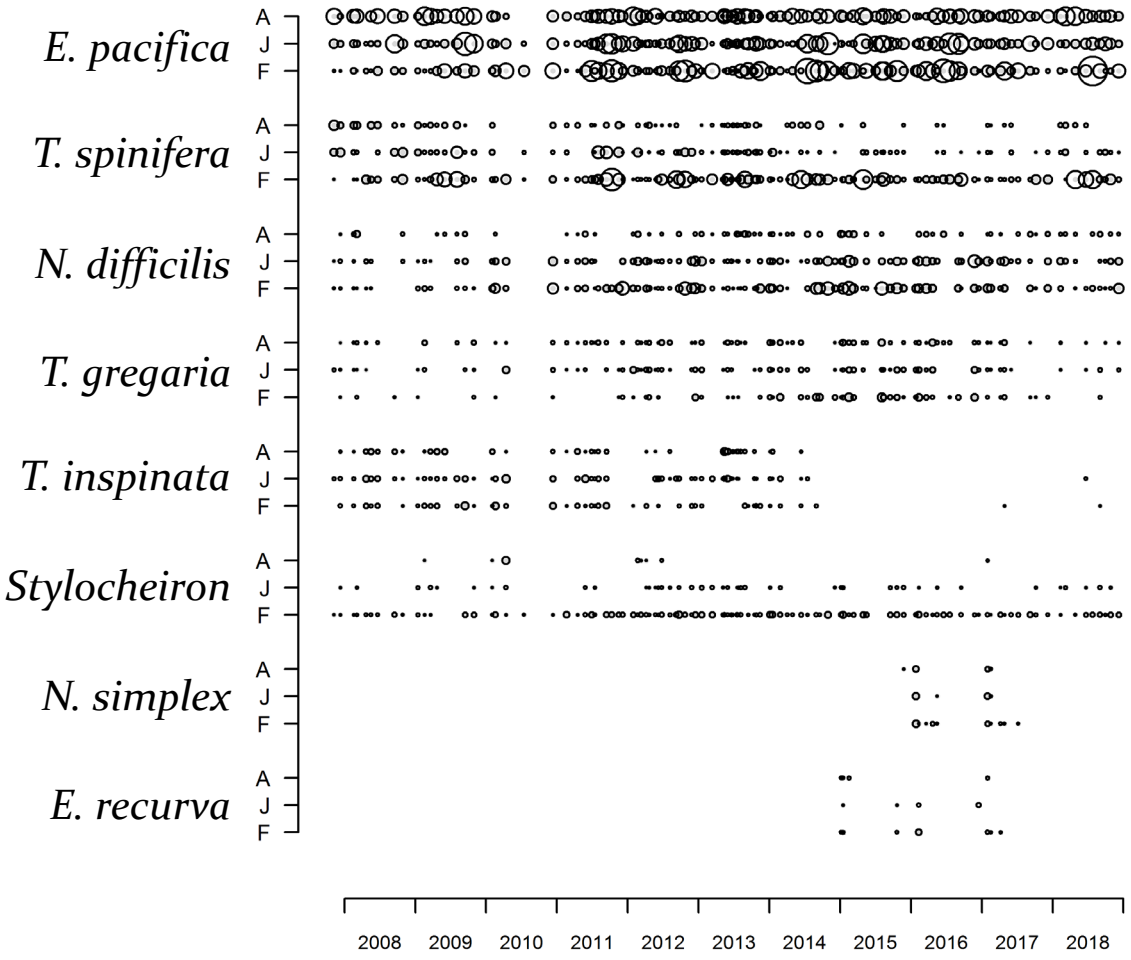
Basin- and local-scale climate variability



Hydrographic observations capture seasonal dynamics and local signature of climate events (2009-10 El Niño, 2014-16 MHW).



Euphausiid assemblage

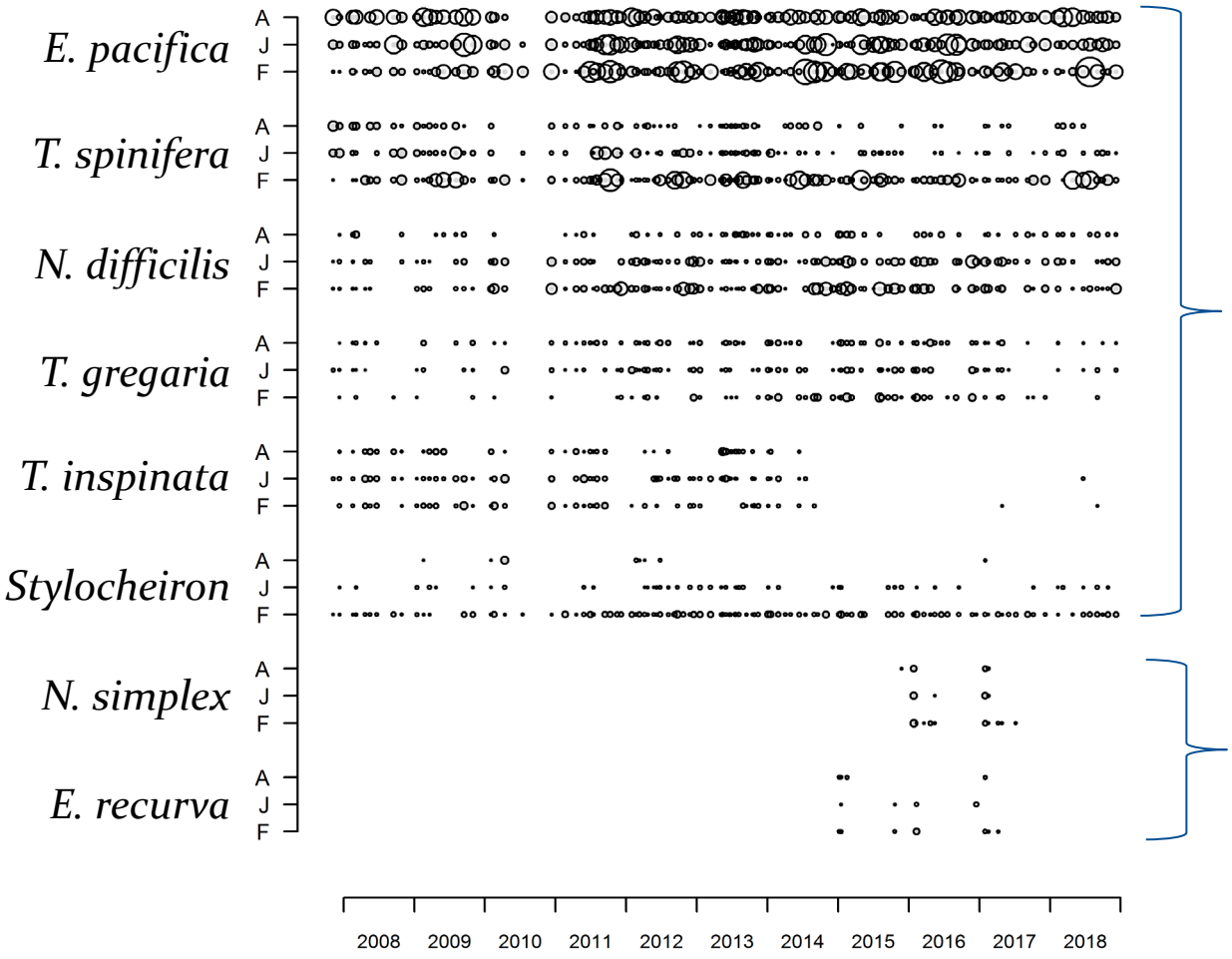


13 taxa recorded along THL
(Top 8 shown; 5 very rare)

80% *E. pacifica*
13% *T. spinifera*

Parsed by species
and developmental stage
A = adult
J = juvenile
F = furcilia (aggregate)

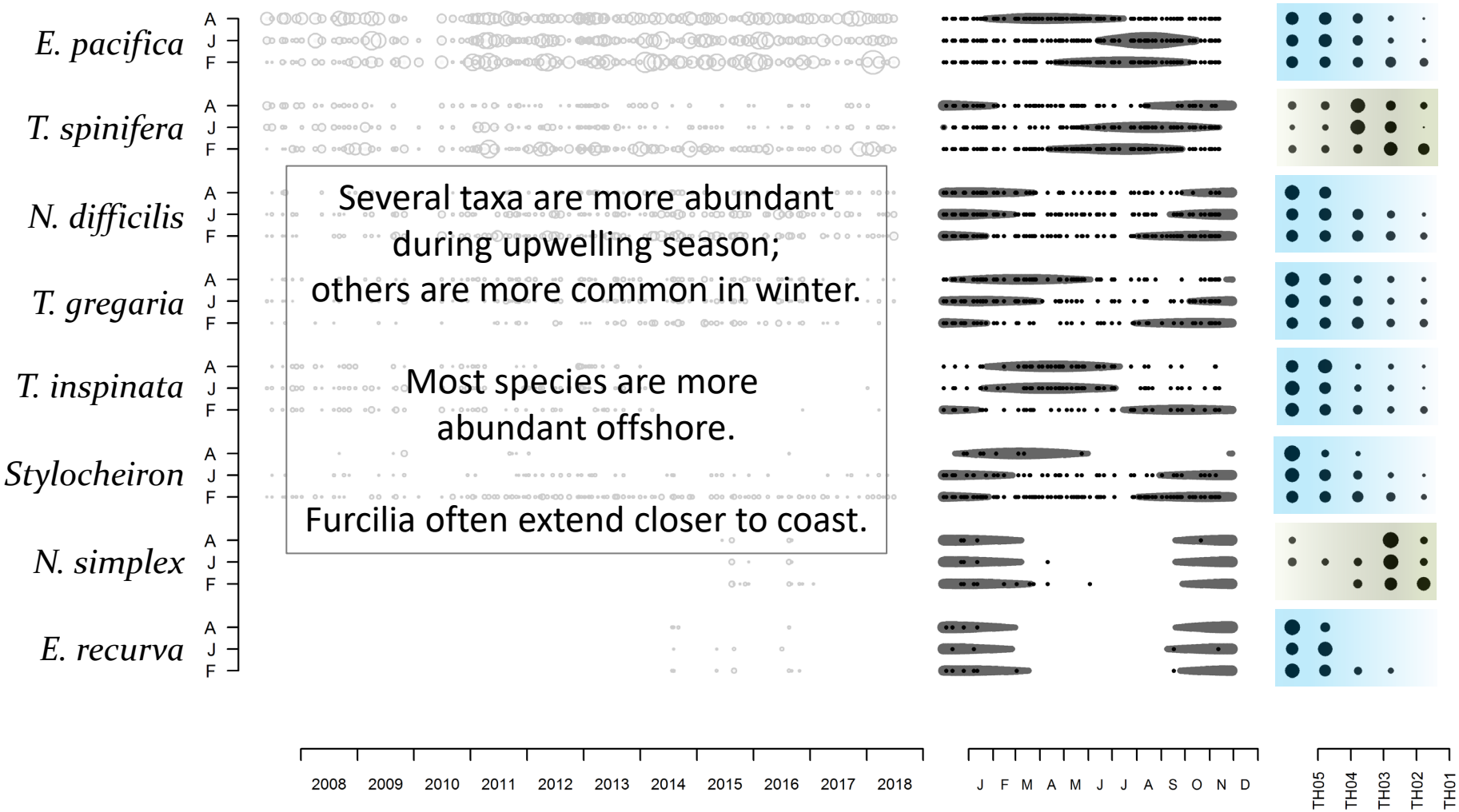
Euphausiid assemblage



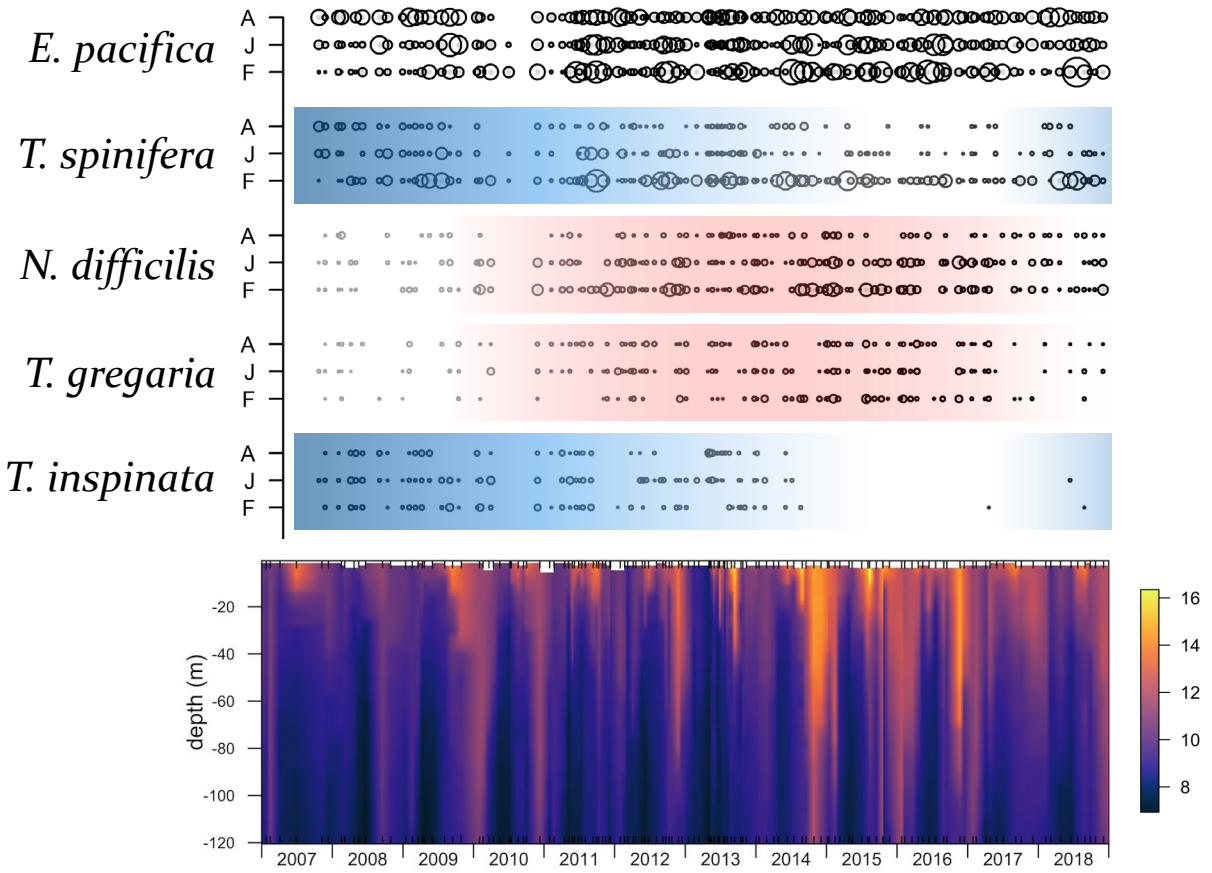
Core assemblage: species-life history classes(SLHC) that occur in >8% of samples and >33% of cruises.

Too rare to include in community analysis.

Euphausiid assemblage: seasons and space



Euphausiid assemblage: Interannual variability

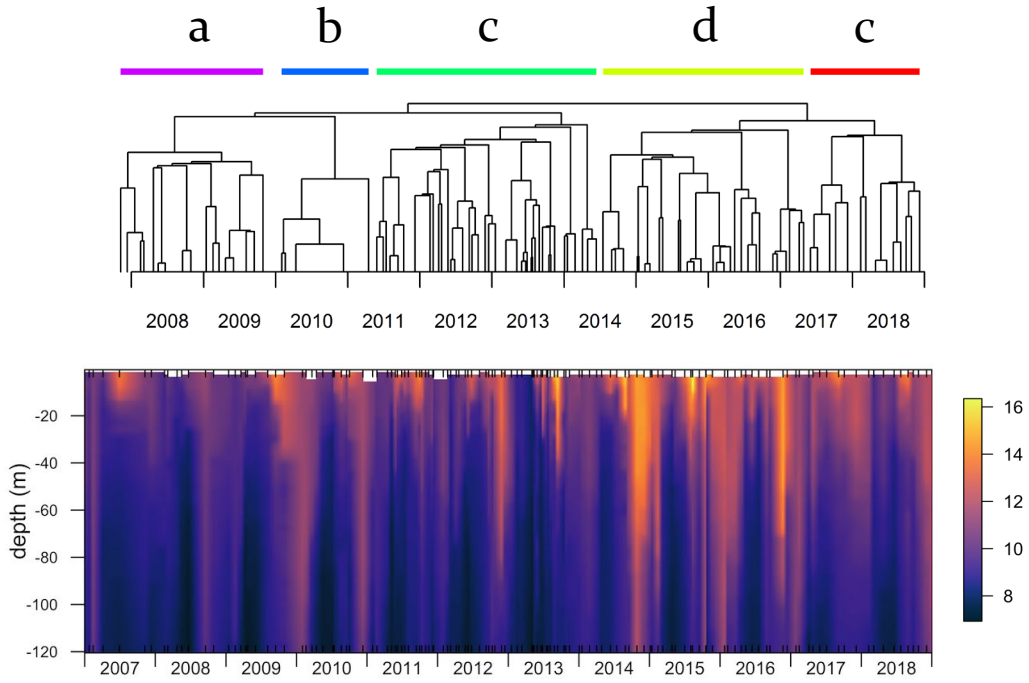


Following 2009-10 El Niño
Cool water taxa decline
Warm water taxa increase

Shifts peak during 2014-16 MHW, then appear to reverse.

Euphausiid assemblage: Interannual variability

Constrained Cluster Analysis (R pkg *rioja*) on aggregated cruise assemblages
clustering algorithm preserves order of cruises



Inspection suggests 5 major stanzas.

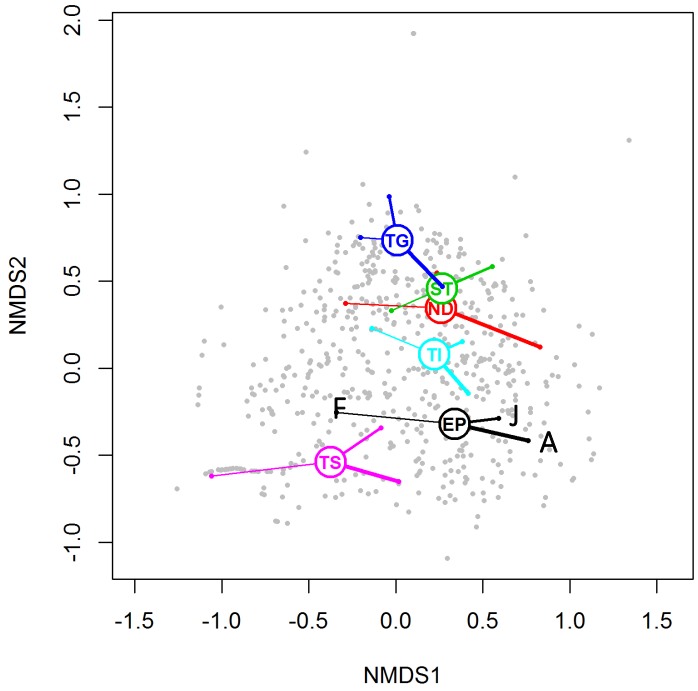
Transitions correspond to onset and dissipation of warm events.

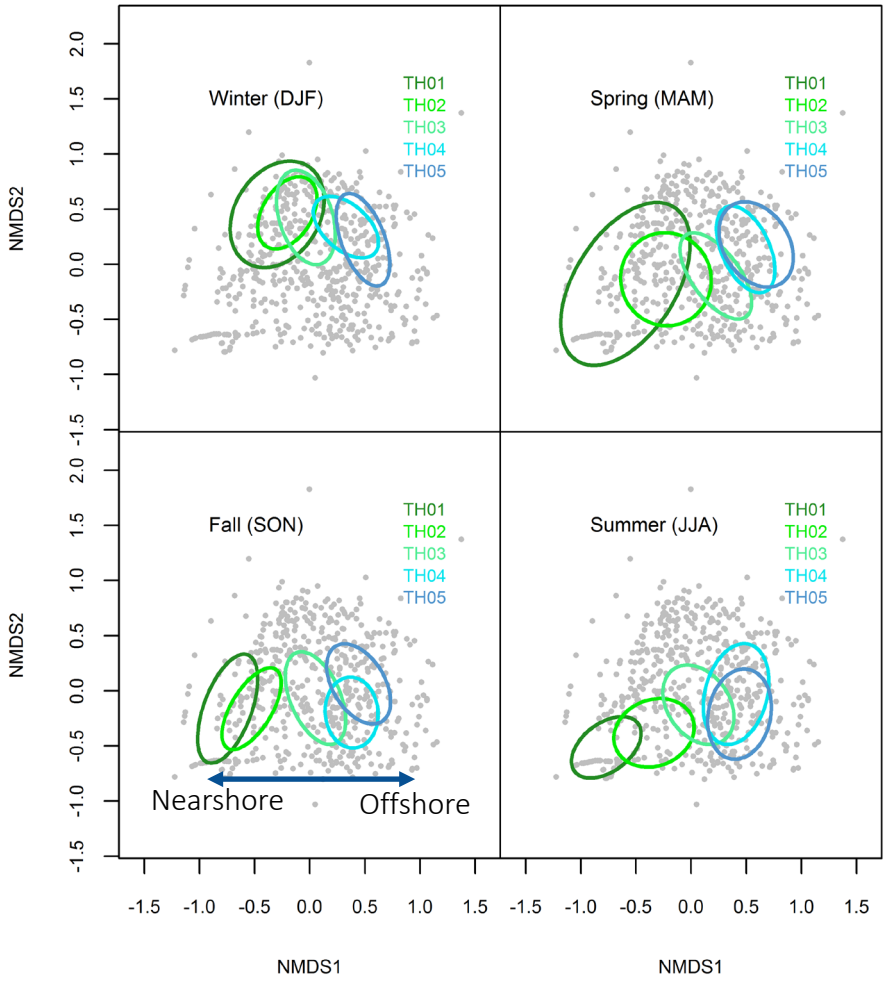
All stanzas, except those just before and after 2014-16 MHW, differ significantly (PERMANOVA $p < 0.01$).

Euphausiid assemblage: nMDS

nMDS on sample (station) data resolves

1. taxonomic and ontogenetic patterns
2. spatial-temporal interaction

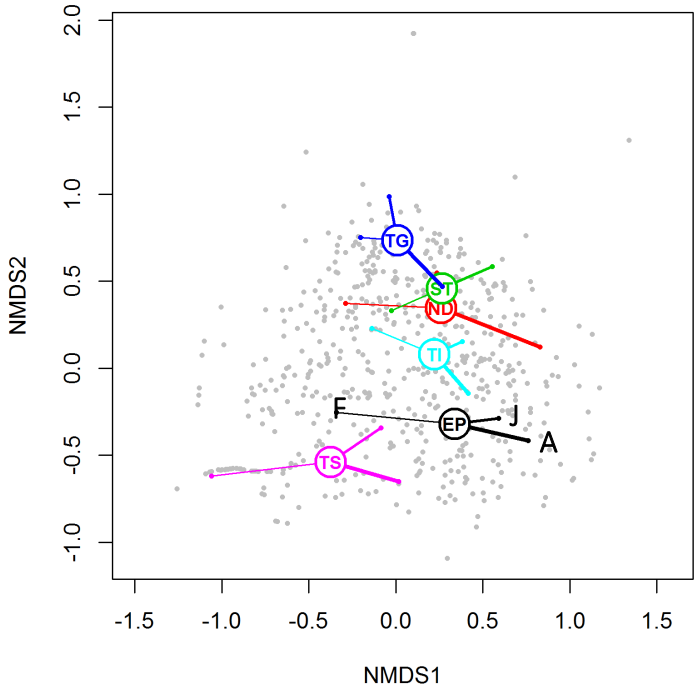


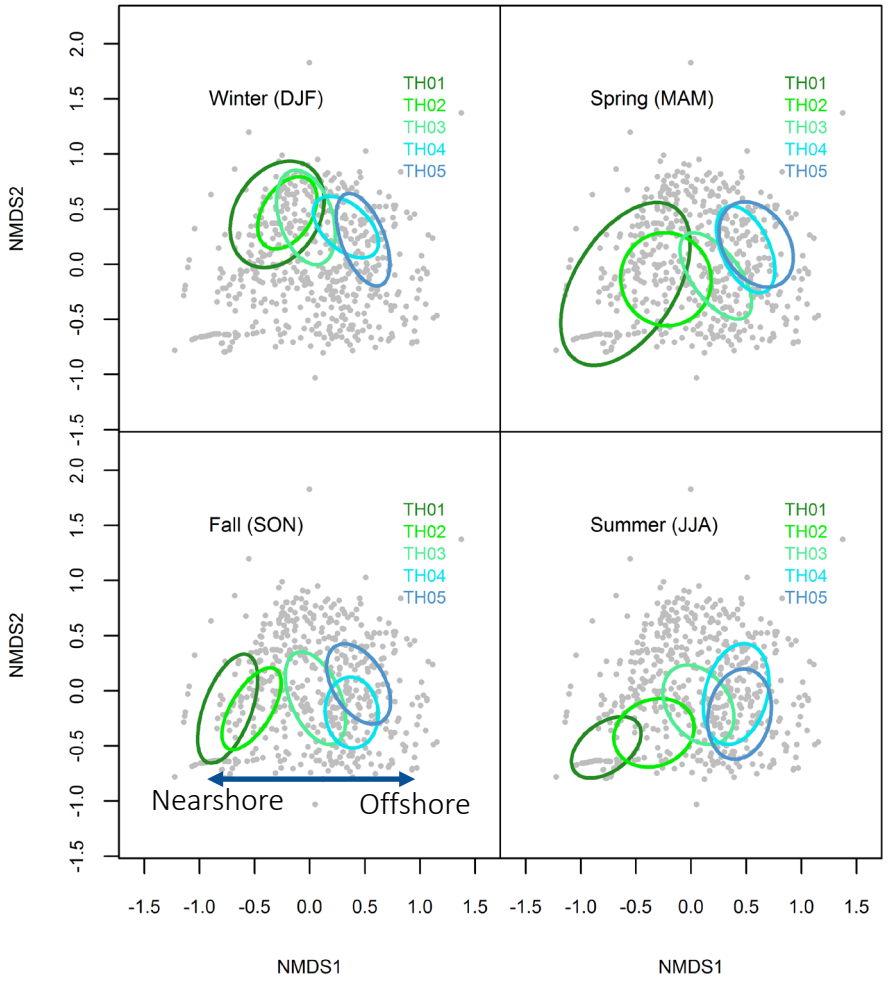


Euphausiid assemblage: nMDS

Convergent-divergent pattern:

1. Seasonal upwelling & downwelling
2. Climate-driven spatial shifts
    a. Contraction of cool-shelf taxa
    b. Expansion of warm-offshore taxa





Climate response strongest over shelf

Station

Nearshore

TH01

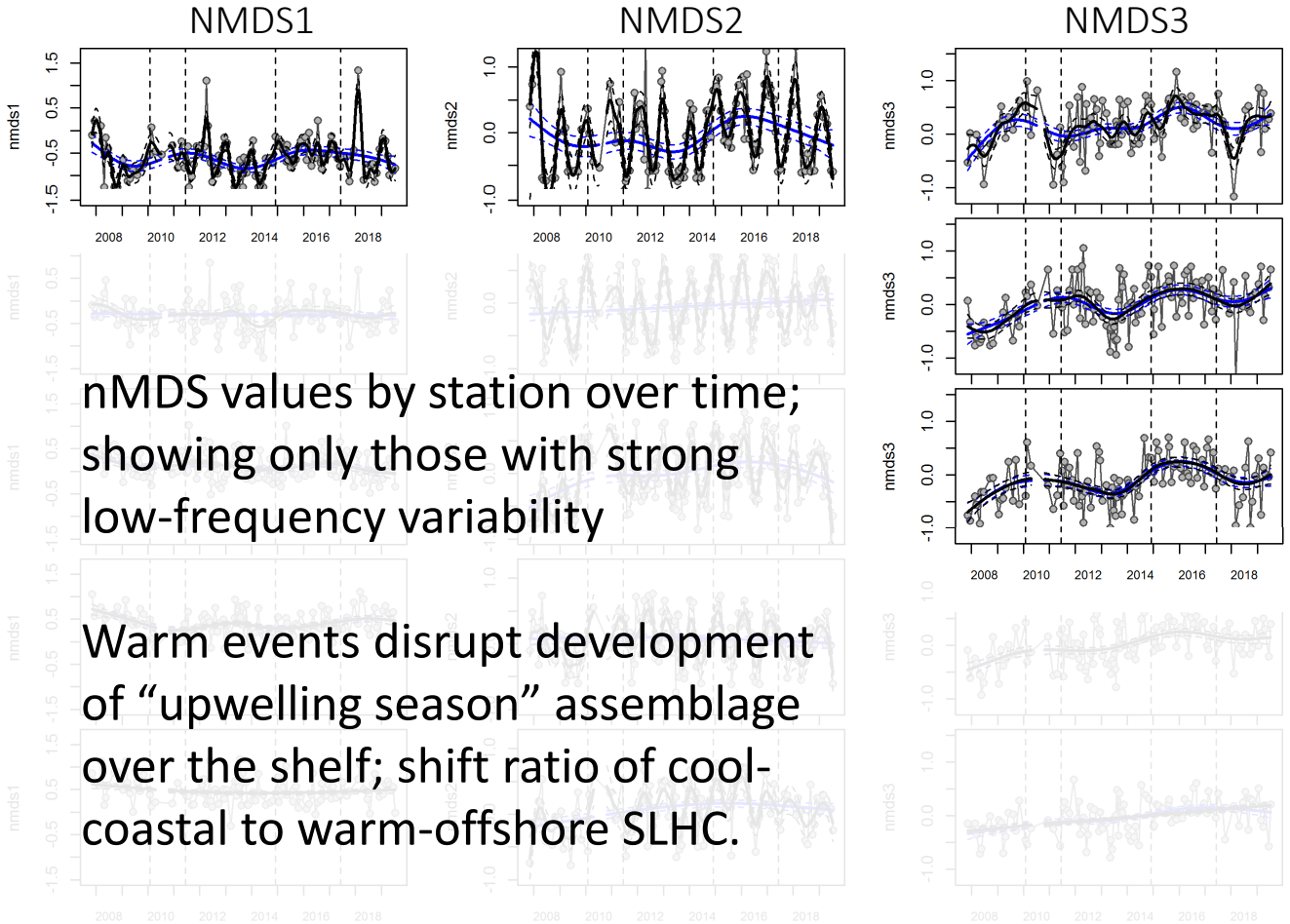
TH02

TH03

TH04

TH05

Offshore

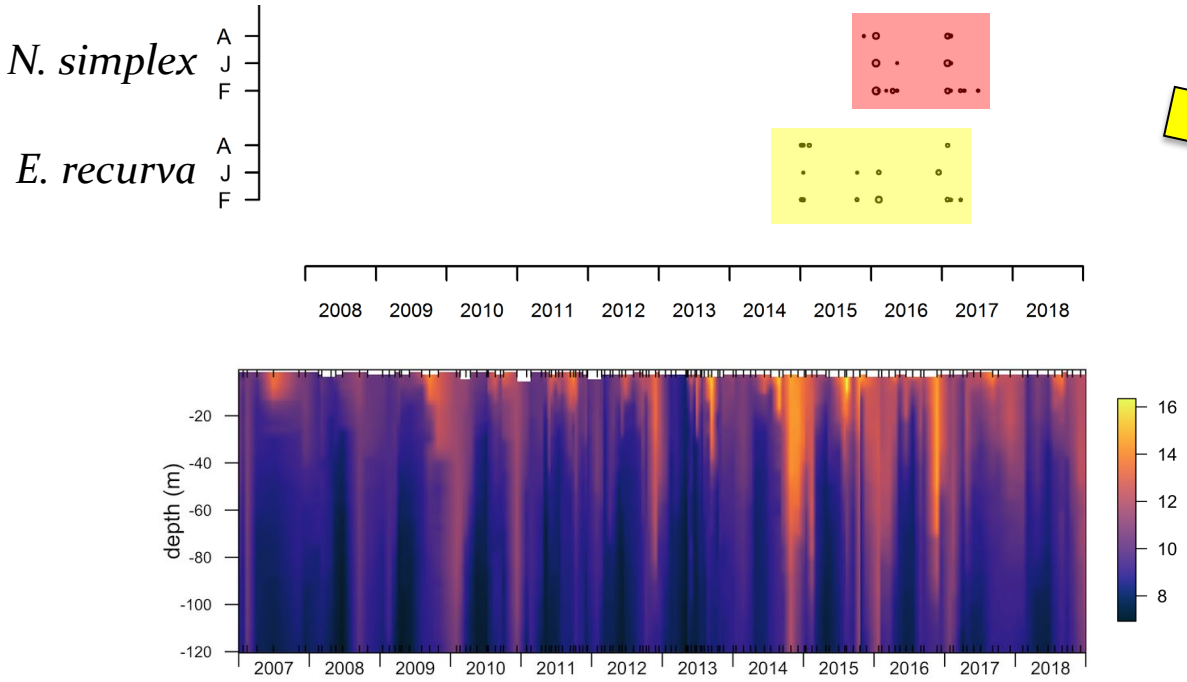


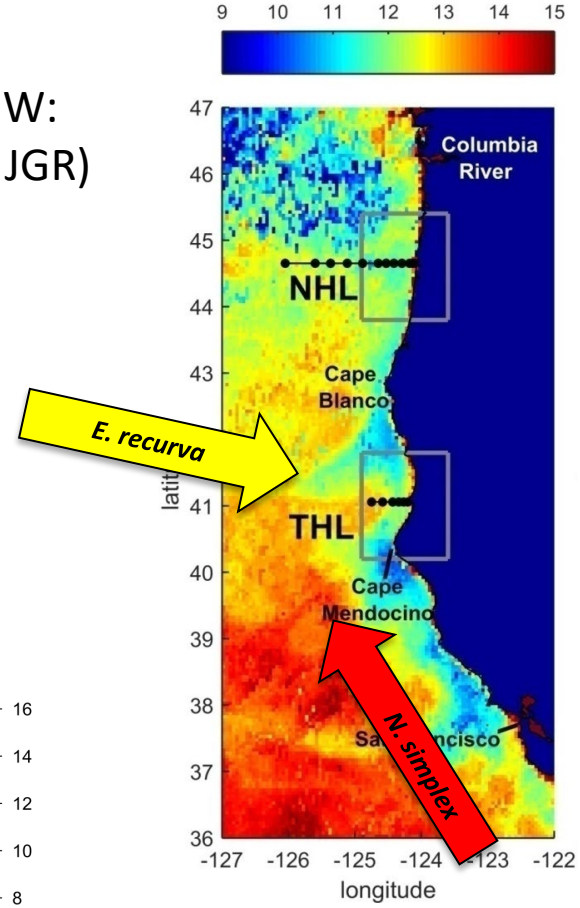
nMDS values by station over time; showing only those with strong low-frequency variability

Warm events disrupt development of “upwelling season” assemblage over the shelf; shift ratio of cool-coastal to warm-offshore SLHC.

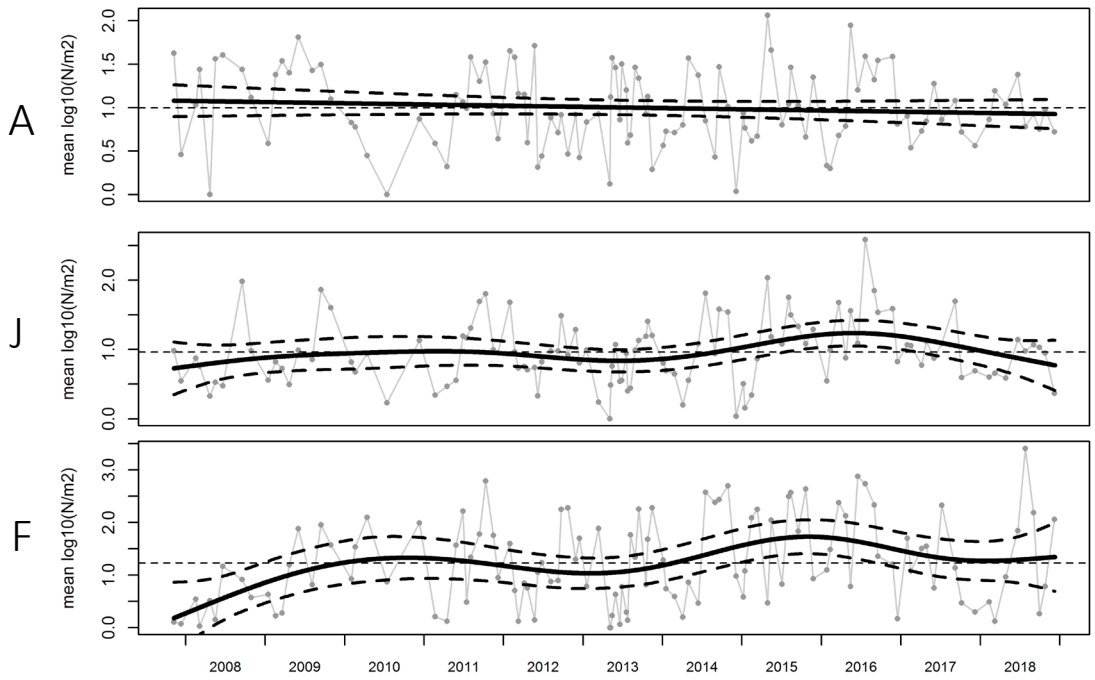
Rare species: Indicators of transport

Occurrence patterns corroborate two-phase 2014-16 MHW:
2014 Blob and 2015-16 El Niño (e.g., Chao et al. 2018 JGR)



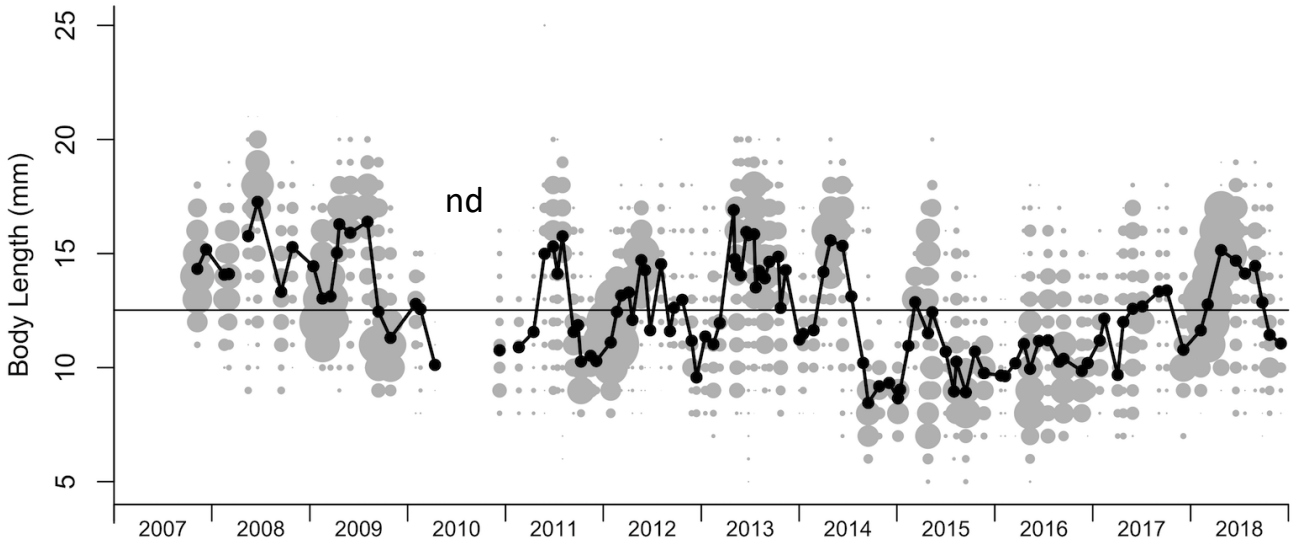


E. pacifica abundance



Little evidence of sustained trends in abundance of adult *E. pacifica*

Adult *E. pacifica* size structure



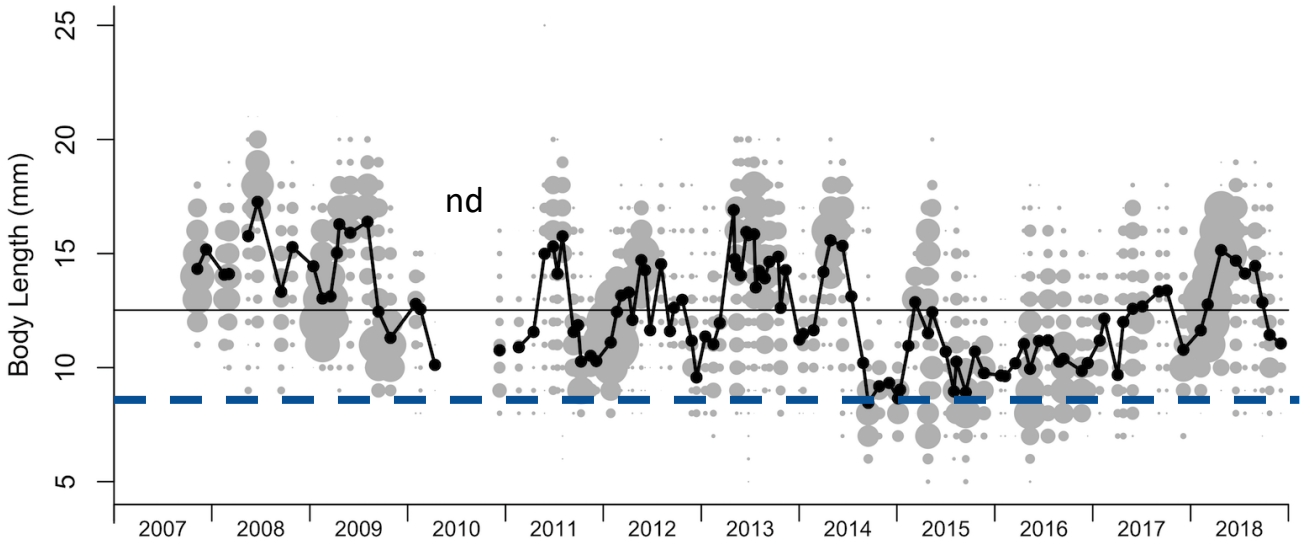
2013
(19.7 mm)

2014
(8.3 mm)

Stage designations based on morphological characteristics, not size-thresholds.

Dramatic effects on biomass.

Adult *E. pacifica* size structure



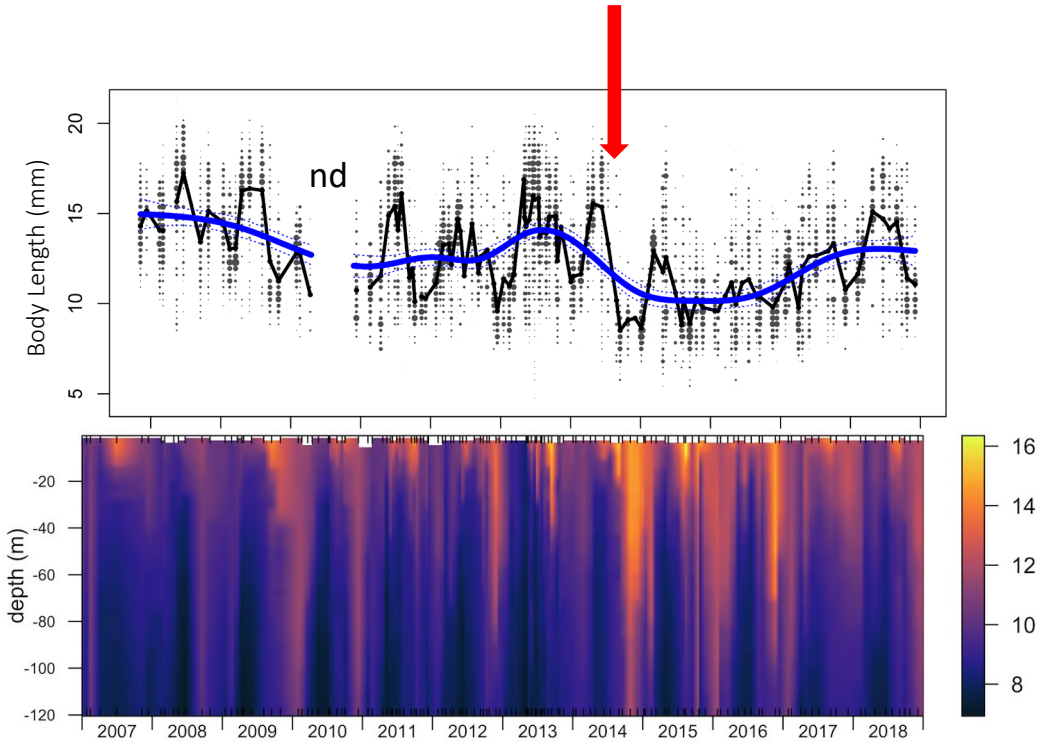
2013
(19.7 mm)

2014
(8.3 mm)

Potential for substantial mis-classification of adults based on length.

Adult *E. pacifica* size structure

- Low-frequency variability
  - Large adults during cool periods
  - Small adults during warm periods
- Sharp transition with arrival of “Blob” in 2014



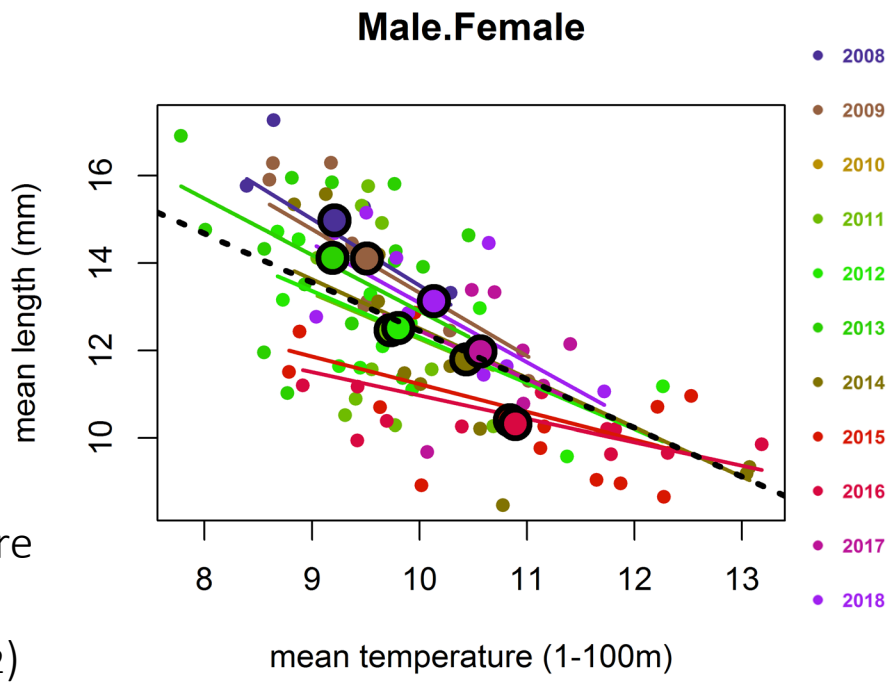
Length in relation to temperature

Adults are larger during cooler seasons within cool years than during warm years

- Underpins decline in size with temperature at interannual scales

NS relation with chlorophyll

Warm → population with smaller size structure
Cold → population with larger size structure
(Temperature Size Rule, Atkinson 1994; Forster et al., 2012)



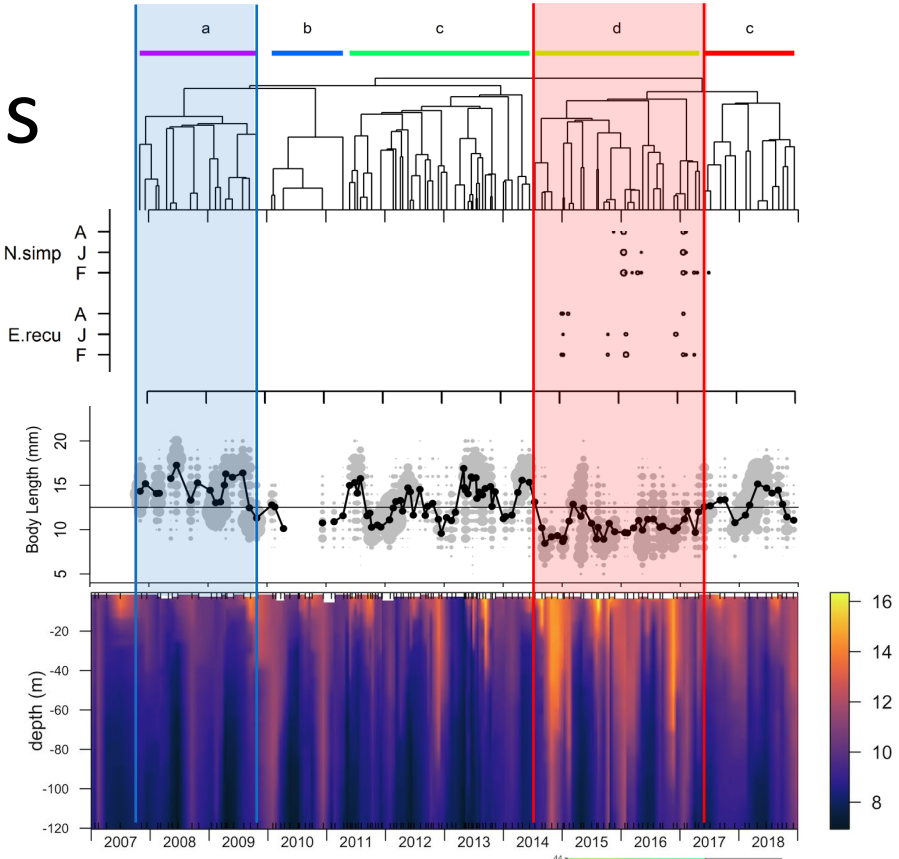
$$\bar{L}_{cruise} \sim f(\bar{T}_{cruise}) + r((m + bT)|Year)$$

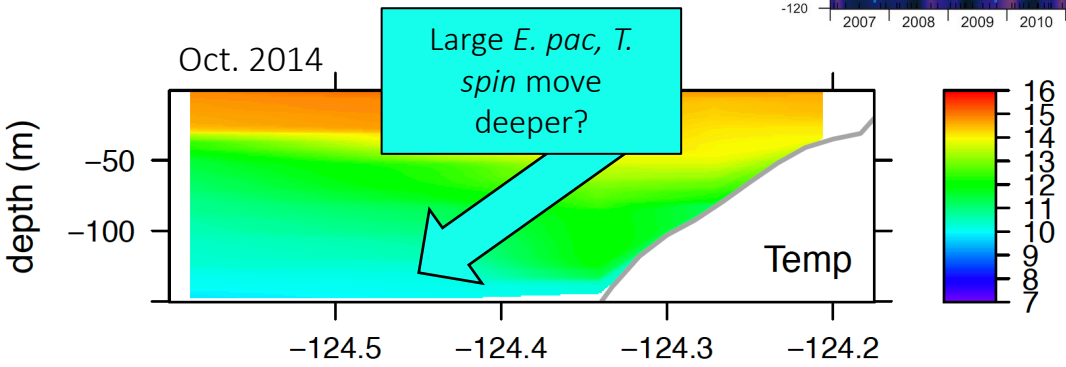
Summary & conjectures

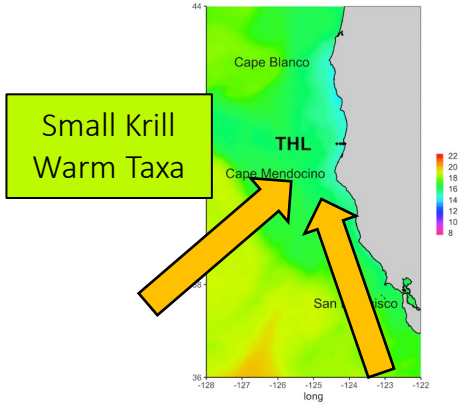
Concurrent shifts in assemblage and size structure driven by changes in characteristics and origin of shelf waters.

Major warming events disrupt or suppress typical seasonal and spatial patterns.

Important energetic and foraging implications for higher trophic levels.







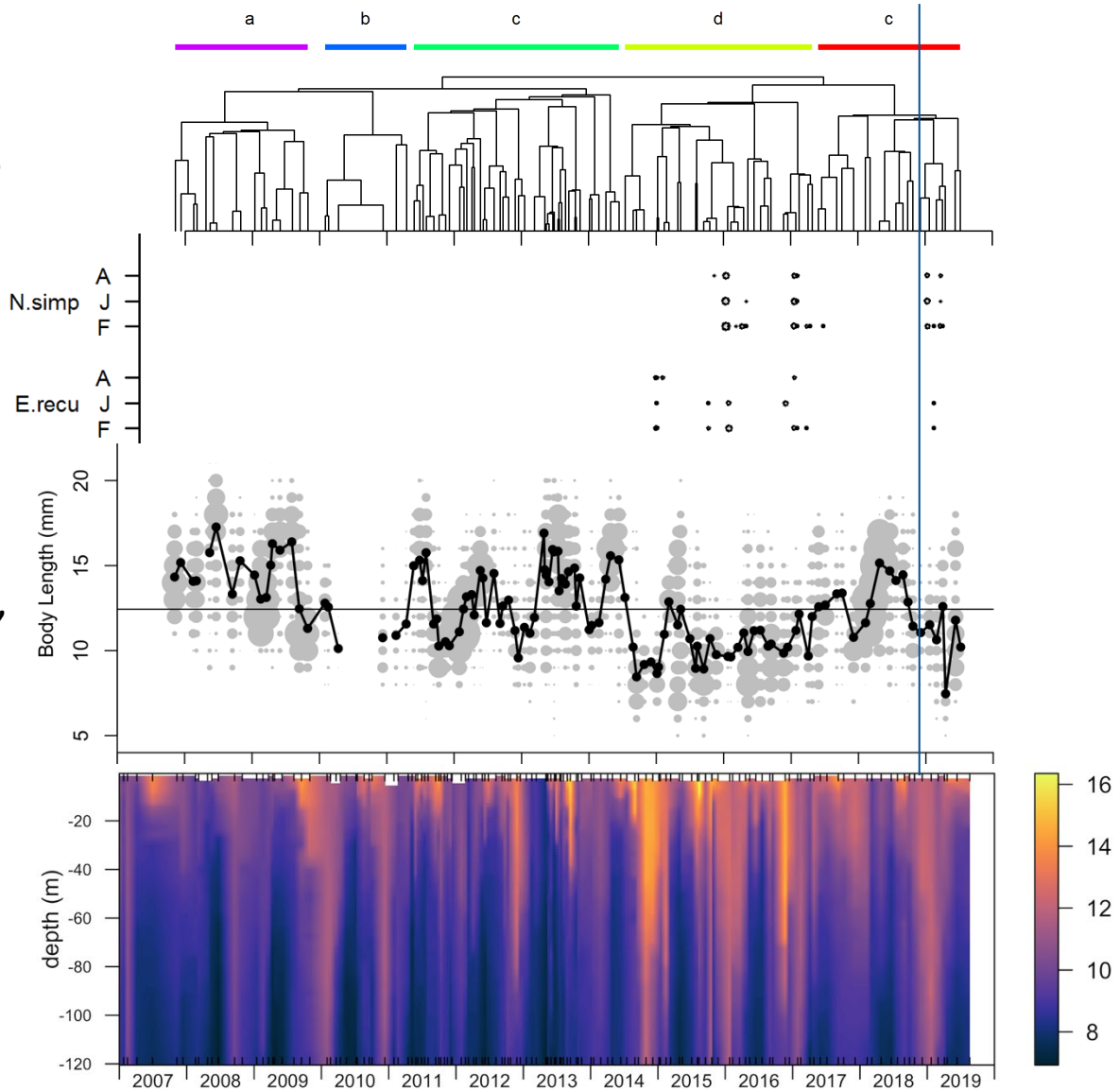
2019 update

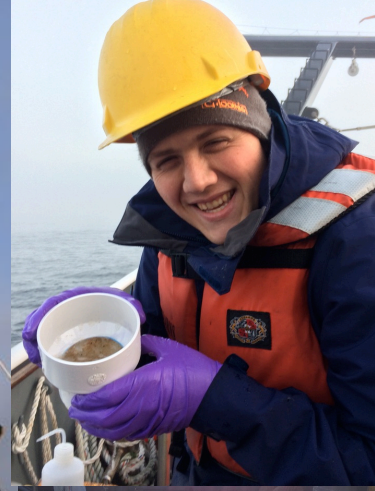
No dramatic shift in assemblage yet apparent

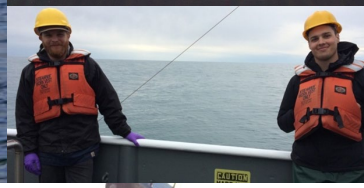
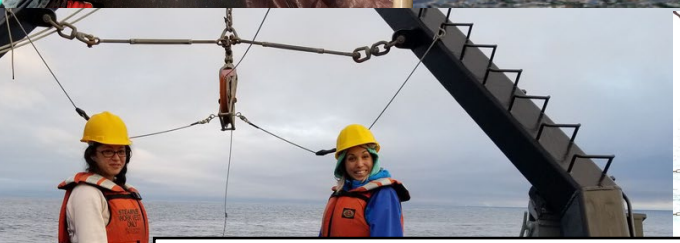
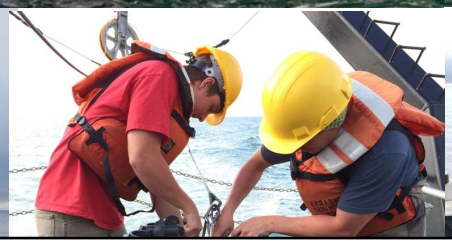
Warm-event species returned

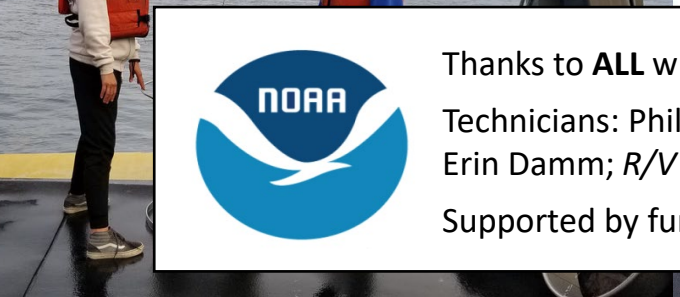
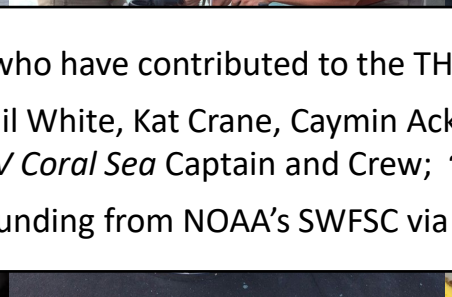
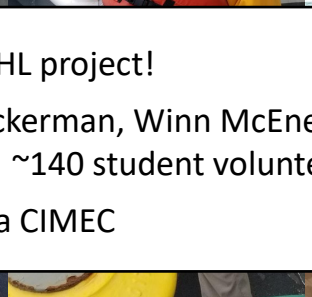
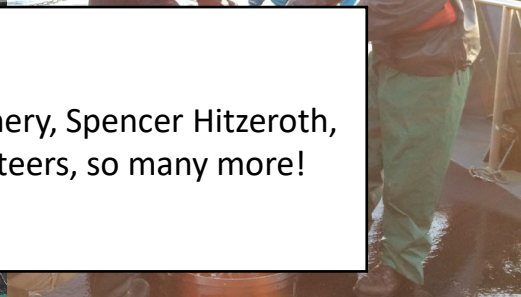
Following mild 2018-19 ENSO, growth pattern disrupted.

2019 dominated by small adults, though some larger size classes are present.



Thanks to **ALL** who have contributed to the THL project!

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