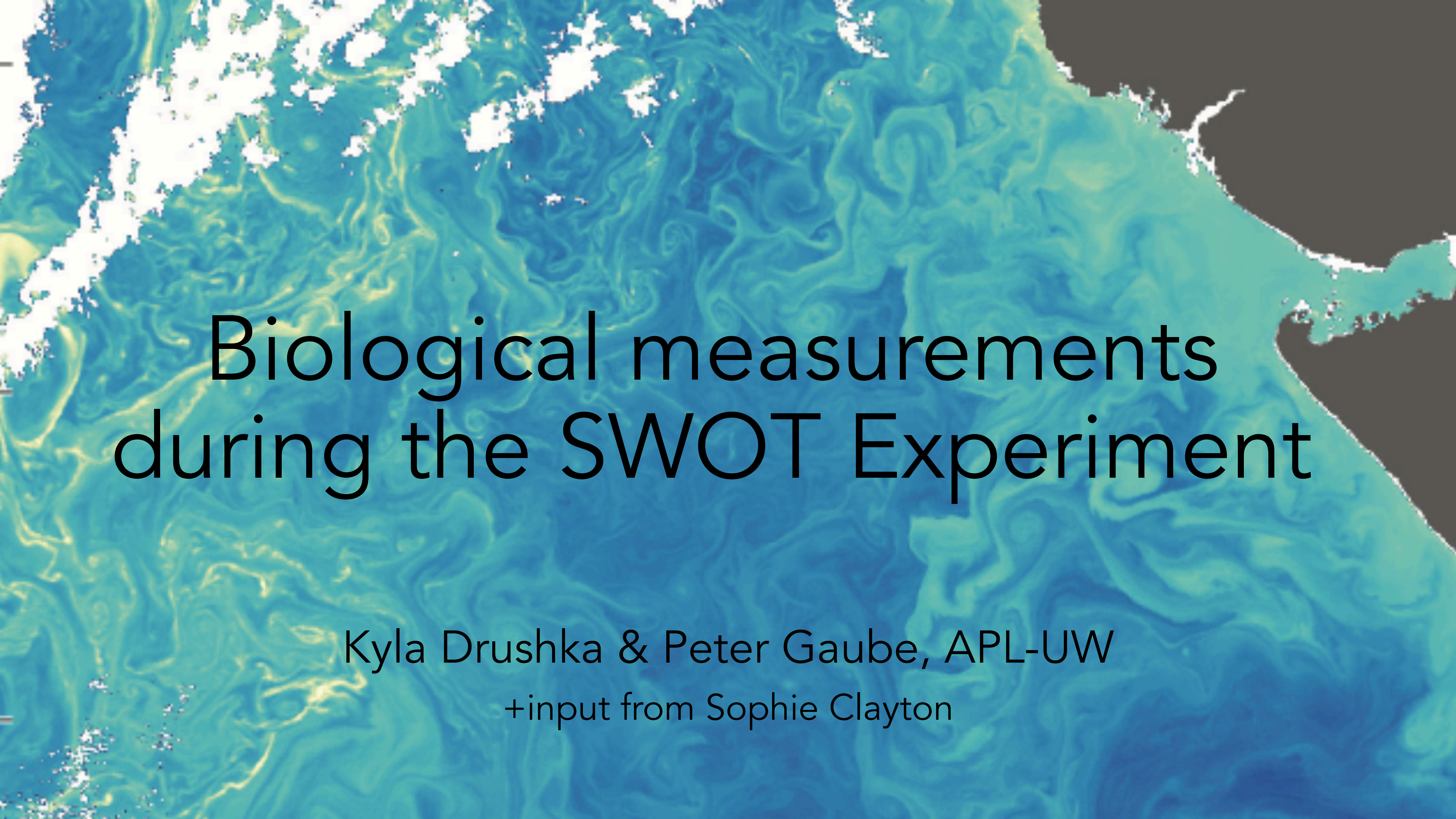


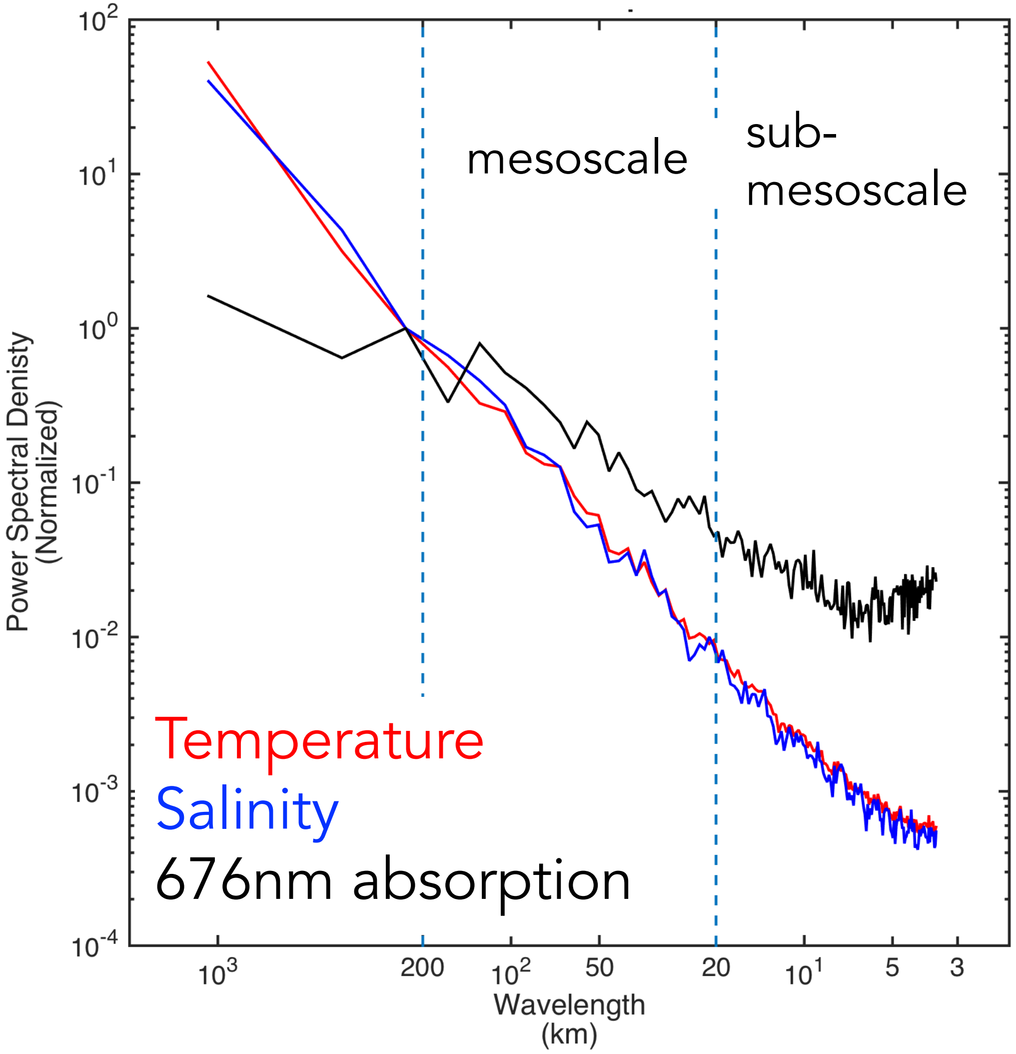
Biological measurements during the SWOT Experiment

Kyla Drushka & Peter Gaube, APL-UW
+input from Sophie Clayton

Ocean biology is extremely energetic at the submesoscale

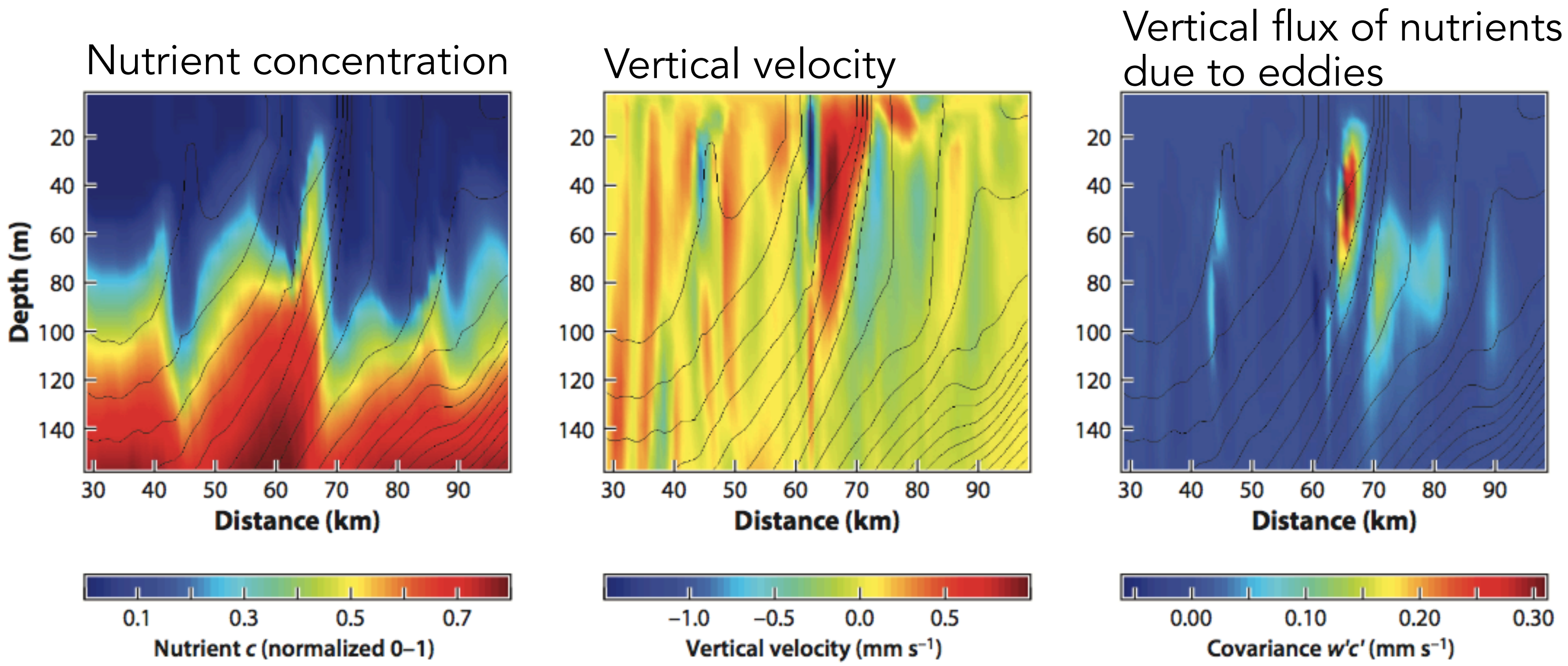
- Light & nutrients control phytoplankton growth to first order
- Submesoscale ocean dynamics can transport nutrients and/or bring phytoplankton into different light/nutrient regimes
- Horizontal stirring also contributes to patchiness in phytoplankton

Underway data from Tara Ocean transect, Hawaii-San Diego (courtesy of E. Boss)



Vertical velocity at submesoscale fronts drives strong nutrient fluxes

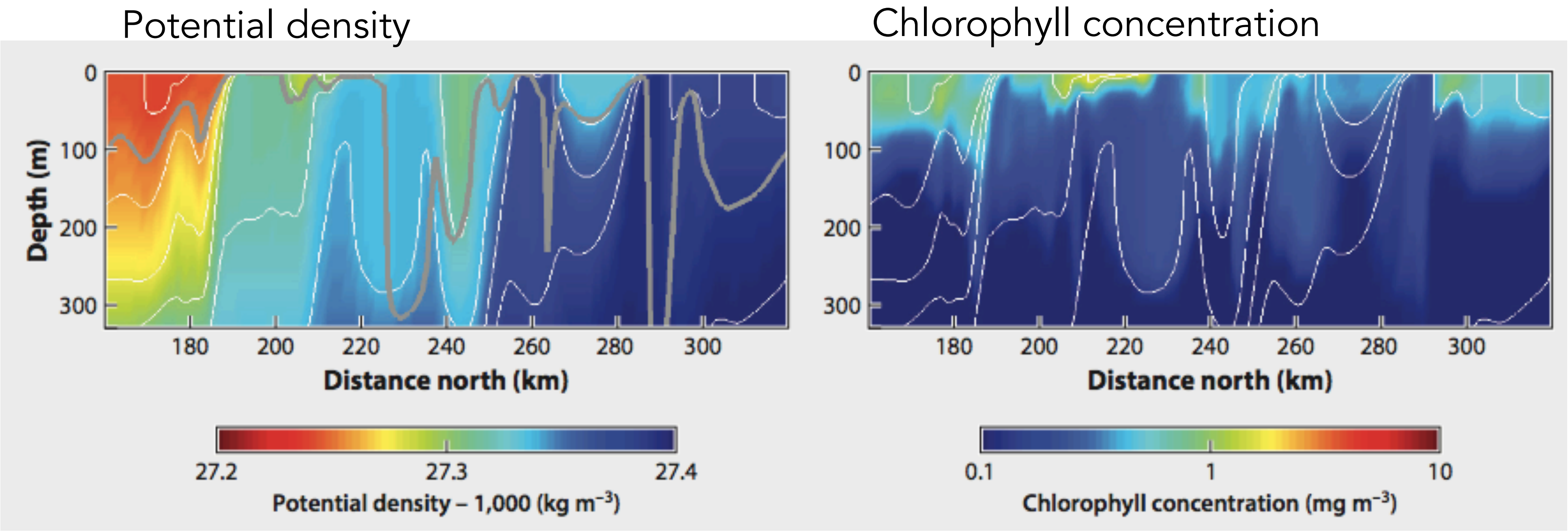
Example from the Process Study Ocean Model
(1km resolution):



Mahadevan 2016

In a light-limited regime, restratification from mixed-layer eddies can trap phytoplankton in the euphotic zone, producing a bloom

Example from the Process Study Ocean Model:

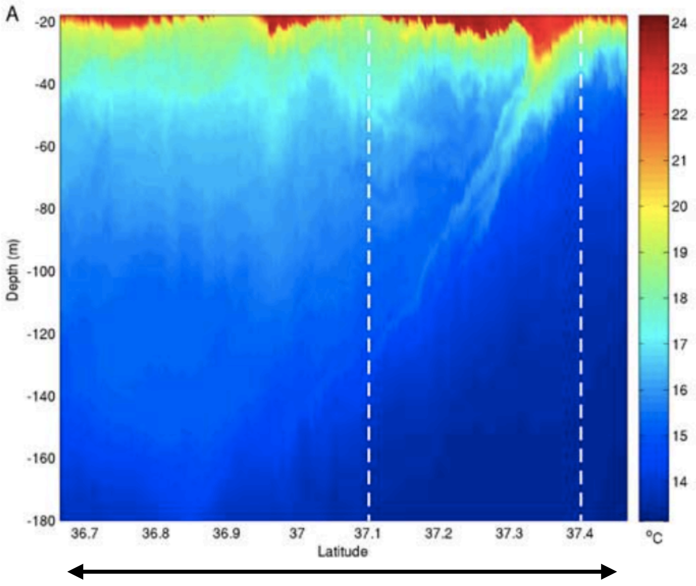


Mahadevan 2016

Downwelling at strong fronts brings phytoplankton out of the euphotic zone – this is a significant mechanism for carbon export

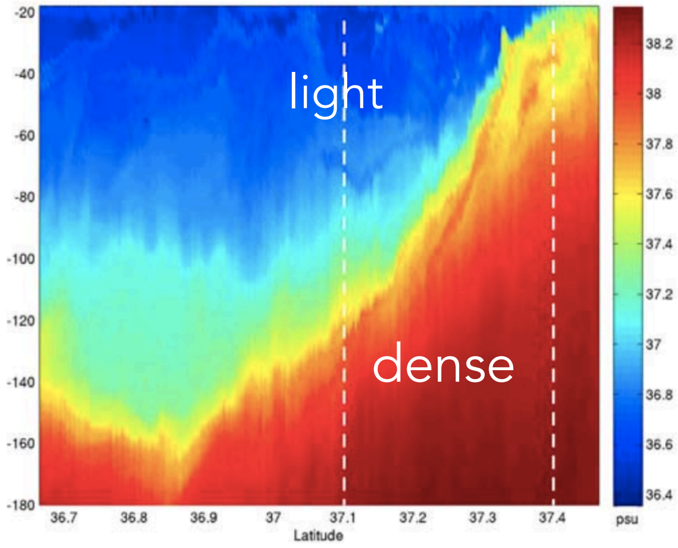
(Omand 2015)

Temperature

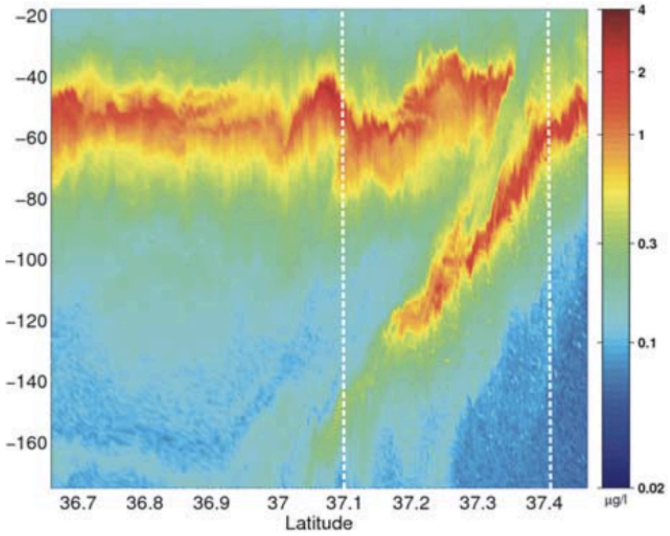


~85 km

Salinity



Chlorophyll



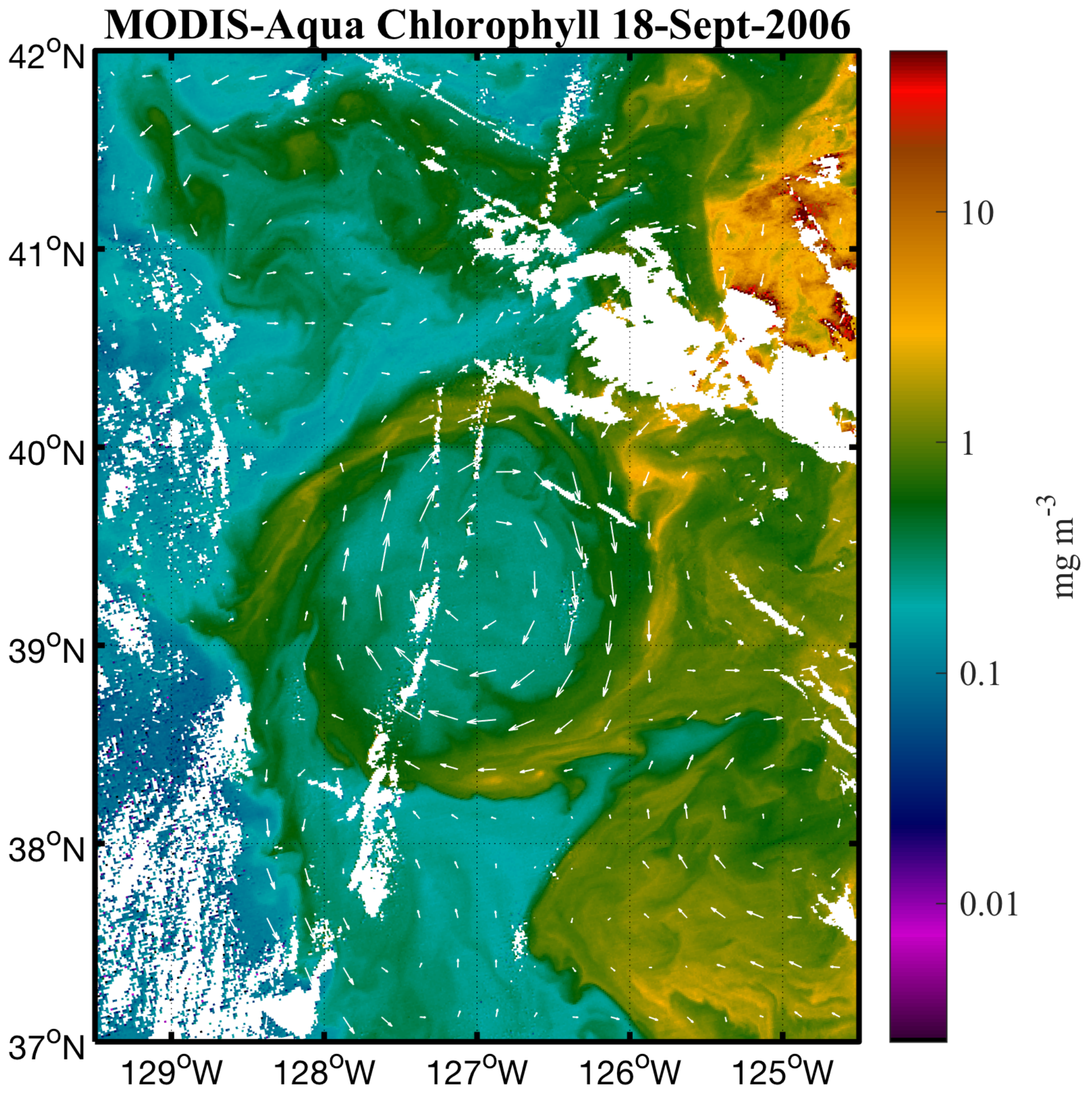
Ruiz et al 2009

Phytoplankton community structure varies on the submesoscale

- Different types/sizes of phytoplankton have different impacts on carbon export – so simply estimating phytoplankton biomass misses part of the story
- Community structure changes at submesoscale fronts
  - Unclear whether fronts act as boundaries, or if certain communities thrive at fronts
- SIO-MASS and PRISM carry hyperspectral imagers that measure different types of pigment – and hence provide information about community structure

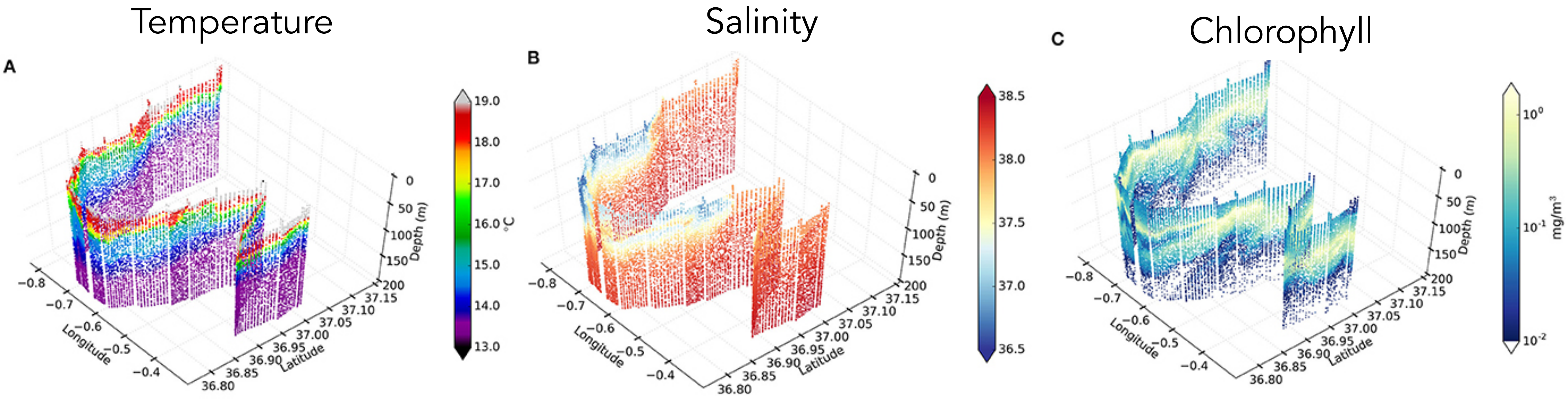
Satellite ocean color may be an important tool for interpreting SWOT observations

- E.g., for identifying features, separating balanced/unbalanced motions, interpolating between overpasses…
- In situ observations are needed to better understand the relationships between SSH, (sub)mesoscale dynamics at fronts, ocean color, and SST/SSS
- In situ optics will complement ocean color and airborne hyperspectral imagers (e.g., MASS, PRISM)
- Quantifying biomass and community structure requires more than just chlorophyll



2014 AlborEx experiment revealed strong submesoscale bio-physical variability

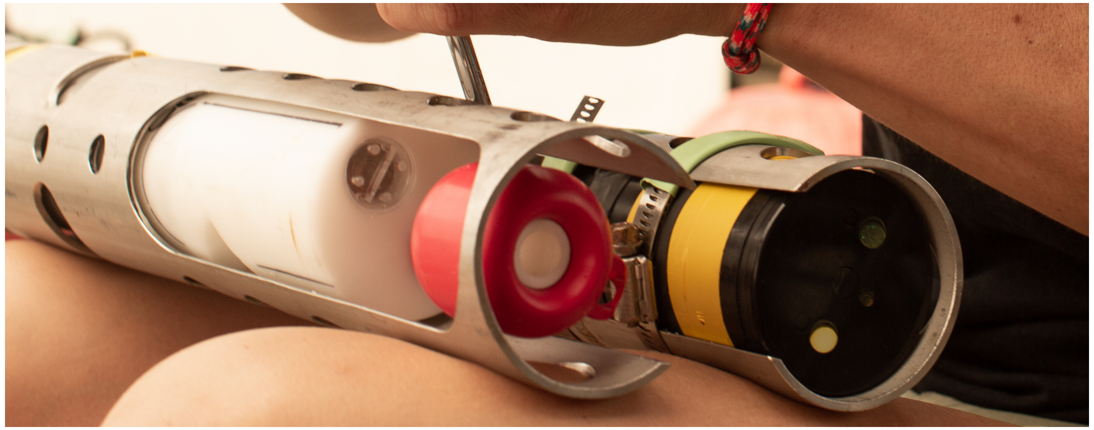
Glider data:



Pascual et al 2017

Submesoscale physics/optics measurements (APL-UW)

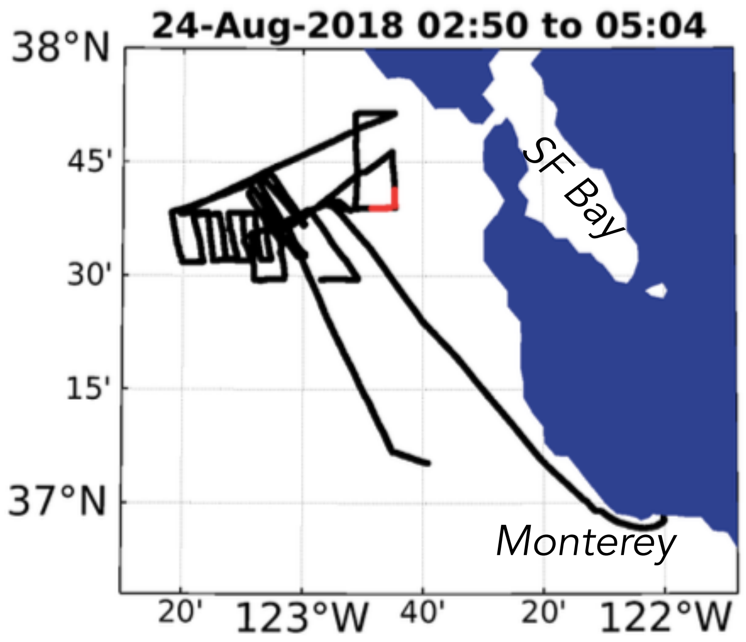
Underway optics-CTD profiler

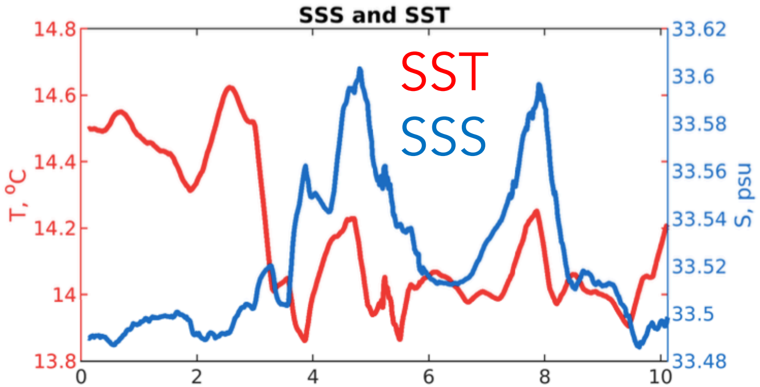


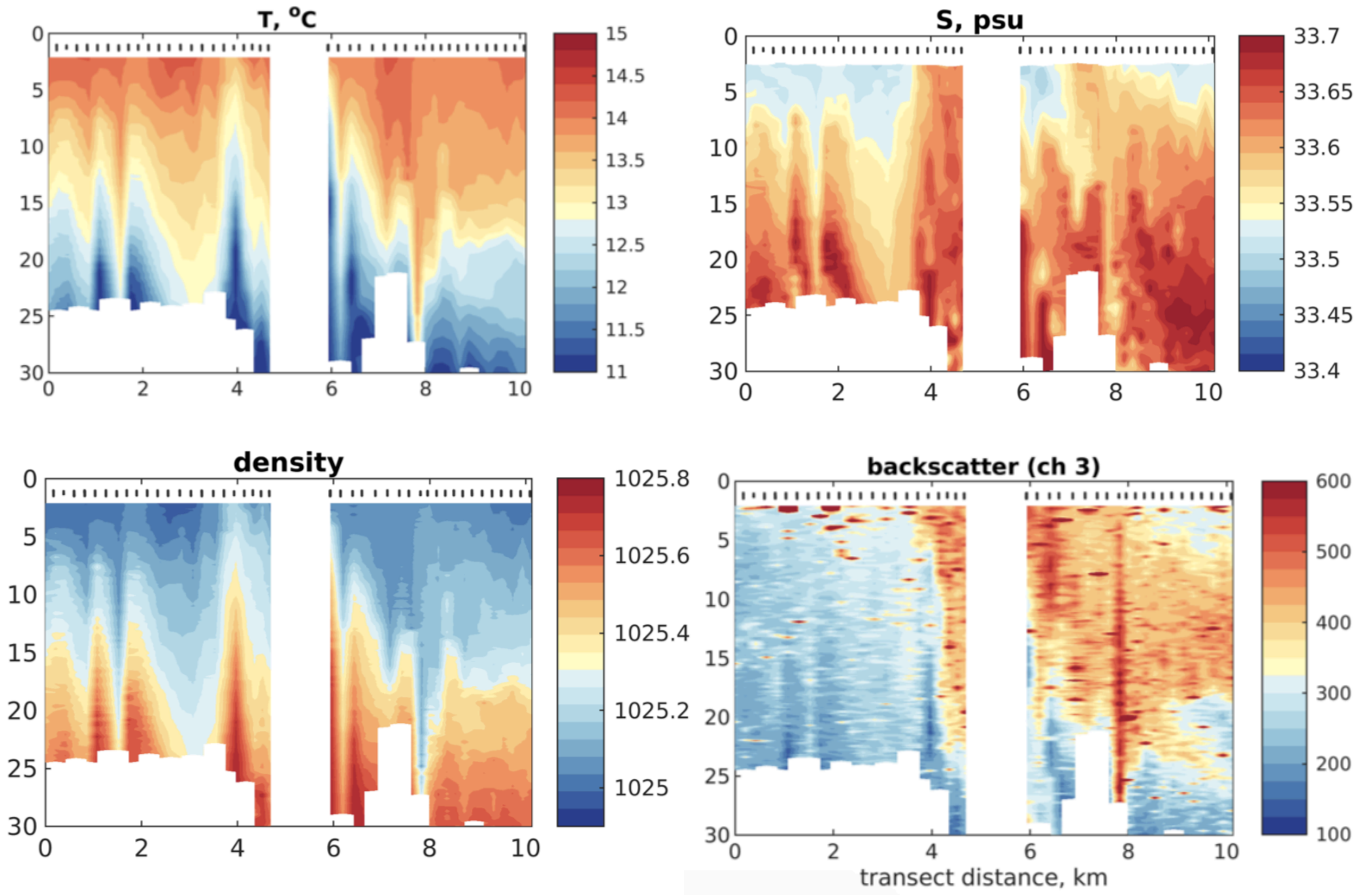
WET Labs ECO triplet optics sensor can measure Chl fluorescence, CDOM, and backscatter – equivalent to what ocean color satellites estimate.

Can be integrated into a variety of platforms (e.g., floats, gliders, AUVs)

August 2018 DopplerScatt/MASS/drifter Experiment Farallon Islands

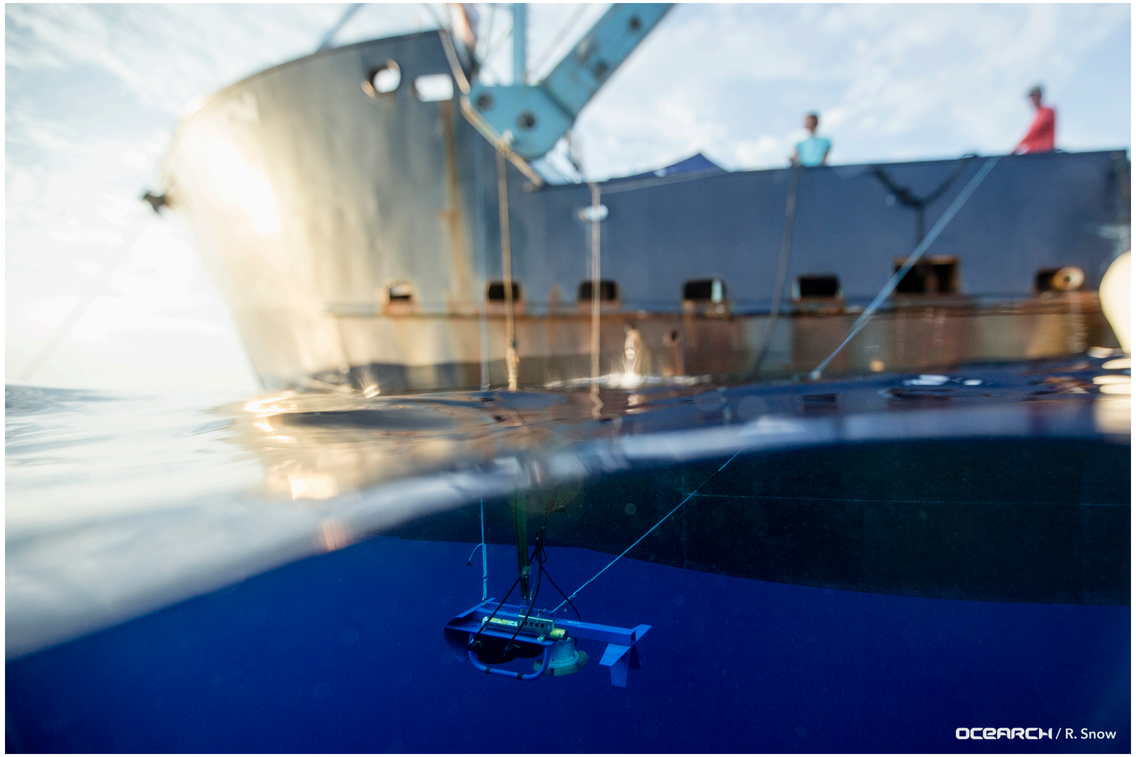






Acoustic backscatter measurements from scientific echo sounders will complement CTD data to give high-resolution density structure.

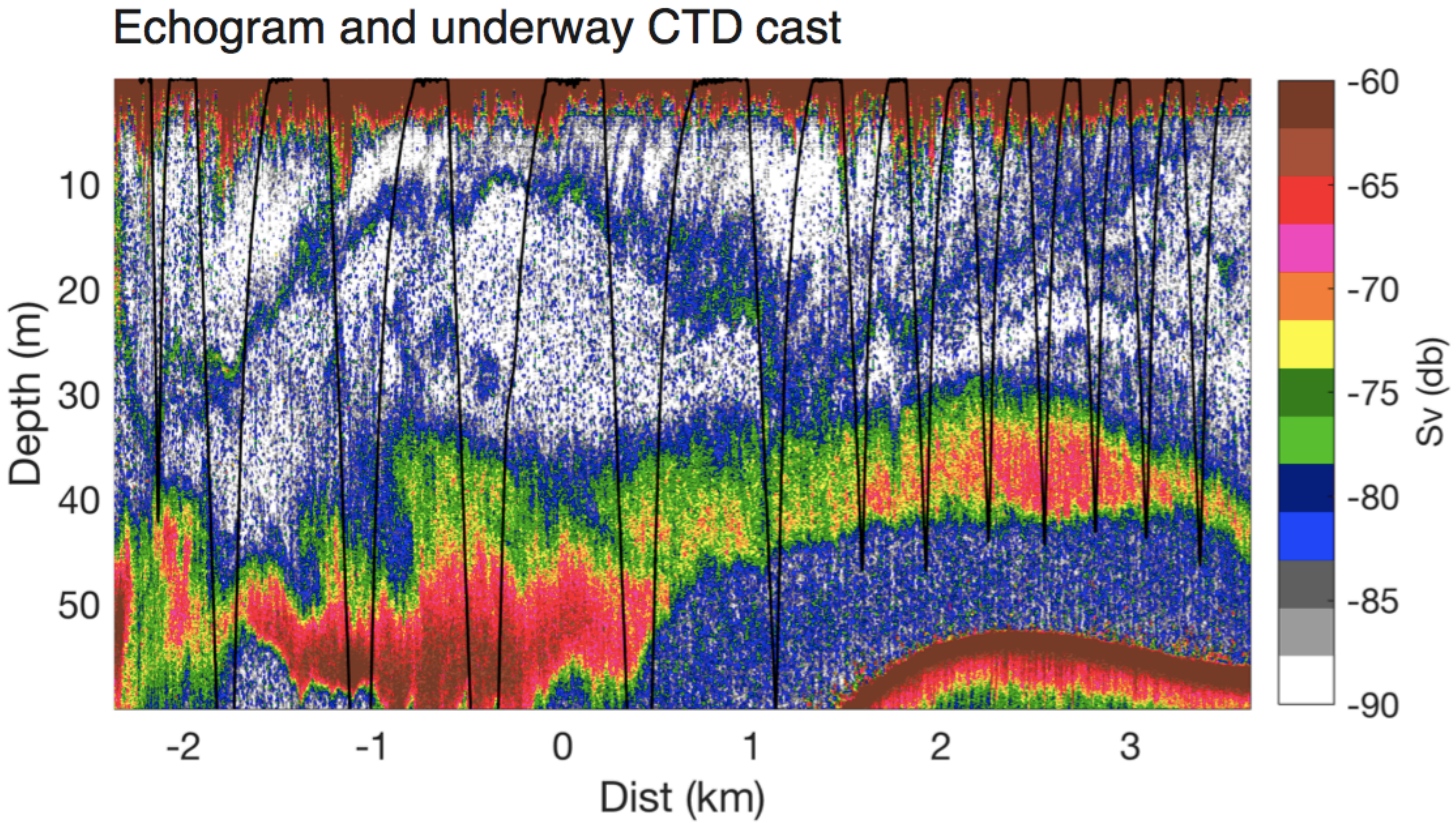
Towed sled with scientific echo sounders
(BioSonics DT-X, 38 & 120 kHz)
+ ADCP, CTD



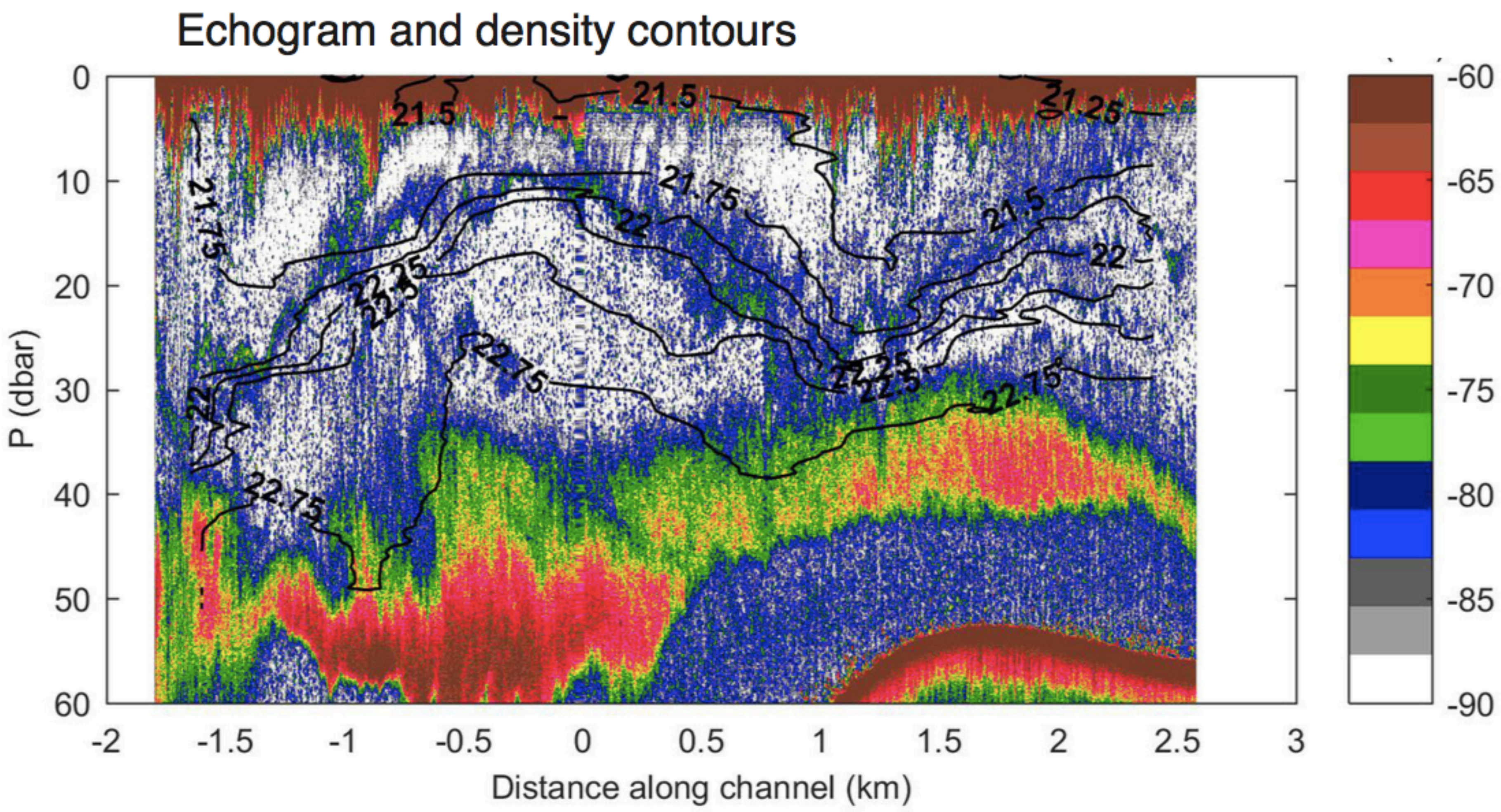
Echo sounders can be deployed from a range of ships and platforms.

Broad-band echo sounders (Simrad EK-80) are installed on R/V Ride and Armstrong (and Saildrones).

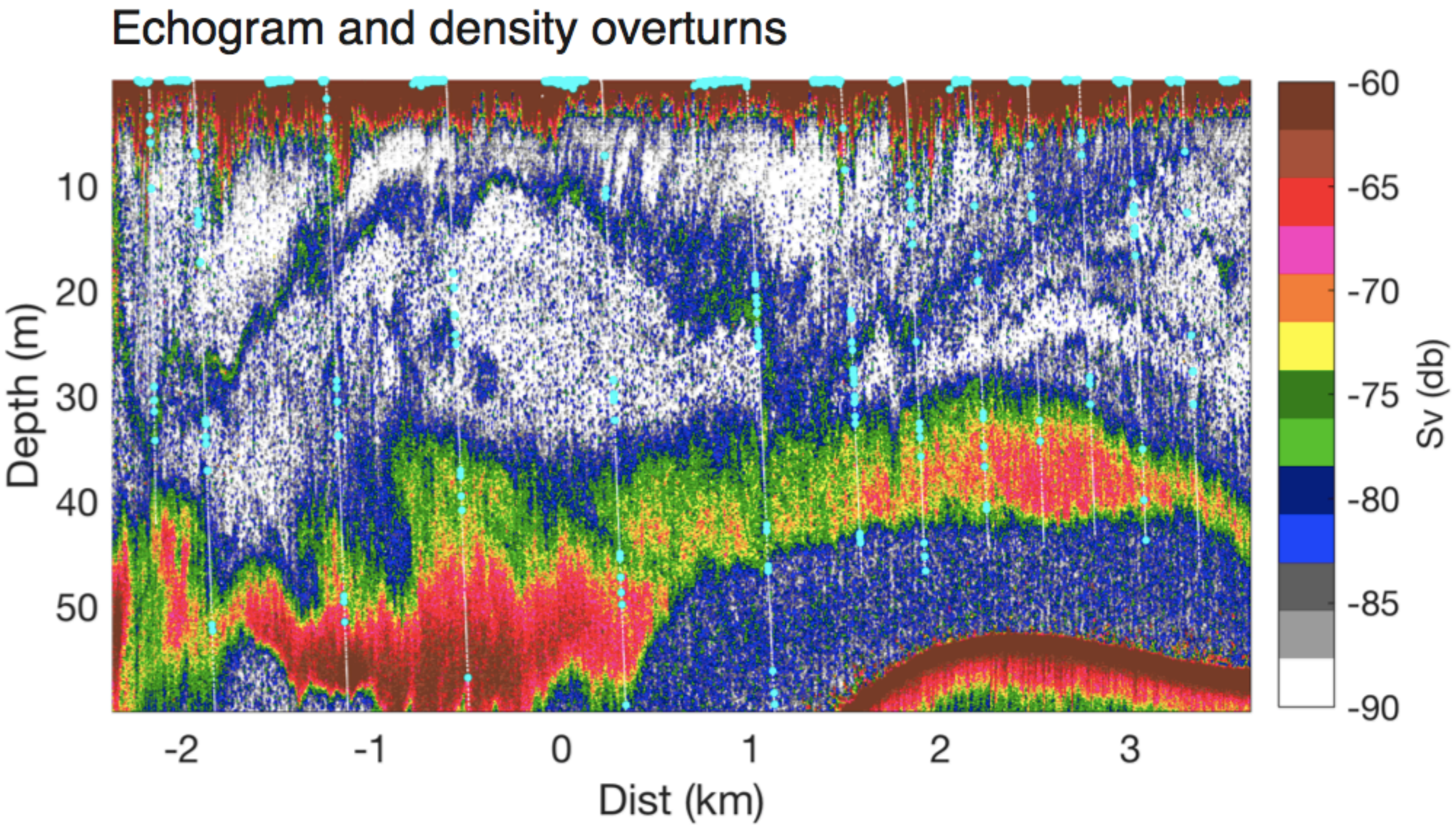
Example from Hood Canal: echo sounder data (~1m horizontal, 0.01 m vertical resolution): signal from marine organisms and density interfaces



Combining acoustic backscatter (high-resolution) with density profiles from CTD (relatively coarse) provides a high-resolution picture of density structure



Combining acoustic backscatter (high-resolution) with density profiles from CTD (relatively coarse) provides a high-resolution picture of density structure



Summary

- Submesoscale ocean dynamics have an enormous impact on ecosystem dynamics and carbon export
- The SWOT Experiment is an exciting opportunity to make complementary biological measurements in order to:
  - (a) Advance our understanding of how submesoscale ocean dynamics impact ecological dynamics and the carbon cycle
  - (b) Gain insights into physical dynamics
  - (c) Develop strategies for using satellite ocean color to help interpret SWOT data
- **In situ optical sensors** complement satellite color and airborne hyperspectral imagery
- **Acoustic backscatter data**, combined with in situ density profiles, can provide an exceptionally high-resolution picture of horizontal and vertical density structure
- Additional measurements (oxygen, nutrients, light absorption/attenuation, phytoplankton imagery) will further fill in details about community structure and biogeochemical cycling

High-resolution underway CTD-optics measurements reveal a high level of biological and physical structure

Santa Barbara, 2017:
~200m horizontal &
10cm vertical resolution