Earth Systems and Climate Change Hub
National Environmental Science Programme

climate change **science brief**

Understanding marine heatwaves

Ocean temperature extremes, particularly marine heatwaves, can cause significant impacts to marine ecosystems including biodiversity, fisheries and aquaculture.

Rising ocean temperatures and increased pressure on marine ecosystems and fisheries mean that understanding trends and changes in ocean temperature extremes is important for informing marine management and planning activities.

Earth Systems and Climate Change Hub researchers have worked with other researchers across Australia to investigate changes in the frequency, duration and intensity of marine heatwaves, and to shed light on the influence human activities have had on marine heatwave trends now, and into the future.

Global trends in marine heatwaves

A significant overall increase in the frequency and duration of marine heatwaves has occurred across the globe. From 1925 to 2016, global average marine heatwave frequency and duration increased by 34% and 17%, respectively, resulting in a 54% increase in annual marine heatwave days globally.

These trends are primarily caused by increasing ocean temperatures. Increases in ocean heat is one impact of climate change, and so we can expect more marine heatwave days globally as our climate continues to change due to increases in greenhouse gas emissions.

Discrete marine heatwave events are emerging as pivotal in shaping ecosystems, by driving sudden and dramatic shifts in ecological structure and functioning. In 2016, a quarter of the world's ocean surface experienced either the longest or most intense marine heatwave since satellite records began. Hub researchers found that intense marine heatwave events across northern Australia and the Bering Sea/Gulf of Alaska in 2016 were up to 50 times more likely due to human-induced climate change. Under the influence of climate change, marine heatwave properties have now reached levels significantly different from what would be expected due to natural variability alone.

Marine heatwaves in Australia

Two unprecedented marine heatwave events occurred in the waters off the coast of eastern Australia in the Tasman Sea region during 2015/16 and 2017/18. The Tasman Sea is widely recognised as a global warming hotspot, with surface temperatures east of Tasmania increasing at close to four times the global average rate. This region also supports critical biodiversity and is an economically important region for wild harvest fisheries and aquaculture, including abalone, Pacific oysters and Atlantic salmon. Hub researchers investigated the causes of these two events.

The **Earth Systems and Climate Change Hub** is funded by the Australian Government's National Environmental Science Program

2015/16 Tasman Sea marine heatwave event

This marine heatwave event occurred deep within the ocean, extending from the ocean surface to more than 400 m depth. It lasted for over 8 months, with temperatures up to ~3°C higher than average.

As a result of the heatwave, the region experienced its first recorded outbreak of the Pacific Oyster Mortality Syndrome – a virus in the Pacific oyster that can result in death. Other impacts included mortality of abalone and reduced performance of farmed Atlantic salmon from local aquaculture.

Researchers found that that the heatwave was substantially more likely under climate change.

2017/2018 Tasman Sea marine heatwave event

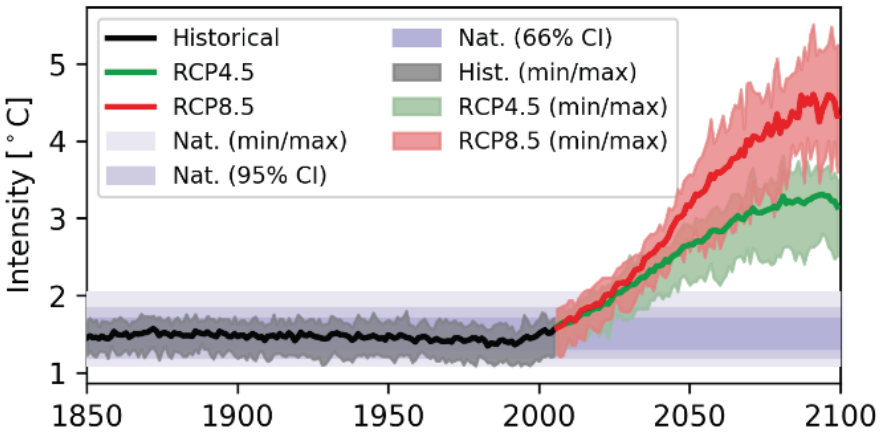
In contrast to the 2015/2016 event, the 2017/18 marine heatwave was relatively shallow in depth, only reaching to a depth of 20 m, but it was much broader in extent.

The record sea surface temperatures experienced during the 2017/18 Tasman Sea event were found to be virtually impossible without the influence of human-induced climate change. However natural variability also played an important role in driving the event.

Future trends in marine heatwaves

Future projections of marine heatwaves indicate that the intensity of these heatwaves and the number of annual marine heatwave days will increase significantly over the 21st century as the climate continues to change.

Projected changes to future marine heatwave intensity



Annual time series for historical (black), RCP4.5 (medium emissions scenario, green) and RCP8.5 (high emissions scenario, red) runs. The grey, red and green shaded regions show the maximum range between individual model runs. The blue shaded areas show the expected range of natural variability based on a 67% confidence interval (darkest blue), and full min-to-max range (lightest blue).

Towards predicting marine heatwave events

While understanding the drivers, causes and impacts of marine heatwave events is important for informing management and planning activities, being able to predict when the next event may occur would provide vital information to allow aquaculture, fisheries and ecosystem managers to prepare for and adapt their operational activities to future events.

In order to predict future marine heatwave events, researchers need to be able to predict sea surface temperatures into the future. This is no easy task as sea surface temperatures are variable, occurring over different time scales and are driven by a number of different climate processes.

Hub researchers have used statistical methods to better understand the predictability of sea surface temperatures, with results suggesting that marine heatwave events may be able to be predicted in the Taman Sea over multi-year timescales, and on yearly timescales off the coast of Western Australia. These findings show that predicting marine heatwave events is likely to be possible with further research and development of decadal prediction modelling systems.

This research was led by ESCC Hub Project 2.3 (component 2): *Decadal-scale predicability of ocean temperature extremes*.

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