Impact and Countermeasures of Climate Change on Coral

Jingmin Sun

Shanghai High Tech Creative School, 201201, China
sjm13761536045@163.com

ABSTRACT
In recent years, with the destruction of the environment, climate warming has become one of the environmental problems that people pay attention to. This can lead to ocean warming, sea-level rise, ocean acidification and increased storm intensity. The results show that coral reefs are facing a great dual crisis of bleaching and death. This paper discusses the changes of coral acidification to the ocean by combining the case of coral in the Great Barrier Reef. This essay discusses the impact of global warming on the life span, distribution and adaptability of coral reefs and also shared and protect methods, the further acidification of coral reefs from three aspects: Science and technology, government and human beings. In order to prevent coral reefs from bleaching due to climate change, there is an urgent need to find a new way to improve the current situation. Human beings need to face the large-scale death of coral in the future. This article aims to find ways to slow down its occurrence from various aspects. This article aims to raise people's awareness of coral degradation caused by climate change and pay attention to global warming.

Keywords: *coral reefs, climate change, countermeasures*

1. INTRODUCTION

Currently, with the destruction of the earth's ecological environment by human beings, the marine environment is gradually damaged by global warming, and coral is irreversibly negatively affected. Coral groups play a very important role in the marine field. First, coral communities balance biodiversity in the ocean. Many marine organisms depend on coral colonies, which provide human beings with a source of fish food. Secondly, coral reefs are rich in material resources. Human beings can also extract marine products, drugs and industrial raw materials from coral reefs. Humans can process coral reefs into different things that can be used in all aspects of our lives. Finally, coral reefs can also slow down waves. Healthy coral reefs can absorb most of the impact of waves and act as natural breakwaters.

Therefore, if the coral in the ocean is destroyed, it will have an indelible impact on the natural environment and human beings. Human beings protect coral reefs in a variety of ways. Some research papers put forward innovative suggestions on how to protect coral reefs in different fields. In terms of science and technology, a university student developed an underwater robot to observe the changes of seawater quality and coral reefs. These small machines can store a lot of information, and when they are connected to each other, they can float in the middle of the sea with the ocean current and constantly feedback data to the laboratory. However, this invention also has some imperfections. This large number of small underwater robots is difficult to link. In other words, if they are separated from each other by ocean currents, the remaining robots will remain in the sea. If this machine becomes marine garbage, it may have a certain impact on the ocean. In addition, if the machine is accidentally eaten by marine organisms, it will also have a bad impact.

This paper hopes to study the impact of global warming on coral and find ways to protect and restore coral reefs. This paper explores the impact of climate change on coral reefs and puts forward several countermeasures. Firstly, this paper briefly introduces the distribution and quantity of coral groups. Secondly, we introduce the impact of global warming on coral longevity and reproduction, as well as some examples. Human beings can curb the damage of environmental warming to coral communities through the development and publicity of science and technology, daily life, government and other fields. We hope to find better ways to reduce the damage of global warming to coral.

2. EFFECTS OF CLIMATE CHANGE ON CORAL REEFS

2.1 The distribution of coral reef

Coral reefs prefer warm, shallow water to grow in. These bodies of water are most commonly found between 30 degrees north and 30 degrees south latitude, which typically are around 22-29 degrees Celsius [1]. As such, the majority of the world's coral reefs are found in tropical zone, shore waters between the tropic of Cancer and the tropic of Capricorn.This distribution is likely to change due to modern climate change, however. A long-term case study done in southwest Japan has shown that extreme climate events, such as typhoons, can alter coral distribution. At the Ishigaki islands, historical aerial photographs were taken over the span of two decades. Researchers analyzed these photos and, together with field observations, concluded that coral erosion was attributed in part to the wind directions of typhoons that swept across the area, meaning that suitable coral habitat will become more limited than it was before. With anthropogenic climate change resulting in the formation of more numerous and powerful typhoons, it is possible that distribution may change in a way that more coral inhabits deeper waters. This potential shift in coral distribution is supported by Maxent (A distribution model). When fed variables that best reflect coral reef distributions in shallow waters of the Atlantic Ocean, Maxent predicts a maximum habitat loss of over 80% by 2100.

2.2. Coral reef population

Since 1955, due to ocean warming caused by climate warming, the Great Barrier Reef in Australia has lost more than half of its coral, the third time in nearly five years. Two things of the reef was damaged by similar events in 2016 and 2017. The reef system, which covers over 2300km (1400 miles), is a world heritage site recognized for its "environmental scientific and intrinsic importance". In 2016 and 2017, corals suffered the most, because a large part of corals were bleached."The reef has only recently begun to recover from the shocks of 2016 and 2017, and now we've experienced a third catastrophe," said lead scientist David Wachenfeld to the BBC. "As a result of climate change, extreme events that cause those consequences are becoming both more severe and more frequent, resulting in more damage in the event." If normal circumstances return, corals can recover, but it may take decades. According to a research published in 2019, injured coral colonies failed to regrow since the majority of the adult corals had died[2]. Some significant tourism reefs in the northern and central areas, according to Dr Wachenfeld, were only "moderately bleached" this year. He went on to say that this suggested the coral in the area will most likely recover. "The reef is still a vigorous, dynamic system," he stated, "but with each consecutive occurrence, the reef becomes more damaged than before." "We must approach these events from a global perspective." Since pre-industrial times, global temperatures have risen by around 1 degree Celsius. The United Nations has warned that if global temperatures rise by 1.5 degrees Celsius, 90 percent of the world's corals will perish[3].

2.3 Coral reef reproduction

Anthropogenic climate changes are thought to have profound impacts on coral reproduction. Coral reefs can reproduce both sexually and asexually. Asexual reproduction involves the budding of pre-existing polyps, generating organisms that are new, exact copies of the parent. This way of reproducing is not very dependent on external factors, so it is not as affected by climate change as sexual reproduction. When corals undergo sexual reproduction, both the male and the female party must secrete gametes simultaneously in order to secure the highest chance of fertilization, which is likely cued by the astronomical cycles and water conditions. Climate change makes simultaneous gamete secretion more difficult. Specifically, some scientists hold that a rise in water temperature and ocean pollution can cause it to go out of sync. Due to this, corals can miss their optimal timeframe by anywhere from a few minutes—lowering fertilization rates—to hours—missing fertilization entirely. A major implication of a lower fertilization rate is that it prompts a major threat to coral genetic diversity. Sexual reproduction is a key step in achieving extensive genetic diversity, (The Ocean Portal Team) which is beneficial in spawning a new colony or surviving a natural disaster. Climate change lowers the rate of successful sexual reproduction, inhibiting complex genetic diversity. This is critical, as entire colonies of coral are at higher risk of collective extinction since they have more common genes prone to disaster than they would have if genetic diversity were not capped by climate change[4].

2.4 The lifetime of coral reef

The skeletons of corals are comprised of aragonite, a calcium carbonate mineral. Corals build their skeletons by stacking aragonite crystal bundles one on top of the other. At the same time, they add more crystals to those bundles, strengthening the skeletons and making them more resistant to breaking from currents, waves, storms, and worms, mollusks, and parrotfish burrowing and biting. Rising sea levels, changing nutrient regimes, and greater ocean temperatures are all threats to reefs, but unlike ocean warming, which causes obvious bleaching, the impact of ocean acidification is more subtle and difficult to detect, making it more difficult to predict[5].

Ocean acidification is caused by rising carbon dioxide levels in the atmosphere, which are mostly driven by the

combustion of fossil fuels. Hoegh-Guldberg found that the calcifying abilities of corals depend on the concentration of carbonate ions in the water. The lower the concentration of carbonate ions in the water, the less the corals can calcify. Decreased calcification ability in corals causes them to become weak and easily damaged [6]. Seawater absorbs carbon dioxide (CO2), causing chemical processes that create bicarbonate (HCO3–) and carbonate (CO32-) ions. Coral polyps, which are small soft-bodied coral creatures, carry saltwater containing HCO3–, CO32–, and calcium (Ca2+) ions into a "calcifying gap" between their cells and the existing skeleton's surface. They remove hydrogen ions (H+) from this region in order to manufacture additional carbonate ions (CO32-), which makes calcium carbonate (CaCO3) for their skeletons simpler. However, when the seas absorb extra CO2, as they do currently, saltwater contains more HCO3– ions but fewer CO32– ions, making it more difficult for corals to build skeletons.Ocean acidification not only impacts adult corals ability to calcify, but also the corals' developmental stages, larval settlement, sexual reproduction, algal symbiosis, metabolism and post-settlement [7].

As is shown in Fig 1, in 2016, the Great Barrier Reef was bleached more than twice as much as in 2015. In 2017, most of the Great Barrier Reef was bleached by global warming. When excessively heated ocean water kills a reef's beautiful algae, mass coral bleaching occurs, a global phenomenon caused by climate change. The Great Barrier Reef exemplifies the extent of the damage: In 2016, 30% of the coral died, with another 20% dying in 2017. It has the same impression as a forest after a terrible fire. Much of the reef's north coast marine environment has become barren and skeleton, with little chance of recovery.

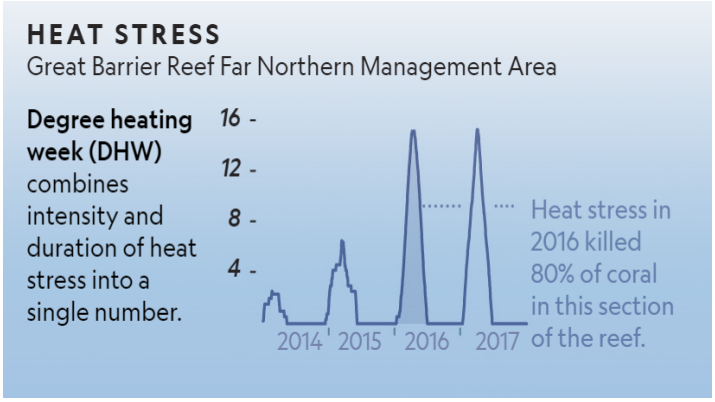

Fig 1. The influence about coral reefs of climate change [8].

When excessively heated ocean water kills a reef's beautiful algae, mass coral bleaching occurs, a global phenomenon caused by climate change. The Great Barrier Reef exemplifies the extent of the damage: In 2016, 30% of the coral died, with another 20% dying in 2017. It has the same impression as a forest after a terrible fire. Much of the reef's north coast marine environment has become barren and skeleton, with little chance of recovery.

2.5 Coral reef adaptation

Climate change is predicted to bring about major changes in the marine environment, of which one of the two components is ocean temperature increase. An inappropriate extent of it can cause coral bleaching, the loss of symbiotic zooxanthellae algae that usually lives inside of coral tissue. Coral bleaching commonly occurs in waters where the temperature is 1-2 degrees Celsius higher than regular summer temperature. (National Ocean Service) As zooxanthellae supplies most of the corals' food, extended periods of incessant bleaching may result in starvation. The other option would be to adapt. It has been found that some coral species may be able to accustom themselves to increased surrounding temperatures and resist bleaching [9]. Other adaptations such as proteins that reverse the denaturation of other proteins and fluorescent dye that deflect light are found in certain coral species in certain regions. Corals possessing these adaptations likely emerged from random gene mutations or gene recombination from sexual reproduction, but they are by no means the rule, as evidenced by persistent coral decline. Overall, coral species adapt to climate change at a slow pace—perhaps not enough to save them. Several adaptations have been undertaken by a few species, but most, their outlook may be grave given current climates[10].

3. COUNTERMEASURES

3.1 Technology

The global warning has caused irreversible damage to the earth's ecosystem, especially the coral reefs in the ocean. In order to protect coral reefs in the ocean, it is urgent to find a new measure to protect coral. Technically, this paper discusses a new technology - power-to-x. As is shown in Fig.2, which can use hydrogen to convert carbon dioxide into carbon dioxide, but this technology is not very mature, and the storage of hydrogen will

become very dangerous. Although these technologies may not compete completely with traditional fossil fuels in some cases, they are still the only way to achieve sustainability. Only by promoting the development of these technologies can we hope to balance the impact of our society on the environment [11].

Another healthy way to reduce the pH value contained in the ocean is to plant aquatic grass, because this plant can well absorb carbon in the ocean, but not all seaweeds will absorb carbon dioxide. For example, invasive Japanese spotted algae growing in Oregon often lose their leaves in winter, and the degraded plant substances will increase the carbon dioxide level in the water, instead of reducing carbon dioxide levels. Seaweed is not the only possible solution. Kelp is also famous for absorbing too many nutrients and making seawater cleaner for shellfish. Most academic papers on the benefits of kelp do not even mention acidification. However, Nicole price of the Marine Science Laboratory in Bigelow, Maine, did not spend much time combining the two. “The biggest challenge for land and Shanghai belt nurseries is to keep their pH low enough because they consume a lot of carbon dioxide.”

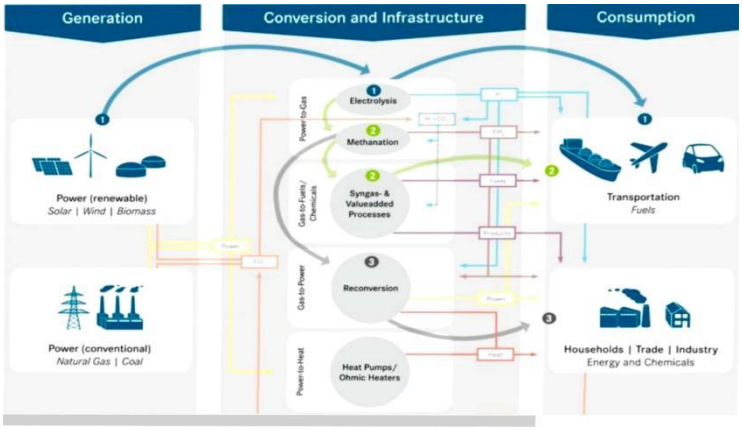

Fig. 2 Hydrogen turbines and Power-to-X technologies in carbon-neutral energy systems [12]

3.2 Government

Governments of various countries are making efforts to protect coral. For example, the Environment Protection Agency(EPA) of the United States, whose full name is the United States Environmental Protection Agency, requires all federal agencies whose activities may affect the coral reef ecosystem in its executive order No. 13089 coral reef protection, Use their plans and powers to protect and strengthen coral reef ecosystems and ensure that any actions they authorize, finance or implementation do not degrade the status of coral reef ecosystems. The environmental protection agency protects coral reefs by implementing the clean water act project to protect the water quality of coral reef waters and coastal zones in coral reef areas. EPA also supports efforts to monitor and assess the state of coral reefs in the United States and to study the causes of coral degradation. Then they are also developing tools to adapt corals to changing environments. Most of EPA’s efforts to protect coral reefs are carried out in cooperation with other federal agencies, states and regions. The first is local research, such as reducing overfishing and restoring coral reefs. The second is the conservation of coral groups, such as establishing some marine protected areas and identifying and detecting coral objects that should be protected. The best way is to establish a coral reserve. People will realize that it is a coral reserve when fishing at sea. At the same time, it can also protect other organisms symbiotic with coral groups in this water area. These plants or animals that live with corals are indispensable. This can be very effective in protecting and changing coral groups.

The Chinese government also attaches great importance to environmental protection. In the “Nansha Island Reef expansion project has no impact on the coral reef ecosystem”, a senior engineer of the State Oceanic Administration, wrote that the coral reefs in China’s surrounding waters account for 2.57% of the total area of coral reefs in the world, ranking eighth in the world. As the seawater temperature rises, the seawater acidifies. Modern coral reefs are in the process of rapid degradation. The Spratly Islands has strictly followed the state's laws in carrying out construction and site selection, focusing on the protection of the ecological environment and fishery. The first is for military construction, the second is for tourism construction, the third is for port and wharf construction, and the fourth is for marine oil and gas exploitation. China has promulgated a series of laws such as the marine environment protection law, the sea area use protection law and the island protection law, earnestly implemented the International Convention on biological diversity, and established a number of marine protected areas to protect coral reefs. In recent years, the restoration of some corals has been actively carried out and achieved good results.

3.3 Public

People can do many things to protect coral. Whether they live near the coast or hundreds of miles away from the coast, they can do some small daily things to protect coral. Most of the harmful things to coral do not happen at the bottom of the sea, but on land. If humans change these little habits, coral will change a lot. When people are at the seaside, most of all often go to some tourist attractions and participate in diving activities during holidays. First, people should avoid touching coral groups or staying near coral groups for a long time. If you touch the coral or stay near the coral for a long time, it will hurt or affect some organisms living on the coral. Second, People should try to avoid using sunscreen that is harmful to coral when they are at the seaside. Some sunscreen carry substances that can kill coral. Therefore, when people play at the seaside, they had better not apply sunscreen, but wear sunscreen clothes. Third, we should clean up the garbage in time to prevent it from entering the sea.

In daily life, people should first reduce the use of fertilizers on grassland, because it will damage water quality. Some fertilizers contain substances that can lead to ocean eutrophication. If a lot of water-rich in trace elements flows into the sea, it can create red tides in the sea. These water may increase the density of algae and phytoplankton, and reduce the transparency of seawater. The photosynthesis of symbiotic algae in coral is inhibited and the ecosystem balance of coral reef is destroyed. Second, people should reduce the number of driving out and choose more environmentally friendly ways to go out, such as taking a bus. Because the carbon dioxide contained in automobile exhaust will enter the atmosphere, these emissions will lead to ocean acidification and acid rain. When the pH value in the ocean decreases, this will lead to the bleaching of coral colonies. Third, people can install catchments at home to reduce rainwater runoff and help prevent water pollution.

4. CONCLUSION

The global alert has caused irreversible damage to the earth's ecosystem, especially coral reefs in the ocean, including damage to coral life, coral distribution, coral adaptability and coral reproduction. In order to protect coral reefs in the ocean, human beings urgently need to find new measures to protect coral. This paper discusses how to slow down and control the damage of climate warming to core reefs under the environment of global warming. On the contrary, more corals face death and bleaching. In the future, in many fields, global early warning will solve the harm caused by global early warning to core reefs. Although these biological and chemical technologies technologies may not compete completely with traditional fossil fuels in some cases, they are still the only way to achieve sustainability. Only by promoting the development of these technologies can we hope to balance the impact of our society on the environment.

REFERENCES

[1] Kleypas, J. A., McManus, J. W., and Menez, L. A. B. (1999b). Environmental limits to coral reef development: where do we draw the line? *Am. Zool.* 39, 146–159. doi: 10.1093/icb/39.1.146

[2] Berkelmans R, Van Oppen M. J. H. The Role of Zooxanthellae in the Thermal Tolerance of Corals: A 'Nugget of Hope' for CoralReefs in an Era of Climate Change. Proceedings: Biological Sciences, Vol. 273, No. 1599 (Sep. 22, 2006), pp. 2305-2312.

[3] Frontiers | Coral Reef Ecosystems under Climate Change and Ocean Acidification | Marine Science (frontiersin.org)

[4] Kubicek A, Breckling B, Hoegh-Guldberg O, Reuter H. Climate change drives trait-shifts in coral reef communities. Sci Rep. 2019 Mar 6;9(1):3721. doi: 10.1038/s41598-019-38962-4. PMID: 30842480; PMCID: PMC6403357.

[5] Jackson, J. B., Kirby, M. X., Berger, W. H., Bjorndal, K. A., Botsford, L. W., Bourque, B. J., et al. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293, 629–637. doi: 10.1126/science.1059199

[6] Cohen, S.S., & Fine, M.M. (2012). Measuring gross and net calcification of a reef coral under ocean acidification conditions: methodological considerations. Biogeosciences Discussions, 9(7), 8241-8272. Doi:10.5194/bgd-9-8241-2012

[7] Albright, R. (2011). Reviewing the Effects of Ocean Acidification on Sexual Reproduction and Early Life History Stages of Reef-Building Corals. Journal of Marine Biology, 2011 1- 14. dio:10.1155/2011/473615

[8] LAUREN E. JAMES AND CLARE TRAINOR, NGM STAFF. TERRAIN RENDERING: CHARLES PREPPERNAU. ART: MATTHEW TWOMBLY. SOURCES: ARC CENTRE OF EXCELLENCE FOR CORAL REEF STUDIES; NOAA CORAL REEF WATCH; ROBIN BEAMAN, JAMES COOK UNIVERSITY; AUSTRALIAN HYDROGRAPHIC OFFICE; GEOSCIENCE AUSTRALIA; AUSTRALIAN INSTITUTE OF MARINE SCIENCE; RAY BERKELMANS AND OTHERS, CORAL REEFS 23, 2004

[9] Logan, C. A., Dunne, J. P., Eakin, C. M. & Donner, S. D. Incorporating adaptive responses into future projections of coral bleaching. *Glob. Chang. Biol.* **20**, 125–139 (2014).

[10] Hoegh-Guldberg, O. Coral reef sustainability through adaptation: Glimmer of hope or persistent mirage? *Curr. Opin. Environ. Sustain.* **7**, 127–133 (2014).

[11] B. Decourt, Weaknesses and drivers for power-to-X diffusion in Europe. Insights from technological innovation system analysis, Int. J. Hydrogen Energy. 44 (2019) 17411–17430

[12] M. Robinius, A. Otto, P. Heuser, L. Welder, K. Syranidis, D.S. Ryberg, T. Grube, P. Markewitz, R. Peters, D. Stolten, Linking the power and transport sectors - Part 1: The principle of sector coupling, Energies 10 (2017), https://doi.org/10.3390/en10070956.