The Impact of Sunscreen on the Growth of Red Mangrove Propagules

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Abstract

Mangroves are important plants to the Florida coastline. They provide habitat for many organisms and protect the coastline from erosion and storms. Many residents and tourists spend time in and around Florida's coasts, often wearing sunscreen to protect them from the sun. While sunscreen in the water has been shown to impact coral health - the common ecosystem in tropical regions- little is known about sunscreen's specific effects on mangroves. The question being asked is what the effects of sunscreen (with and without coral reef safe ingredients) are on mangroves. We are using empty fish tanks with chicken wire to hold the mangrove propagules in place, while testing the effects of different concentrations of reef-safe and non reef-safe sunscreen. To measure the effects, the length of new growth on each propagule is measured, as well as, number of roots and leaves in each tank. We expect to see some mangroves die from the exposure to the sunscreen, and aim to see if the non reef-safe or reef-safe has a greater effect on the growth of the propagules. It is hypothesized that the high concentration of both sunscreens will have greater mortality rates than low concentrations, and the non-reef safe sunscreen will have a greater mortality rate than the reef safe sunscreen.

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Keywords

Mangroves, sunscreen, oxybenzone

1 Purpose

Mangroves make up the coastline of many subtropical lands, holding the ground in place, preventing storm surge, and providing nurseries for growing fish. Mangroves play a key role in protecting the coasts from storms and providing a habitat for marine life. Mangroves are extremely important to the local waterways and are under protection by laws such as the Mangrove Trimming and Preservation act. Similarly, coral is a protected organism that builds the coastline and protects the majority of tropical lands lining the equator. They are vital to the ecosystem in those areas by constructing reefs that provide shelter and food for other organisms, protect from storms, and make up the land itself in many cases. Coral reefs are experiencing mass bleaching or release of their symbiotic dinoflagellates, which results in the corals' eventual death. This bleaching is caused by warming temperature, increasing ocean acidity, and sunscreen has also been shown to induce bleaching [1]. As coral play a similar role in their own ecosystems, the question was raised whether the detrimental effects of sunscreen on coral could cause similar issues for mangroves.

Due to their proximity to the coast, both mangroves and coral are exposed to a variety of pollutants in the water. Sunscreen dissolved in seawater is commonly found in near shore waters [2] due to tourism and recreation opportunities. Sunscreen ends up in the water when people are applying on the beach and getting in the water. Sunscreens contain chemical and mineral UV filters that absorb, reflect, or scatter UV light [2]. Oxybenzone is a chemical filter that has recently been banned from some sunscreens due to its effects on marine organisms. Coral become stressed with the conditions brought on by the sunscreen such as high turbidity and sedimentation on the coral [3]. Removing the chemical oxybenzone from many sunscreens has allowed for coral to maintain photosynthesis and play a vital role in the reef ecosystem, though some sunscreens still contain oxybenzone as an ingredient. While this process is a response only seen in coral, however, the question being proposed is whether the presence of background concentrations of sunscreen in the water could incite similar conditions with other organisms.

The purpose of this experiment is to discover what influence sunscreen with and without oxybenzone has on the growth and ability of red mangrove propagules to survive. Due to the abundance of mangroves in our local waterways, they are vital to the ecosystem and require protection, motivating the testing of whether sunscreen exposure is correlated to the mangrove mortality rate.

2 Methods

2.1 Tank Set-up

To test the impacts of sunscreen on mangrove propagules, five fish tanks were used in this experiment. Four 10 gallon tanks acted as the experimental groups and 1 as the control (20 gallon). PVC frames were built around the top of each tank (Figure 1). Plastic poultry netting (¾ inch hexagonal opening) was zip-tied to each frame to create a location for the red mangrove propagules to sit. (Figure 1). The red mangrove propagules used for this experiment were donated from another local high school. For each tank 16 mangrove propagules were randomly selected from the buckets of propagules and fed through the poultry netting, spaced apart to allow room for growth of roots. Mangrove propagules were then fitted with lifejackets. The lifejackets consisted of 4 inch segments of pool noodle. The noodle segment was cut vertically to fit around each mangrove propagule and secured with a zip tie to keep them from falling into the tank through the poultry netting. Each life jacket was labeled a - p, by writing in sharpie on the pool noodle, to distinguish the mangroves from each other during data collection. On the exterior of each tank were labels to distinguish the tank number and sunscreen concentration. (Figure 1). Each experimental tank was filled with 35 L of water after receiving the appropriate treatment of sunscreen solution. The goal was to have the roots of the mangrove propagules submerged in the water. The tanks were placed on folding tables outside for the duration of the experiment.

Figure 1: Tank 1 set-up with the PVC frame, poultry netting, and lettered life jackets fitted on 16 red mangrove propagules.

2.2 Sunscreen Treatment Solutions

To test the impacts of sunscreen on mangrove propagules, four different sunscreen solutions were created as treatments for the experimental groups and added to the 10 gallon test tanks every three weeks during a water change. Tank 1 = Low Reef-Safe, Tank 2 - High Reef-Safe, Tank 3 = Low Non-Reef-Safe, Tank 4 = High Non-Reef-Safe. The reef safe sunscreen did not contain oxybenzone as an active ingredient. (Banana boat brand) and the non-Reef safe did contain oxybenzone (Neutrogena brand).

Tank 1 = Low Reef-Safe (1.3ppm)
Tank 2 - High Reef-Safe (13 ppm)
Tank 3 = Low Non-Reef-Safe (1.3 ppm)
Tank 4 = High Non-Reef-Safe (13 ppm)

The sunscreen treatment solutions were created through a dilution; two solutions contained the reef-safe sunscreen with water and two contained the non-reef-safe sunscreen and water. A 10,000 ppm stock solution of sunscreen was prepared for the high concentration treatments by diluting 10 mL of the respective sunscreens with water to achieve a volume of 1.0 L. A 1,000ppm low stock solution was created by diluting 1mL of sunscreen with water to achieve a volume of 1.0L. A 45 mL aliquot of the low stock solution was added to the low tank and was diluted to a mark on the tank giving a total solution volume of 35 L to produce a sunscreen solution of 1.3 ppm. The high concentration tank was prepared by diluting 45 mL of the stock solution to a total volume of 35 L, again using the mark on the tank, producing a concentration of 13 ppm. This procedure was completed for the reef-safe sunscreen and the non reef-safe sunscreen.

2.3 Water Changes

Water changes were scheduled every three weeks. During each water change, PVC frames were removed and set aside for measurements. Each tank was emptied and rinsed out with a hose and wiped with a rag to clear of algae. Once the tanks were emptied and cleaned the sunscreen treatment was added first and then the tank was refilled with 35 L of water, to the pre-marked water fill line. The control tank received no sunscreen treatment. The propagules were rinsed gently with water and measured. The measurements collected were the length (cm) of the stem, the number of roots sprouted, and the number of leaves for each propagule. The propagules that were brown and no longer green were marked as dead. This data was recorded. The frames that held the propagules were then placed back on top of their designated tanks.
From the lengths recorded the percent growth was calculated. The percent mortality of propagules in each tank was also calculated from collected data over the length of the experiment.

3 Results

To Figure 2 shows the effect of sunscreen on the survival rate of mangrove propagules over the 17 week experiment. As seen in the graph, the low non-reef safe sunscreen had the highest survival rate at the end of the 13 week period. The control group had the second highest survival rate, this could be due to the lack of adequate sunlight exposure experienced by all groups. The low concentration of reef-safe sunscreen had the third-highest survival rate of around 62.5% while the high concentration of reef-safe sunscreen had the second-lowest survival rate of around 56.25%. Unexpectedly, the group with the high concentration of non-reef safe sunscreen had the lowest survival rate of 50%. Overall the high treatments of both types of sunscreen had lower survival percentages than the low concentrations of either sunscreen. This suggests that the mangroves survived better in tanks with lower concentrations of sunscreen. When looking at the survival rates and death rates of the mangrove propagules, it’s important to consider the extenuating factors that are a potential cause of death. Setting the propagules in small tanks outdoors made them vulnerable to quick water temperature changes since the small tanks did not have the more consistent temperatures of larger bodies of water, this could have influenced the survival rate of mangrove propagules and account for the mortality seen in the control tank. The sharp decrease in survival in the control tank can be explained by several cold fronts that occurred between week 13 and week 17 leaving temperature in the 40’s for an extended period of time.

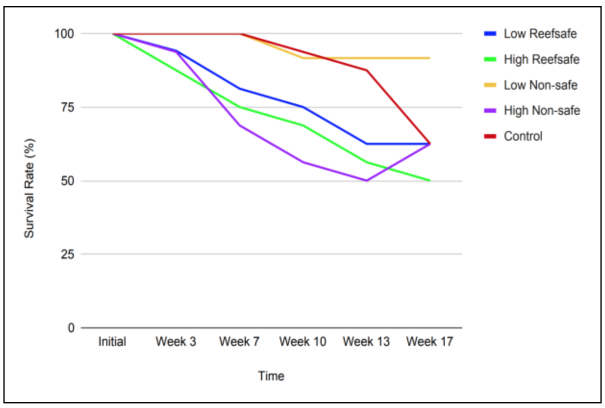

Figure 2: Survival Rate of propagules in respective treatment tanks over time.

Figure 3 shows the average percent growth in each tank. The majority of tanks saw the average size of the mangrove propagules decrease over time. Once a mangrove died it was then excluded from the next calculation when determining the average size. The only tank which saw any positive growth was the high concentration of non-reef safe sunscreen. While this does not support the hypothesis that growth would be stunted by a higher concentration of sunscreen, it shows that growth was not limited by reef safe sunscreen as hypothesized. Although this doesn't support the original hypothesis that a higher concentration of sunscreen leads to more deaths, it demonstrates that the majority of the mangroves were negatively impacted by the sunscreen treatments. One explanation for the deaths experienced in the control tank could be due to the fluctuating air temperature which caused quick and unnatural changes to water temperature. These temperature fluctuations can be attributed to the experiment taking place from September to March in Florida. The mangroves would not normally experience these drastic changes in water temperatures because large bodies of water take much longer for their temperature to change. Another potential reason could be the length of time between water changes. The water was changed every three weeks, weather permitting, and could have been too long as every time the water was changed and the tank was cleaned, there was a considerable amount of algae growth inside the tank.

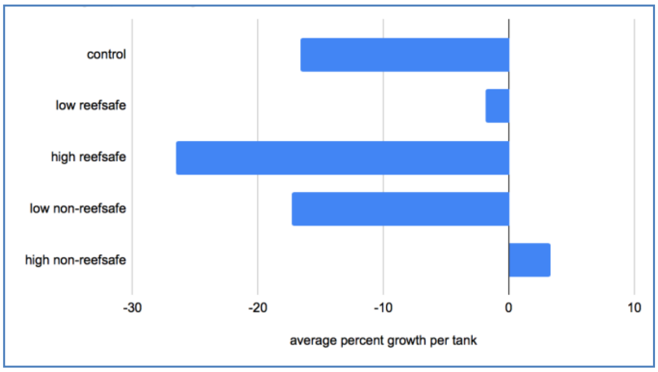

Figure 3: Average percent growth of propagules in each tank at the end of the 17 week treatment period.

Figure 4 displays the percent mortality of the mangrove propagules in each experimental tank including the control group. While the data does not show high non-reef safe sunscreen as having the greatest mortality rate as hypothesized, the figure does show a higher concentration of sunscreen is of greater cause for mortality as the data represents 50% mortality in the tank testing a high concentration of reef safe sunscreen while only a 38% mortality in the low concentration of reef safe sunscreen. For this reason, the limiting effects of sunscreen could come from other factors rather than mere intake of the chemicals in either reef safe or non-reef safe sunscreen. A higher concentration could result in higher turbidity, making sunlight penetrate the water less and limit the plants ability to photosynthesize. The approximately 8% mortality of the low concentration non-reef safe test group is representative of this as a low concentration test group had the lowest mortality rate and a high concentration test group had the highest mortality rate. Also straying from the hypothesis is the data showing that the low concentration reef safe caused the same mortality rate as high non-reef safe, approximately 38%. This means that between low and high concentrations, non-reef safe had a lower average rate of mortality of 23% while the average rate of mortality of reef safe sunscreen was 44%. It can be inferred from this data that the effects of reef safe sunscreen further limit the growth of red mangrove propagules than the effects of non-reef safe sunscreen. Replication of this experiment is suggested to support data.

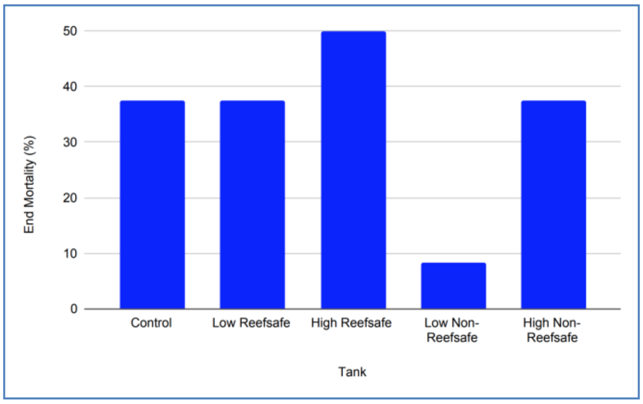

Figure 4: Percent Mortality of mangrove propagules in respective treatment tanks over the 17 week experiment.

4 Conclusion

In conclusion, the collected data does not support the hypothesis that non-reef safe sunscreen has a bigger impact on the growth of mangroves propagules than reef safe sunscreen. The data does support that the sunscreen impacts the ability of mangrove propagules to survive, especially at high concentrations of exposure to sunscreen. Additional experiments utilizing a wider range of sunscreen concentrations may better highlight the difference between reef safe and non reef safe sunscreens. The data supports that propagules exposed to non-reef safe sunscreen had a lower mortality rate than propagules exposed to the reef safe sunscreen. While the original hypothesis that non reef safe sunscreen has a bigger impact on mangroves propagules than reef safe sunscreen, is rejected the data does support that sunscreen impacts the ability of mangrove propagules to survive.

For future experiments the team agrees that measuring the temperature of the water would be very effective in determining if the changing outside air temperatures affected the mangrove propagules growth and survival in all tanks. In the future it would also be interesting to replicate the experiment with a wider range of sunscreen concentrations to better measure the impact of red mangrove propagule growth and better highlight the differences between reef safe and non-reef safe sunscreen exposure. This experiment could also be replicated with other species of mangroves.

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6 References

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