

## Sewage-derived resort runoff threatens coral reefs? A pilot isotopic assessment of nitrogen at Pulau Redang, Malaysia

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In the Anthropocene coral reefs are threatened by a host of global and local stressors. In the past two decades, development of island tourism at Pulau Redang, Peninsular Malaysia, has increased the annual number of visitors by an order of magnitude, from 22,725 visitors in 1995 to 184,043 visitors in 2017 (Data Source: Department of Marine Parks Terengganu, 2017). Sewage-derived nutrient enrichment has emerged as a potential ecosystem scale threat to coral reefs around this island<sup>1</sup>. Here, the spatial extent of sewage-derived nutrient sources across Redang is assessed using stable isotopic techniques to measure  $\delta^{15}\text{N}$  in competitive macroalgae (*Lobophora* spp.), corallivorous gastropods (*Drupella* spp.), and branching corals (*Acropora* spp.), representing nutrient uptake over multiple temporal scales<sup>2</sup>. Combining  $\delta^{15}\text{N}$  with conventional benthic reef monitoring data, we then test the relationship between  $\delta^{15}\text{N}$  and coral reef community composition with a multivariate approach on all 55 benthic cover types, and a univariate approach on community structure indices and major benthic group coverage. We show that *Acropora* has the best potential as a bioindicator of pollution at Redang. Significantly higher enrichment of *Acropora*  $\delta^{15}\text{N}$  was identified in the tourist hub on the east coast ( $3.85\text{‰} \pm 0.18\text{ SE}$ ), where septic tanks and eutrophic waste-water outflows are potential nutrient sources, compared to pristine reefs on the uninhabited northern and western sides ( $3.02\text{‰} \pm 0.04\text{ SE}$ ). Regional *Acropora*  $\delta^{15}\text{N}$  was significantly correlated to regional variance of cover type richness, Shannon diversity index, and Simpson dominance index; coexistence of coral-dominated reefs alongside degraded zoanthid barrrens was only found in the tourist hub region. In Terengganu there is a need for better cooperation between state and marine park authorities to ensure that tourism-derived nutrient enrichment does not cause reef degradation. Determining the ecological impact caused by nutrient enrichment is an important first step in the long-term sustainable development of tourism on the now-booming Terengganu islands.

Keywords: Marine parks; Resilience; Tourism development; Diversity; Water Quality

### References

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