Meter-scale plankton distribution across a mesoscale front

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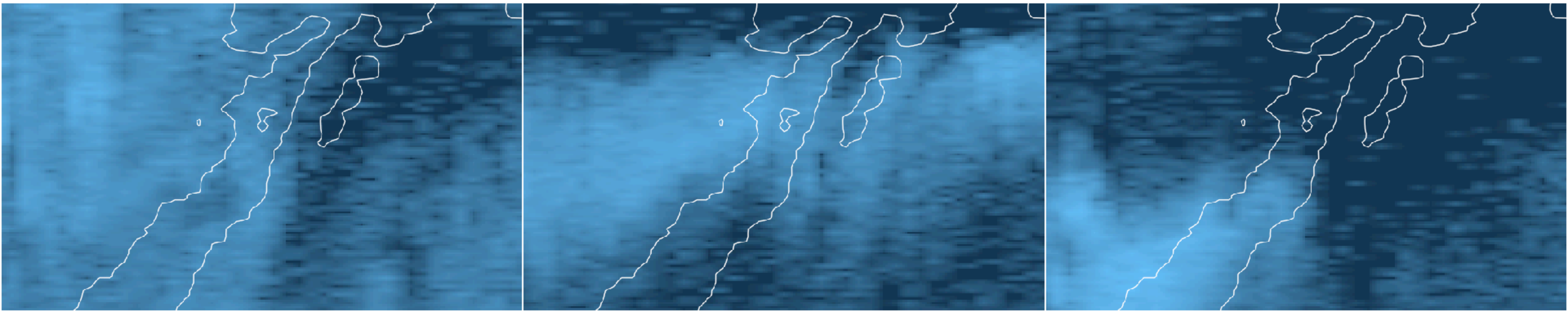
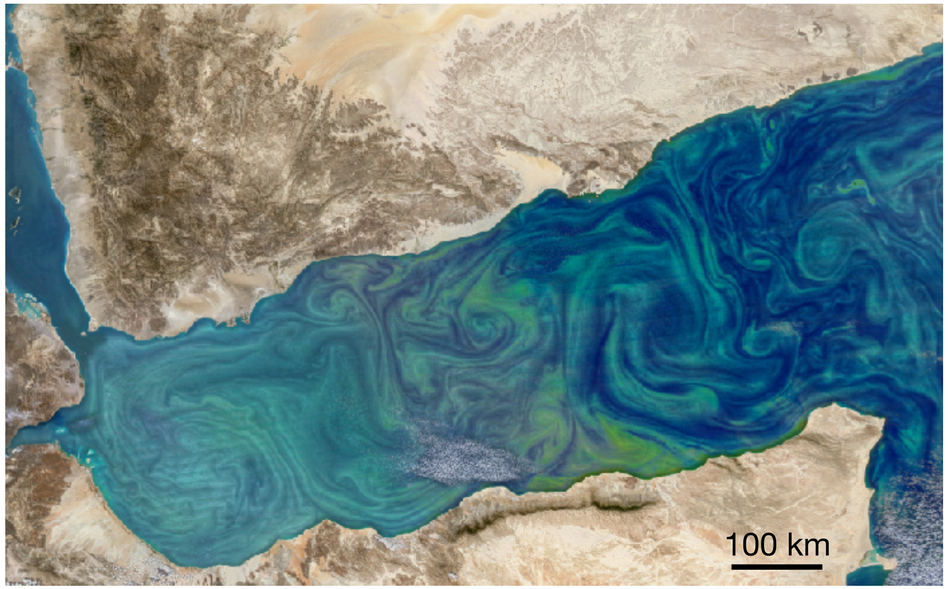
Thelma Panaïotis



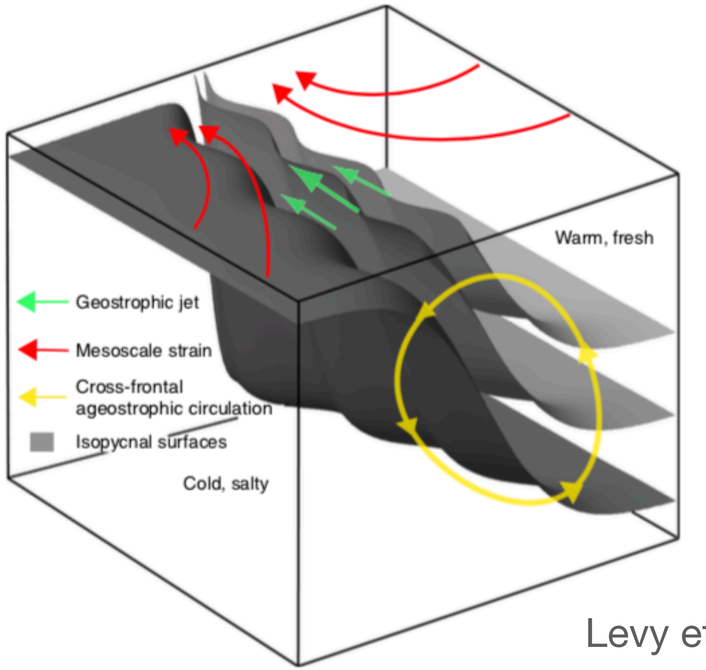
Submesoscale dynamics

Submesoscale

- 1-10 km in horizontal
- 100 m in vertical
- 1 day in time



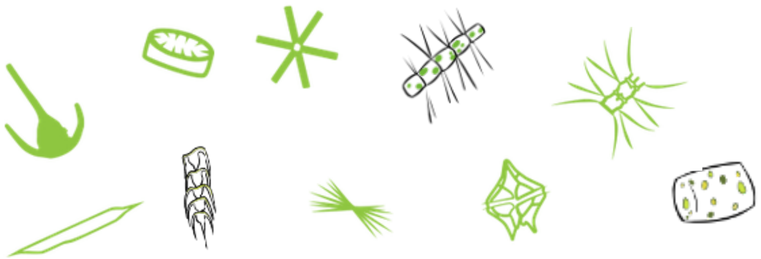
Adapted from Levy et al., 2018
Image credit: NASA

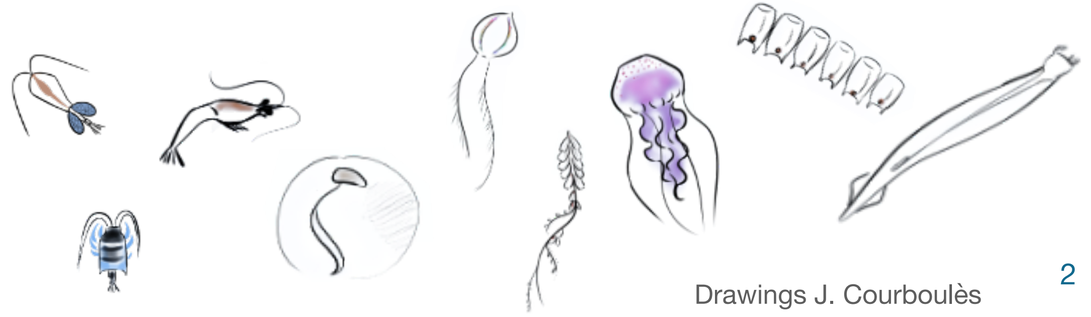


Levy et al., 2018

Frontal submesoscale dynamics

Documented effects on phytoplankton → Effects on higher trophic levels?





Drawings J. Courboulès

(Zoo)plankton sampling tools

Nets, pumps, bottles

- lack of spatio-temporal resolution
- separation between environment and organisms

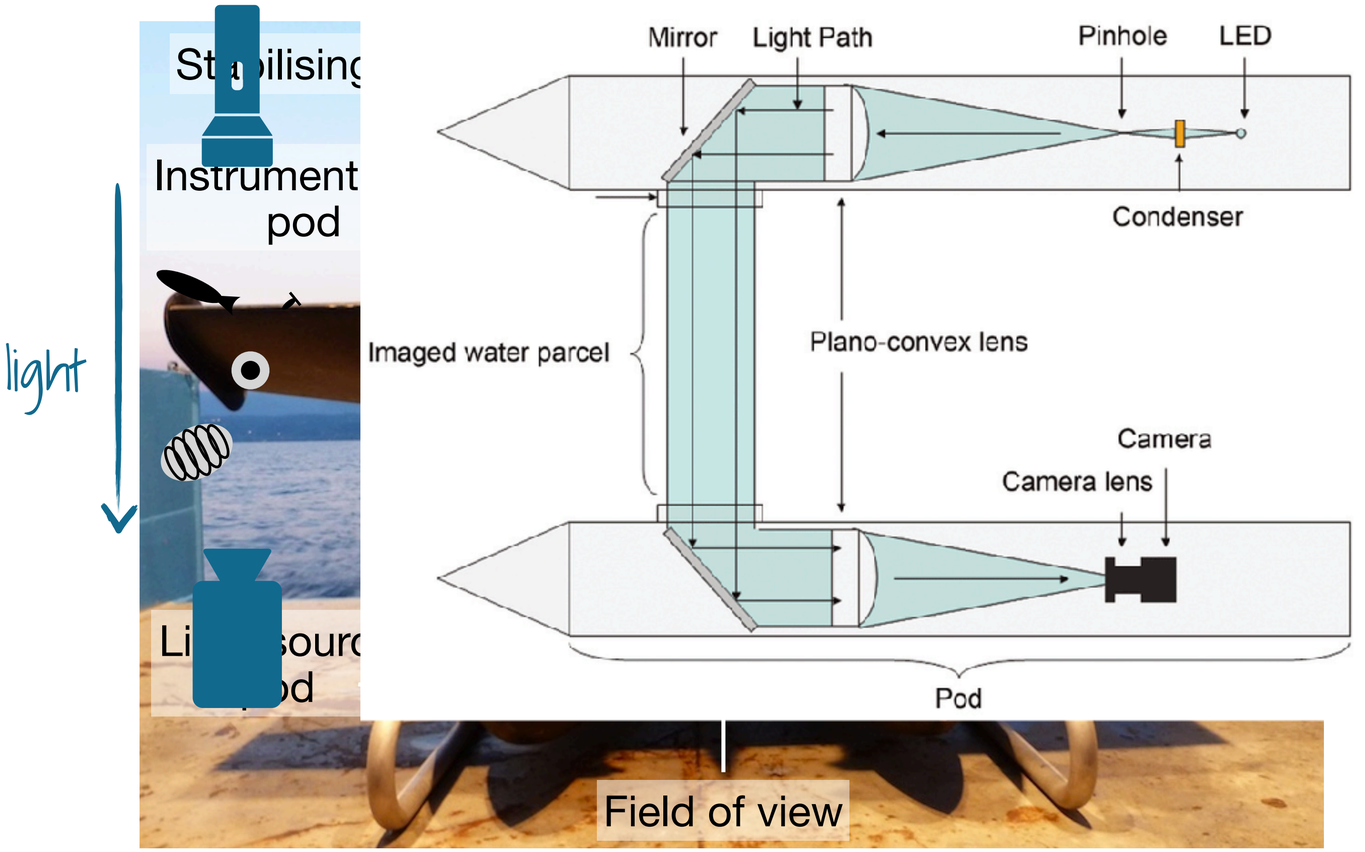
In situ imaging

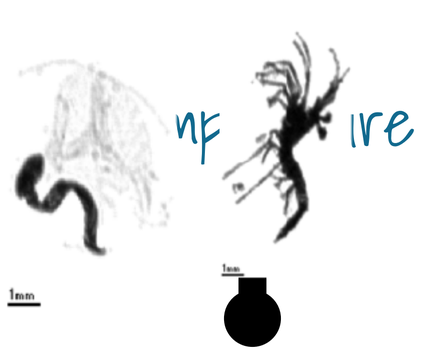
- High spatio-temporal resolution
- Interaction environment - organisms

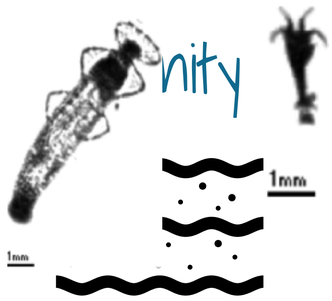
ISIIS

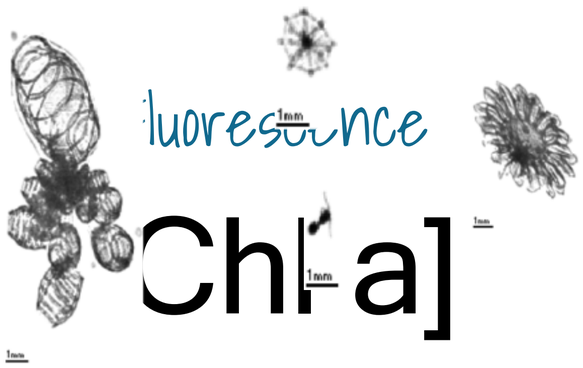
In Situ Ichthyoplankton Imaging System

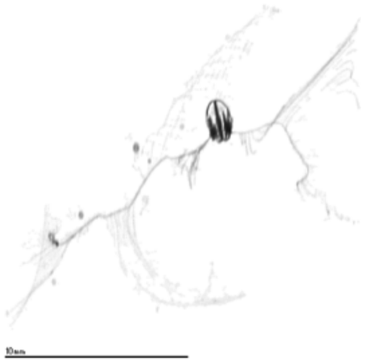
- organisms in 250 µm - 10 cm
- tow-yo
- shadowgraphy, deep depth of field
- high sampling rate (108 L.s^{-1})
- records environmental data

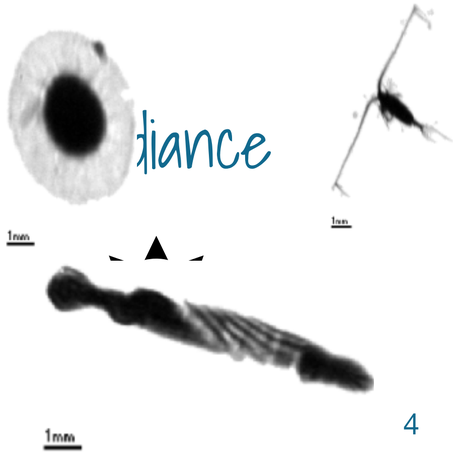










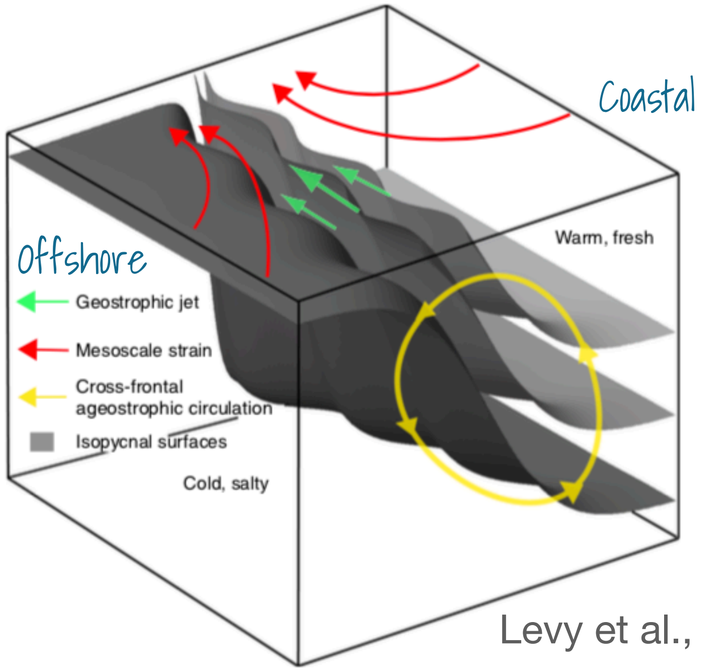


Cowen et al., 2008

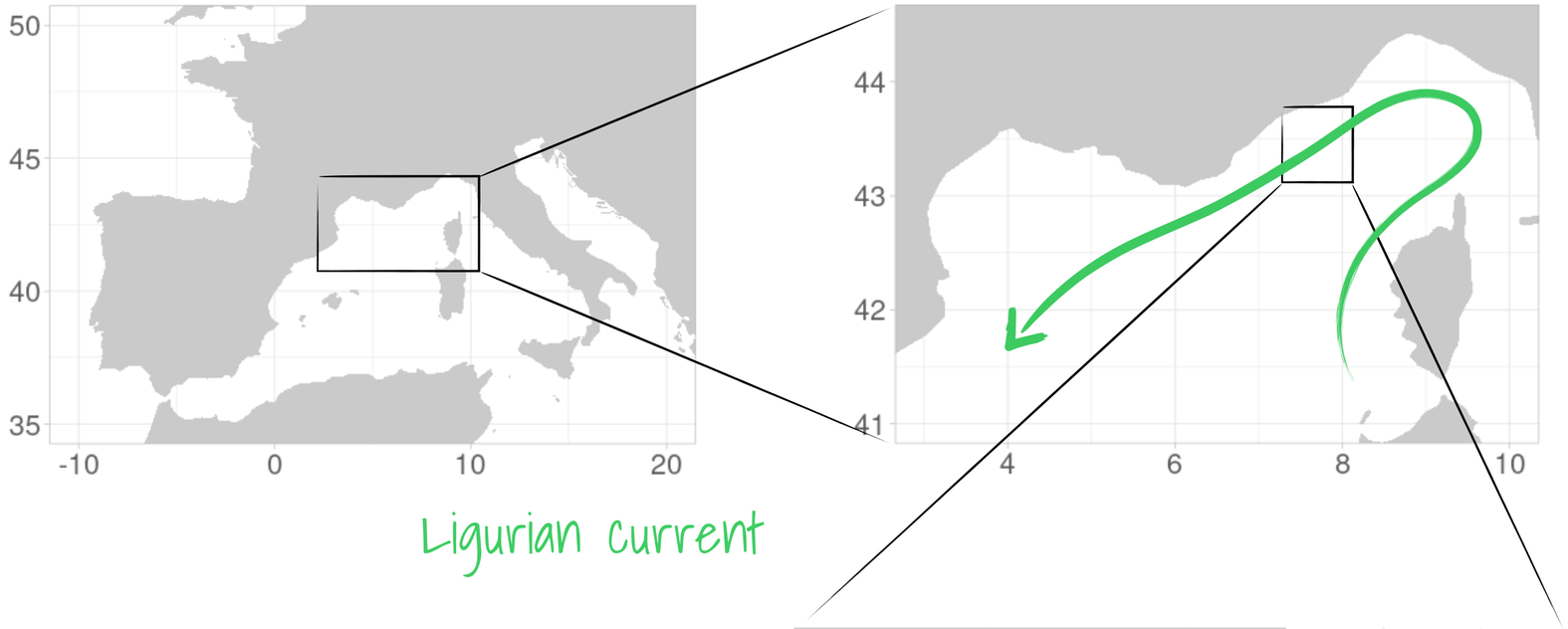
Study area

Sampling plan

- NW Mediterranean Sea
- July 2013 (1 week)
- Study Ligurian Current & Front

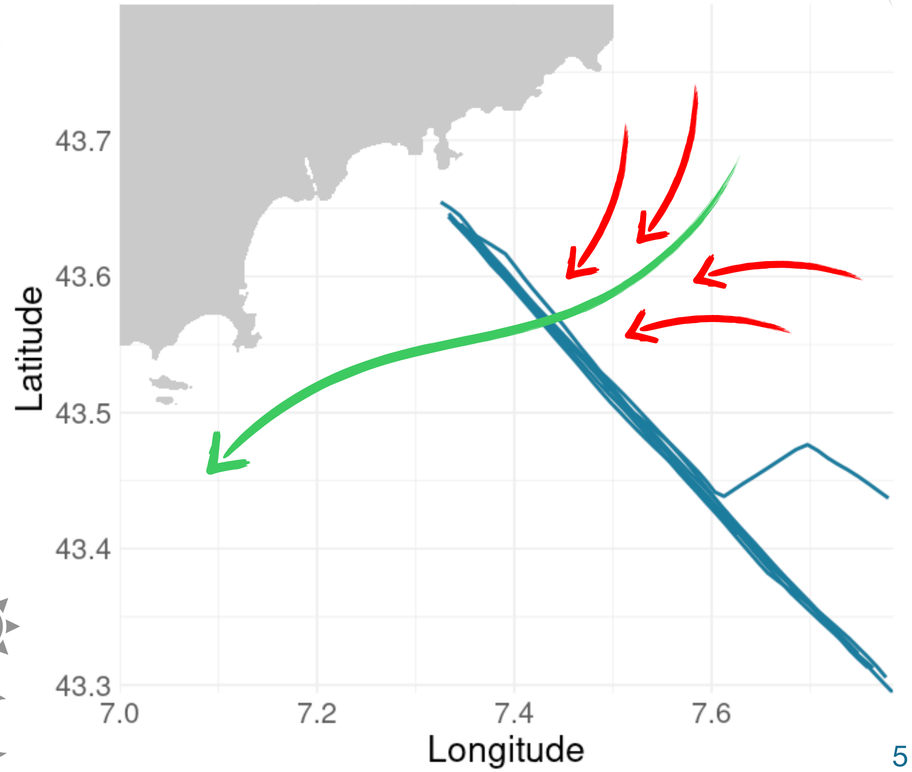


Levy et al., 2018



Ligurian current

Map of VISUFRONT campaign

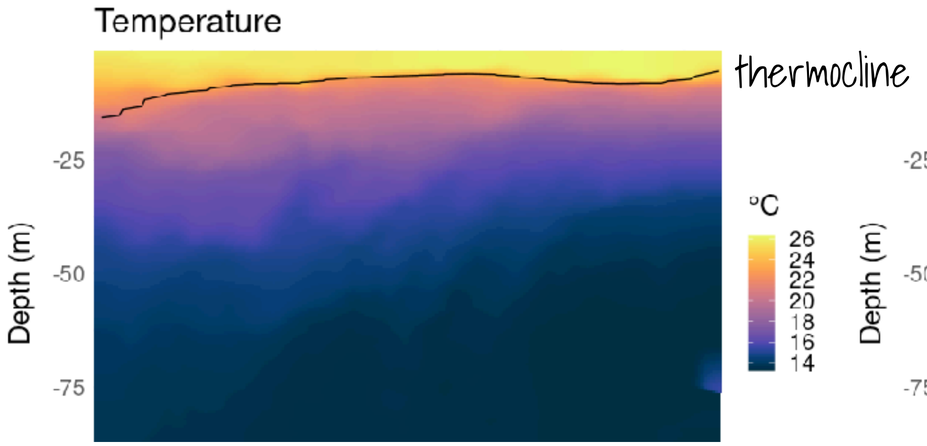


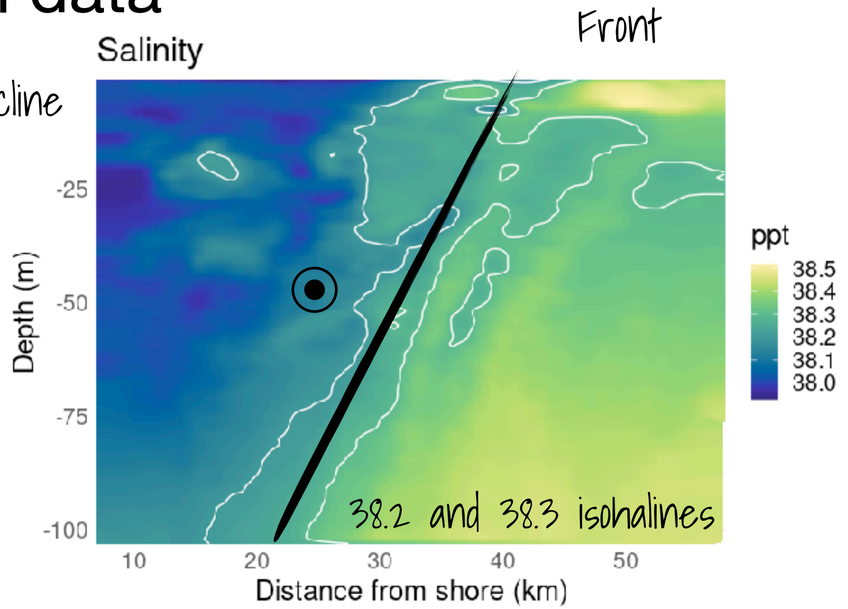
4 day transects

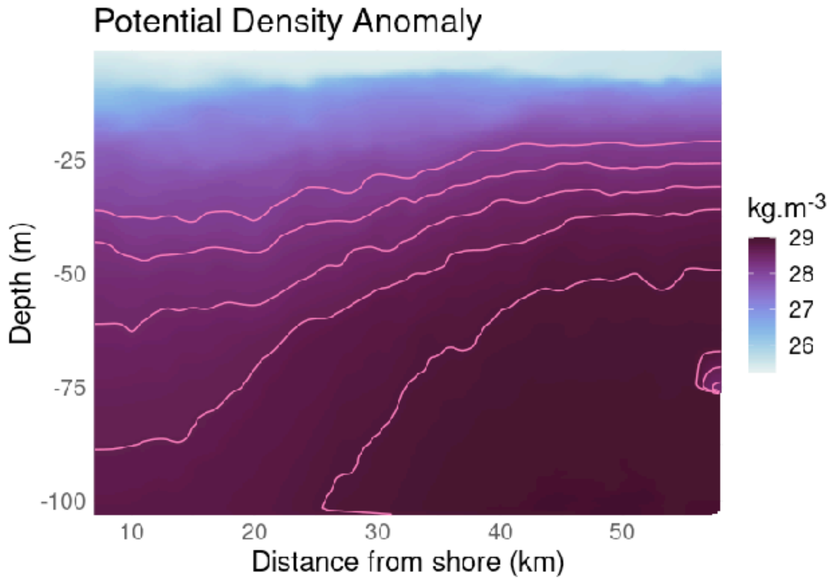
3 night transects

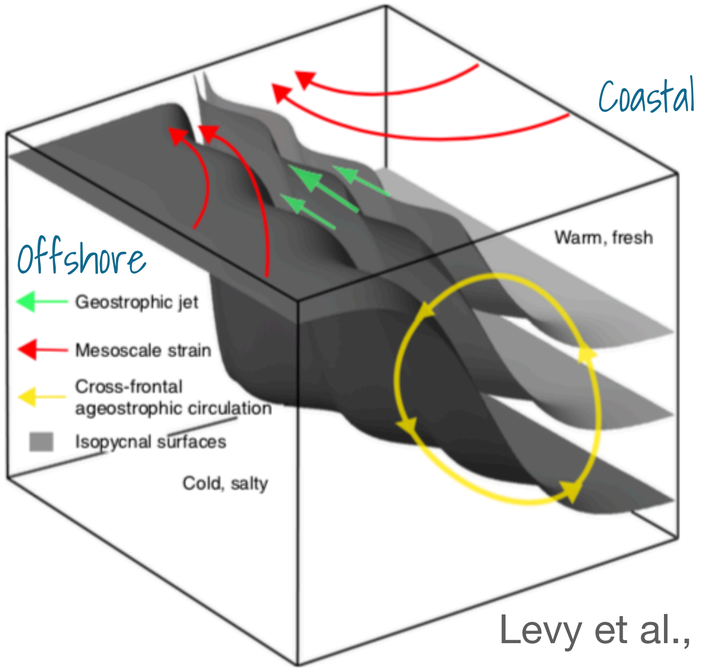
Study area

Interpolated environmental data

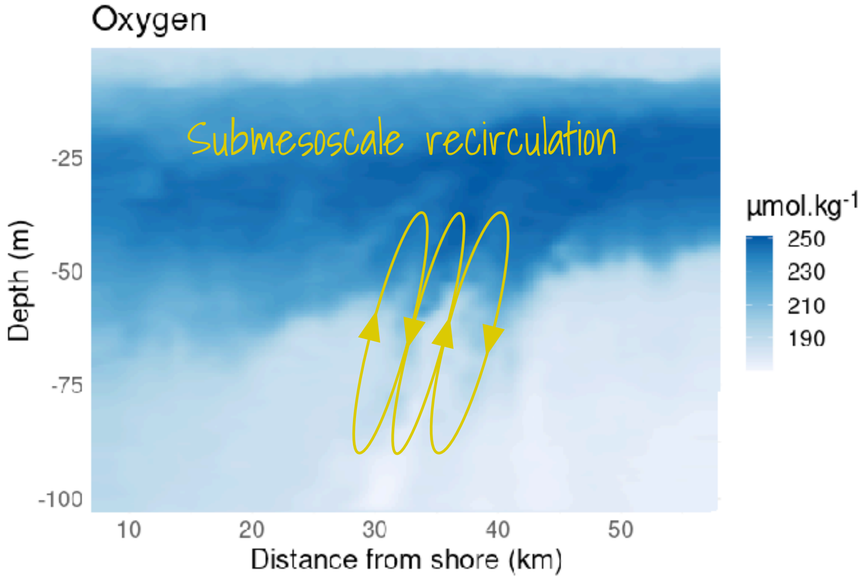








Levy et al., 2018



Strong hydrological signature

Well marked stratification

Oligotrophy

Submesoscale recirculation cells

Influence of front on (zoo)plankton distribution at fine scale

Data processing

A two steps pipeline

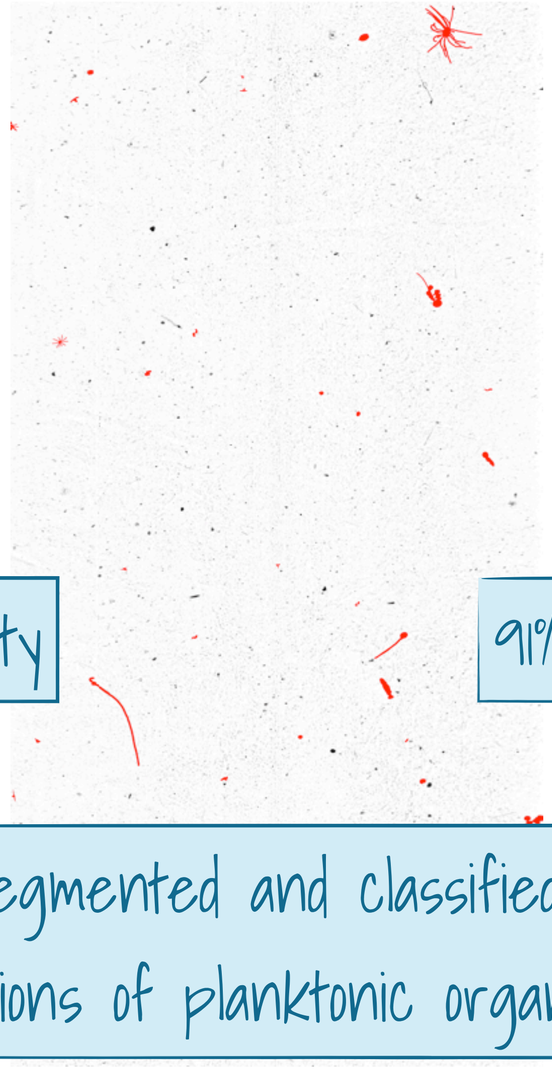
Fully automated pipeline

Apeep

https://github.com/jiho/apeep

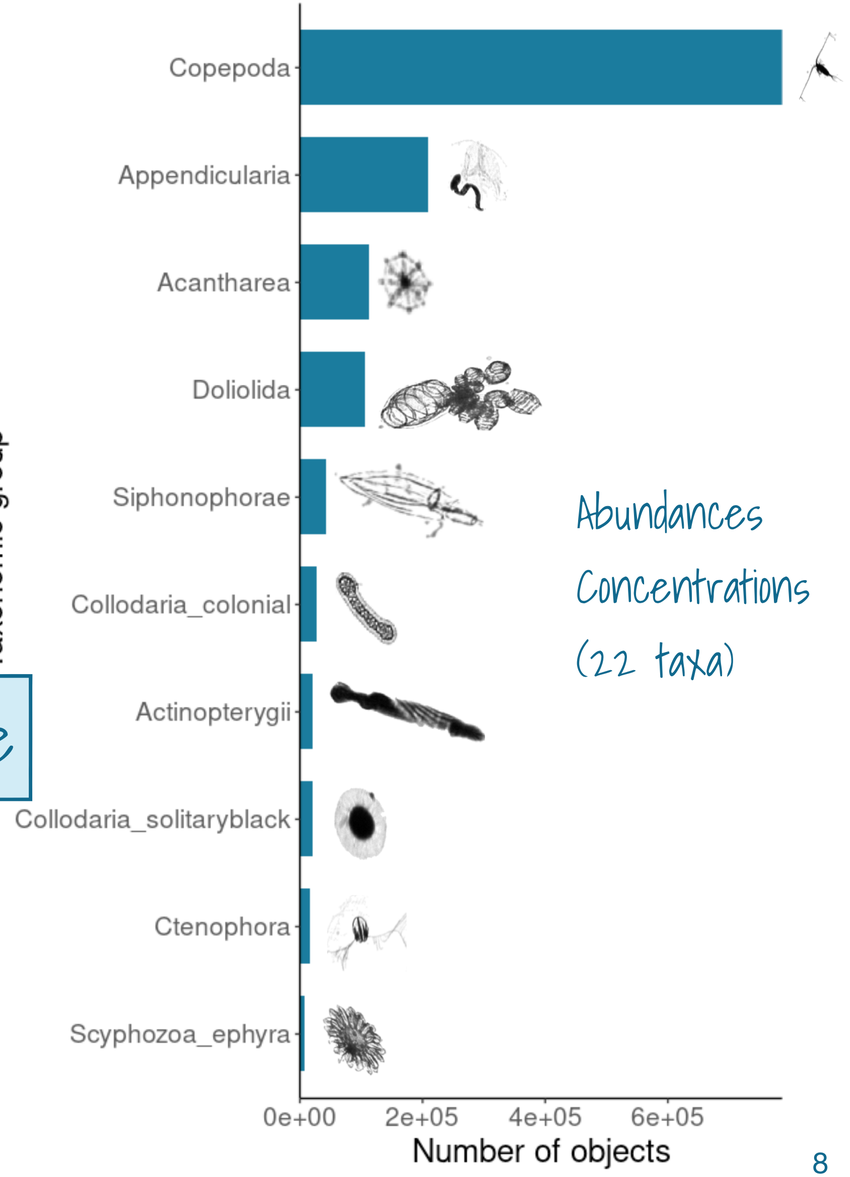
Segmentation

92% sensitivity



Classification

91% confidence

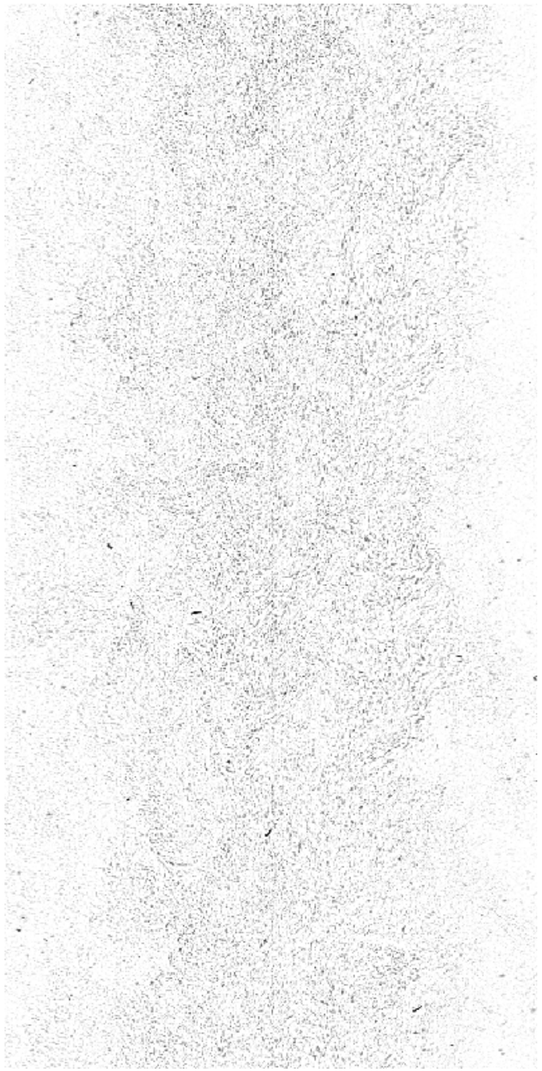


Abundances
Concentrations
(22 taxa)

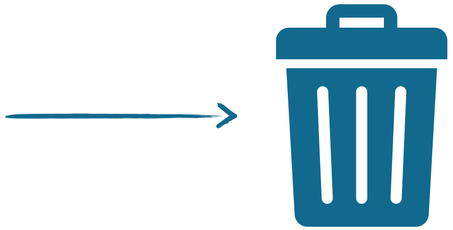
Segmented and classified 8.3 millions of planktonic organisms

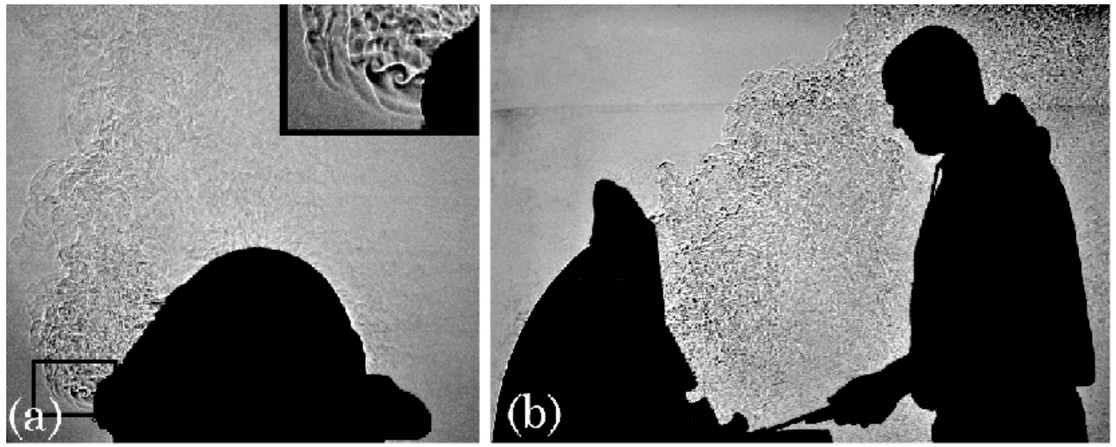
Data processing

A two steps pipeline



Noisy image captured around the thermocline depth

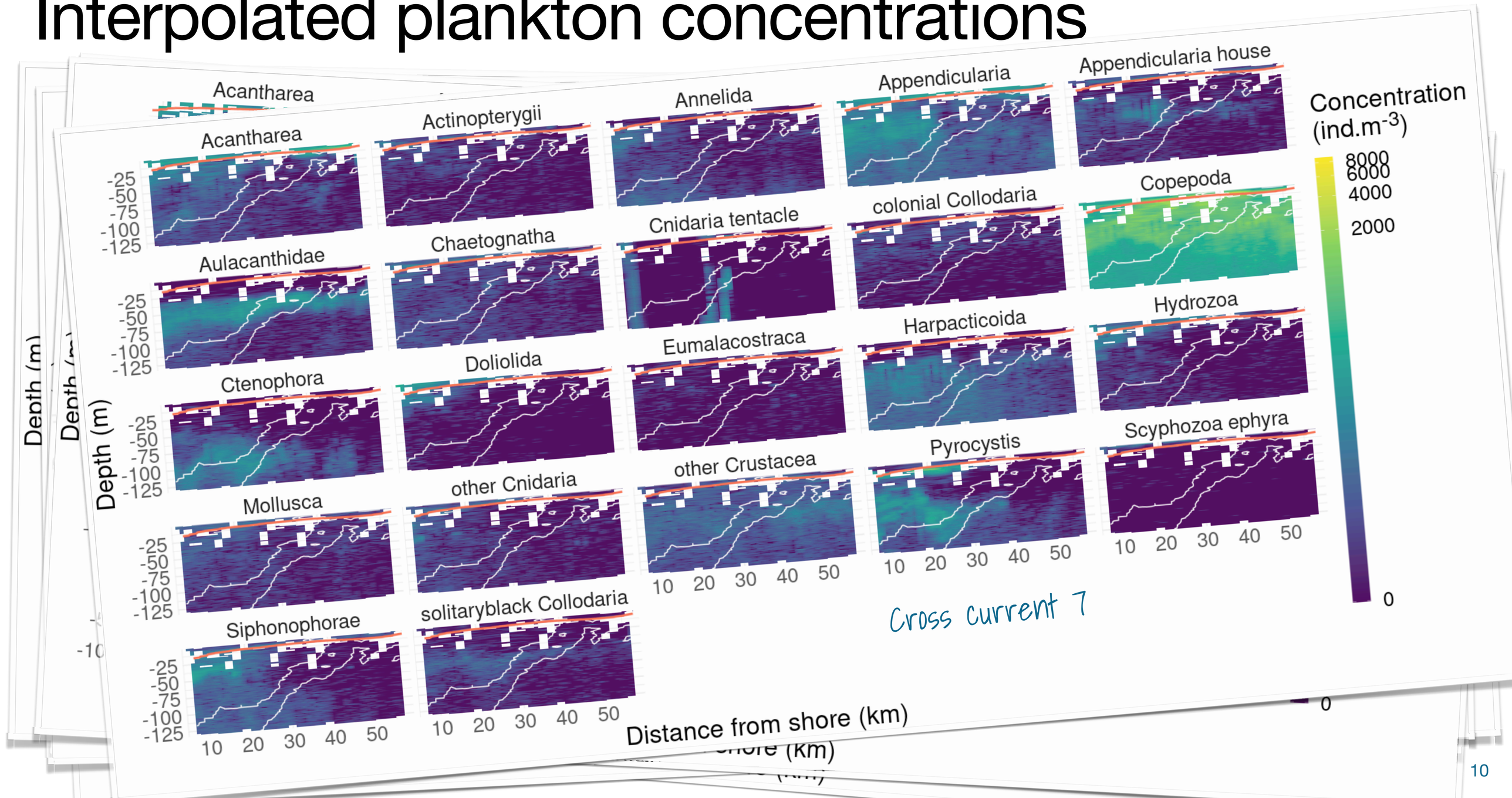




Hargater and Settles, 2009

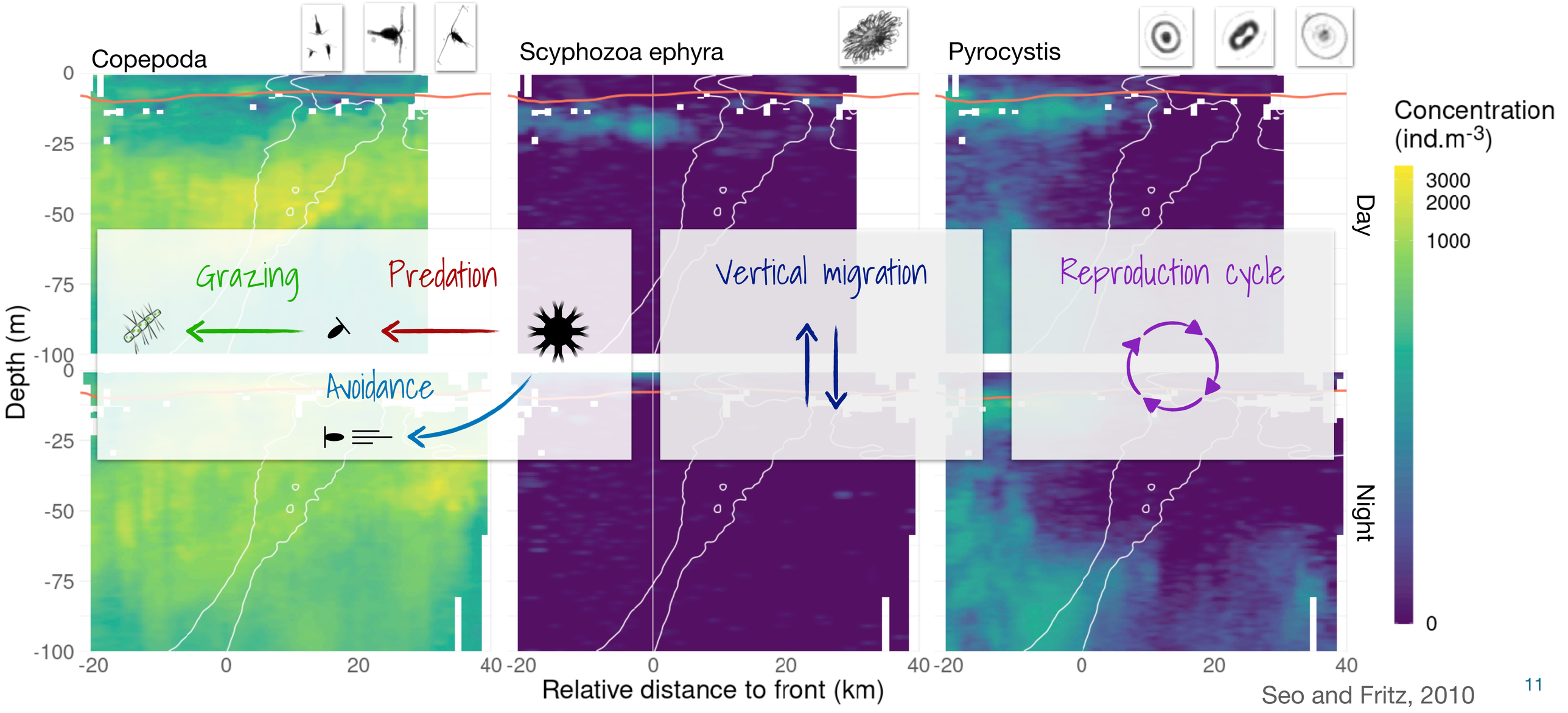
Grumstrup et al., 2017

Interpolated plankton concentrations



Frontal influence

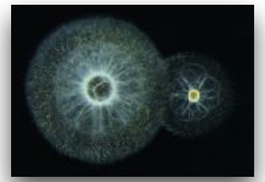
Day / night averages

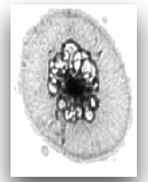


Seo and Fritz, 2010

Solitary Collodaria

Rhizaria > Radiolaria > Collodaria

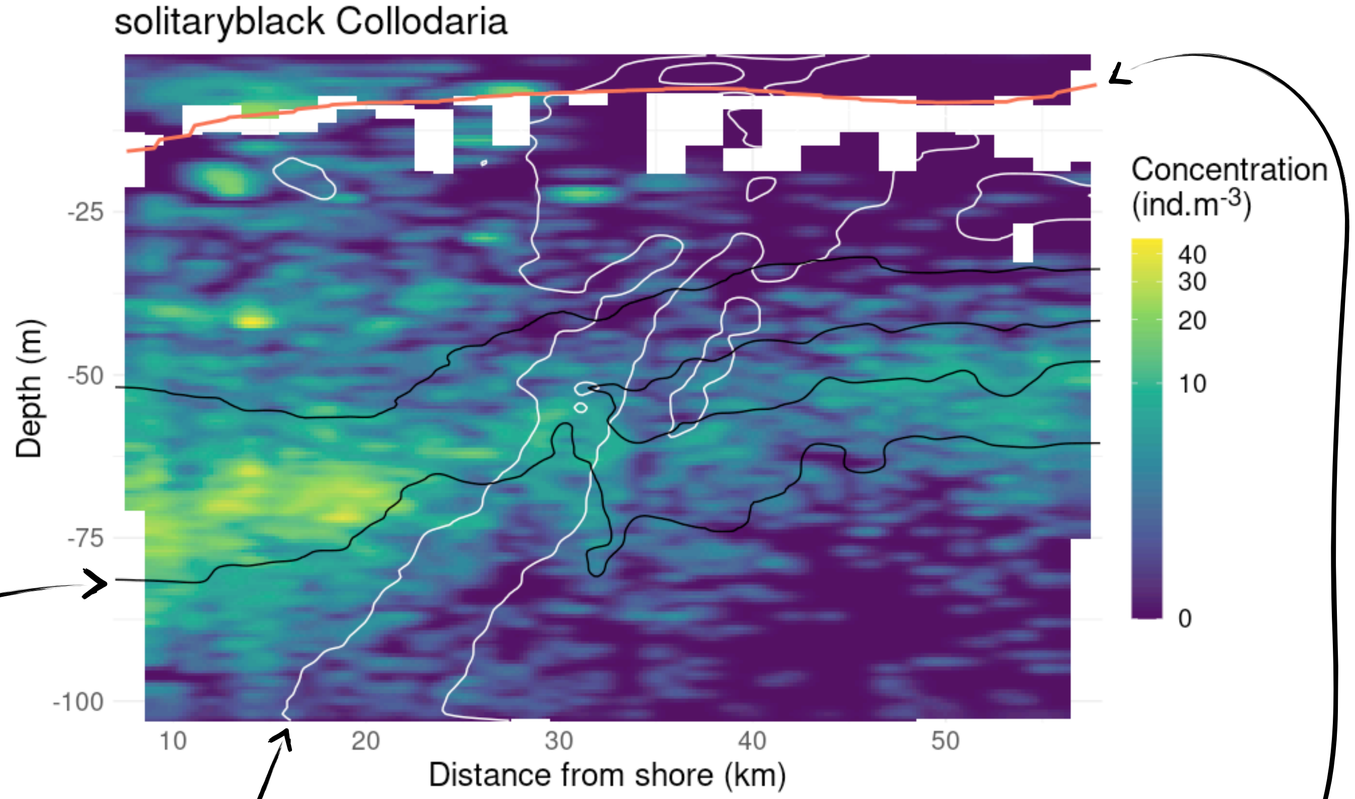


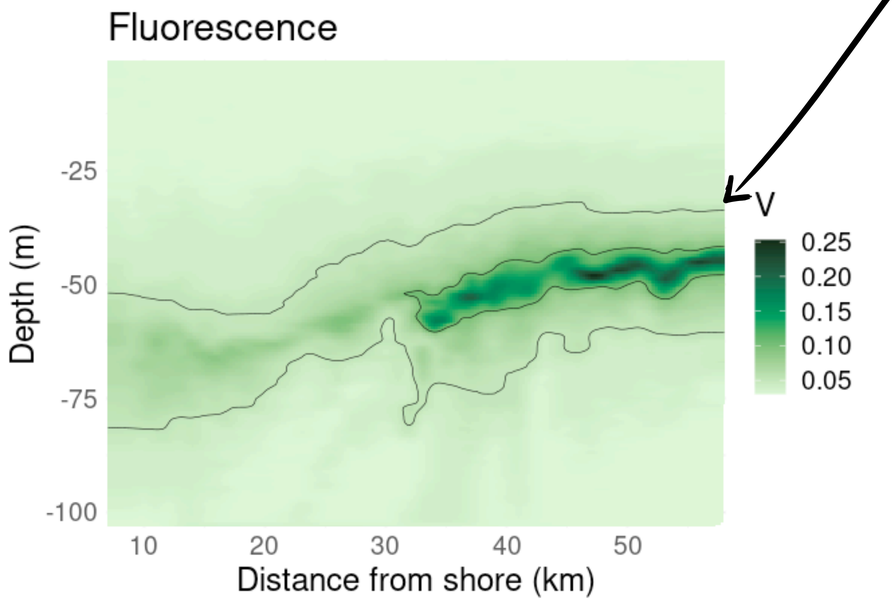


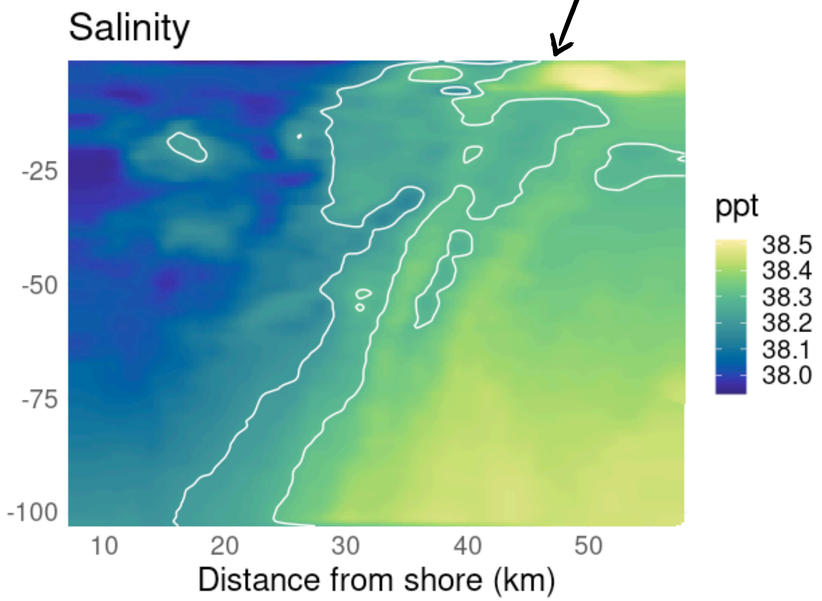
- mixotrophs
- photosynthetic symbionts
- epipelagic

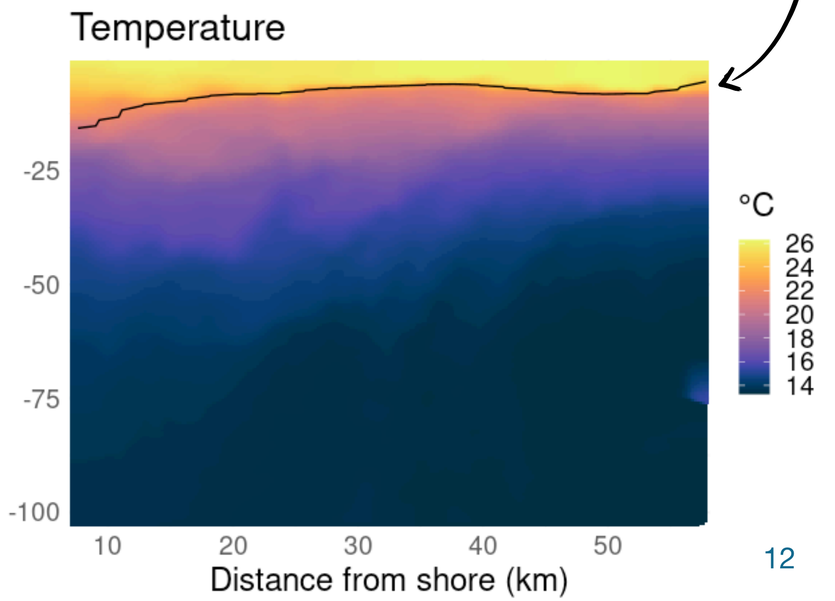
Coastal waters

Deep chlorophyll maximum



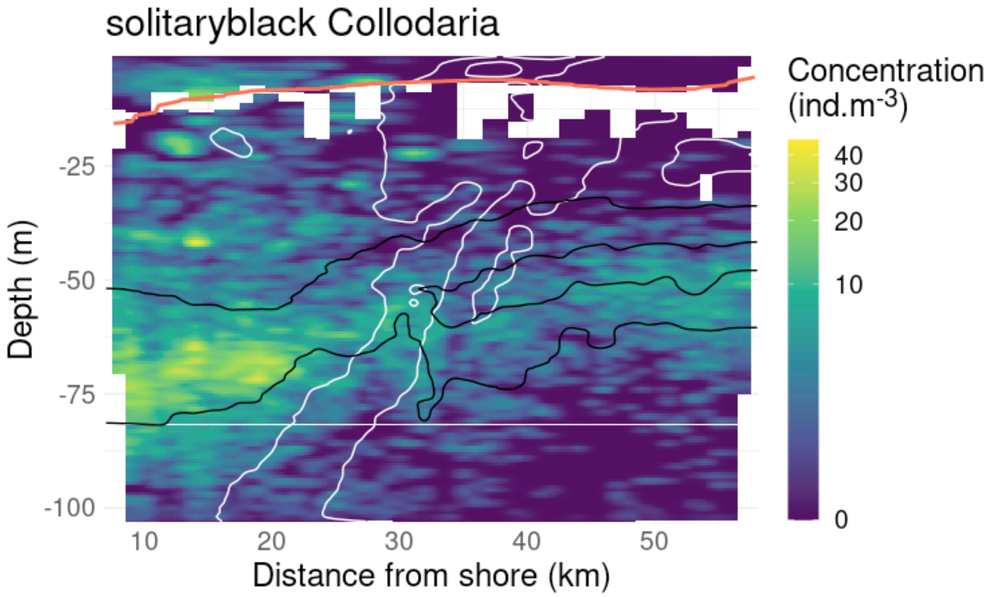






Solitary Collodaria

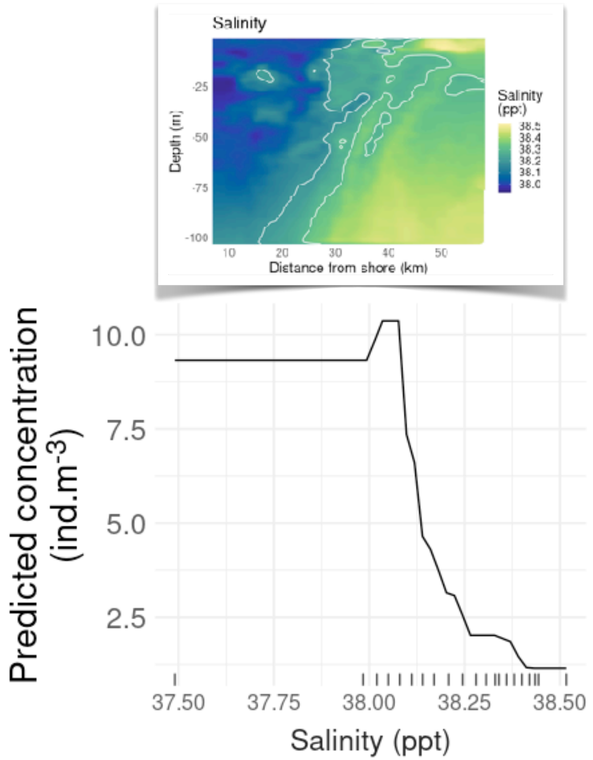
Regression with gradient boosted trees on all transects except one used to test the model



p-value < 0.01

R^2 = 41%

Partial dependance plots

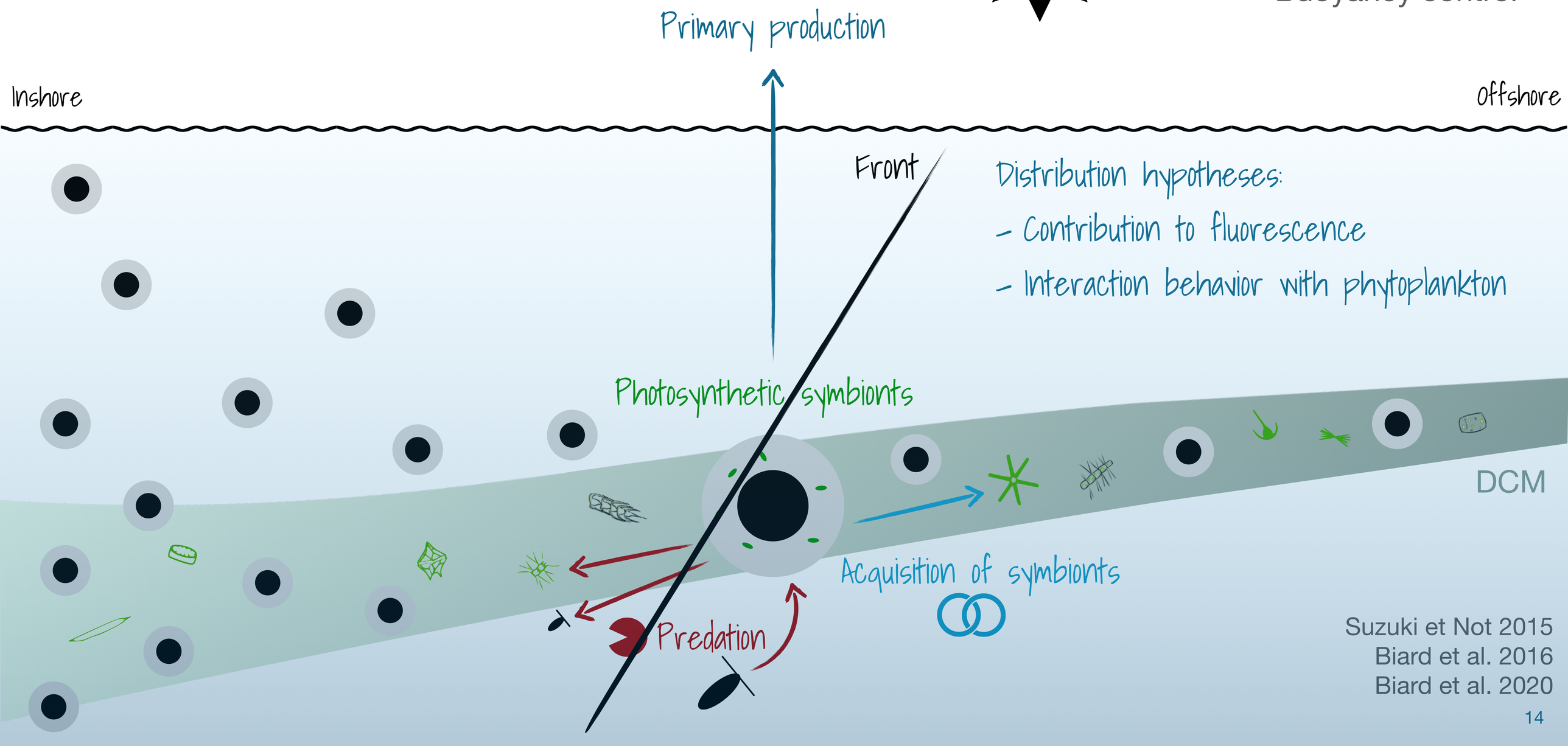


54%

of explained variance

Solitary Collodaria

Mixotrophs
Epipelagic
Buoyancy control



Suzuki et Not 2015
Biard et al. 2016
Biard et al. 2020

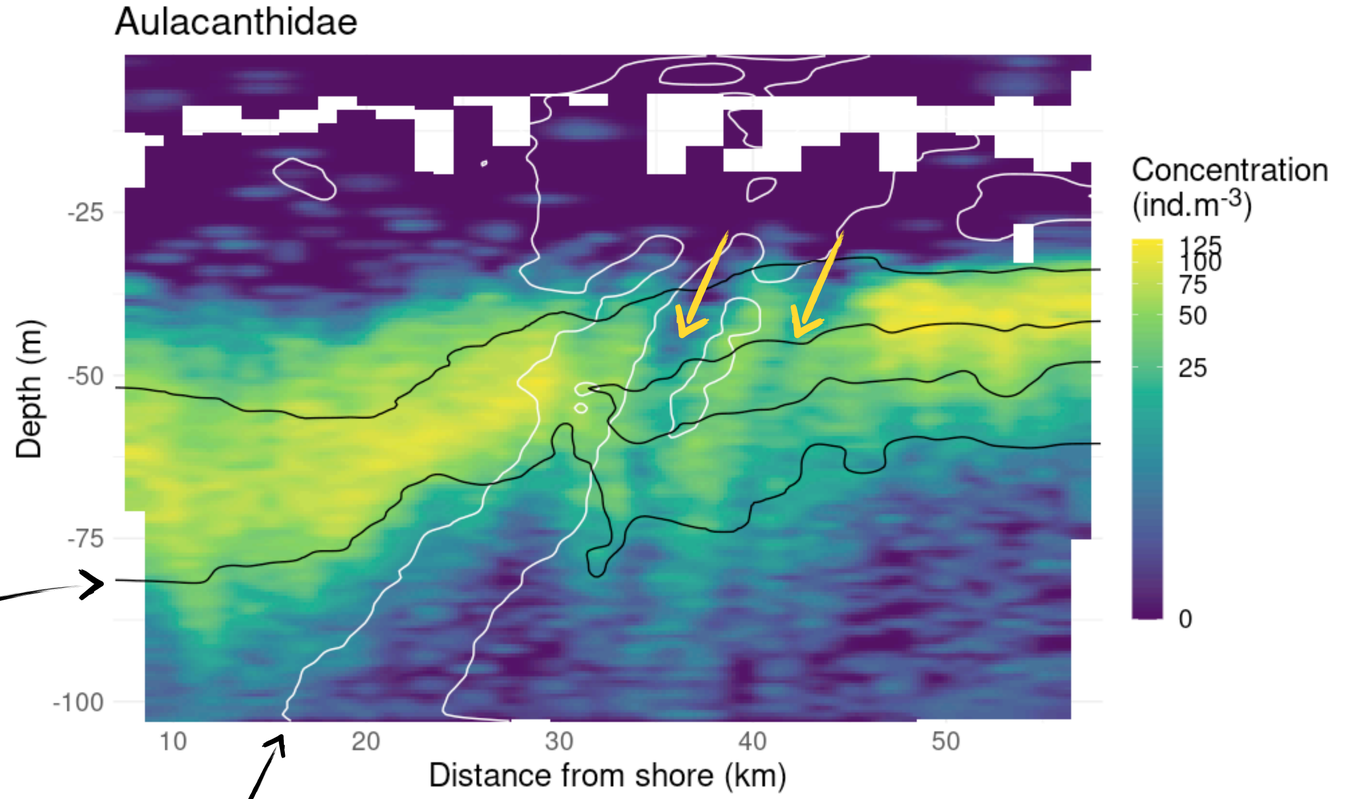
Aulacanthidae

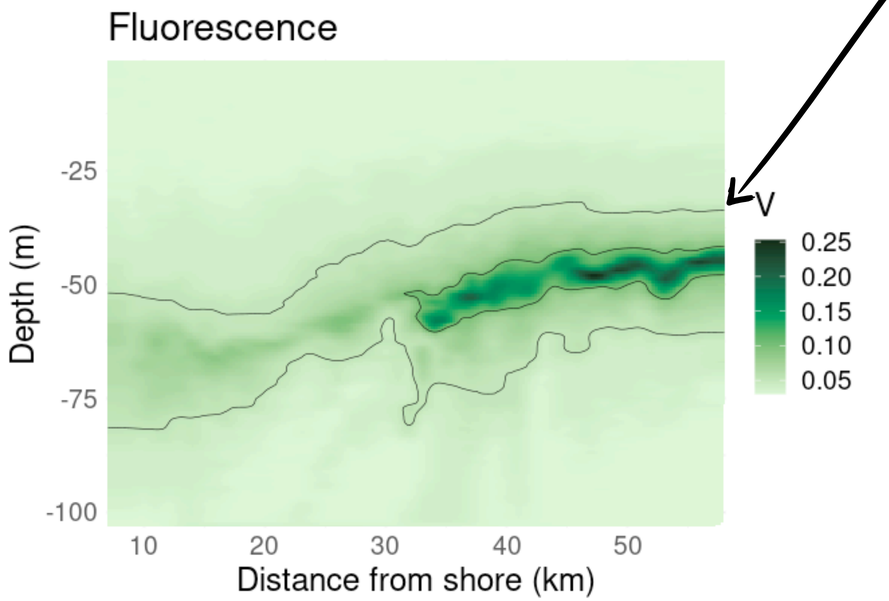
Rhizaria > Cercozoa > … > Phaeodaria

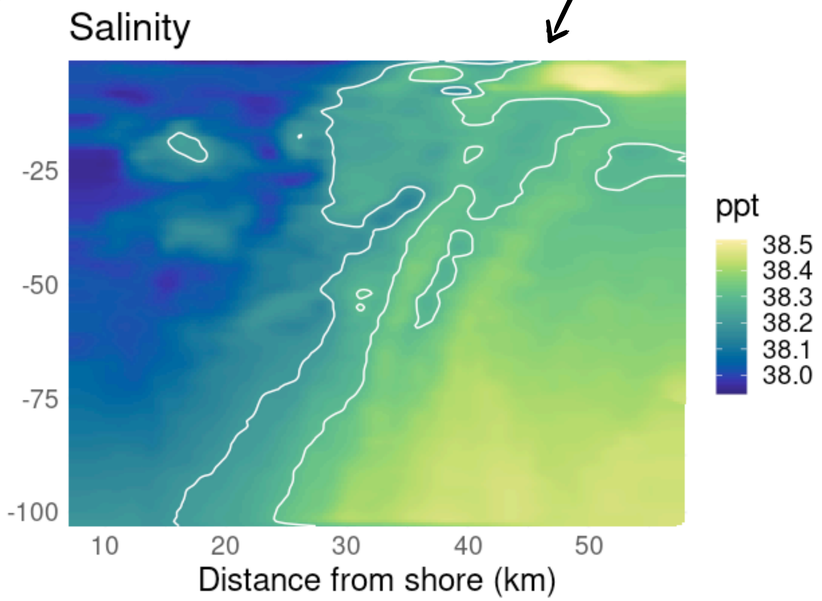
Deep chlorophyll maximum

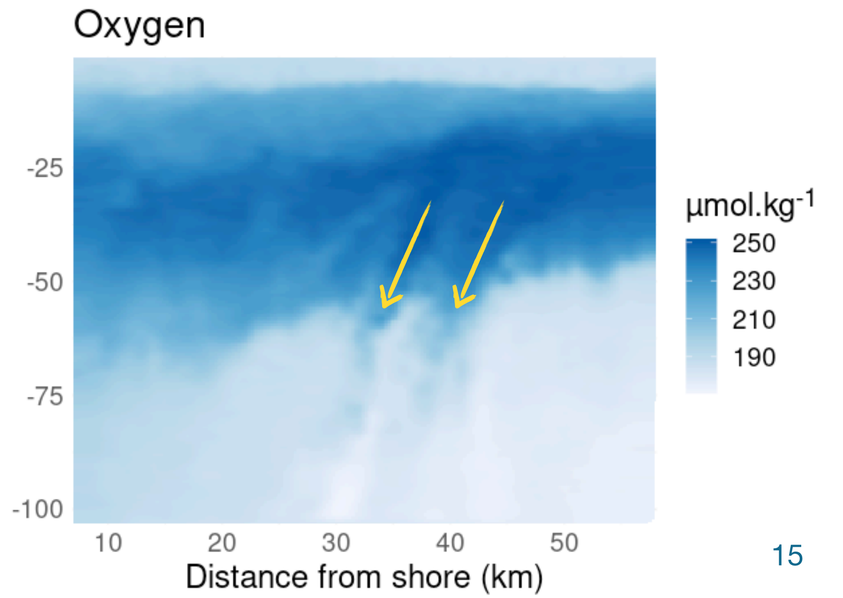
Spread out inshore

Affected by submesoscale recirculation



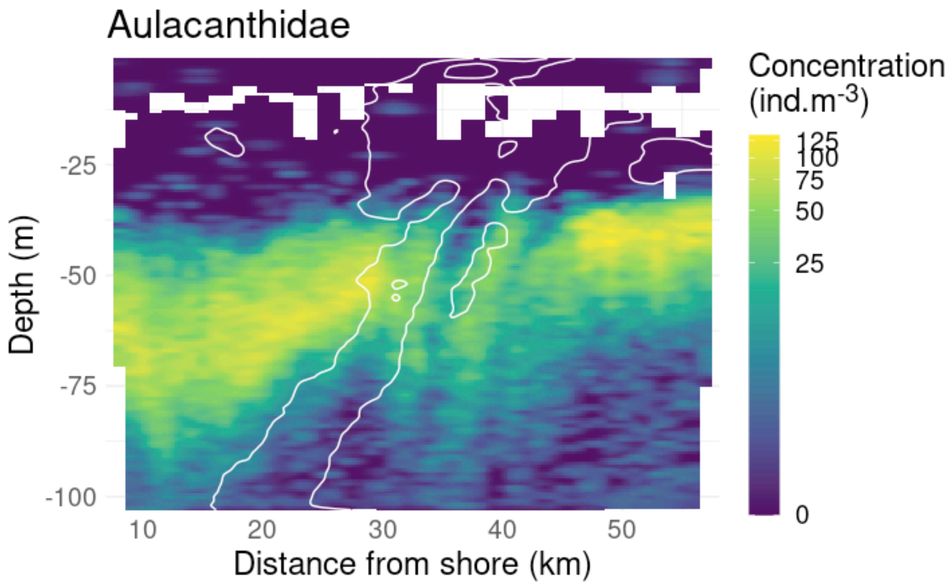






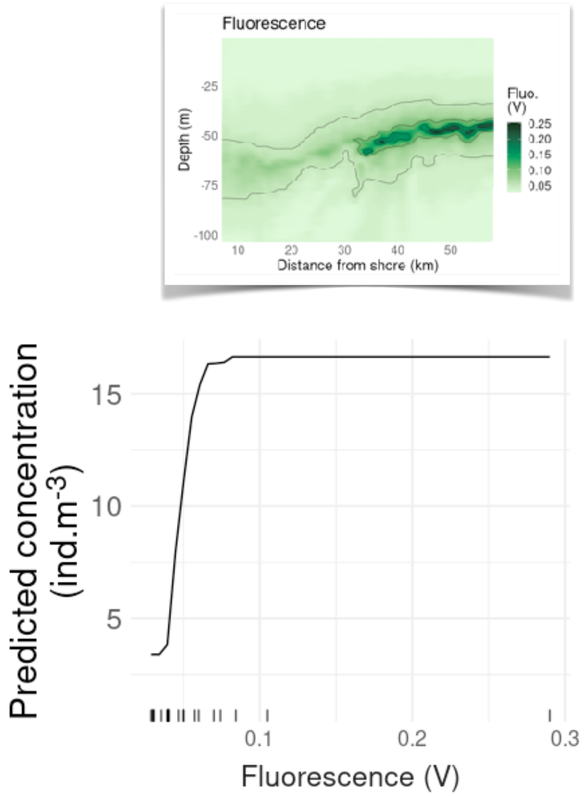
Aulacanthidae

Regression with gradient boosted trees on all transects except one used to test the model



p-value < 0.01

R^2 = 57%



51%

of explained variance

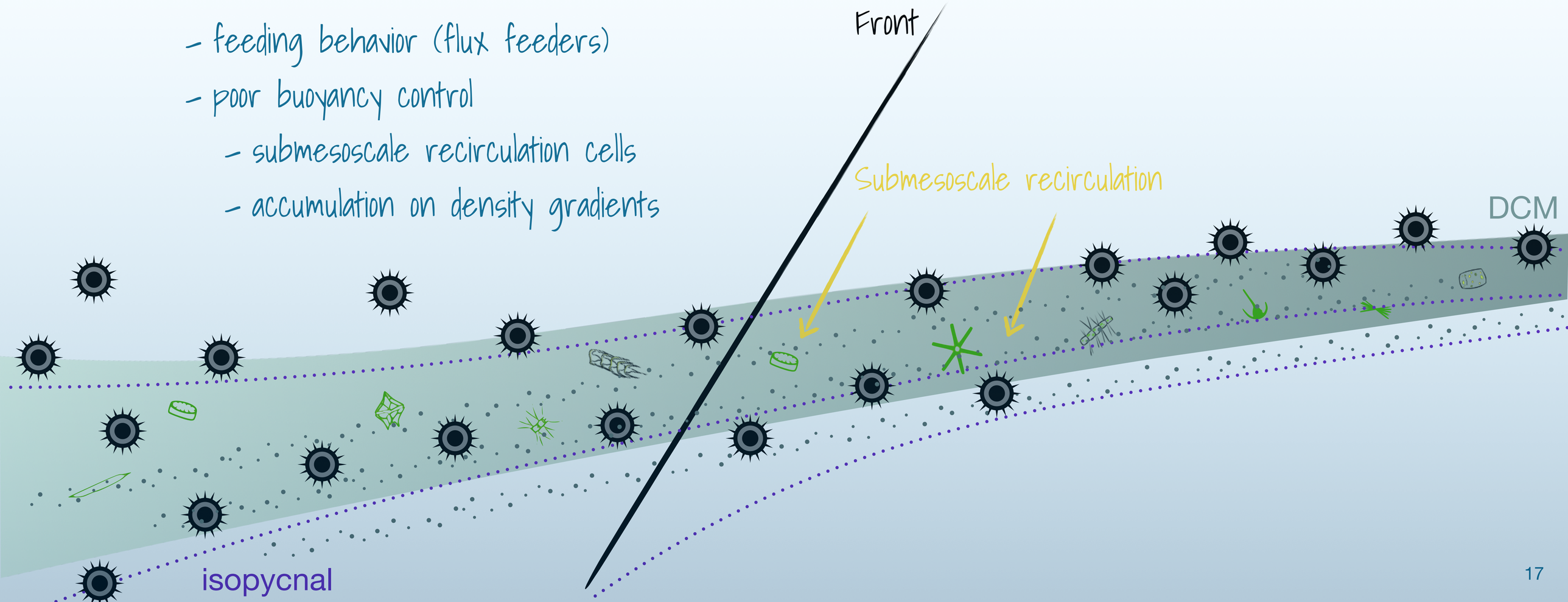
Aulacanthidae

Distribution hypotheses

Inshore

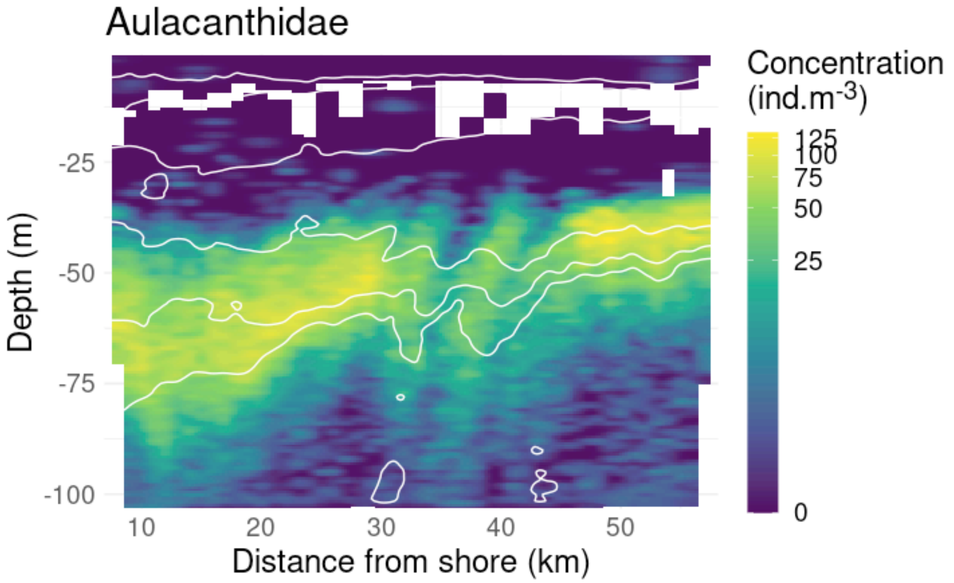
Offshore

- feeding behavior (flux feeders)
- poor buoyancy control
  - submesoscale recirculation cells
  - accumulation on density gradients



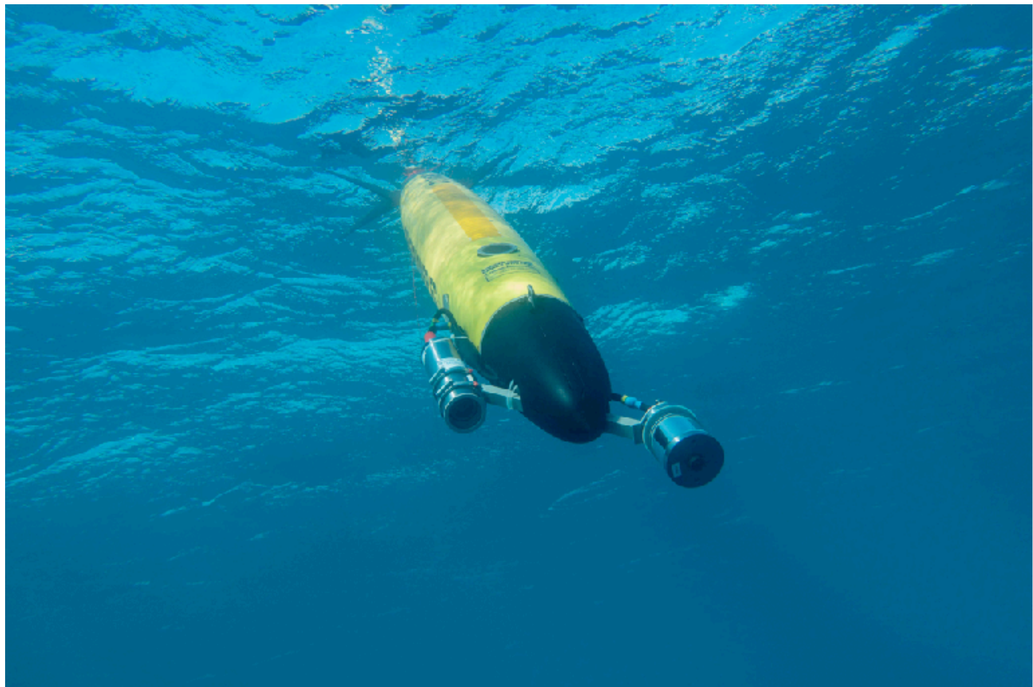
Conclusion

- Strong hydrological signature of the front
- Influence on mesoscale plankton distribution pattern
- Submesoscale plankton distribution patterns



Perspectives

- Model fine scale distribution patterns using anomalies
- Temporal evolution of plankton distribution patterns
  - 5 months mission
  - UVP6 equipped glider
  - ~1M objects, 5000 profiles



Thanks to all co-authors, cruise members, funders and providers of computational resources

Thank you for your attention

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https://github.com/jiho/apeep