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Eutrophication science: moving into the future.

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We were impressed by the timely revisit of the effects of eutrophication in coastal marine systems by Smith and Schindler [1]. We agree that while there has been substantial work towards identifying the causes of regime shifts in coastal systems, our understanding of the drivers is still far from satisfactory. Nonetheless, we feel that a critical point was not addressed in their review; the effects of eutrophication are likely to be substantially altered under future climate conditions. There is a pressing need to understand how local eutrophication and global climate stressors will interact.

While the effects of combined climate stressors are becoming increasingly well studied in marine systems (e.g. CO_2 and temperature; [2, 3]), it has only recently been recognised that local and global stressors are likely to interact in unpredicted ways [4]. For example, the historical and continuing deforestation of algal canopies in favour of small, fast-growing turfs across the world's temperate coastline is a focus of considerable research [5]. Developing theory explains these shifts as a function of altered water quality that enables the cover of ephemeral turfs to expand spatially and persist beyond normal seasonal limits. Yet, our recent work shows that elevated nutrients and [CO_2] can interact to have positive synergistic effects on algal turfs [6] and suggests that future conditions may exacerbate shifts from canopy to turf-domination. Indeed, understanding the degree to which these global and local stressors will combine to accelerate and expand ecosystem-shifts is of key concern.

It is noteworthy, however, that the negative effects future [CO_2] may be substantially reduced in the absence of elevated nutrients [6] and effective local management may help to mitigate the effects of climate change. For example, preventing the harvest of herbivorous fish may suppress algal growth and increase the resilience of coral reefs to climate induced bleaching events [7]. Likewise, we argue that reducing the input of nutrient rich wastewater into coastal marine systems may increase their resilience to phase shifts. In South Australia, the government is implementing policy to recycle 45 % of Adelaide's wastewater. By removing nutrient stress in near-shore marine systems, this recycling program will not only act as a long-term recovery "experiment" that builds on a 30 year dataset documenting the large-scale decline of kelp forests [8] (filling a scientific gap identified by Smith and Schindler [1]) but will also assess the potential for enhancing resilience of these systems to the deleterious effects of future climates.

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