NUTRIENT HISTORY OF THE GREAT BARRIER REEF AQUARIUM

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INTRODUCTION

The Coral Reef Tank at the Great Barrier Reef Aquarium which opened in Townsville in June 1987, provides an ideal system in which to study nutrient cycling on a coral reef. This paper describes the nutrient history of the Coral Reef Tank, highlighting aspects which may be relevant to the management of nutrient discharge in the Great Barrier Reef Marine Park.

A coral reef has been constructed in a rectangular tank, 38m long by 17m wide, with a water volume of 2500m^3. The tank is illuminated by sunlight and subject to waves, currents and potentially tides. The empty tank floor was covered with sand before addition of carbonate rock to create the reef framework. After the tank was filled with water, biological stocking began with representatives of the lowest trophic level and subsequently organisms from higher trophic levels were added. Currently, the tank supports a wide range of reef dwellers typical of the central Great Barrier Reef region.

The Coral Reef Tank is a closed system in which water quality is controlled by algal turf scrubbers (Adey, 1983). The tank is supported by 80m^2 of algal turf scrubbers which process the entire water volume daily. The recently observed spawning of several tank inhabitants, including some scleractinian corals, suggests that the scrubbers are successful in maintaining acceptable water quality for a coral reef.

METHODS

Nitrate is regarded as an important dissolved nutrient in the Coral Reef Tank. It is the principal form of inorganic nitrogen in the tank, because the ammonia resulting from biological activity undergoes rapid bacterial conversion via nitrite to nitrate. Build up of nitrogenous compounds is a common phenomenon in closed circulation aquaria, and routine monitoring of nitrate concentration is a prerequisite for maintaining optimum water quality. Nitrate has been selected to provide a nutrient history of the Reef Tank.

Nitrate analyses were performed by standard automated techniques, following the methods of Ryle et al. (1981). Samples were , collected at a frequency of no less than three per week. Water was filtered through 20um plankton mesh into: polyethylene bottles and stored frozen until analysis.

RESULTS.

Nitrate concentration varied widely with time since the tank was filled with water (Fig. 1). Levels ,in the incoming seawater were <0.05uM. The very high initial nitrate concentration (15.9uM) was the result of nutrient release from the sand and coral rock in the tank', and unconditioned algal scrubbers which were unable to cope with the sudden nutrient rise. The rapid fall in nitrate coincided with a phytoplankton bloom, after which the water was' discarded removing the excess nutrients from the system in the form of phytoplankton.

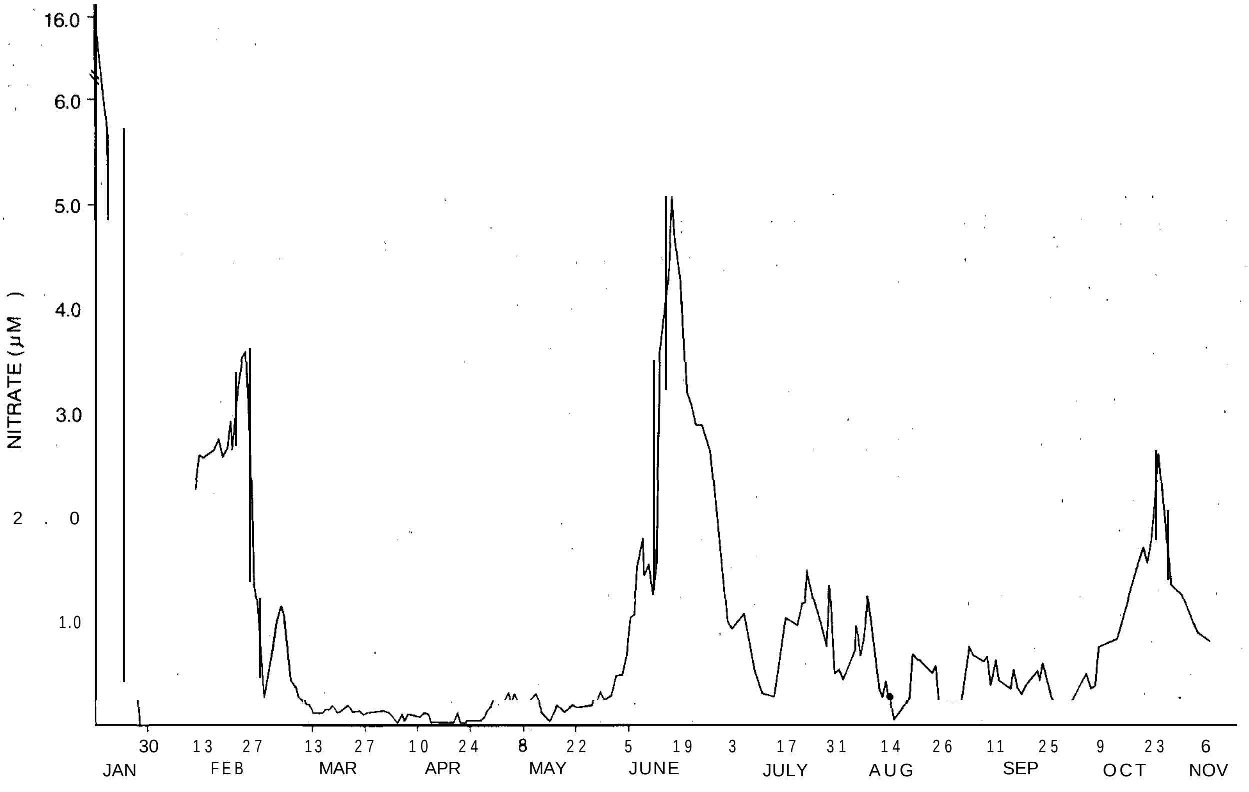

Figure 1. Variation of nitrate concentration in the Coral Reef Tank between January and November 1987.

A similar but lower magnitude nutrient peak (3.6uM) occurred after the second tank fill in mid-February. Residual nutrients from the substrata were again the source of nitrate. A phyptoplankton bloom similar to the first was prevented by excluding 90% of incident sunlight from the tank and the algal scrubbers responded to the elevated nitrate levels by an increase in productivity. Subsequently, there was a decrease in nitrate to levels below 0.3uM in a month.

Nitrate concentration remained low as stocking proceeded until early June when it rose to peak at 5.1uM. This spike was attributed to the intense removal of tank algae which were acting as nutrient cyclers. These tank algae were growing abundantly over the rock surfaces and were removed because of the negative influence on tank aesthetics and the damaging effects of detached algae on the reef benthos. The rapid addition of several field collections at this time may have also contributed to the nutrient problem. These events increased the nutrient loading of the tank at a rate faster than the algal scrubbers could respond, resulting in a rapid rise of nitrate.

Following this June peak, the operating levels of nitrate were more temporally variable as the standing stock in the tank increased. In late October, there was another nutrient spike which, although smaller in magnitude, is clearly discernable as a period of elevated nitrate (2.6uM) compared to the preceding and following periods. This rise in nutrients was associated with tank construction activity. Installation of a water cooling system necessitated isolation of 400m^3 of Reef Tank water for several days in a holding tank, allowing nutrients to accumulate. In addition the accompanying modified circulation resulted in scouring of sand in the tank releasing interstitial nutrients into the water.

Coral mortality in the Coral Reef Tank has occurred in two major episodes. Approximately 20% of the scleractinian corals in the tank died in June-July. This period corresponded most notably to a time of elevated nitrate levels and the dying corals were almost exclusively pocilloporids and species of Acropora. Many of the corals which died had been in the tank for several months and had previously looked healthy. The second episode occurred in late October-early November when 16% of the corals died. Individuals from all of the major coral groups were affected, including some which had survived in the tank for six months. This October-November period was characterized initially by high water temperature (>30°C) and subsequently by elevated nitrate levels.

DISCUSSION

Highest rates of coral mortality in the tank occurred at times of elevated nitrate levels. For the June-July episode of coral death, nutrients were the only water quality parameters which were abnormal, and mortality is directly connected with high nutrients. In October-November, both, temperature and nutrients were above acceptable levels. High temperature is lethal to corals (Jokiel & Coles, 1977; Glynn, 1984), and corals at their temperature tolerance limits are more susceptible to stress by other environmental factors (Coles & Jokiel, 1978). Elevated seawater temperatures in conjunction with high nutrients are identified as the cause of the second mortality event.

The nitrate concentrations at which widespread coral death occurred in the tank were above 2.5uM. This value is a marked increase over general levels on a coral reef (<1uM; Crossland, 1983), but is low compared to concentrations that may be expected within the vicinity of a waste water discharge (Bell et al., 1987). Further, the nitrate spikes associated with coral death in the tank were short-term events and higher coral mortality would ensue if elevated nutrients persisted. The tank nitrate problems caused by the release of nutrients from disturbed sediment highlight the importance of the sedimentary nutrient pool and the danger of suspending sediment in a confined or restricted circulation area.

The scleractinian genus Acropora appears to be particularly sensitive to high nitrate levels in the tank. Adey (1983) also reported that Caribbean Acropora in a coral reef aquarium were more susceptible to disease at high (>5uM) nutrient levels. This result is significant because Acropora is a very important component of many coral communities on the Great Barrier Reef.

It is not possible to attribute the observed coral mortality specifically to nitrate, because elevated nitrate levels in the tank were accompanied by above normal concentrations of phosphate. Kinsey & Davies (1979) suggested that high phosphorus rather than nitrogen would be more detrimental to coral calcification, although the physiological basis of the relationship between nutrients and coral growth remains uncertain.

Nevertheless, it is clear from our experiences in the Coral Reef Tank that the tolerance levels of corals to nitrogen and phosphorus are relatively low; and that enhanced nutrient levels in reef waters would have damaging effects on coral communities.

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