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Climate Change: An Alarm to The Oceans?

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ABSTRACT

Climate change affects all areas of the Earth, with oceans experiencing significant impacts causing irreversible alterations in marine ecosystems, biodiversity, and coastal communities. The oceans, which absorb around 90% of the excess heat from global warming, are facing rising temperatures, acidification, and shifting currents, all of which disrupt marine life. This article examines the diverse impacts of climate change on the oceans, including the degradation of vital ecosystems like coral reefs, mangroves, and seagrasses, which are crucial for carbon storage, coastal protection, and biodiversity. It also looks at the consequences of rising sea levels, marine heatwaves, and the loss of marine species on both the environment and the human populations that rely on the oceans for food, livelihoods, and cultural heritage. With insights from current research and international policies, the article highlights the iminent need for global collaboration and innovative solutions to handle these challenges and protect the health of the oceans, which are central to the Earth's climate system and the future well-being of humanity.

Keywords*: Climate Change, Sea Level Rise, Ocean Acidification, Marine Biodiversity.*

I. INTRODUCTION

According to the UN Climate Change report, the ocean has borne much of the impact of anthropogenic global warming. As the Earth's largest carbon sink, the ocean absorbs much of the excess heat and energy from greenhouse gas emissions. Currently, it has absorbed approximately 90% of the heat produced by rising emissions. This accumulation of heat within the ocean catalyzes numerous cascading effects, such as ice melt, rising sea levels, marine heatwaves, and ocean acidification.[2]

These processes have profound, enduring effects on marine biodiversity and on communities worldwide, particularly those situated in low-lying coastal regions. These communities, comprising about 680 million individuals, include approximately 2 billion people residing in coastal megacities and nearly half of the world’s population who depend on marine resources,

The ocean is integral to the global environment, influencing global climate and weather patterns and supporting extensive biodiversity. Healthy marine ecosystems supply food,

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[2] UN, Climate Change: Ocean Impacts, UNITED NATIONS, https://www.un.org/en/climatechange/science/climate-issues/ocean-impacts (last visited Nov. 7, 2024).

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medicines, employment, and recreational spaces, fostering a connection to nature that is especially significant in many Indigenous cultures.

Oceans generate approximately 50% of the oxygen needed for life on Earth, absorb 25% of global co2 emissions, and capture 90% of the excess heat created by these emissions. The ocean is not only considered the "lungs of the planet" but also serves as the largest carbon sink, providing an essential buffer against the effects of climate change. However, rising greenhouse gas emissions are threatening the ocean's health, causing seawater to warm and become more acidic. These changes harm both marine and land ecosystems, diminishing the ocean's ability to absorb carbon dioxide and maintain ecological equilibrium.

II. NEED TO SAFEGUARD THE OCEAN

Oceanic habitats like seagrasses and mangroves, along with the diverse food webs they sustain, can absorb atmospheric carbon dioxide at rates up to four times higher than land-based forests. This carbon capture ability makes mangroves especially important for combating climate change. As some of the most carbon-dense ecosystems on Earth, mangroves can store an average of 1,000 tonnes of carbon per hectare in their biomass and soil. In addition to carbon storage, mangroves support healthy fisheries, improve water quality, and offer coastal protection against floods and storm surges.[3]

1. Coral reefs, although covering less than 0.1% of the world’s oceans, are crucial both ecologically and economically. They support over 25% of marine biodiversity and provide essential benefits to nearly a billion people, including coastal protection, fisheries, medicinal resources, recreational spaces, and tourism revenue. Marine protected areas (MPAs) are vital for maintaining ocean health, and they currently cover about 6.35% of the ocean, a nearly tenfold increase since 2000. Expanding these areas is key to preserving coral reefs, mangroves, and ensuring the ocean’s resilience to climate change.
2. The ocean also offers great potential for renewable energy. Offshore wind and ocean energy, derived from natural sources like wind, water, and tides, produce no carbon emissions. Offshore wind energy, harnessed through turbines that convert wind into electricity, has made significant strides and could meet over one-third of global energy needs. The first offshore wind farm was established in Denmark. Ocean energy, which taps into the kinetic and thermal energy of seawater, is still in development, with

[3] UN, Climate Change: Ocean, UNITED NATIONS, https://www.un.org/en/climatechange/science/climate-issues/ocean (last visited Nov. 7, 2024).

ongoing exploration of wave and tidal energy systems. This renewable source holds the potential to meet and even exceed current energy demands.

3. In the shipping industry, about 80% of global trade is transported by sea, contributing nearly 3% of global GHG emissions. Achieving zero emissions in maritime shipping by 2050 is essential for climate mitigation. This transition involves shifting from fossil fuels to zero-emission energy sources like hydrogen, ammonia, methanol, or wind. Green shipping corridors—maritime routes connecting ports that support zero-emission technologies—are accelerating this decarbonization effort. By fostering innovation in zero-emission technologies and promoting sustainable fuels, the shipping sector's decarbonization can fuel green economic growth worldwide, contributing to a sustainable blue economy that balances economic progress with ocean health.
4. Coastal communities, which account for over 680 million people (about 10% of the global population), live in low-lying areas highly vulnerable to climate change. Especially in small island nations, these communities face a much higher risk of fatalities from floods and storms—up to 15 times more likely than those in less vulnerable regions. Ocean-climate initiatives must prioritize reducing these risks and building resilience for ecosystems and coastal populations reliant on a healthy ocean. Effective adaptation measures include predictive risk assessments, early warning systems, and nature-based solutions to help communities cope with changing coastal environments.
5. Early warning systems, which allow for timely responses to natural hazards, are crucial for protecting lives and livelihoods from climate-related disasters. A 24-hour warning can reduce damage by 30%. However, one-third of the global population primarily in least developed countries and small island states still lacks access to these systems. The UN Secretary-General has tasked the World Meteorological Organization with ensuring that within five years, every person on Earth is covered by early warning systems, a key measure in addressing the growing extreme impacts of climate change.

III. ROLE OF OCEANS IN MITIGATING CLIMATE CHANGE

The oceans function as the largest heat sink on Earth, absorbing approximately 90% of the excess heat generated by climate change. They also serve as an efficient carbon sink, capturing around 23% of anthropogenic CO_2 emissions. Coastal ecosystems such as mangroves, tidal marshes, and seagrass meadows contribute substantially to this carbon sequestration, storing more carbon per unit area than terrestrial forests. Additionally, some carbon particles have been

sequestered in seabed sediments over thousands of years, though this phenomenon remains insufficiently understood and difficult to measure.

However, the role of oceans as a carbon sink is directly compromised by climate change's adverse impacts on ocean health, establishing a self-perpetuating cycle. Despite only beginning to grasp the vast ecological functions oceans provide, climate change is already disrupting these critical systems. This suggests that we are at the early stages of comprehending the full extent of climate change's potential damage to ocean health.[4]

IV. IMPACT OF CLIMATE CHANGE OVER THE OCEAN

Climate change poses a significant global threat to ocean health, compounding other persistent anthropogenic pressures—environmental changes driven by human activity. Advances in research have improved our understanding of these impacts, highlighting the extensive and multifaceted nature of the issue. Climate change is inducing critical shifts in oceanic conditions, including rising temperatures, sea level increases, and ocean acidification. As oceans absorb increased atmospheric CO_2, acidification intensifies, and oxygen levels decline. Moreover, alterations in ocean current patterns are becoming evident. Together, these changes compromise ocean health and affect marine species.[5]

(A) Rise in Sea Level

One of the most significant impacts of climate change, especially global warming, on the ocean is the rise in sea levels. This increase is driven by two main factors: first, higher temperatures cause the melting of ice sheets and glaciers, adding more water to the ocean. Second, as seawater warms, it expands, taking up more space. Since 1880, sea levels have risen by more than 23 cm, with approximately 6 cm of that increase occurring since 1993, highlighting the rapid pace of human-induced climate change. Current projections show that global sea levels are now rising at a rate of over 2.5 cm per decade.[6]

In recent years, the pace of sea-level rise has quickened, largely due to accelerating ice loss in polar regions. The World Meteorological Organization reported that, as of 2021, the global mean sea level had reached an unprecedented high, with an average annual rise of 4.5 millimeters from 2013 to 2021. Alongside more intense tropical cyclones, rising sea levels

[4] Ibid.

[5] What You Need to Know About Oceans and Climate Change, WORLD BANK, https://www.worldbank.org/en/news/feature/2022/02/08/what-you-need-to-know-about-oceans-and-climate-change (last visited Nov. 7, 2024).

[6] International Fund for Animal Welfare, *The Impact of Climate Change on the Ocean*, https://www.ifaw.org/international/journal/climate-change-impact-ocean (last visited Nov. 8, 2024).

contribute to extreme events, including severe storm surges and coastal hazards such as flooding, erosion, and landslides, now expected to occur annually in numerous regions—whereas such events historically happened only once per century.

(B) Marine heatwaves[7]

Marine heatwaves, defined as "extended periods of unusually high ocean temperatures, are increasing in duration, frequency, and intensity due to climate change. These heatwaves can last from days to months, impacting vast areas of the ocean and reaching depths of several hundred meters. Much like terrestrial heatwaves affect humans, marine heatwaves severely impact ocean ecosystems."

The frequency and intensity of marine heatwaves have doubled, becoming longer and more widespread. According to the IPCC, human activities have been the primary cause of ocean warming since the 1970s. One of the most prominent impacts of rising ocean temperatures and marine heatwaves is coral bleaching. This phenomenon occurs when corals, under prolonged heat stress, expel the symbiotic algae that live in their tissues. Without these algae, corals lose their main food source, become more susceptible to diseases and pollution, and have a higher risk of mortality. Dead, bleached coral reefs, marked by a stark white color, no longer support the diverse marine life they once did and lose their ability to absorb atmospheric carbon dioxide.

The Arctic is especially vulnerable to warming, which disrupts its marine ecosystem. For example, narwhals face decreased prey availability due to melting sea ice, while new species entering the ecosystem due to warming may increase competition for resources.

(C) **Ocean acidification**

Ocean acidification, though not as widely acknowledged, is a serious effect of climate change that poses a threat to marine ecosystems worldwide. The ocean plays a key role as a carbon sink, absorbing large amounts of atmospheric CO_2. However, it can only absorb so much before its ecosystems are negatively affected. When CO_2 dissolves in seawater, it reacts with water to form carbonic acid, which lowers the pH and increases the ocean's acidity. This process, known as ocean acidification, has caused the average pH of seawater to shift from a more alkaline 8.2 to a more acidic 8.1. While this change might seem small, it represents a 25% increase in acidity over the past two centuries.

Ocean acidification presents significant risks to marine life, especially species that depend on

[7] Ibid.

calcium carbonate to build their shells or skeletons, such as corals, shellfish, and certain plankton. As the water becomes more acidic, their calcium carbonate structures dissolve more quickly. This weakens their shells, making them more susceptible to physical damage, disease, and predation. Additionally, these organisms must use extra energy to repair or strengthen their shells, limiting their growth and development, which disrupts the food web and reduces food sources for predators.[8]

Moreover, these calcium carbonate-based organisms naturally store carbon, helping to reduce atmospheric CO_2 levels. However, as acidification weakens their shells, this important carbon-sequestration function is compromised, reducing the ocean's ability to mitigate climate change.

(D) Loss of marine biodiversity

Biodiversity encompasses the vast range of life forms, genetic diversity, habitats, and ecological interactions that support life on Earth. In marine environments, biodiversity is critical for sustaining the health of ocean ecosystems and the multitude of species within them. Additionally, marine biodiversity plays a vital role in supporting global ecological functions, such as oxygen production, carbon storage, nutrient cycling, and climate regulation. Human activities also benefit significantly from marine biodiversity, including fisheries, tourism, and the discovery of new pharmaceuticals.[9]

As temperatures rise, the likelihood of irreversible damage to marine and coastal ecosystems increases. Observed impacts include degradation of essential habitats, such as coral reefs and mangroves, which are crucial to marine life. Species are shifting to higher latitudes and altitudes, seeking cooler waters. According to UNESCO, over half of marine species may face extinction by 2100. With a current global temperature increase of 1.1°C, approximately 60% of marine ecosystems are either degraded or unsustainably exploited. A 1.5°C rise could destroy 70-90% of coral reefs, while a 2°C increase risks a nearly total loss, representing an ecological tipping point.

Climate change has significantly affected ocean biodiversity, both directly and indirectly, through rising sea levels, increasing temperatures, ocean acidification, and other factors. One of the most visible impacts is on coral reefs, often referred to as the "rainforests of the sea," which host more than 25% of marine species, including thousands of fish species, as well as turtles, plants, invertebrates, and marine mammals. Climate-driven disruptions to coral reef

[8] International Fund for Animal Welfare, Climate Change Impact on the Ocean, https://www.ifaw.org/international/journal/climate-change-impact-ocean.
[9] ibid

ecosystems lead to coral die-offs, removing food and shelter for reef-dependent species and jeopardizing their survival. The IPCC projects that a global temperature increase of 1.5°C will eliminate 70-90% of coral reefs, with a 2°C rise leading to the loss of nearly all reefs.

(G) Community livelihood impacts

Communities worldwide depend on fishing and other marine-related activities for their livelihoods, with the ocean being central to their income and well-being. Climate change-induced shifts in ocean temperatures can alter the distribution of fish and other marine species, which can severely affect these vulnerable coastal populations. Rising sea temperatures can further exacerbate existing challenges such as shoreline erosion, flooding, and water pollution, putting additional strain on communities that are already struggling to maintain their livelihoods.

Moreover, climate change contributes to rising sea levels due to the ongoing melting of oceanic ice. This rise in sea levels will amplify the flooding risks these communities face and increase the intrusion of saltwater into crucial freshwater sources. Additionally, the rising seas threaten key wetlands and marshes, which play vital roles in protecting water quality, storing floodwater, reducing erosion, and providing habitats for wildlife.

To address these challenges, supporting community-led conservation and management initiatives is essential. By empowering local communities to create climate-resilient seascapes, we can help both human populations and wildlife thrive. These efforts also contribute to the capture and storage of atmospheric CO2, aiding in the mitigation of climate change.

(H) Changes in migratory patterns

Climate change is also altering the migration patterns of marine species, affecting when, where, and how they move. A notable example is the critically endangered North Atlantic right whale, which has been migrating further north into eastern Canada, including the Gulf of St. Lawrence. This shift is likely driven by rising ocean temperatures. Similarly, beluga whales are experiencing disruptions to their migration routes through Arctic waters, as unpredictable ice patterns caused by climate change pose new challenges. Some belugas have even become trapped in ice due to its rapid melting.

V. INTERNATIONAL CONVENTIONS ON CLIMATE CHANGE OVER OCEANS

Several international agreements focus on the impact of climate change on oceans, underscoring the importance of safeguarding marine ecosystems, addressing the consequences of rising sea levels, and ensuring the sustainable management of oceans amidst climate change.

Some of them are:

1. **Ramsar Convention on Wetlands, 1971**[10] : The Ramsar Convention primarily addresses wetland conservation, many of which are coastal ecosystems that are vulnerable to climate change. Coastal wetlands like mangroves, salt marshes, and seagrasses face risks from rising sea levels and ocean acidification. The convention stresses the importance of these wetlands for biodiversity and as natural barriers against the impacts of sea-level rise and storm surges, encouraging signatory countries to protect such critical areas, particularly in coastal regions.
2. **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973**[11] : CITES addresses the international trade in endangered species, including those in marine environments, many of which face heightened threats from climate change, such as coral bleaching, ocean acidification, and habitat destruction. The convention provides legal protections for endangered marine species like sea turtles, whales, and corals, which are increasingly vulnerable to climate-related impacts.
3. **Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention), 1976**[12] : Focused on the Mediterranean Sea, the Barcelona Convention has been expanded to address the impacts of climate change on marine ecosystems. The convention aims to reduce pollution and tackle climate-induced threats like ocean acidification and rising sea levels. Its Integrated Coastal Zone Management (ICZM) protocol encourages the development of strategies to safeguard coastal areas from climate change, promoting the conservation of marine biodiversity under increasing climate-related stress.
4. **United Nations Convention on the Law of the Sea (UNCLOS) 1982**[13] : UNCLOS is a broad legal framework that governs the use and protection of oceans and their resources. Though established before widespread recognition of climate change, it remains a crucial tool for defining the rights and duties of states regarding ocean conservation. The convention provides a basis for the creation of marine protected areas (MPAs) and the management of transboundary challenges like rising sea levels and

[10] Convention on Wetlands of International Importance Especially as Waterfowl Habitat, Jan. 21, 1971, 996 U.N.T.S. 245.
[11] Convention on International Trade in Endangered Species of Wild Fauna and Flora, Mar. 3, 1973, 993 U.N.T.S. 243.
[12] Convention for the Protection of the Mediterranean Sea Against Pollution, Feb. 16, 1976, 1102 U.N.T.S. 27.
[13] United Nations Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 3.

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biodiversity loss. It also tasks the International Seabed Authority with overseeing seabed mineral resources, addressing environmental concerns related to deep-sea mining that may be intensified by climate change.

5. **United Nations Framework Convention on Climate Change (UNFCCC), 1992**[14] : The UNFCCC highlights the significance of oceans in the global climate system and calls for actions to mitigate the effects of climate change on marine ecosystems, particularly concerning sea level rise, ocean acidification, and the disruption of marine biodiversity. While the UNFCCC does not exclusively focus on oceans, it serves as the principal international framework for addressing climate-related impacts on oceans, including decisions made at the annual Conference of the Parties (COP). The convention urges parties to adopt measures to reduce greenhouse gas emissions contributing to ocean warming and acidification, and promotes international cooperation on adaptation and mitigation, particularly in vulnerable coastal regions.
6. **Convention on Biological Diversity (CBD), 1992**[15] : The CBD acknowledges climate change as a significant threat to biodiversity, including marine species and ecosystems, and calls for international cooperation on both mitigation and adaptation strategies. Its Aichi Biodiversity Targets highlight the need to conserve marine biodiversity and adapt to climate impacts in vulnerable coastal and marine ecosystems. The CBD urges the development of strategies for protecting marine biodiversity, including coral reefs, mangroves, and seagrasses, and emphasizes sustainable fisheries management and ecosystem-based conservation approaches.
7. **Cartagena Protocol on Biosafety, 2000**[16] : While focusing on protecting biodiversity from genetically modified organisms (GMOs), the Cartagena Protocol also acknowledges the risks that climate change poses to marine ecosystems, particularly through the introduction of GMOs and other biotechnologies. It urges parties to implement measures to safeguard the marine environment from potential biodiversity impacts, which could be exacerbated by climate change.
8. **Paris Agreement (under the UNFCCC), 2015**[17] : The Paris Agreement stresses the need to address climate change's effects on oceans, specifically to reduce global temperature rise and mitigate its impacts, such as ocean warming, acidification, and

[14] United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 107.
[15] Convention on Biological Diversity, June 5, 1992, 1760 U.N.T.S. 79.
[16] Cartagena Protocol on Biosafety, Jan. 29, 2000, 2226 U.N.T.S. 208.
[17] Paris Agreement, Dec. 12, 2015, 52 I.L.M. 762.

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rising sea levels. It calls for limiting global temperature rise to below 2°C, ideally to 1.5°C, to reduce the severity of these oceanic effects. The agreement recognizes the particular vulnerability of small island developing states (SIDS) and coastal nations and encourages countries to incorporate ocean considerations in their climate adaptation strategies, especially for vulnerable marine ecosystems like coral reefs.

VI. CONCLUSION

The impact of climate change on oceans is both profound and multifaceted, affecting marine ecosystems, biodiversity, and the livelihoods of millions of people who depend on the sea. Rising ocean temperatures, acidification, sea-level rise, and marine heatwaves are some of the most critical consequences of climate change, leading to widespread coral bleaching, habitat loss, and the disruption of food chains. These changes not only threaten marine life but also the broader global environment, as oceans play a key role in regulating climate by absorbing heat and carbon dioxide.

The degradation of ocean health has far-reaching implications for coastal communities, which are increasingly vulnerable to flooding, storms, and erosion. Moreover, the economic and ecological benefits of healthy oceans, from fisheries to tourism, are at risk. Protecting and restoring marine ecosystems, such as coral reefs, mangroves, and seagrasses, is crucial for mitigating these impacts and enhancing the resilience of both marine and human systems.

To address these challenges, global efforts must focus on reducing greenhouse gas emissions, expanding marine protected areas, and supporting sustainable marine practices. Only through concerted international action and a holistic approach to ocean conservation can we ensure the long-term health of our oceans and the survival of both marine life and the communities that rely on them. Time is of the essence, and the protection of our oceans is an essential component of the global strategy to combat climate change and safeguard the future of the planet.

International conventions addressing climate change's impact on oceans are crucial for ensuring the protection and sustainability of marine ecosystems in the face of rising sea levels, ocean acidification, and other climate-related changes. They provide the legal frameworks and mechanisms for nations to collaborate on mitigating the effects of climate change on oceans, while also supporting adaptation efforts for vulnerable coastal populations and ecosystems. However, the effectiveness of these conventions often depends on strong international cooperation and implementation at the national and local level.

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