Commentary

Climate disruption, high humidity, and reduced cloud formation, caused by the degradation of the Ocean surface biofilm micro-layer due to plankton toxicity from lipophilic chemicals, microplastic and black carbon soot.

Abstract

The world has focused on carbon mitigation and how climate change affects humanity and nature. This discussion paper reverses this thinking and instead considers the significance of carbon sequestration by nature and how marine biodiversity influences climate change.

Summary

The main greenhouse gas (GHG) is water vapor, which accounts for 75% of all GHGs; the second most important is carbon dioxide, followed by methane; particulates such as black carbon (BC) soot also have an impact. The concentration of water vapor in the atmosphere is regulated by air temperature; warmer conditions lead to higher evaporation, which in turn increases the concentration of water vapor, the Clausius-Clapeyron relation. This means that as the oceans and atmosphere warm, a self-reinforcing feedback loop accelerates the evaporation process to cause further warming.

It is not considered possible to directly regulate atmospheric water vapor. This explains why climate change mitigation strategies have focussed primarily on reducing carbon dioxide emissions as the means to reduce water vapor. This research suggests that the current climate change mitigation strategy will not work on its own because it depends on decreasing the concentration of atmospheric carbon dioxide and on the assumption that water vapor is only regulated by temperature.

Seventy-one percent of planet Earth is covered by an ocean that has a surface microlayer (SML) between 1 µm and 1000 µm composed of lipids and surfactants produced by marine phytoplankton. This SML layer is known to promote the formation of aerosols and clouds; it also reduces the escape of water molecules and slows the transfer of thermal energy to the atmosphere. The concentration of water vapor is increasing in our atmosphere, and 100% of this increase is evaporation from the ocean surface; water vapor from land systems is decreasing. This means that the oceans are almost entirely responsible for climate change.

The SML layer attracts toxic forever, lipophilic chemicals, microplastics and hydrophobic black carbon soot from the incomplete combustion of fossil fuels. Concentrations of toxic chemicals are 500 times higher in this SML layer than in the underlying water. Toxic forever chemicals combined with submicron and

microplastic particles and black carbon particulates are known to be toxic to plankton. Peer-reviewed articles report that marine primary productivity or phytoplankton photosynthesis may have declined by as much as 50% since the 1940s. Reduced phytoplankton plant growth equates to a degraded SML membrane, reduced carbon assimilation, and higher concentrations of dissolved carbon dioxide in ocean surface water, which accelerates the decline in ocean pH. The key phytoplankton species responsible for the production of the SML layer are the first to suffer from pH decline, a process called “ocean acidification”.

There is a high degree of certainty in academic institutes that ocean acidification will lead to a regime shift away from the key carbonate-based species and diatoms when oceanic pH drops below pH 7.95 by 2045. The SML layer will decrease, allowing evaporation and atmospheric water vapor concentrations to increase. A reduced SML layer will lead to fewer aerosols, cloud formation and precipitation, as well as increased humidity and temperature. When clouds form under these conditions, the higher humidity will cause torrential downpours and flooding. The result could be catastrophic climate change, even if we achieve net zero by 2050. In parallel, ocean acidification and the collapse of the marine ecosystem could also lead to the loss of most seals, birds, whales, fish, and food supply for 3 billion people.

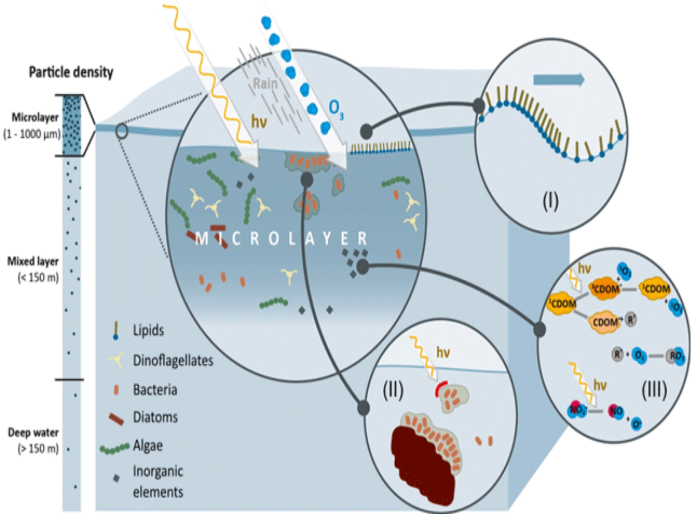


Figure 1: The sea surface as a biochemical reactor Ref 2

1. Introduction

All of the world’s oceans are covered by a surface microlayer (SML) composed of a complex mixture of proteins, carbohydrates and lipids[1]. The SML also contains particulate organic matter (POM), submicron plastic, microplastics, black carbon (BC) soot from the combustion of fossil fuels, chelated heavy metals along with microscopic marine plants and animals. The SML is characterized as having an operationally defined thickness that varies between 1 µm and 1000 µm, with physio-chemical and biological properties that are measurably distinct from underlying waters. [2]

In addition to all the particles, organic and inorganic molecules, the SML layer is also a complex living biofilm or bacteria and nanoplankton living in a mucopolysaccharide gel that binds the communities together in a three-dimensional matrix with the lipids and surfactants.

Although the thickness of the SML is variable, one of the techniques used to quantify the layer used a micro-pH meter. This technique demonstrated a sudden and marked change in pH as the probe passes through the surface layer. [3][4] The SML is described as a laminar layer free of turbulence and reduced gas exchange between the ocean and atmosphere [2]. High lipid layer concentrations are often easily observed as areas of flat water. Figure 2 is from a quiet beach in Portugal. The lipid oil slick and flat water stretched hundreds of meters downwind of the bathers who had just entered the water minutes before the photograph was taken. Lipid sunscreen from bathers may contain photoactive chemicals, for example, oxybenzone, which is known to be extremely toxic at 62 parts per trillion[5] to coral and plankton. Lipids, such as omega 3, produced by phytoplankton have the same effect and flatten large areas of the oceans, but even when they are not evident, they can still have an impact on gas exchange across the SML membrane.

Areas of flat water can be measured from space by satellites using bistatic radar measurements of ocean surface roughness.[6]This measurement system is based on an assumed reduction in wind-driven roughness caused by a pronounced SML layer that acts as a tracer for near-surface microplastics [7] [8].

Figure 2: Lipid oil slick from beach bathers (circled in orange) Source: GOES Foundation

Although it is not possible to measure microplastics directly from space, microplastics have an impact on the SML membrane in surface water throughout the oceans. Considering this mechanism, we wanted to explore how microplastics might impact marine SML surfactants, and in our opinion, the impact of microplastics is an indirect response. Given the toxicity of microplastics, it is conceivable that they could inhibit reproduction and/or kill marine zooplankton that would otherwise feed on phytoplankton. Reducing the numbers of zooplankton (animals) allows key phytoplankton (plants) species to flourish, including carbonate-based coccolithophores and silicon diatoms. This increase in phytoplankton numbers increases lipid production, which in turn leads to a flattening of the water surface could be a possible explanation for the observation.

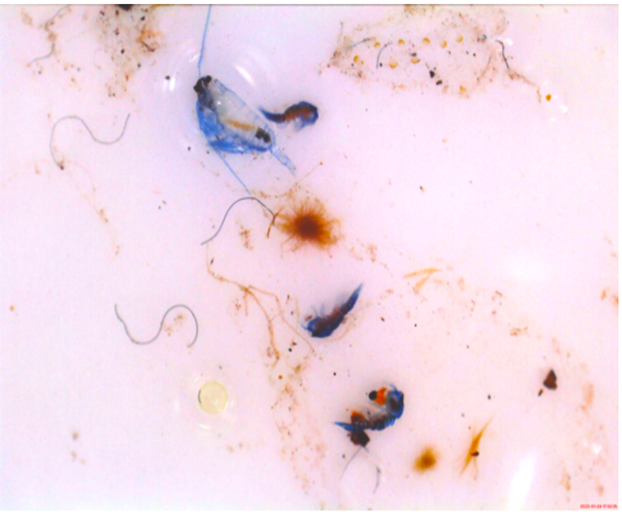


Figure 3: Surface living zooplankton and microplastic fibres. Source: GOES Foundation

The same key species mentioned above produce an enormous amount of polyunsaturated omega 3 fatty acid lipids. [9] The average monthly lipid production by phytoplankton is 108 million tonnes [10]. The research suggests that if the presence of microplastics changes the lipid and surfactant concentrations of the SML[8], this is a very serious consequence of microplastic pollution. Regime shifts already identified in the oceans by a loss of zooplankton, followed by a phytoplankton bloom, may be an indicator.

Phytoplankton numbers are not sustainable without zooplankton recycling nutrients back to surface waters, especially in the deep ocean off continental shelves. The conditions coupled with direct observation lend themselves to a collapse of ocean ecosystems due to the presence of microplastics. This could also be one of the reasons why the High Nutrient Low Chlorophyll (HNLC) zones now cover 25% of the Southern Ocean and are expanding.[11]

Some surface-dwelling copepods develop a blue pigment as a protective mechanism against UV irradiation, indicating that they are using the SML as a habitat.[12]. Fig 3 is a plankton sample taken at 200 nm south of the Canary Islands. Note the blue zooplankton and the high concentration of plastic microfibres, image scale 5000 µm.

Due to the hydrophobicity of SML, it attracts and concentrates hydrophobic particles and lipophilic chemicals such as microplastics and black carbon particles, chemicals such as flame retardants, pesticides, antifouling agents, chelated heavy metals, and petroleum polycyclic aromatic hydrocarbons (PAHs). What these particles and chemicals have in common is that they are hydrophobic. Therefore, microplastic, black carbon and water-insoluble lipophilic chemicals are concentrated in this surface layer of the ocean. Although carbon is nontoxic, given its hydrophobicity, it will become as toxic as microplastics when it adsorbs and concentrates lipophilic toxic chemicals from the ocean surface. One exception are the metals which can dissolve in water, especially if the pH of the SML layer is acidic.[4]

Particles and chemicals can concentrate up to 500 times more in the SML compared to concentrations occurring in the underlying water column [12]. The concentration of the chemicals will be even higher on the surface of hydrophobic particles (microplastic and black carbon) with the SML layer. These particles are toxic to all plankton and will have serious consequences when eaten by zooplankton. [13][14][15][16][17].

Objectives

This paper will outline the following discussion on polycyclic aromatic hydrocarbons (PAHs), clouds and aerosols, evaporation etc. and the impacts they have to the SML layer. The paper will then conclude with recommendations for further research and policy options to be considered.

2.0 Polycyclic Aromatic Hydrocarbons

The GOES Project[1] was commissioned by Clean Water Wave cic (see Authors and Affiliations) to survey the equatorial Atlantic. Water samples of 500 ml were taken twice a day to reflect the diurnal rhythm of planktonic marine life. Analysis of the water samples Fig 4 found the following:

- 1 to 10 particles of microplastic fibre 300 nautical miles (nm) from land
- 100 to 1000 particles per litre, of what appeared to be black carbon. [18].
- Phytoplankton and zooplankton larger than 20 µm were found in concentrations of less than 1 in 20 litres of water

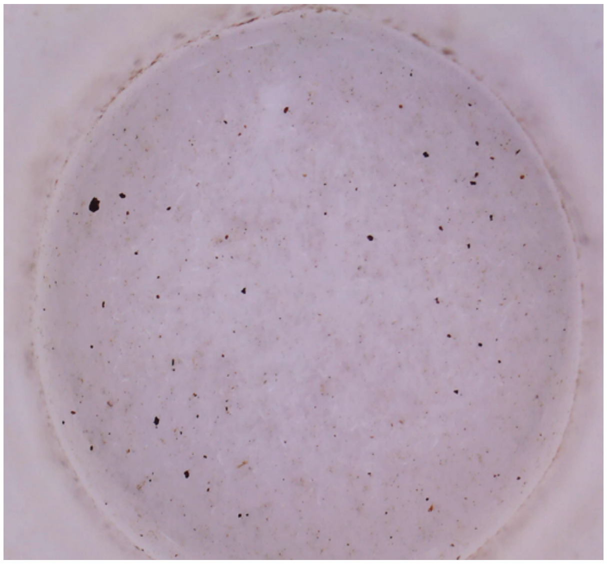


Figure 4: 1000 particles of black carbon particles per litre of water; collected in the Equatorial Atlantic Ocean. Source: Goes Foundation

NOTE:

[1:] *Before sampling was undertaken, a world-leading marine laboratory advised that the GOES Project should expect to find at least 1 zooplankton greater than 20 µm in every litre of water. The survey results confirmed that zooplankton concentrations were down more than 90% from the expected value. Only a few particles of black carbon were expected and finding 1000 particles per litre was a shock. Since the particles concentrate lipophilic toxic chemicals and heavy metals, they could represent the main transport mechanism for toxic chemicals into the plankton.*

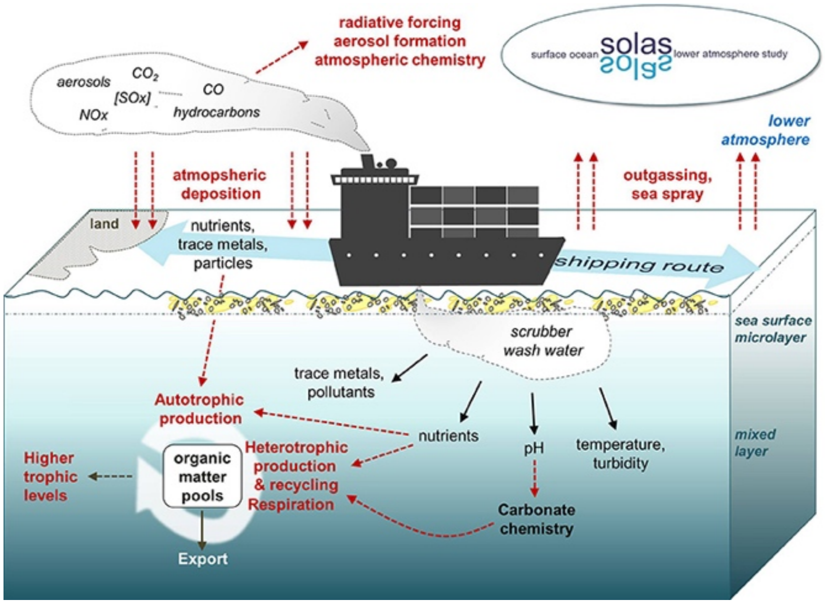


Figure 5: The shipping industry contributed up to 20% of the world's pollution. Ref 20

Polycyclic aromatic hydrocarbons (PAHs) are concentrated in the SML layer [19], and given that the transit route taken by the GOES Project vessel is close to the shipping lanes, it seems reasonable to suggest that the source of some of the black carbon particulate matter could be from combustion of bunker fuel oil.

Combustion of bunker fuel oil results in the production of 1.7 million tonnes per annum of sub 10 µm (PM10) particles of heavy metals and PAHs laden black carbon. According to the IPCC [20], PM2.5 black carbon can account for up to 8% of all GHGs [21], and PM10 particles were not included in their report.

Figure 6 One of the world's largest container ships, photographed by the GOES team approximately 50 km west of Finisterre

Burning fossil fuels on land, including trees and vegetation, are examples of some of the other sources of particulate pollution. As noted above, carbon and other hydrophobic particulate pollution will tend to concentrate in the top 1 mm of the ocean surface, where it will affect the integrity of the SML layer, and lipophilic toxic chemicals can concentrate in factors of a thousand to over a million times on the surface of the particles. Marine lipids are adsorbed onto particles [22] [23], meaning that the higher the concentration of particles is, the lower the concentration of lipids in the surface waters. Therefore, particulate pollution may directly influence the SML, which, in turn, could increase evaporation to the atmosphere from the ocean's surface.

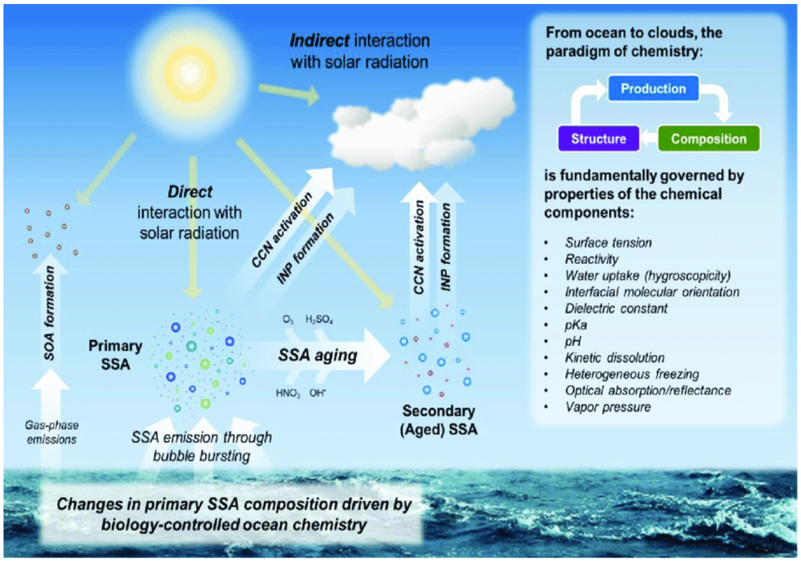


Figure 7,: Surface water evaporation and cloud formation. [30]

Bacteria and organisms living in the SML biofilm layer may also play a critical role in the structural stability of the surface biofilm SML. Given that lipophilic toxic chemicals concentrate in the layer, it is likely that they will have a toxicological impact on the biota with possibly profound implications for the structural integrity of the SML. Rainwater is also contaminated and is now loaded with toxic chemicals over most of the world.[24]

The SML covers 100% of the oceans and thus 71% of the Earth's surface. [25] The SML influences not only sea–air gas transfer but also aerosol–cloud dynamics [26]. The higher the concentration of lipids and surfactants in the SML, especially long chain lipids greater than c-15, the more likely they are to form aerosols, and for the SML membrane to reduce the evaporation of water molecules. Lipids and other polymers in the SML layer are involved in the generation of climatically active aerosols and cloud formation. [27] The transfer of greenhouse gases and aerosols, organic and sea salt aerosols, heat, and water vapor are defined by gradients in tension at the sea-air boundary, [28] [29] the importance of which is only now being recognized.[30]

3.0 Clouds and aerosols

The ocean represents a major source of primary sea spray aerosols (SSAs), and an estimated 2 to 100 giga tonnes of SSAs are emitted from the ocean each year [31]. These are of global importance, as they are a source of particulate matter[32]. SSA and secondary marine aerosols (SMA) contain marine plankton, particulate organic matter and dimethyl sulphide (DMS), all of which are very active in cloud nucleation[33], making them important as they promote precipitation that removes water vapor from the atmosphere[34]. Fig 7.

Magnesium (Mg^{2+}) and calcium (Ca^{2+}) can enhance organic species in the SML, which has implications for increasing the layer's structural stability, surface packing of organic molecules and subsequent interfacial reactivity [31]. However, the seawater chemistry has changed over the last 70 million years, with Ca^{2+} decreasing from 1200 mg/l to 400 mg/l and Mg2+ increasing [35]. Climate change modelling, given the importance of ocean-induced cloud formation and water vapor concentration, should factor in seawater chemistry and its influence on the SML when using historical data to predict climate change influences.

Cloud formation and atmospheric water vapor concentration are therefore controlled by the oceans and regulated by the SML, which is maintained by marine plankton and primary productivity. Any parameter that has a negative impact on marine plankton and the SML will have an impact and may even control the climate, cloud formation and aerosol concentration of the atmosphere.

4.0 Evaporation

The oceans are the source of 86% of the global evaporation and the recipient of 78% of global precipitation. [36] Oceanic evaporation is the process by which water molecules change from a liquid phase to a vapor phase at the SML or air–sea interface.[37] Each water molecule that turns into water vapor takes with it a parcel of heat energy, and that energy remains latent until it is released during condensation in cloud formation. Alarmingly, if the integrity of the SML is compromised, evaporation will increase the concentration of water vapor, meaning that the main warming GHG will trap more infrared radiation from the sun.

Very little data are available for the diffusion of water molecules through the SML layer, but more information is available for carbon dioxide. In the coastal waters of the North Sea, CO2 exchange was suppressed by 15–24% and by 32% in the Atlantic Ocean [25] [38] by the SML layer. Models predict a reduction of 20% to 50% for the global annual net flux of CO2 and, based on Chlorophyll (a) as a proxy for surfactant coverage. In a wind-wave tank experiment, considerable suppression of the CO2 flux rate ranging from 46% to 63% and up to a wind speed of 8.5 m sec–1 was measured. [39]

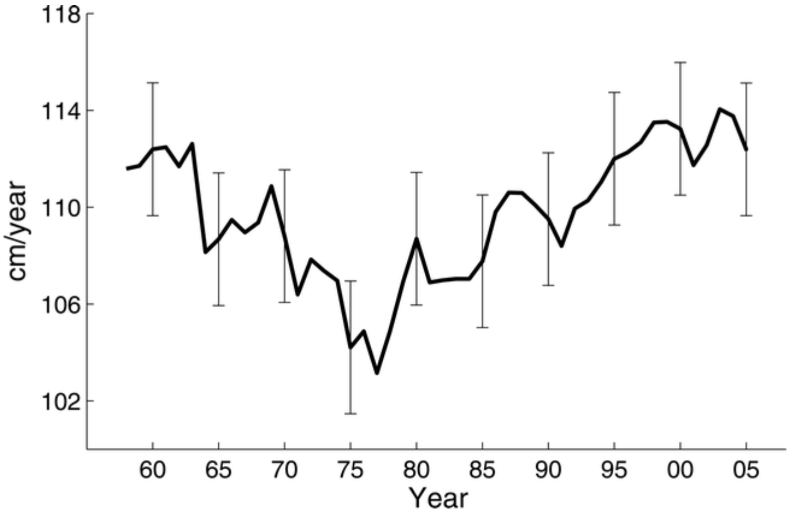


Figure 8 Global water evaporation from ref 35

The evaporation rate is a function of air and water temperature, relative humidity and wind velocity over the water surface. [37] It will also depend upon the surface water lipid layer. Lipid mono layers have been used to reduce evaporation from freshwater lakes by up to 40% [40]. We know that the rate of aerosol formation is controlled by the surface microlayer; this research suggests that the rate of evaporation may also be controlled by the integrity of the SML.

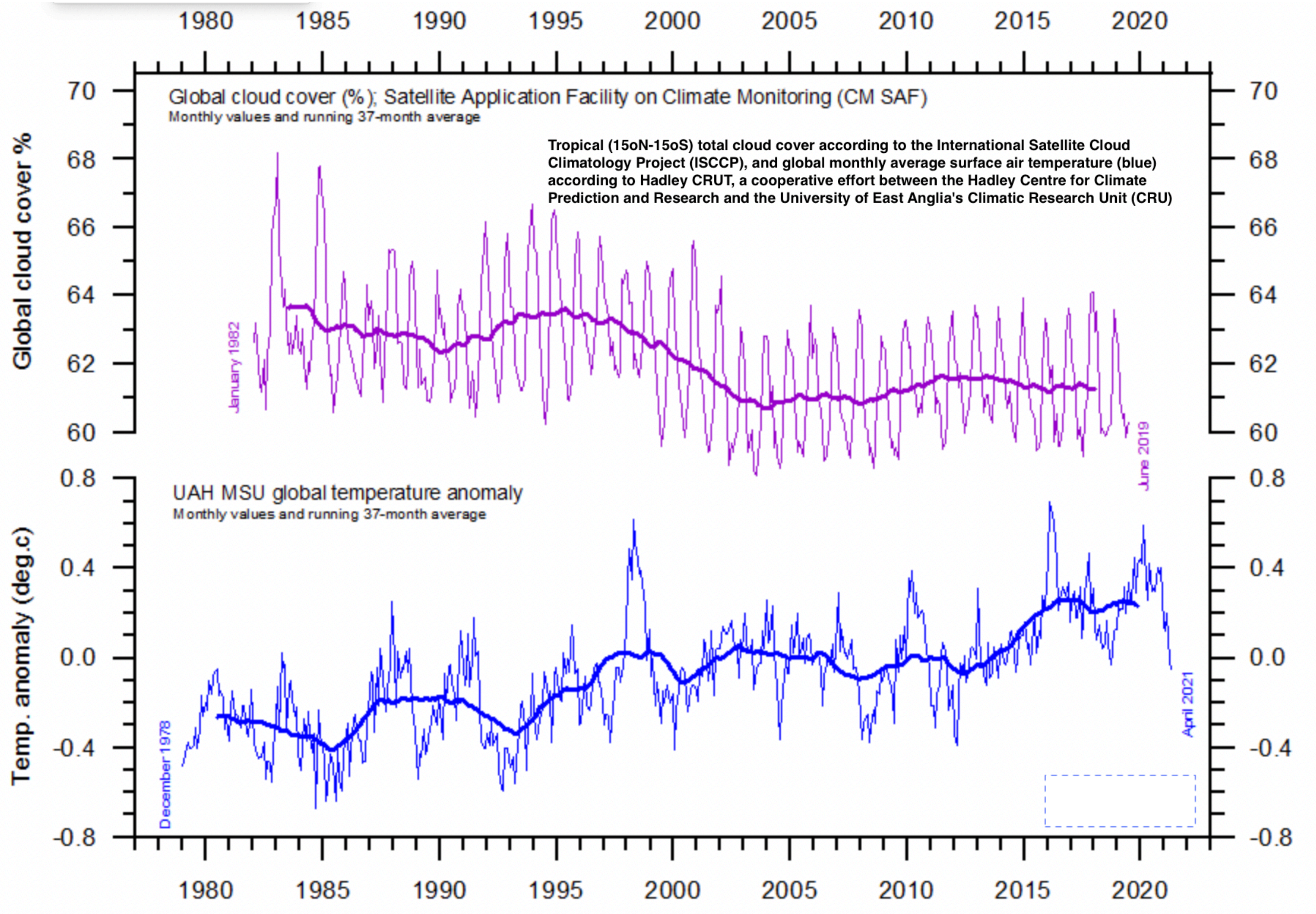


Figure 9 Cloud cover and humidity between 15 deg North and 15 deg south

Water evaporation rates have been recorded since 1958, the data in Fig 7 show a decline to 1977–78 and thereafter an upward trend to 2005, which was the end of the study [37]. The period since 1978 has also been marked by a change in climate worldwide [41][42]. The Arctic has also warmed four times faster since 1979, as published in a recent paper in Nature [43]. The physical mechanisms behind the underestimation in climate models remain unknown, but one explanation was the possible reductions in Asian aerosols. Fig. 8 reflects the humidity increase in Fig. 9 and shows the reduction in cloud cover at the same time from 1980 to 2020. The reduction in cloud cover could be attributed to the reduction in aerosol concentration caused by a diminished SML layer.

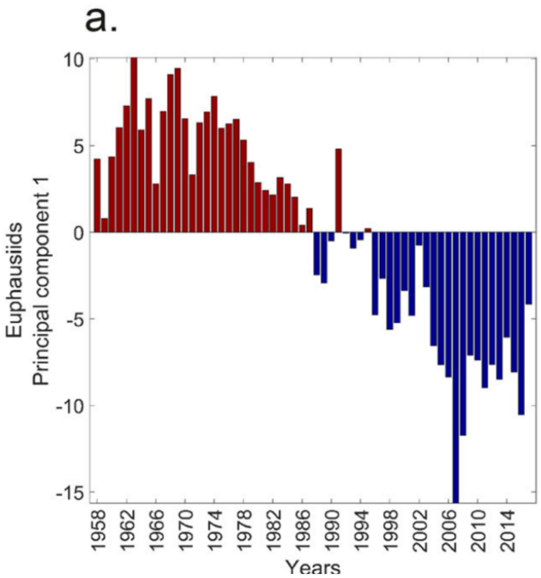


Figure 10 First principal component time-series (PCTS) of euphausiids for the North Atlantic, ref 42

5.0 Evaporation and the tipping point

If it was climate change affecting the concentration of water vapor in the atmosphere, one would expect the graph to closely follow the same pattern as carbon dioxide emission and GHG concentration in the atmosphere. The graph Fig 8 shows a very clear transition on a global scale of decreasing and then increasing water vapor emissions from the world's oceans. This cannot be an atmospheric temperature change due to the enormous inertia of ocean water to a temperature change. This research suggests that the SML layer started to fail and changed the rate of water evaporation. This could occur if there was a change in marine plankton, and the most obvious explanation is pollution on a global scale. It is also conceivable that a chemical or group of chemicals is destroying the SML layer directly; we see parallels with CFCs and the ozone layer.

Nutrients, chemicals, and pollution concentrations have increased at an accelerating rate since the 1940s. Initially, pollution concentrations from the Chemical Revolution would have been low with minimal impact on the plankton, but nutrients would have a more immediate effect and would have increased plankton growth and developed the SML to reduce evaporation. From our research, the increased growth and development of the SML would have progressed to the point when pollution from plastic, black carbon, and lipophilic toxic chemicals outweighed the benefits of eutrophication, at which point the system shifted to a declining SML layer.

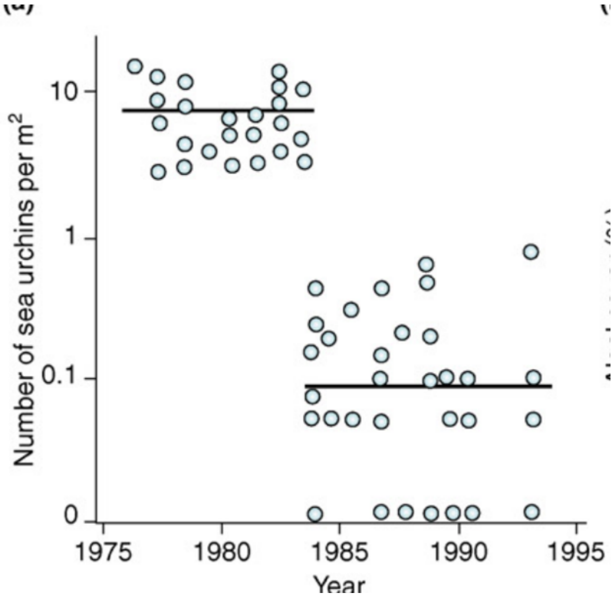


Figure 11 The Caribbean coral regime shift illustrated by changes on Jamaican reefs, ref 45

The research gap analysis suggests that it would be valuable to:

- Review satellite imagery, and surface water structure in relation to evaporation of water.
- Correlating satellite imagery data relationships to anthropogenic pollution and water chemistry with respect to alkalinity, pH, chlorophyll, and plankton samples
- Look for oceanic shifts in plankton productivity

6.0 Regime Shift in Plankton

Euphausiids (krill) are found in the world's oceans, especially at high latitudes. They are an extremely important part of the marine ecosystem and have a mass equivalent to all humanity but have declined by 50%, as detailed in a 60-year study [44] (Fig 9). The reason was attributed to climate change and decadal rhythms. In addition, reports of marine life crashes and regime shifts around the same time in the Pacific [45][46]. In Jamaica, most corals declined by more than 50 percent in the late 1970s to less than 5 percent[47] (Fig 10). More data are required, but there appears to be a total change all over the world at the same time during the late 1970s to marine life, the climate and water vapor pressure.

The events have been related to the Pacific Decadal Oscillation PDO. The cause of the changes in the PDO has not yet been identified, and it may even be due to a combination of factors, including long-lasting fingerprints of El Niño and La Niña events in the tropical Pacific Ocean, changes in atmospheric pressure in the northern Pacific, the impact of industrial pollution, and natural variability. This important phenomenon continues to be a subject of ongoing research.[48]

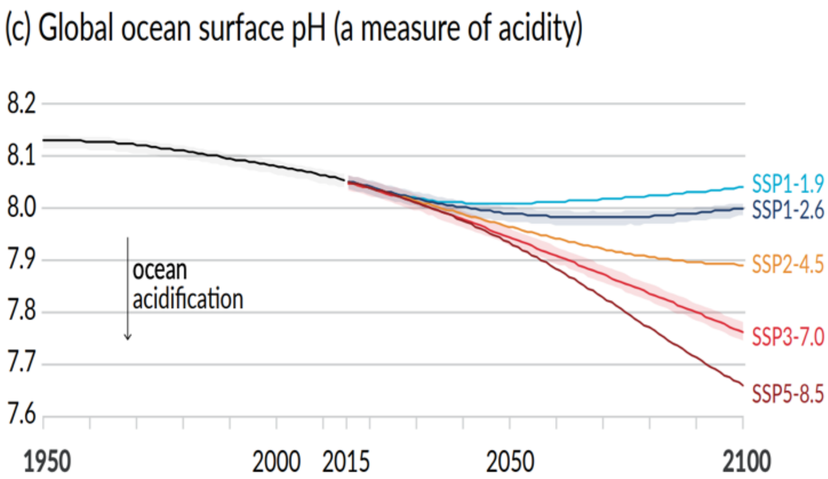


Figure 12: Oceanic pH, from IPCC [52]

Measurements of evaporation over land show a decreasing trend since the 1980s, even though air temperature has increased [49]. It is therefore only the oceans that contribute to the increase in atmospheric humidity [37].

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) estimates that approximately 77% of the land and 87% of the ocean have been altered by humans, which has led to a loss of 83% of wild mammal biomass and 50% of the world’s plant biomass. IPBES also suggests that more than a million plant and animal species are currently threatened with extinction, potentially putting us on a path to what has been dubbed Earth’s sixth mass extinction[50]. A report published in Nature gives us a less than a 10% chance as the most optimistic estimate to survive without facing a catastrophic environmental collapse[51][52].

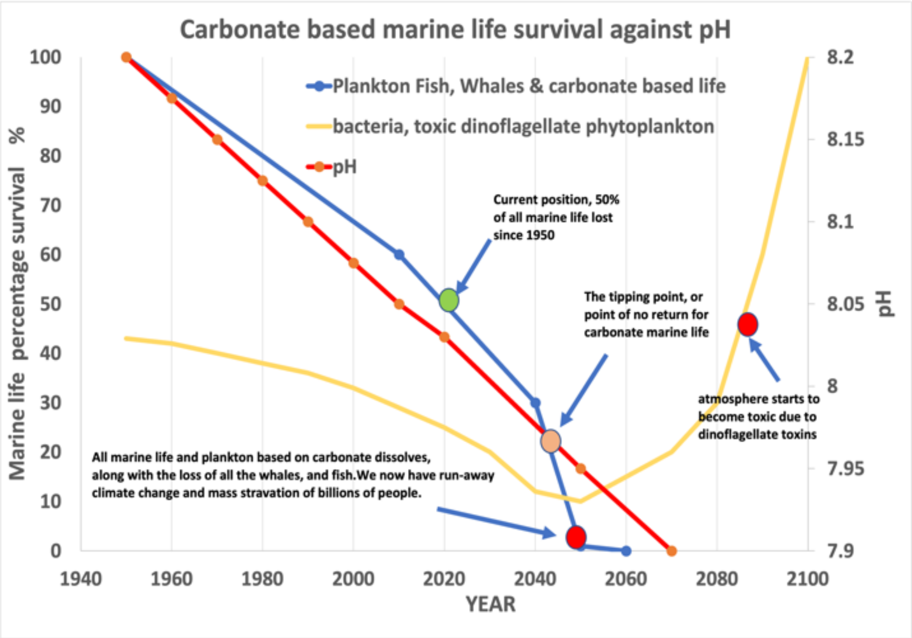


Figure 13. Oceanic pH in relation to marine life. Source: GOES Foundation –Ref 52

Given that we have lost at least 50% of terrestrial plants and the water transpiration from the plants, this would explain why the water vapor concentration is going down from terrestrial sources. The loss of marine plants and animals explains the increase in evaporation and vapor concentration in the world’s atmosphere.

With water vapor representing 75% of all GHGs, the oceans have been responsible for 86% of the total and 100% of the increase in water vapor pressure since 1978. We consider that there is only one conclusion, the oceans, and the anthropogenic impact on the oceans is driving climate change. Anthropogenic carbon dioxide remains very important as part of the mechanism. The ocean SML layer is also closely involved in climate change, and it follows that plankton and the factors controlling plankton productivity are also very important.

It is worth noting that the Lancet 2017 [53]stated that 14000 new chemicals and pesticides have been synthesized since 1950. Of these materials, the 5000 that are produced in greatest volume have become widely dispersed in the environment and are responsible for nearly universal human exposure. Fewer than half of these high-production volume chemicals have undergone any testing for safety or toxicity, and rigorous pre-market evaluation of new chemicals has become mandatory in only the past decade and in only a few high-income countries. The result is that chemicals and pesticides whose effects on human health and the environment have never been examined have repeatedly been responsible for episodes of disease, death, and environmental degradation.

7.0 Plankton productivity and factors

Diatoms and coccolithophores produce most of the marine lipids and surfactants that make up the SML and are also the most sensitive to ocean acidification and climate change. Anthropogenic carbon dioxide production has led to ocean acidification. Carbon dioxide dissolves in the surface water of the ocean, and carbonic acid is formed, which causes the ocean's pH to drop.

In the 1940s, oceanic pH was 8.17; today, it is 8.03, and by 2045, according to the International Panel on Climate Change (IPCC), representative control pathway (RCP) 8.5 (business as usual), oceanic pH will be 7.95 by 2045[54] [55] (Fig 12).

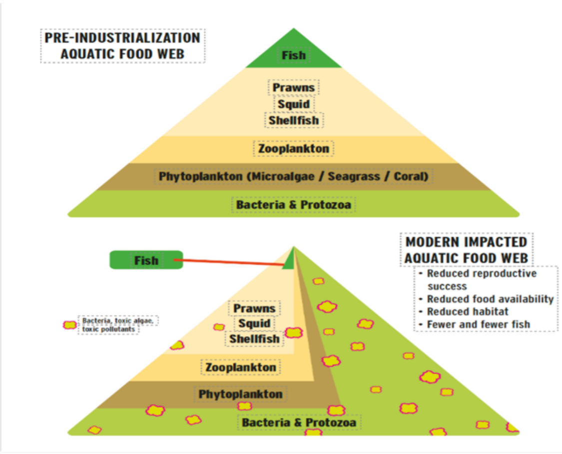
Life forms such as coccolithophores, coral reefs and all ocean organisms composed of magnesium calcite and aragonite start to dissolve at pH 8.04, and the process is essentially completed at pH 7.95. This process has already begun, and some organisms may survive this stressor or evolve to cope with lower pH values and warmer seas, but their reproduction will be seriously compromised, and they will be stressed and predisposed to infection and elevated temperatures. We also know that silica-based diatoms are very sensitive to lower pH[56].

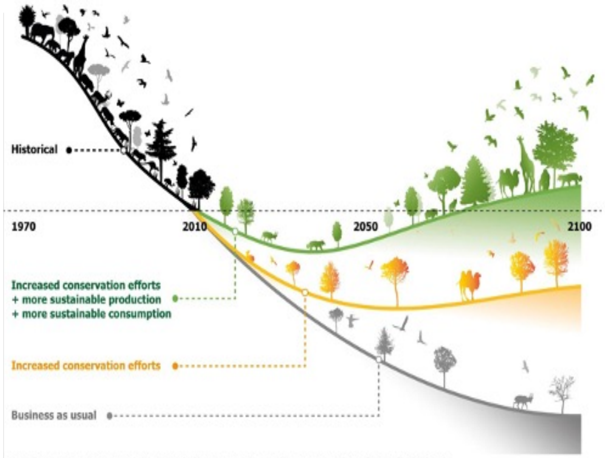
Plankton productivity has also declined since the 1940s [57][58][59][60][61], and many species are threatened with extinction [62]. The GOES Project team compiled peer-reviewed ocean acidification and productivity data and produced a graphical representation (Fig 13) [52].

The GOES Project graph parallels the work of other leading institutions and respected non-governmental bodies (NGOs), such as the International Pollutant Elimination Network (IPEN), whose pyramid graph[63] in Fig 14, and the IIASA-led study bio-curve of terrestrial ecology Fig 15 [64] is provided here by way of illustration. All indicators point to a catastrophic decline in both terrestrial and marine life over the next 25 years and reflect the looming 6th mass extinction, as discussed in the IPCC report.[50]

8.0 Carbon dioxide and marine biodiversity

There is a high degree of certainty (99-100%) that anthropogenic carbon dioxide is causing a decrease in ocean pH, and the consequences include the dissolution of marine life forms that play a key role in sequestering carbon dioxide, which is locked up in the abyss (deep ocean 3000 m-6000 m). Most of the Abyss, which is an area equivalent to the world's land dry land, is covered by 1000 m of organic matter





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)

Figure 14 (Left): pyramid graphic of marine life (what is the IPEN ref 62). Figure 15 (Right): The terrestrial bending the curve ref 63

and sediment,[65] constituting the world's main carbon bank, where all carbon is eventually deposited. Peer reviewed reports suggest that 50% of all planktonic marine life has already been lost and that a further 50% of what is left will be lost over the next 25 years, meaning that only 25% of existing marine life will survive.

The decline in marine phytoplankton will accelerate the process of ocean acidification and, with a very high degree of certainty, will cause a regime shift (probably to bacteria, protozoa, dinoflagellate algae and jellyfish) in the oceans that could lead to the loss of all seals, birds, whales, fish, and food supply for 3 billion people. This represents an existential threat to humanity, and every effort to reduce carbon dioxide emissions must be accompanied by all efforts to bring toxic chemicals, plastic and black carbon particle emissions to zero.[66] There is also scope to buffer the oceans by the addition of calcium carbonate minerals.

The loss of carbonate- and pH-sensitive phytoplankton and zooplankton will also decrease the SML microlayer, leading to increased water evaporation and decreased aerosol formation. The consequences will be an acceleration of water vapor as a GHG and a decrease in cloud formation. The atmosphere will become warmer and more humid, but cloud formation and precipitation will be reduced. Particulate matter from seawater spray, from land, pollution and organic matter from trees may still be able to nucleate clouds. However, when clouds form, due to the higher water vapor concentration, precipitation will be higher, leading to torrential rain and floods.

As energy transfer to the atmosphere increases, wind speed is expected to increase, which will increase evaporation, which will in turn increase wind speed. This is another self-reinforcing loop that will lead to more frequent and stronger hurricanes. Stronger winds and torrential downpours can be expected to occur next to seas that already have low pH and primary productivity, for example, countries surrounding the Mediterranean Sea.

Given that the SML covers the surface of the ocean and 71% of planet Earth [67] [68] but appears that it has not been accounted for in climate change modelling, this would seem to be an oversight that needs attention. The National Oceanic and Atmospheric Administration (NOAA) states that 50% to 80% of our oxygen is produced by marine phytoplankton [69], which also means that 50% to 80% of our carbon dioxide is sequestered by plankton. The Lancet [53] states that pollution, climate change, and biodiversity loss are closely linked and that 80% of the world's wastewater is discharged untreated.

Oceans are responsible for more than 80% of climate change, indirectly due to carbon dioxide emissions and black carbon soot from the burning of fossil fuels. Equally important are toxic lipophilic chemicals and plastic pollution, but the oceans have been neglected and used as a dumping ground for all human waste.

9.0 Conclusion

Humanity faces multiple existential threats, and carbon dioxide emissions must be reduced as a matter of extreme urgency. We must also eliminate the discharge of black carbon, toxic-forever lipophilic chemicals, and plastic into the environment. The marine ecosystem has enormous resilience, but only if we stop the pollution and ecosystem destruction now and achieve a toxic free world by 2030.

Failure to act now to reduce carbon dioxide emissions and eliminate pollution will result in the loss of the SML layer, which will cause higher atmospheric humidity and reduced cloud formation. The consequences will be higher temperatures, torrential rainstorms, and more frequent and stronger winds, even if we achieve net zero for carbon by 2050, which is too late, it needs to be 2030.

Failure to act now will result in ocean acidification and pH 7.95 by 2045, which will cause the loss of coral reef coastal defences and global starvation attributed to the loss of most fish and marine life. A regime shift with the loss of carbonate phytoplankton and declining diatom productivity will collapse the SML layer, leading to potentially uncontrollable runaway climate disruption.

9.1 Recommendations

We must continue with carbon mitigation, but as a matter of urgency, we must eliminate the dumping of all toxic forever lipophilic chemicals, as well as plastic and black carbon soot, into the environment. All wastewaters must be treated, we must not pollute our environment, we must DO NO HARM to nature on land and to marine life in the Oceans. We must start doing some GOOD and transition from destructive farming and unsustainable fishing practices to rewilding and regenerate ecosystems on land and in the oceans. We should also give serious consideration to changing sea water chemistry by increasing calcium and alkalinity concentrations, and we consider this to be a no-risk strategy.

Planktonic marine life is the lungs and life support system for the planet; they can double in mass in just 3 days as soon as we take the toxic brakes off and transition to a nontoxic, carbon net zero world by 2030. The take-away from this report is that if we regenerate marine life, there is the potential to stop climate disruption and make the world a better place.

Citations

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Ethics declarations

The authors declare no competing interests