Forum: Environmental Commission (ENV)

Question of: Measures to address ocean acidification

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Introduction

For decades, the ocean has served as a critical buffer against global warming, and the amount of atmospheric carbon dioxide has largely remained in stasis over the past 10,000 years.[1] However, the ever-increasing use of fossil fuels since the Industrial Revolution has caused the concentration of such carbon dioxide to reach unprecedented, high levels, leaving the ocean to absorb the lethal products of human activity and, consequently, acidify.

When carbon dioxide is absorbed by ocean water, a series of chemical reactions involving fundamental building blocks of marine life occur, resulting in the increased concentration of hydrogen ions—the determinant of acidity. Over the last three centuries, the earth's oceans have soaked up roughly a quarter of the carbon dioxide emitted into the atmosphere,[2] and scientists have estimated that the average pH of ocean water has decreased from 8.19 to 8.05.[3] With the pH scale being logarithmic, this change corresponds to a 30 percent increase in acidity—a pace deemed approximately 100 times more rapid than at any other period during the past 650,000 years.[3] The significance of this environmental issue lies in its unparalleled speed of exacerbation; modern-day ocean acidification is thought to prevail the fastest it has been within the last 20 million years,[4] as opposed to similar but natural pH changes in the past that surfaced over longer periods of time. The most recent instance of a comparably low ocean pH was 14 to 17 million years ago during the middle Miocene, where the earth was several degrees warmer and experiencing a major extinction event.[5] With projections of future atmospheric carbon dioxide levels based on current emission situations predicting a greater infusion of carbon dioxide into the oceans, pH

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[1] EPA, "Understanding the Science of Ocean and Coastal Acidification," EPA (Environmental Protection Agency, June 3, 2022), https://www.epa.gov/ocean-acidification/understanding-science-ocean-and-coastal-acidification.
[2] Brad Plumer, "The World's Oceans Are in Danger, Major Climate Change Report Warns," The New York Times (The New York Times, September 25, 2019), https://www.nytimes.com/2019/09/25/climate/climate-change-oceans-united-nations.html.
[3] John P Rafferty, "Ocean Acidification," Encyclopædia Britannica (Encyclopædia Britannica, inc., March 28, 2020), https://www.britannica.com/science/ocean-acidification.
[4] "What Is Ocean Acidification?," Natural History Museum, accessed July 2, 2022, https://www.nhm.ac.uk/discover/what-is-ocean-acidification.html.
[5] "Ocean Acidification," National Oceanic and Atmospheric Administration, April 1, 2020, https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-acidification.

ought to decline further, and—at the very worst—plummet to between 7.8 and 7.9 by the end of the century.[3]

As a part of global climate change, ocean acidification shares many causes with the infamous environmental threat. Narrowing the causes down to the root origins, there are two main sources of such influx of atmospheric carbon dioxide into the ocean: fossil fuel emissions and deforestation. As aforementioned, fossil fuels are significant contributors of carbon dioxide emissions, and the consumption of such energy sources has risen exponentially since the Industrial Revolution and engendered many environmental concerns, including ocean acidification. Deforestation is a two-fold issue. Purposeful clearing of forested land not only releases excess carbon dioxide but also rids the earth of critical "carbon sinks." In the past, the earth was naturally able to maintain appropriate carbon dioxide levels because plantlife's absorption of carbon dioxide was more than enough to offset naturally produced amounts of the compound. As this plantlife is obliterated, however, the earth loses its ability to regulate atmospheric emissions, resulting in the accumulation of carbon dioxide in oceans.[6]

This process of acidification has marked implications for the ocean and its inhabitants. Increases in ocean acidity cause a decline in seawater concentrations of carbonate ion and aragonite — a major source of calcium carbonate. In the worst-case scenario where pH falls to 7.8, carbonate ion concentrations are predicted to decrease by at least 50 percent. According to marine scientists, if ocean acidification continues at current rates, marine calcifiers—organisms that use carbonates—and other marine life forms are expected to suffer life-threatening damage. They will have substantially less nutrients to maintain their skeletons and shells and, thus, will not be able to invest enough energy into growth and reproduction.[4] Laboratory experiments have proven such hypotheses, showing that organisms placed in a simulation with pH 7.8 seawater underwent less growth than those placed in current levels of acidity at pH 8.05. As the crisis escalates, some organisms will encounter problems even more acute, as researchers have already detected severe levels of marine calcifiers' shell dissolution in the Southern Ocean.[5] Types of fish, squid, and other larger organisms are also not barred from the effects of acidification; an increase in carbonic acid concentrations in their body fluids can burgeon into acidosis, a condition that may impair animal respiration as well as growth.[3]

Furthermore, if oceanic pH continues to decline, the earth's coral reefs, regarded as one of the greatest centers of marine biodiversity, could take a toll and even go extinct. According to a 2020 United

[6] "Climate Interpreter," How are humans causing ocean acidification? | Climate Interpreter, December 20, 2018, https://climateinterpreter.org/content/how-are-humans-causing-ocean-acidification.

Nations (UN) report[7] on the state of the world's corals, the earth lost roughly 14 percent of its coral reefs in the decade after 2009. For a coral reef to grow, it must produce calcium carbonate at a rate faster than its speed of erosion. However, with ocean acidification hindering calcium carbonate generation, conditions place a significant impediment for the development of coral skeletons. Though reefs cover only a small fraction of the ocean floor, it must not translate as a reason for human neglect. Their calcium carbonate branches protect coasts from storms; their fish serve as a vital protein source for millions; and their beauty fosters major tourist attractions. Combined, the coral reefs support an estimated $2.7 trillion per year in services and goods, and, hence, the risk of economic and social problems cannot be ignored.[8]

Disruptions in ocean ecosystems, as mentioned, could result in ripple effects, spreading to affect the economic health and prosperity of many nations. Though acidification is predicted to be most severe in the world's most highly productive and important commercial fisheries, it is a threat to all nations that catch or consume fish and depend on reefs for various purposes. In fact, more than a third of the world's population will be significantly affected by acidification, and, ironically, the world's largest carbon dioxide emitters are among the most vulnerable.[9]

Despite Sustainable Development Goal (SDG) 14.3's call for the minimization of the "impacts of acidification, including through enhanced scientific cooperation at all levels,"[10] to date, ocean acidification is yet to be explicitly included in the mandates of any international treaty, including the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention on the Law of the Sea (UNCLOS), and the Convention on Biological Diversity (CBD). Though the Paris Agreement set a target of limiting average global warming to below 2 degrees Celsius above pre-industrial levels, it does not seek a goal for limiting oceanic pH change, and states still have significant discretion on what environmental action they take with no explicit requirement to address carbon dioxide separately from other greenhouse gas emissions.[11] In 2020, the United States Congress

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[7] Global Coral Reef Monitoring Network (GCRMN), "The Sixth Status of Corals of the World: 2020 Report," GCRMN, February 25, 2022, https://gcrmn.net/2020-report.
[8] Catrin Einhorn, "Climate Change Is Devastating Coral Reefs Worldwide, Major Report Says," The New York Times (The New York Times, October 5, 2021), https://www.nytimes.com/2021/10/04/climate/coral-reefs-climate-change.html.
[9] Ellycia Harold-Koleib, Michael Hirshfield, and Ashley Brosius, "Major Emitters among Hardest Hit by Ocean Acidification," Oceana - Protecting the World's Oceans, December 2009, https://oceanfdn.org/sites/default/files/Acidity%20Vulnerability%20Risk%20Report.pdf.
[10] SDG Tracker, "Goal 14: Life below Water - SDG Tracker," Our World in Data, 2018, https://sdg-tracker.org/oceans.
[11] Karen Scott, "COP26 Failed to Address Ocean Acidification, but the Law of the Seas Means States Must Protect the World's Oceans," The Conversation, May 4, 2022, https://theconversation.com/cop26-failed-to-address-ocean-acidification-but-the-law-of-the-seas-means-states-must-protect-the-worlds-oceans-171949.

increased its fiscal budget for ocean acidification research and monitoring from $6 million in 2014 to $14 million, but experts have expressed that even more is needed.[12] The global spotlight currently shines on the earth's rising temperatures, and shrouded is the urgent ocean acidification crisis.

Evidently, unless more is done to curb the issue at hand, our marine systems are on the path to undergo unprecedented shifts, heading toward the annihilation of ecosystems that could rival past mass extinction events. The choices made today regarding ocean acidification and carbon dioxide emissions stand to impact the very future of life on this planet, even though the worst effects may still feel distant.

Definition of Key Terms

Ocean Acidification

Ocean acidification is defined as the worldwide reduction in the pH value of ocean water, caused by the uptake of carbon dioxide from the atmosphere. It is often broached as "climate change's evil twin" in view of its far-reaching impacts, and is projected to exacerbate as human activity continues to pump carbon dioxide into the atmosphere at record-high levels.[3]

pH

pH is the quantitative measure of hydrogen ion concentration and, hence, the acidity or alkalinity of aqueous or other liquid solutions. The pH scale usually ranges from 0 to 14. Aqueous solutions at 25 degrees Celsius with a pH less than 7 are acidic, while those with a pH greater than 7 are basic or alkaline.[13] With projections of future atmospheric carbon dioxide levels predicting a greater infusion of carbon dioxide into the oceans, seawater pH is bound to decline further, and—at the very worst—plunge to between 7.8 and 7.9 by the end of the century.[3] Compared to the ideal seawater pH, 8.2, the predicted numbers are deemed serious sources of concern, taking into account the pH scale's logarithmic nature.

Carbon Dioxide

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. Although carbon dioxide naturally exists in the atmosphere, emissions have now reached levels that threaten global climate stability, hence the term "climate change."[14] The ocean absorbs roughly a quarter of the carbon dioxide that is released into the atmosphere, and as levels increase from burning fossil fuels,

[12] Thomas Frank, "Ocean Acidification Threatens the U.S. Economy," Scientific American (Scientific American, January 3, 2020), https://www.scientificamerican.com/article/ocean-acidification-threatens-the-u-s-economy.
[13] The Editors of Encyclopedia Britannica, "PH," Encyclopædia Britannica (Encyclopædia Britannica, inc., June 3, 2020), https://www.britannica.com/science/pH.
[14] Mann, Michael E. "Greenhouse Gas." Encyclopædia Britannica. Encyclopædia Britannica, inc., March 19, 2019. https://www.britannica.com/science/greenhouse-gas.

deforestation, and other factors, greater carbon dioxide accumulates in seawater. This triggers a cascade of chemical reactions, causing a drop in pH and the numerous consequences of acidification.[2]

Climate Change

Since the beginning of the Industrial Revolution, human activity has had a devastating impact on Earth's climate. From shifts in weather patterns to ocean acidification, concerns previously dismissed because of its "marginal" impacts on human life have now burgeoned into real, tangible threats.[15] Climate change is no longer an issue of the distant future, with inescapable, human-induced ocean acidification pushing our planet toward a dead end. As the severity of this issue escalates, it is crucial that every sector of society contributes to averting such calamities.

Biodiversity Loss

Biodiversity, the variety of all living forms on our planet, has been in rapid decline over the past few years, with over one million species on the brink of extinction. As ocean acidification obliterates marine habitats and transforms landscapes, this unprecedented loss is projected to exacerbate if society goes along the same path. If oceanic pH continues to decline, major biodiversity centers like the earth's coral reefs could decline and present severe consequences to society and the environment.[16]

Deforestation

Deforestation refers to the removal of forests or large groups of trees for purposes including urban development, agriculture, and wood extraction. This destruction of trees not only releases atmospheric carbon dioxide but also limits the planet's ability to absorb carbon dioxide emissions, thus jeopardizing the benefits of forests and exacerbating ocean acidification. However, amid rapid modernization and urban development, deforestation has settled as an almost inevitable part of global advancement, and it has become yet another obstacle to the alleviation of the acidification crisis.[17]

Timeline of Key Events

1760 - 1840 - The Industrial Revolution

The Industrial Revolution is defined as the period of development in the late 18th century that transformed agrarian and handicraft economies to ones dominated by machine manufacturing and

[15] "The Effects of Climate Change," NASA (NASA, August 26, 2021), https://climate.nasa.gov/effects/.
[16] Briggs, Helen. "Biodiversity: Why the Nature Crisis Matters, in Five Graphics." BBC News. BBC, September 30, 2020. https://www.bbc.com/news/science-environment-54357899.
[17] National Geographic Society, "Deforestation," National Geographic Society, May 20, 2022, https://education.nationalgeographic.org/resource/deforestation.

industry.[18] Unfortunately, such a revolutionary change in society is fated to have an inevitable corollary, which, in this case, is environmental damage. The increased use of fossil fuels since this time has caused the concentration of carbon dioxide to reach unprecedented, high levels, leaving the ocean to absorb the lethal products of human activity and, consequently, acidify. Scientists have estimated that the pace of acidification since the beginning of the Industrial Revolution is roughly 100 times more rapid than at any other period during the past 650,000 years.[3]

December 10, 1982 - United Nations Convention on the Law of the Sea (UNCLOS)

The United Nations Convention on the Law of the Sea (UNCLOS) is an international agreement that established a legal framework for all marine and maritime activities with 167 countries and the European Union as parties.[19] This treaty has been recognized as an agreement that could be used to regulate emissions and thus mitigate ocean acidification. Under Article 212 of UNCLOS, states must take all measures necessary to "prevent, reduce, and control pollution of the marine environment" from any source. Carbon dioxide can be classed as pollution under UNCLOS, and, therefore, states have an obligation to limit or control it. However, as previously stated, ocean acidification is not explicitly mentioned, and Article 212 only stipulates countries should take into account internationally agreed standards and rules.[10]

September 25, 2015 - Adoption of the Sustainable Development Goals (SDGs)

In 2015, all United Nations Member States ratified and adopted the 17 Sustainable Development Goals (SDGs)—a blueprint toward an ultimate sustainable future for all. The goals outline solutions for topics including climate change, poverty, education, economic development, and inequality, and the framework serves as a universal call for action to ensure a brighter future by 2030. Specifically, SDG 14.3 highlights ocean acidification, calling for the minimization of the "impacts of acidification, including through enhanced scientific cooperation at all levels."[20]

December 12, 2015 - Adoption of the Paris Agreement

On 12 December, 2015, 196 parties at the 2015 United Nations Climate Change Conference (COP 21) adopted the Paris Agreement, a legally binding international treaty on climate change. Its

[18] The Editors of Encyclopedia Britannica, "Industrial Revolution," Encyclopædia Britannica (Encyclopædia Britannica, inc., March 13, 2022), https://www.britannica.com/event/Industrial-Revolution.
[19] "United Nations Convention on the Law of the Sea," International Maritime Organization, 2019, https://www.imo.org/en/OurWork/Legal/Pages/UnitedNationsConventionOnTheLawOfTheSea.aspx.
[20] "The 17 Goals | Sustainable Development," United Nations (United Nations), accessed July 2, 2022, https://sdgs.un.org/goals.

primary goal is to cap global warming to below 2 ℃ compared to pre-industrial levels.[21] However, as aforementioned, the Paris Agreement did not set goal for limiting oceanic pH change, and states still have significant discretion on what environmental action they take with no explicit requirement to address carbon dioxide separately from other greenhouse gas emissions.[10]

May 18, 2022 - World Meteorological Organization's (WMO) The State of the Global Climate 2021 Report

On 18 May, 2022, the World Meteorological Organization (WMO), a specialized agency of the United Nations, released their flagship annual climate report, providing details of climate indicators such as temperatures, ocean heat, ocean acidification, sea level rise, sea ice glaciers and extreme weather. According to the report, global oceans peaked in both temperature and acidity on record in 2021, and the organization confirmed that ocean pH levels have reached the lowest point in at least 26,000 years.[22]

Position of Key Member Nations and Other Bodies

United States of America

As the world's second largest and highest historical carbon dioxide emitter, the United States is a significant contributor to global climate change. Yet, the nation ranks eighth in terms of ocean acidification vulnerability, with the change in seawater composition predicted to disrupt the country's fish consumption and catch.[9] In fact, the waters off California are acidifying twice as rapidly as elsewhere on earth, suggesting hastened chemical changes within the United States of America's exclusive economic zones.[23] Thankfully, the government has recognized such concerns and has been proactive in taking steps toward the cause; the United States Environmental Protection Agency is working to address pollutants—such as carbon dioxide and other acid-forming nutrients—that are causing ocean acidification through special monitoring practices and simulations that predict the phenomenon's socioeconomic impacts.[24] Though the United States Congress increased its fiscal budget for ocean acidification research

[21] UNFCCC, "The Paris Agreement," Unfccc.int, accessed July 2, 2022, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.
[22] Emma Newburger, "Earth's Oceans Have Reached the Hottest and Most Acidic Levels on Record, Un Says," CNBC (CNBC, May 19, 2022), https://www.cnbc.com/2022/05/19/oceans-reached-record-heat-acidity-in-2021-un-report-.html.
[23] Denise Chow, "The World's Oceans Are Acidifying - but It's Happening Twice as Fast off California," NBCNews.com (NBCUniversal News Group, December 17, 2019), https://www.nbcnews.com/science/environment/world-s-oceans-are-acidifying-it-s-happening-twice-fast-n1102901.
[24] "What EPA Is Doing to Address Ocean and Coastal Acidification," EPA (Environmental Protection Agency, July 6, 2022), https://www.epa.gov/ocean-acidification/what-epa-doing-address-ocean-and-coastal-acidification.

and monitoring from $6 million in 2014 to $14 million in 2020, experts have expressed that even more is needed.[11]

Australia

Because of its large area of coral reefs and highly acidified waters, Australia has been proactive in researching the state of ocean acidification. The State of the Climate report revealed that the average pH of Australia's surface waters declined by approximately 0.12 between 2010 and 2019,[25] and a 2009 study found that the coral-building 69 reefs within the Great Barrier Reef complex—one of the seven natural wonders of the world—had dwindled by 14 percent since 1990. Another paper estimated that the Great Barrier Reef's coral cover is as low as 20 percent,[26] which could, in the future, strike the tourist sector of Australia's economy. With the Great Barrier Reef Marine Park attracting roughly 1.9 million yearly visits and producing more than A$5.4 billion to the economy,[27] in 2022, the Australian Government announced a further $1 billion investment towards protecting the ecosystem, investing in marine science, and mitigating pollution, hoping to protect and ensure their safe management of the national treasure.

United Kingdom

The United Kingdom ranks as the third most vulnerable nation to ocean acidification due, in large part, to it having the tenth largest fishery catch within its exclusive economic zone and studies predicting extremely acidified waters near the island in 2050. However, though there is noteworthy ocean acidification research being carried out within the country, the integration of the topic into legislation and policies seems to be deficient. Climate change programs are in place, but the country's experts hold that such broad acts and programs will not suffice to combat ocean acidification, with the issue deemed a mere "risk" arising from a changing climate.[28]

Japan

Out of the 187 nations considered in a study, Japan ranks as the most vulnerable nation to the effects of ocean acidification, largely because of its involvement in the fishery industry as one of the ten largest fish consumers and catchers. Japan also has the 32nd largest percentage of coral reef area in the

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[25] Fiona Brown and Chris Garbing, "Ecos - the State of Ocean Acidification," ECOS, November 25, 2020, https://ecos.csiro.au/the-state-of-ocean-acidification/.
[26] Roz Pidcock, "Ocean Acidification: Decline of Great Barrier Reef Likely to Be Worse than Feared," Carbon Brief, April 16, 2021, https://www.carbonbrief.org/ocean-acidifiction-decline-of-great-barrier-reef-likely-to-be-worse-than-feared/.
[27] "Ocean Acidification and Its Effects," Coastadapt, April 27, 2017, https://coastadapt.com.au/ocean-acidification-and-its-effects.
[28] "UK Climate Change - Risk Assessment 2017 - GOV.UK," January 2017, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/584281/uk-climate-change-risk-assess-2017.pdf.

world, and its northern latitude exposes the country's marine species prone to the harms of low aragonite saturation.[22] However, despite these concerns, the country's government is yet to initiate any significant efforts to tackle the issue at hand; monitoring of its domestic seawater chemistry remains limited, and the dissemination of crucial acidification-related information to local communities and decision-makers seems to be lacking.[29]

People's Republic of China

As a signatory of the UNFCCC and Paris Agreement, China has shown its will to fulfill its international obligations in the field of climate change. The state is currently a part of negotiations on an international legally binding instrument on biodiversity, which implies China's interest in ocean acidification mitigation efforts.[30] However, delving deeper into the country's schemes, many find it rather easy to notice a dissonance in China's said intentions and the reality. As emphasized by the National Marine Economy Development Plan, the ocean is a significant economic asset to China. Over half of China's population resides along the coast, and this demographic composes 60 percent of the state's GDP. [31] Such economic benefits are likely the driving force behind China's mistreatment of ocean ecosystems; according to China's environment ministry, in 2018, the country dumped 200.7 million cubic meters of waste into its waters,[32] and experts raised their concerns that many regions are not showing much awareness or lacking strong initiative for the cause, instead desperate to clear the land of waste.[33]

Republic of Korea

As a peninsular region in contact with three seas, the Republic of Korea, or South Korea, cannot ignore the threats posed by ocean acidification. However, although South Korea ratified the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, the country has not made appreciable progress in the reduction of ocean pollution. In fact, South Korea deposited 2.02

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[29] Haruko Kurihara, "Risk Assessment and Management of Ocean Acidification Impacts on Japan's Coastal Habitats and Fisheries," The Pew Charitable Trusts, 2019, https://www.pewtrusts.org/en/projects/marine-fellows/fellows-directory/2019/haruko-kurihara.
[30] Jiayu Bai and Jiaxin Sui, "Chapter 15: Ocean Acidification and Chinas Response," Elgar Online: The online content platform for Edward Elgar Publishing (Edward Elgar Publishing, October 19, 2021), https://doi.org/10.4337/9781789900149.00025.
[31] Jingjing Gun and Jilan Su, "There's a Growing Focus on Ocean Resilience in China – and the Positive Impacts Could Be Global," World Economic Forum, May 26, 2021, https://www.weforum.org/agenda/2021/05/ocean-resilience-is-an-emerging-focus-in-china-with-positive-global-implications/.
[32] Beatriz Martinez Romera, "Chapter 5: Maritime Transport and Ocean Acidification," Elgar Online: The online content platform for Edward Elgar Publishing (Edward Elgar Publishing, October 19, 2021), https://www.elgaronline.com/view/edcoll/9781789900132/9781789900132.00013.xml.
[33] Muyu Xu and David Stanway, "China's Ocean Waste Surges 27% in 2018: Ministry," Reuters (Thomson Reuters, October 29, 2019), https://www.reuters.com/article/us-china-pollution-oceans-idUSKBN1X80FL.

million cubic meters of sewage from livestock farms, 1.61 million cubic meters of urban sewage, and 1.71 million cubic meters of leftover food in 2007.[34] Prompted by such alarming statistics, the country announced in early 2022 that it will "advance the operation of ocean acidification tracking" systems and help to "develop its national strategy" for areas where ocean acidification is rapidly evolving.[35]

Norway

Norway positively stands out in view of its proactive approach toward research and legislative frameworks to address ocean acidification. As a country that borders the Arctic Ocean currently taking in the adverse effects of acidification, Norway frequently includes the issue in its climate-related policies. In fact, the country has committed itself to many international programs and treaties that tackle ocean acidification and also encouraged research initiatives to specifically delve into the topic at hand. For example, the Norwegian Environmental Agency is responsible for the monitoring of ocean acidification within its ocean borders and collecting statistics on the ocean's conditions.[36] As the most diligent ocean acidification activist within the EU,[37] Norway seeks to further increase its efforts to tackle the issue.

Suggested Solutions

Ocean acidification is, without a doubt, a global issue with profoundly negative environmental, social, and economic consequences. However, despite the urgency of the problem and the ensuing detriments to human livelihood, the decline in seawater pH has long been sidelined with the escalation of climate change and other environmental concerns. Though the causes and effects of climate change, deforestation, and ocean acidification—to some extent—go hand in hand, the issue of and the measures necessary to tackle ocean acidification are unique and cannot be tied to the tail of traditional climate change initiatives. Hence, solutions tailored to the question at hand are imperative.

Evidently, there is yet to be any direct responses from the international community aimed at curbing ocean acidification, and this situation can be attributed to the paucity of research. Despite the

[34] Un-hoe Pak, "South Korea: Plan to Reduce Ocean Dumping," The Library of Congress, March 2, 2008, https://www.loc.gov/item/global-legal-monitor/2008-03-02/south-korea-plan-to-reduce-ocean-dumping/.
[35] Ministry of Oceans and Fisheries, Republic of Korea, "The Republic of Korea Will Implement a Project to Support Samoa's Capacity Building in Ocean Acidification Observation in Response to Climate Change. | Department of Economic and Social Affairs," United Nations (United Nations, January 1, 2022), https://sdgs.un.org/partnerships/republic-korea-will-implement-project-support-samoas-capacity-building-ocean.
[36] Catriona L Hurd, "Slow‐Flow Habitats as Refugia for Coastal ... - Wiley Online Library," Wiley Online Library (Journal of Phycology Volume 51, Issue 4, May 8, 2015), https://onlinelibrary.wiley.com/doi/10.1111/jpy.12307.
[37] Charles Galdies et al., "European Policies and Legislation Targeting Ocean Acidification in European Waters - Current State," Marine Policy (Pergamon, May 7, 2020), https://www.sciencedirect.com/science/article/pii/S0308597X19309054.

global abundance of statistics dealing with climate change, internationally coordinated ocean acidification research on the current distribution, levels, and rates of change in pH is critical to concoct adaptation strategies, recognize all causes, and—heeding the varying degrees of acidification worldwide—understand both local and global acidification patterns.[36] Studies that quantify the economic costs of ocean acidification are also lacking, leaving states unable to devise effective and realistic strategies. To prompt further research into this field, states could subsidize ocean acidification-focused studies and look into establishing government-led ocean monitoring programs to facilitate investigation.

The insufficiency of global action arguably also stems from the limited understanding of ocean acidification and its implications. Even if the expansion of research yields new discoveries and alarming revelations, there is no guarantee that such information will alarm, let alone reach the international community and be of use for the development of policies and government initiatives. Given this, it is not only important to communicate key acidification concepts to the general public but also raise awareness among policymakers of the unique threats of and solutions needed to mitigate ocean acidification.[36]

Since the inception of the climate change regime, legal frameworks and other climate-related policies have inundated the status quo. Over the past decade, countless national climate plans, adaptation strategies, and multilateral agreements have been adopted worldwide, but which albeit yield only a fraction of the means needed to curb ocean acidification. International treaties such as the United Nations Framework Convention on Climate Change (UNFCCC) and UNCLOS[10] are broached as potential means to address the question at hand, but this is only because ocean acidification is considered an effect of change in "the state of the climate system"—not by explicit word.[38] In the European Union (EU), though ocean acidification was mentioned in its "10 messages for 2010" as a challenge in favor of marine biodiversity, there is no supportive legislation that specifically addresses the management and mitigation of ocean acidification in European waters.[39] In short, measures worldwide lack specific references to direct ocean acidification abatement.

Thus, states must rectify this situation through the enforcement of appropriate legislation that elucidates its will for direct action on ocean acidification. It is also important to note other necessities in such frameworks; the environmental targets must not be provisional, and all goals and thresholds must be

[38] K.F. Kuh, "United Nations Framework Convention on Climate Change," United Nations Framework Convention on Climate Change - an overview | ScienceDirect Topics, 2018, https://www.sciencedirect.com/topics/earth-and-planetary-sciences/united-nations-framework-convention-on-climate-change.
[39] "EU Adaptation Strategy," European Commission, February 24, 2021, https://ec.europa.eu/clima/eu-action/adaptation-climate-change/eu-adaptation-strategy_en.

quantitative—corroborated by specific research, scrutinized in its feasibility, and boiled down to digits instead of broad terms.

As stated above, ocean acidification and climate change must be tackled with distinct sets of solutions due to both problems' great scope. However, when it comes to their inherent relationship, it is difficult to separate the two. Delving deeper into the root cause of ocean acidification, research claims the tie between carbon dioxide emissions and change in pH. As scientifically described above, the only practical way to mitigate acidification is to cut fossil fuel funds and regulate oil and gas production—all of which are effective antidotes to emission issues. Therefore, while keeping solutions discrete, adhering to guidelines set by frameworks and organizations such as the Intergovernmental Panel on Climate Change (IPCC) aimed at reducing global emissions is an available option.[27] Evidently, to prevent future ocean acidification events, the environment requires a shift from a trajectory of rapidly increasing carbon dioxide emissions to one in which net emissions have been lessened to nearly zero.

Marine pollution is another obvious contributing factor to ocean acidification. The disposal of sewage and manufacturing waste into the ocean disrupts the water's chemistry, and research shows that such alterations can lead to greater carbon dioxide absorption by oceans.[40] To minimize such instances and improve water quality, regulating marine transportation's waste dumping practices is imperative, and monitoring sources of acidification from runoff and pollutants can further decrease stress. Such pollutants would include agricultural and industrial waste—both of which can be controlled by efforts to reuse, redistribute, or recycle unwanted materials and aptly dispose of waste.

Geoengineering solutions have also been proposed to mitigate ocean acidification. Propounding various means to soak up the ocean's excess acid, examples of such proposals include the addition of iron, olivine, or limestone into oceans, chemically absorbing carbon dioxide, promoting microorganism growth, or supplying material for shell development.[41] Despite their constructive intentions, there is more concern surrounding geoengineering options at this time—largely due to the potential ecological side effects. Geoengineering programs may not only wreak havoc on already vulnerable and weak ecosystems but also lead to a school of unprecedented consequences.[27] Moreover, the energy and technology required to mine and distribute the acid-absorbing materials would certainly be a high hurdle for this method.[40]

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[40] Author: Erin Gray – Staff Lawyer, "Climate and the Ocean: How to Combat Ocean Acidification," West Coast Environmental Law, November 9, 2021, https://www.wcel.org/blog/climate-and-ocean-how-combat-ocean-acidification.

[41] Nicola Jones, "How Growing Sea Plants Can Help Slow Ocean Acidification," Yale Environment 360, July 12, 2016, https://e360.yale.edu/features/kelp_seagrass_slow_ocean_acidification_netarts.

Though the future advancement of technology may allow a better outlook on this approach, these schemes are evaluated as unappealing at this point in time.

Scientists are also exploring the idea that carbon sequestering ecosystems—like seagrasses, shell beds, and kelps—may be able to offset ocean acidification and fulfill the dreams of past geoengineering ideas. Though similar in concept with previous disappointments, the cultivation of such organisms is shown to be significantly less intrusive yet remarkably effective. One study claimed that seagrass meadows would grant corals an approximate 18 percent boost in growth, and another demonstrated the meadows' potential to increase seawater pH by 0.38.[40]

As with many other environmental issues, there is no silver bullet solution to ocean acidification; rather, it will take a united, collective effort from different jurisdictions to protect the ocean from acidification—so that it can continue to protect us.

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