How Has Acidification Harmed the Great Barrier Reef and What is the Long Term Impact of These Damages

By Ethan Heeter

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Introduction:

The acidification of the world's oceans has been the cause of great harm to coral all around the world, and more specifically to the Great Barrier Reef. Scientists have been monitoring the Great Barrier Reef for many years and have found out that acidification alongside rising sea temperatures is the main culprit to blame for the Great Barrier Reef's rapid decline. Their findings indicate that if the issue of acidification is not quickly addressed and rectified, the majesty and ecological importance of the Great Barrier Reef will soon disappear from this world forever. The first thing we must do on the road of solving the issue of ocean acidification and saving the Great Barrier Reef from a slow but certain death is to understand the problem of acidification and how it affects the Great Barrier Reef in both the present and in the future.

What Is Acidification?:

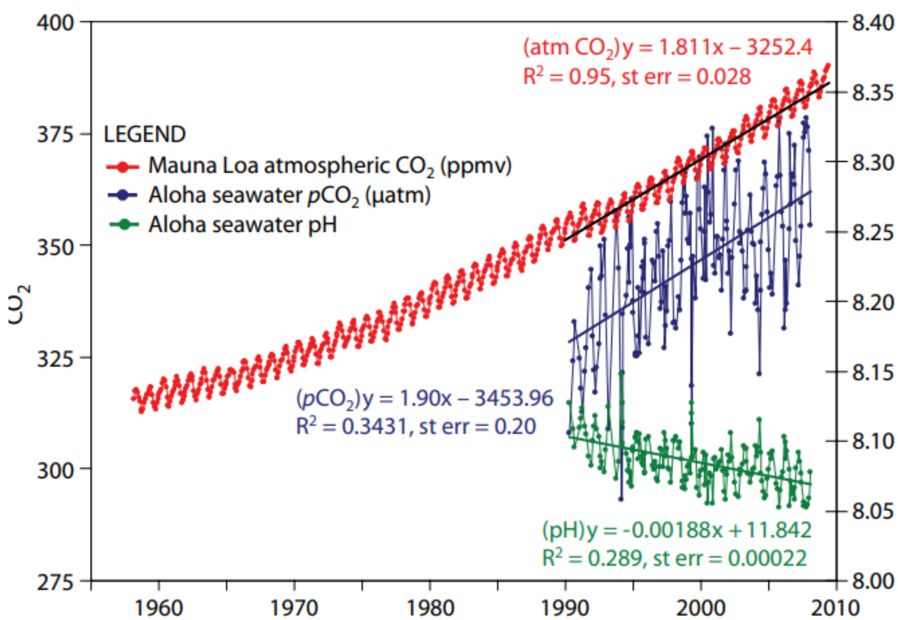
First we must understand what acidification is and how it affects the world's ocean water. Acidification is a process by which atmospheric carbon dioxide is absorbed into a body, in this case the oceans. The absorption of carbon dioxide causes the pH levels of the ocean to slowly decrease, thus making the ocean water slightly more acidic than it was previously. The pH levels of the ocean are very particular and sensitive, even the smallest of changes could have very massive effects on the environment. The carbon dioxide that causes acidification comes mainly from humans, with the major source of carbon dioxide being through our use of fossil fuels, however it can also come from a few different natural sources such as the eruptions of volcanoes.

Our overuse and over reliance on fossil fuels has caused many issues with the environment such as global warming, and ocean acidification is only one of those many issues that we must face in the near future.

The process of ocean acidification starts with the release of carbon dioxide into the atmosphere, whether that be from humans or from natural sources. Once in the air, the carbon dioxide circulates within the atmosphere much like any other gas would. In the atmosphere the carbon dioxide acts as a greenhouse gas, trapping the heat in the air causing the atmosphere to warm. This carbon dioxide then eventually comes into contact with ocean water, which causes the carbon dioxide to be absorbed into the water. Once absorbed into the water, the carbon dioxide will reduce the pH levels of the ocean water, causing the further acidification of the oceans. Many animals and ecological systems rely on the pH of the water being at a certain amount, and the disruption that acidification causes will result in the destruction of the natural oceanic habitats of many different lifeforms.

The ocean has absorbed about a quarter of all carbon emissions(Feely et al. 2007), which is both a good thing, but also a bad thing. It is good that the ocean is absorbing so much carbon dioxide because it helps to reduce the effects of global warming, helping the planet deal with the rising carbon dioxide levels in the atmosphere and therefore combating global warming as a whole. It is bad because all of the carbon dioxide absorbed into the ocean gradually reduces its pH levels, causing a myriad of issues for all lifeforms residing in the oceans. The pH of the world's oceans is currently higher than it has ever been in the past eight hundred thousand years (Feely et al. 2007), a change that is almost completely the result of human-caused carbon dioxide emissions. This is plainly shown in recorded data that shows as atmospheric carbon dioxide levels increase, so does the amount of carbon dioxide in the ocean, and as both of these factors increase, The pH levels of the oceans waters decrease (Feely et at. 2007), a relationship that is perfectly illustrated by figure 1.

Figure 1:



This figure shows that as atmospheric carbon dioxide increases, the seawater also increases in carbon dioxide concentration, coinciding with the decrease in the water's pH levels. Source: Feely, R., Doney, S., & Cooley, S. (2009). Ocean Acidification. Oceanography (Washington, D.C.), 22(4), 36-47.

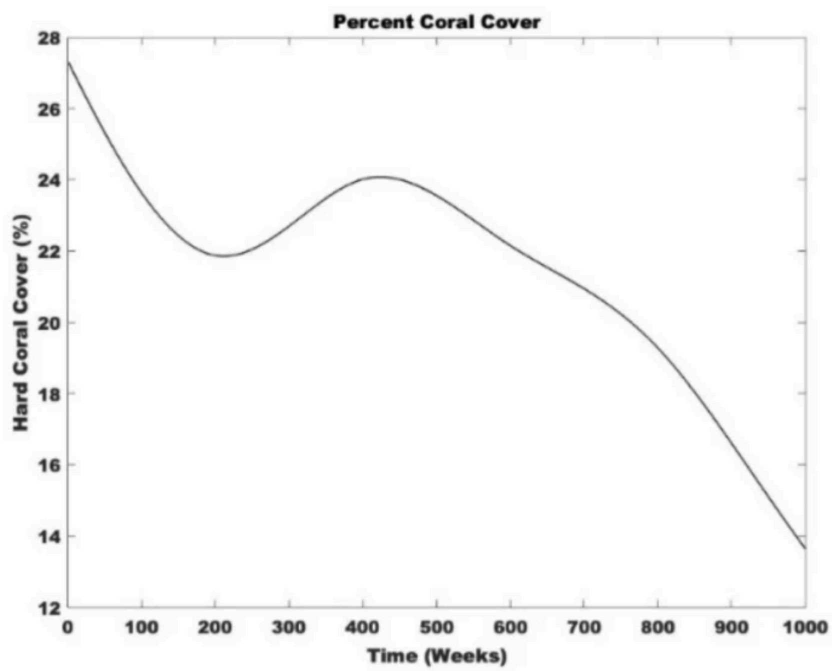
Humans have been burning fossil fuels for a long time, with the industrial revolution being the main point where human carbon dioxide emissions started to skyrocket. The issue of global warming and acidification has had a long time to affect the environment, so reversing all of the damage in a relatively short amount of time would prove to be quite difficult. That is why we must make attempts at the gradual reduction in carbon dioxide emissions, but a massive reduction in emissions would be an even better solution, albeit an unlikely one. If we gradually reduce carbon dioxide emissions, the amount of atmospheric carbon dioxide would gradually decrease, which would also cause a decrease in ocean acidification. Current projections indicate that acidification will worsen, causing the pH levels of the oceans to continue declining (Kleypass et al. 2006), and unless humanity as a whole decides to crack down on carbon emissions, these projections will most likely turn out to be accurate.

How Does Acidification Affect Coral in the Great Barrier Reef?:

The growing acidity of the oceans causes many issues with living organisms, with coral being no exception. Coral is of great importance to the oceans as they are what makes up coral reefs, which are some of the most heavily populated areas in the ocean. Without coral reefs, genetic diversity in the oceans would greatly decrease as all of the animals that called the reefs their homes would lose their habitats. The acidity in the waters greatly harms all coral, making it harder for them to grow and repopulate as well as worsening the coral bleaching and causing the deaths of a large portion of coral reefs on Earth.

One of the worst ways that acidification harms coral reefs is through the bleaching of the reefs coral. Coral bleaching, which is mainly caused by the change in water temperature (Hooidonk et al. 2017), is a process in which the coral espells the algae it needs to survive due to changes in the properties of ocean water, leading the coral to turn white and eventually die. Coral bleaching poses a serious threat to the continued existence of the Great Barrier Reef, as well as all other coral reefs in the world's oceans. Bleaching has already affected the Great Barrier Reef and is one of the main reasons why the Great Barrier Reef has lost over 50% of its coral already (Elnar et al. 2021) as depicted in figure 2. Bleaching will continue to worsen as acidification and global warming worsen.

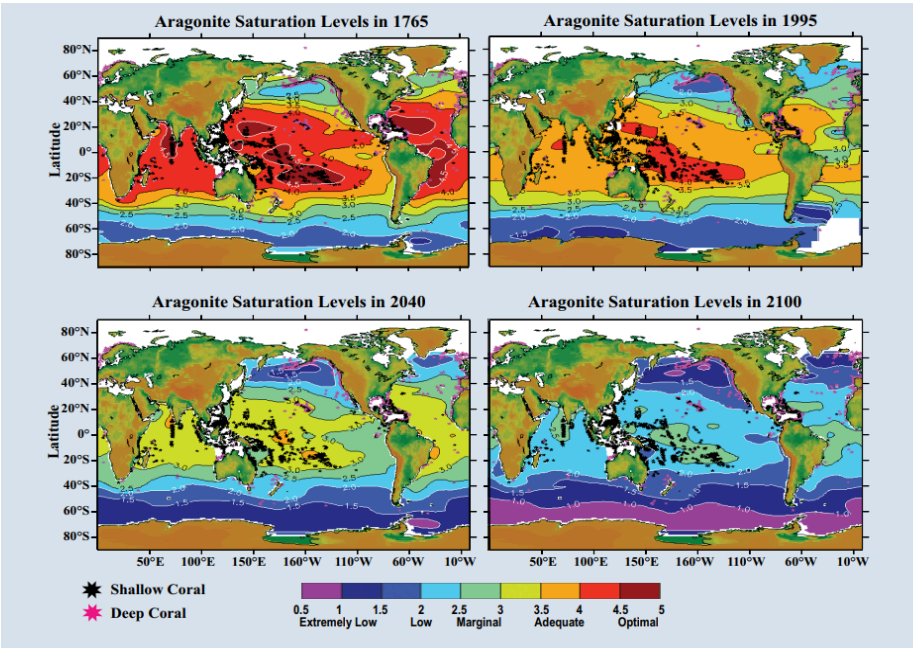
Figure 2:



This figure shows the reduction of hard coral cover over a period of time. As can be seen in the graph, the coral cover has fallen by nearly half. Source: Elnar, A., Cena, C., Bernido, C., & Carpio-Bernido, M. (2021). Great Barrier Reef degradation, sea surface temperatures, and atmospheric CO2 levels collectively exhibit a stochastic process with memory. Climate Dynamics, 57(9-10), 2701-2711.

Another big reason why bleaching is a major threat is because the acidification of the ocean is causing the decrease of the aragonite saturation of the waters, as depicted in figure 3. Aragonite is a material that is needed for coral to grow its exoskeleton, but the saturation of this necessary material has been decreasing, with the Great Barrier Reef specifically having 0.51 less than standard ocean waters (Mongin et al. 2016). This means that the Great Barrier Reef will not have the aragonite needed to repair itself,having even less than normal ocean water, which will ensure the eventual death of the reef. This decline in aragonite concentration is tied to the amount of ocean acidification an area experiences(Mongin et al. 2016), and greatly affects the ability of the Great Barrier Reef to repair itself from the damage it has sustained from coral bleaching or any other source of harm.

Figure 3:



This figure shows the past levels of aragonite saturation from 1765 and 1995, as well as future predictions for 2040 and 2100. Source: Kleypas, J.A., R.A. Feely, V.J. Fabry, C. Langdon, C.L. Sabine, and L.L. Robbins, 2006. Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers: A Guide for Future Research, report of a workshop held 18–20 April 2005, St. Petersburg, FL, sponsored by NSF, NOAA, and the U.S. Geological Survey, 88 pp

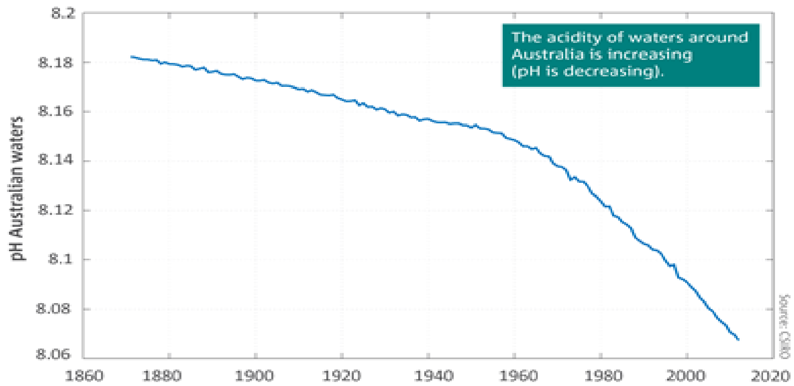
Some may argue that the bleaching of coral and the reduction of coral hardcover is the result of the rising temperatures of the earth, and thus the acidification of the oceans is the lesser of the two threats. The fact that the oceans' waters are increasing in temperature is a big deal when it comes to coral reefs because it is the main cause of coral bleaching, but ocean acidification is also a huge threat on its own and also a threat that only adds to the damage rising temperatures can cause. The pH levels of the water are lowering specifically because of acidification, not the heating of the planet as global warming has no direct effect on the pH levels of water. The pH levels of the water are also the root cause of the reduction in aragonite saturation, meaning that acidification has to be the main culprit in this dramatic reduction in aragonite saturation. The reduction in aragonite makes the recovery of the coral reef as a whole much harder, if not impossible, so acidification plays a huge role in the eventual destruction of the Great Barrier Reef. Both acidification and global warming are however caused by the same thing, which is the release of carbon dioxide into the atmosphere, so lowering the amount of carbon dioxide released by humans into the air would help to solve both the problem of rising ocean temperatures and ocean acidification at the same time.

Both coral bleaching and the reduction of aragonite concentration is affected by one naturally occurring phenomenon, water intrusion. Research done on water intrusions effect on the Chuuk Lagoon showed that if water intrusion is too weak, then the pH will drop due to the combined effects of calcification and respiration (Ko et al. 2016). This increase of acidification occurs when the water is not circulating as quickly, causing the residence time of the water to increase. This process can last anywhere from a month to several, and the entire time it is occurring the pH levels of the water will continue to decrease at an even faster rate than normal. In the studies, it was thankfully shown that coral bleaching did not increase even with weaker water intrusion. Having said that, the worsening acidification would then cause current coral bleaching to be more fatal, as the weak water intrusion also lowers aragonite concentration, making it even harder for the reef to recover from the destructive coral bleaching. These results are applicable anywhere, including the Great Barrier Reef, which would only serve to increase the loss of coral cover the Great Barrier Reef is already experiencing.

What does the future hold for the Great Barrier Reef?:

Lastly, we should understand what the future looks like for the Great Barrier Reef. The future of the Great Barrier Reef does not look very promising given that the trends in pH levels shown in figure 4 show that if no changes are made, the water around the Great Barrier Reef will only continue to become more acidic, causing the reef's downfall even quicker. The current trends in hard coral cover reduction will continue to worsen so long as the rampant pollution of our atmosphere and the world's oceans continue. Current projections indicate that by 2055, ninety percent of all coral in the world will be affected by coral bleaching(Hooidonk et al. 2014), and the further acidification of the oceans makes sure that it will be close to impossible for coral reefs to recover. Steps must be taken to both understand the future of this great natural wonder and to rectify the issues that will ultimately lead to its irreversible loss.

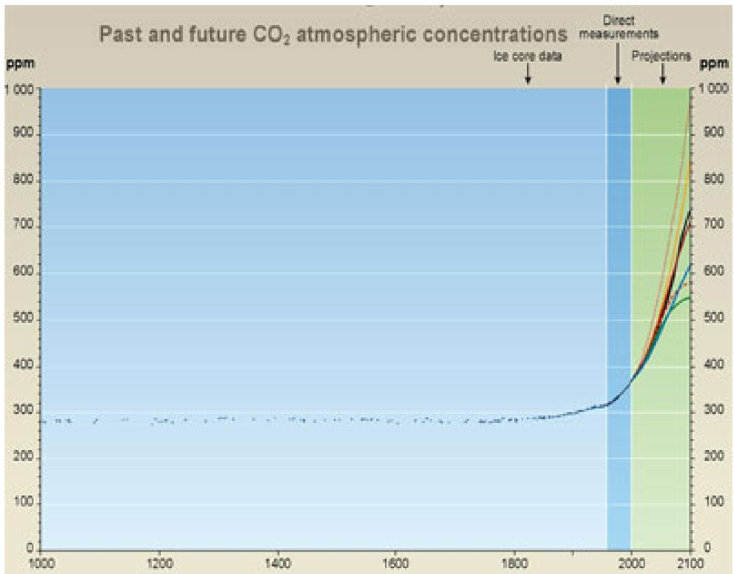
Figure 4:



This figure shows the decrease in pH levels of water around Australia, which is where the Great Barrier Reef is located. Source: CSIRO. (2018). Oceans. State of the Climate 2018. Retrieved April 16, 2022, from https://www.csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate/previous/state-of-the-climate-2018/oceans

Projections of atmospheric carbon dioxide levels are also very useful for our assessment of what the future may have in store for the Great Barrier Reef. In 2005, projections depicted in figure 5 below predicted that the parts per million of carbon dioxide in the atmosphere would cross the threshold of 500 parts per million sometime around or before the 2050s (Butler, 2005). These predictions have proven to be accurate as, according to Rebecca Lindsley of Climate.Gov, the parts per million in 2020 was 412.5 (Lindsley, 2020). 500 parts per million is a highly significant amount for coral as, according to the head of the University of Queensland's center for marine studies Hoegh-Guldberg, "Beyond 500 ppm coral reefs may no longer exist. Much of the Pacific Ocean will likely be marginal for coral reefs while net calcification rates will be approaching zero" (Butler, 2005). If carbon dioxide emissions are not stopped or at least drastically slowed sooner than later, this threshold will be crossed and the capacity for coral reefs to exist may no longer exist. The world's continued increase in atmospheric carbon dioxide is proof that this issue is not being dealt with on a large enough scale to truly solve this problem, so our efforts must increase quickly if coral is to survive.

Figure 5:



This figure shows a projection of the amount of carbon dioxide in the air in parts per million. Notice how most projections show that it will reach 500 ppm somewhere around 2050. Source Butler, R. A. (2005, November 17). Coral reefs decimated by 2050, Great Barrier Reef's coral 95% dead. Mongabay Environmental News. Retrieved April 16, 2022, from https://news.mongabay.com/2005/11/coral-reefs-decimated-by-2050-great-barrier-reefs-coral-95-dead/

Projections indicate that by the end of the century, the pH levels of surface water could be as low as 7.8, a large drop from its normal levels of 8.2, and aragonite concentration would decrease even more (Feely et al. 2007). A drop in ocean water pH of this magnitude would be absolutely devastating to the majority of all ocean life, including the coral that make up the Great Barrier Reef itself. The decrease in aragonite concentration would also lead to the production of new coral being slower, slowing the replenishment of the Great Barrier Reef and thus causing its death to accelerate. The lowering pH, rise in coral bleachings, and the resulting reduction in aragonite concentration threatens the continued existence of the Great barrier reef, so we shouldn't let these predictions become reality. These projections will come to pass unless we focus on reducing atmospheric carbon dioxide emissions, before the point of no return is crossed.

The reduction of atmospheric carbon dioxide would directly reduce the amount of acidification in the ocean over a period of time, as well as helping to solve the crisis of global warming. The only issue is that reducing our emissions is no simple task, as much of the world is powered through the extensive use of fossil fuels. In order to reduce emissions we would need to convert to new sources of clean energy like solar, wind or nuclear power. The substitution of gas powered cars in favor of electric powered cars would also drastically reduce carbon dioxide emissions, a shift that we can see is starting to occur with many car companies releasing new electric cars. The emission of carbon dioxide, however, is not decreasing, with the actual carbon emissions exceeding even the worst case scenario amount predicted by scientists (Hooidonk et al. 2017). If emissions are not reduced by a drastic margin, and the rate of increase of atmospheric carbon dioxide continues to increase or remain the same, the Great Barrier Reef, alongside many other ocean ecosystems, will be lost forever.

Conclusion:

Acidification is one of the greatest threats to all coral reefs around the world, including the Great Barrier Reef. Humanity's failure to reduce carbon emissions by a sizable percentage has led to the deterioration of the entire planet through a myriad of compounding issues, and now if things continue to go on in the current direction, a great natural wonder will cease to exist. A massive and swift effort must be taken in curbing carbon emissions, which would reduce but not completely fix the damage caused by acidification. With the advancements in technology and specifically in advancements of clean energy like wind and solar, hopefully we will be able to efficiently reduce emissions, but this must be done quickly. The advancement of clean technologies such as electric cars is speeding up, but it can’t come soon enough. Every day the acidification of the oceans and decline of the great barrier reef gets worse and worse, and it is humanities responsibility to fix the problem we have ourselves caused, to maintain the majesty of the great barrier reef for future generations to enjoy.

Citations:

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