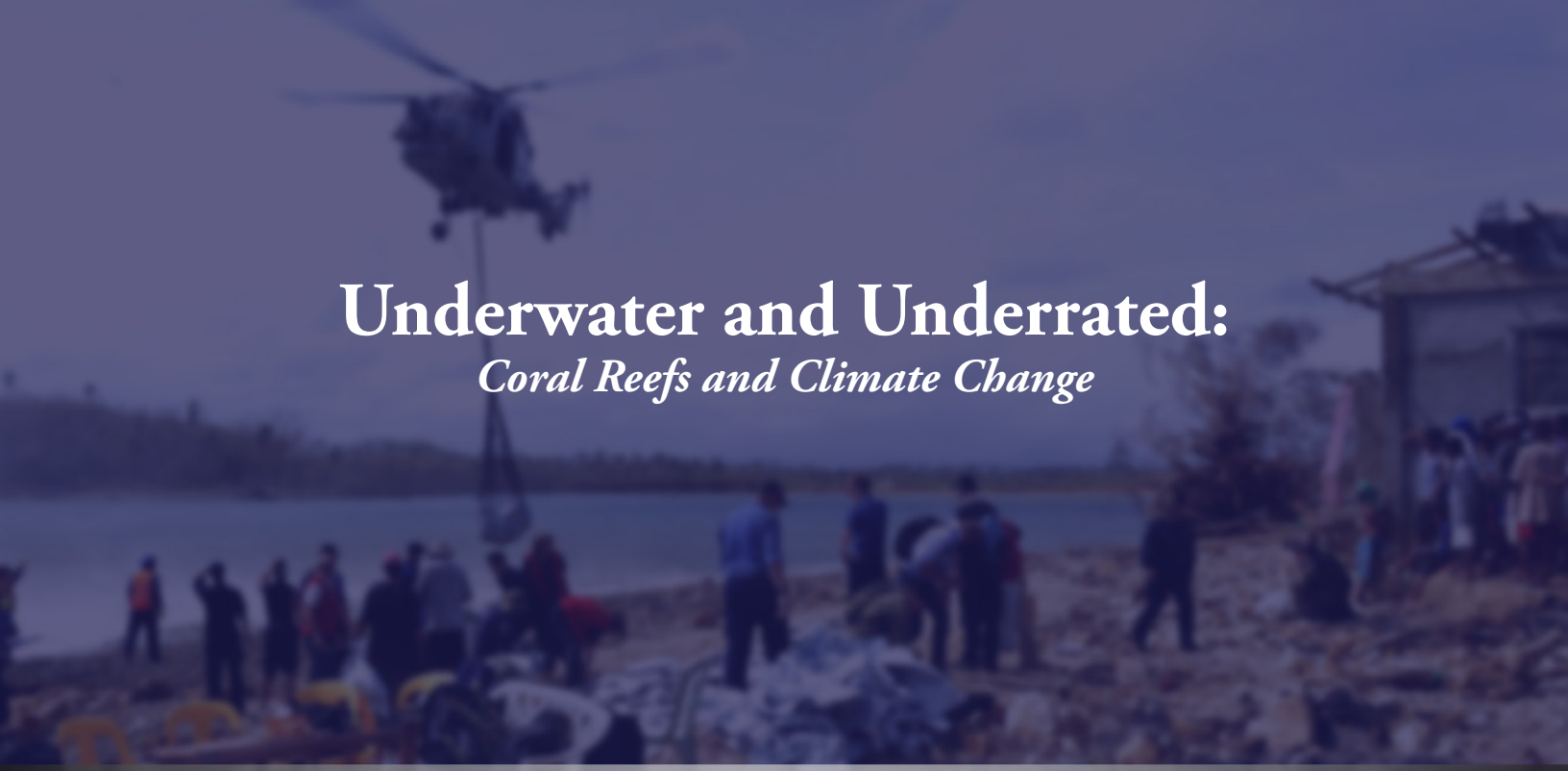

Underwater and Underrated:

Coral Reefs and Climate Change

American Security Project

Perspective

-

Rachel Hagen

December 2018

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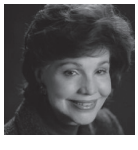

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David Wade is a consultant helping global corporations and organizations with strategic advice, public affairs and thought leadership, crisis communications, political intelligence gathering, and federal and legislative strategy.

Climate Security

In this Report:

Climate change is a complex, intersectional issue that has international security implications. Climate change threatens one of the world's greatest ecologic resources, coral reefs. The UN Intergovernmental Panel on Climate Change (IPCC) reports the near-complete destruction of coral reefs due to climate change will be much sooner than previously assumed. This report highlights the importance of coral reefs around the world, describes potential consequences of climate in-action, and provides recommendations on how to save corals before they are gone.

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IN BRIEF

- Coral reefs are found all over the world, primarily in tropical and coastal locations. They provide socioeconomic stability for millions of people globally.
- Warming ocean temperature and higher acidity levels due to climate change are known to damage coral reefs. Multiple bleaching events have been recorded, and they will continue to worsen if climate action is not taken.
- If climate change eradicates all coral reefs, extreme and far reaching consequences will be felt around the world.
- The reduction of carbon emissions is the true answer to save coral reefs from complete eradication.

About the Author

Rachel Hagen is the Climate and Energy Security Intern at the American Security Project. She will complete her degree in Environmental Science with a concentration in Compliance and Sustainability in May 2019 from Southern New Hampshire University. Coral reef conservation is a personal interest of Rachel's because of her marine biology experience from her university sponsored expedition to Honduras over the Summer of 2018.

Introduction

The 21st century is facing an array of climate change related threats. Intensified storms such as Hurricane Michael in October 2018, longer periods of drought as seen in Central America, air pollution, and more will worsen without prompt climate action. In addition to these threats, one of the world's most valuable ecologic resources is under attack: coral reefs. The costs of losing corals are more severe than acknowledged. Coral reefs play an integral role in maintaining the health of thousands of aquatic organisms and they provide food and economic security for millions around the world. Climate change has already disrupted the health of many corals, and the recent climate assessment published by the IPCC reports the situation is likely to worsen. This report will provide a brief outline of three extremely valuable coral reef locations and how their cultural, ecologic, and economic significance contribute to their respective regions.

What are Coral Reefs?

Coral reef ecosystems are typically found within latitudes 30° north and 30° south around tropic coastal areas.[1] Coral animals, known as polyps, are related to jellyfish and anemones, but differ because of their limestone skeletons.[2, 3] Single celled photosynthetic algae, commonly referred to as zooxanthellae, and the coral animal share a symbiotic relationship.[4] The algae lives inside the tissue of the coral animal and provides energy. In return, the coral animal provides shelter and essential nutrients for the algae.[5] Polyps are translucent animals, but the zooxanthellae produce the different colors reefs are known for.[6] Covering a mere 0.2% of the ocean floor, coral reefs are valued at $1 trillion USD globally for the "…social, economic and cultural services…" they deliver. [7, 8] In total, coral reefs account for as much as 35% of all discovered marine life.[9] Over three billion people around the world depend on ocean resources for roughly 20% of their protein consumption.[10] Additionally, over 500 million people have direct socioeconomic ties to the ocean.[11] Many, but not all, coral reefs are classified as a Marine Protected Area (MPA). MPA's encompass a designated area of the sea to protect the cultural, historical, or ecologic significance of said area.[12] All reef systems discussed in this report are classified as MPA's. Coral reefs are often regarded as "rainforests of the sea" because of their high levels of biodiversity.[13]

Benefits from Coral Reefs

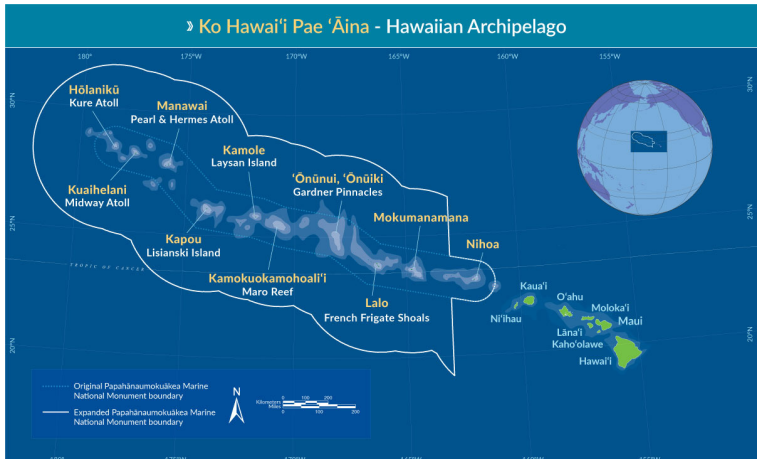
As mentioned before, coral reefs provide an array of ecosystem services. Coral reefs act as incubators for marine life to thrive, meaning they are key habitats for the reproduction and growth of fish, corals, and countless other marine species. Reefs deliver the resources needed for many communities around the world to achieve socioeconomic stability and food security. Of the 100 plus nations where coral reef ecosystems can be found, 80 of those are in developing countries.[14] Of those developing nations, 19 are considered Least-Developed Countries (LDC) because of, "low income, limited resources, and vulnerable economies."[15] The people in LDC's who rely on coral reefs for socioeconomic stability and food security are often a part of the most impoverished communities in the world, making their dependency on coral reefs essential for survival. An article published by *PLoS ONE* found coral reef fishers dominate over one-quarter of the globe's small-scale fishing industry and directly employ 6 million people.[16] Another notable service is that corals can act as an inherent breakwater shield from waves, delivering protection from flooding.

Approximately 2.4 billion, or 40% of the planet's population, live near coastal areas.[17] Of that, over 600 million people live in low elevation coastal zones, meaning the coastal area is 10 meters or less above sea level.[18] The number of people living in low elevation coastal zones is expected to dramatically increase within the near decades. Projections anticipate over one billion people may be living in these areas as soon as 2060.[19] If coral reefs experience mass mortality rates, swelling coastal zones will be left increasingly vulnerable to rising sea levels and mass flooding events due to climate change. Unfortunately, sea levels are reportedly rising at an unpresented rate. Destructive sea level rise has already been reported in major U.S. metropolitan cities. Miami, for example, experienced a three-inch rise in sea level from 1996-2012 and is expecting an additional 15 inches by 2045.[20] This is partially due to the collapse of local corals. Only 10% of the corals found in the Florida Keys are alive today.[21] Without coral reefs, intensified storms due to climate change may skyrocket floodwater costs by 91%, possibly reaching as high as $272 billion.[22] With sea level rise rapidly increasing and populations flocking to seaside areas, the need for coral reefs to provide coastal protection is more essential than ever. This report will continue by examining three well-known reefs to further explain the importance coral reef ecosystems play for their respective communities.

Papahānaumokuākea Marine National Monument (USA)

Ecologic Significance

Papahānaumokuākea Marine National Monument is a compilation of islands, sea mounds, and coral reefs located northwest of Hawaii's main islands. The national monument was established in 2006 under President George Bush, however, President Barack Obama quadrupled the monument's size in August of 2016.[23] President Obama's expansion of the monument now encompasses a total of over half a million miles.[24] Because the monument's location is so exclusive, the biodiversity of the area has flourished. More than 7,000 species or marine life including fish, birds, and others are known to the region.[25] Of that, roughly 2,000 species are endemic to the area, meaning they can be found nowhere else in the world.[26]



The expansion of Papahānaumokuākea Marine National Monument. National Ocean Service image.

Economic Contribution

Human activities within the monument are extremely restricted. Ecotourism and historical access were previously granted to the public at Midway Atoll National Wildlife Refuge, but operational issues due to staff reductions could no longer support public access.[27] Because of this, tourism generates little income, but virtual tours are offered online for individual use. As previously mentioned, coral reefs act as fish incubators. Since Hawaii is surrounded by a marine environment, the state heavily relies on fishing for socioeconomic stability. Fishing is Hawaii's principal agricultural product and the industry is valued at $110 million.[28] It can be assumed the health of coral reefs directly relates to the success of the fishing industry.

Cultural Significance

In addition to its ecologic significance, the cultural history of Papahānaumokuākea Marine National Monument is invaluable to regional native communities. Natives believe the archipelago is where the creation of life began, and where the spirits of their ancestors return after their passing. The monuments name, Papahānaumokuākea, refers to ancestors Papahānaumoku and [W]ākea and the roles the they played in the creation story of the Hawaiian Archipelago.[29] Historically, the ocean provided everyday sustenance for survival for native communities. The area is embedded in native identity.

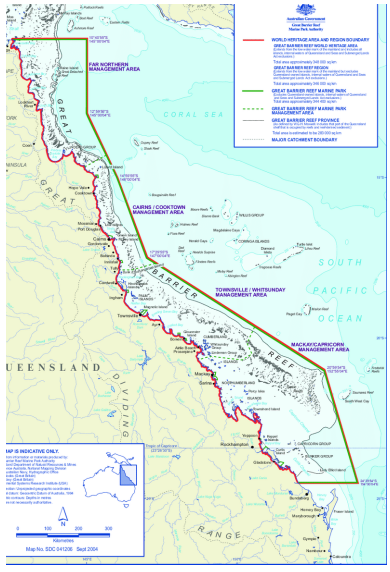
Management Information

Papahānaumokuākea Marine National Monument is named on the UNESCO World Heritage List. The monument heavily regulates human activity to minimize impact and is under the administration of four government organizations. Those are the National Oceanic and Atmospheric Administration, Secretary of the Interior, the State of Hawaii, and the Office of Hawaiian Affairs.[30] The monument is also under the management of an executive board and seven co-administrators who oversee daily operations.[31] The deep spiritual and cultural roots of Papahānaumokuākea Marine National Monument have also played a significant role in its administration. The Office of Hawaiian Affairs "… is responsible for representing the interests of the Native Hawaiian community pertaining to activities in the monument…"[32]

Great Barrier Reef (Australia)

Ecologic Significance

The Great Barrier Reef might be the world's most well-known reef system. Spanning 132,973 miles adjacent to Australia's northeastern coast, the Great Barrier Reef is home to the world's largest reef system.[33] The Great Barrier Reef is included on the UNESCO World Heritage List because of its rich biodiversity. "Its diversity includes but is not restricted to over 410 species of hard coral, over 1,620 species of fish, 2,000 species of sponge, 14 species of sea snake, six of the world's seven species of marine turtle, at least 300 mollusc species, 630 species of echinoderm, and 500 species of marine alga."[34] The Great Barrier Reef is one of the seven natural wonders of the world, marking its importance for not only Australia but also the international community.



Management areas of the Great Barrier Reef. Photo courtesy of the Great Barrier Reef Marine Park Authority.

Economic Contribution

The Great Barrier Reef adds tremendous economic value to Australia. The Great Barrier Reef is valued at 56 billion for the ecosystem services it provides.[35] The reef generates an added 6.4 billion to Australia's economy and employs 64,000 people, making it an invaluable economic asset.[36] The economic contribution of the Great Barrier Reef can be broken down four sections: tourism, research and management, recreational activities, and fishing productions.[37] Each section employs hundreds to thousands of people.

Tourism generates the highest percentage of profits at 90%, translating to 5.6 billion dollars annually.[38] The commercial fishing industry was valued at 193 million in 2012 and plays an essential role in the stability of regional economies.[39] In 2012, the commercial fishing industry funded 160 million to Australia.[40] The reef also provides a variety of other ecosystem services. This includes, but is not limited to, carbon sequestration, nutrient cycling, coastal and storm protection, and ecosystem resiliency.[41]

Cultural Significance

The cultural ties to the Great Barrier Reef span back over 60,000 years.[42] There are two different indigenous communities found in Australia, the Aboriginal and Torres Strait Islander groups.[43] Upwards of 70 different Aboriginal and Torres Strait Islander groups identify closely with the reef and the natural resources it provides.[44] These groups are acknowledged as the traditional owners of the Great Barrier Reef.[45] The Great Barrier Reef provides a variety of cultural services for indigenous communities. Some of those services include cultural traditions, religious and scared locations, stories, languages, and archeology.[46]

Management Information

The Great Barrier Reef is principally managed by the Great Barrier Reef Marine Park Authority under the Australian government.[47] The authority is comprised of an overseeing board, advisory committees, and local advisory committees. The Great Barrier Reef also falls under the administration of six regional Natural Resource Management programs including Burdekin, Burnett Mary, Cape York, Fitzroy, Mackay Whitsunday and the Wet Tropics.[48]

Tubbataha Reefs Natural Park (Coral Triangle-Philippines)

Ecologic Significance

Similar to Papahānaumokuākea and the Great Barrier Reef, Tubbataha Reefs Natural Park is also on UNESCO's World Heritage List for its rich levels of biodiversity. The park encompasses a 97,030-hectare area in the Sulu Sea.[49] Fish and other marine life depend heavily on the reefs for sustenance.[50] Tubbataha's reefs act as a driver for fish preproduction, migration, and dispersal within the region.[51] Tubbataha Reefs Natural Park is found inside the Coral Triangle of Southeast Asia. The Great Barrier Reef may be the most famous and large reef system, but the Coral Triangle is home to the world's largest wealth of marine life.[52] 76% of the world's coral reef species are found in the triangle.[53] Additionally, the region provides over 50% of fish found in the Indo-Pacific region.[54] The diversity of the Tubbataha coral reefs is undisputed.

Map of Tubbataha Reefs Natural Park. Tubbataha Reefs Natural Park image.

Economic Contribution

Because of the vast bio-diversity of the reef, the natural park helps to ensure the socioeconomic success of nearby communities. The Coral Triangle generates a billion-dollar tuna industry for its neighbor nations and directly supports 130 million people.[55] The commercial fishing industry of the triangle delivers 3 billion to its neighboring countries.[56] Tourism also plays a large role in the park's management. Fees generate necessary resources for administation, but because of the park's exclusive location and difficult access, Tubbataha has received a total of less than one million visitors.[57]

Cultural Significance

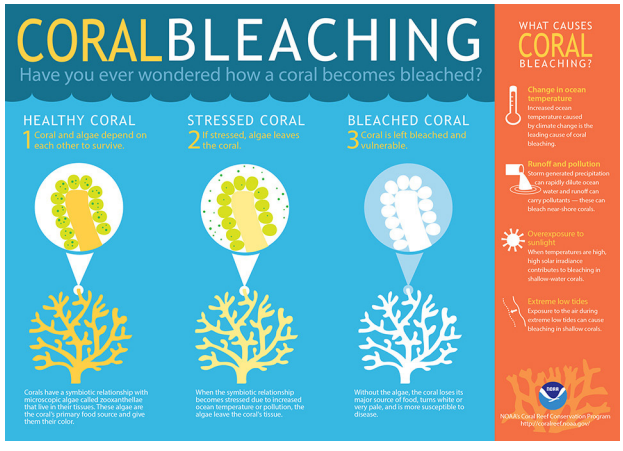
The park's name, Tubbataha, stemmed from the language of the Samal people, a seafaring community from the Sulu Sea.[58] The name translated means "a long reef exposed at low tide."[59] Historically, numerous groups shared the resources provided by the reef system, but no human community settled due to the lack of fresh drinking water.[60]

Management Information

Tubbataha Reefs Natural Park was established as a marine sanctuary in 1987.[61] The sanctuary received national marine park status in 1988 under the leadership of Philippine President Corazon C. Aquino, the nation's first female president.[62] Today, the natural park is under the administration of Tubbataha Protected Area Management Board (TPAMB).[63] The board is comprised of a number of high ranking officials including local university presidents, a World Wildlife Federation member, military officials, and government officials who meet on a quarterly basis.[64]

Threats to the Health of Coral Reefs

As discussed, coral reefs have contributed billions to international economies and local socioeconomic stability. Unfortunately, coral reef health has severely declined on a global scale in recent decades. This decline is largely due to climate change, compounded by other anthropogenic impacts.



Explanation of coral bleaching. Graphic provided by NOAA.

Climate Change Related Impacts

One of the most well-known contributors to coral reef degradation is coral bleaching. Coral bleaching occurs when coral animals release the zooxanthellae living within their tissue.[65] The expulsion of zooxanthellae leaves the skeleton of coral exposed. The animal is still alive during this time, but it is extremely susceptible to disease. Coral animals release their zooxanthellae largely due to heat stress. Warming ocean temperatures due to anthropogenic carbon dioxide emissions are known to increase ocean temperatures, therefore threatening corals.

Coral reefs are facing another climate change induced threat, ocean acidification. Acidification is the absorption of pollutants from fossil fuel emissions, primarily carbon, into the ocean. The world's oceans absorb 30% of all anthropogenic carbon emissions.[66] Since pre-industrial times, the ocean's pH has dropped from 8.2 to 8.1, representing a 26% rise in acidity.[67] The absorption of carbon dioxide emissions decreases the amount of available carbonate ions.[68] Carbonate ions are essential to reef skeletal building and shell building for other marine life. This results in coral reef inability to produce needed levels of skeletal density in addition to shell deformity of other marine life.[69]

Non-Climate Change Related Impacts

Unfortunately, climate change is not the only threat to coral reef ecosystems. Harmful fishing practices such as overfishing and indiscriminate fishing can ultimately lead to dwindling fish populations and reef damage. The overfishing of one, or multiple, living animals from a reef ecosystem may disrupt the role said animal(s) fulfil. This may result in the decline or overproduction of one or more species, potentially impacting the health of coral reef ecosystems.

Pollution also plays a significant role in harming marine ecosystems. The amount of plastic in the ocean is astonishing and can lead to a very serious problem, microplastics. Microplastics, by definition, are plastics systematically broken down into pieces under five millimeters in diameter.[70] "…the accumulated number of microplastic particles in 2014 ranges from 15 to 51 trillion particles, weighing between 93 and 236 thousand metric tons, which is only approximately 1% of global plastic waste estimated to enter the ocean in the year 2010."[71] Research is still underway to determine the true scope of microplastics, but studies already point to its pervasive nature and potential human health and marine life consequences. The ingestion of plastic by marine life can often, "…block digestive tracts, diminish the urge to eat, and alter feeding behavior, all of which reduce growth and reproductive output," which can frequently lead to death.[72]

Eutrophication is another form of anthropogenic pollution that harms the health of marine ecosystems. Eutrophication is the excess of nutrients, primarily nitrogen and phosphorus, into estuaries and seaside areas.[73] Poorly managed sewage systems and fertilizer runoff are the chief drivers for eutrophication.[74] Once the excess nutrients enter water ways, it acts as fuel for damaging algae blooms to grow which results in marine death and the blocking of sunlight.[75]

Consequences of Climate In-Action

Climate change has impacted coral reefs around the globe. In 2014, Papahānaumokuākea Marine National Monument experienced the worst bleaching event known to the region since 1982.[76] The 2014 warming event resulted in damage as high as 91% in some shallow areas.[77] Australia's Great Barrier Reef has famously experienced bleaching events for decades. The Australian reef endured extreme bleaching in 2016, with up to 93% of the northern region impacted primarily due to anthropogenic greenhouse gas emissions.[78] Until 2013, Tubbataha Reefs Natural Park remained relatively untouched from heat stress because of its secluded location. However, the natural park began experiencing severe bleaching in 2014.[79]

The IPCC's most recent climate assessment has indicated the Earth's global temperature has risen by 1°C since pre-industrial times.[80] The IPCC found 99%> of all coral reefs are expected to die by if global temperatures warm to 2°C and cautioned the passing of 1.5°C would result in 70%-90% coral reef loss.[81] With current pledges under the Paris Climate Agreement, global temperatures may still exceed over 2°C.[82] Without taking the IPCC's recommendations seriously, the future of coral reefs are at risk. If the UN's forecast of losing 99%> of the world's reefs become reality, governments will lose billions of dollars and millions of people worldwide will experience severe socioeconomic threats, most notably food insecurity. Food and job insecurity could potentially trigger mass migrations like never before.

This report outlined only three coral ecosystems, but, there are many more that provide equally important and complex ecosystem services. The Maldives, for example, strongly depends on coral reefs for socioeconomic stability and food security. Nearly 400lbs of fish per capita is consumed annually, and tourism generates roughly 28% of the nation's GDP.[83] Liberia also heavily depends on their coral reef fisheries. A report issued by *Oceana* found Liberia within the top 40 countries vulnerable to climate change and ocean acidification, which could potentially trigger extreme food security threats.[84] Liberian fisheries employ over 37,000 people nationally and employ an additional 33,000 people on the small-scale level, making it a valuable socioeconomic asset.[85] Without action, entire communities, even nations, may collapse. The world has reportedly already lost 19% of original coral reef area.[86] The severity of the situation is unprecedented.

Potential Solutions

The IPCC's report outlines potential catastrophic outcomes driven by climate change. However, it does not come without recommendations. Restraining global temperature from passing 1.5°C, "would require a 'rapid and far-reaching,'" transformation of the world's energy consumption.[87] Global carbon emissions must decrease by 2030 and must reach carbon zero by 2050.[88] While this does pose serious challenges, it is not impossible. To ultimately attain carbon zero by 2050, the IPCC suggests policy makers look towards diversifying electricity needs by promoting and heavily investing in alternative energy resources. To achieve this, the IPCC suggested using a carbon tax or other economic lever to reduce reliance on fossil fuels.[89]

Plastic pollution. Image courtesy of Hillary Daniels on Flickr.

However, the serious challenges the U.S. and other countries around the word would experience to achieve carbon zero should not be downplayed. Vehicles that operate on fossil fuels still dominate the market today. While some consumers are beginning to show interest in electric vehicles, this trend is slow. Electric vehicle sales are anticipated to reach 30 million by 2030 and are expected to hold 55% of global new car sales by 2040.[90] China will be principally responsible for this trend. Commercial electric vehicles will account for 19% of Chinese passenger car sales while the U.S. trails at 11%.[91] Similarly, wind and solar are expected to meet 50% of all global electricity needs.[92] While these projections are notable, they do not meet the IPCC's recommendations. The IPCC stated 2050 is the year to achieve carbon zero, not carbon half. If the international community cuts only half of the carbon emissions produced today by 2050, the fate of coral reefs are nearly sealed.

In addition to the reduction of carbon emissions, single-use plastics must also be reduced. As previously mentioned, plastics are extremely invasive in ocean environments. Many marine species consume, and die, from plastics. This problem has not gone unnoticed. The European Union (EU) recently announced their pledge to ban single-use plastics from EU markets in member countries effective 2021.[93] The pollutants include, "… plates, cutlery, straws, balloon sticks or cotton buds…" in addition to the removal of lost fishing gear and the reduction of cigarette filters that contain plastic.[94] The European Commission found 80%of ocean pollution is plastic, and the pollutants outlined by the EU's ban compromises 70% of the plastic pollution found. The ban is an outstanding first step in achieving cleaner oceans. [95, 96]

The anticipated global trend towards alternative energies and the EU's plastic ban will aid the restoration process for coral reefs, but the establishment of Marine Protected Areas, or MPA's, may go one step further. Existing MPA's have seen high levels of success in health and resiliency of coral reefs. Only 27% of the world's coral reefs are protected under MPA status, leaving almost three-quarters exceptionally vulnerable to climate change and other anthropogenic impacts.[97] Additionally, not all MPA's are highly regulated. MPA's encompass less than 4% of the ocean, and of that, less than one percent are no-take zones.[98]

A common misconception regarding MPA's is that they harm local and commercial fishing operations. However, the establishment of MPA's, specifically no-take zones, have consistently shown benefits to these industries. The protection of marine life in well-regulated MPA's allow organisms to successfully grow, reproduce, and migrate without impact. Even though fishermen may be denied access to certain areas, the yield of fish stocks are greater. More MPA's should be established to safeguard additional areas. Existing MPA's, especially ones with little-to-no regulation, should strengthen their protection policies. Over 50% of the world's coral reef ecosystems are severely impacted from local stressors.[99] Climate change is the long-term threat, but local stressors, such as damaging fishing practices, is a concern that can be immediately mitigated. The implementation of new MPA's or reinforcement of current policies may help restore the health of reefs. Unfortunately, no matter the success of further MPA's, if global temperatures rise to 2°C, virtually all coral reefs are anticipated to vanish.

Discussion and Conclusion

Coral reefs play a significant role for a variety of ecologic, financial, and cultural reasons. Because of the ecosystem services they provide, millions of people are directly dependent on corals for both sustenance and socioeconomic stability. The benefits humans receive from coral reefs are irreplaceable. Climate change, however, is on track to change that.

If worldwide temperatures rise past 2°C, nearly all coral reefs will perish. Even with current Paris Climate Agreement pledges, the world may still heat beyond 2°C.[100] Because of this, millions will face extreme food and human security threats. Communities and countries who heavily rely on coral reef ecosystem services will struggle to adapt without them. If the international community does not take firm measures to reduce carbon emissions, the fate of 500 million people will be in question. Does the world have the capacity and resources to handle the socioeconomic ruin of 500 million people? Will food insecurity drive those millions of people away from their homes, as seen in other scenarios before? Where will they go? The far-reaching scope of a worldwide coral reef collapse is unparalleled and arguably one of the most severe consequences of climate change. The decimation of coral reefs would cause a humanitarian crisis on an unmatched global scale. The reduction of carbon dioxide emissions is essential to curb rising temperatures to prevent further coral reef loss.

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