

# Image-based plankton sampling

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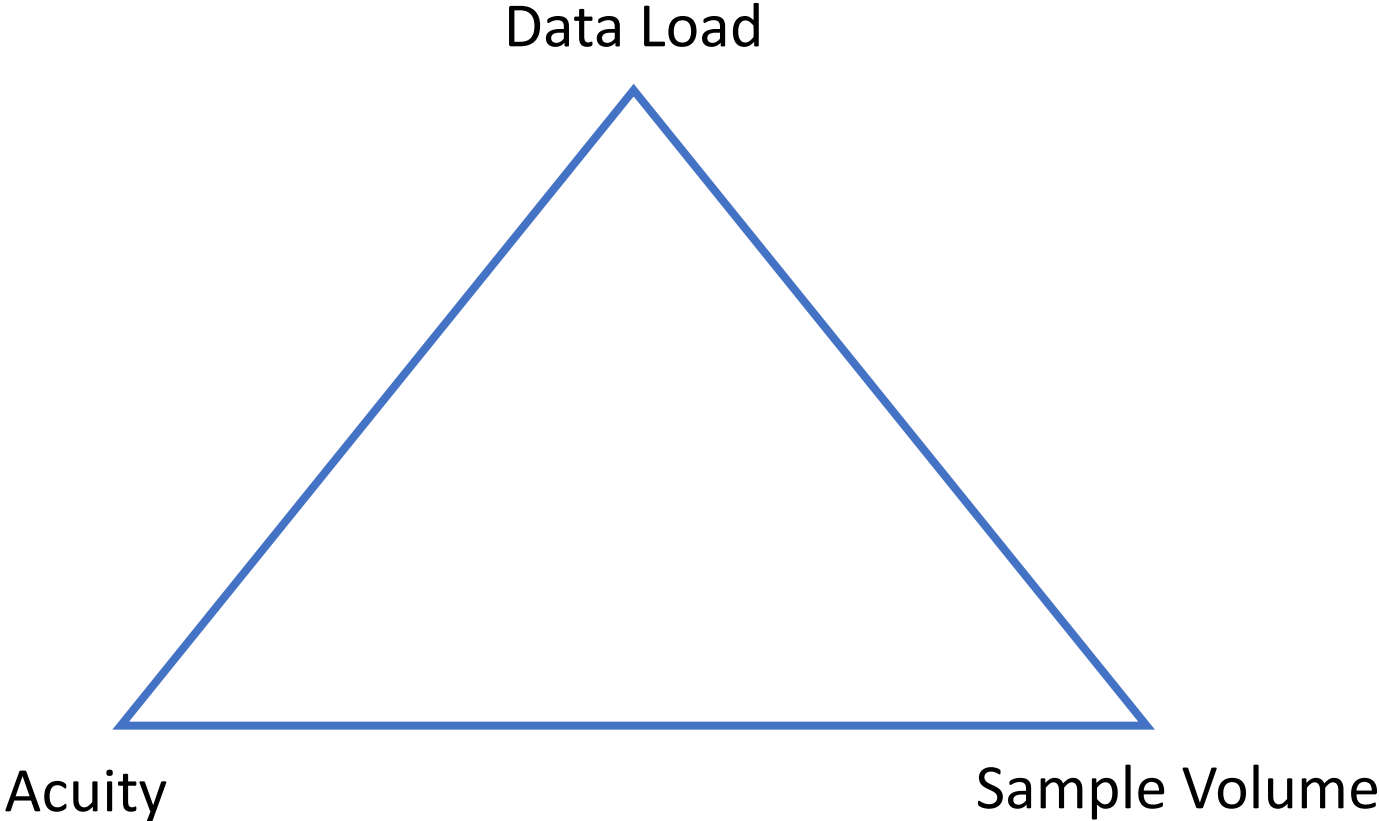
Oregon State University  
Hatfield



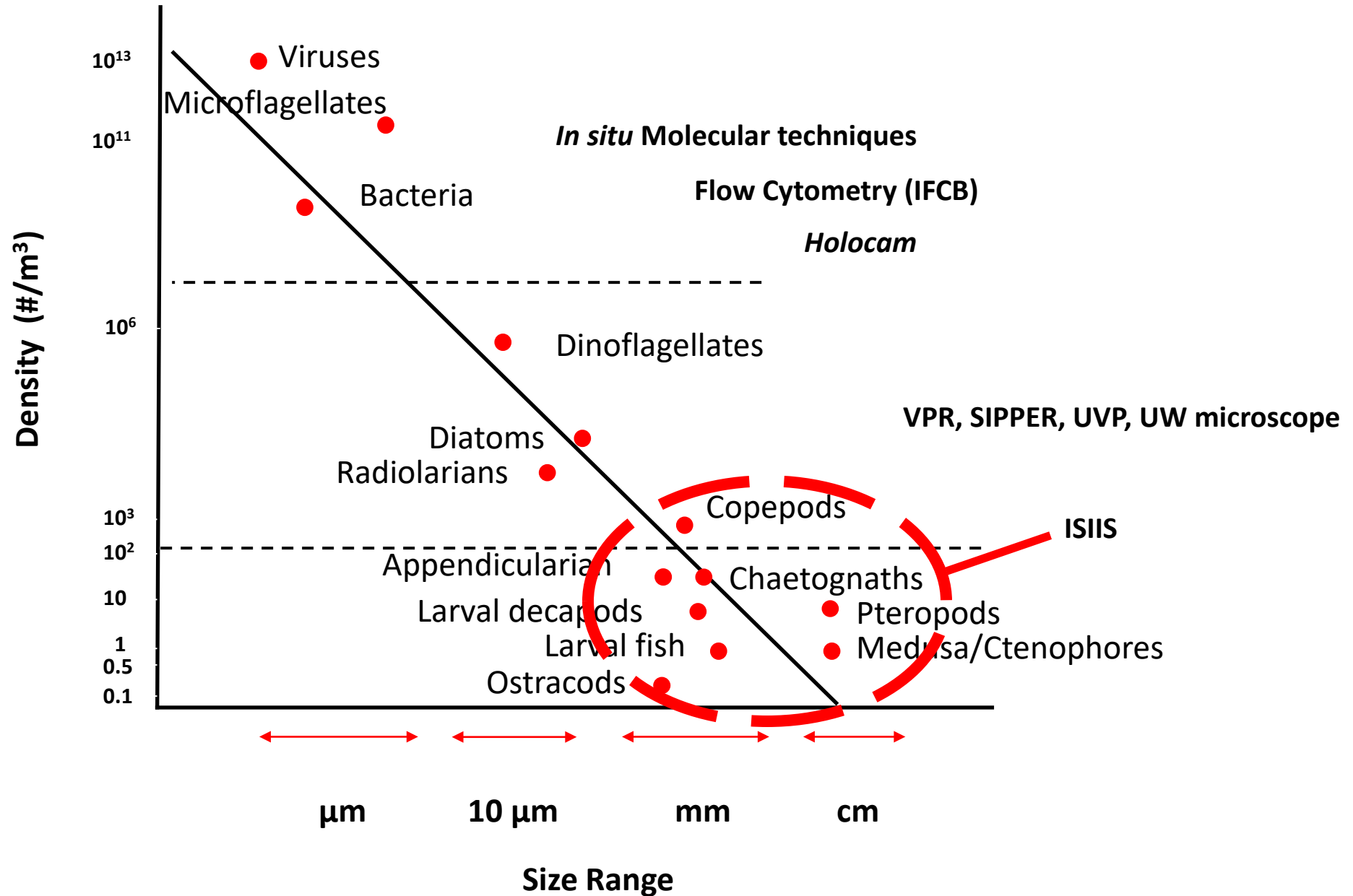
**XSEDE**

Extreme Science and Engineering  
Discovery Environment

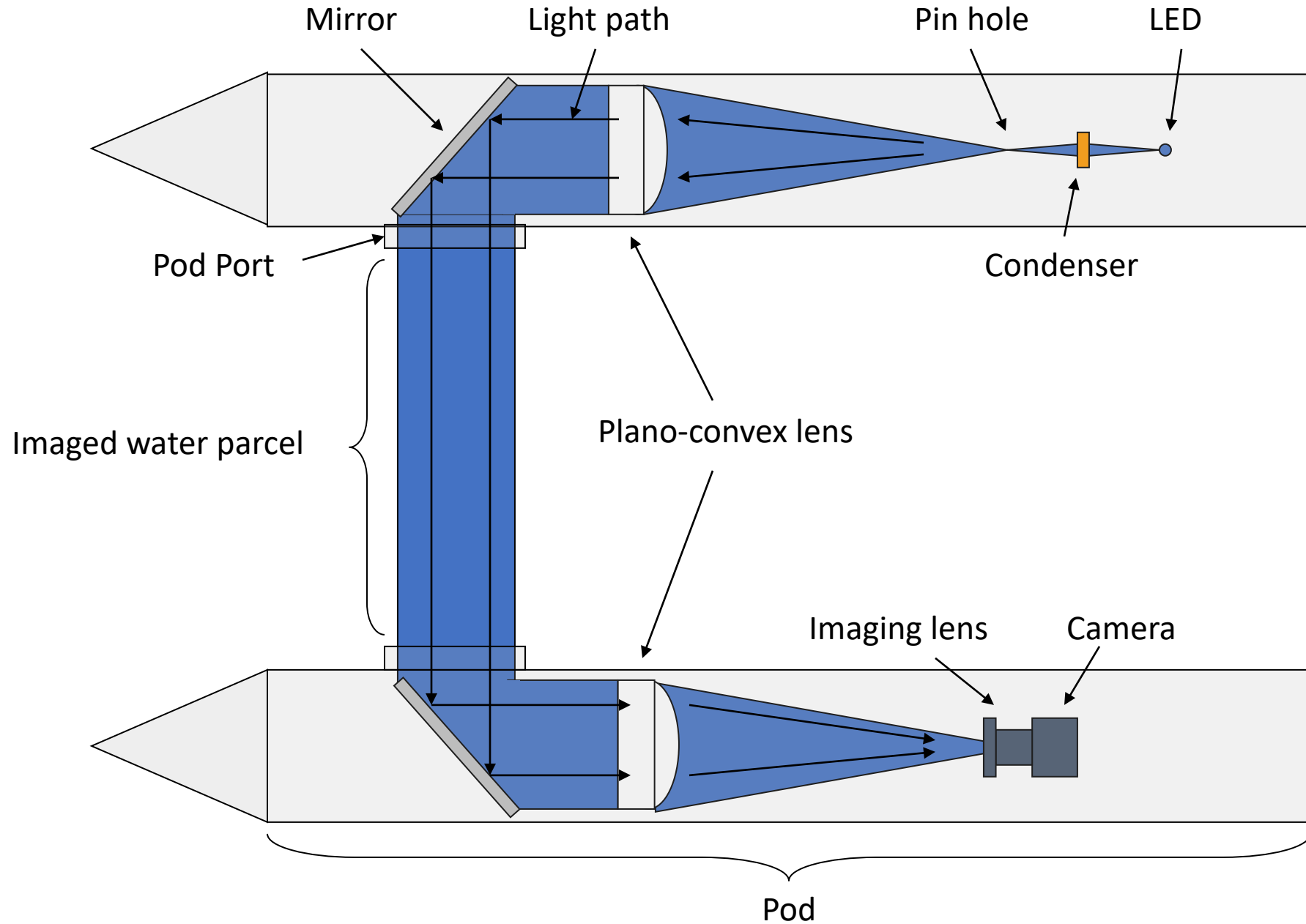
# Design Trade-offs

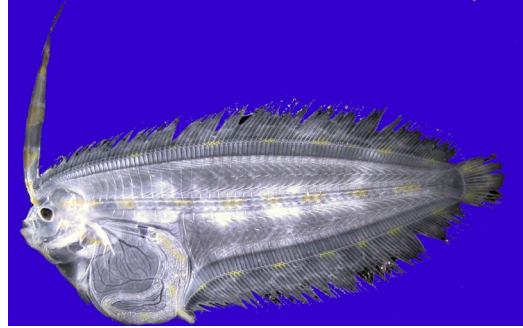


# Plankter size-density relationship

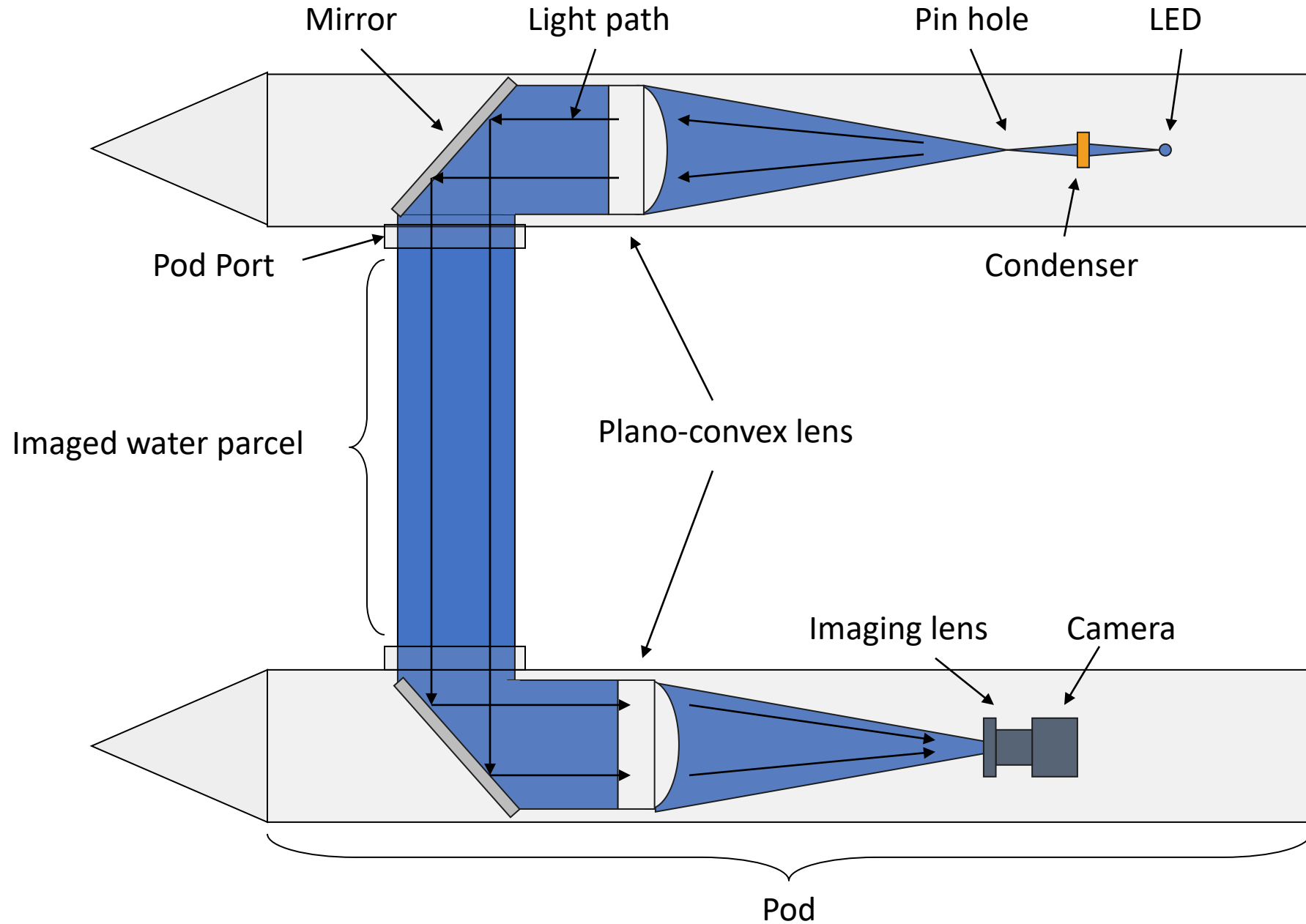


# *In Situ* Ichthyoplankton Imaging System (ISIS)





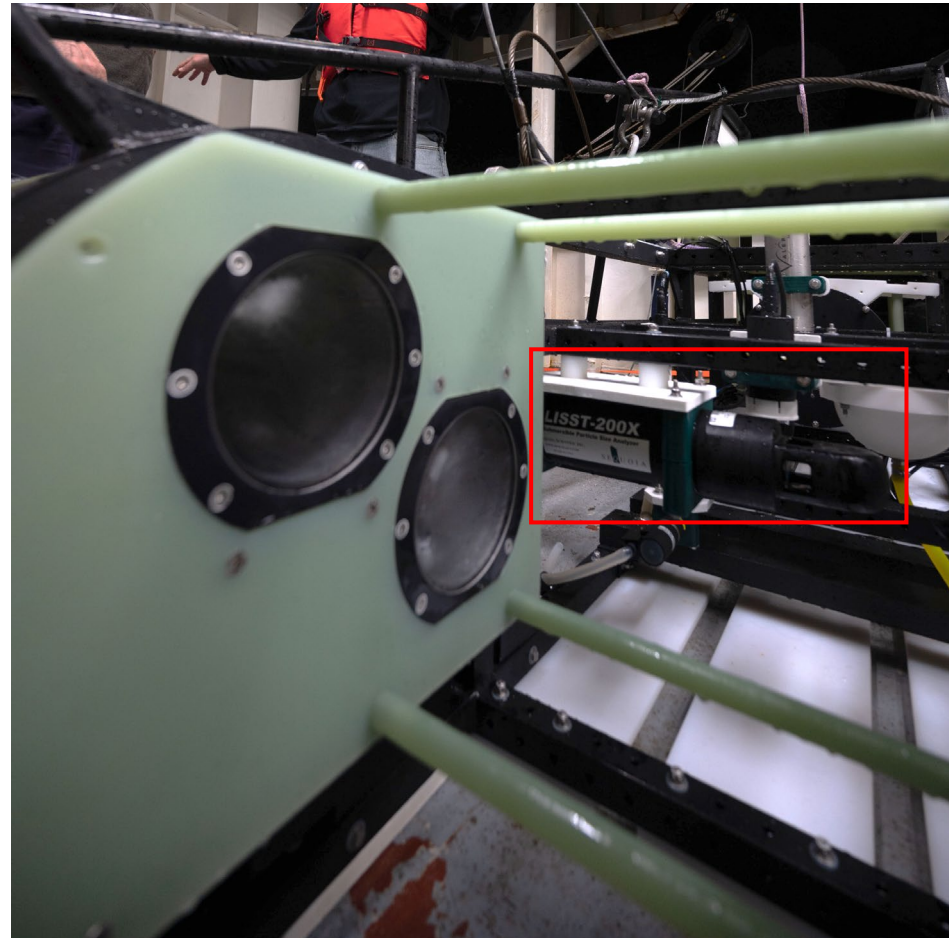
# *In Situ* Ichthyoplankton Imaging System (ISIS)



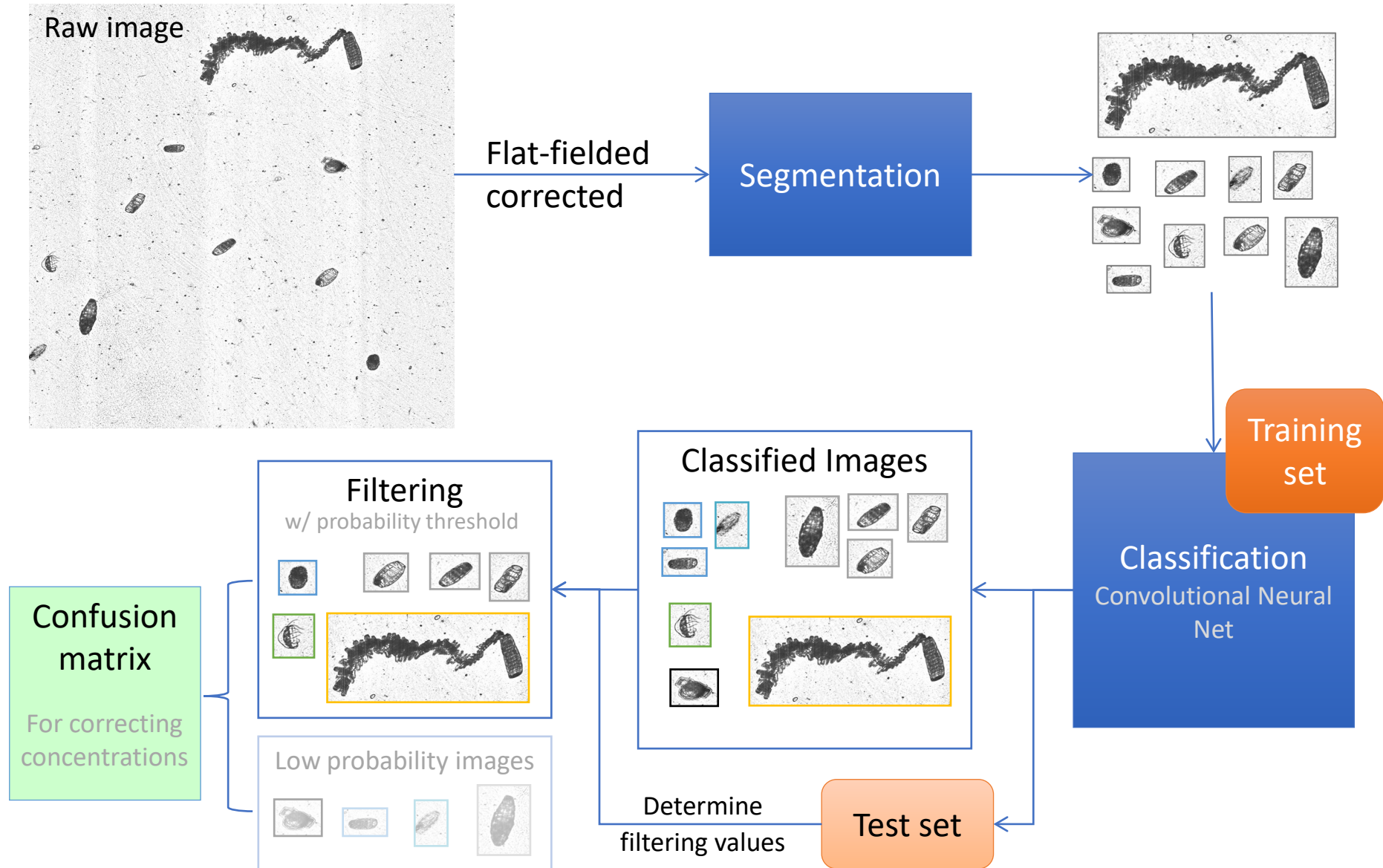
# ISIIS-3 design



- New compact design (Crab trap shedding)
- Dual camera setup
- Enhanced sensor integration (e.g., pH, LISST-200X)

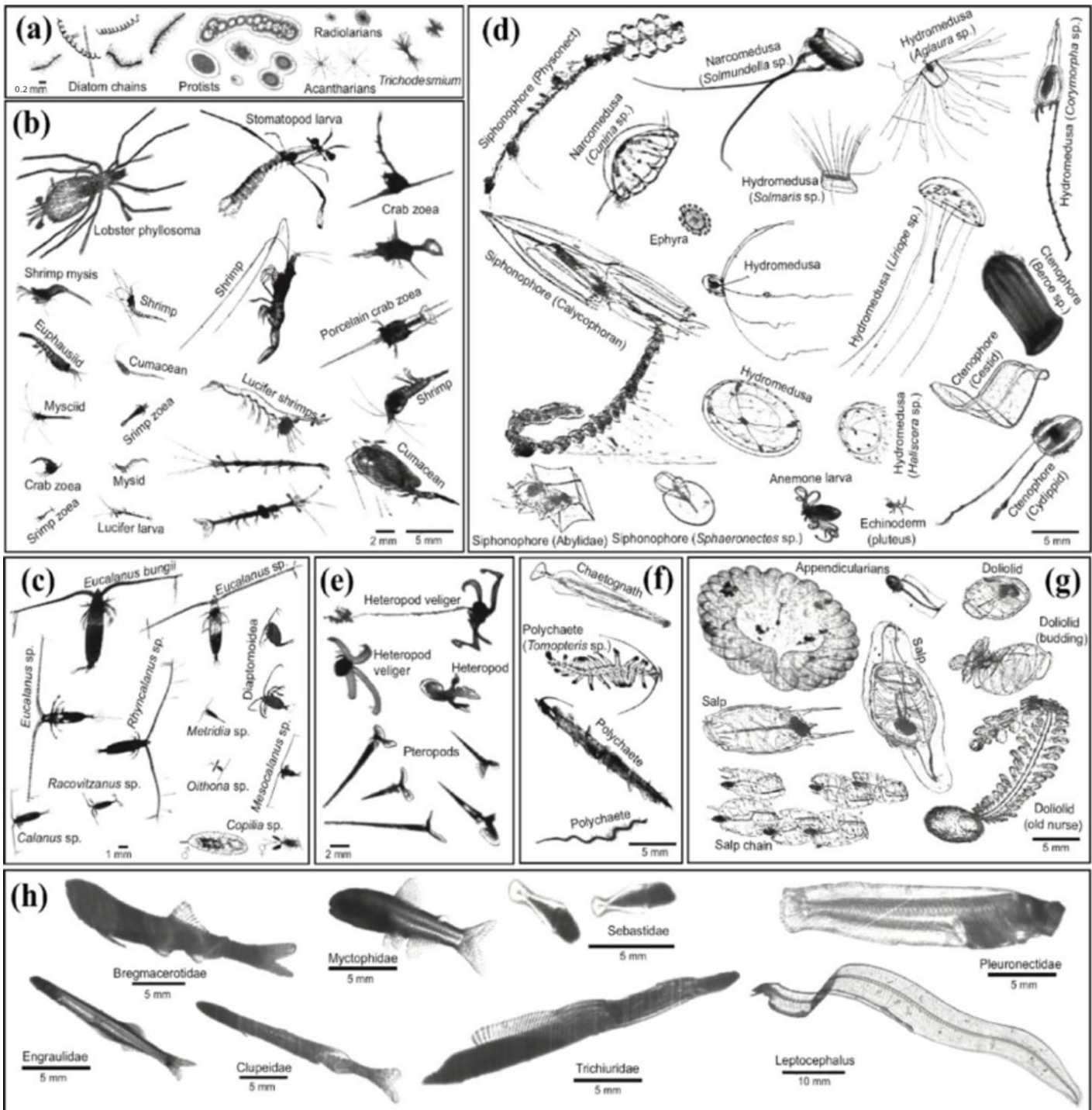


# Image processing & classification





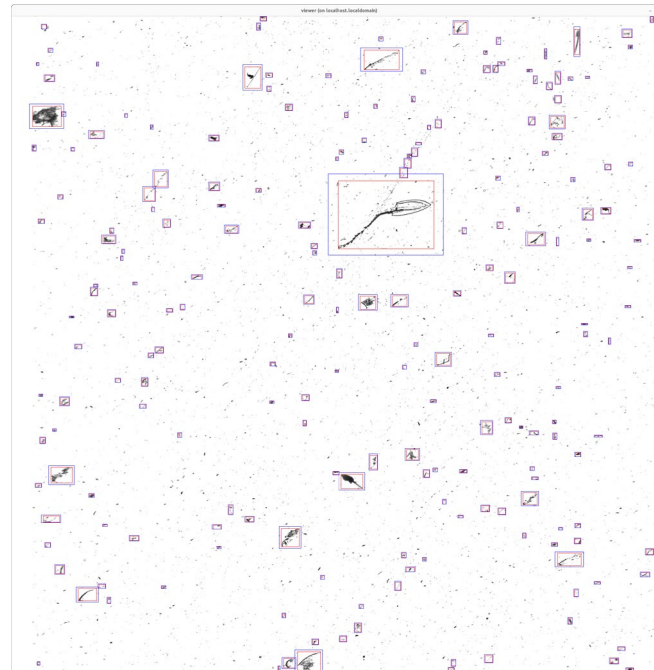
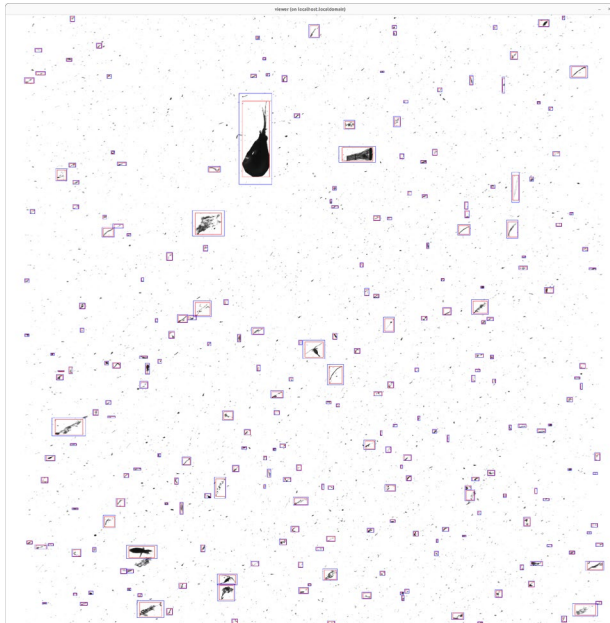
Automated classification of 150+ plankton classes



- (a) Primary producers & protists
- (b-c) crustaceans
- (d) cnidarians, ctenophores, & echinoderms
- (e) heteropods & pteropods
- (f) chaetognaths & polychaetes
- (g) pelagic tunicates
- (h) fish larvae

# Pipeline segments, classifies, and populates database

- Pipeline open-sourced (<https://zenodo.org/record/4641158>)



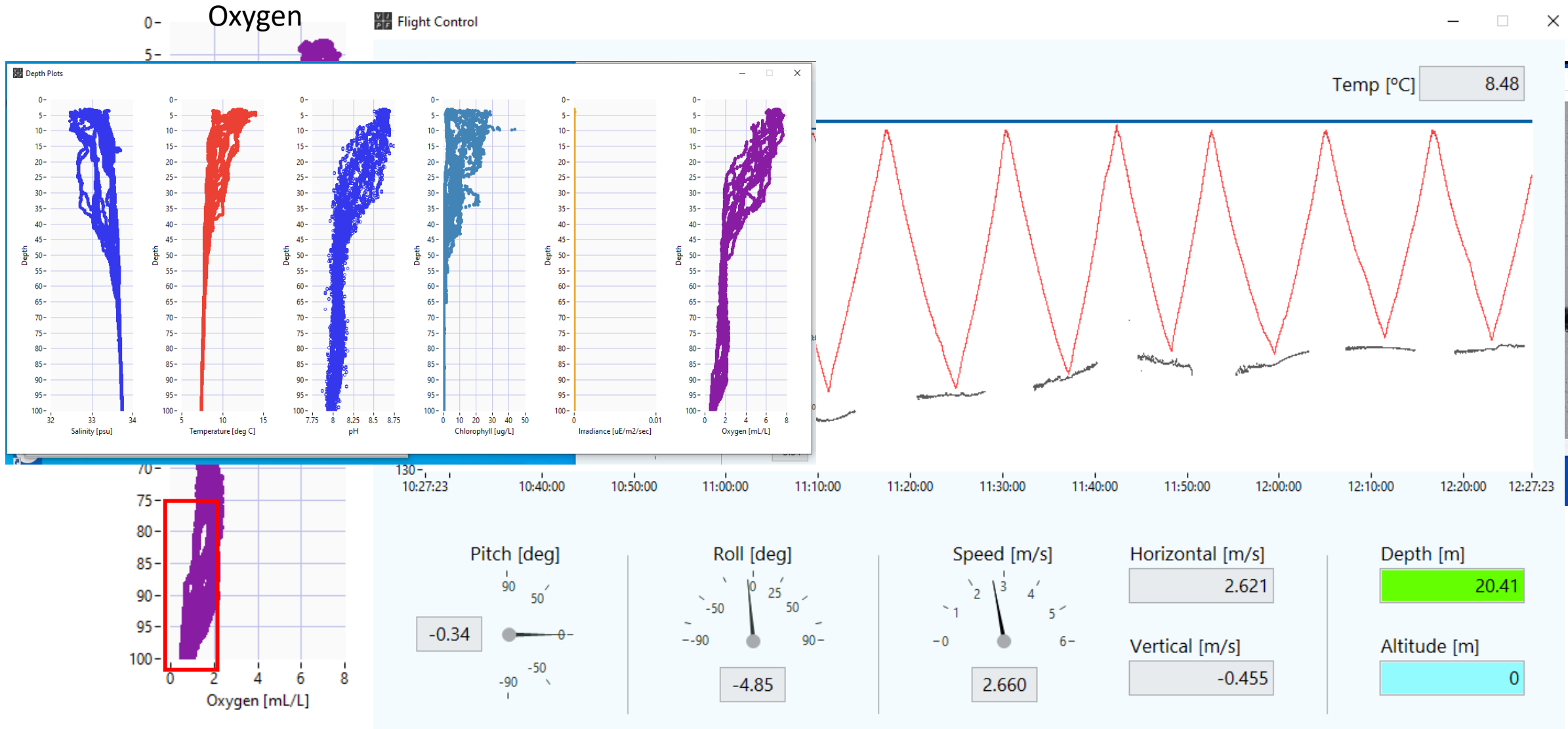
May 6, 2021

Software Open Access

A Convolutional Neural Network based high-throughput image classification pipeline - code and documentation to process plankton underwater imagery using local HPC infrastructure and NSF's XSEDE

Schmid, Moritz S; Daprano, Dominic; Jacobson, Kyler M; Sullivan, Christopher; Briseño-Avena, Christian; Luo, Jessica Y; Cowen, Robert K

# Recent – near-real time (at-sea) analysis enabling adaptive sampling (e.g., low O<sub>2</sub>)

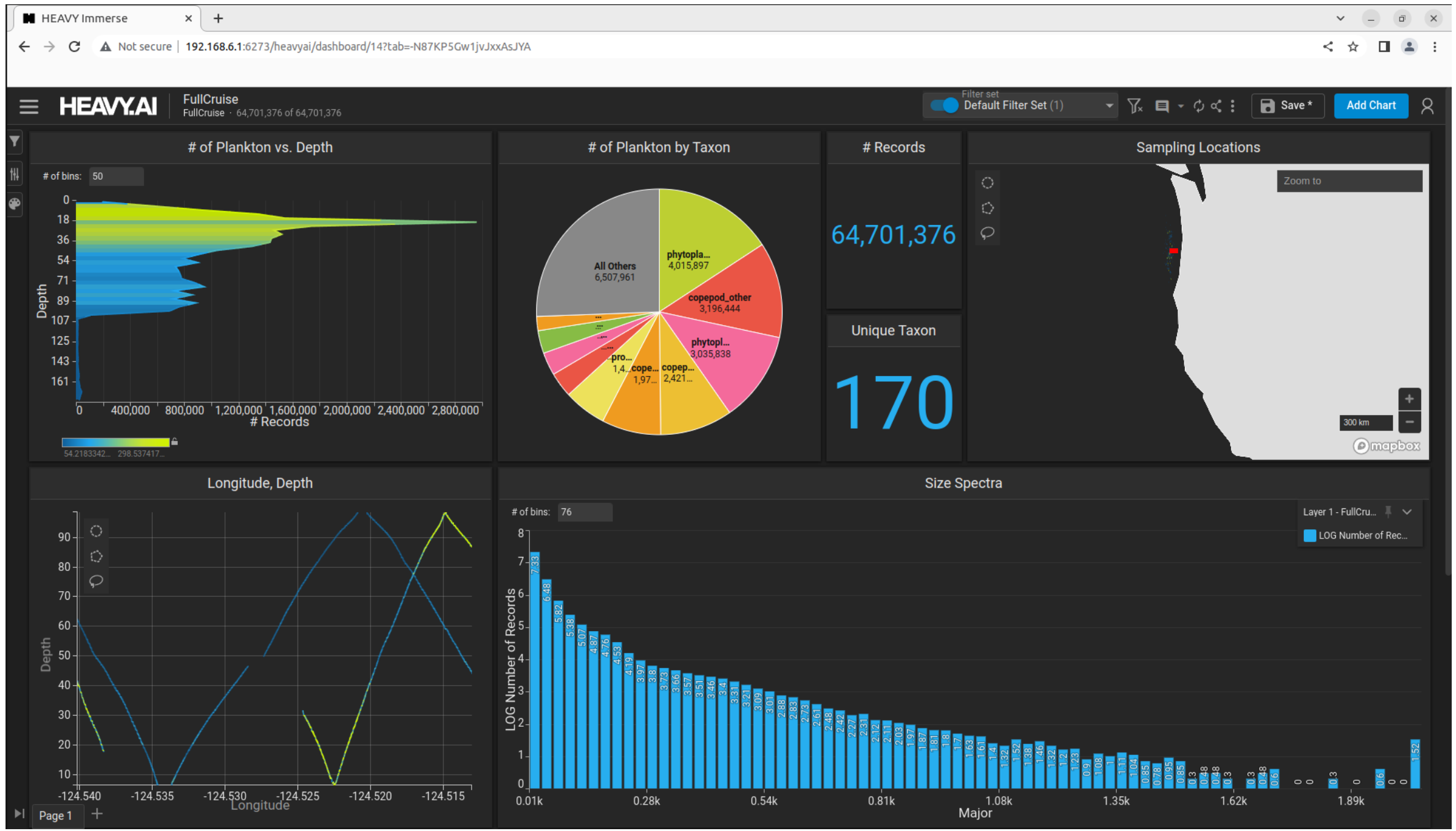


# Western Digital - Ultrastar edge server

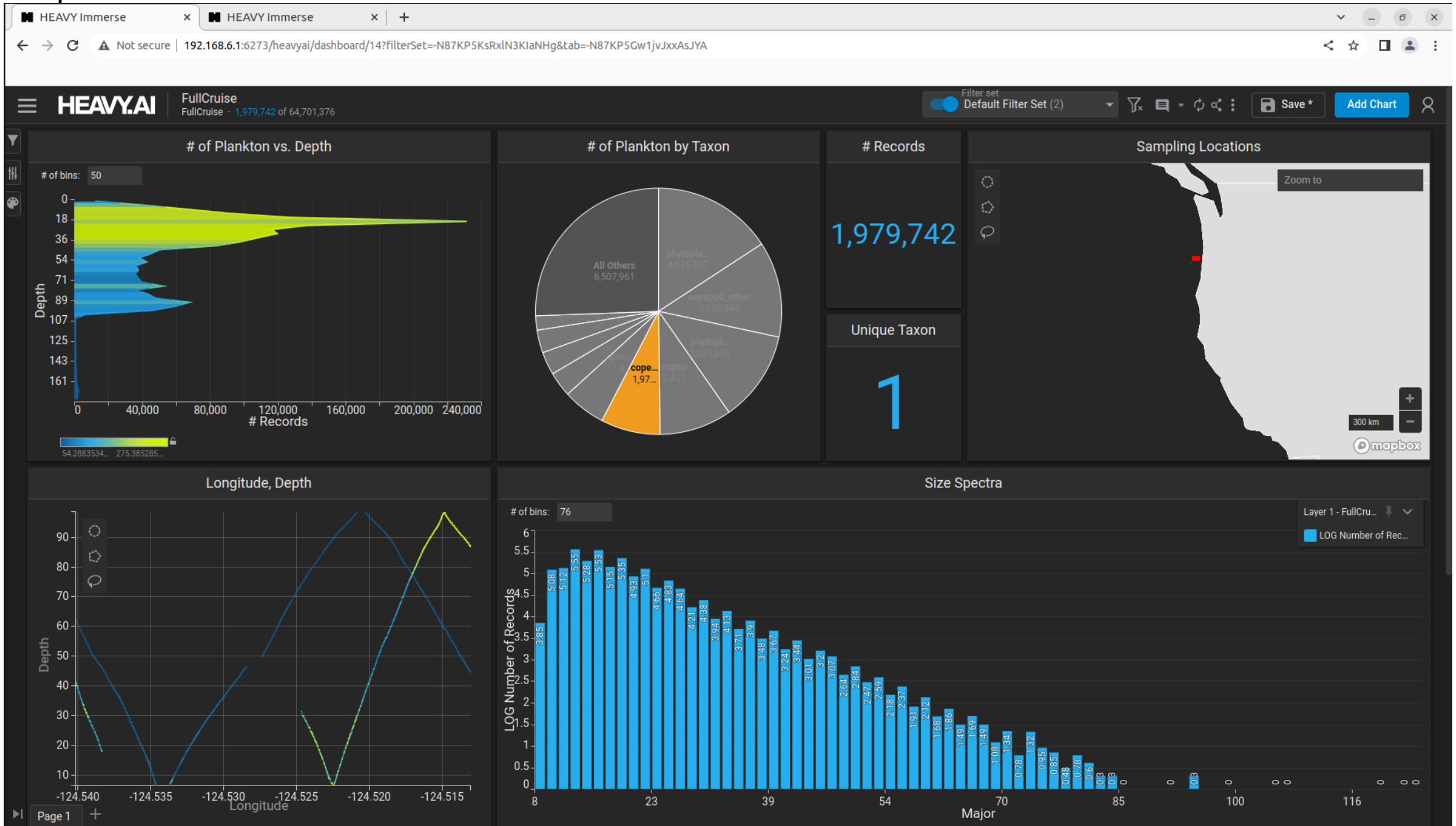
40 TB redundant NVME SSD storage, CPUs & GPUs



# Database webserver

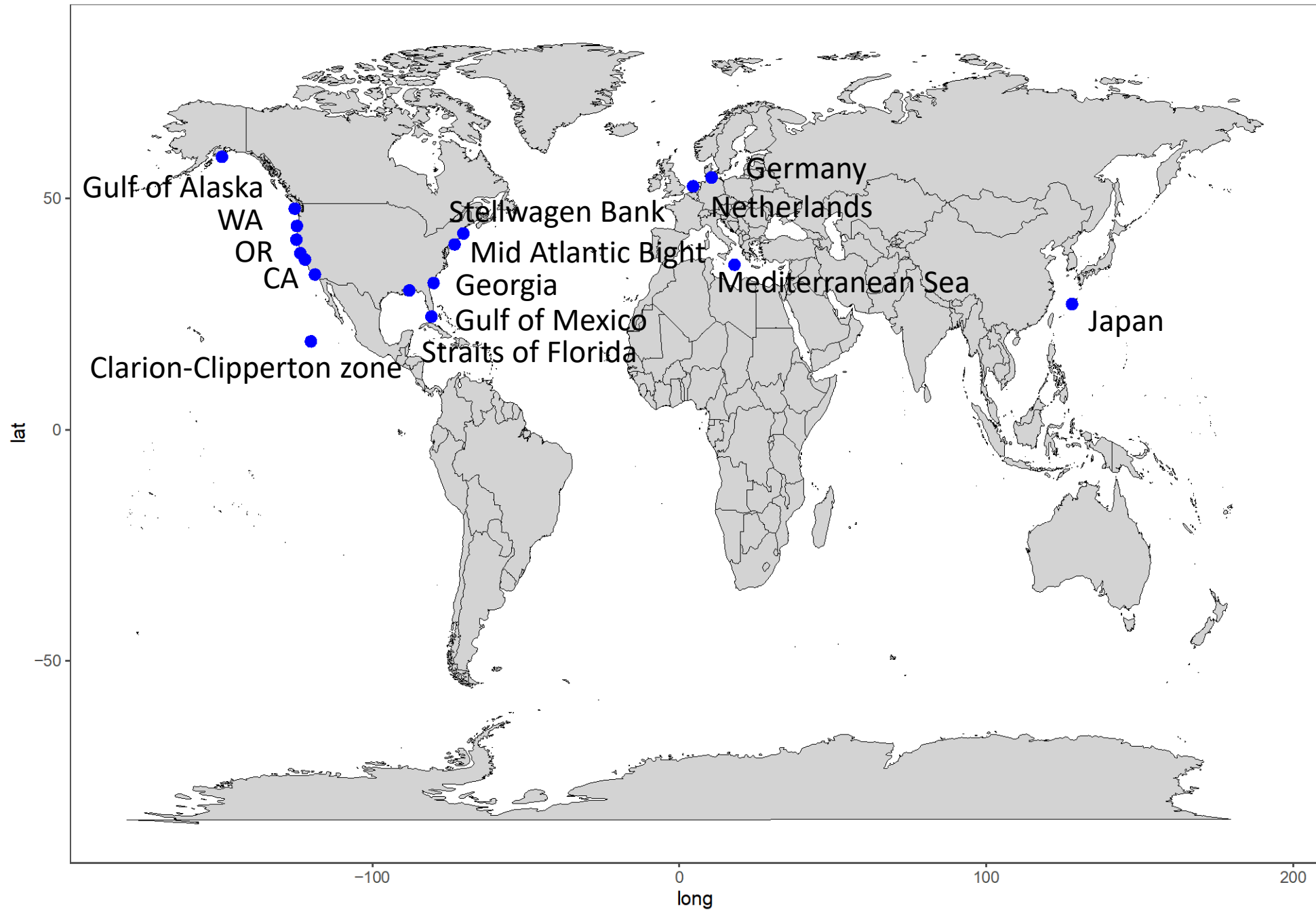


# Example taxon selection



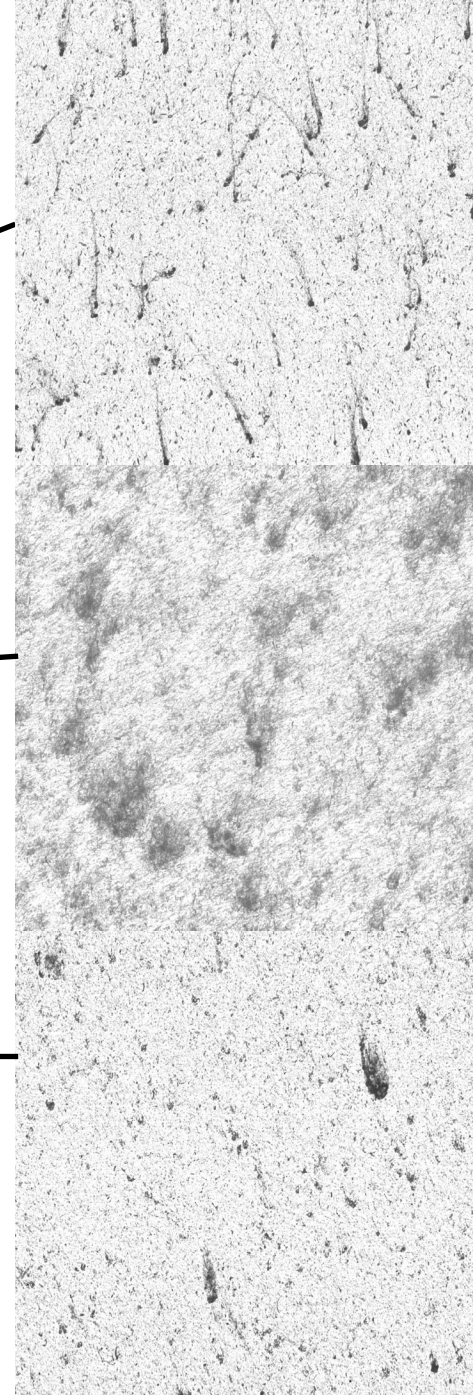
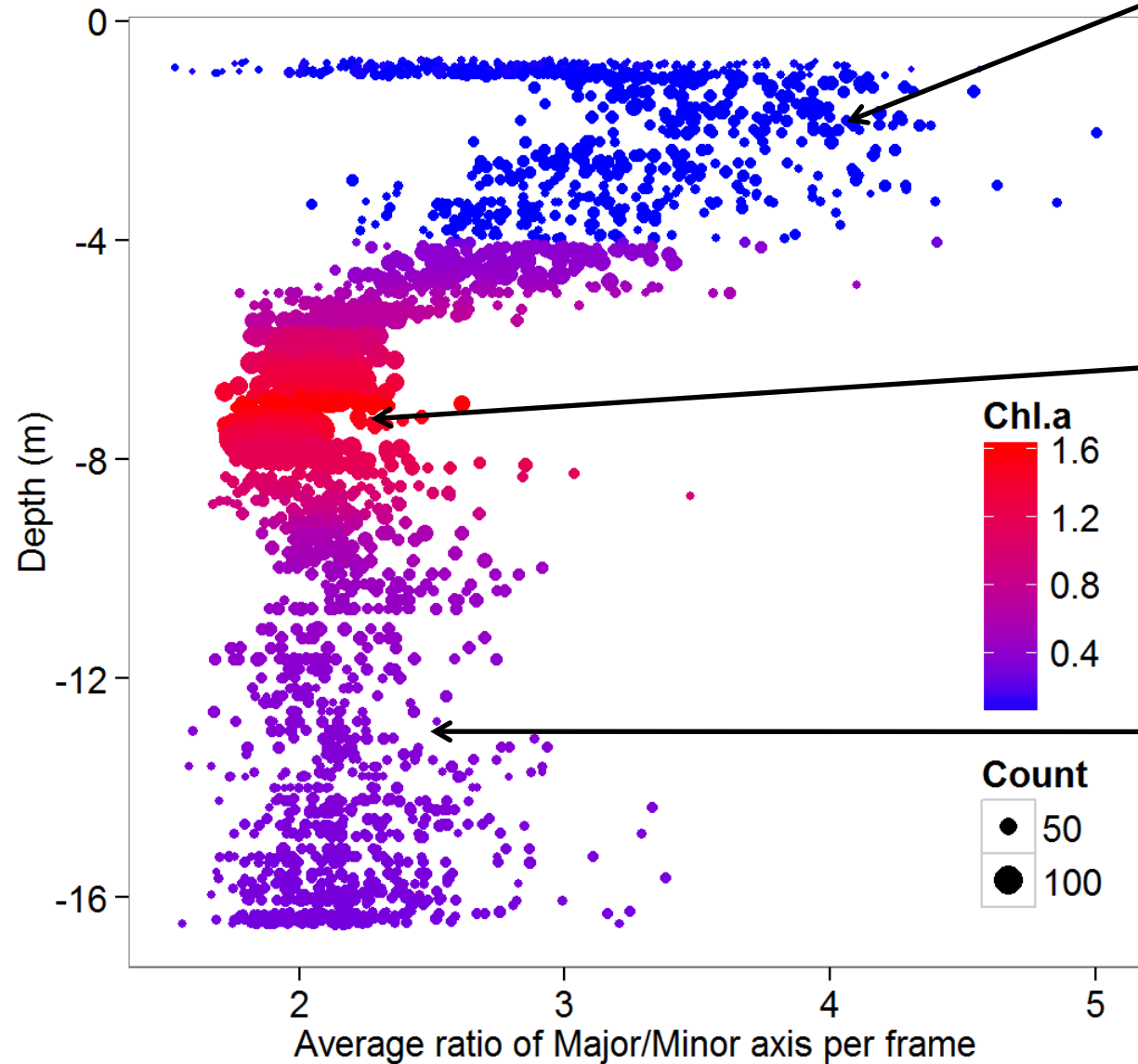
# Example applications

# ISIIS around the world

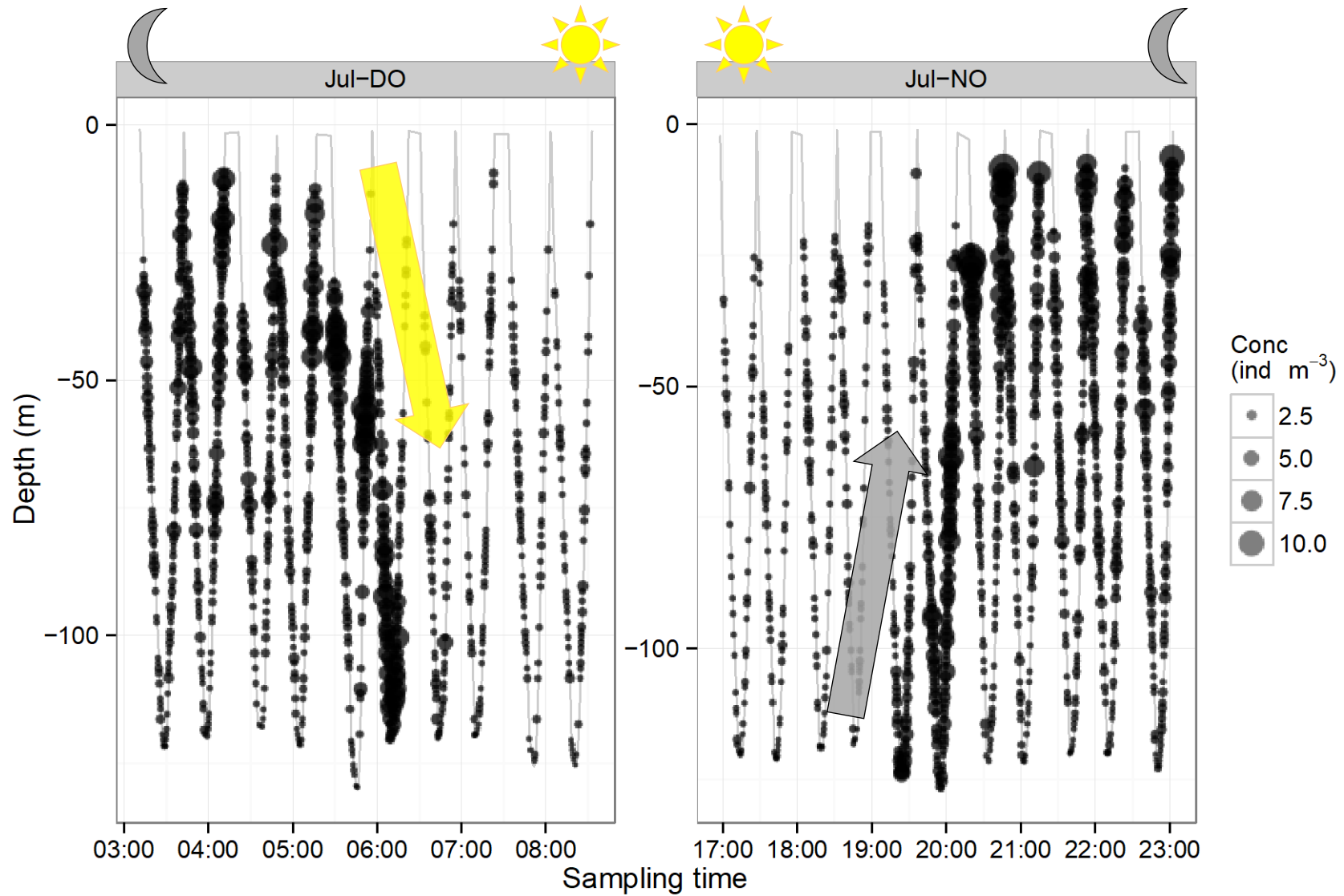




# Fine vertical resolution of phytoplankton floc shape



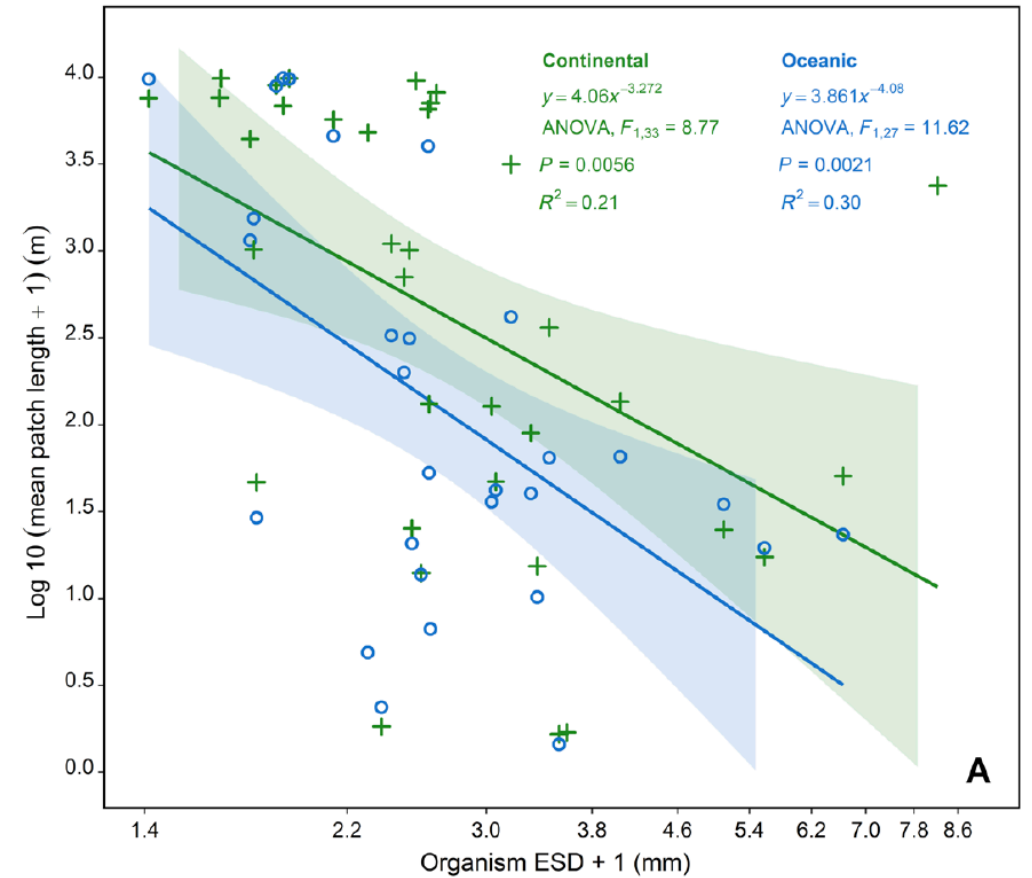
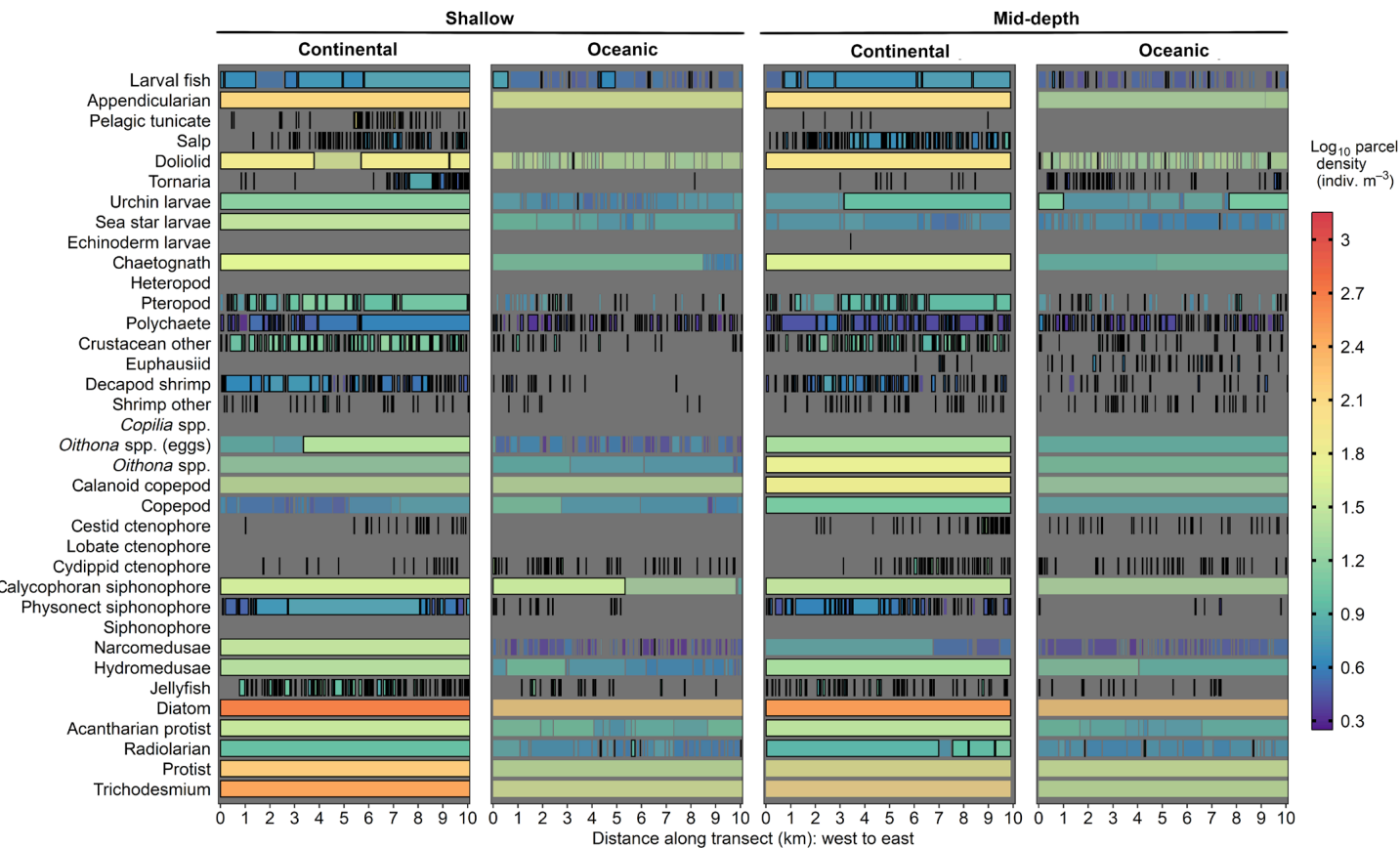
# Euphausiids – an example of DVM



# Straits of Florida – Plankton patchiness along fixed depth transects

How can plankton patch structure be quantitatively described?

→ Resolving patch structure from micro-to submesoscales

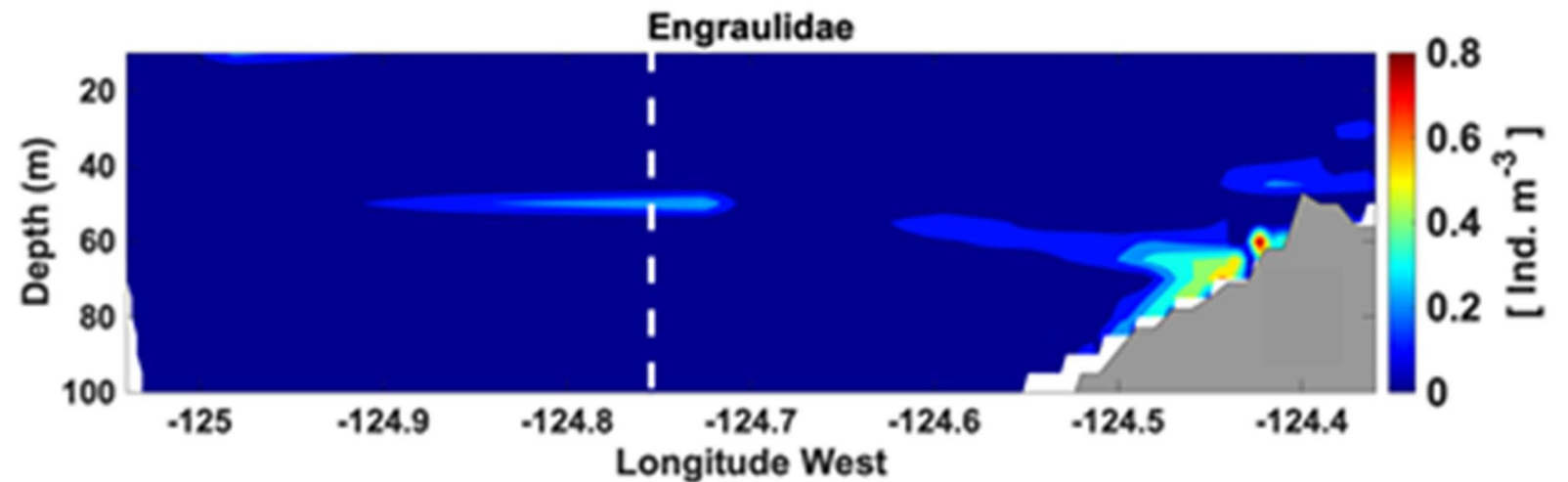
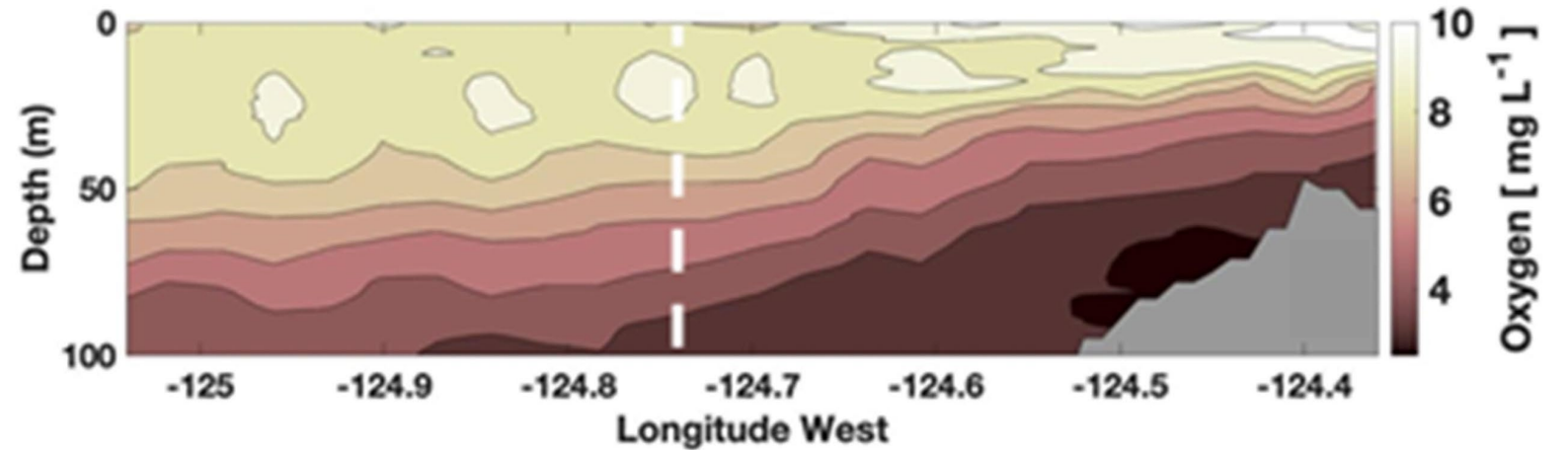
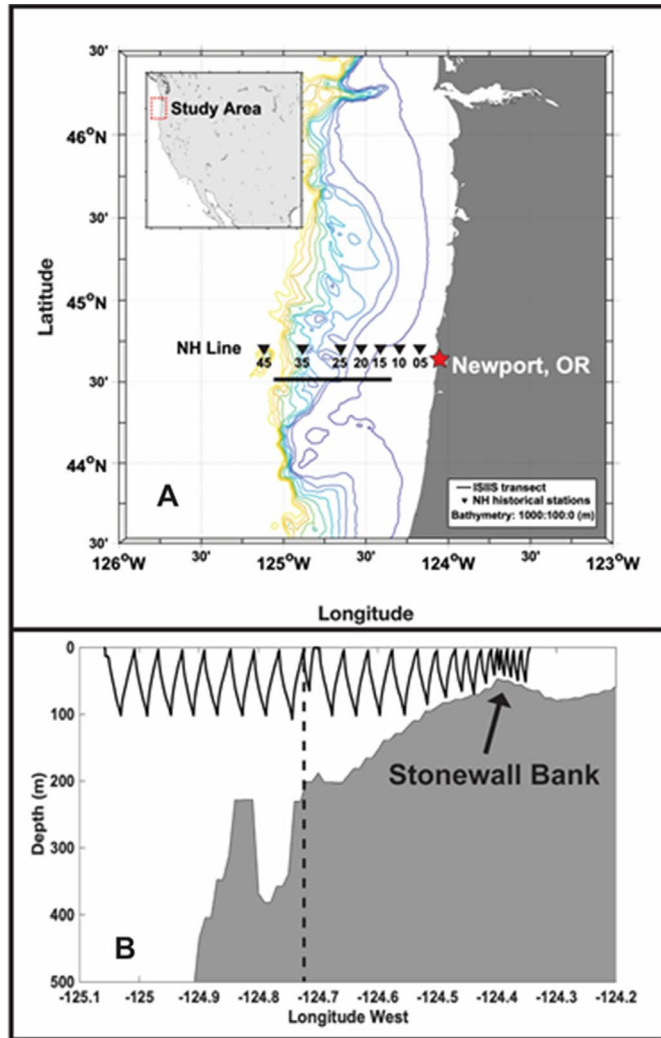


**Plankton patch length scaled negatively with organism size**

Robinson et al. 2021

# Central Oregon – coastal sampling

- Engraulid accumulations in near-hypoxic waters  
→ Feeding on copepods or possible refuge from predation



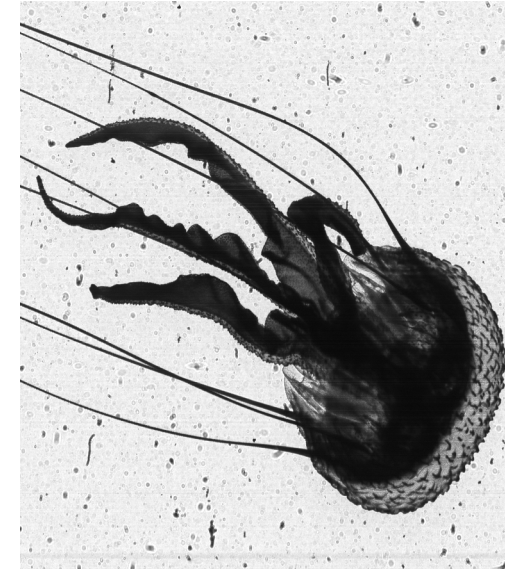
# Next steps

- More cross calibration among sampling systems
- Standardize training sets for AI Image Analysis
- Get beyond demonstration stage to application stage

# Acknowledgements

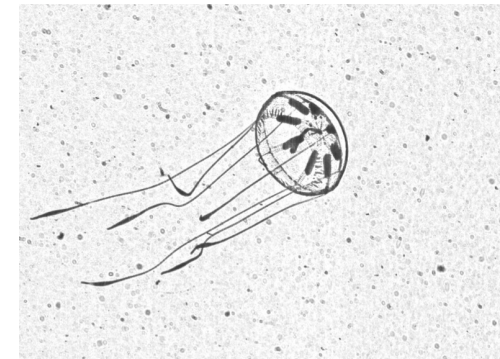
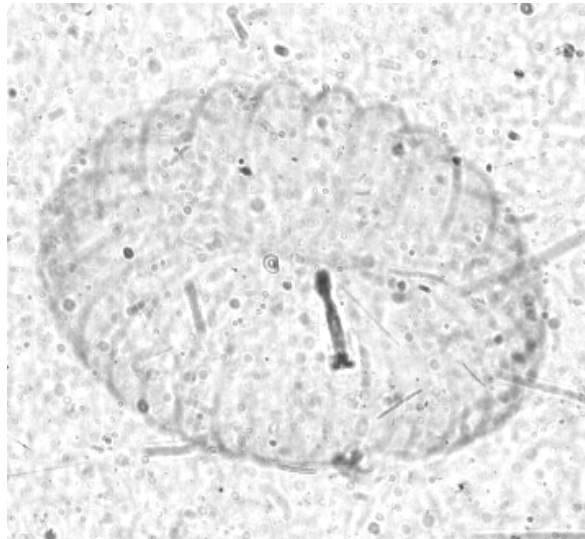
## ISIIS Design/Analysis Team

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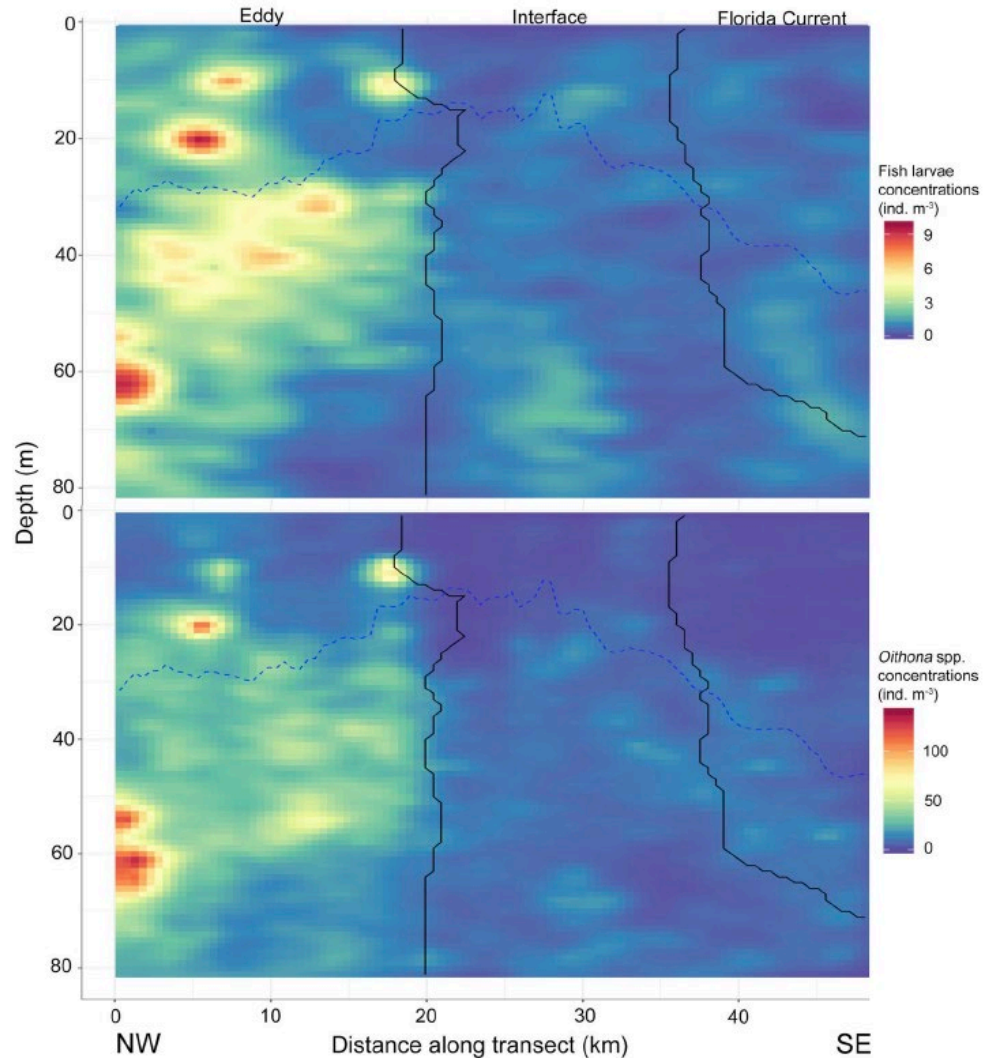


## Field work

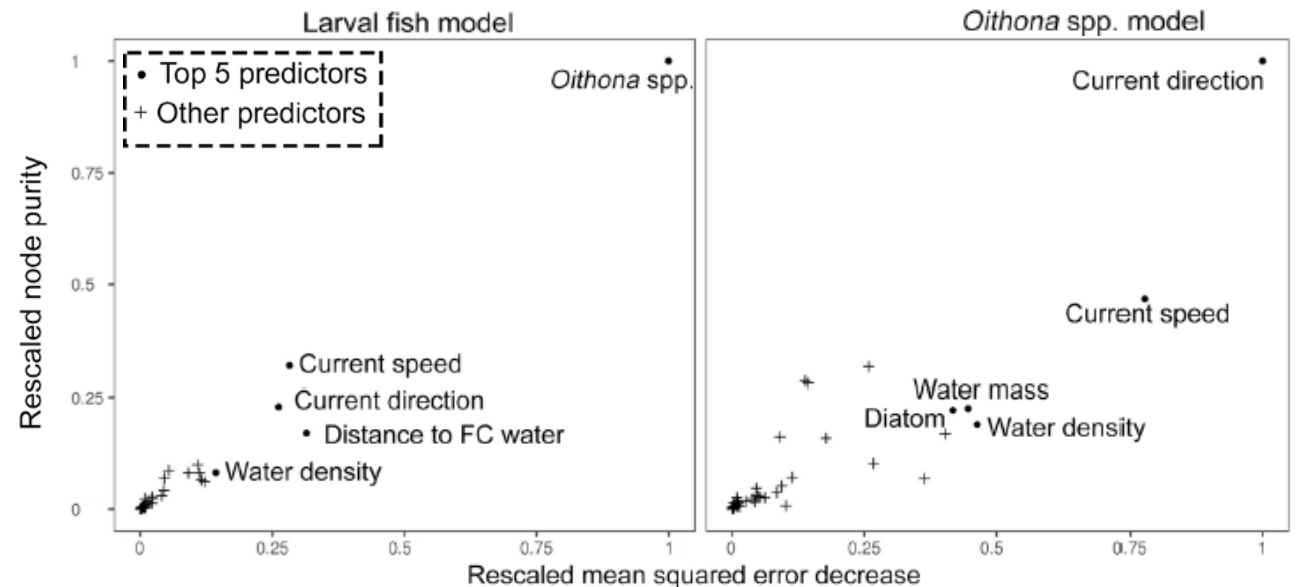
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Jessica Luo (NOAA)  
Kelly Robinson (LSU)  
Dave Richardson (NOAA)  
Jon Hare (NOAA)  
Jean-Olivier Irisson (Villefranche, FR)  
Margaret McManus (UH)  
Will Fennie (OSU)  
Ric Brodeur (NOAA)  
Kelly Sutherland (UO)



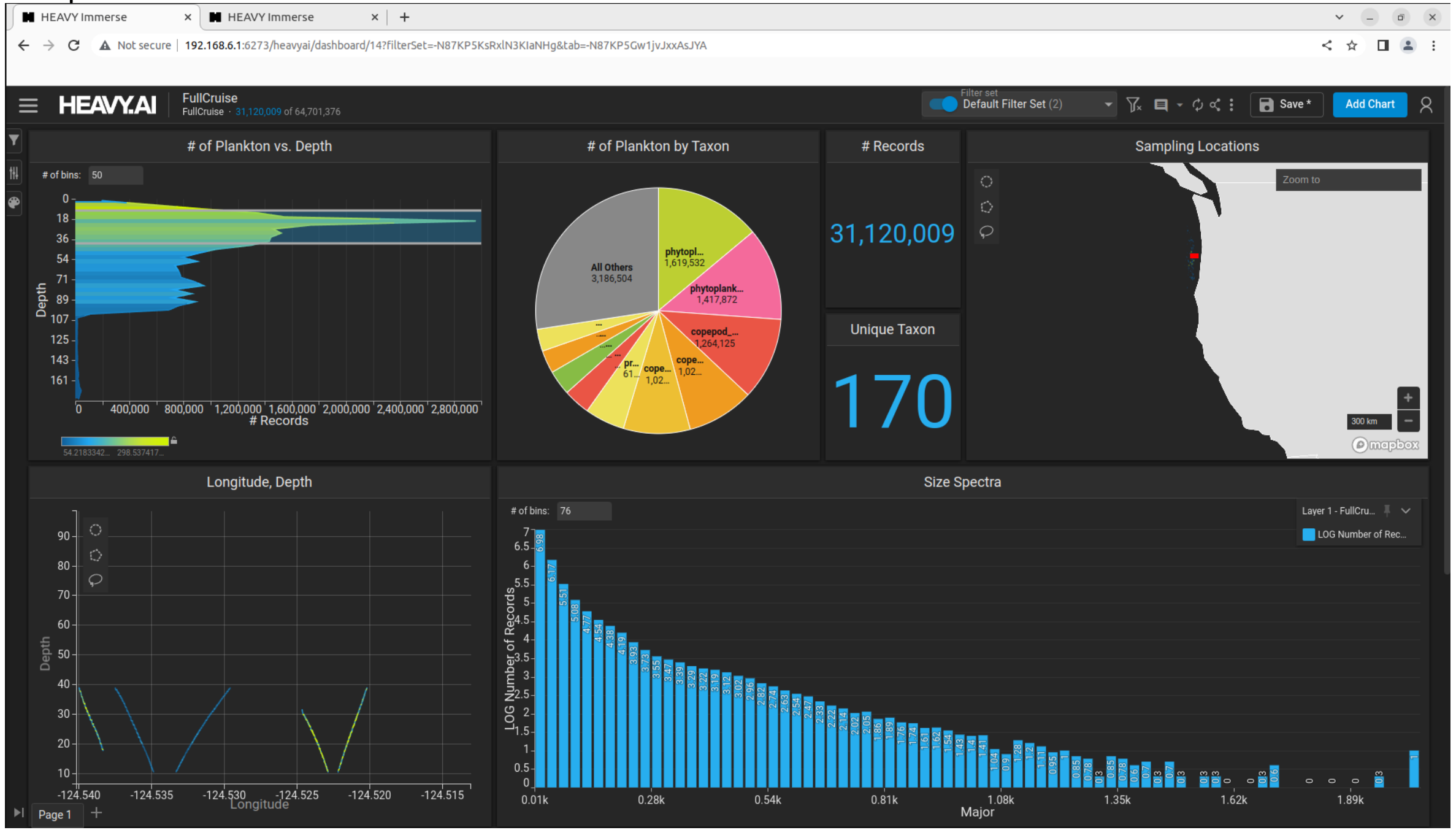
# Straits of Florida - Eddy



- Larval fish and *Oithona* sp. copepods co-occurred at inside eddy edge
- > Biology or physics driven?
- Random Forests models point towards physics driven. Removing *Oithona* as predictor in larval fish model reduced variance explained by 0.3-2% (at ~80% total var explained), and *Oithona* model itself physics driven.

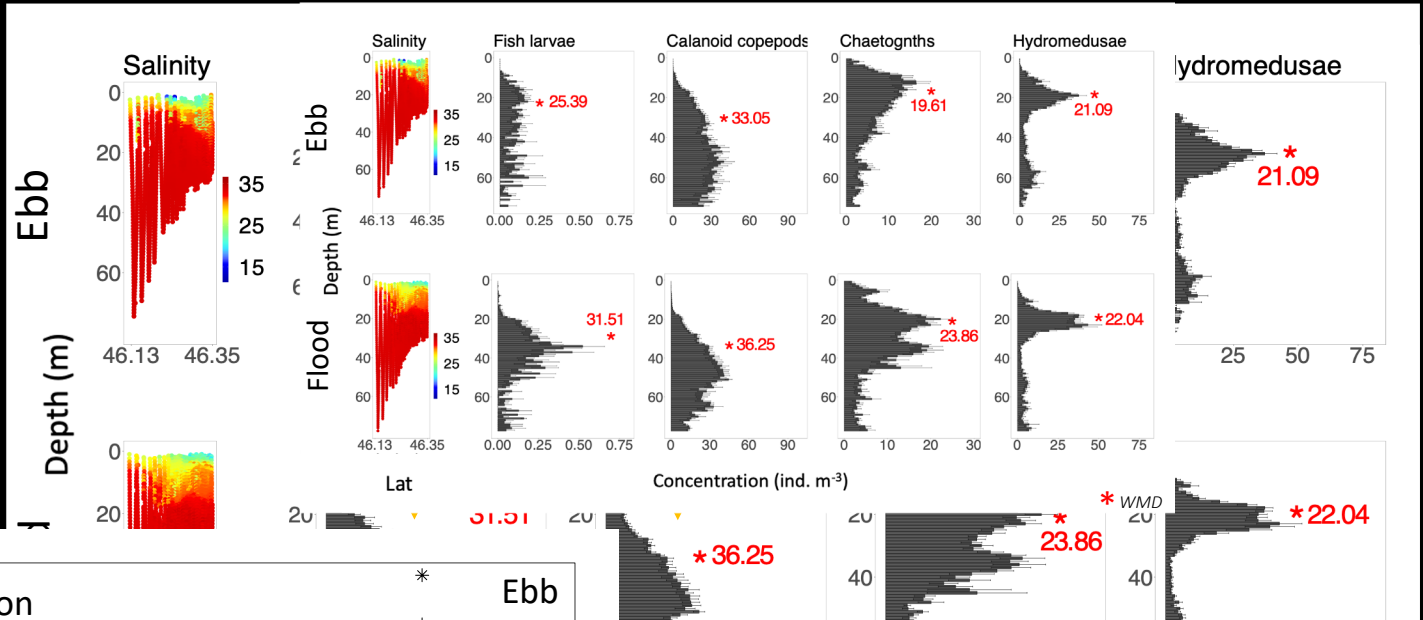
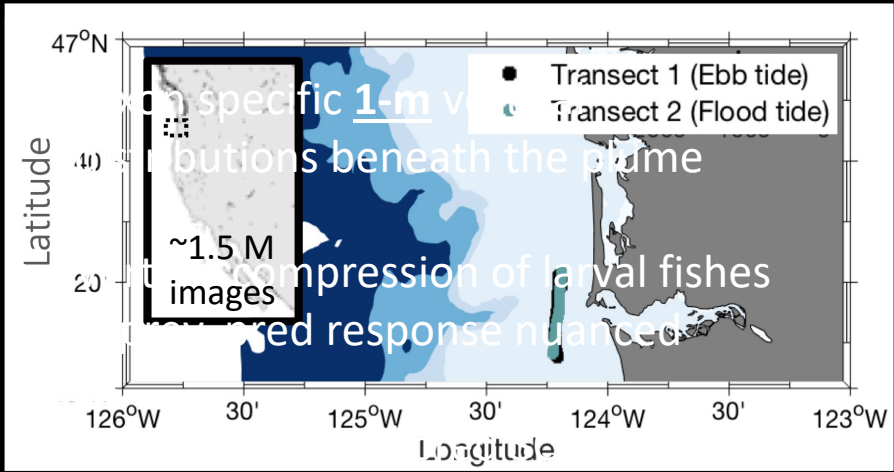


# Example vertical selection



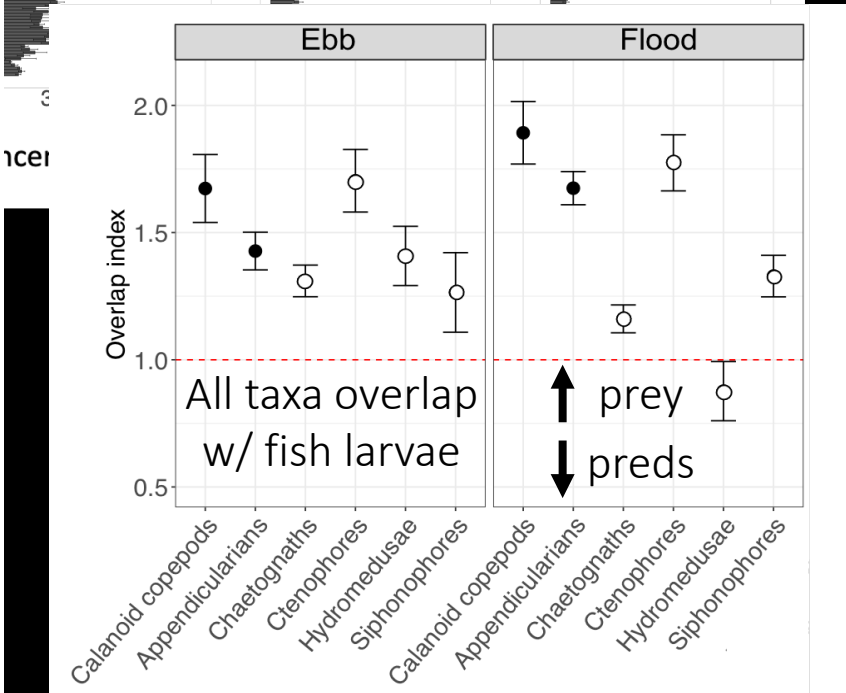
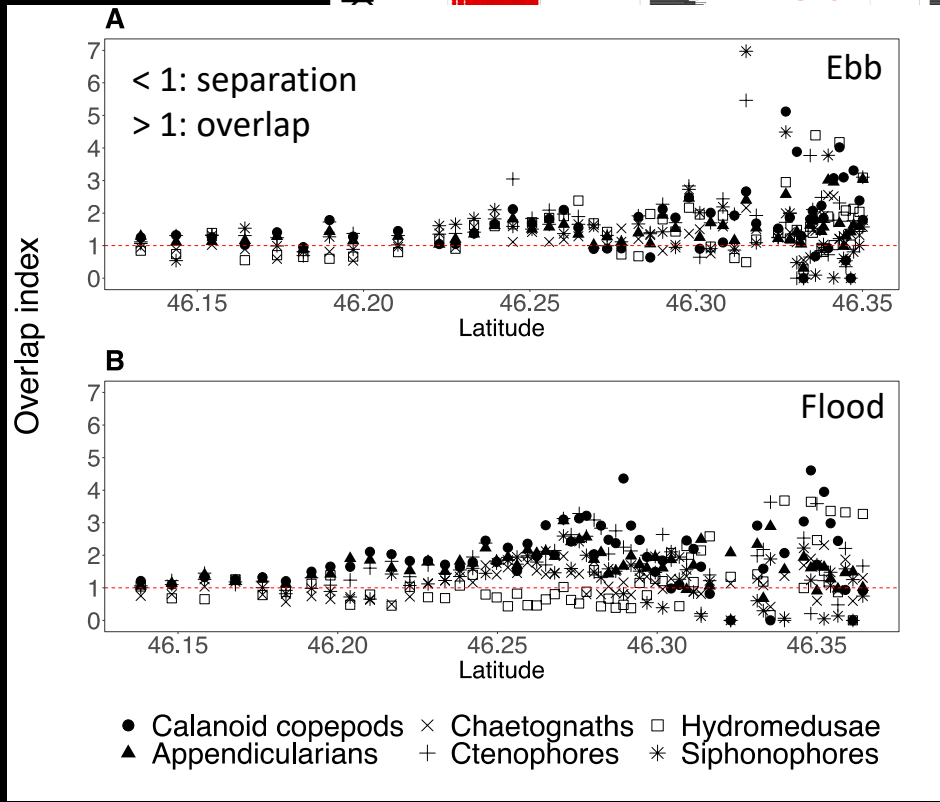


# NCC – Fine-scale larval fish prey availability & predation pressure near a tidally modulated river plume

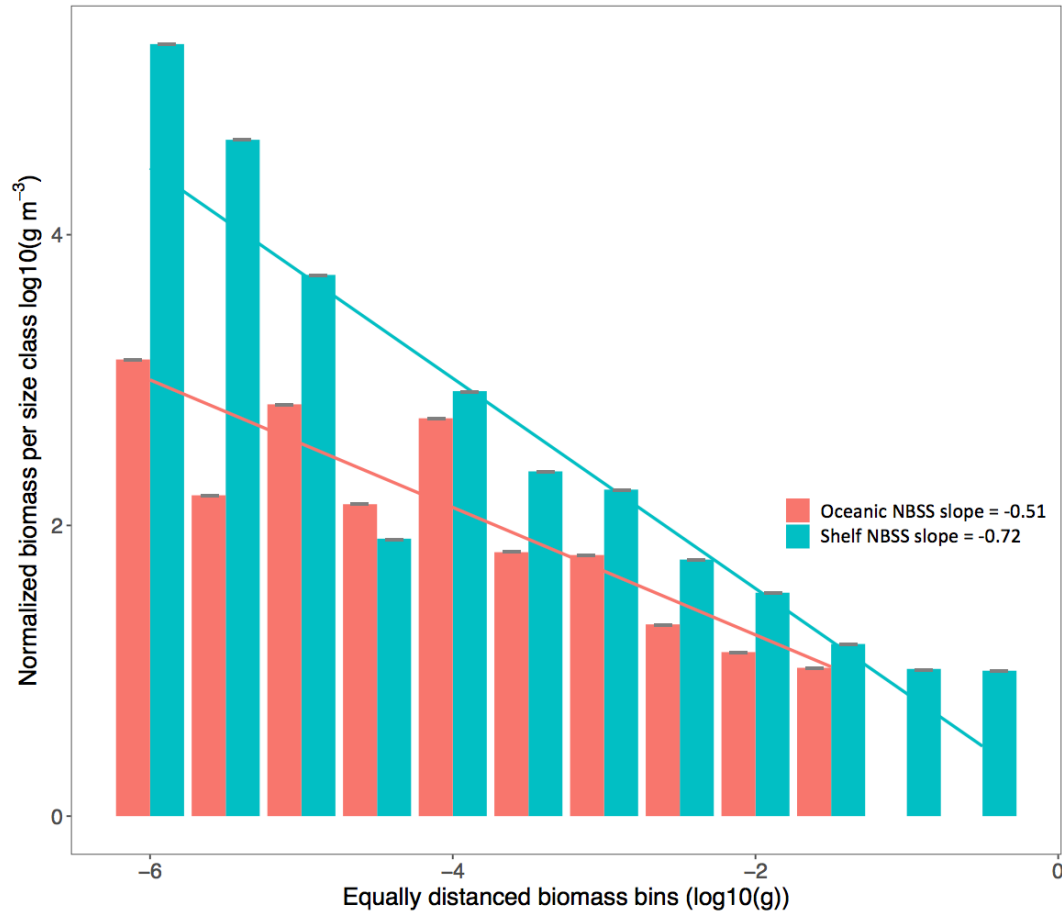


throughout the tidal cycle

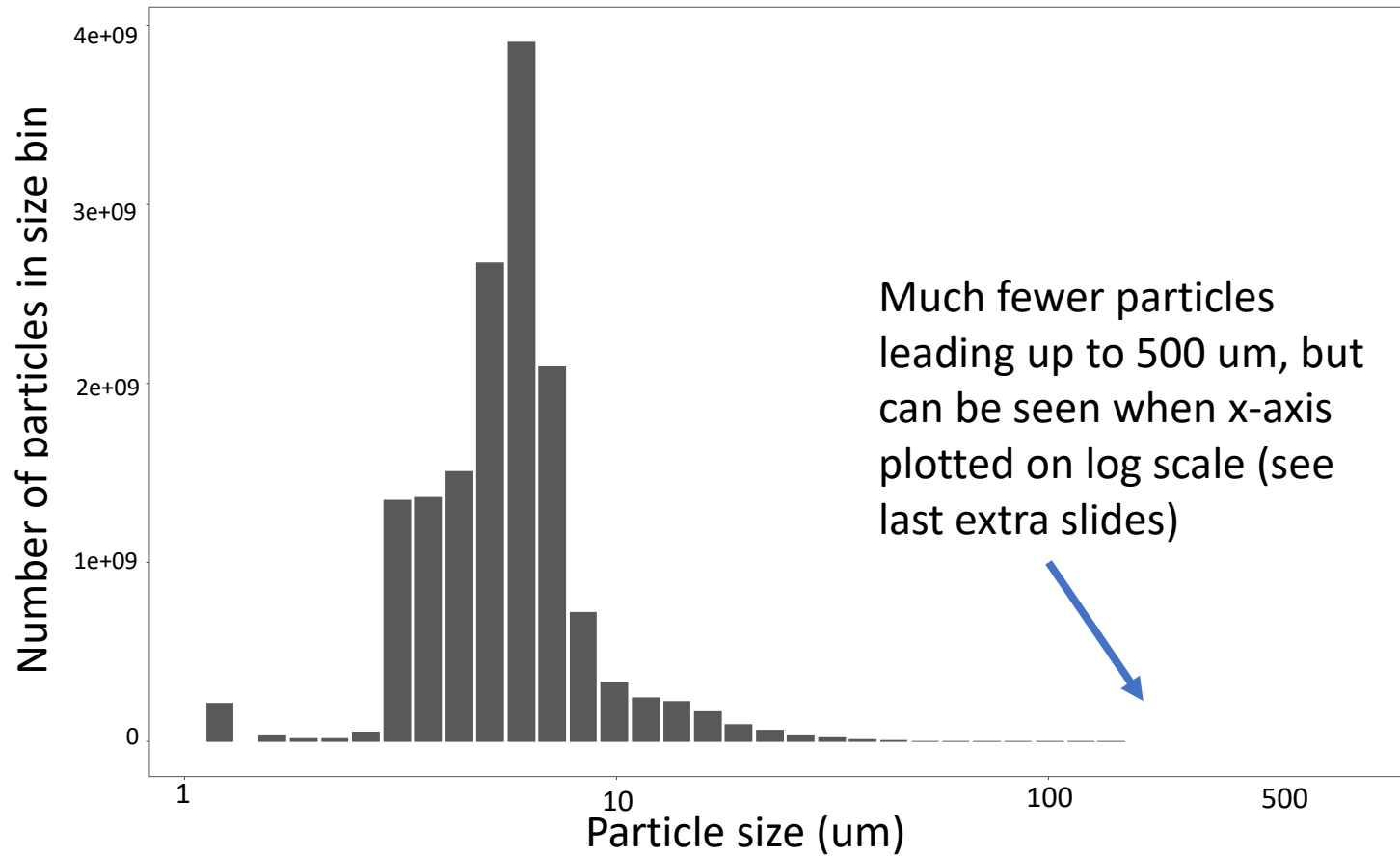
- Trophic envr changes on short time scales
- Swieca et al. 2020



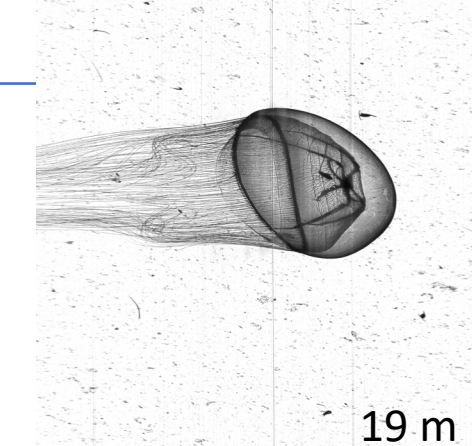
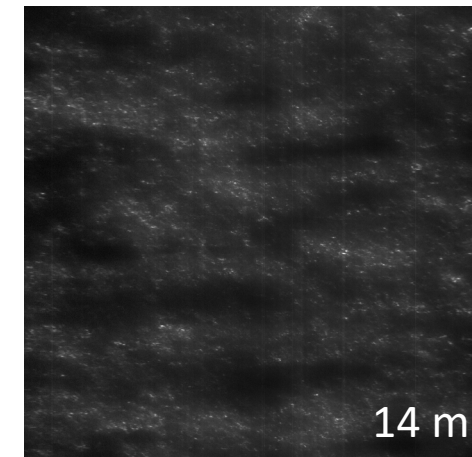
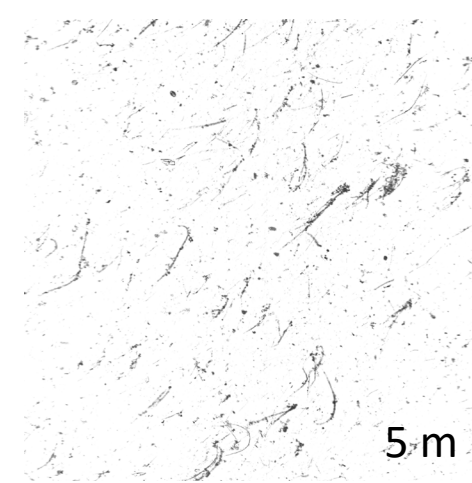
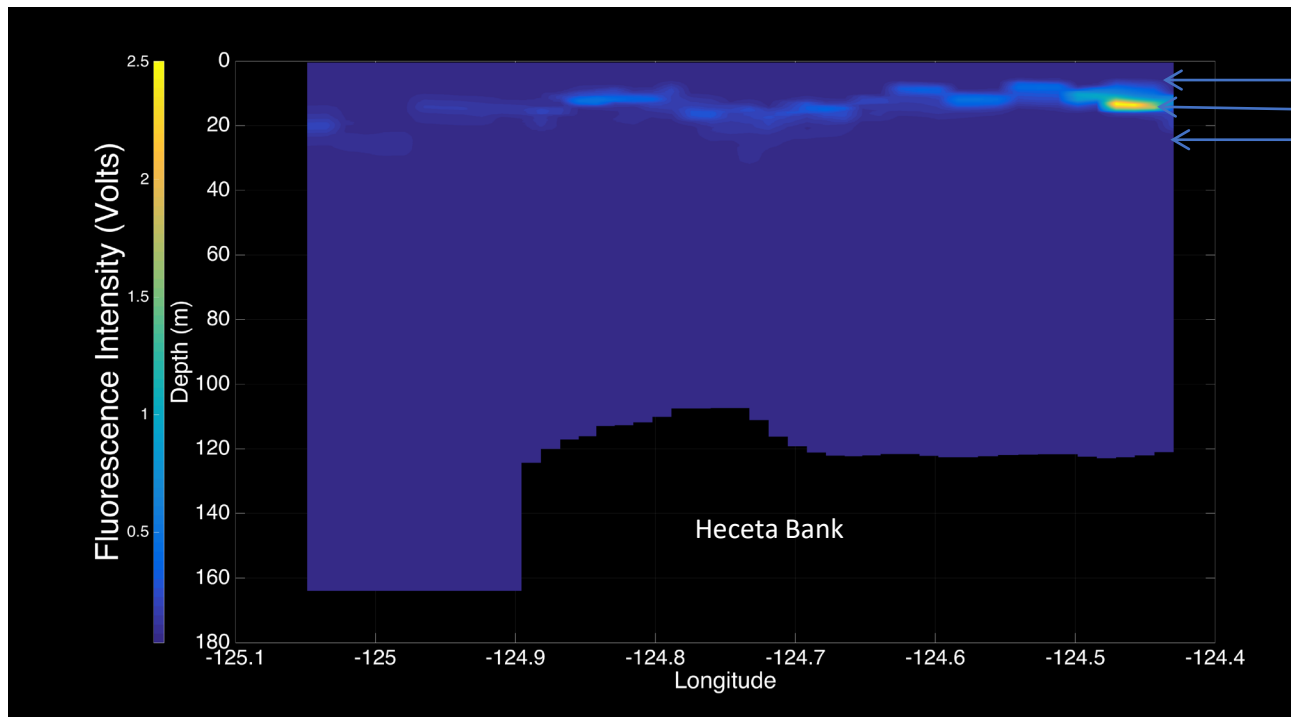
### Biomass and taxonomy from ISiIS



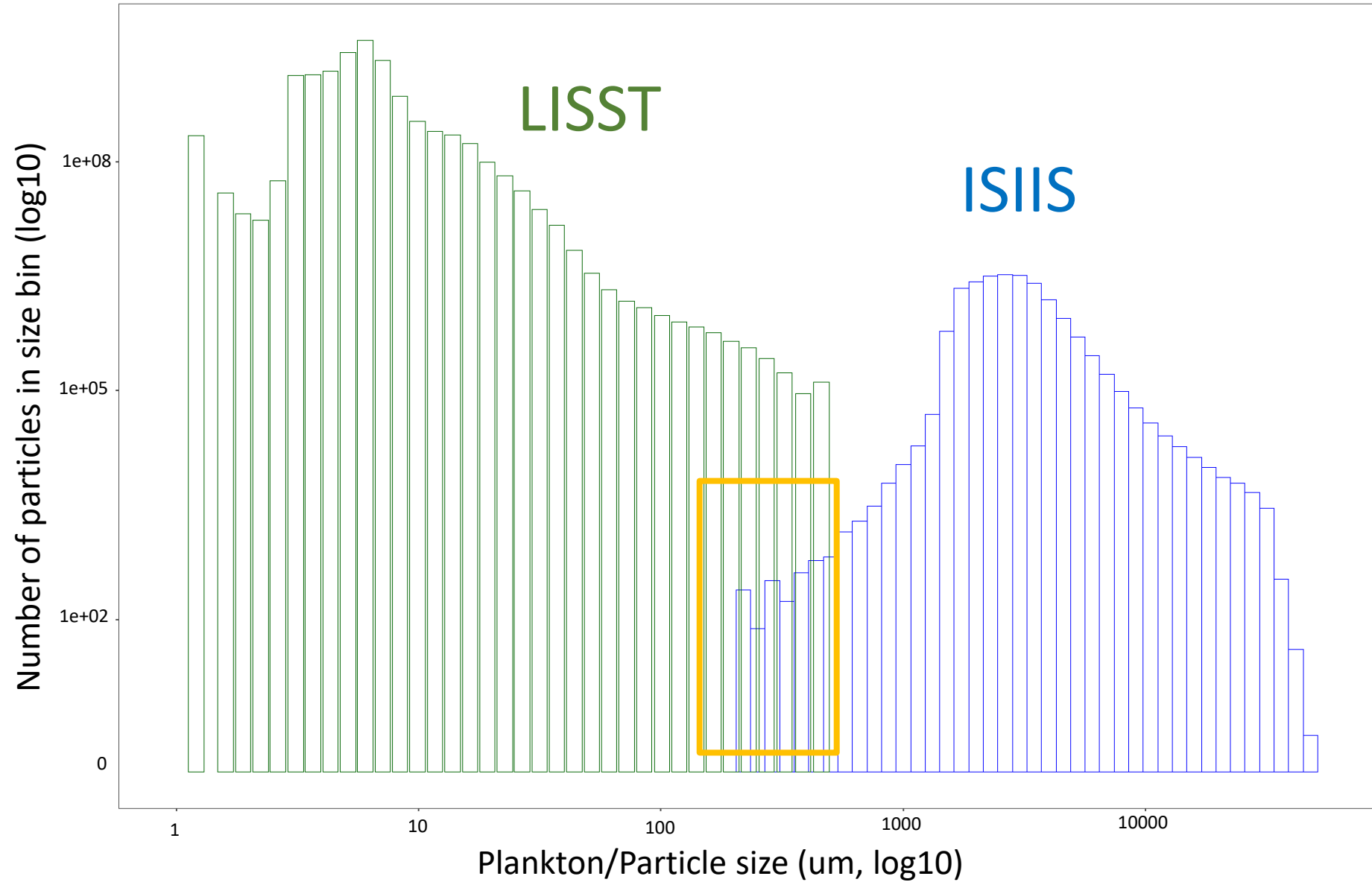
### LISST particle data



Imaging size overlap between 200 and 500  $\mu\text{m}$  for size spectra spanning 9 orders of biomass magnitude



# Combining ISIS and LISST particle imager for spectra ranging from 1 micron to 55,000 micron+



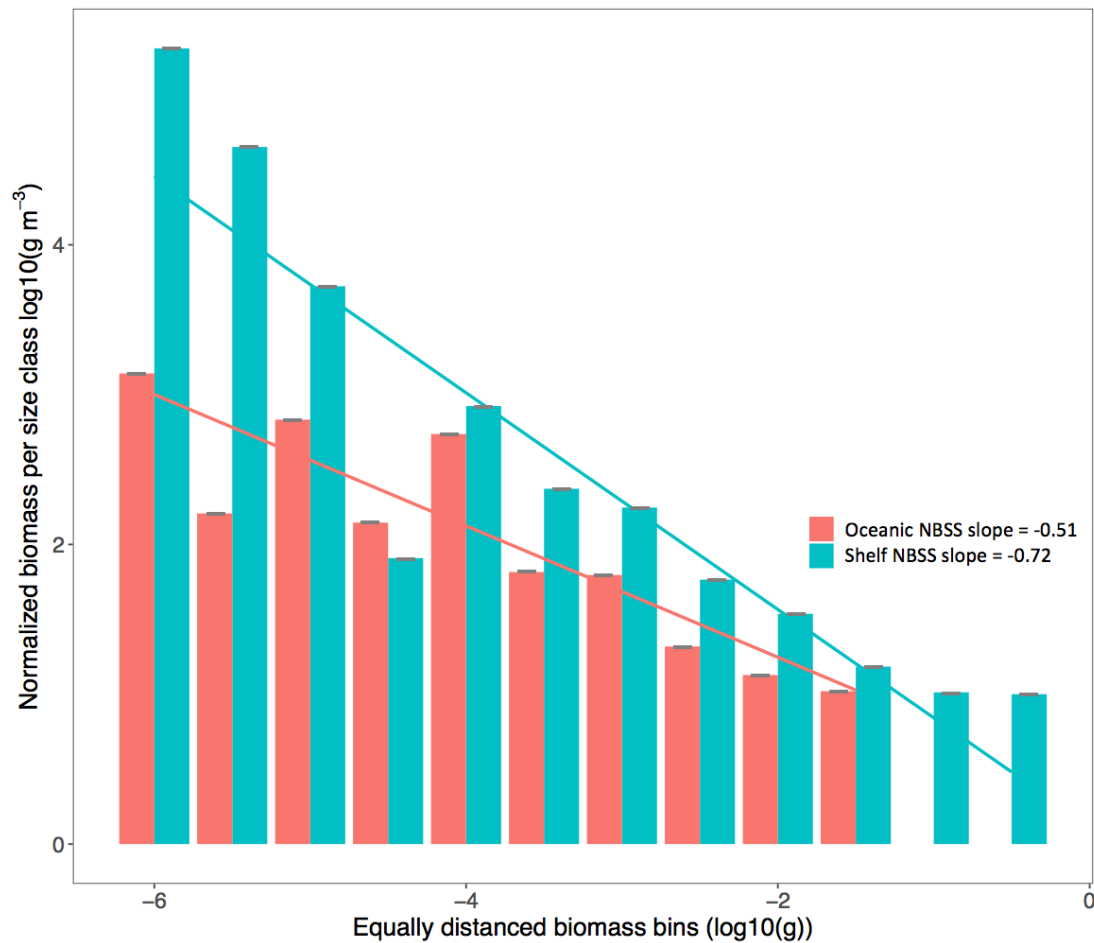
**Size spectra spanning 6 orders of magnitude**

Imaging size overlap between 200 and 500 um for intercalibration

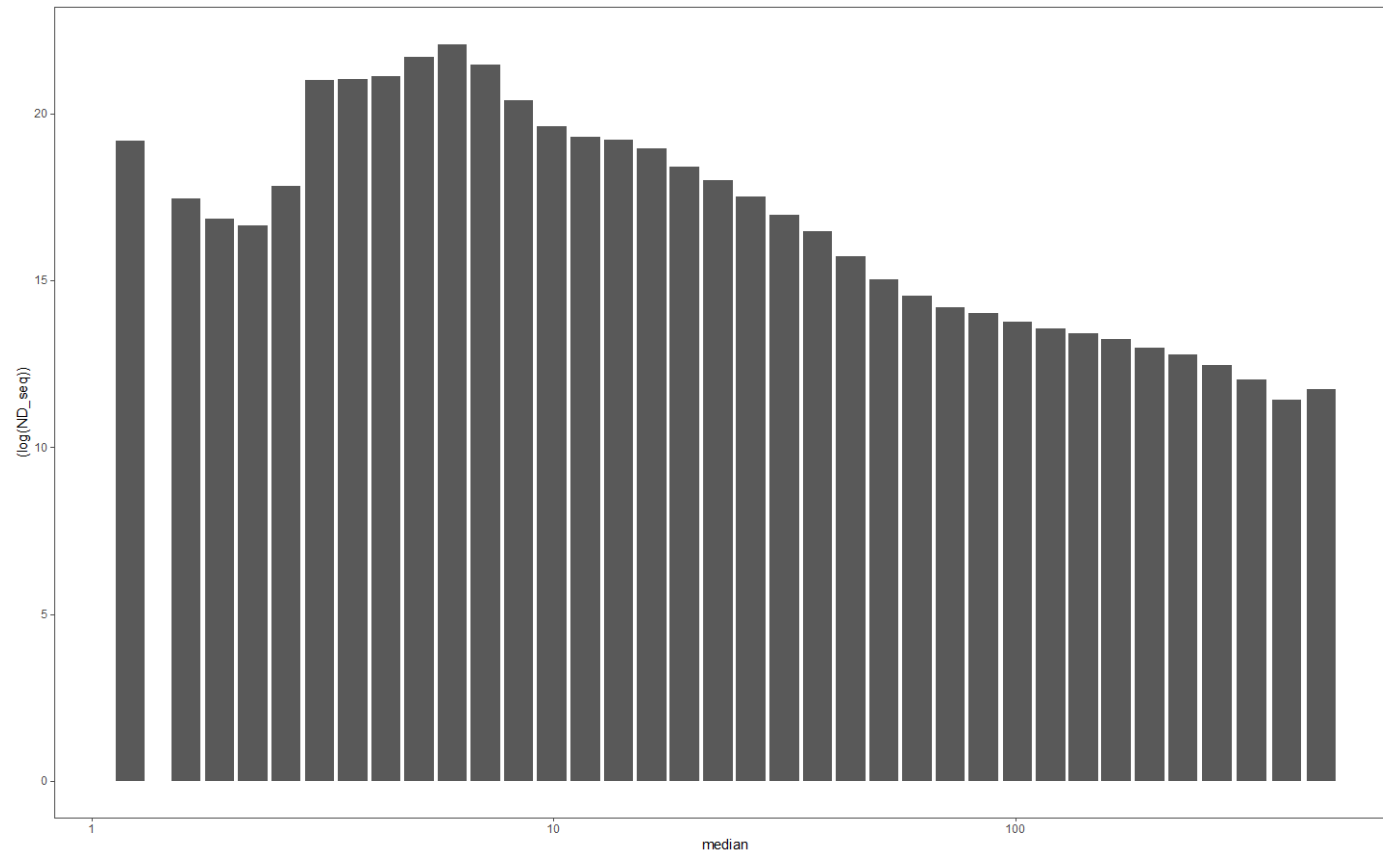
# Size spectra work by combining ISIS and LISST200X

LISST particle data

## Biomass and taxonomy from ISIS



## Log scale LISST data

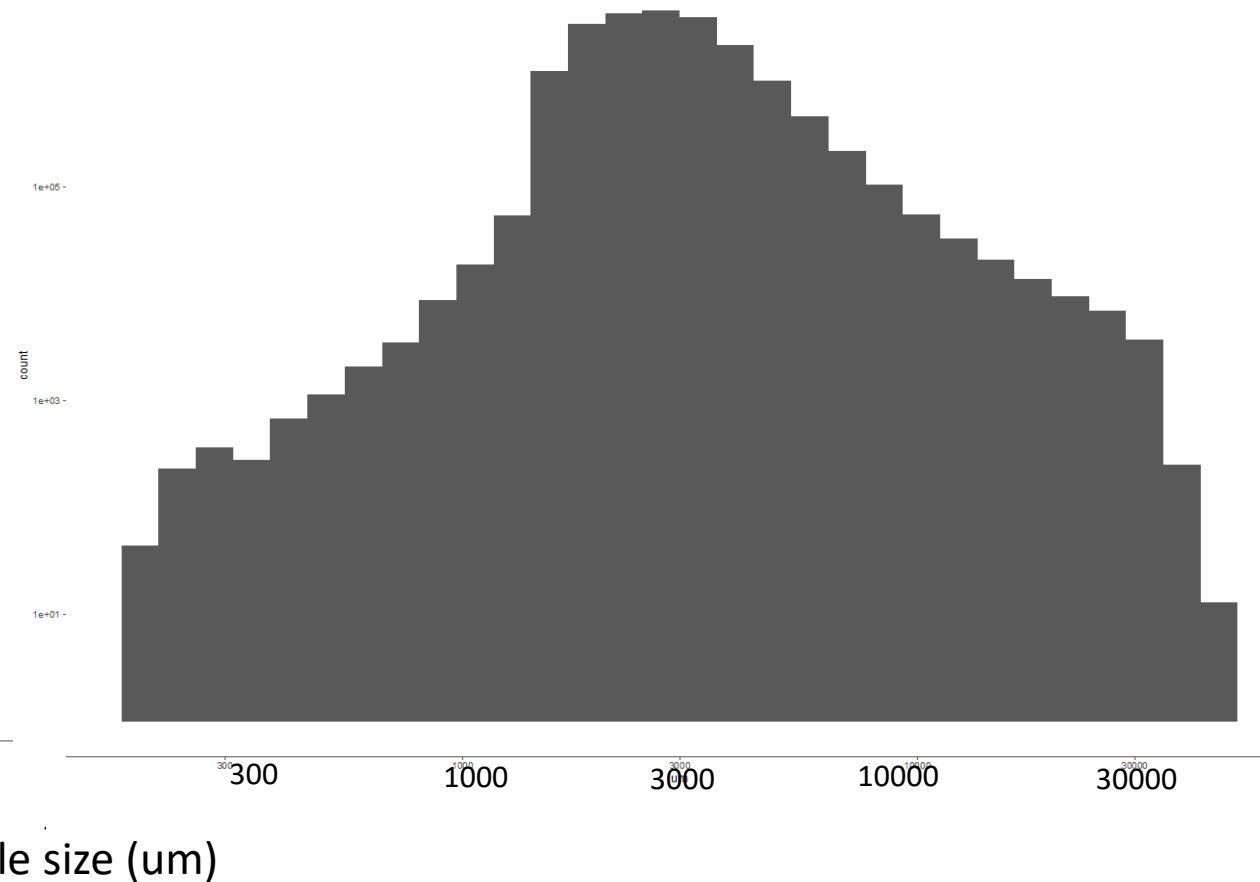
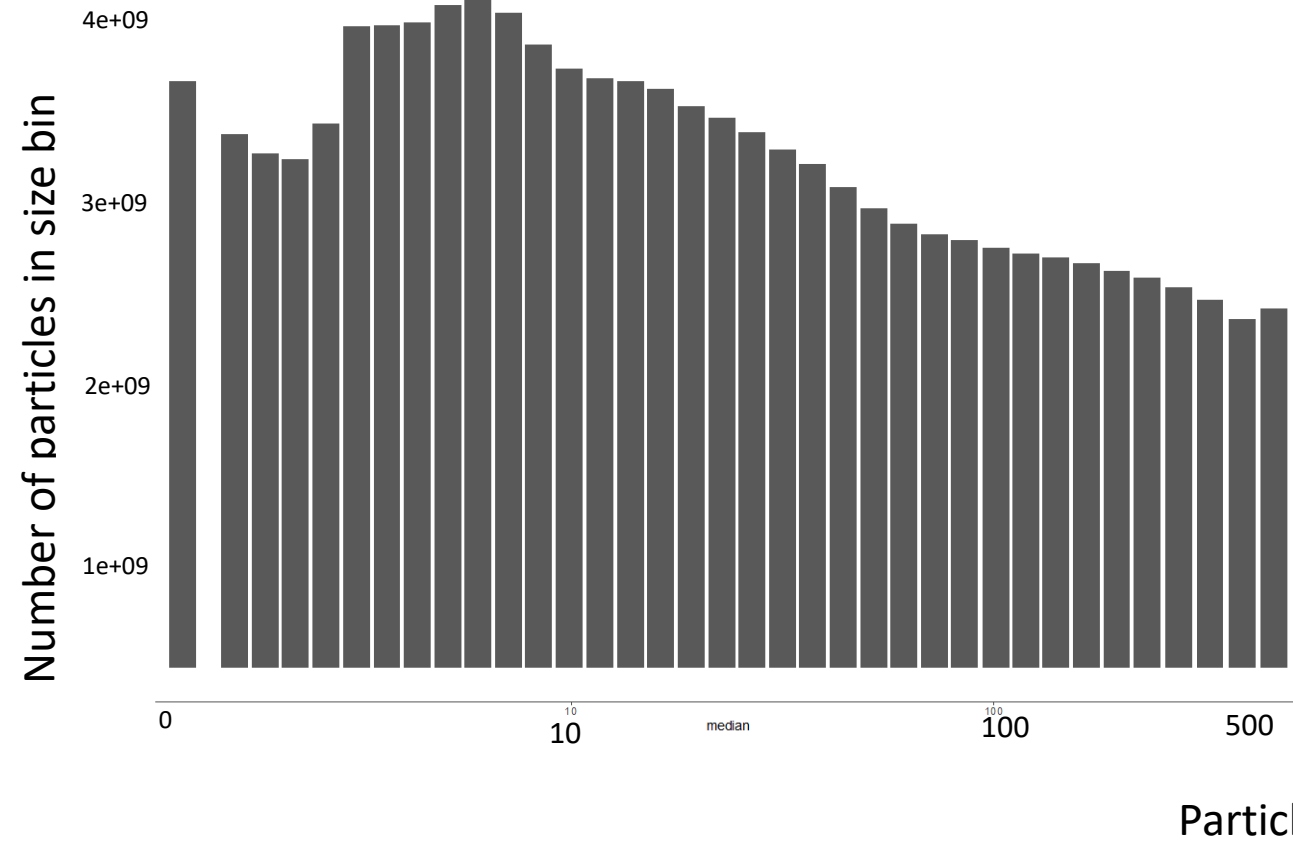


# Northern California Current size spectra work - combining ISIS and LISST particle imager

BOTH AXIS on log10

LISST particle size data

ISIS plankton size data & taxonomy



Imaging size overlap between 200 and 500 um for size spectra spanning 6 orders of magnitude