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Modelling the effect of river load reductions on water quality in the Crown of Thorns Starfish outbreak initiation zone of the Great Barrier Reef

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Abstract: Outbreaks of Crown of Thorns Starfish (*Acanthaster* cf. *solaris,* hereafter CoTS), a predator of corals, cause a loss of coral cover in the Great Barrier Reef (GBR). It has been hypothesised that increased nutrient loads in runoff from agriculturally-developed catchments have increased the frequency and magnitude of CoTS outbreaks (e.g., Brodie, 1992), contributing to a long-term decline in coral cover and condition in the GBR World Heritage Area. The terrestrial nutrient enrichment hypothesis posits that increased nutrient loads in river discharge drive increased availability of phytoplankton as food for CoTS larvae, which in turn leads to increased recruitment and survival of adult CoTS, which eat coral.

In recent decades, four major outbreaks have been observed, all beginning in the "CoTS initiation zone" between Lizard Island and Cairns (14.7º–16.7ºS). We analysed outputs from the eReefs suite of catchment and coupled hydrodynamic-biogeochemical models, which have been applied to a series catchment management and nutrient load reduction scenarios (Baird et al. 2021; McCloskey et al. 2021), to assess the potential for improved catchment management to improve water quality in the CoTS initiation zone.

Catchment modelling suggests that nutrient loads to the GBR have increased by a factor of between 2 and 5 since European settlement and that improvements in land management could reduce these loads substantially (McCloskey et al., 2021). Marine modelling (Baird et al., 2021) has demonstrated that improvements in catchment loads are likely to result in improvements in nearshore water quality, including reduced chlorophyll-*a* (Chl-*a*) concentrations in nearshore waters. Our analysis of predicted changes in Chl-*a* and nutrient concentrations in the Midshelf Wet Tropics CoTS initiation zone, however, shows a very weak water quality response to reduced catchment nutrient loads in this zone. Even a hypothetical scenario in which river nutrient and sediment loads were reduced to zero (while maintaining current freshwater discharge) showed a very limited water quality response within this zone. Notably, a strong correlation between total annual river discharge and elevated nutrient concentrations persisted even in this "zero load" scenario, suggesting that marine and atmospheric forcing drive year-to-year variations in planktonic biomass in the CoTS initiation zone, even during major flood events that appear to precede CoTS outbreaks.

While improved catchment management can be expected to improve nearshore water quality in the GBR, these results are preliminary evidence that this may have limited potential to reduce CoTS outbreaks. Further research is needed into both the terrestrial nutrient enrichment hypothesis and other potential explanations of CoTS outbreaks.

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