Ocean Acidification and Its Effects on Marine Wildlife

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Ocean acidification is the process in which carbon dioxide (CO_2) from the atmosphere absorbs in water to produce calcium carbonate. With the rising CO_2 levels in the atmosphere, and the ocean being a carbon sink, ocean acidification remains a threat to the various forms of marine wildlife, specifically, the shark population. The effects of ocean acidification have the potential to damage shark physiology by altering their blood chemistry and overall neurology. This could result in the imbalance of the ocean's natural order and food chain due to the distress from these apex predators. When analyzing the experiments that have been done to test the effects of acidity on sharks, the results showed that there was a significant decrease in oxygen to the brain. These experiments also revealed the dangers that ocean acidification could have on marine species with exoskeletons. Exoskeletons are able to easily dissolve when exposed to large amounts of calcium carbonate—the chemical made from the mixture of CO_2 and seawater. Some important species that possess exoskeleton are coral reefs. Coral reefs are known to be the habitats for an abundance of species, including sharks. When it comes to determining who is responsible for the rise of ocean acidification, it has been declared a global problem that requires a mass amount of global effort to reverse.

What Is Climate Change and Ocean Acidification?

Climate change is the result of burning fossil fuels that have been emitted into the atmosphere in incredible amounts. It has been deemed a crisis by scientists, who research their ongoing effects, and by environmental activists who aim to promote various forms of conservation. While climate change can have disastrous effects on the atmosphere with a global temperature increase as a common consequence, the Earth's oceans are also being negatively impacted by climate change through a process called ocean acidification. Ocean acidification can be defined as the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide from the atmosphere as a result of climate change (NOAA). Many different types of marine organisms are affected by the ongoing

I am a sophomore at the University of Hawai'i at Mānoa where I am working toward a degree in Marine Biology while also on a Pre-Med track. I am originally from Manhattan, New York, where I have lived for the majority of my life, but I moved to Hawai'i in order to pursue my interest in marine/environmental studies. I wrote this article about ocean acidification in my freshman year during an Introductory Biology Lab course. I was assigned to write a critical analysis of any topic. Before writing this article, I was thinking about focusing on one species that was affected by ocean acidification. As I did more research, I realized that there was a whole marine ecosystem at risk. Writing this article was not only extremely educational for me, but rather eye-opening to the amount of damage that can be done without intervention. Along with my Marine Biology major, I am also currently in the Marine Option Program at UHM where I plan to do more research on the effects of ocean acidification specifically on shark physiology. In addition, I am volunteering at the Hawai'i Institute of Marine Biology where I am aiding in the research of dolphin echolocation.

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increase of ocean acidification. Even sharks, the top predators of the ocean are affected by these chemical irregularities. Not only are sharks at the top of the food chain, but they also create a balance in the ocean regulating the various organisms that live within those marine ecosystems.

Neurological Effects of Ocean Acidification

One of the main causes of ocean acidification is the rising carbon dioxide throughout the water. Seawater is slightly basic on the pH scale, and ocean acidification involves a shift towards pH-neutral rather than a transition to acidic conditions. (NOAA). With the rising carbon dioxide levels in Earth's oceans, it has the potential of altering the blood chemistry in sharks by changing their natural pH levels. Buffers are molecules used to regulate pH levels in the bloodstream. They work by either donating or accepting protons to resist drastic acidic or basic changes. A buffer therefore consists of either a weak acid and its corresponding base, or vice-versa. With this knowledge in mind, ocean acidification has the potential to affect the neurological and cognitive abilities of sharks to hunt and detect food. This would ultimately result in an imbalance of the ocean's food chain and natural order (Pistevos et al.).

Documented Experimentation on Shark Physiology

Several experiments have been done in regard to testing the effects of acidity with the physiology of sharks. One of the biggest concerns of these trials is knowing whether or not the results from those experiments were accurate. This is because things such as stress from captivity and other outside factors were not taken into account. One experiment tested the effects of carbon dioxide on newly hatched Bamboo sharks and what that did to their physiology. The benefit of them being newly hatched is that it was easier to rule out underlying conditions if there happened to be an outlier in the data. According to the results, thirty days post-hatching, juvenile sharks revealed a significant decrease in oxygen to the brain, in contrast to the amount of energy being derived from the lack of oxygen (Rosa et al.). Not only did this experiment show the damage that ocean acidification can do to the biological processes of sharks, but it also demonstrated the idea that these detrimental effects can affect other parts of the ecosystem as well. Testing the increase of carbon dioxide levels in the natural habitat of sharks, even for a month, is vastly different than seeing the long-term effects of a very intricate process like climate change. Hyperactivity has been recorded as one of the most common behavioral symptoms of sharks after long exposure to elevated carbon dioxide levels. Although there are still tons of research to be done, it has been deemed possible that behavioral disturbances from sharks could become a potential consequence of future ocean acidification (Green and Jutfelt).

Significance of Preventing Ocean Acidification

The significance in preventing ocean acidification goes beyond the shark population. Their inability to hunt food normally due to the rising carbon dioxide levels in the ocean has a direct effect on smaller dependent species. In an environment where sharks are already being targeted by humans—shark finning—climate change is another danger that these predators face. While embryo survival and development time are mostly unaffected by elevated CO2, there are clear effects on body condition, growth, aerobic potential and behavior (Rosa, Rummer, and Munday). A shark's ability to hunt and detect prey, is vital for their survival and an integral part of their success at the top of the food chain. Without this ability, the current ecosystem in the ocean becomes unbalanced (Pistevos et al.). Along with hunting for food, alterations in predation pressure can have rather large-scale effects when it comes to tropically structured systems. One of the key components of a healthy marine ecosystem are the survival of the coral reefs. Coral reefs were actually one of the first ecosystems to be recognized as potentially vulnerable to the rise of ocean acidification. This is because of the unique ability from the reefs to produce large amounts of calcium carbonate. Coral reefs are not only structurally complex, but they provide the perfect exterior to create quiet habitats for other ecosystems, thus preserving biodiversity (Kleypas, Yates). Coral reefs are similar to sharks due to their dependency from other organisms. For both species, the balance of the ocean would be disrupted if the carbon dioxide level in the water rose too high.

Long-Term Effects

It has been stated by scientists that carbon dioxide emissions arise from the burning of fossil fuels. Due to this, the chemistry of seawater had been altered at a rate that the Earth has never experienced before. Laboratory experiments have even shown that the effects of ocean acidification could possibly interfere with fertilization, settlement, and reproductive stages of various marine organisms. Along with the burning of fossil fuels resulting in a change in the atmosphere, marine debris is an environmental crisis that relates to the endangerment of ocean habitat and wildlife. Another cause of ocean acidification is the breaking down of plastics in the ocean. Objects such as fishing nets and plastic are some of the main concerns when it comes to the entanglement of marine species and their intricate ecosystems. Species vital to the oceanic ecosystems such as sharks and whales are constantly ingesting micro-litter by filter feeding activities (Fossi et al.). This goes to say that humans have polluted the oceans with so much plastic that not only is climate change a hazard for marine life, but the excess pollution is as well. It has been quoted that the very last thing people have to do is clean the ocean (Fossi et al.). The analo-

gy of a bathtub overflowing with people mopping the floors, serves to provide the idea that instead of turning off the tap, and instead of finding a way to limit plastic production, people are still mopping the floors and doing beach cleanups. While this can be beneficial, the cleaning up will never come to an end without the limit of plastic and materials that are not biodegradable. A shocking statistic is that humans produce about 300 million tons of plastic each year, while about eight million of it goes directly into the ocean. Eight million tons of plastic gets distributed into an ocean that unfortunately, already has about 150 million tons in it (Fossi et al.).

Chemical Reactions that can Endanger Organisms

Ocean acidification does not merely target sharks but most organisms with exoskeletons are also at a high risk of facing the detrimental consequences of ocean acidification. This is because those exoskeletons are made out of calcium carbonate, which due to the rising acidity, will begin to dissolve. A visual analogy of this would be to imagine holding a handful of sand while vinegar—an acidic substance—gets poured on top of it. The chemical reaction would ultimately react by making the sand, in this case the calcium carbonate exoskeleton, start to dissolve. This is what the near future of ocean acidification looks like to many marine organisms. Future studies on the adaptive capabilities of these organisms will prove significant as they will have to adhere and adjust to the warm and acidic waters. Perhaps researching the effects of fresh-water acidification could be used as a guideline for the changing chemistry of seawater (Ishmatsu et al.).

Who Is Responsible?

Climate change is not a national problem but a global one. There are several different ways one can approach it and various different possible solutions. Companies like ExxonMobile, Shell, and Chevron are identified as among the highest fossil fuel emitting companies since 1988. Although it is more difficult for people to protest large corporations like that, protecting the oceans is a more feasible way to play a role in conserving the planet. Ocean acidification however is continuous, meaning that until there is a solution, detrimental effects are more likely to occur. The rise of carbon dioxide in the ocean not only results from the effects of climate change, but it is creating its own disaster in the physical and cognitive abilities of marine wildlife. With ecosystems being so intricate, everything balances off of one another. If an outside factor such as ocean acidification alters one species, such as sharks or coral reefs, it is bound to alter many more after that. Climate change effects are a chain reaction, and the more education that goes along with marine conservation efforts, the more people get inspired, resulting in more change being implemented.

What Can You Do?

Although the long-term effects of ocean acidification have not yet begun, it has been estimated that some parts of the world, such as Hawai'i, will face their dangers before they reach other parts of the world. This can be due to the delicate ecosystems that Hawai'i is known to have, along with the influx of tourism that overpopulate the islands. Education, especially within large communities with higher tourism rates can go a long way when it comes to educating the public on marine conservation. Consulting environmental lawyers on your views and opinions on how to conserve earth's oceans is a great way to potentially get a new law passed. Refusing plastic, although it seems insignificant, can also send a message to companies that people want biodegradable and reusable materials instead of single-use products. There are many things each individual can do in order to reduce the effects of ocean acidification. The one thing to remember is that it also has to be a global effort.

References:

Fossi, Maria Cristina, et al. "Large Filter Feeding Marine Organisms as Indicators of Microplastic in the Pelagic Environment: The case studies of the Mediterranean Basking Shark (*Cetorhinus Maximus*) and Fin Whale (*Balaenoptera Physalus*)." *Marine Environmental Research*, vol. 100, 2014, pp. 17–24.

Green, Leon, and Jutfelt, Frederick. "Elevated Carbon Dioxide Alters the Plasma Composition and Behavior of a Shark." *Biology Letters*, vol. 10, no. 9, 2014.

Ishmatsu, Atsushi, et al. "Fishes in High-CO2, Acidified Oceans." *AGRIS,* Inter-Research Science Publishing, 1 Jan. 1970.

Kleypas, Joan A, Yates, Kimberly K, "Coral Reefs and Ocean Acidification: Oceanography." *Coral Reefs and Ocean Acidification*, https://tos.org/oceanography/article/coral-reefs-and-ocean-acidification. Accessed 1 Dec. 2019.

NOAA. "Ocean Acidification." *National Oceanic and Atmospheric Administration*, https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-acidification. Accessed 23 Nov. 2019.

Pistevos, Jennifer C.A., et al. "Ocean Acidification and Global Warming Impair Shark Hunting Behavior and Growth." *Scientific Reports*, vol. 5, no. 1, 2015. Accessed 20 Nov. 2019.

Rosa, Rui, Rummer, Jodie, and Munday, Philip L. "Biological Responses of Sharks to Ocean Acidification." *Biology Letters*, vol. 13, no. 3, 2017.

Rosa, Rui, et al. "Neuro-Oxidative Damage and Aerobic Potential Loss of Sharks under Elevated CO2 and Warming." *Marine Biology*, vol. 163, no. 5, 2016.