Rebecca Mills

Entering Research 120

Introduction Draft

# Introduction

The Chesapeake Bay is the largest estuary in the United States. The Bay is home to thousands of species and is vital to surrounding ecosystems. This large Bay is extremely beneficial and important to humans, as it provides food, employment, and many other positive factors for human life. The deteriorating health of the Bay has put human health and welfare at risk (Costanza et al, 1992). In recent decades, the Bay has become at risk due to various issues. These include high chlorophyll concentrations, erosion, pollution, overharvesting, and many more. All of these issues greatly affect the water quality in the Bay, which as a result lowers its overall health. Nitrogen and phosphorous pollution in the Bay, as well as algal blooms, are major contributors to the lessening of the Bay's water quality. Nutrient pollution seems to be the issue we should focus on in the Bay, as it causes an excess of chlorophyll and algal blooms to appear in the Bay, harming various species (Smayda, 2003). This high concentration of chlorophyll in the Bay is causing more detrimental harm than good and needs to be addressed (Chesapeake Bay Foundation, 2018).

Chlorophyll is a photosynthetic pigment that is present in plants found in the Chesapeake Bay, such as sea grass and algae. Both water depth and temperature are seen to be a contributor to this chlorophyll increase, along with many other factors (Yu, 2013). Chlorophyll can be both beneficial and harmful to the Bay. Chlorophyll is beneficial because it converts sunlight into energy, which keeps the organisms in the Bay alive (Rabinowitch, 1965). In addition, plants such as sea grass are necessary for various fish and crabs to survive (Chesapeake Bay Foundation, 2018). Many factors can harm sea grass, such as nitrogen and phosphate pollution, leading to algae on water's surface. These factors can lead to a great decrease in healthy sea grass, forcing freshwater life to lose its habitat and destroy the entire ecosystem. Algae is a form of chlorophyll that is one of the main reasons why chlorophyll is receiving a bad reputation in the Chesapeake Bay. The main role of algae is to use photosynthesis to convert sunlight into energy, which can be helpful, but not in the large quantity that is currently in the Bay (Rabinowitch, 1965).

Algae is often present in many areas of the Chesapeake Bay, but starts to become a serious issue when algal blooms begin. Algal blooms form from a result of blue-green algae in the water. A lot of blooms are also the result of higher concentrations of nitrogen and phosphorous in the Bay (Smayda, 2003). Nitrogen and phosphorous levels are high in the Bay

due to many factors, including runoff, human waste, and industry. When agricultural pollution such as runoff from farms, and industrial pollution, such as leaking sewers are present, it leads to a high increase in nitrogen and phosphorous levels, which then creates bacteria, then finally creates algae in the Bay (Chesapeake Bay Foundation, 2018).

This algae concentration is a huge issue because it forms a cover on the surface of the Bay, making it impossible for sunlight to reach the Bay's floor, therefore killing the healthy seagrass that is providing numerous habitats for the large variety of life in the Chesapeake Bay, resulting in the death of many organisms relying on that seagrass for food or a habitat. Many organizations have implemented plans and goals in order to attempt to reduce the levels of nitrogen and phosphorous in the Bay by reducing pollution. Within these various plans are the 2017 and 2025 Watershed Implementation Plans. Here, they are attempting to control the levels of nitrogen and phosphorous and get the levels reduced to a certain target. With goals set in place to lower these nutrient levels, both the nitrogen and phosphorous levels were successfully lowered by at least ten percent (Chesapeake Bay Foundation, 2018). While the levels are still not completely ideal, these goals put in place and actions taken have clearly helped those nitrogen and phosphorus levels decrease. It is hoped that decreasing these major causes of high chlorophyll levels in the Bay will decrease the chlorophyll levels themselves, creating a healthier Chesapeake Bay.

A bigger problem when it comes to algal blooms are red tides. The red tide is a very harmful abundance of algal blooms. These blooms occur and spread very quickly and are almost impossible to control, especially as it is expanding very quickly in global coastal waterways (Smayda, 2003). These are caused when non-point source pollution enters various waterways through local rivers and streams that are affected by agriculture runoff, which includes primarily nitrogen and phosphorus-based fertilizers. In addition, acidification and deoxygenation in ocean waters have been known to contribute to this problem as well. Acidification is a decrease of pH in the ocean because of an excess of carbon dioxide from the atmosphere, and deoxygenation is when ocean water loses oxygen as a result of climate change. When acidification occurs, there is an excess amount of carbon dioxide in the water, and algae needs to release enzymes to compensate for this acidification. This will lead to an increase in algae so it is able to reduce all the acid present (Feirro, 2014). Deoxygenation leads to dead zones, areas with low oxygen. Dead

zones are caused by excess nutrient pollution, which lead to the growth of algal blooms (Joyce, 2000). While it is difficult to track the exact conditions causing these rapid blooms, knowing these key factors is important to putting a stop to the issues. In an experiment conducted to characterize the small-scale variability of phytoplankton chlorophyll in certain areas of the Chesapeake Bay, the presence of algal blooms had a large effect on the variability present. When looking at the results, variability of chlorophyll was significantly higher in 1990, when a spring bloom did occur (Weiss et al, 1997). The experiment included a trial the next year, in 1991, as well. Here, there was no spring bloom present, which led to a much smaller variability of chlorophyll located in the Bay that year. The rise of these algal blooms is concerning, as they affect both humans, plants, and animals. Red tides can cause respiratory issues in fish, which can kill them. When these fish die, they release chemicals into the air that can cause serious health issues in humans that live near the water. This should be a wake up call for people to start caring about this issue in the Bay, as well as other waterways.

With an increase in urbanization happening, the amount of industrial pollution has been increasing, leading to higher nitrogen and phosphorus levels in the water due to runoff from industries. In growing areas, drilling can also affect the abundance of runoff. This is a key wake up call that humans are contributing to the rise of dangerously high chlorophyll levels in the Bay. Agricultural and industrial pollution do not occur naturally. Humans can no longer do as much with the Bay due to these levels of different contaminants. The Chesapeake Bay Watershed Agreement has made it clear that the large amounts of nitrogen and phosphorus in the Bay has made certain areas of the bay considered “impaired” (Chesapeake Bay Foundation, 2014). This will greatly affect recreational and industrial aspects of the Bay, so humans need to start being more aware and find a solution to this issue.

When it comes to human interaction with the Bay, humans are not helping the situation with nitrogen and phosphorus pollution. This nutrient pollution builds up so quickly and creates more chlorophyll than what is considered healthy. For starters, the production of nitrogen and phosphorus fertilizers has increased in past years (Peñuelas et al, 2013). Humans have turned away from the use of natural fertilizers and have been using much more of these nutrient heavy supplements. This creates a problem when it rains and runoff picks up these fertilizers, dumping the nutrient containing toxins into the water. In addition, the burning of fossil fuels has increased

Rebecca Mills

Entering Research 120

Introduction Draft

the decomposition of reactive nitrogen around the world This has increased the formation of nitrogen oxides in the atmosphere. (Peñuelas et al, 2013).

Harmful nitrogen concentrations in the atmosphere are also affecting the levels of chlorophyll in bodies of water such as the Chesapeake Bay due to the nitrogen cycle. Humans have accelerated the nitrogen cycle the past few years due to factors such as increased food production and the use of artificial fertilizers (Nicolas Gruber et al, 2008). Through this cycle, nitrogen is put into the soil through lightning, nitrogen fixation, or fertilizers. Next, plants uptake that nitrogen through their roots. These animals eat the plants, which now contain more nitrogen than expected, and the decomposition of these animals puts nitrogen gas back into the atmosphere for the cycle to repeat itself. While this cycle is occurring, runoff collects nitrogen present in the soil and runs it down to various waterways, then leading to the increase in chlorophyll (Gruber et al, 2008).

There are many unanswered questions when it comes to chlorophyll concentrations in the Chesapeake Bay. For example, we are unsure of all the possible human health risks associated with this rise in chlorophyll in the Bay. There is also the question of how this chlorophyll concentration can be lowered without harming healthy sea grass. While we want the harmful surface level algae to be removed, we do not want to possibly harm the healthy sea grass below that is providing a healthy habitat and food for so many organisms and species (Chesapeake Bay Foundation, 2018).

In this experiment, the difference between chlorophyll concentrations close to the shore in the Chesapeake Bay and in open waters outside the Bay was investigated. It was predicted that the concentrations would be higher in the sample closer to the shore of the Chesapeake Bay. This hypothesis was created because runoff is more prevalent in areas of water close to land, and runoff is one of the main causes of increased chlorophyll concentrations. In open water, runoff is not as big of an issue. Samples from Machodoc Creek in the Potomac River, a river off the Chesapeake Bay, as well as samples right outside the Chesapeake Bay, in open water, were retrieved. If the chlorophyll concentration in Machodoc Creek is higher than in open water, it will act as an indicator that runoff may be a more major issue when it comes to chlorophyll than many might think. If the open water sample is the higher chlorophyll concentration, a deeper look into what the main reasons for these results might be will be done.

Rebecca Mills

Entering Research 120

Introduction Draft

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