IMPACTS OF CLIMATE CHANGE ON THE OCEANS

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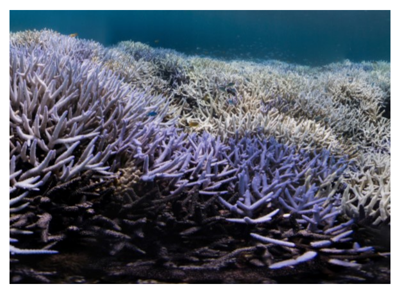

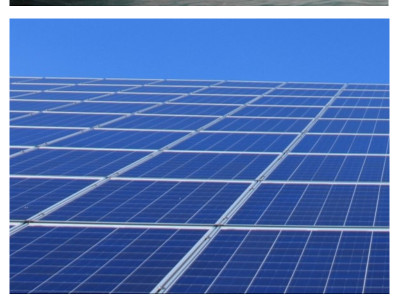

Ocean Warming

Much of the extra heat from climate change is going into our oceans, heating them up. This causes coral bleaching and abnormal migrations, which both in turn affect humans.

A bleached coral

More than 90% of the excess heat retained by heat-trapping gasses since 1955 has been stored in our oceans.[1] So knowing the impacts of climate change on land, imagine what it's doing to our oceans!

One significant impact of ocean warming is coral bleaching. Coral bleaching is the expulsion of zooxanthellae (the algae part of corals) that lives on polyps (the animal part of corals) due to temperature change. This is called bleaching because the zooxanthellae are the part that provides the corals with color; without them, the coral appears white because you can see through the transparent polyps to the white calcium carbonate below. The main problem with coral bleaching, however, is not the change in appearance. Polyps and zooxanthellae live in a symbiotic relationship in which the zooxanthellae provide food through photosynthesis to the polyps. Without them, the polyps lose their major food source, and if they don't recover the zooxanthellae, the polyps die. In the current mass bleaching event, 93% of the Great Barrier Reef has been affected,[2] destroying a vital habitat for thousands of species and a barrier against extreme weather.

Another impact of ocean warming is abnormal migrations. Emerald parrot fish are native to coral reefs in the Caribbean and Latin America, where they eat plants growing on corals. However, due to climate change, the parrot fish are moving to colder areas. In 2006-2007, there were 22 times more emerald parrot fish in the Gulf of Mexico than in the 1970s.[3] When they move to the colder kelp forests, they eat large amounts of kelp, instead of plants on the corals, causing other sea life, like

An emerald parrotfish

crustaceans, sea otters, and gray whales that depend on kelp forests for habitat and/or food, to have to relocate to even colder water.

Emerald parrot fish are just one example of many marine animals moving to colder areas because their original habitat is no longer suitable. There are many more, including phytoplankton, nudibranchs, and dolphins, and these are not just isolated instances. These relocations radically disrupt the food web, and, thus, oceanic and land life. The destruction of kelp forests, as shown in our previous example regarding parrot fish, directly affects humans by decreasing our supply of kelp products such as algin (a thickening agent) or by causing us to overharvest in less affected areas. It also indirectly affects humans through the depletion of various things, such as shellfish and rockfish, that we eat or use.

Sea Level Rise

Ice sheets are melting, causing the sea level to rise. This is flooding our coastlines, harming important ecosystems and cities. It also speeds up saltwater intrusion, making our water less drinkable.

Ice sheets are melting at an astonishing rate. This has multiple impacts, including habitat loss, increasing climate change, and, of course, sea level rise. About 4.3 trillion tons of ice mass were lost from Greenland, Antarctica, and Earth's glaciers and ice caps between 2003 and 2010.[4] The Greenland ice sheet alone has been losing an estimated 287 gigatonnes per year since 2002.[5]

Over 1000 species, including polar bears, arctic foxes, penguins, and narwhals, depend on sea ice for their survival.[6] Sea ice is also crucial to keeping the climate in check: Our oceans reflect about 6% of the sunlight incident on it, while sea ice reflects approximately 10 times that amount,[7] so not only does climate change cause ice sheet melting, but ice sheet melting also causes even more climate change.

One of the most important impacts of ice sheets melting is sea level rise. Simply put, more ice melting into our oceans is more water in our oceans. At an extreme, a complete melt of the Greenland ice sheet would cause 7.2 m (23.6 ft) of sea level rise.[8] Even just in 2003-2010, the sea level rose 12mm (0.5 in).[4] While this may not sound like much, the rate is ever increasing. Additionally, if we don't act quickly, there will be huge consequences. An increase in global temperature of 2°C (since before the industrial revolution) would lock in enough sea level rise to claim the land of 130 million people, and the business-as-usual scenario of 4°C of warming would lock in enough to submerge land occupied by 470-760 million people.[9]

Collaroy Beach, Australia, after a storm

Sea level rise causes coastal floods to happen more often, and this is already very much a real issue affecting people in many parts of the world, including Bangladesh, Micronesia, and Florida. Coastal flood damage costs alone may reach over $100 trillion, assuming no adaptations are put in place.[10] Adaptations are solutions to various problems, like sea level rise, while the bigger picture, climate change, is being worked on. Some examples of sea level rise adaptations are building levees, raising roads, installing drains, and sometimes putting resistant marsh plants on coasts.

Saltwater intrusion is also increased because of sea level rise. Many coastal areas use groundwater extraction as their main source of water, but this lowers the water table causing more saltwater to flow into freshwater aquifers. However, in a simulation of a coastal water well field in southeastern Florida, the total dissolved solids concentration exceeded drinking water standards 10 to 21 years sooner when sea level rise was included.[11] Cities like Hallandale Beach, Florida, will have to build more wells farther inland, a significant investment, and, with continued sea level rise, even these won't last very long.[12]

Solutions

Solutions to climate change fall into two main groups: 1) Adaptation, which is increasing resilience to the impacts of climate change; and 2) Mitigation, which is ending our contribution to climate change.

It is crucial that we deal with climate change as quickly as possible because of ocean warming, sea level rise, and many other problems arising from it. Many people are already being affected, and future generations will be harmed even more. Before going into large-scale adaptations and mitigations, I'd like to talk briefly about some changes that we can make as individuals in our personal lives. First of all, given our current energy supply, we must use less energy. This includes reducing the use of technologies that utilize electricity and gasoline as well as increasing the use of more efficient products. Some examples of energy-efficient products are electric vehicles and fuel-efficient cars, LED lightbulbs, and Energy Star certified appliances. Additionally, we must cut back on our consumption of foods that have a large footprint of heat-trapping gasses, such as lamb and beef,[13] as well as those that require lots of deforestation, such as palm oil. We should also waste far less food, as food waste accounts for 6.7 percent of global greenhouse gas emissions.[14]

Although one person making these changes alone won't make a huge difference, many people doing so will. In fact, it is estimated that only switching to entirely LED lights in the US alone within the next 20 years will save $250 billion and 1,800 million metric tons of CO_2 emissions.[15] Legislative approaches such as a carbon fee and dividend or a cap and trade law have the possibility to encourage people and companies who are less inclined to take some of these measures to do so.

Adaptations

While we need to greatly curb our emissions of heat-trapping gases, we must also acknowledge the fact that we will not stop emitting them tomorrow. Additionally, even if we did, there are enough heat-trapping gases in the atmosphere to cause warming for many years. Given that the impacts of climate change will inevitably continue for some time, we must determine how best to adapt to these impacts and take these actions so that ecosystems and human communities can survive them as well as possible.

A recent sea level rise vulnerability assessment showed San Mateo County, California (which happens to be where Heirs To Our Oceans is based), to be one of the state's most vulnerable counties to climate change.[16] The thorough assessment also identified three broad adaptation strategies: protect, accommodate, and retreat. Protection is stopping water from reaching developments; this often involves the use of seawalls and levees as well as natural and artificial shock-absorbing habitats.


A house on stilts

Retreat is moving the developments farther from the shore. Accomodation is a middle ground between the two: rather than trying to stop the water from reaching the developments with brute force or just moving them farther from the water, individual developments are modified to be more resistant to sea level rise. This can include changes like raising buildings onto stilts or building floating structures. To protect our coastlines from the immense threat of sea level rise, some combination of these three preemptive strategies must be used. In addition, drains and pumps should be installed in vulnerable regions to complement these measures.

Although adaptations to sea level rise are very commonly discussed, there are adaptations to other climate change impacts as well. One notable example is the development of super corals to adapt to coral bleaching. Super corals are corals that have been bred in labs to be more resistant to extra heat and carbon dioxide in their environments.[17] These super corals, originally developed by Dr. Ruth Gates' lab at the Hawai'i Institute of Marine Biology, can be mixed with other corals so that the reefs can better survive mass bleaching events. Similar to the sea level rise adaptations, this technology does not solve the underlying problem of climate change, but it buys us time by protecting the coral reef ecosystems for a little longer.

Mitigations

Ultimately, though, we will not be able to continue to successfully adapt to the impacts of climate change forever. While these adaptations are crucial to our own and the natural environment's health in the short term while the planet is warming, we need to stop causing climate change in the first place. The personal changes that I outlined in the first paragraph of this page are one step, but larger-scale solutions are also necessary.

To reduce our carbon dioxide emissions from energy, we must change our electricity sources and electrify systems dependent on gasoline or diesel. In 2014, about 81 percent of our global energy consumption came from fossil fuels.[18] Energy sources that emit no or almost no heat-trapping gases, unlike fossil fuels, are known as clean. There are many clean energy sources, quite a few of which fall into the group of renewable energy, which means that the resources needed to produce these types of energy will last indefinitely. Two common forms of renewable energy are wind and solar power, which are most often produced with wind turbines and photovoltaic solar panels, respectively. Neither of these energy sources require the burning of fossil fuels, and therefore contribute almost no carbon dioxide to the atmosphere. They are also very low-cost: the International Renewable Energy Association reported that, in 2017, onshore wind power cost six cents per kilowatt hour (kWh) and photovoltaic solar power cost 10 cents per kWh, and prices are continuing to fall.[19]

While there are many upsides to renewable energy, one major issue is intermittency. Most renewable energy sources, including solar and wind, are not always available to be harnessed due to natural conditions. To cope with this, the electricity generated must be stored in a battery, but batteries are still expensive, making 100% renewable energy as a whole an expensive endeavor. Luckily for our climate, the development of lower-cost batteries is a major area of innovation, but it will take some more time until they are competitively priced with fossil fuels, which do not have the intermittency concern. Concentrated solar power (CSP) is a specific form of solar power that solves this problem. CSP involves directing large amounts of sunlight to a single point, heating it up. This creates steam, which is sent through a typical steam-powered electricity plant. Energy storage is built into CSP systems as extra energy is stored in molten salt, but it too is currently very expensive at 22 cents per kWh.

A concentrated solar power tower

Finally, another clean energy option is nuclear power. While technically non-renewable as there is a finite, but large, supply of the materials required to generate it, nuclear power generation also emits no CO_2. It is also extremely cheap at 2.4 cents per kWh in the US,[20] competitive even with natural gas. In addition, nuclear power plants can be run at all times, not just when it is sunny or windy, so expensive battery technology is not needed.

While all of these mitigations have involved reducing our emissions of greenhouse gases, there is another class of mitigations that calls for the removal of carbon already in the atmosphere and oceans, called geoengineering. Many geoengineering strategies to artificially remove or counteract already-emitted heat-trapping gases are risky and controversial, but one of the more widely accepted ones is carbon sequestration. Carbon sequestration involves naturally or artificially removing CO_2 from the atmosphere and storing it so that it cannot affect the Earth's climate. This can involve simple strategies like planting more trees, which take in and store carbon dioxide, as well as complex machines that store carbon underground.

A combination of adaptations and mitigations, as well as personal changes in the short term, must be put in place to protect our planet, including our oceans, from climate change. We need to withstand all of the impacts of climate change that will inevitably occur as well as stop the root of the problem by not emitting heat-trapping gases. If we do not take action, our oceans will be greatly harmed from ocean warming and sea level rise. This harms humans and, as climate change worsens, our and future generations will be increasingly hurt by it. We must take these and more necessary steps to prevent further damage.

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