The Seasonal Changes of the Ocean's Properties Near the New England Shelf Break Front Using the Pioneer Instrument Array

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ABSTRACT

Coastal marine ecosystems are profoundly influenced by processes that originate from their boundaries. These include aqueous boundaries with the atmosphere, oceanic boundary currents and terrestrial aquatic systems, as well as physical boundaries with the sea floor and coast. The physical, chemical and biological characteristics were taken measured over the course of a yearlong student inquiry, located at the New England Shelf Break in the North Atlantic Ocean. The area studied is known for enhanced biological productivity due to upwelling the confluence of two different water masses meeting. Data was collected from Ocean Observatories Initiative's (OOI) Pioneer Array, specifically profiler G. Ocean Observatories Initiative then uploaded their profiler's data to their site, which was then downloaded and analyzed. We observed the seasonality of the thermocline, pycnocline, and halocline, along with the productivity of phytoplankton. Our future plans are to collect data from other profilers to tackle future plans.

In a yearlong independent inquiry, we studied the physical, chemical, and biological characteristics of the water column near the New England Shelf Break Front in the North Atlantic Ocean over an approximately one-year period between March 2014 and February 2015. Oceanographic data was collected from a moored instrumented platform of the Coastal Pioneer Array located at latitude 39.92 °N and longitude -70.77 °W (Figure 1). The array is part of the National Science Foundation's *Integrated Ocean Observatories Initiative*, a networked infrastructure of moored profiling and autonomous sensors measuring the physical, chemical, and biological changes in the ocean. (Figure 2). The purpose of our study was to observe and explain the seasonal changes in the physical characteristics of the water column, such as temperature, salinity, and density, and to attempt to relate these changes to the growth of the phytoplankton crop in the upper sunlight ocean.

The Continental Shelf-Slope is located at a dynamic intersection where ocean currents converge. The shelf break front is the boundary between colder and fresher waters to the north, heavily impacted by river inflow from U.S. east coast region, and warmer, saltier oceanic waters to the south (Vaillancourt *et al.*, 2005, Zhang *et al.*, 2011). The boundary is often the site of high biological productivity including important fisheries for lobster and fin-fish (Zhang *et al.*, 2013, Houghton *et al.*, 2009). The enhanced biological productivity is created by the confluence of the two different waters masses resulting in upwelling of buoyant nutrient-rich shelf water to

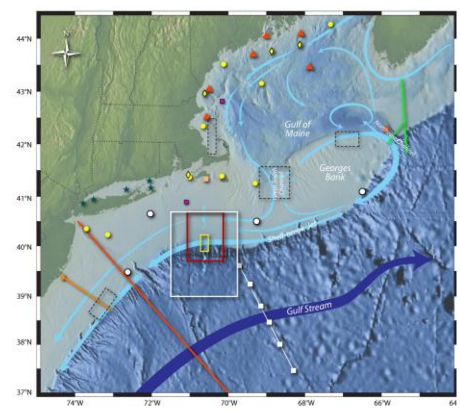

Figure 1. The Pioneer Array (yellow rectangle) is located at the edge of the continental shelf south of New England.

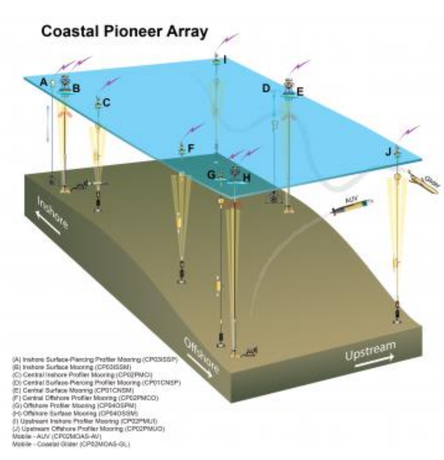

Figure 2. Schematic of the Coastal Pioneer Array of moored instrumented profilers. Our study used data from the profiler "G".

the sunlit surface ocean, stimulating phytoplankton blooms during the spring months (Ryan *et al.*, 2013, Zhang *et al.*, 2013, Houghton *et al.*, 2009). The Pioneer Array is useful for the study of the oceanography of the east coast U.S. continental shelf. The OOI system has been functional since 2013 with the data portal just becoming opened to the public within the last two years.

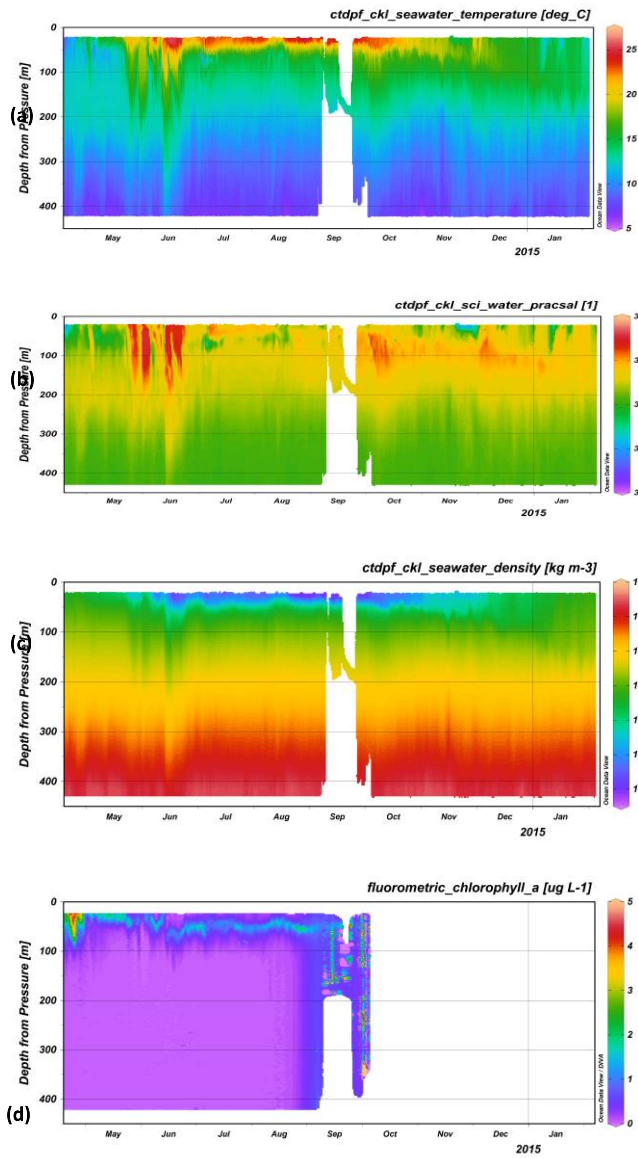

Figure 3. Time-series of seawater (a) temperature, (b) salinity, (c) density, and (d) chlorophyll a concentration from April 2014 through January 2015. Gaps in data coverage are due to malfunctions of instruments or loss of data during satellite transmission.

Since the OOI system is a still in its early days of development and application, we worked closely with the OOI's Observatory User Support Technician to develop a cohesive strategy to download data from the Pioneer Array. The data were downloaded and graphically analyzed using Ocean Data View (ODV) software (Schlitzer, 2017). The OOI offers two types of data: telemetered and recovered. Telemetered data are sent directly from the Pioneer Array via Iridium satellite, to a shore station. However, satellite communications can be interrupted, so telemetered data has a tendency to be fractured. In these instances, we used recovered data, which come directly from the buoy instruments during routine visits to the site by research vessels every six months. We encountered multiple cases of bad or unusable data, causing large gaps in our data collection. After intense scrutiny, the best useable data was concluded to be an approximate year's-worth from March 2014 to February 2015. Our preliminary analyses are based on this time series.

We observed changes in the physical properties temperature, salinity, and density at profiler G (Figure 3a –c). In April, you can see the surface waters are still cold and fresh, but as the season progresses the surface waters warm and become saltier, and the thermocline and pycnocline becomes shallower. Throughout the summer the thermocline stays reasonably shallow and consistent. As the fall and winter approached, the thermocline deepens down to around 250 meters in depth and will continue to fall throughout the winter.

Throughout June there is significant downwelling. The downwelling is noted across multiple parameters to include salinity, temperature, and density. The extent of the downwelling is quite significant, which rule out winds as the causal factor. The area used for this research is north of the Gulf Stream, which occasionally impacted by warm and cold core rings shedding from the north side of the Gulf Stream. It is possible the down welling is caused by a warm core ring.

Phytoplankton abundance can be monitored using the fluorescence from their chlorophyll *a* (Chl *a*) pigment (Figure 3d). In May, we see high Chl *a* at the surface of ocean, but as the season progresses into the summer the phytoplankton's Chl *a* values fall deeper into the water column, we believe this is due to photoinhibition of chlorophyll fluorescence, or perhaps nutrient-limitation, a common feature during summer months. This feature lasts throughout the summer and into the fall. The chlorophyll fluorometer malfunctioned in mid-August and the remaining data are artifacts related to this.

Seasonality is observed in the water column with the salinity parameter. Figure 3b shows the variability of salinity in the water column over the course of ten months. The seasonal changes are quite obvious throughout the year. Depths up to 350 meters in the water column are affected in cases of months like June. Salinity is affected by evaporation, precipitation, and freshwater fluxes, by calculating these fluxes we get an idea of how saline the environment should be. June salinity values are between 36 and 37 ppt, but as we progress throughout the summer the salinity lessens to between 35 and 36 ppt. We would hypothesize that July and August saw heavy amounts of precipitation or lower amounts of evaporation. As the season progresses, fall and wintertime show less evaporation and more precipitation. Though January and December show higher than average salinity, the rest of the winter months within average ranges.

Going forward with our research, we will be expanding our data collection to include overlapping data gathered from the upstream inshore Profiler Mooring (labeled "I" in Figure 2), and compare ocean properties to the data we already have collected from the mooring located on the offshore side of the shelf break front. We will also begin to allocate more energy to scientific analysis with specific hypothesizes in mind. With a plethora of data available some of the questions we plan to tackle over the next semesters are: seasonal development of the water column and linking the seasonal development of the pycnocline with biological production, specifically working on the hypothesis that the level of primary production by the phytoplankton is controlled by the depth of the mixing layer in relation to the penetration of solar radiation, the so-called 'spring bloom hypothesis' (Sverdrup, 1953).

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