Marine Heatwaves

A marine heatwave is an extended period of extremely warm ocean temperatures. The scientific definition of a marine heatwave is when seawater temperatures are warmer than the 90th percentile of the local long-term (25-year) average for at least five consecutive days.

As part of the Moana Project, we developed the Moana Hindcast – a modelled representation of ocean conditions (temperature, salinity, sea level, and current speed and direction) for the past 28 years. The hindcast is based on the Moana Backbone, a hydrodynamic model set up specifically for the Aotearoa New Zealand Exclusive Economic Zone (EEZ). The model has 5km daily resolution, has been validated against all known historical ocean data and provides the present best knowledge of oceanographic conditions across NZ's EEZ.

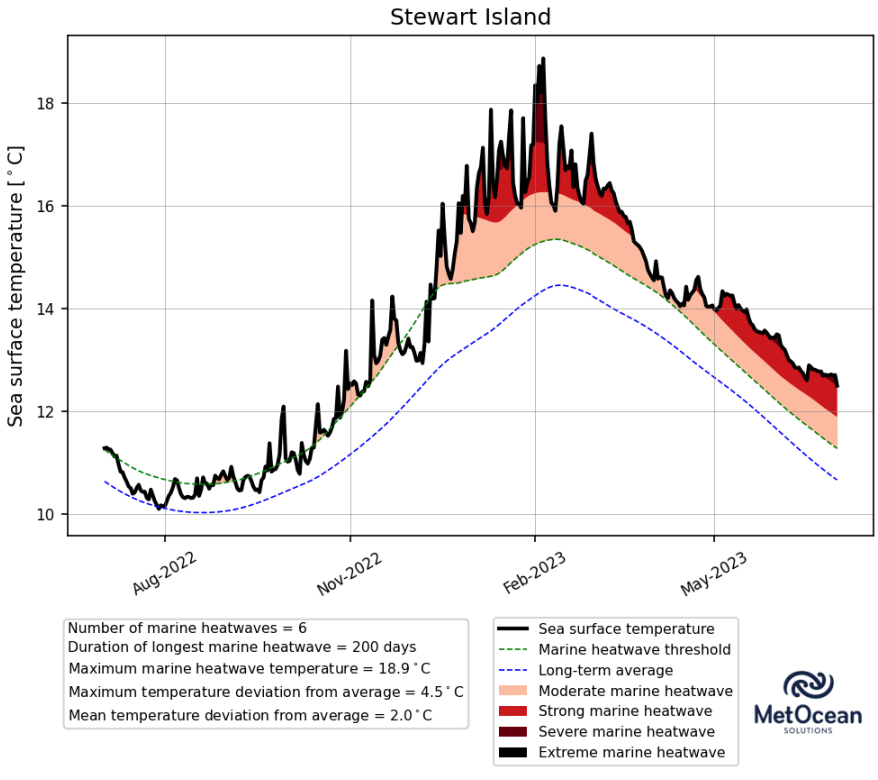
Using the hindcast temperature data as a baseline, we can determine how much present ocean temperatures differ from the 28- year average (for each location and time of year), identify when marine heatwave conditions occur and understand their underlying causes.

Since 2020, we've been providing New Zealand's first marine heatwave forecast as well as marine heatwave conditions over the past year, so the public and project stakeholders can anticipate and prepare for events that may occur in the following week and see how long marine heatwaves have been ongoing in their local area.

Record-breaking marine heatwaves

Since commencing the Moana Project all New Zealand's marine heatwave records have been broken. In the Bay of Plenty, a marine heatwave lasted longer than one year, from November 2021 to November 2022 – the longest continuous marine heatwave recorded in New Zealand waters so far.

Marine heatwaves are classified as 'moderate', 'strong', 'severe' or 'extreme', and in the summer 2022/23 for the first time we saw extreme marine heatwaves in our waters. These events, where ocean temperatures soared more than 5°C above the long-term average, occurred in the areas around the Otago Peninsula and Stewart Island.



(Above) A recent extreme marine heatwave around Stewart Island reached temperatures more than 4°C above the long-term average during summer 2022/2023 and remains ongoing.

These unusually warm waters have been linked to widespread bleaching of marine sponges across the Fiordland National Park, and similar impacts on marine sponges occurred in the Hauraki Gulf associated with a marine heatwave impacting northern New Zealand in the summer 2021/22.

Drivers of marine heatwaves

The Moana Project is investigating how marine heatwaves form and persist, to support the development of new sub-seasonal forecasting tools. Research published by Youstina Elzahaby for the Moana Project showed that in the offshore waters of the eastern Tasman Sea, the strongest, deepest-reaching and most persistent marine heatwaves are typically driven by ocean currents and are not detectable from the surface satellite data alone.

Other Moana Project research demonstrates that monitoring changes in ocean currents and subsurface ocean temperature is key to forecasting the onset of marine heatwaves in fishing grounds along NZ's continental shelf edge and offers predictability of marine heatwaves up to two months in advance.

Our research also suggests that weather-related atmospheric factors are important drivers of marine heatwaves in nearshore waters. Research led by Moana Project researcher Felix Cook demonstrated that in shallow (< 15 m) coastal ecosystems, marine heatwaves generally coincide with blocking high-pressure systems and light winds, factors that are potentially predictable on timescales of weeks.

Ongoing projects led by Elzahaby and Cook have identified a robust set of large-scale oceanic and atmospheric patterns associated with marine heatwaves across the EEZ of NZ. This is providing new mechanistic understanding of marine heatwaves required for producing skilful seasonal forecast tools, with important implications for predicting their ecological impacts across NZ aquaculture regions and key fishing grounds.

Trends in marine heatwaves

The Moana Project has also collaborated with scientists across NZ to investigate how the exposure of our coastal habitats to marine heatwaves has changed over the past half-century. This research used daily in-situ and satellite-derived estimates of surface temperature around our coasts. Our findings show that the rise in exposure of marine ecosystems to temperature extremes over the past fifty years varies significantly across New Zealand. This is linked to complex warming patterns inshore of major ocean currents, which can strongly modify global-scale trends.

Our results also suggest that year-to-year changes in exposure to marine heatwaves, associated with modes of climate variability such as the El Niño–Southern Oscillation (ENSO) and the Southern Annual Mode (SAM), will likely dominate over the long-term trends for some time.