INTRODUCTION

The Cape Tribulation region in the North Queensland Wet Tropics (approximately 16°S) is characterised by steep, rainforest-covered hills falling directly to the sea from over 1000 metres. Rainfall is high, averaging almost 4000 millimetres per year, with annual totals of more than 6000 millimetres not unusual. Most rainfall occurs between January and April and during this period 24-hour falls sometimes exceed 500 millimetres. This region supports an extensive system of coastal fringing reefs fronting over 60% of the coastline between the Daintree and Bloomfield Rivers.

Between April and October south-east trade winds blow onshore, resuspending the shallow shelf sediments and holding a wide band of turbid water against the coast. Water visibility in these prevailing conditions ranges from less than 50 centimetres to about two metres. During the remainder of the year extended calm periods may occur and during these calm spells water visibility usually ranges between two and six metres.

There was considerable controversy during 1984 over the decision to construct a coast road through rainforest from Cape Tribulation to the Bloomfield River in this region (Craik and Dutton 1987). This unsealed road was completed in late 1984 and subsequent observations during the 1985 wet season showed that there was heavy local run-off of silt into coastal waters from the road (Bonham 1985). There was concern that this silt run-off could cause permanent damage to the fringing reef communities in the area. As a result the Great Barrier Reef Marine Park Authority initiated a multidisciplinary study in the area during 1985 to look at the effects of silt run-off on the fringing reefs of the region. This study included sections on reef structure and development (Partain and Hopley 1989), the sedimentary framework of the reefs (Johnson and Carter 1987), sedimentation rates (Hopley et al. 1990), hydrology (Parnell 1989) and coral settlement and recruitment (Fisk and Harriott 1989). As part of this study we conducted a monitoring program on the Cape Tribulation fringing reefs between 1985 and 1988 to look at the potential effect of silt run-off from road construction on coral populations (Ayling and Ayling 1991).

In view of the absence of any pre-impact data from the area, the main problem we faced was how to resolve the question of whether any damage detected was actually the result of silt run-off from the newly constructed road. As the road was constructed in late 1984 there had been a full wet season of run-off before this study started. It was decided that the Cape Tribulation coast could be divided into three locations, two of which could be used as controls for the third in relation to this problem (figure 1).

Location 1. Coastline from Noah Creek north past Cape Tribulation, adjacent to the long-established section of the road that runs from the Daintree River to two kilometres north of Cape Tribulation (control 1).

Location 2. Coastline from two kilometres north of Cape Tribulation to Cowie Point where the newly constructed road runs adjacent to the coast and where silt laden run-off from the road was observed during the 1985 wet season (impact site).

Location 3. Coastline from Cowie Point to just south of the Bloomfield River where the new road is diverted inland and direct run-off is unaffected by any road construction (control 2).

There are potential problems with this approach. It could be argued that silt run-off into the impact site may also be affecting the immediately adjacent control areas. Such potential impact on the so-called controls is made less likely by the blocking action of Cowie Point between locations 2 and 3, and of Emmagen Point and Cape Tribulation between locations 1 and 2, but is still a possibility given the relatively small distances between major silt run-off points in the impact location and the nearest control sites (figure 1). This could be solved by the choice of more remote control sites, but it was decided that fringing reefs from further afield would not

be strictly comparable with the Cape Tribulation impact site. To the south the nearest reefs are between Yule Point and the Daintree River mouth some 30–50 kilometres from the impact site. These reefs are somewhat similar to the Cape Tribulation impact sites (Ayling and Ayling 1995a) but are likely to suffer confounding impact from the extensive coastal development in the area, and from the adjacent large river catchments of the Daintree, Mossman and Mowbray Rivers. To the north the nearest appropriate potential control reefs are off the Cedar Bay coast. These reefs are wider, deeper and more extensive than those of the Cape Tribulation region and were considered not comparable with the impact location sites (Ayling and Ayling 1995a). Regular surveys of these remote northern reefs would also have posed logistic and cost problems. After discussions with the Great Barrier Reef Marine Park Authority it was decided to use the adjacent controls and that the risk of potential control impact was not serious.

Fringing reefs in the Cape Tribulation area occur in two main situations: along steep rocky shores and on coastal sediment bodies such as river mouth bars and beach shoals (Johnson and Carter 1987). The reefs developed on sediment banks are wider and more extensive than those on rocky shores in the region, and generally extended to the sand at a depth of 4–6 metres below AHD. The reef flat on all these fringing reefs is approximately 0.8 metres higher than modern coral growth. This raised flat was formed during the late post-glacial period around 6000 years BP when sea levels were about one metre higher than they are at present (Johnson and Carter 1987). Preliminary surveys on these fringing reefs suggested that they were rich and diverse. Veron (1987) reported 141 species in 50 genera, and this study recorded three species not previously reported from the Great Barrier Reef. We found that many of the reefs supported hard coral cover approaching 50% (Ayling and Ayling 1985).

We found a marked depth stratification in the benthic communities on these fringing reefs (Ayling and Ayling 1991). There was a narrow band of dense *Sargassum* spp. in an approximately metre deep band immediately below low tide level. Below this the cover of *Sargassum* decreased rapidly, while the cover of hard corals increased. From 2–4 metres depth was a stratum dominated by *Acropora* spp. and *Montipora* spp. In deeper water these two groups decreased rapidly in abundance while a number of massive and large explanate coral species became more common. These deep-water corals included the following species and genera: *Pachyseris speciosa, Podabacia crustacea, Goniopora, Alveopora, Platygyra, Hydnophora exesa, Galaxea, Merulina ampliata, Lobophyllia, Symphyllia, Echinopora, Echinophyllia, Oxypora, Mycedium elephantotus, Pectinia lactuca* and a number of faviid species.

The rocky shore reefs were generally shallow, and only included the *Sargassum* band and sometimes a narrow section of coral-dominated reef community. The wider, sediment bank reefs all had a well-developed *Acropora/Montipora* band but only a few of them extended deep enough to have a significant deep-water coral stratum (Ayling and Ayling 1991).

The basic monitoring design we used to detect change that may have been caused by sediment run-off was based on sites of five permanently marked 20 metre line intersect transects set up in the *Acropora/Montipora* community. We established four sites in each of the three locations described above, and surveyed them annually between 1985 and 1988. Mean coral cover in 1985 was almost 50%, and there were no differences between the three locations and no evidence of hard coral death that may have been caused by silt run-off during the previous wet season. Coral cover decreased in all locations during a small cyclonic episode in early 1986 and decreased again in 1987 due to a moderate bleaching event. Over the next 12 months, in the absence of disturbance, coral cover increased in all locations back to the level recorded in 1985.

During a flight over the Cape Tribulation area in the 1985 wet season observations were made of the points where most sediment run-off from the road actually entered the marine system, either through creeks or down gullies. These points are marked on the map in figure 1. None of these five run-off points impinged on the major fringing reef areas but rather occurred along

the rocky shore sections of the coast where the reefs were narrow and fell abruptly to the inner shelf sediments at a depth of only a few metres. The depth stratum that was surveyed at the other 12 sites was not present at these shallow sites. To see if silt impinging directly on the reefs had any affect on benthic communities we surveyed five haphazard 20 metre line transects in the deepest part of each of these sites (sites 13–17) at the same times that the permanent transect surveys were carried out. Coral cover at these run-off sites averaged around 25% (range <5–40%), and changed in a similar pattern to the permanent sites during the 1985–1988 project (Ayling and Ayling 1991).

Although the sedimentation study suggested that sedimentation rates were much higher on the fringing reefs in the new road impact location (Hopley et al. 1990), there was no evidence from our study that this had affected the benthic communities on these reefs compared to the control reefs.

There was some concern that any effect of increased sedimentation rates may not have been evident over the relatively short period of our study (Hopley et al. 1990), and the Great Barrier Reef Marine Park Authority decided to continue the Cape Tribulation benthic community surveys with a three-year project starting in 1994. The decision to continue this project was also influenced by concern that fringing reefs were under stress due to deteriorating inshore water quality and likely to suffer degradation.

The main question we sought to answer with this project extension was whether there was any medium-term degradation of the Cape Tribulation fringing reefs that may have been due either to continuing silt run-off from the road, or to ongoing chronic changes in near-shore water quality.

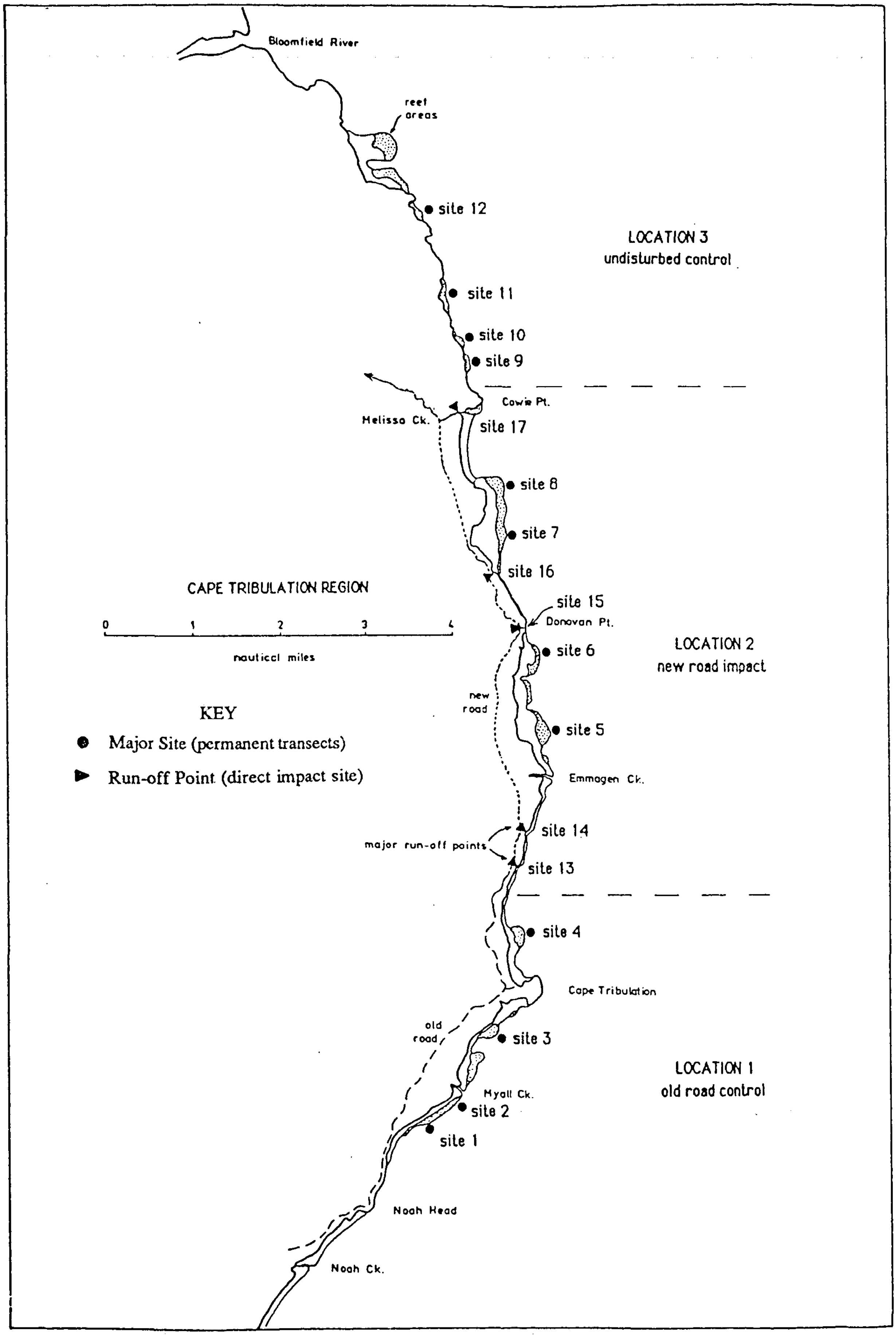

Figure 1. Map of the Cape Tribulation region showing the study locations and sites and the major points of sediment run-off