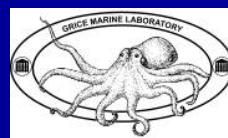




Hydrographic Analysis of the James Island Ebb-Tidal Front in Charleston Harbor, SC

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Introduction

Tidal fronts are common features that develop in coastal ocean waters. These fronts are generally characterized by sharp density gradients and current velocity gradients, surface convergence zones, intense mixing, and build – up of foam and particulates such as phytoplankton (Pinckney, Dustan). Previous research indicates that there are differences in oxygen levels, temperature and salinity, nutrient concentrations, and primary production on the two sides of a tidal front (Tian, et al, Franks, et al, Kingsford and Suthers, Nuno Vaz, et al).

We investigated the James Island (JI) tidal front. It formed at the interface of the Ashley and Cooper Rivers two to three hours after high slack tide. The tidal front moved east to west across the Charleston Harbor off the southern tip of the peninsula. The JI front had a distinct convergence zone characterized by surface froth and floating debris. There was variation in water color corresponding to different sides of the front. The East side was blue and the West side was brown indicative of increased detritus and sedimentation.



Methods

- All sampling took place aboard the Chamberlain. Samples were taken at five stations: 50 meters East and West of the front, 25 meters East and West of the front, and directly on the convergence zone. We transected the tidal front, beginning on the West side and moving East. During the course of the cruise, the front moved West to East and the vessel drifted Northeast. At each station water samples were taken at the surface and at depth. Depth measurements were intended to be at 10 meters, but we were limited by shallow waters. These measurements, were therefore, taken at the maximum depth of each station.

- Temperature – Salinity – Oxygen Concentration:** A LICOR was used to measure temperature, salinity, and oxygen concentration of the surface water and at depth at each station.

- Chlorophyll Concentration:** Surface water samples were collected in small jars and a Niskin bottle was used to collect water samples at depth at each station. From each sample, 50 ml of water were drawn into a syringe and pushed through a GF/D filter. Each filter was placed in a scintillation vial and immediately put on ice for preservation. At the lab all samples were frozen until they were processed. To determine chlorophyll concentration, we added 5 ml of 90% acetone and vortex to each vial and let them set for 24 hours. After this period, fluorescence of the acetone was measured using a fluorometer.

- Phosphate Concentration:** Surface water samples and water collected at depth by the Niskin bottle at each station were placed in 50 ml vials and immediately put on ice for preservation. At the lab all samples were frozen until they were processed. We followed the standard procedures for preparing the phosphate standards, mixed reagent, and raw water samples. Absorbance of the standards and of each water sample was measured using a spectrophotometer. Phosphate concentration was finally calculated based on the linear regression of the phosphate standard ($ABS = m * Conc + b$)

Acknowledgments

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Results

For all graphs: Blue lines represent surface measurements and red lines represent measurements taken at depth. Negative values on the x – axis indicate the East side of the front (water coming in from the ocean), 0 represents the convergence zone and positive values indicate the West side of the front (water coming into the harbor from the Ashley and Cooper Rivers).

Figure 1: Day 1 Temperature (°C)

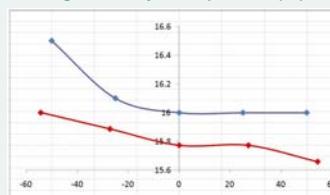


Figure 2: Day 2 Temperature (°C)

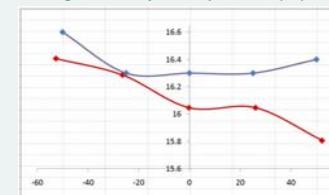


Figure 3: Day 1 Salinity (PPT)

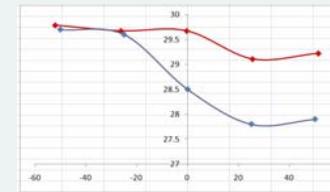


Figure 4: Day 2 Salinity (PPT)

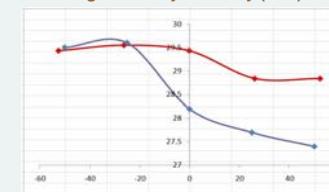


Figure 5: Day 1 Dissolved Oxygen Concentration (mg/L)

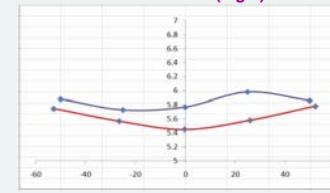


Figure 6: Day 2 Dissolved Oxygen Concentration (mg/L)

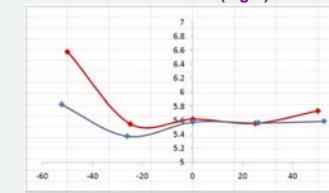


Figure 7: Day 1 Chlorophyll Concentration (µg/L)

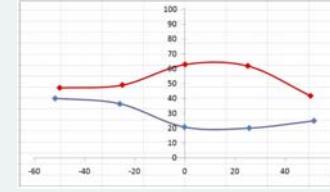


Figure 8: Day 2 Chlorophyll Concentration (µg/L)

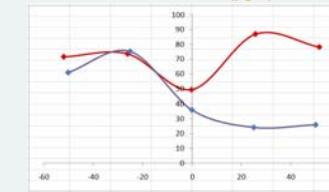
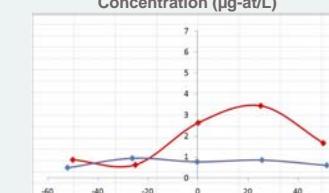


Figure 9: Day 1 Phosphate Concentration (µg-at/L)



Figure 10: Day 2 Phosphate Concentration (µg-at/L)



Conclusions

Statistical Methods: standard T-test. All p – values greater than .05 are not statistically significant. All p – values less than .05 are statistically significant indicating that differences in results are not due to chance.

Temperature: Figures 1 and 2

- For Days 1 and 2, the East side of the front had higher water temperatures than the West side of the front, however, the results are not statistically significant. (All p – values were greater than .05)
- The East side of the front carries incoming ocean water which has a high heat capacity, and therefore, water temperature is less susceptible to change throughout winter.
- The West side of the front is influenced by river runoff which carries cooler inshore waters toward the harbor.
- As expected, water temperature decreased with increasing depth. This is because as depth increases the amount of light penetration decreases.

Salinity: Figures 3 and 4

- For Days 1 and 2, salinity at the surface and at depth was not significantly different on the East side of the front. This is because water coming from the ocean is well mixed.
- On the West side of the front, for days 1 and 2, surface salinity is significantly less than on the East side. (Day 1 Surface: p = .002, Day 2 Surface: p = .006). Water entering the harbor from inland rivers is less saline due to several causes including rainfall and other physical factors.
- As expected, more saline waters were found at depth because as salinity increases so does the density, causing water to sink.

Dissolved Oxygen Concentration: Figures 5 and 6

- For Day 1, the dissolved oxygen concentration was not significantly different between surface water and water at depth. Also, it was not significantly different between the East and West sides of the front. (Surface: p = .354, Depth: p = .876)
- For Day 2, dissolved oxygen concentration was higher on the East side of the front, but was not significantly different. (Surface: p = .925, Depth = .510)
- The lack of significant differences is likely due to the shallow water of the sampling area (maximum depth never exceeded 10 meters). All samples were within the photic zone where photosynthesis was relatively constant.

Chlorophyll Concentration: Figures 6 and 8

- There is no significant difference in chlorophyll concentration between surface waters and waters at depth on the East side of the front. This is likely the result of ocean water being well mixed and the shallowness of the sampling area.
 - Day 1 Depth: p = .749, Day 2 Depth: p = .156
- In contrast, there was a significant decrease in chlorophyll concentration at the surface on the West side of the front. (Day 1: p = .036, Day 2: p = .027) This could be the result of photoinhibition at the very surface as the weather conditions were very clear and sunny.

Phosphate Concentration: Figures 9 and 10

- For Day 1, surface phosphate concentration decreased as we moved from East to West, but was not statistically significant (p = .196). Phosphate concentration at depth, however, significantly increased from East to West (p = .042).
- For Day 2, surface phosphate concentration remained relatively constant on both sides of the front (p = .962). Phosphate concentration, however, was higher at depth on the West side of the front, but was not statistically significant (p = .182)
- Phosphate concentration is higher at depth because there are more phytoplankton – as indicated by the chlorophyll concentration levels – and phytoplankton use phosphates for nutrients. Furthermore, at depth there are processes such as decomposition that release nutrients such as phosphates into the water.