Supplementary information

Results

Spatial patterns in exposure to climate change

The southeast emerges as the most climate-exposed region, experiencing the fastest rates of change across scenarios, but particularly under higher-emissions scenarios (SSP3–7.0, SSP5–8.5) (Figs 2; S2–S5). This region's climate exposure is consistent across variables, including rates of change in cumulative MHW intensity and oxygen content, with changes accelerating through the century (Figs S4–5, Supplementary Table 1). The Coral Sea, temperate east, northwest regions, and Lord Howe and Norfolk Islands also exhibit high exposure, particularly in the near-term under SSP2–4.5, with prolonged impacts under higher-emissions scenarios. In contrast, the south and southwest, including the Great Australian Bight, are projected to retain the slowest rates of change for longer, and to return to lower rates of change sooner than in the more exposed regions of the north and southeast, with deoxygenation reversing in some areas under SSP1–2.6. Rates of change in ocean acidification follow a similar trajectory but show faster and more sustained rates of change across the southern regions.

Spatial patterns in climate refugia

Single-metric climate refugia

Climate refugia are projected to persist predominantly in southern and western regions, and parts of the Coral Sea, under low-emissions scenarios (SSP1–2.6, SSP2–4.5), and become increasingly present in the remaining EEZ throughout the century (Figs S6–10). Under SSP3–7.0, refugia disappear nationwide from 2040, except for a pocket of the southwest region after 2061 that is retained in climate velocity only (Fig. S10) and are even more sparse in the southwest under SSP5–8.5. Climate refugia for rates of change in SST and oxygen content are fragmented, especially along the east coast, but are less fragmented in the south and southwestern regions. Conversely, climate refugia for acidification are primarily present under low-emissions scenarios, emerging across most of the EEZ by 2060. Under SSP2–4.5, climate refugia for climate velocity show a broader coverage under low emissions, concentrated mainly in the south, southwest, and in parts of the east, with more patchy coverage around the north, east, Lord Howe Island, and in the Great Australian Bight (Fig. S10). The fewest climate refugia are projected for cumulative MHW intensity, found only as small pockets under low-emissions scenarios — from 2060 under SSP1–2.6 where they are scattered throughout the EEZ; and from 2080 under SSP2–4.5, in the northern and northeastern regions, and western Tasmania. Climate refugia projected for cumulative MHW intensity are projected to be completely absent beyond the near-term under SSP3–7.0 and SSP5–8.5 this century (Fig. S9).

Multi-metric climate refugia

Under low-emissions scenarios, multi-metric climate refugia are most prevalent in the south and southwestern regions, particularly along the path of the Leeuwin Current, extending to the Great Australian Bight and northwest Tasmania (Fig. 4). In contrast, refugial overlap in these same emissions scenarios is the sparsest in the southeast, northwest, Gulf of Carpentaria, and around Lord Howe Island.

The Coral Sea retains partial refugia along its northern extent and in parts of the northern Great Barrier Reef, while the Tasman Sea shows minimal overlap. High-emissions scenarios (SSP3–7.0, SSP5–8.5) lead to the near-complete disappearance of refugia by mid-century, with only fragmented patches persisting in the southwest and along major boundary currents under SSP2–4.5. Under high-emissions scenarios, multi-metric climate refugia are almost completely absent nationwide, particularly in SSP5–8.5, and under SSP3–7.0 the southwest is the only region that maintains a slight overlap.