METHODS

Selection of Study Sites

Fringing reefs in the area occur in two main situations: along steep rocky shores and on coastal sediment bodies such as river mouth bars and beach shoals. The reefs along rocky shore sections of coast total about 8.3 km in the Cape Tribulation region. These reefs are narrow and generally fall abruptly to the inner shelf sediments at a depth of only 1-3 m below Australian Height Datum (AHD). Reefs developed on sediment banks are wider (from 100-600 m wide) and more extensive, ranging from 300 m to 3 km long, with a total of 13.4 km in the Cape Tribulation region. Most of these reefs have an inner sandy beach and a subfossil outer reef flat with living corals largely confined to the reef slope. These sediment bank reefs generally fall more gently to the shelf sediments, reaching depths of a maximum of about 6 m below AHD. The reef flat on all these fringing reefs is approximately 0.8 m higher than modern coral growth. This was formed during the late post-glacial around 6000 years BP when sea levels were about 1 m higher than they are at present (Johnson and Carter, 1987).

A preliminary assessment of all reefs on the 25 km of coast between Noah Head and the Bloomfield River was made during September 1985 (Ayling and Ayling, 1985) using spot check techniques at 20 sites, including 5 where conspicuous sediment run-off had been observed during a flight over the area in February 1985. It was decided to confine the major study to the deeper sediment bank based reefs where hard corals were abundant as it was the fate of the coral communities of the region we were primarily interested in. Four similar sites where the reef reached a depth of at least 4 m below AHD were chosen in each location (figure 1). Each site was restricted to a short length of reef about fifty metres long having broadly homogeneous coral communities. Four sites were used to give some indication of the range of conditions within each location.

Depth Stratification

As a preliminary to the major survey the depth stratification of the coral communities was measured at one site by surveying five haphazard 10 m intersect line transects to measure the abundance of corals and other encrusting organisms at four depths. These surveys indicated that there was a marked depth stratification in the reef community (results, table 2). It was decided to restrict the main survey at each site to the *Montipora/Acropora* depth strata between about 2 and 4 m depth; this strata had a high coral cover and moderately high diversity and was present at all sites, whereas the deeper strata was not well developed at all sites.

Permanent Transects

At each of the major sites (sites 1-12, figure 1) five haphazardly positioned permanent 20 m line transects were marked with reinforcing rod stakes every 5 m and recorded for coral cover. A fibreglass tape was stretched tightly between the stakes and the intersection of this tape with each coral colony beneath it was recorded in cm. Such

intersect transects have been widely used to estimate the cover of benthic organisms (Loya, 1976; Mapstone et al., 1989).

The permanent transects were set up and surveyed initially in October/November 1985 and resurveyed in September 1986, November 1987 and November 1988.

At the time of the initial 1985 survey a series of stereo photo pairs were taken along a 10 m segment of one of the permanent transects at each site using Terry Done's stereo-photographic apparatus. The results of this were not acceptable as the distance from the camera to the coral was too great for flash photos to be successful in the turbid water we normally experienced. In subsequent years the same 10 m segment was photographed when the water was suitably clear using natural light using a single camera with a wide angle lens. Conditions were only suitable for photography on a small proportion of the days spent in the region.

Haphazard Transects

Within these same 12 sites another five haphazard un-marked transects were surveyed each year from 1985 to 1987. Separate haphazard transects were surveyed each year and the re-surveys were thus independent of each other. Survey dates were October/November 1985, January 1987 and November 1987.

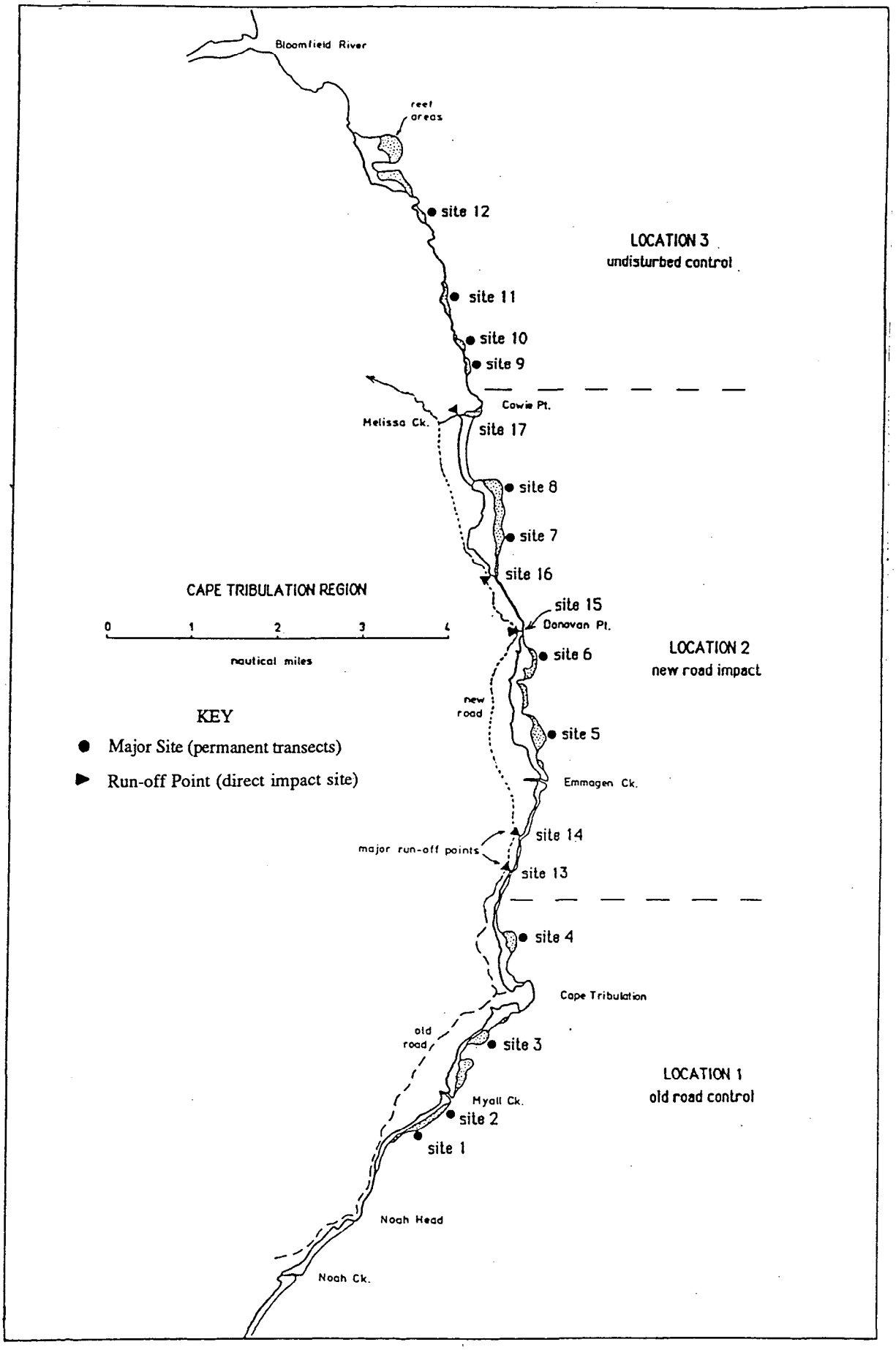
Marked Corals

During October/November 1985 the position of 10 large coral colonies of a range of species was noted within each of the 12 sites. The condition of these colonies was noted at the time of each re-survey.

Direct Impact Sites

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 run-off points impinged on the major fringing reef areas but rather occurred along the rocky shore sections of the coast where the reefs are narrow and generally fall 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 but it was decided that surveys should be made of the benthic communities on the deepest parts of the reef nearest to the run-off point to see if silt impinging directly on the reefs had any affect. At each of these five additional sites (labelled 13-17) five haphazard 20 m line transects were surveyed at the time of the permanent transect surveys in the years 1985-1988. No separate controls were possible for these direct impact sites as this shallow rock fringing habitat was confined to the impact location (2).

Figure 1. Map of the Cape Tribulation Region Showing the Study Locations and Sites and the Major Points of Sediment Run-Off.



Re-surveys

Initially it was planned to make two surveys per year at all sites, one prior to the wet season in the period September-December, and one post wet season during the months April-July. However, the wet season did not finish until May in this region on the years of the survey and by that time strong SE winds had set in and made conditions unsuitable for surveys until September-October. Regular trips to the area were made during lulls in the SE winds but conditions were almost always so bad that sites and transects could not be reliably detected or the corals identified.

Analysis

The haphazard transects at the major sites were analysed using three factor analysis of variance, while the haphazard transects at the five run-off sites were analysed using a two factor analysis of variance (table 1). The permanent transects for each years survey were analysed separately with a two factor analysis of variance to see if patterns were the same at the beginning and end of the program, while changes through time were checked with an analysis of variance of the proportional changes in abundance between successive surveys (table 1). In the majority of cases the data were square root transformed prior to analysis.

Fish Counts

The consistently poor visibility encountered on the reefs during this study made reliable estimates of fish density difficult to obtain. It was also found that at many of the sites there was not enough reef area to allow five replicate fish counts to be surveyed. After a number of attempts it was decided to limit fish counts to a single site in each location, and to use five replicate 50 x 10 m transects counted in separate 5 m wide swathes. A 50 m fibreglass tape was run out by one observer while the fish counter (AMA) recorded all non-secretive reef fish within 5 m of one side of the tape. At the end of the tape the fish counter crossed over and recorded fish in a 5 m strip back along the other side of the tape, while the tape layer wound in the tape. Fish counts were made at sites 1 (location 1), 6 (location 2) and 9 (location 3), and were only made when the underwater visibility was more than 5 m.

Table 1. Analysis of Variance Models Used for Data Analysis.

A. Permanent Transects for Each Annual Survey.

Factor	Source of Variation	Fixed/Random	df	Denominator
A	Location	F	2	Site (A)
B	Site (A)	R	9	Residual

B. Proportional Change in Abundance Between Successive Surveys of Permanent Transects.

Factor	Source of Variation	Fixed/Random	df	Denominator
A	Location	F	2	B(A)*C
B	Site (A)	R	9	B(A)*C
C	Time Interval	F	2	B(A)*C
	A*C		4	B(A)*C
	B(A)*C		18	Residual

C. Haphazard Transects at Major Study Sites.

Factor	Source of Variation	Fixed/Random	df	Denominator
A	Location	F	2	B(A)*C
B	Site (A)	R	9	B(A)*C
C	Time	R	2	B(A)*C
	A*C		4	B(A)*C
	B(A)*C		18	Residual

D. Haphazard Transects at Run-Off Sites.

Factor	Source of Variation	Fixed/Random	df	Denominator
A	Site	F	4	A*B
B	Time	R	3	Residual
	A*B		12	Residual