Questions and answer on GOES Report

Plastic and toxic chemical induced ocean acidification will cause a plankton crisis that will devastate humanity over the next 25 Years, unless we act now to stop the pollution.

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The seas are a vital part of the global ecosystem, leaving the future of all life on Earth dependent on humanity's actions. Sir David Attenborough

1. What is the Global carbon budget?

The IPCC Global Carbon Budget states that: Anthropogenic carbon equates to approximately to 11.1 giga tonnes, of which 5.9 giga tonnes is sequestered, with 5.2 giga tonnes entering the atmosphere. Of the 5.9 giga tonnes being sequestered, the oceans account for 2.5 giga tonnes.

2. What's is happening the oceanic pH

- Even if the world became NET zero for carbon by 2030 (which will be impossible), according to NATURE, [1] ocean pH will still hit 7.95, albeit 5 to 10 years later, and we still lose most of the carbonate based marine life. The loss of more than 50% of all marine life will set up a trophic cascade collapse, and we lose all the seals, whales, birds, and fish, and with them the food supply for over 2 billion people.

- All life on earth depends upon the oceans, so even with all our efforts with carbon and net zero, it's not going to work unless we regenerate nature by eliminating all toxic substances, plastic and chemical pollution for our air, soil and water.

3. The title is pessimistic, inflammatory, and unfounded

- "*The ocean is the linchpin supporting life on Earth, but it is in a declining health due to an increasing footprint of human use and climate change"* [2], Laffoley & J.M Hall Spencer 2021, there will be a regime shift, yet there has been a systematic destruction of the oceans over the last 70 years, and the lack of real action to protect water quality and marine life is well documented. We now have a situation where HNLC zones[3] cover 30% of the world's oceans that are essentially dead zones, and that are spreading, yet there are plenty of nutrients in these areas. It could be that there is a lack of trace nutrients, but why should it happen now?

- There is a long list of reports, failed treaties, failed programmes, and missed targets in relation to 'ocean health'[4]. We think your report submitted to the June 2021 G7 conference, was essentially a request for more funding by the academics, will add to that detailed catalogue. What we should be providing is the guidance to deliver effective action on some of the most toxic ocean pollutants, like photoactive sunscreens, car tyre microplastics, hospital laundry microplastic and pharma along with the other obvious culprits like PCBs. Research programmes should be about providing solutions and the mapping of rapid ocean recovery, not as the Director General stated (UNESCO Ocean conference Paris 2019), we are doing a good job of cataloguing the destruction of the oceans.

- **We provide an estimate of "25 years to save the oceans and humanity",**

  (i) We have already lost in the order of 50% of all life in the oceans [5][6][7]
  (ii) The IPCC data [1] states that surface ocean pH will be pH 7.95 in around 25 years
  (iii) More than 50% of the coral reefs, and 71% or more by 2050 [8], 25% of all marine life in the oceans depend upon coral, so just with the loss of coral reefs, the oceans may not survive
  (iv) The IPCC BioAcid report states that we potentially lose another 50% of the remaining marine life - especially marine life based on magnesium calcite and aragonite [9] by the time the pH reaches 7.98
  (v) Ocean acidification increases the risk of marine regime shift [10]: In natural coastal ecosystems, mean pCO2 levels predicted for as soon as the mid-century will have periods of such low aragonite saturation and high availability of inorganic carbon that this will cause biodiversity loss driven by a decline in habitat-forming species [11]
  (vi) When you plot the above data, it translates into a 75% to 90% loss of marine life over the next 25 years, so for sure we have reasons for concern [12] and on that basis the 25 years in the title is justified

  We have spent the last 40 years working as consultants, designers, manufactures and operators on some of the largest marine public aquaria life support systems, with upwards to 20 million Euros-worth of fish and invertebrates living in in large communities in each of these aquaria over decades. So, we are aware of the cumulative impact of stressors, such as plastic, toxic chemicals, temperature, and pH, all working together over long time frames. We also know, then, when the pH drops below pH 7.95, the system could very easily flip, and you lose all the animals. These aquaria are excellent proxies for polluted oceans, and we are among world experts in this market.

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4. Ocean acidification is having little effect on the plankton

- The GOES report refers to oceanic systems off the continental shelf in water over 1000m in depth, not coastal communities. Ocean acidification pH has now started to have a major impact, but it is going to become much more serious, than climate change over the next 10 years.

- Our concern is with the mechanisms at play involving hydrophobic lipophilic chemicals adsorbed and concentrated onto hydrophobic particles such as micro and nano-plastics. There is an estimated 21 million tonnes of microplastics in the Atlantic, around 7 particles in every litre of water[13]. There are only 10 zooplankton in every litre of water, so you can be sure that most of the zooplankton will be eating plastic. Nano plastic and molecular plastic will be absorbed by phytoplankton, and in both cases the plastic will have adsorbed varying amounts of lipophilic chemicals. Our report goes into detail to explain how this chemical - plastic combination is toxic, and that it is the most likely reason why plankton productivity and life support system for the planet is crashing.

- The ability of the oceans to sequester carbon dioxide is lost as we lose the phytoplankton, and this will accelerate the acidification process.

- If we had not polluted the oceans, then productivity may have been double the current level, and we not now be experiencing ocean acidification.

- It is our view that 'closed communities', for example, the Marmaris Sea, is being affected in the manner described, and at the time of writing, the sea is suffering from huge blooms dinoflagellates referred to as 'Sea Snot' (see video from Reuters from earlier this month here https://youtu.be/9D1BeQQUNQ8).

- The Mediterranean Sea is at a pH7.9 and the water is devoid of fish, but tourists are enjoying crystal clear water. Details provided in a report from the European Commission about the severe decline in fish and marine mammals in the Mediterranean [14]

- According to the IPCC BioAcid report, even if we achieve RCP4.5 by 2030 (which would be impossible), atmospheric carbon dioxide would still hit 500ppm and ocean pH would drop to 7.95. Based on the available data and our own experience, we consider pH 7.95 to be the tipping point. This means that climate mitigation is not going to work, and we are going to lose the oceans.

- There is no hope to save most marine life, we are too late with carbon mitigation. The only hope is if we regenerate marine life, so we must bring on a series of measure now, the most important of which is to stop the pollution from plastic and toxic chemicals. If we are extreme in our language, it is because we believe that we are in grave danger and we must act now – not in 10 or 20 years' time.

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5. Plastic is having no effect on ocean acidification and is no threat to humanity

There are numerous peer reviewed reports that state eroded plastic, especially when coupled with toxic chemicals, is toxic to plankton of all types including cyanobacteria.

- Prochlorococcus was discovered in 1985 and is responsible for up to 20% of our oxygen and carbon sequestration. An excellent report based on observations over a 30 year period has confirmed that plastic is very toxic to the bacteria. [15].

- It is likely that plastic will exert its greatest toxicity to mesoplankton and probably protists, and new references are appearing almost every day on the subject.[16][17][18][19][20].

- Plastic can also act as a carrier for chemicals such as Oxybenzone which is toxic at 62ppt, and we note that Dr Craig Down, who we work with, is referenced as an adviser in the G7 advice piece.

- Discussions with Craig have highlighted those huge volumes, in the millions of tonnes, of oxybenzone is used every year. An estimated 20,000 tonnes are used just in cosmetics and plastics use could be in the region of 3 million tonnes. Add in adhesives, paints, lead plasticisers, TBT, DBT and these plastics transform into sources of extremely toxic leachates, which we all know are making their way into the oceans either via waste-water plants, storm overflows, and poor waste management. Craig states that Oxybenzone is toxic down to 10ppt, and at this level 70,000 tonne would wipe out most larvae and plankton in the world's oceans.

- The peer reviewed papers included in our literature review and think-piece confirm that plastic and toxic chemicals do have a negative impact on phytoplankton. It follows that the same chemicals are impacting on the ability of the oceans to sequester inorganic carbon. If the rate of carbon sequestration is reduced, then the rate of ocean acidification will accelerate.

- Plastic acts as a selective incubator for pathogenic species such as Vibro [21][22][23]. Vibro spp are responsible for killing fish, invertebrates, and corals. Corals are suffering from disease all over the world because of Vibro.

Plastic and toxic chemicals have an impact on marine productivity and ocean acidification and is a threat to humanity, however top marine biological academics do not as yet consider plastic a risk to the marine environment. In reality plastic is going to catastrophic and may results in a total collapse of the marine ecosystem

6. The claims are unscientific, and dinoflagellates will not take over the plankton, and are not toxic

- We are already seeing that carbonate-based marine life affected by ocean acidification, especially those based which are magnesium calcite and aragonite.
- The current oceanic pH is 8.04, in 25 years it will be pH7.95 and we lose a high percentage of the carbonate-based plankton.
- Nature will fill any gap and other non-carbonate phytoplankton/protists. Dinoflagellates and bacteria would be strong candidates, but if you have other suggestions, we would be keen to hear your views.
- The IPEN reports funded by the German and Swedish Government state the same change in biodiversity[5][24], and this is also being observed in the Marmara Sea.

- The GOES team also have direct commercial experience:
  (i) Pump-ashore desalination plants. These systems are now failing all over the world due to dinoflagellate Red Tides (HABS) and cyanobacteria, which block the desalination prefiltration works

  (ii) Pump-ashore aquaculture systems are now installing ozonation systems to address toxin levels. The GOES team have been working with Vietnam's largest shrimp farming company, which due to the toxicity of the local sea water, they have had to move to closed systems.

NOAA states:

Harmful algal blooms, or HABs, occur when colonies of algae—simple plants that live in the sea and freshwater—grow out of control while producing toxic or harmful effects on people, fish, shellfish, marine mammals, and birds. The human illnesses caused by HABs, though rare, can be debilitating or even fatal. While many people call these blooms 'red tides,' scientists prefer the term harmful algal bloom. One of the best known HABs in the nation occurs nearly every summer along Florida's Gulf Coast. This bloom, like many HABs, is caused by microscopic algae that produce toxins that kill fish and make shellfish dangerous to eat. The toxins may also make the surrounding air difficult to breathe. As the name suggests, the bloom of algae often turns the water red.

HABS and atmospheric pollution is an issue [25][26][27][28], this trend will continue to spread and unless we can reverse ocean acidification it will become the norm. In our view, the oceans will become more toxic, respiratory disease risk will increase for those who live next to the sea, and most forms of marine aquaculture will become impossible unless they are onshore and in RAS systems.

Dinoflagellates and bacteria will therefore fill the hole left by the loss of diatoms and carbonate-based plankton.

The GOES team are system thinkers, we join dots across ecosystems, and it is clear to us that the ocean is a direct reflection of what is happening on land, i.e. with an 80% worldwide decline of insects [29], as well as the health of humans as detailed in the Lancet Report[30].

Universities and the academic community can continue to struggle for grants, and catalogue ocean destruction or we can act together and try to regenerate nature everywhere. We need to take action to prevent pollution and protect the oceans, because there is already a major problem with the convergence of stressors on all marine life.

We must take a precautionary approach and implement processes to protect and regenerate marine life as stated in our report, because the sooner we act, the easier it will be to recover the oceans and avoid a catastrophic trophic cascade failure, which will happen if we continue to allow the uncontrolled discharge of chemicals and plastic, and the pH to fall below 7.95.

We need to become net zero for carbon as soon as possible, but it will all be in vain unless we also eliminate toxic chemical and plastic pollution over the next 10 years.

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