THE ROLE OF MIXED LAYER DEPTH IN REGULATING PRIMARY PRODUCTION AT PALMER DEEP CANYON (WEST ANTARCTIC PENINSULA)

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BACKGROUND

Palmer Deep is considered a biological “hotspot” providing predictable food resources and driving penguin foraging locations. Physical mechanisms driving the phytoplankton blooms are not well understood.

QUESTIONS

• Ecologically relevant mixed layer depth (MLD) definition (link water column physics to biological responses)?
• Does MLD regulate phytoplankton blooms?
• Seasonal/spatial biophysical patterns at Palmer Deep Canyon?

GLIDERS

Stats at Palmer Deep Canyon:
• 14 deployments (2007-2015);
• ~3,000 km flown;
• 15,000 water column profiles (up to 100 m);
• Over 2 million individual CTD measurements;
• High spatial resolution (1 profile every ~250 m);
Goals:
1. Map hydrodynamics: focus at the head of the canyon;
2. Capture localized regions of high biological activity “hotspots” using chlorophyll as indicator.

Sensors on gliders:
• Seabird CTD, Wet Labs Fluorescence and Backscatter Eco Pucks.

MAX(N²) IS ECOLOGICALLY RELEVANT MLD DEFINITION ACROSS ANTARCTICA

• Maximum of Buoyancy Frequency (N²) was the most ecologically relevant MLD definition:

  \[ \text{max (} N^2 \text{)} = \max \left[ \frac{g \rho'}{\rho^2} \right] \]

• Quality index (Lorbacher et al., 2006) used to evaluate/filter MLD determined with certainty:

  \[ QI = 1 - \frac{\text{rmsd}(O_b - \text{median}(O_b))}{\text{rmsd}(\text{max}(\rho_b - \text{median}(\rho_b)))} \]

• Chlorophyll depth was adapted from the maximum angle principle (Chu & Fan, 2011).

HIGHER CHLOROPHYLL IN SHALLOWER MLD

Climatological analysis (6 years of data):
• Bloom condition: starting January, shallower MLD, colder and fresh water with increased chlorophyll;
• Late January, deepening of MLD, warmer and saltier water with lower chlorophyll/backscatter;
• Late February/early March, shoaling of MLD and consequent increase in chlorophyll.

Temporal/spatial comparison at the head of the canyon:
• 2015 deployment (ru05/ud134): repeated transects across the head of the canyon;
• Temporal signal is the most evident – follows climatology;
• Shallower MLD in Northern region matching warmer and fresher water;
• No major spatial differences in chlorophyll.

CONCLUSIONS

• Maximum in Buoyancy Frequency (N²) is an ecologically relevant MLD definition;
• Independently of water masses present, the relationship between MLD and chlorophyll holds across Antarctic waters;
• MLD mostly driven by salinity. Increased influence of temperature on MLD later in the season;
• Shallower MLD results in increased water column chlorophyll (increased light availability)?

FUTURE WORK

• Relate MLD freshening and increased stratification with the timing of sea ice melt and retreat;
• Investigate relationship between MLD deepening and mixing with wind forcing.

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