Impact of Human Trampling in Different Zones of a Coral Reef Flat

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ABSTRACT / The effects of trampling on the coral communities of the outer reef flat and reef crest were investigated at Heron Island at the southern end of the Great Barrier Reef. Eighteen months of trampling at various intensities increased the percentage cover of unoccupied substrate and the cover of mobile rubble. The morphology of the coral was the most important feature relating to trampling resistance. Branching corals were reduced on the outer reef flat, and most broken branches were recorded in the initial phases of the experiment. The reef crest was much more resistant.

A short-term trampling experiment showed that trampling detached a greater mass and larger fragments of coral on the outer reef flat than on the reef crest. Further trampling reduced the sizes of the detached fragments on the outer reef flat. A drift experiment indicated that greatest movement of fragments occurred on the reef crest and here the largest fragments moved greater distances.

We concluded that all habitats would be changed by reef walking and that by one measure the outer reef flat was 16 times more vulnerable than the reef crest. The routes taken by reef walkers need to be chosen in relation to the trampling resistance of the habitat.

The destructive effect of human trampling on terrestrial habitats is well recognized and has become a major concern of park and wildlife managers during the last three decades (Liddle 1975, 1988, Wall and Wright 1977, Kuss 1986). The Great Barrier Reef, off the east coast of northern Australia (Figure 1), has been utilized by a developing tourist industry during the past 40 years. However, although a reasonable body of literature exists documenting the effects of a number of different human activities on coral reefs (Endean 1976), only two papers (Woodland and Hooper 1977, Liddle and Kay 1987) are concerned with the effect of human trampling.

Woodland and Hooper (1977) showed that human trampling can cause extensive breakage of living coral, and Liddle and Kay (1987) applied the concepts of resistance, survival, and recovery after trampling to four species of coral. However, the relative vulnerability of different reefs or reef zones with different coral composition has not previously been investigated, and there are no published data on the long-term effects of different intensities of human trampling.

This study was designed to investigate these questions and the results of three experiments are reported here. In the first, the effects of trampling over 18 months on the species and substrates of two zones of the reef were investigated, and in the second and third, the nature of trampling damage and the movement of detached fragments were examined in more detail. The implications of the results for management are also discussed.

Methods

Study Area

The experiments were conducted on the intertidal flats of the coral reef surrounding Heron Island, a coral cay located near the southern end of the Great Barrier Reef off the northeastern coast of Australia (Figure 1). Although all zones on these reef flats are accessible to visitors from the holiday resort and research station located on the cay, our observations indicated that reef walkers only trampled living organisms or damaged nonliving substrates in the outer reef flat and reef crest zones (Figure 1).

The range of coral morphologies found on the reef crests and flats is depicted in Figure 2. Visually, the typical sessile community on the reef crest appeared nearly “two-dimensional,” with encrusting and digitate to low corymbose or caespitose corals predominating. In contrast, that on the outer reef flat had a much greater vertical component, with platelike, open arborescent and high corymbose or caespitose corals being the most common. Experimental sites were chosen in both zones in areas usually visited by few reef walkers.

Long-Term Trampling Experiment

Experimental design and field layout. Sixteen permanent 20-m transects (paths) were located within both a
reef crest and an outer reef flat study site. Four trampling treatments with four replicates were used in the experiment. At both sites, one treatment was a control where no experimental trampling was done along the transect, while the other three treatments were 20 passages, 40 passages, and 80 passages on the reef crest, and 5 passages, 10 passages, and 20 passages on the outer reef flat. A passage is equivalent to walking along a transect once and resulted in an average of 25.3 (SD 0.8, for N = 10) footsteps falling within a 25-cm-wide footpath centered over each transect. Treatments were repeated at three-month intervals for 18 months beginning in May 1982, a total of seven times.

On the reef crest, the transects were positioned parallel to the reef edge in four separate groups of four, and treatments were allocated to transects using a $4 \times 4$ Latin square arrangement. On the outer reef flat, transects were positioned irregularly according to the terrain, and treatments were allocated to transects using a randomized complete blocks design. The preceding field layouts were used so that treatments could be statistically handled in blocks (Winer 1971) because of the heterogeneity of the reef habitat.

**Data and sampling procedure.** Data were collected when the experiment began and at six-month intervals after that. The measurements were made before the trampling treatments were carried out, except for the number of breaks in live coral, which were also counted after trampling. The data are:

1. The percentage cover of sessile animal species and unoccupied substrates along each transect. The latter is divided into four categories: (a) sand, (b) consolidated dead coral (either dead coral fragments cemented together to form a pavement or