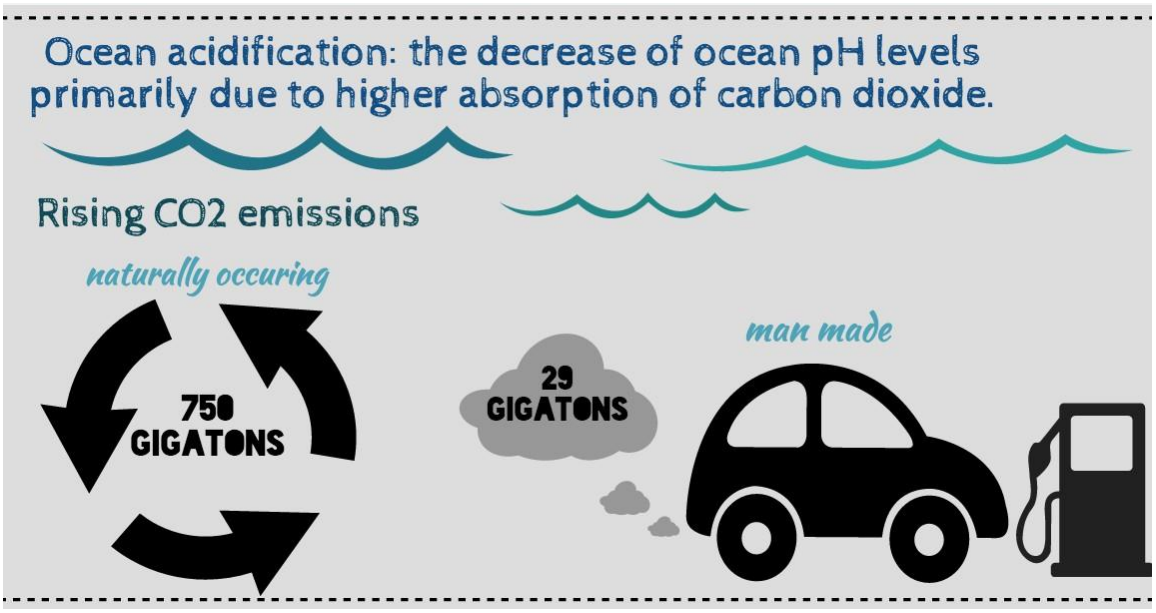
The Ticking Time Bomb: Combatting Ocean Acidification

"I refuse to condemn your generation and future generations to a planet that's beyond fixing." - President Barack Obama, June 2013

As the world advances at a growing pace and new developments in technology and industry abound, one must consider the cost of such progress. Ocean acidification, resulting from rising pH levels, is one of many major consequences of the aggressive increase in carbon dioxide emissions. Since the pre-industrial era, the amount of CO2 in the atmosphere has increased by a third of its previous rate (Wayne). Some argue that this rise in CO2 is not related to human action, but to deny the role of manmade carbon in changing temperatures and rising acidification of the oceans is to deny science itself, and this attitude must be remedied through increased awareness and education. Global CO_2 emissions from fossil fuels went up from about 2,500 teragrams in 1900 to 32,000 teragrams as of 2008, with levels continuing to rise to this day ("Global Emissions"). One teragram is equivalent to 1,000,000 metric tons, or about 40 times the weight of the Statue of Liberty (The Measure). The Presidential Climate Action Project recognizes the human role in the progressive damage to world oceans and calls for global greenhouse gas emissions to undergo a 60% reduction by 2050 in order to prevent further destruction (Hassel). This is an ambitious goal, and unless climate change is brought to the forefront of people's attention, it will go unmet. Individual, scientific, and governmental efforts all play a potential role in combating ocean acidification, as implementing a solution requires increased social-environmental activism in order to bolster federal support and financial backing of new carbon capture technologies.

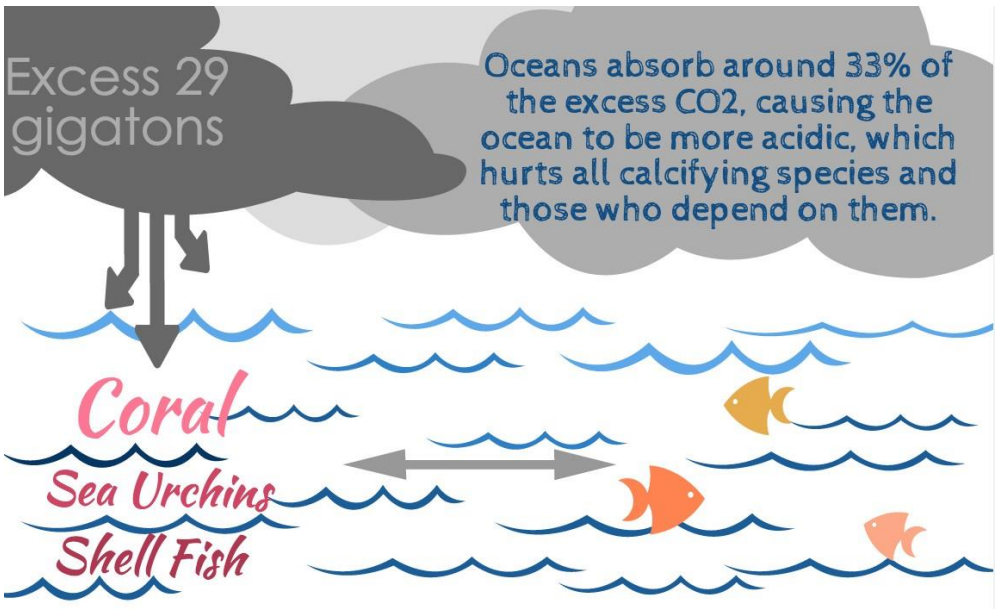


Currently, the amount of CO2 in the atmosphere is at its highest level in 15 to 20 million years. This increase has occurred in a very short period of time. While naturally, this change in the amount of carbon in the atmosphere would take anywhere between 5,000 to 20,000 years, this recent increase of carbon has taken just around 120 years to occur (Wayne). 40% of manmade carbon is absorbed into the Earth and the rest remains in the atmosphere. Roughly 33% of remaining CO2 goes into the oceans at a rate of 300 tons per second. This excess carbon dioxide absorption has caused oceans to become 30% more acidic than they were prior to the Industrial Revolution (Huelsenbeck). Although ocean absorption of excess CO2 helps to slow the rate of global climate change by removing some of the overabundance of CO2 out of the atmosphere, it has and will continue to have detrimental effects on marine wildlife and human life, which is dependent on healthy oceans.

Ocean acidification directly affects the diversity of coral reefs and the development of marine life, thereby impacting fishing industries and people reliant on such food sources. The Pacific Northwest has started to see the effects of acidification as

oyster larvae face mass devastation, a serious threat to the shellfish industry (Grossman). Ocean acidification has the most severe impact on the ocean's calcifying species such as oysters, clams, coral, and sea urchins. Through ocean acidification, the saturation of the necessary calcium carbonate minerals these animals need in order to calcify, or build their skeletons and shells, is lowered. Not being able to complete this process puts all calcifying animals at risk. The presence of these shelled organisms is vital to the survival of the food chain and the billions of people who rely on shellfish and other marine species as not only their main source of food and protein, but also as their source of economic livelihood.

Coral is one of the hardest hit victims of ocean acidification. Studies show a 52-73% decrease in larval settlements on reefs in oceans with lowered pH levels (due to higher levels of CO2), causing coral to struggle to build its skeletons (Van Dien and Stone. For coral, the slowing rate of calcification makes their branches more brittle, and therefore more prone to threats such as coral bleaching. If ocean acidification persists, coral may diminish completely by the year 2050, and the estimated one million species that are dependent on coral may die with it ("Look More Deeply").



Though ocean acidification is the issue at hand, the solution to it lies not directly in the oceans themselves, but at the root of the problem: rising CO2 emissions. Relating back to the call for a 60% decrease in CO2 emissions by the year 2050, we have to acknowledge the difficulty of cutting down CO2 emissions so drastically in a world where the demand for energy is constantly growing. The question to ask, then, is, "How to reconcile the global energy demand with the need to reduce emissions?" The technological answer lies in a two-step process: a means of temporary environmental relief, followed by the synthesis of an artificial carbon cycle. These of course, must be fostered by governmental advocacy and legislation to regulate carbon emissions and provide alternatives to the unsustainable, coal-burning, 20th-century power plants that are still in use.

Stratospheric sulfate aerosols are one aspect of the technological solution. These will give the world a sense of environmental relief, and will hit the pause button on the ticking time bomb that is rising CO2 emissions, creating time to implement the direct solution: carbon capture and enhanced oil recovery. Stratospheric sulfate aerosols are tiny particles that exist suspended in the atmosphere that have the ability to scatter and absorb sunlight. These aerosols occur naturally in volcanic eruptions and desert dust, but are also produced synthetically from human activity. Aerosols have an adverse effect to greenhouse gases in the atmosphere because they cool regions down rather than warm them up. Researchers such as David Keith propose releasing sulfuric particles *above* the ozone layer over the two poles where they will reflect the sun and cool the Earth with minimal damage to the ozone. This is a temporary solution to take care of issues such as sea level rise, the impending sinking of major cities, and the melting glaciers in the poles,

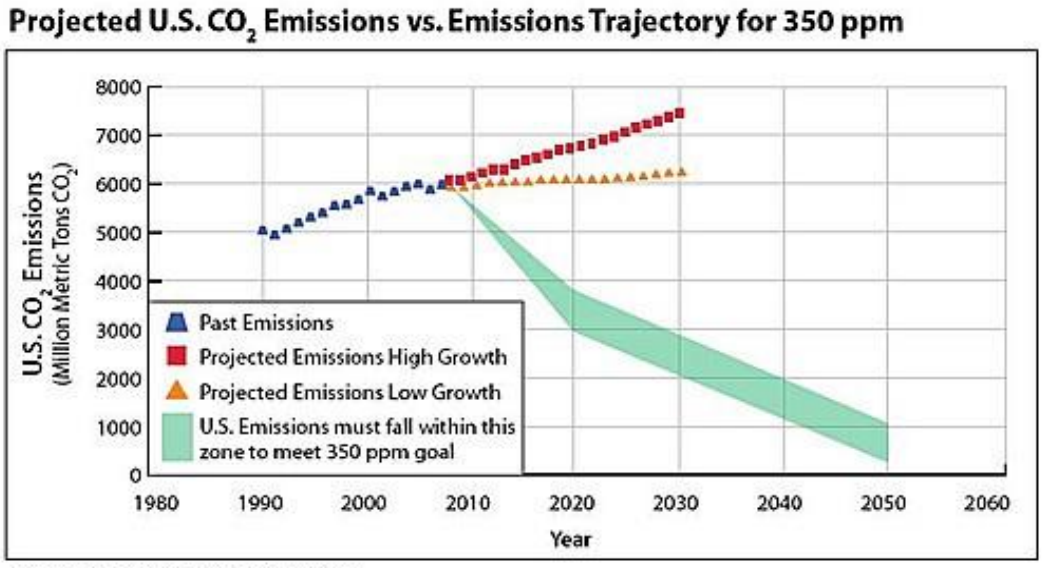
so that focus can then turn to cutting out CO2 emissions entirely. However, because there is no incentive or immediate benefit of releasing these aerosols into the air, nor is their individualized responsibility for carbon emissions, no government agency or private industry will finance this long-term venture. According to Tom Wigley, a scientist at NCAR, releasing these aerosols every one to four years in amounts equal to those naturally occurring in volcanic eruptions gives the world a break of around 20 years in order to cut down CO2 emissions before the grace period is over.

Legislation and policy are the most important aspects of enacting an effective solution to reduce carbon emissions and halt the increasing contamination of ocean waters. In the past decade, the Obama administration has taken a progressive stance on combating ocean acidification by providing funding for research and passing legislation regulating the emission of CO2 and other environmentally harmful operations. However, so far these responses have been virtually ineffective and future cabinets must take a more aggressive position countering this growing threat. There have been many calls for the US government, as well as other administrations globally, to take up this cause before it is too late and the damage done to the ecosystems and to ocean-based economies at home and abroad becomes irreparable.

Since 2008, the United States has increased solar energy by 10 times its former aggregate and tripled wind energy consumption, aiming towards a 30% carbon reduction in the power sector by 2030 via The Clean Air Act ("Climate Change"). In 2009, the *Federal Ocean Acidification Research and Monitoring Act* mandated that federal agencies (including the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation, and NASA) research ocean acidification, its impact on

marine ecosystems, and strategies to diminish and prevent these effects (Atkin). Currently, ocean acidification research is allocated only $6 million a year by the NOAA and $11 million a year by the NSF (Atkin). This is minimal compared to a total annual federal expenditure of $3.50 trillion, and even this allocated small sum of money isn't being spent productively (House). According to the Government Accountability Office, more money should be going towards actual tactics to reduce and prevent ocean acidification as opposed to the mere study of its effects (Atkin).

In June 2013, President Obama announced the Climate Action Plan, a succession of executive actions to combat rising carbon pollution. Perhaps one of the most important developments was the Presidential Memorandums that directed the Environmental Protection Agency (EPA) to focus on establishing carbon pollution standards for the energy sector. The Clean Air Act allows the EPA to issue carbon emission standards for both new and existing power plants, a huge milestone for climate change enthusiasts. In September 2013, the EPA proposed a set of standards for new power plants, and just last year they announced The Clean Power Plan to reduce carbon pollution from already existing plants ("Climate Change"). Both proposals are expected to be finalized by mid-2015, and will be tremendously important in the push to control carbon emissions.



Source: Oceana , based on EIA (2006) and IPCC (2007)

In the United States, power plants are the largest concentrated source of emissions, and so providing them with alternatives and pricing carbon is crucial to combating mounting pollution (“Climate Change"). In addition to these measures, the government can, and should, promote carbon capture technology in the private sector by helping to defray the added cost through tax credits or low-interest, long-term lending, thereby discouraging the operation of coal-fired power plants. Governments should also go further in encouraging the private sector to develop alternative energy options, such as solar and wind. Carbon capture technology is also readily available, albeit expensive, and companies have little incentive, as it is, to invest in alternative methods of reducing carbon emissions.

CC-EOR, short for Carbon Capture and Enhanced Oil Recovery, is a process by which CO2 emissions from industrial and energy related sources is captured, compressed, and injected into oil reservoirs. This process, which synthesizes an artificial carbon cycle alongside the pre-existent carbon cycle, is a key solution to reducing excess carbon in the atmosphere now. The injected CO2 mixes with trapped oil, thus lowering the viscosity of the oil and allowing it to be flushed out towards the production well, which harvests the oil from the ground. This process will prevent CO2 emissions from entering the atmosphere while simultaneously making a profit. According to Tim Bradley, a petroleum engineer at Kinder Morgan, CC-EOR will raise U.S. oil production by more tha n 10%, around 650,000 more barrels of oil daily. Each barrel of oil will eventually release around .42 metric tons of CO2, which will then be captured, recycling around .52–.64 metric tons in a continuous cycle. (Biello). CC-EOR is a stronger alternative to processes without benefits or offset costs such as carbon capture and storage. CC-EOR

should be pushed globally as a scientific solution to this growing issue in conjunction with environmental awareness at home.

The future of environmental regulation is ambiguous, at best. Last year, a number of world leaders, including one hundred Heads of State and Government, met for the UN global Climate Summit. The purpose of the Summit focused on five fronts: cutting emissions; mobilizing money and markets; pricing carbon; strengthening resilience; and mobilizing new coalitions ("2014 Climate Change` Summary"). Though United States government continuously advocates a commitment to environmental sustainability as a top priority, "going green" is often side tracked by more pressing – and socially relevant – issues. The United States has always prided itself on being a leader among nations, but we are already far behind many European countries on issues concerning pollution and the environment. Going into 2015, we must combat ocean acidification as well as the mounting climate change and we must do it through the legislation monitoring and regulating carbon emissions.

The two biggest obstacles the federal government is facing in combatting this global threat are gridlock and lack of citizen support. Not enough people in the United States are actively campaigning for the government to spend more time, money, and energy on finding solutions to climate change or to ocean acidification. This coupled with a debilitating discord between the two major political parties means that very little environmental legislation is likely to be agreed upon in the coming years: a potential situation which would be devastating to our oceans, aquatic wildlife, and marine economies. Fishing, shellfish farming, tourism, as well as coastal areas, are very likely to

face the brunt of ocean acidification as the changing pH levels disrupt entire marine ecosystems ("Tell Congress").

The potential of legislation to mitigate ocean acidification revolves around reducing and ultimately eliminating excess carbon emissions whether through carbon pricing, encouraging the shift to renewable energy sources, or subsidizing newer and more environmentally friendly practices, such as carbon capture. Carbon pricing is a broad classification, which encompasses strategies such as carbon taxes and carbon allowances with a cap-and-trade system. These are important aspects to the federal response, yet some argue that these strategies place unnecessary burdens on our private industry and potentially leave the United States at an economic disadvantage to the rest of the unregulated world. This argument discounts, however, the long-term benefits of these policies once the rest of the world realizes that they must also enact carbon emission regulations to protect their people and livelihoods.

The effects of carbon pollution, such as ocean acidification and sea level rise, threaten not only the livelihoods of people around the world, but also their homes. It is time to enact large scale change by changing cultures of wastefulness and realigning societal values to support sustainable living, as well as using new carbon capture technology and government support to reduce emissions. Productive change relies on the organization of individual actions into a group effort. Such group effort, such as the 2014 People's Climate March, which attracted over 400,000 participants, is necessary and possible within the United States.

To reduce carbon emissions, attention must be focused on the cultural attitude regarding climate change in the US. This involves an examination of individual choice,

especially in the realm of consumer culture. A survey conducted in April of 2014 by the Yale Project on Climate Change found that 33 percent of Americans claim to have financially supported companies that actively try to reduce global warming. Furthermore, almost of half of the population is willing to actively incentivize companies to operate sustainably ("Climate Change in the American Mind"). This is indicative of the power of evolving cultural attitudes. The next step is to ask whether people are willing to go beyond changing their purchasing habits to change their usage habits as well.

In order to create and maintain a positive culture of sustainability to influence actions and reduce individual carbon footprint, there needs to be mass understanding and desire to change. The pressing issues of ocean acidification and sea level rise can be understood through education. Education builds habits and eliminates the idea that these problems are arbitrary. A prominent example of effective climate change education is the UNESCO Climate Change Initiative. This program aims to strengthen the "climate literacy" of children by helping member states of the UN implement climate change education in schools, explore interdisciplinary study, provoke whole-school approaches, and develop non-formal studies and projects outside of the classroom ("Climate Change Education in Sustainable Development"). Young people with a comprehension of the effects of climate change are better equipped to develop green mindsets and behaviors, and thereby create new cultures of environmental-consciousness with greater potential to reduce carbon dioxide emissions and prevent further damage to the ocean ("Climate Change Education"). The future of the Earth's oceans and climate lies with the actions of the emerging generation. Education is a widely achievable, effective solution to move beyond old cultures of wastefulness and disbelief.

However, education cannot stand alone in the redefinition of societal values. Individual action may gain motivation from societal pressure, but without the appropriate infrastructure to support it, green living will not prevail. In order to effect such change, sustainable living needs to be made uncomplicated and more attainable. Much of Europe is structured in a way that makes green living easy and customary. Electric clothes dryers and air conditioning units tend to be regarded as luxuries, rather than necessities. Public transportation is affordable, efficient and readily available in cities such as Stockholm, where taking a cab is twice as expensive as boarding a train (Rosenthal). The impact of this kind of thoughtful infrastructure and mindful culture is obvious, as per capita CO_2 emissions from the consumption of energy were 17.62 tons in the U.S., contrasted with 5.73 in France and 6.57 in Germany, as of 2011 ("Each Country"). The infrastructure of American cities must be redeveloped to keep pace with changing mindsets and support a new, greener culture focused on the reduction of carbon footprint. These long term improvements cost money, and must be financed and supported by the federal government as an additional move towards a more sustainable and environmentally friendly country with reduced carbon emissions. The United States has historically been seen as nation of excess and wastefulness; however, there is a budding desire to change.

It is vital that the public realizes the consequences of human action, as human survival and success are reliant on the preservation of the natural balance of the environment. Ocean acidification and sea level rise not only alter the natural composition of the Earth, but also destroy marine wildlife and threaten to displace people inhabiting coastal regions and islands. Change cannot wait. Ocean acidification is directly linked to human action, and we are therefore responsible for bringing climate change and its

detrimental effects to a halt. Having established the significance of individual mindset and action, society must then restructure to place a high value on conservationism. Following mass motivation to transform, education, infrastructure, federal incentive, and policy are key components in carrying out widespread action. In this sense, it is imperative that governments get involved to aid efforts to lower carbon emissions, and regulate those who may be careless in their consumption, as the societal desire to go green must be aided and supported by a world that celebrates and values such a mission.

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