CORAL ABUNDANCE

Pearson's surveys, 1967 - 1969

The earliest published estimates of coral cover on Green Island reef were made subsequent to the 1962-67 infestation by the crown-of-thorns starfish, Acanthaster planci, and were therefore expressed mainly as proportions of dead coral. Pearson and Endean (1969) subjectively estimated that by November 1968 A. planci had killed over 80% of hard corals from the reef flat to the sea floor (at about 40m). They found most of the commonly occurring genera in the surviving corals, with many colonies of Pocillopora damicornis and Millepora undamaged. Surviving corals ranged in size from single colonies to clumps as large as $100m^2$. It was also observed that the outermost tips of several otherwise-dead staghorn Acropora colonies were left untouched (Pearson and Endean, 1969).

Coral recolonisation studies through mapping of four distinct study areas [P1, P4, P5, P6: Fig.4.1] were commenced by Pearson in March 1967 (Pearson and Endean, 1969). Areas P1, P4 and P5 measured 30m x 2m while area P6 was 10m x 10m. It was apparent from brief re-examinations of the study sites in November 1968 that recolonisation was taking place, but at a very slow rate. In August 1969 the corals in areas P1, P4 and P5 were again mapped and recently-established corals, particularly of Stylophora, Acropora and Seriatopora species, were found growing on dead coral surfaces in all three areas. Pearson and Endean (1969) do not give any quantitative coral cover data from the mapping exercise, and area P6 was apparently not remapped in 1969.

Cursory examinations of several hundred square metres of reef in the vicinity of areas P1 - P5 [Fig.4.1] were also made in August 1969. At site P5 on the north-eastern reef flat, Pearson estimated approximately 50% dead coral cover (mostly Acropora and Porites), 20% live coral cover (likewise) and 1% new hard coral growth. Site P4 was judged to have a similar coral cover [Table 4.1].

Site P3 on the north-western reef flat had similar coral cover to site P2 [Table 4.1], with Acropora dominating the dead coral cover. Acropora and massive Porites colonies accounted for most of the live coral cover. New hard coral cover was again estimated to be about 1%.

The dead coral cover at site P1 [Fig.4.1; Table 4.1] was mainly Acropora, Stylophora and Seriatopora, with live coral mainly recently established colonies of the same three genera. At greater depths (3 - 6m) in the same area they found far less coral regeneration (about 1% new growth). Pearson concluded that the growing colonies were those which had not been attacked during the infestation (Pearson and Endean, 1969).

Woodhead's survey, 1970

In June 1970, Woodhead and Pearson quantitatively surveyed coral abundance in the vicinity of Pearson's sites P1, P2 and P4 [Fig.4.1] (Woodhead, 1971). A quadrat technique was used in which a one metre square quadrat was placed at every second metre along a transect line of unspecified length. The number of coral species, number of coral colonies and total area covered by living hard and soft corals were measured for each quadrat. Pearson and Woodhead conducted separate surveys at sites P1 and P2, but co-surveyed site P4. Their estimates are listed in Table 4.1.

Site P1 was found to have the highest living coral cover of the three, with branching colonies of Acropora, Seriatopora, Stylophora and Pocillopora predominant and very large Porites heads common. Despite the absence of comparable baseline data, Woodhead concluded that the area, where A. planci had been very abundant in 1966, was recolonising and regrowing very well. The back-reef area around site P4 was also judged to be recovering well, with Pocillopora damicornis the dominant species. From the size and distribution of the Pocillopora damicornis colonies, Woodhead felt they had appeared after A. planci had left the area.

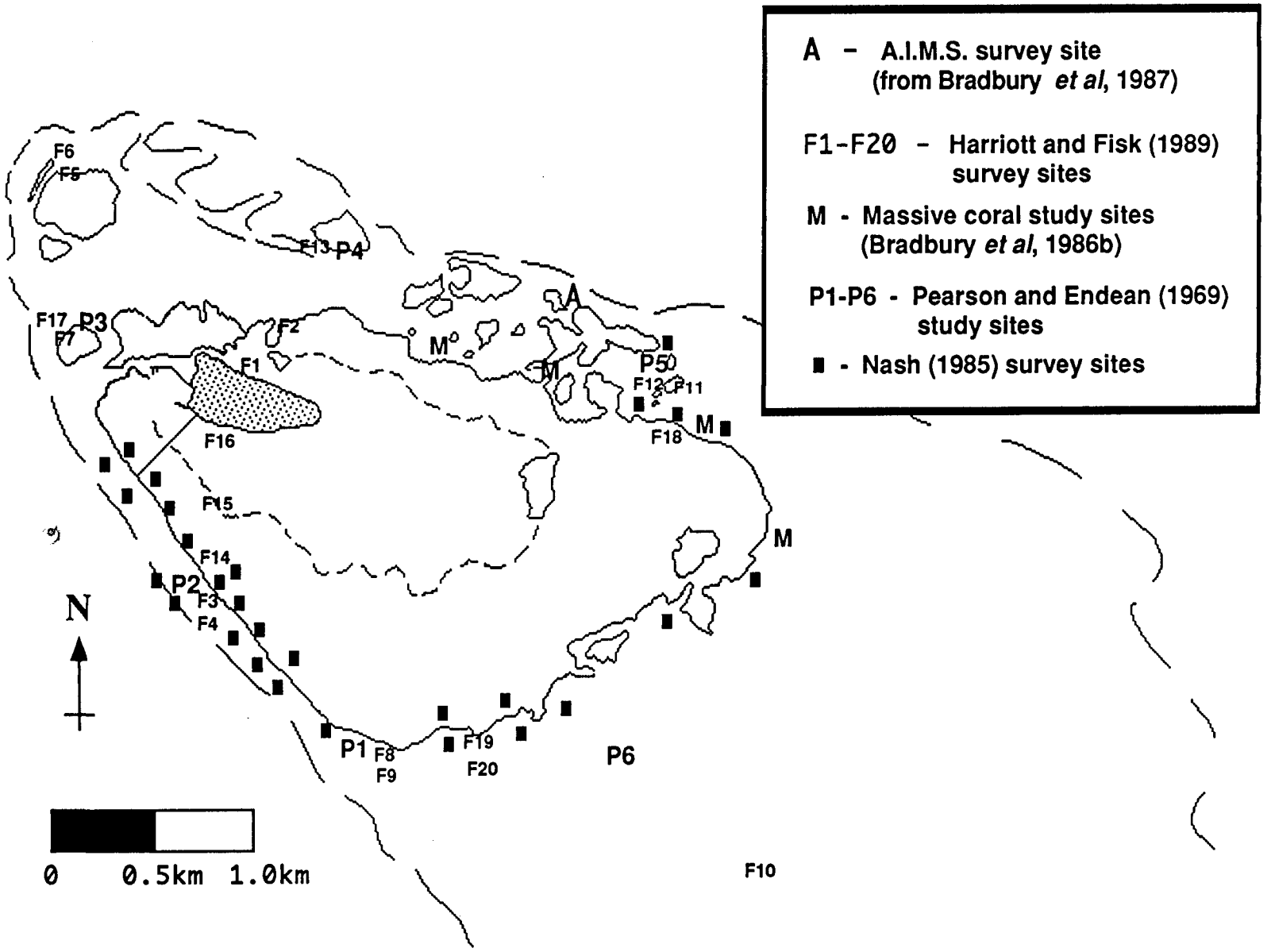

Figure 4.1 Location of coral cover survey sites

Table 4.1:
Coral cover data from surveys of three locations on Green Island reef. Direct comparisons between the surveys are not valid as different survey techniques were used and they were possibly conducted at different locations within the three general areas. Site locations are given in Fig.4.1.
PE = Pearson and Endean (1969); W = Woodhead (two surveys conducted: (P) = Pearson's survey, (W) = Woodhead's survey);
ES = Endean and Stablum (1973b) (two surveys conducted on 'south-western side, seaward slope'); HF = Harriott and Fisk (1989); B = Bradbury *et al.* (1987).

SITE P1	PE	W	HF
Date	8/69	6/70	9/85
Depth	<3m	1 - 8m	3 - 5m
Dead coral	60%	-	-
Live coral	30%	15% (P) 29.5% (W)	16% (3m) 11% (6m)
Soft coral	10%	5% (P) 11.5% (W)	3% (3m) 14% (6m)

SITE P2	PE	W	ES	HF	B
Date	8/69	6/70	11/70	9/85	1/86
Depth	1-6m	<6m	0-15m	3-6m	3-12m
Dead coral	50%	-	-	-	20% (3m) 24% (6m) 26% (12m)
Live coral	5%	2.5% (P) 4% (W)	2% 5.5%	5.5%(3m) 4% (6m)	<1% (3m) 4% (6m) <1% (12m)
Soft coral	15%	21%	9.5% 6%	5% (3m) <1% (6m)	18% (3m) 7% (6m) <1% (12m)

SITE P4	PE	W	HF
Date	8/69	6/70	9/85
Depth	5m	1-6m	5m
Dead coral	50%	-	-
Live coral	20%	14%	3%
Soft coral	-	8%	15%

By contrast, there was little evidence of recovery or recolonisation by hard corals at site P2, where there was considerable sediment movement. Similarly at site P3, where they examined the area but did not conduct a quantitative survey, the greater part of the coral was still dead and regrowing staghorn Acropora branches were on insubstantial or loose bases. Again, high water turbidity appeared a major factor inhibiting the settlement and subsequent growth of young colonies.

In all, Woodhead noted 34 genera and subgenera of corals during this survey, compared with 39 recorded before the starfish infestation. Neither the pre- infestation list nor the list from this survey appear to have been published. Woodhead considered the species assemblage resembled those of two reefs in the same region which had not been infested by A. planci (Low Island and Nymph Island). Although the overall living coral cover at Green Island reef was only about half that of the uninfested reefs (which had been surveyed using a similar technique), he concluded that good recovery was under way, particularly at the southern tip of the reef (Woodhead, 1971).

Endean and Stablum's survey, 1970

Hard coral cover at Green Island reef was surveyed by Endean and Stablum (1973a,b) in May and November 1970. While Endean and Stablum (1973a) conceded that visual estimates of hard coral damage could lack precision and be misleading as they did not take into account 'the overall extent of coral cover or the amount of dead coral normally found on the reef', they proceeded to make visual estimates of the respective amounts of living and recently killed coral present. Several techniques were employed during their series of surveys on a number of reefs - snorkelling, scuba diving, use of a glass-bottomed box from a boat and manta towing - and the methods used at Green Island are not specified.

The proportion of reef surface covered by live hard corals plus the skeletons of recently killed hard corals still *in situ* (termed the 'total hard coral cover') was categorised as 'sparse', 'moderate' or 'dense', while the proportion of recently killed hard corals within the total hard coral cover was categorised as 'low', 'marked' or 'high'. The extent of soft coral cover was also assessed (Endean and Stablum, 1973a). Survey areas were located so as to correspond with areas at which A. planci observations were made by Barnes (1966).

At two reef flat sites - one to the west of the cay [B4: Fig.3.1; 0-5m depth] and the other on the north-west side of the reef [B5: Fig.3.1; 0-3m depth] - hard coral destruction was considered almost total, soft coral cover was extensive and hard coral recolonisation was negligible. On the seaward slope along the south-west and southern sides [B2, B3, B1: Fig.3.1; 0-15m depth] there was extensive destruction of hard coral, with a high proportion of dead coral rubble plus algal covered coral skeletons *in situ* . Hard coral recolonisation was minimal along the south-western slope, while at B1 there were scattered surviving corals in shallow water with some apparent regeneration. On a submerged reef along the south-east side of the reef [B9: Fig.3.1; 3-10m depth], patches of soft coral were interspersed with hard coral, some of which had apparently survived predation and others appeared to be recolonisers. Total hard coral cover at the latter site was categorised as moderate, while at all other sites it was considered sparse. At all sites the proportion of recently killed hard corals was categorised as high (Endean and Stablum, 1973a,b).

Quantitative data on the proportions of living hard coral, recently established coral colonies and soft corals was obtained by Endean and Stablum (1973b) along transects at sites B1, B2, B3 and B9 [Fig.3.1]. Quadrats were placed along the 100m transect lines and photographed, the images of the various benthic components later being excised and weighed to determine the relative cover of each component. Data from transects along the seaward slope on the south-western side of the reef [B2, B3: Fig.3.1] are included in Table 3.1. At site B1, live hard coral cover was estimated as 15.6% and soft coral cover was estimated as 11.6%. At site B9, live hard coral cover was estimated as 18.3% (although this was reduced to 10.1% if one of the quadrats covering an atypically large coral colony was omitted from the analysis) and soft coral cover as 20.8%. At sites B1 and B9, about half of the living hard coral colonies were considered to be recently established (Endean and Stablum, 1973b).

Endean's survey, 1979

Following the second reported A. planci outbreak in 1979, Endean (1982) conducted transect surveys at certain unspecified locations on Green Island reef in December that year. The survey techniques employed were those used by Endean and Stablum (1973a,b). From the surveys, he estimated that approximately 60% of the reef's hard coral cover had been recently killed by the starfish.

Nash and Zell's survey, 1980

Green Island reef was surveyed by Nash and Zell (1981) at some time between March and May 1980. The survey utilised the manta tow method, with observers towed on a manta board for 20 minute periods at a speed of about 1.5 knots, thus covering a distance of 1km or less of reef. Data recorded included the numbers of A. planci present, percentage cover by hard coral, soft coral, macroalgae and dead standing hard coral, substrate type, depth, slope, colony size, coral species diversity and the visually-dominant benthic organisms. The entire margin, some of the reef flat and much of the back reef lagoon was surveyed, although specific locations are not given.

It appears the only data from Green Island to be published is A. planci abundance and percentage dead standing hard coral cover. Manta tow data were standardised for a 500m tow unit, with 24 tow units undertaken at Green Island. Of these, exactly half showed 51 - 100% of colonisable substrate to be occupied by dead standing hard coral, nine showed 16 - 50% occupation and three showed 6 - 15% occupation. None of the tows fell within the lowest occupation category (0 - 5%) and dead coral cover was very high relative to the other reefs in the vicinity which were surveyed over the same period (Nash and Zell, 1981).

Cameron and Endean's survey, 1981

In January 1981, Cameron and Endean (1981) resurveyed Green Island reef, possibly utilising the same technique as Endean's 1979 survey, and estimated that approximately 90% of the reef's hard coral cover had been killed. They noted that destruction of the remainder, including massive corals, was in progress (Cameron and Endean, 1981; Endean, 1982).

Ayling's survey, 1983

As part of a survey of reefs conducted between January and March 1983, Ayling (1983) estimated the overall cover of live hard and soft corals on Green Island reef. Estimated hard coral cover was less than 5%, with soft coral cover between 5% and 10% and coral rubble the dominant feature.

Nash's observations, 1984

Nash (1985) saw little evidence of hard coral regrowth during his 1984 trochus shell survey, which incorporated sites on the south-western reef edge and slope, the reef edge and slope at the southern tip and the slope around the eastern extremity of the reef [Fig.4.1]. He noted that the tabular corals which had once covered a large proportion of the shelf between the boulder zone and drop-off on the south-western reef edge were nearly all dead and covered by an algal turf. Remaining colonies on the shelf were predominantly Pocillopora damicornis and branching Acropora species. He found the south-western slope at about 20m depth to be devoid of living hard and soft corals, with the macroalga Padina the only conspicuous species (Nash, 1985).

A.I.M.S. study, 1985

Colonies of the massive corals Porites and Diploastrea were surveyed at four sites [Fig.4.1] around the perimeter of Green Island reef in April 1985 (Bradbury *et al.*, 1986b). The level of damage to various size classes of the corals caused by the A. planci infestations was assessed and some Porites colonies were cored to establish the date of coral damage. The height difference between the scarred surface and living surface of each colony was measured and there was a high correlation of infestation date with peak level of scarred surface (Bradbury *et al.*, 1986b).

Harriott and Fisk's surveys, 1985

Twenty transect sites were established by Harriott and Fisk (1989) between July and September 1985 to assess the status of the Green Island coral community following the 1979/81 A. planci infestation. The sites [Fig.4.1] were located both on the reef flat (0.5m depth) and on the reef slope (2m - 6m depth). Within each site, four 30m line transects were randomly placed and the intercepts of hard and soft corals recorded.

The 1985 surveys showed high hard coral cover at sites F16 (20% cover) and F15 (28% cover) on the reef flat directly south of the cay [Fig.4.1], where Montipora digitata colonies were dominant and there was no evidence that A. planci predation had occurred (Fisk *et al*,1988). Coral cover on the reef slope at the southern tip of the reef [F8 : Fig.4.1] is given in Table 4.1 - this site being an isolated patch dominated by Pocillopora damicornis and apparently undamaged by A. planci predation (Harriott and Fisk, 1989). Aside from a transect at 3m depth in area F7 [Fig.4.1] which had 11% hard coral cover, the remaining transects all yielded a hard coral cover of less than 10%. Highest soft coral cover (47%) and lowest hard coral cover (1%) were both recorded at F20 [Fig.4.1] at 6m depth. Photographs of some of the sites are included in Harriott and Fisk (1989).

A.I.M.S. survey, 1986

Green Island reef was surveyed in January 1986 by the Australian Institute of Marine Science as part of a study to assess the distribution and effects of crown-of-thorns starfish on the Great Barrier Reef (Bradbury *et al.*, 1987). The entire reef margin was surveyed using a manta tow technique with observers towed for two minute periods at speeds of 1.5kn. Cover of live and dead coral was recorded as one of six relative percentage categories (Bradbury *et al.*, 1986a).

Two sites - one fore-reef and one back-reef - were surveyed in detail using a line transect technique. Transect lengths of 100m were surveyed with benthic life forms recorded as one of 21 categories. Sampling was carried out along depth contours at 3m and 6m below the reef crest, with additional sampling along a 12m depth contour when possible. These depths were selected as they 'characteristically contain high coral cover and are subject to the most obvious damage and changes associated with Acanthaster outbreaks.'. Locations of the permanent line transect sites were noted on aerial photographs and pickets were positioned at 6m depth to assist in relocation of the sites (Bradbury *et al.*, 1986a).

Although no A. planci were found during the manta tow survey, the effects of previous outbreaks were apparent. Small live colonies of branching and tabulate Acropora were noticeable along the north-western and south-western slopes, but live coral cover over the reef as a whole was low (less than 10%). Dead coral cover was generally moderate to high (10-50%), rising to 50-75% in the south-west, and consisted 'mainly of dense patches of branching and massive Porites' (Bradbury *et al.*, 1987). Concern was expressed by an assessor of Baxter (1987) over the accuracy of this statement - comment was made that dead branching Porites is very difficult to distinguish from dead branching Acropora, and that live branching Porites is rare at Green Island and may have been confused with the more common Heliopora. It appears the statement should read 'branching Acropora and massive Porites'

Confusion also arises when the locations of the detailed transect sites are considered. A figure depicting the locations shows the 'front' site to be on the north-eastern reef slope [A: Fig.4.1], with the 'back' site on the south-western reef slope in the vicinity of Pearson's site P2 [Fig.4.1]. These locations correspond well with the site descriptions given in the text - the 'front' site in 'a relatively broken and undulating area, consisting of patch reefs rising from a gently shelving substrate' with the 'back' site 'more steeply sloping'. However, it is inconsistent with other literature on Green Island reef to refer to the generally more exposed south-western slope as the 'back reef'. It appears also that the 'tow numbers' have been reversed. If it is assumed that the 'front' and 'back' sites have been reversed in the report, then the detailed surveys were carried out at three depths on the south-western slope and at two depths on the north-eastern slope.

Live hard coral cover was low (13% at 3m; 14% at 6m) at the north-eastern reef slope site, being mainly remnant massive Porites and foliose corals. There was no evidence of recent A. planci predation, with all the dead coral colonies covered with algae. Dead coral cover was moderate (16% - 3m; 18% - 6m), algal cover was about 17% (3m) and 11% (6m) and from the data the dominant organisms were soft corals (34% - 3m; 21% - 6m) - not 'sponges' as the text suggests.

At the south-western reef slope site (see Table 4.1 for data), hard coral cover was lower and dead coral cover higher than at the other site. Soft corals were common only at 3m, while algae were dominant at all depths (30% - 3m; 32% - 6m; 51% - 12m) (Bradbury *et al.*, 1987).

Harriott and Fisk's surveys, 1986

Following the passage of Cyclone Winifred in February 1986, Harriott and Fisk (1986) resurveyed six of their transect sites [F1, F3, F5, F6, F7, F13: Fig.4.1] to assess its effect on coral cover. Hard coral cover was significantly reduced at only one site - the shallow (2m depth) coral transplant site at F5 [Fig.4.1] - and there was no significant change in soft coral cover at any site. The minor effect of the cyclone on the coral community may have been partly due to the reef's early stage of recovery from A. planci infestation, with small colonies contributing most of the live cover (Harriott and Fisk, 1986).

Harriott and Fisk (1989) resurveyed twelve of the 1985 transect sites [F1 - F12: Fig.4.1], in August/September 1986. There was no significant difference in hard coral cover between the surveys at any of the sites, while soft coral cover increased at one site [F8: Fig.4.1] and decreased at another [F10: Fig.4.1].

A.I.M.S. surveys, 1987

Australian Institute of Marine Science personnel surveyed Green Island reef in February 1987 (Bass *et al.*, 1988) utilising a manta tow technique, with observers towed for two minute periods at speeds of about 1.5 knots. A total of 51 tows were used to survey the reef margin, with deviations through the patch reefs to the north-west of the cay and at the southern edge of the eastern reef tip. Coverage of live and dead hard coral was categorised for each of the tows, with a median cover of both live and dead coral of 1-10% over the 51 tows. Highest cover of live hard coral (11-30% category) was recorded during one tow along the reef edge to the north of the cay and three tows around the eastern tip of the reef. Cover of dead hard coral was highest (31-50% category) in an area on the reef edge to the north of the cay, areas on the north-eastern and south-western reef edges and on the reef edge due west of the cay (Bass *et al.*, 1988).

A benthic line transect survey was also conducted, presumably at the north-eastern reef slope site [A: Fig.4.1] surveyed by Bradbury *et al.* (1987) as data was not collected at 12m depth. Three 100m transects were laid along the 3m and 6m contours and the benthos classified according to the 21 categories given in Bradbury *et al.* (1986). At 3m depth, total live hard coral cover was almost 5%, dead hard coral cover almost 6% and algal cover about 40%. Dead hard coral cover was similar at 6m, but live hard coral cover (almost 3%) and algal cover (about 29%) were lower (Bass *et al.*, 1988).

The reef was re-surveyed in June 1987 utilising the manta tow technique, but without the benthic line transect survey. A total of 62 tows were used to survey the reef perimeter, with the exception of the eastern tip, and the scope of observations was expanded to include estimates of soft coral and sand/rubble cover on each tow. Median categories over the 62 tows were determined, with both live and dead hard coral cover included in the 1-10% cover category, and soft coral and sand/rubble categorised as 11-30% cover. Highest live hard coral cover (31-50% category) was observed at the southern tip of the reef. Cover of dead hard coral was highest (11-30% cover) in areas along the reef edge to the north of the cay, the reef flat at the eastern tip and along the slope at the southern tip of the reef. Soft coral cover was highest (31-50% category) in areas along the northern reef edge and on the reef flat at the eastern tip of the reef (Bass *et al.*, 1989a).

Endean *et al*'s survey, 1987

Massive coral colonies within an unspecified region of Green Island reef were surveyed in February 1987 by Endean *et al.* (1988). Nine belt transects, each 30m long (along slope) and 10m wide (downslope) were located at random within the region and each massive coral colony present was measured at its maximum diameter. Each colony was also assigned to a 'damage' class: intact - 1/3 dead; 1/3 - 2/3 dead; >2/3 dead or recently killed.

From analyses of size distributions, it was concluded that recruitment of massive corals at Green Island was very low. Further, more than 50% of Porites colonies larger than 20cm diameter, and 2/3 of other massive colonies in the 21 - 50cm size class, fell in the highest damage category (Endean *et al.*, 1988).

Harriott & Fisk's surveys, 1987

The twelve sites surveyed in August/September 1986 were resurveyed in November 1987, with eight additional sites across the eastern bommie field also surveyed. Fisk *et al.* (1988) give the coral cover estimates from this survey and describe the coral community as predominantly large numbers of small (<20cm mean diameter) colonies with significant contributions from colonies regenerating following partial mortality. The dominant genus in the community was Acropora, as it was following the first outbreak, and most regeneration was from the tips of branching staghorn colonies. Small patches of tissue on massive colonies also made a significant contribution (Fisk *et al.*, 1988).

McCormick and Choat's surveys, 1988-89

In conjunction with surveys of fish abundance in May 1988 and April 1989, McCormick and Choat (1989) quantified the sessile organisms and substrata on the tops of bommies both within and outside the Green Island seagrass beds [Fig.3.1]. One 20m and two 10m line intercept transects were sampled on each of five bommies at each site, with the organisms placed into broad life-form categories. Soft corals and macroalgae were found to be the dominant components, although specific data is unpublished at present.

A.I.M.S. survey, 1989

Green Island reef was surveyed by the Australian Institute of Marine Science in February 1989 (Bass *et al*, 1989b). A manta tow technique was utilised with observers, towed for two minute periods at speeds of about 1.5kn, categorising cover of live and dead hard coral, soft coral and sand/rubble. A total of 48 tows were used to survey a clockwise path through the seagrass beds and across the sanded reef flat at a distance of about 150m from the cay until adjacent to the eastern tip of the cay; then around the reef perimeter and back across the reef flat to the south-west of the cay.

Median categories over the 48 tows were 1-10% cover for live and dead hard coral, 11-30% for soft coral cover and 51-75% for sand/rubble cover. Highest live hard coral cover (31-50% category) was observed at the southern tip of the reef. Cover of dead hard coral was highest (11-30% cover) at the eastern tip of the reef and within areas along the south-western reef edge. Soft coral cover was highest (31-50% category) in the first tow (apparently within the seagrass beds to the north-west of the cay) and at the southern tip of the reef (Bass *et al.*, 1989b).

Harriott & Fisk's surveys, 1989

The sites surveyed in November 1987 were resurveyed again in October/November 1989, although data is unpublished at present (Fisk, 1990a). In conjunction with a survey in November 1989 on the distribution of juvenile crown-of-thorns starfish at Green Island reef, Fisk (1990b) obtained estimates of hard coral cover, soft coral cover and proportion of rubble at 10 stations [F1 - F10: Fig.3.1]. These estimates, obtained using line intercept transects of 20m length, are also unpublished.

HARD CORAL TRANSPLANTS

Tibbs' transplants, 1984

In 1984, about 200 colonies of hard coral were transplanted by Mr. P. Tibbs (operator of the Green Island dive shop) from Arlington Reef to an area adjacent to the north side of the Green Island jetty. A 4m x 4m site within the transplant zone was mapped and photographed before and after the transplanting exercise. While the hard coral cover increased by only 1.3% (from 5% to 6.3%) the area was visibly different due to the presence of branching corals, which had been rare prior to the transplant operation (Harriott, 1984).

Harriott and Fisk's studies, 1985-86

In May 1985 Harriott and Fisk (in press) transplanted hard corals from Arlington and Middle Cay Reefs to a site at the north-western extremity of the reef [F5: Fig.4.1]. Both whole colonies (genera Favia, Favites, Leptastrea, Platygyra and Porites) and fragments (staghorn Acropora, plate Acropora, branching Porites, Pocillopora damicornis, Seriatopora hystrix and Stylophora pistillata) were transplanted into 2m square quadrats. Three quadrats were mapped about ten days after transplantation and 28 were mapped in July 1985. All 40 quadrats were remapped in October 1985 and surviving coral cover calculated. The experiment was terminated by the passage of Cyclone Winifred in February 1986, during which virtually all transplants were removed.

A number of further studies relating to aspects of coral transplantation to enhance rehabilitation of damaged coral reef communities were conducted by Harriott and Fisk (in press) utilising corals from Middle Cay Reef. At some time in 1985, and again between February and September 1986, the survival rates were tested of different sizes of Acropora fragments transplanted to site F5 [Fig.4.1].

An experiment was conducted over a two month period from September 1985, and again for a seven month period from February 1986, to examine differences in survival rates of branched and unbranched Acropora fragments transplanted to both fore-reef and back-reef sites on Green Island reef (specific site locations not given). Survival of fragments was higher at the back-reef than the fore-reef site during the first period, while there was no clear relationship between location and survival during the second period.

In February, May and July 1986, transplants were established at site F5 (with the May transplants in slightly deeper water) to examine the effect on survival rates of staghorn Acropora branches of varying degrees of aerial exposure during transportation. Similarly, transplanted fragments of Pocillopora damicornis were established in February (along with massive faviid colonies) and July 1986 at site F5 [Fig.4.1] following varying degrees of aerial exposure. These transplants were monitored at one or two month intervals until September 1986.

Harriott and Fisk (in press) concluded the most practical way to accelerate regrowth was by the transplantation of large (>30cm diameter) coral pieces. The use of pieces of large, branched staghorn Acropora was recommended, with pocilloporid and faviid corals also suitable. Branching poritid coral was considered unsuitable for aesthetic reasons.

HARD CORAL RECRUITMENT

Harriott and Fisk (1988) commenced a coral recruitment study in May 1985 utilising cut coral blocks as settlement plates. Plates were located at 3 - 5m depth at one fore-reef and one back-reef site at Green Island reef and at nearby Michaelmas and Upolo Reefs. At each site two wire racks were positioned 20 - 40m apart, each rack supporting eight plates which were inspected at six-monthly intervals. Plates were bleached and inspected using a dissecting microscope, with coral spat identified to family level.

Following collection and replacement of the plates in October 1985 and March and September 1986, there was evidence for a summer dominance of Acroporid recruits subsequent to the mass coral spawning period, and a winter dominance of Pocilloporid recruits. More unexpected, in the light of the reef's relatively depauperate coral fauna, was the higher recruitment at Green Island reef than at Michaelmas or Upolo Reefs, suggesting Green Island reef was not totally self-seeding and coral planulae were transported between reefs in the interval between spawning and settlement (Harriott and Fisk, 1988). In addition, spawn from Michaelmas and Upolo Reefs may have been transported away more effectively or thoroughly than spawn from Green Island reef (reviewer's comment, draft of this review).

In October 1986 the number of sites was increased to four fore-reef [R5 - R8: Fig.4.2] and four back-reef [R1 - R4: Fig.4.2] sites, with 15cm square ceramic tiles used in place of the cut coral blocks (Fisk, 1987a). At two fore-reef [R6, R8: Fig.4.2] and two back-reef [R1, R3: Fig.4.2] sites, racks were also deployed at 6m depth to determine whether coral spat settlement was depth-related (Fisk, 1990a).

Settlement plates were recovered in November 1987 and a replacement set deployed. A winter dominance of Pocilloporid recruits was again observed, with Pocilloporid spat abundances at Green Island reef about 30% of those at Upolo and Michaelmas reefs (Fisk, 1988). For the summer period, spat abundance was again higher at Green Island reef than the other two reefs, with a dominance of Acroporid recruits (Fisk, pers. comm.). Settlement plates were deployed in October 1989 and retrieved in March/April 1990 and are currently under analysis (Fisk, 1990a).

JUVENILE HARD CORALS

In November 1985, Harriott and Fisk (1989) marked-out natural substrata at sites R1, R3, R6 and R8 [Fig.4.2] to study the population dynamics of juvenile hard coral colonies (defined as colonies with mean diameters of less than 20cm). Five replicates of two substrate types - dead standing Acropora spp. plates (0.23 - 1.0m^2) and smoother limestone substrata (e.g. consolidated substrata and dead massive Porites colonies, 1.0m^2) - were studied at two depths (3m and 6m) at each site.

Juvenile coral colonies on the substrata were mapped, identified to genus level and their dimensions measured. Their presence or absence was noted in May 1986 and colonies were re-mapped and measured in September 1986.

Juvenile coral colonies were more abundant and recruitment was higher at the back-reef site, while growth rates were consistently higher at the fore-reef site. Acropora species were the most dominant and successful recruits, with greatest abundances, recruitment rates and growth rates (Harriott and Fisk, 1989).

Colonies were remapped and measured on an annual basis - in November 1987 (Fisk, 1988), November 1988 (Fisk, pers. comm.) and November 1989, with this data added to an established database (Fisk, 1990a).

CORAL SPECIES

Appendix 3 lists the coral genera and species appearing in the published literature on Green Island reef. Cornelius (1982) includes species lists of both hard and soft corals in the Cairns region from surveys conducted by members of the Queensland Fisheries Service (now the Fisheries Branch of the Queensland Department of Primary Industries) and the Queensland National Parks and Wildlife Service. While he considers the list to be directly applicable to Green Island reef he does not denote the species actually recorded there, so these lists have not been included in Appendix 3.

The soft coral species list compiled by R. Garrett (Queensland Fisheries Service) for the Cairns region, which is included in Cornelius (1982), shows high soft coral diversity - 6 orders, 22 families, 47 genera and 114 species recorded, 16 of which were new to science when listed. However, this list applies to the entire Cairns region and not specifically to Green Island reef as suggested by the Green Island Management Committee (1980) and the Australian Littoral Society (1982, 1990).

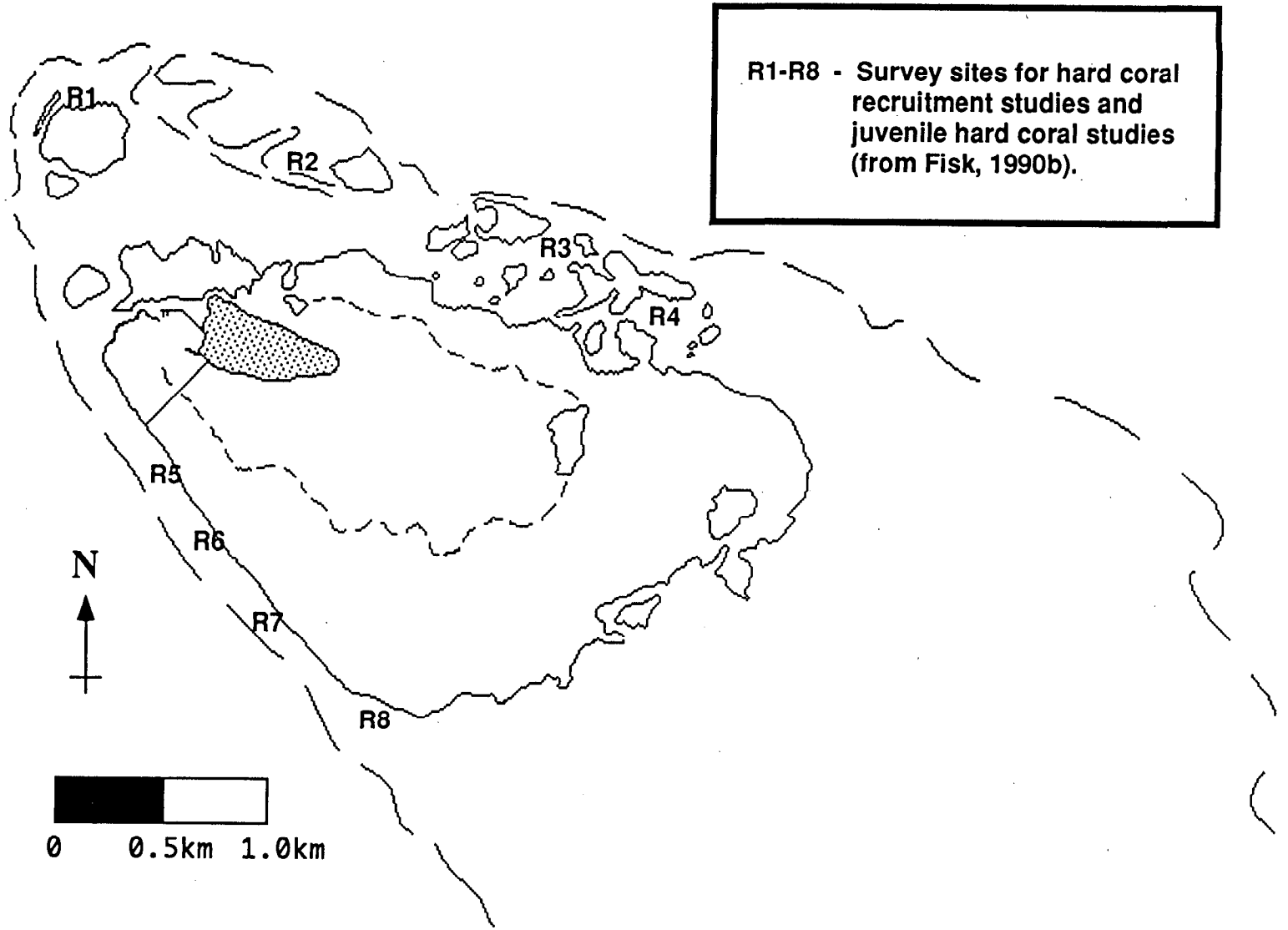

Figure 4.2 Location of juvenile hard coral population dynamics study sites