DISCUSSION

CORAL COVER

If the tourist activities at the pontoon site and the DSDD site were having any detrimental effect on hard coral communities then a reduction in coral cover at either of these sites in comparison with the control site would be expected. In fact, there was an increase of 5.6 percentage points in coral cover at both control sites that was significant at the 95% probability level but not at the 99% level accepted here. There were similar or larger increases in coral cover at the DSDD deep site, the shallow pontoon site and the semi-sub site - the latter significant at the 99% level. Given the cover of fast growing acroporid corals at these sites, ranging from 20-45% in the shallow sites, this sort of increase in cover is to be expected over a 12 month period as a result of colony growth alone.

There was only a very slight increase in coral cover at the DSDD shallow site, possibly a result of the relatively low cover of fast growing acroporids at this site: 18.8% compared to 27.3%, 27.5% and 44.5% at the other 3 shallow sites. In contrast there was a 4.3 percentage point reduction in coral cover at the deep pontoon site due to the death from shading of most acroporids and some poritids and other species beneath the pontoon. Over the first few months the shaded corals changed colour to a dark brown in an attempt to cope with the reduced light levels. Many corals subsequently died but others have been able to survive under the new low-light regime. Other corals in the vicinity of the pontoon were damaged or destroyed by mooring chain abrasion. There was, however, no reduction in coral cover in the shallow pontoon site, despite being exposed to potential damage from large numbers of inexperienced snorkel divers every day. Such use may be expected to cause coral damage in shallow water from careless swim fin kicking or by snorkelers standing on the reef to rest or clear their mask, but any such effect is not great enough to reduce live coral cover over the period of this study.

The fast growing acroporid corals increased in cover over the period of this study at all sites with the exception of the shaded deep pontoon site where a 17% reduction in total acroporid cover was recorded (from data in table 2). The mean increase in cover of these corals at the other 6 sites was 21.6% (range from +12.7% to +28.4%) The combined cover of all other groups of hard corals, mainly poritids, faviids and pocilloporids, did not show the same consistent change, with a mean increase recorded of only 4.7% (range from -5.1% to +14.1%). Like the acroporids these other corals also showed a reduction at the deep pontoon site where a change of -5.3% was recorded.

Snorkel diver activities and similar scuba diver effects may also be expected to reduce the average height of erect, branching and plate forming corals, even if it does not reduce live coral cover. Similarly if the semi-sub activities along the reef edge to the north of the pontoon were occasionally breaking erect or plate forming corals this might be expected to reduce coral height. The coral height measurements made along each of the permanent coral transects did in fact show up a significant reduction in coral height in the deep pontoon site due to the death from shading of branching acroporids beneath the pontoon and the breakage and destruction of some erect corals in this area by the pontoon mooring chains. Although this demonstrated the sensitivity of this method to overall changes in coral height, no reductions in coral heights were detected at any of the other sites.

OTHER ENCRUSTING ORGANISMS

Soft corals were not abundant in this region of Norman Reef, ranging from 4-10% cover at the majority of sites. These populations were very stable through time with a maximum change of 1% in cover over 12 months.

Any nutrient enrichment resulting from the tourist activities in this area may be expected to lead to an increase in the cover of macro- or turfing algae. In fact, although there was an increase in turf cover at both DSDD sites and the deep control site and a decrease in macroalgal cover at the shallow pontoon site, there were no significant changes at any site. Mean macroalgal cover ranged from 0.2-2.0% at the beginning of the survey period and from 0.2-2.1% 12 months later. Similarly, turfing algae ranged from 0-1.9% initially and from 0-3.3% 12 months later.

It has been postulated that sponges respond to any organic pollution by increasing in abundance (Wilkinson, 1987). Sponges were not common in this region of Norman Reef ranging from 0-2.8% cover - there were no significant changes over the period of the survey.

FISHES

Most of the obvious changes in the reef community around heavily used tourist destinations are in fish populations. Many reef fishes are opportunistic and quickly gather at sites of disturbance or feeding, while others may be repelled by the constant tourist activity. There is anecdotal evidence that chaetodontids (butterflyfishes) decrease in density at areas of heavy diver activity (Wendy Richards, personal communication re Agincourt Reef pontoons), but this may be due to reductions in coral cover and/or quality as many of these fishes are obligate coral feeders.

The initial survey in late March 1987 was not completed prior to all tourist activity. The Deep Sea Divers Den had been using a permanent mooring (a chain wrapped around a small coral knob) at the pontoon site for their boat 'Tropic Queen' for about 12 months prior to this initial survey. The divers had been feeding large fishes, including *Lethrinus nebulosus*, *Platax orbicularis* and *Cheilinus undulatus* (maori wrasse), and relatively small numbers of these species had been attracted to this site. As a result total lutjanids, lethrinids and ephippids were slightly higher at the pontoon site than at the other two sites prior to the establishment of the pontoon.

As has been mentioned, the main fish species attracted to diver activities were *Platax orbicularis*, *Lethrinus nebulosus*, *Cheilinus undulatus*, *Caesio cuning* (fusilier) and *Hipposcarus longiceps*. These species were present at the pontoon and DSDD sites during the final survey, all except *Caesio cuning* in relatively small numbers, but did not increase significantly over the period of the survey. The most obvious fish effect was the large school of about 200 *Lutjanus bohar* and *L. gibbus* adjacent to the pontoon during the final survey. This resulted in a significant time effect on the density of the family Lutjanidae due to an order of magnitude increase from an initial mean of 5.4 per 1000 square metres to a final mean of 51.6.

There was also an order of magnitude significant increase in the surgeon fishes *Acanthurus xanthopterus* and *Naso brevirostris* in the immediate vicinity of the pontoon, but this was due to the presence of schools containing only 23 and 16 individuals respectively. There was a slight decrease in the density of butterfly fishes (chaetodontids) at the pontoon site over the 12 month survey period, especially immediately beneath the pontoon where only 3 individuals were recorded during the final survey. However, there were similar slight falls in the other 2 sites; these decreases were not significant overall.

MANAGEMENT IMPLICATIONS

All evidence to date suggests that the level of use of Norman Reef by tourist and dive operators between April 1987 and July 1988 was not having any significant widespread detrimental effect on the reef community. The only effects on encrusting communities detected during this survey have been due to the hardware installation at the pontoon site. There was a non-significant reduction in coral cover and a significant decrease in coral height at the deep pontoon site attributable to shading induced coral death and mooring chain abrasion. No effects on encrusting communities or coral heights that can be directly attributable to the activities of swimmers, snorkel divers or scuba divers have been observed.

Some fish species have been attracted to the vicinity of the pontoon installation by fish feeding activities, causing a significant increase in the density of lutjanids (snappers and sea perch) and 2 species of surgeonfishes at this site. However, these are fishes that normally occur in resting or feeding schools on the reef and no unusual effects can be expected from the gathering generated by the pontoon. There were naturally occurring larger schools of these and a number of other similar species observed on several dives during both surveys on the large bommie 450m to the NNE of the pontoon site where one of the semi-sub transects was located (see map figure 7).

Since this survey was initiated, the use of Norman Reef by dive charter boats has increased markedly. The Deep Sea Divers Den now have a second boat and mooring SW of the DSDD site that was part of this survey. In addition about 5 other boats occasionally anchor or moor along the face of the reef between the pontoon and the northern end of the reef.

In view of the increasing use of the 2.5 km long back edge of this reef it is suggested that a further 3 monitoring sites be established to cover these new centres of activity, and provide additional control sites. This would include an expansion of the semi-sub site to include both a deep coral site and fish counts, and bring the total number of sites to 6. The position of additional sites would be determined by means of a user survey carried out in conjunction with Marine Parks: one site would be in the area most heavily used by transient boats and the other in the least used back reef area as an additional control.

Survey methods used would be basically the same as those used for this survey but would be expanded in some areas. Broken but still living coral would be scored at all sites, probably during a 30 minute haphazard search of the entire site area. This would give another measure of the coral damage caused by diver activity that may in the long term lead to aesthetic degradation while not causing any significant decrease in coral cover. A number of photos taken annually from fixed points of a fixed scene will also be set up to look at aesthetic changes in the long term. Estimates of the area in square metres showing damage caused by anchoring activities would be recorded in the 50 x 20m transects used for fish counts to get a more widespread picture of the effect on the coral community of boat anchoring. Surveys at 12 month intervals of the new and previously established sites should be sufficient in view of the results from this study.