The role of transport and environmental variability influencing the spatiotemporal patterns of zooplankton in the Northern California Current, USA

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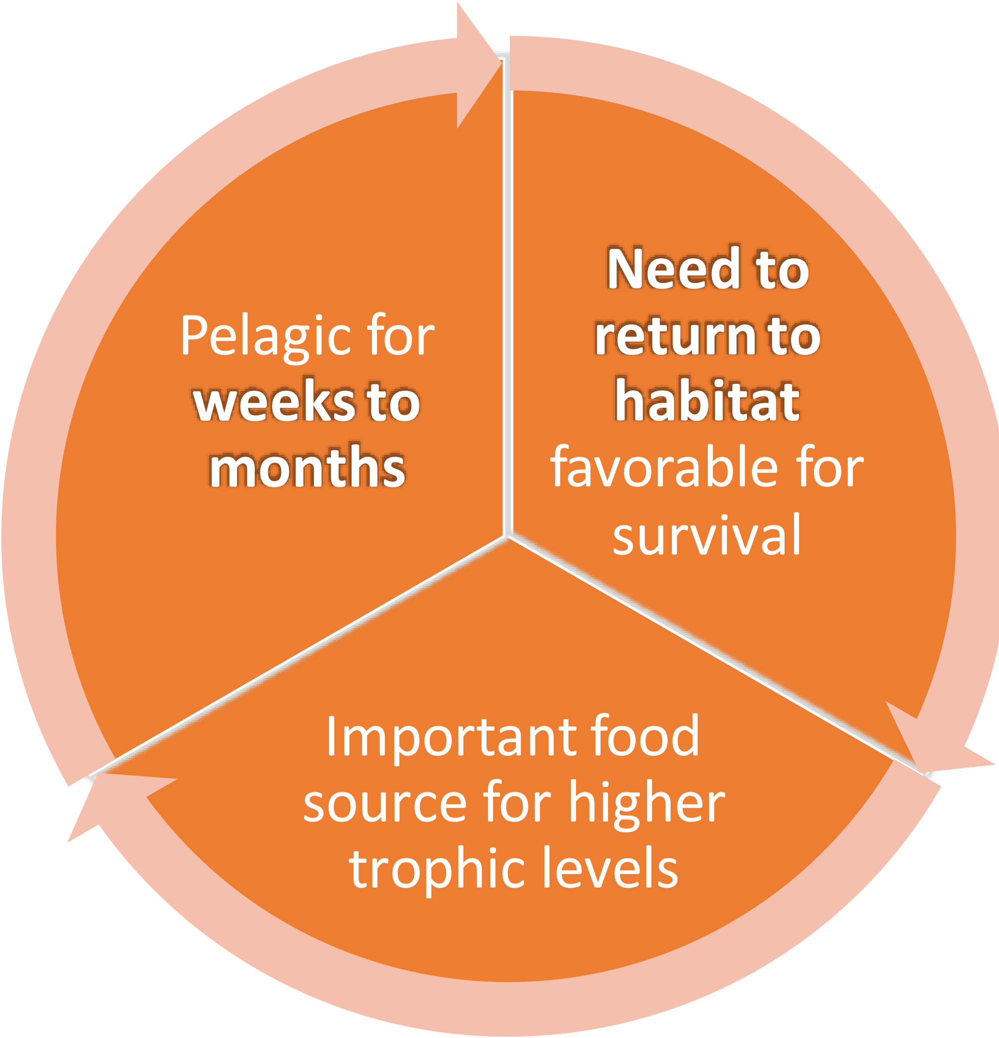
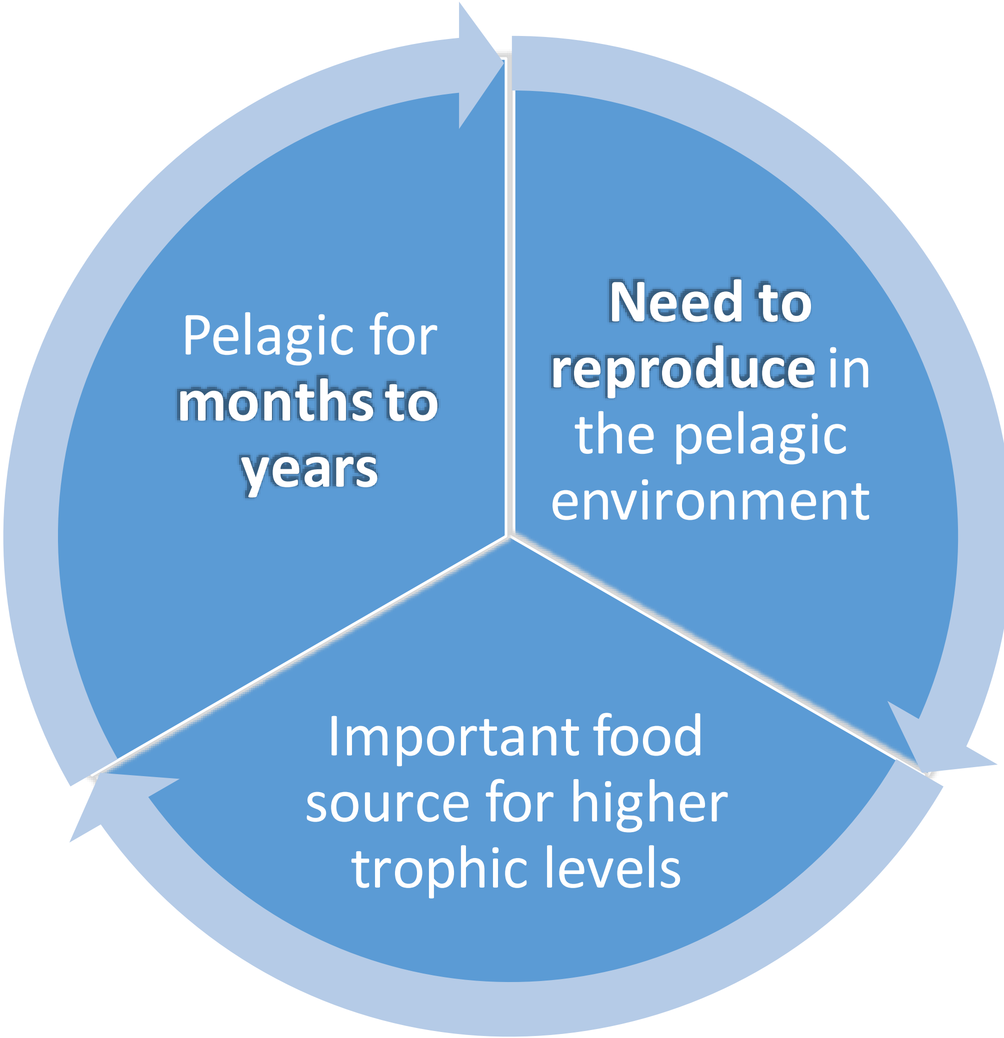
CIMERS
Cooperative Institute for Marine Ecosystem and Resources Studies

OSU Department of Fisheries, Wildlife, and Conservation Sciences

Meroplankton



Holoplankton



Biophysical processes contributing to spatiotemporal variability

Meroplankton

Pelagic *weeks to months*

Need to *settle in suitable habitat*

Adult production → food resources
Transport → source location, dispersal, retention, settlement
Environment → suitable for survival
- temperature

Is there a suite of biophysical processes that best explains the spatiotemporal variation in mero- and holoplankton?

- **Transport**
- **Environment**

Holoplankton

Pelagic *months to years*

Need to *reproduce*

Adult production → food resources
Transport → source location, remain in suitable habitat
Environment → suitable for survival and reproduction
temperature, food, ocean acidification

- **Barnacle larvae**
- **pteropod *Limacina helicina***

Methods- Juvenile Salmon Ocean Ecosystem Survey (JSOES)

Biological sampling

- June 1998 – 2022 (24 years)
- 60 cm 335-um oblique bongo
- All samples collected during the day

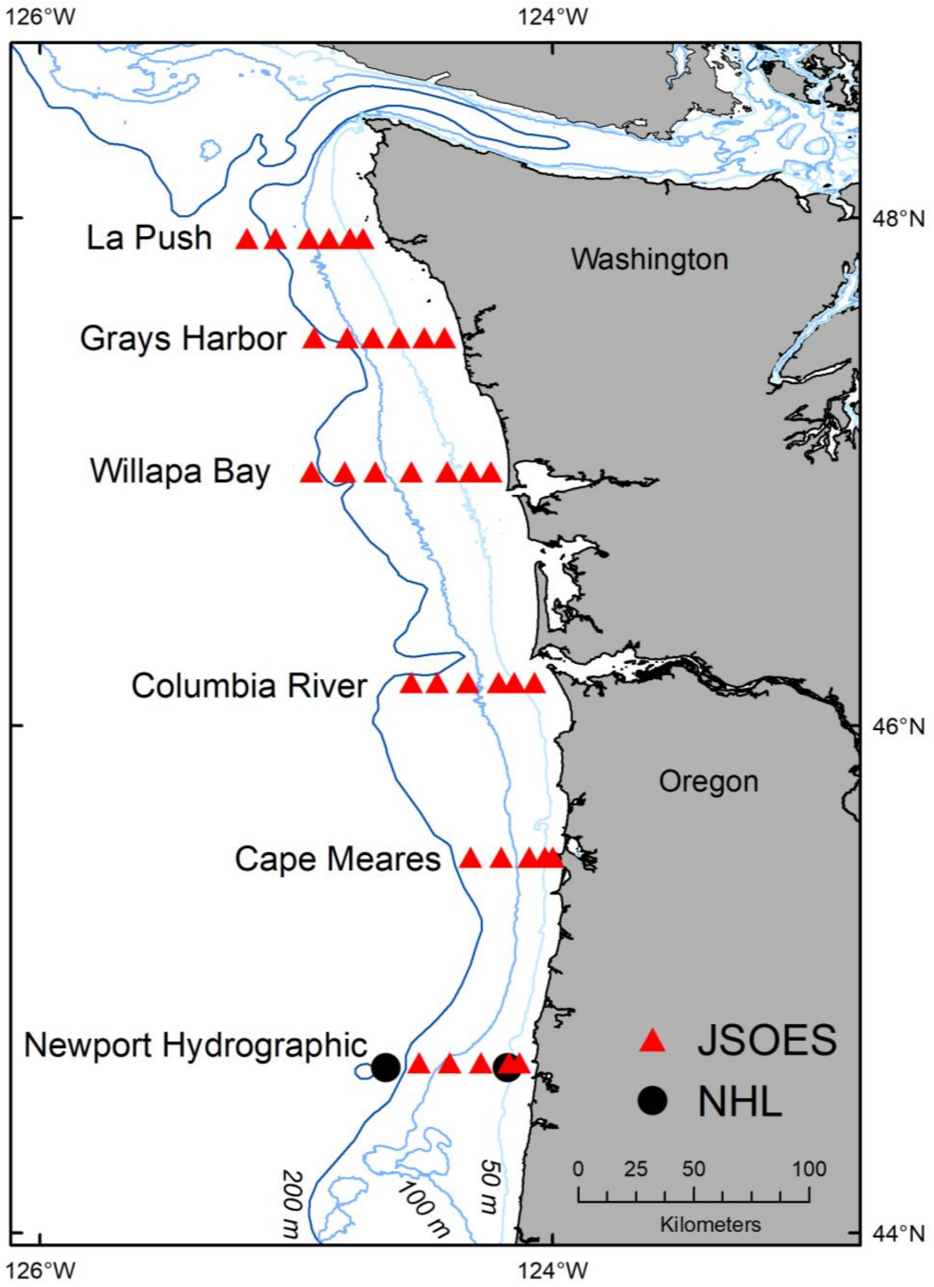
Cheryl Morgan OSU-CIMERS

Environmental data

- Co-located water column data (T, S, Oxy) and surface chlorophyll
- Aragonite saturation derived from T, Oxy (Juranek et al. 2009)

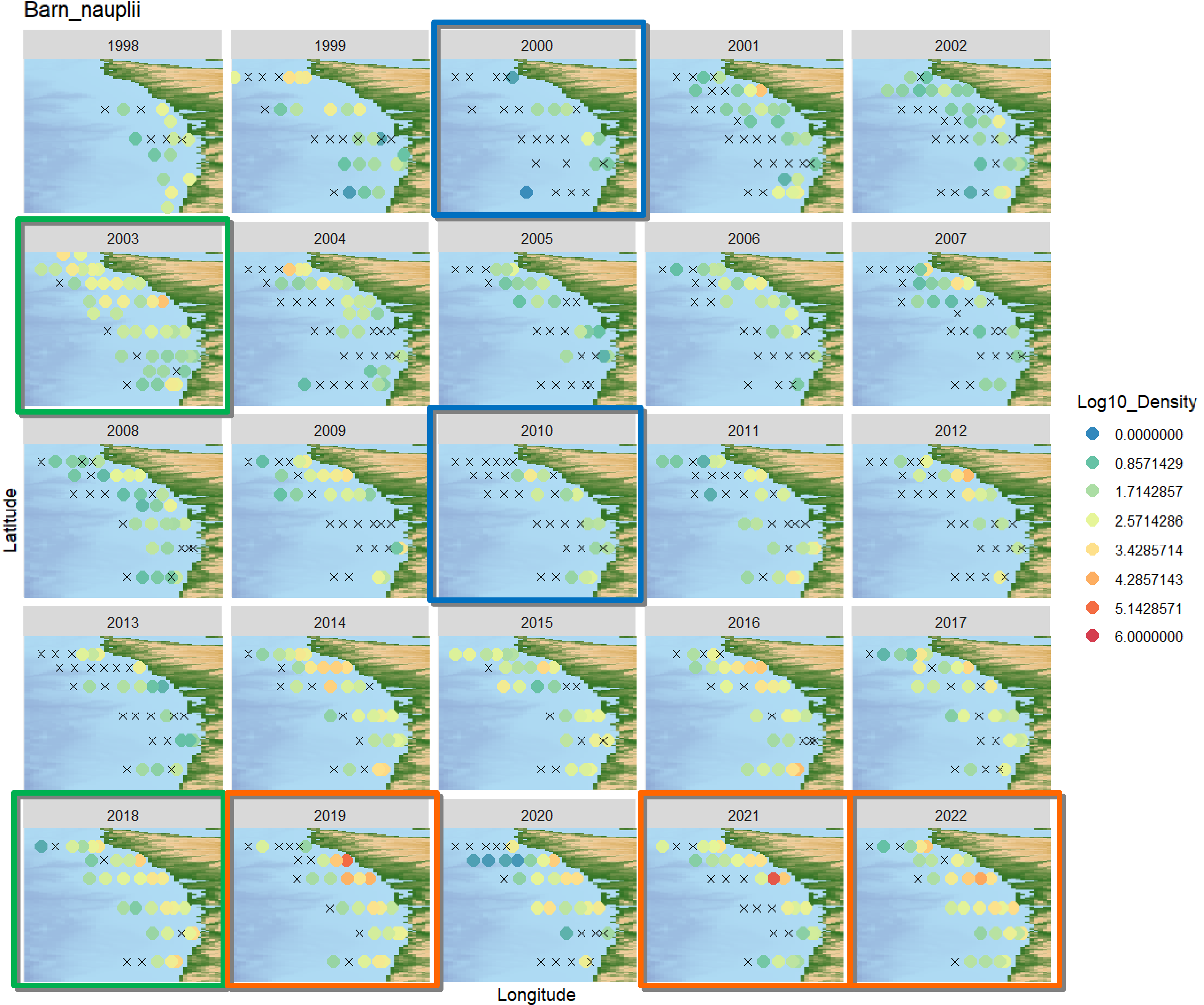
Spatiotemporal modelling

- sdmTMB (R package- Anderson et al. 2024)
- Environmental covariates
  - Upper 20m temperature
  - Extracted Chlorophyll-a
  - % of the water column undersaturated for aragonite
- Tweedie distribution



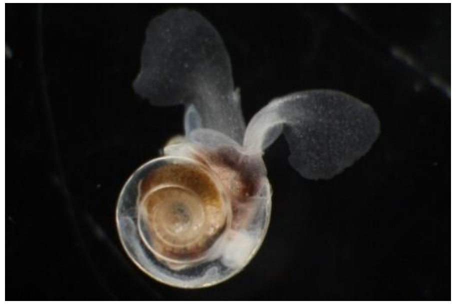
Barnacle nauplii

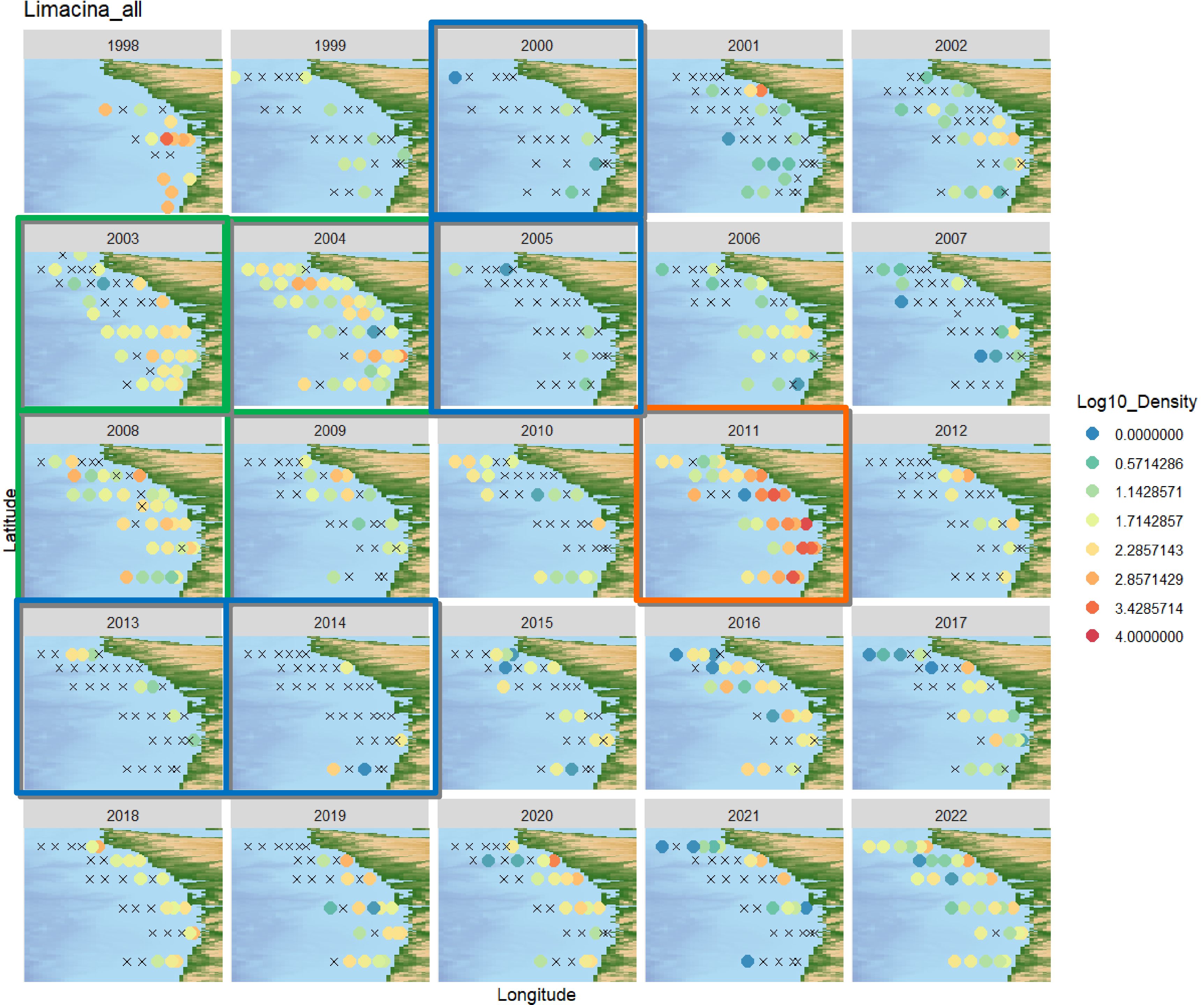
- Adults inhabit rocky shoreline
- PLD ~weeks to 1 month



Limacina helicina

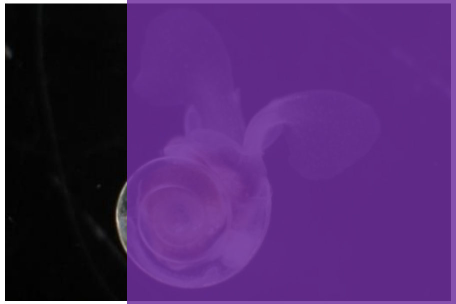
- Life span ~1 year

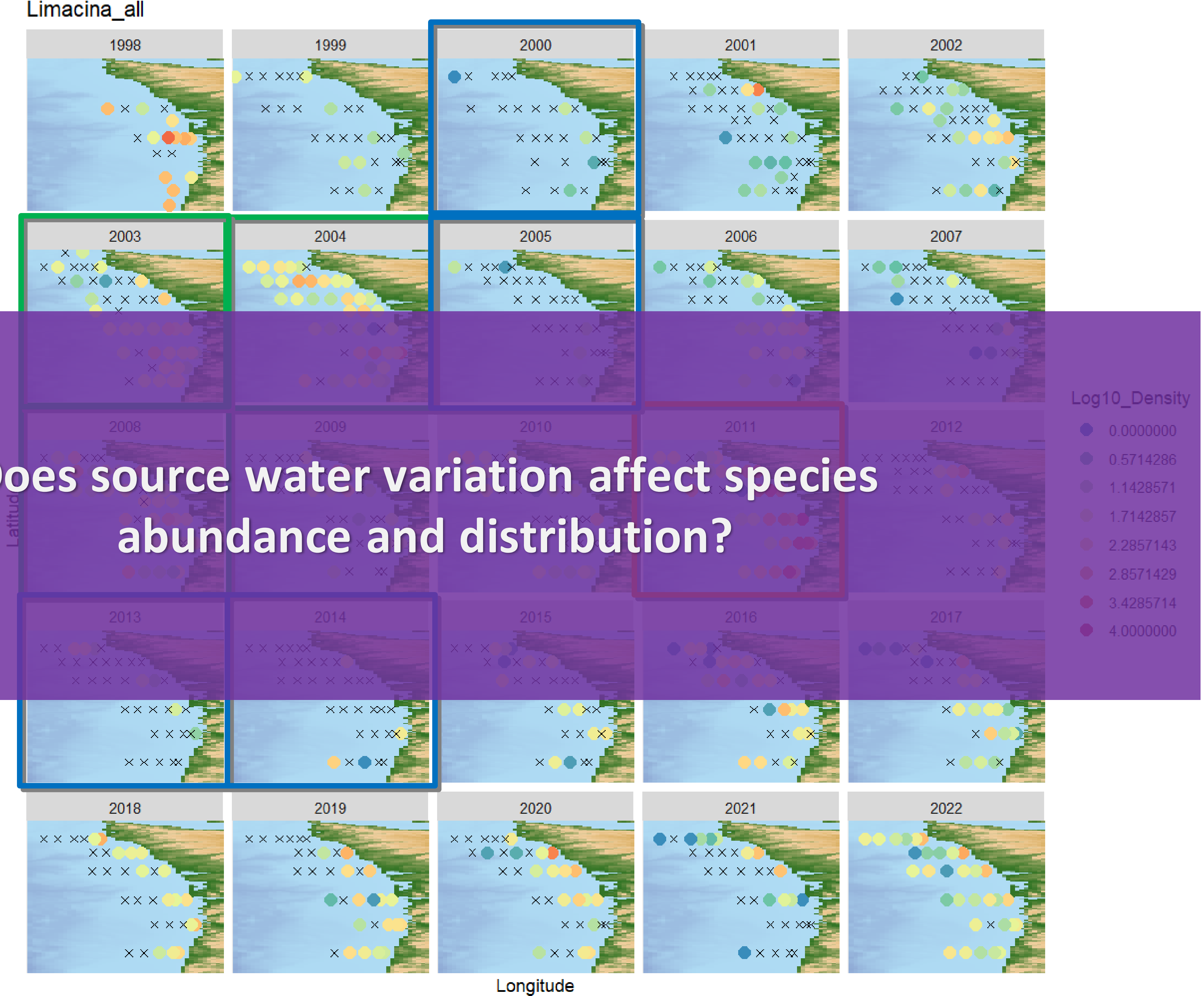




Limacina helicina

- Life span ~1 year





Does source water variation affect species abundance and distribution?

ROMS and particle tracking

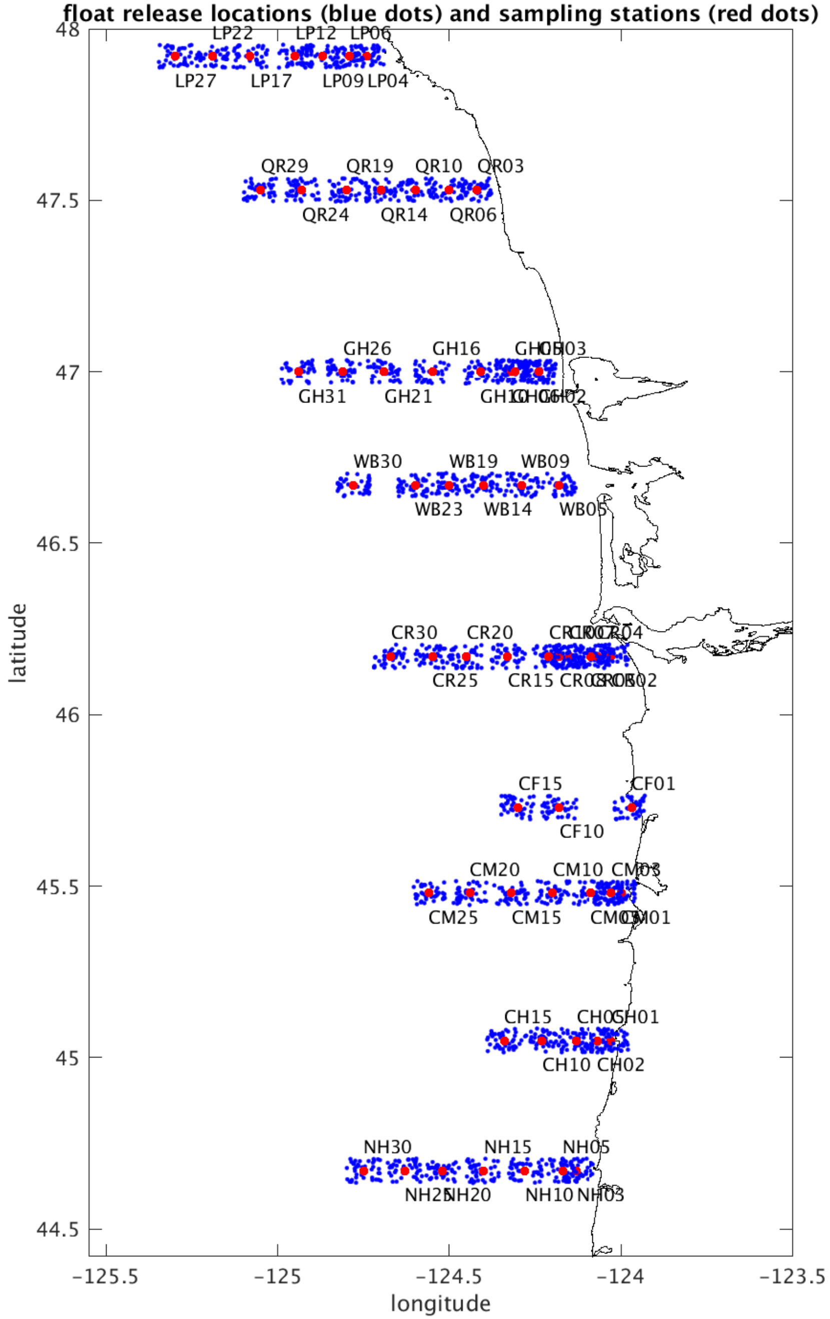
ROMS model

- 2.5 to 3.7 km spatial resolution
- 42 vertical levels
- domain 30°N – 48°N (northern WA)

Backwards Lagrangian particle tracking

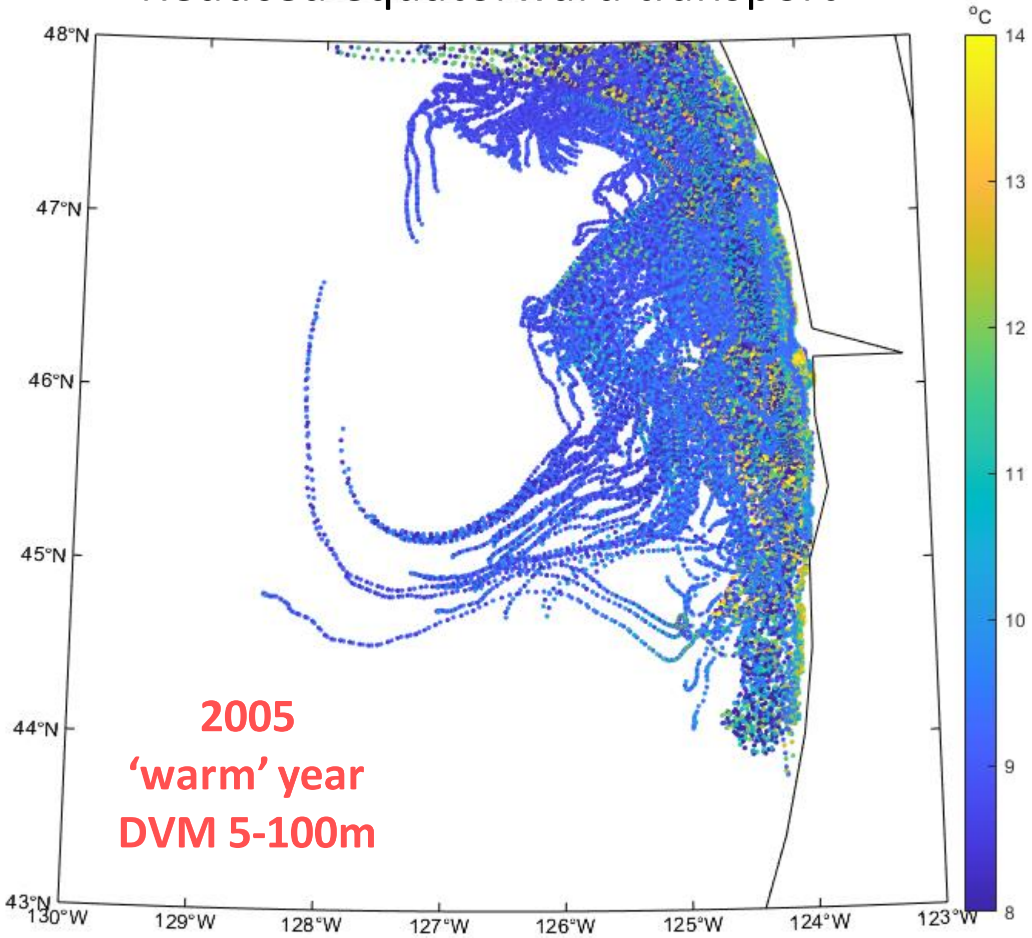
- 60 stations
- 50 floats released at each station daily from July 10 (mean plankton sampling date June 20)
- Tracked backwards 120 days

- 6 vertical migration patterns
  - Passive
  - 5m- in the surface boundary layer
  - 12m- below the surface boundary layer
  - 30m- below the surface boundary layer
  - DVM- 5 – 30m
  - **DVM- 5 – 100m**

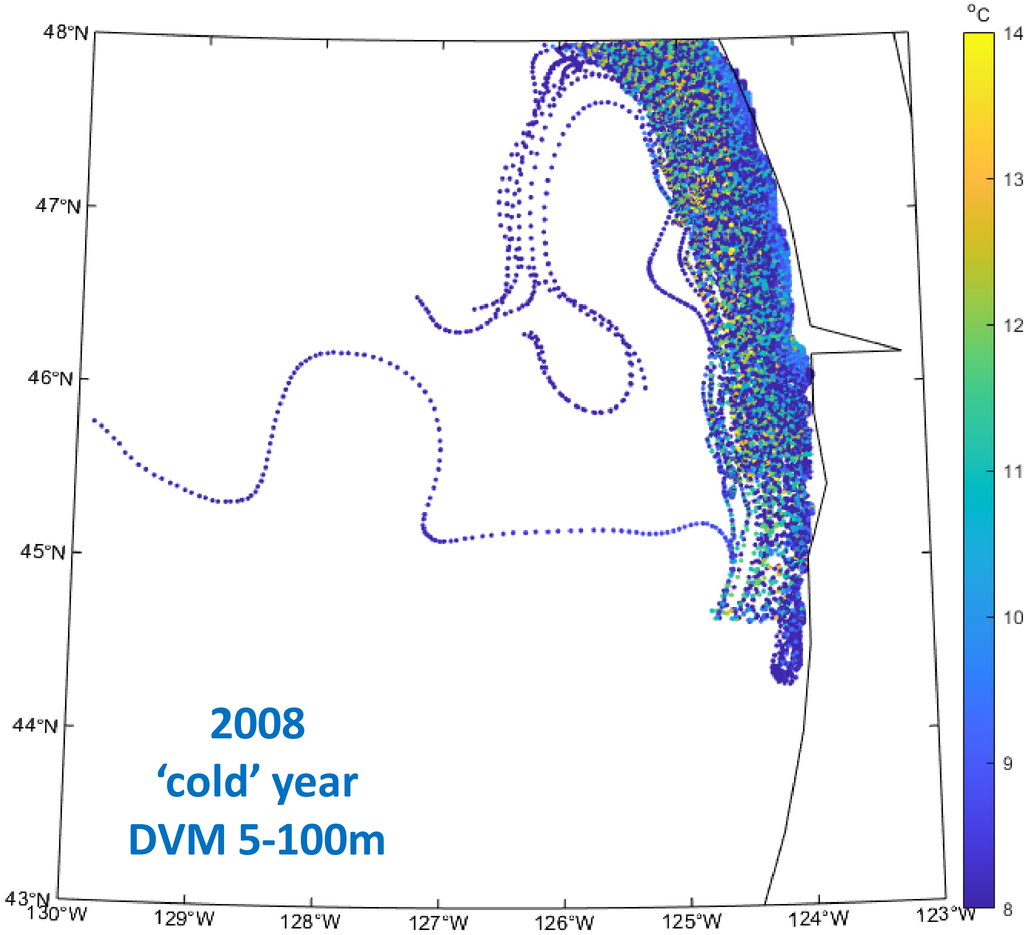


Float tracers tracked backwards in time 90 days

2005
Warm year
Delayed upwelling
Reduced equatorward transport

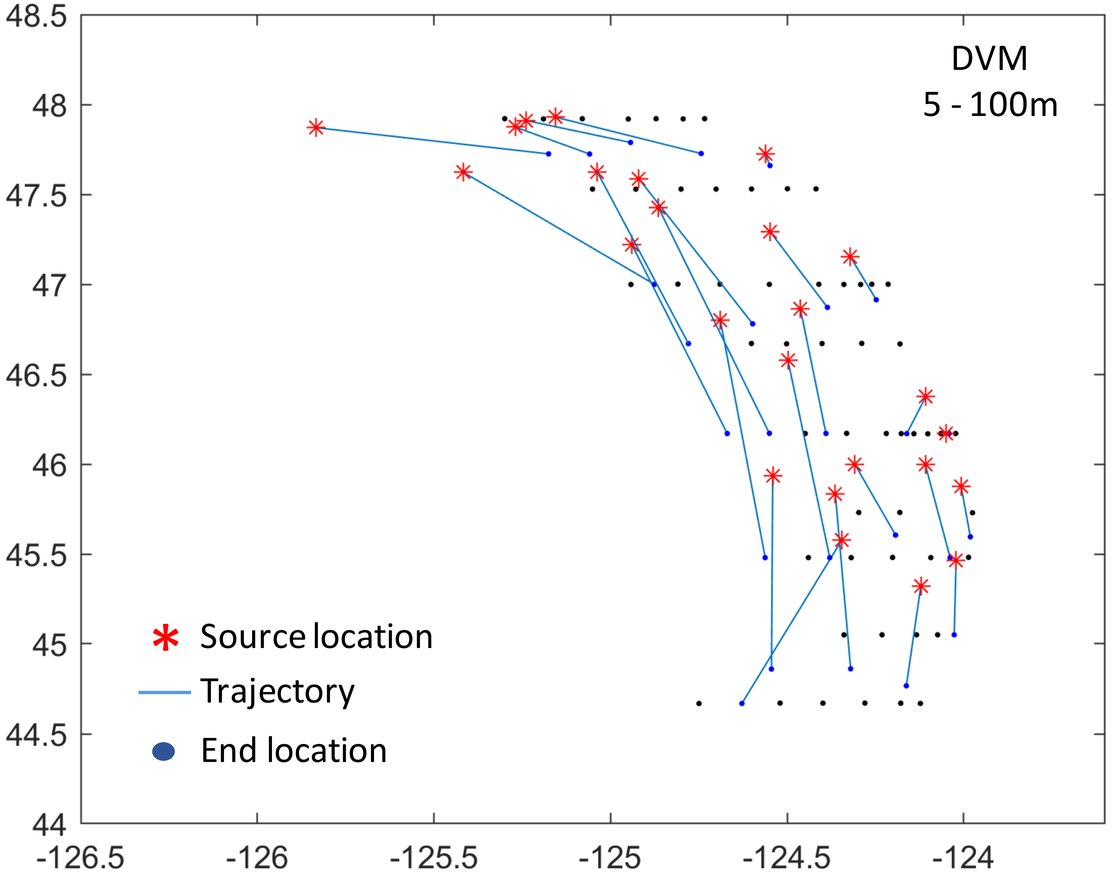


2008
Cold year
Strong equatorward transport



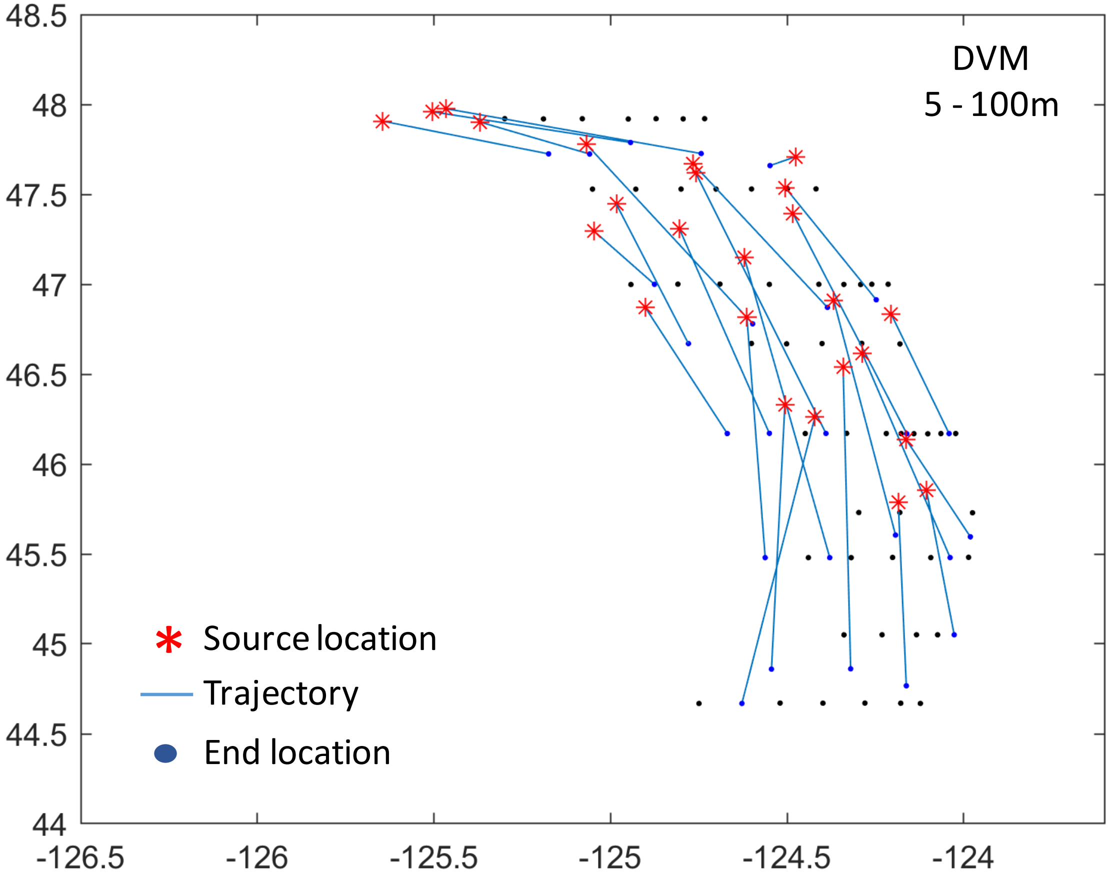
Source water location 15 days prior to sampling

2005 warm year



Weaker alongshore flow inshore

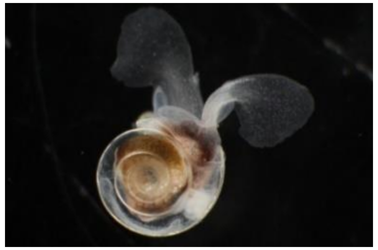
2008 cold year



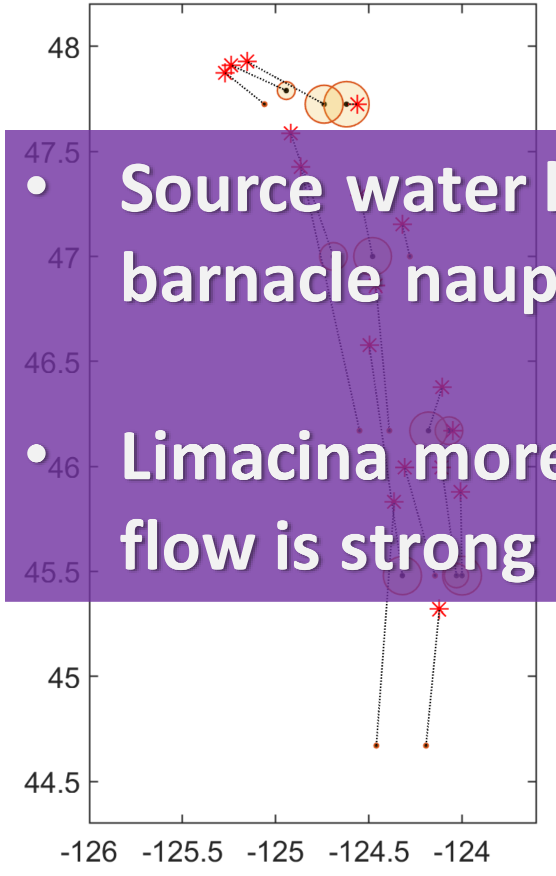
Stronger alongshore flow at all stations

Barnacle nauplii

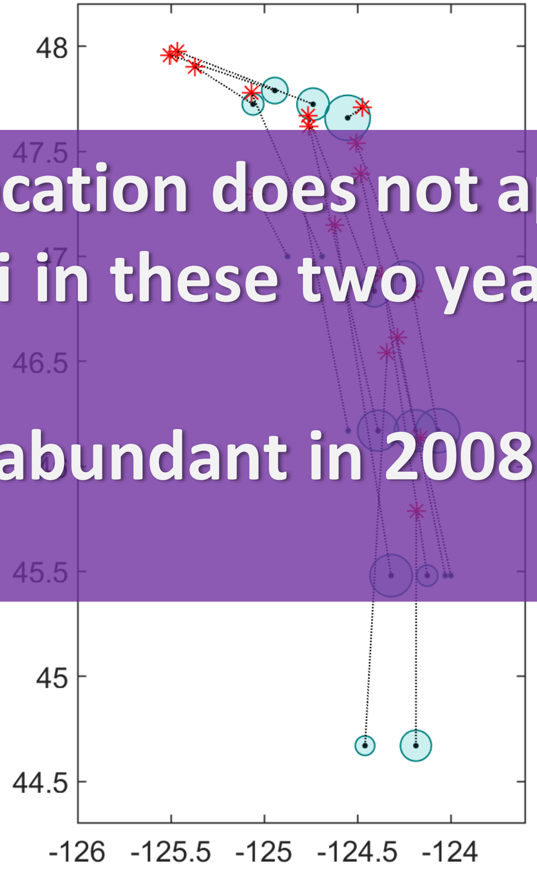
Limacina helicina



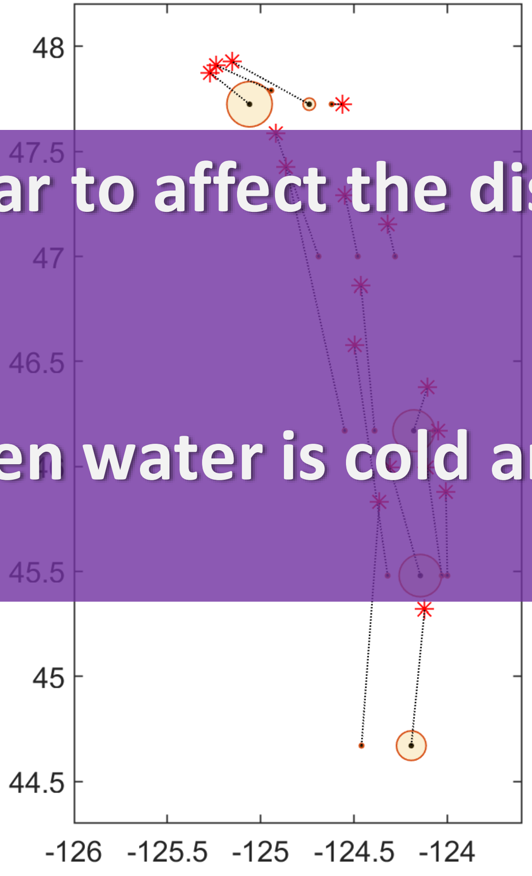
2005
DVM 5 – 100m



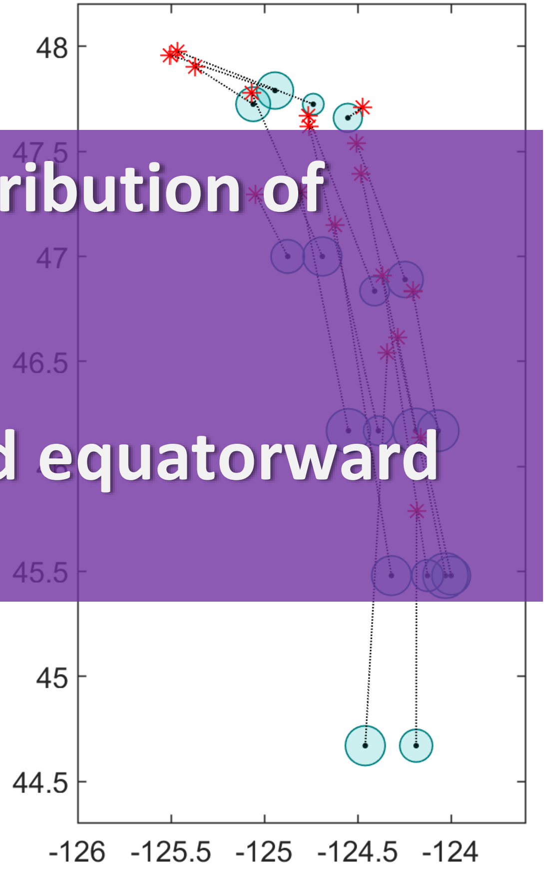
2008
DVM 5 – 100m



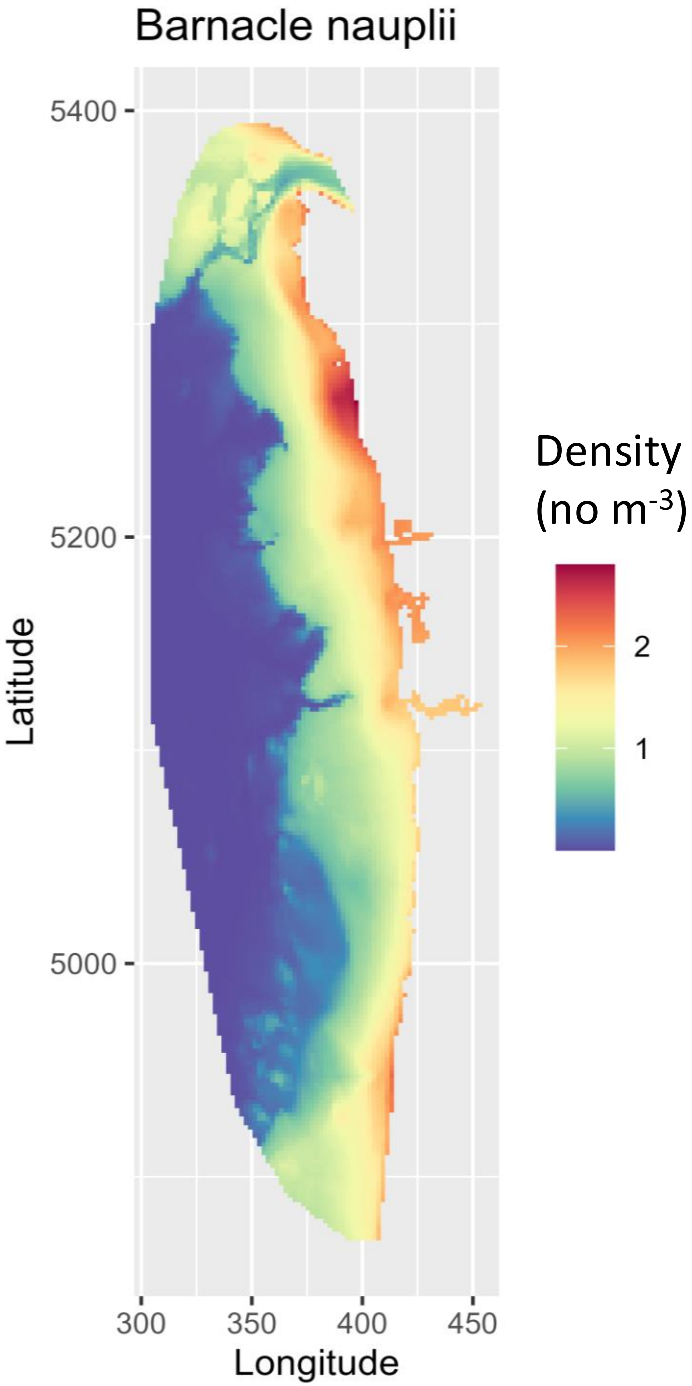
2005
DVM 5 – 100m



2008
DVM 5 – 100m

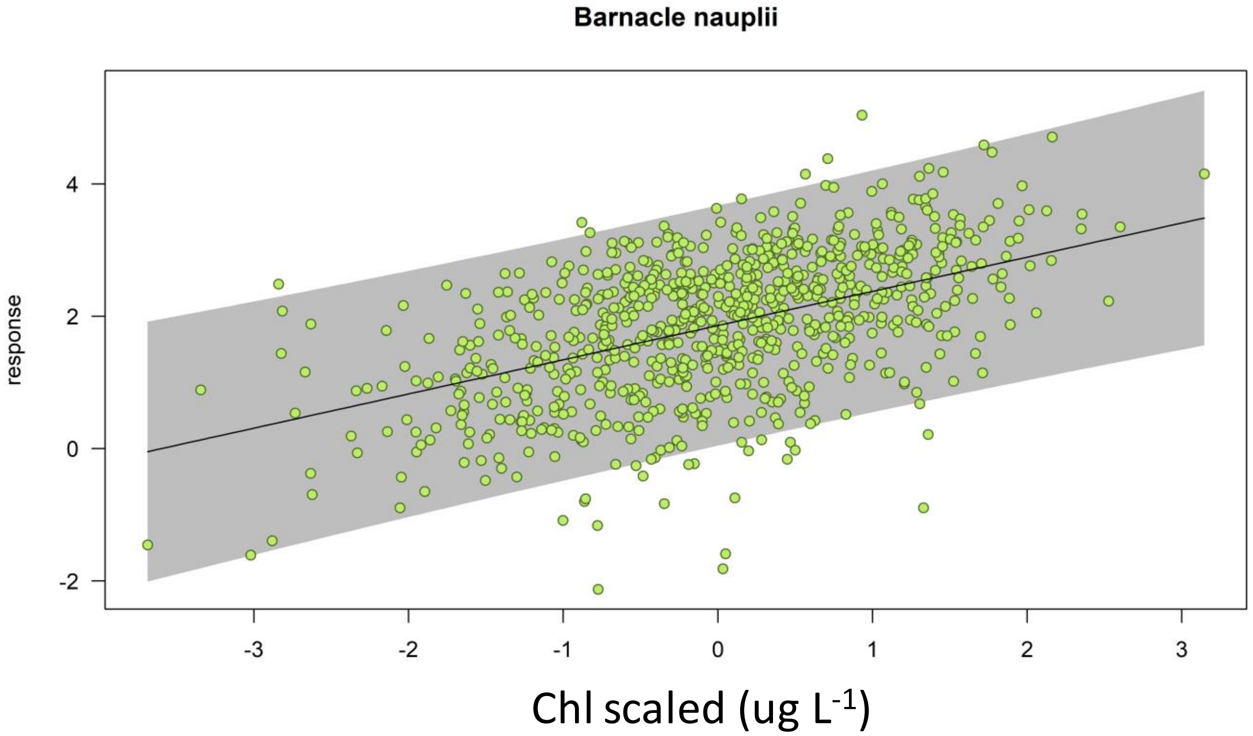


- **Source water location does not appear to affect the distribution of barnacle nauplii in these two years**
- **Limacina more abundant in 2008 when water is cold and equatorward flow is strong**



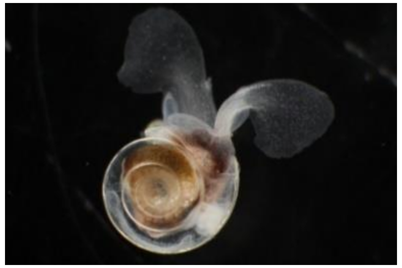
Barnacle nauplii

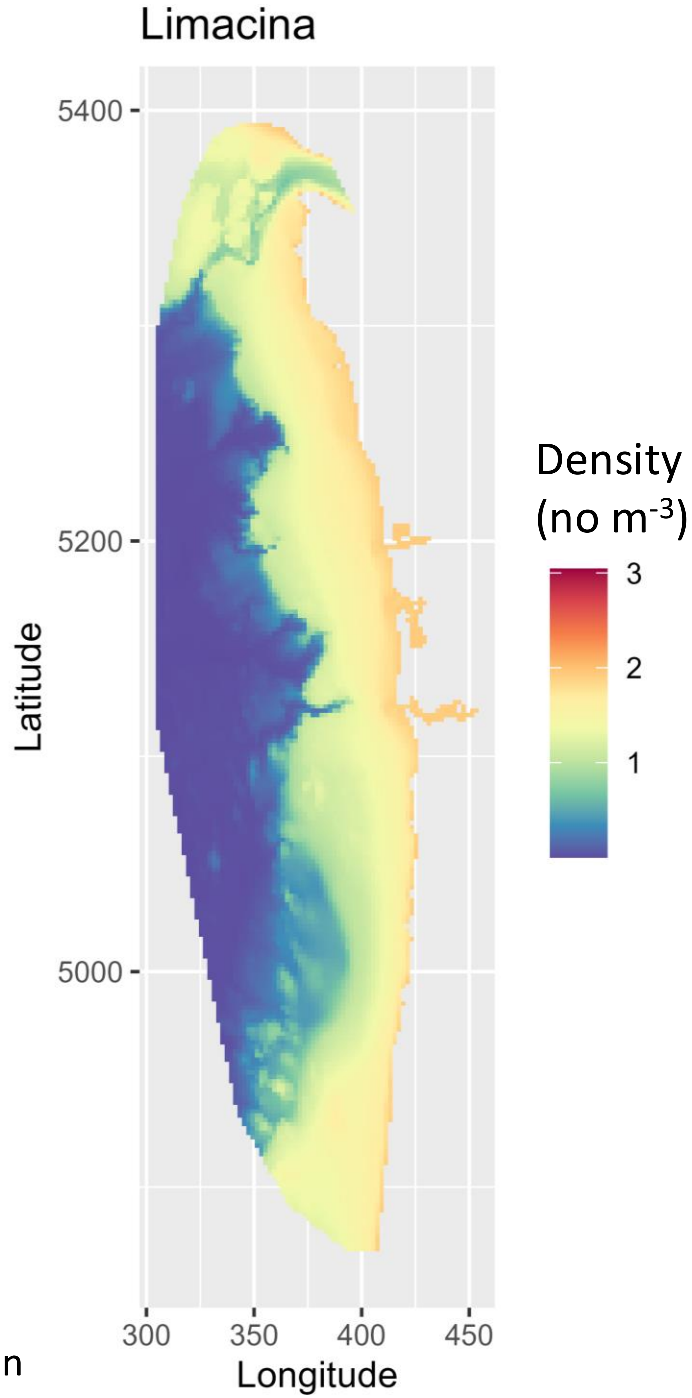
Density ~ 1 + depth + chl



Environment or adult reproduction?

Full model:
Density ~ 1 +
depth +
chl +
20m temp

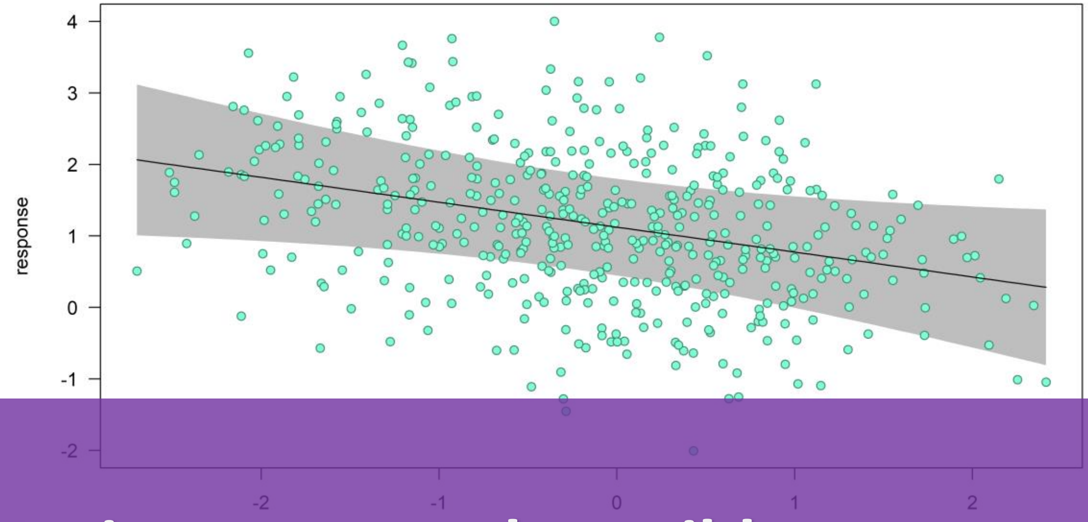




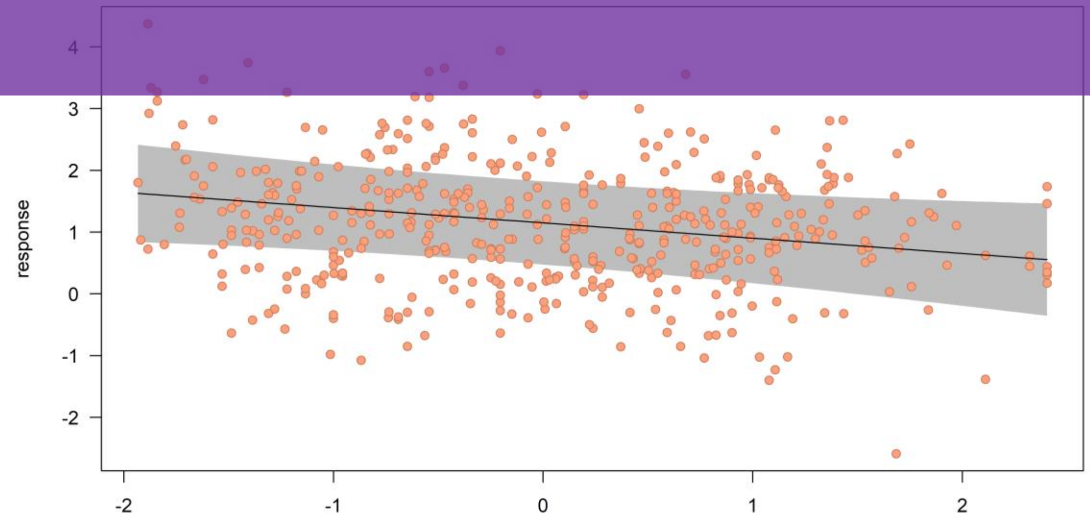
Full model:
Density ~ 1 +
depth +
chl +
20m temp +
aragonite saturation

Limacina helicina

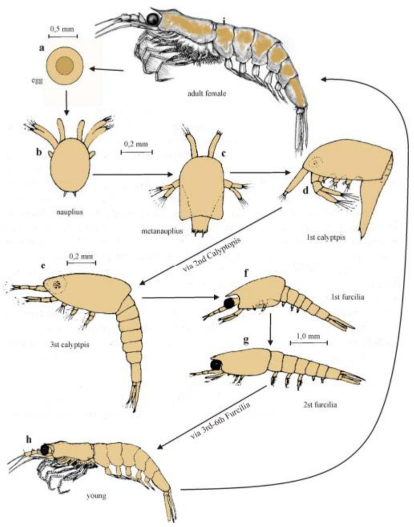
density ~ 1 + depth + temperature + aragonite saturation



Environment and possibly transport?



Common patterns across other taxa?



Brinton 2000

Euphausia pacifica		
calyptopis	density ~ 1	
furcilia	density ~ 1 + depth + temp + chlorophyll	more offshore, cooler temps, less chl

Thysanoessa spinifera		
calyptopis	density ~ 1	
furcilia	density ~ 1 + depth + temp	more nearshore, cooler temps

- Adults inhabit intertidal cobble fields
- PLD ~1.5 months

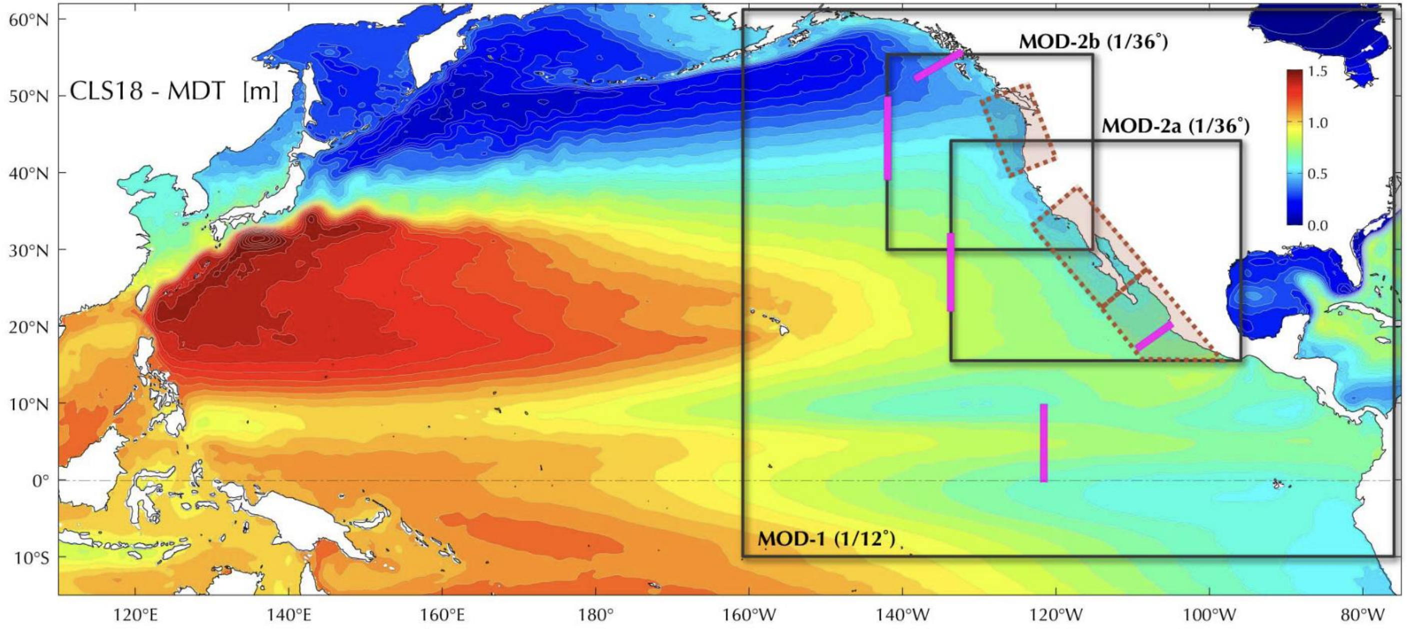
Porcellanidae		
Zoeae I	density ~ 1 + depth	more nearshore
Zoeae II	density ~ 1 + depth + temp + chlorophyll	warmer temps, more chl
Megalopae	density ~ 1 + depth + temp + chlorophyll	warmer temps, more chl

Summary

- It’s complicated!!
- Transport didn’t appear to play a strong role, but it might be more important if we track floats back longer than 15 days
- Environmental factors were more important for taxa that had been in the pelagic environment longer
  - *Limacina helicina*
  - Krill furcilia (2 species)
  - Porcellanid zoeae II and megalopae
- Difficult to infer mechanism with only annually resolved data
- A more sophisticated modeling technique that incorporates stage based survival could help ellucidate what environmental drivers are explaining these complex spatiotemporal patterns?
  - David Green S16- KRILLPODYM

Next steps:

- Run similar analysis for all 24 years using ROMS with larger domain



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Advisor: Melanie Fewings

Develop user-friendly GUI to track particles

- Investigate whether vertical migration behaviors affect source water location
- Add additional covariates to the SDM modelling
  - Alongshore flow
  - Proximity to estuaries

Thanks for listening!

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- Kim Bernard
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