The Gull

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"You can make anything by writing."

– C.S. Lewis

Essay on the Yellow Wallpaper

Sunshine Booth

Mental health is just as important as physical health. Some would argue that it is even more important. Some would say that if mental health is bad, then that will lead to unhealthy physical health. Historically at the time of this story, women were objectified by most of society, to be mothers and homemakers, and nothing else. Women in these times were also expected to be seen and not heard, and most people didn't take them seriously. In *The Yellow Wallpaper* by Charlotte Perkins Gilman, basing the story upon her real-life experiences, the rest cure and gender societal norms did more harm than good, with the "recovery" of the narrator being an unexpected one.

Gilman based *The Yellow Wallpaper* on her own experience. She had a baby girl, and experienced post-partum depression. She went to a world-famous doctor, and he prescribed her the rest cure. Like the woman in the story, he didn't allow her to do anything creative, which made her even worse. The short bio in the textbook says, "However, this so-called "rest-cure" only further deepened Gilman's depression and so she sought—and found—a cure for herself in her true callings: the literary and political work…" (Berke et al. 203). Like the woman in the story, she found comfort in writing. However, unlike the woman, she was able to continue writing regardless of what others said.

Gilman relates herself through the woman in the story, having the reader feel sympathetic towards her, even though she is going against what is prescribed for her. In the research paper by Johnson, "Drawing on Gilman's experience of post-partum depression and breakdown, the story is far more than an indictment of nineteenth-century attitudes toward women and an account of one woman's incipient psychosis… and the story as a whole describes a woman attempting to save herself through her own writing…" (Johnson, pp. 3). Gilman was against the historical societal norms in general, and it spanned across many things, from her marriage to her health.

One could even see this as Gilman being a flawed hero. She started out doing what was expected of her, then branched out into doing what she wanted. Her bio states:

> She led an unconventional life… At the age of thirty-four, she divorced a husband who sought to "domesticate" her, leaving both him and her daughter to pursue an independent career… editing and publishing her

> own feminist magazine, Forerunner; and lecturing for the American Woman Suffrage Association and other organizations on the need for social reform to ensure equality between men and women. (Berke et al. 202).

Gilman is a perfect example of post-modernism by being the flawed hero women needed. She worked for herself, but in doing so, she helped others. She even said herself that she just wanted to help improve humanity. She didn't conform to what was expected of her and used unexpected measures for the time to get her point across.

The protagonist Jane's husband was a doctor, who put her on the rest cure, and refused to let her write, or give in to any wishes she wanted. She told him that she was uncomfortable in the room, and that she wanted to go to other rooms instead, but he refused because it would be giving into her delusions, and that it would be a slippery slope:

> At first he meant to repaper the room, but afterwards he said that I was letting it get the better of me, and that nothing was worse for a nervous patient than to give way to such fancies. He said that after the wall-paper was changed it would be the heavy bedstead, and then the barred windows, and then that gate at the head of the stairs, and so on, (Gilman, pp. 205).

Her husband John tells her that the house is doing her good, and the room she is in is the best room possible. She has the best air circulation up in the room, and although she might not see it, she is getting better. He also dismisses her by saying if they were in any other room, he wouldn't be able to be with her. Her brother is a doctor as well and agrees with her husband's diagnosis.

The gender norms are seen in the story because the men are not listening to what the woman has to say or taking her seriously. Female gender norms are also seen with the housekeeper, Jennie, who takes Jane's place taking care of the baby, and doing the housework. At one point a Fourth of July Party is mentioned, "Well, the Fourth of July is over! The people are gone and I am tired out. John thought it might do me good to see a little company, so we just had mother and Nellie and the children down for a week. Of course I didn't do a thing. Jennie sees to everything now. But it tired me all the same."

(Gilman, pp.207). Even though Jane didn't do anything because of her depression, she still suffered.

Jane feels that writing is one of the best things for her recovery, even though she knows that John hates that she writes. She at first has to sneak around, feeling almost guilty for doing so, however she eventually gets a bolder attitude and continues:

> At first, she writes with humility, sneaking out her forbidden journal carefully. She says all the expected things—her husband is understanding and knowledgeable and she is at fault for not responding to his care. But then a tone of complaint—a minor tone—enters her writing. Though she does not attack John directly, she knows at heart that her own treatment would have better results than his is having… (Wagner- Martin, paragraph 5).

Jane writes because she knows it helps, and her tone in her writing shifts slowly as she writes. She has to hide her writing from her husband and her housekeeper as well.

The protagonist is an unreliable narrator, with a downhill progression as she continues in the room. She goes from hating the wallpaper, to being thankful that her baby didn't have to be in the room, to studying the wallpaper, to eventually not wanting anyone to find out the secrets of the wallpaper. She admits to her appetite getting better, and that she has a better outlook on life:

> Life is very much more exciting now than it used to be. You see I have something more to expect, to look forward to, to watch. I really do eat better, and am more quiet than I was.... I had no intention of telling him it was BECAUSE of the wall-paper—he would make fun of me. He might even want to take me away. I don't want to leave now until I have found it out. There is a week more, and I think that will be enough. I'm feeling ever so much better! (Gilman, pp. 211).

Our narrator is getting closer and closer to her "recovery." She admits she is feeling better, and as the story progresses on, the reader can tell she is going off the deep end, regardless of what her husband and Jennie say or think. She starts lying and saying she is sleeping when in reality, she is studying the wallpaper, seeing a woman, and trying to set that woman free.

At the end of the story, the narrator ends up setting the woman free, and in doing so, realizes that she actually enjoys being in the room, and the reader can tell that she has lost it. She enjoys tearing down the wallpaper, and she realizes the groove she found earlier in the wall fits her perfectly. She states, "It is so pleasant to be out in this great room and creep around as I please! I don't want to go outside… For outside you have to creep on the ground, and everything is green instead of yellow. But here I can creep smoothly on the floor, and my shoulder just fits in that long smooch around the wall, so I cannot lose my way," (Gilman, pp. 214). She feels free, just like the woman she freed from the wallpaper. When her husband comes to get her, she locked the door to the room, and thrown the key away, to the outside where she hates to be. She even finds it annoying that he got in her way when she was crawling around the room.

This resulted from her husband not listening to her and could be seen as being free from her husband's influence and societal norms. She did not care that she made her husband faint and decided he was in the way of what she wanted. Regarding societal norms, she does not care that she is going along a disregarded path and has thrown away the key to her so-called expected life. When her husband looks at her, she responds with, "I've got out at last," said I, "in spite of you and Jane. And I've pulled off most of the paper, so you can't put me back!" (Gilman, 215). She herself is Jane, yet she talks as if she is a different person. She has escaped the wallpaper that is the expectations of her life, and she believes that she cannot ever be trapped anymore.

In *The Yellow Wallpaper,* no one listens to the narrator, and she goes from feeling guilty about her condition to finding a way to help herself in the end. Gilman writes of a woman, who like her, escapes the expectations of her life, and refuses to go back. The societal norms of everything, from her not being allowed to write or mentally stimulate herself, to her suggestions being ignored or pushed away, furthers her downward slope into insanity. Due to the rest cure and under stimulation, recovery was only reached once the woman in the yellow wallpaper was freed, both literally and figuratively. Charlotte Perkins Gilman writes of a woman who was put on the rest cure by a respected doctor, and suffers for it, until she finds a recovery of her own, by doing what she wants in the end with disregard to everyone else.

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The Effect of Biocide Type and Concentration on Surface Fouling and Nearby Estuarine Crustaceans

Erik Graulich

Introduction

Increasing greenhouse gas (GHG) emissions are driving global warming which threatens nations around the globe with unprecedented changes in rainfall, drought, fires, and sea level. A significant emitter of greenhouse gasses is the maritime shipping industry, which was responsible for 11 billion tons of goods moved around the planet in 2021 alone (Placek, 2022). According to the Department of Transportation in 2020, maritime shipping accounted for 40% of all trade value and 70% of international trade going both in and out of the United States, which is 18% of America's GDP (DOT, 2021).

This global commerce, which moves 80% of goods by sea, contributes significantly to greenhouse gas emissions and the transport of marine hull-fouling invasive organisms that hitchhike around global ports on ships' hulls (UNCTAD, 2021). Hull fouling occurs as organisms attach themselves to ships' hulls which impacts the hydrodynamics and decreases fuel economy by 1-2%, as well as reducing maneuverability. Marine fouling poses an economic challenge to shipping companies due to its effects on fuel economy when completing trans-oceanic voyages (Pistone et al., 2021). Reducing hull fouling, which decreases drag and improves fuel efficiency, also is one of the most energy and cost efficient strategies to reduce the greenhouse gas emissions from shipping (Farkas et al., 2020). On average, a containership running its engine at 55% power will consume 2,192 kg of fuel per hour, by coating the hull in antifouling paint to reduce the friction caused by organisms stuck to the bottom, the overall fuel consumption will decrease (Aijjou et al., 2019). It is estimated that over the course of an entire year, fouling is costing shipping companies $36 billion dollars in extra fuel costs (Perkins, 2011).

To combat the threat of fouling, improve hull performance and fuel efficiency, special antifouling paints are applied to the lower submerged portion of the hull on all ocean going vessels. Today the majority of antifouling paints use the copper-based chemical biocide, cuprous oxide (Cu_2O), as the main active ingredient to prevent hull fouling, with a zinc stabilizer (Bighiu, 2017). However, this biocide affects more than just the area on the surface of the ship's hull, it can also contaminate the water column with biocide, damaging the local ecosystem (Soroldoni et al., 2021). Modern copper-based antifouling paints can be split into two distinct groups of paint: hard and soft (Nicholson, 2022). Hard antifouling paint, as the name suggests, forms a hard paint layer that contains the biocide which causes the paint to be toxic to any potential fouling organism that tries to settle on it. Soft antifouling paint, on the other hand, is designed to slowly peel off the hull of the ship, releasing the biocide while also releasing any fouling organisms as it sloughs off. Before the use of copper-based biocides, Tributyltin (TBT) was the most common biocide used in marine bottom paint. However, in the early 1980's it was discovered that TBT was decimating the shellfish population in Europe, as well as lowering algae growth, leading to a European ban in 1982 (Alzieu, 2000). These metal based biocides have been found leaching into local waterways as well as affecting the soil in boatyards and marinas, damaging invertebrate populations such as earthworms.

Recently there has been a surge of research into environmentally friendly antifouling alternatives, specifically in silicone and polymer-based coatings that function by resisting the attachment and growth of organisms (Maan et al., 2020; Below, 2021). If an organism did manage to attach itself to the hull, it would be brushed off by the force of the water moving along the surface of the ship's hull while underway. Considering the potential negative environmental impacts on coastal environments in shipping ports, and the potential export of harmful metals to nearby waters, it is desirable to find a less toxic solution to the hull biofouling problem. This project compares an alternative bottom paint solution designed to lower the environmental impact of copper based bottom paint on the surrounding ecosystem. In this project, varying percentages of cuprous oxide were used to determine if a lower percentage of biocide can be used without sacrificing effectiveness, as well as testing an 'eco' brand that did not contain any copper.

Hypothesis

H_{ac}: As the percentage of copper in the paint increases, settlement of fouling organisms will decrease.

$$P_{65} > P_{46} > P_{e} > P_{o} \qquad P = \text{paint}$$

H_{oc}: Settlement of fouling organisms is independent of copper concentration.

H_{am}: As the percentage of copper in the paint increases, the mortality of crustaceans exposed to the paint will increase.

$M_{65} > M_{46} > M_e > M_0$ M=mortality

H_{om}: Mortality of crustaceans is independent of copper concentration.

The independent variable in the coating study is the percent of cuprous oxide in each bottom paint coating. The dependent variable is the amount of fouling that grows on each coating. The control is an untreated substrate. The location and time underwater were kept constant throughout the experiment. In the survivorship experiment, the independent variable is the water exposed to various bottom paints, with the control being water with no bottom paint exposure. The experimental setup and time each organism spent exposed to the treatments were constant.

Materials and Methods

Three bottom paints with compositions of 61% and 46% cuprous oxide, as well as an 'Eco' active ingredient paint with 0% Cu_2O were tested with an unpainted control. Each paint was applied to the front and back of a set of wooden blocks with the dimensions of 20cm by 10cm by 5.0cm. The blocks were then chained together in three rigs containing one block of each antifouling paint type. The experimental rigs were placed in the Elizabeth River in Norfolk on 9/14/2022 and removed for examination on 11/22/2022, for a ten-week soak. The fouling surface of each block was then subdivided visually into a grid with ~ 3 cm^2 subsections, for close inspection to assess the percent coverage of fouling organisms on the treatment paint coated and control uncoated surfaces, respectively.

To determine if the biocide would actively leach out of the painted surface into the surrounding environment, each painted block was placed into a bucket filled with 8L of river water to soak for two weeks (from 11/28/2022 until 12/12/2022). To conduct the survivorship test, crustaceans common to the Chesapeake Bay were collected to test the potential for biocide leaching into the water from the painted surfaces. An experimental setup of 24 cups, each filled with 250ml of treated water: 6 cups of water the painted boards with 61% cuprous oxide; and 6 cups of water soaked with the 46% cuprous oxide boards, another 6 with the 'Eco' active ingredient paint with 0% Cu_2O, and finally 6 cups were filled with untreated water from the Rappahannock River as the control. One Atlantic Mud Crab, *Panopeus herbstii*, and one common Grass Shrimp, *Palaemonetes pugio*, collected from the lower Rappahannock River were added to each cup and left for a 24 hour exposure. The next morning, dead crabs and shrimp were counted and removed from the cups. The water was then exchanged with new water to refresh the water quality of the same treatment group and also the control. The experiment then ran for another 24 hours, after which any new dead crabs and shrimp were counted, and all surviving mud crabs and shrimp were collected for return to the Rappahannock River. The difference in crab/shrimp mortality was analyzed statistically using a Single Factor ANOVA test. Also a T-test: Two-Sample Assuming Equal Variances was used to determine if there was a significant difference between the control and each treatment, respectively.

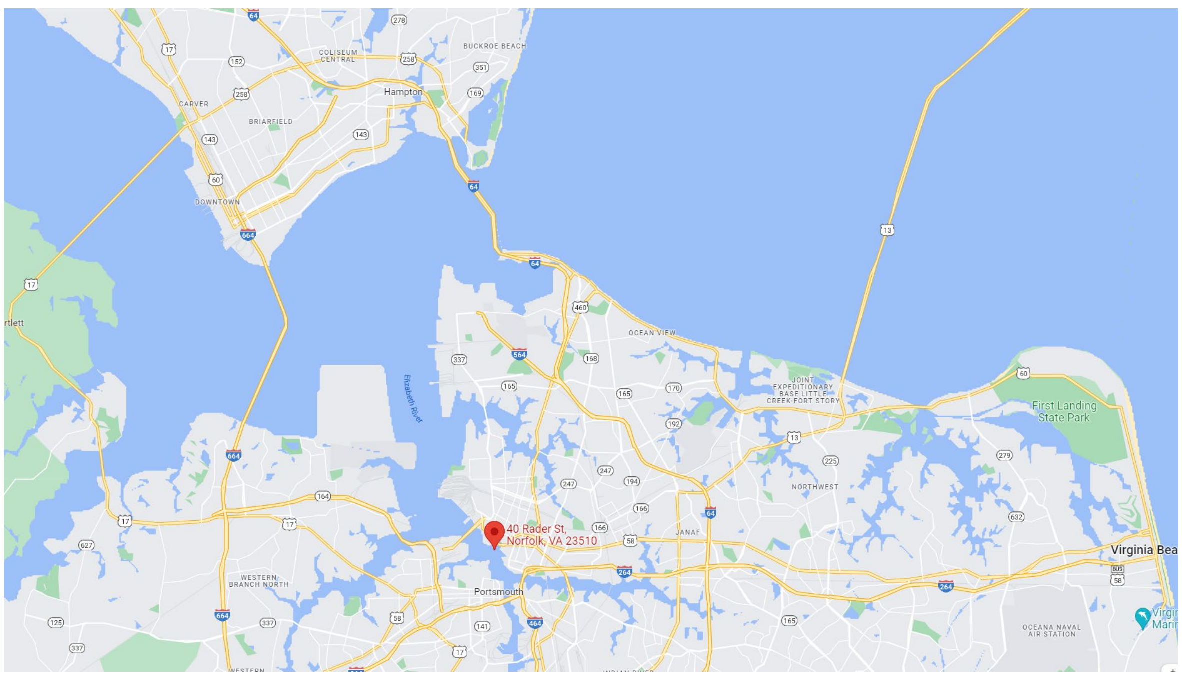

Figure 1. The testing site location for the fouling coverage treatments along the banks of the Elizabeth River in Norfolk, Va.

Results

After being submerged in the Elizabeth River for 10 weeks, the control group had a higher percent coverage than all of the painted treatments (Figure 2). Barnacles, *Amphibalanus spp.* and sea squirts, *Molgula manhattensis*, were the prominent fouling organisms on the control surfaces. The 0% 'Eco' Cu_2O, 46% Cu_2O, and 61% Cu_2O treatments were all similar in coverage, with no live organisms visible on the painted surfaces. An ANOVA: Single Factor test yielded a result of $p=7.31x10^{-9}$ indicating a strong statistical difference between the control and the treatments.

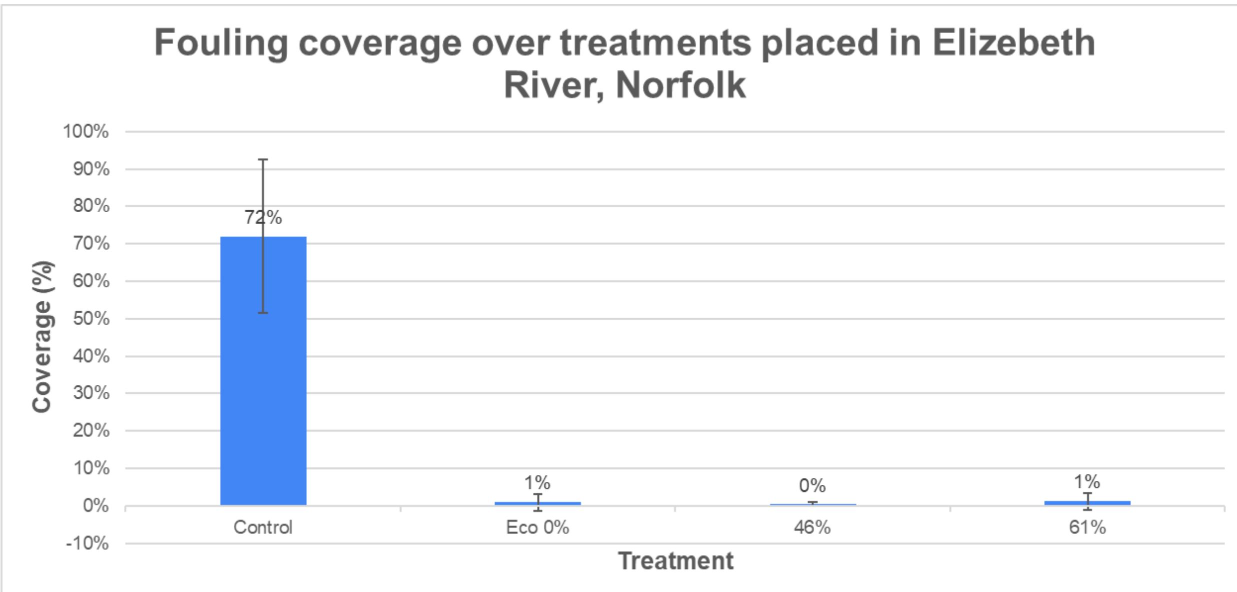

Figure 2. Average percent coverage of fouling organisms on each painted treatment. The control had significantly greater fouling coverage of 72%. The three biocide paint treatments 0% 'Eco', 46% Cu_2O and 61% Cu_2O were 0-1% covered with fouling organisms. ANOVA test yielded $p=7.31x10^{-9}$ indicating a strong statistical difference between the control and the treatments.

After 48 hours of the survivorship exposure trial, the mud crab and grass shrimp mortality rates for all painted treatments were equally deadly with 66% mortality (Figure 3); where the control experienced no loss after day 1, and only 25% mortality overall. In the first 24 hours, the 0% 'Eco' Cu_2O treatment had the lowest mortality rate of 8%, followed by the control at 25%, the 46% Cu_2O treatment had a mortality of 42%, and the 61% Cu_2O treatment had 50% of its organisms die. During the second 24 hours, the control had the lowest mortality rate of 0%, the 61% Cu_2O treatment came in second at 16%; the 46% Cu_2O had a moderate mortality rate of 24%, and the 0% 'Eco' Cu_2O treatment had the highest mortality at 58%. Using an ANOVA: Single Factor test to determine statistical differences yielded $p = 0.177$. T-tests between the control and 0% 'Eco' Cu_2O treatment; and the control and 46% Cu_2O treatment both had $p=0.111$. T-test between the control and the 61% Cu_2O treatment, yielded $p=0.064$, very close to the 0.05 alpha set for significance.

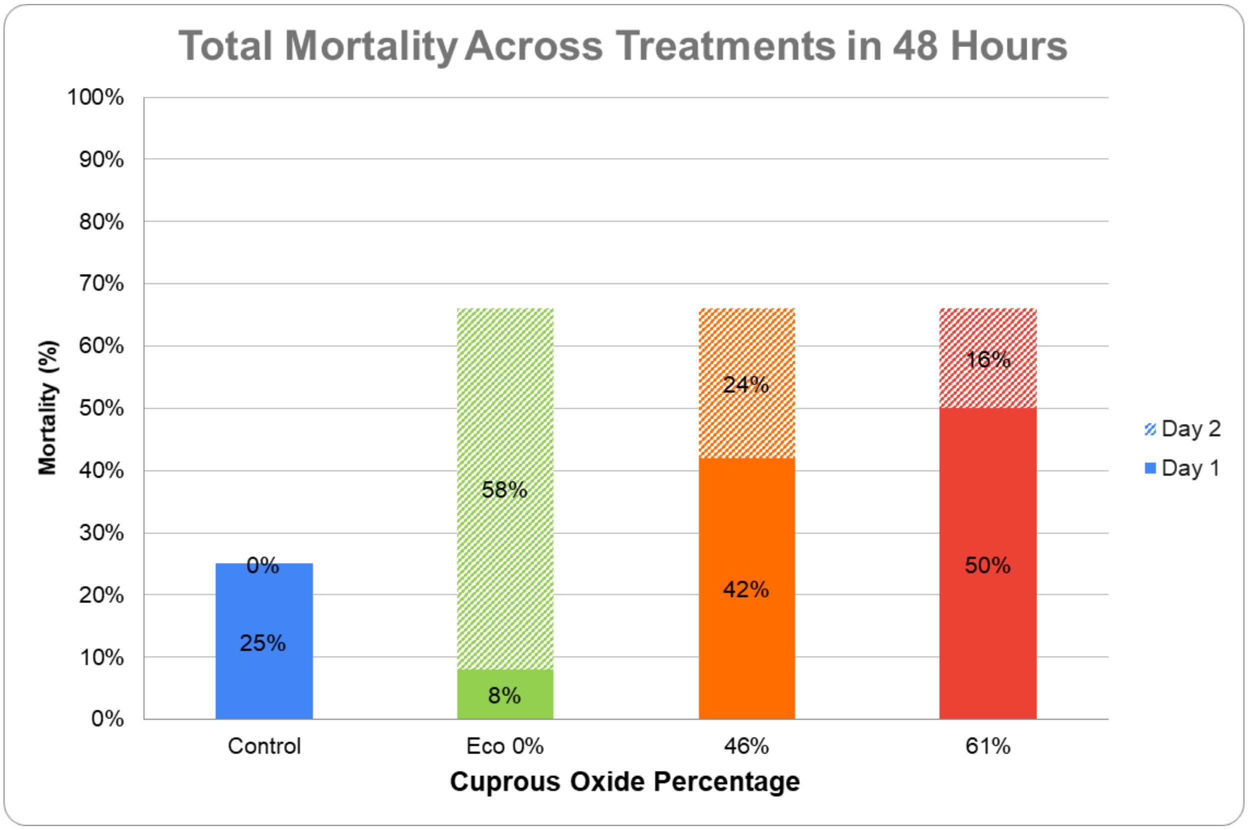

Figure 3. Total mortality for the 48 hour exposure experiment. In the first 24 hours, 25% of the mud crabs and grass shrimp died with no deaths during the second 24 hours in the control group. Only 8% died within the first day in the 0% 'Eco' Cu_2O treatment however during the second 24 hours 58% of the organisms died. 42% of organisms died during the first 24 hours in the 46% Cu_2O treatment with another 24% dying during the second 24 hours. The 61% Cu_2O treatment had the highest day one mortality at 50% with only a further 16% mortality during day two 2.

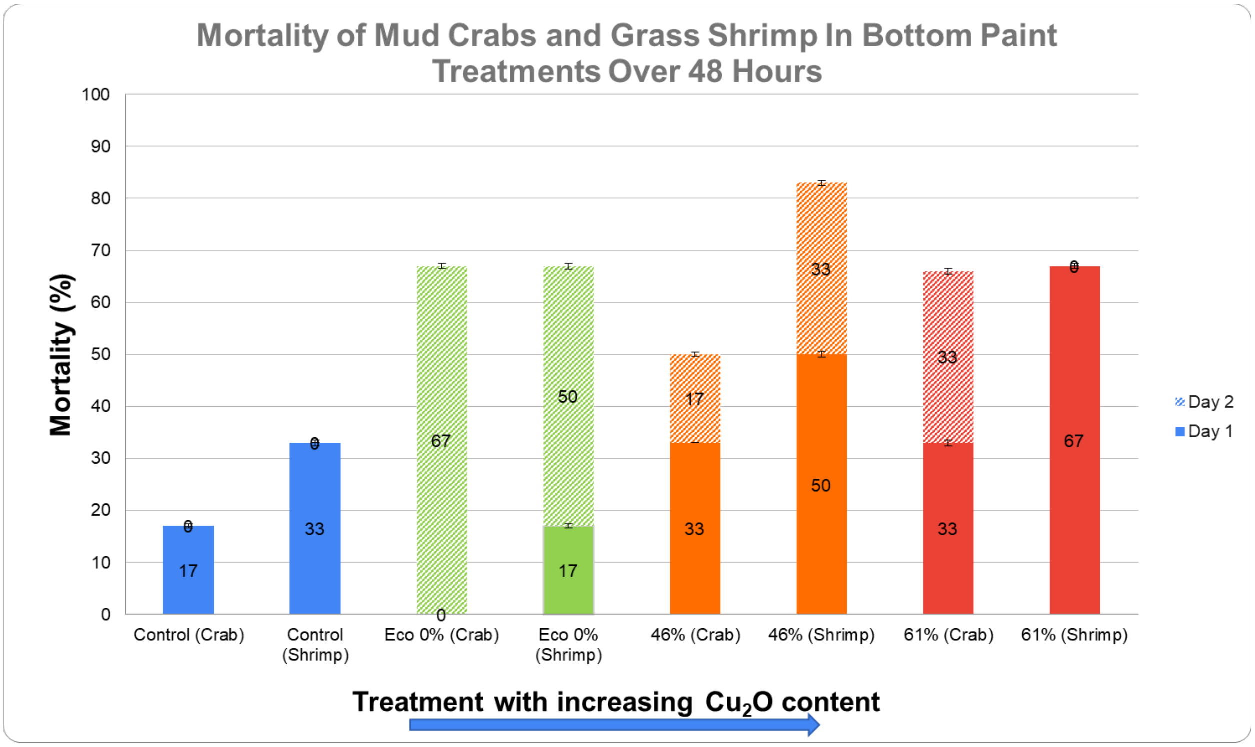

Figure 4. The mortality treatments were divided into mud crabs and grass shrimp. The control had greater loss of shrimp, 32%, than crabs 16%. After 2 days both the 0% 'Eco' Cu_2O treatment and the 61% Cu_2O treatment had an equal mortality in both the mud crabs and the grass shrimp. The 46% Cu_2O treatment had a higher shrimp mortality than crab mortality.

Discussion and Conclusion

Across all four bottom paint treatments, there was a significant difference in biofouling coverage by paint type vs. the control, ANOVA $p=7.31x10^{-9}$, with a set significance alpha=0.05. Based on these results, the hypothesis, H_{oc}: *Settlement of fouling organisms is independent of copper concentration*, is rejected. This conclusion is supported by past research which found that copper based biocides are significantly effective in staving off fouling on multiple substrates and depths (Kojima et al., 2016). During the mortality experiment, the results tested with an overall ANOVA p=0.177, which is not considered significant when using the 0.05 significance alpha, however, the data is trending in that direction. The low p-value result suggests that more testing would improve statistical confidence. Based on these results, the hypothesis, H_{om}: *Mortality of crustaceans is independent of copper concentration*, cannot be rejected. This result is in agreement with a similar study that found that the leaching of antifouling paints is harmful to earthworm populations (Soroldoni et al., 2021). Another study that looked into the concentration of heavy metals suspended in the water column in areas with high ship traffic, like harbors and marinas, found that there were elevated levels of heavy metals which posed potential harm to the environment (Bighiu, 2017).

The similar mortality rate of the 'Eco' 0% Cu_2O, with supposedly 100% inert ingredients, and the 46%, and 61% Cu_2O paints raises some questions about what exactly the 'Eco' paint is composed of. The official name of the paint is 'HRT ECO Black', which claims to be a more eco-friendly solution in big green letters on the paint can, but the small print on the can then states "economical." In a deeper dive researching the active ingredient in 'Eco', the chemical agent is known as ECONEA®, created by Janssen PMP (CHEMPOINT, 2008). Janssen PMP claims that ECONEA® is 10x more effective than copper-based biocides, while also being better for the environment. However, upon consulting the Safety Data Sheet (SDS) it is found that ECONEA® should not be exposed to the environment (Janssen, 2015). Further, it states that ECONEA® is toxic to invertebrates if they are left in its presence for 48 hours; fish after 96 hours exposure; and toxic to algae after 72 hours. The conclusion put forth by this experiment shows that when choosing between antifouling paints with known biocide and 'alternatives', that they all are just as harmful to the environment. So called 'Eco-friendly' antifouling paints still have to contain some form of biocide in their composition to make them viable for antifouling purposes, which defeats the eco-friendly marketing. Calling a paint with a deadly biocide 'Eco', is an irresponsible act of greenwashing and the label should not be allowed in the market for such paints.

In 2021, a total of 1,908 ships had either exported or imported 1,959,750 containers into and out from the Port of Virginia (The Port of Virginia, 2022). The Port of Virginia, also known as the Norfolk International Terminal, is a combination of terminals along the Elizabeth River in the lower Chesapeake Bay in Norfolk, Virginia. All the hulls of these international container ships are coated with some form of antifouling paint and with nearly 2,000 annual entrances and exits from Norfolk, this represents millions of gallons of biocide paint exposed to the Bay's waters (Maggart, 2020). These ships are not just coated once either, about every 5 years a ship needs to go into port to be repainted with another coating of a million gallons of paint. These ships covered with biocide paint leaching into the local waters, enter our Chesapeake Bay daily. A long term study into the effects of copper in sediments found that even after 2 years, copper can still be found in benthic organisms, albeit in slightly lower concentrations than in freshly spiked sediments (Thit et al., 2021). The Norfolk area of the lower Bay is consistently being dosed with ‘fresh’ biocide as ships continually come and go. It can be inferred from the results of this study, that the presence of these biocides in paint on ships' hulls is harming marine organisms in the Lower Chesapeake Bay, as well as any other locations with major shipping ports. Moreover, it also can not be overlooked that blue crab populations in the Chesapeake Bay are at an all time low, as shipping, and therefore biocide exposure, are at an all time high (Chesapeake Bay Program, 2022; The Port of Virginia, 2022).

These data suggest that the better bottom paint choice is to buy a paint that either lasts longer or a paint that spreads further with less paint. Both of these would reduce the overall amount of new biocides added into local waterways and the related damage to our estuarine ecosystem. To improve this experiment, a longer testing period would be needed with more surfaces at a greater variety of test sites and salinities. Instead of keeping the paints submerged for 10 weeks, keeping them submerged throughout the spring and summer season when fouling is the greatest would demonstrate effectiveness over time. Having more types of paint to create more samples would help to get a better understanding of large scale use of antifouling paints and any changes that might result from that. As for the mortality experiment, adding in some different organisms to test exactly to what types of marine life these paints are most deadly. Understanding the impacts and reducing the use of these deadly biocides to the absolute minimum needed is critical to protecting the estuarine environment for a healthy Chesapeake Bay for the future.

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Carbon Taxes, Trading, and Accountability

Libbie Hospodar

As education and awareness of climate change and its causes increase, so does our ability to adopt methods of reducing our greenhouse gas emissions to a stable and healthier level. A popular method is known as carbon pricing, which holds those polluting the atmosphere responsible for their emissions. There are two main methods used to implement carbon pricing: carbon taxes and carbon can and trade (Columbia University…, n.d.). The methods share a number of similarities, but each has its own pros and cons.

Carbon taxation works by placing a price on each ton of greenhouse gasses (GHGs) emitted, with the purpose of changing businesses' and consumers' behavior to reduce their emissions (Diedrich, 2022). Carbon taxes can be placed directly on emissions, or on goods and services. An emissions tax is based on the amount of GHGs emitted, while a goods and services tax is placed on GHG-intensive goods and services. Benefits provided by carbon taxes are the certainty of funds being available for cleaning and controlling pollution, and a steep decrease in emissions directly after implementation. Additionally, due to uncertainty about the imapcts and the effect on the environment by emissions changes, taxes are preferred in the short term by most economists (London School of Economics, 2014). Tax effectiveness depends on the level the tax is set at; if a tax level is set too low, people will just foot the cost, while a tax set too high will have adverse effects on profits and consumers. Taxes do not ensure that emissions will fall below a certain number, only that emitters know how much they have to pay for the GHGs released as a result of their actions. So the total amount of reduction that will occur is unknown. Also, political pressure may cause specific sectors to be exempt from the tax and thereby reduce environmental effectiveness (Stavins, 2018).

Fig. 1 - A basic diagram of a carbon market (Diedrich, 2022).

Carbon cap-and-trade markets are another form of carbon pricing. They work by setting a limit on how much GHGs can be emitted by an entity (typically a company) and allowing the entities to trade allowances if their emissions exceed or are lesser than the cap. Markets also allow businesses to purchase offsets, such as working forests, that absorb and sequester excess GHGs (Diedrich, 2022). Cap-and-trade markets have two forms: compliance and voluntary. Compliance markets are created when the cap is enforced by a national or international carbon reduction program or emission trading systems (ETSs).

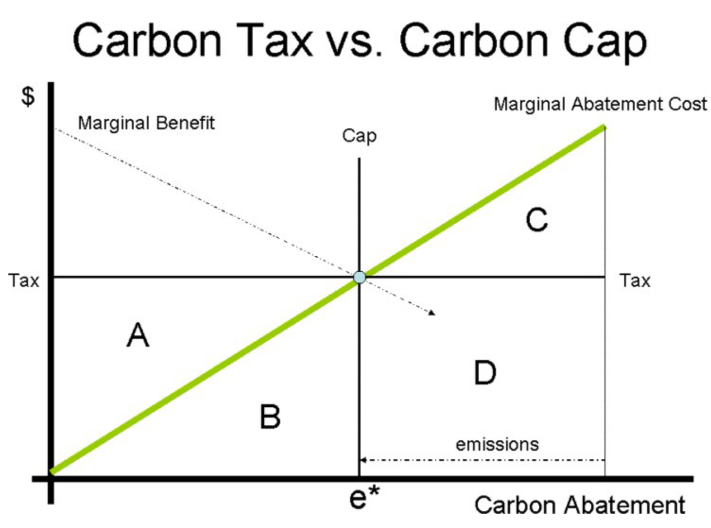

Fig. 2 - An economic chart comparing costs and effectiveness of carbon taxes and markets. (Haab & Whitehead, 2020).

Voluntary markets also have an emissions cap, but their limit is not reliably enforced. Carbon markets have many upsides such as having cost- and environmental-effectiveness, balancing the emissions burdens amongst various sectors, and allowing for countries to become in sync with each other in regards to climate change policies (Stavins, 2018). However, there are some concerns about carbon markets which include pollutant levels reaching the maximum allowed by the government each year and continuing to boost climate change; companies paying a relatively small amount of money to pollute or using offsets as a scapegoat when emissions are high; and having a weak cap on emissions or high amounts of allowances (Diedrich, 2022). The European Union's ETS is an example of the last concern. The set cap for the market is not low enough to make any real progress towards reducing GHGs. While lowering the ceiling would solve the problem, it would also cause prices to go up. Overall, I do prefer the cap-and-trade system, but I think a hybrid version of the two methods would work best and be the most applicable.

New satellite technology is being used to collect data on GHG concentrations throughout Earth's atmosphere and attempts to track where carbon pollution is coming from on a model named, Climate Trace.

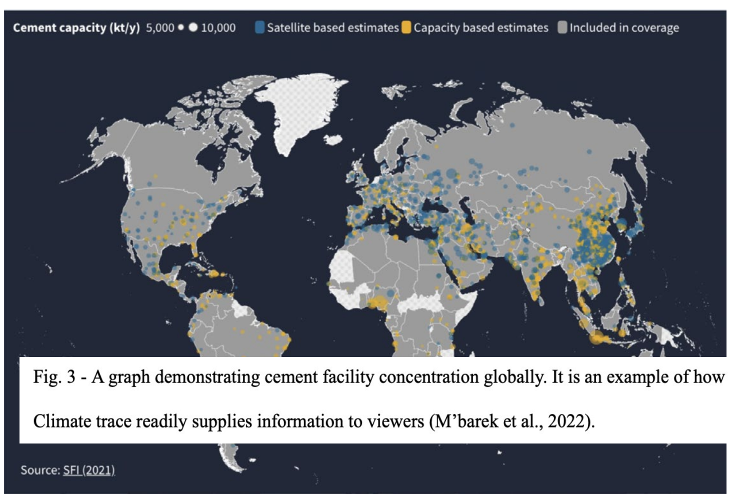

Fig. 3 - A graph demonstrating cement facility concentration globally. It is an example of how Climate trace readily supplies information to viewers (M'barek et al., 2022).

Climate Trace is an accessible map of point-source GHGs across all sectors, that even provides documents entailing data and methodology that can be downloaded for personal use. It allows major GHG emitters to be pinpointed and recognized, and provides a lot of opportunities for analysis. For example, it could be concluded that emissions vary depending on culture by cross-analyzing major sectors such as transportation, food consumption, and waste generation per capita with global cultural concentrations. Additionally, this data model holds large emitters accountable for their actions by providing more accurate measurements of gas emissions than what the companies report. Climate Trace also lets us reflect on ourselves and how we impact the world around us, for example, Climate Trace reports that 41.07 billion tons of CO_2 were emitted in 2021. That means around 5.2 tons of CO_2 were emitted per person in 2021 (Population..., 2022). Such a large number makes me wonder where all of this CO_2 is coming from and how I can lower it. I think having such a public and visual model of this data will make an impact on carbon pollution emission levels, especially with increased education and awareness of GHGs and climate change.

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Positive Phototaxis

Braden Hudgens

Introduction

The seafood industry of the Chesapeake Bay is a billion-dollar industry, reaching 1.4 billion dollars in sales across Virginia and Maryland alone, comprising a significant part of the regional economy. The preservation of the Chesapeake Bay's fish population is extremely important, for this reason, it is alarming to see fish catch rates today significantly lower than they were in the 20th century (CBF, 2020). Striped Bass harvest peaked in 1973 when 14.7 million pounds were harvested, but dropped to under two million pounds less than a decade later. While multiple causes for decreasing fish populations exist, such as eutrophication and habitat loss, overfishing is the primary contributor to the decline of predatory fish populations in the Chesapeake Bay in recent years.

Phototaxis describes organisms' relationship to light in terms of its attractiveness. Fish have been observed as being positively phototaxic, meaning that they are attracted towards light (Sakamoto et al., 2017). The strength of the attraction has been linked to the frequency of the light, where higher frequency light tends to attract more fish. The most attractive light colors for fish that have been observed are blue and green, which are able to appear the most intense in natural waters (Xu et al., 2022).

In recent years, waterfront property owners on Chesapeake Bay tributaries have been installing green lights on docks to attract fish. An example of this is the adoption of bright LED lights, commonly referred to as "green lights," becoming commonplace on many docks in the bay. They are installed with the purpose of attracting fish at nighttime to a concentrated area that can be fished. Anecdotally, fishermen have observed that catches under green light conditions have exceeded those of either white light or no light. Given the overfished state of many species in the Chesapeake Bay and coastal Atlantic, the concern arises, will using green lights to attract fish cause further overfishing in already depleted fish populations?

The presence of light has been demonstrated to have an impact on the behavior of marine species. In natural waters, artificial light also has the effect of attracting phytoplankton. As a result, zooplankton and other plankton-consuming organisms are attracted to the light to feed. This process can follow up an entire food web until apex predators have become present at the light (Martins et al., 2006). Fish species have also been observed being attracted to specific light frequencies (Marchesan et al., 2005). Although the use of greenlights is primarily limited to recreational use, such as a light installed on a dock, lights can also be utilized by the commercial fishing industry. Lights have been demonstrated to dramatically increase the catch rates in Atlantic cod traps, even contributing to an 80% greater haul (Bryhn et al., 2014).

In this study, the impact of green lights on fish phototaxis was determined on a recreational level. No matter the reason behind the attraction of fish to green lights, what is important is the significance of the attraction to green lights. This experiment explored the difference between the number of organisms harvested with and without the presence of light. Plankton samples were also collected to determine if the presence of plankton might also impact the fish catch rates.

Hypothesis

Experiment 1

H_a : Fish catch rates are significantly greater in lighted water

H_o: Fish catch rates do not vary with light.

Experiment 2

H_a : Plankton catch rates are significantly greater in lighted water.

H_o: Plankton catch rates do not vary with light.

In this experiment, the location in which samples were taken was kept constant. Also, all samples at the site were taken in the late evening after dark. The independent variable is the presence of artificial light at the location the dependent variables are the fish and plankton catch rates recorded with and without light.

Materials and Methods

Figure 1. All samples were taken from docks in the Ware River, a tributary of Mobjack Bay in the lower Chesapeake Bay.

All samples were collected at a dock located on the Ware River, Gloucester County, Virginia. An LED spotlight was installed on the dock and aimed at the surface of the water. During the months of September and October, samples were collected using a cast net thrown on the water under the illumination of the green light. For half of the sampling nights, the light was on during net sampling and for the other half, the light was off with only natural light of the moon shining. On lighted sampling nights, the light was powered on ten minutes before samples were taken. To collect samples, a cast net was thrown at the same location for a total of three times per night in ten-minute increments. After each cast, the quantity and species of fish were recorded. For the plankton data, both natural and artificial light samples were taken on each sampling day. The plankton tow was dragged through the artificially green-lighted water three times over ten-minute intervals. Then on the same night, the same sampling process was repeated in a dark area of water, with only the natural moonlight. Plankton were preserved in jars with alcohol for later identification in the lab. For analysis, only the larger meso and macroplankton in the size range of 0.20-20, and 20-200mm were identified to a coarse identification of:

fish larva, crab zoea, copepod, chaetognath, etc and counted.

Results

Throughout the duration of the experiment, catches were higher in the water under green lights than in the ambient lighted water (Figure 1). The mean net catch with the green light was 10.2 fish, and the mean net catch with natural lighting was 2.7 fish. The median net catch with the green light was 7.5 fish. The median net catch with natural lighting was 2.5 fish. The range net catch with green light was 14 fish. The range net catch with green light was 4 fish.

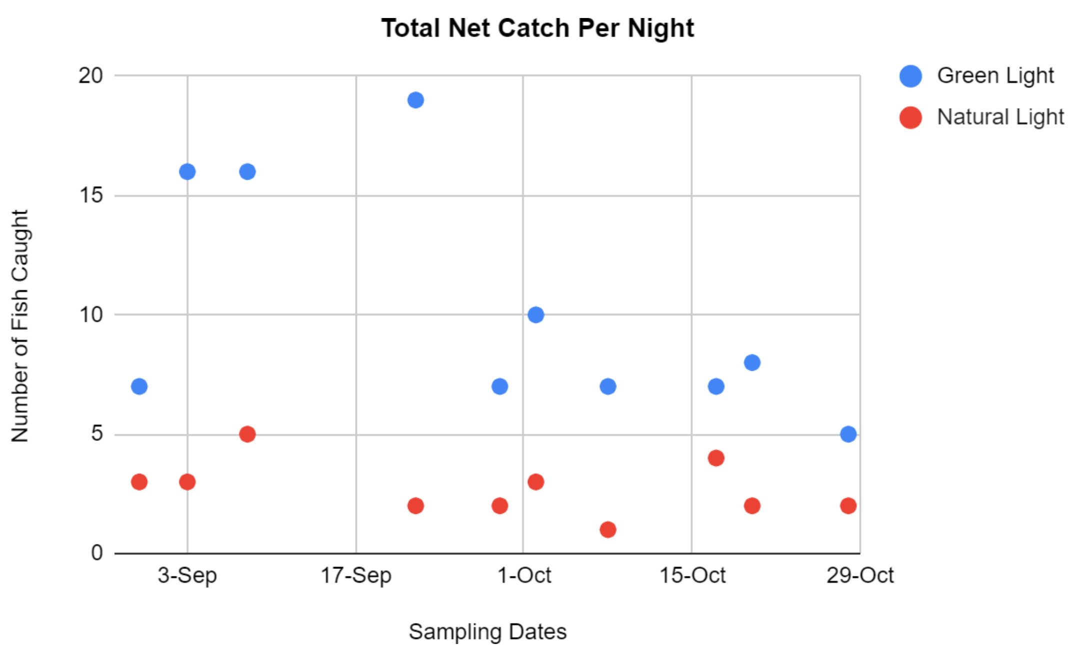

Figure 2. This chart includes the net catches for every trial. The trial with the highest net catch occurred on September 22nd, when 17 fish were caught under green light conditions. The trial with the lowest net catch occurred on October 1st, when 1 fish was caught in natural lighting. The maximum net catch under natural lighting occurred on September 5th, when 5 fish were caught. The minimum net catch under green light occurred on October 28th, when 8 fish were caught.

The average number of fish caught per cast was 420% greater under green lights than under ambient lighted water (Figure 2). The greatest disparity between average fish caught per throw occurred between the dates of September 15th and September 22nd. The catch rate on the 22nd under artificial light conditions was 900% greater than the catch rate on September 15th under natural light conditions. The smallest difference between the average fish caught per throw occurred between the dates of October 16th and October 17th. The catch rate on the 17th under artificial light conditions was 177% greater than the catch rate on September 16th under natural light conditions. In the casts under artificial light, the average catch rate per individual cast peaked on September 22nd with a mean value of 6.3; as opposed to the casts under natural light, when the average catch rate per individual cast peaked on September 5th with a mean value of 1.7. The lowest mean catch rate per individual cast in artificial light occurred on October 28th and had a value of 1.7. The lowest mean catch rate per individual cast in natural light occurred on October 7th and had a value of 0.3. A T-test was taken and a value of P= 6.67e-3.

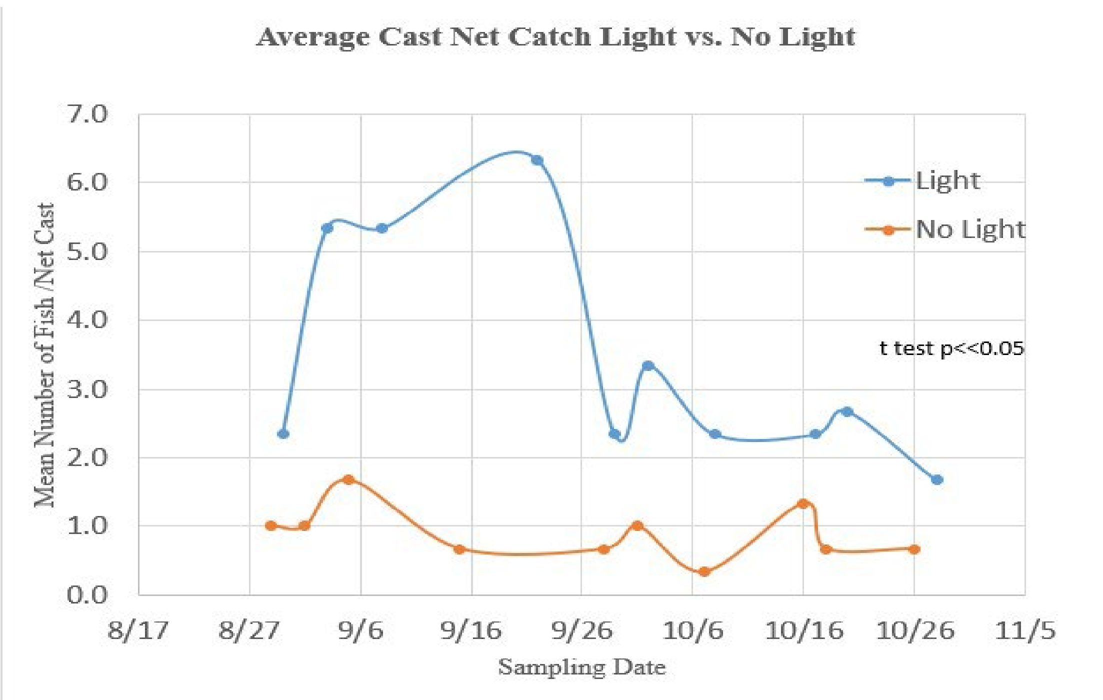

Figure 3. This chart contains the average fish caught per cast per trial. The mean percent difference between green light and natural light throws was 420%. The results are significant with a P= 6.67e-3.

The average number of macroplankton caught per tow under green light was 6.7. This was 670% greater than the average amount of macroplankton caught per tow under natural light which was 1 (Figure 3). The median macroplankton caught per tow under green light was 5, and the median macroplankton caught per tow under natural light was 0; a t-test yielded a value of p= 0.245.. Under both lighted and ambient conditions, the quantity of macroplankton caught decreased with each successive tow pulled.

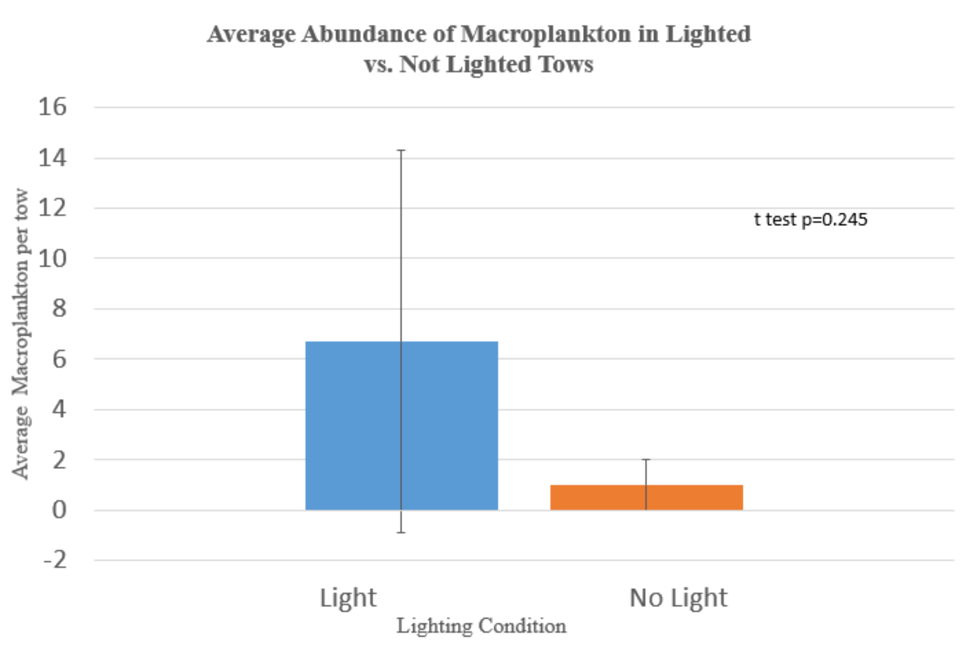

Figure 4. Mean macroplankton in lighted tows was 6.7, and the mean in unlighted was 1. Macroplankton quantities were not statistically greater in the presence of light than without p = 0.245.

Conclusion

The data indicate a significant increase in the amount of fish caught when a green light was present as opposed to fish caught in only ambient light. Based on this, the hypothesis, *H_o: When recording catch rates of fish in both light and dark water, fish catch rates will not vary with light,* is rejected. Similar results were reported in another study where Chinese carp, *S. waltoni* were observed to be attracted to green light (Xu et al., 2022). The difference in the amount of macroplankton caught in artificial and natural light was observed to be not statistically different. Based on this, the hypothesis, *H_o: When recording catch rates of plankton in both light and dark water, plankton catch rates do not vary with light,* cannot be rejected. This conclusion disagrees with the results of another experiment that concluded that artificial lights increased the quantity of plankton in the water they covered (Bryhn et al., 2014).

The lack of a statistical difference in the catch rates of macroplankton is likely due to a small number of trials run. To improve results in future experiments, more sampling should be done to strengthen the catch rate of macroplankton. Replicating both experiments across various testing sites would also strengthen the data. Lastly, a more consistent sampling schedule would make the differences in catch rates of fish in both light conditions more comparable.

The effectiveness of recreational green lights have the capacity to negatively impact fisheries in the future. Many fish populations have seen a steady decline recently due to overfishing, as green lights increase in popularity, fishermen are becoming more effective at catching their limit (Sumaila & Tai, 2020). Furthermore, the use of a green light at night makes it much easier for fishermen to poach fish without being seen by wardens. It is for these reasons that green light use by fishermen will aid in decreasing an already declining population of fish in areas where they become common.

Since more fish can be harvested through the use of green lights than is naturally possible, the use of green lights for fishing should be limited in order to maintain healthy fish populations. One way that this could be implemented is by establishing a "light season" which gives a frame of time in which artificial lights can be allowed for fishing. Another solution is to ban the practice altogether. This has been done in a similar situation of "spotlighting" deer. Similar to phototaxis in fish, the use of light at night gives the hunter an unfair advantage in hunting as deer freeze when the bright light shines on them at night. No matter how it is done, reducing the use of artificial lights in fishing is necessary to maintain healthy and sustainable fisheries for the future.

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The Impact of Shoreline Hardening on Nearshore Fish Populations

Kayleigh Miller

Introduction

The shallow water environments of the Chesapeake Bay are a vital part of the estuarine ecosystem that provides a habitat for many fish and invertebrate species. The small fish and invertebrates that depend on the shallows are the primary food source for larger, more economically important fish species, like trout and flounder. By the end of this century, the relative sea level in the Chesapeake Bay is projected to rise by 1.59 meters (Burke & Dunn, 2010). The Bay's natural and inhabited infrastructure is at risk from storm surges brought on by tropical storms and nor'easters.

Shoreline engineering in response to rising sea levels has altered the shoreline environment. Shoreline Hardening introduces armoring to the shoreline; this can come in many forms, but typically riprap or bulkheads are used (Gittman et al., 2015). Fears of property damage due to rising sea levels results in property owners implementing rigid, resistant material directly on the shoreline to prevent erosion which significantly alters the natural habitat in the shallow water environment (Bulleri & Chapman, 2010). This is true for the Chesapeake Bay, as NCCOS reports that in some Chesapeake Bay tributaries, as much as 80% of shorelines have experienced some form of shoreline armoring (NCCOS, 2020). Recent studies have found that hardened shorelines often intensify the storm surge effects of sea level rise, increasing storm surge height up to 0.5m (Zhang & Li, 2019). Shoreline hardening most significantly impacts nearshore shallow water environments that provide nurseries for juvenile fish species.(Kornis et al. 2018).

Shallow water habitats are suggested to be an important refuge for *Fundulus heteroclitus*, *Callinectes sapidus*, and *Palaemonetes pugio* to avoid predation (Ruiz et al., 1993). With the loss of habitats like SAV beds and oyster bars, small nearshore fish and invertebrate species are now primarily inhabiting shallow nearshore waters less than 35cm in depth. In the absence of hiding places associated with the complex SAV and oyster habitats, the shallow water habitat provides fish and invertebrate species with a refuge from larger, predatorial species. However, other studies suggest that there is insufficient evidence to support that shallow water systems serve as a refuge for nearshore fish and invertebrate species; notably, their findings are within the context of tropical estuarine systems (Baker & Sheaves, 2007).

This study focuses on the abundance of fish species and the diversity of fish and invertebrate species between three beach sites along the lower Chesapeake Bay with varying degrees of shoreline hardening, from the natural shoreline to all riprap.

Hypotheses

H_{O1}- There will not be a difference in fish abundance between natural and hardened shorelines.
H_{A1}- There will be a difference in fish abundance between natural and hardened shorelines.

H_{O2}- There will not be a difference in diversity between natural and hardened shorelines.
H_{A2}- There will be a difference in diversity between natural and hardened shorelines.

H_{O1}- There will not be a difference in fish abundance across sampling dates.
H_{A1}- There will be a difference in fish abundance across sampling dates.

The factors held constant throughout this study were the relative time of day, the four locations sampled across the lower Chesapeake Bay, the seine net used for the sample, and the specific beach area within the sample site. The independent variable for this study is the sites sampled, as each site has a varying degree of human engineering along its coastline. The dependent variables are the diversity and abundance of species caught.

Materials and Methods

Three sample sites were identified on the shoreline of the lower Chesapeake Bay. Two sites are directly on the Chesapeake Bay shoreline, and a third is along the York River. The sampling areas were selected due to their relative location along the lower

Chesapeake Bay and the lack of large debris or obstacles that would disrupt the process of seine sampling.

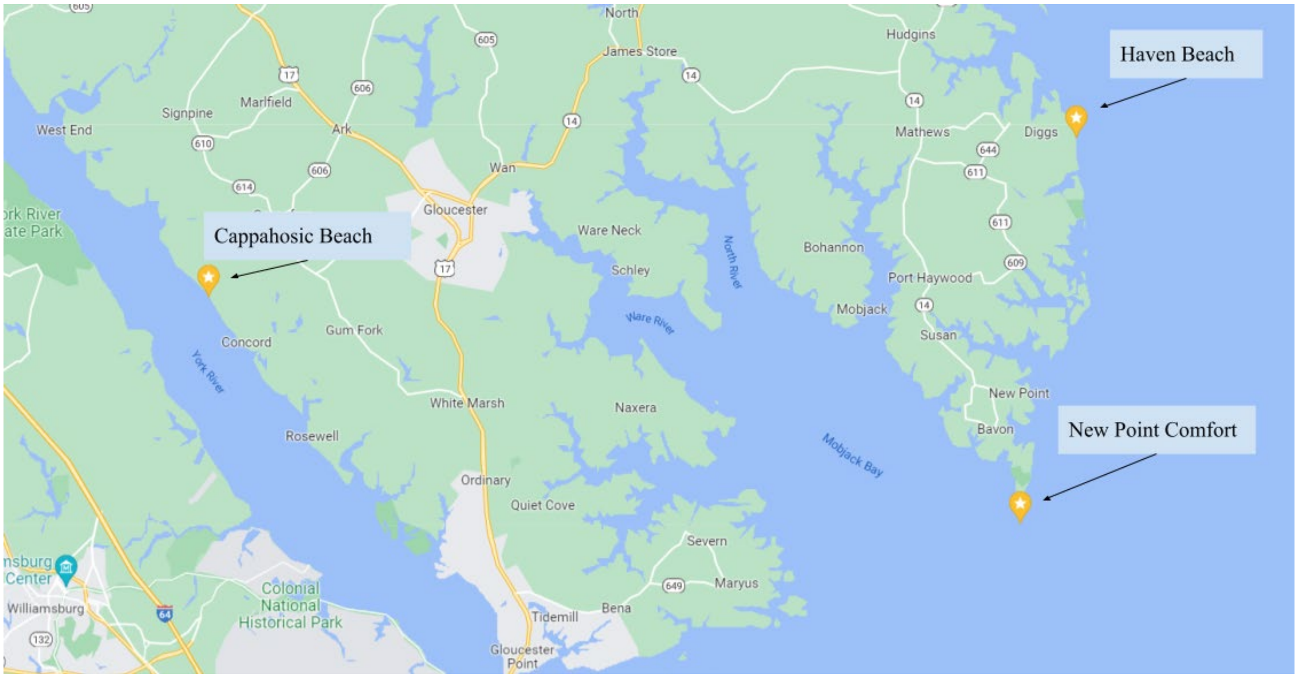

Figure 1. Map of the three locations tested on the lower Chesapeake Bay: New Point Comfort, Haven Beach, and Cappahosic Beach.

Figure 2. From left to right in order of increasing shoreline engineering, satellite pictures of each sampling site: New Point Comfort (natural), Haven Beach (natural+armor), and Cappahosic Beach (armored) .

Seine nets are commonly used to sample shallow nearshore environments. Seine nets are effective in water depths less than 2 m and in areas where vegetation, rocks, or woody debris are absent or can be removed manually (Buchanan et al., 2021, p. 3).

This study utilizes a beach seine net with an arm length of 4 m, a net height of 1.5 m, and a purse mesh size of 5 mm. The seine net was pulled parallel to the shoreline for approximately 20 meters. Once reaching the 20-meter mark, the net was extended to its full size and pulled back to the shore. The fish and invertebrates caught were collected from the seine and photographed to determine quantity and species. Each fish was photographed and released. This procedure was carried out three times at each sampling site from August 9, 2022, to September 2, 2022. The fish and invertebrate species collected were identified using the Life in the Chesapeake Bay field guide (Lippson, 1997, p. 115–144). All of the collected data was transferred to an Excel spreadsheet for analysis. The hypotheses were tested using ANOVA statistical tests and the Shannon Index for diversity utilizing an online calculator (Omnicalculator.com).

Results

At the New Point sampling site, the total number of fish and invertebrates caught on August 9th was 55; on August 26th, was 71; and on September 2nd, was 59 (Figure 3). At the Haven Beach sampling site, the total number of fish and invertebrates caught on August 9th was 96; on August 26th, was 24; and on September 2nd, was 30. At the Cappahosic Beach sampling site, the total number of fish and invertebrates caught on August 9th was 3; on August 26th, was 3; and on September 2nd, was 4.

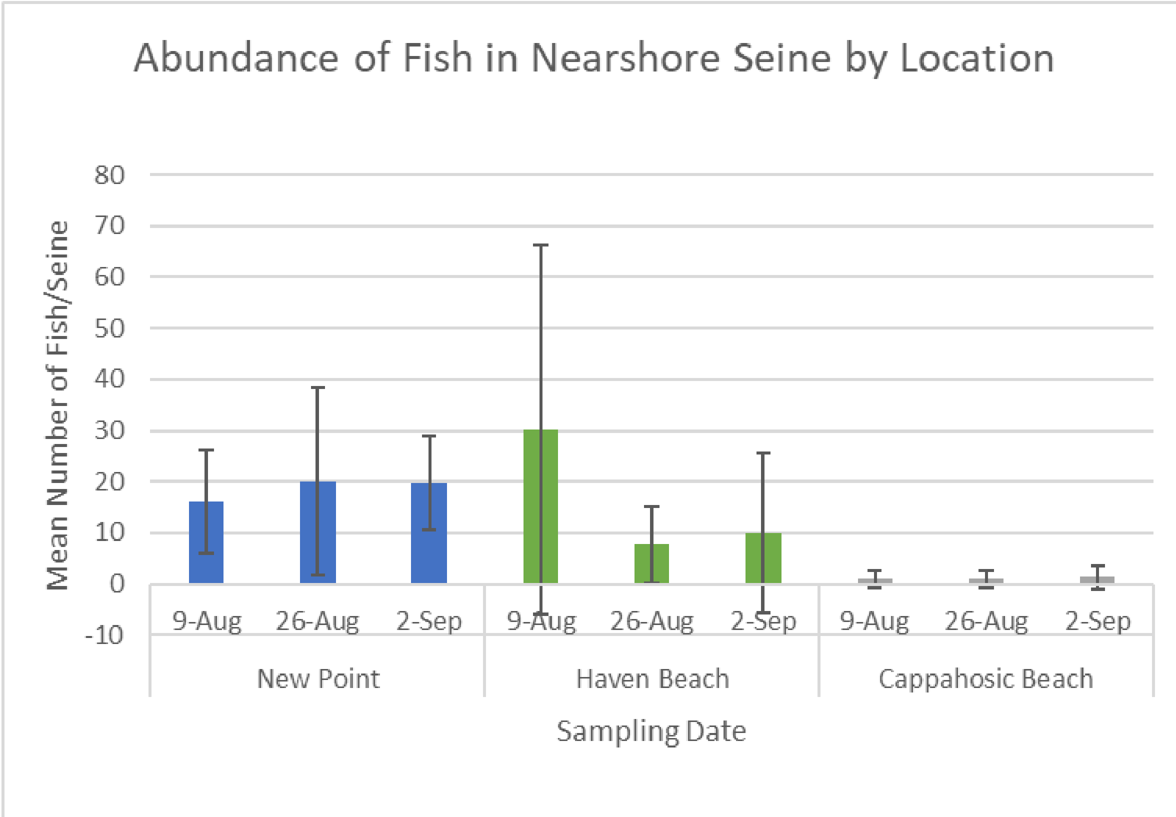

Figure 3. At New Point, the mean fish catches over the sampling dates were 16.0, 20.0, and 19.7; at Haven Beach, the mean fish catches were 30.3, 7.7, and 10.0; and at Cappahosic Beach, the mean fish catches were 1.0, 1.0, and 1.3.

At the New Point sampling site, the Shannon Index and evenness of fish and invertebrates (Figure 4) caught on August 9th was 1.40 and 0.87, with the predominant species being *Fundulus majalis*; on August 26th, it was 1.37 and 0.71, with the predominant species being *Fundulus heteroclitus*; and on September 2nd, it was 1.39 and 0.77, with the dominant species being *Fundulus majalis* (Appendix A). At the Haven Beach sampling site, the Shannon Index and evenness of fish and invertebrates caught on August 9th was 0.49 and 0.24; on August 26th, it was 0.79 and 0.49; and on September 2nd, it was 0.15 and 0.21, with the predominant species throughout all dates being *Anchoa mitchelli*. At the Cappahosic Beach sampling site, the Shannon Index for all sampling dates was 0, with an evenness of 0, with the predominant species being *Menidia menidia*.

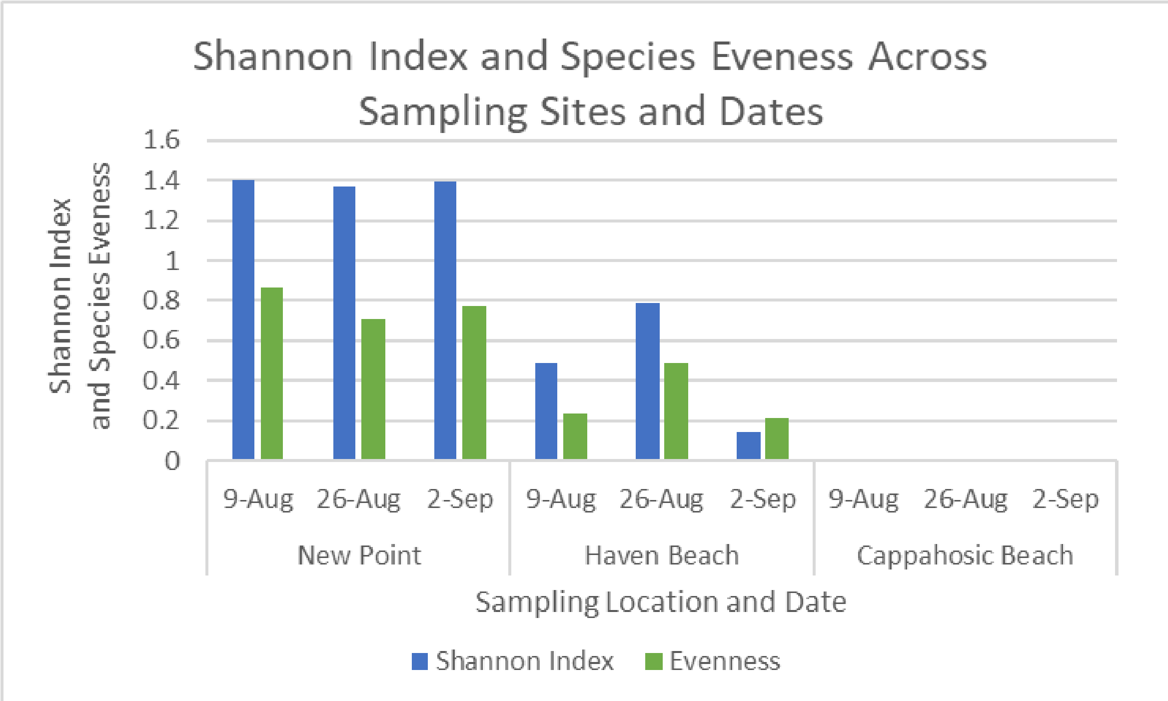

Figure 4. At New Point, the Shannon Index values over the sampling dates were 1.4, 1.37, and 1.39; at Haven Beach, the Shannon Index values were 0.488, 0.789, and 0.146; and at Cappahosic Beach, the Shannon Index value for all dates was 0. At New Point, the evenness values over the sampling dates were 0.868, 0.705, and 0.774; at Haven Beach, the evenness values were 0.235, 0.49, and 0.211; and at Cappahosic Beach, the evenness values for all dates was 0.

ANOVA statistical tests indicate no statistical difference in abundance between sites: New Point and Cappahosic, p=0.0733; Haven Beach and Cappahosic, p=0.4897; and New Point and Haven Beach, p=0.8699. Additionally, no statistical difference is found within site data between sampling dates at each site with ANOVA for Cappahosic, p = 0.9710; Haven, p = 0.5792; and New Point, p = 0.9319.

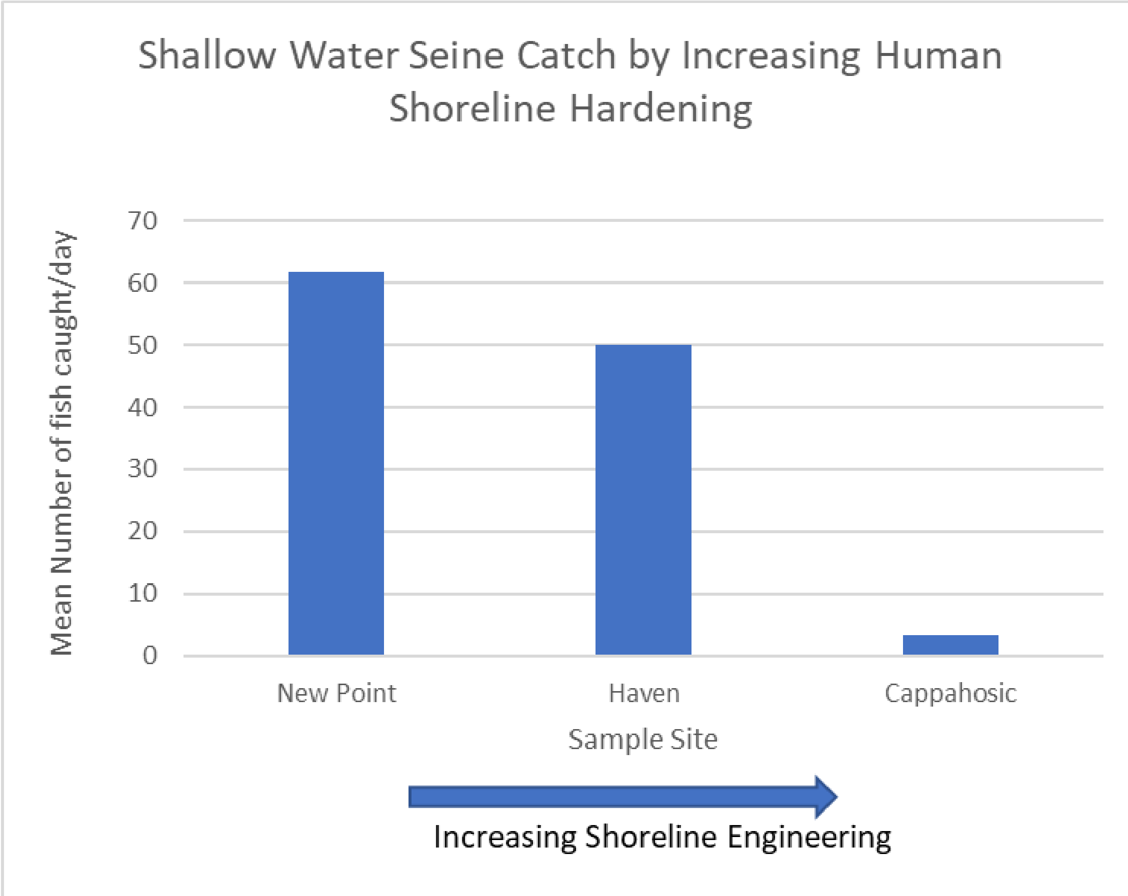

Figure 4. The value of the mean fish caught per day along a gradient of increasing shoreline hardening. The mean value of fish caught per day at New Point is 61.7; Haven has a mean of 49.9; and Cappahosic has a mean of 3.3.

Conclusion and Discussion

Across the three sampling sites, following the gradient from natural to engineered, there was a decrease in fish abundance, as well as fish and invertebrate diversity. However, the null hypothesis, there will not be a difference in fish abundance between non-engineered and engineered shorelines ANOVA of $p = 0.3301$, cannot be rejected. With further analysis, however, the New Point Comfort and Cappahosic Beach results yielded an ANOVA $p=0.0733$, which strongly suggests that further sampling would produce a statistically significant difference between these sites. The null hypothesis that there will not be a difference in diversity between non-engineered and engineered shorelines is rejected, as the Shannon Index for diversity greatly varied between sample sites. This study also fails to reject the null hypothesis that there will not be a difference in fish abundance and diversity across sampling dates. Cappahosic produced a within-site p-value of 0.9710; Haven Beach shows slightly less statistical variance, having a p-value of 0.5792; and New Point Comfort produced a within-site p=0.9319. The results of this study are consistent with a large meta-analysis of similar studies that concluded that engineered structures resulted in 45% lower abundance than shorelines without engineering (Gittman et al., 2015).

If this study were continued, more sample sites along the lower Chesapeake Bay and a more extensive study period would yield more significant results. The sampling dates should be more evenly spread across seasons to maximize the range of species utilizing the coastal nearshore environment. This study did not record information about the sampling sites, such as water quality, tide, and temperature data, which would provide more context for each sample. Fish identification was completed by taking pictures of the collected fish in each trawl and using the photographs to determine species. In the future, this should be done in the field, recording catch size as well as species.

Based on this research, hardened shorelines did reduce the diversity and abundance of fish and invertebrates in the nearshore zone relative to the natural shoreline. The suggested alternative to shoreline hardening is a shoreline management approach defined as the living shoreline. Living shorelines are an alternative coastal edge consisting of natural materials that promote natural growth while stabilizing the shoreline (VaDEQ, 2021). Living shorelines stabilize coastal infrastructure while mimicking natural coastal ecosystems such as salt marshes, oyster reefs, and seagrass beds (Bilkovic, 2016). Living shorelines are developed using soft engineering techniques, such as planting native vegetation along the shoreline and installing oyster reefs and bio-logs (NOAA, 2020).

The goal of the living shorelines approach is to foster the sustainability of shoreline resources by implementing living shoreline designs where appropriate and applying traditional shoreline hardening only in areas where site conditions make them necessary. These recommendations reflect the Commonwealth's preferred approach for shoreline stabilization, using living shoreline treatments whenever adequate erosion control can be achieved through these soft engineering techniques to preserve ecosystem services. As sea level continues to rise, the pressure to harden shorelines only increases, thus negatively impacting nearshore fish populations. Improved shoreline management in the form of living shorelines protects coastal infrastructure and promotes the resiliency of nearshore fish populations.

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Appendix A

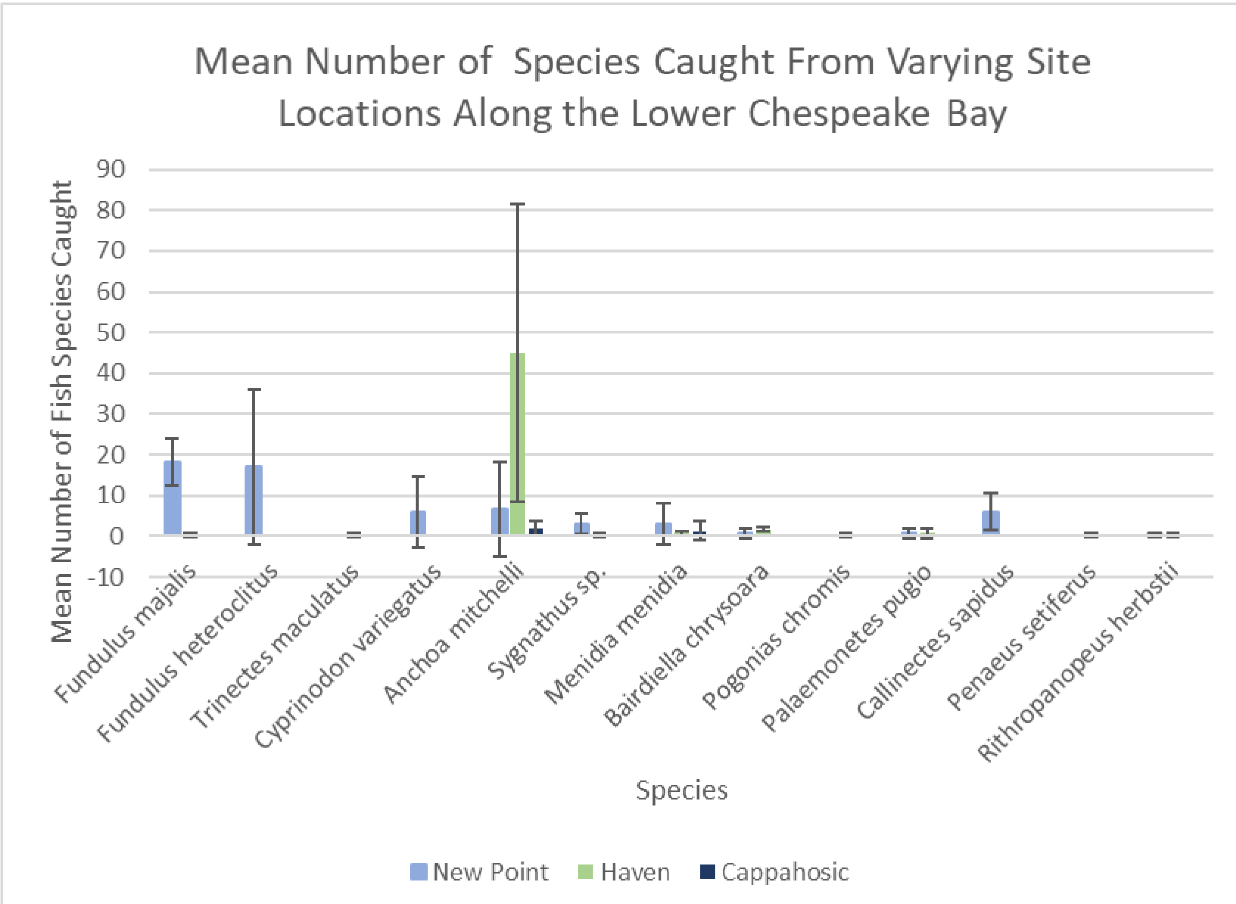

Figure 5.

Untitled

Ellie Peterson

When I was a child, I was always wandering around and extremely curious. Having my family stationed in Germany naturally brought out the tiny adventurer within me. When I first arrived in the village, I immediately began to explore near my house. And oh boy! What wonders did six-year-old me find? The side of the driveway was a tremendous cliff made of crescent moons begging to be climbed, like Jack's beanstalk. It guarded an enclosed field with a small pond that seemed like I was journeying through a fairy tale meadow. It would soon turn into a winter wonderland with igloos hidden under the deep glistening snow and filled with all kinds of creatures in the spring. On the other side of the house was a canopy of vines that blocked out the sun and would put the enchanted forest to shame. In the spring they would bear raspberries and blackberries while a nearby tree grew crabapples.

Eventually, I followed a winding creek that curved so much you would think it was a giant snake. As I listened to it babbling and bubbling, I reached a lush green hill. On top, I found a park that fit all the criteria of being abandoned yet was still maintained and usable. Of course, there was the standard slide, swings, and merry-go-round. However, there was some equipment I had never seen before. There was a hand-pumped well that looked like an old red wrench, and it drew sparkling water that looked cleaner than water from a fountain. Nearby there was a spring rider that made me feel like I was a knight in shining armor riding their horse into battle to defeat the deadly dragon. However, the thing that would totally enrapture my young mind and quickly become my favorite to play on was the zipline. As I rode it down the hill, I felt like I was the dragon instead of the knight. It was as if I was soaring free through the clouds like I was as weightless as a dandelion fluff in the wind. Sadly, it came to an end way too quickly for my liking. After spending what felt like an eternity playing, I would begin my journey back to my new home.

As I walked, I ran into one of my neighbors; she was an older lady named Karen. She was incredibly kind, and when she found out I was exploring the village, she generously invited me to explore her prized garden. Excitedly, I went home and asked my mom if I could. Once I had gotten to her backyard, I saw a magnificent sight. Her garden looked as if I had just fallen through a rabbit hole, tumbling alongside Alice. On the side of a small hill, she had dancing daffodils that looked oh so happy, roses that were as red as Dorothy's ruby shoes, and a calming mini pond with a waterfall where you could hear the frogs croaking their melodies throughout the night. My absolute favorite thing about her magical garden would be the bright red tulips with a deep black center that looked so beautiful and elegant. As the sky turned a brilliant orange, I knew the day was done. Waving goodbye, I ended an amazing day filled to the brim with adventure.