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Nicola K. Browne
University of Queensland; Curtin University

Andrew G. Bauman
Nova Southeastern University, abauman@nova.edu

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Editorial

Marginal Reef Systems: Resilience in a Rapidly Changing World

Nicola K. Browne [1,2,*] and Andrew G. Bauman [3,*]

1 School of Biological Sciences, University of Queensland, Brisbane, QLD 4072, Australia
2 School of Molecular and Life Sciences, Curtin University, Perth, WA 6102, Australia
3 Department of Marine and Environmental Sciences, Nova Southeastern University, Dania Beach, FL 33004, USA
* Correspondence: n.browne@uq.edu.au (N.K.B.); abauman@nova.edu (A.G.B.)

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Marginal coral reefs live under sub-optimal environmental conditions (e.g., low light, high sediment inputs, and variable temperatures) and include turbid and mesophotic reefs, high-latitude reefs, high-temperature reefs, and high CO_2 seep reefs near volcanic vents. These reef systems are typically characterised by low biodiversity, reduced habitat complexity, and low coral cover, and are dominated by stress-tolerant and weedy coral communities. Given that the range of marginal reefs will likely extend with future climate change, studying these reefs may provide potentially novel and useful insights into the effects of future climate change on coral reefs. Further, marginal reefs allow us to test hypotheses about resilience in the face of increasing local and global stressors that impact biodiversity, ecosystem function, and carbonate accretion. Biodiversity is considered to be a cornerstone of reef resilience, and as such, reef conservation has focused greatly on biodiversity hotspots. However, there is increasing evidence that marginal reefs with lower biodiversity may have greater resilience to future ocean warming. The six papers in the Special Issue focus on two important marginal reef systems, which may have the potential to serve as climate change refugia: turbid reefs and high-latitude reefs.

The first paper reviewed the geological origins of turbid reefs, their current ecological and environmental states, and their potential responses to increasing local stressors and global change (Zweifler et al., 2021) [1]. Importantly, the review provided a comprehensive overview of new descriptors for classifying turbid reefs as either persistent, fluctuating, or transitional as well as acknowledging key differences in sediment sources (i.e., natural versus anthropogenic). These differences were discussed with regards to future reef threats, conservation management options, and their potential for climate refugia status.

Turbid reefs have traditionally been described as degraded systems, characterised by low coral cover and diversity, and high bioerosion rates with reduced reef complexity and reef accretionary potential. Yet in recent years, there have been a growing number of examples of turbid reefs with high coral cover and/or diversity as well as high reef accretionary potential. Reef accretionary potential is the product of both calcium carbonate production, typically driven by corals and other calcifying organisms (e.g., CCA), and carbonate removal by physical, biological, or chemical mechanisms. Turbid reefs are vulnerable to elevated nutrients given their proximity to land and sources of runoff, and hence rates of bioerosion driven by elevated nutrients could result in higher rates of carbonate removal, reduced reef complexity, and accretionary potential. Yet, this was not the case on two inshore reefs in Western Australia where low bioerosion rates resulted in a positive reef accretionary state (Dee et al., 2023) [2]. Future studies should aim to collect high-resolution environmental data with rates of bioerosion to provide important empirical relationships that may be used to predict future reef states.

High temperature and light data were found to be positively correlated with Black Band Disease (BBD) progression rates on encrusting *Montipora* spp. on a high latitude reef in Okinawa, Japan (Das et al., 2022) [3]. Understanding what drives disease progression on corals is fundamental for controlling disease outbreaks on reefs. Global warming is increasing sea surface temperatures on high-latitude reefs, which some argue will result in faster coral growth rates and increases in diversity due to range expansions. However, this study demonstrates that these marginal reef types may also be at increased risk from diseases given the link between temperature and disease propagation rates.

Reductions in coral cover and diversity from the tropics to high-latitude regions are likely due to a combination of biotic and abiotic factors such as temperature, light, aragonite saturation, nutrients, and competition with other benthic marine organisms. The second review paper in this Special Issue examines these factors as a means of improving our current understanding of what has and will drive range expansions (Abrego et al., 2021) [4]. This is critical in assessing the potential role of high-latitude reefs as climate change refugia.

The assessment of climate change refugia status also relies on detailed baseline benthic data and the resilience of coral communities to global change such as rising sea surface temperature (SST). For example, a study by Ross et al., (2021) [5] which provides a detailed 20-year study of 118 high-latitude reef sites in five marine parks located in the South-West of Australia, found that current conditions were favourable to the ongoing survival of existing coral genera. Further, there had been minimal signs of expansion in coral cover indicating temporally stable high latitude reef communities. Studies such as these provide invaluable benchmarks for assessing future changes as well as potential climate change refugia. The third paper in the series also tracks changes pre, during, and following a bleaching event on high-latitude reefs in South Africa (Porter et al., 2021) [6]. This study assessed 14 sites over a 120 km stretch of coastline where long-term temperature records have shown no record of increasing SSTs. Importantly, the bleaching event resulted in mild rates of bleaching with low coral mortality, which was in part attributed to upwelling along the central and southern reef complex. However, reduced temperatures due to upwelling may only provide temporary protection as upwelled water temperatures will also likely rise in the future.

Conflicts of Interest: The authors declare no conflict of interest.

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