Bull. Mar. Sci. Fish., Kochi Univ.
No. 14, pp.31-34, 1994

Proceedings of the Concluding Workshop on Coral Reef Studies, Kochi, November 1993

Fluctuation of the Abundances of Microbial Communities in Coral Reef with the Tidal Cycle

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In oligotrophic tropical and subtropical areas, coral reef is considered to be of relatively high productivity and it has rather complicated ecosystems. Among the organisms living in the reef area, corals with their symbiotic microalgae of zooxanthellae are one of the most important producers of organic matter. Our previous finding showed that coral produced much abundant organic matter as mucus, especially when it got some physical stimulation. Since the corals at reef edge part were affected by tidal water movement, significant amount of mucus was produced and was transported into a lagoon. It was often visible that the viscosity of seawater in lagoon increased by mucus so much as that traces of boat remained on seawater surfaces. These facts lead us to suppose the fluctuation of the concentration of organic matter, which must result in the changes in microbial abundances and community structures.

In the present study, fluctuations of bacteria, heterotrophic nanoflagellates, and pico-sized cyanobacteria on coral reef edge and in lagoon water were investigated along with tidal cycles, and discussed the serial changes in growth and consumption of microbes.

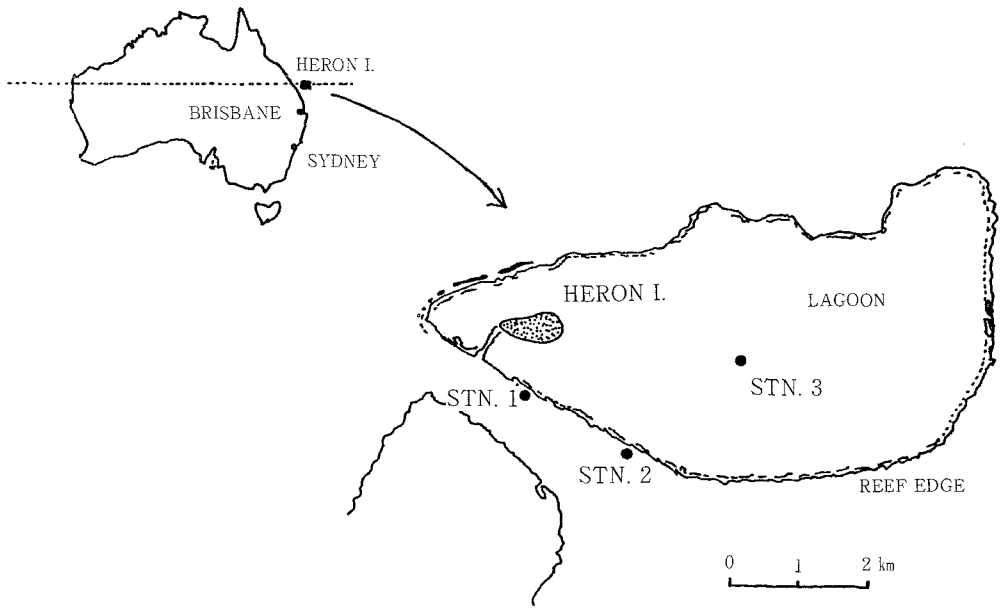

Fig. 1. Location of seawater sampling stations at Heron Island, Great Barrier Reef, Australia. Stations 1 and 2 were situated on the reef edge, while Stn. 3 was in a lagoon.

Materials and Methods

Water samples were collected from three stations situated on reef edge and in lagoon of Heron Island (151°55'E, 23°26.6'S) Great Barrier Reef, Australia (Fig. 1) on September 14 and 15, 1993. Along with tidal cycles, the surface water was sampled, immediately fixed with glutaraldehyde (final conc. 1 %), and brought back to the laboratory of Heron Island Research Station (HIRS), the University of Queensland. One to 3 ml of subsamples were filtered through 0.2 μm Nuclepore filters after stained with DAPI, and the abundances of bacteria, hetetotrophic nanoflagellates (HNF), and pico-sized cyanobacteria were counted under an epifluorescence microscopy with a conventional method.

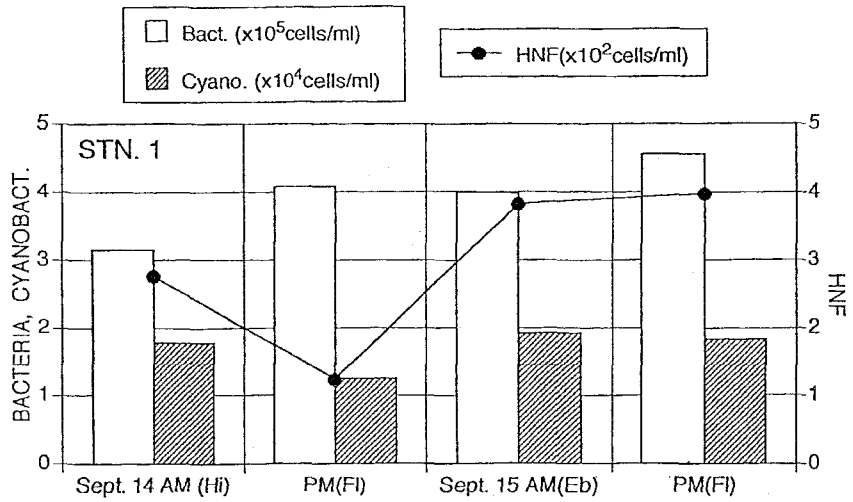

Fig. 2. Fluctuations of the densities of bacteria, heterotrophic nanoflagellates, and cyanobacteria along with tidal cycles at Stn. 1. Hi: high tide; Fl: flood tide; Eb: ebb tide.

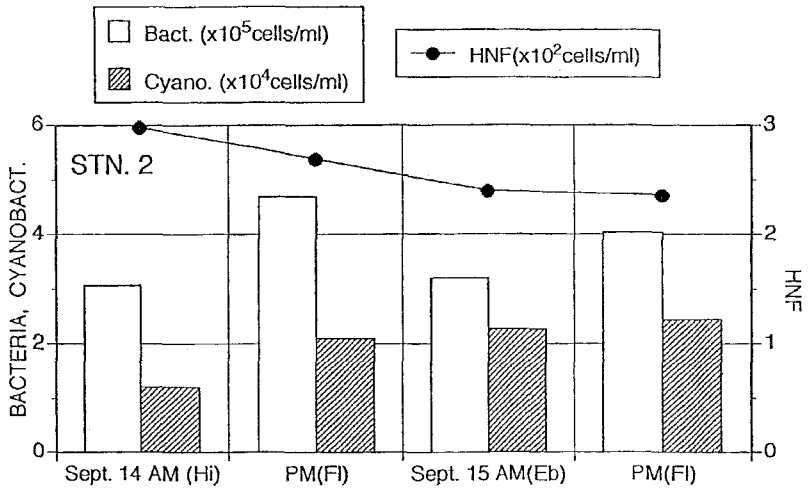

Fig. 3. Fluctuations of the densities of bacteria, heterotrophic nanoflagellates, and cyanobacteria along with tidal cycles at Stn. 2. Hi: high tide; Fl: flood tide; Eb: ebb tide.

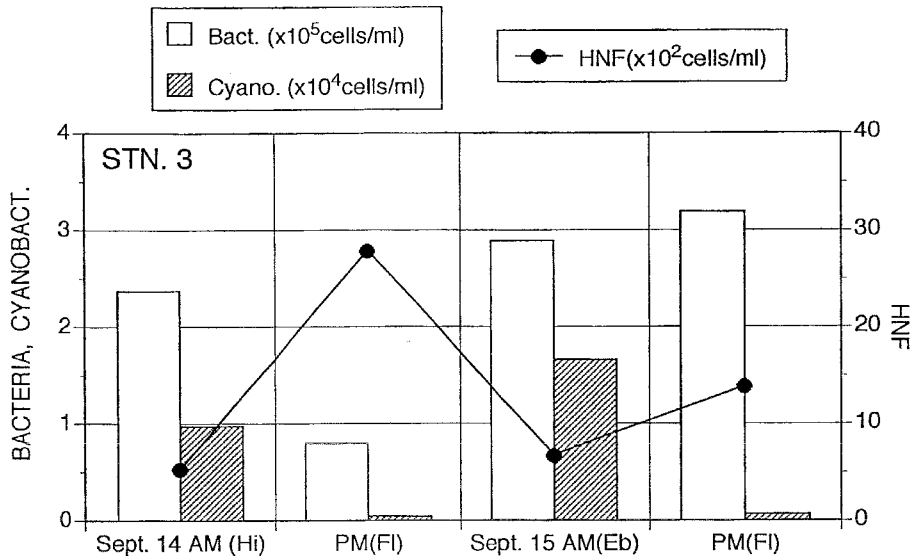

Fig. 4. Fluctuations of the densities of bacteria, heterotrophic nanoflagellates, and cyanobacteria along with tidal cycles at Stn. 3. Hi: high tide; Fl: flood tide; Eb: ebb tide.

Results and Discussion

Fluctuations of the abundances of microbes on reef edge and in lagoon were illustrated in Figs. 2, 3, and 4. Bacterial densities were in the range of 2 to 5 x10^5 cells/ml, while those of HNF were in the level of 10^2 cells/ml. These numbers were comparable to those in coral reefs of Lizard Island, Great Barrier Reef (Moriarty 1979), or of others (summarized in a review, Ducklow, 1990), however, they were slightly lower than those in the open ocean (Yoshinaga et al., 1991), suggesting that abundance or biomass of microorganisms in coral reef ecosystems were not so high as to be expected. However, density differences between bacteria and HNF were more or less three orders of magnitude, which are consistent with those obtained in the other marine environments (Nakamura et al., 1994).

Densities of pico-sized cyanobacteria, probably *Synechococcus* spp., were shown in Figs. 2 through 4 with shaded columns. The fluctuations were relatively small, around 2x10^4 cells/ml, except for in the lagoon. These abundances were also well-coincided with the numbers previously reported (Moriarty et al., 1985).

Abundances of these three categories of microorganisms were relatively constant at two stations on the coral reef edge (Figs. 2 and 3), while changes in those parameters were significant at a lagoon station and were reciprocal along with tidal cycles (Fig. 4). This result implies that an environment around a reef edge is like a continuous culture due to the usual water current coming in and out of lagoon over reef flat, while environmental conditions in the lagoon fluctuate much with tidal current. In fact, abundances of bacteria and pico-sized cyanobacteria were low during the flood tide period as seawater of oligotrophic open ocean came into the lagoon, while at the high and ebb tide period numbers of bacteria and cyanobacteria increased but those of HNF were still low. These results were implicated as follows; bacteria and cyanobacteria in lagoon grow by using organic mucus and/or inorganic nutrients produced and transported from corals at reef flat, and reached maximum just after high tide (ebb tide), however,

HNF did not yet respond and were still in low numbers, while during the flood tide (just after low tide) HNF started to grow on bacteria and cyanobacteria, resulting in the increase of HNF and low abundances of bacteria and cyanobacteria.

In the present study, unfortunately the concentrations of organic matter were not determined. Moreover, hourly changes in densities of bacteria, HNF and cyanobacteria were not monitored along with tidal cycles. To confirm the speculation mentioned as above, densities of microbes must be determined more frequently and relationship between microbial fluctuations and tidal cycles should be clarified.

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(Recieved 30 November, 1994)