Fijian Coral Reef Damage and Recovery from Cyclone Kina

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ABSTRACT: Early in 1993, Cyclone Kina struck the Fiji Islands, causing more than $100 million in property damage and damaging the coral environment as well. A few days after the cyclone, the most damaged reef was studied. The same reef had been studied 6 months before. This reef crest is dominated by *Acropora*. Comparison showed that 80-90% of the *Acropora* was torn from the outer reef and deposited in the inner lagoon. The larger foraminifer *Marginopora* had been reduced from a significant population to one living in-place specimen.

Coral transects at the airport and a site 15 kilometers east were run about every 6 months. Damage at the airport was greatest, probably because of a small submarine canyon that focused wave energy on the transect area. In both regions, a black band of algae developed, probably due to sediment covering the outer portion of the inner reef flat. This seemed to kill the benthic organisms and allowed the opportunistic algae to invade the area. It is estimated that it will take a few years to 30 years for the reef to recover to pre-Kina conditions.

Introduction

A visual survey of the major near-shore marine and terrestrial environments was conducted during June 1992. This was done as part of an initial study of Fijian environments in the initiation of a long-term global change survey. Of special importance to this study was a general survey of the coral environments off the Savusavu airport on Vanua Levu Island, Fiji (Figure 1).

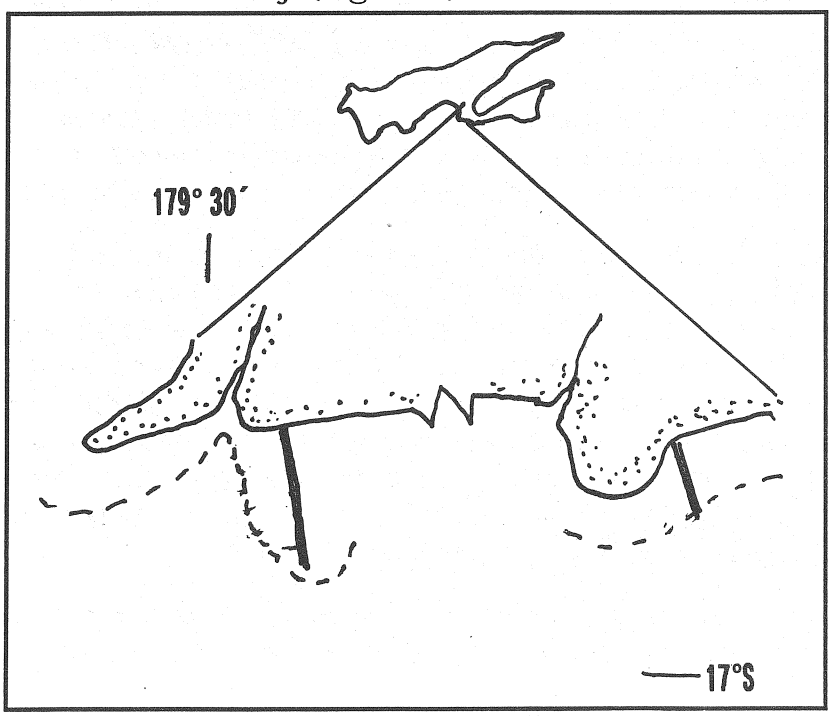

Figure 1. SKETCH MAP OF CORAL TRANSECT LOCATIONS

On January 3, 1993, Cyclone Kina hit Fiji. Our scientific party reached the Fijian Islands within a few days and altered our research plans to study damage done by the cyclone. Kina had caused more than $100 million in damage, including destroying up to 80% of the root crops and upsetting transportation throughout the islands. To date, our main concentration has been on coral damage and recovery.

In: C.M. Isaacs and V.L. Tharp, Editors. 1995. *Proceedings of the Eleventh Annual Pacific Climate (PACLIM) Workshop, April 19-22, 1994.* Interagency Ecological Program, Technical Report 40. California Department of Water Resources.

Procedures

Two reef areas (Figure 1) were selected for detailed research. The first was the Airport reef surveyed the previous summer; the second was a reef to the east of the airport about 15 kilometers by the Hibiscus Highway, just off the MuMu Resort.

Line transects were made off each area using the point intercept method. At the airport transect, observations were made at 20-cm intervals out to 45 meters offshore. At the MuMu transect, the 20-cm intervals were recorded for only the first 25 meters offshore. From that point, observations were made every meter to the reef crest.

At each point on the transect, we recorded the substrate and organisms found. We also made note of the condition of the reef surrounding the points. Reef terminology is shown in Figure 2.

The reef flat at the Airport transect extended about 500 meters offshore, compared to 300 meters offshore at the MuMu transect. The reef crest portions were each about 20 meters wide. The transects were performed at low tide with the aid of view boxes made of acrylic. Still and video photography were used for documentation and identification.

Transect Results

Figure 2 illustrates the main observations from the Airport transects. The inner reef flat corresponds to that portion of the reef flat that was documented at 20-cm intervals. The outer reef flat extends out to the reef crest, which is slightly elevated above the reef flat and dominated by *Acropora*. Before the damage by Kina (August 29 on Figure 2), *Marginopora* (larger foraminiferans containing symbiotic algae and commonly referred to as puca shells) was common and well represented in each zone of the reef. The outer reef displayed a healthy, mature growth of *Acropora*.

In January 1993 (Figure 2), the most obvious result of Kina at the airport was the destruction of about 80% of the *Acropora*. The 70-meter-wide band of *Acropora* stands near the reef crest appeared to have been planed off. *Acropora* hash from the outer reef appears to have been spread onto the reef flat, filling depressions on the flat. This hash did not exhibit the characteristic bleached color of old reef rubble; most still appeared to have the color of living *Acropora*. Therefore, we concluded that this hash was very recently broken off living stands. In some cases, the *Acropora* hash may have traveled some 400 meters over the reef flat.

SCUBA work on the seaward slope documented some *Acropora* hash and one large displaced table coral that scratched the seaward slope as it fell (Figure 3).

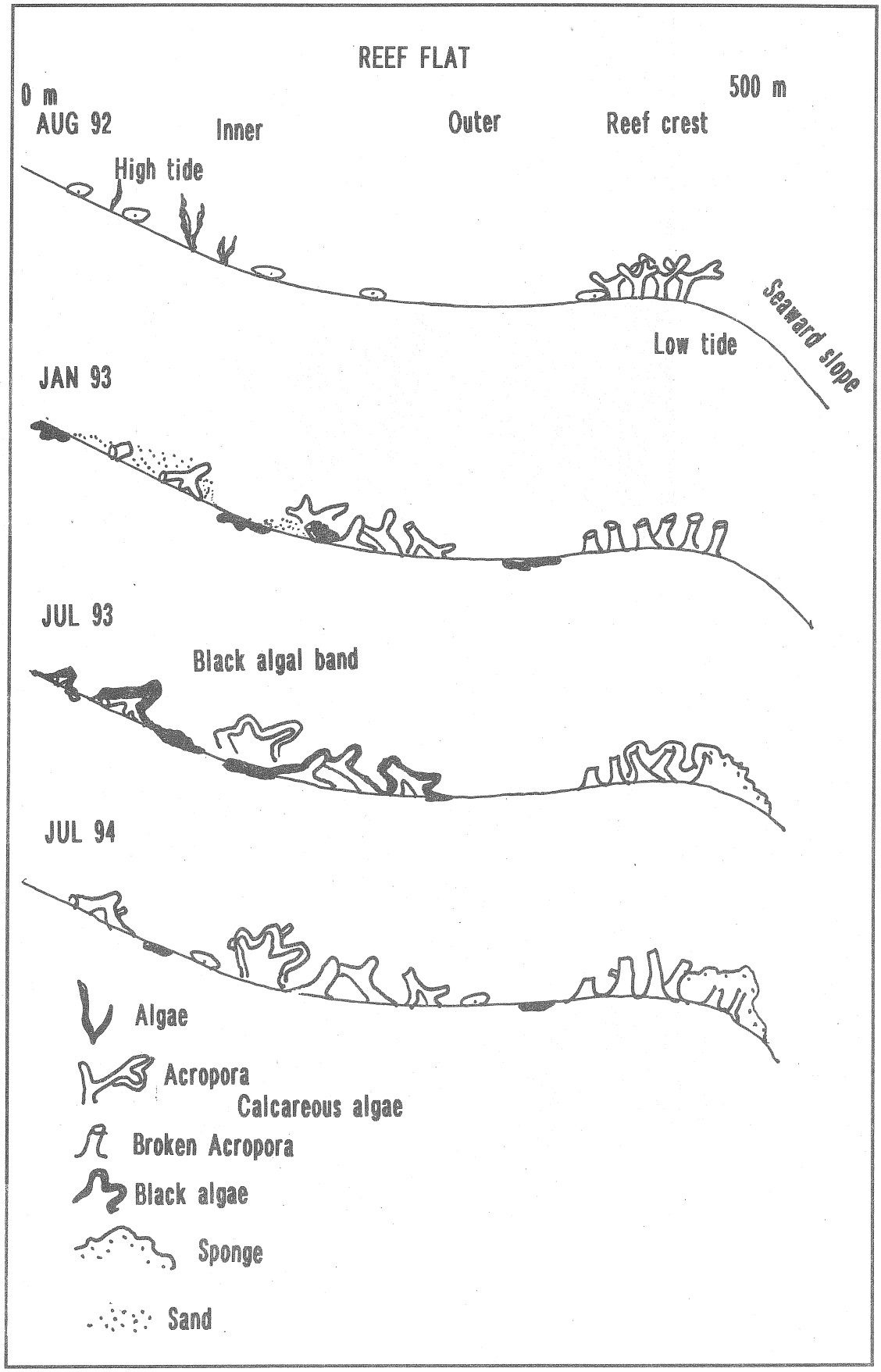

Figure 2. AIRPORT TRANSECT

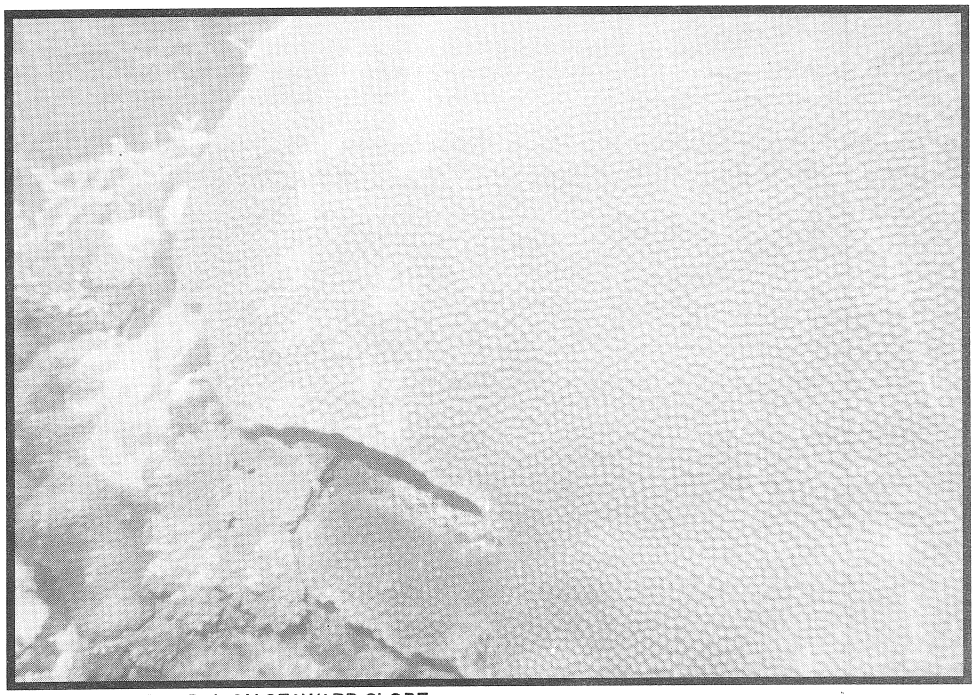

Figure 3. TABLE CORAL ON SEAWARD SLOPE

The inner reef flat also contained sediment of silt to sand sizes. These sediments were deposited in the deeper pockets, sometimes covering the small algae and seagrass beds of the area.

During this transect, only one living *Marginopora* foram was observed; evidently the others were washed away by intense wave action during the cyclone. There also appeared to be a significant amount of dead sea urchins, many of which had broken and/or missing spines. The population of brittle stars and blue sea stars seemed unaffected by the storm, owing perhaps to their ability to hide in the crevices and holes in the reef flat.

A week after the Airport transect, we performed the MuMu transect. This reef appeared to be less damaged than the reef at the airport. There was significantly less *Acropora* hash in the reef flat crevices, and the stands of living, healthy *Acropora* did not appear planed off, as did those at the airport. Only a few *Acropora* stands appeared to have had tips broken off by the storm. Populations of *Marginopora* were prevalent throughout the entire reef flat, and other fragile organisms such as alga and several species of sponge survived the storm and were found along the entire transect. Figure 4 shows a detailed view.

By July 1993 at the airport, the outer portion of the inner reef flat was covered by black encrusting algae to the degree that we referred to this as a black algal band. This black algal band appears to have covered a

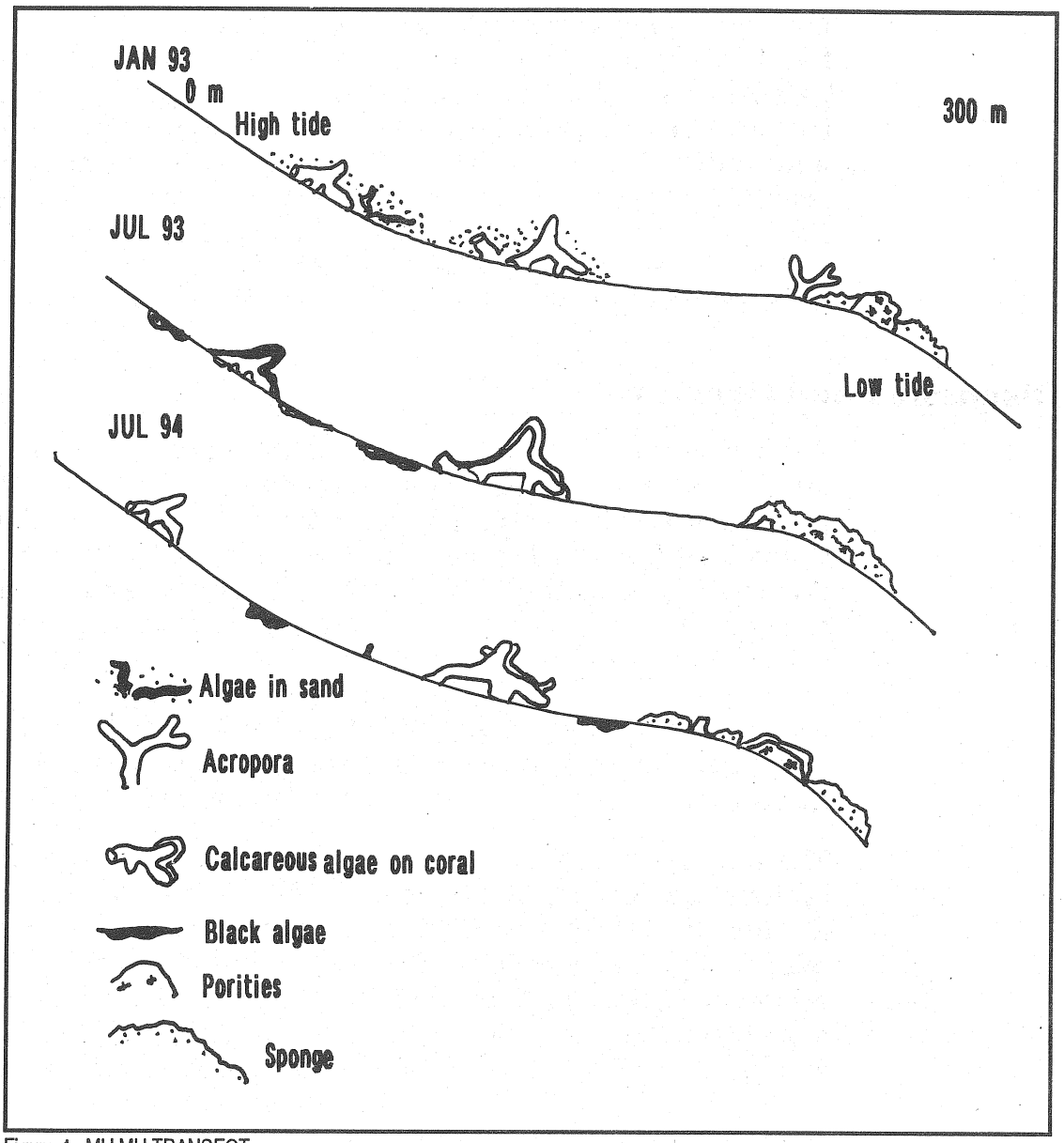

Figure 4. MU MU TRANSECT

10-meter-wide patch about 80 meters from the shore. The band appears to have covered some of the broken *Acropora* stands. In the mid-reef region, the cyclone rubble, including *Acropora* hash, was mainly encrusted with pink calcareous algae, which was starting to form a hard ground. A thick, mainly brown sponge covered the cyclone-cropped *Acropora* stands. This sponge coverage encompassed about 70% of the total outer reef area.

At MuMu there was no significant change in July 1993 from the transect in January. The only similarity to the airport reef was that a band of black encrusting algae also covered a 10-meter-wide patch of *Acropora* that had been broken off by the storm. This patch was about 70 meters from the shore.

During a transect performed at the airport in July 1994, the black algal band on the inner reef appeared to have broken up, leaving only small patches. Small corals (*Acropora, Pocillipora*) appeared to be recruiting in the open areas. The brown sponge cover on the outer reef was considerably reduced, with small corals recruiting on dead *Acropora* regions previously covered. Throughout the reef flat area, juvenile *Acropora* and *Pocillipora* were growing from the bases of corraline calcareous algae, exposed fossil reef, and dead in place corals. *Marginopora* also appeared to be returning to the reef flat area, as well as the urchin populations.

Discussion and Conclusion

We believe the considerable destruction to the coral reefs was not due only to Cyclone Kina, but to a combination of the cyclone and effects of the 3-year El Niño leading up to and surpassing the cyclone. The Weekly Climate Bulletin of January 12, 1994, states, "the warm episode conditions that have persisted in the tropical Pacific during the last three years showed signs of weakening in December [1993]." We have been aware of this El Niño and noted at least some coral bleaching on each of our trips to Fiji. The coral damage we observed then was the result of a one-two punch. The first was the weakening of the coral by the long El Niño due to the pond of warm water in the western tropical Pacific. The second was this specific cyclone and other storms spawned by the El Niño conditions.

The only record of a similar event we could find affecting Fiji was the cyclone of February 1965 (Cooper 1965). This cyclone also followed the El Niño if 1962 and 1963. Cooper mentions severe coral damage but mainly reports general conditions such as the types of dead fish. Both cyclones (1965 and 1993) developed in the western tropical Pacific and approached Fiji from the northwest. The 1965 cyclone passed by islands at longitude 170°E, and the 1993 cyclone entered the waters between the two main islands, Viti Levu to the south and Vanua Levu to the north.

After the 1993 cyclone, the Airport and MuMu regions studied exhibited differences in wave damage, with the most severe damage at the airport. The most probable reason for this difference is that just west of the Airport transect is a small submarine canyon cut by a stream. This depression concentrated wave energy in this section of reef. Although there is a stream west of MuMu, it has not cut a submarine canyon and, thus, there is no enhancement of wave energy.

The black bands of algae at each transect may also be influenced by the streams. Sediment brought in by rain associated with the cyclone was deposited in the outer portion of the inner reef flat at both sites. This sediment cover killed the benthic organisms, allowing the opportunistic black algae to invade the area after the sediment was removed by wave action.

From visual observation, the transects could have been located anywhere. The same general zonations occur throughout the surrounding area, despite local patchiness.

The reef has not continued its pre-Kina conditions in a year and a half. Since the last cyclone was in 1965, it seems likely that the reef will return to pre-Kina conditions sometime within a few to 30 years. However, sources suggest that the El Niño-like conditions appear to be developing in the equatorial Pacific as this is being written.

Reference

Cooper, M.J. 1965. Destruction of marine flora and fauna in Fiji caused by the hurricane of February 1965. *Pacific Sciences* 20:137-141.