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The Effects of Ocean Currents on Marine Pollution

Background: I am a senior a Canyon Crest Academy. I have grown up in Solana Beach and have always had an affinity for the ocean. This summer I had the amazing opportunity to be a volunteer intern for the Clear Blue Sea organization. I conducted research on the basics of ocean pollution and the effects ocean currents have, and I included some of the information I learned while collaborating with other interns and professionals at the Clear Blue Sea organization.

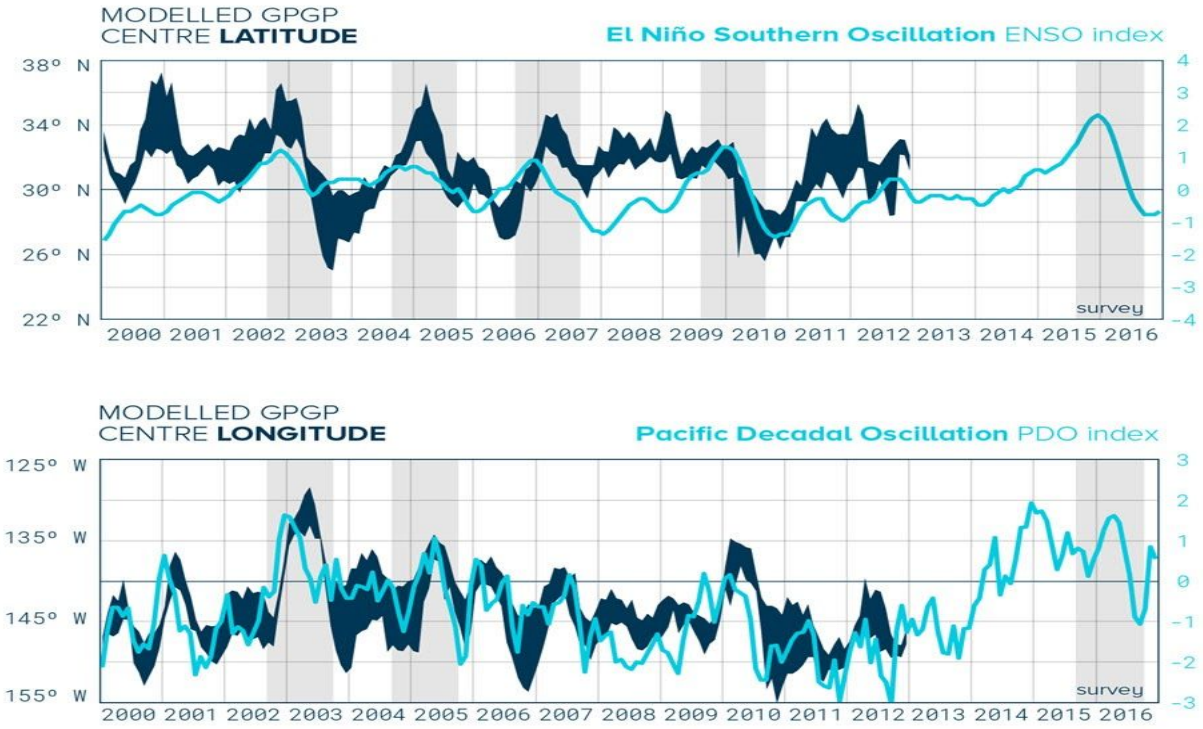
Over the past several decades, plastic debris has been entering the ocean in detrimental amounts. This debris has accumulated in 5 large sections of the ocean; the largest patch of debris is known as the Great Pacific Garbage Patch. The amount of plastic debris in the ocean is continually increasing. The Ocean Cleanup's most recent study estimates that the Great Pacific Garbage Patch is about 1.6 million square miles. However, this is just the surface area of the garbage patch. There are debris throughout the upper water column. An article in the *Biogeosciences* journal declares, "Models indicate that the largest decrease in their concentration occurs within the first few metres of water. . . Our results show that plastic concentrations drop exponentially with water depth, and decay rates decrease with increasing Beaufort number." (Beaufort number refers to the equation for wind speed above the surface of the ocean). This garbage patch is located between California and Southeast Asia north of the equator. Its exact location is constantly changing due to the currents and weather conditions.

These currents and weather conditions make it challenging to pinpoint the precise location of the garbage patch. Through the NASA Garbage Patch Visualization Experiment, conclusions can be drawn about how the plastic debris collects in the garbage patch and how the garbage patch moves. The NASA Garbage Patch Visualization Experiment represented data from the NOAA buoys. These buoys were released from the different coastal points on each continent. In fact, most of the waste that reaches the ocean arrives from the mouths of rivers. Therefore, these models can accurately demonstrate the path of the debris from the entrance point to the final destination.

These buoys traveled mostly with the natural ocean currents. In general, the buoys traveled from the Pacific coast of the United States down towards the equator. From there, many of the buoys traveled west crossing the Pacific Ocean above the equator. Some continued to travel north along the coast of Asia, then make their way back to the United states in the north. This path includes the California current, the North Equatorial current, and the Kuroshio current. These different currents cause the debris that originated on the land to accumulate in the north Pacific Ocean off the coast of California. The Ocean Cleanup places the most recent location at "32 degrees north and 145 degrees west." In their diagram, the latitude coordinates change between 26 to 36 degrees north, and the longitudinal coordinates change between 130 and 155

degrees west. Although this is a wide range it is still useful when trying to locate the Great Pacific Garbage Patch.

1. Movement of the Great Pacific Garbage Patch



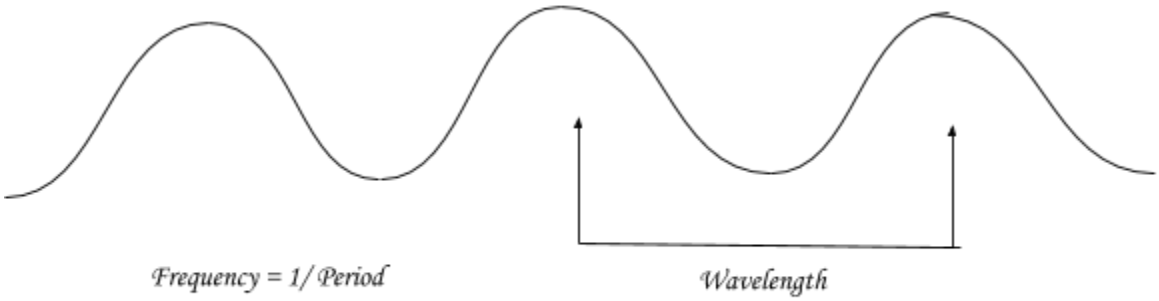
In my project on tracking pollution from the mouths of rivers, my mentor showed me how to add random vectors to my pollution projections to simulate the random movements in the ocean. Weather, wind, and even animals can affect the movement of pollution in the ocean. As the animals move through the water they create some of the most unpredictable changes in the pollution's location. Effects from the wind and weather are more predictable but still subject to random movements.

In general, Doppler radar can be used to measure the speed and direction of currents and the movement of pollution. Doppler radar is based off the Doppler effect: a shift in frequency due to a moving object in the radar. The frequency increases when the current is heading towards the radar and decreases when the current is moving away from the radar. The frequency of the reflected signal changes proportionately to the velocity of the current. The transmitted signal is in the HF band (24 MHz). This is a transmitted frequency of 24 million cycles per second. The wavelength is the velocity divided by the frequency. The wavelength of the transmitted electromagnetic wave is 12.5 meters.

2. Wave Mechanics

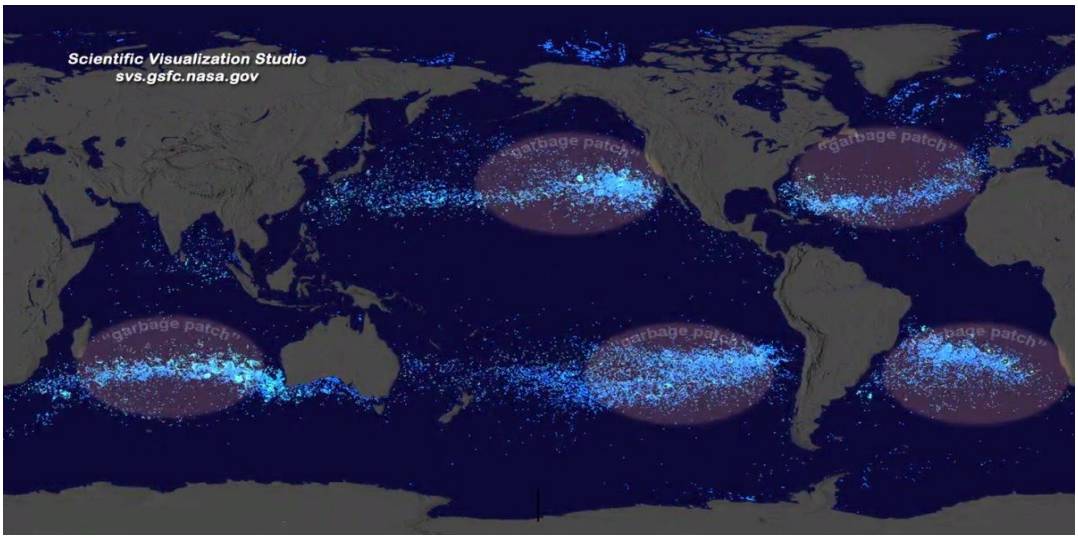
Frequency= 24 million cycles/ second
Wavelength = 12.5 meters
Velocity = 3 x 10^8 meters/ second

λ= v/f ⟶ 12.5=300000000/24000000



To further investigate the effects of ocean currents on the movement of pollution, Nikolai Maximenko's ocean models provide deeper clues into the movement of debris in the ocean. After the Tsunami in Japan in 2011, Maximenko used his ocean models to track the location of the debris. There are many limitations that make studying this topic extremely challenging: the conditions of the ocean, the equipment needed, and simply the vast area that needs to be studied further. To gain a full picture of this catastrophic issue many more research expeditions should be conducted. The Floating Robot for Eliminating Debris (FRED) that Clear Blue Sea is sending out into the Pacific Ocean should include sensors to collect more data on the effects water temperature, sea life and wind have on the movement of the garbage patch.

3. Garbage Patch Simulation



In my experience at Clear Blue Sea, I had the opportunity to work with and learn from engineers with different engineering majors. It was an amazing experience to be able to contribute to discussions on how to effectively remove plastic debris from the ocean. I loved how I was able to apply what I learned in my physics class and my previous internship. All of the knowledge that I have gained through my own research and working with others has lit a fire inside me. I am more motivated than ever to fight for the health and safety of our oceans. From small acts such as boycotting straws to continuing my research on ocean currents and pollution beyond my internship, I am eager to contribute everything I can to protect the ocean and the environment.

Works Cited

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