November 2019

OCEAN HEATING

Global heating driven by rising greenhouse gas emissions is having a pervasive and accelerating effect on the ocean. The most direct impact is the heating of the ocean itself, which recent studies show is occurring faster and deeper than previously thought.

Of the eight priority issues identified by the International Programme on the State of the Ocean (IPSO) to be addressed to help avert ecological disaster in the global ocean, global heating is the highest priority. It is the pre-eminent factor driving change in the ocean.

ABOUT OCEAN HEATING

The ocean has absorbed 93% of the excess heat trapped by human-emitted greenhouse gases since the 1970s (Levitus et al., 2012). This has tempered global heating but has caused the temperature of the ocean to rise, with multiple knock-on effects including deoxygenation.

Since the 1970s, the average global sea surface temperature has risen at a rate of 0.11˚C per decade and a total rise of approximately 1˚C since pre-industrial levels. Long-term effects have been detected at a depth of 700m. The deep ocean is also affected. Ocean heating has now been observed to full ocean depth with one third of the excess heat absorbed 700m below the sea surface (Levitus et al., 2012). By 2100 the ocean will have absorbed 2 to 4 times more heat than between 1970 and the present if global temperature rise is limited to 2˚C, and 5 to 7 times at higher emission scenarios (IPCC, 2019).

But the situation may be even more alarming. Recent studies have found that the ocean is heating up 40% faster on average than indicated by IPCC in 2013 (Cheng et al., 2019-a). It is not surprising that 2018 was the hottest year for the ocean on record (Cheng et al., 2019-b).

These temperature increases may not sound large, but even incremental changes can have a profound effect on ocean chemistry, ecosystems and sea levels. Hypothetically, if all the heat absorbed by the ocean since the 1950s was suddenly added to the atmosphere, air temperatures would soar by around 36°C (Levitus et al, 2012).

IMPACTS

The heating of the ocean is causing enormous and growing impacts.

Deoxygenation

Oxygen is vital to life in the ocean. As the sea temperature rises oxygen becomes less soluble and the ocean more stratified leading to deoxygenation (Gao et al., 2012). This increases mortality and alters the range of fish and other species (Gattuso et al., 2015).

Accelerated sea level rise

As seawater warms, it expands, filling a larger volume. The warming of the ocean as a result of climate change is a significant contributor to global sea level rise (NOAA, 2019). In the last 100 years global mean sea level rose by 0.19m, which is greater than the average rate over the last 2000 years (IPCC, 2019).

Reduced ocean mixing
As the ocean warms, there is increased stratification (layering of water of different salinity and density) in the upper layers, resulting in reduced movement of nutrients from deeper layers. This makes shallow-dwelling organisms more vulnerable (Gao et al., 2012). Between 1970 and 2017 stratification in the upper ocean (200 m) increased by between 2.18% and 2.42% (IPCC, 2019).

Reduced biodiversity
Heating and associated deoxygenation are driving the extinction of vulnerable species and causing non-native species from different biogeographic regions to spread beyond their range and become established across the ocean (Laffoley and Baxter, 2016).

Weather changes
Warmer waters are bringing more frequent marine heatwaves – periods of extreme warm sea surface temperature that persist for days to months (Frölicher, 2018). There is also evidence of recent increase in global wave power as a consequence of oceanic warming (Reguero et al., 2019).

Acceleration of polar ice melt
Warmer waters around Antarctica are contributing to a melt rate six times faster that during the 1980s (Rignot et al., 2019). Melting of sea ice and glaciers, and prevention of sea ice formation, will disrupt the sinking of water in the polar regions which could disrupt the ocean's circulation system (NOAA, n.d.). This thermohaline circulation system plays a vital role in regulating Earth's temperature. The 2018 IPCC Report says that the likelihood of a summer free of sea ice in the Arctic Ocean would be once in a century with 1.5°C of global heating, and once in a decade if temperatures rise by 2°C (IPCC, 2018).

Redistribution of important ocean species
Ocean heating has already begun to cause a change in distribution of many marine species including invertebrates, fish and marine mammals. This will lead to local extinctions and cause permanent changes to ecosystems (Gattuso et al., 2015). It is also rapidly altering the fundamental ecology of coastal habitats upon which people rely (Welch, 2019). For example, krill, the keystone species of Antarctic waters, have moved four degrees of latitude south to seek more favourable conditions (Atkinson et al., 2019).

Impacts on coral reefs
Reef-building corals found in the tropics and sub-tropics are extremely vulnerable as they are unable to adapt fast enough to higher temperatures. Since the 1980s, rising sea surface temperatures due to global warming have triggered unprecedented mass bleaching of corals, including three pan-tropical events in 1998, 2010 and 2015/16 (Hughes et al., 2017).

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