ARC Centre of Excellence for Climate Extremes Briefing Note 5 (a joint note with the NESP Earth Systems and Climate Change Hub)

Earth Systems and Climate Change Hub

National Environmental Science Programme

climate extremes

ARC centre of excellence

Heatwaves in the ocean threaten marine ecosystems across the world

A joint ARC Centre of Excellence for Climate Extremes and NESP Earth Systems and Climate Change Hub briefing note

Key Points

- **Marine heatwaves are becoming longer and more frequent. The annual number of marine heatwave days averaged across all parts of the ocean has increased by 50% between 1925-1954 and 1987-2016.**

- **A global assessment of marine heatwaves has concluded that they have "the capacity to restructure entire ecosystems and disrupt the provision of ecological goods and services in the coming decades" and that "marine conservation and management approaches must consider marine heatwaves and other extreme climatic events if they are to maintain and conserve the integrity of highly valuable marine ecosystems over the coming decades".**

- **The study identifies marine ecosystems in the southwest Pacific, including around southeast Australia, as being particularly at risk from marine heatwaves.**

A marine heatwave occurs when the ocean is unusually warm for a prolonged period of time[1,a]. Marine heatwaves can affect large parts of the ocean and can last from days to over a year. Just as heatwaves on land can be detrimental to land-based species and agriculture, heatwaves in the ocean can damage marine ecosystems and industries that rely on them. For example, a 251-day-long heatwave in the Tasman Sea during 2015-2016 coincided with the outbreak of disease in oyster farms, poor quality abalone and reduced yields from salmon farms in Tasmania[2].

A recent scientific paper by Smale et al. (2019)[3], to which the National Environmental Science Program's Earth Systems and Climate Change Hub and the ARC Centre of Excellence for Climate Extremes have contributed, highlights the increasing threat posed by marine heatwaves to marine ecosystems and related goods and services.

Previous research focussing on individual marine heatwaves or particular parts of the ocean has demonstrated how these events can have a large impact on marine ecosystems, affecting the growth, reproduction and survival of the species within them. Some ecological effects are short-term, but others may persist well after a heatwave has dissipated. The Smale et al. study extends this work to a global assessment of the impacts of marine heatwaves. It provides evidence that marine heatwaves can alter the fundamental structure of marine ecosystems across the world, posing a challenge to the industries that rely on them and a threat to local biodiversity. This is of particular concern given other research showing that, as the oceans are warming, marine heatwaves are becoming longer and more frequent. An analysis of the annual number of marine heatwave days averaged across all parts of the ocean has shown a 50% increase in the average number of days between 1925-1954 and 1987-2016[4].

The study surveys 116 previous research papers to examine the response of ecosystems to eight marine heatwaves. All of these heatwaves damaged marine ecosystems, but the impacts on individual species varied[b].

The study also summarises the knock-on effects on the services that impacted ecosystems provide to society. These "ecosystem services" are significant, with hundreds of millions of people benefitting from coastal marine ecosystems[5,6]. **It concluded that "a wide range of ecological goods and services derived from marine ecosystems have been severely impacted by recent marine heatwaves".** For example, marine heatwaves can affect the distribution and abundance of commercial fish species, as happened during the "Ningaloo Niño" marine heatwave off Western Australia in 2011[7]. Ecosystems impacted by marine heatwaves may also have decreased socioeconomic value through being less attractive for recreational activities, such as snorkelling over coral reefs or scuba diving through underwater kelp forests.

The Smale et al. study identifies parts of the ocean off southeast Australia, along with other regions in the Pacific, Atlantic and Indian Oceans, as "hot spots" with particular vulnerability to marine heatwaves. Marine heatwave days are increasing rapidly in these regions, threatening many species living near the upper end of their tolerable temperature range. In addition, ecosystems in these regions are being subject to other potentially damaging effects, such as over-fishing or pollution.

Explainers

a. A formal definition that can be used to identify marine heatwaves has only recently been proposed. Work led by Australian researchers has proposed a definition based on the principle that a marine heatwave is "a discrete prolonged anomalously warm water event in a particular location"[1]. This definition has been widely used in subsequent work investigating the impacts of marine heatwaves and how they could be affected by climate change. Freely available software[8] has also been developed to identify marine heatwaves from ocean temperature data and compute their characteristics. It allows "marine heatwave days", days on which a marine heatwave is in progress, to be identified for each location in the ocean. The software also computes statistics describing the frequency, duration and intensity of marine heatwave events.

b. All marine species can tolerate only a limited range of water temperatures and live in parts of the ocean that lie within this range. The Smale et al. study found that species living closer to the upper end of their tolerable temperature range were more negatively impacted by marine heatwaves than other species. The impact can be a marked change in the area inhabited by a species and the study noted that "recent observations have shown that equatorward range edges of both plant and animal species have retracted poleward by >100 km following severe marine heatwave events". Immobile species, like corals, were found to be most heavily impacted, while some mobile species were not greatly affected. Some tropical fish benefitted from marine heatwaves, as the warmer water allowed them to extend their usual habitat into temperate regions. The study highlights the detrimental effects of marine heatwaves on foundational species that underpin important ecosystems. It includes specific examples of the association between the length and frequency of marine heatwaves and damage to ecosystems, including a decline in seagrass in Cockburn Sound, Western Australia.

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