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Ocean Acidification:

Waters and Wallets at Stake in the United States

An Advocacy Brief to US Republican policymakers on the socioeconomic implications of ocean acidification research...

INTRODUCTION

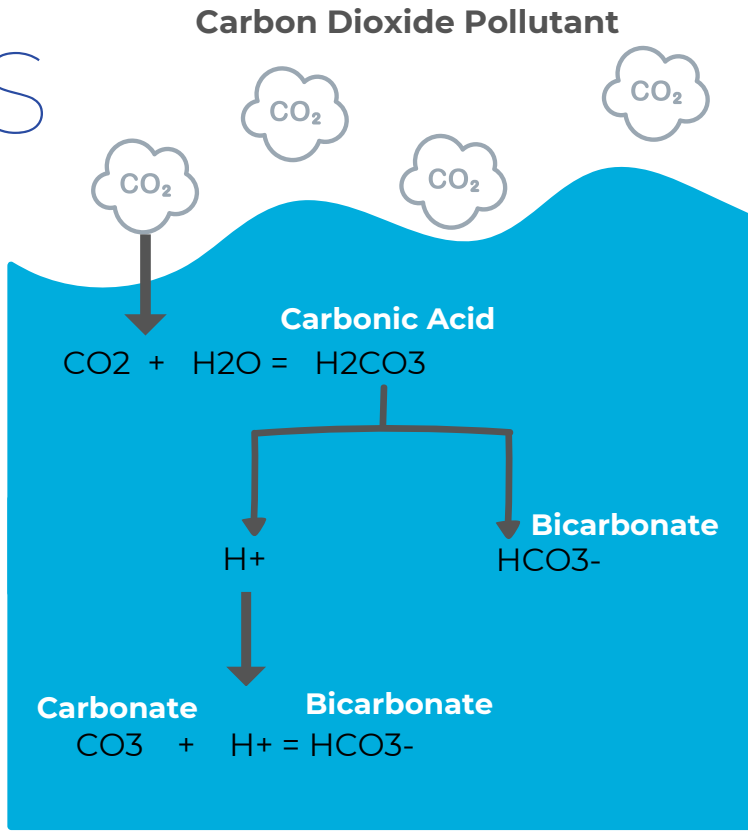
Our nation faces a massive decision in the face of anthropogenic change. It is the decision between a healthy future for all citizens or an uncertain timeline for all living things. It is the decision between clean air and water, or global food storage. It is the decision between a bolstered economy, and one depleted of resources. One of the killers working in union with global warming is ocean acidification. Ocean acidification is the result of carbon dioxide entering water, altering carbonate chemistry, increasing the concentration of hydrogen ions, and lowering the pH value of the ocean. It is based on the same simple chemistry we use in our kitchens, our laboratories, and our classrooms to teach fundamental truths about the chemical composition of our planet.

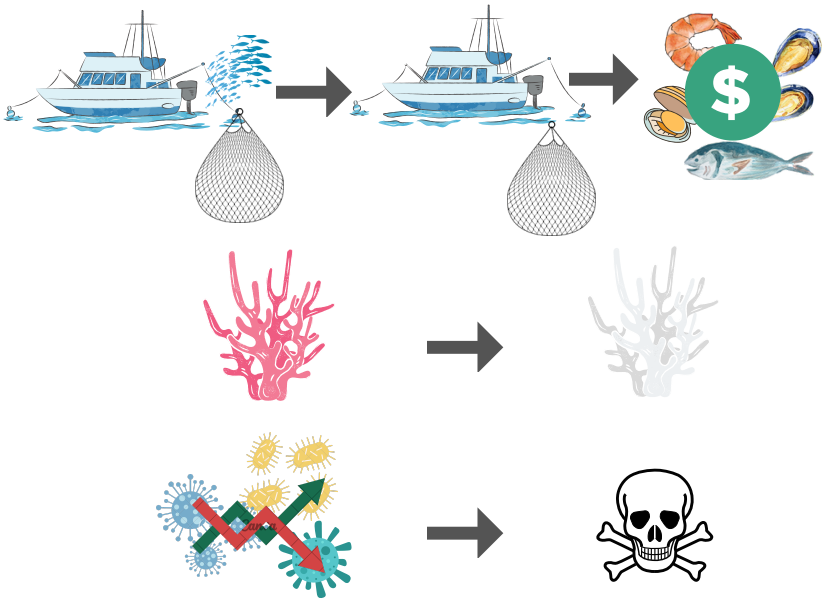
While acidification directly targets calcifying species like shellfish and corals, it has unprecedented indirect impacts on human and economic conditions. Coral reefs in Hawaii, South Florida and Puerto Rico are a backbone to tourism, to which acidification poses billions of dollars of loss. Dangerous blooms of red algae and jellyfish have harmful effects on other species as well as humans, and will continue to drive money away from beach destinations. The fishing industry is being turned upside down by shellfish degradation, and imbalances in microbial communities have the potential to collapse entire food webs that humans rely on. Historically politically conservative states face some of the largest challenges and worst predicted outcomes in terms of species survival, and economic impact. While acidification is a countrywide threat, local proactivity makes en enormous impact on success.

The global ocean pH is expected to dip to 7.8 if current practices are not amended [5]. Similar to humans, the ocean and its inhabitants operate under a very specific pH range. Just 0.1 lower and massive mortality events can occur. The science is not new, as researchers since the 1860s have recognized how CO_2 has the ability to chemically change our planet's atmosphere and oceans [5]. Unfortunately, their predictions are coming true, and the impacts are jarring. This brief will dive deep into the specific processes, instances, and financial and social implications of ocean acidification in the United States.

THE PROCESS

1. CO2 enters the ocean whenever polluted air makes contact with the water's surface.
2. When CO2 enters the ocean it reacts with H2O to form Carbonic Acid H2CO3. Carbonic acid dissociates into H+ ions and Bicarbonate HCO3-. [5]
3. A greater H+ concentration increases acidity, dissolves shells, and damages health. [5]
4. Excess hydrogen binds to existing carbonate, and limiting its availability. Carbonate is an essential building block for shells. [5] Bicarbonate can not be used to build shells.
5. Fisheries have smaller harvests, and unhealthy catch. Seafood market prices skyrocket.
6. Corals lose their photosynthetic plankton, and calcium carbonate building blocks, smashing tourism, and the economies that rely on them.
7. Microbial communities disrupted, nutrient cycling thrown off, and food web collapse.





A healthy pH for marine ecosystems falls at about 8.1, and by 2100 it is predicted that CO2 will increase up to 1000 part per million by volume [2]. While these changes seem small, the pH scale is logarithmic, a one unit decrease represents a 10 fold increase in acidity.

RED STATES IN THE **RED**

While only 12% of Republicans believe that climate change should be a top priority, and 23% saw climate change as a major threat to the country's well-being [11], Republican states could be hit the hardest by climate impacts like ocean acidification. Meanwhile 84% of Republicans list strengthening the economy as their top priority [11], but lack of attention to ocean acidification could have these states losing millions to billions of dollars per year.

FLORIDA

Florida faces a risky future in the wake of ocean acidification, especially communities along the Florida panhandle and southwest coast. Florida is one of the only states with in shore reef formations, and corals are the most well studied victims of acidification. The Florida Reef Tract (FRT) is valued at $7.6 billion, and one of their ecosystem services, offshore storm protection, is valued at $1.6 billion [8]. A variety of species in the region have already been identified as victims to increased acidification, including the stone crab, the Atlantic blue crab, larval hard clams, and more [7]. These industries bring in tens of millions of dollars per year. Another threat to the Florida ecosystem is the effect of increased CO2 incantations on harmful species like the famous Red Tide Algae. In addition to its impacts on tourism, it produces a neurotoxin that kills finned fish valuable to the fishing market, and affects human health [12]. (See page "Red Tide Algae")

https://matadornetwork.com/read/travel-guide-8-best-beaches-southwest-florida/

LOUISIANA

One of Lousiana's trademark industries is the oyster fishing market. Oysters are one of the many mollusk species susceptible to ocean acidification. Like other shellfish they build their own shells using calcium carbonate in their environments.

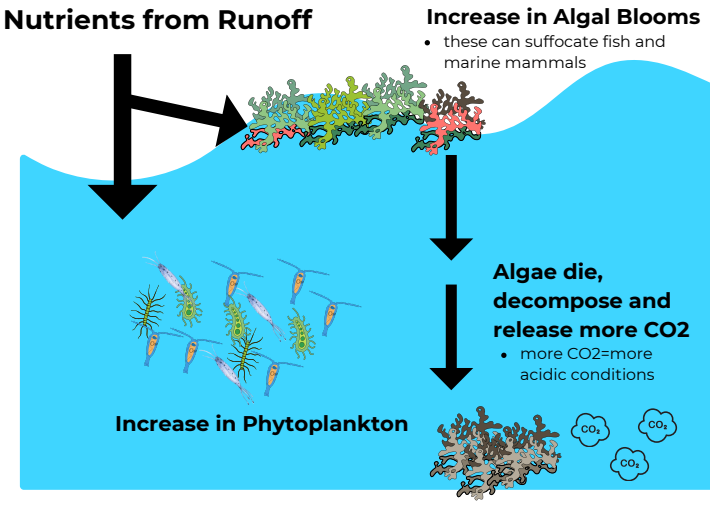
The oyster market brings in over $30 million per year and supplies thousands of jobs [10]. The rivers that flow into Louisana's costal waters are riddled with pollution and lead to subsequent acidification [10]. This pollution also leads to growth of algae, which contributes to released CO2 and increased acidity during their decomposition. The wide network of seafood industries in LA bring in $2.4 billion per year [10]. There are many other shellfish and seafoods that will be affected by acidification, and there is no doubt this will translate into decreased profits.

Yhttps://www.fishfisheriesforward.org/fwf-commission-sets-2019-20-louisiana-oyster-season#

THE CAROLINAS

Both North and South Carolina were listed as states at the highest risk of economic decline due to ocean acidification. An intricate network of estuaries have shown high eutrophication [8] (which leads to algal blooms) and low carbonate saturation. Enhanced eutrophication, enhances primary productivity, and can increase acidification trends.

EUTROPHICATION GRAPHIC



The oyster industry is rapidly rowing and may contribute upwards of $100 million to North Carolina alone by 2030 [3]. In order to protect this growing benefit, the vulnerable waters where these oysters lie must be protected. Jobs provided by the shellfish market are even more important to the Carolinas, as they hold a greater social importance compared to other states with greater job availability [8]. There is an urgent need for calcification and pH to be routinely measured with water parameters, as recent losses at shellfish farms cannot be traced back to disease or salinity [3].

While the economic importance of preventing acidification in these states is pertinent, so is the cultural importance of many threatened species. In depth monitoring across the south and south east is essential to promising the health of these communities. Agencies like the Southeast Coastal and Ocean Acidification Network (SOCAN) have been working with stakeholders to facilitate the communication and research about acidification in the region [8]. Agencies lime this need more funding, and more need to be established to cover all vulnerable areas.

INVASIVE AND DANGEROUS SPECIES

MICROBES

Marine microbes play an irreplaceable role in maintaining healthy aquatic ecosystems. Their roles in nutrient cycling of carbon, nitrogen, phosphorous and sulfur, build the base of food webs that millions of species rely on. Microbes are incredibly diverse, and account for 90% of the biomass in the oceans [4]. While essential nutrient cycling microbes have been negatively impacted, potentially invasive microbes have been on the rise. Decline in pH increases the polysaccharide and other organic matter degradation, as well as the prevalence of cyanobacteria blooms [4]. This blooms have very toxic effects on humans and other life forms, and are a direct result of excess runoff. In the wake of warming waters, pathogenic microbes have expanded their ranges, and set roots in new ecological niches. It is widely known that pathogens prefer warmer environments for growth, but studies also show that lowered pH values can promote the growth of harmful microbes [4].

Corals have been a direct target for ocean acidification, due to their mutualistic relationship with photosynthetic bacteria and calcified base. Reduced pH has been shown to cause an increase in pathogenic microbes living with corals, such as Vibrionaceae and Alteromonadaceae [4]. Since the acidifying process in oceans is very slow, and responses are quite unpredictable, these conditions are difficult to replicate in laboratory settings. There is an urgent need for research funding in this area. Microbes live inside of us, on us, around us, and are present in the millions with every drop of water. They control the world without even being seen, but changes in their populations will produce impacts that are completely obstructive.

RED TIDE ALGAE

https://fred.ifas.ufl.edu/extension/economic-impact-analysis-program/disaster-impact-analysis/harmfulalgalblooms/

Karenia brevis, also known as a red tide algae, blooms off the coast in response to chemical changes in the water. While red tides are a naturally occurring phenomomen they are made worse by increased pollution and have become longer lasting and more toxic [2]. Coupled with severe storms in places like Florida, increased runoff continues the dangerous cycle. It has been established that increased CO2 concentrations contribute to their growth, and this has also been modeled in the laboratory. While short term exposure to lower pH's decreased the a closely related algae strain's photosynthetic ability and efficiency, long term exposure saw these abilities completely recovered [2]. This indicates a high adaptability for the harmful species, and a competitive advantage for growth in a vulnerable ecosystem. Unfortunately this means it will outcompete threatened species, and grow in prevalence and potency. The 2018 Red Tide Algal Blooms in Florida were completely destructive, and resulted in a loss of approximately $2.7 billion in tourism [15]. The breakout

required $15 million of emergency funds for clean up efforts [12]. Hotels and restaurants were hit hard; hotels on Sanibel and Captiva island saw a 78% cancellation rate [13]. Its harmful neurotoxin cannot be removed during seafood preparation putting humans at great risk [12]. Greater attention and funding allocated to red tide recovery is essential for preventing these losses in the future and preserving small businesses, as the tide will only grow stronger.

JELLYFISH

A common costal nuisance that beach goers seek to avoid is jellyfish. While some jellyfish cannot inflict harmful stings, others can be very dangerous. Even those that do not harm humans have the ability to completely shut down infrastructure and tourism. Jellyfish fall under the same phylum classification as corals, but there are many subcategories. The term jellyfish represents cubazoans like the box jellyfish, hydrazoa like the Portuguese man of war who are actually colonial animals, and scyphozoans who appear as “traditional jellies”.

Cubazoa

Hydrazoa

Scyphozoa

Unlike their coral relatives they are not as sensitive to ocean acidification and warming waters, and have been growing in numbers through a phenomenon called jellyfish blooms. These blooms are not uncommon in the United States, occurring along the east coast from the Chesapeake Bay, to the South East, and around into the Gulf of Mexico [6]. Jellyfish have been known to clog the water intake screens of power plants, leading to reduced energy in these areas [13]. They have had impacts on fishing by clogging nets led to a loss of $10 million in the Gulf of Mexico in the early 2000s [13]. These problems are not just isolated to the United States, but have global affects on places like the North Sea, Japan, China, and more.

Jellyfish are using a series of conditions to their advantage

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1. **Warm and Acidic Waters**
2. **Eutrophication**
3. **Infrastructure**
4. **Loss of Predators**

A study done on Moon jellyfish (Aurelia aurita) shows that they can withstand high temperatures, low pHs and low oxygen concentrations [1]. Even under the worst predicted outcome of stressors, there were only minimal effects on their population [1]. All eyes should be on jellyfish, and other species that benefit from these changes, as they have the ability to become catastrophic invasive species and decimate our oceans. Their life cycles are incredibly complex, so further research and replication is key to understanding how they react to these processes.

IMPACTS ON TOURISM

The United States is home to unique coastlines which draw tourists from across the country and all over the world. Coral reefs enhance South Florida, Hawaii, and Puerto Rico with their beauty and ecosystem services. A myriad of recreational activities such as snorkeling, fishing, scuba diving and more rely on their health and accessibility. While the total benefits of coral reefs tally in at nearly $34 billion, $10.8 billion come from tourism alone [9]. South Florida is in the most critical position, and while slightly reduced emissions are expected to help Hawaii and Puerto Rico avoid successive bleaching events, the Florida reefs require a mora radical response [9]. The bleaching threshold temperatures and pH values were already surpassed by 2000 [9].

We are decades late in enacting a critical and specific regional response. A study done on tourists to the Great Barrier Reef off of Australia found that there would be an 80% decline in future trips if there were massive decrease in coral cover and fish diversity [14]. The risk of a similar scenario in the United States is growing, and we must prevent it.

IMPACTS ON FISHING

One of the first groups of people that will be impacted by acidification is fisherman. The availability of large and healthy harvests is on the decline, and paired with overfishing, puts many businesses at risk. A laboratory study done on various commercial species exhibited that mussels and oysters are incredibly sensitive, and even large organisms like Sea Bass suffer under these conditions [3] The fishing industry supports hundreds of thousands of jobs from harvesting to retail and is responsible for a $34.2 billion in US gross National Product (Data from 2007) [3]. In addition to fishing as an occupation, it also represents a leisure based activity; saltwater fishing for recreation supported 350,000 jobs and $43 billion of income in 2000 [3]. Researchers forecasted the future economic losses, based on acidification rise into the year 2060. Using current data that predicts the concentration of

https://www.mywestshore.com/great-commercial-fishing-boat/

CO_2 through this time period, they estimated a net loss of $1.7-10 billion from the mollusk industry through the mid century [3]. In order to mitigate these losses, there must be a deep evaluation of fishing management techniques. Fisheries should incorporate mathematical models influenced by temperature, pH, salinity, and oxygen concentration into their business plans. Recent studies on species' reactions to the changing chemistry need to be taken into account to avoid extra stress on the populations. Adopting a model that combines economic needs and conservation needs is the best route for success of all stakeholders.

KEY ASKS

1. INTUITIVE FISHING MODELS

We need to develop collaborative Fishing Models, working with fishermen from harvest to the market. Acidification parameters must be included in water testing, as it can influence harvest seasonality and success, and will be useful way to collect local data. The synergistic effects of overfishing, acidification, and ocean warming must be evaluated to sustain a successful seafood market.

2. COMMUNICATION WITH STAKEHOLDERS

A variety of stakeholders from fisherman, boat captains, hotels, travel agencies, seafood salesmen, tourists and more have investments in the health of this ecosystem. They are also the people who work most closely with the environment, and should be included in the scientific and policy developing processes. Collaboration and transparency is essential to success and rehabilitation.

3. RESEARCH FUNDING

There needs to be increased funding for acidification related studies. Replicating environments and predicting future scenarios is incredibly difficult in laboratory settings, and requires state of the art technology. The NOAA (National Oceanic and Atmospheric Administration) Sea Grant for Ocean Acidification needs to be increased and prioritized. More funding for invasive species studies is required to understand how animals like jellyfish have the potential to explode and exploit our oceans.

4.BUILD POLICY MOMENTUM

The United States just joined the International Alliance to Combat Ocean Acidification in 2022, although it was formed in 2016 (NOAA.gov). The Coastal Communities Ocean Acidification Act introduced by Carlee Pingree passed the House in 2023, and would require the NOAA to support local and state entities with resources too respond to mean acidification (Congress.gov). It would also require the incorporation of rural and tribal voices in the conversation. Fully passing influential bills like this one will have trickle down effects on communities, and undoubtedly exhibit positive results.

5. EDUCATION

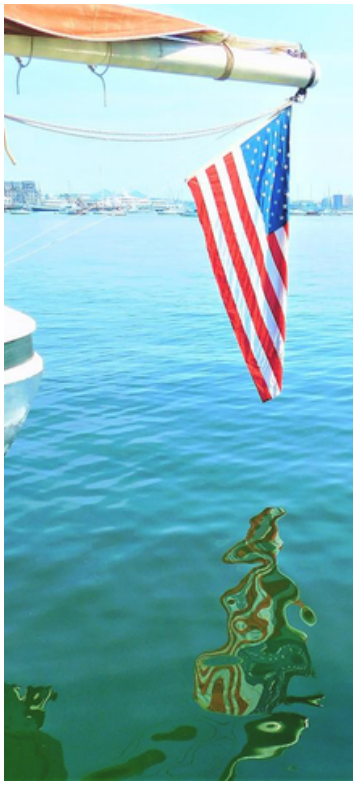
A huge portion of policy success relies on educating citizens on the how and why of ocean acidification. Tourists need to be educated on the proper ways to interact with vulnerable ecosystems to prevent further damage. The basics of ocean acidification should be taught in union with chemistry and biology lessons in high schools across America.

1. TASK FORCE CREATION

States in vulnerable conditions need to foster the formation of task forces and commissions that can stimulate conversation with stakeholders, and develop plans to access current acidification rates. Some states have already done this including New York. Massachusetts, Oregon, Maine and more, but states in critical condition like Florida, Louisiana, North an South Carolina have yet to do so [10].

CONCLUSION

We strongly urge policy makers across the country to consider ocean acidification as a huge issue for not only coastal ecosystems, but an intersectional issue that will impact state and national economies, working class individuals, cultural symbols, and food security. Its potential to spur the growth of invasive species like red algae and jellyfish has unpredictable effects on cascades of energy throughout the oceans. It will continue to threaten job security and the fishing market, as well as consumers who rely on seafood products. The beauty and cultural significance of our coastlines is part of what makes the United States a special place for everyone. The country's economic needs and conservation needs do not have to clash, but have great potential for harmony. It is now necessary to establish the United States as a a leader in preventing the acidification crisis, and protecting our people, and our future.



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