LEARNING TO PLAY WELL WITH OTHERS: A PROPOSED INTERNATIONAL SOLUTION TO MITIGATING OCEAN ACIDIFICATION

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I. INTRODUCTION

While ocean acidification is a major crisis affecting the shellfish industry and local economies in the United States, it is an international issue and should be handled as such. Countries throughout the world are attempting to face the impacts of ocean acidification independently. For example, rising acidity levels are causing the exterior of shellfish to deteriorate in the Pacific Northwest and coral composition to weaken in Australia. Although the cause of these various, widespread issues is the ocean's altering composition, the methods to mitigate the negative results are not treated in a comprehensive manner. Rather, these international ocean acidification implications are approached from an individualistic perspective.

This article will be broken up into four sections. First, this article will explain the background issue of ocean acidification and its potential negative environmental, economic, and social impacts. Second, current legislative and judicial developments in the United States addressing ocean acidification will be discussed. Third, an international section will address solutions employed in other countries facing effects from ocean acidification, as well as potential international solutions attempted or proposed. Finally, this article will conclude with suggestions for future change and potential solutions to face this international crisis, including legislative and scientific reform to mitigate or adapt to impacts of ocean acidification.

Ultimately, this article argues that a comprehensive international approach to ocean acidification is not only encouraged, but necessary, as this is an

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inherently international environmental crisis. As a specific proposal, this article posits the formation of an international panel of five countries, potentially including those with booming economies, high rates of pollution, dependence on aquaculture, and environmentalist tendencies. This proposal will be further discussed at the conclusion of this article.

II. OCEAN ACIDIFICATION: A SCIENTIFIC EXPLANATION

Simply put, ocean acidification is "the decrease in pH of the Earth's oceans and changes in ocean chemistry caused by chemical inputs from the atmosphere, including carbon dioxide."[2] Ocean acidification entails three reactions. First, oceans absorb about one-third of the carbon dioxide humans emit by burning fossil fuels, driving cars, and clearing forests. Second, as carbon dioxide dissolves into the oceans, it forms carbonic acid, lowering the pH of the seawater. This causes seawater to become more acidic. Seawater is usually more basic on the pH scale with a number between 7 and 9, but the increasing carbon dioxide may lower the pH toward a more acidic range. Finally, these rising acidity levels deplete the seawater of carbonate ions, which are essential ingredients for coral and shelled sea creatures. As a result of these stressors, oceans have become roughly 30% more acidic since the Industrial Revolution, with many scientists believing acidification is occurring faster now than at any other time over the past 300 million years.[3]

Major biological impacts occur due to the chemical alterations to the ocean. Shellfish and coral must utilize substantial amounts of energy to build their shells, which means these organisms will have less available energy to find food or reproduce.[4] This reduces their ability to survive and compete with other sea creatures for resources. If the surrounding water is acidic enough, the coral and shells can dissolve. Currently, research regarding the impacts of sea surface temperature affecting survivability has only been conducted on coral reefs.[5] There are various other animals shown to be affected by rising acidity levels through lab

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[2] 33 U.S.C. § 3702.
[3] *Carbon Program, A Primer on pH*, NAT'L OCEANIC AND ATMOSPHERIC ADMIN., PACIFIC MARINE ENVTL. LAB., http://pmel.noaa.gov/co2/story/A+primer+on+pH (last visited May 22, 2018).
[4] *Id*.
[5] Rachel Warren, *The Role of Interactions in a World Implementing Adaptation and Mitigation Solutions to Climate Change,* 369 PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY: MATHEMATICAL, PHYSICAL AND ENGINEERING SCIENCES 217, 232 (2011), http://rsta.royalsocietypublishing.org/content/roypta/369/1934/217.full.pdf (last visited May 22, 2018).

experiments conducted by the National Oceanic and Atmospheric Administration (NOAA). Researchers have found that with higher acidity levels, squid become lethargic, krill embryos fail to hatch, reef fish are easily confused and can no longer detect predators, finfish are at risk due to alterations in the food web, and shelled plankton that exist near the bottom of the food chain struggle to locate food.[6]

While the scientific community has essentially developed an understanding of the biological and chemical processes that lead to rising ocean acidity levels, researchers still do not completely understand which species will suffer the greatest impacts due to acidification and to what extent.[7] Thus, researchers cannot determine what the precise impacts will be on population levels and biological processes.[8] Increasing acidity levels in the ocean may cause lobsters to create larger shells after they molt; the reason for this is unknown, but it may be to compensate for the lack of the shell's thickness due to heightened acidity levels. This attempt to enlarge shells has a potentially debilitating effect as the lobsters will be exerting more energy into building their shells, rather than activities which are vital to survival.[9] For example, one current concern is whether jellyfish will be affected at all, and, if the studies suggesting jellyfish may not suffer severe impacts are true, jellyfish have the potential to dominate ecosystems (an already existent problem).[10]

Another unknown impact of acidification is the reduction of low-frequency sound absorption that occurs due to the pH-dependent decline in dissolved borate ions.[11] Researchers have found that the effect on sounds

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[6] NAT'L OCEANIC AND ATMOSPHERIC ADMIN., PACIFIC MARINE ENVTL. LAB., *supra* note 3.
[7] Marja Makarow, Reinhart Ceulemans, & Lars Horn, *Impacts of Ocean Acidification*, 37 EUROPEAN SCIENCE FOUNDATION: SCIENCE POLICY BRIEFING 1, 1 (Aug. 2009), http://archives.esf.org/fileadmin/Public_documents/Publications/SPB37_OceanAcidification.pdf (last visited May 22, 2018).
[8] Ellycia Harrould-Kolieb, Matthew Huelsenbeck, & Virginia Selz, *Ocean Acidification: The Untold Stories*, OCEANA 1, 11 (Nov. 2010), http://oceana.org/sites/default/files/reports/Ocean_Acidification_The_Untold_Stories.pdf (last visited May 22, 2018).
[9] *Id*.
[10] The Ocean Portal Team & Jennifer Bennett, *Ocean Acidification*, SMITHSONIAN NAT'L MUSEUM OF NATURAL HISTORY (2015), http://ocean.si.edu/ocean-acidification (last visited May 22, 2018).
[11] Scott C. Doney, William M. Balch, Victoria J. Fabry, & Richard A. Feely, *Acidification: A Critical Emerging Problem for the Ocean Sciences*, 22(4) OCEANOGRAPHY 16, 18 (Dec. 2009) (citing P.G. Brewer & K. Hester, *Ocean Acidification and the Increasing Transparency of the Ocean to Low-Frequency Sound*, 22(4) OCEANOGRAPHY 86–93 (2009)),

throughout the ocean may be significant: "a decline in pH of only 0.3 causes a forty percent decrease in the intrinsic sound absorption coefficient."[12] While this potential sound alteration has been discussed, researchers still do not understand how this will affect oceanic species, particularly whales and other marine mammals.

Furthermore, acidification may also affect light propagation, as a more acidic and decalcified ocean will be "devoid of the ubiquitous calcium carbonate particles such as microscopic coccoliths, [therefore] light scattering and attenuation would be reduced, resulting in deeper euphotic zones."[13] Researchers further postulate that the altered acidity levels could affect shipping and naval interests, with a particular impact on the integrity of ship hulls, as the current composition of ships may not be tailored to handle heightened acidity.[14]

Finally, in regards to potentially solving the problem, it is unknown if adding iron or fertilizers to oceanic waters could cause man-made phytoplankton blooms, which might then absorb carbon dioxide from the atmosphere.[15] Some believe that when the phytoplankton die, they may sink down into the oceans and trap the consumed carbon dioxide deep into the sea, but it is unclear whether this may affect marine food webs dependent on phytoplankton or if the dead, carbon dioxide-filled phytoplankton at the bottom of the sea may just cause the water to become more acidic.[16] Before an informed solution can be made, numerous questions regarding the process and impacts of ocean acidification must be answered.

A. Why Should We Care? Negative Impacts of Rising Ocean Acidity Levels

Throughout the United States, major biological hotspots are struggling due to ocean acidification impacts. In the Pacific Northwest, effects include upwelling, algal blooms, oyster die-off, and a struggling shellfish industry, which

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https://tos.org/oceanography/article/ocean-acidification-a-critical-emerging-problem-for-the-ocean-sciences (last visited May 22, 2018).

[12] *Id*.

[13] *Id*.

[14] *Id*.

[15] The Ocean Portal Team, *supra* note 10.

[16] *Id*.

is a major part of the area's economy.[17] California is faced with upwelling, algal blooms, impacted recreational and commercial fishing and shellfish aquaculture, and declining tourism for marine ecosystems and scuba diving.[18] Corals in Hawaii are currently having trouble building up their skeletons and suffering from coral sensitivity, which could significantly affect tourism with snorkeling and scuba diving, a significant economic contributor for Hawaii.[19] In Alaska, acidification is causing upwelling, ice melt, freshwater input, and algal blooms.[20] This may negatively impact Alaska's seafood industry, and commercial fishing is the third-largest driver of economic activity within the state.[21] Estuaries on the East Coast are suffering from dead zones, freshwater inputs, and increased impacts on vulnerable species, with a particular focus on clams.[22] In Florida, corals are becoming more sensitive, and Florida's most important fish species depend on these coral reefs.[23] Major bodies of water in the United States are being altered, such as the Gulf of Maine and the Gulf of Mexico. In the former, the primary concerns entail algal blooms, vulnerable species, freshwater input, and cold spots; in the latter, coral sensitivity and dead zones are potential effects.[24]

Impacts on biological processes from ocean acidification must be mitigated or adapted to, as "a large part of the world's population (around one billion people) relies on seafood as their primary source of animal protein. Ocean acidification thus has the potential to impact food security."[25] Food security, particularly in fishing communities, could be influenced by a variety of factors pertaining to acidification impacts including the migration of populations to the coasts, impacting coastal infrastructure, altering biological processes due to changing fishing techniques, increased amounts of pollution, and a heightened demand for fishing product.[26] Economic impacts due to rising acidity levels are

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[17] NATURAL RES. DEF. COUNCIL, STATES ARE VULNERABLE TO OCEAN ACIDIFICATION (2015), https://www.nrdc.org/resources/states-are-vulnerable-ocean-acidification (last visited May 21, 2018).
[18] *Id*.
[19] *Id*.
[20] *Id*.
[21] *Id*.
[22] *Id*.
[23] *Id*.
[24] *Id*.
[25] *Ocean Acidification International Coordination Centre: Nuclear and Isotopic Techniques in Ocean Acidification,* INT'L ATOMIC ENERGY AGENCY, https://www.iaea.org/ocean-acidification/page.php?page=2243 (last visited May 21, 2018).
[26] Tim W. Daw, Neil Adger, Katrina Brown, & Marie-Caroline Badjeck. *Climate Change and Capture Fisheries: Potential Impacts, Adaptation and Mitigation*, FAO FISHERIES AND

not understood or have not been quantified, though these effects raise serious concerns amongst communities that thrive on fisheries as a resource.[27] "Ocean acidification's impacts on oyster and other U.S. mollusk harvests alone could cause up to $6.4 billion in losses by 2060."[28] Studies have predicted that fisheries will now be catching more warm-water species, which will be smaller in size, limiting the fish supply in the United States, affecting both imports and exports of aquaculture.[29] The wide-reaching effects of ocean acidification are not only environmental in nature, but can affect the economy, food security, and recreational opportunities.

These negative impacts lead scientists to question whether marine organisms will be able to adapt to these rising acidity levels. This is currently being explored by marine biologists throughout the country, as some sea organisms that rely on building shells do appear to have acclimated.[30] Santa Barbara marine biologist Gretchen Hofmann has found that a limited number of marine organisms do have the capacity to adapt to acidification, but "that adaptive capacity has its limits and the continuing burning of fossil fuels could push ocean acidity past a tipping point, rendering some mollusks and other organisms unable to construct shells."[31] Some plants and animals which are potential victims to ocean acidification, including mussels, abalone, rock oysters, plankton, and some fish, appear, at least in the beginning stages, to adapt to or evolve with these rising acidity levels.[32] However, which organisms are able to adapt to the changing chemical composition of the oceans depend on a variety of factors, including where their habitats are, their population size, and the amount of stress on the organisms due to forces such as warming temperature and pollution.[33]

AQUACULTURE TECHNICAL PAPER No. 530 (2009), http://www.fao.org/docrep/012/i0994e/i0994e03.pdf (last visited May 22, 2018).
[27] *Id*. at 2.
[28] *Id*.
[29] *Id*.
[30] *Ocean Acidification Benefits*, YALE ENV'T 360 DIGEST (Dec. 2, 2009), https://e360.yale.edu/digest/ocean-acidification-benefits-some-marine-organisms-study-says/2169/ (last visited May 22, 2018).
[31] Elizabeth Grossman, *Examining How Marine Life Might Adapt to Acidified Oceans*, YALE ENV'T 360 DIGEST (May 14, 2014), https://e360.yale.edu/features/interview_gretchen_hofmann_examining_how_marine_life_might_adapt_to_acidified_oceans (last visited May 22, 2018).
[32] Craig Welch, *Sea Change: Can Sea Life Adapt to Souring Oceans?*, SEATTLE TIMES (Nov. 2, 2013), https://apps.seattletimes.com/reports/sea-change/2013/nov/2/can-sea-life-adapt/ (last visited May 22, 2018).
[33] *Id*.

Furthermore, upwelling plays a role in determining whether a species in its habitat will be able to adapt to rising acidity levels. The water chemistry along coasts is rarely static since the ocean's carbon dioxide may vary with the time of day and tides, so organisms along the coasts may more easily adapt to altered acidity levels.[34] Upwelling occurs when heavy winds blow along the shore, and "deep, cold water that naturally holds more CO_2 suddenly wells up from the bottom and gets drawn toward the beach. That means some West Coast urchins have spent millions of years being exposed to high-CO_2 waters."[35] However, this adaptation skill likely only applies to organisms with large population sizes that are used to varying acidity levels, not open-ocean fish species with small population sizes.[36]

Although a fish with a higher acidity level in its blood may be in harmony with its oceanic environment, the chemical reactions occurring within the fish's body may be altered.[37] A small change in the pH levels within an organism can hugely impact survival. "In humans, for instance, a drop in blood pH of 0.2-0.3 can cause seizures, comas, and even death. Likewise, a fish is also sensitive to pH and has to put its body into overdrive to bring its chemistry back to normal."[38] In order to stabilize itself, the fish will burn extra energy in an attempt to expel the excess acid out of its blood through its gills, kidneys, and intestines; with this energy being spent elsewhere, the fish will have less energy to digest food and escape from predators.[39] The acidic water also impacts natural defense systems, as fish might not flee from threatening noises or have trouble with their sense of smell, which helps with their sense of direction.[40]

The ability to adapt or evolve is even more unlikely as acidity levels are rising at an unprecedented rate. Although marine organisms have been able to adapt in the past, they may not be evolving fast enough.[41] Scientists are currently using a naturally occurring experiment along the West Coast, studying California mussels and purple sea urchins, in order to determine whether these species have genetic adaptations to assist them in more acidic waters.[42] While jellyfish and

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[34] *Id*.
[35] *Id*.
[36] *Id*.
[37] The Ocean Portal Team, *supra* note 10.
[38] *Id*.
[39] *Id*.
[40] *Id*.
[41] Lauren Sommer, *Climate Change: Can Marine Life Adapt to More Acidic Seas?*, KQED NEWS (Sep. 26, 2012), https://www.kqed.org/news/76799 (last visited May 22, 2018).
[42] *Id*.

algae may be able to adapt and flourish in higher acidity levels, scientists argue that these are not the most vital marine organisms; meanwhile, coral reef habitats are essential ecosystems and are extremely vulnerable to ocean acidification.[43] Currently, most corals throughout the world have already reached their threshold, and scientists predict that entire ecosystems made up of coral reef habitats may be decimated within decades because of global warming and ocean acidification.[44] Unfortunately, the destruction of oceanic ecosystems will be rapid, as "humans are changing ocean chemistry at a rate 100 times faster than anything experienced in tens of millions of years."[45] Throughout history, when these rapid rates of altered oceanic composition have occurred, they were linked to mass extinctions.[46] Therefore, while scientists may be able to find data representing an ability to adapt to rising acidity levels in a limited number of marine organisms, it is unlikely that all sea life will be able to adapt to or evolve with the rapid rate of rising acidity levels.

As previously stated, two of the main societal impacts of rising acidity levels are the potential of an unstable economy, particularly along coasts, and an uncertain future in food security. As previously discussed above, ocean acidification could have a debilitating effect on international economics. According to *The State of the World Fisheries and Aquaculture Report of 2014*, global aquaculture production came in at an all-time high in 2012, with 90.4 million tons valued at $144.4 billion.[47] Furthermore, across the globe, roughly 58.3 million individuals were involved in the fisheries and aquaculture industries, and, with rising acidity levels affecting the ability to harvest these marine organisms, this industry could face dire circumstances in the future.[48] While the possible impact on the economy due to acidification is clear, a less discussed issue is the concern of food security. In 2012, world leaders met in Rio de Janeiro, Brazil to discuss the necessary participation of all civil society in committing to future sustainable development to ensure an economically, socially, and

[43] *Ocean Acidification: Frequently Asked Questions*, CTR. FOR BIOLOGICAL DIVERSITY, http://www.biologicaldiversity.org/campaigns/endangered_oceans/pdfs/OceanAcidificationFAQ.pdf (last visited May 21, 2018).
[44] *Id*.
[45] *Id*.
[46] *Id*.
[47] FOOD AND AGRIC. ORG. OF THE UNITED NATIONS, THE STATE OF THE WORLD FISHERIES AND AQUACULTURE REPORT 6 (2014), http://www.fao.org/3/a-i3720e.pdf (last visited May 21, 2018).
[48] *Id*.

environmentally sustainable world for future generations.[49] The negotiations focused on a few main issues, including poverty eradication and food security through sustainable agriculture.[50]

With changing environmental conditions having significant and unknown impacts on organisms and their ecosystems, the world's food security is in flux. It is unclear whether populations, particularly in poorer communities, will be able to thrive on unstable food resources. As previously mentioned, a large part of the world's population relies on marine organisms as the main source of protein in their diet. With the inability to consume shellfish and some fish species due to rising acidity levels, these individuals will need to locate a new source of protein, which may not be available in some areas of the world. While rising acidity levels may be classified as an "environmental problem," the impacts are not solely on ecosystems. The change in acidity levels will impact the economy, food security, recreational activities, international trade, and job security.

B. Resilient Oceanic Species: Are There Any Potential Benefits to Rising Acidity Levels?

Although there are clearly major ecological concerns regarding acidification, a few studies recognize that heightened acidity levels in the oceans can have beneficial effects in limited respects. Justin Ries conducted a study in which he attempted to determine the biological effects on eighteen separate marine organisms by comparing four varying oceanic acidity levels.[51] The first testing environment matched modern atmospheric carbon dioxide levels, while two others were set at double and triple pre-Industrial Revolution carbon dioxide levels.[52] These levels are predicted to occur over the next century if greenhouse gas emissions continue to rise. The fourth carbon dioxide level was ten times pre-Industrial Revolution levels. While heightened acidity levels to that extent will not occur in our lifetime, Ries argued that these levels could occur in the next 500 to 700 years.[53] According to his results, Ries discovered that "oysters, scallops,

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[49] UNITED NATIONS, THE FUTURE WE WANT REPORT 2012, 1 (2012), https://sustainabledevelopment.un.org/content/documents/733FutureWeWant.pdf (last visited May 21, 2018).
[50] *Id*. at 19.
[51] YALE ENV'T 360 DIGEST, *supra* note 30.
[52] Justin Ries, *Acidic Oceans May Be a Boon for Some Marine Dwellers*, SCIENCE (Dec. 1, 2009), http://www.sciencemag.org/news/2009/12/acidic-oceans-may-be-boon-some-marine-dwellers (last visited May 21, 2018).
[52] *Id*.
[53] *Id*.

and temperate corals grew thinner, weaker shells as acidity levels were increased . . . but some species – including blue crabs, lobsters, and shrimp – grew thicker shells that could make them more resistant to predators."[54] Furthermore, species that may benefit from rising acidity levels could grow bigger shells or skeletons, which will provide greater protection.[55] Ries says "a bulkier shell might be more resistant to crushing by predators. American oysters, scallops, temperate corals, and tube worms all fared poorly and grew thinner, weaker shells. The biggest losers included clams and pencil urchins; their exoskeletons dissolved at the highest CO_2 levels."[56]

Ries's study revealed that algae and seagrass may, in fact, benefit from ocean acidification because these organisms "use CO_2 and bicarbonate during photosynthesis."[57] Creatures that feed on the seagrass, including manatees and green sea turtles, which are both limited in population numbers, may profit due to the increased amount of their main food source.[58] A separate study found that the European green crab, *Carcinus maenus*, is one of the marine species in the United States that is thriving with heightened acidity levels.[59] This invasive species is benefitting from warming water temperatures due to increased carbon dioxide levels as native populations are threatened, opening up room for this invasive species.[60] "Highly resilient to acidification, they thrive in their changing adopted habitats, further outcompeting the organisms that naturally live in them."[61] These invasive species are flourishing, even though carbon dioxide levels are destroying coral reefs.[62]

A last type of marine creature that may reap beneficial consequences from acidification are jelly-like organisms like the stinging jellyfish, as they are

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[54] YALE ENV'T 360 DIGEST, *supra* note 30.
[55] Ries, *supra* note 52.
[56] *Id*.
[57] Matt Young, *Ocean Acidification: Winners and Losers Among Marine Life*, PANDA'S THUMB (Oct. 9, 2013), https://pandasthumb.org/archives/2013/10/ocean-acidifica.html (last visited May 22, 2018).
[58] *Id*.
[59] Brian Mastroianni, *Ocean Acidification Benefits Invasive Species*, CBS NEWS (Nov. 6, 2015), https://www.cbsnews.com/news/ocean-acidification-benefits-invasive-species/ (last visited May 22, 2018).
[60] *Id*.
[61] *Id*.
[62] Patrick J. Kiger, *Acidic Ocean Benefits 'Killer Algae,' Jellyfish*, THE SEEKER (Nov. 10, 2015), https://www.seeker.com/acidic-ocean-benefits-killer-algae-jellyfish-1770445083.html (last visited May 22, 2018).
[62] *Id*.

especially tolerant due to not containing an exoskeleton which depends on steady carbon dioxide levels.[63] However, these so-called "winners" are dependent on other species and habitat. As Young notes:

> There will likely be significant shifts in the mix of species as a result of ocean acidification, and the new marine ecosystem may not be what humans want. The ocean food chain is composed of many interrelated species, and a drastic reduction in the numbers of one species may in turn cause a population crash in another.[64]

Ries's study, containing conflicting results since it explains both negative and positive significant biological impacts due to acidification, "suggests that the effects of increased CO_2 on marine environments will be more complex than previously thought."[65] For example, David Hutchins, a professor of Biological Sciences at the University of Southern California, studies phytoplankton.[66] This miniscule marine organism is an essential ingredient for marine life, as the phytoplankton processes nitrogen from the atmosphere, playing a vital role in the food web.[67] Hutchins claims that the phytoplankton could also be one of the future "winners" adapting to acidification, as studies show the organism could thrive and produce more nitrogen for the entire food web.[68] However, phytoplankton are the cause of many biological crises occurring along the West Coast of the United States, including harmful algal blooms, colloquially known as red tide, which produce the toxin domoic acid.[69] Ultimately, algal blooms have shut down entire shellfish industries and cultivated diseases within sea lions, which have shown up on Northern California beaches suffering from seizures.[70] Consequently, while there are limited benefits to marine organisms regarding rising acidity levels, the negative biological impacts are too great to ignore.

C. Rising Acidity Levels: An International Problem

Ocean acidification is ultimately a concern for the international community, with implications reaching beyond merely the desire to have a

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[63] *Id*.
[64] Young, *supra* note 57.
[65] Ries, *supra* note 52.
[66] Sommer, *supra* note 41.
[67] *Id*.
[68] *Id*.
[69] *Id*.
[70] *Id*.

diverse and beautiful ocean environment. This issue stretches beyond biological impacts as it may also have societal and economic implications. Countries that depend primarily on oceanic tourism will be in economic turmoil. "Tourism and recreation account for seventy-two percent of the ocean economy's total employment and thirty-one percent of its GDP."[71] This could be particularly difficult for countries with budding eco-tourism industries. Australia, for example, had an economic contribution of reef-specific tourism activity of $389 million in 2012 alone.[72] Thus, putting a beautiful and diverse oceanic environment at risk can have extreme negative economic effects on countries that rely on visitors wanting to see exotic fish, crustaceans, and mammals.

As stated by the White House under the Obama Administration, there is a need for international partnership in attempts to mitigate or adapt to rising acidity levels. After attempts to strategize independently, the United States government recognized the need to work alongside other nations. "Developing and implementing international engagement strategies and facilitating partnerships is a key part of the U.S. Strategic Plan."[73] The United States recognized the need to formulate a plan promoting the cooperation of multiple nations, as this problem did not arise and is not intensified by one nation alone, ultimately forming the International Coordination Centre. "The International Coordination Centre will seek to facilitate, promote, and communicate about global actions on ocean acidification and the United States will be represented on its Ocean Acidification Advisory Board."[74] This idea of cooperation amongst nations has been promoted throughout the world as this is a growing international problem.

The oceans are such a precious resource both environmentally and economically, which incentivizes nations to work alongside each other. As the oceans assist in absorbing carbon dioxide from the atmosphere, it has been widely accepted that without this biological process, global warming would intensify significantly. "Without the oceans, the CO_2 content in the atmosphere would be

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[71] *How Important is the Ocean to our Economy*, NAT'L OCEANIC AND ATMOSPHERIC ADMIN., http://oceanservice.noaa.gov/facts/oceaneconomy.html (last visited May 21, 2018).
[72] AUSTRALIAN GOV'T: GREAT BARRIER REEF MARINE PARK AUTH., DEP'T OF SUSTAINABILITY, ENV'T, WATER, POPULATION AND COMMUNITIES, ECON. CONTRIBUTION OF THE GREAT BARRIER REEF (2013), https://www.environment.gov.au/system/files/resources/a3ef2e3f-37fc-4c6f-ab1b-3b54ffc3f449/files/gbr-economic-contribution.pdf (last visited May 21, 2018).
[73] THE WHITE HOUSE: OFFICE OF SCI. AND TECH. POLICY, THE CHALLENGE OF OCEAN ACIDIFICATION (2014), https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/the_challenge_of_ocean_acidification_june-2014.pdf (last visited May 21, 2018).
[74] *Id*.

much higher and global warming and its consequences more dramatic. However, the uptake of man-made CO_2 by the oceans results in ocean acidification, often referred to as 'the other CO_2 problem' alongside global warming."[75] Therefore, as heightened acidity levels are already having a world-wide effect and will only continue to intensify, on not only marine species and water composition, but also carbon dioxide levels in the atmosphere, ocean acidification solutions must come from an international approach. As Britain's Plymouth University professor Jason Hall-Spencer, a lead author on a report addressing benefits and setbacks on marine organisms due to rising acidity levels, acknowledged:

> Based on a synthesis of evidence available to date, we predict the problems associated with harmful marine life will get worse in response to rising CO_2. . . Pathogens like cholera do not recognize national borders so seawater warming is a health issue for cities like London, and it remains to be seen which organisms will spread and cause problems as Arctic shipping routes open up.[76]

While there may be geographically and nominally distinct oceans throughout the world, the Earth's surface is comprised of roughly 70% water, often without discrete boundaries separating these oceanic entities. Countries must recognize the potential effectiveness, increased amount of resources, and fresh new solutions that could be dedicated to mitigating or adapting to the crisis of ocean acidification from an international approach.

III. CURRENT LEGAL & POLICY DEVELOPMENTS IN THE UNITED STATES

As there has not yet been consensus on an international approach, the United States is attempting to mitigate or adapt to rising acidity levels independently. This section will first explain the current legislation in the United States regarding ocean acidification, on both the federal and state level, mainly focusing on the coastal states. Second, cases regarding ocean acidification will be discussed. This will be effective in determining how the law has handled negative impacts from rising acidity levels and whether further legislation or solutions will be necessary. Finally, proposed legislation in the United States will be explained, focusing on alternative solutions that others have suggested in the past.

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[75] *Promoting Global Cooperation in a Changing Ocean World,* INT'L ATOMIC ENERGY AGENCY, https://www.iaea.org/ocean-acidification/page.php?page=2181 (last visited May 21, 2018).
[76] Kiger, *supra* note 62.

The United States does not currently have a strong national legislative approach to address ocean acidification. However, the federal government has engaged in legislation targeting climate change mitigation and greenhouse gas emissions, which ultimately causes rising acidity levels. Federal initiatives have included renewable energy tax credits, vehicle emissions standards, an executive climate action plan, and attempts at passing legislation to implement a nation-wide cap and trade program. Legislation on clean air has ultimately given deference to the Environmental Protection Agency (EPA) to regulate and limit greenhouse gas emissions. After the 2007 Supreme Court decision *Massachusetts v. EPA* determined the EPA has authority under the Clean Air Act to regulate greenhouse gases, the agency covered greenhouse gases from large stationary sources with permitting programs in 2011.[77] In 2014, the U.S. Supreme Court held that the EPA reasonably interpreted the Clean Air Act to require sources that need permits based on their conventional pollutants to comply with the Best Available Control Technology (BACT) for greenhouse gases.[78] Thus, even if an administration attempted to repeal the Clean Air Act or permitting process, the EPA would have to engage in formal rule-making. This would likely result in defending the prior legal and scientific consensus regarding EPA's regulation of air pollutants and carbon's link to climate change in court. While there is a viable argument that "air pollutant" is vague and broadly defined in the Act, this legal challenge would be problematic considering the scientific and legal precedent.

The U.S. government previously recognized rising acidity levels to be of increasing concern and has initiated efforts to develop a deeper understanding of the issue and potential solutions. The National Research Council issued a report in 2010, responding to a Congressional mandate in the 2006 Magnuson Stevens Fishery Conservation and Management Act.[79] This report encourages the collection of scientific information, which the National Research Council intends to use to identify any uncertainties surrounding future research of the issue.[80] In March 2009, the Ocean Carbon and Biochemistry Program Subcommittee on Ocean Acidification (OCB) released a white paper delineating the structure of a

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[77] *Clean Air Act Permitting for Greenhouse Gases,* ENVTL. PROT. AGENCY, https://www.epa.gov/nsr/clean-air-act-permitting-greenhouse-gases (last visited May 22, 2018).
[78] *Id*.
[79] Ryan P. Kelly & Margaret R. Caldwell, *Ten Ways States Can Combat Ocean Acidification (And Why They Should)*, 37 HARV. ENVTL. L. REV. 57, 66 (2013), *available at* https://digital.law.washington.edu/dspace-law/bitstream/handle/1773.1/1610/6WJELP287.pdf?sequence=4&isAllowed=y (last visited May 22, 2018).
[80] *Id*. at 67.

U.S. National Research Program.[81] The OCB's paper recognized ocean acidification as "urgent" and "distinct from climate change," while outlining a list of recommendations: "standardization of CO_2 measurement protocols, expansion of monitoring sites, and establishment of global CO_2 field studies, among others."[82] The OCB recommended that the U.S. National Research Program on ocean acidification receive funding of $50 million per year, which is considerably modest in comparison to other similar programs focusing on oceanic research.[83] Congress instituted legislation in order to support this program and its research, noting that the program's purpose was to provide for:

> (1) the development and coordination of a comprehensive interagency plan to: (A) monitor and conduct research on the processes and consequences of ocean acidification on marine organisms and ecosystems; and (B) establish an interagency research and monitoring program on ocean acidification;
>
> (2) establishment of an ocean acidification program within the National Oceanic and Atmospheric Administration;
>
> (3) assessment and consideration of regional and national ecosystem and socioeconomic impacts of increased ocean acidification; and
>
> (4) research adaptation strategies and techniques for effectively conserving marine ecosystems as they cope with increased ocean acidification.[84]

Furthering U.S. efforts, the federal government passed the Federal Ocean Acidification Research and Monitoring Act of 2009 (FOARAM Act) to speak to the consequences of heightened acidity levels.[85] The FOARAM Act formed the Joint Subcommittee on Ocean Science and Technology, which strove to "develop research strategies and monitoring plans on ocean acidification."[86] According to

[81] Heidi R. Lamirande, *From Sea to Carbon Cesspool: Preventing the World's Marine Ecosystems from Falling Victim to Ocean Acidification*, 34 SUFFOLK TRANSNAT'L L. REV. 183, 198 (2011).
[82] *Id*. at 198 (citing Ocean Carbon & Biogeochemistry Program, *Ocean Acidification: Recommended Strategy for a U.S. National Research Program* (2009)).
[83] *Id.* at 199.
[84] 33 U.S.C. § 3701.
[85] Lamirande, *supra* note 81, at 199.
[86] *Id*.

the FOARAM Act, the "Joint Subcommittee on Ocean Science and Technology of the National Science and Technology Council shall coordinate federal activities on ocean acidification and establish an interagency working group."[87] Furthermore, the Subcommittee shall:

> (1) develop the strategic research and monitoring plan to guide Federal research on ocean acidification required under section 3704 of this title and oversee the implementation of the plan;
>
> (2) oversee the development of— (A) an assessment of the potential impacts of ocean acidification on marine organisms and marine ecosystems; and (B) adaptation and mitigation strategies to conserve marine organisms and ecosystems exposed to ocean acidification;
>
> (3) facilitate communication and outreach opportunities with nongovernmental organizations and members of the stakeholder community with interests in marine resources;
>
> (4) coordinate the United States Federal research and monitoring program with research and monitoring programs and scientists from other nations; and
>
> (5) establish or designate an Ocean Acidification Information Exchange to make information on ocean acidification developed through or utilized by the interagency ocean acidification program accessible through electronic means, including information which would be useful to policymakers, researchers, and other stakeholders in mitigating or adapting to the impacts of ocean acidification.[88]

Regarding legislation imposed by the United States specifically on ocean acidification, Congress passed further legislation in 2009. The United States established a federal interagency working group and research program within NOAA called the Oceanic Acidification Task Force.[89] The Task Force is comprised of independent scientists and policymakers. Congress implemented various statutes to legitimize the task force and working group. The legislation

[87] 33 U.S.C. § 3703.
[88] *Id*.
[89] Kelly & Caldwell, *supra* note 79, at 66.

consists of a strategic research plan, NOAA ocean acidification activities, National Science Foundation ocean acidification activities, National Aeronautics and Space Administration (NASA) ocean acidification activities, authorization of appropriations, water quality standards and implementation plans, and the NOAA Biennial report.[90] Furthermore, NOAA founded an Ocean Acidification Program in 2011 with the mission "to better prepare society to respond to changing ocean conditions and resources by expanding understanding of ocean acidification, through interdisciplinary partnerships, nationally and internationally."[91]

Although the federal government made strides in regulating pollutant emissions, which ultimately causes rising acidity levels, it is unclear where the federal government stands on this issue today. The Trump Administration withdrew from the Paris climate agreement, proposed deep budget cuts for NOAA and the EPA, advocates for offshore oil and gas development, promotes deregulation and rollback of policies aimed to mitigate climate change and limit pollution, and alleged that "global warming was created by and for the Chinese."[92]

Due to the lack of clarity in the federal government's future engagement with environmental regulation, states may need to accelerate their response, particularly in coastal regions. Few states are as advanced and active as those on the West Coast as their economy relies heavily on the fishing and seafood industry. The amount of state law regarding the topic at all is staggeringly low, as many states rely primarily on federal law. Washington, California, and Maine have attempted to address the issue individually.

In 2013, the Washington Legislature created the Washington Marine Resources Advisory Council.[93] This group includes legislative, executive, and elected officials, as well as nongovernmental organizations and the private sector.[94] The Washington Marine Resources Advisory Council is tasked with maintaining a sustainable, coordinated focus on ocean acidification, advising and working with the Washington Ocean Acidification Center on the effects and

[90] 33 U.S.C. §§ 3704 - 3708; 1313; 857-19.
[91] *NOAA's Ocean Acidification Program*, NOAA OCEAN ACIDIFICATION PROGRAM, http://oceanacidification.noaa.gov/ (last visited May 22, 2018).
[92] Donald Trump (@realDonaldTrump), Twitter (Nov. 6, 2012, 1:15 AM), https://twitter.com/realdonaldtrump/status/265895292191248385?lang=en (last visited May 22, 2018).
[93] *Ocean Acidification Blue Ribbon Panel,* DEP'T OF ECOLOGY: STATE OF WASHINGTON, http://www.ecy.wa.gov/water/marine/oceanacidification.html (last visited May 21, 2018).
[94] *Id*.

sources of acidification, delivering recommendations to the Governor and Legislature on acidification, seeking public and private funding resources to support the Council's recommendations, and assisting in conducting public education activities regarding acidification.[95] The Marine Resources Advisory Council is further advised by the extensive work conducted by the Washington Blue Ribbon Panel on Ocean Acidification.[96]

Similarly, California has created an initiative to address rising acidity levels through actions aiming to improve water quality and to reduce emissions.[97] Regarding water quality, California focuses on actions primarily aimed at reducing point and nonpoint source pollution. California aims their initiative at reducing sulfur and nitrogen emissions and at reducing carbon emissions.[98] California has attempted to discuss the issue of ocean acidification outwardly with the scientific and legal community. For instance:

> the issue is featured in the draft strategic plan of the Ocean Protection Council, and the Southern California Coastal Water Research Project has hosted an acidification workshop. However, California has been slow to respond to the emerging data on its acidifying waters with policy changes on major initiatives, and, as of now, no marine waters are included on the State's list of waters impaired for pH under the federal Clean Water Act.[99]

Along the East Coast, the Maine legislature passed a joint resolution pointing out ocean acidification as a specific and direct threat to Maine's economy due to the potential impact on clams, mussels, and lobsters.[100] The legislature called for "research and monitoring in order to better understand ocean acidification in the Gulf of Maine and Maine's coastal waters, to anticipate its potential impacts on Maine's residents, businesses, communities and marine

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[95] *Id*.
[96] This author had the privilege of participating in the Blue Ribbon Panel through the Climate Impacts Group at the University of Washington.
[97] Ryan P. Kelly & Margaret R. Caldwell, *Why Ocean Acidification Matters to California, and What California Can Do About It: A Report on the Power of California's State Government to Address Ocean Acidification in State Waters*, CTR. FOR OCEAN SOLUTIONS (March 2012), https://woods.stanford.edu/sites/default/files/files/OceanAcidification.pdf (last visited May 21, 2018).
[98] *Id*.
[99] *Id*. at 11.
[100] *Coastal States Respond to Ocean Acidification*, WILEY REIN, LLP, http://www.wileyrein.com/newsroom-newsletters-item-4795.html (last visited May 21, 2018).

environment and to develop ways of mitigating and adapting."[101] Furthermore, a bill funding extended study on ocean acidification was proposed and submitted to Maine's legislature; however, the bill ultimately died in the senate on February 18, 2016.[102] Although Maine's efforts have been delayed, the state has made impressive efforts to find a solution for an environmental issue often overlooked by the public.

While there have been Congressional and statewide attempts to face the emerging problem of acidification and its far-reaching effects, case law has also addressed this issue. For example, in *Center for Biological Diversity v. Lubchenco*, the National Marine Fisheries Service (NMFS) addressed ocean acidification in connection to the Endangered Species Act (ESA).[103] NMFS stated that rising acidity levels "may impact ribbon seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying the organisms," but "the nature and timing of such impacts are . . . extremely uncertain."[104] The case goes into detail about ocean acidification and the potential impact on the ribbon seal. According to the data, the prey species for the ribbon seal (mostly squid, along with fish and crustaceans) is "especially vulnerable to ocean acidification because of its high-energy swimming method and high metabolism rate."[105]

Regarding ocean acidification, the Center for Biological Diversity (CBD) alleged that NMFS "arbitrarily ignored ocean acidification impacts beyond 2050 that NMFS itself has foreseen."[106] NMFS set the foreseeable future for ocean acidification at 2050, because ocean acidification's long-term effects are not completely understood, as the impacts may not come to fruition for decades.[107] NMFS concluded that the results regarding the impact on ribbon seals due to increasing acidity levels were "extremely uncertain."[108] Because NMFS did not study the effects of ocean acidification beyond 2050, CBD argued that the future cutoff date for study was arbitrary and capricious, as there was existing science

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[101] *Id*.
[102] An Act To Create the Ocean Acidification Council, 38 ME. REV. STAT. tit. 38, § 33 (2016).
[103] Ctr. for Biological Diversity v. Lubchenco, 758 F.Supp.2d 945, 952 (N.D. Cal. 2010).
[104] *Id*. at 953.
[105] *Id*. at 970.
[106] Holly P. Jones, David G. Hole, & Erika S. Zavaleta, *Harnessing nature to help people adapt to climate change*, 2 NATURE CLIMATE CHANGE 504 (June 26, 2012) https://pdfs.semanticscholar.org/4165/946143fa628fb507dd32d70d01e4f83d8ed6.pdf (last visited May 22, 2018).
[107] *Id*.
[108] *Id*.

demonstrating that ribbon seals would be directly affected by these future corrosive waters.[109] However, the court did not find 2050 to be arbitrary and capricious due to both agency deference and the uncertainty of future greenhouse gas emissions.[110] Therefore, the case left it to NMFS to determine how long into the future an agency must consider the impacts from ocean acidification on endangered species.

Similarly, in *Center for Biological Diversity v. United States Environmental Protection Agency*, CBD brought a claim challenging the EPA's decision to not identify any Washington or Oregonian waters experiencing ocean acidification as "impaired" under the Clean Water Act.[111] The EPA issued a memorandum addressing the emerging problem of ocean acidification in 2010, recognizing the "'seriousness of aquatic life impacts associated with' ocean acidification, and instructing that 'States should list waters not meeting water quality standards, including marine pH [water quality criteria], on their 2012 303(d) lists.'"[112] However, Washington's 2010 list did not determine that any coastal or estuarine waters were impaired due to pollutants associated with ocean acidification.[113] The EPA determined that no waters in Oregon or Washington were impaired due to ocean acidification, as EPA evaluated all waters in Oregon and approved the state's assessment, and similarly approved Washington's determinations.[114]

Regarding its claim, the CBD submitted comments and scientific studies to Washington, Oregon, and the EPA arguing that water quality standards in both states were violated due to ocean acidification.[115] However, the court granted the EPA summary judgment as "the science surrounding ocean acidification and its causes and effects is complicated and still developing."[116] The opinion states, "in an area characterized by scientific and technological uncertainty . . . this court must proceed with particular caution, avoiding all temptation to direct the agency in a choice between rational alternatives."[117] As ocean acidification is still not a

[109] *Id*. at 971.
[110] *Id*.
[111] Ctr. for Biological Diversity v. United States Envtl. Prot. Agency, 90 F.Supp.3d 1177 (W.D. Wash. 2015).
[112] *Id*. at 1183 (citing WA-01116-31 ("EPA 2010 OA Memo") at 1, 4).
[113] *Id*. at 1184.
[114] *Id*.
[115] *Id*.
[116] *Id*. at 1209.
[117] *Id.* (quoting Ctr. For Biological Diversity v. United States Envtl. Prot. Agency, 749 F.3d 1079, 1088 (D.C. Cir. 2014)).

fully understood concept, many courts are extremely hesitant to overrule an agency that the court believes should be given deference.

While case law demonstrates that courts are still somewhat uncomfortable analyzing claims about ocean acidification, there has been proposed federal and state legislation. One suggestion regarding solutions within the United States has been to first focus on coastal areas.[118] Focusing on coastal areas first could assist in ameliorating the harm in sites that require the most urgent attention, as they have the greatest impact on populations living along the water. An approach of making the coasts the first priority would help mitigate ocean acidification's effects while more research is developed and the world continues to tackle high carbon dioxide emissions.[119]

While the United States has not yet developed a standard approach to addressing ocean acidification, it does have the opportunity of turning to other nations and evaluating the success of their approaches. Therefore, it is essential to address the current developments in other nations throughout the world regarding ocean acidification solutions.

IV. CURRENT DEVELOPMENTS IN OTHER NATIONS

Regarding specific nations, Germany's Biological Impacts of Ocean Acidification (BIOACID) program "explores the responses of marine species to an acidifying ocean and to multiple related stressors."[120] China and Japan have similar programs.[121] Additionally, the European Project on Ocean Acidification focuses on research and education through collaboration among twenty-seven European organizations.[122] According to studies, the following countries are some of the major emitters of pollution while also being among the hardest hit by ocean acidification: Japan, France, United Kingdom, Netherlands, Australia, and the United States.[123] In order to make an informed ocean acidification plan, the United States may want to refer to these countries' plans already set in place.

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[118] Kelly & Caldwell, *supra* note 79, at 69.
[119] *Id*.
[120] *Id.* at 67.
[121] *Id*.
[122] *Id*. at 67-68.
[123] Ellycia Harrould-Kolieb, Michael Hirschfield, & Ashley Brosius, *Major Emitters Among Hardest Hit by Ocean Acidification: An Analysis of the Impacts of Acidification on the Countries of the World*, OCEANA (Dec. 2009), http://usa.oceana.org/sites/default/files/Acidity_Vulnerability_Risk_report_2.pdf (last visited May 22, 2018).

The Ocean Carbon and Biogeochemistry (OCB) program within the U.S. Carbon Cycle Science Program, an interagency body that coordinates and facilitates activities affecting the carbon cycle and climate, published a recommended strategy for a U.S. National Research Program.[124] This proposal discusses various countries outside of the United States and how they have addressed ocean acidification. Japan has five major programs which fund research pertaining to ocean acidification. Japan's Ministry of Environment supports programs that assist in determining future impacts of ocean acidification on marine organisms.[125] The Ministry of Education, Science, Sport, and Culture and the Japan Agency for Marine Science and Technology further support this research into rising acidity levels through Earth Simulator supercomputer modeling.[126]

Similarly, Australia focuses on the Antarctic in its efforts to mitigate and adapt to ocean acidification.[127] Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) performs research that includes monitoring changes in seawater chemistry and the responses of some key species in the Southern Ocean. Futher, "[i]n the tropics, a collaborative observational and modeling program between CSIRO, NOAA, NIES (Japan) and University of Queensland has begun in the Great Barrier Reef and South Pacific Regions."[128] The Australian Institute of Marine Science and several Australian universities, including the Australian National University, the University of Queensland, the University of Sydney, and James Cook University, are all attempting to address the problem of ocean acidification affecting the Great Barrier Reef through "large-scale monitoring of reef waters, paleontological reconstructions from coral cores, and field and laboratory experiments on reef organisms."[129]

The United States has the advantage of looking to these nations and evaluating the success of their programs, which can assist in determining whether the U.S. government should follow a similar route in addressing the potential

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[124] OCEAN CARBON & BIOGEOCHEMISTRY PROGRAM, SUBCOMMITTEE ON OCEAN ACIDIFICATION, OCEAN ACIDIFICATION – RECOMMENDED STRATEGY FOR A U.S. NATIONAL RESEARCH PROGRAM (Dec. 23, 2008), http://cmore.soest.hawaii.edu/oceanacidification/documents/OCB_Ocean_Acidification_Whitepaper_Nat_Prog.pdf (last visited May 22, 2018).
[125] *Id*.
[126] *Id*.
[127] *Id*.
[128] *Id*.
[129] *Id*.

impact of ocean acidification. However, these varying solutions present the argument necessitating an international approach. While there may be a limited number of international solutions currently attempting to address this environmental crisis, these similarly structured independent national ocean acidification plans demonstrate the underlying need for an international plan focusing on the world's oceans as one international entity.

A. International Approaches

Presently, there is no international plan focusing on ocean acidification as its own separate environmental concern with proposed strategies; rather, rising acidity levels are merely an afterthought of rising carbon dioxide levels in the atmosphere. While there is a clear urgency and obvious concern regarding the effects on ecosystems due to ocean acidification in the scientific community, this has not yet been translated into an international treaty or solution.[130] As Heidi Lamirande stated in her article for the Suffolk Transnational Law Review, "existing international law has been overlooked and underutilized in regard to protecting the marine environment and preventing ocean acidification specifically, the time is now ripe for an international treaty addressing such needs."[131]

Two vital implementations which do attempt to address ocean acidification within a broader framework are the U.N. Framework Convention on Climate Change (UNFCCC) and the U.N. Convention on the Law of the Sea (UNCLOS).[132] Each of these strategies offers certain benefits and restrictions. "While the UNFCCC is the preeminent instrument to deal with emissions of CO_2, the UNCLOS presents a viable alternative outside the frequently challenging UNFCCC context."[133] However, these frameworks do not solely focus on the emerging concern of ocean acidification; rather, UNCLOS covers various environmental concerns from marine boundaries to the protection of marine ecology.[134] Members of UNCLOS have a general obligation "to protect and

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[130] Second International Symposium on the Ocean in a High-CO_2 World, *Monaco Declaration* (Oct. 6-9, 2008), https://www.reefresilience.org/pdf/MonacoDeclaration.pdf (last visited May 22, 2018).
[131] Lamirande, *supra* note 81, at 205.
[132] Verónica González, *An Alternative Approach for Addressing CO_2-Driven Ocean Acidification*, 12 SUSTAINABLE DEV. L. & POL'Y 25 (2012), *available at* http://digitalcommons.wcl.american.edu/cgi/viewcontent.cgi?article=1517&context=sdlp (last visited May 22, 2018).
[133] *Id*.
[134] *Id*.

preserve the marine environment" with a responsibility to take "all measures . . . necessary to prevent, reduce and control pollution of the marine environment from any source."[135]

While UNCLOS may not specifically focus on the rising acidity levels in ocean water, there are advantages to this framework. UNCLOS is widely accepted and covers a broad range of environmental topics; since it is a binding dispute resolution mechanism, the goal is to convince as many States to ratify as possible.[136] However, UNCLOS has a considerably vague framework, lacking provisions on how participating nations will "protect and preserve the marine environment."[137] A more specific international framework focusing solely on ocean acidification could enable an element of clarity regarding allowable greenhouse gas emissions and combating rising acidity levels which has not yet been addressed in such a venue.

The Paris Climate Change Talks, known as the 21st Conference of the Parties to the UNFCCC, occurred in Paris, France in 2015. Tens of thousands of climate activists, negotiators, policy makers, scientists, and attorneys attempted to finalize the next phase of the plan focused on international climate policy.[138] These parties ultimately reached a landmark agreement on December 12, 2015, allegedly "charting a fundamentally new course in the two-decade-old global climate effort."[139] After four years of negotiating, the new treaty uses a common framework that commits all participating countries to put forward their best environmental practices. The Paris Agreement and accompanying UNFCCC Conference of the Parties decision reaffirms the goal to limit global temperature increases, commits all countries to regularly report emissions, extends a mechanism to address "loss and damage" resulting from climate change, and calls for new mechanisms for emission reductions.[140]

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[135] *Id*. (citing United Nations Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 397).
[136] *Id*.
[137] *Id*.
[138] Jessica F. Green, *Wondering What's Different About the Paris Climate Change Negotiations? Here's What you Need to Know.*, THE WASHINGTON POST (Dec. 1, 2015), https://www.washingtonpost.com/news/monkey-cage/wp/2015/12/01/wondering-whats-different-about-the-paris-climate-change-negotiations-heres-what-you-need-to-know/?noredirect=on&utm_term=.17469fe0f9f2 (last visited May 22, 2018).
[139] *Outcomes of the U.N. Climate Change Conference in Paris*, CTR. FOR CLIMATE AND ENERGY SOLUTIONS, https://www.c2es.org/international/negotiations/cop21-paris/summary (last visited May 22, 2018).
[140] *Id*.

While the Paris Agreement was initially considered a success, previously unsuccessful programs with lofty and encouraging goals should be considered. The Kyoto Protocol, a legally binding treaty with the goal of eliminating the free rider problem by encouraging all major emitters to reduce their emissions, failed to take into account domestic politics that affect the process.[141] In response, the Paris Agreement is supposed to focus on a bottom up approach, which means that countries involved in the conference will reduce greenhouse emissions in the way and at the level in which individual countries see fit.[142] Intended Nationally Determined Contributions allow each nation to plan its own policy, incorporating personal preferences, which lessens the role of enforcement as treaties must be ratified domestically in order to have any legal effect.[143] There will no longer be a distinction between developed and developing countries for reducing emissions, as each country is encouraged to develop its own plan.[144]

However, this conference did not specifically discuss ocean acidification. While leaders have acknowledged that the oceans may be one of the world's most precious and vital ecosystems, the conference did not directly discuss the oceans due to political intricacies. Because the oceans are transboundary in nature, and the Climate Change Convention is focused primarily on emissions of greenhouse gases within national territories, oceanic environmental issues were not specifically addressed in Paris.[145]

Although the conference may have indirectly discussed potential solutions to ocean acidification through plans to reduce carbon dioxide emissions, the conference became highly focused on politics, rather than the environment. Prior to the Conference, Vladimir Putin claimed that Russia was at the forefront of climate change, even though he is an alleged longtime skeptic.[146] Putin claimed Russia "has been contributing actively to addressing global warming. Our country

[141] Green, *supra* note 138.
[142] *Id*.
[143] *Id*.
[144] *Id*.
[145] Eric Holthaus, *Remember the Oceans! The Most Important Consequence of the Paris Climate Talks will be the Fate of the Oceans*, SLATE (Nov. 25, 2015, 12:26 AM), http://www.slate.com/articles/health_and_science/science/2015/11/ocean_acidification_and_climate_change_at_the_paris_talks.html (last visited May 22, 2018).
[146] Michael Roston, *What Climate Change Looks Like: Dissolving Shells*, THE NEW YORK TIMES (Nov. 30, 2015), https://www.nytimes.com/interactive/projects/cp/climate/2015-paris-climate-talks/what-climate-change-looks-like-dissolving-pteropod-shells (last visited May 22, 2018).
[146] *Id*.

is taking the lead."[147] It was unclear what Putin's motives behind this statement were, as Russia is, in reality, the fourth largest greenhouse gas polluter, and a global survey of forty countries revealed that Russians had the second lowest concern about global warming out of every country surveyed, only falling behind the Ukraine.[148] Political researchers have postulated that this statement was announced perhaps to seemingly be a team player in the conference or to gain political good will, as Russia is currently seen as an extremely aggressive player in Crimea.[149] Unfortunately, while the countries participating in the Paris Agreement may have good intentions, it is a treaty under international law, with only certain limited provisions being legally binding.[150]

Most recently in the international field, the United Nations Development Programme released its Goal 14 targets. One of these goals is to "[m]inimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels."[151] Although vague, the targets, focusing on "Life Below Water," are encouraging. The attempt is to turn the targets into reality before 2030.[152]

B. Implications: What Do We Still Need?

By utilizing an international agreement, which removes the current ambiguity regarding approaches to ocean acidification, society will be educated on the multiple facets of climate change, including both global warming and ocean acidification.[153] While the majority of the American population understands that global warming is a significant negative environmental effect caused by climate change, many individuals are uninformed of the process of ocean acidification and the significant impact it can have on the economy, food security, and recreation. An international framework tailored specifically to ocean acidification may have the advantage of providing discrete regulations, which could be more easily followed and monitored.

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[147] *Id*.
[148] *Id*.
[149] *Id*.
[150] CTR. FOR CLIMATE AND ENERGY SOLUTIONS, *supra* note 139.
[151] *Goal 14 Targets*, UNITED NATIONS DEV. PROGRAMME, http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-14-life-below-water/targets/ (last visited May 22, 2018).
[152] *Id*.
[153] Lamirande, *supra* note 81, at 209.

Some have argued that this potential international treaty would need a specific anthropogenic CO_2 level for greenhouse gas emission levels to stabilize around 450-500 parts per million (ppm).[154] Currently, emission rates are increasing so rapidly that marine organisms may soon not have the ability to adequately adapt to the increasing CO_2 absorbed by the oceans. Thus far, marine organisms and ecosystems have been able to adapt to rising acidity levels, but, with the anticipated rate of greenhouse emission levels heading towards 1,000 ppm within the next one hundred years, marine organisms and ecosystems depending on the chemical balance in ocean waters will likely succumb to the rising acidity.[155] Therefore, an international agreement focusing specifically on ocean acidification could effectively institute regulations regarding activities influencing acidity levels, which current international legislation and treaties are lacking.

While an international approach is clearly necessary, there are opportunities for more locally based solutions, often through specific state channels. Although there is legislation in the United States which can be used to address ocean acidification, such as the Clean Air Act, the Clean Water Act, the Coastal Zone Management Act, state laws, and local ordinances, these regulations do not focus solely on the issue of ocean acidification.[156] However, they do provide a multitude of layers necessary to protect coastal waters by controlling emissions, runoff, and land use patterns through zoning and permitting.[157] Furthermore, by implementing these regulations in the context of rising acidity levels, residential and agricultural runoff could be reduced as beach and river contamination could be minimized, which would reduce the pollutants causing acidification in the oceans.[158]

Fortunately, many states have already passed legislation which will limit residential runoff, even though these regulations are not focused specifically on acidification. Until there is an international solution focused solely on ocean acidification, researchers suggest four approaches for states and local governments to indirectly address rising acidity levels. First, the Clean Water Act

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[154] *Id*. at 206.
[155] *Id*.
[156] *See* R. P. Kelly, et al., *Mitigating Local Causes of Ocean Acidification with Existing Laws*, 322 SCIENCE 1036-37 (May 27, 2011), https://www.centerforoceansolutions.org/sites/default/files/publications/Kelly%20et%20al%202011.pdf (last visited May 22, 2018).
[157] *Id*.
[158] *Id*.

directs state government agencies to confirm that precipitation runoff and other pollutants, which have the ability to increase acidity levels, are monitored, limited, and consistent with maintaining a sustainable aquatic ecosystem.[159] Second, local and state governments have the ability to control coastal erosion by reducing nutrient and sediment loading of the water, thereby protecting the physical integrity of habitats belonging to marine organisms.[160] Third, local and regional planning, zoning, and permitting policies focused on land use change can reduce indirect and direct carbon dioxide emissions and runoff.[161] Finally, enforcing federal emission limits for pollutants like nitrogen oxide and sulfur oxide from sources such as coal-fired power plants have the capability of decelerating causes of ocean acidification.[162] Although these localized solutions may have a positive effect on reducing acidity levels, a more wide-based solution must be in place in order to have a significant impact on a transboundary body of water.

V. SUGGESTIONS FOR FUTURE OCEAN ACIDIFICATION SOLUTIONS: COASTAL RESILIENCY STRATEGIES

Currently, nations address ocean acidification individually, with the only seemingly effective international approach being UNCLOS, which does not seem to be incredibly successful regarding acidification. An international or domestic approach to ocean acidification should touch on a plethora of concerns: initiatives to further research on this newly considered ecological development, a plan for providing information to the public regarding the process and small, realistic steps the public can take, limitations on greenhouse emissions and runoff from countries, and plans for mitigation and adaptation on a worldwide scale. Communities, particularly along the coasts of the United States, should be prepared for severe acidity levels, rather than allow the problem to worsen and merely attempt to react to the negatively impacted seafood industry. "Resilience is our ability to prevent a short-term hazard event from turning into a long-term community-wide disaster."[163] Thus, a robust system focusing on ocean acidification is necessary moving forward, in both domestic and international spheres.

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[159] *Id*.
[160] *Id*. at 1036-37.
[161] *Id*. at 1037.
[162] *Id*.
[163] *What is resilience?,* NAT'L OCEANIC AND ATMOSPHERIC ADMIN., http://oceanservice.noaa.gov/facts/resilience.html (last visited May 22, 2018).

First, while there are relevant United States agencies and programs working on the issue, including the National Science Foundation (NSF), NOAA, and NASA, these organizations do not primarily focus on the changing chemical composition of the ocean.[164] As previously discussed, acidification is a complex scientific concept that is still not fully understood. Fortunately, there are departments within these organizations that do focus on acidification, and their research could be further expanded.

The Division of Ocean Sciences within the NSF supports a Biological Oceanography Program, which investigates the biology, ecology, and biogeochemistry of planktonic and benthic systems of open ocean and coastal regions.[165] Similarly, the Chemical Oceanography Program strongly emphasizes its focus on the formation and future of organic and inorganic geochemical materials.[166] Studies in acidification also fall under the Marine Geology and Geophysics (MGG), Earth System History (ESH), and Geobiology and Low-Temperature Geochemistry (GG) programs.[167] Each of these programs focuses on a specific concept:

> MGG considers the genesis, chemistry, and mineralogical evolution of marine sediments, as well as interactions of continental and marine geological processes; ESH addresses the mechanisms and feedbacks that drive the Earth's climate system and determine its natural variability; and GG promotes studies of the interactions between biological and geological systems at all space and time scales. Finally, the NSF's long-term ecological research program (LTER) supports the type of long-term interdisciplinary research necessary to understand the consequences of decreased calcification rates at the ecosystem scale.[168]

Although these programs within larger administrations gather research and conduct experiments on acidification, perhaps a separate entity could be formed to

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[164] Joan A. Kleypas, et al., *Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers: A Guide for Future Research Report*, INSTITUTE FOR THE STUDY OF SOCIETY AND ENVIRONMENT (June 2006), https://www.isse.ucar.edu/florida/report/Ocean_acidification_res_guide_compressed.pdf (last visited May 22, 2018).
[165] *Id*. at 14.
[166] *Id*.
[167] *Id*.
[168] *Id*.

focus solely on ocean acidification processes and impacts on an international scale.

Second, the plan should have the goal of providing information to the public regarding not only the scientific process of acidification, but also reasonable acts that these individuals may be able to take to mitigate the problem. As stated by NOAA, "[a] community that is more informed and prepared will have a greater opportunity to rebound quickly from weather and climate-related events."[169] Perhaps this could be as simple as including ocean acidification in educational science classes or filming a documentary focused on the issue. Furthermore, this factor of an international approach should touch on how individuals can lead more ecologically conscious lifestyles in their day to day lives. This could include information on what types of chemicals are most harmful to marine organisms and what products to avoid in cleaning or household uses. If the public knows about ocean acidification and takes action, perhaps it can have a ripple effect and spur advancements in other fields, such as the further development and use of clean cars, advancements in renewable energy, and an increase in the availability of clean drinking water. Individuals from other professional fields, and not just environmental scholars, may become involved in finding solutions to the problem.

Third, it is essential that an international approach contain some sort of limitation on emissions and pollution, such as runoff. While the Paris Conference attempted to sort out national emission standards, these are not consistent throughout the world. Not all nations are being held accountable, only those opting to participate in the program. While there is pressure from countries insisting that the future of the environment is essential to humans flourishing on this planet, some do not have the means and resources to comply with these standards. One suggestion for approaching an international solution gradually is first attempting to regulate countries on a smaller scale. The United Nations could assist in this effort by first attempting to regulate developed countries that are suffering some of the greatest impacts due to acidification and are also some of the greatest emission creators, such as the United States, China, Russia, Australia, and the United Kingdom. Although this plan would begin on a smaller scale, if these limited countries demonstrate success, the project could then be expanded. As it has been stated in various studies, increasing environmental quality on this planet is projected to have enormous economic benefits regarding healthcare and food production into the billions of dollars. Less developed countries could then

[169] NAT'L OCEANIC AND ATMOSPHERIC ADMIN., *supra* note 163.

mirror the success of these developed countries, potentially with assistance from more developed countries or organizations like the United Nations. While the countries that participated in the Paris Conference are currently attempting to comply with their set limits for carbon dioxide emissions, this will be a challenge, as compliance and enforcement are a difficult feat.

Finally, plans for mitigation and adaption must be incorporated into an international approach. As with the Washington Ocean Acidification Blue Ribbon Panel, which proposed both mitigation and adaptation plans to rising acidity levels within the state of Washington, the potential international solution must also include these considerations. However, these mitigation and adaptation strategies must be specifically tailored to each country or ecosystem experiencing impacts, which are mainly areas with an ocean coast. The strategies could be modeled after a plan like the Ocean Acidification Panel's outcome, and perhaps first tailored to the top ten affected developed countries in the initial planning stages before expansion. While this is not a full list of the factors necessary in an international plan for ocean acidification, hopefully this will fuel dialogue regarding other considerations to include.

A. Alternative Suggestions: Natural Solutions, Public Education, Congressional Declaration, Claims for Relief

While the ideal solution to acidification may be an international solution, this will not be a reality in the immediate future. Instead, we must turn to alternative suggestions to assist with mitigation or adaptation. A few suggested alternatives include finding natural biological processes to regulate the altered ecosystems, providing detailed information regarding the problem to the public, issuing a Congressional declaration to spur more research and regulation, and having the option of making a claim for relief if the problem is not solved before the impacts are widely felt.

First, regarding natural solutions, researchers have conducted an experiment attempting to assist ecosystems in adaptation processes. By utilizing a model of pH regulation, along with abiotic calcification, scientists showed that "the enhanced kinetics of calcification owing to higher temperatures has the potential to counter the effects of ocean acidification."[170] Researchers have found

[170] Malcolm McCulloch, Jim Falter, Julie Trotter & Paolo Montagna. *Coral Resilience to Ocean Acidification and Global Warming Through pH Up-Regulation*. 8 NATURE CLIMATE CHANGE 623 (April 1, 2012), https://www.nature.com/articles/nclimate1473?page=5 (last visited May 22, 2018).

that while natural processes may assist some marine organisms in counteracting the altered pH levels, calcifying organisms are unable to quickly adapt to these heightened acidity levels as carbon dioxide levels increase.[171] Therefore, while there may be the option of allowing natural biological processes to handle this chemical alteration, this will not be a viable alternative for many species. However, some researchers argue that there may be "hotspots" in the ocean with natural variation, ideal for potential adaptation.[172] If these geographic areas can be located, scientists and policy makers will want to study and protect these sites as organisms have most likely developed the genes necessary in order to evolve and adapt to the altered composition of the oceans.[173] If these genes do exist, perhaps they can be artificially spread to other organisms in other geographic locations. Alternatively, scientists have discussed preserving these areas where oceanic chemistry and pH are stable as calcification reserves or refuges for marine organisms that may be more vulnerable to lower pH levels and more acidic water.[174]

Second, the public should be informed about ocean acidification. The public must be informed not only about the scientific process and the biological impacts, but about why they should care about this environmental issue. Thus, the attention of ocean acidification's impacts may be shifted from purely environmental aspects to focusing on economic, societal, and recreational effects.

Third, Congressional declarations may be issued to spur more research and regulations regarding mitigating or adapting to heightened acidity levels with designated Congressional funding. As stated in the Congressional Declaration of Purpose for the National Environmental Policy Act:

> The purposes of this chapter are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.[175]

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[171] *Id*.
[172] Grossman, *supra* note 31.
[173] *Id*.
[174] *Id*.
[175] 42 U.S.C. § 4321.

Finally, if all else fails, at risk populations and individuals may want to file for claims of relief if the effects of acidification cannot be avoided. However, potential claims of relief regarding transboundary resources, such as the oceans, are complex. There is uncertainty as to whether a claim for relief due to impacts from acidification could be made against a state that fails to mitigate ocean acidification and whether the failure to provide such measures would violate the state's obligation under UNCLOS.[176] Some policy theorists have explored the option of bringing any claims of relief related to climate change under the dispute resolution procedures in Part XV of UNCLOS if the claims are against parties involved in the Convention.[177] If disputes cannot be resolved solely through negotiations, Part XV of UNCLOS does provide four options for dispute settlement: (1) the International Tribunal for the Law of the Sea; (2) the International Court of Justice; (3) an arbitral panel; or (4) a special arbitral panel.[178] Because climate change law is currently somewhat limited, claims may need to refer to methods outside of standard environmental law practices. For the time being, Part XV of UNCLOS could prove to be a useful approach in bringing claims of relief in ocean acidification cases, but there is still the question of against whom the claim would be brought. "A claim could potentially be brought against a state with both a high financial ability to address the problem and high historical per capita contribution to carbon concentrations in the atmosphere above accepted levels," which could be based on the per capita emissions comparison discussed in the Kyoto Protocol.[179]

It has been postulated that two ecosystems are at severe risk and could make the first potential claims regarding ocean acidification: coral reefs and polar regions. Coral reefs are extremely vulnerable to altered acidity levels as the ecosystem depends on the process of calcification to survive, and the surrounding island states depend on these coral reefs for food, tourism, ecosystem services, and barrier protection.[180] Similarly, polar regions may be the first to experience negative impacts, as human populations in this area exist mainly by relying on the ocean as their primary natural resource.[181] Yet, parties attempting to bring UNCLOS claims based on acidification will have extreme difficulty in

[176] Yangmay Downing, *Ocean Acidification and Protection Under International Law From Negative Effects: A Burning Issue Amongst a Sea of Regimes?*, 2 CAMBRIDGE JOURNAL OF INTERNATIONAL AND COMPARATIVE LAW 242 (2013), http://cilj.co.uk/wp-content/uploads/2016/11/Vol-22.pdf (last visited May 22, 2018).
[177] *Id*.
[178] *Id*.
[179] *Id*.
[180] *Id*. at 259.
[181] *Id*.

establishing the causal link between ocean acidification and damages to marine resources, as research into the issue is still somewhat limited. Therefore, while there may be alternative options in facing this environmental crisis, none would be as effective and far-reaching as an international approach focused on ocean acidification mitigation or adaptation measures.

B. Proposal: International Panel Approach

Regarding an international approach to ocean acidification issues, outside of an alternative treaty attempt, this article proposes an international panel to discuss concerns and identify potential solutions. For this international panel, there would be five permanent member countries with four other countries in rotating spots. The five initial countries should have large economies, heightened pollution levels, high rates of aquaculture consumption, and environmentalist tendencies. They should also be representative of different areas of the globe facing varying impacts. The four rotating spots would be reserved for countries hoping to join in the debate due to pressing environmental or oceanic crises. With an odd number, there would likely be an opportunity for clarity on difficult decisions. To make discussion productive and solutions viable, there should be no veto power on this international panel, which may rule out some potential panel candidates.

The proposed initial five countries are: the United States, France, Peru, Japan, and Australia. All of these countries represent different regions of the globe. Furthermore, they each bring a different perspectives to the table, such as a high level of GDP, high rates of pollution, high rates of consumption of marine food sources, or an environmental political agenda. For example, according to the World Bank's ranking of GDP in 2016, the United States is first, Japan is third, France is sixth, Australia is fourteenth, and Peru is forty-ninth.[182] For air pollution ranking according to the World Health Organization, all of these countries are hitting their air pollution targets except for Peru.[183] Regarding fish and seafood consumption, according to the Food and Agriculture Organization of the United Nations, Peru is second, the United States is fourth, Japan is fifth, France is

[182] *GDP (Current US$)*, THE WORLD BANK, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?view=map&year_high_desc=true (last visited on May 22, 2018).
[183] THE WORLD HEALTH ORG., ANNUAL AMBIENT AIR POLLUTION (2014), http://www.who.int/phe/health_topics/outdoorair/databases/AAP_database_results_2014.pdf (last visited May 22, 2018).

twenty-seventh, and Australia is fifty-third.[184] Finally, regarding environmental agenda, this article examines the measurement provided by the Environmental Performance Index (EPI). The EPI ranks 180 countries on twenty-four performance indicators across ten issue categories covering environmental health and ecosystem vitality, which can provide insight into countries' environmental policy goals.[185] According to the EPI, France is second, Japan is twentieth, Australia is twenty-first, the United States is twenty-seventh, and Peru is sixty-fourth.[186]

While one may argue that Australia and Peru are out of place, both of these countries have strong interests supporting inclusion on this panel. As discussed in this article, rising acidity levels greatly impacts coral reefs. In Australia, the Great Barrier Reef's economic, social, and iconic value to the country is $56 billion.[187] It supports 64,000 jobs and contributes $6.4 billion to the Australian economy.[188] With the health of this ecosystem at stake, Australia's economy could be significantly impacted. Meanwhile, Peru would be representative of South America's interests on this panel. Peru in particular was chosen due to the country's dependence on fisheries. In a 2009 study by Oceana, Peru ranked first for countries depending on fisheries with respect to total catch within the exclusive economic zones.[189] In 2017, the World Bank reported that Peru is still one of the world's leading producers of fish, providing nearly 20% of global fish catches, and aquaculture accounts for 7% of the country's exports in the past decade.[190]

This panel will not only have five permanent players, but four rotating positions. The five initial members would vote on inclusion for the rotating positions, and this could enable countries facing sudden and extreme hardship due

[184] *Consumption of Fish and Fishery Products*, FOOD AND AGRIC. ORG. OF THE UNITED NATIONS, (2018), http://www.fao.org/fishery/statistics/global-consumption/en (last visited May 3, 2018).
[185] *Environmental Performance Index*, YALE CTR. FOR ENVTL. LAW & POLICY (2018), https://epi.envirocenter.yale.edu/ (last visited on May 22, 2018).
[186] *Id*.
[187] John O'Mahony, et. al., *At What Price? The Economic, Social, and Icon Value of the Great Barrier Reef*, DELOITTE (2017), https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-great-barrier-reef-230617.pdf#page=30Deloitte (last visited May 22, 2018).
[188] *Id*.
[189] Harrould-Kolieb, Hirshfield, & Brosius, *supra* note 123.
[190] Press Release, The World Bank, The World Bank Supports Fishery and Aquafarming Innovation in Peru (Jan. 27, 2017), http://www.worldbank.org/en/news/press-release/2017/01/27/the-world-bank-supports-fishery-and-aquafarming-innovation-in-peru (last visited May 22, 2018).

to rising acidity levels to express their concerns and voice their ideas. This could include small island nations facing crises due to food insecurity to major carbon dioxide emitters searching for opportunities to improve.

VI. CONCLUSION: THE IMPORTANCE OF AN INTERNATIONAL STRATEGY

Ocean acidification is a complex topic, not just regarding the chemistry behind the issue, but also how to attempt to tackle a solution. As the oceans are viewed as an international zone, no one country can claim ownership of any ocean, so no nation has specific jurisdiction over issues occurring in one of these bodies of water. However, there have been international attempts to address issues dealing with the oceans at large. The main governing force is the United Nations, which utilizes the expertise and advice of a multitude of countries to address major political, economic, and environmental events that affect oceanic waters.[191] The main conference addressing international solutions to oceanic problems is, as previously discussed, UNCLOS. However, many nations do not view these negotiations as international law.

Although UNCLOS remains the governing policy regarding international waters and creating nautical policies, nations do have the individual obligation to protect the ocean and its biodiversity up to 200 nautical miles from the coastline.[192] This 200-mile line is labeled as the exclusive economic zone (EEZ), which is based on the continental shelf, and allows for the exploitation of resources such as oil mining, fishing, submarine activity, and transportation by sea and air, falling under the regulations of the nation that has jurisdiction over the EEZ.[193] However, before UNCLOS, the jurisdiction of the waters outside of this zone was ambiguous. Now, the United Nations has made a clear body of policies regarding the regulation of the seas at large. Although UNCLOS attempts to "regulate and mitigate the pollution and environmental damage caused by every nation on Earth through studies, reports, and other methods of environmental activism," there has been no separate focus on mitigating or adapting to ocean acidification.[194] Because of the transboundary nature of the ocean acidification issue, it is unlikely that individual nations will be able to face the problem effectively. Therefore, an international strategy, focusing solely on

[191] Elizabeth Borneman, *Who Owns the Oceans?*, GEOLOUNGE, Oct. 21, 2014, https://www.geolounge.com/owns-oceans/ (last visited May 22, 2018).
[192] *Id*.
[193] *Id*.
[194] *Id*.

the issue of ocean acidification, rather than merely mentioning that it is caused by greenhouse gas emissions, is necessary. While these emissions do contribute to the issue and there has been extensive research and debate regarding the ultimate impacts, time, money, and resources must be dedicated to the issue of ocean acidification exclusively in an international approach.