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Honors Option Essay

Ocean Acidification and Coral reefs

Climate change is a pressing issue in today's world in terms of conservation. Human activity has increased greenhouse gas production, and in result, is warming the planet. However, climate change can be seen through a variety of signs beyond warming. Considering the broadness of how climate change affects conservation, I will be focusing on the detriment that an aspect of climate change, specifically ocean acidification, has on coral and coral reefs and the subsequent effect on humans, as well as potential conservation strategies that could help mitigate the consequences of ocean acidification to preserve these natural systems.

Ocean acidification occurs when oceans absorb the excess carbon dioxide in the atmosphere derived from anthropogenic sources, causing the ocean to be more acidic. Not only is this intake of carbon dioxide increasing pH levels, but also is lowering calcium carbonate saturation states. Particularly, the lowering of calcium carbonate saturation states have a disproportionate effect on calcifying marine species, such as coral reefs, since many rely on calcium carbonate for the formation of internal structures, skeletons, and shells. The hard skeleton of coral is composed of calcium carbonate, and its structure is highly conducive as a habitat for a diverse community of marine organisms. As such, the dissolution of calcium carbonate as a result of rising levels of carbon dioxide would be hazardous for coral reef ecosystems to continue to thrive, and would result in a massive loss in biodiversity, making coral-dependent organisms become rare or extinct. Coral may react to ocean acidification by cutting back on skeletal density to maintain its spread and growth. However, in doing this, the coral leaves itself more vulnerable to erosion from grazing fish species and natural disasters, ultimately lowering structural complexity and resulting in less habitat biodiversity as well as a diminished ability for reefs to protect coasts (Hoegh-Guldberg et al., 2007).

Most predictions on ocean acidity focuses on either low latitude regions or average global conditions, but that does not mean it is not important to look at high-latitude ecosystems as well. One research study hypothesized using ocean-carbon cycling models that these reduced saturation states would occur in high-latitude ecosystems, which are typically colder, extending throughout the Southern and subarctic Pacific oceans in approximately one hundred years. Results, however, demonstrate that these detrimental conditions may occur sooner than even predicted. The changes in pH level have dangerous consequences for calcifying organisms, including cold-water coral being threatened, and have an impact on biodiversity (Orr et al., 2005).

Further, it has been suggested that some dinoflagellates in the *Symbiodinium* genus contribute to the overall health of coral reefs through endosymbiosis, thereby it was thought that coral calcification was associated with the dinoflagellates' photosynthesis rates. It was found that areas with high rates of carbon fixation coincided with higher levels of calcium accumulation along the surface of the coral. *Symbiodinium* also uses HCO to provide carbon dioxide for photosynthesis, and the reaction of these compounds produce hydroxide, which neutralize protons during calcium carbonate deposition. The significance of this reaction is that it demonstrates how the processes for photosynthesis and calcification go hand in hand and work harmoniously together, and may even be inherently connected (Hofmann et al., 2010). Experiments have shown that calcium carbonate dissolution can have significant impacts on the carbon fixation ability of photoautotrophs such as these living in marine systems, which could potentially cause global ecological disturbances in the near future (Kroeker, Kordas, Crim, & Singh, 2010).

Loss of these dinoflagellates leads to another consequence of ocean acidification: coral bleaching. One study in comparing bleaching, productivity and calcification rates while manipulating levels of carbon dioxide present found that high carbon dioxide served as a mechanism for coral bleaching (in part with warmer temperatures). Interestingly, it was noted that acidification had even more of an effect on bleaching and productivity than it did on calcification for the coral. With high doses of carbon dioxide, there was approximately 45% bleaching for the three coral species tested over an 8 week period, and intermediate levels of carbon dioxide also led to significantly more bleaching than control conditions. In fact, results showed that carbon dioxide levels had the main impact on coral bleaching and warming served to emphasize the effect for certain species . This indicates future bleaching should not just take into account global warming but acidification too (Anthony, Kline, Diaz-Pulido, Dove, & Hoegh-Guldberg, 2008).

Coral decline also has a significant impact on humans, in terms of both the economy and provided ecosystem services. As carbon dioxide levels in oceans continues to increase, the consequences become further and further pronounced. With the degradation of coral reefs, they become less appealing to tourists, which will significantly reduce ecotourism and profit coming into the economies of some low-income coastal areas, such as the Caribbean basin and islands that depend heavily on ecotourism for income. Coral is also essential for reef-based fisheries. With the degradation of coral, less of the reef fish can be supported and thus less can be harvested. This will have devastating impacts on places like Asia, where a fourth of the yearly fish catch from coral reefs go toward feeding approximately 1 billion people. Ocean acidification will not only limit this important subsistence resource but also possibly lead to overexploitation. Lastly, reefs provide coastal protection from natural disaster. When storms hit, people, infrastructure, and other marine ecosystems will be generally more vulnerable with decreased calcification of coral reefs (Hoegh-Guldberg et al., 2007).

In order to preserve these reef ecosystems, it seems the most logical in general to mitigate carbon dioxide emissions in general, but it was also suggested that reducing local hindrances for coral reefs would do the most good first. This would include things such as managing water quality and pollution so corals do not face these stresses in addition to dealing with ocean acidification. One article suggested that it is important to maintain ecological resilience through measuring coral recovery time after disturbance. Considering the size and frequency of disturbances, such as a disease outbreak, along with a lessened ability to grow and compete, the ecosystem could change from a coral to an algal-dominated state, and lack the ability to return to a coral-dominated state. The loss of ecological resilience happens due to slower coral recovery rates after disturbance and an increase in competition from the presence of macroalgae. In order to conserve these coral-dominated ecosystems, ideally carbon dioxide should be stabilized so as not to inhibit calcification and prevent macroalgae communities from taking over so as not to outcompete and weaken coral propagation ability. A strategy for this would be to promote the grazing of fish and invertebrate herbivores to ensure that the algae does not outcompete the coral (Hoegh-Guldberg et al., 2007).

Overall, coral reefs and other calcifying organisms are significantly under threat by ocean acidification. Although some have hypothesized that coral actually can survive, and sometimes even thrive, under the high levels of carbon dioxide, but have only found this to be somewhat true for some species of coral in the short-term, and not in the long-term. However, this tolerance ability leads to speculation that coral then may have the biological capacity to possibly benefit from low pH levels, but this is yet to be sufficiently tested. Currently, there is no evidence that coral can adapt to low pH, but it is likely that they may have the ability to acclimatize to some degree to the conditions of ocean acidification (Hofmann et al., 2010). Coral is going to show mixed responses to these high levels of carbon dioxide (Anthony et al., 2008), so further research and a close watch will be required in order to determine the fate of coral reefs in our future.

References

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