Investigating submesoscale biophysical dynamics on the Gulf Stream front

Patrick Gray, Ivan Savleyev, Kate Smith, Anna Windle, Jessica Gronniger, Marina Lévy, Nicolas Cassar, Emmanuel Boss,
Guillaume Bourdin, Yoav Lehahn, Sheri Floge, Greg Silsbe, Zackary Johnson, Dana Hunt, Julian Dale, David Johnston

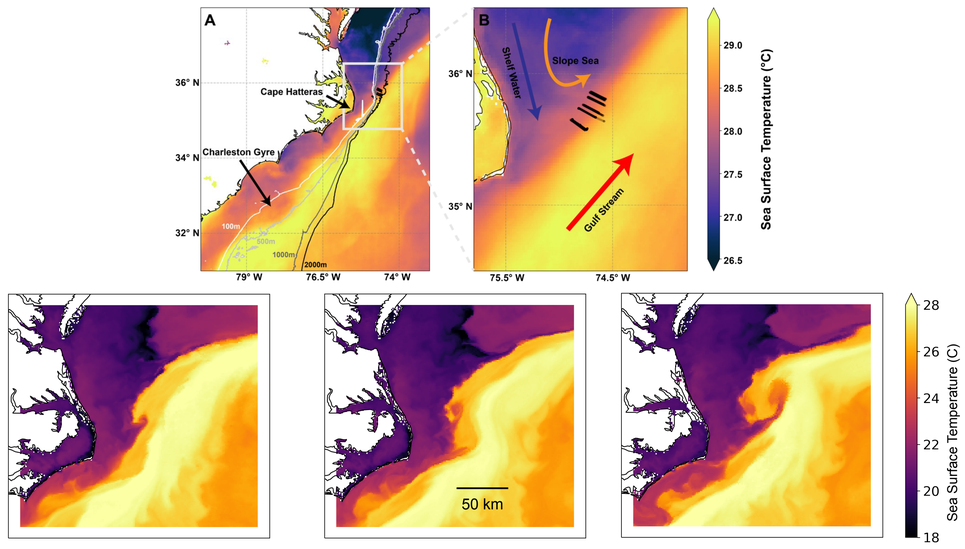
Overview

The impact of fine scale (0.1-10km) ocean physics on phytoplankton biomass and diversity is poorly understood. To better understand these interactions we conducted 70 transects over two years across the Gulf Stream front with a tow-yo profiler, ADCP, and a variety of optical measurements.

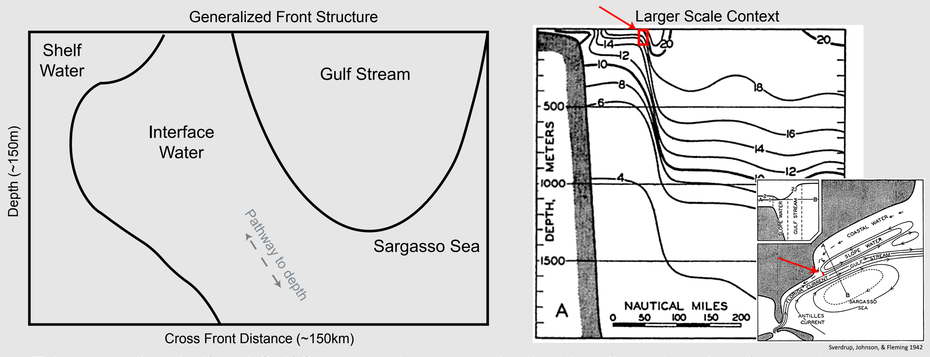
Basic Questions

- What are the multi-scale biophysical dynamics at the Gulf Stream front?
- Does the front drive an increase in phytoplankton biomass?
- Does the front matter for export to depth?
- What controls phytoplankton biomass at the fine-scale on the front?

Study Area Overview

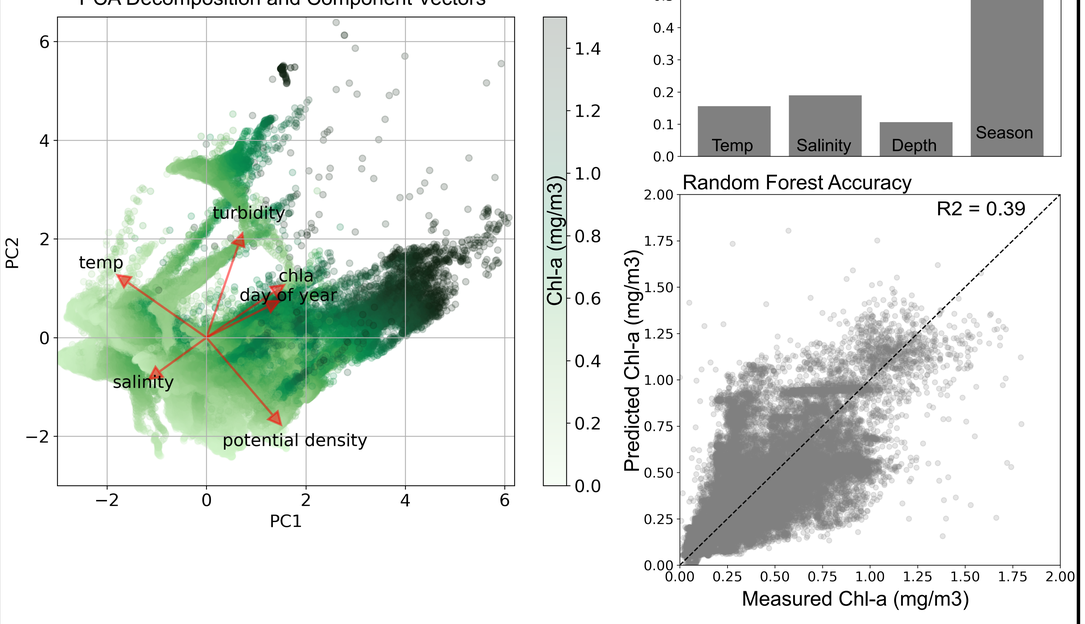


Gulf Stream Front Structure



Takeaway: the shelf and Gulf Stream water are rarely directly adjacent, an interface water mass is typically at the front with highly variable origins and properties

Importance of Seasonality and Water Mass History

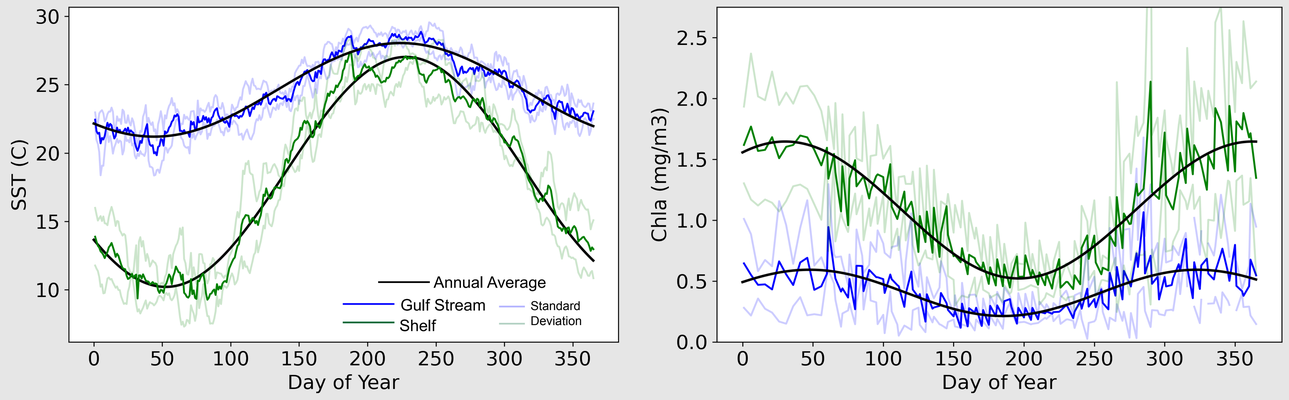


Takeaway: to first order chlorophyll-a is correlated with and able to be predicted by seasonality and water mass (T and S), but there is a large spread beyond just these two variables.

Conclusions

- What are the multi-scale biophysical dynamics at the Gulf Stream front?
  - Seasonality and water mass history account for ~50% of chla variance
    - vertical movement and fine-scale dynamics seem to account for the remainder
- Does the front drive an increase in phytoplankton biomass?
  - chl-a is increased at the front from: advection of shelf water & linkage to deeper Sargasso waters
- Does the front matter for export?
  - Cold filaments of coastal water often appear to be subducted at the interface
- What controls phytoplankton biomass across scales on the front?
  - Mesoscale - seasonality and water mass history
  - Submesoscale - frontal eddies, cold filaments, vertical movement
  - Fine-scale - equally turbulent mixing and biological response?

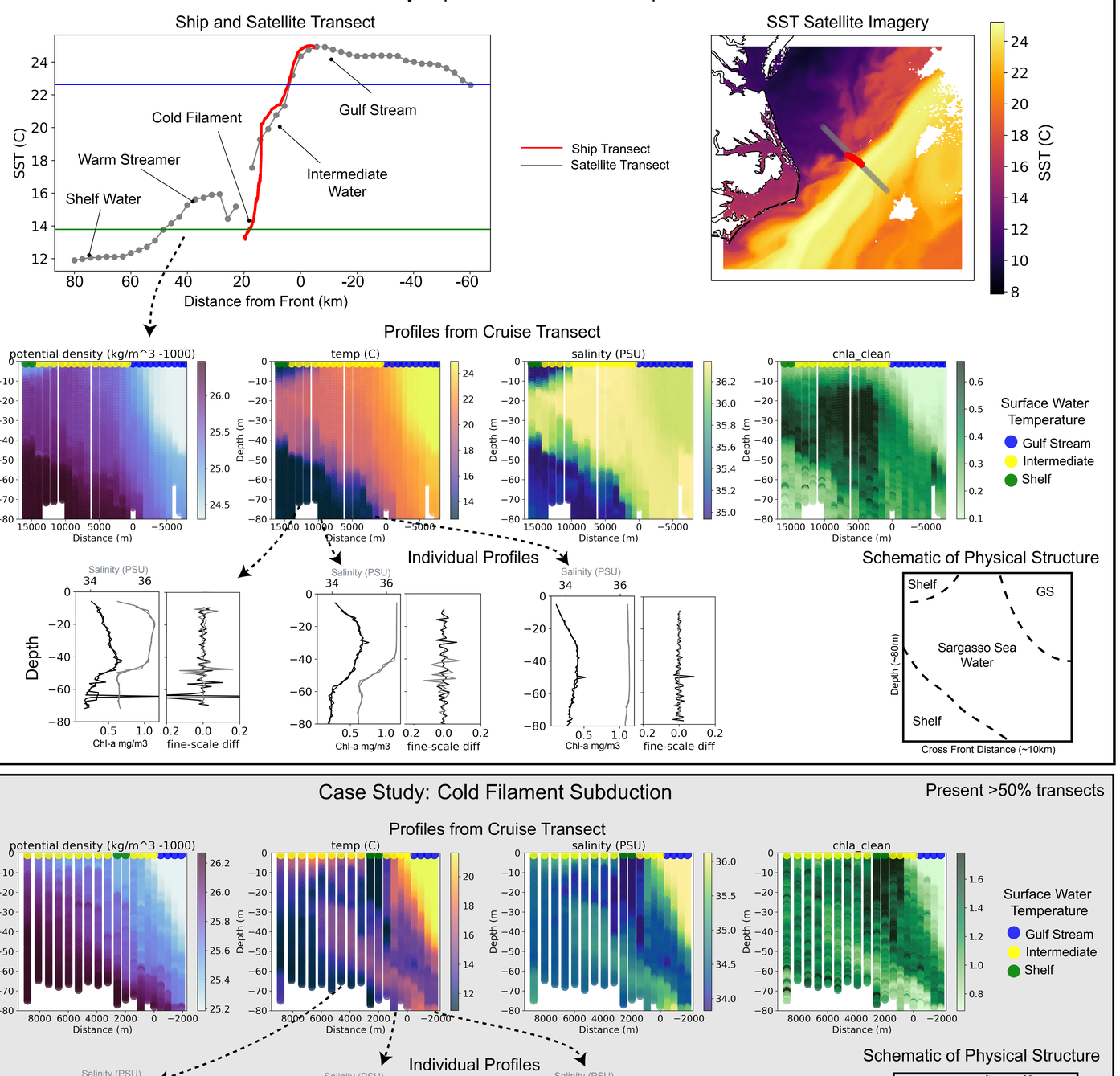
Seasonal Patterns of SST and Chlorophyll-a on the Gulf Stream and Shelf



Takeaway: though seasonal patters are evident, day to day variability in chla is almost the same in magnitude as seasonality.

Case Study: Upwelled Water from Depth

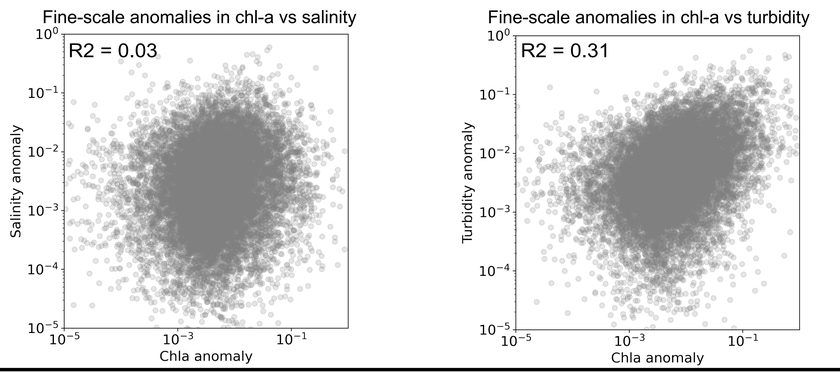
Present >50% transects



Case Study: Cold Filament Subduction

Present >50% transects

Drivers of Fine-scale Variability



Takeaways:
Fine-scale anomalies in chl-a are common, high in magnitude (often >30%) and lower in the Gulf Stream. They are only correlated with turbidity.

They are uncorrelated with:
- turbulence
- temperature anomalies
- salinity anomalies
- acoustic backscatter

They could be: large particles, aggegations, zooplankton, zooplankton grazing impacts, uneven impacts of mixing

NASA
MORTIMER B. ZUCKERMAN STEM LEADERSHIP PROGRAM
Marine Robotics & Remote Sensing
Duke | NICHOLAS SCHOOL of the ENVIRONMENT
Duke University Marine Lab
1865 THE UNIVERSITY OF MAINE
School of MARINE SCIENCES
אוניברסיטת חיפה University of Haifa جامعة حيفا
LEON H. CHARNEY SCHOOL OF MARINE SCIENCES
בית הספר למדעי הים על שם ליאון צ'רני