NEW RESEARCH INTO THE IMPACT OF CLIMATE CHANGE AND HUMAN ACTIVITY ON THE OCEAN AND ITS ECOSYSTEMS

A SUMMARY OF "THE SWEETMAN PAPER"

Overview

In February 2017 the scientific journal *Elementa* published new research by an international group of scientists from 20 research institutes exploring how the ocean, globally, is set to change over the 21st century.

Major impacts of climate change on deep-sea benthic ecosystems[i] concluded that, as a result of climate change, the deep ocean floor – earth's largest habitat – will be starved of food by the end of this century. Food supplies for animals and microbes at the seafloor of the deepest regions of the ocean could fall by up to 55% in the next 80 years.

Using modelling techniques, the researchers examined how climate change will affect deep-seafloor ecosystems in continental margin, abyssal and polar settings by 2100. They considered how these changes may combine with other man-created stressors such as fishing, mineral mining, and oil and gas extraction.

After publication of the report, co-author Dr Andrew Sweetman, Associate Professor at the Lyell Centre for Earth and Marine Science and Technology at Heriot-Watt University, Edinburgh, was quoted as saying: "We need to wake up and start really realising that with the deep ocean, even though we can't see it … we are going to be having a huge effect on the largest environment on the planet. It is pretty scary."

This briefing provides an overview of the report and some of its key findings.

1. About the research

Many existing observational studies have demonstrated that climate change and human industrial activity is increasing temperature, deoxygenation and acidity in the ocean's deep waters. The ocean absorbs 25% of industrial area carbon dioxide emissions and 93% of the heat. Much of this absorption occurs in deep waters below 200m.

However, current understanding of the exact nature and consequences of climate change to the deep sea and its ecosystems is still poor.

The new research was conducted by an international group of scientists from 20 leading oceanographic research centres across the world.

They used earth system models and projected climate change scenarios, developed for the Intergovernmental Panel on Climate Change (IPCC), to quantify impending changes to the deep ocean.

The team looked at sea and ocean beds from the Arctic to Antarctic Oceans, focusing on bathyal (200-3000m) and abyssal (3000-6000m) depths within the benthic (deep sea) region.

As well as examining how the deep ocean's food sources will be affected by climate change, the team examined the impact of increased seabed temperatures, declining oxygen levels and increasingly acidic seawater.

2. Main finding

Rising atmospheric greenhouse gases and increasing levels of atmospheric carbon dioxide are bringing significant changes to the environmental properties of the ocean realm. The rise is causing changes in oxygenation of the water column and food supply.

These will bring impacts on deep sea ecosystems. Most deep sea organisms have adapted strategies for living under constant environmental conditions over thousands of years, so even small changes in temperature, oxygen, acidity and food supply can have a devastating effect.

3. Findings about temperature change

Earth system model analyses suggests that some abyssal ecosystems are warming at rates of 0.01 to 0.1C per decade.

The study indicates that by 2100 there will be a dramatic temperature change in the bathyal depths in the Pacific, Atlantic and Arctic Oceans. Temperatures will increase by 4C.

In the abyssal depths, temperatures could rise by up to 1C.

Even small changes in temperature, could have a major impact on fragile ecosystems.

4. Findings about oxygen levels

Warming of the ocean is expected to result in lower oxygen concentrations, with levels at abyssal seafloor habitats falling by as much as 0.03mL L^{-1} by 2100.

Oxygen concentrations will drop by 3.7% or more in the bathyal depths of the North East Pacific and Southern Oceans.

5. Findings about carbon dioxide levels

Water masses absorb carbon dioxide from the atmosphere, and this causes waters to become more acidic. The study predicts that there will be significant reductions in pH (increases in acidity) in the bathyal depths of all oceans by the year 2100 – for example, a decrease of 0.29 to 0.37 pH units.

Levels of carbon dioxide will rise in the deep sea. This is likely to be disastrous for organisms with shells, such as molluscs, as well as corals. Fish and other creatures will also be affected.

6. Findings about organic matter

Concentration of organic matter in the deep ocean is expected to drop dramatically, reducing the amount of already-scarce food available for deep sea organisms.

There are likely to be significant declines in all areas of the ocean, but it may be greatest in the abyssal and bathyal Indian Ocean where the amount of available food is likely to decrease by 40-55% by the end of the century.

7. Findings about the impact on ecosystems

Although deep ocean temperatures may cool in some regions, the impact is still expected to be negative because most deep sea organisms have adapted strategies for living under constant environmental conditions over thousands of years.

The study predicts the following effects on ecosystems:

Temperature rises

- Fauna body size decreases
- Fauna metabolism increases
- Fauna migrates to cooler locations

Oxygen concentration falls

- Abundance of larger fauna falls
- Abundance of smaller fauna rises
- Organic-rich sediment declines
- Habitat ranges compress

Acidity increases

- Abundance and diversity of calcifiers (eg corals) decreases
- Fauna metabolism and energy demand increases

Food supply decreases

- Biodiversity decreases
- Organic sediment layer grows thinner
- Abundance of fauna decreases
- Microbial contribution to carbon cycling decreases

8. What the report demonstrates

Climate change is starving deep sea ecosystems of food

Dr Andrew Sweetman, co-author of the study, said:

“Deep seafloor ecosystems provide services that are vitally important to the entire ocean and biosphere; we should all be concerned at what’s happening on our ocean floors.”

"Abyssal ocean environments, which are over 3000m deep, are some of the most food-deprived regions on the planet. These habitats currently rely on less carbon per m^2 each year than is present in a single sugar cube. We've shown that large areas of the abyss will have this tiny amount of food halved by 2100. For a habitat that covers half the earth, the impacts of this will be enormous."

Increase in deep ocean temperature is "very worrying"

Dr Andrew Thurber, co-author of the study and professor at Oregon State University, said:

"Deep-sea ecosystems are not just going to experience a reduction in food, but will likely also experience an increase in ocean temperature of 1°C within 85 years."

"This is very worrying because increasing temperature will increase the metabolism of animals and microbes that live in the sediment, meaning they will require more food at a time when much less is available."

The need for more deep ocean research

Dr Lisa Levin, co-author and professor at Scripps Institution of Oceanography, UC San Diego, said:

"Because many deep-sea environments are naturally very stable in terms of environmental conditions, even slight changes in temperature, oxygen, food supply, and pH are likely to significantly lower the resilience of deep-sea communities to the impact of human activity."

"These many challenges call for intensified observations of and spatial planning for the deep ocean, coordinated at an international level."

---

[i] Andrew K. Sweetman' Andrew R. Thurber, Craig R. Smith, Lisa A. Levin, Camilo Mora, Chih-Lin Wei, Andrew J. Gooday, Daniel O. B. Jones, Michael Rex, Moriaki Yasuhara, Jeroen Ingels, Henry A. Ruhl, Christina A. Frieder, Roberto Danovaro, Laura Würzberg, Amy Baco, Benjamin M. Grupe, Alexis Pasulka, Kirstin S. Meyer, Katherine M. Dunlop, Lea-Anne Henry and J. Murray Roberts

Prepared by the Deep Sea Conservation Coalition 2017