OCEAN ACIDIFICATION

How CO_2 Emissions and False Solutions Threaten Our Oceans

food&water watch

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Food & Water Watch champions healthy food and clean water for all. We stand up to corporations that put profits before people, and advocate for a democracy that improves people's lives and protects our environment. We envision a healthy future for our families and for generations to come, a world where all people have the wholesome food, clean water and sustainable energy they need to thrive. We believe this will happen when people become involved in making democracy work and when people, not corporations, control the decisions that affect their lives and communities.

Food & Water Watch has state and regional offices across the country to help engage concerned citizens on the issues they care about. For the most up-to-date contact information for our field offices, visit *foodandwaterwatch.org*.

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Executive Summary

Rising levels of carbon dioxide (CO_2) emissions in the earth's atmosphere are causing a phenomenon called ocean acidification. As the oceans absorb more and more CO_2, this results in seawater becoming more acidic and creates increasingly unfavorable conditions for calcifying sea life such as shellfish and corals. Unfortunately, these marine organisms are already experiencing the effects of acidification, which will only continue and increase with time.

Ocean acidification is setting off a chain reaction throughout entire ocean ecosystems, bringing with it serious implications for marine habitats, coastal regions, fisheries, livelihoods, environmental stability and food security. It is pervasive and unlike other current environmental crises, its legitimacy is unquestionable and backed by scientific evidence: CO_2 emissions are the direct cause of ocean acidification.

Addressing such a widespread issue requires concerted and collective action at every level, beginning with the only viable option to mitigate the effects of ocean acidification: significantly reducing and stopping CO_2 emissions from entering the atmosphere. Secondly, addressing coastal pollution inputs that add to acidification will be equally important in combating the ramifications of acidification. Thirdly, this crisis must be taken seriously — more research, as well as funding to do the research, is exceedingly needed.

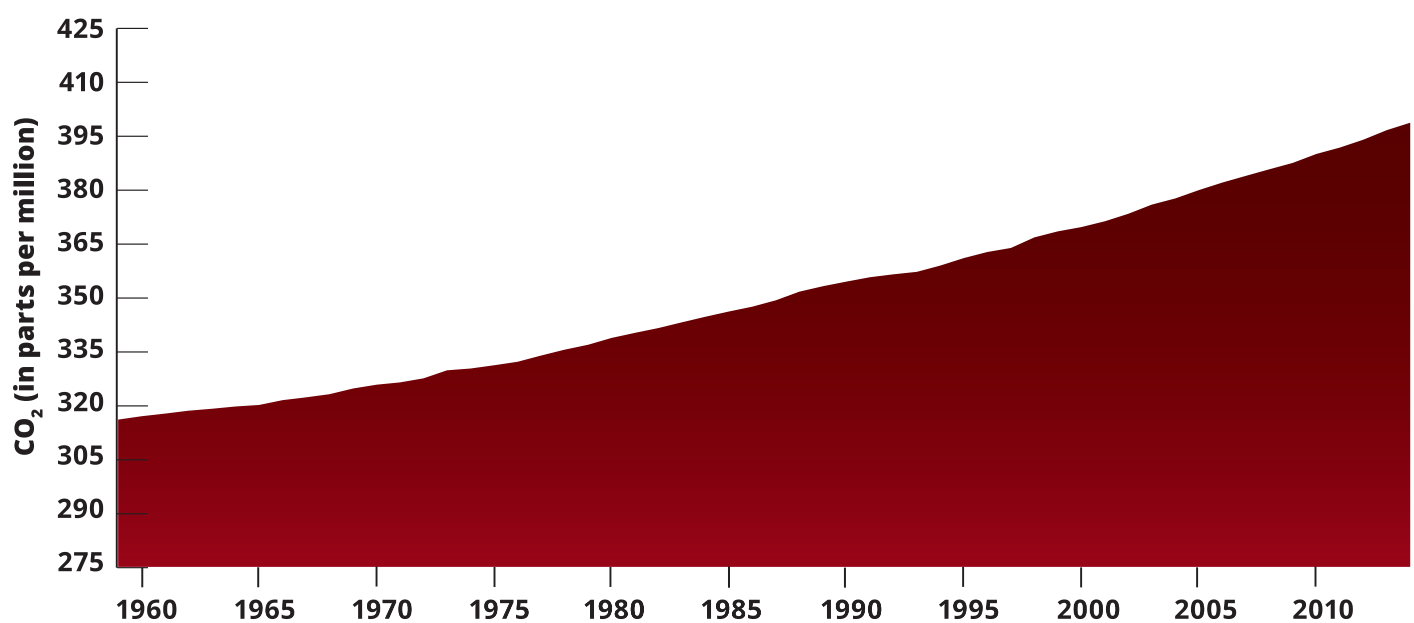
There is no time to waste debating whether ocean acidification is real; it is already happening and will only get worse if the status quo continues. It will affect everyone, directly or indirectly, and everyone shares the oceans in one way or another. This report serves to delve deeper into the specifics of ocean acidification, its greatest impacts, what will be our best options going forward and what options are not worthwhile. The unbridled destruction of our environment has to stop — we must protect our vital common resources.

Background

Since the Industrial Revolution began in the late 18th century, human-caused — or anthropogenic — pollution from the burning of fossil fuels, cement production and deforestation has caused rapid increases in CO_2 emissions.[1] Prior to this time, atmospheric CO_2 levels ranged between 180 and 300 parts per million (ppm), but because of increased emissions from industrialization, these levels have now surpassed 400 ppm.[2] (See Figure 1.) The rate of change in emissions over the last 200 years is alarming — increasing at a rate 100 times faster than any change seen in the last 650,000 years.[3] (See Figure 2 on page 3.)

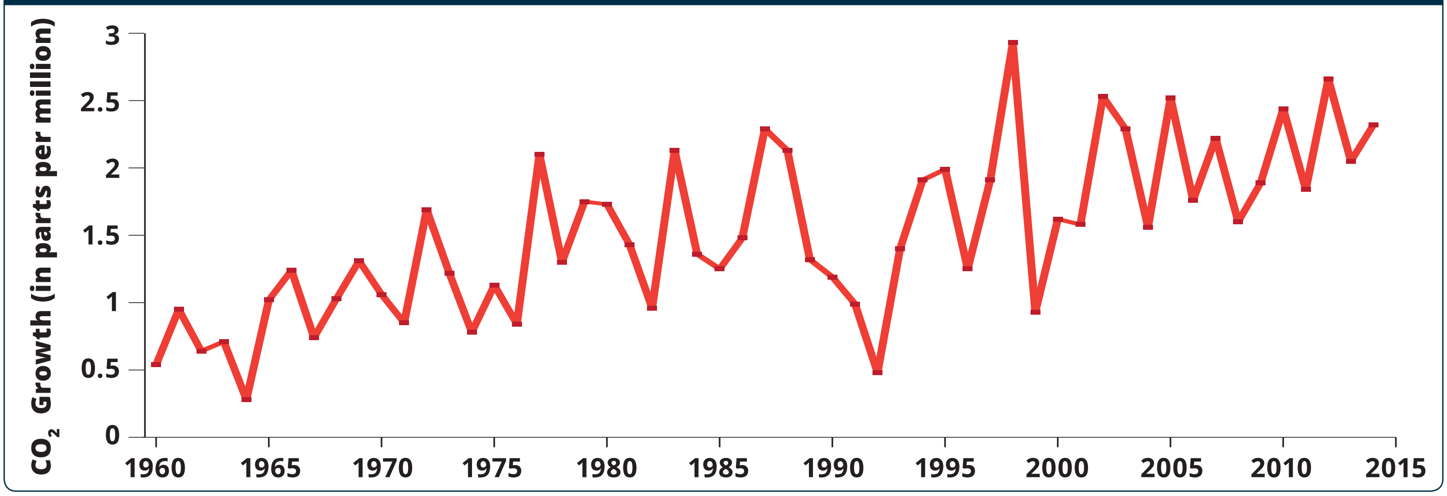
Although these emissions go first into the atmosphere, not all of them stay there — only about half of emissions over the last 200 years have remained in the atmosphere.[4] Of the remaining 50 percent of emissions, the oceans have

Fig. 1 • Atmospheric CO_2 at Mauna Loa Observatory



SOURCE: Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/) and Ralph Keeling, Scripps Institution of Oceanography (scrippsco2.ucsd.edu/).

Fig. 2 • Annual Mean Growth Rate of Atmospheric CO_2 at Mauna Loa



SOURCE: Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/) and Ralph Keeling, Scripps Institution of Oceanography (scrippsco2.ucsd.edu/).

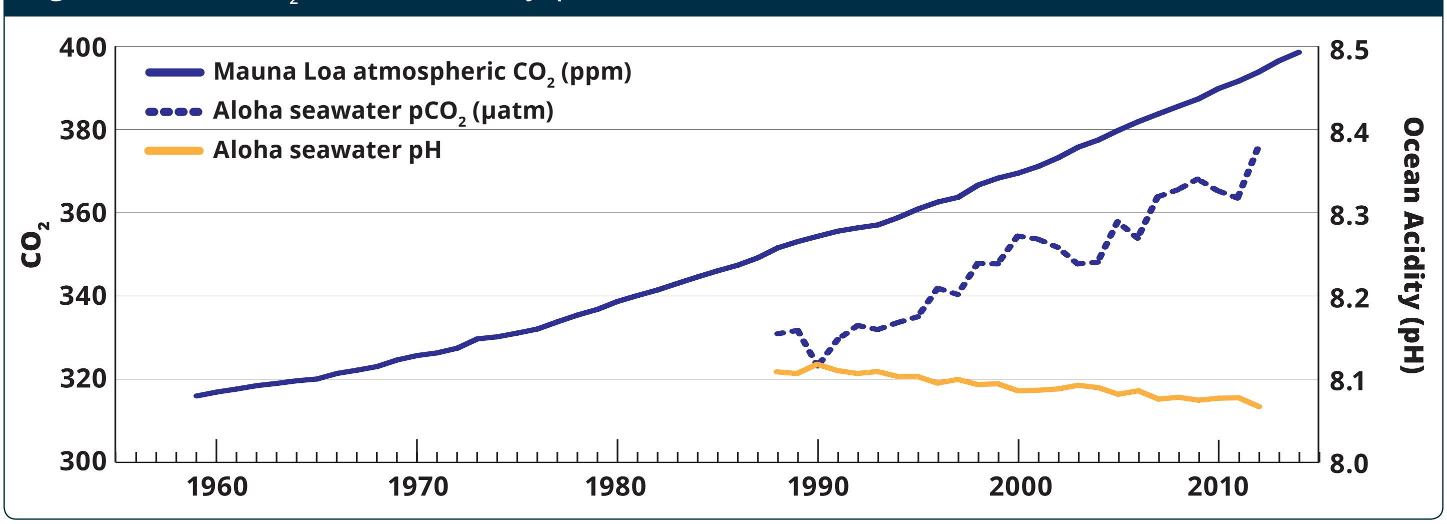
absorbed about 30 percent and the land has absorbed about 20 percent.[5] If the oceans had not absorbed these emissions since the Industrial Revolution, atmospheric levels of CO_2 would currently be 55 percent higher.[6]

Although the oceans have a natural buffering capacity to absorb some CO_2, and even need certain amounts of CO_2 to support life and maintain the carbon cycle, they cannot accommodate the rapid and large influx that has occurred over the past several decades. The ocean can only take on so much CO_2 before it becomes over-burdened.[7]

Think of the ocean as a houseplant that needs mainly water and sunlight to survive, but if it gets too much of either, this can kill the plant. Similarly, as carbon emissions continue, the oceans are getting too much carbon, and it is beginning to cause significant damage — disrupting the fragile balance of the ocean's ecosystems. This damage has manifested as ocean acidification, which happens when the ocean absorbs too much CO_2.[8] Specifically, this causes the pH of seawater to decrease while simultaneously decreasing the availability of carbonate ions (CO_3^{2-}), which are necessary for the production of minerals such as calcium carbonate, used by shellfish and corals to build their shells and skeletons.[9]

The pH of water operates on a scale from 0 to 14, with zero being the most acidic and fourteen the most basic.[10] With regard to acidification, increased levels of CO_2 since the beginning of the Industrial Revolution have already caused pH levels to drop by about 0.1 units, from a normal pH of 8.2 to 8.1.[11] (See Figure 3.) Even though a 0.1 change in pH might seem minimal, it is important to note that the pH scale is logarithmic, and a one-unit decrease in pH

Fig. 3 • Dissolved CO_2 and Ocean Acidity (pH)



SOURCE: Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/) and Ralph Keeling, Scripps Institution of Oceanography (scrippsco2.ucsd.edu/); Dore, John E. et al. "Physical and biogeochemical modulation of ocean acidification in the central North Pacific." *Proceedings of the National Academy of Sciences*. Vol. 106, No. 30. July 28, 2009 at 12235 to 12240.

corresponds to a 10-fold increase in seawater acidity.[12] The current decrease in pH of 0.1 units is actually quite significant because it equals an increase in acidity of about 30 percent.[13]

This rapid rate of change in ocean chemistry has significant implications for the ability of ocean ecosystems to adapt, since in the past when such marked changes occurred they did so over very long periods of time (millions of years).[14] However, the current change has happened in a very short amount of time and at a rapid rate, meaning that it is very likely that organisms and ecosystems may not be able to adapt in time.[15]

Models projecting future levels of atmospheric CO_2 predict that the pH of surface ocean waters could decrease by another 0.2 to 0.3 units by 2060 — to an average pH of 7.9 to 7.8.[16] Such an increase in acidity is equivalent to about a 150 percent increase from the beginning of the Industrial Revolution.[17] This will also reduce saturation states of the calcium carbonate minerals calcite and aragonite by about 25 percent, further decreasing the regions of the ocean that will support calcification for various sea life.[18]

In addition to acidification from anthropogenic CO_2 emissions, climate change is causing changes in seawater temperature and other aspects of the ocean environment, which only add to the problems of acidification.[19] Pollution, overfishing and nutrient run-off (which can cause coastal acidification) will complicate and magnify other ocean problems.[20]

The Chemistry of Ocean Acidification

To understand the full gravity of these changes in ocean chemistry, it is necessary to understand some of the chemical processes occurring in the ocean. The chemical reaction that results from added CO_2 causes two significant events: it decreases the seawater pH, and it decreases the availability of carbonate ions (CO_3^{2-}), which are used to build shells and skeletons in calcifying sea life (if there are not enough of these ions, shells and skeletons will dissolve).[21] Calcifying sea life includes several species of shellfish, such as mollusks and crustaceans, as well as corals, among others.[22]

When CO_2 dissolves into the ocean, it combines with the water and forms carbonic acid (H_2CO_3).[23] This quickly splits apart, however, releasing a proton (H^+) and forming a bicarbonate ion (HCO_3^-).[24] (See Figure 4.) Bicarbonate ions can also split further, releasing another proton (H^+) and forming a carbonate ion (CO_3^{2-}).[25] pH is a measure of the concentration of protons (H^+) present in water, and as

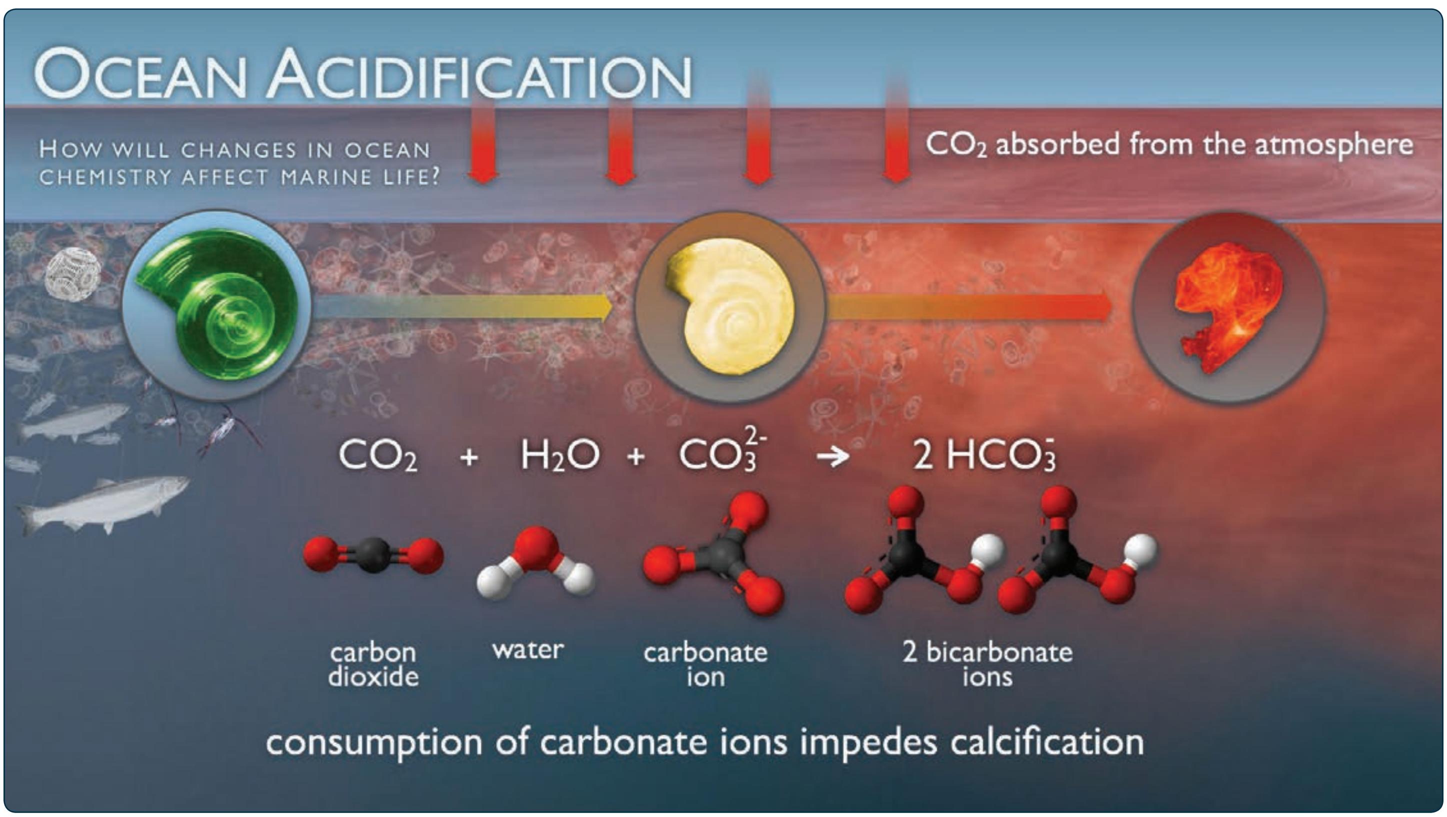


IMAGE COURTESY OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) PACIFIC MARINE ENVIRONMENTAL LABORATORY (PMEL) CARBON GROUP
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their concentration increases, this in turn decreases pH and makes the water more acidic.[26] With acidification, so much CO_2 is dissolving into the ocean that it is increasing the proton concentration and subsequently making waters more acidic.

The other significant event associated with the dissolving of CO_2 into the ocean relates to the built-in buffering capacity of oceans. As the above chemical reactions occur, this disrupts the pH equilibrium and signals the buffer system to kick in. When sustainable amounts of CO_2 dissolve into the ocean, the buffer mechanism can return the water to equilibrium. It does this by consuming excess protons (H^+), and in the process carbonate ions (CO_3^{2-}) are also consumed — the buffer reverses the process of bicarbonate ions splitting into a proton and carbonate ion ($HCO_3^- \longleftrightarrow CO_3^{2-} + H^+$).[27] However, when too much CO_2 goes into the water, as is now happening, the ocean buffer tries to compensate for the added CO_2 and in the process consumes more and more carbonate ions in an attempt to get back to equilibrium.[28]

This decreasing availability of carbonate ions in turn affects something called the "saturation state" of seawater. The saturation state is the concentration of minerals in seawater.[29] In this case, it refers to the concentration of calcium carbonate ($CaCO_3$); calcium that is already present in seawater combines with the previously mentioned carbonate ions to create the mineral building blocks that calcifying organisms use to build their shells and skeletons.[30]

Saturation state is important to calcifying sea life because it determines whether they can build their respective structures. If seawater is oversaturated with carbonate ions (CO_3^{2-}), this causes a crystal of calcium carbonate ($CaCO_3$) to grow, and calcifying organisms are able to build their shells and skeletons.[31] When seawater is undersaturated with carbonate ions, however, this causes a crystal of calcium carbonate to dissolve; calcifying organisms cannot form their structures, and existing structures will begin to dissolve as well.[32] Ocean acidification is causing a decrease in the availability of carbonate ions, ultimately decreasing saturation levels.[33]

One last point to make about the chemistry of ocean acidification is that calcium carbonate exists in different forms, most commonly as aragonite and calcite in seawater, and various shellfish and corals primarily use one of these two forms.[34] However, aragonite is more soluble (it dissolves more rapidly in acidified waters) than calcite, so calcifying organisms that use aragonite will experience the effects of acidification more rapidly than those that use calcite.[35] This is important because some organisms, such as corals and mollusks, mostly use aragonite to form their shells and skeletons, whereas various types of plankton, sea urchins and other organisms mostly use calcite.[36]

Effects of Ocean Acidification

The repercussions of ocean acidification follow a path similar to a chain reaction. The first effects will be felt in oceans closest to the North and South Poles and in deeper ocean waters, as well as by tiny shellfish known as pteropods that play an important role in the foundation of many food webs. Shellfish and corals will simultaneously experience effects, which will only worsen as time goes on and as CO_2 emissions continue. More importantly, these events are not far off in the future — several studies show that acidification is already happening.

These problems will cause further repercussions that will be felt throughout entire ocean ecosystems, affecting fisheries, coral reefs and coastal areas. This in turn will cause significant socioeconomic problems for populations that rely on ocean ecosystems, fisheries, coastal habitats, coral reefs and tourism — for food security, income, jobs, livelihoods and other factors. Ocean acidification is a highly pervasive issue, and its effects will be felt globally and with great significance.

Polar Waters, Deep Oceans and Saturation Levels

Colder ocean waters toward the North and South Pole will experience acidification before warmer tropical waters.[37] This is because atmospheric CO_2 dissolves into colder waters more easily than into warmer waters.[38] Colder waters also tend to be undersaturated with carbonate ions, making higher-latitude areas susceptible to the effects of acidification much sooner than other parts of the ocean.[39] Because aragonite is more soluble than calcite, this also means that structures formed from aragonite will dissolve faster, and marine organisms that form their shells from aragonite will have a harder time doing so.[40] Already, Southern Ocean waters are undersaturated with respect to aragonite, and it is predicted that they will be completely undersaturated by the end of this century.[41]

Additionally, surface waters tend to be oversaturated, whereas deep waters are typically undersaturated; but as acidification continues, the depth at which undersaturation occurs will increasingly become shallower — it will shoal — making the zone of saturated or oversaturated waters increasingly smaller.[42] Consider how a swimming pool typically has a deep end that gradually becomes shallower in depth; as acidification continues, the area, or depth, at which calcifying sea life can live will shrink from the deep end of the pool toward the shallow end. The point at which undersaturation occurs is deeper for calcite than it is for aragonite; this is called the saturation horizon.[43] Calcite does not start to dissolve until much deeper depths, compared to a shallower depth for aragonite. [44]

According to some estimates, shrinking of the aragonite saturation depth in the North Pacific, North Atlantic and Southern Ocean will occur by the end of this century.[45] This means that the range of optimal conditions for calcifying organisms to build their shells and skeletons is increasingly shrinking with acidification. This is of concern because many of the world's commercially important fishing areas are in higher-latitude waters, including the northern Bering, Chukchi and Barents seas in the Arctic, and a krill fishery in the Southern Ocean; about 50 percent of U.S. domestic fish by weight is caught in Alaska.[46]

Pteropods, Shellfish and Corals

A type of calcifying, planktonic snail known as a pteropod or "sea butterfly" — named for its resemblance to a snail with wings — plays an important role in food webs and as a foundational organism in ocean ecosystems.[47]

However, pteropods have already experienced effects from acidification.[48] These tiny sea creatures form their shells from aragonite, making them more sensitive to the effects of acidification, and a recent study showed evidence of pteropod shell dissolution happening in waters off the coast of California.[49] This is a very significant and alarming finding, because scientists had already shown that this happens in laboratory settings and that acidification would eventually cause shell dissolution to happen, but with this recent study there is evidence that acidification is already happening in ocean waters.

As pteropods are affected by acidification, this will cause problems for commercially important finfish that consume pteropods for food, including juvenile pink salmon, chum, sockeye salmon and pollock, among others.[50] A decrease in pteropod populations could be especially significant for pink salmon, with some models showing that if pteropod numbers decrease by 10 percent, this could cause a 20 percent decrease in the body weight of fully grown pink salmon.[51] Although some of the species dependent upon pteropods for prey can switch to other food sources, this could in turn place new pressures on juvenile fish such as salmon if they become an alternative source of food for predators.[52]

SEA BUTTERFLY / PHOTO COURTESY OF NOAA

SPINY LOBSTER / PHOTO COURTESY OF NOAA

Species under threat from ocean acidification:[55]

- Bay scallops
- Oysters
- Soft clams
- Crabs
- Lobsters
- Shrimp
- Hard clams
- Temperate corals
- Pencil urchins
- Conchs
- Serpulid worms
- Periwinkles
- Whelks

Along with pteropods, corals and shellfish will experience significant effects from ocean acidification — making it harder for corals to form and build reefs, and similarly making it difficult for shellfish to form their shells and skeletons.[53] All of this will be compounded by acidification simultaneously causing the dissolution of calcifying organisms.[54]

Several experiments also show that ocean acidification is likely to have the most significant effects during reproduction and early stages of life, times when marine species are most sensitive to CO_2 concentrations.[56] Some sea life show decreased rates of survival and growth, along with higher rates of deformities and even behavioral changes, when in acidified waters.[57] This could have far-reaching implications for population size and biodiversity, as well as for ecosystem health and resiliency.[58] Affected species include the hard clam, eastern oyster and bay scallop, among others.[59]

Effects on shellfish will mean potential declines in commercially important species such as clams, oysters and sea urchins, ultimately causing serious problems for fisheries.[60] Under projected emissions scenarios, ocean acidification could cause the calcification rates of some mussels and Pacific oysters to decrease by 25 percent and 10 percent, respectively.[61] Scientists also have projected that with decreased calcification, mussels and oysters will have significant decreases in shell strength by the end of the century.[62] And, if concentrations of atmospheric CO_2 double in the future, this could cause calcification rates for corals to decrease by 10 to 30 percent.[63]

Degradation of coral reefs will reverberate throughout ecosystems. Not only do reefs serve as important habitat for many marine species, but also they play an important ecosystem role by providing storm protection and various other functions.[64] Current effects to reefs have already caused reductions in habitat diversity, which in turn decreases the ability of coral reefs to support biodiversity.[65] This is associated with subsequent changes in fish communities, and is especially important with regard to commercial fisheries, such as lobster, whose densities are linked to habitat complexity.[66] On a larger scale, acidification will decrease the ability of reefs to serve as breakwaters and to protect coastal areas and mangroves from storms.[67]

Aside from the repercussions of acidification on an organism's ability to form shells or skeletons, other effects include decreased reproductive abilities, slowed growth and increased likelihood of contracting disease.[68] All of these problems could cause further issues throughout ecosystems and food webs, only magnifying the consequences of acidification.[69]

Various studies and recent news stories have documented that ocean acidification is already happening. Some show that marine organisms will react differently to increased concentrations of CO_2.[70] For example, one study found that red king crabs and tanner crabs experienced reduced growth and survival as a result of acidification, citing that "even a modest decline of ~0.2 pH units, a decline expected within the next century, had significant effects on both species."[71]

Ocean acidification also affects the ability of larval fish to detect the smell of predators.[72] This could cause significant repercussions for the survival of entire species, directly affecting the ability of juvenile fish to survive.

Coastal Effects

Although most acidification, especially in open ocean waters, is caused by the uptake of anthropogenic CO_2 emissions, activities like shipping, exploitation of our natural resources and chemical dumping can cause repercussions such as eutrophication, diminished biodiversity, significant habitat loss and habitat modification in coastal waters.[73] Eutrophication is caused by nutrient run-off from agricultural, land-use and other industrial processes.[74] Entering ocean surface waters, the nutrients cause algal blooms that then go through a process of microbial respiration.[75] As the respiration process occurs, it decreases the amount of oxygen in surface waters and releases CO_2 as a byproduct, decreasing seawater pH on top of the declines already occurring from acidification.[76] As a result, coastal waters face higher changes in pH and will potentially experience these changes at faster rates than open-ocean waters, especially with the added effect of shoaling mentioned earlier.[77] (See map below.)

In addition to eutrophication, coastal ocean waters undergo natural fluctuations in pH, via a phenomenon called upwelling. This happens when ocean waters cycle from the surface, down to the depths and back up again.[78] During this cycle, already CO_2-rich waters from the deep open ocean come up to shallower coastal waters, causing seasonal and periodic surges in CO_2 concentrations along coasts.[79] However, increased amounts of atmospheric CO_2 are causing more permanent and long-term increases to surface waters, further contributing to acidification.[80]

As more and more CO_2 emissions go into the atmosphere, this complicates upwelling, because each time ocean waters come into contact with the surface, more CO_2 gets

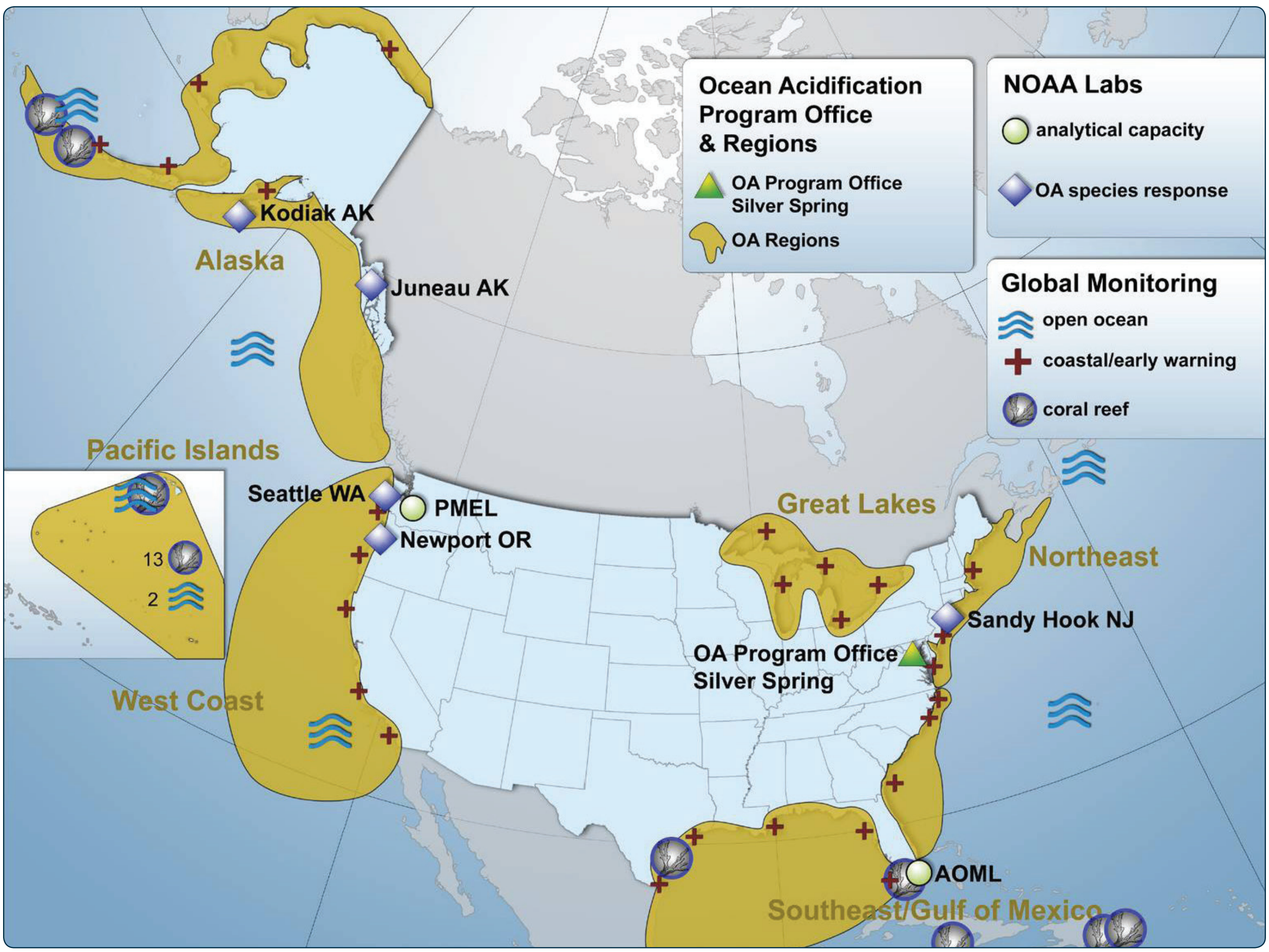


IMAGE COURTESY OF NOAA PMEL CARBON GROUP • WWW.PMEL.NOAA.GOV/CO2 • USED WITH PERMISSION absorbed.[81] Although ocean cycling happens very slowly — over several decades — it has completed full cycles since the beginning of the Industrial Revolution.[82] Not only will the natural process of upwelling bring up CO_2 from the depths to the surface, but also the concentration of CO_2 present in each cycling is increasing due to increased atmospheric levels.[83]

Evidence already exists showing how coastal regions are experiencing problems from acidification. Prior to the Industrial Revolution, only about 10 percent of ocean waters off the coast of California were corrosive to calcifying organisms such as pteropods, but now about 30 percent of the waters that reach the surface during upwelling periods are corrosive.[84] Other studies that looked at coastal waters in Maine, the Chesapeake Bay and New South Wales in Australia have found that freshwater inputs, pollutants and soil erosion can cause higher rates of acidification in coastal waters than that caused by atmospheric CO_2 alone.[85]

Another study done in Portland Harbor, Maine on young hard-shell clams found that the shells began dissolving within 24 hours of starting the experiment.[86] The hard-shell clams were exposed to conditions similar to the coastal environment, and after two weeks many of the shells had all but completely dissolved.[87] There are also signs that the waters of the Chesapeake Bay are already unfavorable to shell preservation for oysters, and it is predicted that portions of the Bay will become increasingly corrosive to oysters in the future.[88]

In the Pacific Northwest, a 2012 study shows that Pacific oyster larvae off the coast of Oregon experienced negative effects from acidified waters.[89] Oyster hatcheries off the west coast have experienced die-offs since 2005, and it is speculated that these could be caused by acidification.[90] Because of this, hatcheries have had to invest in water treatment and monitoring facilities. As recently as February 2014, reports have emerged of large-scale die-offs of scallops and oysters in the Pacific Northwest and along the coast of British Columbia, Canada.[91] It is speculated that these die-offs are happening because of ocean acidification.[92]

This means that as atmospheric levels of CO_2 continue to increase, coastal waters will experience more-severe acidification unless events like nutrient run-off and the resulting eutrophication are greatly mitigated.[93] This puts vital ecosystems, home to commercially important fin- and shellfish fisheries, at greater risk of suffering the effects of ocean acidification at faster rates.[94]

Socioeconomic Effects

As the chain reactions from acidification continue, this perpetuates its effects throughout ocean ecosystems, causing socioeconomic repercussions for commercial fisheries, coastal communities and tourism.[95] The well-being of the Atlantic and Pacific fisheries depends a great deal on calcifying organisms, such as crustaceans, and if these populations suffer significant effects from acidification, leading to decreased harvests, these fisheries could lose millions of metric tons in harvests and billions of dollars in annual revenue.[96]

Already, families in Washington state and throughout the Pacific Northwest have experienced large oyster die-offs, most likely from acidification.[97] One company even had to move part of its oyster hatchery operation to Hawaii where waters are less acidic.[98] Salmon fisheries also will be affected because salmon rely on pteropods for a significant amount of their food and nutrient intake.[99] Other finfish species face potential population declines because many — including haddock, halibut, herring, flounder and cod — depend on mollusks as a food source.[100] Moreover, predators higher up in food webs that rely on these fish will also have dwindling populations, including swordfish, tuna, shark and salmon.[101]

PHOTO COURTESY OF U.S. FOOD AND DRUG ADMINISTRATION

Coral reefs, although important for tourism and shoreline protection from storms, serve as a major part of the foundation to ocean food webs as well. Studies have shown that as acidity increases, their skeletons dissolve, making it harder to form new structures.[102] The loss of coral reef ecosystems could lead to serious changes in habitat for many commercially important fish species that depend on reefs for food and shelter, ultimately leading to a significant decrease in fishery populations.[103]

Developing nations, island nations and coastal communities around the world are particularly vulnerable to the changes from acidification, especially those that rely on calcifying species for their main source of protein — seriously jeopardizing regional food security.[104] Nations in the Pacific rely heavily on mollusks, sponges, corals and crustaceans.[105] Coral reefs are also vital to subsistence and artisanal fisheries that are important for providing protein and income, and coral reef loss will further affect tourism, food security and shoreline protection for some of the most at-risk populations around the world.[106] According to 2009 data from the United Nations Food and Agriculture Organization (FAO), several countries, including Bangladesh, Cambodia, Gambia, Ghana and Indonesia, obtain more than 50 percent of their protein from seafood.[107]

SLATE PENCIL URCHIN / PHOTO COURTESY OF NOAA

Fisheries and food sources will also suffer serious repercussions to livelihoods, not only in jobs, but also in income.[108] The National Ocean Council reported that: "In 2010, U.S. commercial ports supported more than 13 million jobs. Similarly, in 2011, commercial fisheries supported 1.2 million jobs and $5.3 billion in commercial fish landings, and marine recreational fisheries supported 455,000 jobs."[109] In many coastal areas, there are no economic alternatives to livelihoods tied to ocean ecosystems.[110] It is also estimated that within a few decades for many island and coastal areas, ocean chemistry will not support mollusk harvests.[111] Acidification will undoubtedly cause significant consequences for many populations and their local welfare.

The Big Picture

Alarmingly, there is no quick fix or technological solution to remove the CO_2 that already has dissolved into the oceans.[112] In a paper looking at acidification's economic consequences on commercial fisheries, the authors find that, "The projected increase in anthropogenic CO_2 emissions over the next 50 years, primarily associated with industrial growth in developing nations, will accelerate ocean chemistry changes to rates unprecedented in the recent geological record."[113] There is no way to reverse these changes, at least not for several thousands of years — this is how long it will take for natural processes to slowly bring ocean chemistry back to pre-industrial pH levels.[114] The only way to address ocean acidification is to reduce and stop CO_2 emissions from going into the atmosphere.[115]

To date, very few studies have been able to show whether marine organisms have the capacity to adapt to existing and future changes from acidification.[116] Previous changes in pH have occurred over several thousands of years — at a much slower rate of change. However, the current change in pH has happened at a radically faster rate, and over only 200 years. This has serious implications for species' ability to adapt, with many at risk of not being able to do so in time.[117]

As acidification increases and causes more changes to species, this could lead to entire reorganizations of ecosystems, food webs and many important processes in our oceans, and potential regime shifts in ecosystems could decrease their resiliency.[118] Acidification also could cause biodiversity losses in marine ecosystems, most likely through potential species extinctions.[119] We are at an ecological tipping point — on the verge of a fundamental shift — in how ocean ecosystems function and survive.

Ultimately, and something in need of urgent attention, the changes in ocean chemistry caused by acidification will decrease the ability of oceans to absorb CO_2, which will mean that more CO_2 stays in the atmosphere, and this could affect the rate and scale of global warming in the future.[120] It also will make it much harder to address atmospheric levels of CO_2.[121] We are running out of time, and options, very fast.

False Solutions

The only true solutions to address ocean acidification are to stop emissions from entering the atmosphere and to keep carbon in the ground in the first place. Although it would certainly be nice to have more options and ways to address this serious problem, the fact of the matter is that there are none. Yet this has not stopped ill-conceived and poorly thought-out policy alternatives from surfacing, again and again.

Specifically, the idea that we can address this problem through air pollution trading, offsets, water quality trading, geoengineering and pricing nature completely misses the mark. These are false solutions and can even cause more problems than those they claim to fix. Moreover, these are market-based approaches — constantly heralded as more efficient, effective and better than direct regulation and enforcement. But in reality many of these have shown no amount of legitimate success — something that we cannot afford, as we are operating on borrowed time. The crisis of ocean acidification is already here.

Air Pollution Trading

In the context of this report, air pollution trading refers to various market schemes to address greenhouse gas emissions, most often releases of nitrogen oxide (NO_x), sulfur oxide (SO_x) and carbon dioxide (CO_2). However, the attempted market solutions to date show a troubled past and instill minimal confidence in regard to making significant emissions reductions.

Most often pollution trading schemes have manifested as cap-and-trade markets, wherein a total cap on emissions is set for the market and each polluter is assigned an allowed amount of pollution in the form of emissions credits. If a polluter does not use all of its allotted emissions credits, it can trade the remaining amount with another polluter that wants to pollute above the allowed level. In theory, the cap declines over time, decreasing the total amount of allowed pollution, and ultimately reduces overall emissions. However, this has not been the case in reality, as the following examples show. Oftentimes,

no reductions occur, or those that do materialize happen at rates well below what has been achieved with direct, source-by-source regulation of pollution.

U.S. Acid Rain Program

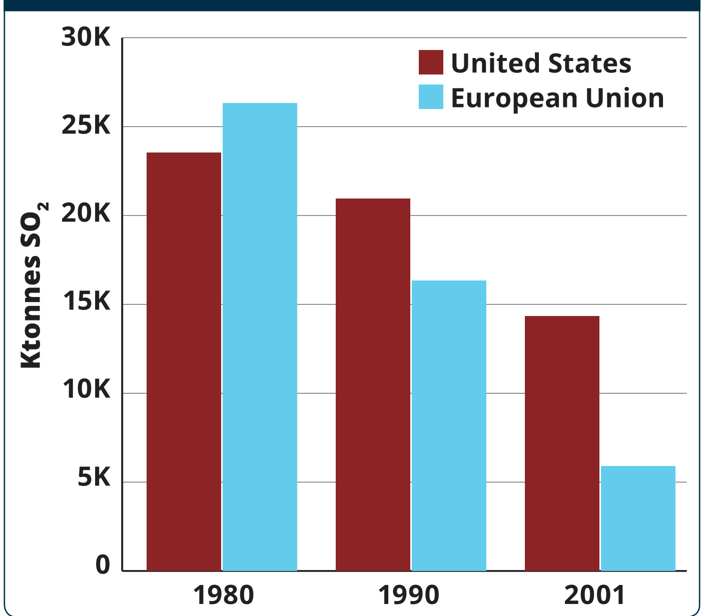
Title IV of the 1990 Clean Air Act Amendments, known as the Acid Rain Program, or ARP, has become the poster child for pollution trading proponents. The ARP was enacted to address the main causes of acid rain — sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions from coal-fired power plants — through a system of buying and selling emission allowances.[122] The goal of the ARP was to reduce annual SO_2 emissions to about 9 million tons by 2010, down from the 15.7 million tons emitted in 1990.[123] Recent modeling indicates that this reduction goal was reached by 2007.[124] What remains unclear is whether the reductions achieved under the ARP were due to market mechanisms, or whether these decreases where achieved *in spite of* pollution trading.

Prior to the enactment of Title IV, an assessment projection indicated that reductions in SO_2 as great as those achieved under a market-based ARP could be attained if older coal-fired power plants simply complied with the Clean Air Act's New Source Review (NSR) technology retrofitting requirements.[125] But with the introduction of trading, those technological modifications fell by the wayside. As one 2005 report indicates, "Experience since 1990 has shown that most of these facilities have managed operations to avoid triggering NSR, resulting in facility life being extended longer and adoption of new control technologies being slower than many analysts predicted in 1990."[126]

While we may never know the real impact of substituting trading mechanisms for technological upgrades on U.S. SO_2 emissions, results from Europe's contemporaneous acid rain approach indicates that we would have done much better sticking with regulatory approaches. A 2004 comparative study of the U.S. trading approach to SO_2 with the European Union's and Japan's regulatory "command and control" systems show a much greater reduction without trading. Whereas the United States attained a 39 percent reduction in SO_2, the EU achieved 78 percent reductions.[127] (See Figure 4.) Japan's emissions fell by 82 percent.[128] We also know that the U.S. Environmental Protection Agency (EPA) now attributes at least 1 million tons of SO_2 reductions during the ARP to factors unrelated to trading, namely the increased availability and switch to low-sulfur coal sources from the Powder River Basin in the early 1990s.[129]

Was the ARP a successful trading program? Only if you ignore the reductions that would have been achieved had the United States continued to force these industries to comply with the law and upgrade their reduction technology, without allowing trading.

Fig. 4 • Total SO_2 Emissions in the United States and European Union, 1980–2001



SOURCE: European Union. "Assessment of the Effectiveness of European Air Quality Policies and Measures, Case Study 1: Comparison of the EU and US Approaches Towards Acidification, Eutrophication and Ground Level Ozone." Project for DG Environment, carried out by Milieu Ltd, the Danish National Environmental Research Institute and the Center for Clean Air Policy. October 4, 2004 at 7.

The Los Angeles Air Pollution Programs: Rule 1610 & RECLAIM

While Congress was enacting Title IV of the 1990 Clean Air Act Amendments, the city of Los Angeles was experimenting with its own air trading approaches to cut down on several pollutants. Although the success of the ARP's trading achievements are debatable, there is little doubt that the L.A. programs were abject failures.

Rule 1610 was approved in 1993.[130] It allowed stationary sources of air pollution (typically L.A.'s oil refineries) to purchase emissions credits from scrapyard operators who were removing older, highly polluting cars off of the roads.[131] The pollutants traded were volatile organic compounds (VOCs).[132] The Rule 1610 program underscored many of the inherent problems with trading programs. Scrapyards were removing engines from old vehicles before demolishing them and selling both the engine and the emissions credits to increase profits.[133] The oil refineries, all located in clusters among communities of color, continued to emit VOCs, along with many other co-pollutants such as benzene, a known carcinogen.[134] These increases in stationary source emissions led to localized "hotspots" of increased impairment.

The early 1990s also saw Los Angeles introduce the Regional Clean Air Incentives Market, or RECLAIM, to try to reduce smog in the region.[135] Pre-RECLAIM regulatory approaches showed dramatic reductions in many smog-related pollutants, including NO_x.[136] These reductions stopped abruptly with the implementation of the new market system. In fact, for the first two years of RECLAIM, emissions actually increased, with only minor reductions (3 percent) in the years following.[137] RECLAIM never did reach its goals. According to an April 2001 article in the *Los Angeles Times*, one month before the program was scrapped:

> *Manufacturers, power plants and refineries have reduced emissions by a scant 16 percent—much less than was anticipated by this time. Businesses were given 10 years to eliminate about 13,000 tons of pollution annually, but as the program nears its end they have eliminated just 4,144 tons....*[138]

RECLAIM also shares a major problem with the ARP and all trading programs: it de-motivated technological advances to pollution control, allowing industries to rely on credit purchasing instead of innovation to reduce emissions.[139] The 10 years of RECLAIM was, in effect, a decade lost on making any significant inroads on L.A.'s air problems.

The Carbon Credit Marketplace

With a total value of $30 billion in 2013, the biggest pollution marketplace experiment is the ongoing CO_2 cap-and-trade scheme that attempts to reduce climate-altering greenhouse gas emissions from industries around the globe.[140] Carbon trading was included as one of the mechanisms for meeting national emissions targets of the Kyoto Protocol, a United Nations agreement where a number of nations (the United States was not one of them) agreed to implement caps on carbon emissions and set up credit selling mechanisms to incentivize reductions.[141]

The European Union has taken the lead in developing an Emissions Trading System (ETS) for CO_2 emissions. Thirty countries are part of this regional cap-and-trade system.[142] The ETS only covers certain sectors, such as power generation and steel manufacturing, but not others, such as transport and agriculture. The ETS aims to reduce CO_2 emissions in these sectors 20 percent by 2020.[143] Trading started in 2005.

While it is still too early to measure the ultimate successes and failures of the carbon trading program, it is safe to say that the system has been fraught with significant problems and, at times, seems to be teetering on complete collapse. The price for carbon has been incredibly volatile, and the EU ETS is currently on life support after the price of carbon allowances shrank to €2.46 per ton of CO_2 in April 2013, from a high of €29.69 per ton of CO_2 in July 2008.[144] Because of this collapse, the European Union has had to intervene and will withhold 900 million emissions permits in hopes of saving the market and propping up the price of emissions permits.[145]

This kind of volatility undermines economic planning, while allowing some companies to reap a windfall with over-allocation.[146] And it has attracted hackers and outright fraud, culminating in shutting down the spot market in 2011 after a group of Eastern European hackers cost EU governments up to €5 billion in an attack.[147] From stolen and fraudulent credits to stockpiling, plunging demands and miscalculated caps, the carbon cap-and-trade program has more problems associated with it than any traditional regulatory program could.

California also has a cap-and-trade market, which launched in January 2013. However, it too has faced problems, such as the recent investigation of 4.3 million offsets for their validity, and subsequent invalidation of more than 80,000 of those offsets due to noncompliance with verification requirements.[148] In addition, the market has yet to show any significant emissions reductions — only 3.3 percent reductions were achieved for 2013, but this was due largely to decreased emissions from out-of-state power imports.[149] The way in which these reductions came about raises additional concerns about "resource shuffling." This happens when a polluter in California offshores its emissions liability to an actor outside of the market, increasing the potential for no real in-state reductions.[150]

Offsets

Offsets are proposed as an additional alternative for meeting emissions reduction requirements. They too are tradable credits, and represent a theoretical emissions reduction, avoidance or sequestration of emissions or other pollutants from an entity falling outside of the targeted industry in a cap-and-trade market.[151] Through offsets, a company pays to prevent emissions outside of the cap, instead of reducing emissions at the source.[152]

For example, a power plant in California could pay for a section of forest to not be cut down in Oregon. This would count toward the polluter's required reductions even though emissions are not reduced in California but are in theory prevented in Oregon. Because trees store carbon but also release greenhouse gases into the atmosphere if they are cut down, not cutting down trees is considered an offset.

But, the assumptions behind offsets do not hold up. The U.S. Government Accountability Office (GAO) points out that, "In theory, offsets allow regulated entities to emit more while maintaining the emissions levels set by a cap and trade program or other program to limit emissions."[153] The reason this is theoretical is that it typically is unclear whether offsets create the emissions reductions they promise.[154] Pollution continues at the source while it is assumed that reductions are made at the offset location, which may or may not be the case.[155]

The supposed benefits that offsets are intended to provide often fail to materialize. Offsets are supposed to be more cost-effective than trading emissions credits, are supposed to provide incentives for emissions sources outside of the cap to reduce their emissions by selling offsets, and are supposed to reduce the costs of complying with cap requirements.[156] But in reality, they allow polluters to substitute unverifiable reductions for real reductions.

Some of the offset classes currently in existence include forestry, biodiversity, mine methane capture (MMC), livestock and ozone depleting substances (ODS), among others. While all of these classes of offsets are problematic, forestry and biodiversity offsets stand out. In order for an offset to be valid, it must meet several requirements, including permanence. However, a tree can burn down or be damaged by natural disasters, and many of the contracts for forestry offsets are not permanent, running for only 25–100 years.[157]

Moreover, California continues to consider using international forest offsets from countries such as Mexico, Brazil and Indonesia. These proposed international offsets would come out of a highly controversial program called REDD+ and risk privatizing indigenous lands, preventing communities from using forests and ultimately making shared natural resources off-limits to the public.[158]

Significant concern has been voiced about international forest offsets. Some critics "question the wisdom of entrusting the world's last tropical forests to the instability of profit-led global commodity and trading markets that have proven to be highly unstable and unpredictable … and historically suffer from drastic boom and slump cycles."[159] Others argue that offsets do not reduce emissions, but rather move the reductions elsewhere, usually to countries in the global South where it is less expensive to make the reductions.[160] Pollution continues at the source while it is assumed that reductions are made at the offset location, which may or may not be the case.[161]

Biodiversity offsets represent an especially ludicrous mechanism in that they allow a land developer to destroy biodiversity, such as wetlands, so long as they replace it with an equal amount of biodiversity somewhere else. When it comes to re-creating the destroyed biodiversity it is not specified where it must be located — there is often no required distance that the new habitat must be from the original site. In addition, it is not usually required that destroyed habitat is "replaced" with the exact same biodiversity — a wetlands could be "replaced" with mudflats. This causes serious problems of redistribution, which can lead to significant ecosystem loss and disruption at a local level.[162]

Water Quality Trading

Similarly unproductive is the idea of using water quality trading in order to mitigate coastal effects such as eutrophication from nutrient run-off.[163] Nitrogen and phosphorous are the leading nutrient inputs from human activities that result in eutrophication.[164] Specifically, nutrient loading is caused by agricultural and fertilizer run-off, sewage and wastewater, animal waste or manure, atmospheric deposition of nitrogen and phosphorus, groundwater inflow and aquaculture.[165] Since pre-

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industrial and pre-agricultural levels, nutrient run-off of phosphorous into the oceans has increased threefold, and nitrogen run-off has increased even more over the last four decades.[166]

Fertilizer application is especially problematic, as it has increased globally at alarming rates, with nitrogen and phosphorus usage rising eightfold and threefold, respectively, since the early 1960s.[167] Aquaculture production also causes significant nutrient-loading events from fish feed and other production inputs.[168] Fish consume only a fraction of their feed, and the rest decomposes in the water.[169] In addition, nutrients from aquaculture sites affect an area 3–9 times the size of the confined aquaculture zone.[170]

In 2010, the U.S. EPA, for the first time, sanctioned water pollution trading when it enacted the Chesapeake Bay Total Maximum Daily Load, a pollution allocation scheme intended to finally put an end to the devastating levels of nitrogen, phosphorus and sediment plaguing the Bay.[171] Under the EPA's plan, designated "nonpoint" sources of pollution under the Clean Water Act, such as farms, are now free to sell nutrient and sediment credits to "point" sources such as power plants, wastewater treatment plants and other "end-of-the-pipe" industries. The stated rationale behind nonpoint-to-point source trading programs is that it is cheaper to reduce discharges from sources like farms than it is to force technological improvements in the point source sector.[172]

The coal-fired power plant industry has been quick to adopt the notion of water pollution trading.[173] They see it as a way to avoid technological responses to the massive amounts of nitrogen pollution coming from their facilities and killing local waterways. These nitrogen discharges jumped sharply over the last couple of years as Clean Air Act requirements forced the industry to better control its nitrogen air emissions; now, their nitrogen is pouring straight into our waterways instead of into the air.[174]

Although the federal government had never before signed off on water pollution trading, this market approach has been implemented on a state level across the country for some 30 years. Tellingly, there is not a single documented case of water quality improvements resulting from nonpoint-to-point source pollution trading.[175] And given the government's inability and unwillingness to verify nonpoint source reductions, and the potential for point sources to increase discharges under the guise of credit purchasing, there is little likelihood that these kinds of trading programs will have any beneficial impact on water quality.

Trading is illegal under the Clean Water Act, and it fails on many fronts.[176] Pollution abatement, particularly from non-point sources, is often uncertain and unverified, which may result in fraudulent reductions and further environmental harm. Even where pollution abatement from a credit generator is verified, increases of pollution from the credit purchaser may lead to localized impacts or "hotspots."[177] Trading is likely to create disproportionate and immoral environmental impacts on low-income populations that use waterways that are most susceptible to localized impacts.[178]

Trading also results in immoral outcomes via the commodification of our natural resources. No one should own, or be able to cash in on, our water and air. These resources are supposed to be held in the public trust and protected by the government so that all citizens have safe drinking water and clean air to breathe.

In effect, water quality trading allows a pay-to-pollute approach; it does not cease pollution altogether. This makes the push to use pollution trading as a solution to address eutrophication, which is directly caused by nutrient run-off, nothing short of ludicrous — especially since agricultural run-off is one of the greatest drivers of eutrophication in coastal waters, and it is a largely non-point source of pollution not regulated under the CWA. As long as pollution continues to enter public waterways, as it does with water quality trading, this will do nothing to address eutrophication, and subsequent acidification events.

Geoengineering

Geoengineering approaches to climate change attempt to address the impacts of greenhouse gases without stopping CO_2 emissions from entering the atmosphere, doing absolutely nothing for issues like acidification.[179] The ideas span a wide range, but they often create more problems than those they attempt to solve, ultimately offering very little in the way of meaningful change. For instance, some geoengineering ideas that have been proposed to decrease levels of atmospheric CO_2 have the potential to worsen acidification. A study from the Royal Society, an independent body of distinguished scientists, states that, "Direct injection of CO_2 into the deep oceans or fertilization of the upper oceans with iron, have the potential to exacerbate chemical changes to the oceans."[180]

Other geoengineering approaches aimed at directly addressing acidification look to add alkalinity to ocean waters in an attempt to reverse the pH changes caused by added levels of CO_2.[181] But in reality, this is not a legitimate option — adding alkalinity to address the saturation state of calcium carbonate would only achieve, at most, half of the changes in pH needed.[182] Conversely, if enough alkalinity were added to raise the pH, this would cause oversaturation of calcium carbonate levels in ocean waters.[183] Both of these scenarios have the potential to cause significant ecosystem changes that previously were not an issue.[184] Moreover, raising the alkalinity by adding massive amounts of limestone to the oceans would cause significant ecological damage from mining the limestone, transporting it and adding it to the oceans.[185]

Trying to genetically modify fish is not an option either, but some have proposed action along these lines, such as carrying out research to select for species or strains of fish that are less sensitive to pH and calcium carbonate levels in seawater.[186] At best, geoengineering can be effective only at a local scale, but it risks damaging or altering ocean ecosystems in unknown ways.[187] We cannot engineer our way out of the reality of the situation; there is no technological fix for CO_2 emissions except to stop them. Recently, a group of scientists did a study looking at geoengineering approaches versus directly reducing emissions, and they found that the most effective approach is to reduce emissions — there are no shortcuts on this one.[188]

Natural Capital Accounting

Natural capital accounting (NCA) is touted as a way to better see the value of nature's resources — things like water, forests, ecosystems and biodiversity — and

show the costs of environmental destruction in hopes that companies will curtail their footprints.[189] Basically, the thinking goes that if companies can see the value of nature in dollars, they will be less likely to destroy it. NCA also is seen as an alternative approach to government regulation, offering a market-based solution. But NCA has numerous flaws and is inherently inappropriate for incentivizing companies to voluntarily take action, whether by reducing emissions or degrading the environment less.

With CO_2 crises like ocean acidification, the ultimate goal is to get companies to leave carbon in the ground and not create more CO_2 emissions. While the political will to address CO_2 emissions is significantly lacking, assigning dollar values to nature is not a substitute and will not lead to the end result of reduced emissions. NCA is not designed to lead to any significant actions on the part of companies; it is an accounting method to assign dollar values — highly inaccurate values — to common resources that are used as inputs to production.[190] In practice, it serves only as a risk analysis, showing where the company has the most risk by relying on scarce or precious resources, and allowing it to plan for future risks and cost savings, and to determine ways to increase effectiveness.

Companies know that it will cost them more money to leave carbon in the ground and to improve their practices so that they degrade and pollute less. But NCA will not incentivize them to clean up how they do business — it will only show companies how much it will cost to not destroy the environment as part of their operations. That is the real risk at issue here — the cost to companies of having to finally do things above board. NCA is not about showing the value of the environment, it is about showing the cost to business of not being allowed to destroy the environment *carte blanche*.

The concept behind NCA of "putting a price on nature to save it" will in reality do very little to address ocean acidification and protect the vital ecosystems most at risk. Unfortunately, reports on acidification, such as that by the National Research Council, still promote this as a policy option to complement other approaches.[191] They propose using pricing mechanisms to better understand the socioeconomic effects of acidification, rather than focusing on regulations, ceasing pollution and protecting ocean ecosystems.[192] As long as political will is insufficient to make companies change how they operate, initiatives like NCA will not make companies voluntarily take on extra costs to clean up how they do business.

No Time to Waste: Best Policy Options Going Forward

Addressing ocean acidification will neither be easy, nor will it be resolved through shortcuts and techno-fixes like those mentioned above. There are actions, however, that will stem its progression and mitigate its effects. The most important of these actions is markedly reducing CO_2 emissions: if only one action could be taken to address acidification, this would be it. There must be a transition from fossil fuels to renewable energy, and fundamental changes to how transportation systems operate.

Regarding mitigation options, efforts must focus on protecting entire ecosystems and not just commercially valuable species. In the United States, there must be increased enforcement of the Clean Water Act as well as revisions to this legislation to make it stronger. There is also a great need for state and local legislation to mitigate the effects of acidification. Lastly, there is still a great deal that is not known about ocean acidification, and this requires scaling up research, along with increased funding to carry out the research. The oceans are critical to all other life and ecosystems throughout the world, and the cost of inaction will be far greater than the cost of action.

Reduce CO_2 Emissions and Transition to Renewable Energy

The best option, and best chance, to combat ocean acidification is to dramatically reduce CO_2 emissions, stop relying on fossil fuels and transition to renewable energy sources like wind and solar.[193] This means serious reorganizations of where we get our energy and changes to transportation systems on a global scale.[194] There is no alternative and no escaping these facts.

Making these changes is beneficial in the long term for social and economic health. There are even significant opportunities for job creation in facilitating this transition, from infrastructure programs to update building efficiency to the construction of wind and solar operations, among many others. It will be less of a burden to proactively address the challenges posed by anthropogenic CO_2 emissions than to wait to address them when things are much worse in the future.[195] There might be greater costs in the next few decades, but this would create significant benefits and pay-offs for the next several generations — achieving true sustainability for future populations.[196]

Regulate Agricultural Runoff

Addressing eutrophication in coastal waters requires addressing nutrient run-off, and ultimately agriculture needs to be regulated at the state level. Voluntary approaches, such as trading, that have never worked to reduce pollution from the agricultural sector must be abandoned. Rather, states must regulate agriculture in the same way that point sources are regulated — requiring load reductions and monitoring to prove that reductions are in fact being made. The CWA gives states this authority.[197]

Waterways and watersheds are common resources, available and needed for many uses by all of us. That is why water has long been considered a public trust, something that we all have a stake in and must protect.[198] In order to do that, we require compliance from users. A market in water quality turns this on its head. It replaces compliance with compensation. Instead of saying that a polluter doesn't have the right to pollute our common resources, markets sell that right. You are allowed to pollute if you simply pay enough.

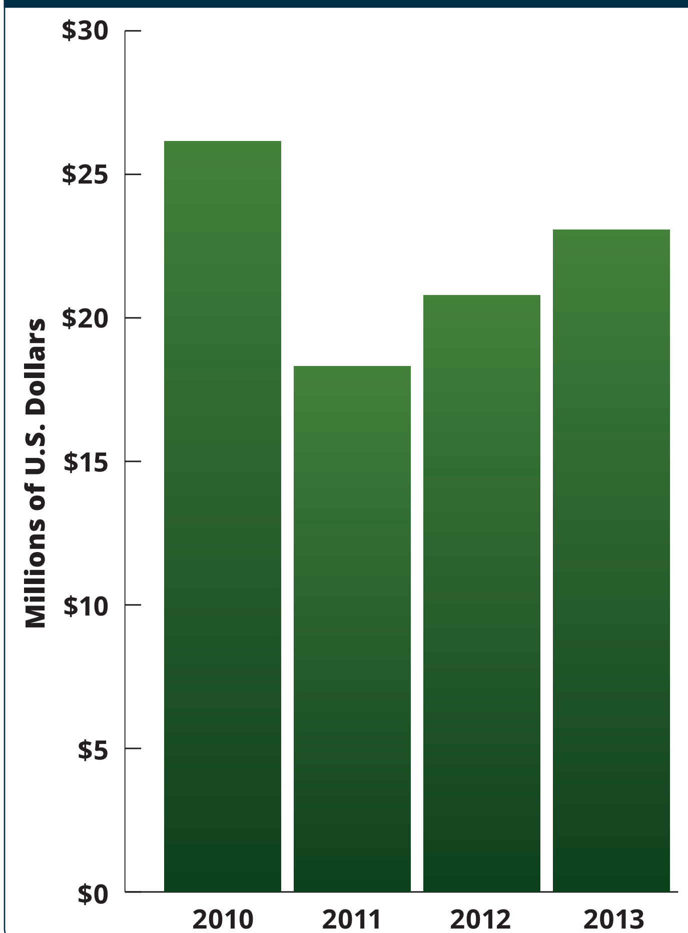
Pollution trading introduces a new and unmanageable approach. Once a price is put on nature, all of our common resources can be bought, sold and packaged. Worse, as we've seen in the past five years, a market can be manipulated, repackaged and resold as derivatives, bonds and other market measures. But the common resource doesn't gain from this trade. Only the traders and the polluters gain. Markets are not the answer to the challenge of water quality. Instead, we need to regulate those who dump pollutants into our waterways. We should not be selling the right to pollute, but reinforcing the idea that nobody has the right to pollute everybody's water.

Increase Research and Funding

Although ocean acidification is already happening and causing problems for ecosystems, a great deal is still unknown about this phenomenon, and more research is needed to better understand how it will affect the oceans in the long term.[199] Most studies on acidification have been published only since 2004.[200] It is important to determine how acidification will affect finfish and other non-calcifying marine species. Preliminary studies on finfish performed in laboratories have observed some effects on internal pH balances and other problems, but without more investigation it is hard to say how these species will fare in more acidic oceans.[201] There is also a significant need for further research to better understand both the interaction of eutrophication and acidification in coastal waters, as well as how this unique situation will play out over time as CO_2 emissions increase and nutrient run-off continues.[202]

The United States needs to carry out more research, especially scaled-up and in-depth research, which requires greater funding. Unfortunately, the level of current funding for acidification pales in comparison to the need and urgency of ramping up its research. For the 2013 fiscal year, U.S. government agencies spent a total of some $23 million on actions directly related to ocean acidification.[203] (See Figure 5.) However, according to some estimates, a multi-agency U.S. national research program would need between $50 million and $100 million per year to provide a concerted research effort.[204] This is considered the minimum amount required for scientists to provide new information about acidification and how to go about future actions, mitigation and adaptation.[205]

Fig. 5 • Approximate Total Agency Expenditures on Ocean Acidification FY 2010 – FY 2013



SOURCE: U.S. Government Accountability Office. "Ocean Acidification: Federal Response Under Way, but Actions Needed to Understand and Address Potential Impacts." GAO-14-736. September 2014 at 39.

Conclusions

The days of kicking the can down the road and putting off action until later have passed. Ocean acidification is directly caused by CO_2 emissions, and it is affecting our oceans right now — and only increasingly so without significant action to change course. The only viable options going forward are to significantly reduce CO_2 emissions as well as nutrient run-off to coastal waters. Simultaneously, more research is needed on ocean acidification, as well as adequate funding to carry it out. There is no technological fix for acidification, and there are no short cuts, either.

The goal can no longer be to aim for an "allowable level of pollution"; polluting must be made completely unacceptable. Permitting a certain amount sends the dangerous message that it is acceptable to pollute to a point, leaving the door open for rampant abuse, as we have already seen. That is a message that we can no longer afford to send. There is no substitute for the oceans and for the irreplaceable, teeming depths of biodiversity contained within them. Inaction, and substandard solutions, will be far more costly — we must protect our common resources now and for future generations.

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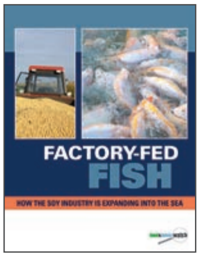
More Food & Water Watch Research on Common Resources



Factory-Fed Fish: How The Soy Industry is Expanding Into the Sea

Seafood is one of our last wild food sources. Fish are a vital part of many people's diets because of poten¬tial health benefits, fresh taste and the connection that fish give us to our oceans and coasts. Around half of the world's seafood, however, now comes from farms rather than from the wild. In some of these farms, fish are grown in crowded, polluting cages and may be fattened on commercially prepared, soy-based diets. While the soy industry stands to make large profits from the expan¬sion of factory fish farming, there is no guarantee that soy-based aquaculture feed can consistently produce healthy fish or promote ecological respon¬sibility. In fact, by causing fish to produce excess waste, soy could lead to an even more polluting fish farming industry.

No Accounting for Taste: Natural Capital Accounting and the Financialization of Nature

Natural capital accounting is the latest effort to financialize our air, water, forests and land by putting a price on nature to save it. The theory claims that if private companies and countries account for environmental resources used in the production of other goods — accounting for their cost to the environment — we can better see the sustainability of our current economic path. But it is not the solution it appears to be. Natural capital accounting is plagued with myriad problems. To implement it requires assigning a financial value to nature, privatizing it and commodifying it — bringing the environment under economic control.

The Weakest Link: Problems and Perils of Linking Carbon Markets

Proponents of cap and trade increasingly seek to create a globally linked carbon market under the false reasoning that doing so will achieve improved economic efficiency and better emissions reductions than individual markets alone, because carbon dioxide (CO_2) is spread globally throughout our atmosphere. While promoted as a way to reduce carbon emissions, the main drive behind linking is economic efficiency and cost reduction. Focusing on economic concerns downplays the real priority of reducing emissions.

Incentivizing Fracking: The EPA's "Clean Power Plan"

On June 2, 2014, the U.S. Environmental Protection Agency (EPA) released a new "Clean Power Plan." The plan aims to cut the nation's carbon emissions 30 percent below 2005 levels by 2030. The plan, with its reliance on cap-and-trade schemes and state market solutions, along with woefully unambitious carbon goals, is far from what is needed to actually make a difference on climate change. But just as important, the plan will lead directly and indirectly to a continued drive to increased dangerous hydraulic fracturing, or fracking, for natural gas.

Food & Water Watch

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