Diatom Dynamicity in the face of Climate Change

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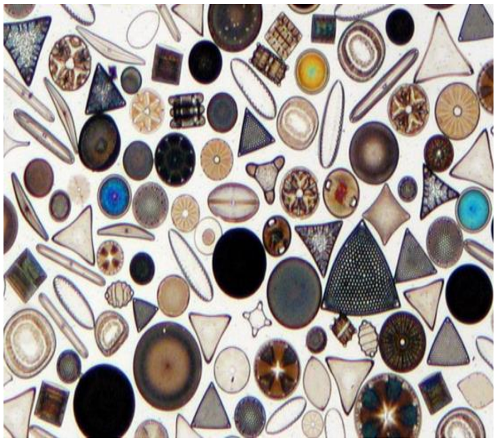

Figure 1: Array of diaoms *Dutkiewicz, Stephanie. "Ocean Acidification May Cause Dramatic Changes to Phytoplankton."* MIT Darwin Project*, 23 July 2015, darwinproject.mit.edu/ocean-acidification-may-cause-dramatic-changes-to-phytoplankton/.*

Marine ecosystems geographically make up about 71% of the earth's surface area and are biologically more diverse as compared with terrestrial ecosystems. This incredible diversity is sustained by a complex food web that is dependent on the energy supplied by microscopic single celled eukaryotes called diatoms[1]. Alongside making up the most diverse group of protists on earth, diatoms are also a unique class of silica-covered phytoplankton that carry out about 20% of all photosynthesis on earth[1]. In terms of the marine food web alone, diatoms account for 40% of all marine primary production and the circulating particulate carbon that is an important food source for deep-water organisms[2]. Playing such a crucial role in the global carbon cycle, diatoms are essentially found in waters all over the world, as long as there is sufficient sunlight and nutrients available to carry out photosynthesis[1].

Climate change and ocean warming as a result of human activity are currently causing marine organisms to shift their distribution polewards[3]. A study by Bopp et al 2005 explored the effect of climate change on the distribution of diatoms by using a global model of ocean biogeochemistry alongside a climate model. Their results suggest climate change leads to greater nutrient depletion conditions in the ocean surface, which favors bigger phytoplankton in comparison to diatoms[4]. Furthermore, their results showed that at 4 times the average CO_2 concentration, diatoms displayed a 10% reduction in relative abundance on a global scale and up to a 60% reduction in the North Atlantic and Sub-Antarctic Pacific[4]. As diatoms are the base of essentially all marine food webs in existence, even a minor reduction in abundance could significantly impact higher trophic levels. The current risk ocean warming poses to diatom abundance is undeniable however there is still a lack of understanding as to how exactly these risks will manifest.

Because diatoms are so diverse in size, morphology and composition, each species differentially contributes to the export of oceanic carbon and movement of particulate matter[2]. A model simulation study conducted by Treguer et al 2018 projects a decline in the contribution of diatoms to primary production everywhere outside of the Southern ocean[2]. Despite anthropogenic induced environmental challenges, research shows that diatoms are surprisingly dynamic organisms that have been able to adapt to such conditions.

To evaluate how diatoms have adapted to ocean warming, a study by Schaum et al 2018 focused on the marine diatom Thalassiosira pseudonana. Researchers conducted whole-genome sequencing among populations selected from different warming environments, as well as between evolved and ancestral lineages and observed for genetic divergences[5]. Furthermore, the study found that evolutionary thermal tolerance adaptations under severe conditions (32°C) is slow compared to more moderate temperatures (26°C), which are rapid and linked to phenotypic changes in metabolic rate and elemental composition[5]. This rapid response was also apparent for populations from environments that experienced fluctuations between extreme and moderate temperatures. Consistent with the observed phenotypic changes, the most rapidly evolving genes found were associated with transcriptional regulation of the oxidative stress response as well as redox homeostasis[5]. This study is significant in that it highlights how diatoms have the capacity to adapt to a variety of temperature conditions phenotypically, but also in a manner that is genetically heritable.

Similarly, another study conducted by Jin and Agusti 2018 looked at thermal adaptive strategies of diatoms in the tropical Red Sea by isolating 4 different species. After 200-600 generations of growth, researchers observed that the diatoms developed 2 distinct adaptive strategies to warming conditions (30°C). Two of the species increased their optimal growth temperature and maximum growth rate in response to the warming condition while the other two species shifted from being thermal specialists to generalists, increasing the temperature range in which they could flourish[6]. These adaptations however do not come without a tradeoff, as the study also points out processes like photosynthetic efficiency and growth rate can be impacted as a result, potentially affecting competitive fitness[6].

Diatoms are undoubtedly one of the most important organisms found in marine ecosystems. It is mind boggling but at the same time humbling to know that something microscopic can play such a crucial and significant role in sustaining marine biodiversity. Anthropogenic emissions are on the rise and as such are devastatingly contributing to the reduction of these organisms, which could have detrimental impacts on all trophic levels. Despite the negative outcomes of human activity however, it seems that there is a silver lining in that research is beginning to understand the dynamicity of diatoms. In response to climate change, diatoms have evolutionarily adapted thermal strategies to combat the changes that come with ocean warming. Some of these adaptations include altering their temperature tolerance range, increasing optimal growth temperatures and maximal growth rates. As noted by Jin and Agusti 2018, such adapted thermal strategies in response to warming among phytoplankton could help halt the sharp decline in diversity that is emerging from climate change in tropical waters[6]. Better understanding the capacity for adaptation diatoms possess in response to rising water temperatures will contribute greatly to effectively carrying out biodiversity conservation efforts.

Citations

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