

Forum:	Environmental Commission (EC)
Issue:	Strategies to assess and counteract the effects of coral bleaching
Student Officer:	Ilianna Mavroeidi
Position:	Deputy President

PERSONAL INTRODUCTION

Dear delegates,

My name is Ilianna Mavroeidi, and I am currently attending the 11th grade of Pierce-The American College of Greece. This year, I will have the utmost honor of serving as a Deputy President of the Environmental Commission (EC) in the 11th Platon School Model United Nations conference and more specifically, as an expert chair on the topic “Strategies to assess and counteract the effects of coral bleaching”.

My MUN experience began growing last year, and since then I have had the opportunity to participate in numerous conferences, discuss extremely heated topics, collaborate with excellent people, and most importantly, foster long-lasting friendships with people I share passions with. MUN offers everyone a unique chance to do all that, develop and practice necessary skills, and gain an understanding of international politics and current affairs.

This is going to be my third time chairing, and I am very eager for it, due to the nature of the topic and the committee as a whole. This year’s topics in the EC are extremely prominent since they refer to current and grave issues that concern not only the environment but also, our own lives. Especially the phenomenon of coral bleaching is a crucial one since our planet is steadily affected by it, and not a lot is being done to avert it.

Lastly, I would like to stress that the sole purpose of this study guide is to serve as a basis for your preparation and therefore you should not limit it only to this document but also, conduct further research on your own. To do this, you are encouraged to take advantage of the bibliography, which you will find towards the end of the study guide.

I wish you a fruitful debate and I am looking forward to meeting you all at the conference in March!

Should you have any inquiries, do not hesitate to contact me at: Ilianna.mavroeidi@acg.edu.

Yours truly,

Ilianna Mavroeidi

TOPIC INTRODUCTION



Figure 1: Image depicting a coral before and after it experienced bleaching.

Corals are a crucial source of life for Earth—they are its heart, scattered all across its water bodies. Just like a heart, they are composed of a simple internal and an extraordinarily complex external, while their value for humans and the Earth is immense. Coral bleaching, which can cause their death, is essentially like the body being deprived of its basic needs.

Corals help preserve approximately 25% of all marine life as they provide shelter, spawning grounds, and food for a substantial number of marine animals. Additionally, corals act as a natural storm barrier, protecting the land from storm surges, waves, and erosion. ¹

Corals do not only possess an environmental value but are also crucial for the medical sector. Many species of corals contain certain pharmaceutical substances which are used to treat and/or cure several diseases, including cancer, such as prostaglandin which derives from sea fans, and bryostatin obtained from coral rhizomes.

Finally, coral reefs are of significant cultural value to some island communities, since they are a part of their land, are involved in many of their traditions, and supply the populations with a lot of benefits and essentials for life.

Unfortunately, coral bleaching is continuously affecting the world's corals and it is considered one of the gravest natural disasters for many reasons. After a major bleaching event, it is extremely difficult for corals to revive and obtain their vibrant colors back, considering that they grow approximately 1cm per year.² Thus, the situation is gradually deteriorating and so do the effects on humans and wildlife.

¹ National Geographic. "Corals." National Geographic, www.nationalgeographic.com/animals/invertebrates/facts/corals-1.

² Greenpeace. "What is Coral? What Are the Causes, Impacts, and Solutions of Coral Bleaching?" Greenpeace East Asia, www.greenpeace.org/eastasia/blog/6119/what-is-coral-what-are-the-causes-impacts-and-solutions-of-coral-bleaching/.

Coral bleaching is a global event; everyone is affected by it and hence, everyone should be concerned. However, that is not the case. People are not being motivated and measures are not being taken to save the planet from the impacts of coral bleaching. There is an urgent need for action to minimize coral bleaching events and, consequently, minimize their effects on human and animal life, as well as the environment. If we do not act to prevent coral bleaching, it is estimated that within the next 30 years, bleaching will kill most of the world's remaining corals; that is, the entire ecosystem might be eradicated in our lifespan.

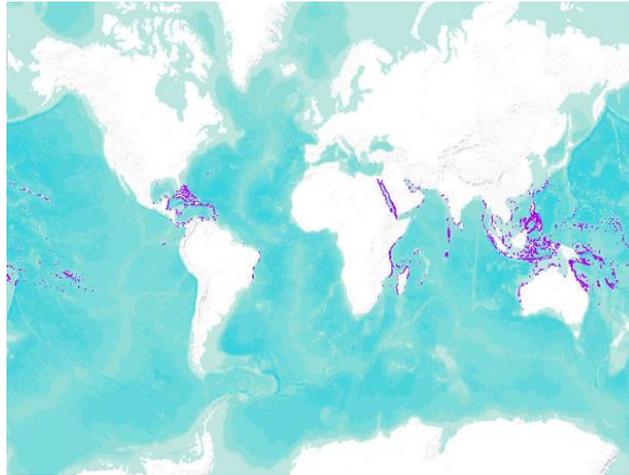


Figure 2: Image depicting the areas affected by coral bleaching.

DEFINITION OF KEY TERMS

Corals

Corals are sessile invertebrate animals that are part of the Cnidaria family of vibrant and captivating creatures. They usually assemble colonies that consist of numerous identical polyps. Contrary to popular belief, corals are considered animals since, in contrast to plants, they do not produce their own food-either the algae that live inside them provide corals with it or they collect it themselves with their tentacles.

Coral bleaching

Coral bleaching is the process through which corals lose their bright colors and become white. Bleaching might often lead to the death of a coral and ultimately, the endangerment of an entire reef ecosystem.

Coral farming

“Coral farming is the process whereby fragments of corals are collected from local reefs, raised in farms until mature, and then installed at the restoration site.”³

³ "Plant Forest, Restore Coral Reefs and Ocean Ecosystems – SUGi." Support Sustainable Biodiverse Forests with SUGi, www.sugiproject.com/projects/the-coral-farm.

Coral polyps

“Coral polyps are tiny, soft-bodied organisms related to sea anemones and jellyfish. At their base is a hard, protective limestone skeleton called a calicle, which forms the structure of coral reefs.”⁴

Coral reefs

Coral reefs are underwater ecosystems that comprise colonies of individual organisms known as coral polyps, which belong to corals. Corals that compose coral reefs extract calcium carbonate from seawater and create a hard exoskeleton to protect their bodies.⁵

El Niño

The El Niño is characterized by above-average sea surface temperatures in the central and eastern tropical Pacific Ocean. It is a part of the El Niño-Southern Oscillation, a recurring climate phenomenon in the area that occurs every two to seven years and causes consistent temperature variations.

Low tide

“The alternating advance and retreat of seawater along a coastline caused by the moon’s gravitational pull on the Earth and the Earth’s rotational force is called a tide. Low tide is when the water recedes to its furthest extent.”⁶

Mutualism

Mutualism is a type of ecological interaction between creatures of different species in which one benefits from the other.

Ocean acidification

Ocean acidification is the continual decrease of the ocean’s pH levels due to the sequestering of excessive amounts of CO₂ from the atmosphere in the water.

Reef tourism

Reef tourism is a section of tourism that depends on coral reefs meaning tourists visit and explore coral reefs for recreational purposes. Reef tourism can happen either with or without making direct use and contact with the corals.

⁴ National Geographic. "Corals." National Geographic, www.nationalgeographic.com/animals/invertebrates/facts/corals-1.

⁵ "Losing Our Coral Reefs." State of the Planet, 10 Dec. 2019, news.climate.columbia.edu/2011/06/13/losing-our-coral-reefs/.

⁶ National Geographic Society. "Tide." National Geographic Society, 30 Aug. 2019, www.nationalgeographic.org/encyclopedia/tide/.

BACKGROUND INFORMATION

Corals are vividly colored and mesmerizing invertebrates, that is, animals without a backbone. They usually assemble colonies that consist of numerous identical polyps, forming coral reefs, one of the most valuable ecosystems in the oceans. However, in recent years, corals have started experiencing the phenomenon of coral bleaching, which deprives them of their colors and often leads to their death. Coral bleaching has many adverse impacts on humans, wildlife, and the planet as a whole, and thus, it needs to be addressed as soon as possible.

Main morphologies of corals

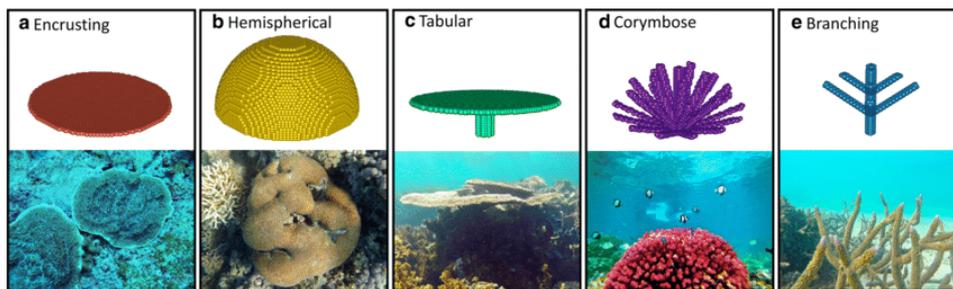


Figure 3: Image depicting the main morphologies of corals.

There are many types of corals with countless different morphologies, but most experts catalog four (4) of them as the most important ones, namely the encrusting, the hemispherical, the corymbose, and the branching.

Encrusting corals typically attach to rocky surfaces underwater. They grow greater in diameter rather than upwards and they hold an advantage over other corals. Due to their shape, they are more resilient to violent storm conditions since they hardly ever experience breakage.

Regarding hemispherical corals, there are many species of them, and as their name suggests they have the shape of a hemisphere or a dome. They have a spongy texture and have grooves all over them, often resembling a brain-like appearance.

Corymbose corals are irregular, dense, and bushy corals that require a lot of sunlight and currents to flourish. Although they are a fast-growing type, they are vulnerable to predation and bleaching.

Lastly, branching corals have a tree-like shape and grow extremely fast. Unfortunately, they are also prone to mortality as a result of temperature rise, algae overgrowth, and predation.

Apart from the above, there are more coral morphologies around the planet such as the digitate, foliose, laminar, massive, and submassive. As suggested above, each coral morphology has different amounts of resilience to heat, thermal stress, and other environmental conditions and hence, different amounts of resilience to the causes of coral bleaching. Each coral is affected differently by them and that is why the issue is so grave and challenging to tackle.

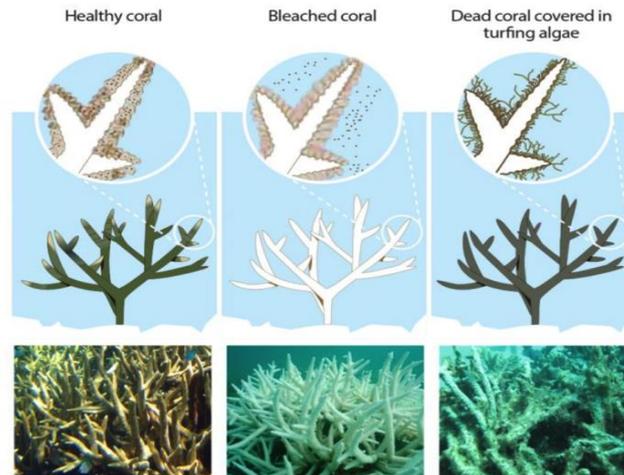


Figure 4: Image depicting the stages that lead to the death of a coral due to coral bleaching.

The coral bleaching process

Corals are in a mutualism relationship with a species of algae known as Zooxanthellae, which lives within the corals. The alga's pigments are the source of the corals' vibrant colors while it provides corals with food through photosynthesis. The two are symbionts, as one relies on the other for survival. Changes in the ocean environment, notably the rise of sea temperatures, lead corals to expel the algae from their bodies due to extreme "stress". That is exactly when the bleaching process begins. The first apparent sign of bleaching is when the coral starts to become pale. Gradually but steadily, the coral loses its vivid colors and turns completely white; if the environment maintains this modified state, the coral does not let the algae back in its tissue. Through the bleaching the skin of the corals becomes clear and consequently, the skeleton underneath is visible. That is where the white, bleached color is owed to. If the white skeleton is clear and bright, the coral is alive but if it becomes fuzzy, filled with algae, it is a strong sign that it has died. A bleached coral is more susceptible and vulnerable to diseases and other harmful factors, meaning it has a greater mortality risk than a healthy coral.

Causes of coral bleaching

Climate change and global warming

Climate change and global warming are the leading causes of coral bleaching, considering that most bleaching instances occur due to raised sea temperatures. As atmospheric temperatures rise due to the aforementioned phenomena, the sea surface and depths gradually become warmer as well. The ideal water temperature for corals to flourish is 20-28 °C. Corals are very susceptible to temperature rise and a difference of as small as 1 degree Celsius, for a long period, might cause the coral to “stress” and expel the algae. If such temperatures persist for more than eight weeks, there is a high probability that the coral will die.

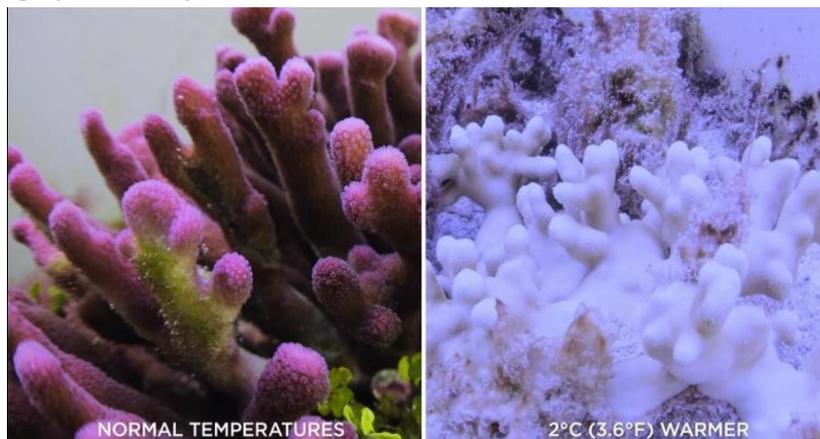


Figure 5: Image depicting coral bleaching due to a temperature increase.

Carbon pollution

Carbon pollution is also a major cause of coral bleaching seeing as a lot of other critical causes stem from it. Atmospheric carbon pollution, which primarily derives from CO₂ emissions by burning coal or mining, generates an increase in atmospheric temperatures, as a result of entrapped heat. Therefore, carbon pollution results in climate change and global warming which causes coral bleaching. Increased amounts of CO₂ and other greenhouse gasses in the atmosphere also cause ocean acidification which, too, leads to bleaching.

Ocean acidification

Ocean acidification is when the ocean presents a decreased pH level, for a continuous period. Ocean acidification is essentially caused by CO₂ and the burning of other fossil fuels which dissolve from the atmosphere and into the oceans. Acidification leads to a decrease in carbonate in the water which is a key material in many marine animals' growth. More specifically, ocean acidification impairs the corals' ability to sequester calcium carbonate. A form of calcium carbonate is aragonite, the main ingredient in a coral's skeleton. As a result, the coral cannot re-grow and the consequences of bleaching remain unsolved.

Pollution

In addition to carbon pollution, runoff and other types of pollution can also cause coral bleaching. This includes pesticides and wastewater which end up in the sea as well as several sunscreen products which contain chemicals harmful to corals. Precipitation during a storm can dilute seawater and carry runoff filled with various pollutants such as the above. This is particularly dangerous for near-shore corals which are exposed to diluted and/or polluted waters.

Extremely low tides

Tides are caused by a combination of the Sun's and moon's gravitational forces, therefore there is no way to prevent them from happening. The lowest water level anyone can observe on the planet is that of a low tide. Consequently, corals in shallow or near-shore waters remain uncovered by water when the low tide occurs, leaving them exposed to the air. This exposure is a cause of coral bleaching, since corals' natural habitat is underwater, leaving them with no resilience to the atmospheric air.

Excessive sunlight

Apart from producing warmer sea temperatures, excessive sunlight is a cause of coral bleaching for a few other reasons. Most importantly, sunlight produces a lot of harmful radiation and solar irradiance which bleaches corals in shallow waters.

The El Niño

The El Niño is a phenomenon that generates a rise in sea temperatures due to which the largest coral bleaching event occurred (2014-2017), damaging approximately 70% of corals globally. The El Niño is characterized by above-average sea surface temperatures in the central and eastern tropical Pacific Ocean. It is a part of the El Niño-Southern Oscillation, a recurring climate phenomenon in the area that occurs every two to seven years and causes consistent temperature variations. In its course, large-scale air movements in the tropics are disrupted, culminating in various global consequences, such as the rise in sea temperatures which is one of the main causes of coral bleaching.

At this point, it is crucial to note that there are other factors that cause the distraction of corals, such as destructive fishing and industrialization. Those factors are not directly correlated to coral bleaching, but they definitely exacerbate the situation of the affected corals.

Effects of coral bleaching

Environmental effects

Bleaching leaves corals vulnerable and lacking essentials for living since the algae which provide them with food and nutrients have been expelled out of their tissue. Bleached corals have decelerated growth rates since they experience a dearth of vital ingredients (inter alia, of aragonite) and nutrients to develop and flourish. They also

have a declined reproductive capacity, meaning that they cannot reproduce easily, and thus, bleached reefs are rarely, and difficultly replenished. Lastly, corals affected by bleaching tend to have increased disease vulnerability seeing as, due to all the above, they possess limited strength to combat diseases, and, hence, they have raised mortality rates. Evidently, bleaching is destructive for coral populations. This vulnerability caused by bleaching also makes corals more susceptible to invasive species, including seaweed and several species of algae. This susceptibility along with the increased vulnerability to diseases and elevated mortality rates often result in long-lasting shifts in coral population composition.

The aforementioned changes in combination with dying corals cause substantial changes in fish populations as corals are a source of habitat, food, protection, and spawning grounds for those fish. If the reef ecosystems degrade and change, fish relying on it lose the benefits of the reefs and need to emigrate to secure the essentials. Other species of fish, which are already at risk, are under threat of becoming locally extinct, something that will hold huge consequences for all local marine life and humans. Seeing as corals support organisms at the very base of the food chain, a change in marine animal populations due to coral bleaching might cause the disruption of the food chain as a whole, thus, affecting all species. All the above will eventually generate a loss of biodiversity and genetic diversity, which, too, has many negative consequences on the planet.

Social effects

Coral reefs work as natural wave and storm barriers for near-shore communities protecting them from various natural disasters and coastal erosion. When corals experience bleaching, they are too vulnerable to hold back the waves, and hence, coastal communities are left bare to the erratic seas. To protect themselves and their lands, people in such communities are required to build manmade storm barriers which are extremely expensive, more fragile, unecological, and often do not work as well as the natural coral ones.

Furthermore, due to the changes in fish populations and the extinction of several species caused by coral bleaching, the overfishing problem is exacerbated, leaving fewer quantities for humans to fish for and consume. Populations relying on local reef ecosystems for food, continue to fish, as they need it to sustain their families and as a result, fish in the seas grow less and less in quantity over time and so do fish stocks. Nevertheless, corals are also very crucial for the medical sector and hence, bleaching also has an adverse effect on medicinal resources. More specifically, certain species of corals comprise specific pharmaceutical substances which are often applied for the treatment and cure of several diseases. Such substances include prostaglandin, which derives from sea fans, and bryostatin obtained from coral rhizomes, which are used to cure cancer, heart diseases, and other illnesses. Coral bleaching deprives corals of those substances and humans cannot exploit them for medicinal purposes.

Lastly, coral reefs are of significant cultural value for many island populations because they serve as religious sites-in regions abundant with reefs, such as Japan- and as a source of multiple marine resources, and thus, their destruction by bleaching is devastating for their cultures and lifestyle.

Economic effects

Corals provide food, shelter, and spawning grounds for an abundance of fish species, and if corals are bleached and eventually die, those fish emigrate to other reef ecosystems, or when it comes to already at-risk species, they might become locally extinct, since they do not have access to the essentials for living. Hence, due to the shift in fish populations and the death of corals, communities financially relying on those marine species or corals, in general, will have a reduced income. Fishers will not be able to catch any reef fish, resulting in adverse impacts on food supply and other financial activities.

In addition, reef tourism is gravely affected by coral bleaching. Bleached corals lose their aesthetic appeal, and the immigration of marine species leaves limited underwater wonders for tourists to admire. Reef tourism is also a significant source of revenue for some island populations, producing billions of dollars each year. If reef tourism collapses, the livelihoods of such populations are under threat.

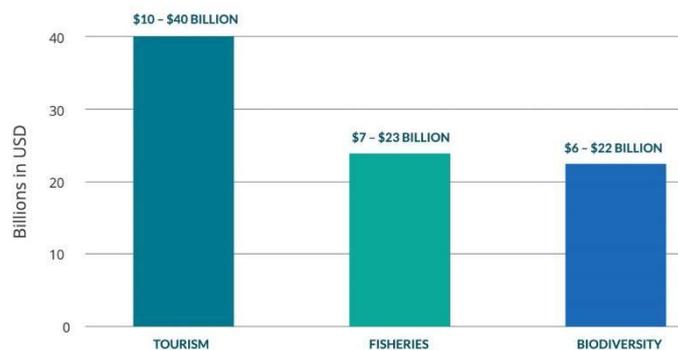


Figure 6: Image depicting the estimated economic loss generated by coral bleaching in the sectors of tourism, fisheries, and biodiversity.

The Great Barrier Reef

The Great Barrier Reef is the largest coral reef ecosystem and largest living structure on the planet, while it is considered one of the seven natural wonders of the world. It is located along the coast of northeast Australia, and more specifically off the coast of Queensland and it is comprised of over 2,900 individual reefs and 900 islands over an area of roughly 344,400 square kilometers. The Great Barrier Reef has been severely affected by coral bleaching over the past decades and especially in the years 1998, 2002, 2006, 2008, 2011, 2016, 2017, and 2020, either as a result of an increase in temperatures, mainly generated by the El Niño or by other equally significant factors, with a total of at least 29% of all the reefs and 69% of the northern ones dying during the 2016-2017 outbreak. Approximately 75% of the Reef is believed to have been seriously damaged after all those bleaching events. Yet, in 2021 the Australian

government decided not to classify the Reef as an endangered World Heritage Site, despite UNESCO's requests to list it as "in danger".

For the most part, coral bleaching in the Great Barrier Reef is generated by the temperature increase due to climate change and global warming. Hence, the only way to minimize it would be an effort to lessen carbon emissions as agreed in the Paris agreement, in order to control ocean temperatures and acidification. Additionally, significantly improving the quality of water flowing on the Reef could be proven very beneficial since polluted water has an adverse effect on coral growth and reproduction. Lastly, it is very important to thoroughly consider the management of fishing practices, coastal and marine development and shipping, to counteract coral bleaching in the Reef. The condition of the Great Barrier Reef keeps deteriorating and unless radical measures are not implemented soon, the Reef will not have time to replenish and thrive.

MAJOR COUNTRIES AND ORGANIZATIONS INVOLVED

Australia

Australia is the home of the largest coral reef and largest living structure on the planet (one of seven natural wonders of the world), the Great Barrier Reef. Sadly, the reef has been immensely affected by coral bleaching. More specifically, 29% of the reef died in 2016 (mainly due to the El Nino phenomenon) and almost all its reefs were severely affected. In the northern region, an average of 67% of corals died in 2016⁷. The Great Barrier Reef Foundation and other initiatives to protect coral reefs such as the Reef Initiative 2030 aim to protect and restore damaged reefs especially the Great Barrier since it is of significant value for humans and the planet.

United States of America (USA)

The USA and its territories host a large part of the world's living coral reefs including the ones in the Hawaiian regions (which have experienced severe bleaching), Florida, and American Samoa. The USA in collaboration with the U.S. Environmental Protection Agency has held many initiatives and acts and even launched a task force exclusively aiming to protect and preserve the coral reefs of the USA region and its territories. Since many of the world's major reefs are located in USA waters, protecting them is vital for the ecosystem. Fortunately, they try to raise awareness and conduct research to find the best ways to help the corals thrive and protect them from bleaching while they have also implemented measures, such as but not limited to banning sunscreen which consists of coral-harming chemicals and other waste and fishing restrictions.

⁷ Rhodes, Larissa, and Stacey Piculell. Chasing Coral. Netflix, 2017.

Belize

The Belize barrier reef, the second largest reef in the world, is situated in Belize. The reef used to be endangered, but locals and experts implemented several innovative measures and they succeeded in saving it. It all started during Hurricane Iris (2001) which was destructive for coral reefs. Many of Belize's corals were bleached and later died, and others were also uprooted which made it difficult to restore the reef. However, Lisa Carne, the director and founder of Fragments of Hope, Ltd., started a project to save the reef. After a lot of campaigning, trial and error she managed to launch a project to replant corals in the area. Contrary to the initial reactions this solution was proven to be highly effective considering that 89% of replanted corals survived after 14 years and Belize's reef is once again flourishing.

United Nations Environment Program (UNEP)

The UN Environment Program is the sub-body of the UN related to the environment which was enacted in 1972. It is the global authority when it comes to environmental matters, and it has carried out many reports on corals and coral bleaching. Every year, it publishes, in collaboration with other programs and organizations, a report on coral reefs, namely the "Status of Coral Reefs of the World" report. UNEP offers an abundance of information on coral reefs, coral bleaching, its causes, and effects as well as ways to target and eliminate it, including a full guide on how to restore coral reefs. They have additionally established a unit called the Coral Reef Unit (CRU) with the target to preserve coral ecosystems and represent UNEP in coral-related events.

Coral cay conservation (CCC)

Coral Cay Conservation is an NGO founded in 1986 with the aim to preserve coral reefs which exhibit signs of bleaching. It has earned many awards after its expeditions and actions to protect coral reefs and ameliorate the livelihoods of people financially dependent on such ecosystems. Since its establishment, its members have organized more than seventeen (17) conservation-centered projects to preserve coral reefs.

Global Coral Reef Monitoring Network (GCRMN)

The GCRMN was established in 1995 by the International Coral Reef Initiative (ICRI), with the task to monitor and report on the world's coral reefs and, sticking to its task, it has published numerous reports since its establishment. The GCRMN is responsible for collecting data about the condition and status of corals and reefs as well as devising appropriate solutions and handing them to other organizations and centers for research.

TIMELINE OF EVENTS

Date of Event	Description of event
1981	The Great Barrier reef is recognized as a world heritage site by UNESCO
1994	The International Coral Reef Initiative is founded by eight governments
1995	The Global Coral Reef Monitoring Network is established by the International Coral Reef Initiative
1998	The first-ever coral bleaching event is reported, caused by the El Nino
2010	The second global-scale coral bleaching occurs
April 2010	The Action Plan to conserve the coral reef ecosystem in Japan is published
20 December 2010	UN GA Resolution 65/150 is adopted
22 December 2011	UN GA Resolution 66/194 is adopted
2014-2017	The El Niño occurs, generating the most destructive coral bleaching ever recorded
2015	The third global-scale coral bleaching event
8 September 2021	The Secretariat of the Pacific Regional Environment Programme approves a new coral reef action plan
5 October 2021	The GCRMN publishes the 6th Status of Coral Reefs of the World report for the year 2020
6 December 2021	Global Fund for Coral Reefs allocates USD 10 million for reef conservation

PREVIOUS ATTEMPTS TO SOLVE THE ISSUE

United Nations General Assembly Resolution 65/150

Resolution 65/10 of the UN GA, titled “Protection of coral reefs and related ecosystems for sustainable livelihoods and development” Asks and urges member states to implement measures and create legislations to protect coral reefs. Moreover, it requests from the serving Secretary-General, Ban Ki-Moon, to draft a report on the respective Resolution.⁸

UN GA Resolution 66/194

UN GA Resolution 66/194 is a modified form of the homonymous Resolution 65/150. It stresses the need to address the destruction of coral reefs and underlines the

⁸ "Protection of Coral Reefs for Sustainable Livelihoods and Development :." United Nations Digital Library System, digitallibrary.un.org/record/698792?ln=en).

importance of understanding the benefits coral reefs offer to humans and the planet in general. Lastly, it urges member states to act, take measures and find the necessary approaches to adequately protect coral reefs.⁹

Status of Coral Reefs of the World 2020

The Status of Coral Reefs of the World 2020 is a report published by the Global Coral Reef Monitoring Network in collaboration with the International Coral Reef Initiative (ICRI), the Australia Institute of Marine Science, and UNEP. It presents the most complete scientific picture of the impact that rising temperatures have had on the world's reefs to date. Such reports are published by the respective organizations and bodies each year and the report for the year 2020 was issued on the 5th of October 2021.¹⁰

International Coral Reef Initiative (ICRI)

The ICRI is an informal partnership of nations and organizations, initiated in 1994, working to protect coral reefs and related ecosystems all around the planet. They mainly focus on promoting the sustainable management of reefs, capacity building, and raising awareness. The Secretariat members are chosen voluntarily, and they organize meetings, conferences, workshops, and side events annually. Its decisions are not binding on its members, but its efforts have had a critical role in highlighting the importance of coral reefs in various sectors. The work of ICRI is frequently recognized in UN documents, underscoring the Initiative's key role in the international campaign to preserve coral reefs.

Japan's attempts to preserve coral reefs

Japan hosts many of the world's major coral reefs in its waters but in the last decades, the corals have been considerably impacted by bleaching. According to reports, almost 70% of Okinawa's reef has died due to bleaching while 90% of the reef is affected by it. In recent years, the Japanese government and the Ministry of Environment have taken drastic measures and actions to preserve Japan's reefs. In 2010, they published a 21-century action plan for Japan and especially, Okinawa with the goal to examine the economic and social benefits of coral reefs and natural coastlines and establish a new structure for their preservation and restoration. The prefectural government of Okinawa initiates a project (2010-2016) to conduct research on coral reefs and ways to replenish them including other sub-projects such as raising awareness and informing the public. The initial project comprised 2 main parts, namely a pilot study for coral outplanting and research on reef restoration. The actions Japan took were overall successful and the lessons and findings they

⁹ "Protection of Coral Reefs for Sustainable Livelihoods and Development :." United Nations Digital Library System, digitallibrary.un.org/record/721567?ln=zh_CN.

¹⁰ "Status of Coral Reefs of the World 2020." UNEP - UN Environment Programme, 8 Oct. 2021, www.unep.org/resources/status-coral-reefs-world-2020.

concluded upon during their attempt of outplanting corals were proven crucial for future respective projects and research.

POSSIBLE SOLUTIONS

When a flower suffers from a disease, and the whole garden is in danger, we cut the flower from the roots and not the stem, to ensure the disease is eliminated; Similarly, to counteract the effects of coral bleaching and eradicate them, we need to examine, analyze and target its causes.

Drastic measures need to be carried out to assess the causes and effects surrounding coral bleaching, and to mitigate the phenomenon as soon as possible and as efficiently as possible. Those measures fall under various categories, require a lot of work, and are complex and sometimes difficult to manage.

Long-term solutions

Combatting climate change

The major cause of coral bleaching is climate change, which derives directly from global warming. Thus, measures to deter it need to be implemented all across the planet. That could include, inter alia, the encouragement of member-states to adopt and strive to achieve the targets set during the Paris Agreement, by reducing the atmospheric temperatures by 1.5-2 °C and by cutting carbon emissions to the minimum. Alternatively, other measures to minimize carbon emitted in the atmosphere or disposed of in the oceans are strongly suggested to prevent coral bleaching. It is important to note that the specific target would require years to eradicate and thus, it is a long-term solution.

Coral farming

Nevertheless, replenishing already affected coral reefs should also be seriously considered as a long-term solution as many of them have already been lost to bleaching. Taking an example from Belize and their tactics to replace the deceased corals, a possible solution would be to replant corals in major coral reefs and experiment with coral farming. After meticulously examining each reef's morphology and coral species, respective species can be planted all across the reef, to boost coral growth and revitalize reefs.

Short-term solutions

Legislation

Moreover, to protect corals and avoid further impacts of coral bleaching, it is important to implement regional and global laws and legislation as well as treaties and conventions-which have not been occurring at all for the issue at hand- to protect

corals from human-derived damage. Those could include but not be limited to, minimizing fertilizer use and marine debris, and improving seawater quality.

Collaboration between nations

In a few cases, when addressing reefs that are located in international waters, and therefore, belong to no country or territory, in particular, communication and collaboration between nations on how to manage them and protect them are vitally important for the reef's safety.

Marine protected areas

Additionally, it is necessary to designate all reefs as marine protected areas, to guard them against human involvement such as fishing and trawling, which not only destroys reefs but also further exacerbates the already destructive effects of coral bleaching, for instance, overfishing and loss of biodiversity. Along with that, it is important to consult experts on how to manage reefs, how to protect them from bleaching and how to handle their effects efficiently and ecologically.

Raising awareness

A key solution to the matter at hand is raising awareness and educating; many people are not aware of the value of corals, the issue, and how their actions gravely affect the lives of corals. They need to be instructed and motivated because small everyday actions by each one of the citizens of this world can be a big step towards averting the causes of coral bleaching and eventually, the issue itself.

Funding

Lastly, to do all the above and act against coral bleaching, investments and funding are required. Through those investments, research centers and other organizations could support and conduct biological research for each reef in particular and, hence, discover the causes and effects of coral bleaching each one of them is experiencing as well as find the most appropriate and feasible measures to protect and replenish each reef, for it to flourish abundantly in the future and make the seas lush again.

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