How to save the oceans and fight climate change

The GOES Report… on water pollution, green chemistry and practical strategies we can follow to effect change now.

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There is one good thing that has come out of Covid. With no tourists causing extra wastewater pollution, sunbathing or swimming off beaches, we are witness to the health of coral reefs and coastal marine ecosystems recovering all around the world. There are a number of reasons for this, and one of them is particularly surprising. We don't immediately think of cosmetics or sunscreens being toxic to marine life, but the reality is remarkably different.

Many of our cosmetics contain an ingredient called oxybenzone. It is used in products to protect us from the damaging effects of UV light from the sun. Sunblock is probably the wrong name for this cosmetic ingredient, because oxybenzone does not block UV light, it just changes it to a longer, less energetic wavelength that is safer for human skin. But, in changing the wavelength free radicals are released that are really dangerous, especially to corals, algae and plankton, and to a lesser degree, people. The chemical itself is relatively non-toxic, but the way in which it reacts with sunlight, plastic particles and nature makes it just about the most toxic chemical on the planet.

We ask ourselves, when chemical companies manufacture a product, or when Governments provide a license to allow the use of a product, are these alarming synergistic factors considered?

We now know that oxybenzone is horribly toxic to all marine life, especially the tiny planktonic plants and animals and coral reefs. [1],[2] When cosmetics, containing oil-like (hydrophobic, water-hating) products such as oxybenzone are washed off from your skin into the sea, they form a film on the surface of the water. The next time you are on a beach, with a lovely calm sea, check it out, you will see a toxic oil slick trailing behind sunscreen coated swimmers.

When the sea becomes turbulent, the oil slick becomes dispersed throughout the water to form an emulsion of droplets. Oil hates being in water, so it forms tiny spheres, or sticks onto particles, especially hydrophobic micro-plastics which act like sponges to absorb oily chemicals. The presence of microplastics in the sea is well documented [3][4] and they are everywhere, from the Tropics to the Poles, from the water surface to the deepest trenches [5][6][7], even down to 11,000 metres below the surface. More than 200,000 tonnes come from car tyres[8] and 80,000 tonnes ends up on the snow and ice in Arctic, with most of the rest ending up in the oceans.

There are more particles of micro-plastics in the world's oceans than animals, even when you include the smallest microscopic zooplankton. Take a litre of seawater from almost any location and there may be up to 10 particles of plastic visible to the naked eye. There may also be over 100 particles too small to see without a microscope, but they are there none the less.

Oxybenzone is just one of many hydrophobic very toxic chemicals. Here is the thing: if we dissolved just one teaspoonful (5ml) in 100 Olympic sized swimming pools, this is equivalent to a concentration of 62 parts per trillion[8], and this is enough to stop coral larval stages seeding new coral reefs, and is one of the key reasons why we have lost more than 50% of the coral reefs around the world. Chemicals that are toxic to nature are also toxic to humans and oxybenzone is no exception.

Regulators look at chemical risks on the basis of there being safe concentration to nature and humans, but the sorry story is that there is no such thing as a 'safe' concentration for these hydrophobic chemicals, because when they get sucked onto micro-plastic sponges their concentration is amplified many thousands or even millions of times. Coral, plankton, small fish, shrimps and a whole host of other animals, feast on these toxic particles. There are now numerous studies[9][3][10][11][12] showing that the particles are mistaken as food by plankton, and because they are at the root of the food chain, all plants and animals in that chain are impacted, including us. We probably don't need to point out that this is also how toxic chemicals are getting into our diet and affecting our health. [13][14] .

The good news is that with "green chemistry" and environmentally aware companies' safer sunscreens are now coming on the market. The bad news is that 75,000 tonnes of oxybenzone could wipe out most marine life in all the world's oceans, and the estimated current global production for this chemical is around 3,000,000 tonnes per year based on it being added at a 1.5% by weight as a UV stabiliser in plastic, paint and adhesives. Around 20,000 tonnes are used every year in sunblock and cosmetics, so next time you buy sun block, check out the label and don't purchase any product containing Oxybenzone. Purchase safer mineral based products using zinc or titanium dioxide unless it has been certified reef safe.

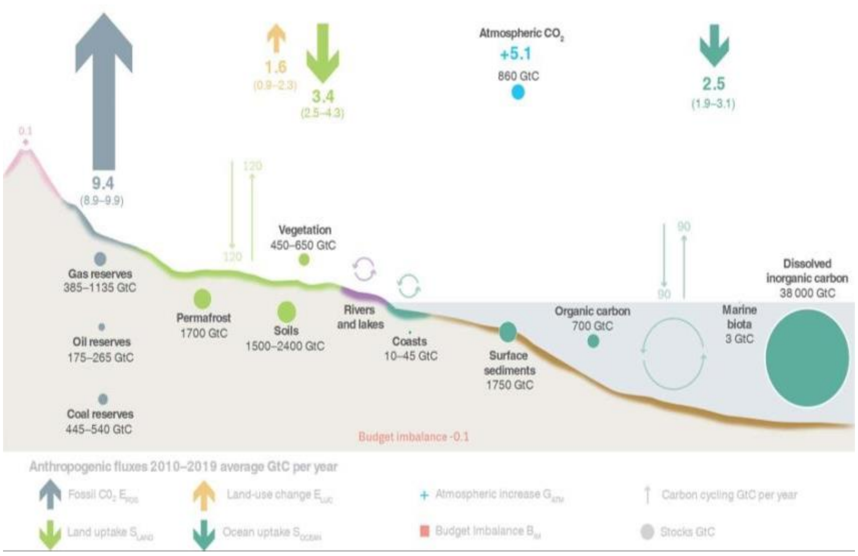
So, while COVID has brought some good news for our oceans, the absence of tourists isn't able to help us with another omnipresent chemical group, commonly known as PCBs. These nasties were banned in the 1970s, but they are so persistent, don't break down easily, and are still wreaking havoc on marine life. Here again, like oxybenzone, we have a chemical group that makes its way up the food chain. It might not surprise you to know, that most of the whales and dolphins found dead on beaches have very high levels of these highly carcinogenic, neurologically damaging and endocrine disrupting chemicals in their tissues.

Snow and ice in the Arctic is no longer white, it is black with carbon pollution and micro-plastics from car tyres[15]. The plastic contains toxic chemicals and allows chemicals such as PCBs to become much more toxic. [17] The tyres also contain carcinogenic chlorinated organics and PAHs[18] The earth's magnetic field draws atmospheric particle pollution down at the poles. The dark coloured ice adsorbs more energy from the sun and melts a great deal quicker than white snow. The planet also adsorbs more energy as a consequence. Pristine areas of the Artic are now grossly polluted and contaminated.

A really insightful study by a European consortium MARBEF[16] found that the concentration of PCBs on particles (mainly small plants called phytoplankton but including microplastics) was 0.7ug/g dry weight in the North Sea and was the same concentration in the Antarctic. The UK NHS [17] recommended that pregnant women should consume no more than two fish a week in order to avoid mercury, dioxin and PCB toxicity to the unborn child. The physiological response of mammals such as humans, is to protect the mother by dumping toxins into the foetus. As stated above, it is shocking that tiny zooplankton are consuming particles loaded with PCBs and other chemicals and then pass them up the food chain to shrimps, fish, seals, birds and whales.

Marine mammals cannot choose to avoid eating fish and cannot avoid all the toxic impact of our pollution irrespective where they live in the world's Oceans. Regulators and governments should be thinking again about the risks posed by the many thousands of chemicals they deem to be low risk and that "dilution is the solution to pollution" means tragedy for all life in every ocean around the world.

There really is no safe place to get away from toxic, hydrophobic chemicals: neither the Southern Ocean nor even the deepest part of our oceans is unaffected. Horrific levels of PCBs have been found in the Mariana Trench, 500km south of Japan and 11km deep under water [18]. Orca whales can no longer breed in Scotland due to PCB pollution [19]. Beluga whales in the St Lawrence River Canada have high concentrations of organochlorines, heavy metals, and benzo-a-pyrene [20] and one of the highest level of cancers in any group of animals ever investigated. Whales washed up on the east coast of the USA were found to have concentrations of lead in their brains 150 times higher than would cause brain damage in children [21].



The evidence is there, the proxies are there, but the actions to protect our oceans and us are, weak, not joined up or totally absent.

It really seems utterly criminal to be losing whales at such an alarming rate due to toxic chemical pollution. These wonderful animals, at the top of the food chain, tend to suffer the most from chemical and substance pollution and are a reflection of what's happening further down the food chain among the plankton.

It surely doesn't take much of a leap to apply the evidence, and the proxies of the manifestation of chemical pollution, to see how this must be impacting on planetary life support mechanisms.

There is no doubt in any of our minds that the process of oceanic/pelagic plankton photosynthesis (primary productivity where CO2 is used to make their food and oxygen) is the key for our climate regulation and stability. When these little plants die, along with the zooplankton such as copepods that eat them, they sink 5000m or more into the abyss and their carbon is locked out of the equation. The abyss is therefore, by far, our greatest carbon sink. For the avoidance of any doubt, carbon is not locked out by the coastal communities of plankton which sit over the continental shelf. At these depths (200m) carbon is recycled back into the food chain.

The abyss is also where most of our persistent toxic-for-ever chemicals like oxybenzone, PCBs and plastics of varying sizes will end up. At this time, there has been no studies on how the toxic layer at the bottom of our oceans could impact on the health of the oceans or our long-term survival.

Data reported in Global Carbon Budget 2020[22], confirm figures for the Earth's carbon budget in terms of carbon dioxide as carbon C: 9.4 Giga tonnes from anthropogenic sources, and 2.5 Giga tonnes Oceanic sequestration. Climate change is caused by the 5.1 Giga tonnes excess. However recent data published after the IPCC report by Woods Hole Oceanographic Institute [23] states that the ocean biological pump, is double what was previously thought. This could therefore raise the carbon sequestration of the oceans to 5 Giga tonnes, but we have climate change and increasing carbon dioxide concentrations in the atmosphere, so this can't be correct.

However, as stated above, we also know that oceanic productivity has dropped by 50% over the last 70 years. It seems logical that, if the oceans had not lost 50% of the planktonic plants, then the carbon sequestration by the oceans would have had the potential exceed the carbon input from fossil fuels and we would not have climate change.

Trees and plants on land sequester carbon, but it is important to note that mangrove swamp trees sequester 30% of this carbon, yet they only take up 0.6% of the land surface area.[24]. Also, most forests are in equilibrium, as trees grow, they adsorb carbon dioxide and produce oxygen, when they die, they consume oxygen and produce exactly the same amount of carbon dioxide they absorbed when growing. The net carbon flux of most terrestrial plants and forests is therefore zero, this is why wetland systems, marsh lands, peat bogs and mangrove swamps are so important. By way of example, the peat bogs of Scotland and Ireland, sequester more carbon than the Amazon Rainforest.

The wetland ecosystems are responsible for absorbing most of terrestrial carbon dioxide, but they take up less than 7% of land area [28][29][30]. The oceans are actually much more important for biological carbon sequestration than reported by the IPCC. Indeed, the GOES team calculate that the oceans sequester more than 4 times more carbon than terrestrial ecosystem and around 50% of all the anthropogenic carbon.

Carbo Flux, Giga tonnes of Carbon as C.	**Global Carbon Budget 2020 data[22]**		**GOES 2021 data**		**GOES 21 Carbon flux if we restore ocean productivity by eliminating pollution**	
	Carbon to atmosphere	Carbon sequestered	Carbon to atmosphere	Carbon sequestered	Carbon to atmosphere	Carbon sequestered
Carbon from the burning of fossil fuels	9.4	---	9.4	---	7.7	---
Terrestrial ecology sequestration	---	3.4	---	0.6	---	1.2
Soil sequestration				1.1		1.5
Ocean ecosystems	---	2.5	---	2.5	---	5.0
Silicate mineral absorption	---	---	---	1.7	---	1.7
volcanoes	0.1	---	0.1	---	0.1	---
Land use change (eg burning trees)	1.6	---	1.6	---	1.6	---
Total carbon flux	11.1	5.9	11.1	5.9	9.4	9.4
Total Carbon to atmosphere every year Giga tonnes of C.	5.2		5.2		**0.00 balance**	

*Note.GOES counters the Global Carbon Budget (GCB) 2020 data. Volcanic emissions were not included, this increased the atmospheric input from 5.1 to 5.2. GCB did not include carbon absorption by silicate minerals which equates to approx. 1.7 Giga tonnes. This drops the terrestrial sequestration from 3.4 to 1.7 (3.4-1.7), however if most terrestrial carbon sequestration is just in mangrove swamps, peat, bogs and marsh lands, then it can't be more than 10% of all carbon sequestration = 5.9 * 0.1 = 0.6. Soil absorption by fungi and bacteria have been included in GOES data, this could be as high at 1.5 giga tonnes at C if we just leave land alone, [32] a figure of 1.1 has therefore been used. However, if we stop using herbicides, fungicides and pesticides on land and just leave it alone, C sequestration increases from 1.1 to 1.5, if we protect and expand mangroves, marsh, bogs and wetlands, given that it is a small land area, it should not be difficult to double sequestration from 0.6 to 1.2. We have lost 50% of ocean productivity, if we eliminate pollution and restore the oceans, sequestration increases from 2.5 to 5.0. Productivity takes 60 years to double on land and only 3 days in the oceans, so if we take the brakes of the ocean ecosystem then the above figures are possible. We then just need to reduce our carbon consumption by 20% to drop it to 7.7giga tonnes/year, and we bring the planet in to balance and save the oceans and terrestrial ecosystems at the same time.*

The oceans are really important, it therefore becomes critical that we try and understand why they are dying. Oceanic productivity (photosynthesis by planktonic plants) and the spatial distribution of pelagic plankton are linked to climate change, ask any good gardener and they will tell you that increased temperature, carbon dioxide, nitrogen and phosphorous, are things that plants love, so there should be a massive growth in marine plant numbers. We do see phytoplankton plants blooming but in a bad way, typically in in coastal zones, where they have been feasting on excess nutrients, they use up all the oxygen, kill much of the life in the water, and ultimately, they also die and leave a dead zone. We are also now seeing phytoplankton blooms in the arctic regions due to rapid nutrient input from melting snow and ice.

In our geological past (70 million years) in the late Cretaceous period, carbon dioxide concentrations were three times higher than today, water temperature at high latitudes was more than 15°C warmer but oceanic productivity was much higher than the current level.

It is our opinion that the real decline in oceanic pH and marine productivity started in the 1950s, when we started to manufacture toxic-for-ever chemicals such as DDT and plastic. Based on papers published in Nature, NASA and others [34] [35] [35][36][37] [38], we have lost 40% to 50% of all life in the oceans and will, over the next 25 years, continue to see a drop in ocean productivity by up to 1% year on year. Over the next 25 years and by 2045 we will have lost 75% to 80% of all marine life.

The decline in marine productivity should not be linked to climate change and we must urgently reframe our thinking on climate change mitigation strategy if we are to find solutions that will work and work fast!

The evidence and most logical explanation for the drop in ocean productivity is that the impact of aquatic pollution from priority chemicals, such as Oxybenzone, PCBs, PBDE, TBT, Mercury, Lead and other priority substances bound up in plastic for which we need examination and global action[33]. A reframe and recognition is urgently needed, and we should now consider that the following are the reasons for climate change:

- Climate change is not impacting on the oceans as much as oceans are causing climate change.
- The drop in ocean productivity is reducing the ability of nature to sequester carbon: if we had not lost oceanic productivity, we may have avoided climate change, but it is not too late to reverse.
- It is not only anthropogenic carbon dioxide, but anthropogenic discharge of toxic chemicals and plastic, that are responsible for destroying oceanic productivity and the planets' ability to sequester carbon dioxide
- Unless we stop the discharge of toxic chemicals and plastic over the next 10 years, there will be no scope to avoid and destruction of the oceans and ocean acidification and avoid the worst of climate change.

The GOES team hope that this discussion paper will highlight to government and regulators, and ring the alarm bells, how very small concentrations of hydrophobic chemicals are affecting our planetary life support systems and that we are heading for a total collapse of the marine ecosystem, upon which all life on earth depends, at pH of 7.95 by 2045

Carbon dioxide in the atmospheres dissolves into seawater to form an acid, and this drops the pH (acidity) of the seawater. There are lots of studies on pH and the pH stability of seawater; it is very well understood chemistry, but in basic terms, the higher the alkalinity the lower the solubility of calcium carbonate, and the more stable the pH.

From the BIOACID group's work [39][40] their data demonstrated for us that a stunning 30% to 50% of Mollusca, Corals, Echinoderms, calcifying macro algae and tropical species are negatively impacted (reproduction) at a pH between pH7.97 to pH8.05. Let's be clear - Oceanic pH is currently 8.05 and its on its way down and the remaining 50% Corals are already screaming out for help. Coral reefs are incredibly important ecosystems, because along with their symbiotic algae, they cover less than 3% of the Earth's seabed, but they are the nursery ground for 25% of all marine life. Coral reefs are also totally dependent on what happens to pelagic plankton[41] in the oceans off-shore, and 0.5 billion people depend directly on corals and their fish communities as a source of food, and for their economy. In fact, the very existence of many island and coastal communities depends upon coral reefs. We could potentially lose more than 80% of the world's coral reefs over the next 10 years.

Why does that matter? [42]Well, we know that the current rate of acidification is over 10 times faster than any time in the last 55 million years, and that during the late Cretaceous period (70 million years ago), ocean chemistry was completely different, with calcium alkalinity five times higher and magnesium concentrations much lower[43].

This really matters, because our oceans have now flipped this calcium/magnesium balance, and now have low calcium alkalinity, and high magnesium concentrations. This change in chemistry makes our oceans much more susceptible to change (acidification) and calcium in the form of aragonite dissolves at a higher pH. Magnesium salts are much more soluble than calcium, so the high magnesium concentrations mean that the shells and skeletons of most marine life become more soluble.

Figure 1 Late Cretaceous sand stone rock from Luz in the Algarve Portugal

In the Cretaceous period, ocean pH was around pH7.5 but remember this was 70 million years ago (when the calcium was high, and magnesium was low) and carbon dioxide concentrations in the atmosphere were actually three times higher and Arctic temperatures 15°C warmer than they are today. But there were no mass mortalities, and the oceans were incredibly productive. Today, ocean chemistry change means they are now 50 times more sensitive to carbon dioxide and acidification because of the drop in calcium alkalinity and the increased concentration of magnesium.

Taking all of the above into account, the GOES Foundation team have concluded that the oceanic tipping point is a pH of 7.95 which we reach by 2045/50 under RCP 8.5 from the IPCC. In the southern oceans it could be 10 years earlier, they are the most productive oceans on the planet, but we could see their collapse by 2035[44] and this will have ramifications all around the world. Ecosystems will start crashing [45] and ocean currents will stop or change direction - the Gulf stream has already slowed down by 15%[46]. We may lose the planktonic plants that are the life support system and climate regulator for our planet – it will be run-away climate change. Cyanobacteria, protists and jellyfish will take over the oceans, and may help sequester carbon, but we expect the oceans to become a toxic soup[47] as *a consequence.*

Let's spell out what this looks like in reality because the consequences will be catastrophic: it means we lose all the whales, dolphins, birds, seals, fish and food supply for around 2 billion people, and life on earth for humanity will be in jeopardy over the next 25 years.

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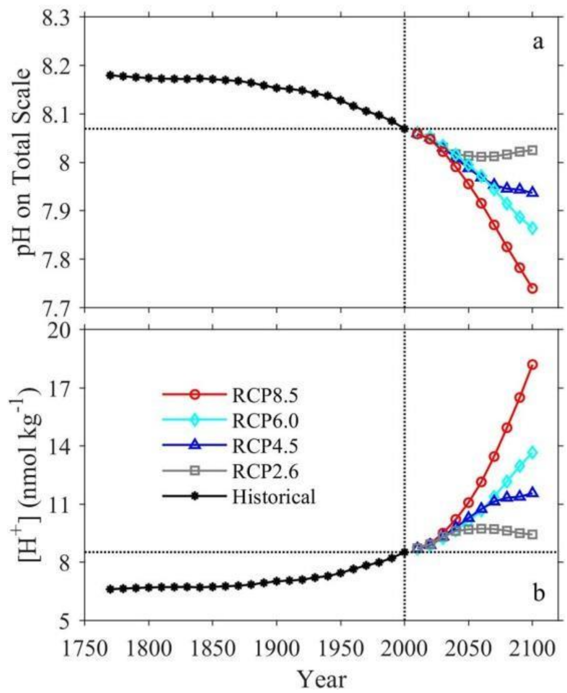
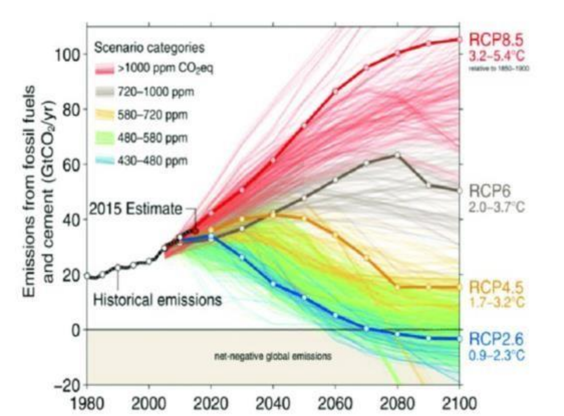
[48]From the IPCC report "***reasons for concern***", taking the data for only Ocean Acidification, we enter high risk for all major lifeforms (Taxa) at an atmospheric partial pressure of 500ppm. Under RCP 8.5 we hit this point by 2040. In the very unlikely event that the world achieves a carbon reduction in accordance with RCP 4.5, the lag time would still result in 500ppm of

atmospheric carbon dioxide and tragically this will mean the oceans will still experience a full trophic cascade failure, it will just be delayed by a decade.

As the GOES team see it, current efforts in combating climate change by only reducing carbon dioxide emissions are in vain, futile, and a strategy that cannot work, unless we also restore life in the oceans and biodiversity everywhere – this means we must stop the pollution loading on land from hydrophobic chemicals so that it doesn't reach the sea – this needs to be acted on as a global emergency, just as we have been able to do with COVID.

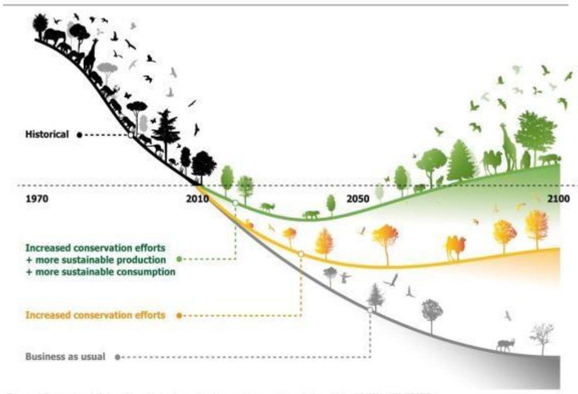


Our proposed timetable of ecosystem trophic cascade breakdown events is supported in this paper by peer reviewed reports and illustrated by proxies. If we accept that ocean productivity, climate change and life on earth are controlled and regulated by a group of organisms that most people don't even know exist (planktonic pelagic plants, bacteria, protists and animals) then there is good news. With a collective understanding of the mechanisms that matter, it is absolutely possible to act on chemical and plastic pollution and reverse the decline in planktonic productivity – we consider this to be our best chance, and maybe our only chance of mitigating the effects of climate change.



So, what should be our next steps? Restoring productivity in the oceans is our best chance of sequestering carbon dioxide from the burning of fossil fuels. But according to the rate of change of pH we will lose most life in all the world's Oceans over the next 25 to 30 years, and this will be catastrophic for humanity.

The burning of fossil fuels produces carbon dioxide, methane is 15 times more of a greenhouse gas than carbon dioxide, and it is emitted by gassing-off from under-ground and from methane nodules under water. One of the greatest sources of methane is from our own waste. Most municipal wastewater in Europe and North America is biologically treated, but high percentage of the resultant sludge Reference for graphic [33] ferments and produces methane. More than 80% of the world has no effluent treatment and this results in massive methane production where the polluted lakes even catch fire. The city of Bangalore in India has 10 million people, but they have a climate change footprint equivalent to 150 million because of their methane emissions from untreated wastewater [49]



This artwork illustrates the main findings of the article, but does not intend to accurately represent its results (https://doi.org/10.1038/s41586-020-2705-y)

Action plan

While we must continue to reduce and stop the burning of fossil fuels and embrace renewable energy, there are other things we must and can do: some of the actions are for Governments and regulators and some of them are for each and every one of us.

Climate change is an equation: the carbon dioxide produced by burning fossil fuels must be removed from the atmosphere by plants, on land and in our oceans. While we all love to plant trees, and this is a very good, we need to remember that the largest carbon sink we have is in our oceans. We all depend upon the oceans for our survival, but the oceans are dying as consequence of aquatic environmental pollution from toxic hydrophobic chemicals and plastic. It is therefore not possible to stop climate change by just reducing carbon dioxide emissions. We must also act to help nature recover on land and in the oceans, and if we succeed then nature in the oceans has the capacity to remove our carbon dioxide, and all we have to do is stop the pollution to create a clean environment for all humans and nature to live in harmony and balance.

What we all can do:

1. Textiles cause 10% of the world's pollution: buy natural fibres and don't follow fast fashion.
2. Plastic cloths cause micro-plastic pollution, so avoid fleeces and similar products. Washing machines with plastic filters are also available. Wash clothes only when they really need to be cleaned.
3. Try and purchase organic food: it is more expensive, but you avoid the toxic effects of herbicides and pesticides, which is better for you and for the environment. Try and grow more of your own food without chemicals
4. Cosmetics and cleaning products: many of them are horribly toxic, and absolutely avoid cosmetics containing oxybenzone. Inform your retailer that you only want ocean safe, reef friendly products
5. Carpets and furniture contain fire retardants called PBDEs, which are toxic-for-ever chemicals; there are alternatives that are environmentally safe.
6. Don't purchase any products containing Teflon or fluorocarbons: examples include Teflon non-stick coatings. 99% of us now have Teflon in our bodies, and it is toxic to us and horribly toxic to all life.
7. Plant a tree, protect peat bogs, marsh lands, wetlands, mangrove swamps.
8. Pick up your litter and minimise or stop buying products with single use plastic.
9. Do not flush your old drugs and pharmaceuticals down the toilet: return them to shop where they were purchased.
10. Try to minimise your travel: not only are you producing carbon dioxide but causing plastic particle pollution from car tyres.
11. Insurance companies are now considering lifestyle as an insurance risk, live a nontoxic life, not only will you feel better and live longer, it will end up being much less expensive on your pocket and on nature

What Governments and Industry can do:

1. Act to stop all forms of toxic chemical pollution from municipally treated wastewater. Less than 10% of effluent treatment plants in Europe and North America is fitted with tertiary treatment systems to remove toxic chemicals and microplastics. All systems should be fitted with tertiary treatment. This would also deal with AMR (antimicrobial resistance) and virus transmission such as coronavirus
2. Every Kg of organic matter treated by municipal wastewater systems generates 0.5 to 1.0 kg of bacteria sludge. The sludge is loaded with plastic pollution, toxic chemicals and pathogens. It must not be allowed to enter the environment or allowed to decompose and produce methane. It may be burned to produce energy, or biochar may be an option.
3. 80% of the world has no effluent treatment: not only does this waste cause pollution, but the fermentation of the waste generates methane, which is 15 times more powerful greenhouse gas than carbon dioxide. Wealthy countries must help finance appropriate technology for low-income countries to treat all wastewater.
4. Rural community drinking water systems must be provided to low-income countries to reduce the dependency on plastic bottled water.
5. Storm water treatment: Pollution for our roads includes plastic particles and toxins from car tyres and brake pads, most of this pollution is not treated and it enters our rivers and oceans.
6. All industrial wastewaters must be recycled, and a zero-discharge policy should be adopted at the earliest opportunity.
7. Every possible effort should be made to stop plastic pollution from all sources.
8. Use sustainable drinking water systems, stop Reverse Osmosis (except for seawater desalination) to provide drinking water. RO must be stopped as the RO reject water destroys rivers and aquifers.
9. The most critical terrestrial ecosystems for carbon sequestration and biodiversity must be protected and extended: these include peat bogs, marsh land, wetlands, mangrove swamps and sea grass.

10. Plant as many trees as possible and do not cut them down or clear forest by burning the trees. Burning trees contributes more than 20% to the annual atmospheric carbon dioxide emission, some 6 Giga tonnes every year.
11. Move to support food production using sustainable organic techniques, using only environmentally benign chemicals, and absolutely no municipal sludge (toxic chemicals and plastic content are unacceptable).
12. Action is needed to ensure toxic chemicals are designed out of home furniture, domestic cleaning products and personal care products. Now is the time to ban the sale of toxic-for-ever, chemically coated fluorocarbon/non-stick pots and pans.
13. An immediate ban on lipophilic toxic chemicals that are now known to concentrate on particles in the ocean and a recognition that there is no safe concentration.
14. Toxic cosmetic ingredients must be banned, and green chemistry innovation supported. For example, develop safe alternatives to oxybenzone for inclusion in sunblock and the 3500 cosmetics in which it appears. Indeed, oxybenzone is so toxic it should be banned with immediate effect.

We all have responsibility, and we can all play a part in restoring the balance of the entire planet. We know what needs to be done, so now is time for action, not just talk. The Goes Foundation team have laid out a Win-Win Strategy. Each and every one of us know that it makes absolutely no sense whatsoever to dump toxic chemicals and plastics into the ocean, the soil or the air. The way we are living is profoundly wrong [50] but with a concerted effort, we have an opportunity to act and take a precautionary approach to solve the issues before we self-destruct.

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GOES Collaborative Data Collection Project (CDCP)

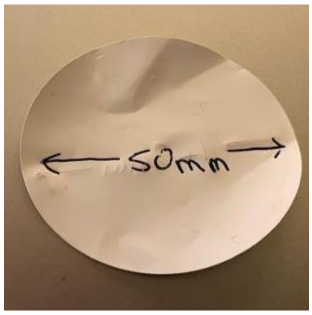
Citizen science can provide invaluable information to answer questions that are either too difficult or too expensive for Oceanographic ships to collect. An example would be the Fisher Collaborative Data Collection Project [51][52]. At GOES Foundation we propose a similar CDCP with ocean cruising yachts in order to collect micro-plastic and plankton numbers data across oceans.

There are around 5,000 yachts crossing oceans every year, from Arctic regions to the equator, if some of these yachts were to start collecting data, then it would be in invaluable for the measurement of oceanic pollution and productivity. The data will be fed into a data base, and when there are sufficient results AI (Artificial Intelligence) will be used to analyse the data, which will all be displayed on www.GoesFoundation.com. However, we don't just want to collect data, the information will be used to inform and educate, and help identify and initiate innovation of technology that can start to have a real impact on fighting climate change and protect our oceans.

Citizen science is often not considered seriously, that is why we have taken the time to test the procedures and to make sure that it is possible to collect and analyse the sample to produce relevant data onboard a typical ocean-going yacht. We know how difficult it is to do a plankton trawl from the back of a yacht, especially at night, we have therefore made it a quick easy task, to obtain precise measurements with just the minimum of tools. Thanks to Dr. Jesus Ramon Barriuso Diez from San Sebastian, for designing and manufacturing the filter for GOES

Objective.

Collect data on micro-plastic, zooplankton and phytoplankton concentration in oceanic water where the depth exceeds 1000m. Secchi disc reading may also be taken at the same time as well as other observations, from observations of surface plastic to whale sightings.



Sample collection.

1. A 250ml water sample is collected at 12:00hrs and 24:00hrs from the ocean surface, once every few days. Time day/night and GPS position are recorded
2. The sample is added to a gravity filter, the water reservoir contains 250ml, so it is just filled up till it over-flows. The water then slowly passes through the filter with a filter paper ratted at 1 um. The filter is then just left for around 10 to 30 minutes for the water to pass through the unit.
3. Remove the filter paper with tweezers, and place under a USB microscope at about 20 times magnification, count the number of plastic fibres and particles that can be easily identified. Count all zooplankton and count all the visible algae phytoplankton
4. The information is recorded and sent to GOES by email, or it is up-loaded directly to the database.
5. The information will be displayed on the website, and with skippers permission, the position of the yachts will be tracked by AIS and displayed on www.GoesFoundation.com