



Catastrophic impact of hurricanes on atoll outer reef slopes in the Tuamotu (French Polynesia)

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Abstract. Underwater effects on coral reefs of the six hurricanes which ravaged French Polynesia between December 82 and April 83 were observed by SCUBA diving around high islands and atolls during September and October 1983. Special attention was paid to Tikehau atoll reef formations (Tuamotu archipelago) where quantitative studies on scleractinians, cryptozoa and fishes were conducted in 1982 immediately prior to the hurricanes. On outer reef slopes coral destruction, varying from 50 to 100%, was a function of depth. Upper slope coral communities composed of small colonies well adapted to high energy level environments, suffered less than deeper formations. However, there is a narrow erosional trough in this zone at a depth of 6 m that was probably the result of storm-wave action (plunge point). Coral destruction was spectacular at depths greater than 12 m: 60 to 80% between 12 m and 30 m and 100% beyond 35 m, whereas earlier living coral coverage ranged from 60 to 75% in these zones. The outer slope was transformed into a scree zone covered with coarse sand and dead coral rubble. Dives on different sites around steep outer slopes (>45°) of the atolls and more gentle slopes (<25°) of some parts of the high islands permitted the formulation of an explanatory hypothesis: direct coral destruction by hurricane-induced waves occurred between the surface and 18–20 m; on low-angle slopes broken colonies were thrown up on reef flats and beaches; on steep slopes avalanches destroyed much of the living corals and left scree slopes of rubble and sand.

Introduction

Storm induced catastrophic effects have been described as a major geomorphological agent for tropical islands and reefs (Stoddart 1969, 1970; Eide 1976). Most of the studies carried out on the effects of cyclones, typhoons or hurricanes on coral reefs referred to shallow water areas, reef flats and littoral zones (Stephenson et al.

1958; Blumenstock 1961; Stoddart 1962, 1963, 1965; Ogg and Koslow 1978; Rogers et al. 1982). Except for recent studies on the effects of the typhoon Pamela on the coral reefs of Guam (Randall and Eldredge 1977) and on the hurricane Allen's impact on Jamaican coral reefs (Woodley et al. 1981; Kjerfve et al. 1986), little attention has been paid to hurricane impact on outer reef slope formations. Previous investigations have indicated that damage caused by hurricanes was usually localized and restricted to shallow water areas (Banner 1961; Stoddart 1962, 1963; Glynn et al. 1964; Ogg and Koslow 1978; Woodley et al. 1981; Rogers et al. 1982, 1983; Kjerfve et al. 1986). The geological effects of hurricanes on upper reefs and beaches, their importance in the formation of boulder ramparts or in the distribution of sediments were also well investigated (Blumenstock 1961; Ball et al. 1967; Baines et al. 1974; Flood and Jell 1977; Hernandez-Avila et al. 1977).

Diving surveys on outer reef slopes around several islands of French Polynesia during September and October 1983, subsequent to the hurricanes which devastated the South Pacific region between December 1982 and April 1983, revealed that coral destruction could be an extensive and catastrophic phenomenon on atoll outer slopes (Laboute 1985). During the hot season 1982–83, six hurricanes (Lisa: 11–13 December 1982; Nano: 20–27 January 1983; Orama: 22–27 February 1983; Reva: 6–14 March 1983; Veena: 7–13 April 1983; William: 15–21 April 1983) ravaged French Polynesia (Fig. 1). Their mean characteristics were the following ones (maximum values in brackets): central storm pressure = min. 950 hPa; max sustained wind speed = 45 m/s (62 m/s); radius of maximum winds > 28 m/s = 100 km (150 km); mean sea level change (storm surge) = 2–3 m (4 m); local wave height = 8–10 m (12 m) (Services Météorologiques Pacifiques 1983). Hurricanes intensities and tracks were similar to those registered for hurricanes of the early century (1903–1905) which wrought catastrophic damage to Polynesian islands. On the contrary, tropical storms and hurricanes occurring in French Polynesia between these