Earth Systems and Climate Change Hub

National Environmental Science Programme

climate change **science brief**

Understanding future extreme sea level events for Sydney's beaches and harbour

Global sea level rise is causing an increase in the frequency of extreme sea level events. These events impact our waterways and coastlines, increasing the likelihood of coastal inundation and erosion.

The Earth Systems and Climate Change Hub investigated how extreme sea level events may change for Sydney's beaches and harbour under a warmer climate.

This information and data, and the sea level rise webtool used to communicate the data, will assist coastal practitioners to understand the risks of extreme sea level events and inundation of coastal structures and ecosystems at locations around the Australian coastline.

Inundation events pose a risk to communities

Coastal inundation events in Australia are expected to occur more frequently due to climate change and the resulting sea level rise. In coastal communities such as Sydney, there is emerging evidence that once historically rare inundation events are now occurring much more frequently, even as often as every year.

Extreme sea levels for protected waterways, such as Sydney Harbour, are caused by tide, atmospheric driven storm surge and seasonal sea level effects.

Extreme sea levels for open ocean beaches, such as Sydney's Narrabeen-Collaroy beach, are further exposed to damaging surf conditions from sea and swell waves. This results in increased sea levels through the processes of wave setup and runup.

The Earth Systems and Climate Change (ESCC) Hub has improved our understanding of how marine and coastal extremes are changing under a warmer climate through research and analysis into a range of coastal and near-shore variables, including sea-level trends, extreme sea-levels and waves.

Understanding risk through high-resolution climate projections

The Canute webtool developed by the ESCC Hub (https://shiny.csiro.au/Canute3_0/) allows coastal practitioners to explore how extreme sea level events will change for both protected harbours and open ocean beaches exposed to dangerous wave conditions at locations around the coastline of Australia.

RIGHT: **Extreme sea level events are likely to become more frequent due to climate change, particularly for protected harbours.**

Canute provides access to future sea level rise projections as well as return level plots (see Figure 1). These plots are commonly used by engineers to design how high coastal structures, such as seawalls or wharfs, need to be.

The coastal structures need to be designed to a height which extreme sea levels do not return to, or exceed, for an estimated average interval in years, e.g. a 100-year return interval.

Return level plots can be used, for example, in combination with the Guidelines for the Assessment of Public Ferry Wharf Safety (NSW Transport Roads and Maritime Services, 2016). These guidelines recommend considering the predicted water level during a 1-in-50 year storm event, taking into account barometric effects, wind setup and wave setup. Canute allows coastal managers to access this information and apply it in coastal planning and management activities.

Sydney's Narrabeen-Collaroy beach and Harbour

When a return level plot (see Figure 1) is applied for Narrabeen-Collaroy beach it shows that extreme sea levels expected on this wave-exposed beach are larger than those experienced within Sydney Harbour.

In addition, the level of a 1-in-50 year storm is comparatively much higher than a 1-in-10 year storm for the beach compared to the Harbour due to the steeper return level curve.

Additional sea level rise will increase the frequency of occurrence of particular return levels for the protected harbour more dramatically than the wave exposed beach. For example, with sea level rise, a 1-in-50 year storm level will become a once a year event sooner for the protected harbor (Figure 2a) than for the wave exposed beach (Figure 2b).

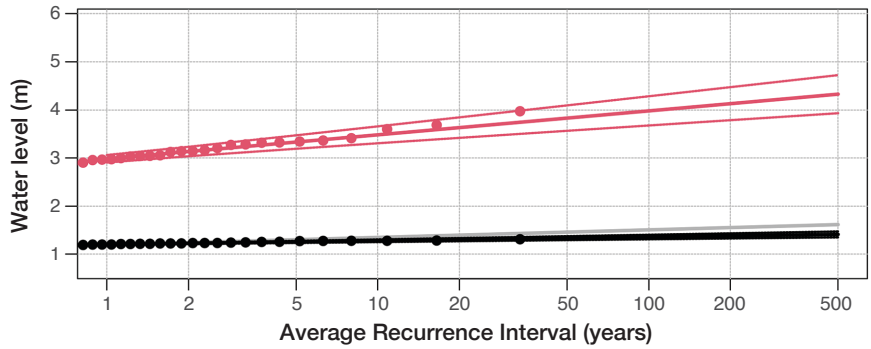

FIGURE 1 **Return level plot of coastal extreme water level.** Red lines are the water level including dangerous surf (wave setup) for Narrabeen-Collaroy. Black lines are the water levels modelled without dangerous surf (wave setup) for Narrabeen-Collaroy. The grey line is Sydney harbor tide gauge located 15 km from Narrabeen-Collaroy. Dashed lines represent the 95% confidence intervals and dots represent ranked semi-empirical extreme water level estimates.

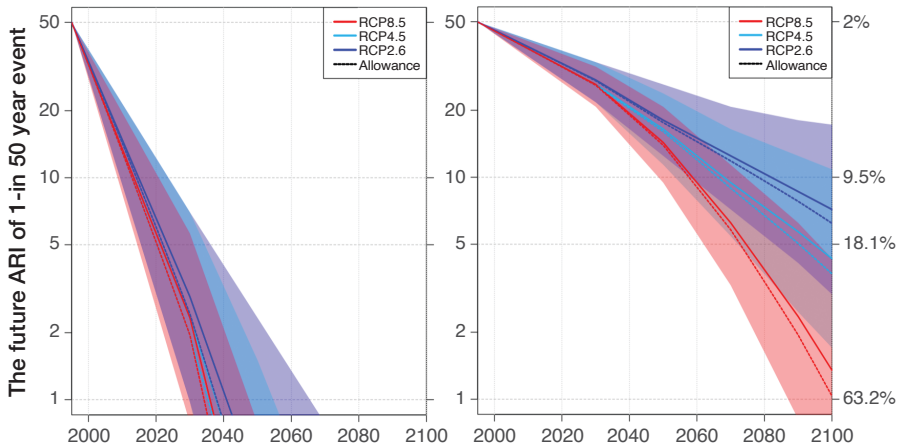

FIGURE 2 **Plume plots of the change to a 1-in-50 year Average Recurrence Interval (ARI) event caused by sea level rise for Sydney Harbor (left) and Narrabeen-Collaroy beach (right).** Coloured regions indicate the Representative Concentration Pathway (RCP) projected 95% uncertainty ranges of the change in ARI due to sea level rise (see colour key for RCPs). Right axis of each plots represents the Annual Exceedance Probability (AEP) as a percentage (%).

Implications for coastal planning

Research under the ESCC Hub highlights that extreme sea level events are likely to become more frequent as a result of climate change and subsequent sea level rise. This increase in frequency is likely to be greater for locations that exhibit lower variability in extreme sea levels, such as protected harbours, than neighbouring beaches exposed to dangerous surf.

The ESCC Hub has supported updates to the Canute webtool to explore how extreme sea levels could change in the future at a regional level. The Hub has also contributed to the development of improved sea level rise projections so that coastal managers and engineers can access the best available science to inform decisions and activities into the future.

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