DISCUSSION

In our report on the first four annual surveys of the Cape Tribulation fringing reefs we argued that there was no evidence that there had been any effect on the coral communities that may have been due to silt run-off from the new road (Ayling and Ayling 1991). The only changes to the fringing reef communities during this time resulted from obvious natural disturbances. A small cyclone that crossed the coast near Cooktown in April 1986 gave rise to winds between 40–50 knots in this region and caused extensive coral breakage on the study reefs. This resulted in a 25% overall reduction in coral cover, mainly of the dominant *Acropora/Montipora* species, between 1985 and 1986. In early 1987 a coral bleaching episode bleached a mean of around 33% of the corals on these fringing reefs and resulted in some coral death. There was an average 4% decrease in overall coral cover between 1986 and 1987, probably as a result of this bleaching event. Both these disturbances affected all locations equally and coral cover remained similar at all locations. During 1988 there were no disturbances and coral cover increased markedly at all locations back to the levels of around 50% cover that were recorded in 1985. This previous study showed that all these fringing reefs exhibited a combination of high coral cover, high coral diversity, high coral growth rates and good recovery following disturbance. We suggested that this indicated that the Cape Tribulation reefs were in a healthy state and not suffering from chronic siltation stress as had been suggested by Hopley et al. (1990).

At the time of the first of the new round of surveys in 1994 coral cover in the southern location 1 was the same as that recorded in 1988, whereas cover in the other two locations was up by about 25% on 1988 levels. Although we have no record of changes during the six-year gap between these surveys, it seems clear that there had been significant disturbances during this time. Tropical cyclone Joy affected reefs in the Cairns area in December 1990 with strong south-east winds and coral damage recorded on offshore reefs as far north as Cooktown (A.M. Ayling, unpublished data). This episode would have affected the Cape Tribulation reefs at least as severely as the 1986 cyclonic episode. Given the level of damage recorded on Low Isles, Undine and Mackay Reefs, coral damage was probably especially severe at the three sites of location 1 south of Cape Tribulation itself. It seems likely that the reefs of location 1 had been so badly damaged by this episode that they had only recovered to 1988 coral cover levels by the time of the 1994 survey four years later. At the time of the 1994 survey there was also evidence in shallow water at many of the sites that there had been a low level of wave damage to corals during the previous half year, and some evidence of a bleaching episode over the past year.

Over the three years covered by this new project coral cover remained stable in location 1 (but with a level 13% below the other years in 1996), increased by about 15% at location 2, and stayed the same in location 3. There were several other disturbances during this time that may have negated or reduced any increase caused by normal coral growth. At the time of the 1995 survey there was evidence at most sites of recently repaired wave damage to the corals, probably caused by several strong wind episodes (winds over 30 knots) that occurred during the June to August period. At the time of the survey in November 1995 the damaged corals had already repaired themselves and appeared to be in good condition.

In March 1996 this region received flood rains, with 24 hour falls of between 500–1000 millimetres and four-day totals of around 1500 millimetres. This gave rise to huge fresh water run-off from local catchments, and the flood plume from the Daintree River caused extensive coral death down to about four metres below AHD around the south face of Snapper Island, immediately to the south of the Cape Tribulation region (Ayling and Ayling 1997a, b). There are a number of moderate sized creeks that may impinge on the Cape Tribulation study area including Myall Creek, Emmagen Creek, Tachalbadga Creek, Donovan Creek and Melissa Creek. The Daintree flood plume flowed north from the mouth, and we may assume northward movement of the much smaller plumes from the Cape Tribulation catchments given the south-east winds that prevailed at the time. If that was the case the sites at most risk would be sites 1–

3, site 5 and site 6. Any plume from Melissa Creek would probably be deflected off the coast by Cowie Point and hence away from sites 9 and 10. At the time of the 1996 survey, nine months after this event, we noted many dead coral colonies at sites 1–3 and site 5. These corals had been dead for some time and may have resulted from freshwater inundation during the March flood event. Coral cover decreased by between 5% and 32% at these four sites between 1995 and 1996 (mean 16%) and this was responsible for the reduced coral cover recorded in location 1 in 1996. There was also evidence of recent wave damage at most sites in 1996, probably from a strong south-east wind episode in October.

This recent study confirmed the findings from the previous study, suggesting that these reefs are able to maintain rich coral communities despite being subject to regular disturbance from a variety of sources. At the time of the last survey in December 1997 overall coral cover was almost 64% in the major study sites, 30% higher than the mean recorded in 1985 at the start of this project. Over the intervening 12 years these reefs have been subject to at least two close cyclone approaches, a moderate bleaching event, a severe flood event, and a number of strong south-east wind episodes.

As mentioned in the methods section there were some other sources of coral death observed in these communities. During the 1985–1988 project we regularly found small dead patches on explanate *Montipora* colonies that were apparently caused by a fungal or bacterial infection, but this was not a significant source of coral death and was rarely observed during the present series of surveys. *Drupella* grazing was another minor source of coral death, but the grazed patches were always small and involved only one to three *Drupella* individuals. The voracious coral predator *Acanthaster planci* has never been observed on these reefs. These sources of coral mortality are insignificant compared to the physical disturbances discussed previously.

As has been pointed, out these surveys have been confined to the shallow *Montipora/Acropora* coral stratum that was present at all the major sites. At the time of the 1994 and 1997 surveys clear water conditions let us check on the condition of corals in the deep-water coral stratum from 4–6 metres below AHD that was only present at about five of the sites. This deeper stratum is dominated by more massive corals of a number of genera, including *Galaxea*, *Podabacia*, *Hydnophora*, *Favia*, *Platygyra* and *Pectinia*. Corals in this depth strata also looked healthy in the four sites where they were checked (sites 2, 6, 8, 12).

Although most of the run-off sites are not positioned in the coral-dominated depth strata they also either maintained or increased coral cover over the course of this project. Grand mean coral cover from the five sites was 27% in 1985 and 31% in 1996, a 15% overall increase. At site 17, the one site that was located in the coral-dominated community, coral cover increased from 48% to 67%, a 40% increase. As these were the sites where most sediment from the new road entered the near-shore reef community, it might be expected that any long-term detrimental effect caused by silt run-off would be first felt here.

The composition of the coral communities at the run-off sites was different from that at most of the permanent transect sites. Poritids, faviids and *Turbinaria* spp. were more strongly represented at the run-off sites than in the permanent sites (with the exception of the aberrant site 5). Although the run-off sites were in shallower water than the permanent sites this was not a depth-related difference. These three coral groups only made up 13% of total hard coral cover in the similar 0–2 metre depth stratum at the permanent transect sites (Ayling and Ayling 1991), compared to 54% in the combined run-off sites in 1996. The coral community composition at site 5 was similar to that in the run-off sites, with a larger contribution to coral cover by these three groups (almost 50%) compared to the other permanent sites. We have previously suggested that this was due to the presence of fine silt at site 5 resulting from the proximity of the Emmagen Creek mouth. The same feature was a characteristic of site 17, at the mouth of Melissa Creek — the major contributor to the coral cover of the run-off sites.

There has been some concern that increased nutrient levels in the near-shore water mass may be leading to an increase in the cover of algae and a corresponding reduction in coral cover. Although the cover of *Sargassum* has fluctuated significantly over the 12 years of this study, both in the permanent transect sites and in the run-off sites, there has been no trend toward increasing cover. The cover of turfing algae has only been recorded since the 1994 survey. There has been a significant increase in the cover of algal turf in the permanent transect sites since that time, primarily in location 1. It is possible that this relates to the timing of the surveys. Algal turf flourishes during summer and decreases during winter. The 1994 survey, when cover was lowest, was made in early October, the 1995 and 1996 surveys in November and the 1997 survey in December. It is possible that the turf cover had not increased to its full extent at the time of the October survey. Turf usually covers most available space, including some living coral, by mid-summer. It is too early to say whether this increase represents a real, nutrient-driven change or is just a function of the timing of the surveys as suggested.

Hopley et al. (1990) found that siltation rates in the new road location during the previous study were six times higher than in the northern control location 3, and over three times higher than in the old road location 1. They found that the mud component was similar at all sites in all three locations but the sand component was significantly higher in the new road location. Correlation of siltation rates with weather factors suggested that sand siltation rates were related to maximum wind speed; extensive resuspension of sand only occurred at wind speeds over 20 knots. They considered that silt run-off from the new road had increased the amount of sand lying on the reefs of the new road location and it was resuspension of this that resulted in the six-times difference in siltation rates. Siltation rates were high in all locations (mean of 110 mg sediment per square centimetre per day) and they suggested that the reefs were suffering siltation stress and would be unable to recover from any future disturbances. In a related study Partain and Hopley (1989) reported that these reefs ceased prograding about 5000 years ago and claimed that this was because sedimentation levels had passed beyond the threshold that allowed for active reef growth.

At the conclusion of our latest project the new road had been in position for 13 years. We found no evidence that the apparent increase in sediment available in location 2 had any effect on the fringing reefs in this area. Coral cover in location 2 had increased by 45% since 1985, a higher increase than in the other two locations. Coral cover in site 7, in location 2, was 82.9% in 1997, higher than at any other site and an increase of 95% over 1985 levels. It is hard to escape the conclusion that these reefs are healthy and vigorous. They have been subjected to a number of natural impacts over the past 13 years and have continued to show increases in coral cover.

In conclusion we would reiterate that our studies, now covering a moderate 12-year time period, indicate that the Cape Tribulation fringing reefs are apparently healthy with a high cover of a wide variety of corals, high growth rates and the ability to recover rapidly from major disturbances.

The Cape Tribulation fringing reefs are closely comparable with those of most other coastal regions of the Great Barrier Reef, with the exception of those in the area of big tides between Mackay and Port Clinton where maximum tide range is more than five metres (table 6). Coral cover is usually very high on the reef slope of fringing reefs with the exception of reefs within the big-tide area mentioned above. Grand mean coral cover from over 100 sites between Cape Flattery and Keppel Islands was over 62% (excluding the big-tide sites), very similar to that recorded on the Cape Tribulation reefs.

Cape Tribulation fringing reefs have a similar community composition to those studied in other regions. Coral cover on fringing reefs in other areas is also usually dominated by acroporids on the upper slope (60–80% of total coral cover), as it was at Cape Tribulation. In most regions explanate *Montipora* spp. are usually more important than *Acropora* spp., accounting for between 50–90% of acroporid cover. In deeper water (more than five metres below AHD), or

in particularly silty sites, faviids and *Turbinaria* spp. may also be abundant, sometimes covering up to 20% of the substratum (e.g. Blind Rock in Shoalwater Bay; see Ayling et al. 1998). This is similar to the community composition at the silty Cape Tribulation sites (sites 5 and 17).

Table 6. Summary of hard coral cover on Great Barrier Reef fringing reefs. Figures show grand mean percentage cover from groups of 20 metre line transects. [1] Ayling et al. 1996; [2] This report; [3] Ayling and Ayling 1995a; [4] Ayling and Ayling 1998; [5] Kaly et al. 1993; [6] Ayling and Ayling 1995b; [7] Ayling et al. 1998; [8] Van Woesik 1992. na = not available.

Region	Date	Latitude °S	No. Sites	Hard coral cover mean	Hard coral cover sd
Cape Flattery[1]	Feb 1996	14.9	5	**46.2**	12.2
Cape Tribulation[2]	Dec 1997	16.0	12	**63.7**	15.2
Cairns Section Nth[3]	Jan 1995	16.5	34	**81.0**	7.5
Magnetic Island[4]	Feb 1998	19.2	24	**55.6**	15.8
Middle Reef[5]	Aug 1993	19.2	5	**74.6**	3.9
Hamilton Island[6]	Mar 1995	20.3	6	**54.4**	5.7
Sir James Smith Gp.[8]	1991	20.7	56	**22.0**	na
Northumberland Is.[8]	1991	21.5	20	**11.7**	na
Shoalwater Bay[7]	Dec 1995	22.3	34	**37.8**	16.2
Keppel Islands[8]	1991	23.2	8	**54.3**	na

No fish counts were carried out during this project but the clear water that was encountered during the 1994 and 1997 surveys enabled large fish to be observed easily. It was our impression that there were more large fishes on all reefs (not just on the protected reefs north of Cape Tribulation) during these surveys than during the previous round of surveys, especially the grass emperor *Lethrinus laticaudis*, the bar-cheek coral trout *Plectropomus maculatus* and several species of cod. Of particular note was a sighting of a potato cod *Epinephelus tukula* about 75 centimetres long, a species we have previously only seen in the passes and front reef faces of the outer barrier reefs north of Cooktown.