Marinet
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Briefing Paper

Marinet Film, *WTF? – Where's The Fish?*

Mass Extinction in the Ocean.

In the Marinet film we make a forecast that 94% of all marine species will be extinct by 2050 unless there is a change in present practices which impact on the ocean.

This Briefing Paper addresses the evidence for that prediction.

In geological time, it is widely recognised that there have been at least 5 mass extinction events experienced by Life on this planet. Some people believe that a sixth mass extinction event is now underway. The previous mass extinction events have, to the best of scientific knowledge, been due to externally sourced physical events (e.g. meteorite collisions) but in the case of the forecast sixth mass extinction the cause is a change in planetary conditions due to the activities of Mankind i.e. ourselves.

We provide in this Briefing Paper the evidence for a sixth mass extinction event. Before we do so, we first provide a brief summary of each of the previous 5 mass extinction events as an illustration as to the nature of the impact of these phenomena.

Historical Mass Extinction Events.

In terms of geological time all of these extinction events are preceded by the **Cambrian explosion** in Life. This event took place approximately **540 million years ago** and this is the time when most major phyla first appeared in the fossil record. [Note. *phylum* : a primary division in the kingdom of animals or plants e.g. Arthropoda (insects, crustaceans, arachnids and myriapods)]. Before the Cambrian explosion most organisms were simple and composed of individual cells, occasionally organized into colonies. Over the next 70 to 80 million years the rate of diversification accelerated and the variety of life began to resemble that of today. Almost all present day animal phyla first appeared during this period.

Source: https://en.wikipedia.org/wiki/Cambrian_explosion

Note: In considering mass extinction the term 'taxonomy' will arise. **Taxonomy** is the science of classifying (taxonomy), defining and naming groups of biological organisms on the basis of shared characteristics. Organisms are grouped together into one of 8 taxa (singular: taxon) and these are given a taxonomic rank. These ranks are hierarchical. The ranks are *domain*, *kingdom*, *phylum* (*division* is sometimes used in botany in place of *phylum*), *class*, *order*, *family*, *genus* and *species*. The Swedish botanist Carl Linnaeus is regarded as the father of taxonomy.

Source https://en.wikipedia.org/wiki/Taxonomic_rank and https://en.wikipedia.org/wiki/Taxonomy_(biology)

Ordovician-Silurian Extinction: This occurred around **450 million years ago**. Small marine organisms died out. Almost all major taxonomic groups were affected during this extinction event. Extinction was global during this period, eliminating between 49% to 60% of marine genera and nearly 85% of marine species.
[Note: *genus (pl. genera)* this taxonomic category is below the *family* and above the *species* level. It includes group(s) of species that are structurally similar and this classification uses a capital lettered Latin name. For example: the genus *Panthera* (incorporating such species as lion, leopard, jaguar, panther, tiger and the like)].

During this extinction marine genera such as brachiopods, bivalves, echinoderms, bryozoans and corals were particularly affected. This extinction was marked by a profound cooling.

Before this late Ordovician cooling, temperatures were relatively warm and it is the suddenness of this change to a cooler climate and the elimination of habitats due to an accompanying sea-level fall that are believed to have precipitated the extinctions. The falling sea level disrupted or eliminated habitats along the marine continental shelves. Evidence for the glaciation that took place has been found through deposits in the Sahara Desert. A combination of lowering of sea level and glacially driven cooling were likely the driving agents for the Ordovician mass extinction.

Source:
https://en.wikipedia.org/wiki/Ordovician%E2%80%93Silurian_extinction_events

Devonian Extinction: This occurred around **375 million years ago**. Around 75% of species went extinct and tropical marine species were hit the hardest.

By the Late Devonian, the land had been colonized by plants and insects. In the oceans there were massive reefs built by corals and stromatoporoids. The land continents of Euramerica and Gondwana were beginning to converge into what would become Pangaea.

The extinction seems to have only affected marine life. Hard-hit groups include brachiopods, trilobites, and reef-building organisms; the reef-building organisms almost completely disappeared. The causes of this extinction event are unclear. Leading hypotheses include changes in sea level and ocean anoxia (absence of dissolved oxygen), possibly triggered by global cooling or oceanic volcanism.

Source: https://en.wikipedia.org/wiki/Late_Devonian_extinction

Permian-Triassic Extinction: This occurred around **250 million years ago**. It is the Earth's most severe known extinction event with up to 96% of all marine species and 70% of terrestrial vertebrate species becoming extinct. It is the only known mass extinction of insects.

Some 57% of all biological *families* and 83% of all *genera* became extinct.

Source: https://en.wikipedia.org/wiki/Permian%E2%80%93Triassic_extinction_event

Triassic-Jurassic Extinction: This occurred **200 million years ago.** This extinction event profoundly affected life on land and in the oceans. On land around 80% of all *species* were lost. In the seas, a whole *class* (conodonts : a now extinct *class* of marine animals, ressembling eels in appearance) and 23-34% of marine *genera* disappeared.

About 42% of all terrestrial tetrapods (the *class of* four-limbed animals, which also includes snakes) went extinct. This event vacated terrestrial ecological niches, allowing the dinosaurs to assume the dominant roles in the Jurassic period. This event happened in less than 10,000 years and occurred just before the Pangaea landmass started to break apart.

Statistical analysis by scientists of the marine losses at this time suggests that the decrease in diversity was caused more by a decrease in *speciation* than by an increase in extinctions.

Source: https://en.wikipedia.org/wiki/Triassic%E2%80%93Jurassic_extinction_event

Cretaceous–Paleogene (**K–Pg**) **Extinction,** also known as the **Cretaceous–Tertiary** (**K–T**) **Extinction**. This occurred around **66 million years ago.** There was a sudden mass extinction of some three-quarters (76%) of the plant and animal species on Earth.

A wide range of species perished in the K–Pg extinction, the best-known being the non-avian dinosaurs. It also destroyed a plethora of other terrestrial organisms, including certain mammals, pterosaurs, birds, lizards, insects and plants.

In the oceans, the K–Pg extinction killed off plesiosaurs and the giant marine lizards (Mosasauridae) and devastated fish, sharks, mollusks (especially ammonites, which became extinct) and many species of plankton.

As stated, it is estimated that 75% or more of all species on Earth vanished.

Source:
https://en.wikipedia.org/wiki/Cretaceous%E2%80%93Paleogene_extinction_event
The Current Mass Extinction.

Anthropocene (Holocene) extinction. This extiction event is a hypothesis whose proposition is that there is an ongoing extinction event of species during the present Anthropocene (Holocene) epoch, mainly as a result of human activity. (Note: Anthropocene is the current geological age, viewed as the period in which human activity has been the dominant influence on climate and the environment. Some geologists argue that the Anthropocene age began with the Industrial Revolution).

The large number of extinctions spans numerous families of plants and animals, including mammals, birds, amphibians, reptiles and arthropods (*arthropods*: primarily insects, but also their relatives such as arachnids, millipedes and some crustaceans).

With widespread degradation of highly biodiverse habitats such as coral reefs and rainforests, as well as other major habitats, the vast majority of these extinctions are thought to be *undocumented* as no one is even aware of the existence of the species before they go extinct or because no one has yet discovered their extinction.

The current rate of extinction of species is estimated at 100 to 1,000 times higher than natural background rates.

There is widespread consensus among scientists that human activity is accelerating the extinction of many animal species through the destruction of habitats, the consumption of animals as resources, and the elimination of species that humans view as threats or competitors. However some scientists contend that this biotic destruction has yet to reach the level of the previous five mass extinctions.

In November 2017 a statement titled "World Scientists' Warning to Humanity: A Second Notice" led by eight authors and signed by 15,364 scientists from 184 countries asserted that, among other things, "*we have unleashed a mass extinction event, the sixth in roughly 540 million years, wherein many current life forms could be annihilated or at least committed to extinction by the end of this century*." Earlier in 1992 the late Henry W. Kendall, a former chair of the Union of Concerned Scientists (UCS) Board of Directors, wrote the first warning World Scientists' Warning to Humanity, which begins: "*Human beings and the natural world are on a collision course*." A majority of the Nobel Prize laureates in the sciences signed this first document and about 1,700 of the world's leading scientists appended their signature.

Source: https://en.wikipedia.org/wiki/Holocene_extinction

A Mass Extinction is not just a phenomenon where a significant swathe of life within the taxonomic structure is eliminated. It is also a phenomenon with a cause; and that cause, whilst having an active agent (e.g. meteorite), is delivered by a profound alteration in the physical and chemical systems that support life on the planet. It is the alteration in these physical and chemical systems, within whose boundaries life is adapted to live, which is the disruptive factor(s) that actually means that life, throughout the taxonomic structure, finds its ability to survive insufficient and thus impossible.

The types of physical and chemical changes that an external cause will destabilise are: global mean temperature (hotter or cooler), atmospheric composition (CO2 and/or oxygen levels), ocean alkalinity (reduced alkalinity, aka. acidification), ocean anoxia (insufficient dissolved oxygen), ocean toxicity (chemicals which destabilise DNA or eliminate reproductive capability) and, on land, such events as alteration in climate patterns (rainfall and desertification).
[Note: an "external cause" is an event such as a meteorite or a volcanic eruption relating to the 5 mass extinctions in the geological record, or Man in the case of the hypothesis involving the present extinction.]

This is not an exhaustive list of changes. Furthermore, these and additional changes will interact with one another, thus intensifying their impact. A mass extinction is thus a doom-loop phenomenon i.e. one event sparks another, which then triggers another until the whole system collapses.

Below we list factors identified by the Union of World Scientists in 2017 as being in operation in connection with the hypothesis of a sixth (Anthropocene) mass extinction event.

First however we record some of the significant changes in physical, chemical and biological systems which, in the opinion of Marinet, indicate that the oceans are on an accelerating trend towards a new mass extinction.
[Note: we have quantified this possibility as a 94% mass extinction of marine species by 2050 if current trends continue, based on previous mass extinctions rates which range from c.70% to 95% of all marine species, see earlier data].

Physical and Chemical indicators:

- The ocean has absorbed 90% of the additional heat in the atmosphere caused by human released CO2. The ocean is therefore a sink for human released CO2 and its related excess heat. If this excess heat had stayed in the atmosphere, instead of being absorbed by the ocean, the atmosphere would have warmed by 36°C (65°F) [ref. http://www.marinet.org.uk/iucn-reports-that-oceans-are-disguising-the-full-extent-of-

global-warming.html and http://www.marinet.org.uk/oceans-are-the-sink-that-is-taking-the-brunt-of-global-warming-say-researchers.html]

- The temperature of ocean surface waters is now rising by 0.1°C each decade (regionally variable) [ref. http://www.marinet.org.uk/iucn-ocean-surface-waters-warming-by-0-1c-per-decade.html]

- In addition to absorbing 90% of the heat generated by human released CO2, the ocean has also absorbed 30% of the CO2 itself. This generates carbonic acid and, in turn, affects the alkalinity of the ocean. The alkalinity of the ocean, currently pH 8.1, is under pressure as a result. The alkalinity has reduced by pH 0.1 units since 1800 and is likely to fall by 0.3 to 0.5 pH units if present trends continue. Reduced alkalinity (acidification) of sea water reduces the ability of marine life to extract the calcium carbonate needed for their internal/external skeletons (i.e. coral reefs, fish, and mammals, phyto- and zoo-plankton). Consequently the ability of marine creatures to survive is compromised as is their ecosystem role e.g. phytoplankton, at the base of the food chain and generators of free oxygen, are jeopardised. Under these circumstances a doom-loop can develop. [ref. https://en.wikipedia.org/wiki/Ocean_acidification]

- Dissolved oxygen levels in the ocean have decreased, on average by 2% in the last half century. Such change has the capability of altering ecosystems significantly. [ref. http://www.marinet.org.uk/oxygen-levels-in-the-oceans-are-declining-say-scientists.html]

Biological indicators:

- Change in ocean temperature and related alkalinity (acidification) will likely impact significantly on coral reefs. Coral reefs occupy less than 1% of the ocean floor and support around 25% of all marine life. [ref. https://coral.org/coral-reefs-101/coral-reef-ecology/coral-reef-biodiversity/]

- Commercial fish stocks are declining globally whilst the world's human population continues to rise. The UN Food and Agricultural Organisation (FAO) reported in 2018 (data for 2015) that:
    - 7% of world stocks are under-fished
    - 60% of world stocks are fully fished
    - 33% of world stocks are over-fished

  In 1974 10% of world stocks were over-fished. In 2015 the level is 33%. [ref. http://www.fao.org/state-of-fisheries-aquaculture]

- Animals in the deepest ocean now contain man-made fibres and plastic [ref. http://www.marinet.org.uk/animals-in-the-deepest-ocean-are-ingesting-waste-plastic.html] and by 2050 it is predicted the weight of all waste plastic in the ocean will

equal the weight of all fish [ref. http://www.marinet.org.uk/plastic-waste-in-the-oceans-will-equal-the-amount-of-fish-by-weight-by-2050.html]

In summary, the sixth (Anthropocene) mass extinction is a hypothesis as is Marinet's prediction that it will eliminate 94% of all marine species by 2050. What is not a hypothesis is that there have been 5 mass extinctions previously in geological time and that one of these (Permian-Triassic) resulted in c. 96% of all marine species being made extinct. Mass extinction events are therefore inherent to the history of life. Marinet's evidence proposing we are in the throes of the sixth mass extinction is cited above. We now conclude this Briefing Paper with the evidence, and their references in distilled form, from the Union of Concerned Scientists November 2017 report (op. cit).

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Unsustainable marine fisheries: In 1992, the total marine catch was at or above the maximum sustainable yield and fisheries were on the verge of collapse. Reconstructed time series data show that global marine fisheries catches peaked at 130 million tonnes in 1996 and has been declining ever since. The declines happened despite increased industrial fishing efforts and despite developed countries expanding to fishing the waters of developing countries. (*Pauly, D., and D. Zeller. 2016. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. Updated. Nature Communications 7:10244*).

Ocean dead zones: Coastal dead zones which are mainly caused by fertilizer runoff and fossil-fuel use, are killing large swathes of marine life. Dead zones with oxygen-depleted (hypoxic) waters are a significant cause of stress on marine systems and the number of identified locations have dramatically increased since the 1960s, with more than 600 systems affected by 2010. (*Diaz, R. J., and R. Rosenberg. 2008. Spreading Dead Zones and Consequences for Marine Ecosystems. Updated. Science 321:926–929*.

Forest loss: The world's forests are crucial for conserving carbon, biodiversity and freshwater. Between 1990 and 2015 total forest area decreased from 4,128 to 3,999 million hectares, a net loss of 129 million hectares (3%) which is approximately the size of South Africa. Forest loss has been greatest in developing tropical countries whose forests (often biodiverse hotspots) are now commonly converted to agriculture uses. (*Food and Agriculture Organization of the United Nations. 2015. Global forest resources assessment 2015. http://www.fao.org/forest-resources-assessment/en/*).

Dwindling biodiversity: The world's biodiversity is vanishing at an alarming rate and populations of vertebrate species are rapidly collapsing (World Wildlife Fund 2016). Collectively global fish, amphibians, reptiles, birds and mammals declined by 58% between 1970 and 2012. Freshwater, marine and terrestrial populations declined by 81%, 36% and 35% respectively. (*World Wildlife Fund. 2016. Living planet report*

2016: risk and resilience in a new era. McRae, L., Deinet, S. and Freeman, R., 2017. The Diversity-Weighted Living Planet Index: Controlling for Taxonomic Bias in a Global Biodiversity Indicator. PloS one, 12(1), p.e0169156).

Climate change: Global fossil-fuel CO2 emissions have increased sharply since 1960. Relative to the 1951-1980 average, the global average annual surface temperature has, in parallel to CO2 emissions, also risen rapidly risen. In the current 136 year long record of meteorological data the 10 warmest years have occurred since 1998. The most recent year of data, 2016, ranks as the warmest on record. Temperature increases will likely cause a decline in the world's major food crops, an increase in the intensity of major storms and a substantial sea level rise inundating major population centres. (*Boden, T. A., G. Marland, and R. J. Andres. 2017. Global, regional, and national fossil-fuel CO2 emissions, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory. US Department of Energy, Oak Ridge, Tenn., USA 2009. doi 10.3334/CDIAC 1*) and (*NASA's Goddard Institute for Space Studies (GISS). 2017. Global Temperature. https://climate.nasa.gov/*)

Population growth: Since 1992, the human population has increased by approximately 2 billion individuals, a 35% change. The world human population is unlikely to stop growing this century and there is a high likelihood that the world population will grow from 7.2 billon people now to between 9.6 and 12.3 billon by 2100. Like the change in human population, the domestic ruminant population, which has its own set of major environmental and climate impacts, has been increasing in recent decades to approximately 4 billion individuals on Earth. (*FAOSTAT. 2017. FAOSTAT Database on Agriculture. http://faostat.fao.org/*).

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