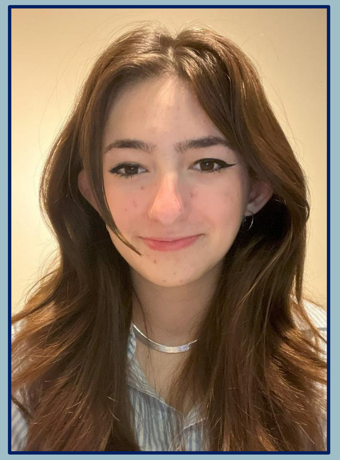
Ocean Optics: Development of Glider-Based Productivity Analysis in BC Waters Using Backscatter

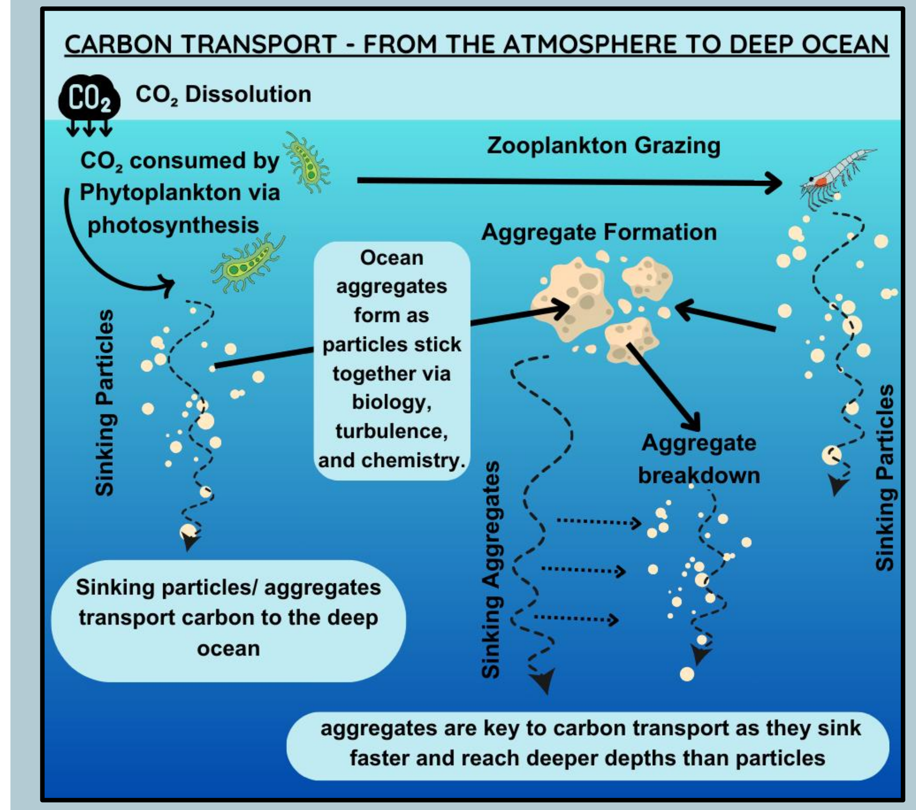
By: Emily Koopmans, Supervised By: Roberta Hamme
Chemistry and Ocean Science Honours Program, University of Victoria



Particles and Optical Backscatter

Estimating ocean particulate concentration is essential for understanding how the biological pump sequesters atmospheric carbon dioxide.

Optical backscattering, where light is scattered by waterborne particles, serves as a proxy for particulate matter and is an indicator of organic matter.



We developed a method of processing glider-borne backscatter sensor data that allowed mapping of the concentrations of large aggregates and smaller particles in offshore BC waters along Line P.

Figure 1. Simplified diagram of how the biological pump sequesters carbon.

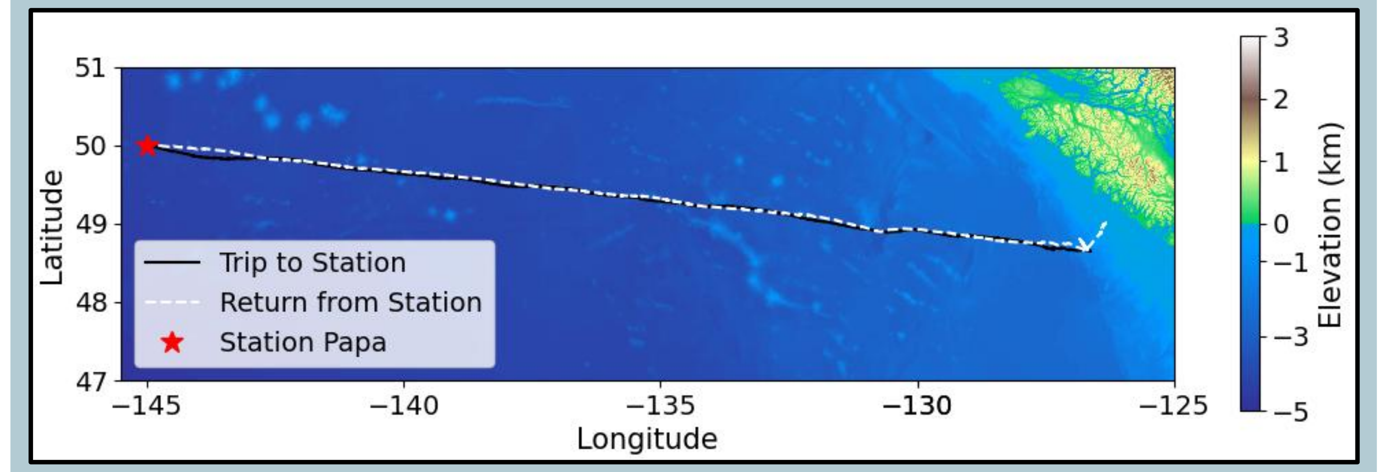
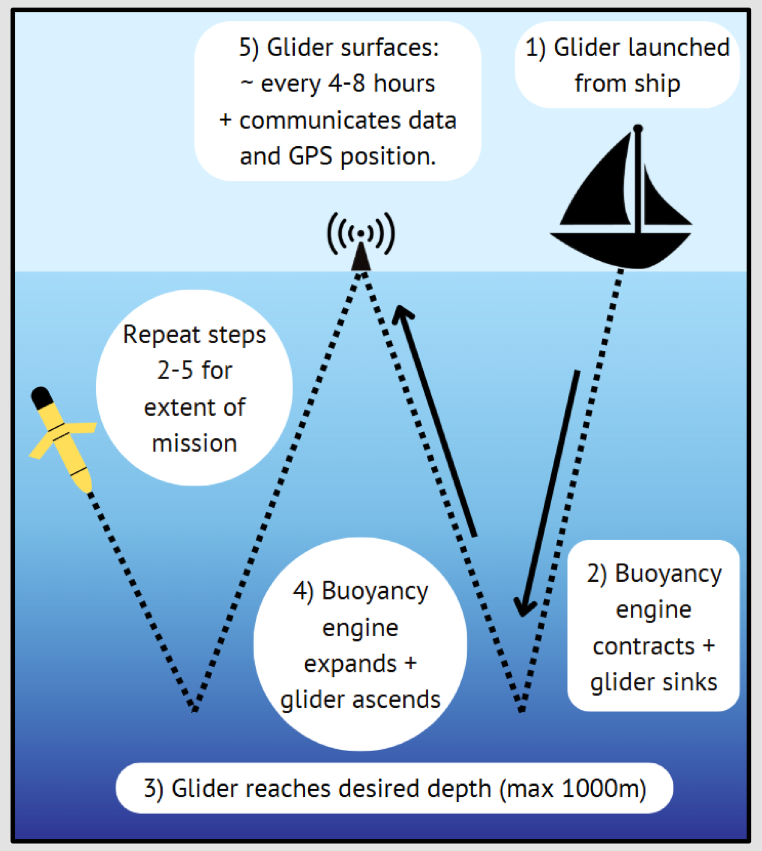


Figure 2. Map of Glider Mission. From offshore near Tofino to Ocean Station Papa (50º N, 145º W) along Line P. The mission spanned from August to November 2023.

What is a Glider?



= An autonomous underwater vehicle equipped with sensors for various measurements[3].

Figure 3. How a glider operates. Created using the information on the C-PROOF platforms page[3].

Methods

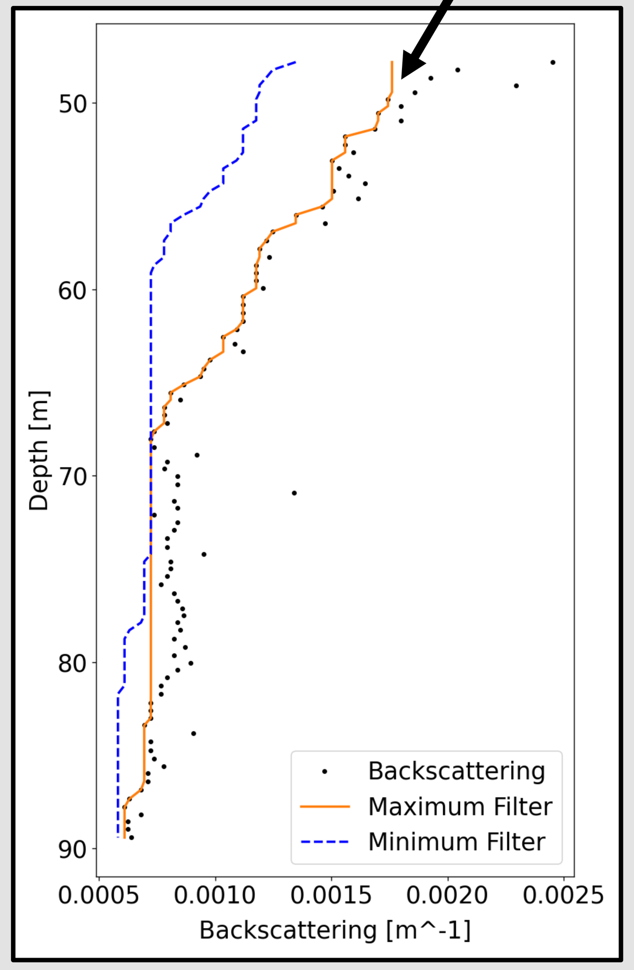
The total backscatter was partitioned into components[2]:

1. **Backscattering from Small particles**
   - Roughly <100 μm²
   - Sink slowly and get often stuck in the surface ocean or recycled before they reach the deep ocean.
2. **Backscattering from Instrument Noise**
3. **Backscattering From Larger Aggregates**
   - Roughly >100 μm up to multiple mm².
   - Sink faster and transport larger amounts of organic carbon to deeper depths.

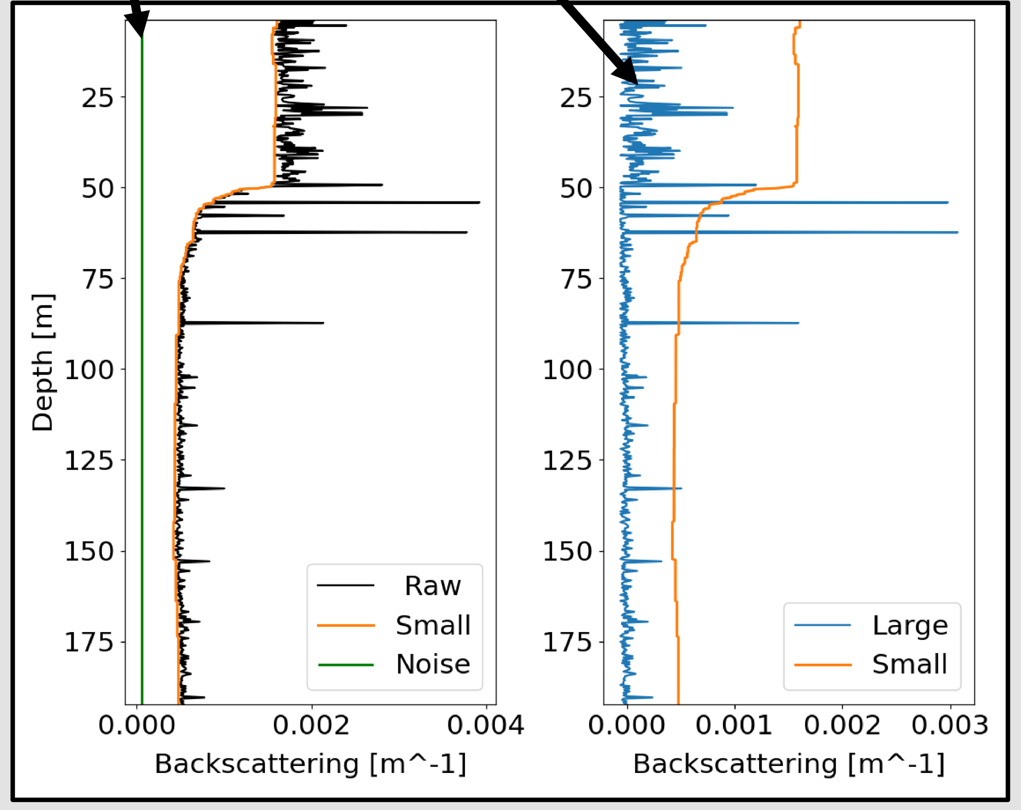
This allowed for identification of regions dominated by each size class.

Processing of a single profile:

Raw = *Small* + *Noise* + *Large*



Large particle backscattering: isolated by subtracting small particle and noise scattering from the total raw.



Small particle backscattering: Isolated with a 43-point running minimum and maximum filter.

Backscatter from instrument noise: estimated using the backscatter at depths >180m.

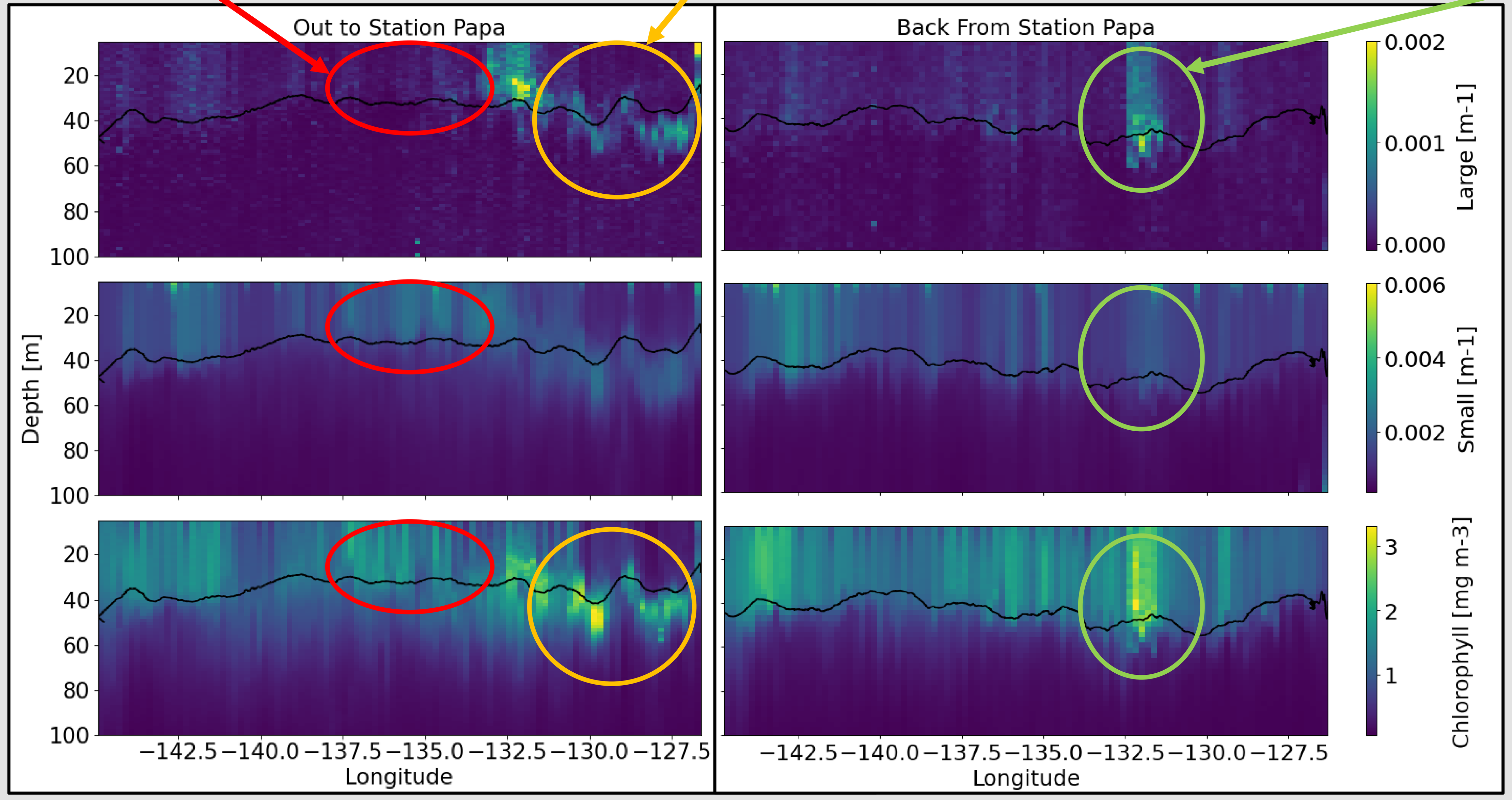
Results

The figures below show the small and large backscatter results alongside the chlorophyll concentration for the outgoing and return trips of the glider. The black line in the figures represents the mixed layer depth.

The red circles below show high productivity (chlorophyll), but the backscatter is dominated by smaller particle signals

The orange circles highlight a peak in particle concentration and chlorophyll below the mixed layer, likely due to surface nutrient depletion. These nutrients are essential to photosynthesis thus, phytoplankton production shifts to this depth where nutrients are more available, yet sufficient sunlight still penetrates[4].

The green circles are the opposite of the red. There is high chlorophyll, but the backscatter is dominated by the larger aggregate size.



Carbon transport to the deep sea is likely higher at the green circle than the red, as large aggregates sink faster and deeper than small particles.

Conclusions and Future Work

Summary of Findings:
- Our method successfully processed optical measurements from glider-borne backscatter sensors.
- Mapping backscatter signals identified distinct particle size distributions.
- Correlation with chlorophyll data supports the method's use as an indicator of organic matter

Significance & Impact:
- Provides a new approach for analyzing oceanic particulate distribution.
- Enhances the application of gliders in carbon cycle research.

Future Work:
- Apply this method across additional glider missions and environments.
- Further refine particle size and composition classification techniques.
- Investigate links between particulate distribution, productivity, and carbon cycling.

(Photo by Ben Allsup, Teledyne Webb Research)

Acknowledgments

We acknowledge and respect the Lək̓ʷəŋən (Songhees and Esquimalt) peoples on whose territory the University of Victoria stands.
Thank you to Roberta Hamme for her guidance, the C-PROOF team for data and support, and the Jamie Cassels Undergraduate Research Award for funding.

References

1. Downing, J. (2006). Twenty-five years with OBS sensors: The good, the bad, and the ugly. *Continental Shelf Research*, 26(17-18), 2299-2318. https://doi.org/10.1016/j.csr.2006.07.018.
2. Briggs, N., et al. (2020). Major role of particle fragmentation in regulating biological sequestration of CO2 by the oceans. *Science* 367,791-793. *DOI:10.1126/science.aay1790*
3. Platforms. *(n.d.). C-PROOF. https://cproof.uvic.ca/platforms/*
4. *Diaz, B.P., et al.* Seasonal mixed layer depth shapes phytoplankton physiology, viral production, and accumulation in the North Atlantic*. Nat Commun 12, 6634 (2021). https://doi.org/10.1038/s41467-021-26836-1*
5. *dfo-rosie713. (n.d.). C-PROOF data. https://cproof.uvic.ca/gliderdata/deployments/dfo-rosie713/dfo-rosie713-20230810/*