Geographic Diversity of Phytoplankton Species along the Outer Banks 2005 to 2013

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The phytofinders of First Flight High School, Kill Devil Hills, NC, is a student run club dedicated to collecting and identifying phytoplankton along the Outer Banks. Club members regularly sample and analyze phytoplankton populations in search of potentially harmful algal bloom species, including Pseudo-nitzschia, a marine diatom that produces domoic acid, a potent neurotoxin known to be dangerous to humans. The obserations are contributed to the National Oceanic and Atmospheric Administration (NOAA) Phytoplankton Monitioring Network, which has worked with the students from the beginning.

I. Phytoplankton

Phytoplankton, commonly known as microalgae, is a keystone species for aquatic food webs. Similar to terrestrial plants, phytoplankton contain chlorophyll. Since they require sunlight to live, phytoplankton float in the upper part of the ocean where sunlight reaches the water. Phytoplankton converts inorganic nutrients such as nitrates, phosphates and sulfur into proteins, fats, and carbs. Dinoflagellates and diatoms make up the two main classes of phytoplankton. Dinoflagellates use a flagella to move and have complex shells that cover their body. Diatoms have rigid structures and do not rely on flagella to move, but the ocean currents to travel.

II. The Piers

Students of this club sample at two piers, the Army Corps of Engineer Field Research Facility located in Duck, North Carolina, and Jennette's Pier located in South Nags Head, North Carolina. The First Flight PhytoFinders have only recently been collecting at Jennette's Pier due to the temporarily closing of the pier in order to rebuild it. The Jennette's Pier is a part of the North Carolina Aquariums. The PhytoFinders started collecting at Jennette's pier in October 2013, but have been collecting data from the Duck Field Research Pier since 2005. The two piers are located 20.8 miles from each other with the Army Corps of Engineer Field Research Facility pier stretching 1840 feet from the dunes and Jennette's Pier only 1000 feet from the dunes.

Figure 1: Satellite view of Jennette's Pier located in Nags Head, North Carolina GPS Coordinates: 35.910 N, 76.596 W

III. Storm Drains

Storm drain runoff may affect the data the PhytoFinders see. Storm drain runoff acts as fertilizers which can be responsible for toxic algae blooms. Recently, the town of Nags Head has embarked on a project to re-direct storm drains to eliminate direct ocean discharge. The project involved solving a drainage problem in South Nags Head, which is where Jennette's Pier is located, and removing a drain pipe. This project has allowed the town of Nags Head to acquire an 11-acre tract of land that may be used to re-direct the storm water runoff. With the help of scientists at the North

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Carolina Coastal Studies Institute in Manteo, North Carolina and the University of North Carolina at Chapel Hill, an ongoing study has started that focuses on nine ocean outfalls from Kill Devil Hills to South Nags Head. This project is part of a pilot project paid for by the state Department of Environment and Natural Resources (DENR). The state provided $15 million to clean up pollution from the storm water outfalls. The recent development of storm drains in Nags Head means that the ocean is healthier, which can account for the differences in phytoplankton between the Jennette's Pier and the Army Corps of Engineer Field Research Facility.

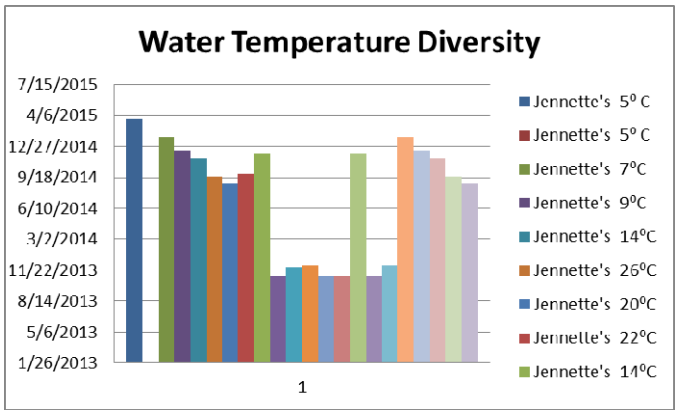

Figure 2: Differences in Water Temperature Between the Two Piers

IV. The Gulf Stream

The Gulf Stream is a powerful ocean current that transports water, heat, and organisms from the tropics to the colder and higher latitudes. Observations of the Gulf Stream eddies, often called the Gulf Stream rings, revealed that cyclonic rotating eddies contained cold water with elevated concentrations of phytoplankton and other nutrients. The anticyclonic rotating eddies contained warm water with low concentrations of phytoplankton and nutrients. At the northern end of the Outer Banks, where Duck is located at, the gulf stream collides with the Labrador Current resulting in an up-welling of nutrient rich water. Off the coast of North Carolina, the Gulf Stream can affect water temperatures by providing warmer water. Water temperatures strongly influence the growth rates of phytoplankton. Since cold water contain more nutrients than warmer waters, phytoplankton tend to be more abundant in colder waters. The cold surface water provides easier access for the deep water to rise to the surface, bringing nutrients to sunlit area where phytoplankton can use them. The Gulf Stream is located just 50 miles off the Army Corps of Engineer Field Research Pier. The Jennette's Pier, located 20.8 miles farther south, and is 25-35 miles off the Gulf Stream. Theoretically speaking, since the Field Research Facility pier is farthest from the Gulf Stream, the y should have a higher and more diverse phytoplankton population than the Jennette's Pier's population of phytoplankton.

V. Environmental Factors

Within 24 hours of collecting samples from the Field Research Facility in Duck and Jennette's pier, environmental factors such as wind direction, wind speed, tides, and pH are recorded. Over the span of 10 years, the pH levels have varied. A decrease in pH levels could be the result of the rising levels of atmospheric CO_2. A decrease of pH levels changes the bioavailability of essential algal nutrients. In addition, a lower pH level also decreased the nitrogen fixation in cyanobacterium. Since Jennette's Pier is located in Nags Head where projects to reduce the amount of runoff in the ocean, the pH levels at the Army Corps of Engineer Field Research Facility may be slightly more acidic than the pH levels at Jennette's Pier. The PhytoFinders measure the wind direction and speed to determine if a lack of phytoplankton could result from the direction of the wind. According to data from the last 8 years, the wind speed and direction has been the same at the two piers. Over the summer, PhytoFinders Nathan Butcher and Jodi Awtrey embarked on a collaborative citizens science project where they were given the chance to collect and analyze data at Jennette's Pier. In late July, they were disappointed by the lack of phytoplankton they saw under the compound light microscopes. By being aware of the wind direction and the current winds of that time, they concluded that the lack of phytoplankton was a result of a west wind that occurred a few days prior that swept the phytoplankton out farther into the ocean along with other factors. The PhytoFinders also record the

weather for that day. Generally, phytoplankton responds more positively to more precipitation in summer than winter. The increased precipitation in winter had a higher chance of reducing chlorophyll a; where as an increase in precipitation in the winter has a higher chance of increasing chlorophyll a. Due to being 20.8 miles apart, it is not uncommon for it to rain in Duck but not Nags Head and vice versa. This can affect the diversity of the species between the two locations. The various wind speeds that the PhytoFinders have observed contribute to the variations of the diversity between the Field Research Facility and Jennette's Pier. Storms.

VI. Storms

The Outer Banks of North Carolina can be prone to bad weather such as thunderstorms or tropical depressions. Many factors can result in the two piers having different effects of bad weather. A thunderstorm may start off strong in the northern parts of the Outer Banks, but it can quickly die off before reaching the southern part of the Outer Banks. Due to this action, the data of phytoplankton at the Field Research Facility in Duck will be different than the data at Jennette's Pier. Tropical storms that develop in the south Atlantic Ocean may head for the Outer Banks but can get pushed out farther into the Atlantic Ocean often missing or barely touching the Outer Banks. This would result in the southern part of the Outer Banks to experience more of the storm than the northern parts, which would account for any differences in the phytoplankton population at that time.

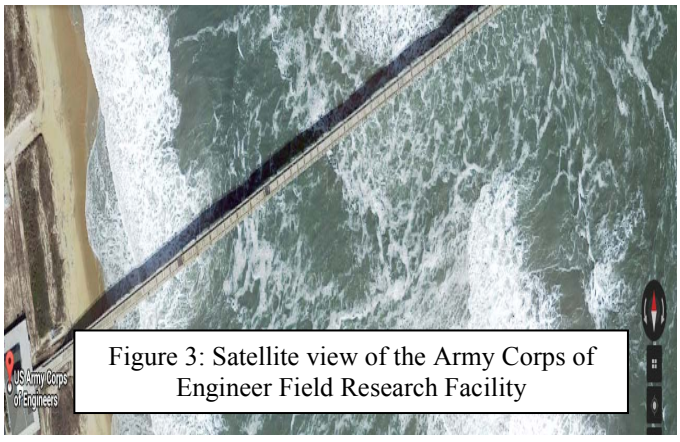

Figure 3: Satellite view of the Army Corps of Engineer Field Research Facility

VII. Procedure

Within 24 hours of collecting the samples, the PhytoFinders record the air and water temperature, wind speed, tides, pH, weather, and sample time. These are all environmental factors that the PhytoFinders record that could result in the diversity of the species between the 20.8 mile distance of the two piers. Samples were collected using a 20µm plankton net following an established hand towing protocol. Multiple replicates were examined through optical microscopes for potentially harmful phytoplankton species present at each site. Counts of all identifiable genera and species are recorded.

Pier	Date	pH	Air Temp (°C)	Salinity (ppt)	Weather
Duck FRF	11/4/2013	7	19	30	Cloudy
Jennette's	11/4/2013	6	16	30	Cloudy
Duck FRF	11/18/2013	7	21	35	Sunny
Jennette's	11/18/2013	7	20	32	Partly Cloudy
Duck FRF	12/9/2013	6	13	30	Cloudy
Jennette's	12/9/2013	5.5	19	30	Cloudy

Figure 4: Table depicting the different environmental conditions recorded at both piers

IX. Why Phytoplankton

Long term monitoring of phytoplankton populations and associated environmental parameters at the two sites contributes useful baseline information for phytoplankton research. The First Flight PhytoFinders continue to sample phytoplankton populations in hope to one day be able to further their skills to make predictions. Since phytoplankton is a key indicator of environmental conditions, the PhytoFinders closely monitor the presence of a variety of phytoplankton species. For example, an algae bloom can cause a drop in dissolved oxygen levels, which negatively affects

the marine life. Sampling data at two locations provides a more accurate representation of the condition of an environment. If both locations show a great difference in data, then the PhytoFinders are able to conclude that the difference may be a result of abnormal fluctuations. The data that the PhytoFinders collect can possible lead to new research to determine what could be causing any abnormal fluctuations observed in the PhytoFinders future.

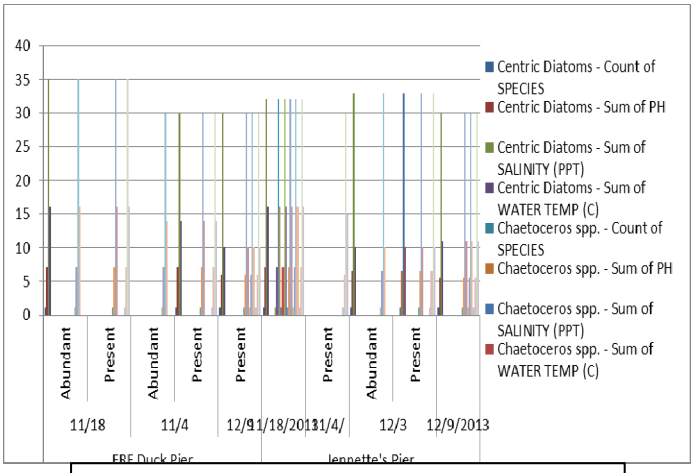

Figure 5: Species Diversity of Winter 2013

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