Impacts of External Forces on the Area of Tangier Island

**Introduction**

 Tangier Island is a small island in the middle of the Chesapeake Bay. The locals are known for their distinct dialect which can be traced back to seventeenth-century Cornwall, England. Their lives revolve around fishing, church, and community (Jackson, 2007). Tangier is a “dry” town, meaning alcohol is not allowed to be sold on the Island, which directly relates to their strict Christian beliefs (Jackson, 2007).

While it is unclear of when Tangier Island was originally settled, some of the first records of the Island state that, in 1778, Joseph Crockett purchased four-hundred fifty acres of land on Tangier (Shores, 2000). Today there is a mere 1.3 square miles of land that is barely above the sea level, but it is continually shrinking due to sea level rise. It is estimated that the island loses fifteen feet of shoreline per year (Paolisso, 2018).

Tangier Island was originally used for farming, cattle raising, and fishing which did not require many people to live on the island (Jackson, 2007). However, in 2016, it was recorded that the island is home to over 450 residents who are practically living on top of each other (“Eastern Shore Hazard,” 2016). The increased population has definitely caused some adverse effects to the surrounding habitats.

 Anytime something new is introduced into an environment, there are consequences. It was hypothesized that if there are people living on Tangier Island, then there will be destruction to the surrounding natural habitats. As technology has progressively become more advanced, humans have done their best to implement these improvements all over the world. Tangier Island is no exception. For almost every problem that has arisen, a solution has been implemented to fix it. In order to receive electrical power, a power cable was laid on the Chesapeake Bay floor. In order to receive aid, supplies, and tourists from large boats, channels were dredged to make the water system deeper, and in order to aid in stopping the erosion of the island, a sea wall was installed.

 In the process to improve quality of life on Tangier Island, humans have destroyed natural habitats without thinking twice about the repercussions. For example, on May fifth of 1978, an underwater power cable was run from the Eastern Shore to Tangier Island (“Our History,” 2019). While the underwater cable was an easy solution to their lack of a power source, it was an unnatural addition to the environment which creates a disruption to the lives of the organisms that dwell in the area.

Studies have shown that underwater cables are at a high-risk from damage by anchors, fishing activity, and vessel impact, along with the movement of the cable or seabed. These many factors have led manufacturers to find ways to protect the cable. They began by encasing the cables with metallic armor wires (Attwood, 2000). A study of the underwater cable that runs from the mainland of Sweden to the island of Gotland found that the most frequent cause of failure was external damage, however, no failures occurred on sections buried into the seabed (Attwood, 2000). This leads experts to believe that most if not all of the cable should be buried underground, which would cause another disruption to the plants and animals that live in that area. In order to bury the cable, workers would have to dig a trench, place the cable into it, and then fill the trench back in. Digging trenches would cause many of the same stressors as dredging which will be further discussed later in this paper. However, in this case, the trench has to be filled back in which displaces organisms that may have gotten stuck in the dredged material and destroys the plant life that was once in the position of the trench.

Another example of destruction to the habitats in the area of Tangier Island for the advancement of human life is dredging. Dredging is the excavation and relocation of sediment. It is commonly used to create or maintain navigable depths for shipping channels or harbors (Wenger, 2017). In the case of Tangier Island, a channel was dredged to allow larger boats to commute to and from the mainland carrying everything from supplies to tourists. While dredging was thought of as a great idea for the people and economy of Tangier Island, it caused the organisms a great deal of stress.

Some of the stressors include suspended sediment, contaminated sediment, hydraulic entrainment, and underwater noise. These dredging-related stressors are directly related to higher mortality rates in fish. The stressors were devastating to the early development of fish as eggs and larvae were most likely to suffer lethal impacts while the adult population was more likely to have behavioral effects (Agunwamba, 2012).

To elaborate on the stressors that fish face in an environment where dredging occurs; suspended solids greatly affect the health of the environment. In areas that have large quantities of suspended sediments, photosynthesis in plants is reduced and the process of eutrophication is aggravated which accelerates the release of nutrients into the water column. This creates a loss of vegetation which ultimately decreases natural marine purification. Additionally, once the sediment is removed from the channel that is being dredged, it must be placed somewhere. Most times it is placed in a different marine environment. If the dredging site is contaminated with heavy metals for example, by placing the dredged material in another marine location further contaminates the area and in the case of heavy metals, poisons the fish.

In a study of the effects of dredging on the Bonny channel in the Niger Delta, the water quality was tested. Some of the parameters that were assessed in this study included temperature, dissolved oxygen, pH, total dissolved solids, total suspended solids, and nitrogen and phosphate concentrations. The results showed that major factors that were influenced by dredging were dissolved oxygen, total dissolved solids, total suspended solids, hand heavy metals (Agunwamba, 2012).

As humans have found ways to fix the lack of electricity on Tangier Island and have created deeper channels to allow for larger boats, they have also found a way to slow down erosion to the island. It has been documented many times that Tangier Island has a severe case of erosion. The 450 acres of land that Joseph Crockett purchased in 1778 (Shores, 2000) has dwindled to 1.3 square miles (Paolisso, 2018). In an effort to stop the erosion, a seawall was constructed on the western side of the island. It has been extremely effective in preventing any further erosion (“Eastern Shore Hazard,” 2016). However, armoring the shoreline has many adverse effects on estuarine and nearshore marine ecosystem functions. Some of the ways it can influence these areas are by degrading water quality, spreading invasive species, and destroying ecologically valuable habitats (Prosser, 2018).

The sea wall that was installed on Tangier Island is referred to as riprap. It consists of granite or concrete stones that are placed at an angle. It only allows a small number of nutrients to be exchanged but it does create a unique habitat for biota. Riprap increases the energy of the shoreline by reflecting waves, which increases nearshore erosion and deepens the adjacent littoral zone. Consequently, these factors create a loss of shallow refuge (Prosser, 2018).

Overall, the purpose of this project is to determine how human activities have affected the natural environment surrounding Tangier Island. The focus will remain around the underwater power cable, the effects of dredging channels, and the seawall on Tangier Island.

**Specific Aims**

Throughout time, as man has created new and improved solutions to problems, these solutions have been implemented without a thought of the consequences it will have on nature. As power was installed to the island, a power cable was run across the Chesapeake Bay (A&N Electric Coop.). Currently, there is little to no public information about how the underwater power cable was installed or the effects it has had on the environment. However, from other studies around the world, one can assume that there will be similar effects. Similarly, the dates in which dredging projects occurred on Tangier Island are public knowledge but it is unclear of the methods used and the effects on organisms in the area. Finally, the type of seawall that was constructed around the island is known and other studies help to show some of the possible effects that this type of seawall has on the environment (Prosser, 2018). It is important to understand the effects that human improvements have on the surrounding environments in order to know if it is worth the destruction it causes and if the island should be saved.

The purpose of this project is to determine how human activities have affected the natural environment surrounding Tangier Island. The focus will remain around the underwater power cable, the effects of dredging channels, and the seawall on Tangier Island. I hypothesize that if there are people living on Tangier Island, then there will be destruction to the surrounding natural habitats. In order to test the central hypothesis, I propose the following specific aims.

**Aim 1. To determine the effects of the underwater power cable.** Since it is unclear whether the cable lies on top of the floor of the Bay, if it is buried or if there is a combination of both, I will propose an experiment for each scenario. If the power cable is positioned on top of the floor of the Chesapeake Bay, it will be monitored by a video camera. The recordings will be reviewed to observe how the animals work around the cable and how plants have adapted to this barrier. Whenever there is damage that needs to be repaired, the process will be recorded and the activity of the organisms that live there will be monitored. I hypothesized that if the power cable is placed on the surface of the Bay’s floor, the animals who dwell in that location will have to move around the cable. If the power cable is buried under the surface, the original status of the environment would need to be known and then compared to the status of the environment today. It would be helpful to know what soil was replaced once the trench was made and what organisms were displaced along with the soil. If the cable was buried under the surface, the plants would not be able to grow above it. In the case that there is a combination that the cable is above and below ground, the aforementioned studies shall take place in its respected location. If the cable is both buried in some locations and laid on the floor of others, then the animals will have to avoid the area that is above ground and the plants will not be able to grow above the cable if it is below the ground.

**Aim 2. To determine the effects of dredging in the area of Tangier Island on the natural environment.** The population of fish and amount of vegetation in the area should be recorded before the dredging takes place. It should be compared to the results recorded during and after the dredging has taken place. If dredging occurs in a location with a lot of fish, then the fish population will decrease in that area. The results of this study would then be compared to that of a similar study in the Niger Delta by Amelia Wenger in 2017. It is important to note that in the case of a buried power cable, the soil is removed and then replaced but in the case of dredging the soil is removed from the location and is not placed in the same location.

**Aim 3. To determine the effects of the sea wall on the organisms that dwell in this area.** The populations of organisms in the area should be monitored. As the waves are reflected off of the seawall, the slope of the floor and the number and type of vegetation changes, this should be closely monitored over a long period of time, as it will affect what types of animals are able to live here. I hypothesize that if the sea wall remains intact for several years, then the slope of the bay floor will increase. The results of this study should be compared to studies of similar seawall completed by D. J. Prosser in 2018.

**Expected Outcomes**

**Aim 1. To determine the effects of the underwater power cable.** Expected Outcomes: If our hypothesis is correct that if the power cable is placed on the surface of the Bay’s floor, the animals who dwell in that location will move around the cable differently than if it was not present, then we expect to see slower movement of fish in the area immediately around the cable. If we get this overall effect, we will then categorize the data by species. By grouping the fish by species, we will be able to see if it is a determining factor in the speed in the relative area.

Potential Outcomes and Alternatives: It is possible that there are other factors that affect the speed that the fish swim at that we have not yet taken into account. For instance, the direction and force of the water current will be measured around the area of the power cable. A potential alternative is to record the location of the fish and whether they tend to stay near the cable or avoid it.

**Aim 2. To determine the effects of dredging in the area of Tangier Island on the natural environment**. Expected Outcomes: Our hypothesis was that if dredging occurs in a location with a lot of fish, then the fish population will decrease in that area. If it is correct, then we expect to see decreased population of fish during the dredging project with a slight increase after the project is completed. We will continue to monitor the site for one year after the project has been completed to determine if the population returns to the initial amount or remains at a deficit.

Potential Outcomes and Alternatives: It is possible that the fish leave the area and immediately return after the dredging is done. We will be able to determine if fish left rather than died by the length of time it takes for the population to return to the initial amount. Another possible outcome is that there is no change in the population of fish. This would mean that the fish are not affected by dredging.

**Aim 3. To determine the effects of the sea wall on the organisms that dwell in this area.** Expected Outcomes: The hypothesis for this aim is that if the sea wall remains intact for several years, then the slope of the Bay floor will increase. If our hypothesis is correct, then we expect to find an increase in the slope of the Bay floor in the area with a sea wall and the slope of the floor with no barrier should have no change. We will also take note of the amount of vegetation present in these areas in the beginning and end of the study. As the seawall reflects the wave energy, it increases the wave energy along the shore and increases the slope of the Bay floor. As a result of the increase in energy, plants are uprooted. We expect to find that a decrease in plant life will result in a decrease of fish and crustaceans.

Potential Outcomes and Alternatives: It is possible that there because of the increase in the slope of the Bay floor, there is an increase in deep water fish in the area. Another effect of the sea wall might be that there is no change in the slope of the bay floor but a decrease in the amount of plants along the wall. This would result in less fish because the plants create a place to hide from predators.

**Significance**

Tangier Island receives its power from an underwater power cable that runs from the Eastern Shore. While it is common for cables to buried while on land, underwater power cables are relatively new. There are only a handful of studies done on underwater power cables around the world and none of these studies focus on the environmental effects of the cable. This is why this study will be extremely important to Tangier Island and other islands that receive power in similar ways.

There have been many dredging projects on Tangier Island from creating a channel for large boats to efforts to restore old projects to the required depths. The Army Corps. of Engineers has been in charge of hiring companies for most of the projects. They were in charge of everything from when it will take place to who will complete the job. While there is some research on dredging that the Army Corps. has taken into account, this research will be able to better inform them of environmental factors that are affected by dredging that has not been studied yet (Tangier Channels…, 2018). Hopefully, they will take this into account for their next projects and use more environmentally friendly methods.

Tangier Island consists of only 1.3 square miles of land and is under a constant threat from erosion. For this reason, a seawall has been installed in hopes of slowing the erosion down and possibly saving the island from becoming submerged by the rising sea level (Prosser, 2018). Since the wall has been installed, there has been no further research to the area. It is especially important to provide more research on Tangier Island because of the threat that erosion might destroy the island.

**Aim 1. To determine the effects of the underwater power cable.** Currently, there is no research on the underwater power cable on Tangier Island. The goal of this experiment is to provide the public with information about the power cable and how it affects the organisms in their environment. Specifically, it will provide information on how the buried power cable has affected the plant life in the area and how the power cable that rests on top of the Bay floor effects the movements of animals in the area.

**Aim 2. To determine the effects of dredging in the area of Tangier Island on the natural environment**. This research will show the effects that dredging has over a long period of time. Dredging on Tangier Island has allowed for an increase in revenue for the town and its members (Tangier Channels…, 2018). We hope that this research will lead to more efficient ways of dredging and less harmful ways of completing this feat in the future.

**Aim 3. To determine the effects of the sea wall on the organisms that dwell in this area.** The seawall was funded by the Army corps. We hope that this research will lead to other forms of protection from erosion that are better for the environment (Tangier Channels…, 2018). Our intention is to persuade the Army corps, to use barriers that do not change the environment as this one did, in their next projects. A possible solution includes living shorelines.

**Project Design**

**Aim 1. To determine the effects of the underwater power cable.** The goal of this aim is to test the hypothesis that if the power cable is placed on the surface of the Bay’s floor, the animals who dwell in that location will move around the cable differently than if it was not present. Rationale: It has been proven in other studies that several fish species, sharks, skates, and rays have a high sensitivity to weak magnetic and electric fields similar to that produced by the power cable to Tangier Island (Westerberg, 2008). To address this fact and the hypothesis, we will determine how fish activity is altered due to the presence of the underwater power cable.

Experimental Design: In this experiment, 100 fish found in the vicinity of the power cable will be tagged with a small transmitter. The transmitter will relay information about the speed and location of the fish. It will be constantly monitored as seen in the study done by Westerberg and Lagenfelt in the Baltic Sea (2008). The information collected will be compared to the activity of a control group of fish that dwell in a part of the Bay that is not affected by the power cable. The fish will be monitored around the clock for a period of two months.

**Aim 2. To determine the effects of dredging in the area of Tangier Island on the natural environment.** The goal of this aim is to test the hypothesis that if dredging occurs in a location with a lot of fish, then the fish population will decrease in that area. Rationale: Dredging causes a high number of stressors to fish in the direct environment which leads to a higher mortality rate (Wenger, 2017). To address the hypothesis, we will determine fish populations before, during, and after a dredging project takes place.

Experimental Design: Before a dredging project takes place, the population of fish should be determined. While the project is in progress population counts should be taken every day. After the project has finished population counts should be taken once a week for a month, to determine if fish return to the site meaning they left instead of died. The information collected will be compiled for a conclusion and then compared to the results of similar studies. In order to estimate the population size, we will use a sonar system in a boat to detect the amount of fish along a specific path. The number of fish found will be divided by the area of water along the path, this will determine the density of fish. The density will then be multiplied by the area of the body of water to estimate the total population. Several samples will be taken and the average size of those sample will be used to calculate an estimate of the entire population (Damonte, 2003).

**Aim 3. To determine the effects of the sea wall on the organisms that dwell in this area.** The goal of this aim is to test the hypothesis that if the sea wall remains intact for several years, then the slope of the bay floor will increase. Rationale: As seen in the study done by Prosser in 2018, the type of sea wall installed on Tangier Island increases the energy of the shoreline by reflecting waves, which increases nearshore erosion and deepens the adjacent littoral zone. This increase in wave energy causes a decrease in the amount of vegetation. A decrease in the amount of vegetation and an increase in the slope of the Bay floor ultimately leads to a loss of shallow refuge for fish and crustaceans (Prosser, 2018). To address the hypothesis, we will observe any changes in the slope of the Bay floor near the sea wall.

Experimental Design: In order to determine the effects of the sea wall on the slope of the Bay floor, we will observe and record the angle of the floor. The angle will be recorded every week for two years and it will be compared to the control. The control site will be on the same side of the island as the sea wall, but it will be located in the wetland part of the island that does not have a seawall. The angle of the slope for the two locations will be taken at relatively the same time to prevent as much variation in from outside factors as possible.

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