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Coral reef ecosystem decline: changing dynamics of coral reef carbonate production and implications for reef growth potential

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Global-scale deteriorations in coral reef health have caused major shifts in species composition and are likely to be exacerbated by climate change. It has been suggested that one effect of these ecological changes will be to lower reef carbonate production rates, which will impair reef growth potential and, ultimately, may lead to states of net reef erosion. However, quantitative data to support such assertions are limited, and linkages between the ecological state of coral reefs and their past and present geomorphic performance (in other words their growth potential) are poorly resolved. Using recently collected data from sites in the Caribbean and Indian Ocean, and which have undergone very different post-disturbance ecological trajectories over the last ~20-30 years, the differential impacts of disturbance on contemporary carbonate production regimes and on reef growth potential can be explored. In the Caribbean, a region which has been severely impacted ecological over the last 30+ years, our datasets show that average carbonate production rates on reefs are now less than 50% of pre-disturbance rates, and that calculated accretion rates (mm yr-1) are an about order of magnitude lower within shallow water habitats compared to Holocene averages. Collectively, these data suggest that recent ecological declines are now propagating through the system to impact on the geomorphic performance of Caribbean reefs and will impair their future growth potential. In contrast, the carbonate budgets of most reefs across the Chagos archipelago (central Indian Ocean), which is geographically remote and largely isolated from direct human disturbances, have recovered rapidly from major past disturbances (specifically the 1998 coral bleaching event). The carbonate budgets on these remote reefs now average +3.7 G (G = kg $CaCO_3$ m-2 yr-1). Most significantly the production rates on Acropora-dominated reefs, which were most severely impacted by the 1998 bleaching event, average +8.4 G, comparable with estimates under pre-human disturbance conditions, and are reflected in high reef growth rates (4.2 mm yr-1). These reefs thus retain the capacity to grow at rates exceeding measured regional mid-late Holocene and 20th century sea-level rise, and close to IPCC sea-level rise projections through to 2100. However, their positive growth potential is strongly tied to the persistence of several key coral species, and thus the frequency and magnitude of future disturbance events will be key determinants of near-future reef growth.