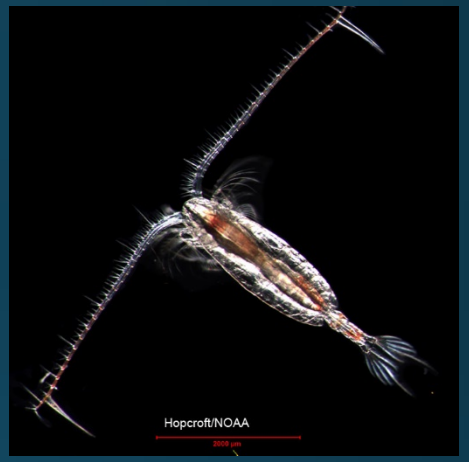
# Zooplankton abundance trends in the Shelikof Strait, western Gulf of Alaska 1990-2017

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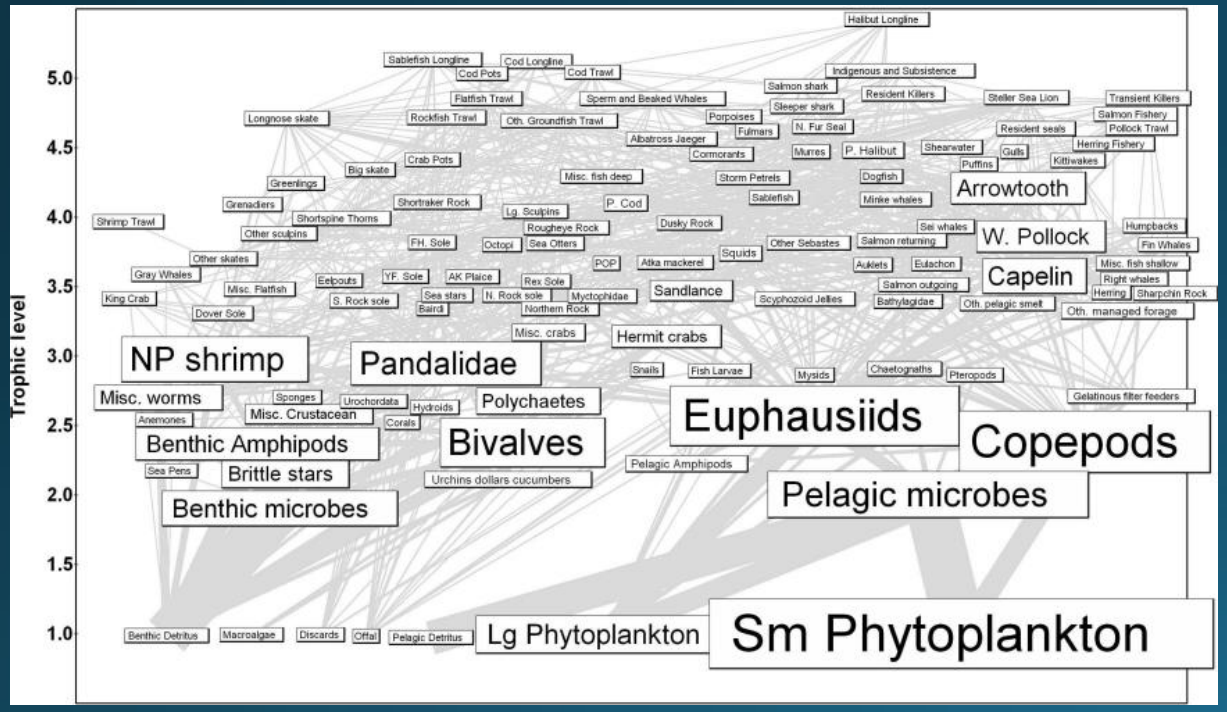
NOAA FISHERIES

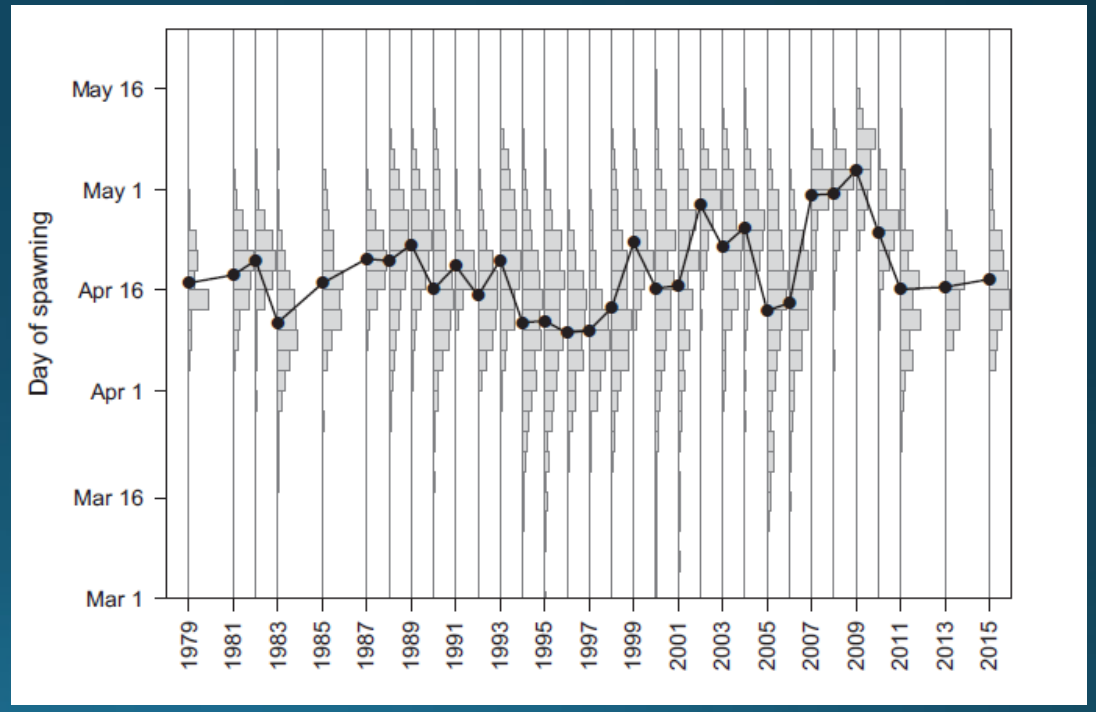
EcoFOCI
Ecosystems & Fisheries-Oceanography Coordinated Investigations

# Outline

- Zooplankton dynamics in the Gulf of Alaska – who cares?
- Lines of inquiry and approaches
- Patterns and trends
- Correlates
- A phenological change?
- Conclusions and implications

# Zooplankton dynamics in the Gulf of Alaska – who cares?

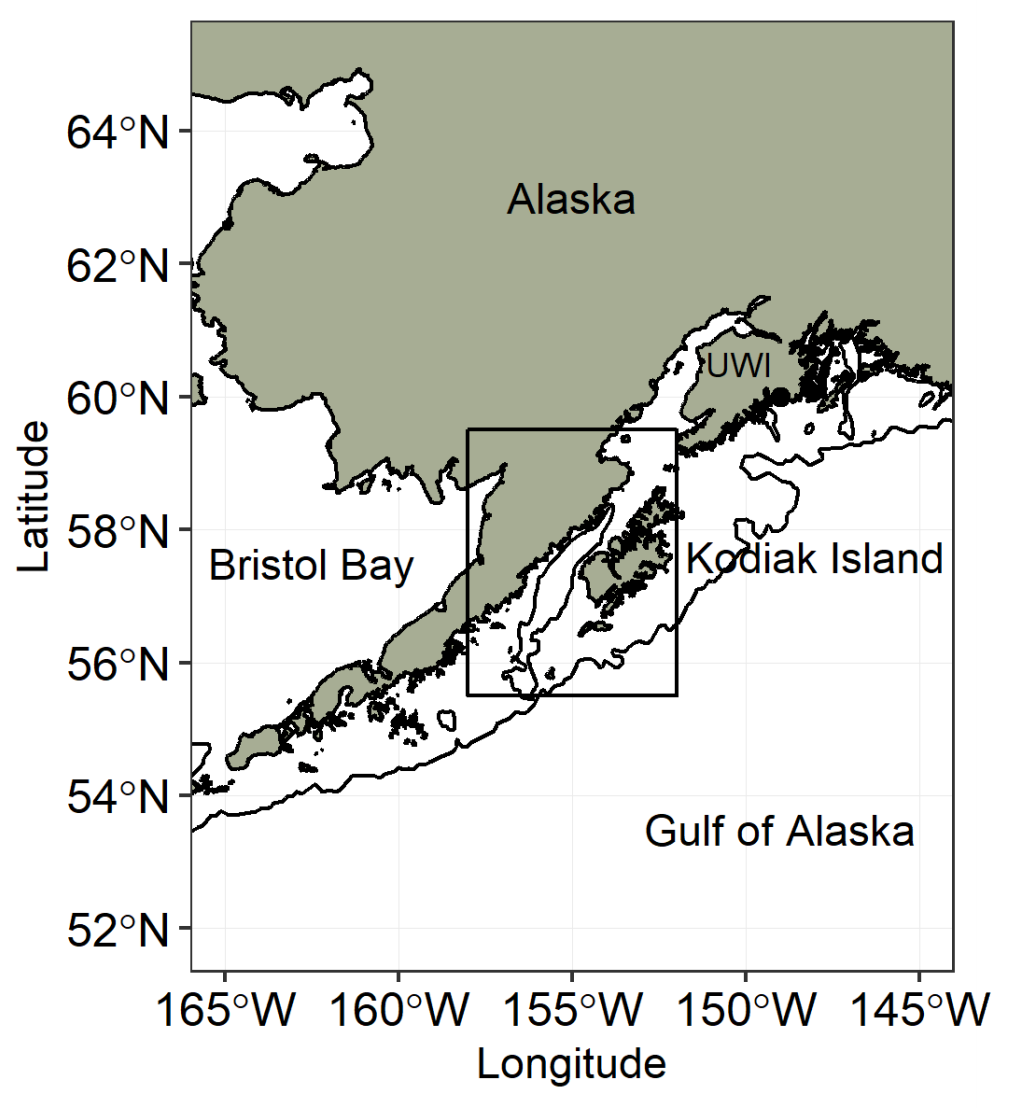


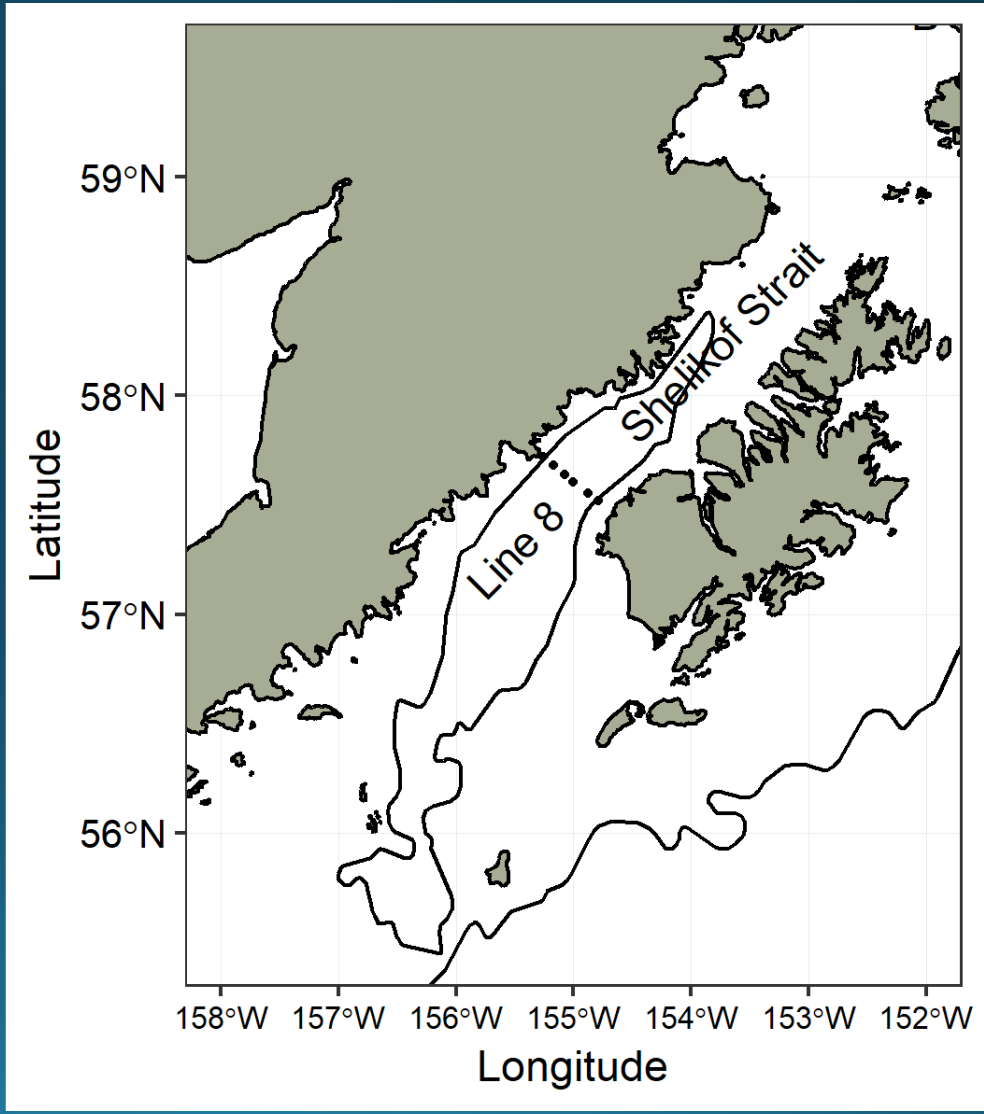




Gaichas et al. 2012

Rogers and Dougherty 2019

# Line 8 Shelikof Strait – spring (May/June)



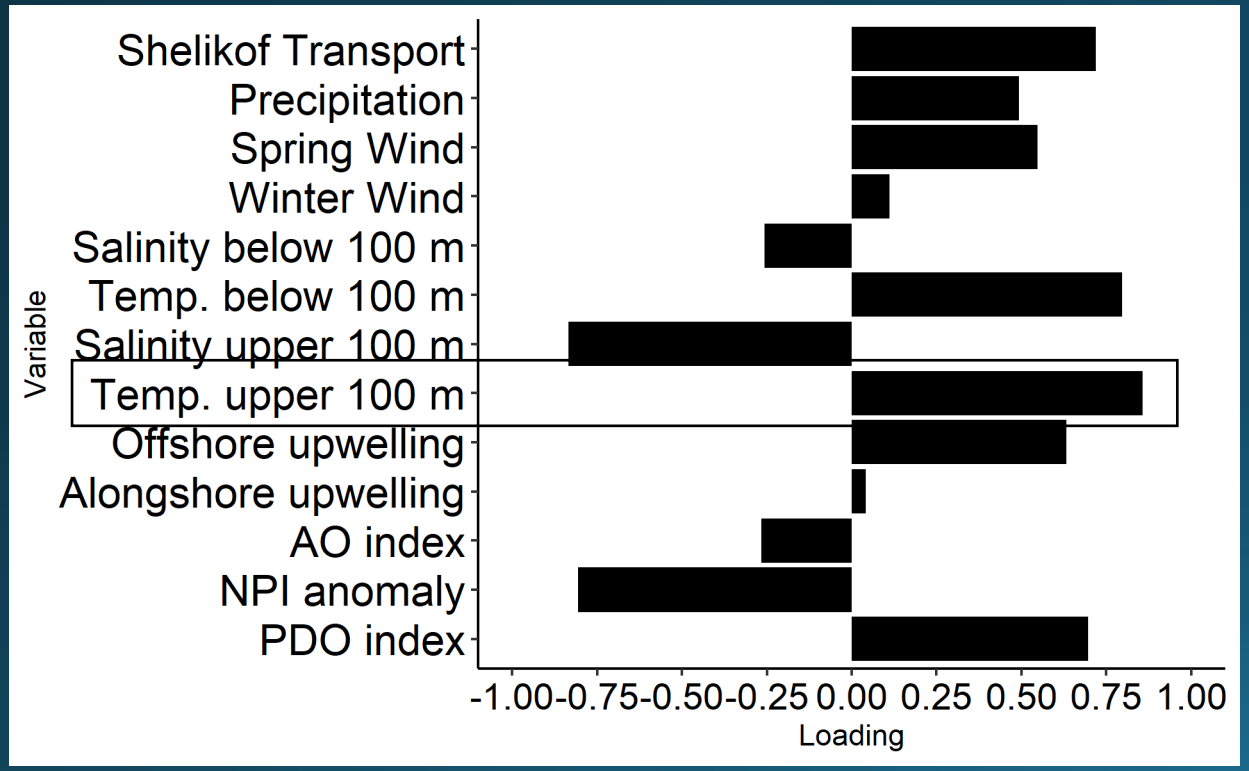



# Lines of inquiry and approaches

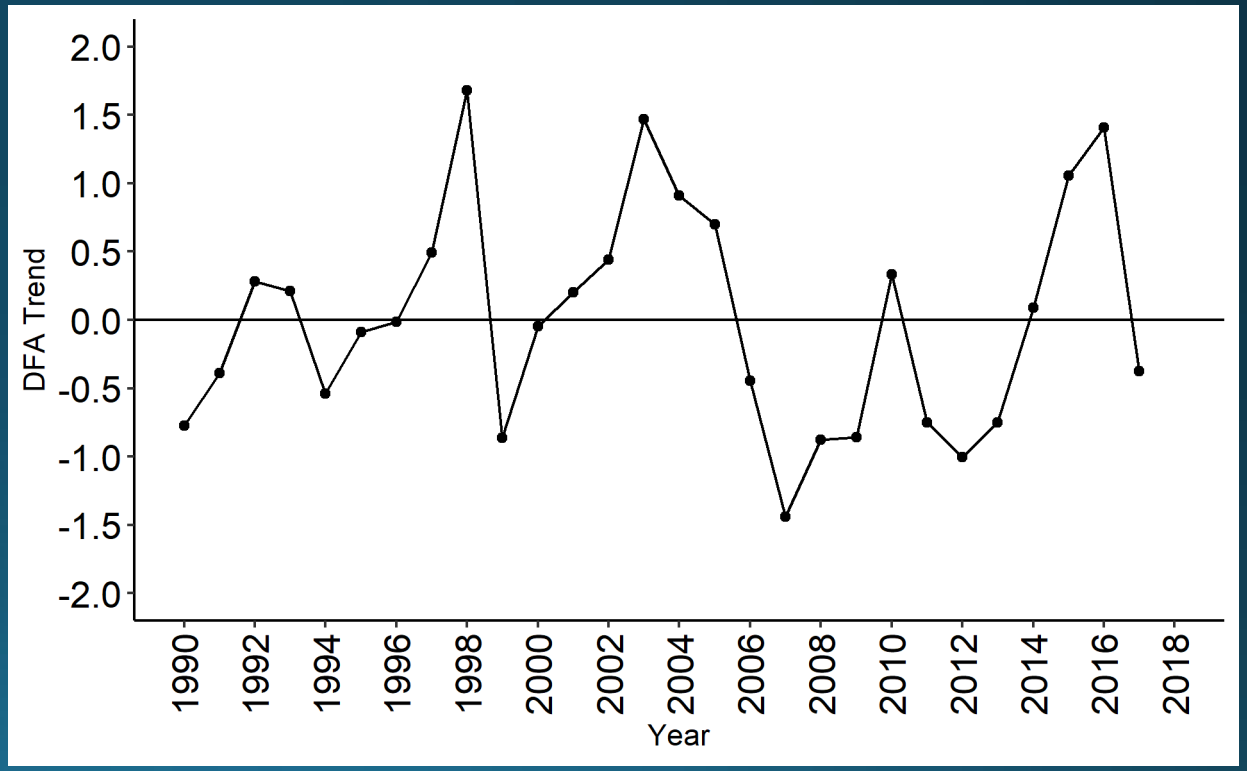
- Have there been trends and/or patterns in environmental conditions and zooplankton abundance over time in the Gulf of Alaska?
  - Use Dynamic Factor Analysis (DFA) to look at multivariate trends
- Are there any monotonic trends present in the environmental or zooplankton time-series?
  - Use trend analysis (Mann-Kendall)
- Do the patterns in environmental data correspond to trends in zooplankton data?
  - Model individual species and life stages with GAMs

# Environmental DFA

## Loadings

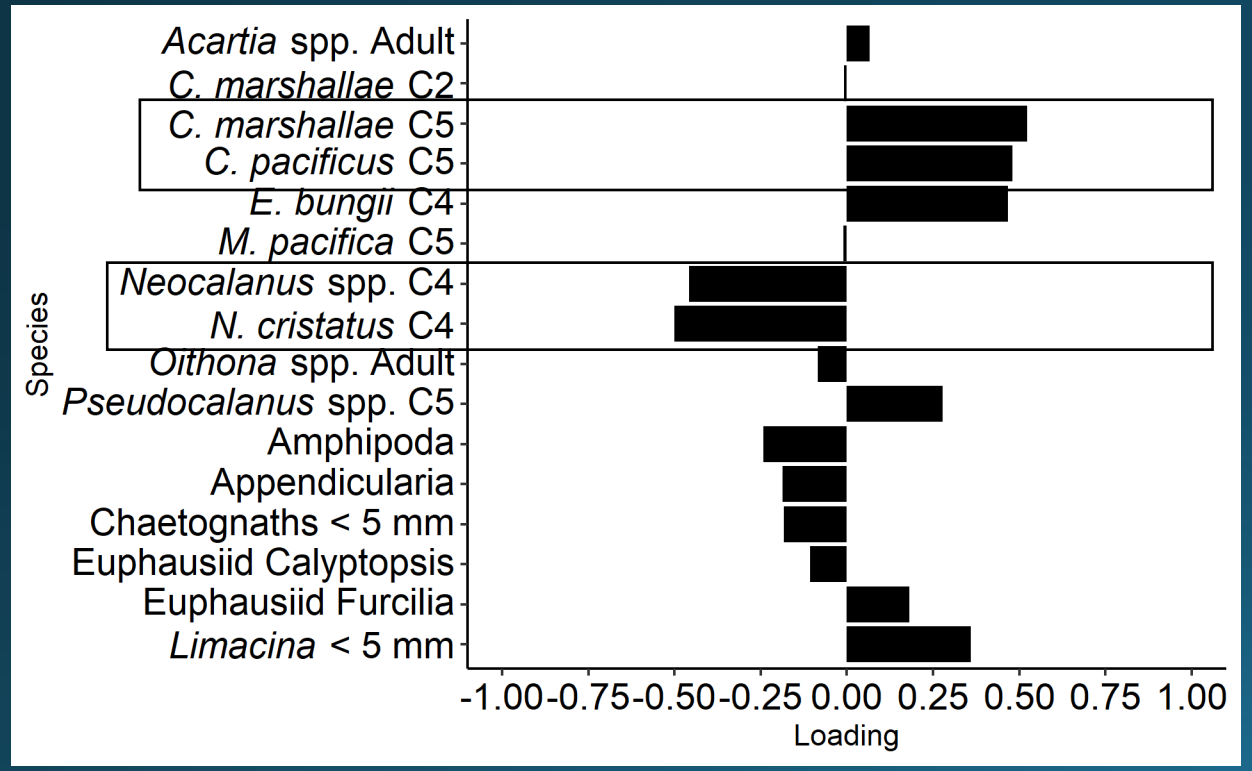



## Trend

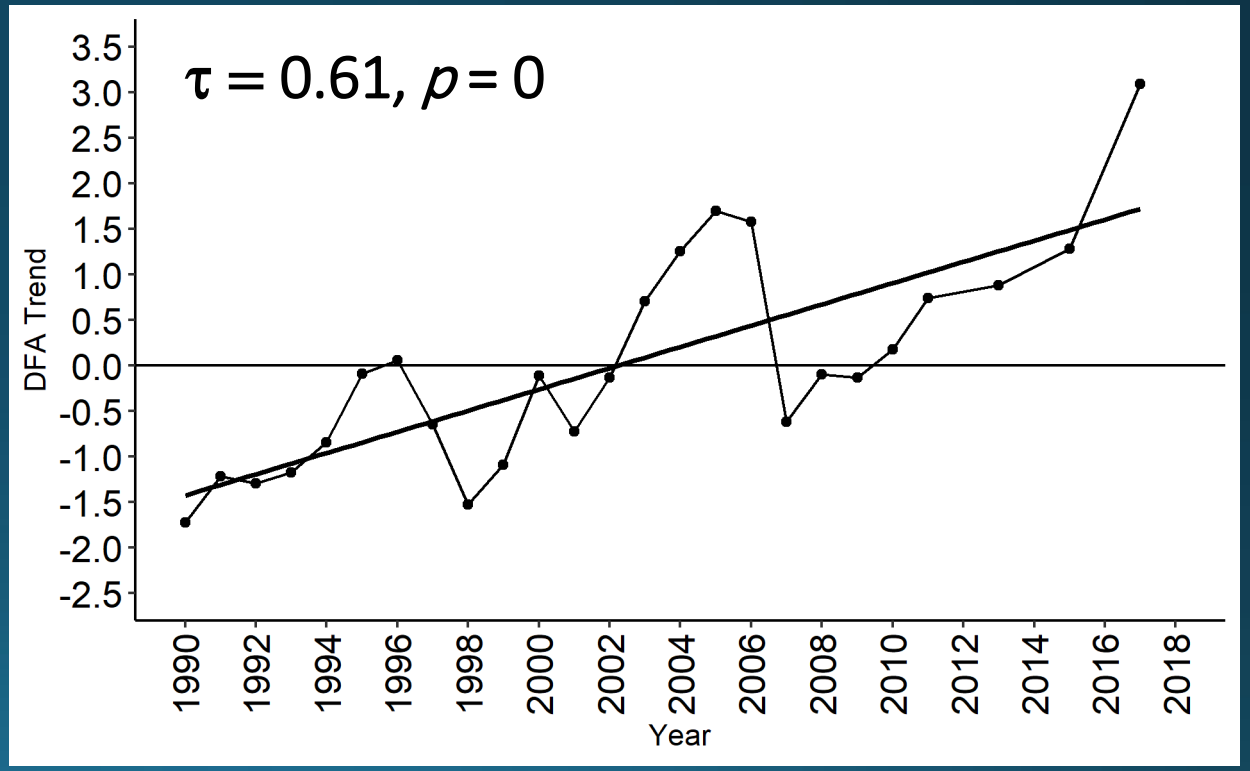


# Zooplankton DFA

## Loadings

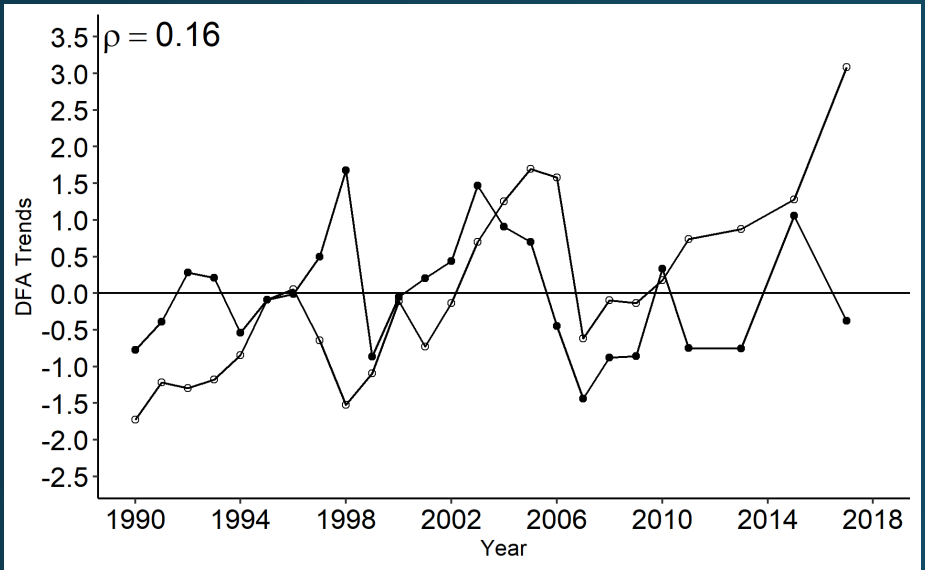



## Trend

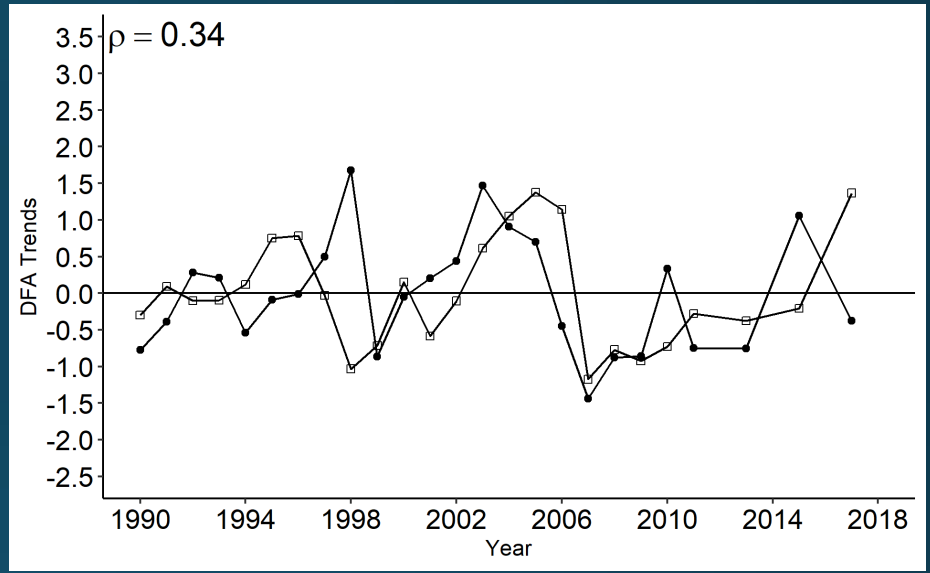


# DFA Trend Comparison

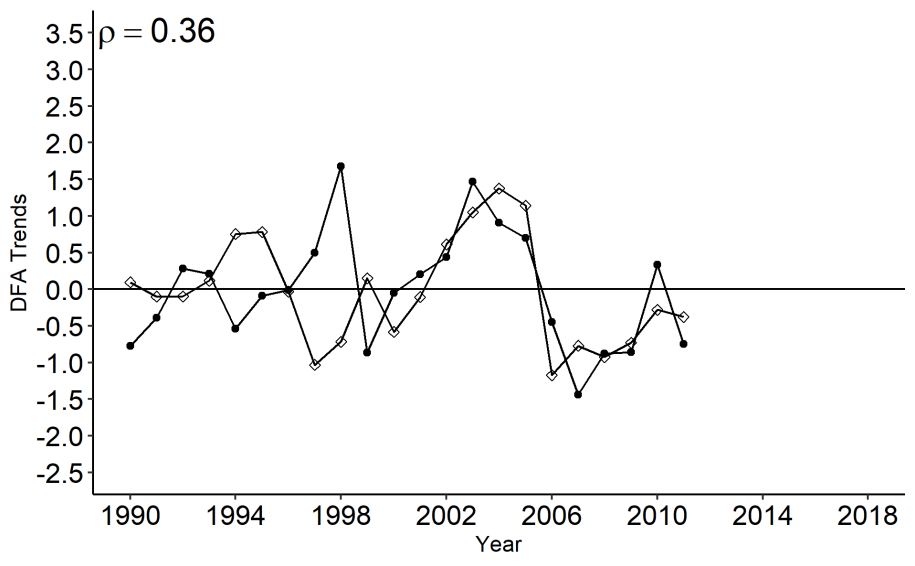
DFA Time-series




DFA Zoop. Residuals



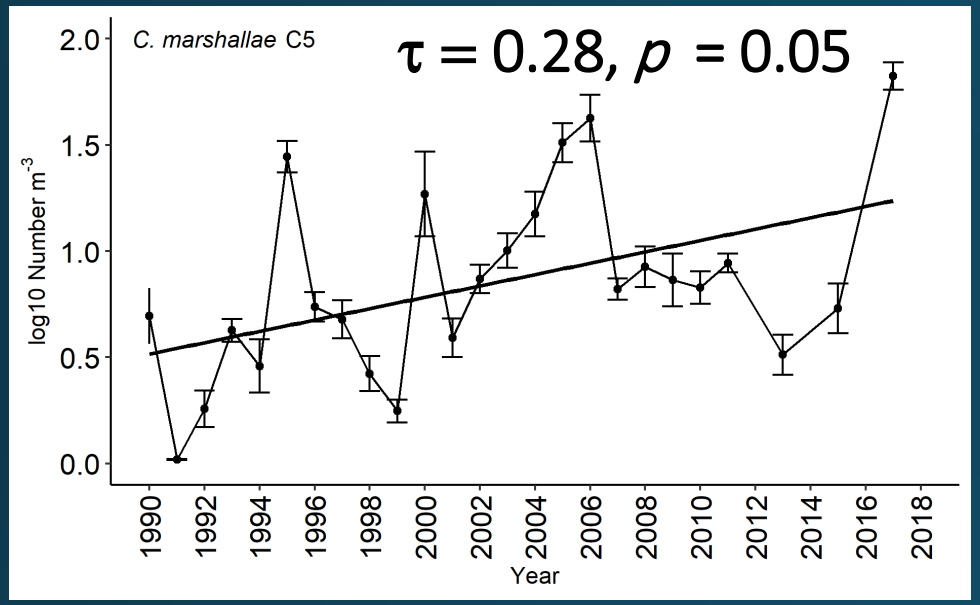

DFA Zoop. Residuals Lag-1



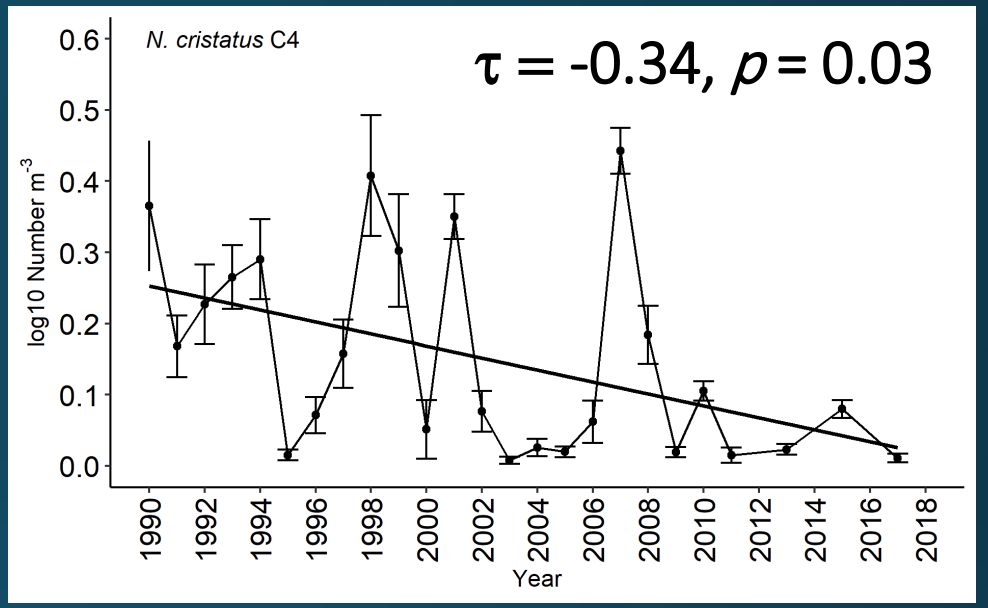

| Time Period | Residuals | Residuals Lag-1 |
|---|---|---|
| 1990 - 1999 | -0.07 (0.83) | -0.65 (0.04) |
| 2000 - 2017 | 0.59 (0.02) | 0.88 (0.0002) |

# Trends

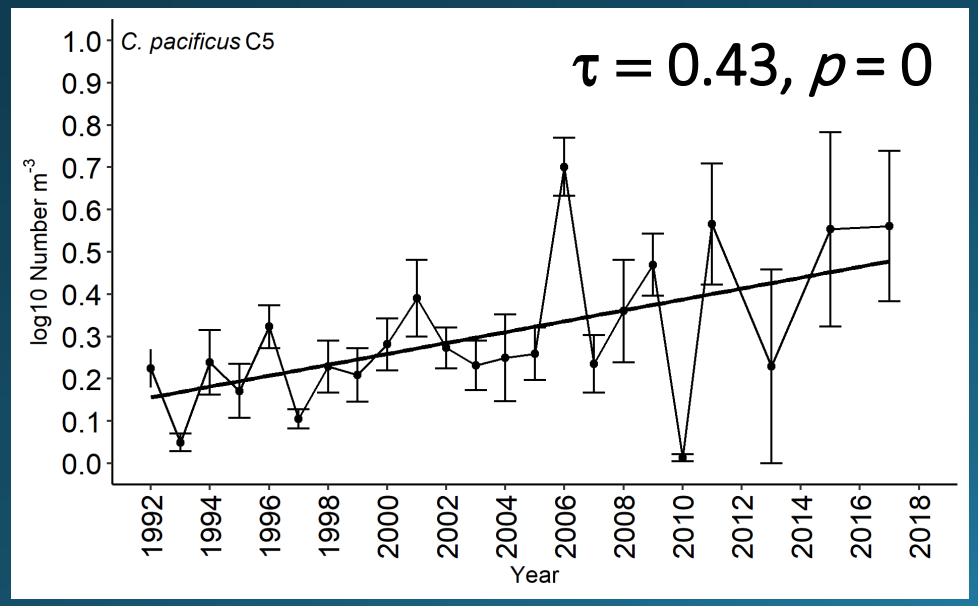
*C. marshallae* C5



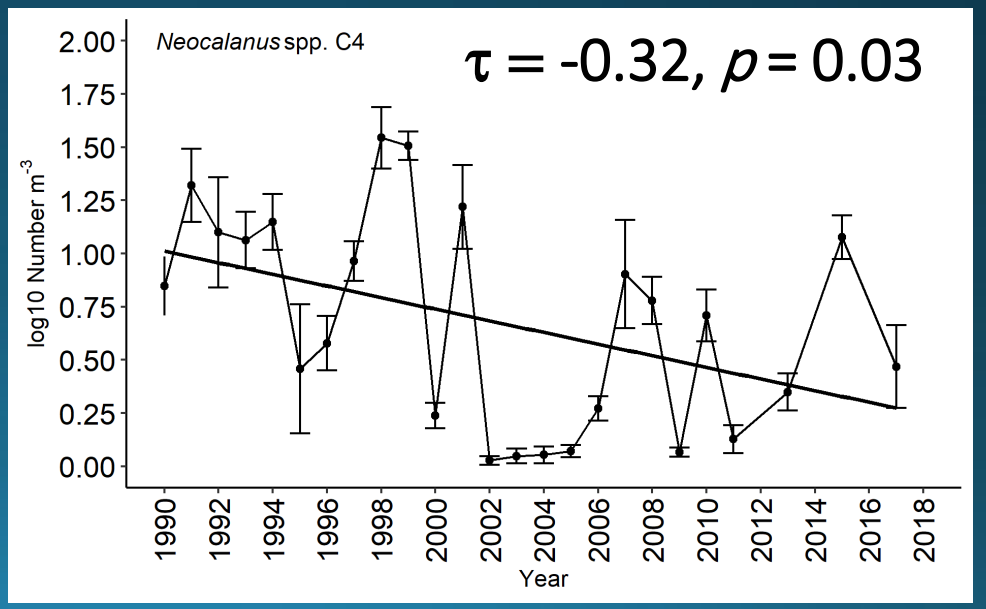

*N. cristatus* C4




*C. pacificus* C5

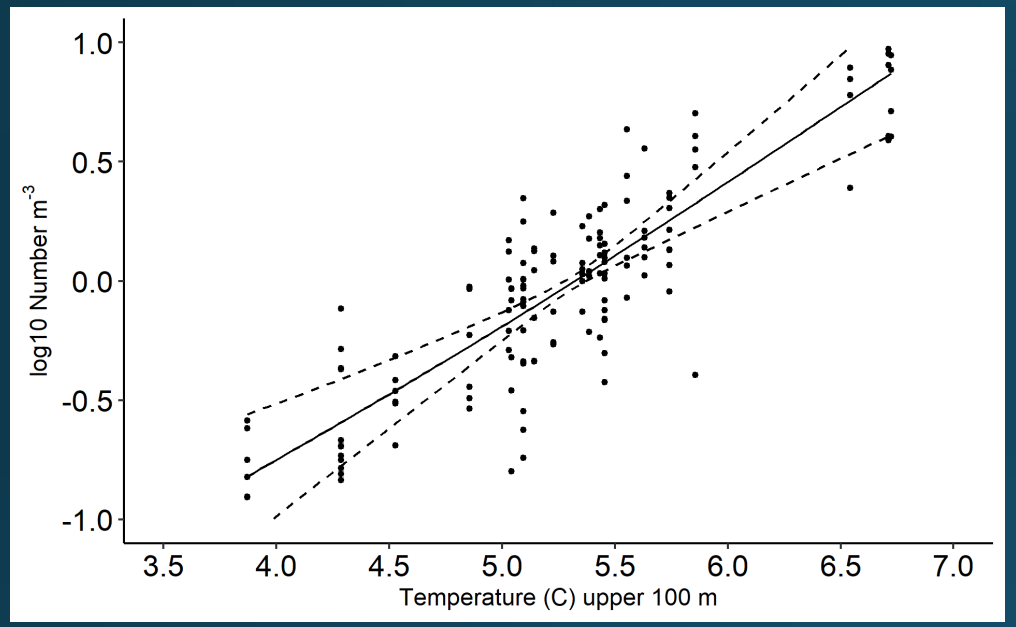



*Neocalanus* spp. C4

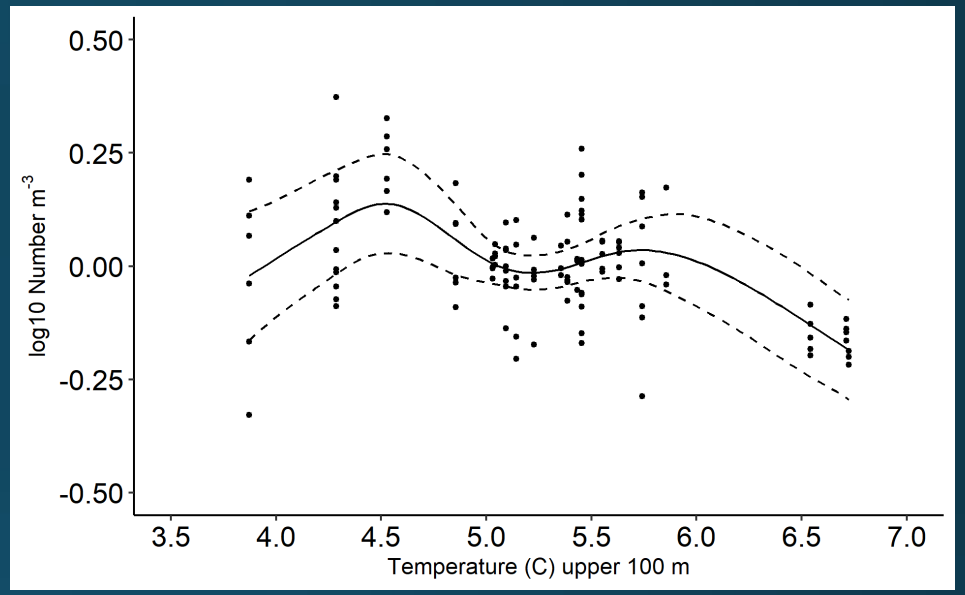


# GAMS – upper 100 m temperature

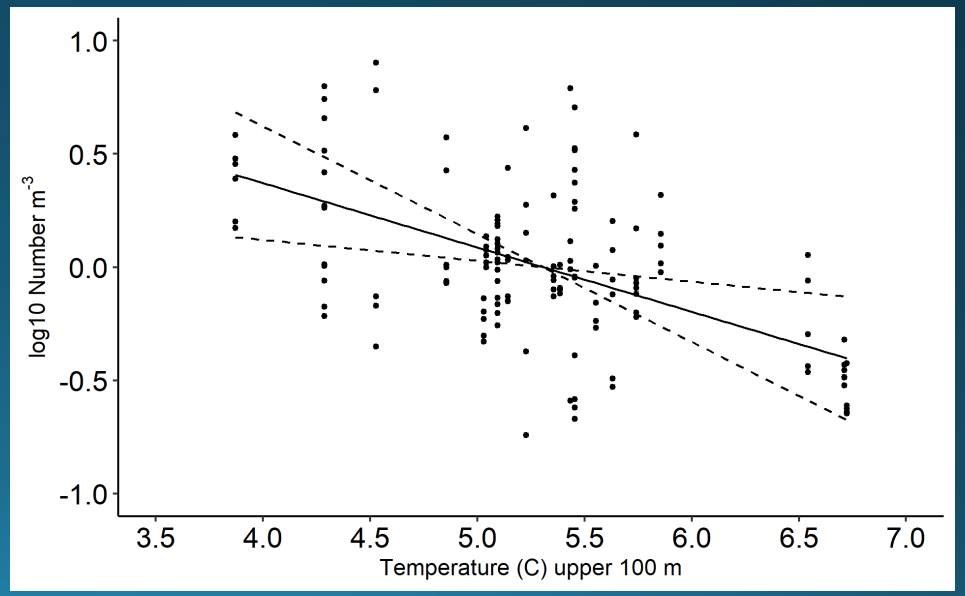
*C. marshallae* C5




*N. cristatus* C4

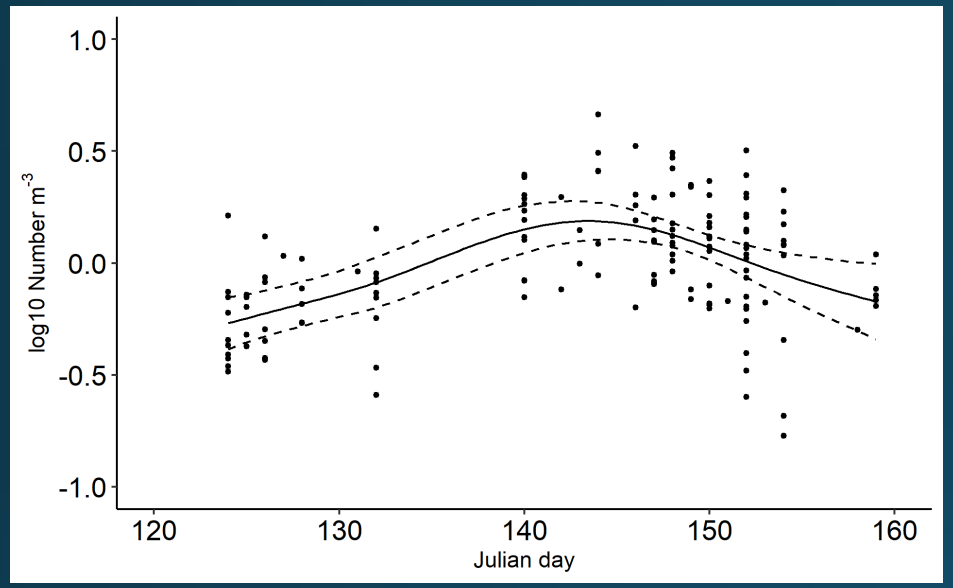



*Neocalanus* spp. C4

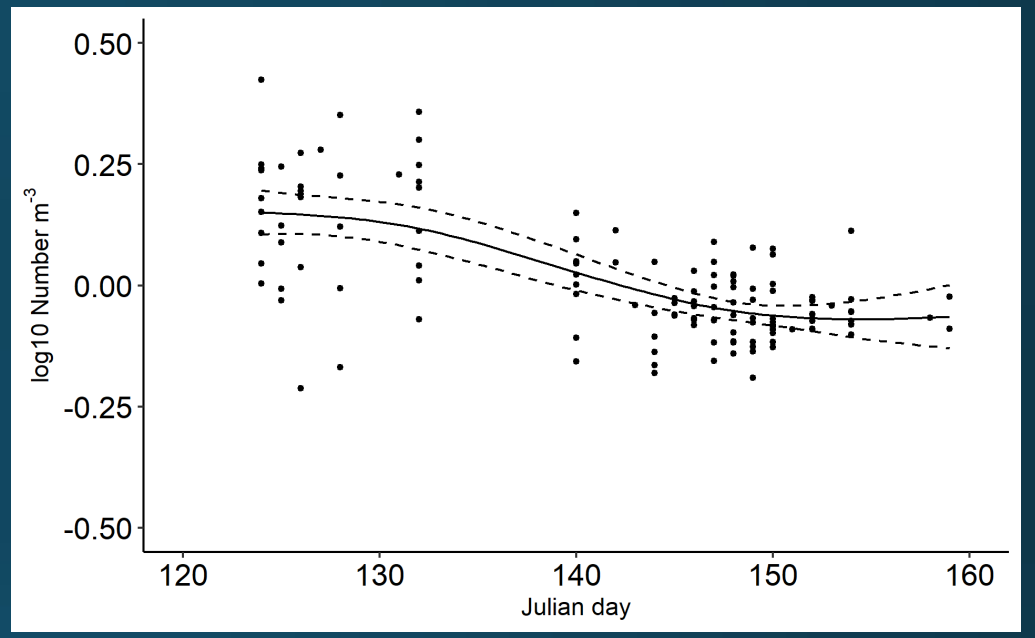


# GAMS – Julian Day

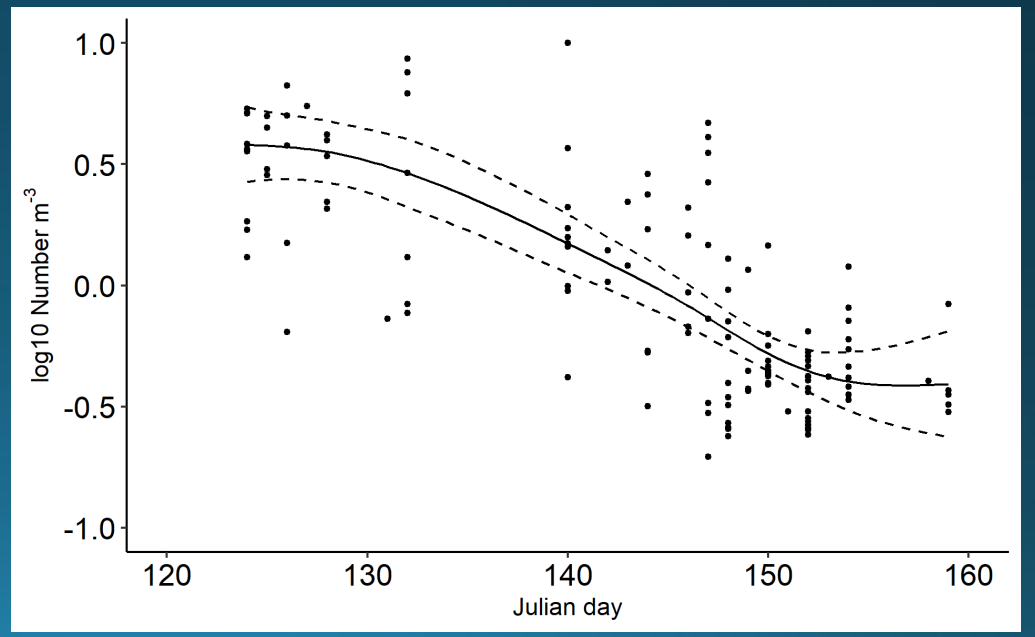
*C. marshallae* C5




*N. cristatus* C4

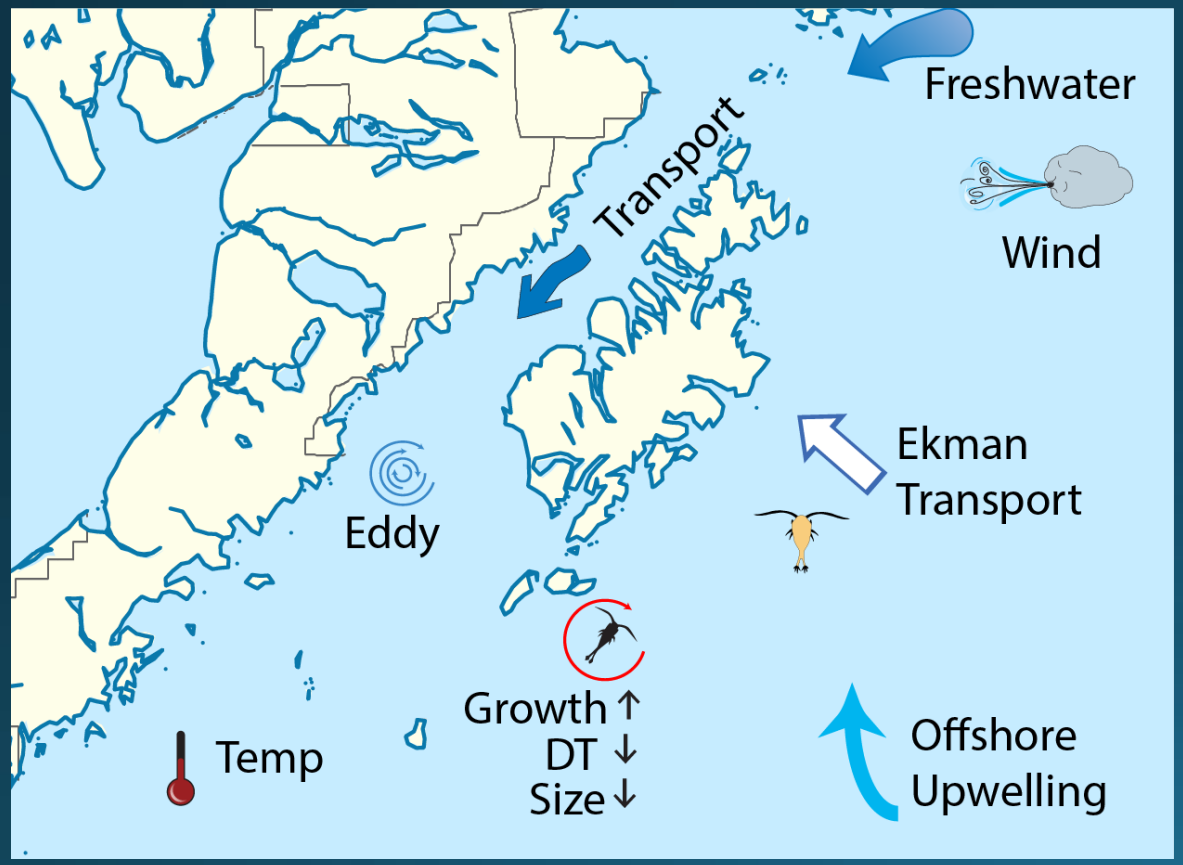



*Neocalanus* spp. C4

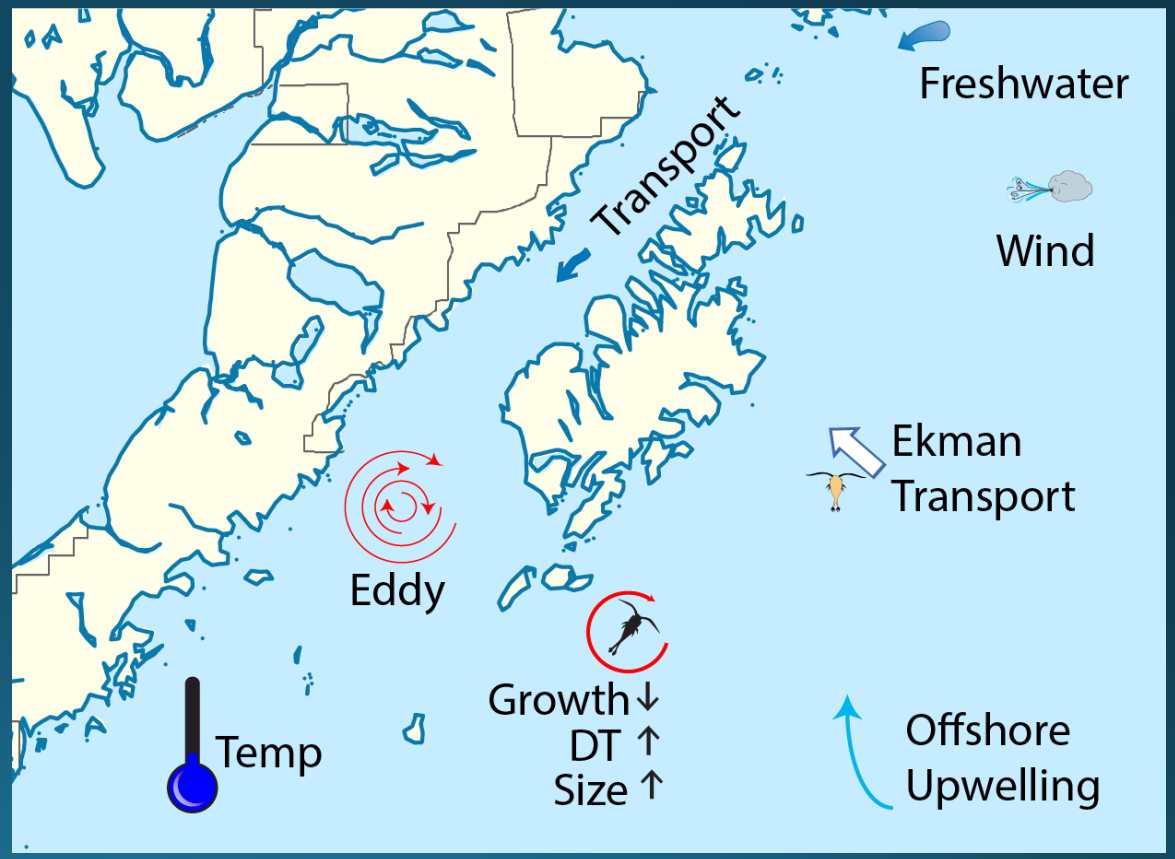


# A conceptual model

## PDO +

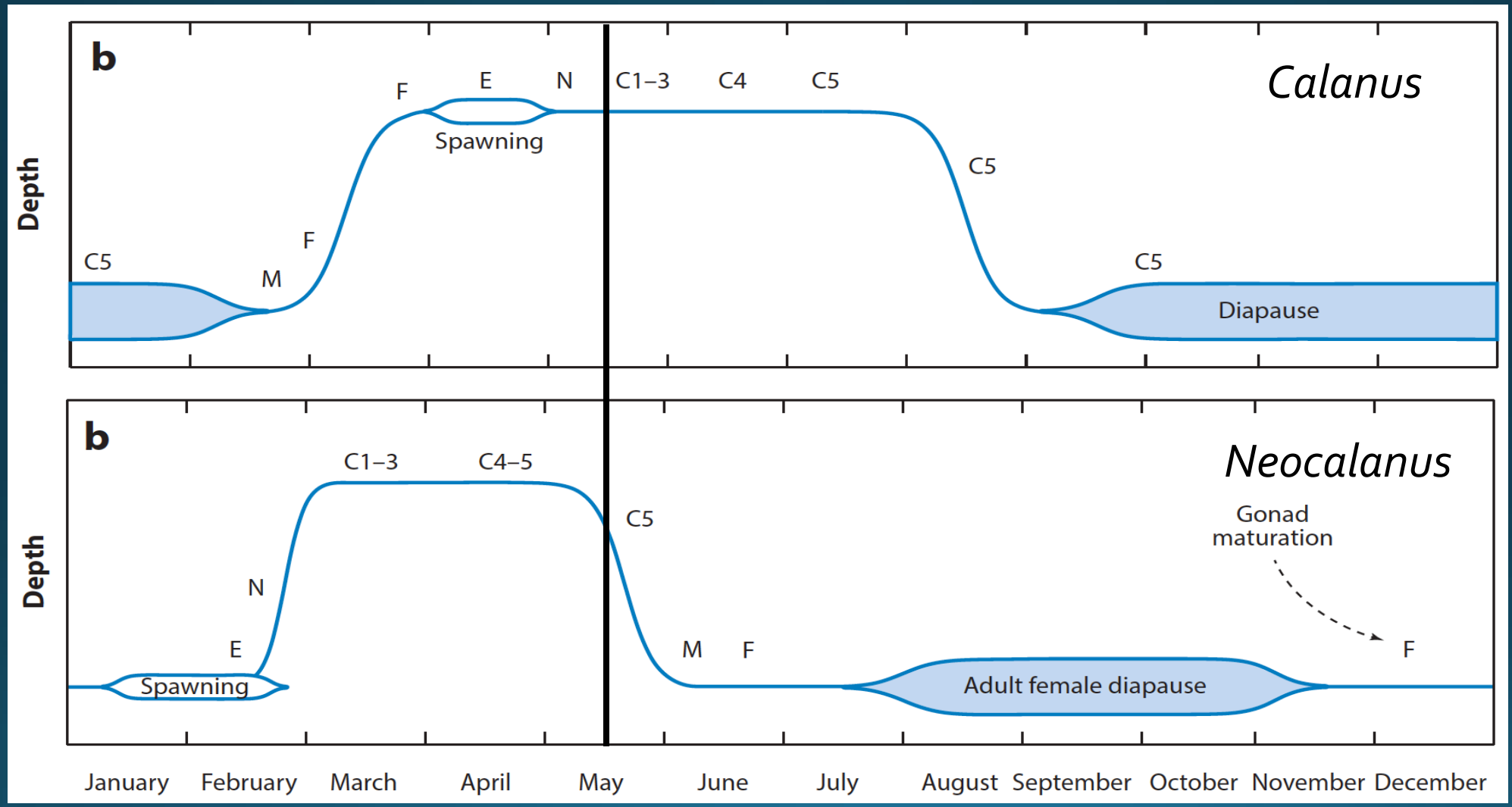



## PDO -



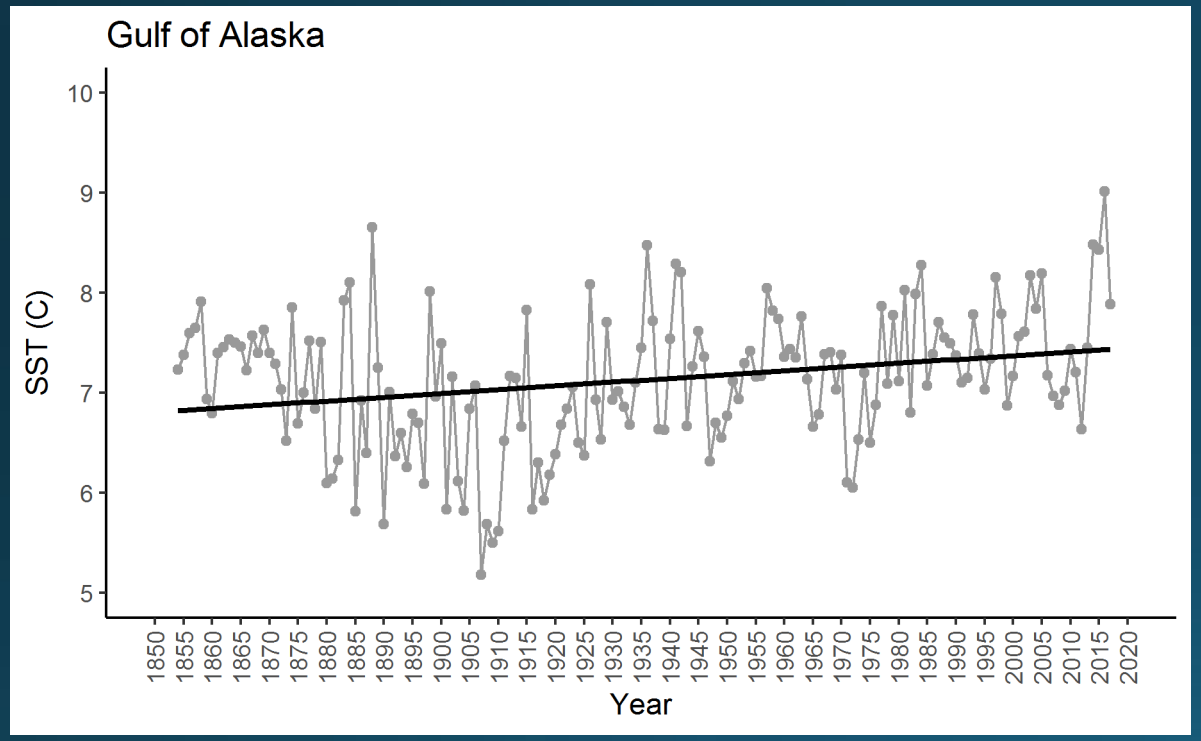

Coyle and Pinchuk 2003, 2005; Coyle et al. 2013; Napp et al. 1996; Sousa et al. 2016

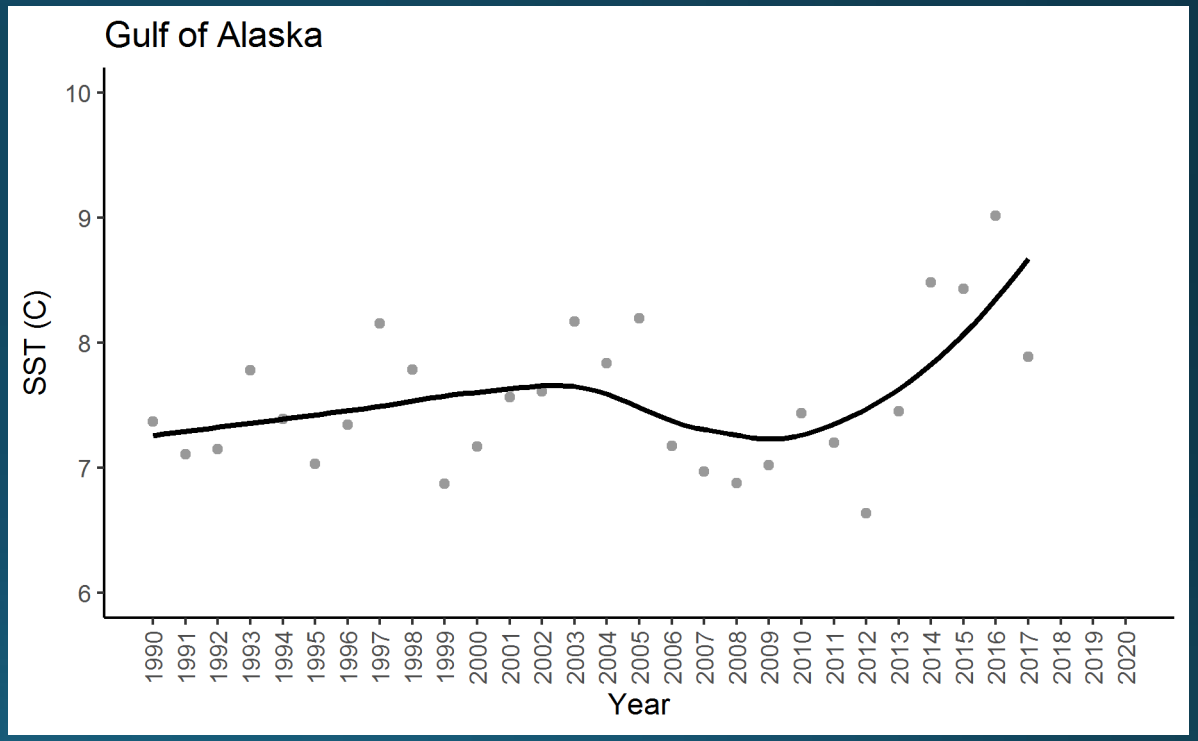
# A phenological change?




Baumgartner and Tarrant (2017)

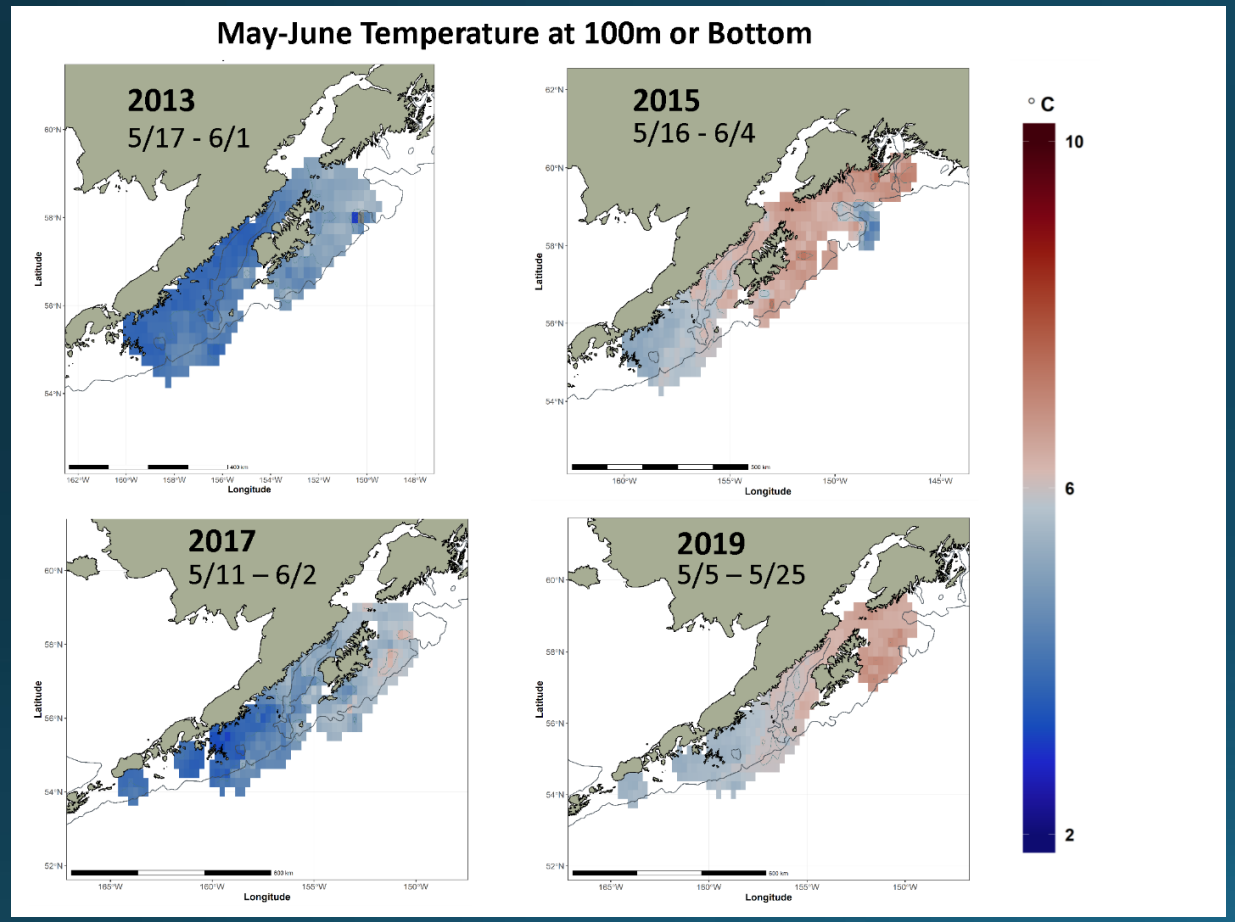
# Warming

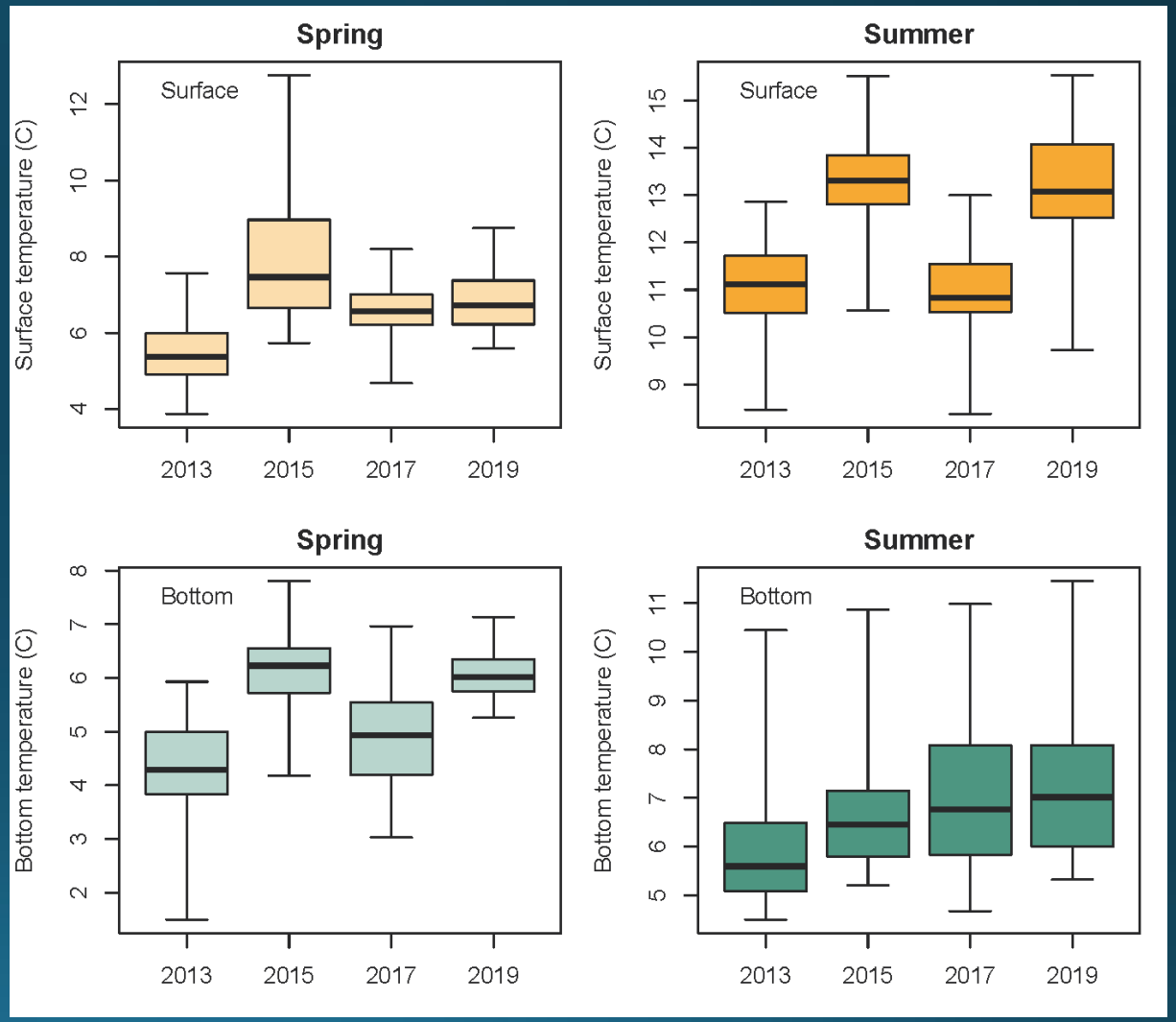



NOAA ERSST v5

# The “Blob”

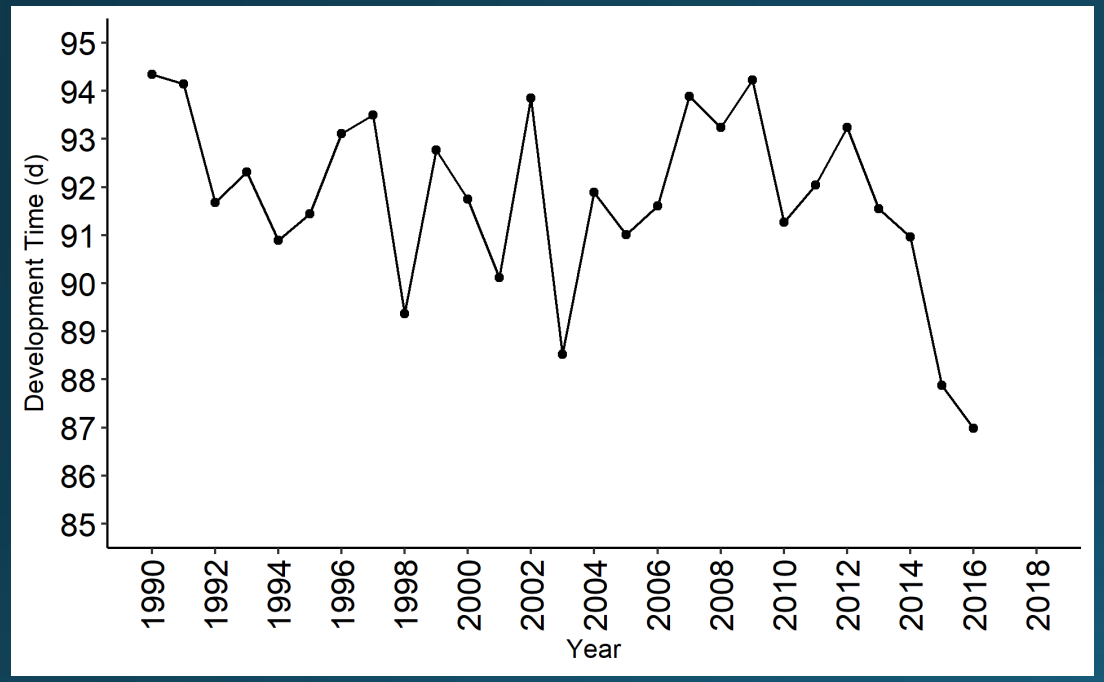



L. Rogers

# Development times

*C. marshallae* C5

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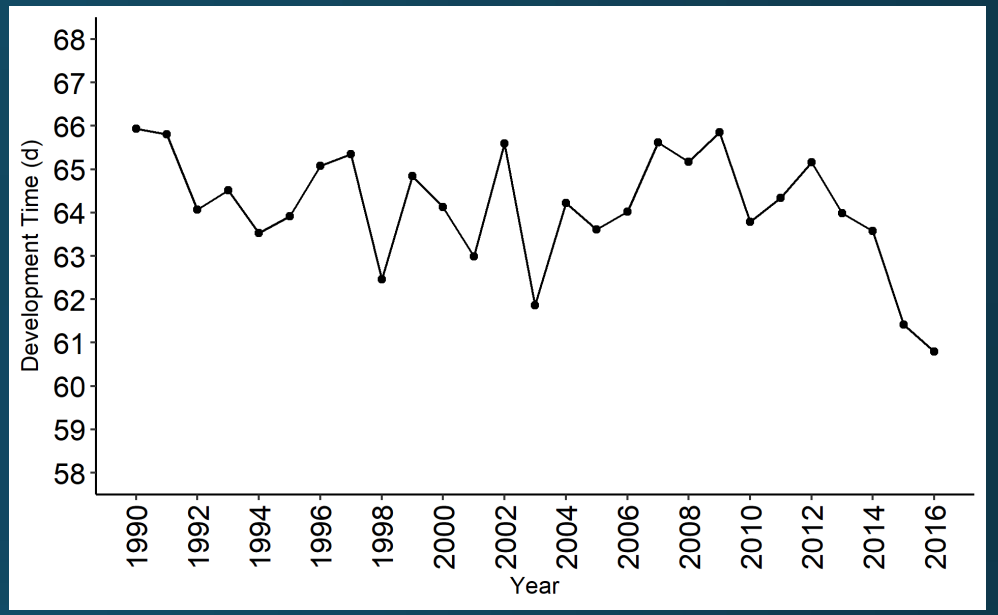
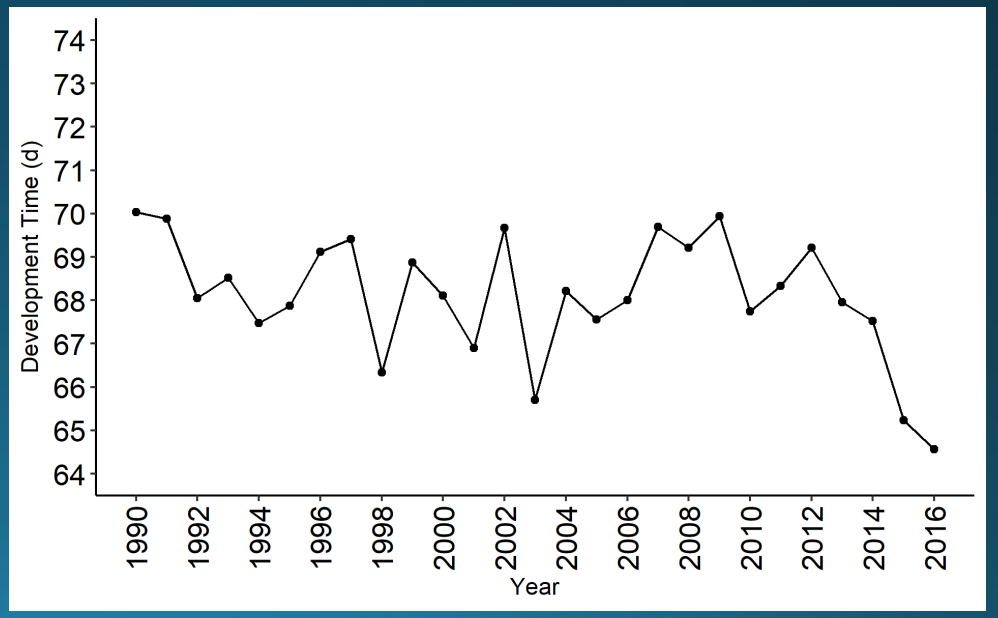



*Neocalanus* spp. C4



# Conclusions

- Have there been trends and/or patterns in environmental conditions and zooplankton abundance over time in the Gulf of Alaska?
  - Environmental multivariate pattern related to PDO and local oceanography
  - Zooplankton multivariate pattern related to abundance changes in large copepods with one cohort per year

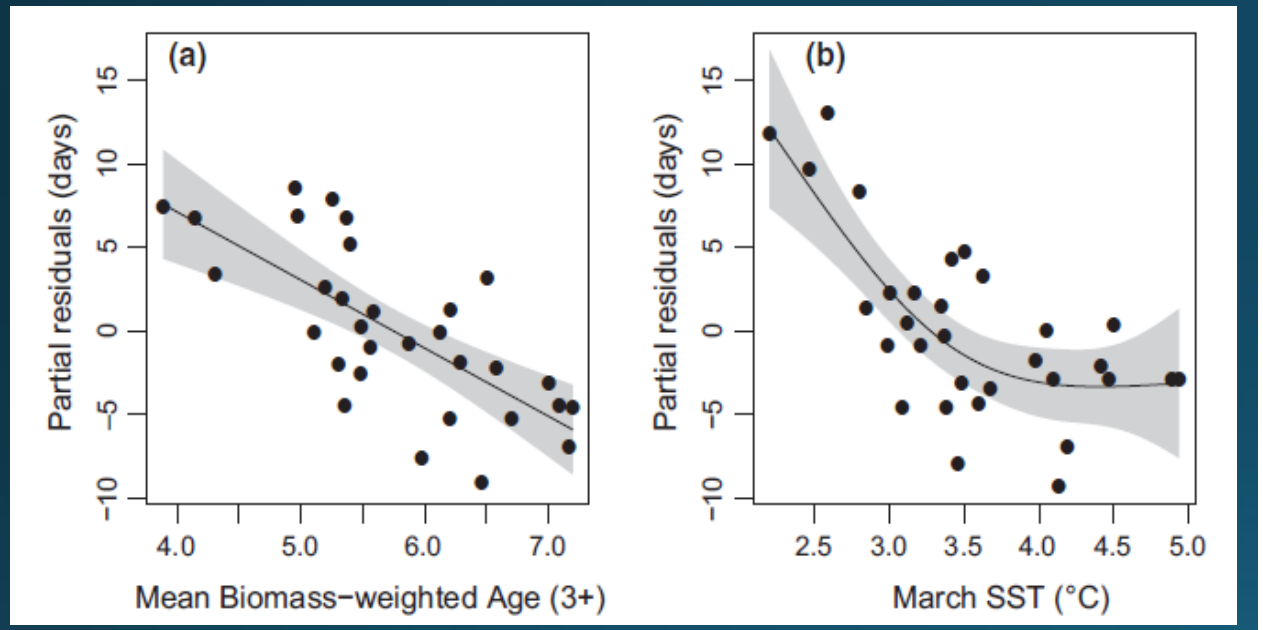
- Are there any monotonic trends present in the environmental or zooplankton time-series?
  - No trends in the environmental time-series, except for precipitation (not shown), though is a longer-term warming trend
  - Zooplankton DFA and four species of copepods had trends present

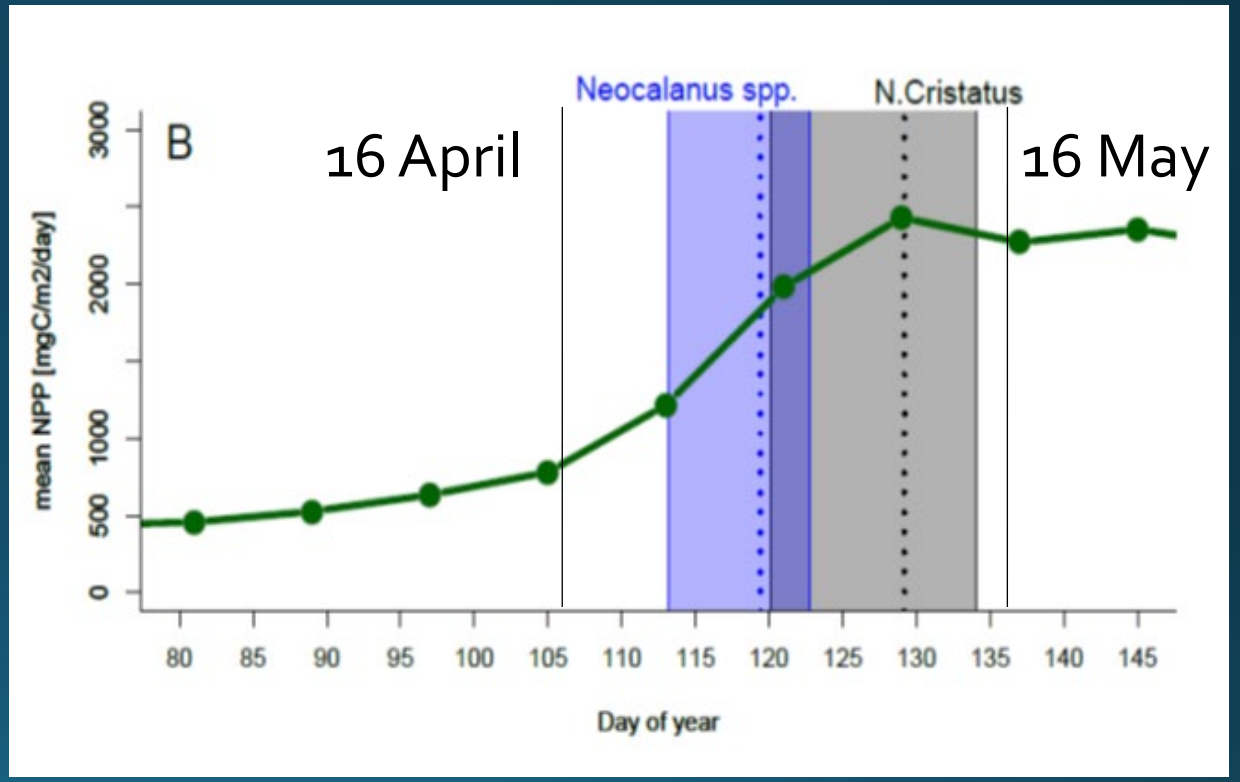
# Conclusions

- Do the patterns in environmental data correspond to trends in zooplankton data?
  - DFA time-series show correlations with various environmental factors, highlighted the relationship between large copepods and surface temperature/Julian day
  - Conceptual model

- A phenological change?
  - Long-term warming and recent warming events suggest effects on copepod development rates
  - Application of development time models show that time to reach stage may differ by as much as 7 days

# Implications



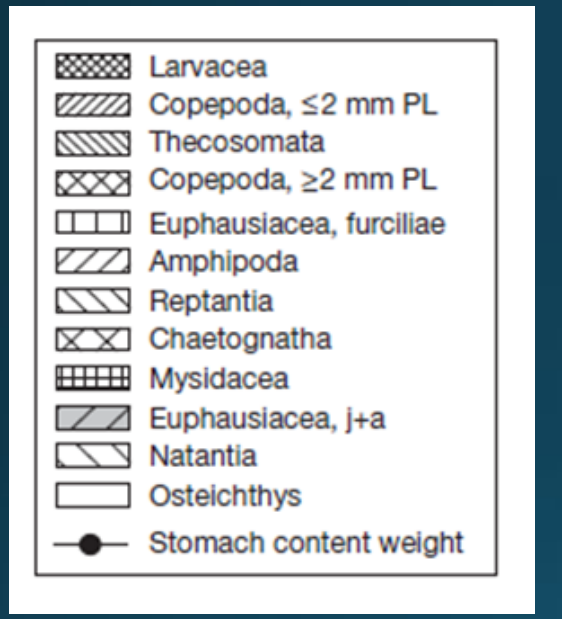



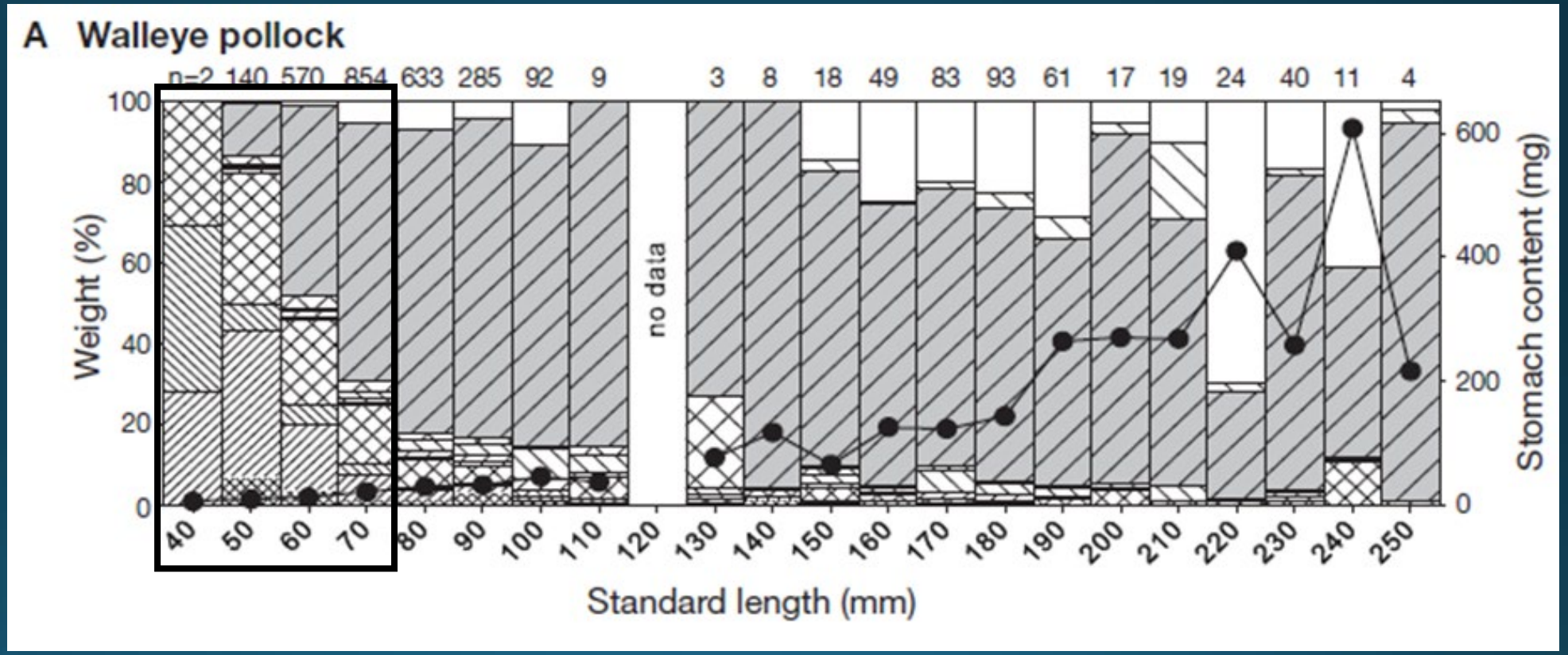

Match-mismatch?

Rogers and Dougherty 2018

Nielsen et al. 2019

# Juvenile prey field




Wilson et al 2009

# Implications

- Oceanography + phenology + species composition =
  - Match/mismatch in time and space
  - Match/mismatch in size (predator/prey interaction)
  - Match/mismatch in prey quality

# Acknowledgements


- EcoFOCI Zooplankton Team
  - Nissa Ferm, Colleen Harpold, Jesse Lamb, Adam Spear
- Captains and crews
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- Matt Wilson