Environmental and spatiotemporal influences on winter ichthyoplankton assemblages of the northern California Current ecosystem

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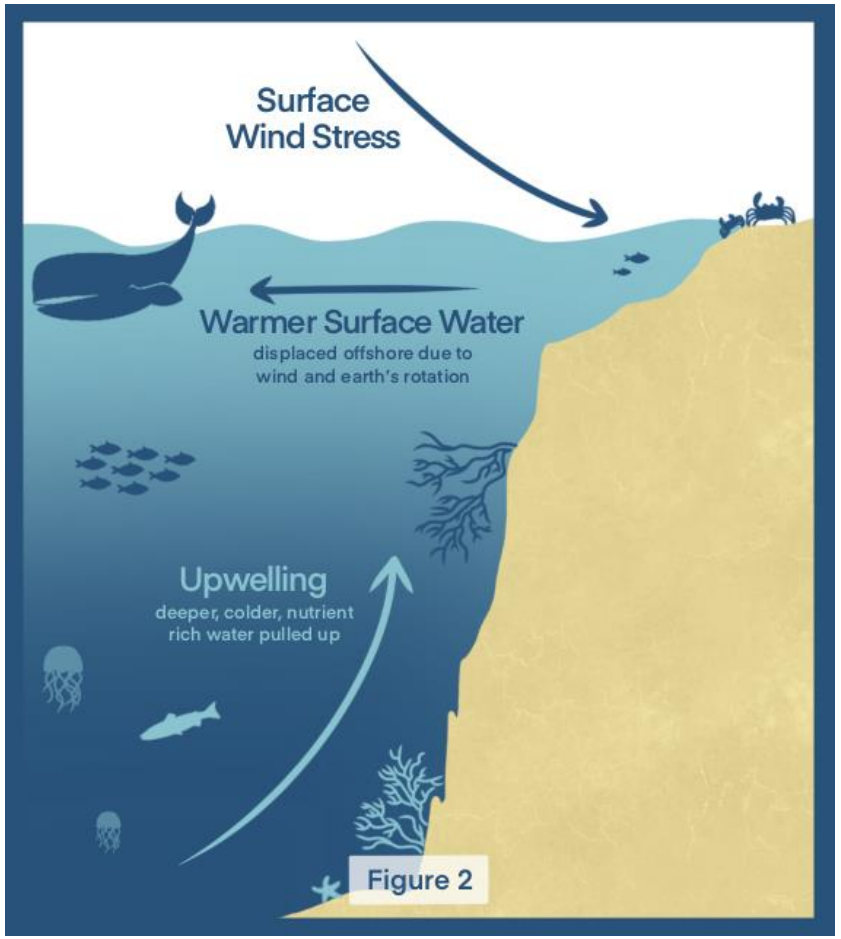
Introduction – Larval Fish Assemblages

- Inhabit the upper 100 m of the water column
  - 96% of larvae, day & night
- Aggregate horizontally and vertically
  - Vertical migration
- Known influence of broad oceanographic and fine-scale environmental factors

References: Auth and Brodeur, 2006; Thompson et al., 2014; Auth et al., 2007; Pattrick et al., 2021; Huebert et al., 2010; Pepin, 1991; Bœuf and Payan, 2001; Johnson-Colegrove et al., 2015; Whiney et al., 2021

Introduction – NCC LFAs

- NCC = Eastern boundary current system
  - Varied upwelling regimes
- Supports important fish populations
- Peak larval spawning, abundance, and diversity in winter
  - Minimal offshore transport due to relaxation of upwelling
- Larval dynamics can be useful indicators



Source: Mallika Gupta, California Sea Grant

References: Schmid et al., 2023; Auth, 2011; Doyle, 1992; Brodeur et al., 2008; Daly et al., 2013

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- Larval dynamics can be useful indicators

- Relatively scarce winter LFA research
- Lack of depth-stratified winter LFA research



Source: NOAA, 2009

References: Schmid et al., 2023; Auth, 2011; Doyle, 1992; Brodeur et al., 2008; Daly et al., 2013

Objectives

1

Characterize winter ichthyoplankton assemblages in the NCC

2

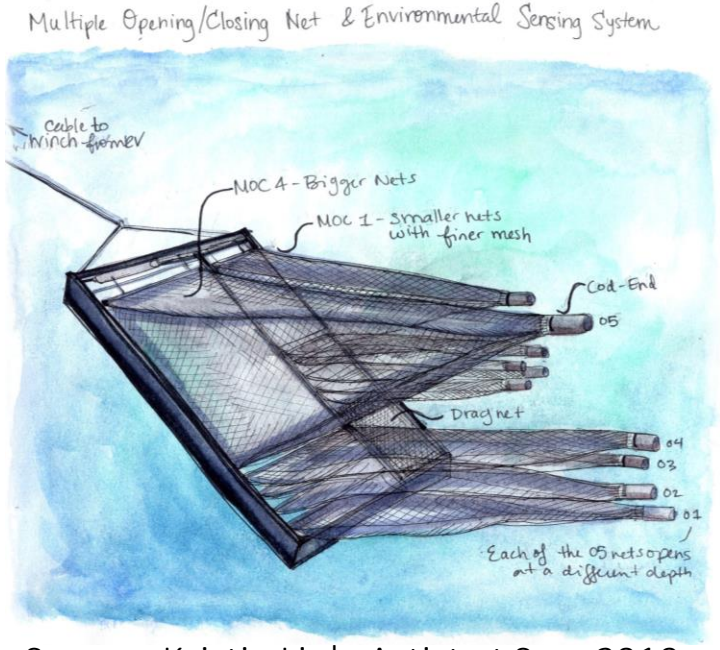
Explain variation in winter ichthyoplankton assemblage composition using fine-scale spatiotemporal and environmental factors

3

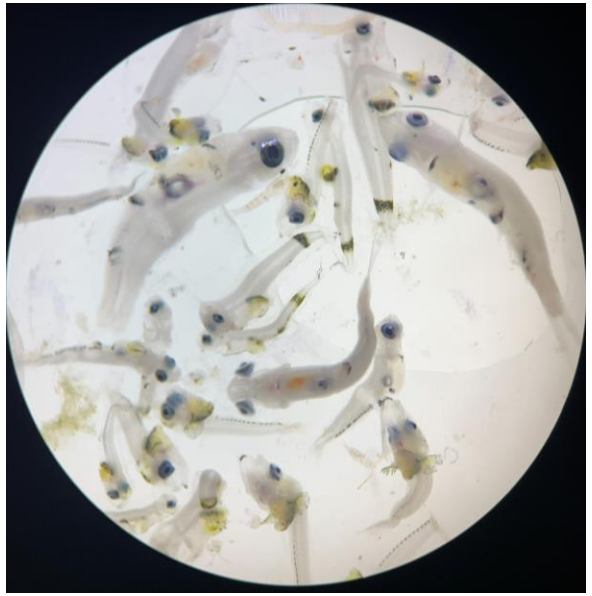
Examine taxon-specific diel variation in vertical abundance distribution

Sampling and Data Collection

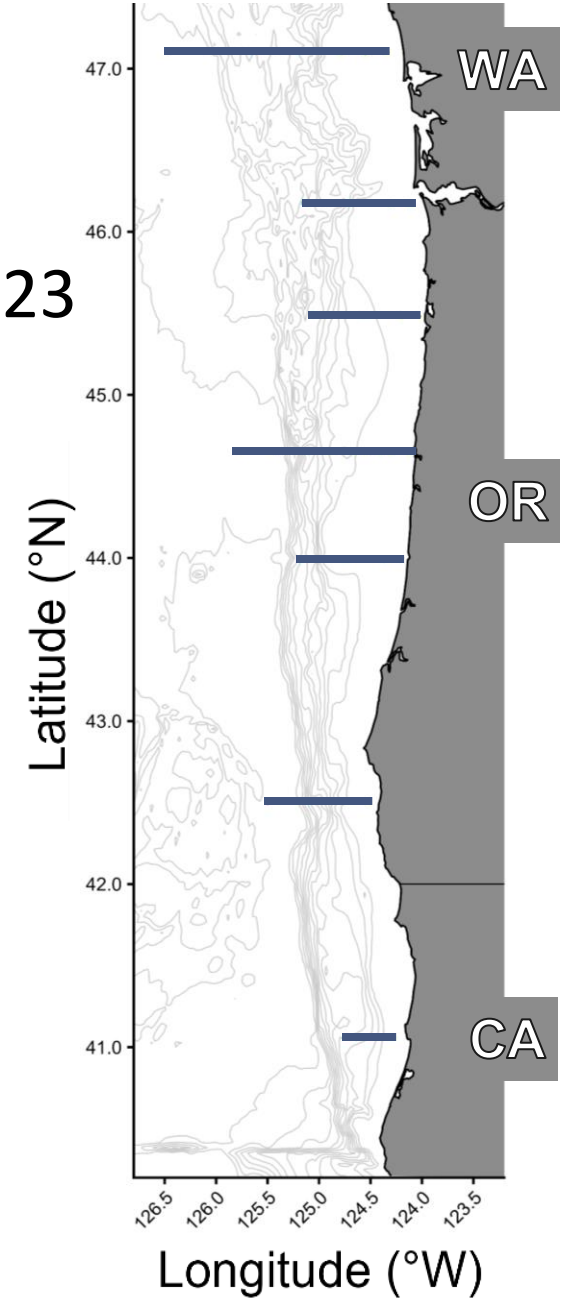
- Sampled in the NCC (41–47°N) in 2018, 2019, 2022, & 2023
- Plankton collected using a coupled MOCNESS
- Sensor package towed vertically
- Ichthyoplankton visually identified and counted



Source: Kristin Link, Artist at Sea, 2019



Source: Luke Bobay



Data Analyses

1: characterize assemblages

- Cluster analysis
- Indicator species analysis

2: influences on assemblages

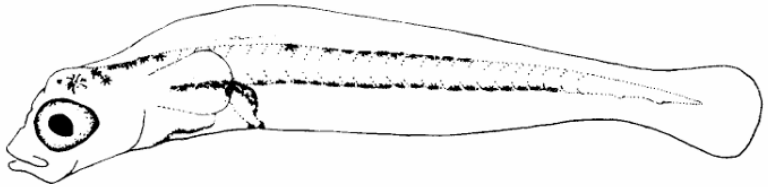
- Distance-based RDA
  - Permutation-based ANOVA
  - Variance partitioning analysis

3: diel variation in vertical distribution

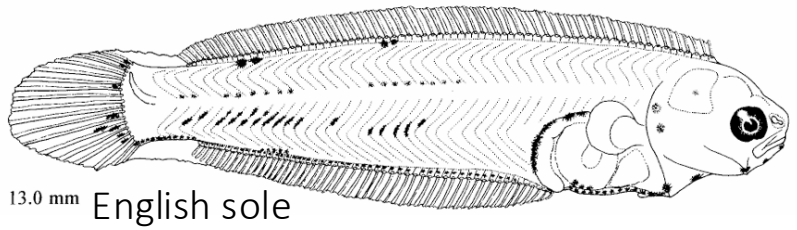
- Negative binomial generalized linear mixed effects model

Cluster Composition

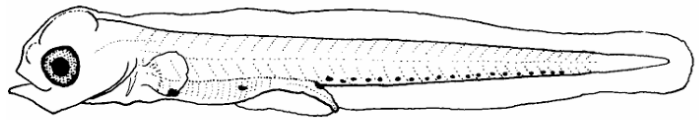
- 7 total clusters:
  - Cluster 1 – *Sebastes* spp. (Rockfish)
  - Cluster 2 – *Parophrys vetulus* (English sole)
  - Cluster 3 – Mesopelagic taxa
  - Cluster 5 – Coastal taxa
  - Cluster 6 – Osmerids (Smelts)
  - Clusters 4 and 7 – single samples



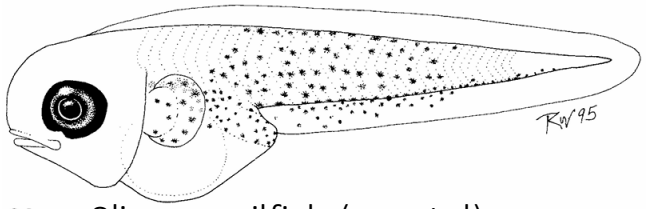
4.6 mm Kelp rockfish



13.0 mm English sole



5.3 mm Northern lampfish (mesopelagic)



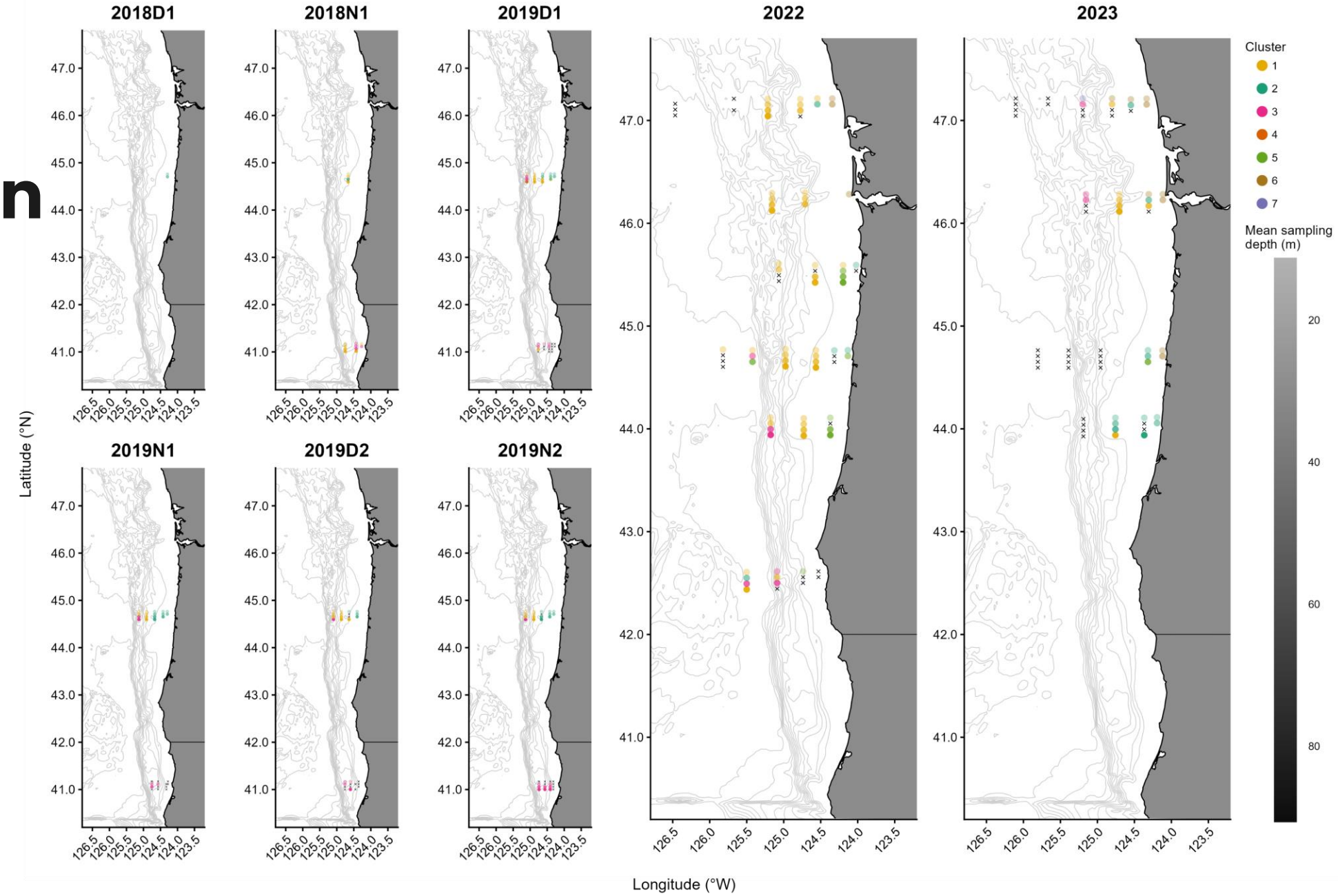
2.2 mm Slimy snailfish (coastal)



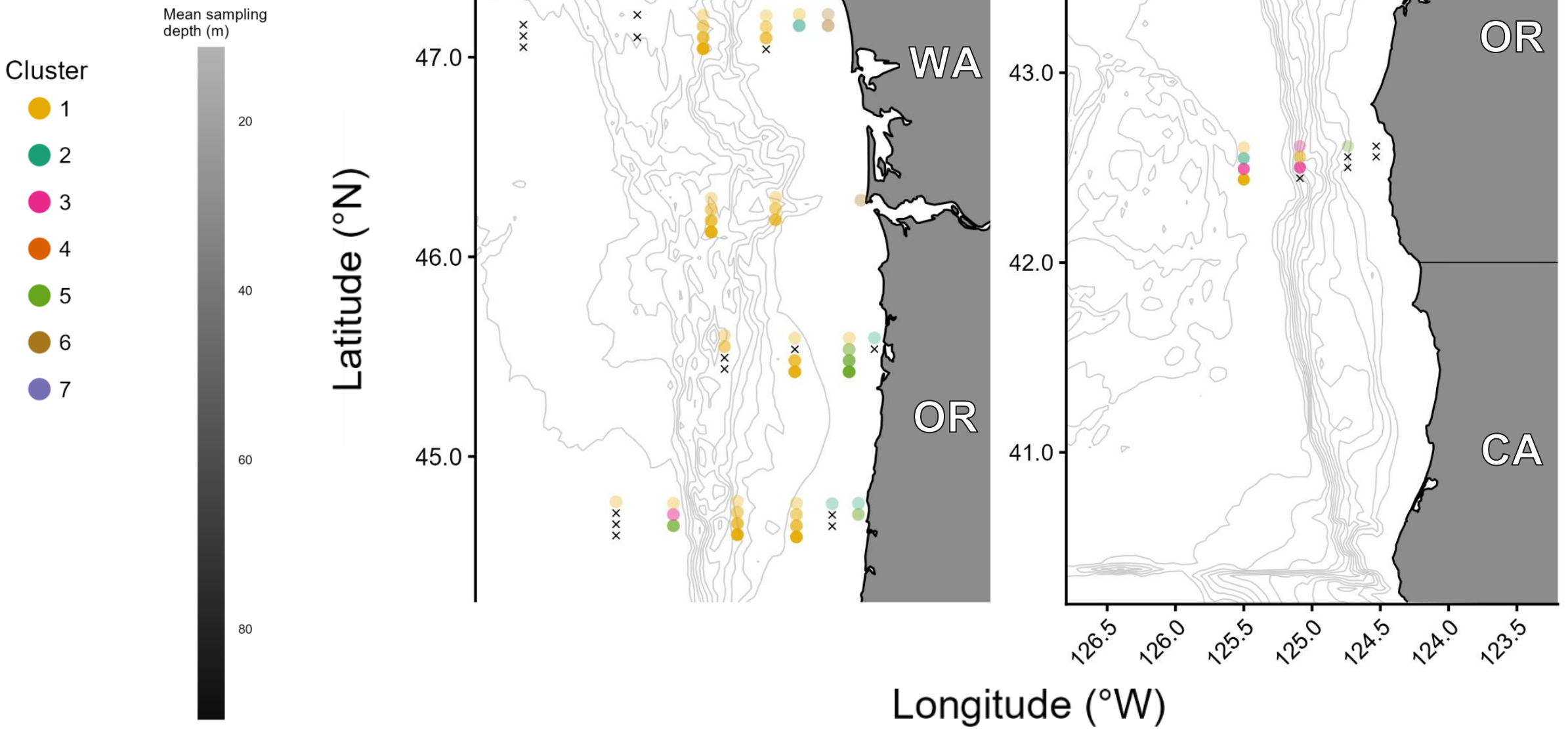
8.3 mm Surf smelt

Source: CalCOFI, 1996

Cluster Distribution



Cluster Distribution

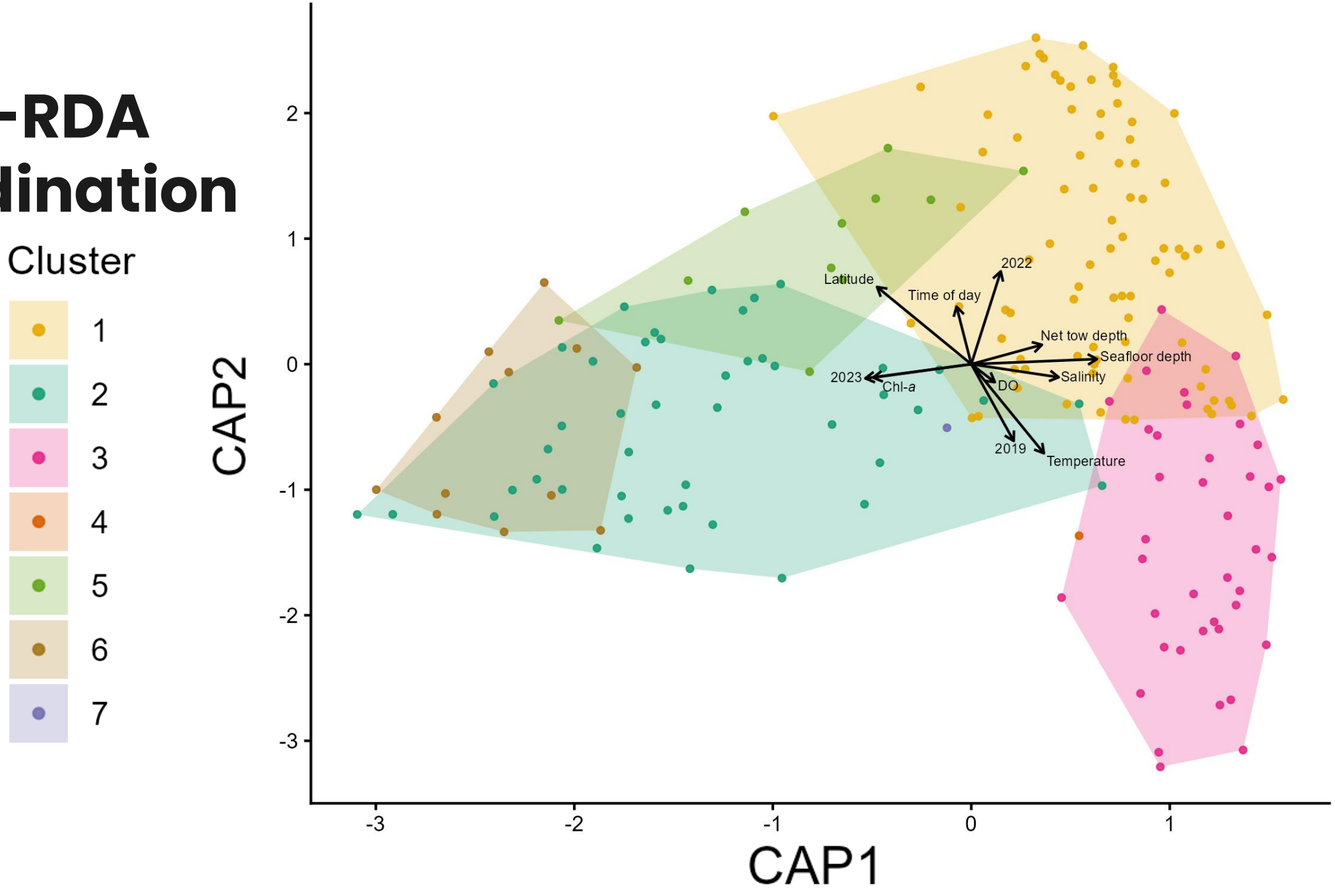


Db-RDA and VPA

- Fit spatiotemporal base model and full model
  - Base: year, time of day, latitude, net tow depth, and seafloor depth
  - Full: base + temperature, salinity, DO, and chl-*a*
- Both models explain significant amounts of variation
  - Significant additional variation explained by full model

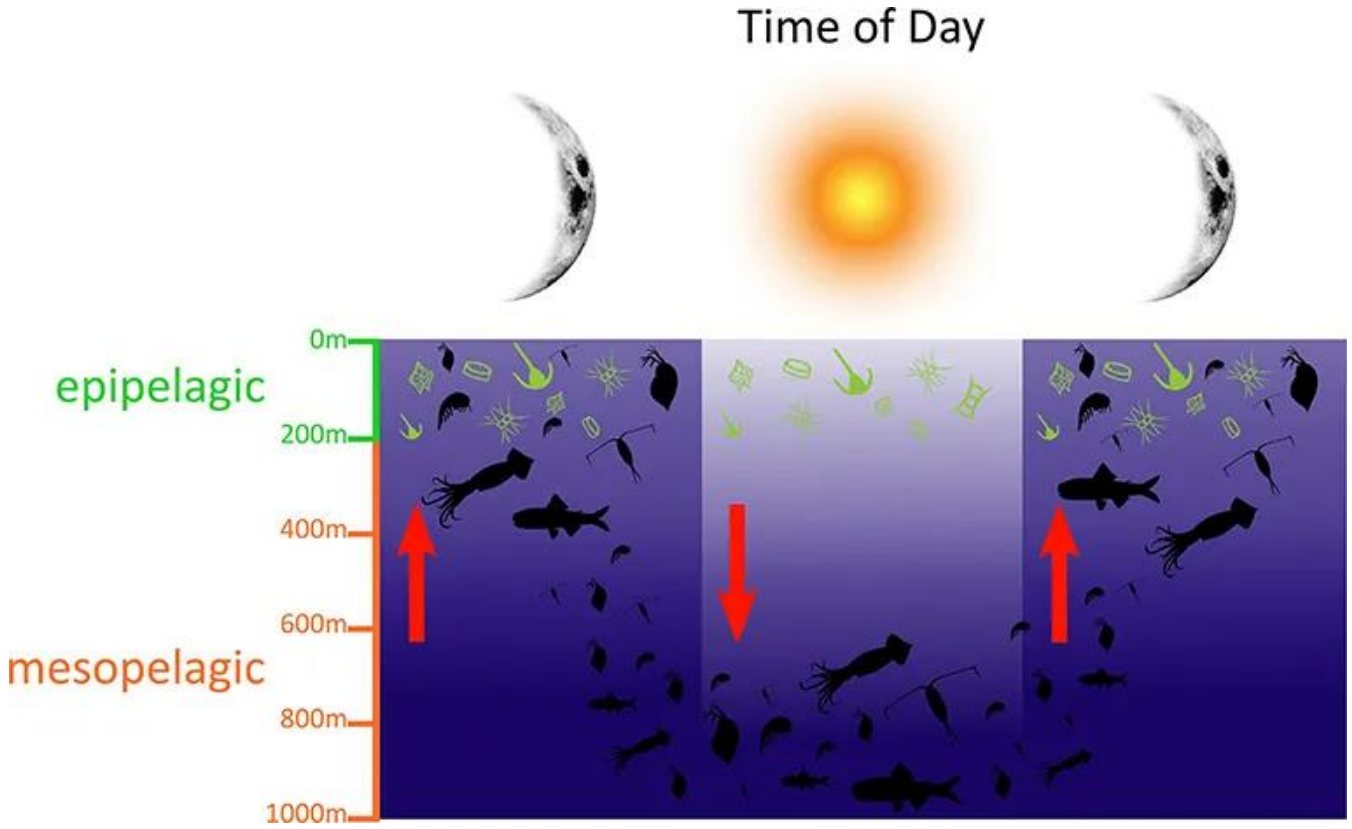
VPA results	
Covariates	**Percent of variation explained**
Spatiotemporal	3.72%
Environmental	1.92%
Spatiotemporal and Environmental	1.57%

Db-RDA Ordination



Negative binomial GLMM

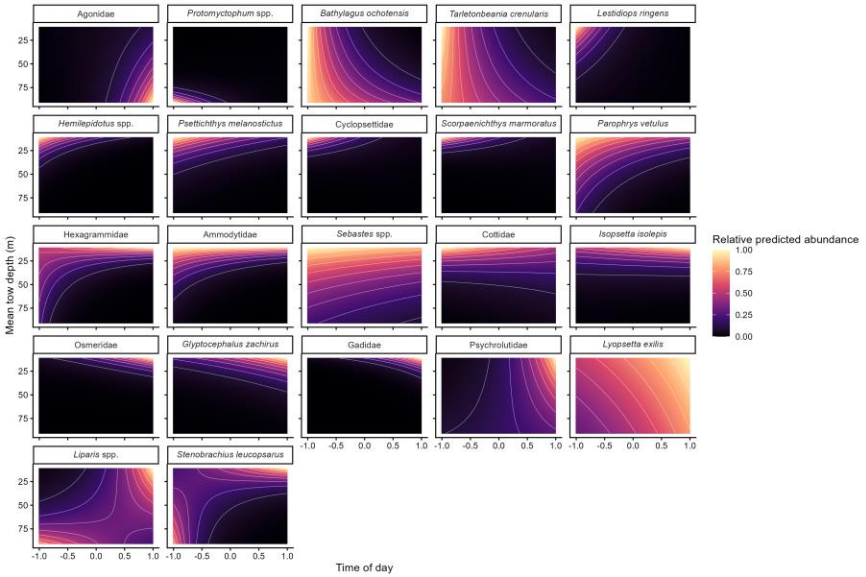
- Fit to ichthyoplankton counts
  - Fixed effects same as full db-RDA model covariates
  - Full interaction among taxon, time of day, and depth
- Interaction term significant for many taxa
- Model alone does not address DVM



Source: Freer and Hobbs, 2020

GLMM Plots

Vertical distribution across the day



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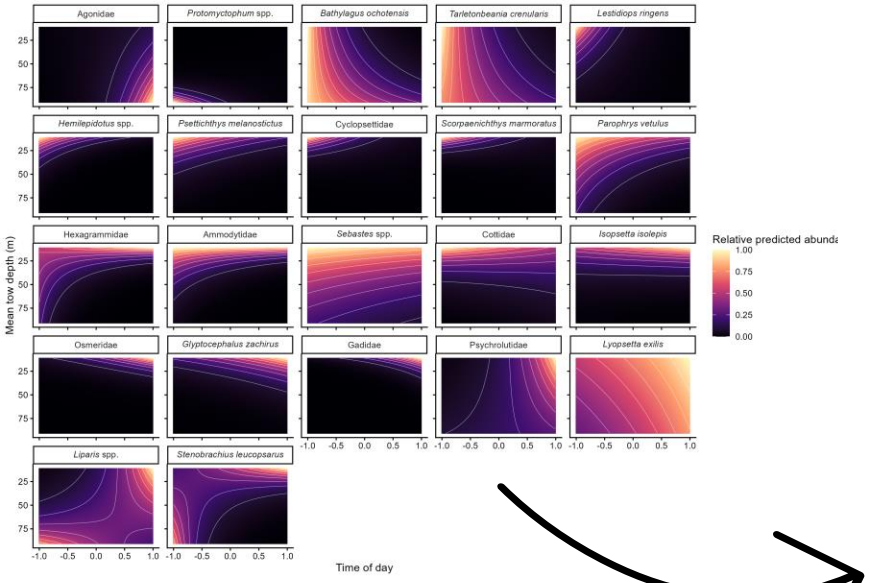
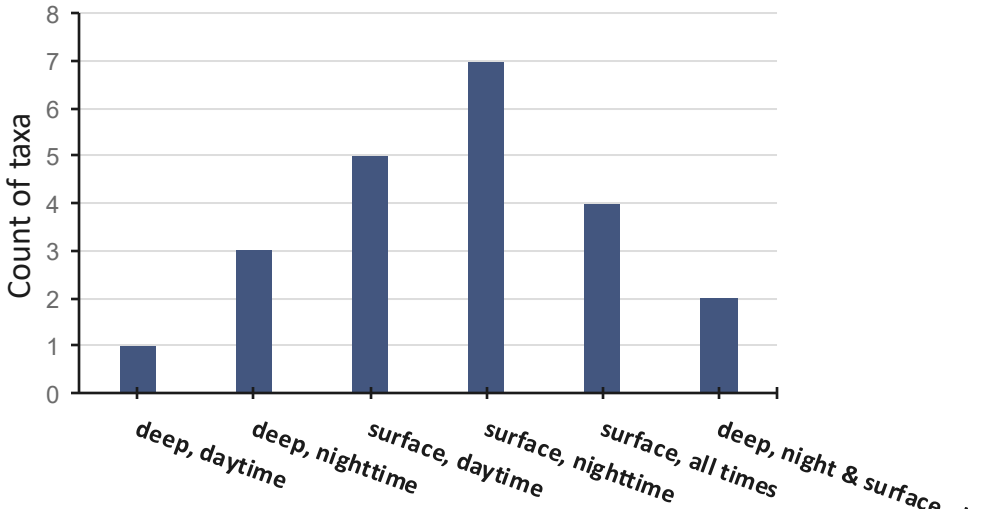
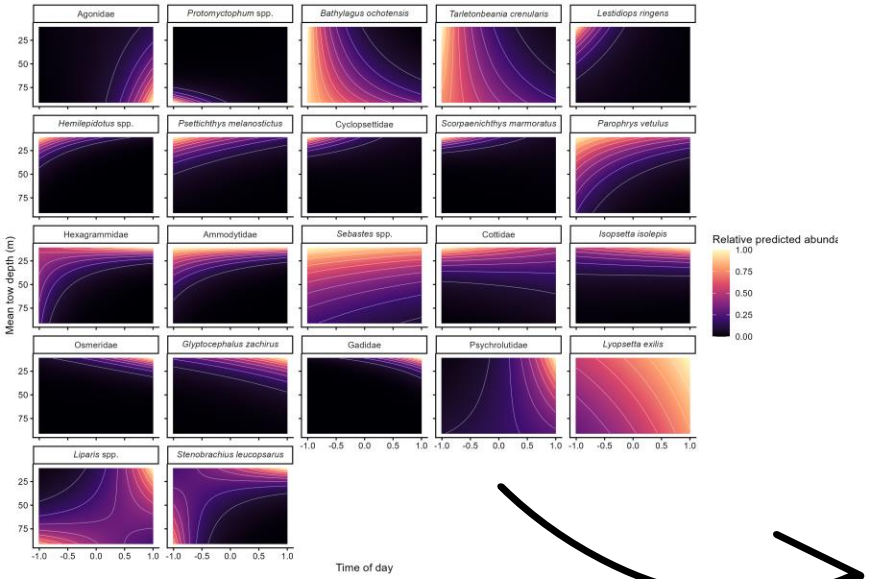




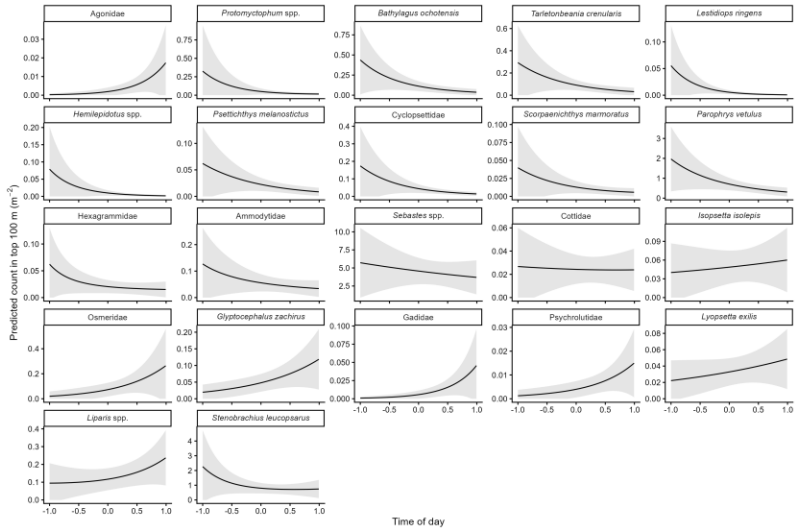
Position and time of greatest abundance

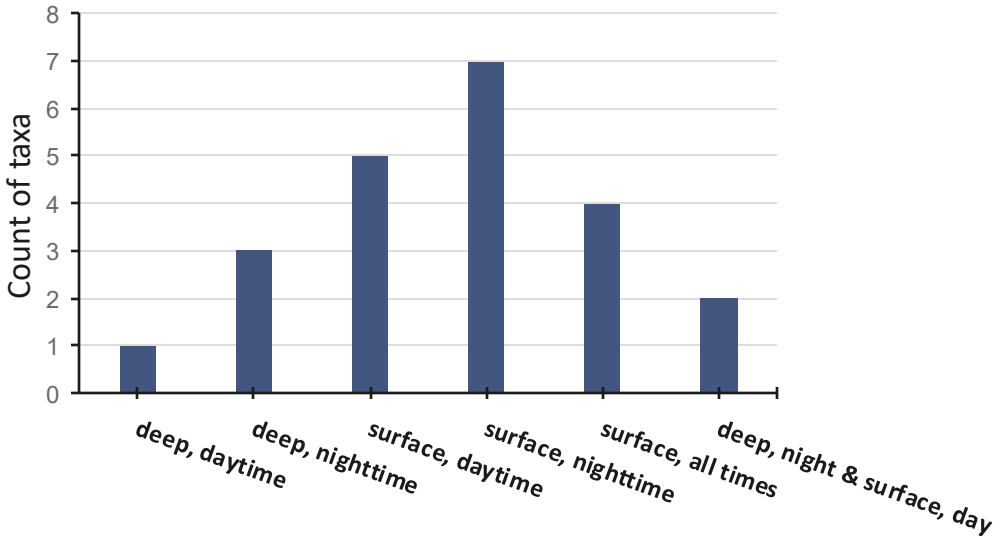
GLMM Plots

Vertical distribution across the day



Time effect on total abundance





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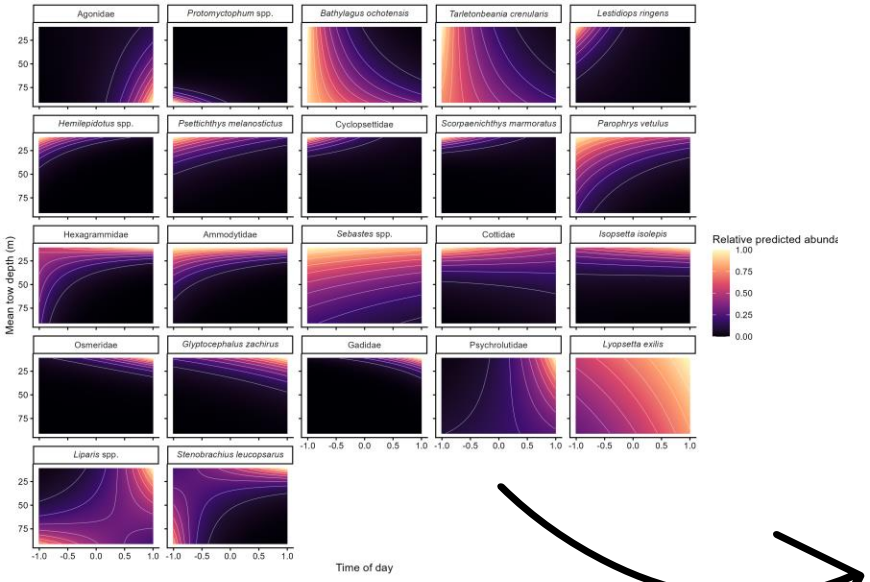

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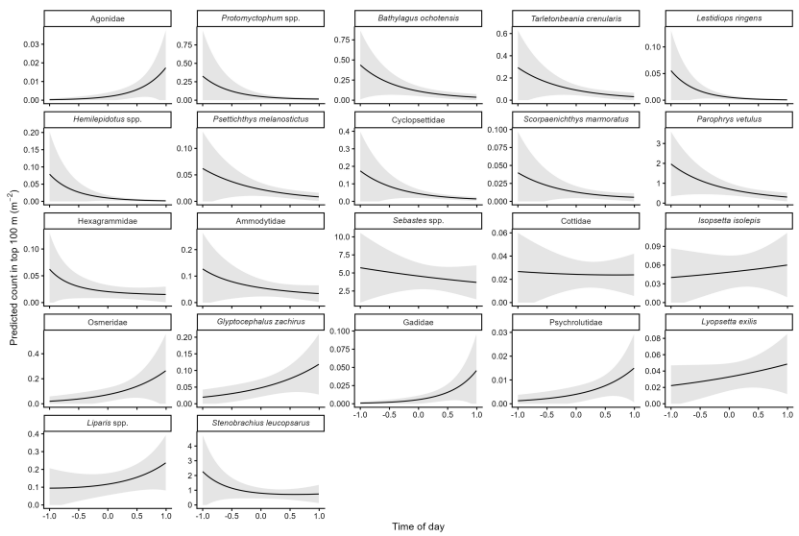
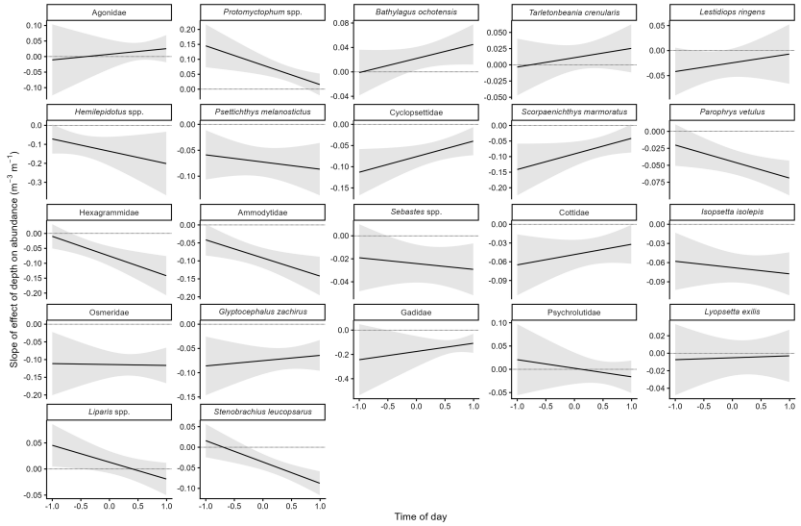
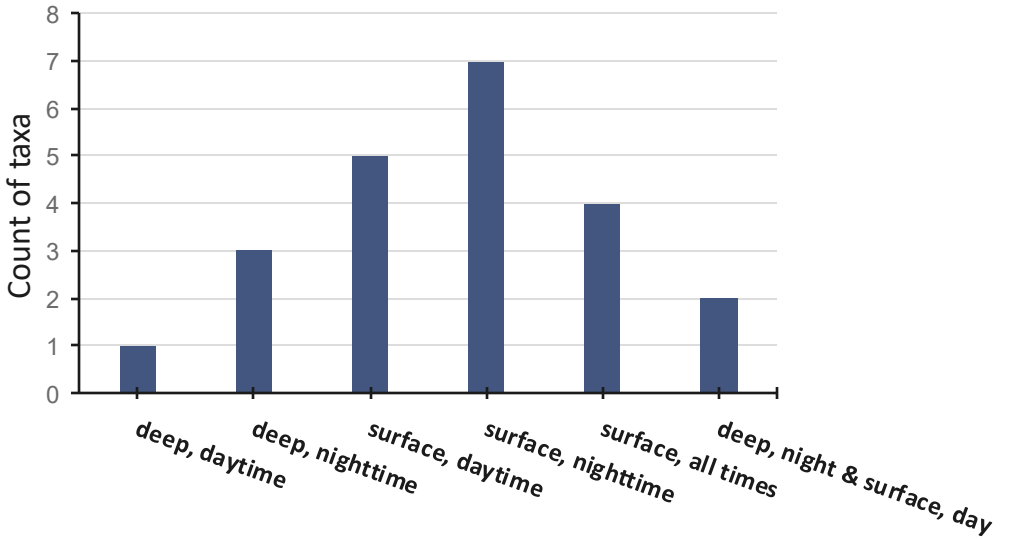


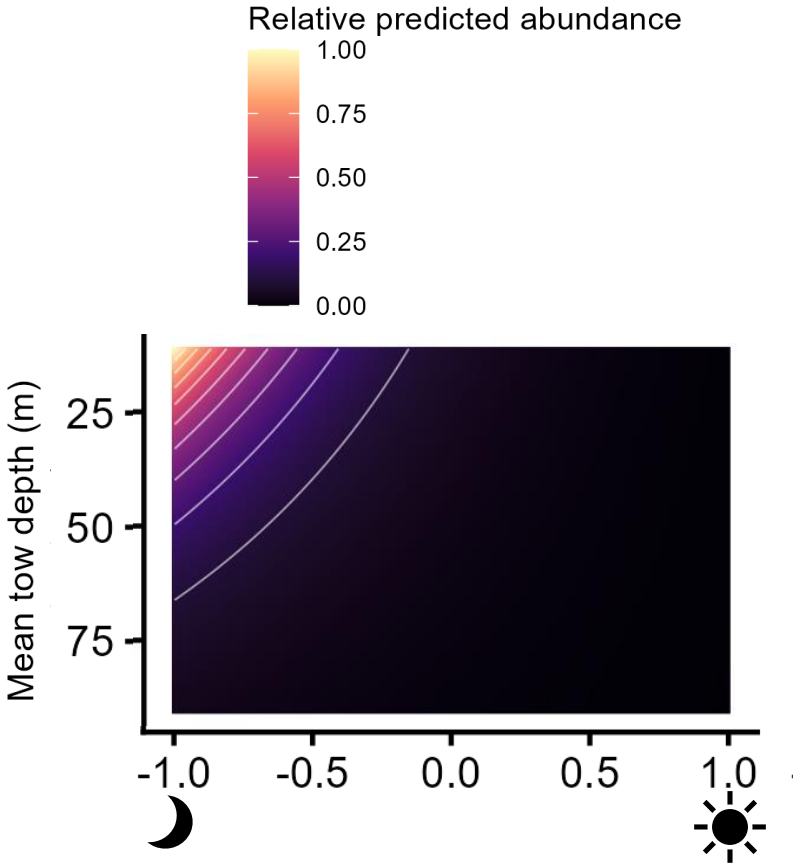
Time effect on abundance gradient

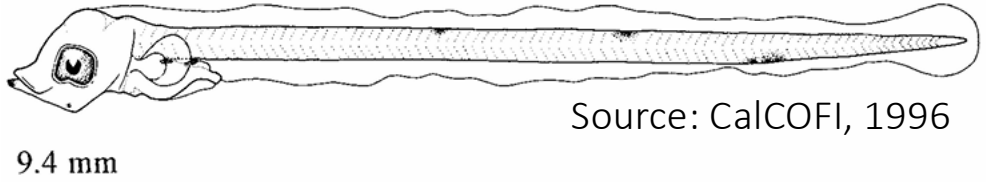




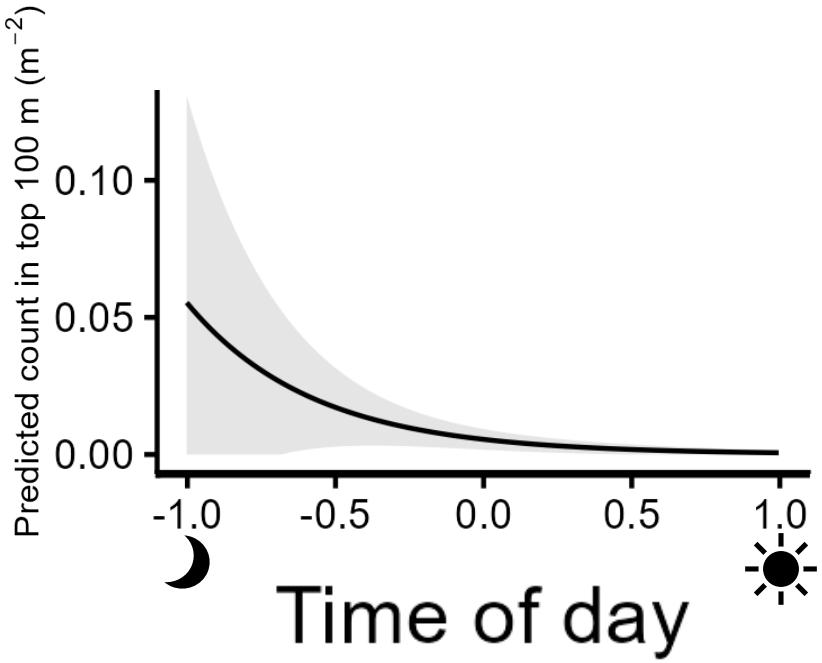
Position and time of greatest abundance

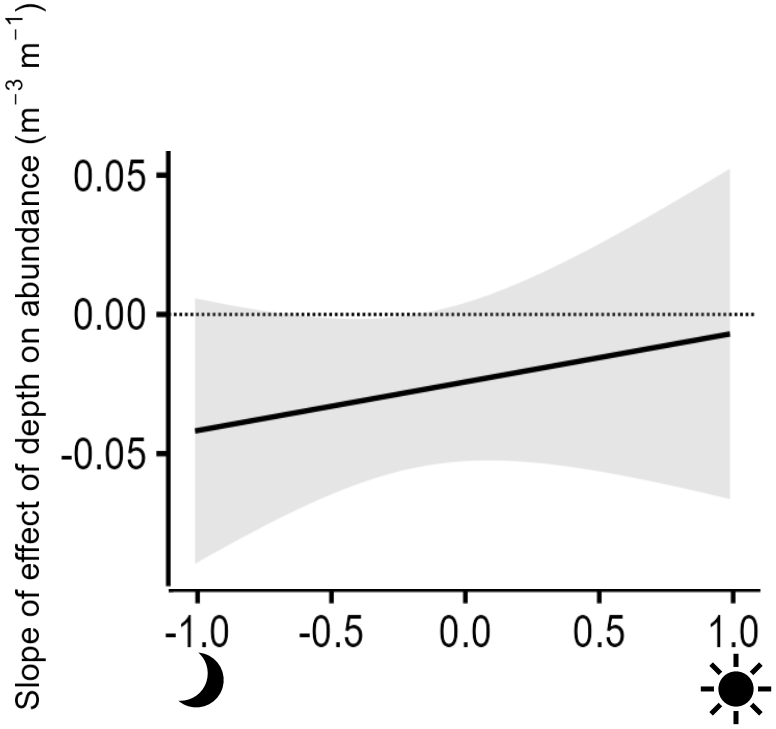
Lestidiops ringens (Slender barracudina) – most abundant at shallowest depths at night



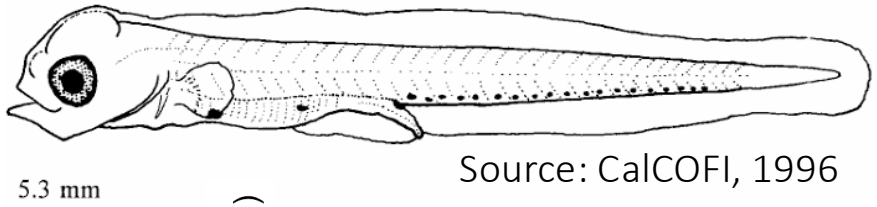


Source: CalCOFI, 1996





Stenobrachius leucopsarus (Northern lampfish) – most abundant at deepest depths at night AND shallowest depths during the day



Source: CalCOFI, 1996

Conclusions – LFAs

- NCC ichthyoplankton cluster into ecologically distinct assemblages during winter
  - Distributed according to adult habitat affinities
- Winter ichthyoplankton assemblages are significantly influenced by spatiotemporal and environmental factors
  - Depth
  - Temperature and DO
  - Time of day

References: Doyle et al., 2002; Thompson et al., 2014; Rodriguez et al., 2015; Auth, 2011; Chen et al., 2025

Conclusions – DVM

- Some taxa exhibited a distribution opposite of expected DVM---shallow during day and deep at night
  - Previously observed, coined reverse or type-II DVM
- Several taxa exhibited only part of the DVM cycle---abundant near surface at night but absent during day
  - Daytime absence due to migration below 100 m? Unlikely.
  - Visual net avoidance?
- Potential seasonal difference in adaptive advantages of DVM

References: Auth et al., 2007; Auth and Brodeur, 2006; Thompson et al., 2014

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Acknowledgements

- National Science Foundation for funding
- Crew of R/V *Sikuliaq* for facilitating sample collection
- Student volunteers and other OSU Plankton Lab members for sample collection and processing
- PICES for supporting my attendance

Thank you for your attention!