Trapped in the Beaufort Gyre:
Is the Arctic Ocean Becoming a Plastic Sink?

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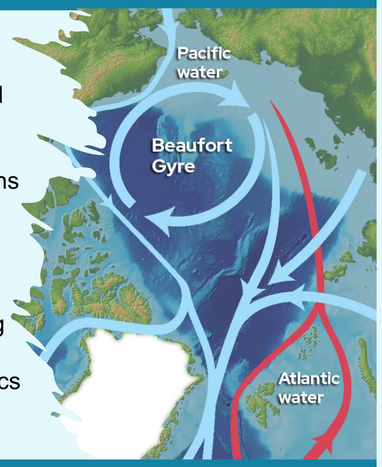
Introduction

The Beaufort Gyre (BG) is a major clockwise current in the Arctic Ocean, located north of Alaska and Canada. In recent decades, melting sea ice and steady wind patterns have caused it to store more freshwater, deepen water layers, and raise regional temperatures (Proshutinsky et al., 2015; Timmermans et al., 2023). New research suggests the gyre may also trap microplastics (tiny plastic particles) from around the world. Like the Atlantic and Pacific garbage patches, the BG's slow currents and layered structure may keep these plastics circulating for years. This study examines two types: positively buoyant and neutrally buoyant microplastics to understand how pollution behaves and persists in the Arctic.



Methodology

We used the Community Earth System Model version 2 (CESM2) to simulate microplastic transport in the Arctic Ocean. This model uses tiny "tracer particles" that act like plastic, helping us see where the plastic goes in the water and sea-ice over time. Model outputs were analyzed using Python, including libraries such as Xarray, Matplotlib, Cartopy, and NumPy.

The Model uses 2 different simulations:

Baseline Run

Microplastics are taken up into sea ice but are only released when the ice fully melts or melts from the bottom.

Source-tagged Run

Microplastics are tracked based on where they came from. (Pacific, Atlantic, & Indian Oceans)

With these simulations, we analyzed:

Sea Surface Height + **Microplastic Concentration**

Results & Discussion

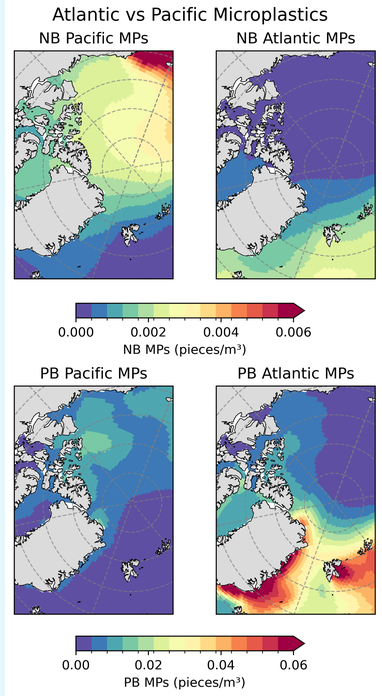


Fig. 1: Microplastic concentration on the sea's surface from both Pacific and Atlantic sources, in 2017

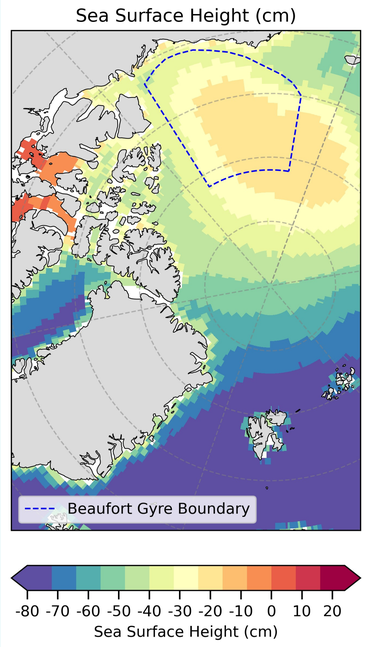


Fig. 2: Sea surface height (SSH) in the Arctic for 2017, with the Beaufort Gyre boundary outlined in blue, showing elevated SSH in the gyre's center.

- Most microplastics in the gyre comes from the **Pacific and are positively buoyant** (Fig. 1).
- Positively buoyant microplastics respond more strongly to SSH changes compared to neutrally buoyant ones.
- Atlantic plastics seem to **respond more strongly** to changes in SSH than Pacific plastics (Fig. 4, bottom).
- The **higher positively buoyant microplastic concentration** in the gyre shows it is **trapping** microplastics.

The Beaufort Gyre's strength affects how microplastics build up, depending on their type and where they came from.

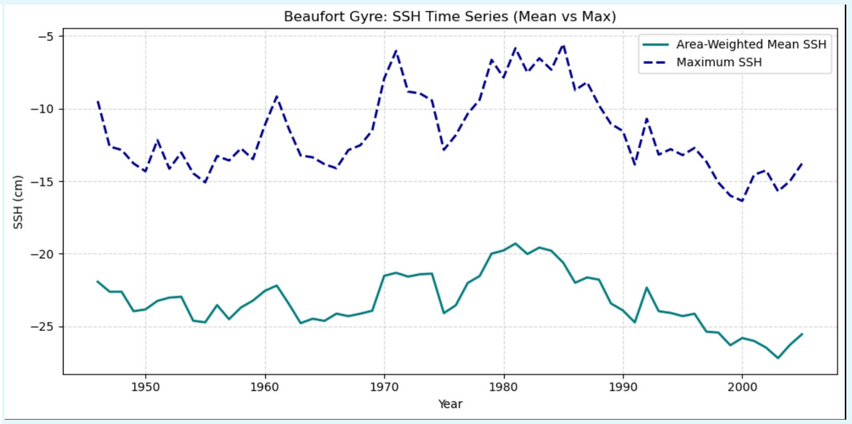
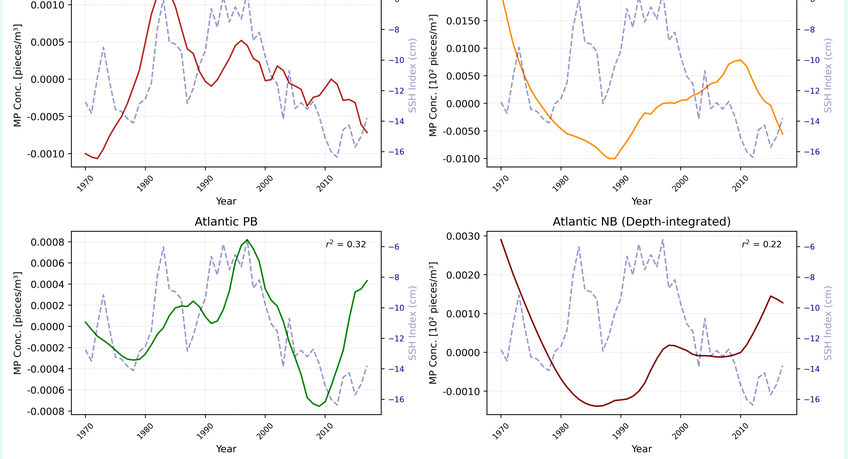


Fig. 3 & 4: Time series of sea surface height (SSH) in the Beaufort Gyre region, comparing area-weighted mean SSH (solid line) and max SSH (dashed line) from 1958–2017. In Fig. 4, detrended microplastics from both the Pacific and Atlantic are added to compare the convergence relation in SSH, including correlation coefficients (r^2).



Limitations & Future Work

While the model captures general trends, it does not fully reflect the dynamics of the Beaufort Gyre.
Future research would explore these dynamics in more detail, including tracing Pacific microplastic pathways to improve understanding of inflow timing and residence within the Beaufort Gyre.

Conclusion

The Beaufort Gyre plays a **key role in retaining plastics**, particularly from the Pacific, during periods of when the gyre is stronger. Positively buoyant plastics closely align with sea surface height (SSH) variability, while neutrally buoyant plastics exhibit a weaker variability in the gyre.
Together, these findings show that the Beaufort Gyre is a dynamic microplastic trap, shaped by sea surface height, structure, and source pathways.

Resources & Acknowledgments

This research was made possible through the RECCS Summer Internship at the University of Colorado Boulder, with support from CIRES, INSTAAR, and funding from NSF (award # 1757930 & 2138317). Special thanks to Alex, Lingwei and Jed for their incredible mentorship and guidance, and NCAR for providing Derecho computing resources. We also gratefully acknowledge M.L. Timmermans for providing the Beaufort Gyre boundary code used in this analysis.

***Scan the QR code** for interactive figures, analysis code, and the full works cited list.*