INTRODUCTION

The fringing reefs along the coastline to the north and south of Cape Tribulation are the most extensive on the east Australian coast (Craik and Dutton 1987). A checklist of scleractinian corals on the reefs includes 141 species belonging to 50 genera, including three species not recorded elsewhere on the Great Barrier Reef (Veron 1987).

The reefs consist of a primarily dead erosional reef flat with macroalgae on the outer edges, and a living coral zone from 1.4m depth to a maximum of about 8m depth (Ayling and Ayling 1985; Johnson and Carter 1987; Craik and Dutton 1987). The living coral zone is a veneer over a porous unconsolidated base composed mostly of rubble and is due to cyclonic activities (Hoyal 1986) coupled with a paucity of cementing organisms. Ayling and Ayling (1985) noted two types of reef slope morphology, one shallow (2 to 3m) and the other deeper (5 to 8m), with the latter type generally being more extensive and wider than the first.

The region is famous for the proximity of dense tropical rainforest to the foreshore, and the forest contains many small creeks that empty into the coastal waters. The region typically has high rainfall (average annual rainfall at Cape Tribulation is 3750mm (Bureau of Meteorology 1971)). The prevailing winds are from the north-east during the wet season and from the south-east during the winter trade wind season when long periods of rough conditions occur along the coast. In addition, the region is prone to periodic cyclonic conditions (Ayling and Ayling 1986), and several small cyclones affected the area during the study period.

The combination of coastal streams and weather conditions results in generally turbid conditions along this part of the coastline. The effect of turbidity in reducing light levels may limit coral growth below the depths at which it has been observed in this area. Most turbidity results from the resuspension of fine mud and silt, and corals that survive on these reefs must generally be adapted to low light levels and high sediment fall-out (Johnson and Carter 1987; Cortes and Risk 1985).

In late 1984, amid protests from conservationists, a controversial decision was made to construct an unsealed road through the coastal area north from Cape Tribulation to the Bloomfield River (figure 1). One of the environmental concerns expressed about the road and its manner of construction was that any increased sediment run-off might damage the fringing reefs (Bonham 1985; Veron 1987; Hoyal 1986). Of particular concern was the effect that increased sedimentation might have on scleractinian corals some of which are known to be affected by sedimentation rates above ambient levels (Bak 1978; Lasker 1980; Cortes and Risk 1985).

The environmental study programme designed to monitor the effects of the road on the fringing reefs at Cape Tribulation was initiated in 1985, and is described in Craik and Dutton (1987). The section of the study described here was intended to supplement the large scale biological monitoring of the reef communities by A.M. and A.L. Ayling. The purpose of the study was to examine the recruitment patterns of coral spat, and the early stages of the life history of the corals; and to determine if increased sedimentation had adverse effects on these small corals, even if other monitoring programs could not detect changes in the established and larger corals.

STUDY DESIGN

The study design was similar to that of other studies run concurrently i.e. a comparison between reefs in 3 pre-defined zones, the first (south zone) adjacent to an older and presumably stable road in the south of the region; the second (central zone) adjacent to the recently-constructed road; the third (north zone) to the south of the Bloomfield River where no rivers emptied onto the coastline so that the reefs should be unaffected by increased sediment and should act as a 'control' site.

In the absence of prior information on hydrodynamic conditions (a study was carried out concurrently by Hoyal) it was assumed that reefs would be most affected adjacent to the areas of sediment input from coastal rivers. The objectives of the study were:

1. to compare spat recruitment onto artificial substrata in the three experimental zones in both summer and winter periods;

2. to compare the population dynamics (recruitment, mortality and growth) of juvenile corals in the three zones on an annual basis;

3. to assess the contribution of coral recruitment as a determinant of reef community structure;

4. to correlate differences in coral population characteristics among the three zones with environmental conditions at the sites and the extent to which they had been altered from ambient levels.

Very little information has previously been published on the population dynamics of corals on fringing reefs. Bull (1982), Morrissey (1980) and Heyward and Collins (1985), have reported on coral distribution and reproduction at Magnetic Island, near Townsville, while Harriott (1983, 1985) studied reproduction and recruitment of corals on the fringing reefs surrounding Lizard Island. Much recently available information on Australian fringing reefs is included in Baldwin (1987).

METHODS

Reefs selected for the study were a subset of those studied by Ayling and Ayling (1985), and are shown in figure 1. Their nomenclature was adopted for ease of comparison. In October 1986, the study site at reef No. 3/10 could not be relocated, and a seventh reef (No. 3/9) was included in the study from that time on. The timetable for study periods and natural events during the study is given in table 1. The study had two parts: the first to determine recruitment of coral spat onto artifical settlement plates at each site, and the second an analysis of small corals mapped in $1m^2$ quadrats.

Coral spat recruitment

For the study of coral spat recruitment, two settlement racks were deployed approximately 3m to 5m apart at each of the six reefs. All racks were in water depth of 2 to 3m. Plates were collected and replaced twice yearly, after summer (April/May) and after winter (October/November).

During the first two six-month periods (summer 85/86 and winter 86), the type of settlement plates used was two pairs of coral blocks cut from colonies of massive *Platygyra* sp., and a piece of *Acropora palifera* (Fisk and Harriott 1987). Following a separate study comparing the effectiveness and efficiency of different types of settlement plates (Harriott and Fisk 1987), the remaining spat results were collected using ceramic tiles.

Four pairs of tiles were attached to each rack, with two pairs of horizontal and two pairs of vertical plates. Plates were attached to the rack by a bolt placed through a hole drilled in the centre of the tile. Because of the shallow depth of the settlement racks and rough weather conditions during some periods of the study, entire racks were occasionally lost from the reefs. This is discussed further in the results section. In many cases, some tiles or tile pairs were lost from racks. Generally, at least two of the four pairs of tiles remained, so one vertical and one horizontal pair of tiles were usually taken as the standard sample unit and were analysed. In 1987/88, more tiles were lost from some racks, so one pair of vertical tiles from each rack were used for some comparisons. As large numbers of spat settled on all surfaces, the reduction in the number of tiles to be analysed was not expected to decrease the sensitivity of the data set.

The upper surfaces of the horizontally oriented plates were frequently coated with a layer of fine silt up to 5mm thick. Once collected, tiles were labelled, cleaned and bleached in a solution of chlorine. Coral spat were identified to family level where possible. A record was kept of whether each coral spat was apparently alive or dead at the time of collection. This was determined by the degree of erosion and discolouration of the skeleton.

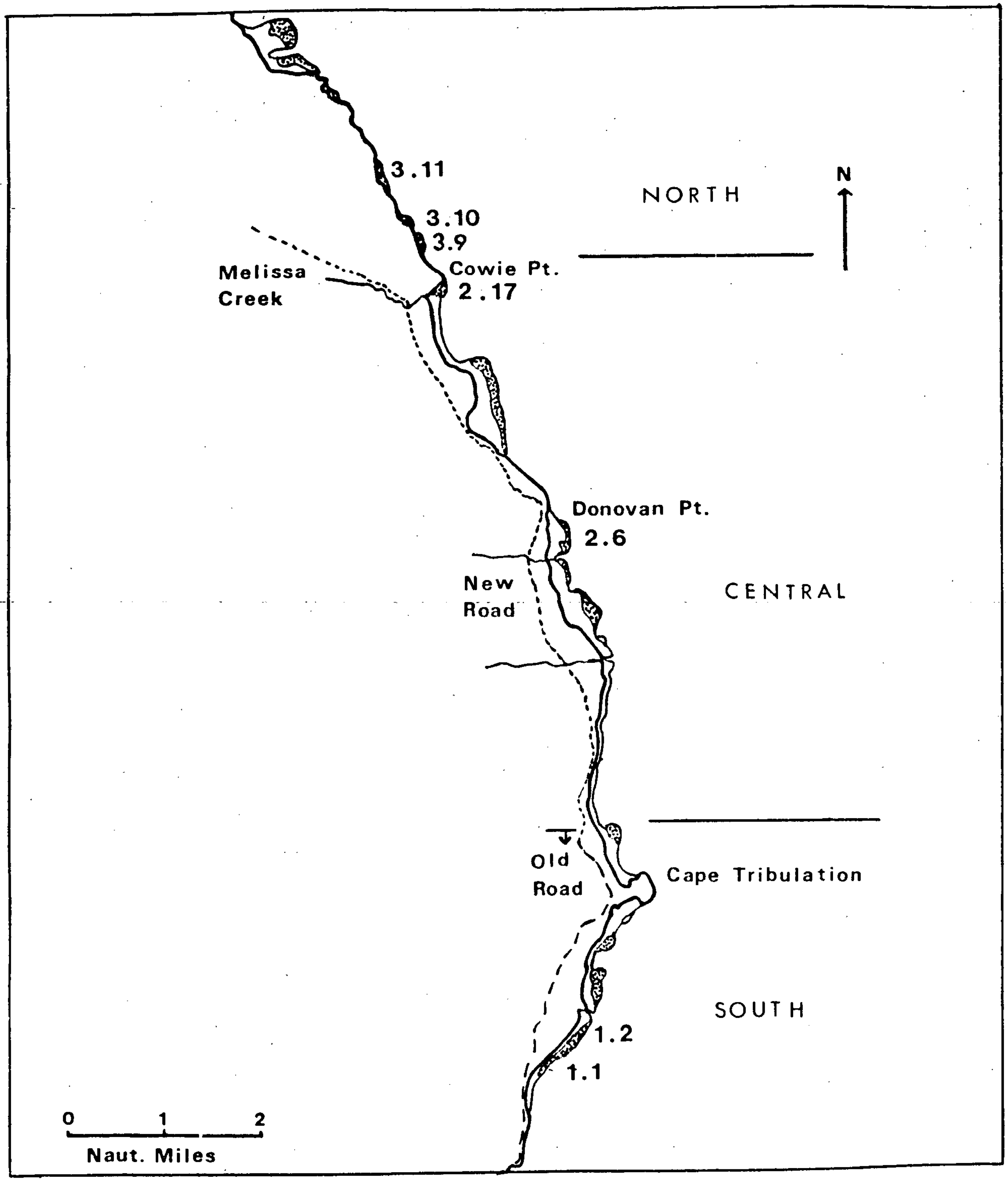

Figure 1. Location of reefs in study area. Zones referred to in the text are shown along with the individual reef numbers. The location of the old and new portions of the road are marked.

Table 1. Timetable for the field project

Time	Event
Late 1984	Road construction
Late 1985	Multidisciplinary study designed and initiated
October 1985	Settlement plates installed. (coral surfaces)
November 1985	Initial juvenile maps
Jan-April 1986	Cyclones Winifred and Namu and rain depression Vernon
April 1986 and June 1986	Settlement plates (coral surfaces) collected and replaced with tiles (on two separate trips due to bad weather)
October 1986	Settlement plates collected and replaced. Additional juvenile quadrats mapped. Reef 3/10 replaced by reef 3/9
Jan-Feb 1987	Coral bleaching
May 1987	Settlement plates collected and replaced
October 1987	Settlement plates collected and replaced Juvenile quadrats mapped
April 1988	Settlement plates collected

Positive identification of coral spat even to family was difficult, partly because many of the types of spat encountered differed from those that the authors had most frequently recorded in previous studies of mid-shelf reefs. In Fisk and Harriott (1987), the second most abundant category of spat at Cape Tribulation was identified as belonging to the family Faviidae. Subsequently, with study of increased numbers of spat, and with access to the coral spat raised from known parents by Dr Russell Babcock (James Cook University), this spat type has been re-assigned to the family Acroporidae, probably the very small juvenile of the abundant plate Montipora species. These species are not abundant on the mid-shelf reefs studied previously, and in its early stages the morphology of the spat resembles that of a small faviid, demonstrating some of the pitfalls in spat identification at this early stage in their taxonomy.

Juvenile coral dynamics

Because of constraints on field time caused by bad visibility, weather and logistics, only three of the intended four replicate $1m^2$ quadrats were marked and surveyed at each site in November 1985. Each quadrat was re-mapped in October 1986, when an additional quadrat per site was added. As mentioned previously, navigational difficulties meant that one of the sites (No. 3/10) was not relocated, and four new quadrats were mapped at site No. 3/9. In October 1986, movement of loose substrate as a result of wave action meant that one quadrat at site No. 3/11 could not be found, so two new quadrats were mapped. All quadrats were re-mapped in October 1987. Mapping involved the recording of the presence/absence of colonies using a previous map drawn from a subdivided quadrat frame; set over fixed stakes. Size was also measured using a maximum diameter and a width perpendicular to this diameter (plus height).

Positive identification in situ was possible to genus level and often species level with the exceptions being very small colonies (<2-3cm dia.) and some larger faviid colonies (5-6cm dia.). Juvenile colonies were defined for the purposes of this study as those with a mean diameter (LxB/2) of less than 20cm. Quadrat sites were selected for their relatively high abundance of small colonies and for having mostly hard substrata within the area. These patches of solid substrata were relatively uncommon in the study areas.