PHYTOPLANKTON DYNAMICS AT PALMER DEEP CANYON (WEST ANTARCTIC PENINSULA)

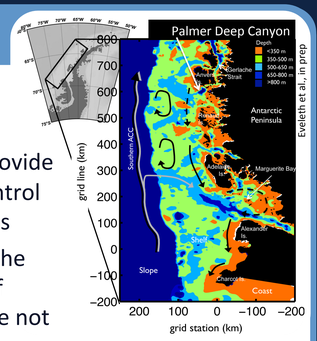
Filipa Carvalho[1], Oscar Schofield[1], Matthew Oliver[2], Josh Kohut[1]

[1] Department of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ, USA

[2] College of Earth, Ocean, & Environment, University of Delaware, Lewes, DE, USA

email: filipa@marine.rutgers.edu

Background



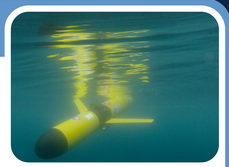
- Palmer Deep Canyon is a biological "hotspot"
- Phytoplankton blooms provide dependable food that control penguin foraging locations
- The mechanisms driving the timing and the location of phytoplankton blooms are not well understood.

Questions

At Palmer Deep Canyon:

- Is there a seasonal pattern in the water column physical properties?
- Is mixed layer depth (MLD) important in regulating the timing and location of phytoplankton blooms?

Gliders

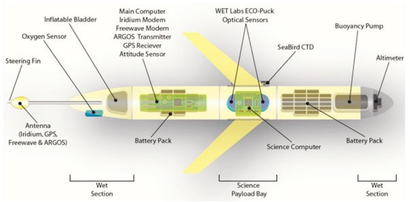


Statistics at Palmer Deep Canyon:

- 23 deployments (2007-2015)
- ~ 5 000 km flown
- 25 000 water column profiles (to 100 m)
- Over 2 million individual CTD measurements

Goals:

1. Map out the hydrodynamic patterns at the center, along the edges and outside of the canyon
2. Capture localized regions of high biological activity ("hotspots") using chlorophyll fluorescence proxy.



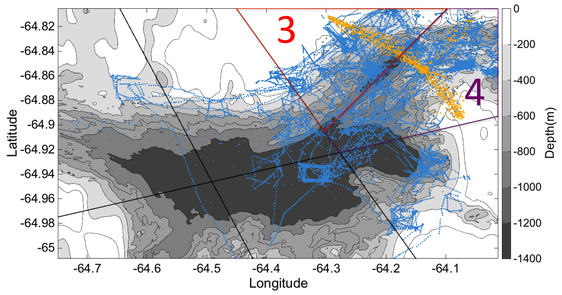
Schematics of a Slocum glider

Sensors on gliders:

- CTD, Fluorescence and Backscatter Eco Pucks, FIRe (Fluorescence Induction and Relaxation).

Glider Dataset

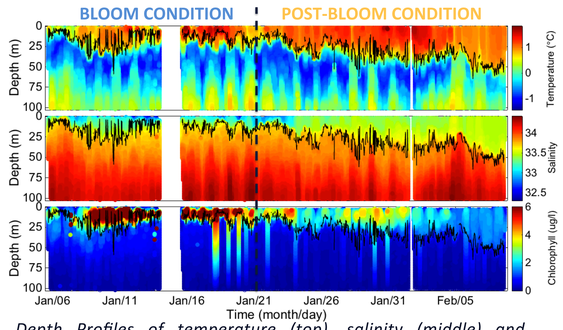
- Focused coverage at the head of the canyon;
- High spatial resolution (one profile every ~200 m);
- Increased temporal resolution - glider ru05 sampled the head of the canyon for over a month (yellow dots, January – February 2015);



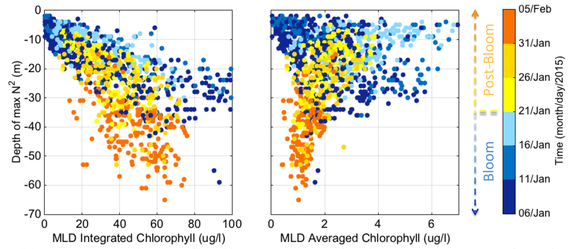
Bathymetry of Palmer Deep Canyon with all glider CTD measurements (blue dots). Bins used in analysis are indicated by the numbers 3 (red) and 4 (purple). Glider ru05 measurements used in this study are highlighted in yellow.

Higher chlorophyll in shallower mixed layers (light as a driver?)

- Shallower MLD = ↑ Chlorophyll in the water column
- During bloom MLD mostly salinity-driven (ice melting)
- Bloom ends around Jan 21st
- Post-bloom MLD deepens (↑ wind mixing) and becomes more thermally dependent (↑ solar exposure)



Depth Profiles of temperature (top), salinity (middle) and fluorescence (bottom) for glider ru05 in 2015, and MLD (black line) calculated by the max of buoyancy frequency (N^2).

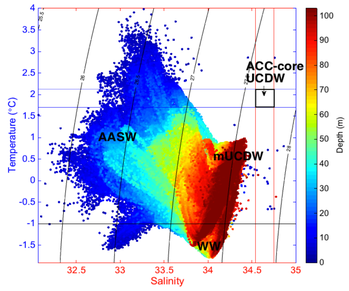


Mixed Layer Depth (MLD) integrated (left) and averaged (right) chlorophyll for glider ru05 in 2015. Timing of the measurement is in color.

- During the bloom (blue):
  1. ↑ MLD integrated chlorophyll with increased MLD
  2. MLD averaged chlorophyll is greatest at shallower depths (increased light availability)
- Post bloom (yellow), MLD deepening does not result in increased MLD integrated chlorophyll;
- Possible threshold depth for MLD (until where light availability is optimal for the overall phytoplankton population)

Seasonal Changes in the Water Column Physical Properties

- No pure Upper Circumpolar Deep Water (UCDW) is found in the upper 100m of the canyon;
- Surface Water (AASW) dominates with a broad range of temperatures and salinities that progress seasonally;



TS diagram from all glider CTD measurements at Palmer Deep Canyon in the upper 100m (during austral summer months, 2009-2015). Water masses present in the canyon are indicated as AASW: Antarctic Surface Water, WW: Winter Water and mUCDW: modified Upper Circumpolar Deep Water, the end member derived from Antarctic Circumpolar Current (ACC) deep water. Depth of the measurement is colored.

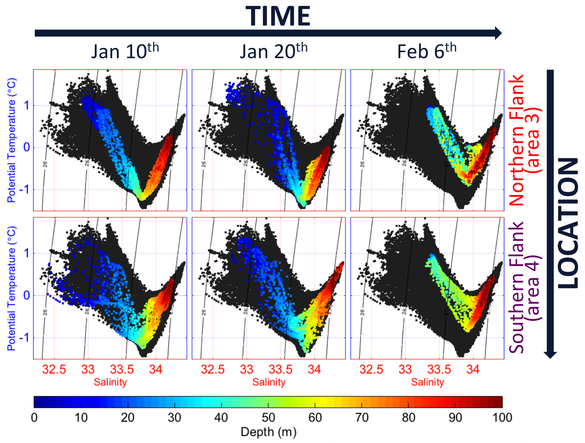
Individual Glider sections (right)

Spatially (from top to bottom):

- Area 3 (northern flank) is saltier – HF radar surface current measurements showed a stronger inflow from offshore in area 3;
- Area 4 (southern flank) is fresher – possibly more dominated by coastal processes.

As season progresses (from left to right):

- Surface water (AASW) gets saltier and thermally homogeneous (more mixing?)
- Greater thermal stratification;
- Winter Water (temperature < -1°C) disappears;



TS diagrams comparing areas 3 and 4 (northern and southern flanks, respectively) at 3 points in time. Depth of the measurement is colored.

Conclusions & Future Work

- Shallower MLD results in increased integrated chlorophyll (because of increased light availability?)
- During the bloom, integrated chlorophyll rises when MLD is deeper (is there a MLD "sweet spot"?)
- MLD is mostly driven by salinity. Increased influence of temperature on MLD later in the season
- Northern flank of the head of the canyon more influenced by offshore processes while the southern one gets more influenced by coastal processes
- Future work include, relating MLD freshening and increased stratification with the timing of sea ice retreat, investigating the relationship between MLD deepening and mixing with wind forcing and evaluating the causes of the declining of the bloom (grazing, light, nutrients, …)

Acknowledgements

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