AIDA 4

ONE OCEAN created by AIDA GREEN

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ONE OCEAN

The ocean is a fundamental component of the global ecosystem.

It is heavily affected by human activities such as pollution, overfishing and tourism. Even though freediving is a gentle way to approach the ocean and marine life, our behaviour still has an impact.

In this chapter we will build on our understanding of the marine environment in addition to the Rules of Behaviour from AIDA1 and AIDA2, and knowledge from AIDA3.

Please consider that your local water-environment may have specific environmental concerns, which you should familiarise with.

The information presented here are not meant just for the classroom. We are asking you to implement your knowledge and environmental awareness into your diving, training and living, so that we all take responsibility for the ocean's health.

AIDA Green encourages all freedivers to be ambassadors for the ocean.

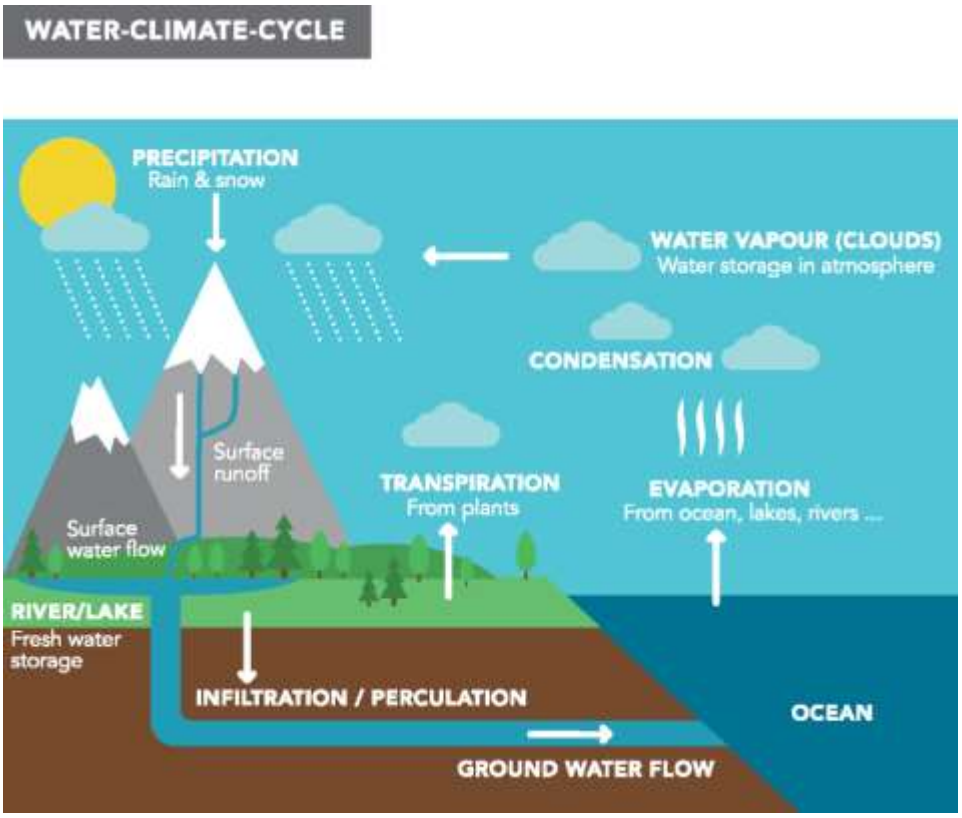
Please note, that when the word Ocean is used in this material, it encompasses the entire Earth's water systems such as sea, rivers and lakes.

THE IMPORTANCE OF THE OCEAN

The ocean is crucial for life on the planet: it regulates the climate, it produces oxygen and it influences the weather.

CLIMATE CONTROL

Between the ocean and the atmosphere there is a continuous exchange of heat, water and energy. This interaction influences the energy and water cycles that drive the planet's climate system.



The ocean regulates the weather and the climate by absorbing most of the solar radiation that reaches the Earth.

Water evaporates from the ocean producing clouds that eventually bring rain over land areas sustaining every form of life, including human life. The ocean is therefore our main source of freshwater.

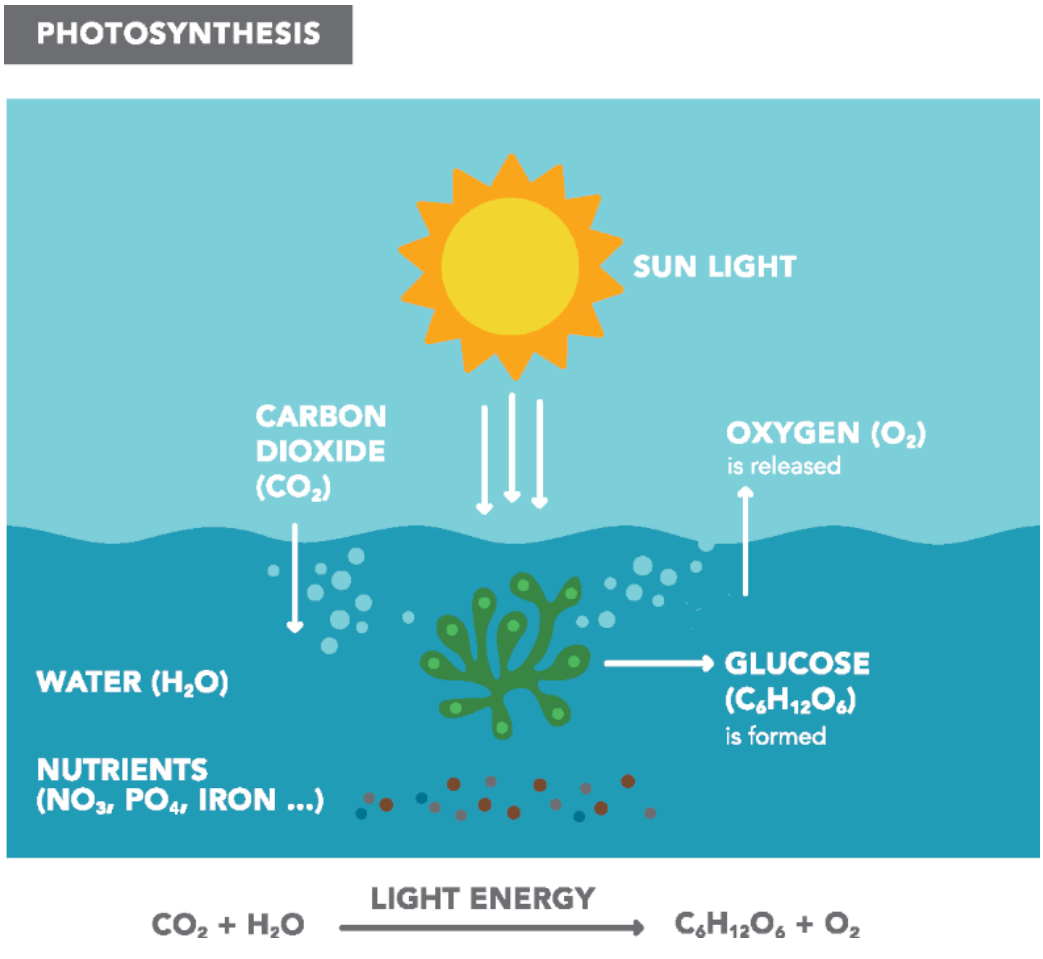
Changes in the ocean-atmospheric system results in changes in the climate that, in return, causes further changes to the ocean and the atmosphere. These reciprocal interactions have tremendous physical, chemical, biological, economic and social repercussions. For example, both draught and floods drastically modify the composition and fertility of the soil. As a consequence the yield of crops and agricultural produce is greatly affected by climate change, with potentially devastating effects on people and economy.

OXYGEN

The ocean produces most of the oxygen available on the planet. Just like rainforests, marine organisms like phytoplankton, algae, kelp, marine plants and corals use sunlight as a source of energy to convert water and carbon dioxide into sugar through photosynthesis, producing oxygen as byproduct.

Most of the oxygen currently available in the atmosphere has been produced by photosynthetic organisms in the ocean throughout billions of years. The consequent accumulation of oxygen in the atmosphere enabled the development of life on our planet.

In terms of proportion, the oxygen currently produced by terrestrial plants constitutes around 20-26 % of the total (rain forests alone, such as the Amazon, give an input of around 12-20%), while the remaining 74-80 % is produced by marine organisms (phytoplankton alone is estimated to produce over 50% of the total).



HUMANS and the OCEAN

- The ocean provides food, medicines mineral and energy resources. It supports jobs and national economies as well as serving as a highway for transportation of goods and people.
- The ocean is a source of inspiration, fascination, recreation, rejuvenation and discovery. It is also an important part of the heritage of many cultures.

THE STATUS OF THE OCEAN

GLOBAL WARMING and CLIMATE CHANGE

Global warming is the long-term temperature rise in the world's climate system. The earth's atmosphere naturally traps heat. This creates a natural 'greenhouse effect' that keeps the Earth's surface warm.

Normally greenhouse gases in the atmosphere are absorbed by plants, trees, plankton and further photosynthetic organisms.

However the amount of greenhouse gases produced by human activities are currently exceeding the amount that nature can naturally absorb, so the concentration of greenhouse gases in the atmosphere keeps increasing, alongside with the average temperatures of the planet.

The main human activities that are responsible for the ongoing global warming and climate change are fossil fuels combustion, animal farming, destruction of the forests and of the marine ecosystems.

Even if all human activities should suddenly cease, and so the connected emissions, the current amount of greenhouse gases accumulated in the atmosphere would require hundreds of years to be absorbed by natural processes. Despite scientists recommendations, many countries keep pursuing the myth of limitless economic growth burning fossil fuels in higher and higher amounts, causing a continuous rise of greenhouse gases concentration in the atmosphere (https://www.esrl.noaa.gov/gmd/ccgg/trends/).

Global warming consequences include drastic changes in climate patterns, the reduction of ecosystem biodiversity, an increase of uncontrolled wildfires, the rise of the ocean temperatures. These effects have a direct impact on all ecosystems as well as on water, energy, wildlife, agriculture and human health:

- **Water**: ice and glaciers are melting at the poles and at high altitudes. Sea levels are rising, lakes and reservoirs are suffering from drought and less snow is accumulating.
- **Weather**: Higher temperatures cause more extreme weather-associated events such as storms, heat waves, floods, fires and droughts. Increased desertification and costal erosion are also consequences of global warming.
- **Ecosystems**:
    - Habitat modifications, often leading to irreversible changes.
    - Disturbance of season-dependant biological cycles, such as pollination and spawning
    - Changes in reproductive and migratory cycles
- **Agriculture and food supplies** are affected by scarcity and poor quality of water sources. Diseases caused by waterborne bacteria are becoming more frequent.
- **Human health**: exposure to extreme temperatures and poor air quality increases the occurrence of airborne disease and viruses.

Temperature changes are not uniform across the globe. The increasing average global temperature induces extreme weather events, including exceptional snowfall and frosts in certain areas of the planet. As a consequences crops suffer severe damages, causing food shortages and changes in the migrations patterns of several animal species, which are obliged to relocate to more suitable areas.

OFFSHORE DRILLING

Oil and gas industry activities release enormous amounts of toxic by-products and greenhouse gases, and they cause hundreds of oil spills in the water, all of which have long-lasting impacts. Even the most advanced clean-up operations remove just a fraction of the oil spilled. Some of the cleaning methods include the use of hazardous chemicals. The search for new oil fields is done using air-gun seismic tests, which produce a series of blasts that are 100000 times louder than a jet engine, causing deafness, disorientation, stranding and death of hundreds of cetaceans.

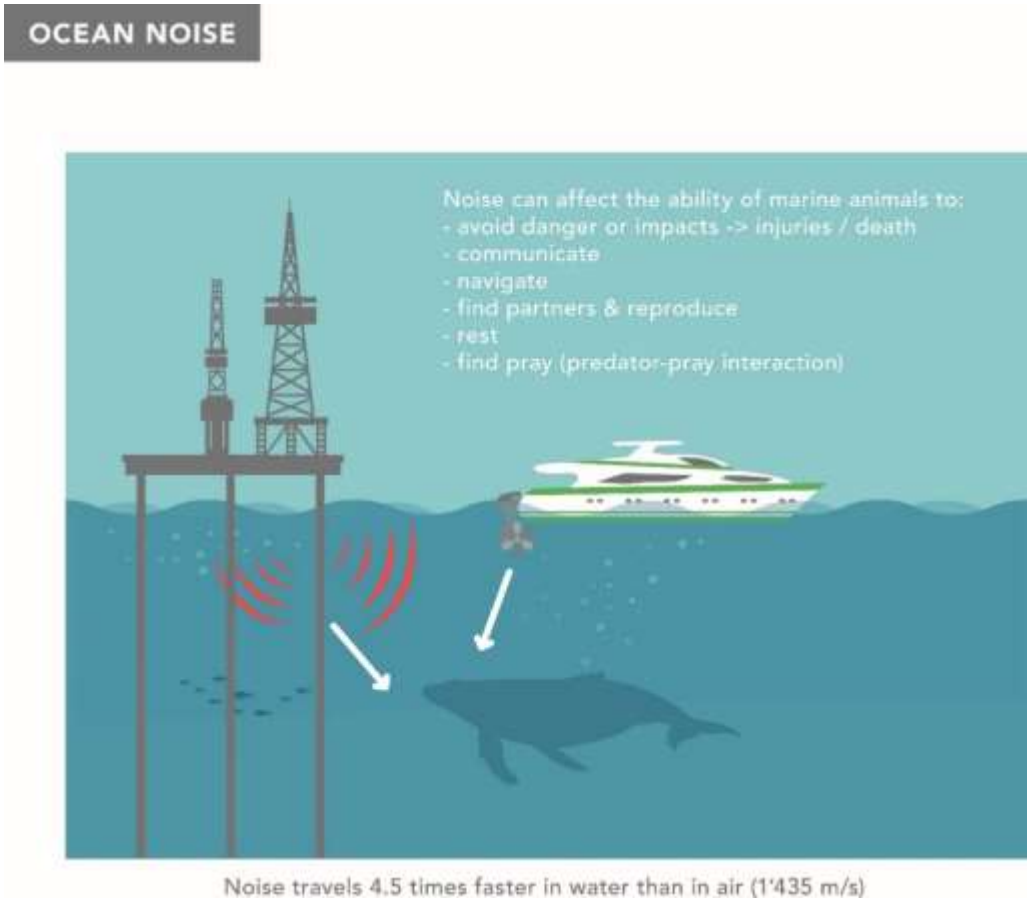
OCEAN NOISE

Sound travels faster in water than in the air - approximately 1550 metres (5085 feet) per second in seawater, which is 4.3 times faster than in air.

Cetaceans such as dolphins and whales depend on sound for communication, for hunting, for orientation, for navigation and to communicate with each other.

Human generated noise deriving from fracking, drilling, large ships engines and airgun seismic tests are increasing, modifying the underwater acoustic landscape. The impact on cetaceans and other marine animals is tremendous and it includes deafness, lack of orientation, disruption of hunting and mating patterns, stranding and death.

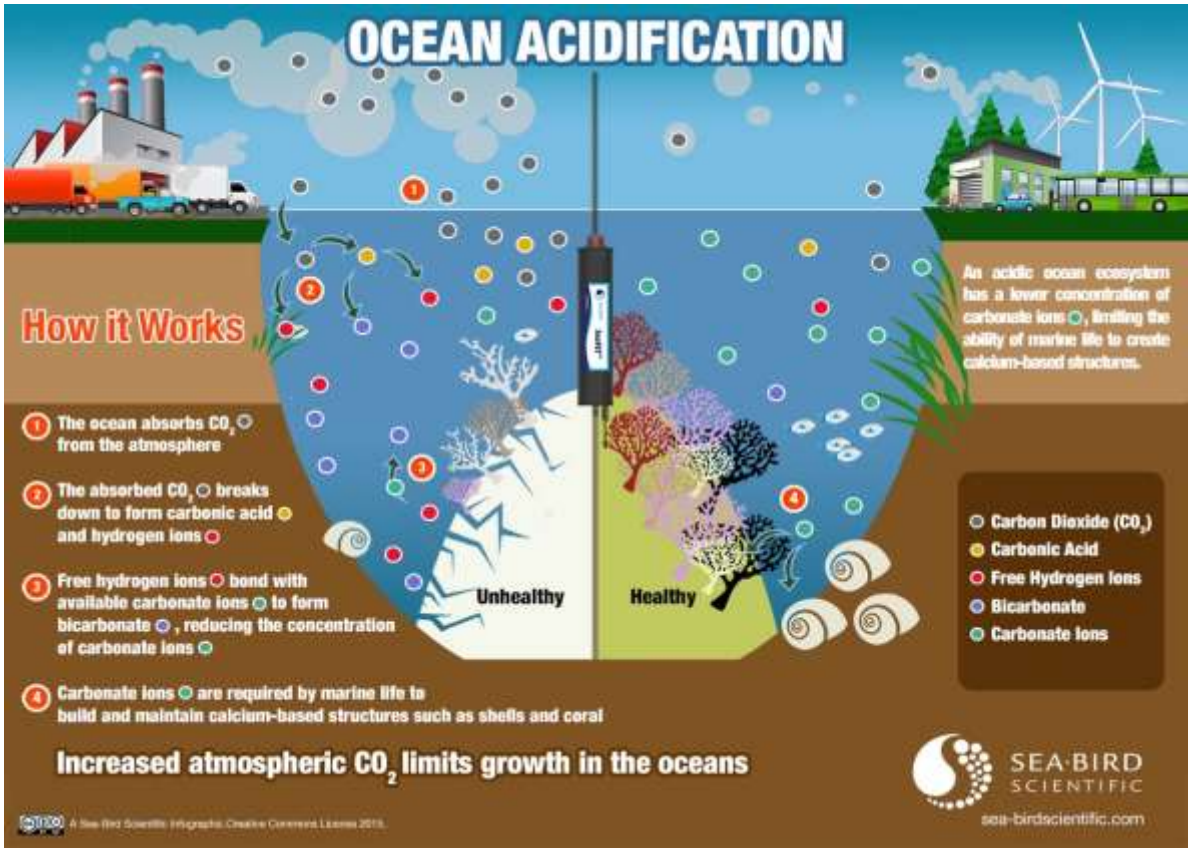
Ocean Noise video: https://www.youtube.com/watch?v=GFPTpbSFr74#action=share



ACIDIFICATION

WHAT IS OCEAN ACIDIFICATION?

The ocean is not only the planet's most important source of oxygen. It also absorbs most of the carbon dioxide (CO_2) produced by human activities.
Ocean acidification is a direct consequence of greenhouse emissions: the more CO_2 we introduce in the atmosphere, the more it gets absorbed by the ocean. Once dissolved in the ocean, the CO_2 reacts with the water producing carbonic acid, in the same way that it happens in our blood when we hold our breath. Increased carbonic acid concentration rises the hydrogen ions concentration, therefore the acidity of the ocean. If CO_2 emissions continue with the current trend, by 2100 ocean acidity will have risen 150%.



CONSEQUENCES

- The hydrogen ions bond with the carbonate ions dissolved in the ocean to form bicarbonate ions (hydrogen ions + carbonate ions ⇔ bicarbonate ions). This process increases the concentration of bicarbonate ions and reduces that of carbonate ions. Calcifying organisms such as corals, molluscs, coralline algae and many species of plankton need both carbonate ions and calcium ions to produce their skeletons and shells of calcium carbonate (calcium ions + carbonate ions ⇔ calcium carbonate, also called limestone). The reduced availability of carbonate ions caused by ocean acidification therefore compromises the capacity of all calcifying organisms to build and maintain their shells and skeletons. Their growth and fertility rate are negatively affected, and their limestone skeletons and shells are progressively dissolved. As a consequence the growth of coral reefs is compromised by the same mechanism, and the delicate balance of the whole reef ecosystems is jeopardised.

- A higher CO_2 concentrations in the ocean favours the growth of algae and seagrasses, as it increases their photosynthetic activity, making it easier for them to compete for space with corals and other reef building organisms. This induces the progressive and irreversible disappearance of the coral reefs as they get covered by algae.
- Ocean acidification lowers the immune response of many marine animals, including corals, exposing them to lethal diseases. Reproductive failure and higher death rates occur as a result of an increased exposure to pathogens.
- The dissolution of shells and skeletons of calcifying organisms caused by acidification rises even more the concentration of bicarbonate ions in the ocean (hydrogen ions + calcium carbonate ⇔ calcium ions + bicarbonate ions), leading towards its saturation. However, bicarbonate is also a product of the dissolution of CO2 in the water (CO2 + water ⇔ carbonic acid ⇔ bicarbonate + hydrogen ions). If the ocean get saturated with bicarbonate ions because of the dissolution of the limestone shells, skeletons and rocks caused by ocean acidification, its capacity of absorbing further CO2 from the atmosphere is greatly reduced. This can lead to an even steeper rise of CO2 concentration in the atmosphere, which would cause a more severe greenhouse effect and more serious consequences on the climate. The whole cause-effect sequence can be resumed as:

Rise of CO2 in the atmosphere → rise of CO2 in the ocean → ocean acidification → dissolution of limestone rocks, shells and skeletons → ocean saturation with bicarbonate ions → ocean reduced capacity of absorbing further CO2 from the atmosphere → steeper rise of CO2 in the atmosphere → uncontrolled greenhouse effect, climate collapse.

CORAL REEFS

IMPORTANCE AND FRAGILITY OF CORAL REEF ECOSYSTEMS

Coral reefs cover less than 1% of the ocean, but they host 25% of all marine species. This means that coral reefs support more species per unit area than any other marine environment, including over 4000 species of fishes, 800 types of hard corals and hundreds of other marine species.

Coral reefs provide shelter, food and a substrate for marine organisms to grow. Their structure is built by calcifying organisms such as corals, molluscs, sponges, calcareous algae, bryozoans, foraminifera etc. that combine together the calcium ions with the carbonate ions to produce their skeletons and shells of calcium carbonate (limestone). Throughout this work, coral reefs sequestrate enormous amount of carbon from the water and store it into the substrate. Due to this efficient carbon sequestration system and to their high biodiversity, reefs are referred to as the rainforests of the ocean.

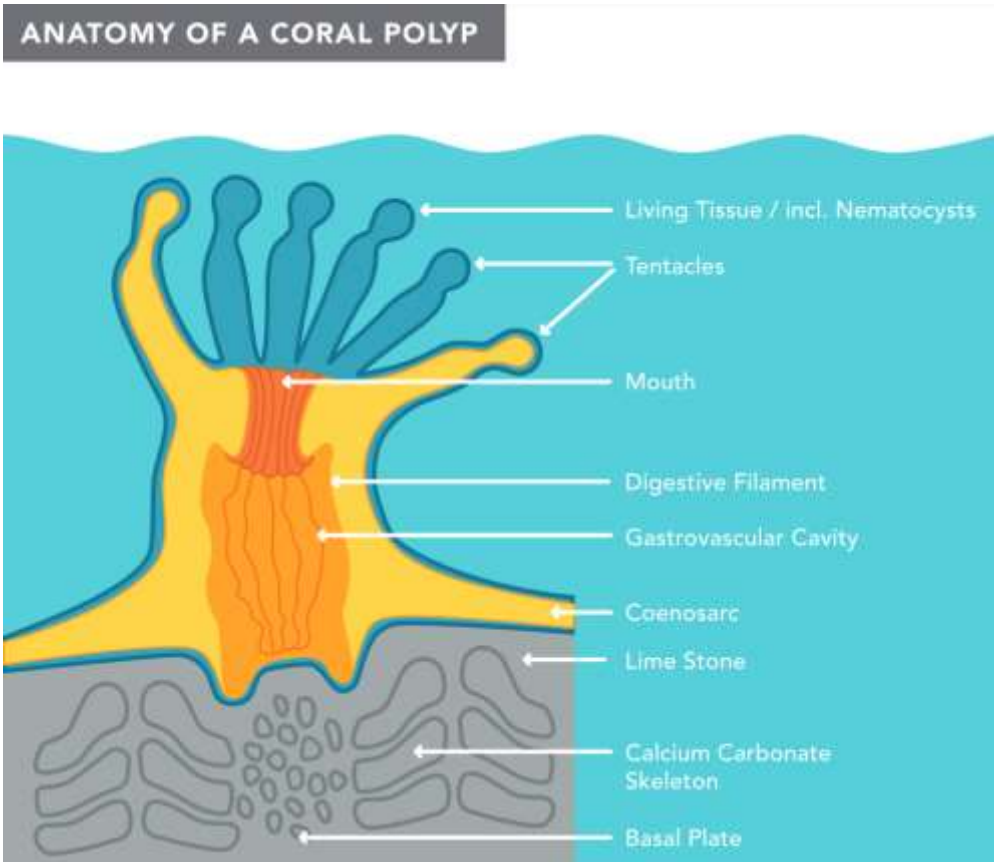
Coral reefs are complex ecosystems where all species are interconnected and interdependent, exchanging nutrients in a very efficient recycling system. Each species, as essential component of such system, performs a specific task to maintain its delicate balance. This enable them to thrive in waters which are poor of nutrients, however if just few species are eliminated from the reef, the whole ecosystem can collapse in a domino effect.

Humans profit economically from coral reefs, as they are the base of local economies through tourism. The commercial value of coral reefs is estimated to be several hundred million euros per year.

Coral reefs protect coastal areas from wave action preventing erosion, property damage and loss of life. Globally, around half a billion people live within 100km of coral reefs and benefit from their production and protection.

WHAT ARE CORALS?

Corals are colonial organisms composed by thousands of tiny animals (0.5 – 20 mm) similar to upside down jellyfishes, called polyps. Their “head” is in the bottom and it contains a stomach with an opening on the top, which functions as both mouth and exit, used for eating zooplankton and to clear away debris. Surrounding the opening there is a circle of tentacles that the polyp uses for hunting plankton, for self-defence and for removal of waste products.



Within the same coral colony, all polyps are interconnected and genetically identical (clones), as they are all descendants of a single polyp who funded the colony and then reproduced itself sequentially through binary divisions (asexual reproduction). One night per year, all polyps of all corals in the same area also reproduce sexually by spawning eggs and sperms in the water. By the consequent fertilization, a tiny little larva called planula is generated. The planula live in the water column for a few days/weeks and then it settles down on a solid substrate, as a rock or a dead coral, where it metamorphoses into a new polyp, the founder of a new coral colony.

Polyps are among the very few animals that build the substrate on which they grow. In the specific case of hard corals, this substrate is made of calcium carbonate (limestone) that polyps produce combining together dissolved calcium ions with dissolved carbonate ions, like all other calcifying organisms. Most of the coral reef structure is made of limestone produced by hard corals. A great help in this building work is provided by a very special guest: some microscopic algae, called zooxanthellae, that live inside the body of the polyps. Polyps and zooxanthellae have a mutualistic relationship (endo-symbiosis) in which each receive important benefits from the other. The polyps transfer the algae inorganic nutrients such as nitrogen and phosphorus and provide them a safe place to live and to make photosynthesis, sheltered from predators. The algae in return supply oxygen, carbohydrates, amino acids and fats produced by photosynthesis to the polyps, contributing to 60% of their overall nutritional requirements (the remaining 40% comes from eating plankton).

The photosynthetic activity of the zooxanthellae, and in particular the absorption of dissolved CO_2, greatly helps the polyps in building their limestone skeletons, facilitating the formation of calcium carbonate. Thanks to such help, reef building corals can grow from 1 to 6 cm per year depending on the species.

Moreover, the photosynthetic pigments of the zooxanthella are responsible for the colours of the corals, as the polyps themselves are completely transparent. As discussed in the next paragraph, when the corals are affected by some environmental stressor, the polyps expel their zooxanthellae, in this way they lose their coloration and the underneath skeleton becomes, made of white limestone, becomes visible.

WHAT ARE CORAL REEFS?

Coral reefs are made by a large variety of calcifying and non-calcifying organisms living together. As the name suggests, the main constituents of coral reefs are coral colonies. Other important components are sponges, molluscs, coralline algae, worms, hydrozoans,

bryozoans, foraminifera and further marine organisms. All these species have been growing together throughout hundreds of millions of years, and through their incessant deposition of layers of limestone they created colossal geological structures such as coralline islands, atolls and thousands of kilometres of fringing and barrier reefs.

Over 3000 species of corals are currently known, and within each species there is a great variety of shapes and colours. Some of them can be easily confused with rocks, due to their globular shape and dull colours, so many unaware tourists stand on them to take rest while swimming over the reefs, killing hundreds of polyps in one time. On the other hand, branching corals are extremely fragile, and they can be easily destroyed with just a mild touch, vanishing the construction work done by the coral colony throughout several decades. In many popular tourism destinations, masses of unaware tourists stepping all over the reef led to the destruction of entire portions of coral reefs within a very short time.

THREATS TO CORAL / CORAL BLEACHING

Coral reefs are among the most fragile ecosystems of the planet. Their state of health is greatly affected by both environmental and anthropogenic threats. Corals can live only within specific environmental conditions, and when these condition changes, corals suffer from different levels of stress. The main environmental stressors are:

- Changes in temperature.
- Changes in light intensity.
- Changes in nutrients availability (too many or too few)
- Changes in water clearness (turbidity has a negative impact)
- Presence of human pollutants (micro-plastics, heavy metals, pesticides etc.)
- Acidification

When corals are stressed, they expel the symbiotic algae from their tissues, losing their coloration. Since the polyps are completely transparent, it is then possible to see the white limestone skeleton beneath them. The occurrence of this phenomenon is known as “coral bleaching”.

By losing the zooxanthellae, the corals lose their primary source of nutrients (60% of the total), so they have to rely only on the few nutrients obtained from the digestion of the plankton. This allow them to survive for a limited amount of time, from a couple of weeks to a couple of months depending on the species. If the environmental stressor regresses within this timeframe, the polyps accept back the zooxanthellae, recovering its original colour and its primary source of nutrients. If instead the stressor persists, the coral colony starve to death, and its living tissues are decomposed by microorganisms.

Severe bleaching on branching coral

ANTHROPOGENIC (HUMAN) THREATS

Beyond the environmental stressors, which are indirectly caused by humans, other threats to coral reefs are directly caused by human activities, such as:

- **Water pollution** caused by industrial discharges, oil spills, animal farming discharges, agrochemicals runoffs, human sewage.
- **Land reclamation** is one of the most destructive practice carried out especially on small islands, where coral reefs are literally buried under constructive materials to gain more dry space on land. Even the nearby reefs get severely affected and often suffocated by the amount of sediments stirred up by the dredging operations.
- **Overfishing**. Fishes are critical components of the reef ecosystem and their numeric reduction compromises the delicate balance of the whole food web of the reef.
- **Ghost nets** and other abandoned fishing gears entangle and suffocate corals, trapping and killing also many other marine animals that live within the reef ecosystem, such as fishes, turtles, dolphins etc.
- **Destructive fishing** such as dynamite, cyanide and trawling nets fishing.
- **Collection of living species** for the aquarium market.
- **Coral mining** for construction material.
- **Unsustainable tourism** as mass of unaware tourists stand on corals, feed fishes, chase marine animals, pick up shells and other marine organisms for souvenirs,

consume high amounts of seafood at restaurants etc. provoking the disappearance of entire reefs within just few years, as it happened in many popular tourist destinations.

- **Sunscreen residuals** as the majority of sunscreens, except the ones based on titanium dioxide and non-nano zinc oxide, are highly toxic to corals.
- **Plastic**, as plastic bags and other objects entangle corals suffocating them, while micro-plastics are ingested by the polyps, poisoning them.

The decline of coral reefs worldwide is well documented and mass bleaching events are becoming more frequent. Entire coastlines are polluted to the point of non recovery, leading to the imbalance of ocean food webs, the extinction of marine species and the increased frequency of coral diseases, causing irreversible changes in reefs delicate ecosystems.

Progressive decay of a coral colony due to coral disease

SEAGRASSES

Seagrasses provides food, shelter and nursery grounds for many marine organisms such as fishes, molluscs, crustaceans, sea urchins and sea turtles. They filters nutrients and chemicals in the marine environment, producing oxygen and stabilising coastal sediment, helping to protect the coastline from erosion.

WHAT ARE SEAGRASSES?

Terrestrial plants, such as trees, vegetables and common grass, evolved from some primordial algae that colonized the dry lands hundreds of millions of years ago. Seagrasses

are the successive evolution of some terrestrial plants that around 100 million years ago adapted back to marine life. For such reason seagrasses have different biological and morphological features from macro-algae (also known as see-weeds), and they are more similar to terrestrial plants: they have roots capable of absorbing nutrients, of propagating and of producing buds; their leafs can do photosynthesis but cannot absorb nutrients; they reproduce sexually through pollination, producing flowers and seeds.

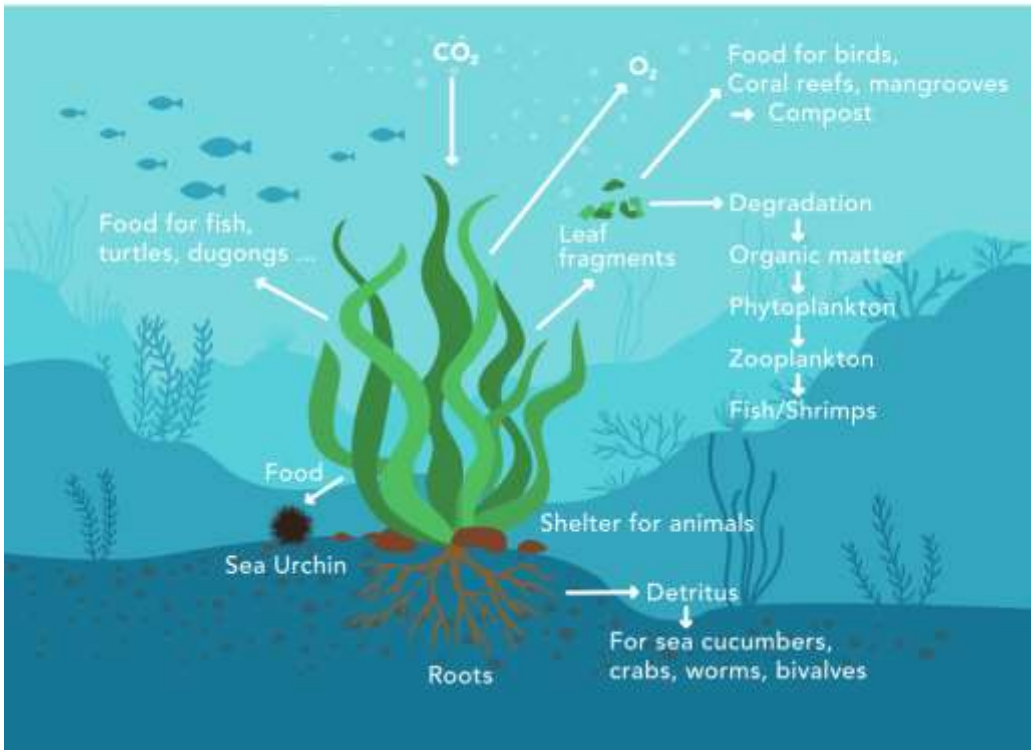
There are 72 known species of seagrass throughout the world's coastlines. Their leaves range in size from small paddles (1cm / 0.39in) to long blades (5m / 196in) and their complex root systems provide a strong anchorage to the seafloor.

The majority of seagrass species are fully submerged and live in shallow waters covering large areas, forming giant underwater meadows. Some are intertidal and others can grow up to a depth of 40 m / 130 ft.

Seagrass absorbs large amounts of CO_2 through photosynthesis and transfer it into the roots where it can be stored for thousands of years. For this reason, similarly to coral reefs, seagrasses offer a valuable contribution in reducing the impact of greenhouse emissions and global warming.

Seagrass filters the water, cleaning it and creating healthy ecosystems where many other marine species can thrive. Several species of fishes, crustaceans and other marine animals lay their eggs among seagrasses, so when they hatch the larvae and juvenile individuals can get sheltered from predators between their leaves. The presence of seagrasses is therefore important for ensuring replenishment of fish stocks and other marine animals through successful reproductive cycles.

SEAGRASS



CURRENT SITUATION

Unfortunately, seagrass is one of the most rapidly declining ecosystems on earth. Coastal development, destructive fishing practices, anchor damage and sewage pollution have contributed to the progressive disappearance of many seagrass meadows.

Estimates suggest that 20-25% of seagrass has been lost in the last 50 years. The current rate of decline is 7% per year.

This loss causes the reduction in the absorption and storage of CO_2, a decline in fishing grounds, a decrease in water clarity and an increase in coastal erosion.

WHAT YOU CAN DO TO HELP PROTECT SEAGRASS AND CORALS:

- Do not touch, step, walk, kick or stir sediment with your fins on the seagrass and corals.
- Do not pollute, discourage others from polluting.
- Use a reef safe sunscreen and biodegradable soap (double check the ingredients as most brands contain harmful substances).
- Make a proper anchorage for boats: do not anchor on seagrass or coral reefs, try to find sand patches and designated areas (specified in marine charts).
- Encourage others to stop overharvesting marine life. Do not use destructive or illegal fishing practices and discourage others from engaging in these activities.
- Urge individuals to stop destroying habitats on land and in the ocean.

- Support the establishment of marine protected areas or marine sanctuaries.
- Advocate for and support coastal zoning initiatives, mapping and identification of seagrass beds and coral reef areas.
- Support marine conservation organisations.

SIMPLE DAILY ACTIONS TO HELP THE HEALTH STATUS OF THE OCEAN

- Reduce water pollution and runoff at home. Rinse your equipment either while you shower or in a bucket.
- Put your suit on in the water whenever it is possible, so to avoid the use of soaps.
- Use only biodegradable soaps and shampoos.
- Mindfulness of plastic use, follow the “Rs” rules: refuse, reduce, reuse and recycle.
- Use only coral reef friendly sunscreens (titanium dioxide or non-nano zinc oxide based)
- Avoid burning fuels as much as possible. Chose environmental friendly ways of transportation.
- Eat local and seasonal. Reduce the consumption of fish, meat and other animal-based products, chose plant-based alternatives.
- Choose brands that offer eco sustainable products or suggest to your favourite brand or sponsor to start making products that are environment friendly.
- Be a wise and responsible consumer. Maintain your gear in good condition to extend its lifespan, repair items before buying new ones, buy second hand ones and consider if a new item is a necessity or not. Consume less, consume better. All of these actions are going to help both your pocket and the environment.
- Choose ecotourism destinations, sustain environmental conservation project and promote the setup of Marine Protected Areas
- Promote the use of renewable energy sources, support political decisions that promote them.

- Make every dive a clean-up dive.

Be an ambassador of the ocean. The best way to make a difference in the ocean is for us to work together and to educate others. Be a role model and take responsibility on each of your everyday activities.

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KNOWLEDGE REVIEW A4

1. Why does the oxygen we breathe come from the ocean?

Most of the oxygen in the atmosphere has been produced by photosynthetic organisms in the ocean throughout billions of years. This accumulation of oxygen in Earth's atmosphere was necessary for life to develop and to be sustained on land. Phytoplankton are microscopic algae that make photosynthesis and that are the main responsible for the global oxygen production (over 50% of the total). Photosynthesis uses sunlight to transforms water and carbon dioxide it into sugar. The waste product of this process is our precious oxygen,

2. What factors are contributing to global warming?

Fossil fuels combustion, livestock rearing and the destruction of forests and ocean ecosystems increase the concentration of greenhouse gases in the atmosphere.

3. Why will animals with shells be affected by acidification of the ocean?

Ocean acidification decreases the concentration of carbonate ions, limiting the ability of marine life to create their calcium-carbonate structures. The increased concentration of hydrogen ions increases the dissolution of such structures.

4. Why are the corals important for marine ecosystems?

Corals provide shelter and food, creating habitats in which marine life can grow.

5. What is the reason corals become white (a "white appearance")?

When corals are under conditions that cause them stress (temperature, pollution, nutrients, etc), they expel the algae living in their tissues. As the photosynthetic pigments of the algae are responsible for the colours of the corals, when they are gone it is possible to see the white limestone underneath the transparent living tissue of the corals. This is called coral bleaching.

6. Things you can do to help protect seagrass and corals:

- Do not touch, step, walk, kick or stir sediment with your fins on the seagrass and corals.
- Make a proper anchorage of a boat
- Refuse, reuse, reduce, recycle plastic.
- Chose less polluting forms of transportation. Limit the use of pollutants such as soaps.
- Reduce your consumption of meat, fish and other animal products. Chose plant based alternatives
- Support marine protected areas.
- Advocate for and support coastal zoning initiatives, mapping and identification of seagrass beds and coral reefs areas.
- If you fish, practice responsible fishing, do not use destructive or illegal fishing practices and stop others from engaging in these activities.
- Support conservation organisations.
- Learn more about marine ecosystems.
- Do not pollute and stop others from polluting.