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Responses of seagrass to nutrients in the Great Barrier Reef, Australia

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ABSTRACT: Declines in seagrass biomass and growth have been widely reported in response to anthropogenic impacts. In contrast, the distribution and biomass of seagrass in the carbonate sediment around Green Island reef, part of Australia's Great Barrier Reef (GBR), has measurably increased during the past 50 yr, possibly due to increases in the availability of nutrients from local and regional anthropogenic sources. Using historical aerial photography, increases in seagrass distribution at Green Island have been mapped. The growth, morphological and physiological responses of 2 seagrass species (*Halodule uninervis* and *Syringodium isoetifolium*) to elevated sediment nitrogen (N; 100× control) and/or phosphorus (P; 10× control) were measured to investigate whether increased nutrients could account for the observed increase in distribution. Increases in the growth rate, amino acid composition and tissue nutrient content of both species occurred in response to elevated sediment N, but not P. Concentrations of the N-rich amino acids asparagine and glutamine increased 3- to 100-fold in seagrass leaves from N treatments. The $\delta^{15}N$ values of leaves decreased in response to additions of nitrogen, probably due to increased discrimination against the ^{15}N isotope, because N availability was surplus to demand. The low $\delta^{15}N$ value of seagrasses in the Green Island back reef suggests that their primary source of N is either from N_2 fixation or fertilisers and that the N from sewage is not a large component of their N budget. This study is the first to demonstrate N, rather than P, as the primary limiting nutrient for growth of seagrass in carbonate sediments and supports the hypothesis that the increase in the seagrass distribution and biomass at Green Island was caused by an increase in nutrient availability. We also hypothesise that seagrass distribution and biomass in many regions of the GBR may be limited by nutrients and that the lack of substantial seagrass meadows in the southern GBR could be due to these reefs receiving less nutrients from the mainland.

KEY WORDS: Seagrass · Great Barrier Reef · Nutrients

INTRODUCTION

Phosphorus is the most likely nutrient to limit the growth of seagrass in carbonate substrata due to strong binding of PO_4^{3-} by carbonate ions (Lide 1994) and fast rates of N_2 fixation by microorganisms in tropical sediments (Smith & Hayasaka 1982, Capone et al. 1992, Welsh et al. 1996). Experimental fertilisation of seagrasses growing in carbonate sediment in the Bahamas and Florida Bay, USA, have reported limitation of seagrass growth by P availability (Short et al. 1985, 1990, Fourqurean et al. 1992a,b). Carbonate sediment usually dominates in regions that receive little or no riverine inputs of sediment or nutrients. Thus, the growth of seagrass in carbonate sediments could also be limited by the availability of micronutrients such as iron, which are derived from terrigenous soil (Duarte et al. 1995).

Anthropogenic nutrient inputs to reef ecosystems have caused a detrimental effect on, or loss of, the existing coral communities in many parts of the world. The discharge of sewage into Kaneohe Bay, Hawaii, resulted in the ecosystem becoming dominated by plankton, benthic filter feeders and algae with sections of the bay losing 99.9% of their corals (Maragos et al. 1985). Loss of corals and the proliferation of macroalgae have also been associated with the discharge of sewage and anthropogenic nutrient sources in the Red Sea (Walker & Ormond 1982), Japan (Kuhlman 1988), Bermuda (Bach & Josselyn 1978) and Florida, USA (Lapointe 1989).

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