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# The Greater Effects of Ocean Acidification: Shellfish in the Arctic

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Ocean acidification is up for competition as “climate change’s evil twin” (Bennett). There are many members of society who have yet to learn what ocean acidification is. Despite this, there are scientists that are still discovering more on the issue and what the implications of ocean acidification are (Newcomb). Lined up with the multitude of reasons for climate change, ocean acidification is stemmed from the increase in carbon dioxide that is generated by the human population and the increase in freshwater runoff due to abnormal warming in the Arctic (PMEL Carbon Program). It is evident that ocean acidification can bring forth serious outcomes. “Ocean acidification”, a term founded in 2003 (Bennett), has affected and continues to affect a wide variety of places and living things, but in an immense way it has and will continue to impact the shellfish population (Bennett). As the term and the realization of the implications of ocean acidification are still relatively new, there is still a great amount of research to be done (Narita, Rehdanz, and Tol). Due to the fact that a large portion of the research that has already done is on the ecological side, this is mainly what will be focused on here in this paper. One aspect of the ecological side that are suffering in response to this acidification is the shellfish family (Bennett).

Currently, the shellfish population is being affected globally, but the population is even more vulnerable in the Arctic for specific physical, economical, and social reasons within the respective Arctic communities. Through the process of acidification, shellfish are struggling to grow, reproduce, and survive (Bennett). Shellfish are only one group of organisms in a wide array of the global biodiversity, and these organisms being affected also place stress on the trophic levels of the Arctic, the Arctic human population, and the Arctic economy. The Arctic connections are emphasized deeper

into this paper. Scientists have found a few ways in which the human population can help with ocean acidification, but the thoughts along with that is if these adjustments can help the shellfish population and if there is enough time to help these creatures. Ocean acidification is a developed issue as it deals with ecological, cultural, and economical impacts across the world. It breaks into the surface of a world of issues that scientists are working to solve.

Carbon dioxide in the atmosphere affects the ocean's level of carbon dioxide as the top layer of ocean takes in the atmospheric carbon dioxide (Bennett). Once the top layer has absorbed it, the carbon dioxide dissolves in the seawater it lingers on (Bennett). From there, hydrogen ions break off and disperse throughout the seawater (Bennett). By scientific definition, an escalation in hydrogen ions in a substance increases the acidity. Therefore, as the hydrogen ions accumulate, the ocean then becomes more acidic. It is crucial to know that even though the process is called "ocean acidification," the ocean has not become acidic (Bennett). The process is called acidification because the pH level is slowly decreasing on the pH scale. To be acidic, a substance must be below a pH of 7. As the ocean has absorbed about 30 percent of the carbon dioxide produced thus far, the pH level has dropped from an 8.2 to an 8.1 since the Industrial Revolution (Bennett). A small change in the pH may seem miniscule, but this shift can have huge repercussions. If one were to think about the human body, a 0.1 outside of the pH balance of the body is enough of a change to cause seizures and possible death (Bennett). If this small of a change can create this large of an impact in the human body, think about the damage it could cause for a whole ecosystem. Usually a body of water has the potential to use its natural buffer to

adjust when there are small movements toward a higher or lower pH level, but now there is so much carbon dioxide in the atmosphere that the ocean cannot keep up (Bennett). Ocean acidification is a complex process that stems from the carbon dioxide that continues to be generated by the human population. Ocean acidification is also increased by continuous amounts of freshwater runoff, especially noticed in the Arctic region. Freshwater infill can lead to acidification because river water holds more organic matter that will go through a process called remineralization, and this process gives off carbon dioxide (Cheek). For this reason, there is a noticeably high acidification found on the continental shelves along the Arctic coasts (Cheek). Another way that acidification can increase is through fertilizer and other nutrients being washed into the ocean by rainfall (Newcomb). As temperature rises in the Arctic and rainfall becomes more frequent (Hansen et al.) this change in weather patterns will only be another factor that could increase in the vulnerable Arctic. Ocean acidification is occurring around the globe due to atmospheric carbon dioxide being almost uniform around the world (Narita, Rehdanz, and Tol). Although this is a serious topic of conversation for the whole world, it is important to focus even more on how this process if affecting the Arctic. Naturally, the Arctic Ocean has more advanced levels of carbon dioxide because of the cooling process that happens on the top layer of water on the ocean; through this process the water then sinks into the ocean and carries atmospheric carbon dioxide with it (Cheek). Colder waters in higher latitudes are then more receptive to taking in carbon dioxide. One more danger to the Arctic is that as the sea ice continues to decrease each year, there will be more open ocean to absorb carbon dioxide; this will only intensify ocean acidification. Due to the fact that the Arctic Ocean is more prone to ocean acidification,

as explained earlier, it is changing faster and absorbing the impacts of the changes in a much greater amount compared to the rest of the world. Aggressive changes are occurring with the depth and distance acidification is making (Bennett). Within a short amount of time the acidity has increased farther and deeper as shown off of the coast of Alaska (see figure 1) (Allen).

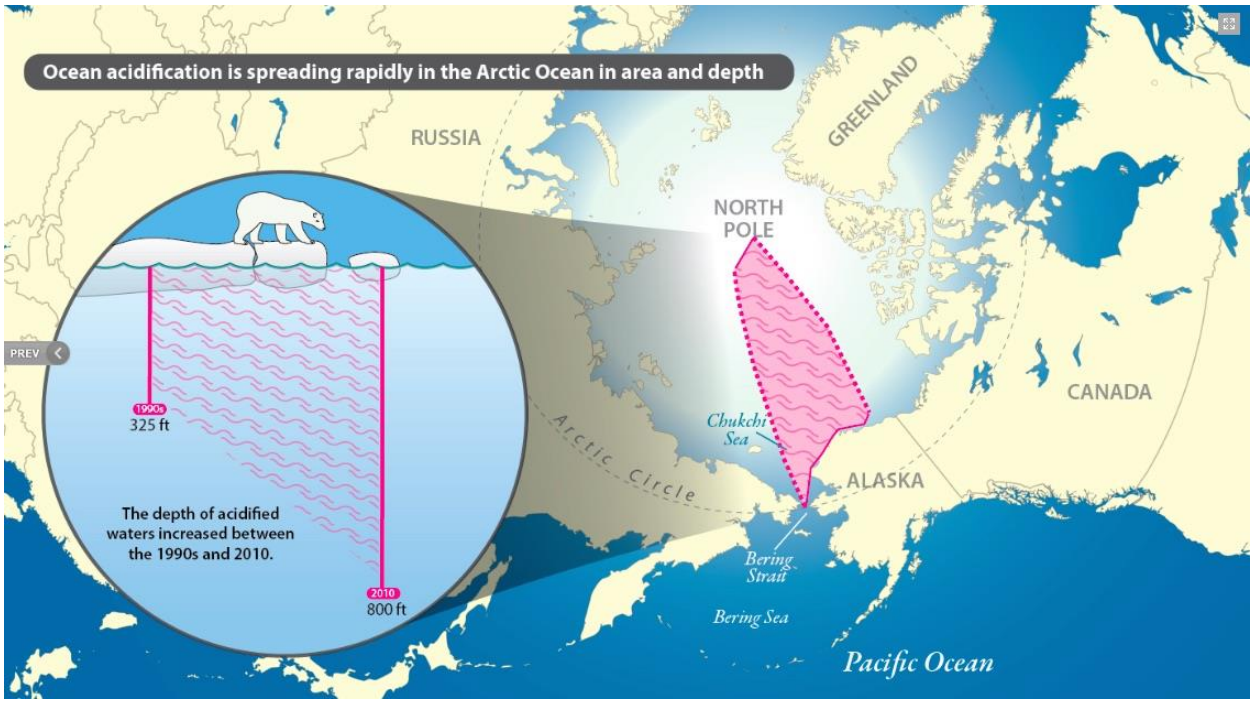


*Figure 1 - In this figure, it is displayed and stating that "Ocean acidification is spreading rapidly in the Arctic Ocean in area and depth" and "The depth of acidified waters increased between the 1990s and 2010" from Beeson, Tammy. Ocean Acidification is Spreading Rapidly in the Arctic Ocean in Area and Depth. University of Delaware: NOAA Climate.gov, 2017. Print.*

Ocean acidification is affecting shellfish, the food web, humans, and the economy. All of the ways in which these are affected can be led back to the source of shellfish and how they are affected by the process. As mentioned before, when a pH level lowers

and becomes more acidic, more hydrogen ions are present. When more hydrogen ions are present within the ocean they are bonding with carbonate molecules that are floating around in the ocean (Bennett). Carbonate molecules are also what shellfish use to build their protective shell (Bennett). As the carbon dioxide increases, then the shellfish have to compete with the hydrogen ions for the carbonate (Bennett). Therefore, after working hard to hopefully gain carbonate molecules, the shellfish have less energy to find food and grow to its fullest potential (Bennett). This leaves the shellfish vulnerable to be eaten and die more often before reaching its maximum growth. As acidity increases it is possible for the protective shells to dissolve in such conditions (Bennett). Image 1 gives an example of what acidification can do as it shows the acidity affecting a protective shell over time. To explain overall consequences for shellfish, this process could deplete the shellfish population. Due to the rapidly changing Arctic Ocean acidification, it is extremely difficult for shellfish to adapt to these conditions. When faced with a changing environment, some organisms can make there way to more favorable waters, but not all organisms will do this and instead will suffer through the changes (Cheek). As mentioned before, shellfish are not the only organisms affected by ocean acidification, but there is much more information on how shellfish are being altered. This is because they are relatively easy to examine in laboratory experiments, so scientists have been able to take advantage of this positive factor and do more research (Narita, Rehdanz, and Tol). Another reason is because shellfish are decently “tractable” due to their low trophic level (Narita, Rehdanz, and Tol). With shellfish being at the low end of the trophic level, this calls for disorder in the food web starting with the fish that feed on them.

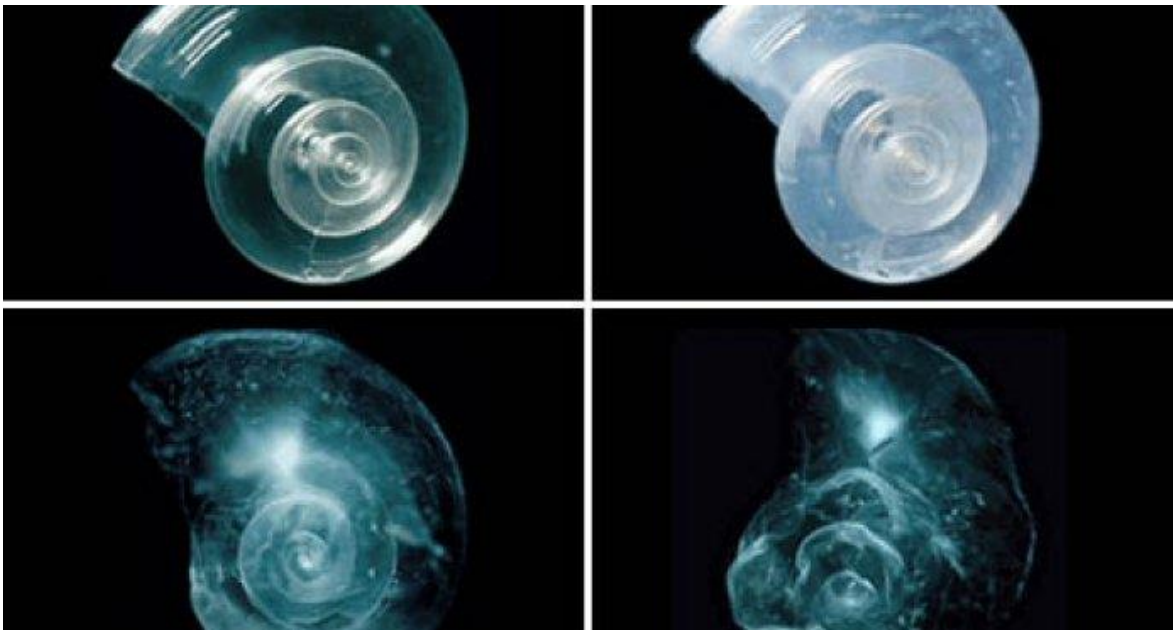

*Image 1 - This image shows the impacts on a shell from increasing acidity. It can be related back to how the shells of shellfish are being broken down and having a difficult time growing and reproducing from Littschwager, David. Ocean Acidification. National Geographic Society, 2017. Print.*

When something is altered in the bottom of a food web it has the potential to cause chaos in the entirety of the food web (Bennett). The ecosystem in the Arctic is particularly sensitive as there is less biodiversity due to the extreme conditions (Payer, Josefson, and Fjeldsa). With less biodiversity, a small change in one organism in the environment can put the whole ecosystem in danger as each species is essential to the food web. Therefore, shellfish have a lot of control over the well-being of other species such as the fish. If the populations of shellfish decrease, then there is limited food for certain fish to consume. This now has the ability to affect the fish populations. Rising damage could be seen in fisheries and then lead to problems within the human population. Growth among the human population is continuing to occur, and naturally

there will be an increase in the demand of amount of food produced. Therefore, the distressed shellfish population can have impacts on the human population.

Roughly a billion people depend on food from the ocean as a main source of protein (PMEL Carbon Group). Food security is a substantial topic of discussion as many people in the world today are already not getting the amount of food that they need. As fish populations decrease from the decrease in shellfish, this leads to a problem with thinking ahead to plan food security. This is an even larger problem for the indigenous in the Arctic as they have limited room to change their ways with less cultural and nutritional substitutes (Allen). The indigenous people in the Arctic depend on fish for cultural practices, social and spiritual identity, and their diet (Nuttall and Callaghan 377-409). Fishing is a key piece to their diets, but fishing practices lead back to their identity with artwork, cultural celebrations, written and oral histories, and festivals, as well (Nuttall and Callaghan 377-409). One specific cultural community celebration example is the whaling tradition. Like stated earlier, when the bottom on the food chain is impacted then it will continue to change the rest of the species along the way; this could mean large animals such as whales and seals. The Arctic people are working hard to keep history and indigenous culture alive in the youth, and whaling is one part of this attempt. Narrowing in on the northern coast of Alaska, in the town of Barrow, there is a community emphasizing the importance of keeping this old tradition alive (Hoag). As the town works as a team on each whaling hunt experience, “it pulls everybody together” (Hoag). This points to how it truly means something for this community and all others with this traditional practice. Hunting and fishing are a part of their history and way of life, and it was said that “adaptation will mean something

different to each Arctic community" (Allen). As there is so much history revolving around the process of catching, preparing and participating in the community meals, even the smallest adjustments of the fish regulations can affect the practices leading into the future (Tesar 1-28). There are now fishing restrictions in place due to shortages especially noticed by fishing industries, and this hits hard on the indigenous peoples hunting needs (Tesar 1-28). Food access in the Arctic is already hard to come by, especially in the highest parts of the Arctic due to locations of many communities. The indigenous peoples have relied on their own hunting and gathering resources to provide what they need (Nuttall and Callaghan 377-409). As each community will change in its own ways, none of the changes will be simple due to the fact that their way of life will be immensely altered. They risk loss of food sources, their indigenous history and identity, and now their economic structure.

The economy is the last factor that will feel the impacts of ocean acidification on shellfish. Right away one can infer that with a decline in the fish population due to the impacts on shellfish there will be a decrease in the output of fisheries around the world. This will impact jobs that are held in the fisheries and processing companies along with that. In the research done by Narita, Rehdanz, and Tol, even though the economical impacts were a relatively new topic to consider, they could find the outcome of over 100 billion US dollars in costs with the impacts of shellfish on the fish populations (Narita, Rehdanz, and Tol). This educated research was made under the assumption that the fishing industries will have an increasing demand. Over time the impact on the fisheries could have a tackling destructive power over the global economy. Specifically, in the Arctic, the economy is affected. Some fisheries of the highest value are placed in

Alaska (NOAA). To put it into perspective, “60 percent of the United States commercial fisheries by weight are from Alaska” (NOAA). The research found that seasonally the surface waters of the Chukchi and Beaufort seas could reach threatening levels of acidification for shellfish by the year of 2030 (NOAA). As this is an area of large production, it is alarming that there is an increasing threat to the fisheries in this area due to ocean acidification. This has great potential to harm the global economy.

Ocean Acidification impacts are still being explored in the world of science. Shellfish have a strong emphasis placed on them as there is clear evidence on how acidification is impacting them, but there are so many species that are affected by this other than shellfish, and humans are one of them. This subject is in great need of long-term research in how it will affect the world ecologically (Cheek). There have been many short research studies done, but no one has complete knowledge on how this will end up if nothing changes in relation to the acidification of the ocean. With all of the open questions, there is a rush to find ways to adapt and plan for the change the scientists know is coming. There can be a few positives to look to as ocean acidification increases. There are small signs of adaptations found in shellfish. Some organisms can regulate their body pH level to a certain extent, but this takes more energy to exert as a consequence (Cheek). For most shellfish, they will have to move locations to thrive at all in the changing conditions as stated earlier. Other organisms with also thrive with the lowering of the pH balance. Crustaceans are said to have a positive reaction to the changing balance as it makes their protective shell stronger (Bennett). Photosynthetic algae and sea grasses will also benefit with the increasing acidity (PMEL Carbon Group). Although there are a few species and organisms that will flourish with

the changing conditions, this will not make up for the struggles and extinctions that could occur in other species and organisms. On the human initiative side, there are developing efforts to follow through with long-term research and to find solutions and adaptations to the ocean acidification now. A start to helping the issue is with reducing carbon emissions and ecological footprint (Bennett). As what seems to be a simple solution just by cutting the main source of the problem, this will only bring a change in the future and not the present. Right now, if humans completely stopped releasing carbon now it would not be noticed until at least 20 years into the future. Although this time span may seem far off or unchangeable for some our own personal gain, it is something that needs to be altered to help with future generations. Next, there are also initiatives to find more carbon sinks and promote their growth (Bennett). Ecosystems such as marshes along the coast are areas that take in great amounts of carbon dioxide and in return keep it from being absorbed into the ocean; this is an example of a carbon sink. Lastly, there is research being done with “black boxes” (Newcomb). This study started with Bill Mook and Joe Salisbury in the Gulf of Maine (Newcomb). Within the oyster hatchery, this farmer and oceanographer respectively created the black boxes to measure the carbon dioxide and alkalinity by putting sensors in them (Newcomb). They built the black boxes with the financial assistance of NOAA’s Ocean Acidification Program and Integrated Ocean Observing System (Newcomb). By doing this they are able to see compare their levels of carbon dioxide and alkalinity with how well the oysters did during the time in use. Image 2 is picturing the black boxes that were developed for research in an oyster hatchery. They hope to continue and expand their

research and assist with the increasing desire of long term research on ocean acidification (Newcomb).

*Image 2 - "Black boxes" created by Bill Mook and Joe Salisbury in order to measure carbon dioxide and alkalinity in oyster hatcheries from Mook, Bill. Oyster Farm. NOAA Research News, 2017. Print.*

In conclusion, the process of ocean acidification is an increasing problem, and it can be compared to the severity of climate change. It has distressed the ocean all around the globe, but the Arctic region is absorbing the impacts of it in faster and more intense ways. There is a great deal of research that still needs to be done, but with the severity of the issue scientists are in search of ways to adapt and solve this at this moment. By just understanding the matter of ocean acidification nothing will begin to make its way to recovery. The human population must act now and not just speak up in

order to help the future generations of not just humans, but other living organisms as well.

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