IMOS Integrated Marine Observing System
State and Trends of Australia's Oceans | Report

1.1 Long-term changes in temperature around Australia

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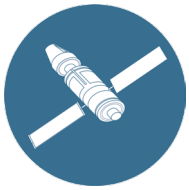
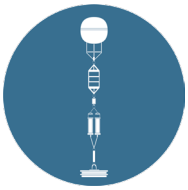
Summary

Coarse long-term temperature data around Australia from 1870 and fine-scale temperature measurements from the three long-term stations since the 1940s confirm a strong warming trend over the past 100 years, with the strongest warming in the Southeast and the Southwest. This background warming signal is propagating throughout the ecosystem, impacting the physical, chemical and biological characteristics of Australia's marine environment.

Key Data Streams



Satellite Remote Sensing



National Reference Stations

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Rationale

The clearest impact of climate change impacts on the ocean is warming, particularly of surface layers that are in closest contact with the atmosphere. Temperature is of fundamental importance to the physics of the ocean. It describes the heat content of the ocean, affects the density and buoyancy of water, and helps distinguish water masses.

Temperature also drives the biology in the ocean. As warming reduces the density of water, and thus enhances stratification, it can lead to lower nutrient concentrations in surface waters, particularly in subtropical and tropical waters. This reduces primary productivity and diminishes phytoplankton and zooplankton biomass. This can then reduce fish biomass in the ocean (Irigoien et al., 2014; Richardson & Schoeman, 2004), especially under climate change (e.g. Galbraith, Carozza, & Bianchi, 2017). Temperature also drives changes in the distribution of marine plants and animals, with most species moving towards cooler temperatures at higher latitudes (Poloczanska et al., 2013). The pace of life in the ocean is also governed by temperature, through its impact on photosynthesis and metabolic rates.

Methods

To investigate long-term changes in sea surface temperature (SST) around Australia, we have used two different datasets. The longest time-scale is from 1870-2018, we used HadISST1, a monthly 1° global product, which is a blend of *in situ* and satellite temperature measurements (Rayner et al., 2003, available from https://www.metoffice.gov.uk/hadobs/hadisst/). We averaged HadISST1 in the six marine bioregions within the Australian EEZ. We also calculated the difference in SST between the present and the past from HadISST data using a linear regression over the entire time series and taking the difference between the estimated temperature in 2017 and that in 1870.

From 1944-2018, we used the longest observed temperature time series in Australia. This is from the three long-term National Reference Stations: Port Hacking, Maria Island and Rottnest Island (AODN dataset: "IMOS - ANMN National Reference Stations - Combined long-term hydrological data product (1944-2014)").

Results and interpretation

In Australia's marine bioregions, there was a slight cooling or no change in temperature between 1870 and the early 1900s (**Figure 1**). Since 1920, there has been steady warming, particularly in the south. The greatest warming has been in the South-east (1.1°C century^{-1}), the South-west (0.99°C century^{-1}) and the Temperate East (0.93°C century^{-1}) bioregions, with less warming in the North-west (0.6°C century^{-1}), North (0.74°C century^{-1}) and Coral Sea (0.8°C century^{-1}). The general spatial pattern shows that there has been warming throughout all of Australia since 1870, particularly in the South-east (**Figure 2**).

Data from the long-term National Reference Stations in Australia confirm the surface warming from HadISST1 data, showing strong warming over the past 80 years over all depths in the top 50 m. At Maria Island, all depths show a near-linear increase in temperature, up to ~2°C. Since the 1950s at Port Hacking there has been less warming, ~1.5°C. At Rottnest Island there has been moderate warming of ~0.75°C, including some more recent cooling.

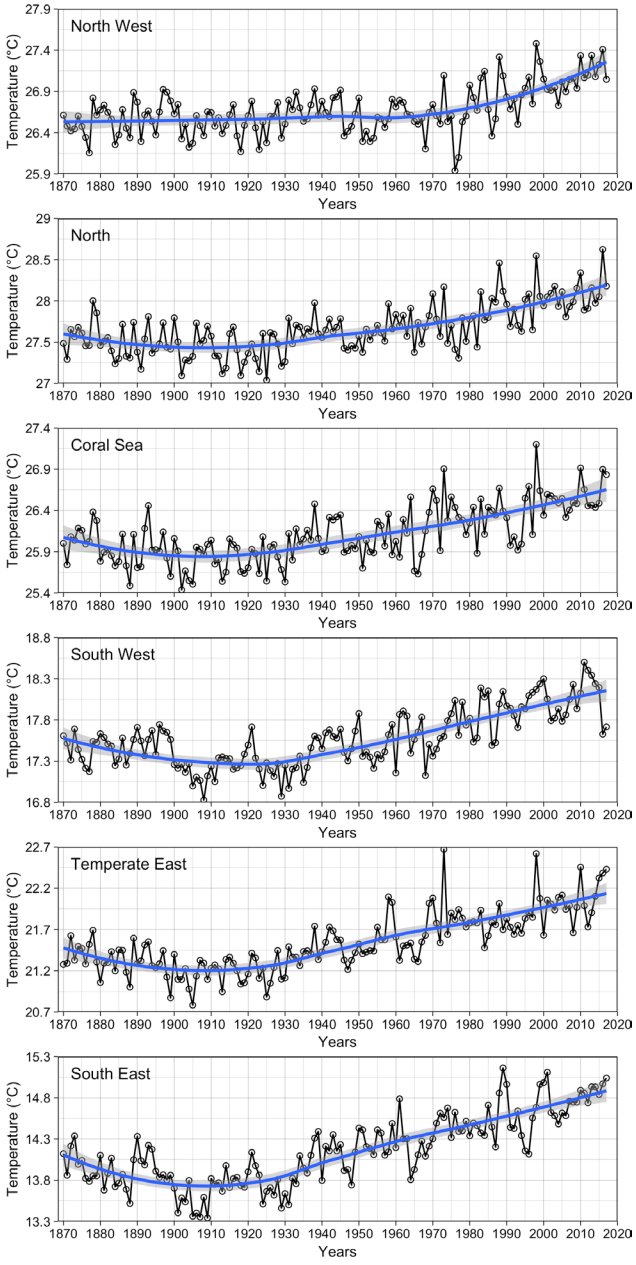

Figure 1. Long-term (since 1870) temperatures (°C) from HadISST in each marine bioregion. Note the different y-axis scales. A loess smoother was included to highlight the long-term pattern

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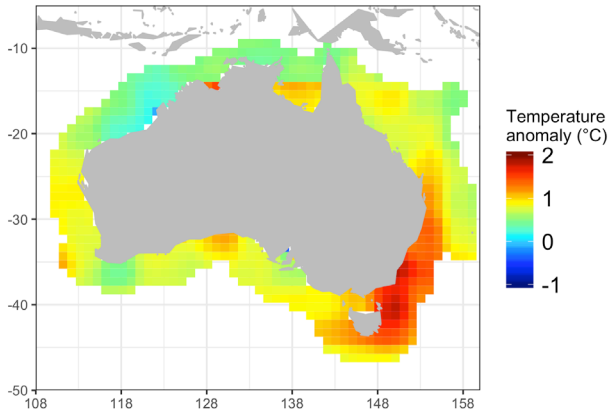

Figure 2. Difference in sea surface temperature between 2017 and 1870, based on a linear trend over the time series.

Implications for people and ecosystems

The HadISST1 data and temperature measurements from the three long-term stations confirm a strong warming trend in Australian waters over the past 150 years. The strength of the warming varies regionally. It is partly a consequence of global warming, amplified by changes of the regional ocean circulation (Ridgway, 2007). The South-east and Temperate East bioregions are warming the fastest because of changes to the path of the East Australian Current, causing increased warm-water incursions into Tasmanian waters (Hill, Rintoul, Coleman, & Ridgway, 2008).

This rapid warming has important implications for the distribution of marine organisms, permitting tropical and subtropical species to survive further south (Johnson et al., 2011; Last et al., 2011). However, resident cold-water coastal species in southern Australia are limited in the extent they can move further south before running out of habitat.

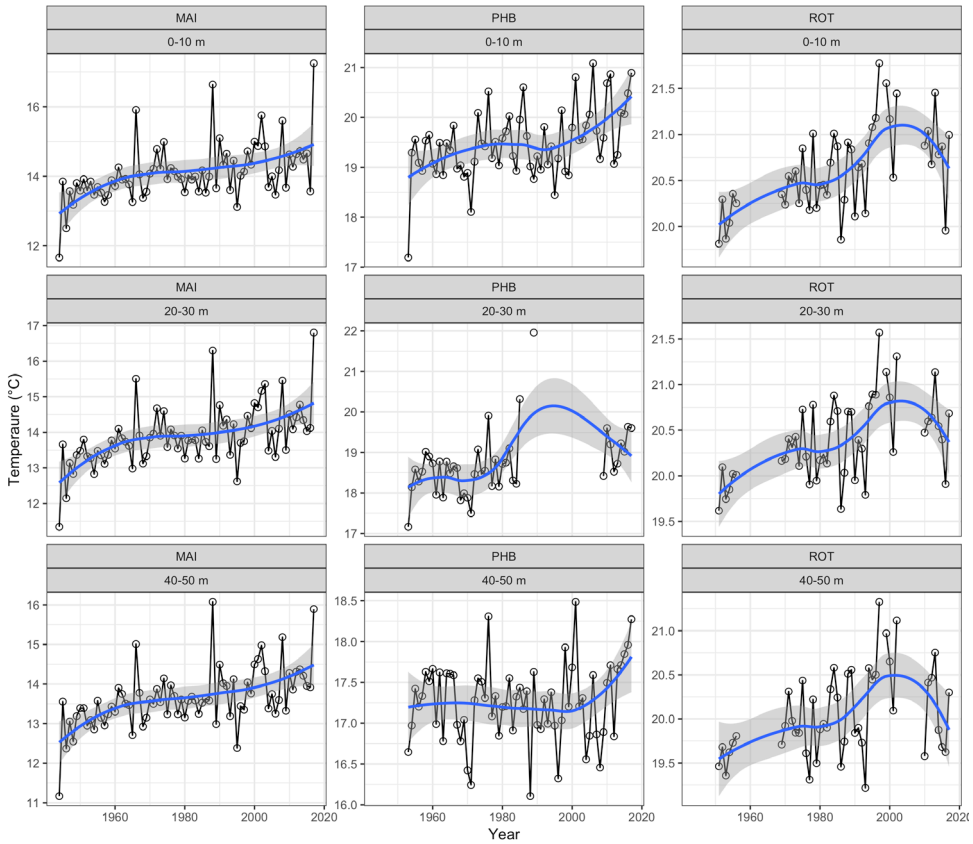

Figure 3. Long-term mean annual temperatures (°C) from Maria Island, Port Hacking and Rottnest Island reference stations in three depth strata in the top 50 m (n=4,500). Note the different y-axis scales. A loess smoother was included to highlight the long-term pattern

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Data Sources

IMOS National Reference Stations.
http://imos.org.au/facilities/nationalmooringnetwork/nrs/

IMOS Satellite Remote Sensing.
http://imos.org.au/facilities/srs/

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