Influence of Climate Change On Marine Species and Its Solutions

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Abstract-Marine species are the major components of living organisms on the Earth that have dominated nearly 90 percent of the habitat of Earth. Climate changes have changed the distribution of the marine species among the world and causing extinctions and eventually greatly impacts the whole marine ecosystem. This paper is going to discuss the impacts of climate change on marine species and what humans could do to protect the marine species under the change of the climate. This paper first introduces the global background about the climate change and how does it affects marine species. Then evaluates the whole systems into three smaller parts: fish industry, coral reefs and seagrass. The protection of coral reef and seagrass habitats are necessary to maintain the marine ecosystem. Finally the paper proposes several solutions to minimize the impacts of climate change on marine species. The advanced technology, government support and volunteer works would be essential to save the marine species from the undergoing life threatening situation. From now on, humans should stand together to protect our common habitat and save other species who share the Earth with humans. This paper is important because it evaluates the recent conditions of marine species under the climate change and it explores the potential solutions to solve the ongoing issues.

1. Introduction
The oceans encompass around 70% of the Earth's surface, demonstrating their significance to the global environment. The condition of marine systems is crucial for the whole earth as the seas are made up of different environments that support a diverse range of marine creatures, in addition to having a significant impact on global heat transport and precipitation. They also supply a vast range of commodities and services to humans, such as food, recreational possibilities, and transportation corridors. Human-caused greenhouse gas emissions are predicted to cause significant global climate change in the twenty-first century, according to present scientific data. Climate change will exacerbate challenges already posed by human growth, land-use change, pollution, and overfishing in coastal and marine ecosystems. Temperature changes in coastal and marine ecosystems will have an influence on organism metabolism as well as ecological processes such as production and species interactions. Temperature ranges in the environment are appropriate to particular species. Climate change will cause species’ geographic distributions to expand or contract, resulting in new species combinations that will interact in unanticipated ways. Species that are unable to migrate or compete for resources with other species may face extinction on a local or global scale. Climate change will likely alter patterns of wind and water circulation in the ocean. These changes may affect the vertical movement of ocean waters (e.g., upwelling and downwelling), which can increase or decrease the availability of essential nutrients and oxygen to marine organisms. Changes in ocean circulation patterns can also affect regional ocean and land temperatures and marine species distributions [1, 2].
As the above figure indicates, a great amount of people are suffering from the climate change caused by human activity. A relatively small amount of studies are made about the effects of climate change on the oceans. There are some investigations being made on the solving or eliminating the effects of climate change on marine systems. However, these solutions and technologies all required huge investments. The overall technology cost to decrease the carbon dioxide emissions, deforestation and plastic waste is excessive for some of the developing countries. In order to reduce the emission and deforestation, they need to stop their development and work on their environment. None of these developing countries are willing to stop developing in modern society. Even some of the world leaders do not believe in climate change and do not trust scientists. Solving the climate change issues could not be achieved alone; gathering the efforts both from the public and governments could work much more efficiently than alone. Therefore, this paper is going to discuss the potential solution from both technologies and from human efforts.

This paper evaluates the current conditions of marine systems and the impacts of climate change on it through the fish industry, coral reef habitats and seagrass. Then summarizes the current popular solution to decrease the impact of climate change impacts on the ocean and indicates its potential risks and flaws. By evaluating the potential risks and the feasibility, the paper contributes several possible solutions to the current issues in corporations from government and citizens.

2. The Marine Species Under Climate Change
Living organisms' habitats and their lives mainly depend on the temperature, acidification of the surroundings. The climate change, which indicates the sea level rising, carbon dioxide level increasing in the atmosphere, global warming and decreasing of arctic ice minimum. The fundamental basis for the living organism is to survive and reproduce. As a result, the importance of the bioclimatic envelope emerges as an indication of the length of time a particular individual must wait before entering a breeding habitat. All other phenological parameters' effects are proportional to their magnitudes in relation to the envelope. Small bioclimatic envelopes make species more vulnerable to disturbance and extinction than larger envelopes. The envelope width is a fundamental indicator of a species' vulnerability to environmental and ecological changes.

Mismatch also occurs during the process of survival and reproduction. If the pace of climatic change exceeds the rate of adaptation, the population's phenology "drifts out" of the moving envelope, and it "jumps out" if the envelope variability surpasses the population's capacity to manage phenology fluctuation. The drifting and jumping out potentials depend on a number of factors. For phenotypic plasticity to work, the cue initiating migration must track the bioclimatic envelope. Although some timing
cues, such as photoperiod, are unaffected by climate change, adaptation via phenotypic plasticity is unlikely for populations that rely on these cues, compared to those that rely on climate-driven variables, such as temperature. Thus, as the global temperature is rising, the temperature in the ocean is also rapidly increasing. Due to the temperature increasing, the marine species need to change the location of their habitats based on their envelope. The surface temperature is warmer than before, the fishes adapted to the specific temperature need to migrate lower in sea level to find the region that fits for their living. As the majority of marine species shift downwards, the original species that live in the deep ocean will lose their habitat due the competition as the more species fight for smaller habitats. Under such conditions, extinction would occur. Since the extinction happens in the ecosystem, the whole marine ecosystem would be affected by the extinction.

2.1 Fishing industry under climate change
There is an immediate and future threat to global food security from climate change. Aquaculture (that is, aquatic farming)—one of the fastest growing food sectors on the planet—remains a major unknown in science.

If existing regionally lopsided production patterns continue in the future, a loss in aquaculture production potential might have an impact on world economies and food security. Finfish and bivalves may not grow as well as they used to because Asian countries currently generate roughly 90% of all marine farmed biomass. Selective breeding may compensate for certain declines in growth performance, however species nearing their tolerance limits, trade-offs between growth and tolerance performance, numerous stressors, and hurdles to knowledge transfer may make such approaches difficult.

Countries with improved or less impacted regions could contribute stability and accessibility to the global economy through trade. The variability of the seas in a country's EEZ could minimize the shift in production potential for some areas, depending on farm site, at the country level—especially for countries with abundant marine resources. Because the percentage of productive waterways required to supply seafood demand is so small, even if production potential drops in most locations, appropriate species and/or farm placement could result in a future gain in biomass. Due to the decreasing amount of marine species and extinction, humans would encounter a decreasing amount of edible fish. Countries living on the islands would be greatly affected by the decrease as the edible fish serves as the main food source for these countries [5].

2.2 Coral reef under climate change
Coral reefs are among the world's most diverse and valuable ecosystems. They can host 4,000 fish species, 800 stony coral species, and hundreds of other species. Coral reefs are home to more than a quarter of all marine fish. The reefs serve as safe havens for them to feed, reproduce, and raise their young. When coral reefs are severely destroyed, they can have a huge impact on the surrounding population, resulting in local residents losing a significant portion of their economic revenue and aquatic species living on the reefs losing their habitat. Corals cannot withstand water temperatures below 18 degrees Celsius, and most corals can only survive in conditions between 23 and 29 degrees Celsius. This limits the geographical distribution of coral reefs. Some corals, however, can withstand temperatures of up to 40 degrees Celsius for a short period of time. As a result, most corals dwell between the tropics of Cancer and Capricorn, in subtropical and tropical waters. Thus, the rate at which climate change is occurring, according to most experts, is potentially beyond the capacity of coral reefs to adapt and recover. However, scientists have noticed that coral reefs have exhibited resilience to an increase in sea surface temperature and bleaching in some locations, particularly those in remote portions of the Pacific where reefs are far removed from human impacts [5].

2.3 Seagrass under climate change
Algal forests and seagrass meadows—two of the world's most productive and diverse coastal marine ecosystems—are built on the basis of marine macrophytes. These habitats supply fish and invertebrates with nursery grounds and food, as well as erosion protection, carbon sequestration, and nutrient fixation.
Temperature is the most critical range limiting factor for marine macrophytes, and ocean warming is the most serious concern among global climate change variables. The loss of dominating macrophytes along their equatorial range boundaries, as well as range extensions into polar regions, are expected and documented as a result of global warming.

While genetic adaptation is thought to be too slow to keep up with the increasing rate of anthropogenic environmental change, a set of non-genetic mechanisms involving the functional composition of the associated microbiome, as well as epigenetic modification of the genome and its regulatory effect on gene expression and transposable element activity, may help rapid adaptation.

Under the current climatic changes, seagrasses and macroalgae are under risk in a variety of ways. Early life stages' physiological responses and durability (both seeds and spores) are inextricably linked to their genetic and epigenetic traits. Environmental changes also have an impact on the symbiotic relationship between microbiome communities and their hosts. Biochemical alterations in macrophytes can have serious consequences for trophic levels that feed on seagrass-derived organic matter, such as reduced energy transfer due to reduced carbon fixation, as well as a severe loss in critical fatty acid production. Traditional modeling approaches should enlarge the concept of niche stability by coupling physiological and ecological insights in primary productivity models and ecological niche models, allowing for a more holistic understanding of the constraints that these important foundation species will face in the near future. For a more comprehensive understanding of phenotypic variation and more realistic change scenarios that are critical for mitigation and conservation, research on seagrasses and macroalgae should ideally be multi-disciplinary, incorporating genetic, epigenetic, and microbiome levels of intra-specific variation and ecotypic differentiation [5].

3. Solutions
The ocean is responsible for the bulk of the planet's life-sustaining ecosystem. It sustains a vibrant economy and contributes to global food security. It is home to a large quantity of biodiversity, plays a vital role in climate control, and supports a thriving economy. Future increases in global mean temperature, as well as simultaneous ocean acidification, deoxygenation, and sea-level rise, are projected to have devastating effects on vital marine ecosystems and ecosystem services [6, 7]. The marine species such as the edible fishes should be protected as its importance to the island countries and for the whole marine ecosystem.

Lowering the global warming rate is essential to slow down the extinction and decreasing amount of marine species. The protection of coral reefs is also crucial as it serves as the home for many marine species. Lack of coral reefs would cause thousands of marine species to lose their home and face extinction. The seagrass should be protected since it provides the nutrients to many marine organisms. There are three sorts of measures that can be taken to minimize the scale and impact of climate change on marine ecosystem: (1) Atmospheric greenhouse gas concentrations must be reduced, (2) human destruction should be reduced, (3) ecosystems and natural habitats must be protected [8].

3.1 Carbon Reduce
Carbon emissions from people’s daily uses are the major reason for climate change. By reducing global warming, marine species could remain in their habitats. Hence, the carbon reduction becomes the first step to minimize the impacts of climate change. To reduce the greenhouse gases concentrations in the atmosphere, such as carbon dioxide, the carbon capture would be effective. However, the carbon capture would only work in the small scale; if the scale shifts to the global level, it would rarely have any impacts and reductions. The carbon capture is costly and not efficient, the most efficient carbon reduction needs cooperation of government and public [9, 10].

Increasing carbon level in the atmosphere is caused by human activities throughout the past hundred years [11]. Therefore, the carbon reduction is a continuing project that could not be completed within a short time period. Hence, the most effective way to reduce the greenhouse gases concentrations in the atmosphere would be deduction of usage of fossil fuels. The regulations should be manipulated. Reduction of fossil fuels can be achieved in different ways, despite the technology that could reduce the
cost, the new rules should be published and people should follow. People could decrease the amount of chances to drive private cars to reduce the usage of petroleum. Reduce the use of electricity during daily lives and reduce the use of paper to save energy and trees. Still the more advanced technologies to capture carbon are needed, however, without the cooperation of humans, the most advanced machine still could not solve the issue from the root.

3.2 Destruction Reduce
Despite the carbon emissions from the factories, some of the factories destroy the marine environment in a variety of ways that enlarges the impacts of climate change on marine ecosystems. Some of the real estate companies plan to reclamation for more profits which directly impacts the marine environment as it could change the ocean currents which is related to the global climate. Also, deforestation also impacts the climate greatly as the green plants serve the major role to reduce the carbon levels on earth. Therefore, the government should regulate the market to reduce the destruction of coastal environments and forests.

3.3 Ecosystem Protection
Other than decreasing or slowing down the climate change, the protection for the marine ecosystem is also necessary. In order to protect the marine and coastal ecosystem, laws should be enforced to stop intervention and destruction. The US government has set seven objectives to help fish, wildlife, plants, and ecosystems adapt with climate change's effects (National Fish, Wildlife and Plants Climate Adaptation Strategy). These objectives are intended to motivate and empower natural resource managers, lawmakers, and other decision-makers to pursue successful climate-change adaptation measures in the next five to ten years. Despite the effort from the government, people as individuals should also stand out. Since climate change is caused by human activities in the past hundreds of years, the change of behaviors and thinking would also help to reduce the impacts and slow the climate change. Solving the problem from where it originated, people could work together to reduce the pollution.

The volunteer work would be needed to clean up the environment and educate people about the concept of climate change and how people should protect the environment. Additionally, volunteer work should be supported by the government as it serves human and earth goodness. By the effort of protection, the coral reef habitats and seagrass habits should be protected and remain to serve the oceans [12].

4. Conclusion
Ocean, as the major component of earth, has an active role in the climate system. Small changes within the ocean could affect the whole Earth’s climate model. Study proves the climate changes have great impacts on global climate system and the marine ecosystem. The economy such as the food industry would be greatly impacted by the climate change. The paper summarizes several potential ways to minimize the impacts of climate change on the ocean throughout human activities and several technologies. It includes the way to decrease the carbon dioxide emissions, solar radiation and ecosystem protections through both government support and human corporations. The government and citizens should work together to slow down and eliminate the negative impacts of climate change. This paper provides several further advance suggestions on the solution of climate change with cooperation with people. The people’s corporation is the key factor to decrease the impacts of climate changes and also the governmental supports is necessary. In the future, people should work with the government to protect the whole biosphere together to reduce the destruction brought by climate change. The people should not only expecting the government’s effort could solve the ongoing issues as it is not a simple task can be achieved by one organization or one group. This paper gives alarm to the society of the seriousness of climate change and its effects on climate change and advocates more people and scientists to work together to minimize the influence of climate change.
References

[1] C.P. Palmer, Marine Biodiversity and Ecosystems Underpin a Healthy Planet and Social Well-Being | United Nations. (Accessed 11/17 2021).

[2] J.A.K. James H. Cowan Jr., Robert R. Twilley, Steven R. Hare, Victor S. Kennedy, Coastal and marine ecosystems & Global climate change, Potential Effects on U.S. Resources. August 2002.

[3] Figure 1. Descriptive title for figure. Reprinted from “Climate Change.”

[4] O.C. Hoegh-Guldberg, Rongshuo; Poloczanska, Elvira S.; Brewer, Peter G.; Sundby, Svein; Hilmi, Karim; Fabry, Victoria J.; Jung, Sukgeun; Skirving, William; Stone, Dáithí A.; Burrows, Michael T.; Bell, Johann; Cao, Long; Donner, Simon; Eakin, C. Mark; Eide, Arne; Halpern, Benjamin S.; McClain, Charles R.; O’Connor, Mary I.; Parmesan, Camille; Perry, R. Ian; Richardson, Anthony J.; Brown, Christopher J.; Schoeman, David; Signorini, Sergio R.; Sydeman, William J.; Zhang, Rui; van Hooidonk, Ruben; McKinnell, Stewart M., The Ocean, 2014.

[5] J.J. Anderson, E. Gurarie, C. Bracis, B.J. Burke, K.L. Laidre, Modeling climate change impacts on phenology and population dynamics of migratory marine species, Ecological Modelling 264 (2013) 83-97.

[6] H.E. Froehlich, R.R. Gentry, B.S. Halpern, Global change in marine aquaculture production potential under climate change, Nat Ecol Evol 2(11) (2018) 1745-1750.

[7] E.S. Poloczanska, M.T. Burrows, C.J. Brown, J. Garcia Molinos, B.S. Halpern, O. Hoegh-Guldberg, C.V. Kappel, P.J. Moore, A.J. Richardson, D.S. Schoeman, W.J. Sydeman, Responses of Marine Organisms to Climate Change across Oceans, Frontiers in Marine Science 3 (2016).

[8] N.R.C.D.o.E.a.L.S.B.o.A.S.a.C.A.s.C.P.o.A.t.S.o.C. Change, Advancing the Science of Climate Change,  (2010) 377.

[9] J.-P. Gattuso, A.K. Magnan, L. Bopp, W.W.L. Cheung, C.M. Duarte, J. Hinkel, E. McLeod, F. Micheli, A. Oeschlies, P. Williamson, R. Billè, V.I. Chalastani, R.D. Gates, J.-O. Irisson, J.J. Middelburg, H.-O. Pörtner, G.H. Rau, Ocean Solutions to Address Climate Change and Its Effects on Marine Ecosystems, Frontiers in Marine Science 5 (2018).

[10] C.J. Preston, Ethics and geoengineering: reviewing the moral issues raised by solar radiation management and carbon dioxide removal, WIREs Climate Change 4(1) (2012) 23-37.

[11] H. Shaftel, NASA Climate Change and Global Warming,  (November 17, 2021).

[12] Nfwpcap, National Fish Wildlife and Plants Climate Adaptation Strategy, (2012).