Cecily Hayek
Entering Research 120
Introduction Final Draft

Introduction

Water is essential to all organisms and the ecosystems in which they all live. Therefore, the contents of the bodies of water are crucial. In cases where the balance of nutrients and substances within the system is abnormal, the health of the body of water suffers (Molot et al. 2012). This imbalance of nutrients causes several things to go wrong.

One process that is required that is interrupted by excess nutrients that takes place in major bodies of water is photosynthesis. This process affects the health of many different types of plants and animals that live in the water (Friedrichs et al. 2018). Photosynthesis adds dissolved oxygen into the water when performed by aquatic life (Friedrichs et al. 2018).

As the effects of climate change are starting to worsen, the process of photosynthesis accelerates to unhealthy levels. Climate change causes abnormal levels of photosynthesis because photosynthesis requires carbon dioxide, and climate change ends up significantly increasing the amount of carbon dioxide in different systems. This is not just occurring in one area, however (Friedrichs et al. 2018). One of the largest cases in the world of this occurring is in the Chesapeake Bay.

In the Chesapeake Bay, many different factors work together and affect its overall health These factors range from detrimental to almost harmless. One factor that affects its health is the eutrophication of the bay (Friedrichs et al. 2018). Eutrophication is the process in which bodies of water are invaded by excess nutrients, which in turn increases the level of algae (State of the Bay 2016).

Algae can be beneficial in aquatic environments; however, it is dangerous to have very high levels of algae and can lead to harmful algae blooms (Molot et al. 2012). This balance between healthy and dangerous is difficult to determine because it is often different in different areas. For example, this increase in algae decreases water quality in the Chesapeake Bay (Molot et al. 2012). In other areas, algae help create a healthier environment in which dissolved oxygen levels are normal (Molot et al. 2012). The excess nutrients enable algae to grow. When algae grow during the day, it takes in carbon dioxide and produces oxygen during photosynthesis.

Cecily Hayek
Entering Research 120
Introduction Final Draft

At night, however, during cellular respiration, the algae take in oxygen. This is interesting because the algae float at the top of the water's surface, which blocks sunlight from reaching the floor of the bay (Friedrichs et al. 2018). This causes other plants in the bay, like the seagrass bed and the infamous bay oysters to not produce enough dissolved oxygen (Friedrichs et al. 2018).

Oysters are essential to the health of the bay because they help filter the water from dead algae, fish, and also other nutrients from the bay. Oysters used to be absolutely everywhere in the bay, making the water clear and the bay healthy (State of the Bay 2016). After a large amount of overfishing, the oyster population was depleted.

It was then impossible for the smaller population of oysters to maintain the same level of clarity, and thus makes the water rather opaque (State of the Bay 2016). An increase in algae also does not help water quality (State of the Bay 2016). Algae floats at the top of the water and causes the water to appear murky and green rather than clear (Friedrichs et al. 2018). Removing algae could potentially help water quality, at least at the surface (Friedrichs et al. 2018).

This is still an issue today, as the visibility of the water is very poor and needs to be improved. When John Smith first discovered the bay, he reported that he could see 20-30 feet below the surface (State of the Bay 2016). Now, you can see about one foot down. This is a huge problem, for obvious reasons. This decrease in visibility is a clear sign that human intervention has caused it (Friedrichs et al. 2018).

Water quality is based on the physical and biological components in water (Friedrichs et. al. 2018). It is used to determine whether water is safe for human consumption, contact, and the health of the ecosystem (State of the Bay 2016).

No natural activities could have done this level of destruction (State of the Bay 2016). This also means that drastic measures must be taken to fix this imbalance (Friedrichs et al. 2018). Some systems are in place now to help with the shortage of oysters, but the amount we have now is still minuscule compared to that of the number of oysters in the 1600's (State of the Bay 2016).

These systems are also mainly put in place to help the harvesting of oysters rather than the push to rebuild the natural population. This is counterintuitive because the only way to ensure that the bay will be able to be a home to the oysters is to continue to help the bay by replenishing the oysters. This does not include growing new oysters that are only there to be grown, harvested, and sold (State of the Bay 2016).

A different program has been put in place to help reduce nutrients and increase water quality (State of the Bay 2016). An example of this would be the Chesapeake Bay 2010 Total Maximum Daily Load (Friedrichs et al. 2018). This program was put in place to help control the number of nutrients that contribute to the excess growth of algae (Friedrichs et al. 2018). The plan has not been in place for very long but has been projected to increase the health of the bay drastically (Friedrichs et al. 2018). This plan has not been fully implemented, however, it is important because the amount of nutrients in the bay has an effect on more than just water quality (Friedrichs et al. 2018).

The algae cannot grow without having nutrients. Nutrients that help algae grow also get into the bay from runoff. This runoff is from the areas surrounding the bay (Friedrichs et al. 2018). This includes the farms, industrial areas, suburban areas, rivers, and they all drain into the Chesapeake Bay before they reach the ocean (Friedrichs et al. 2018). This means that fertilizers, insecticides, and any chemicals that are used in these areas get into streams, then the rivers, and finally the bay (Friedrichs et al. 2018). These chemicals introduce new uncontrolled nutrients into the bay, which in turn throws off the balance of the bay (Chai et al. 2018). Nutrient levels also affect natural processes, most importantly photosynthesis and respiration (Friedrichs et al. 2018). In one study, levels of increased dissolved oxygen were found because of all of the excess nutrients (Friedrichs et al. 2018).

This is another reason why the water quality of the bay is so poor. Without improving the water quality, the bay will continue to deteriorate and become worse than it is now. The most important factor in determining water quality, however, is dissolved oxygen (Friedrichs et al. 2018).

Dissolved oxygen is a product of wind and also is one of the products of photosynthesis in aquatic plants. Dissolved oxygen is critical to maintaining life in the Chesapeake Bay. Without dissolved oxygen, the bay would lose all of its inhabitants (Friedrichs et al. 2018). This is an issue because not only is the loss of an ecosystem like the bay bad, it is also bad for those who live and work directly with the bay. Without the bay, thousands of people will have no job or way to earn money. The health of the bay is more important than we think (Molot et al. 2012).

Increased levels of dissolved oxygen in some areas of the water can cause hypoxia, or dead zones, in the water (Chai et al. 2018). Dead zones in the water enable no life to flourish and are harmful to fish and plants alike (Da et al. 2018). The zones are bad for the animals that inhabit the areas, but also the people that rely on the fishing business (Friedrichs et al. 2018). This is because the fish cannot survive with such low levels of oxygen (Da et al. 2018). The optimal amount of dissolved oxygen depends on the location (Molot et al. 2012). For the Chesapeake Bay, it should be about 5 mg/L (Chai et al. 2018).

Anything less than this amount can cause aquatic life to stress (Chai et al. 2018). In the 2016 State of the Bay report for the Chesapeake Bay, there were not any anoxic areas (State of the Bay 2016). This means that there were no areas with less than 0.2 milligrams per liter of oxygen (State of the Bay 2016).

The Chesapeake Bay has proven that it is strong and is fighting to keep itself alive. It needs help to remove these excess nutrients and algae (Friedrichs et al. 2018). The research previously conducted has addressed the bad effects of both excess nutrients and algae, but not a lot of research discusses dissolved oxygen and its effect on algae (Friedrichs et al. 2018).

Dissolved oxygen levels in the Chesapeake Bay may be affecting other aspects of the bay. Since dissolved oxygen is directly related to photosynthesis and respiration, we assumed that algae would be heavily affected by it too (Friedrichs et al. 2018). The case we want to explore is dissolved oxygen's effect on algal growth. If we can decrease the level of algae, can we somehow get the dissolved oxygen levels back to normal?

As mentioned before, the state of the bay is crucial to many different organisms (Molot et al. 2012). Some animals depend on it as their habitat, while others work on the bay. If the bay's health is not improved, then these organisms will suffer (Friedrichs et al. 2018). Therefore, determining the correlation between dissolved oxygen and algal growth is very important.

Cecily Hayek
Entering Research 120
Introduction Final Draft

We want to investigate the relationship between levels of dissolved oxygen and growth of algae. The purpose of this study is to investigate the high levels of dissolved oxygen in the Chesapeake Bay.

If there is a higher average of dissolved oxygen levels in the Chesapeake Bay, compared to other bodies of water, then it can be attributed to the large amounts of algae. We collected water samples at the Chesapeake Bay, as well as the Coan and Potomac River. Our results will show the correlation between algae and dissolved oxygen. If it is positive, then the more dissolved oxygen there is, then the more algal blooms there will be.

Citations

Continuous Monitoring Reveals Drivers of Dissolved Oxygen Variability in a Small California Estuary. Springer. Santana, Rafael; Lessa, Guilherme; Haskins, John; Wasson, Kerstin. 2018

The competing impacts of climate change and nutrient reductions on dissolved oxygen in Chesapeake Bay. Friedrichs, Marjorie A. M.; Da, Fei; Hinson, Kyle E. Biogeosciences 15(9):2649-2668. 2018

Impacts of Atmospheric Nitrogen Deposition and Coastal Nitrogen Fluxes on Oxygen Concentrations in Chesapeake Bay. Journal of Geophysical Research-Oceans, V-123, I-7, Pages (5004-5025) Da, Fei; Friedrichs, Marjorie; St-Laurent, Pierre. 2018

Long-term changes in hypolimnetic dissolved oxygen in a large lake: Effects of invasive mussels, eutrophication and climate change on Lake Simcoe, 1980-2012. Molot, Lewis A.; Palmer, Michelle E.; Winter, Jennifer G.; Young, Joelle D. Journal of Great Lakes Research 44(4):779-787.2018

Redox reactions and weak buffering capacity lead to acidification in the Chesapeake Bay.Huang, Wei-Jen; Luther, George W., III; Pierrot, Denis; Li, Ming. Nature Communications 8(1) Nature Publishing Group 2017-28

A Sixteen-year Decline in Dissolved Oxygen in the Central California Current. Chai, Fei; Xue, Huijie; Anderson, David M.; Chavez, Francisco P. Nature Publishing Group 2018

Cecily Hayek
Entering Research 120
Introduction Final Draft

Worsened physical condition due to climate change contributes to the increasing hypoxia in Chesapeake Bay. Shen, Jian; Park, Kyeong; Wang, Ya Ping; Yu, Xin.Science of the Total Environment. 630:707-717.2018

"2016 State of the Bay Report." *Chesapeake Bay Foundation*, Chesapeake Bay Foundation, 2016, www.cbf.org/about-the-bay/state-of-the-bay-report/f2016/.