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ΤΜΗΜΑ ΝΑΥΤΙΛΙΑΚΩΝ ΣΠΟΥΔΩΝ

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ΣΠΟΥΔΩΝ ΣΤΗ ΝΑΥΤΙΛΙΑΚΗ
ΔΙΟΙΚΗΤΙΚΗ**

**THE IMPACT OF HUMAN ACTIVITIES
IN THE MARINE ENVIRONMENT**



Διπλωματική Εργασία που υποβλήθηκε στο Τμήμα Ναυτιλιακών
Σπουδών του Πανεπιστημίου Πειραιώς ως μέρος των απαιτήσεων
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Prologue:

It is beyond doubt that the Earth is currently facing an environmental crisis. Scientists from all over the world are warning their governments and the political system to take immediate actions before it is too late.

The human activities, which are guided by economic interests, are responsible for this environmental catastrophe and the consequences of these actions are already observable.

Until now, Earth is (and probably will be) our only home and it is of great importance to maintain it clean, balanced and of course habitable. Unfortunately, the results of human activities are already devastating, as Ice is melting, forests are destroyed and oceans are polluted on a daily basis. It is our duty to spread the ecological message and transfer knowledge to people who remain benighted. We all need to change the way we live and more importantly industries have to shift to a more sustainable way of operating.

This dissertation will focus on the impact of human activities in the marine environment and will analyze some of the most eminent threats to our oceans.

Such threats, which continuously harm our seas and all the species which live on it, are: **1) Ocean pollution 2) Plastics 3) Over – Fishing 4) Climate change** to name but a few.

We will also pay particular attention to the perils arising from oceanic abuse and then we will mention possible solutions which could contribute to environmental protection.

Αναμφίβολα, η Γη αντιμετωπίζει μία περιβαλλοντική κρίση. Επιστήμονες από όλον τον κόσμο προειδοποιούν τις κυβερνήσεις και το πολιτικό σύστημα, πως πρέπει να γίνουν άμεσες ενέργειες, πριν είναι πολύ αργά. Οι ανθρώπινες δραστηριότητες, οι οποίες καθοδηγούνται από οικονομικά συμφέροντα, είναι υπεύθυνες για αυτή την περιβαλλοντική καταστροφή και οι συνέπειες των οποίων είναι ήδη εμφανής.

Μέχρι τώρα, η Γη είναι (και θα μάλλον θα συνεχίσει να είναι) το μοναδικό μας σπίτι, συνεπώς είναι μεγίστης σημασίας να τη διατηρήσουμε καθαρή, σε ισορροπία και φυσικά κατοικήσιμη. Δυστυχώς, τα αποτελέσματα των ανθρωπίνων δραστηριοτήτων είναι ήδη καταστρεπτικά, καθώς οι Πάγοι λιώνουν, τα δάση καταστρέφονται και οι ωκεανοί μολύνονται καθημερινώς. Είναι καθήκον μας να διαδώσουμε το οικολογικό μήνυμα και να μεταφέρουμε γνώση σε ανθρώπους που βρίσκονται στο σκοτάδι. Όλοι πρέπει να αλλάξουμε τον τρόπο που ζούμε και κυρίως, οι βιομηχανίες πρέπει να αλλάξουν σε έναν πιο βιώσιμο τρόπο λειτουργίας.

Αυτή η διπλωματική θα επικεντρωθεί στην επίπτωση των ανθρωπίνων δραστηριοτήτων στο υδάτινο περιβάλλον και θα αναλύσει κάποιους από τους πιο κύριους κινδύνους των Ωκεανών. Κίνδυνοι που συνεχώς ζημιώνουν τις θάλασσες και τα είδη της είναι: **1) Η μόλυνση των Ωκεανών 2) Τα πλαστικά 3) Η Υπέρ-αλίευση 4) Η κλιματική αλλαγή.** Τέλος, θα αναφερθούμε στους κινδύνους οι οποίοι εμφανίζονται λόγω της κακής διαχείρισης των ωκεανών, ενώ θα προταθούν και λύσεις.

Introduction:

Oceans are indispensable. Without them, life here on Earth would not be possible, or at least life as we know it today.

Millions of years ago, life started to exist inside the Earth's oceans in the form of micro-organisms. It required hundreds of thousands of years for these micro-organisms to evolve and slowly but steadily to transform into a life more complex.

The first species started to appear and then the cycle of complex life commenced here on Earth.

In the hypothetical scenario in which oceans magically disappeared from our planet, the consequences would be chaotic as they would lead the humankind and all the other earthling species to their doom.

We, humans, should feel blessed that the oceans will stay here on Earth and they cannot just vanish. But should we really feel secure about our planet's future or should we worry about the impact of human activities to the oceans and their life? Is their existence a major relief for us which ties our hands and letting us enjoy the trip of life or should we take immediate actions to secure and maintain the oceans and the marine ecosystem? Can the human activities disturb the oceans and the marine ecosystem and have a severe impact to the planet's environment?

Unfortunately, the answer to the last question is "yes". Humans are more than capable of affecting with their actions the whole planet, as they could destroy all life on Earth if they wished to.

In our case though, it is not just a matter of wish (to destroy or not the planet's life), but a matter of many, much more complicated factors. Such factors could be, first of all, economical interests. We do know that profit comes first even if vital elements, like the environment, are involved. In the name of money, the ecological morality has been sacrificed too many times in the past. But as the economy evolves and the competition becomes tougher, as technology becomes another servant of profit and the market more and more demanding, this sacrifice, the sacrifice of "environmental awareness", turns out to be more painful than ever before. Scientists from all around the world are currently trying to convince governments to take measures immediately. But the measures already exist and the laws are there waiting to be enforced. So, environmental negligence, which is a product of speculation, is not the only factor which threatens the marine (and non- marine) environment. Corruption is the factor that comes next and includes the non – implementation of measures and laws.

Human greediness combined with the thirst for money and in respect with other parameters, led and still leads to environmental catastrophes, oceanic abuse (which this dissertation is going to focus on), disturbance of the ecosystem, pollution, etc. The most recent result of such actions is climate change which is the hottest topic in the scientific community and for governments. It affects global temperature, which in turn threatens life on Earth.

We will refer to the issue of climate change in one of the following chapters, since it has direct effects on the marine ecosystem.

It is really frustrating and discouraging to realize that some governments do not realize the importance of maintaining the oceans and their life untouched or at least in a healthy state.

Contrary to the significance of protecting the oceans, humans do their best in order to fully exploit the ocean floor's minerals (oil, gas, and hydrocarbons), the marine species (fish, mollusks, shellfish, seaweeds, corals, etc.) and the ocean's surface (vessels, passenger ships, etc.).

Thousands of merchant vessels, passenger ships, fishing boats, navy ships and other types of vessels are navigating the oceans. Their environmental footprint is noteworthy as all these ships are responsible for a considerable amount of oceanic and air pollution, as well as disturbance of marine life.

Another major issue which gradually but steadily disturbs the balance of marine ecosystem is over-fishing.

Billions of fish are captured every year by fishing boats. Fishing is responsible for the huge decrease in fish stocks. Fish of all sizes are captured every day, from fish eggs and tiny fish to enormous ones, like tunas and sharks. Even marine mammals are killed for their flesh, fish oils and for other market reasons. Mammals like dolphins, whales, seals and sea lions are also victims of the fishing industry and their deaths cause severe ecological damage, since their role in marine food webs is very crucial.

Unfortunately over-fishing is not the only problem yet. The marine species have more perils to fear, as oil spills, sea and air pollution, plastics and micro-plastics, marine ecosystem disturbance (through ballast water for example – which accidentally transfers species from one place to another), weapon tests (nuclear or other military tests), underwater or surface explosions (accidentally or on purpose), climate change and oceanic acidification. All these are great threats not only for the oceans but the entire planet.

It is also worth mentioning that even activities non-related to the oceans, can have a devastating effect.

For example, deforestation indirectly affects the oceans as it affects the world's climate.

Given the above, it is undoubtedly important for the current and future generations to know why oceans are vital, which human activities cause damage to marine ecosystems and furthermore: “Which actions shall we take in order to save the oceans and consequently ourselves”.

Chapter 1

Marine Pollution

One major issue, which is also a chronic phenomenon, is the pollution of the seas due to human activities. The pollution can either occur directly (through ships, ports, industries, etc.) or indirectly (through inner land activities).

But above all, what do we mean when we use the term “marine pollution”?

By the term “marine pollution” *we refer to all the harmful materials which are thrown directly or indirectly to the sea, causing serious damage to the marine environment, disturbing the balance of the marine ecosystem and producing anomalies to the water life which is affected.* Such harmful materials which enter the seas could be chemicals, plastics, industrial trash, oils, human waste, lubricants, types of non-disposable particles, grease, radioactive materials and many other objects (solid or liquid). Even noise, which is produced by human activities, is considered a type of pollution, as it disturbs marine species and therefore the marine ecosystem.

1.1

Chemical Pollution: occurs when fluids, possibly toxic, are released into the water resulting in ocean pollution. Chemicals can find their way to the sea by several ways, either directly from the surface of the sea (by vessels which carry hazardous chemicals) or indirectly from land (by industries which discard chemicals accidentally or on purpose).

Many industries discard toxic liquids into rivers, which eventually transfer the hazardous liquids to the sea, while others discard them on land. These chemicals will eventually penetrate the ground and reach an underground river which leads to the sea.

In one way or another, chemicals constitute a major part of marine pollution and therefore pose a huge threat to the aquatic environment and humans themselves.

Mercury is a chemical element, which is also known as a “heavy metal” and it is a very good example of how chemicals are polluting the seas.

According to multiple studies there are serious concentrations of mercury in several species of fish. As U.S. researchers mention in several studies, mercury in fish is a phenomenon of global concern.

The Centre for Food Safety of Hong Kong (government site), after analyzing the samples of a study which was related to fish consumption and mercury, came up with the conclusion that low or in some cases high concentrations of mercury was found in fresh fish or canned fish. They suggest the consumers to be more careful and selective regarding the fish consumption, especially pregnant women who should totally avoid large, predator fish like tuna for example or shark species.

Due to “*bioaccumulation*”, the bigger the fish is the higher the concentrations of mercury, plastic, or any other toxic material accumulated in their tissues.

This means that big fish are exposed to mercury toxicity much longer than smaller ones. Mercury builds up in fish, just like car emissions build up in birds or other animals. Through the years, mercury levels increase inside the fish and this is why scientists suggest consumers to avoid eating large fish, as they could carry dangerous levels of mercury (or for that matter plastic).

But the question remains: *How does mercury find its way to our oceans?*

According to Dr. Cherie Winner from the *Woods Hole Oceanographic Institution*, the type of mercury which should concern us is called “*monomethylmercury*” or simply “*methylmercury*”.

As Dr Winner states, we really do not know how methylmercury finds its way to our oceans. Mercury itself is almost harmless but somehow it is converted to the much more dangerous type of methylmercury.

The methylmercury issue is still puzzling the scientific community as from what we know until now not enough quantities of this type of mercury are entering our oceans. But still the samples from fish suggest the exact opposite.

The scientific community knows at least how mercury (the non-dangerous type) enters the seas. Mercury is released mostly from fossil fuels, as coal for example, releases 160 tons of mercury per year. Some also comes from natural sources such as volcanic eruptions, but still the biggest source is the human, land activities.

Even though scientists know where mercury comes from, the big mystery still remains as they cannot identify any natural process which converts mercury into the highly toxic and unhealthy for animals and humans who consume it, methylmercury.

But why is methylmercury dangerous for people who accidentally consume it?

According to World Health Organization (WHO), mercury is among the top 10 most perilous chemicals which can cause serious damage to the human health.

Large concentrations of mercury “*can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys and may also be fatal*”.

In conclusion, heavy metals like mercury exist in our oceans and also exist inside fish. The larger fish have a higher chance of carrying larger quantities of mercury due to bioaccumulation. As a result scientists and health organizations suggest consumers to avoid eating big fish.

Except for mercury other toxic chemicals also exist in the ocean, such as cadmium and lead.

Another major issue is the billions of tons of plastic found in the sea which also accumulates in fish and disturbs the marine ecosystem.

1.2.1

Oil spills: Oil spill incidents, also cause major damages the marine environment. In the last decades, several oil spill incidents have taken place around the world. By the term “oil spill” we refer to the (accidental or not) release of liquid petroleum to the environment and more specifically to the marine environment. Such a disaster occurs when for example a tanker vessel sinks and crude oil is released to the environment.

The environmental impact of an oil spill can last for years if not decades. According to **Woods Hole Oceanographic Institution** (WHOI), the impact of such an ecological catastrophe depends on the type of petroleum released, the amount of it, as well as other parameters such as the location of the incident, currents, temperature, etc.

Gulf War Oil Spill

Oil spills are in most cases a result of human negligence. One of the most disastrous was caused on purpose in 1991.

This oil spill is known as the “*Gulf War Oil Spill*” or “*The Kuwaiti Oil Fires*”. It was 1991 during the Gulf War, when the Iraqi troops withdrew from Kuwait but also opened pipelines and the valves of oil wells and set fire in order to prevent the U.S. forces from landing in the area. More than 700 oil wells were approximately destroyed by the Iraqi soldiers, spilling around 60 million barrels of oil into the environment. It is estimated that **10 million barrels** of oil were spilled into the Persian Gulf.

The soil was greatly affected. According to experts, 10 million cubic meters of soil was contaminated, 2/5 of Kuwait’s freshwater were also contaminated and the air pollution was enormous. As the oil wells were set aflame, the fires kept burning for several months and the air was greatly polluted as huge amounts of carbon dioxide were being released daily.

It is worth mentioning the fact that the average temperature around the area dropped by 10° (degrees Celsius) as light could not pass through the thick layer of black smoke, which was formed as the fires were burning for almost 9 months.



A satellite image (Landsat) by NASA showing just a part of the affected area, as the oil spill is heading towards the Persian Gulf. During the 9 month period in which the fires were active, toxic rains affected the whole area and nearby regions. (The image belongs to NASA)

According to scientific studies which analyzed the oil spill, there was a huge damage to the marine environment in the Persian Gulf, as millions animals died.

As Dr Makram A. Gerges - an Egyptian journal of aquatic research from NIOF (National Institution of Oceanography and Fisheries) – mentions, the area which was affected heavily was the Saudi Arabian coast, less the Kuwaiti, Iranian and Iraqi coasts. The level of the disaster was chaotic.

Some scientists suggest that such oil spills may have irreversible impact on the marine environment.

How does oil affect fish and other marine species?

Fish are usually the number one victims of an oil spill. The number of fish deaths after an oil spill depends on the amount of petroleum which was spilled and on the type of petroleum. Another parameter could be the type of waters in the area of impact.

In most cases, the petroleum floats on the surface and this is the reason why shellfish and finfish can stay unaffected. This scenario changes if the waters are shallow or confined.

Many fish species though die as petroleum affects them internally (by accidental ingestion) or externally (through their skin and eyes). Fish may die almost instantly if they found themselves trapped inside the core of the oil spill or slowly if they ingest large amounts of petroleum around the area of impact.

Oil also affects fish eggs, fish growth and organs.



Areas around oil spills are literally “dead zones” as numerous fish find tragic death due to the oil exposure.

The number of fish which die after an oil spill is enormous and cannot be specified.

It is crystal clear that oil spills have seriously decreased the fish population globally.

But fish are not the only possible victims of an oil spill. Marine mammals like whales can be affected as well or even other protected species like sea turtles.

There are also fish which are protected as their numbers have sharply declined during the last decades. Such protected marine species could be sharks, seahorses, Bluefin tuna, leafy and weedy sea- dragons, etc.

Contaminated waters could seriously threaten marine species which are already endangered, directly (through direct contact and contamination) or indirectly.

In this case, by the word “indirectly” we refer to the scenario in which for example a whale (a protected marine species) cannot find enough quantities of fish in order to satisfy its feeding needs as vast numbers of fish died from a possible oil spill.

It is really important for the sake of environmental balance to protect all the endangered species on Earth as their extinction could have a catastrophic domino effect which would undoubtedly also affect humans.

Unfortunately, the oil spill in the Persian Gulf in 1991 was indeed the biggest one but not the only one. A serious number of oil spills have occurred in the past and it is more than certain that more are about to follow up.

1.2.2

The BP Oil Spill

Another tragic and ruinous oil spill took place in the Gulf of Mexico in 2010.

The accident is known as the “*Deepwater Horizon Oil Spill*” or the “*BP Oil Spill*” or simply the “*Gulf of Mexico Oil Spill*”.

The accident happened after BP’s drilling rig exploded. As a result of the explosion, 11 workers lost their lives and 17 workers injured.

The drilling rig was located 40 miles southeast off the Louisiana coast, inside the Gulf of Mexico.

Almost **200 million gallons** of oil spilled into the ocean resulting in the worst oil spill in the history of the U.S.

Three companies were found guilty and responsible for carrying the burden of the oil spill accident. The first one, which was the most responsible, was BP the oil colossus. The second one was Transocean, the drilling contractor and the 3rd one with the least responsibility for the accident was Halliburton, one of the largest oil field services company.

The oil spill affected the shorelines of four Gulf States: Alabama, Florida, Mississippi and Louisiana.

The oil giant BP was damaged by multiple billions of dollars. According to several sources the total amount in fines for the oil spill reached \$60 billion, as BP has to compensate for the cleanup, the environmental damage and the families of the victims.

Although, the whole accident was valued in billions of dollars, in reality the environmental damage in the Gulf of Mexico is priceless.

The effects of the oil spill were huge, as various organisms were affected. Fish, marine mammals, sea birds and even plankton became “oil victims”.

An undefined number of fish died as a consequence of the accident.

At least four species of marine mammals were killed by the oil spill, including types of dolphins and whales. Sea turtles and sharks died as well as the toxic oil infected them heavily.

But marine species were not the only victims. It is estimated that more than 1 million birds died because of the floating oil. The deaths of all those species did not all happen immediately, but in a long period of time, as the oil cleanup is a long-term procedure.



A large number of **dead** whales, and more specifically “sperm-whales”, dolphins and sharks began washing ashore at the nearby coasts after the 2010 oil spill accident.



It is really sorrowful, considering that many of these animals, which were killed because of petroleum

in the Gulf of Mexico, are protected species which may go extinct in the near future. Even though the oil spill was responsible for a serious number of deaths, as reported by **a study in 2011**¹ which focused on how marine mammals affected by petroleum in the Gulf of Mexico, it was pointed out that many dolphins and whales became seriously sick by the toxicity of oil. The toxic fluid weakened their immune system and damaged their lungs. According to Dr. Lori Schwacke and Dr. Teri Rowles, the dolphins which were studied had multiple serious health issues such as lung disease, damaged livers and indications of chronic inflammation.

1.2.3

Another victim of oil spills: Plankton

We should also evaluate the damage that is caused to the smaller organisms of the ocean, like *Plankton*.

By the term *Plankton* we refer to the diverse collection of organisms which live in large bodies and which are unable to swim against a current.

These organisms, like for example phytoplankton, are indispensable for the balance of marine ecosystems. Among their many other roles, two are crucial:

- 1) they are a vital source of food for the zooplankton.
- 2) They produce most of the oxygen in our planet. Contrary to the popular belief that trees are the main sources of oxygen, the truth is that the ocean (through the phytoplaktonic production) is the main reason why we are able to breathe.

¹ The results of the study were posted in the journal “Environmental Science & Technology”. It was part of the Natural Resource Damage Assessment for the Deepwater Horizon oil spill.

Phytoplankton (algae) could be characterized as “*the plants of the sea*”, as they require sunlight for photosynthesis just like shore plants. Consequently, phytoplankton lives only in the sea’s surface so it can receive all the required sunlight. As we already know from biology, the procedure of photosynthesis includes the conversion of carbon dioxide into oxygen. Therefore, considering that the oceans and fresh water cover the 71% of the Earth’s surface, we can easily understand why phytoplankton is responsible for most of the breaths we take.



A picture captured by NASA’s aqua satellite, showing the blooming of phytoplankton during springtime in the Bay of Biscay, France and the area it covers.

Although, phytoplankton individually is tiny, the concentration is enormous and they cover wide areas across the oceans. In the right conditions and of course in an untouched environment phytoplankton can grow explosively and release huge amounts of oxygen which is essential for life here on Earth.

Unfortunately, when oil spills do occur, phytoplankton can be damaged as well. Crude oil is less dense than water and therefore it floats on the surface of the ocean. As a result it may reach spots which are covered by phytoplankton populations and affect them heavily.

Although, there are not many studies regarding the “phytoplankton – oil” interaction, it is quite clear that petroleum does affect phytoplankton.

The bizarre results of some studies, which focused on the oil spill impact on phytoplankton, showed that depending on the type of phytoplankton (cyanobacteria, green algae, coccolithophores, etc.) crude oil could either stimulate the growth of

phytoplankton or inhibit it. Two conflicting results regarding the same species have been reported.

Although, someone could hastily conclude that crude oil may have a good impact after all, as it benefits some specific types of phytoplankton, this is totally not true. First of all, the results showed that only some types of phytoplankton may experience a boost on their growth, while others may be damaged.

Secondly and most importantly, further research is needed in order to conclude if this abnormal and not natural growth of some phytoplankton types due to oil spills may result in something worse in the future that is not predicted yet.

On top of that, petroleum remains a toxic liquid which can be consumed by fish, jellyfish, shrimps, **zooplankton** and other animals which feed on phytoplankton.

So, even if some types of phytoplankton can grow faster because of an oil spill (while other types may go the opposite way around), animals which consume phytoplankton will accidentally ingest the toxic liquid.

Another type of plankton, which actually consumes the above mentioned category, is called "*zooplankton*".

Both phytoplankton and zooplankton are categories of Plankton, but they do have some differences. Phytoplankton is much smaller than zooplankton (20-200 micrometers) while zooplankton may reach 20 millimeters in length.

Phytoplankton could be considered, as we already mentioned, as plants of the sea which live mostly near the surface while zooplankton are microscopic animals which are also very weak swimmers and live deeper, in the darker and colder part of the ocean.

Zooplankton feed on phytoplankton (or smaller zooplankton species) and they are extremely important in the food chain. Fish of all sizes, crustaceans or even whales feed on zooplankton.

In a nutshell, when an oil spill occurs, petroleum will probably float (depends on the type) on the sea's surface as it is a less dense liquid. It may connect with areas where phytoplankton exists and affect it in one or another way.

Zooplankton species, which feed on phytoplankton, will get affected by the ingestion of oil and die or they will transfer the toxic liquid to other species which will eat them. The natural phenomenon of "bioaccumulation" will take place and the amount of toxicity will increase as we move from the smaller to the larger marine species.

Industrial Waste, Marine Littering and Ballast Water

Heavy metals and oil spills are indeed a massive issue which has tragic results for the marine environment. But woefully, the marine pollution is not limited to these 2 categories. There are far more factors which contribute to the ocean pollution.

As we already mentioned above, toxic chemicals which are used or produced by several industries may find their way into the ocean, either from rivers which empty their waters into the sea or through underground waters which are connected to the sea or through the rain (toxic rain).

Other industries throw directly their waste into the ocean in order to get rid of it while others do that unintentionally.

Waste in the ocean may appear in a variety of forms, but the most toxic forms include dredged material, industrial waste, sewage sludge and even radioactive waste.

In the Maritime Industry, *asbestos*, a toxic material used for building vessels, is banned according to SOLAS after July, 2002. But many vessels were built before that regulation and as a result asbestos fibers may have found their way into the ocean.

Even though there are no concerns so far regarding asbestos and the marine environment, it is still a good example of how toxic materials, chemicals or else, may find their way into the sea, causing serious trouble to the marine residents.

The real threat which arises from the maritime industry though is not of course asbestos but vessels.

Merchant vessels and cruise ships are responsible for a significant proportion regarding the marine pollution and littering.

Merchant vessels and most specifically tankers have caused many serious accidental oil spills as we mentioned before. Bulkers on the other hand are not as dangerous for the environment as tankers are, but these types of vessels are not innocent either.

Bulk vessels which mostly carry raw materials, soy, wheat and minerals are not big threats when it comes to their cargo, but they do are a threat for the ocean when it comes to littering and pollution.

First of all, just like all the other means of transport, vessels produce a lot of carbon dioxide. Carbon dioxide is responsible both for the climate change which we are facing right now and for the ocean acidification. Both the climate change and the ocean acidification are probably the biggest threats we, humans are facing right now, but we will analyze these perils in one of the following chapters.

Apart from the gas emissions vessels are responsible for much worse dangers.

Merchant vessels and especially cruise ships are responsible for significant amount of littering. People on board tend to throw their garbage in the ocean and a lot of those trashes are not easily disposable. The littering is much worse when it includes plastic trashes, as plastic is a real headache for our environment.

Many merchant vessels, mostly in the past decades (before IMO introduced heavy penalties for the offenders), got rid of anything they really didn't need into the ocean, from human waste, garbage and plastics to oil, lubricants and scrap.

The noise pollution is also a considerable problem for marine life. The presence of hundreds of thousands of vessels and boats (of all types) across the globe has seriously disturbed aquatic life.

There are several reasons why noise pollution seriously affects fish and marine mammals. Many marine animals use sound in order to find their prey, as light is very limited in the depths of the ocean. The extensive noise which may come from vessels or nearby ports, affect this special trait and so many animals cannot hunt properly.

Other than that, noise pollution can even cause hearing loss (permanent or temporary) when the noise is extremely loud to nearby marine animals. Fish will also change direction when loud noises happen nearby or even they may abandon a whole area because of continues noise, leaving that area much less populated. Some studies also suggest that loud noises can cause stress to marine animals and this could result in behavioral changes.

Lastly, another hot and more complicated issue which concerns the maritime industry is *Ballast Water*. There have been some serious cases in which marine organisms from one place accidentally transferred to another place through ballast water. The untreated ballast water can put a local ecosystem at huge risk by introducing new species to it and this is why today there are specialized procedures which every vessel that uses ballast water is obligated to follow.

Such incidents, in which species were carried from one place of the world to another, occurred a few times in the past. The risk of such an event is huge, as the local ecosystem can collapse.

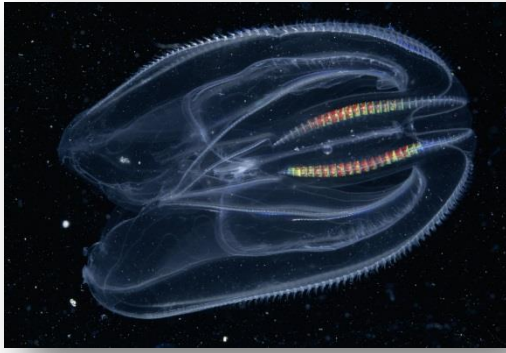
A great example of such an occurrence is the “***Black sea invasive species***” incident. In 1982, the *comb jellyfish* arrived to the Black Sea from the Atlantic Ocean.

The main food of comb jellyfish is zooplankton, which is also the main food of other fish in the Black Sea. But the jellyfish also fed on those fish eggs and larvae.

So, in their new home, the jellyfish were consuming zooplankton, which were also the main food of other fish and the eggs of those fish. The worst thing was that in their new place, jellyfish had no enemies, so they were just populating and conquering the whole Black Sea. By the mid 90's the jellyfish were the 90% of the Black Sea's total biomass. The fishing market collapsed as there were no fish to catch. The fishing industry lost around \$1 billion since the jellyfish arrived.

A domino effect occurred which also affected the number of dolphins in the Black Sea, as dolphins did not have fish to feed anymore. Even the amount of oxygen in the Black Sea dropped.

Scientists found the solution by introducing another “alien species” to the Black Sea's ecosystem in order to fix the anomaly. They threw a predator which was feeding on jellyfish and did not affect the other fish and as a result the fish populations started to recover, while the jellyfish started to vanish.



The comb jellyfish arrived from the Atlantic Ocean to the Black Sea through a vessel's Ballast tank and spread chaos to the local ecosystem for years.

Because of the growing environmental concerns about Ballast Water, IMO adopted in 2004 the “*International Convention for the control and Management of Ships' Ballast Water and Sediments*”.

The goals of this convention are to minimize the environmental impact of Ballast Water and the accidental transportation of species.

Except for large species or at least observable ones, like jellyfish and fish for example, microscopic organisms like Cholera: *Vibrio Cholerae* (bacteria) could also pose a threat regarding Ballast Water. In 1991, this form of Cholera which was only known in Bangladesh arrived in Peru and killed more than 10,000 people.

There are hundreds of organisms that can be carried through Ballast Water causing trouble to the local environment they arrive. IMO has listed the top 10 most dangerous ones:

- Cholera Vibrio cholerae (various strains)*
- Cladoceran Water Flea Cercopagis pengoi*
- Mitten Crab Eriocheir sinensis*
- Toxic algae (red/brown/green tides) (various species)*
- Round Goby Neogobius melanostomus*
- North American Comb Jelly Mnemiopsis leidyi*
- North Pacific Seastar Asterias amurensis*
- Zebra Mussel Dreissena polymorpha*
- Asian Kelp Undaria pinnatifida*
- European Green Crab Carcinus maenas*

So, the Maritime industry is responsible for a variety of pollutions regarding the oceans, as it produces noticeable amounts of carbon dioxide, it also produces noise pollution which disturbs marine animals, it contributes to the marine littering, it is heavily responsible for oil spills and for possible invasions of species from one place to another through Ballast tanks.

Of course the Maritime Industry is not the only one to blame for ocean pollution. As we already alluded, many industries not related to the Maritime field, use the oceans as their personal trash can.

Shockingly, the subject of ocean pollution is not limited only to the immoral actions of industries or individuals. In the past, even governments were using the ocean as a method to dispose nuclear and radioactive waste.

From 1946 to 1993, thirteen countries used this practice to get rid of radioactive waste. Since 1993, the ocean disposal method has been banned by international treaties.

However, there are many reports claiming that some companies still use the ocean in order to dump radioactive and other hazardous materials. More specifically some reports mention that companies take advantage of the situation in Somalia (Civil War, non-governed, terrorism and poverty) in order to leave their toxic waste near its coasts. That of course puts in great danger not only the marine ecosystem there but the people who consume fish around the area.



As a result of corruption by the local authorities, in Nouadhibou, Mauritania, companies abandon their old, unwanted vessels.

Consequently, the area around the port of Nouadhibou is literally a ship graveyard. Rusted boats and vessels are left there to slowly rot and this is clearly another case which shows how humans use the oceans in order to throw away anything they don't need. From toxic chemicals and industrial waste, to radioactive materials and rotten vessels, the ocean is so far serves humans as a gigantic trash can.

Ports, as it would be expected, illustrate perfectly the situation we are currently facing in respect of marine pollution. Most of the ports have almost zero garbage management and as a result the water area around them is extremely hostile for marine life.

In some ports the sea surface is literally covered by garbage. It is not a phenomenon limited only to third world countries. Most of the ports and especially the hubs are regions of huge pollution where the word “ecology” has no place.



Karachi port, in Pakistan is a very busy port where hundreds of vessels come and go daily. The pollution though, is beyond any shadow of doubt a major concern in Karachi. In 2003, an oil spill occurred after a Greek registered vessel, Tasman Spirit, ran aground and cracked spilling thousands of tons into the Arabian Sea. That is probably the biggest environmental catastrophe in Pakistan so far. But unfortunately that incident did not awaken the government and the port authorities and Karachi still is a source of enormous pollution. Air pollution, lack of proper waste management and port’s poor infrastructures are some of the issues that the port is facing.

Sadly, Karachi is also the home of “mangrove forests”. Mangroves are trees which live near coasts or even underwater and they play an important role against flooding, they produce oxygen and they are rich in biodiversity. These forests are now threatened by the extensive pollution which is created by the human activities.



Chapter 2

Plastic and Microplastic Pollution

Plastics and Microplastics are deservedly the number one threat in respect to marine littering.

It is true that plastic bags, bottles, spoons and forks, plates, wraps, cups, straws and so many other plastic materials, have seriously assisted the way we humans live. Their contribution to modern societies and their role in today's fast-paced rhythm, which characterizes human lifestyle, is an acceptable reality that we need to face. Plastics are indeed a very good solution to our daily needs and in many cases they do untie our hands. A world without any plastic at all would be all of a sudden a much more difficult world to live in.

However, this reflects the good side of using plastics. On the other hand, plastics damage heavily the environment.

Plastics do help us and assist our lives but they also carry a huge environmental burden. Their assistance comes together with an enormous cost, as the whole environmental balance is put at stake.

Leo Baekeland, a Belgian chemist, who is considered the "Father of Plastics" would have never imagined how catastrophic his invention would become and how big the environmental effects of using plastic would be.

2.1

Plastic and Microplastic: Definitions

First we all need to know what is plastic and how it is produced.

Plastic is a material consisting of any of a wide range of synthetic or semi-synthetic organic compounds that are malleable and so can be molded into solid objects.

Plastics are typically organic polymers of high molecular mass and often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, however, an array of variants are made from renewable materials such as polylactic acid from corn or cellulose from cotton linters.

Due to their low cost, ease of manufacture, versatility, and imperviousness to water, plastics are used in a multitude of products of different scale, including paper clips and spacecraft. They have prevailed over traditional materials, such as wood, stone, horn and bone, leather, metal, glass, and ceramic, in some products previously left to natural materials (wikipedia definition of plastic).

The most common type of plastic is PET which refers to "Polyethylene terephthalate" which belongs to the polyester family.

Polyester is a synthetic fiber derived from water, air, coal and petroleum.

PET is the most common type of polyester, used to create plastic bottles and other plastic materials. The raw material which is processed and used to create

“Polyethylene terephthalate” is **crude oil**. Unfortunately, this type of plastic is far from eco-friendly and that is the root of the environmental concerns regarding plastic. There are 2 basic reasons why plastic is considered as a “sworn enemy” of the environment:

- 1) Plastic is not biodegradable, which means that it does not decompose in soil or water. More specifically, plastic may need up to 1000 years in order to decompose and thus until then it will just pollute the environment with its existence.
- 2) Plastic is toxic, which means that it can seriously affect most of the animals or even micro-organisms which accidentally consume it. It can heavily affect an animal’s immune system and health, while it is also carcinogenic for humans themselves. Through the bioaccumulation biological phenomenon, plastic can climb through the food chain, affecting many animals and even humans.

Leo Hendrik Baekeland, as already mentioned above, is considered to be the “Father of all Plastics”, as he was probably the first to introduce “*Bakelite*”, the first plastic made from synthetic components. That invention was the kick-off for the Plastics Industry in order to “conquer the world”.

Microplastics on the other hand are super tiny plastic particles, up to 5mm in length, which are a result of breakdown of bigger plastic objects. Plastic cannot decompose fast, as it requires hundreds of years to do so, but it can certainly dissolve into very small pieces of plastic. As humans, dump millions of tons of plastic into the ocean every year, some plastic objects break into smaller pieces, some of which are microscopic. These ultra-small pieces of plastic are known as “Microplastics”.

The term “microplastics” was introduced in 2004 by Professor *Richard Thompson*, a marine biologist at the University of Plymouth in the United Kingdom.

There is a good reason why we need to separate plastic into regular-sized plastic and microplastic. Except for the obvious reason, which has to do with the size, microplastics are far more dangerous than whole plastic objects.

First of all, small fish or other small marine animals, misunderstand these tiny, plastic particles for food and digest it. Bigger sized animals can also accidentally consume microplastics as they may also do with whole plastic objects. But the difference is that small animals cannot eat a whole plastic bottle. If the plastic bottle breaks down though, small marine animals may feed on the countless plastic particles. So, in this way, the number of plastic’s victims grows dramatically regardless of the size of the animal.

On top of that, microplastics are microscopic, as their name suggests and therefore the task of cleaning the ocean becomes much harder. It is impossible for science to search and find all these microplastic particles in order to remove them.

In reality, microplastics are so small that they can also pass through most of the filter systems.



This is an image from Independent, which shows how microplastics look like. These small pieces of plastic are often misunderstood for food by several marine animals which consume them and become sick as a result of plastic's toxicity.

The production of plastic started around the early 40's and later on, in the following decades, escalated enormously.

According to several statistics, humans produce around **300 million tons** of plastic per year, 50% of which is single-used plastic. Approximately, 8 million tons of plastic is dumped into our oceans annually.

According to *Plastic Oceans International*, a non-profit organization which aims to inform people about the hazards of plastic, 1 in 3 species of marine mammals have been found entangled with marine litter and over 90% of all seabirds have plastic pieces inside their stomachs.

It is also really concerning the fact that **91%** of the plastic we produce globally is not recycled, as *National Geographic* emphasizes.

Considering that the last decades, humans have produced billions of tons of plastic and most of these tons have not been recycled, we can realize the size of the issue and we can also conclude that we live in a "Plastic world".

How Plastic affects the Oceans and the Environment

The numbers above regarding plastic are the reason why scientists are so skeptical and problematized.

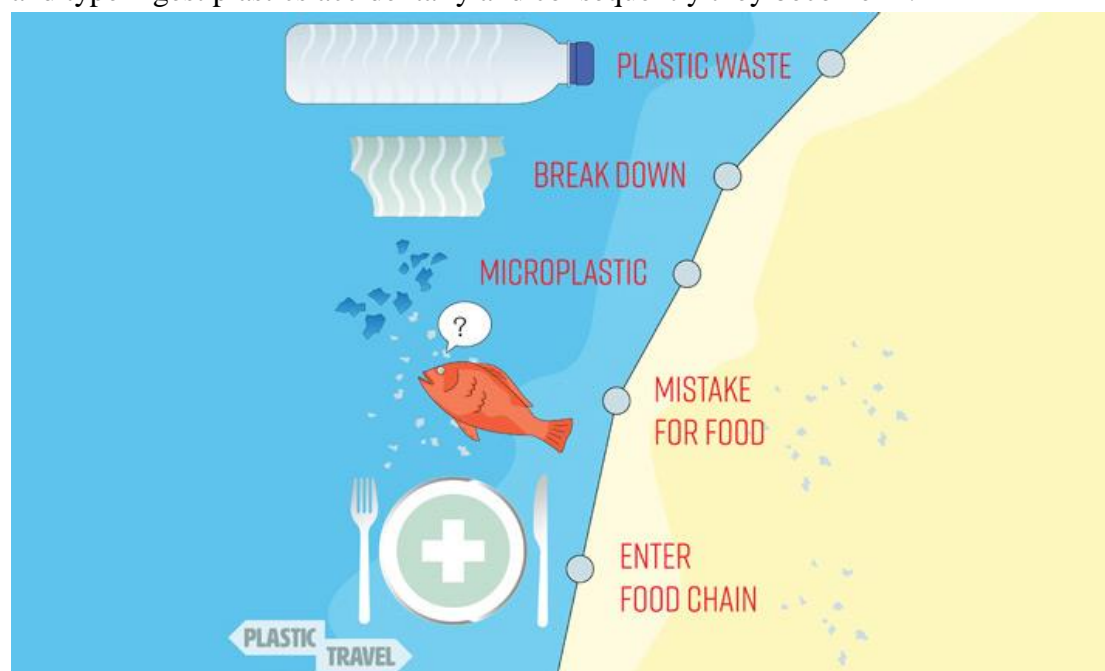
We clearly produce much more plastic than the planet can sustain.

Millions of tons of plastic find their way into the ocean each year and many of these breakdown into billions of microplastic particles.

In 2015, a study (*A global inventory of small floating plastic debris*) concluded that a number between 15 to 51 trillion particles of microplastics exist in our oceans, weighing between 91 and 236 metric tons.

But why is plastic so critical for our oceans?

Plastics and microplastics threaten to empty our oceans. Marine animals of any size and type ingest plastics accidentally and consequently they become ill.



Picture by "Mount Elizabeth Hospital"

The image above shows how plastic decomposes into microplastic and how it enters the food chain.

A plastic bottle in this case, enters the ocean, slowly breaking down into much smaller pieces (microplastics). A fish mistakes these pieces for food and eats them. That fish will later become sick from the toxicity caused by plastic. Another fish or marine mammal will eventually eat that fish and so plastic will travel up the food chain.

A study from Lund University in Sweden concluded that nanoplastics, which are smaller in size than microplastics, can cause brain damage to fish. The study found that nanoplastics can travel in the food chain through algae and zooplankton, and end up in much bigger fish. The study revealed that nanoplastics can cross the blood-brain barrier and thus accumulate inside the fish. This accumulation would result in brain damage and behavioral change in fish. On top of that, the study found that animal plankton would die once it was exposed to nanoplastics and this is deadly serious as we talk about the base of the food chain.

But brain damage is just one thing that plastics can cause. Other fish which accidentally swallowed a bigger plastic object may find a more painful and fast death, as the plastic can heavily harm its internal organs. Plastic is also toxic and when enough quantity of it is accumulated inside a fish, that can cause very negative results, affecting the immune system of the fish. Various studies underline that many fish never reach maturity, as they die because of plastic. That has a double result, firstly the populations of fish decrease, and secondly and most importantly fish breeding never takes place, as fish die in a much younger age prior to the breeding period.



Fish which consume plastic may die instantly, due to internal bleeding, brain damage, high level of toxicity and other causes.

It is also certain that plastic will move up to other, bigger species in the food chain, affecting their health as well.

Fish are of course not the only victims of plastic. According to several studies, every marine mammal was found with small or large amounts of plastic inside them. “It’s shocking – but not surprising – that every animal had ingested microplastics,” said Sarah Nelms, of the University of Exeter and Plymouth Marine Laboratory (PML), lead author of the research published in the journal Scientific Reports.

With such huge quantities of plastic and microplastic floating all over the ocean it is crystal clear how all marine animals are affected.

Another report says that 56% of all whale and dolphin species, from small-fish eating dolphins to gigantic blue whales, were reported to have eaten plastic that they mistook for food.

You do not need to be small in order to get affected by plastic debris. In reality, every year marine mammals also die from plastic.

It is estimated that 100.000 marine mammals and sea turtles die each year from plastic, either by getting choked or trapped inside it.

There are many more which also die as a result of plastic toxicity.

For example the number of dead dolphins has increased sharply the last years and scientists are concerned about how many dead dolphins will be washed up.

But when they studied them they came up with the conclusion that this phenomenon is another result of the ocean pollution. Plastic toxicity affects the immune system and consequently dolphins die from common diseases from which they normally would not have died.



Greenpeace Philippines created this large sculpture of a whale and left it on a beach after filling its mouth with plastic materials of all types. This was their way of protesting against plastic pollution and emphasizing the environmental damage plastic does.

Even though, the image above refers to a sculpture and not a real whale, whales are indeed victims of plastic and many of them have found tragic death after eating accidentally big amounts of plastic waste.



As BBC reports, a dead sperm whale found in Indonesia. The unlucky animal had ingested 64 pounds of plastic trash. Sperm whales are considered as endangered species.

A seal is trapped inside a plastic net and struggling to survive. The plastic net has caused serious injuries around the seal's neck. Many marine animals are getting trapped inside plastic bags or nets and so they die from the injuries or starve to death.





Sea turtles are another victim of plastic pollution. Just like the other marine species, sea turtles eat toxic plastics and die. They ingest plastic which causes blockages within their digestive system and therefore they die.

It is also very common for sea turtles to get trapped inside plastic bags or nets and slowly but painfully die.

Except for all the marine animals and microorganisms like zooplankton which are getting seriously affected by plastic waste and microplastics, seabirds are also victims. According to several reports, as many as 1 million seabirds die each year from plastic pollution.

There are 3 basic reasons why seabirds eat plastics.

First of all, it looks like food. When seabirds fly they often see something floating on the sea's surface and they mistake it for fish. Another reason could be that it smells like food. Studies show that the smell of krill feeding on the algae that coats marine plastic debris is similar to natural scents that many seabirds follow when hunting for food (*WWF quote*). Thirdly, plastic floats, which make it easy for seabirds to fly on the floating plastics and grab them.

Another study showed that the following tragedy occurs: Many seabirds leave their nests in order to hunt and bring food to their chicks. Often, they catch floating pieces of plastic as they confuse it for fish. Then, the seabirds feed their chicks with plastic and as a result the little ones die.

Another way that plastic kills seabirds is "entanglement". Seabirds get stuck, especially in abandoned, plastic fishing gear and slowly die as they cannot escape. Among the other reasons could be suffocation and high levels of toxicity.

In conclusion, marine life is currently facing many enemies, such as oil spills, chemicals and of course plastics. Plastics and microplastics are probably the biggest threat as marine animals mistake them for food. Therefore, plastic climbs all the way up the food chain, causing a serious decrease in aquatic populations. Plastics and microplastics are therefore of major concern which needs to be faced immediately as they are a global threat.

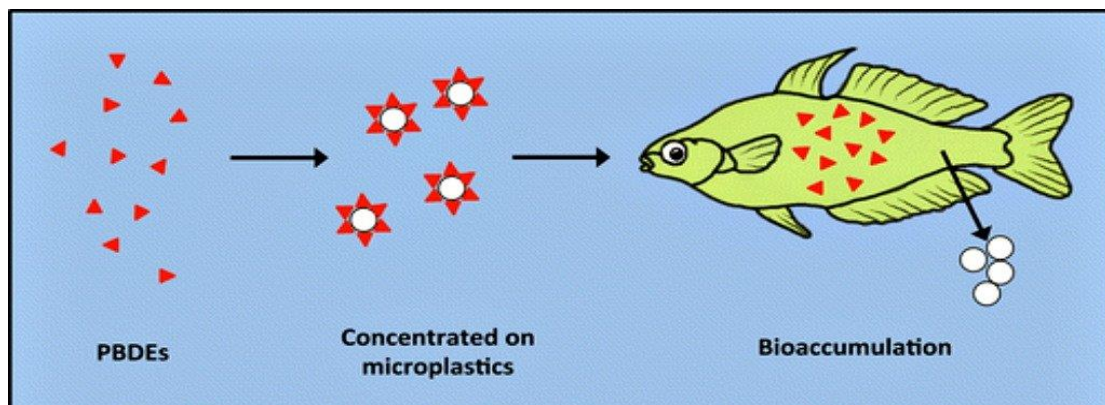
A decrease in marine life will of course affect the global economy in many levels, but most importantly, it can disturb and ruin the entire ecosystem. It could prove to be an environmental disaster without return.

Many countries whose economy is based on fishing are already facing such issues. If the economy of certain countries collapses, then (due to the domino effect) many other countries will get affected as well.

Coastal communities or islands are also affected by this decrease, as fish are a basic food in their diet. Many communities depend, one way or another, on fishing.

Last but not least, scientists are now warning fish consumers to pay particular attention to the fish they buy, as many fish out there are infected by microplastic and heavy metals. Both plastic and heavy metals can undoubtedly damage human health, as they are carcinogenic.

Someone who consumes fish containing accumulated amounts of plastic or heavy metals puts his health at serious risk.



Fish and marine animals are exposed to plastics and microplastics. These animals mistake plastic particles as food. As they keep eating and eating those particles, plastic is accumulated inside them and this is the reason why big fish contain serious amounts of plastic in them.

The Mediterranean Sea at risk

The impact of plastics and microplastics is more observable in the Mediterranean Sea. The importance of the Mediterranean Sea is an undisputed fact, as it serves the economy of more than a dozen countries in 3 different continents. It is also a major boost for tourism, as it provides each country with countless beaches and fresh fish.



When a tourist visits a Mediterranean country, he definitely expects sunlight, golden beaches, clean waters and fresh sea-food.

But in reality he will probably get only the first one (Sunlight).

The Mediterranean Sea is clearly affected by plastics and microplastics. In fact 21 countries are surrounding the Mediterranean Sea and therefore a lot of human activities are taking place. Also, more than 200 million tourists visit the Mediterranean countries each summer, which results in a +40% increase in marine

littering.

According to a WWF report, the Mediterranean Sea is in great danger because of plastics and microplastics which are threatening to eliminate most of the marine life. Currently, more than 17.000 different species exist in the Mediterranean Sea, including dolphins, seals, sharks, sea – turtles, rare types of fish or even whales. The great disadvantage that the Mediterranean Sea has is that it is almost completely landlocked, as it is bounded by Asia in the East, Africa in the South and Europe in the North. Only a very small opening through the Gibraltar strait connects the Mediterranean waters with the Atlantic Ocean. That means that the perpetual littering which is done by human activities across the Mediterranean Sea does not spread to the Atlantic Ocean and all the plastic and non-plastic trash which exists inside the Sea stays within. Consequently, pollution in the Mediterranean Sea can only get worse and worse and so every piece of plastic will remain trapped within the Mediterranean waters.

Of course there is a limit on how much littering the Mediterranean Sea can withstand. Scientists have already observed a concerning decrease in the Mediterranean fish populations, which already leads to devastating results in the economy. With toxic waters, full of plastic, dead zones start to appear, fish populations and tourism is heavily affected.

It is more evident than before that immediate measures have to be taken by the European Union and all the concerned countries in order to protect the priceless “service” of the Mediterranean Sea.

For the reasons mentioned above, the Mediterranean Sea is also one of the worst possible places for an oil spill to occur.

The Great Pacific Garbage Patch



The *Great Pacific Garbage Patch* illustrates very vividly the issue of plastic pollution in the oceans. It is a perfect example of the size of global marine littering.

But what is exactly “The Great Pacific Garbage Patch”?

The Great Pacific Garbage Patch (GPGP) is the largest of the five offshore plastic accumulation zones which exist around the aquatic world. It is located between California and Hawaii and it is estimated that it includes somewhere between 1.15 and 2.41 million tons of plastic waste. The GPGP covers an area of about 1.6 million square kilometers. That means that there is a huge area in the Pacific Ocean, between California and Hawaii, 3 times the size of France (e.g.) which is full of accumulated plastic trash. Other Garbage Patches are located in the Atlantic and Indian Ocean, but this one is the worst.

As already mentioned above, plastic is a non-biodegradable material and therefore it may take hundreds of years for it to vanish completely.

As a result, there are plastics floating which are older than 50 years of age.

This verifies the fact that plastic and microplastic is one of the greatest, if not the greatest, enemies of the Oceans.

All these plastics accumulate, forming the largest Garbage Patch, under the influence of ocean currents and more specifically by the North Pacific Gyre, which is a large

system of circular currents formed by global wind patterns and forces created by the Earth's rotation (as National Geographic defines it).

The Great Pacific Garbage Patch is of course a huge dead zone as it makes life there extremely unfriendly and dangerous for all marine animals and sea birds.

Marine animals are getting trapped as they find themselves surrounded by millions of plastic items or die after ingesting dozens of plastics which they've mistaken for food. The surface there is completely blocked by the enormous size of the plastic waste patch and therefore sunlight cannot pass through. As a result algae do not grow as it would have been expected.

Despite the many horrific effects of the GPGP to the environment, we can thankfully spot 2 positive results of this Garbage Patch.

- 1) First of all, it forces us to better understand the size of marine pollution and the impact of plastics to our Oceans.
- 2) Secondly and most importantly, it makes cleanup of the Ocean much easier. Many of the plastics which exist in the Ocean are accumulated in 5 specific locations. So, cleaning these 5 locations would be a great first step, although there are many other steps we need to take in order to protect our oceans and restore them.

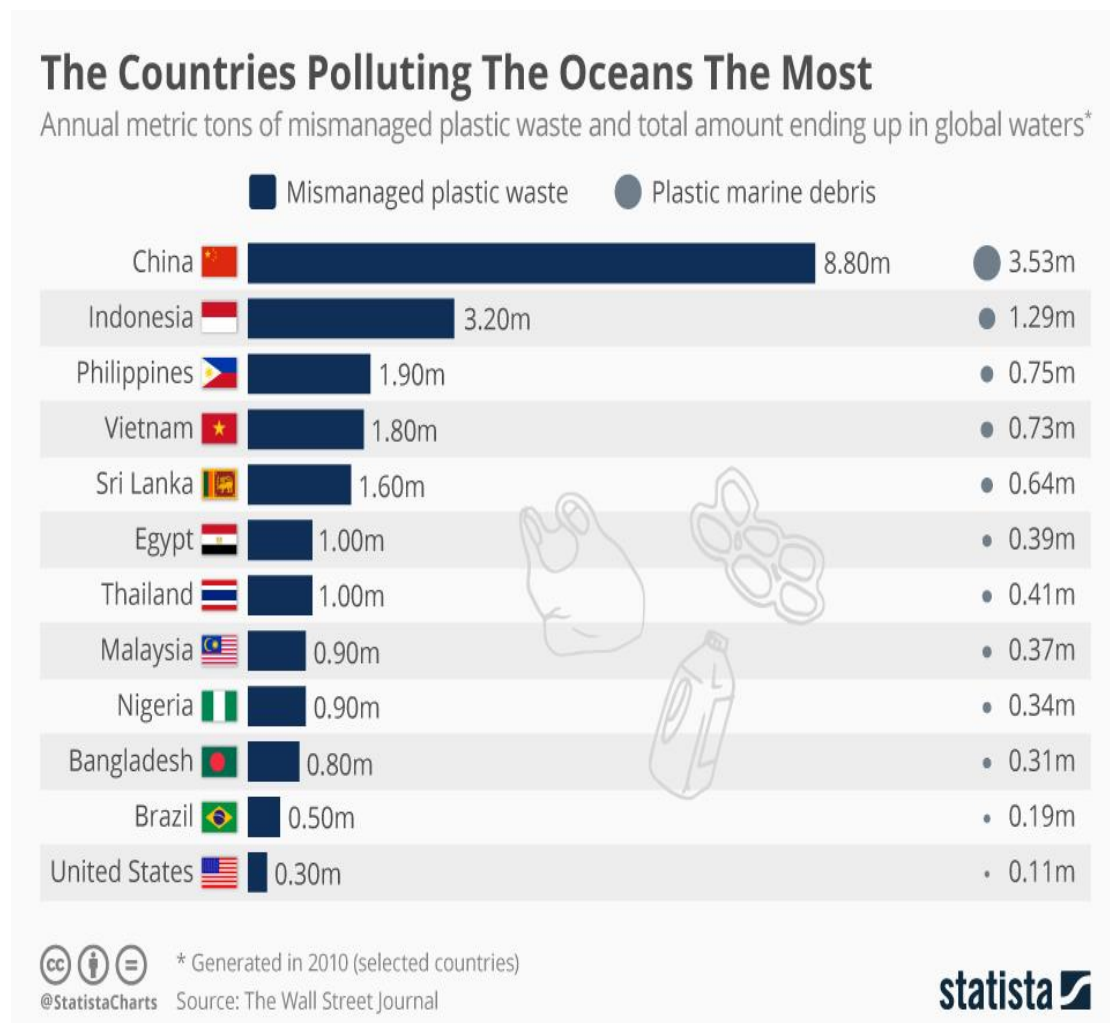
Plastics and microplastics are now widespread in the oceans. Plastics are literally found everywhere, even at the deepest known location, the Marianna Trench.

The leaders in Plastic Pollution

With all this fuss about plastic and microplastic, their impact on the environment, the scientific warnings about the “not so promising” future of our oceans and the international campaigns against plastic which occur everywhere lately, it is worth digging a little more in the subject and pointing out which countries are the top leaders of plastic littering.

In 2010, a team of researchers in the U.S. and Australia led by Jenna Jambeck, who is an environmental engineer at the University of Georgia, made an extensive analysis regarding plastic waste in our Oceans. The result showed that the biggest problem, regarding plastic pollution, comes from Asia and more specifically China and Indonesia.

An enormous number of 3.53 million metric tons of plastic waste found their way from China into the Ocean, while 1.29 million metric tons of plastic ended up in the Ocean from Indonesia. Together these 2 nations account for more than a third of plastic waste, according to a recent report in the Wall Street Journal.



2.6

Coral Reefs and Plastic

Unfortunately, even coral reefs are not unaffected by the “plastic plague” which tortures our oceans.

According to a new study, published in the journal “Science”, **plastic is associated with disease on coral reefs.**

The researchers examined 159 coral reefs in the Asia-Pacific region and more specifically, reefs near Myanmar, Indonesia, Thailand and Australia.

They concluded that the presence of plastic raised the risk of disease in coral reefs by **89%!** On the other hand, Corals without any plastic around them had only 4% of being affected. The spikey coral species had

also more chances of accidentally catching a plastic item and therefore more chances of being affected. The percentages above are true for the following diseases: skeletal eroding disease, white syndrome, and black band disease, all of which can quickly kill corals.

“Plastic debris stresses coral through light deprivation, toxin release, and anoxia, giving pathogens a foothold for invasion”. (Quote by science.sciencemag)

Coral Reefs are of huge importance as they support marine bio-diversity, protect coastlines from the damaging effects of waves, provide shelter for many marine organisms, and are the source of nitrogen and other essential nutrients for marine food chains that play a key role for our ecosystem in general.



RICHARD WHITCOMBE/SHUTTERSTOCK.COM
SOURCE: SCIENCEMAG

Chapter 3

Acidification and Climate change: Their Impact on our Oceans

Our Oceans are already facing great difficulties due to human activities globally. Plastic pollution, marine littering, heavy metals and oil spills are only some of the issues which degrade the aquatic environment.

In addition to the above Climate Change is also here, bringing with it major concerns and scientific upheaval.

A consequence of climate change is ocean acidification which furthermore threatens pelagic food webs and ecosystem function.

3.1

Ocean Acidification

By the term “Ocean Acidification” we refer to the ongoing decrease in the Ocean’s pH. This phenomenon is caused by the uptake of carbon dioxide (CO₂) in the atmosphere. The Ocean is slightly alkaline with a pH value of 8.1 on the pH scale. Ocean Acidification means that this value constantly and steadily falls and heads towards a neutral value. More specifically, the pH of our Oceans tends to reach 7, a value which is not acidic but not alkaline either.

This sounds like a tiny difference but the results could be disastrous as marine life would be detrimentally affected.

Ocean acidification is closely related to climate change and this is why some scientists called it “climate’s change equally evil twin”. The reason why these 2 phenomena are related is because when one is taking place, then the other will follow. The unnatural increase of the Earth’s average temperature is a result of human activities. One major factor which affects heavily the Earth’s temperature is gas emissions, like carbon dioxide. At the same time carbon dioxide in the atmosphere dissolves in the ocean resulting in ocean acidification. This is the reason why climate change and acidification are related: because they have a common parameter, **carbon dioxide**.

In the past scientists thought that this might be a good thing, as carbon dioxide was dissolving in the ocean and so less carbon dioxide was released in the atmosphere, slowing down climate change. But what they did not know was that oceans which behave as a sponge, when it comes to carbon dioxide, would experience a change in their chemistry.

Scientists did not worry about acidification, also because of natural “buffering”, as rivers carry enough dissolved chemicals from rocks which end into the ocean and this natural procedure keeps the pH stable.

But the amount of carbon dioxide which is released in the atmosphere, especially the

last decade, is so huge that natural buffering cannot maintain a stable pH.

The problem with ocean acidification is that it happens so rapidly, especially in the last years during which the emissions of carbon dioxide are greater than ever, and so marine animals do not have enough time to adapt to this change.

It took millions of years for marine species to evolve and they did that under specific conditions. Changes did happen through the millions of years of life on Earth, but in most cases changes were taking place slowly. A natural change in the Earth's conditions could take several thousands of years and during this period of time, marine and non-marine species had enough time to adapt and evolve in order to survive.

But this time things are quite different. Ocean acidification is not a result of a natural procedure, but a result of abusive, human activities which were escalated after the industrial revolution. As technology evolves the environmental damage becomes greater. The amounts of greenhouse emissions increase every year and therefore more and more carbon dioxide dissolves into the oceans.

Ocean Acidification is especially problematic for corals, oysters and other marine animals with a carbonate skeleton or shell. These animals are already getting affected by the acidification as they are vulnerable to even the slightest drop in the ocean's pH. Another group which is getting affected by the ocean acidification is the so called: "*coccolithophores*".

Coccolithophores are single-celled, plant like organisms that live in large numbers. They belong to the plankton family and more specifically in the phytoplankton category. We already mentioned in a previous chapter why plankton species are indispensable for our ecosystem and how dramatic changes we could have if their populations decrease.

3.1.1

Marine life in danger because of Ocean Acidification

As we already mentioned before, ocean acidification occurs when carbon dioxide in the atmosphere, produced by human activities, dissolves in the ocean.

The amount of carbon dioxide, which is created by numerous human activities – mostly industrial based, is colossal.

On one hand, the Ocean works as a brake, absorbing the unwanted effects of the gas which would cause a much faster and more intense climate change. But on the other hand chemical reactions happen inside the Ocean when amounts of carbon dioxide interact with the Ocean's chemical composition and as a result the ocean becomes more acidic.

Once again we need to clarify that when we refer to the word “acidic” we mean that the slightly alkaline pH of the Ocean (of 8.1), tends to become neutral, as it drops steadily towards 7.

Even though the pH difference is not great, the environmental concerns from the scientific community are just and fair.

There are certain marine species which will be heavily damaged by this small change in the oceanic pH. These species rely on the pH levels of the ocean in order to build their **calcium-based shells or other structures**.

It is obvious that the world's top scientists, who study the effects of ocean acidification and the changes which already occur in marine ecosystem, have focused their attention on **calcifying marine species**.

Ligia Azevedo, an IIASA (International Institute for Applied Systems Analysis) researcher declares calcifying marine species as indispensable for the ecosystem worldwide. These species have multiple key-roles, as they are a good *food source* for various marine predators, they work as *nursery habitats* for fish and they form a *natural defense* against storms and erosions.

Regarding these key-roles, we have already elaborated extensively in previous chapters about the importance of a species being a vital food source in the marine environment and how it affects the whole food chain.

But what is a “nursery habitat” and why is it important for the marine ecosystem?

In the marine terminology, a nursery habitat is a subcategory of all marine habitats, where juveniles of a species occur, with a greater level of productivity than other juvenile habitats. In other words nursery habitats are specific areas which assist the production of marine species, support their growth, protect them from dangers like bigger predators, provide a decreased level of mortality for these species and form an excellent and safe habitat for several marine species.

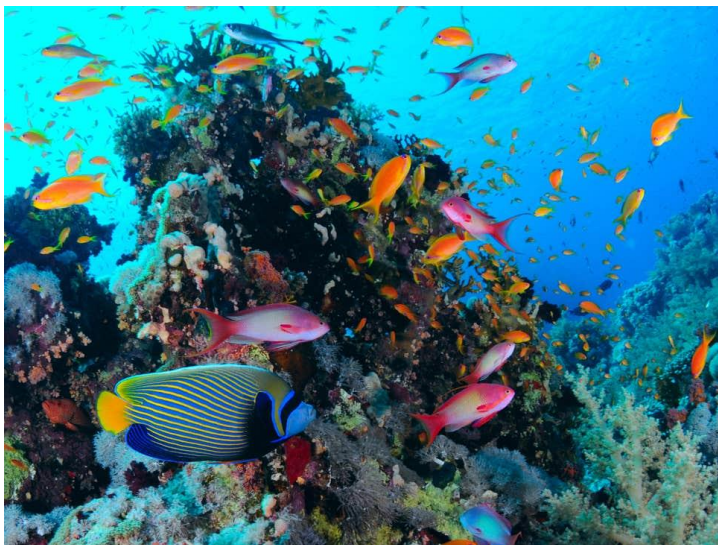
Such habitats could be salt marshes, sea-grass, mangroves (just like the mangrove trees in Karachi, Pakistan who are under great danger because of the port pollution and poor waste management) and of course coral reefs.



The root system of mangrove trees forms an ideal nursery habitat for many marine species. The nursery habitats are extremely important for the marine ecosystem as they support bio-diversity.

Pic source: oceanwealth, credit: Octavio Aburto

Coral reefs, which are an essential nursery habitat for many marine species and play a major role for the ecosystem in general, are constructed of Calcium Carbonate (CaCO₃). As acidification affects calcification, coral reefs are already under existential threat (higher sea temperatures are also a negative factor for coral reefs).



The importance of coral reefs is undoubted. Without their existence the consequences would be dramatic, not only for marine species and the marine's ecosystem balance, but for humanity as well. Among the many threats, acidification constitutes one more, as it affects calcification.

Picture from Independent

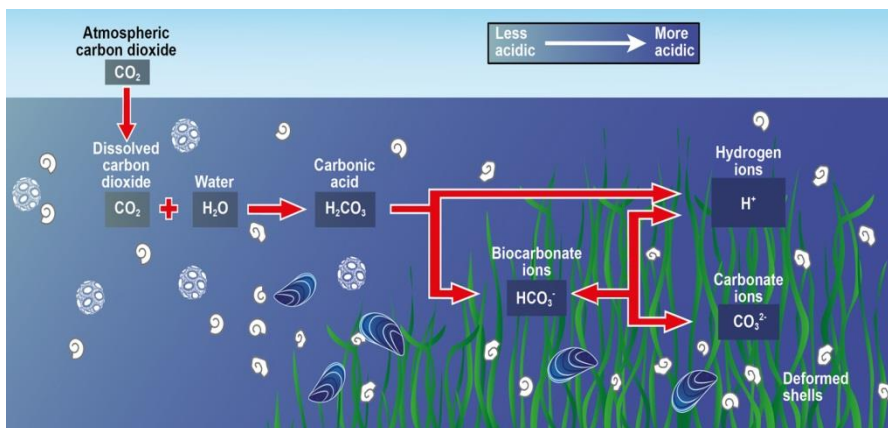
Considering that ocean acidification influences negatively marine calcification and therefore calcifying species, we can easily understand the vast number of species which are threatened.

Oysters, clams, barnacles, mussels, sea urchins, shallow sea water corals, deep water corals, calcareous plankton (like coccolithophores), starfish and others are all affected and threatened by ocean acidification.

All these species rely on calcium carbonate in order to create shells, exoskeletons and other structures which dissolve or are vulnerable to a more acidic environment. Even the slightest change in the Ocean's pH would have a huge impact for these marine organisms.

But these organisms would not be the only victims of ocean acidification. The impacted species would be many more and the whole ecosystem could collapse, as everything is connected. In a dramatic scenario, in which calcifying species and corals have gone extinct, other fish and marine organisms would start to experience immediate difficulties as they were tightly connected to them. Fish populations would drop greatly and therefore marine mammals would starve to death. Countries and communities, in which fish are their main source of protein and food, will starve as well. With marine ecosystems failing, the land ecosystem will follow next, as the one is strictly connected to the other.

In a nutshell, ocean acidification is a result of fossil fuel emissions. Carbon dioxide (CO_2) produced in out of control amounts by human activities pollutes the Earth's atmosphere. $\frac{1}{4}$ of the produced carbon dioxide dissolves in the Ocean's surface. The amount of carbon dioxide dissolving in the Ocean's surface is enormous and therefore chemical reactions occur. These chemical reactions lower the Ocean's pH level, turning it from an alkaline one to a neutral one. Also, a key mineral which exist in the Ocean among the countless minerals the Ocean has, carbonate ions decreases. As a result, calcifying species like corals, oysters, plums which rely on this mineral cannot create their shells, skeletons and biological structures. Their existing carbonate structures start to dissolve. This procedure could result in their mass extinction from the marine environment and therefore many other marine species will be impacted as well. As calcifying species have disappeared, there will be a huge shortage in food resources which would result in a fast decrease in fish and marine mammals' populations. Eventually the whole ecosystem on Earth will collapse.



A picture showing the chemical reactions which occur as CO_2 dissolves in the Ocean's surface.

Source: Plymouth Marine Laboratory (pml.ac.uk)

3.1.2

Possible economic, social and political impacts of Ocean Acidification

The economic impact of Ocean acidification is theoretically already observable. The fishing industry, which has already been downgraded by the decline in fish populations, has to take seriously into account acidification.

The economic crisis in the fishing market and the industries which are connected to this market are the last thing we have to worry about, as the survival of the ecosystem comes first.

But it is true that Ocean Acidification is another factor which will affect the fishing field heavily, a field which is already damaged by pollution.

As we already mentioned in this chapter, ocean acidification will impact many calcifying species. If their populations drop significantly and if the coral reefs of the world become less, then fish will decrease as well. With less food sources available and with less nursery habitats to host juveniles, the world's oceans will become much emptier.

These changes will bring havoc to the fishing industry and all industries connected with it. Economic crisis will strongly hit economies which are based on fishing.

People of these countries will become poor and they will lose a major food source.

This will bring not only economic related issues but social as well. Coastal communities will decrease as people will change location to the hinterland and this will be a result of the downfall in fisheries. Thousands of people will face unemployment.

This entire economic and social crisis will consequently affect the political system and thus political changes might follow. Penalties and law enforcements will focus on industries which produce notable amounts of CO₂ and a low emission policy will be adopted worldwide in order to reverse environmental destruction.

Climate Change

World news media consider Climate change to be one of the hottest topics in their agenda.

Government representatives or even presidents and scientists from all over the world have regular meetings regarding climate change in order to discuss and seek possible solutions.

It is a topic that quite often is discussed in the parliament of each country, in the European Parliament, in social media, in many universities across the globe and it is the reason of many protests around the world.

The climate is really changing and we are already experiencing the first results.

Tropic storms occur in the Mediterranean region, record-breaking high temperatures in the North and a general increase in the average global temperature.

Higher average temperatures also mean warmer oceans and as a slight decrease in the ocean's pH could have a large impact on its life; this is the case again with climate change. A slight increase by 1° or 2° degrees Celsius could result in an enormous outcome regarding the marine ecosystem.

Unfortunately, climate change is even worse than that. The previous goal which was set by many governments was to limit climate change by 2° on average. This scenario now sounds ultra-optimistic and it is almost sure that we should expect even higher temperatures in the future.

Even though scientists have warned us big time about the dramatic results of a permanent increase in average temperature, the reality shows that governments and industries around the globe have not taken drastic measures to fight this “monster” created by the human activities.

Just like acidification, global warming (which we are currently facing) and climate change (which refers to increase or decrease of the average temperature) could occur naturally. It is well known that there were periods in the past when the average temperature here on Earth was much colder or hotter than it is today.

As the scientific community of geologists suggests, at least 5 Ice Age periods have taken place in the past with the earliest one billions of years ago and the most recent one approximately 2.6 million years ago. During these periods the average temperatures were low enough to keep the snow from melting. But there were also periods, like the Eocene period, when the average temperature was higher than it is today. Back then, there were no humans to disrupt the environment and its temperature.

Again, during the Eocene period, carbon dioxide and methane played a major role in temperature increase.

Today, these 2 greenhouse gases, are the main causes of global warming and therefore climate change. The difference between now and the Eocene period is time.

Back then, global warming was caused naturally and during a long period of time, while now global warming is a result of recent human emissions coming from: transportation, industries, intentional fires and animal agriculture.

But how do greenhouse gases contribute to the average increase in temperature?

A lot of people know what greenhouse gases are and the fact that they are bad for the planet. They also know the reason why greenhouse gases are bad and that reason is “global warming”. But what many people do not know is “why” greenhouse gases increase the average temperature here on Earth. How does this mechanism work?

In a nutshell, greenhouse gases are called the gases which have the ability to absorb and emit an amount of the outgoing energy radiated from the Earth’s surface. As the Sun emits shortwave radiation to every possible direction, Earth is caught by this radiation. Once the Sun’s radiation passes the Earth’s atmosphere, first the clouds and then the Earth’s surface absorb it. Then the ground heats up and re-emits this energy as longwave radiation in the form of infrared rays. We can say that the Earth reflects the incoming heat back to space, while most solar energy is absorbed at the surface.

So, when the Earth radiates energy from its surface towards space, these greenhouse gases which exist everywhere in the atmosphere, absorb and emit some of this outgoing energy, trapping it inside the Earth’s atmosphere. Greenhouse gases’ molecules absorb and then re-radiate the trapped energy back to the Earth, preventing it from being released back into Space. This mechanism, in which the Earth’s radiation is absorbed by greenhouse gases and then the heat gets released inside the Earth’s atmosphere, is called “the greenhouse effect”.

Greenhouse gases like carbon dioxide (CO₂) and methane (CH₄) exist naturally on Earth. These 2 gases were responsible for the average temperature being higher than it is now during Eocene period.

During the last two centuries, human activities worldwide, created an unnatural amount of greenhouse gases that literally conquered the planet’s atmosphere. The industrial revolution was the starting point for the mass production of greenhouse gases and later on technological improvements, transportation evolution, industrial competition and recently the excessive and redundant meat and dairy production, clearly triggered the amount of greenhouse gases released in the atmosphere.

All the parameters mentioned above, along with deforestation, fires and other human activities form the main causes of today’s climate change.

Of course there are some natural ways which can also increase global warming, like for example volcanic activities or an increase in solar radiation, but right now these natural phenomena are not the ones who accelerate the change in the world’s climate. In other words, there would be probably no concerns regarding climate change if it depended only on natural phenomena and not on human activities.

It is crystal clear that humans carry the burden for this arising threat and it is humans that should be responsible to take actions quickly, in order to reverse the situation.

The greenhouse gases which we need to reduce significantly in the near future are: 1) Carbon Dioxide (CO₂) 2) Methane (CH₄), 3) Nitrous Oxide (N₂O) and 4) Chlorofluorocarbons (CFCs) or simply “aerosols”.

3.2.1

The Impact of Climate Change on the Ocean

The Ocean plays a protective role for life in our planet and this happens for several, good reasons.

One of these reasons is that it prevents an immediate change in the Earth’s climate. The Earth’s climate changes and that is a fact indeed. But the climate would have changed much earlier if the Ocean did not function as a shield which filters much of the incoming solar radiation.

Twenty five percent of the atmosphere’s carbon dioxide dissolves on the Ocean’s surface and this amount is enough in order to slow down climate change. But this process only slows down the phenomenon, it does not stop it completely and as we saw in Chapter 3.1 it also comes with the cost of Ocean Acidification.

Carbon dioxide and other greenhouse gases which are produced from human activities keep up with the greenhouse effect which becomes more and more intense as gas emissions increase. The Ocean’s protection is limited as it cannot keep up with the unstoppable and unnatural gas emissions and therefore global warming finally takes place. Even if the Ocean could naturally absorb all the carbon dioxide in the Earth’s atmosphere then we need to keep in mind that an even faster acidification, than the one which occurs now, would take place with catastrophic consequences for life on Earth. But in the long run or at least in some years from now, we will probably reach that point when disastrous consequences will take place because of ocean acidification.

A pessimistic but also realistic debate regarding the Earth’s future could be: “What comes first, ocean acidification or climate change?” as both events occur simultaneously and are closely connected to each other.

Hence, as climate is changing and average temperature increase, the world’s oceans will not remain unaffected.

Scientists have noticed major changes regarding the ocean temperatures. Even at depths of 1.000 m, the effects of global warming are observable. When the climate becomes warmer, then the oceanic waters will become warmer and this dramatic change will certainly affect fish (as is already the case).

The migratory, reproductive and feeding behavior of fish is not the only issue here. There are several other issues, at which we also need to pay attention and find solutions rapidly.

If we could put on a list ways in which global warming and climate change affect the ocean, then the list would look like this:

- **Warmer waters:** Fish, marine creatures, mammals and other marine organisms evolved under certain conditions. The environment in which they evolved through thousands or millions of years had some specific characteristics on which their evolution was based on. Even a small change in one of those conditions could hugely impact their lives. We could see differences in the way these marine species act, communicate, immigrate, hunt for food or move. These massive changes in many species would obviously disturb the balance of the marine ecosystem.
- **Ice melting:** Higher temperatures will make the ice melt in the poles. This ongoing phenomenon has already decreased the areas covered by ice considerably. West Antarctica, Greenland and other cold, iced regions have already experienced warmer temperatures and therefore enormous areas of ice have vanished. The continuous shrinking of the poles disturbs the respective, native ecosystems. On top of that, the sea level rises globally and this affects the Ocean in general. Coastal regions are threatened to be wiped off the map by the unstoppable rise of the sea level.
- **Changes in ocean currents:** Warmer temperatures can really affect the winds globally and the winds are responsible for the direction of the ocean currents. This seems not to be a big deal, but in reality currents really affect many marine organisms which rely on them, especially the marine organisms which are unable to swim against it. A big change in the ocean currents could have huge consequences for the marine ecosystem.
- **Climate change affects the chemistry of sea water:** Climate change is closely connected to Ocean Acidification. These two phenomena could be characterized as “Evil twins”. They both share a common parameter which holds the lion’s share for their existence. This parameter is of course the burning of fossil fuels, which generates carbon dioxide (CO₂). Human activities, especially the land-based ones, are the major source of carbon dioxide. The amount of carbon dioxide released in the atmosphere is extreme and with the assistance of some other greenhouse gases, they all together increase the average temperature as they capture radiation and emit heat inside the Earth’s atmosphere. The Ocean which works as a massive shield, which protects us from an even faster and more pronounced climate change, absorbs a large amount of carbon dioxide. But as we have already analyzed in this chapter, this absorption causes Ocean Acidification which as a result reduces oceanic pH, making it almost neutral, thus changing the chemistry of sea water and directly impacting many calcifying marine species.

Warmer Waters

Earth is getting warmer and therefore the Ocean is getting warmer. Changes in water temperatures can really affect many marine species which have evolved under specific conditions. These specific conditions also include stable temperature in which the marine species act, move, grow, reproduce and hunt. Even a tiny change in these conditions can affect the way these marine species live. Therefore, as the climate gets warmer and the Ocean's waters get warmer, many marine species may try to adapt to this change by shifting towards cooler areas. These marine populations will try to find the right conditions in which they evolved and thus they will move to another, new region of the Ocean.

According to the *Climate Change Indicators in the United States* report (EPA's report) over a hundred of marine species have shifted to cooler waters, all the way up the U.S. coastline. American lobster, black sea bass, and red hake are just 3 among the dozens of species which moved their average center of biomass by an average of 109 miles over a period of just 32 years.

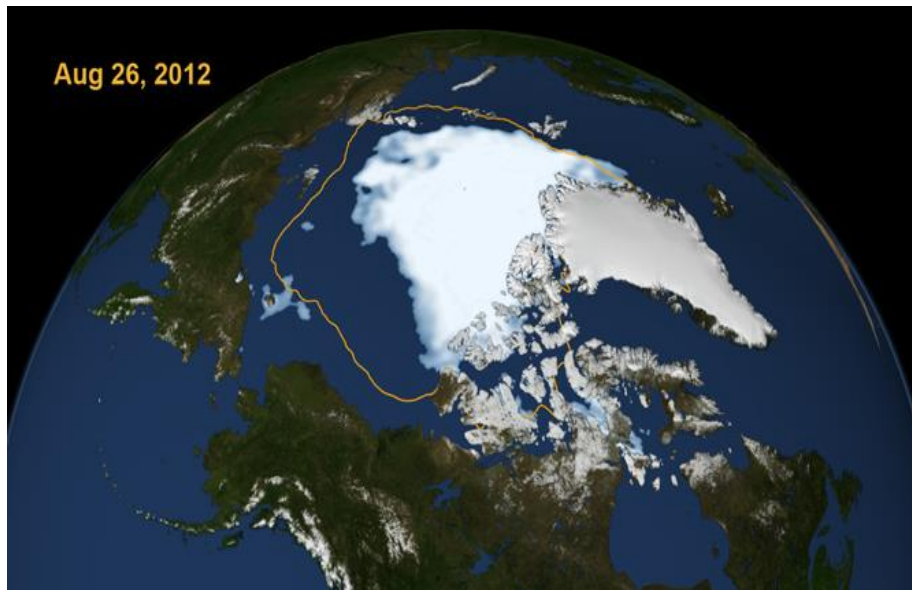
The massive immigration of marine species could have sad ecological and economical results. First of all, many marine species are considered economically important. Which means that they service coastal (and non-coastal) communities by providing them food and assisting economic growth (through fishing and related professions). When these species change their location, that means that nearby coasts will be economically stunned, as a massive decrease in the availability on those species will take place.

But that is not all the bad news. Actually a drop in the coastal economy is really insignificant compared to the real peril which arises from marine species' immigration. When the center of the biomass of a species shifts from one place to another, then we cannot be sure about the consequences. What we do know is that one sea region, which used to be the home of a marine species before is now left without it, while another sea region all of a sudden hosts a marine species which was never meant to be there. In other words, we cannot be sure whether the ecosystem will be disturbed or not when massive changes in its bio-diversity occur. An extreme but good at the same time example is the Black Sea – Alien species incident, in which a marine species arrived to the Black Sea through a vessel's ballast tank and conquered the whole sea. The ecosystem then literally collapsed. Therefore, when massive shifts occur in the Ocean and marine species leave an area for another, in order to find cooler waters, this could really impact heavily the marine ecosystem and lead some marine species to extinction.

Ice Melting

When we talk about the climate change, ice melting is probably the first thing which crosses our mind. A serious amount of ice has disappeared from the Earth, as the poles have shrunk considerably. The unusual high temperatures which are a result of human activities have caused massive ice melting, icebergs to collapse and huge pieces of ice to get separated.

The melting of ice in the poles is so intense that it is clearly observable from space.



This is a picture from NASA which shows the extent of the ice melting, which considered being the biggest “minimum” recorded for more than three decades.

Every summer the Arctic size comes to a minimum. The yellow line above shows the average “minimum” extent for the period between 1979 and 2010. In 2012 though, it is obvious that the “minimum” surpassed by far the average values. This could be considered as a result of the global warming.

During 2012 Greenland experienced huge ice melting and it was the year that according to National Geographic, scientists worried a lot since that was the first time they were experiencing something like that. Although, 2012 was considered to be a really bad year, the ice melting then was just a preview of what may follow the next years.

Indeed, in the summer of 2019 the Arctic ice sea minimum acquired its second lowest ever, after 2012.

“This year’s minimum sea ice extent shows that there is no sign that the sea ice cover is rebounding,” said Claire Parkinson, a climate change senior scientist at NASA’s Goddard Space Flight Center in Greenbelt, Maryland (source: NASA – quote on NASA’s website).

So it is obvious that ice melting does not get any better after 2012. In fact scientists warn us that polar ice will shrink even more in the next years to come.

But what does that really mean for us? How does ice melting affect the oceans and marine life?

The biggest concern regarding ice melting is sea level rise. When billions of tons of ice melt each year then the sea level increases.

First of all, that means that coastal areas will disappear as the sea level can rise up to several inches, depending on the amount of melted ice.

A possible rise of sea level because of global warming could seriously affect billions of people.

According to the U.N. Atlas of the Oceans, 8 of the world's 10 largest cities globally are coastal or very close to a coast. Almost 40% of the world's population lives nearby coasts. This 40% equals to about 3 billion people who will be heavily affected if the ocean level rises dramatically.

If that happens then coasts and whole cities will disappear, massive immigrations will occur with people moving in the hinterland. The damage will cost trillions of U.S. dollars. The soil on which agriculture could be supported will be contaminated by sea salt and other minerals. Many land animals will be affected as their food sources will vanish.

Some scientists predict that thousands of islands could go underwater. As sea level rises, islands like Maldives, Marshall Islands, Solomon Islands, Fiji, Palau, Seychelles, Cook Islands to name but a few, could disappear, in less than 100 years from now.



A traditional village on the Tarawa lagoon, Kiribati. (Matthieu Rytz) (Source: Washington Post)

According to an article posted in Washington Post, Kiribati, a nation of islands in the central Pacific is facing annihilation as the rising ocean level has already destroyed

several villages and has broken through several fresh water ponds. In some years from now the Republic of Kiribati could exist only in our memories.

But humans are not the only ones who will be affected by the increase in sea level. Marine animals, marine birds and semi-marine animals are threatened even with extinction as their natural home melts and the sea level rises. Their extinction sounds like an extreme and very pessimistic scenario but in reality global warming could do this in some decades from now.

Animals, which totally depend on ice, are seals, walruses, polar bears, penguins and others.

All the animals above spend a serious amount of their life outside water. They use the ice to rest, eat, hunt (polar bears), socialize with their own species and most importantly they use the ice to lay eggs (penguins) and breeding.

Harp seals for example use the ice to give birth. Once the pups are born, they spend a considerable amount of time on ice for nursing and resting. That means that these marine mammals are not ready since day 1 to spend the rest of their lives in the Ocean. The ice melting caused by global warming forces the pups to jump into the Ocean more times, even when the pups are not ready. That makes them vulnerable to various threats as the baby seals lack experience and have not yet adapted to the marine environment. As the ice melting forces young seals to the Ocean more often than normal, American scientists found a connection between stranded seals, which were found on the U.S. coastal region, and ice melting.

As the young seals lack experience, it is very usual for them to get lost while discovering the marine environment. This of course causes stress to these species as they miss completely their direction.

We have already referred to the food chain and the importance of it multiple times during the previous chapters. We explained how all marine species are related through the food chain and how the extinction of one species could cause the collapse of an entire ecosystem. Acidification for example threatens calcifying marine species, but at the same time it also threatens all the marine species which feed on them.

In this case, ice melting affects the seals, which spend less and less time on ice.

Therefore polar bears are also affected, as seals are a vital source of food for them.

As we delve more into the icy food chain we can see better how everything is connected. Sea ice is coated with a greenish-brown mat made up of many algae species, as National Geographic mentions. Zooplankton eats this type of algae and gets eaten by many fish and other marine creatures. These fish and marine creatures are eaten by seals and beluga whales which also inhabit the ice region. Seals and beluga whales are eaten by polar bears. That clearly means that if you take out one of these species which were mentioned above, then the polar ecosystem will not be the same again.

So, ice-melting is clearly disturbing the balance of the polar ecosystem as polar bears can go extinct with their food sources dropping every year. Young seals are forced more and more to stay into the water, even when they are not ready to do so and their breeding is obviously affected heavily as the available ice covered area declines.



Penguins also use ice in order to lay eggs. Male penguins take care of the eggs as female penguins go for an extended hunting trip. It is clear that ice is indispensable as it provides several services for many marine animals, especially for those which spend a significant amount of time outside the water. The polar ecosystem is thus experiencing an enormous crisis which will probably prove to be irreversible. Ice forms a natural habitat for a vast number of species and therefore it should remain untouched.

Finally, the issue of ice melting could threaten other marine animals as well. As the sea level rises, animals like sea turtles that lay thousands of eggs on several beaches around the world may experience difficulties with the procedure. The rising sea level can cover several coasts and beaches and then sea turtles will need to find different destinations in order to lay their eggs.

3.2.2

The main reasons behind climate change

Climate change is beyond any doubt the biggest threat humanity faces nowadays. The world's average temperature has already increased and the results are already observable in nature. Ice-melting, unusual high temperatures which are responsible for long-term dry periods, tropical storms which cause massive floods at places which cannot handle them, changes in the chemistry of the ocean, warmer seas and the possible extinction of many species are the main consequences of climate change. As we already mentioned above, the climate has changed many times in the history of our planet. Ice ages or very warm periods, which lasted for thousands if not millions of years, have taken place in the past. All these periods when the climate was warmer or colder than it is now, occurred in a natural way. But this time is different as humans are forcing the climate to change in an unnatural way.

There are 2 main reasons behind this unnatural phenomenon that we need to focus on regarding global warming and climate change:

- Greenhouse gases
- Deforestation

These 2 are the main causes of global warming which are a result of human activities and each of them can break down to some more subcategories.

Of course, there are some natural causes which can also lead to climate change, such as volcanic activity and solar energy.

Therefore, it is more important to focus on the causes of global warming for which humans are responsible. If we have the knowledge of what we do wrong, then we can take actions in order to limit the causes. Although, experts do know which human activities are responsible for climate change, yet no actions have been taken so far in order to combat the problem; or at least efficient actions have not been taken.

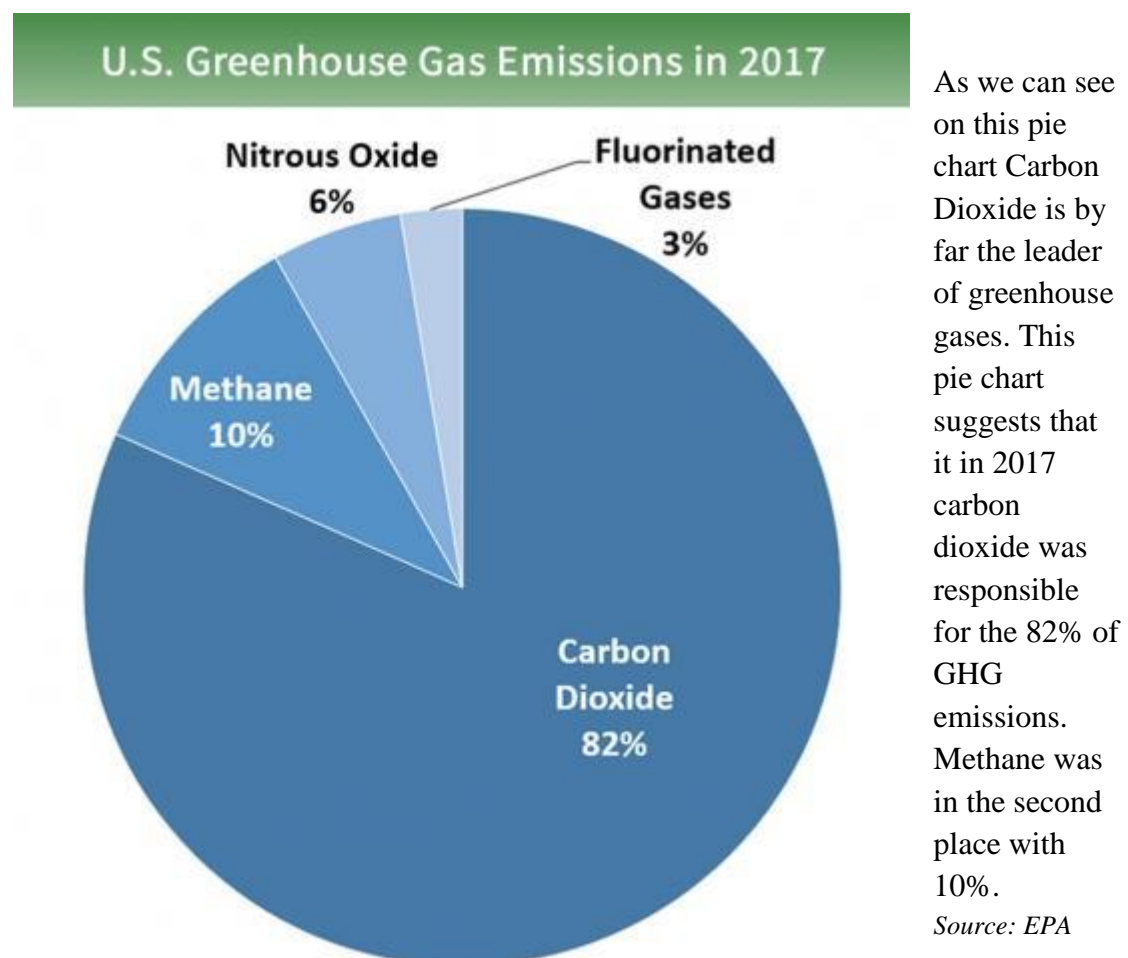
The main sources of Greenhouse Gases

Previously, we talked about the greenhouse gases (GHG) and how they trap heat inside the Earth's troposphere, resulting in a global warming phenomenon. We focused on carbon dioxide (CO₂) which is the main concern regarding greenhouse gases, but we also mentioned other types of GHG like methane.

Therefore, it is now wise to delve into the main sources which produce greenhouse gases uncontrollably, as a result of human activities.

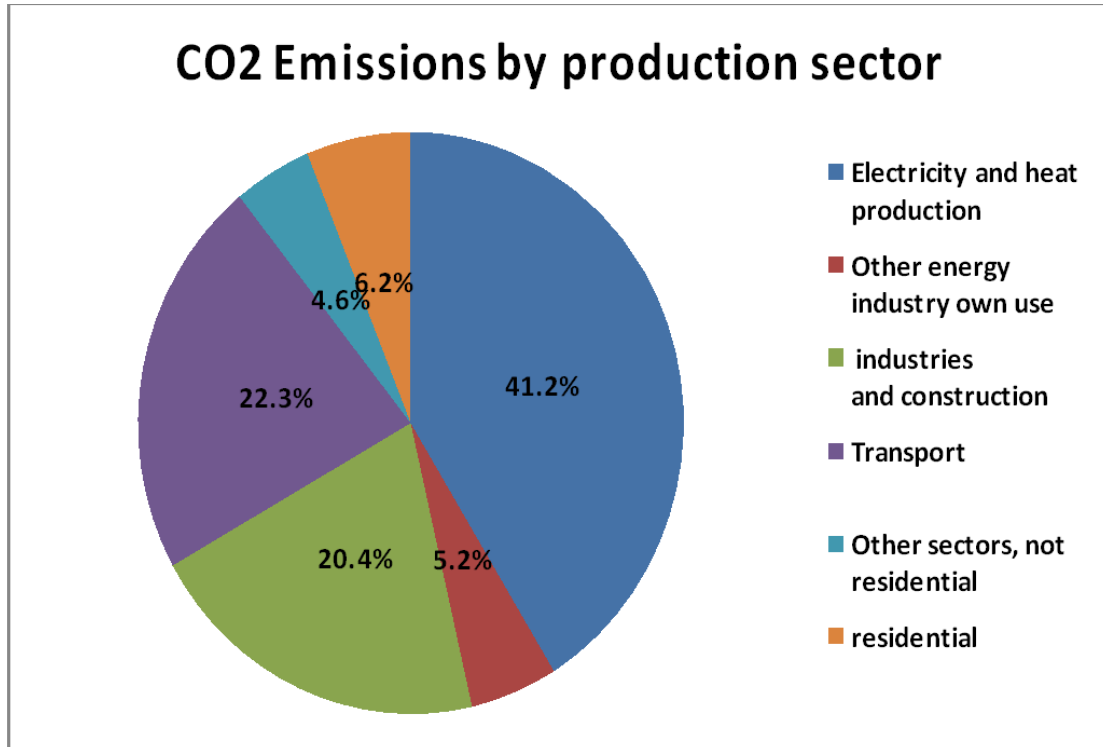
Carbon Dioxide (CO₂) can be found all over the Earth's atmosphere. It is the most common greenhouse gas which has catastrophic results in the environment, especially in the amounts it is released in the atmosphere. It is responsible for Ocean Acidification, which is of major concern for the scientific community and a major contributor to global warming.

Methane (CH₄) is another greenhouse gas produced by natural sources, such as emissions from animals as they digest food (livestock), natural wetlands, biomass burning (like forest fires) and others.



But which sectors are responsible for the production of carbon dioxide?

The statistics change through the years as industries evolve technologically. None the less, some specific sectors always remain at the top of the list of carbon dioxide producers.

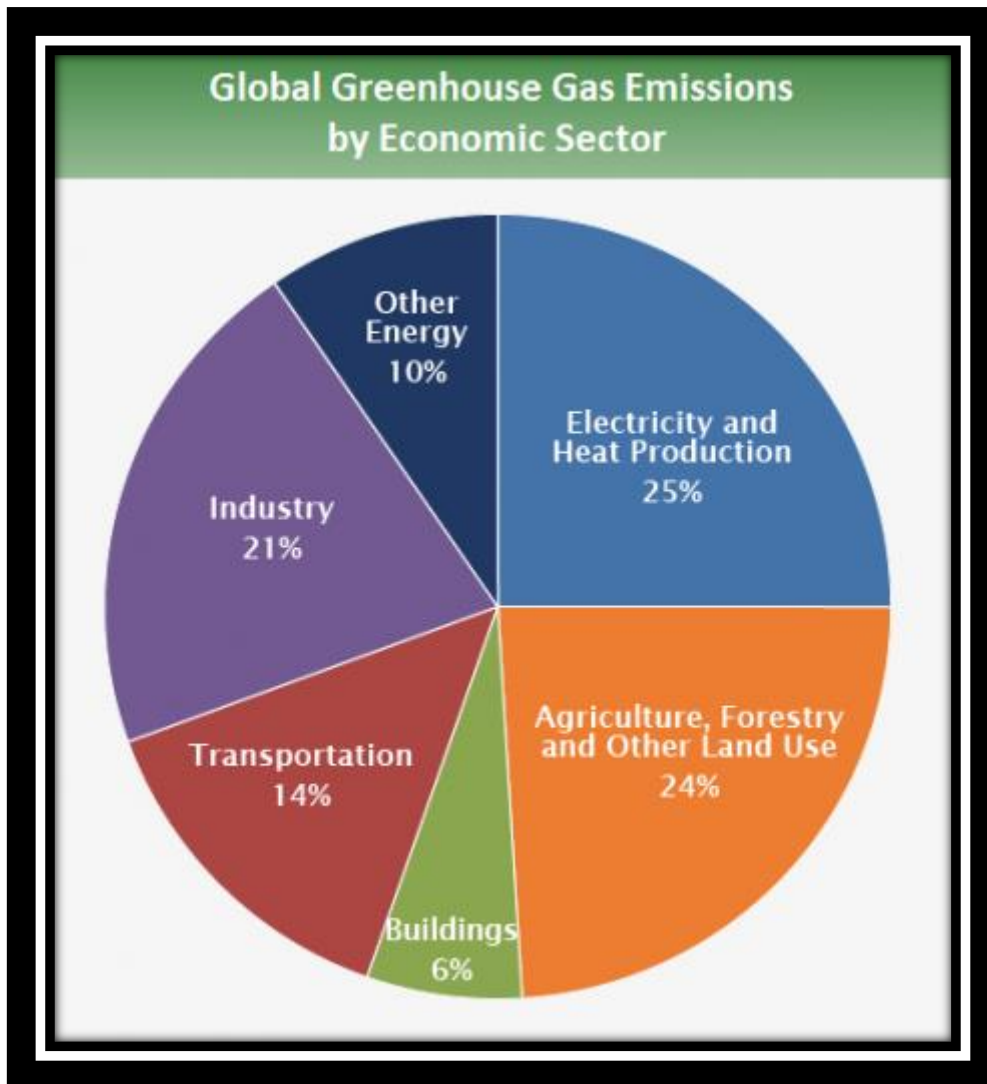


CO2 Emission percentage by production sector in the world, source of data IEA.

When it comes to carbon dioxide the energy sector holds the lion's share. Electricity and heat production lead the carbon dioxide production as they are responsible for 41.2% of the total CO₂ in the atmosphere. If we also add the 5.2% of other industries then we conclude that the energy sector is responsible almost for the half the total carbon dioxide production.

Transportation is also a major player on this with 22.3%. Millions of cars, trains, maritime vessels, airplanes and all means of transportation are responsible for a large amount of carbon dioxide which is released in the atmosphere.

These statistics differ from time to time but they surely give us a good overview on which sectors produce the most CO₂.



Source: EPA

When we introduce the rest of the greenhouse gases to the pie chart the statistics change again. The pie chart above includes not only carbon dioxide but all the possible greenhouse gases which are produced by different sectors.

Again the electricity and heat sector leads the greenhouse gases race, but a new sector is introduced in this pie chart. Agriculture, forestry and land use are responsible for 24% of the total greenhouse gases.

Contrary to the popular belief that transportation is the main producer of greenhouse emissions, in reality energy and agriculture are by far more important contributors.

How Animal Agriculture Affects the Climate

During the last decades, a lot of scientists have clarified that meat and dairy production is not as innocent as we think it is.

Many studies conclude that livestock and meat consumption leave a large environmental footprint on Earth. In other words, meat production and animal products really damage the planet and support global warming.

A study published in the *Journal Science*², created a huge dataset based on 40,000 farms in 119 countries and covering 40 food products which account for almost the 90% of what is globally eaten. The study focused on the environmental impact of these foods and concluded that agriculture is responsible for a serious number of environmental issues. Like mass extinction of wildlife (as deforestation occurs and trees are replaced by livestock), enormous fresh water consumption, air pollution and of course Greenhouse gases emissions.

But this study is not the only one which confirms that meat consumption has a huge environmental impact. Many others support this idea and advise people to cut down on the amount of meat in their diets.

Even a UN (United Nations) report has suggested that people should switch to a more plant-based diet in order to tackle the ongoing climate change.

According to UN statistics livestock animals easily outnumber humans, as the total of chickens (19 billion), cows (1.5 billion), sheep (1 billion) and pigs (1 billion) is about 21.5 billion.

All these animals which belong to livestock have a huge environmental impact regarding climate change.

Methane emissions coming from these animals boost global warming but that is not the only issue. Livestock needs land and therefore many trees are cut down in order to open space for livestock.

So, extreme meat consumption has led to an extreme increase of livestock animals and therefore greenhouse gases (methane) have raised and deforestations have occurred. The environmental impact is much bigger as it includes 1) Water consumption 2) Land use 3) air pollution 4) and the creation of antibiotic – resistant bacteria.

But methane indeed is a greenhouse gas and therefore it triggers global warming even more. But why is deforestation connected to climate change?

² Title: Reducing food's environmental impacts through producers and consumers

Authors: J. Poore^{1,2*}, T. Nemecek³
22nd February 2019

Deforestation

Trees are essential for supporting life. They produce habitat for wildlife, they produce the oxygen that we all need, they support bio-diversity, they protect us from floods and they have a vast number of other roles. Just like the oceans, forests are indispensable and without them life, at least as we know it, would not be possible. Thus, among the many roles that forests have, they also protect us from carbon dioxide just like the Oceans. But the Oceans do that in the cost of Ocean Acidification, while forests do that without any cost.

Carbon dioxide (CO₂) is necessary for plants and trees to grow. During photosynthesis, trees and plants absorb carbon dioxide from the atmosphere, store carbon above and below ground and produce oxygen as a bio-product of photosynthesis.

As the United States Department of Agriculture mentions: *“Forests in the United States absorb and store about 750 million metric tons of carbon dioxide each year, an amount equivalent to 10% of the country’s CO₂ emissions.”*

This means that forests not only absorb a great amount of carbon dioxide but they convert it into oxygen through the biological procedure of photosynthesis.

Sadly, just like our oceans, forests did not remain untouched by human activities. Huge areas of trees have been taken down by hand or fires. Humans need open lands for many reasons related to economy. They need lands in order to build industrial zones, new towns, they need lands in order to invest in livestock and of course they need land for cultivation. We need to mention at this point that most of the land which is used for agriculture is connected to livestock, as billions of animals globally need to feed in order to grow and later on reach our plate.

But as deforestation in most cases is prohibited for environmental reasons, every year thousands of fires turn trees into ashes with the governments across the world searching for whom to blame.

From January 1st to September 12, 2019 there have been 36,286 wildfires. Indeed some of them could have started accidentally or by a natural phenomenon, but that is only a tiny percentage.

As the forests decline every year, less carbon dioxide is absorbed. The amount of carbon dioxide produced each year increases or remains on approximately the same levels, but the number of trees around the globe drops rapidly.

On top of that, the thousands of wildfires which take place annually form another huge source of carbon dioxide, as the burning trees release CO₂ to the atmosphere and other greenhouse gases like methane. This means that humans transform their shield against climate change into “fuel” in order to accelerate global warming.

Among the thousands of wildfires which took place in 2019, the wildest and most painful was the Amazon forest wildfire.

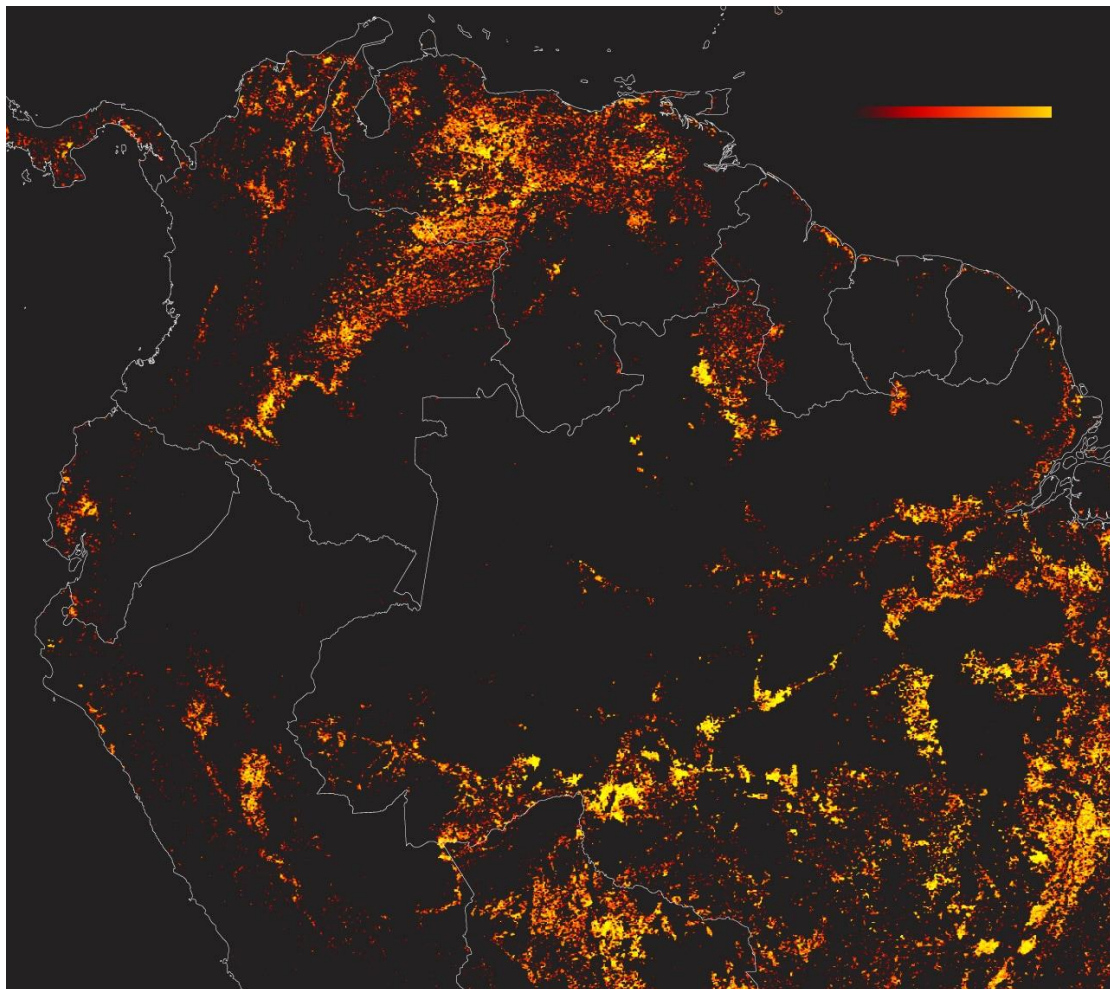
The Amazon rainforest is responsible for the production of the 20% of the Earth's oxygen and therefore it is also called as "The lungs of the Earth".

But humans decided to reduce and damage the Earth's lungs by putting several fires across the Amazon.

According to National Geographic, the Amazon has already lost around 17% of its total size over the past 50 years.

From August 15 to August 22, 2019 around 2,240,000 acres of the Amazon's trees were burned.

That proves that despite the scientific warnings about the global warming and climate change, people continue to do their best in order to damage the environment.



Source: Washington Post

As the Amazon crisis rises, fingers are pointed to the farmers of nearby locations who are accused for putting the fires in order to use the land for their own goals.

Chapter 4

Overfishing

Among the numerous threats that our oceans are currently facing, overfishing could be considered a major one. Fish populations and marine life in general are already declining as climate change, acidification, plastic and general littering slams the world's seas. Billions of fish die every year as a result of human, shore or ashore activities.

As humans have not put a limit yet in regards to air pollution, carbon dioxide production, deforestation, plastic usage and many other harmful for the environment activities, it is obvious that they would not control and manage properly fishing. The fishing industry and more specifically over fishing is a major threat to marine life.

Unlike land animals, of which the number of the slaughtered ones is known by FAO (Food and Agriculture Organization of the United Nations), the fishing industry does not produce a respective number. We only know how many tons of fish are caught every year. This happens as fishing is a much more massive practice than animal agriculture. A single catch by a fishing boat may include thousands of fish trapped inside their fishing nets.

But the question remains and it is indeed a wise one. How many fish do we catch per year? This question is important as seas run out of fish and scientists predict that by the year 2048, most of the fish will have been wiped out. Although, there is no official number which determines the number of fish caught by the fishing industry, there are some studies which try to estimate the number by using data for specific fish catches. These studies also use FAO reports (tonnages captured per single species, tonnages captured per multi-species and tonnages captured per general categories). According to such a study, (Fish count study: sector 4) which used all the available, official data, it is estimated that 0.97 – 2.7 trillion wild fish are caught globally each year.

The study concludes that there is a big need for reducing these numbers immediately. Another four-year study, led by Dr Boris Worm, of Dalhousie University, Nova Scotia, a scientist in the fields of “Marine ecosystem”, “Marine Biology”, “Fisheries science” and other related fields, projected that by year 2048 the world's currently fished sea-foods will collapse.

He stated: *“This is what is projected, not predicted, to happen. I am confident we will not go there because we will do something about it. But if this trend continues in this predictable fashion, as it has for the last 50 years, the world's currently fished sea-foods will have reached what we define as collapse by 2048. Every year a higher percentage of the currently fished stocks has collapsed. We are losing it piece by piece”*. (His statement was found on Telegraph UK).

The statement above clarifies that the future collapse in marine populations and therefore fisheries is a fact and not a prediction. Scientists now are sure about the

future outcome of over fishing and they can clearly see future threats.

Prof Callum Roberts, of the University of York, who was not involved in the study, said: *"The animals and plants that inhabit the sea are not merely embellishments to be wondered at. They are essential to the health of the oceans and well-being of human society."* (His statement was found on Telegraph UK).

What Prof Callum Roberts states, is that the marine ecosystem is heavily disturbed by human activities which include over fishing. All the marine species play a key role sustaining and maintaining the balance of the marine ecosystem, which balance also connects with the land based ecosystem. All species are important and are irreplaceable parts of the whole ecosystem, but over fishing is threatening to damage its balance.

But what do we define as “overfishing” and which parameters convert a simple fishing activity to an overfishing abuse?

To make it simple and perfectly clear, overfishing occurs when too many fish are caught.

But that action could also be considered as a very productive catch. So, which factor separates fishing from overfishing?

The difference between fishing and overfishing is that fishing follows the international (or national) rules regarding the number of fish which a fishing boat is allowed to catch, while overfishing occurs when an abusive fishing action is performed which does not comply with fishing regulations.

More specifically, overfishing is simply catching way too many fish at once and as a result the breeding population of a species (or many species) does not have the privilege to recover in numbers. Over fishing is connected to fish numbers decline while regular fishing gives to the respective species the opportunity and the time to recover their populations.

Also, overfishing is not necessarily a single or a one-time action. This process is in most cases repeatable and hence millions of fish are caught in a very small period of time and consequently their populations drop dramatically. Commercial fishing, which carries the burden of overfishing, has dropped the fish numbers considerably the last 50 years as researches have concluded. In order to increase their profit, commercial fishing boats can even use fishing tactics which are both harmful for the marine life and illegal, in respect of law.

The main reason behind overfishing is without any doubt: profit. Commercial fishing aims to increase their profitability by increasing uncontrollably the number of fish they caught. Their speculative goals lead commercial fishing to poor fishing management and therefore to the abuse of the marine life.

4.1

Overfishing threatens specific species

Empty oceans could be the result of overfishing (along with other human activities which damage the marine life) in some decades from now. But in the short term future, there are some specific species which are really threatened by extinction as overfishing affects their populations.

The fishing tactics which aim for good catches, meaning thousands of fish at one single catch, cannot be controlled easily. Therefore many endangered species are caught among the thousands of other fish. Sometimes the fishing boats will realize that “accidental catch” soon enough and then throw the unwanted animal back to the Ocean, while in other cases the endangered marine species has already died or even injured lethally. This unwanted catch is called “bycatch” and it is the reason why billions of unwanted fish are caught accidentally many of which are endangered species and many of which also die.

To conclude, overfishing does double damage to marine life. First of all, it catches fish in such a volume, and therefore fish populations drop rapidly and have no chance to recover. Secondly, overfishing is connected to bycatch, which means that many species are caught accidentally, while some of them are already endangered.

The damage of overfishing triples if we consider that a possible decrease in one species numbers could be associated with the decrease of another species numbers, as the second one relies on the first one regarding food sources.

Some of the endangered species which are threatened by “bycatches”, as a result of overfishing, are:

- 1) **Atlantic’s Halibut** (it is categorized as endangered by IUCN, the International Union for Conservation of Nature).
- 2) **Blue Fin Tuna** (a beautiful tuna species which is the largest in size and the most endangered. According to IUCN the Blue Fin Tuna is endangered).
- 3) Several types of **Sharks**, many of them endangered species
- 4) **Atlantic Cod** (U.S. and Canada have categorized these fish into the “Avoid list”)
- 5) **Atlantic Salmon** (along with many other types of Salmon)

There are certainly many more endangered species which are having their populations decline as a result of over fishing.

But the Atlantic Ocean is not the only place in which endangered species could face extinction because of over fishing. According to a report by the International Union for the Conservation of Nature (IUCN), which report was funded by the European Commission, several species are currently facing extinction in the European Seas because of it.

To be more specific, “*more than 90 species of marine fishes in Europe’s waters are threatened with extinction*”, as Allie Wilkinson (a science journalist) notes.

Many species in the Mediterranean Sea, The Baltic Sea, the North Sea, the Black Sea and the European part of the Atlantic Ocean are experiencing intense overfishing actions and as a result their populations drop in numbers.

Scientists warn the European Union as the Mediterranean Sea, a sea which hosts a great biodiversity of 10.000-12.000 species, is hugely impacted by human activities which include pollution and overfishing, while climate change and acidification do not make the situation any better.

As we have already noted, the problem with the Mediterranean Sea is that it is a Sea surrounded by land, with only a small opening through the Gibraltar canal. Therefore, marine pollution and overfishing are exponentially worse within the waters of the Mediterranean Sea.



Almost 60% of fish stocks in the EU are unsustainably fished. (Source: Euractiv. Author: Paola Tamma)

While overfishing takes place, a single catch can produce thousands of fish at the same time. Among the so wanted catch many other unwanted marine species are caught accidentally, while some of them are endangered species.

Overfishing is responsible for billions of fish discarded back to the sea, dead or alive.

4.2

Illegal fishing practices and illegal fishing: Another form of Overfishing

As we already defined overfishing, it is the action which abuses fish populations and drops their numbers seriously. Thousands of fish are caught at the same time, in one or even more catches and the frequency in which overfishing happens does not let marine species to recover their numbers. Therefore, the Oceans become empty, certain species face extinction and the whole native ecosystem is under attack.

If for example a Sea or a local ecosystem is the habitat of 20 million sardines and then a fishing boat catches 2 hundred thousand sardines in one catch, and this action reoccurs in a small period of time, then that local ecosystem's sardines will face extinction as their numbers drop rapidly. The situation becomes even worse if more than one fishing boats occur in that area. Sardines will not have enough time to reproduce during the breeding season and therefore their number will collapse.

But what happens when a marine species population is already low? Is it considered “overfishing” if you fish a small amount of a species which is already rare?

In this case, overfishing is not about numbers. A fishing boat does not have to catch thousands of Blue Fin Tunas in order to be accused of “overfishing”.

Blue Fin Tunas for example are endangered species and it is really difficult to find one. That is why some countries, like Japan for example, pay a serious amount of money, even millions if you bring them a big one. So, technically “Blue Fin tuna overfishing” cannot even take place, as there is no chance to find more than 5 or 6 at the same place and at the same time.

But overfishing is not only about numbers. It is also about ecosystem harassment and fishing abuse. It is about disturbing the marine ecosystem and threatening species with extinction.

So, from a theoretical point of view, if a fishing boat could somehow target only sharks or endangered salmons in the Atlantic Ocean, then even if its catch would be small, still the ecological damage would be huge as these species are already low in numbers. So, abusing a species which numbers are already in decline could be also characterized as a form of “overfishing”.

Even the compounds of the word: “over” and “fishing” make it crystal clear that “overfishing” occurs when someone is fishing over the acceptable amount.

Thus, when a species is already endangered and protected by International lists, then even a single catch could be considered as “over-fishing”.

Other than that, in most cases it is strictly prohibited to catch intentionally species which are endangered (or at least during specific seasons). Such a catch is clearly illegal.

Overfishing is illegal as it seriously damages the environment and the economies of many countries. Along with overfishing, fishing in restricted areas, fishing of specific marine species, catching fish with prohibited methods and fishing within protected areas, are all considered as illegal actions.

We already elaborated on why overfishing is an illegal action and how it threatens the marine ecosystem and it is quite obvious why fishing inside protected or forbidden zones is illegal, or even how dangerous it is for the environment to target endangered marine species; but which fishing methods are illegal?

First of all, **explosives** form an illegal way of fishing. Explosives, dynamites or “blast fishing” as it is called, is a prohibited method of fishing, (almost) globally!

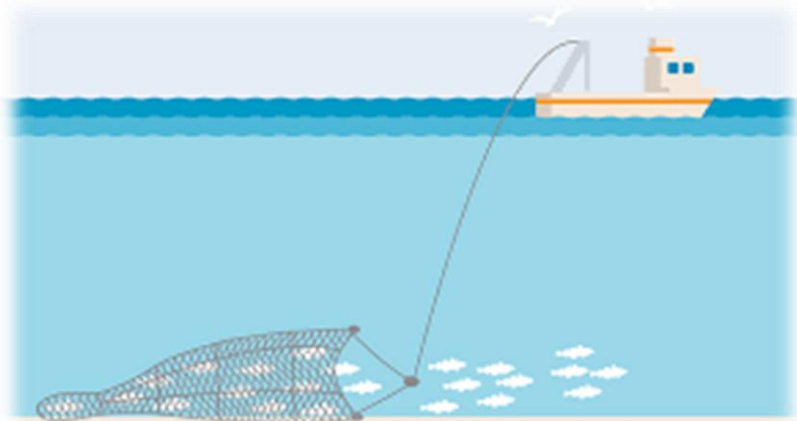
Only in the country of Tanzania, on the central eastern coast of Africa, blast fishing is considered legal.

Blast fishing is really disastrous for the marine environment as it kills every species which are near the explosives and this includes endangered species. Also, in many cases it damages coral reefs which are also impacted by the explosions. On top of that, the explosion produces a great amount of noise which, as we have already noted in Chapter 1, forms a type of marine pollution (noise pollution and disturbance of the marine ecosystem).

Another type of illegal fishing (illegal in many countries) is “cyanide fishing”, in which fishers squirt concentrated sodium cyanide onto reefs in order to stun fish or other marine animals. Later on, they capture the stunned species mostly to trade them in the aquarium market or in the live fish market. But in many cases cyanide kills fish, corals and other marine organisms.

Last we have “bottom trawling”. It occurs when a fishing boat drags a huge net across the Sea floor, scooping everything on its way. In many cases it harms sharks, sea turtles and even coral reefs. It is

an action of overfishing which can even affect plankton species and therefore the whole food chain. Bottom trawling is also referred to as “dragging” and in many cases it is illegal.



Beyond any doubt, these actions (overfishing and illegal fishing) deserve to be among the greatest dangers which threaten the marine world.

Many governments have tried to implement some measures in order to fight the threat of overfishing but the sad truth is that they failed horribly. Overfishing continues to exist globally and as a result the oceans are running out of fish.

The laws are there but there is a huge lack of real implementation. The sad truth is that in most cases international or national laws do not work properly when it comes to the marine world and there is indeed a good excuse for that. The Ocean is chaotic and it is quite difficult for the authorities to trace illegal actions.

But as the clock is ticking and the Ocean is running out of time, governments really need to find a way in order to protect the Oceanic world from illegal actions that harm our ecosystem.

Overfishing has also a serious impact on the economy. As we have already explained, overfishing lowers a marine species numbers so fast that there is no recovery and reproduction time. Therefore fish become fewer and that has an impact on the economy. Fisheries run out of fish and consequently their profits drop. People lose their jobs all around the world as the fishing sector slowly collapses.

Then a social crisis arises as unemployment strikes coastal and non-coastal regions. Countries and coastal cities which depend on fish experience a protein and food crisis in general.



Picture's source: National Geographic

Above we see Pacific Bluefin Tunas which are listed as endangered species by **IUCN**. Nonetheless, some countries do not prohibit fishermen to catch Pacific Bluefin Tunas, as it is considered a very expensive fish (because of its rarity) which can be sold for hundreds of dollars per kilo. Unfortunately, it is considered as an exquisite dish which is quite popular in Asia and very attractive for sushi eaters. Therefore, Bluefin Tunas are traded in Tokyo's market a lot.

4.3

Whaling, Dolphin Hunting and Seals

In sub chapter 4.2 we explained how over fishing does not always refer to huge numbers but in some cases it is defined by the kind of the “catch”. For example, hammerhead sharks, fin whales and blue whales are only some of the many marine species which are categorized as “endangered”. If fishermen decide to illegally catch some, they do not need to catch thousands or even hundreds of them in order for their actions to be considered as “overfishing”. Depending on the kind of the marine animal, overfishing could be considered as a catch of thousands of fish or even a small catch of a species which faces extinction. Therefore, whales, many types of sharks, dolphins and seals could come face to face with extinction in the near future, even if a much smaller number, in comparison with other marine animals, is caught every year.

Whaling is the word that describes the hunting of whales. It is considered as a very old practice or even ancient, as there is strong evidence that whale hunting commenced thousands of years ago (around 4.000 years ago).

Whaling, which includes the hunting of all types of the whale family, escalated at the 16th century when fishermen used to hunt whales and sell their products in the market. Basques are considered to be the first to catch whales massively for commercial purposes. Until then, whaling was just regional, done by people who lived near the coasts and their food was depending on fish.

When whaling entered the fishing sector, there was another product except for meat which was produced by whales and became very popular between the 16th and the 19th century. That product was whale oil and it was used for a variety of reasons, but most importantly it was used as lamp fuel and for soap production. With no electricity through all these years it is quite obvious why whale oil was so famous in the market.

But even nowadays, when whale oil does not have a significant use in our society, as fuel lamps were replaced by electricity, whaling still occurs.

Some countries are still hunting whales, even though they are endangered, for 2 basic reasons: The first reason is “Economy” and the second reason is “Tradition”.

In some countries whaling has a long history which continues to write pages today, despite the fact that these pages are both bloody and disrespectful for the marine ecosystem.

In 1986, commercial whaling was banned by the International Whaling Commission (IWC) as the number of whales around the world dropped greatly.

The decision was taken by IWC some years earlier and more specifically in 1982 when the International Whaling Commission decided that there should be a pause on whale hunting, starting from 1986. This pause continues until now with some exceptions as Norway, Iceland and now Japan are still killing whales for commercial

purposes. The IWC's whaling ban is also known as "whaling moratorium" and prohibits the hunting of whales for commercial goals. They clarified though that whaling could be considered completely legal as long as it is limited and aboriginal. In other words, whaling is legal, as long as a country's exclusive economic zone does not forbid it and the whale hunting is performed by natives but not for economic purposes.

So despite the fact that whaling is officially banned since 1986, many countries still allow it by using the window that IWC opened by permitting traditional and non-commercial whale hunting.

Some of the countries in which whaling occurs are Canada, Faroe Islands, Indonesia, Philippines to name but a few.

Iceland, Norway and now Japan are supporting commercial whaling and therefore they do not comply with the whaling moratorium. Japan recently pulled out of the International agreement after 30 years, as the country's request for a more commercial friendly modification was not satisfied. So at July 1st 2019, Japan started again whaling for profit.

After three decades, Japan decided to send their fleet again in order to capture whales for commercial purposes, a decision that shocked the world and prompted outrage among activists.



Picture's source: dw.com

Whaling is the main reason why whales have lost an enormous number of their population. It is estimated now that only 10,000 – 25,000 Blue whales now exist worldwide. Before whaling, the largest population was in the Antarctic, numbering approximately 239,000.

Bowhead whales are possibly in an even worse position than Blue whales as it is estimated that a number somewhere between 8,000 and 12,000 reflects their real population.



The Blue Whale is an enormous marine creature with million years of existence. It is one of the largest known animals to have ever lived on this planet. It can only be compared in size with the biggest herbivore dinosaurs which lived millions of years ago. But Blue

Whales are still here, among us. However, the existence of this magnificently gigantic creature is not certain as human activities dropped their populations significantly.

Whales are not just giants who inhabit the Earth's Oceans. Whales are much more than that and their existence is crucial for both the food chain and the environment. Most types of whales belong to the top of the marine food chain; therefore they are categorized as "Apex predators" or "Alpha Predators". If you remove the head of the food chain then the whole ecosystem can collapse. In this case if whales go extinct the marine ecosystem will certainly collapse as the phenomenon of "trophic cascade" will commence. Whales are not just top predators; they also control certain species populations to a normal level, while assisting some other marine organisms to thrive. More specifically whales eat tons of krill, a species which feeds on algae, zooplankton and phytoplankton. With no whales around, krill population would increase and therefore phytoplankton would collapse.

On top of that whales are closely connected to phytoplankton as they help it to reproduce. Whale feces are high in iron and nitrogen which are important minerals as they fertilize phytoplankton when they reach them near the Ocean's surface.

Furthermore, when whales swim from the depths of the Ocean back to the surface in order to breathe (as marine mammals do), they knock phytoplankton up to the sunny surface and that helps phytoplankton to photosynthesize and reproduce.

In the previous chapters we explained the importance of phytoplankton in the food chain, as it provides food for many marine species, and for the environment, as it produces oxygen and absorbs carbon dioxide from the atmosphere slowing down climate change.

With no whales in the Ocean, the food chain would totally collapse and the humankind would face environmental issues immediately.

Unfortunately, whales are not the only marine mammals which suffer from human activities. Dolphins and Seals are facing the same issues that whales do. Although, just like whaling, dolphin hunting and seal hunting is considered illegal, as these species are endangered, pretty much the same countries which allow whaling also allow the killing of dolphins and seals. In some countries marine mammals hunting is a practice of survival, while in some others it is done for industrial fishing purposes. Many dolphins become victims of the so called “Dolphin Drive Hunting”. A method used to drive dolphins and other small cetaceans into a small bay where the unlucky creatures find a horrific death by hand. Once the dolphins are driven to the small bay a real massacre begins which literally turns the water red from the liters of blood. This inhumane method is very popular in Taiji, Japan and in the Faroe Islands.

Some activists managed to capture this horrific picture which shows dozens of dolphins and some small whales dead, as natives sliced them to death near their heads. This incident, which is very common there, occurred in the Faroe Islands which is not the only place on Earth where such practices take place (picture source: businessinsider.com).



Just like dolphins, seals may have the same fate in some countries like Canada. As Seal hunting is legal there, the poor mammals are very often killed by a rifle or in a worse scenario by clubbing. People who hunt seals often use a club and deliver several hits to the Seal’s head. Or they use a specific weapon, specially designed to kill Seals, called “Hakapik”. It is a painful and inhumane method of killing.



Chapter 5

Conclusions and Solutions

This dissertation aimed to provide information to the reader about how human activities, mostly industrial-based, have harmed the marine environment.

In the chapters above we mentioned and analyzed all the important issues which the global Oceans are currently facing. We focused on how the marine ecosystem is disturbed and what the future consequences could be. In some cases, human actions like overfishing will certainly do have massive consequences, while in some other cases like the climate change or the plastic pollution, the scientific community is not exactly certain which the results will be.

Scientists are sure that plastics, global warming and Ocean acidification will have a catastrophic impact to the environment but we cannot be one hundred percent sure how severe the outcome of ours actions will be.

Overfishing can be based on statistics and numbers and therefore it is estimated that by 2050 (or even earlier than that) the world's Oceans will become almost empty.

In conclusion, the Ocean and its life are getting abused in an uncontrollable degree.

Marine pollution due to plastics and microplastics grows annually. A diet which includes fish is nowadays possibly dangerous for the human health, as marine pollution has contaminated many marine species with plastics and heavy metals. Coral reefs, which are vital habitats of many marine species and a key factor of the marine ecosystem in general, are also endangered by the marine pollution, as plastics and other toxic trash have made them vulnerable to diseases.

Although oil spills are not a daily threat, when they do happen the results are chaotic for marine life which gets affected by the incident.

Climate change and Ocean acidification are two phenomena which come together as a result of the massive production of carbon dioxide due to human activities. Both become worse as forests decline and phytoplankton lowers in numbers.

Overfishing occurs globally as some parts of the fishing industry do not understand that this practice makes it only worse. Many decide to catch as many fish as they can, an action which decreases rapidly the fish population and leads many endangered species to their extinction.

On top of that, in some countries natives and fishing companies target marine mammals, like seals, dolphins and whales without taking into account that these species are already low in numbers. A scenario, in which whales have gone extinct, is a disastrous scenario which would certainly destroy the entire marine ecosystem. However, if the marine ecosystem comes to its doom, then it is only a matter of time for the remaining ecosystems to follow.

Solutions

Regarding marine littering, it is important that the World's leaders will finally implement an environmental policy which has no place for the offenders and ensures the Ocean's integrity. Therefore, heavy and not sustainable fines should be given to any industry that does not comply with the rules. So far, in most cases, the penalties for the offender were affordable and not deterrent. The new policy which shall be implemented in order to save the environment, must work the opposite way. The fine for the potential offender should so catastrophic that it could lead even a huge company to bankruptcy. This would be a great deterrent for the possible offenders who will double value their actions.

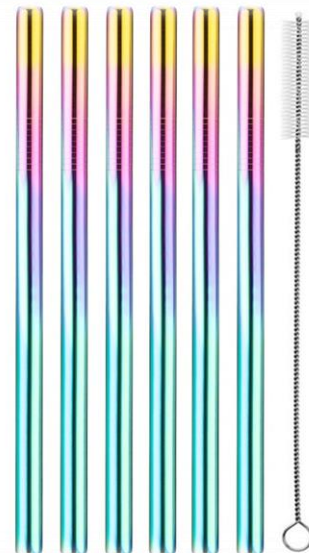
Except for the above policy, all the governments around the world need to change philosophy and move to the next step regarding plastic production.

Some measures have been taken already in many countries which have increased the taxes in regards to plastic items. Furthermore, many companies have now excluded plastic cups or bags completely from their service, while others have adapted a rewarding system for the customers that use reusable items. But further actions have to be done, as plastics continue to be a massive issue. Trillions of plastic materials, including cups, bottles, straws, wraps and bags are produced annually. Therefore, governments should take more extreme measures, like reducing by law the plastic production globally. Governments should also fund startup companies which aim to produce alternatives of plastic bags, cups, straws and others. That would totally motivate new entrepreneurs to get involved in this industry.

For example metallic straws could replace plastic straws which are not even recyclable. Billions of plastic straws are produced each year which are not used more than 2 times. Metallic or bamboo straws for example could take over plastic straws and this would be already a massive, ecological change if it is followed worldwide.

Metallic straws, which last eternally and are easy to clean, could benefit economically consumers as well, as consumers would buy them only once, unlike plastic straws.

Coffee shops and other related companies could use paper straws instead, if they are afraid that some consumers could steal the metallic ones.



There are also reusable bags which could replace the plastic ones or reusable cups and bottles. Consumers all around the world and especially in Asia, which is considered the plastic leading continent, should get informed by their governments through campaigns, about how they can replace plastic with reusable items and act accordingly. Each country, should also participate in a massive funding which will aim to clean the Oceans globally. Some studies estimate that such an action requires up to \$50 billion in order for it to have efficient results. Considering, that countries have given much more all these years for armies and defensive weapons, it should be really easy to gather this amount, especially if the participants are many.

Regarding climate change, scientists have already proposed solutions. The UN lately, suggested that among the many changes we should all make, people could definitely switch to a plant-based diet. Many other studies come to this conclusion. The animal agriculture is responsible for a serious amount of greenhouse gases and for serious usage of land. These lands which are now used for agriculture (in order to feed billions of animals annually) and for livestock could become forests.

Scientists conclude that a plant based diet, a vegetarian or even better, a vegan diet could reduce greatly our environmental footprint.

This switch would also support the marine world, as fish also are not included in a plant-based diet. Therefore, fishing would be replaced by cultivation and the fish population would instantly grow again.

The American Diet Association and the British Diet Association, along with many other studies and official announcements, have clarified that both vegetarian and vegan diets are healthy and beneficial if they are balanced. Therefore, people could easily make the switch, as no lack of nutrients or deficiencies will occur.

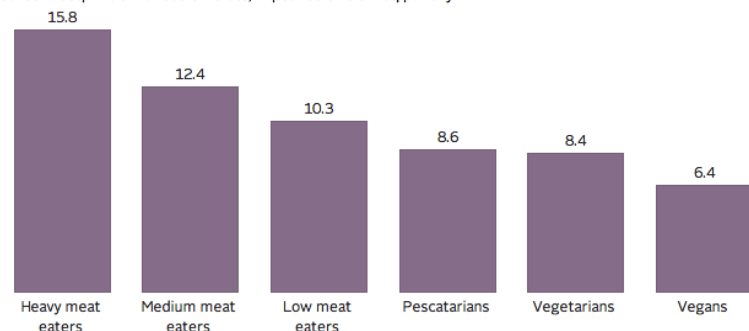
Furthermore, according to a study from Oxford University, a vegan diet could reduce the carbon footprint up to 73%. The percentage is enormous but totally realistic if we consider that a notable amount of greenhouse gases would vanish, forests would grow bigger, whales would not be hunted and as a result the marine ecosystem will thrive. On top of that, people who switch their diet for environmental purposes tend to reduce their plastic usage as well.

Another study on climate change which examined the carbon footprint of each diet, concluded that plant based diets are much better for the planet.

Author: Peter Scarborough

Less meat, fewer emissions

Carbon footprint of various UK diets, in pounds of CO₂-eq per day



Source: Scarborough et al. (2014)



Governments must also return forests back to normal.

Although, China has already planted billions of trees the last four decades, some scientists are concerned as some trees are not native to the region.

A well-organized planting strategy should be followed globally, with trees that match in each region in order to expand our forests again.

Also, Amazon's burned grounds should be restored completely and immediately. The countries of Latin America should invest money and time on this effort in order to save both the climate and the continent's biodiversity. No farmlands should be allowed there and the offenders who will try to use the burned lands for the own benefits should be jailed.

A more ecological way of energy production and a more ecological fuel should be used in order to reduce fossil fuels' emissions. Vessels should invest on scrubbers and governments should assist this market in order to motivate ship owners to use them. Car owners should also invest in a more ecological way than petroleum.

Over fishing would be totally destroyed if most of the humans on Earth change their diet. Other than that, just like with marine littering, governments should follow a more strict policy with heavier penalties for the offenders. Whaling on the other hand should be banned completely for all countries regardless traditions or coastal economies.

In a nutshell:

- 1) Governments should follow strict polices with heavy fines (not affordable fines)
- 2) Plastic should be replaced by bio disposable and reusable items
- 3) Governments should invest and fund Ocean cleaning
- 4) Meat consumption should be reduced drastically
- 5) Whaling should be banned completely and other countries should penalize countries which do not comply, with economic retaliation
- 6) Governments should follow strict polices with heavy fines regarding overfishing

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Note: All the sources used on this dissertation are considered official or reliable.

King regards,

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