RESULTS

CROWN OF THORNS

Mean *Acanthaster planci* density for each survey is recorded in table 2, along with data on the cover of coral and other encrusting organisms where this is available. Patterns through time are illustrated in figure 2. Raw data from the *Acanthaster* counts are included in the appendix.

TABLE 2. SUMMARY OF *ACANTHASTER* DENSITY: 1983-1989

Acanthaster density measured with ten 50 x 20m transect counts (five counts in 1983); estimates of the abundance of the major groups of encrusting organisms are also shown.

Reef	Date	*Acanthaster* density (no./ha)		Hard Coral	Dead Hard Coral	Soft Coral	Sponges
		mean	sd	(mean percentage cover)			
BACK REEF SLOPE							
John Brewer	May 83	12	18	30-50		5-15	
	Feb 84	192	155	15-30		5-15	
	Nov 84	7	7	6.8	23.9	2.0	<5
	May 86	6	7				
	June 89	0	0				
Lodestone	May 83	260	121	15-30		5-15	
	Nov 84	3	7	2.0	36.1	0.2	<5
	May 86	0	0				
	June 89	0	0				
Davies	Nov 84	1	3	27.7	<5	4.8	<5
	May 86	0	0				
	June 89	34	19				
FRONT REEF SLOPE							
John Brewer	Nov 84	18	11	5.6	28.3	0.5	<5
	May 86	1	3				
	June 89	0	0				
Lodestone	May 86	2	4				
	June 89	0	0				
Davies	Nov 84	5	13	46.1	<5	3.5	<5
	May 86	3	7				
	June 89	64	45				

The patterns of the *Acanthaster* infestation on John Brewer and Lodestone were similar, although the peak on Lodestone occurred about 8 months before that on John Brewer. In September 1982 no *Acanthaster* were evident on either reef. By May 1983 Lodestone was at the peak of an outbreak with densities of 260 per ha recorded on the back reef slope while a similar peak of almost 200 per ha occurred on John Brewer early in 1984. Small numbers remained on these reefs for the next few years. Similar outbreaks were apparently

experienced on the front reef slope of these reefs (personal observations), although counts were not made in this habitat during the peak of density on either reef.

Davies Reef showed a completely different pattern of *Acanthaster* abundance. In November 1984 there were a few scattered *Acanthaster* on the front reef slope in depths of more than 20m - the five individuals recorded in this series of counts were all at the deep end of the transects and others were seen on the deeper slope outside the transect area. This deep water population remained stable for the next few years (in 1986 the *Acanthaster* encountered were also toward the deep end of the transects), but moderately high numbers appeared in shallower water on both front and back reef in early 1989 and by June 1989 considerable damage to coral communities had occurred throughout Davies Reef.

Before these *Acanthaster* outbreaks all three reefs had a rich coral cover of between 30-50%, primarily fast growing acroporids. This was reduced to less than 5% within 12 months of the peak of the outbreaks on John Brewer and Lodestone Reefs. By June 1989, 6 years after the peak of infestation, there was considerable growth of new coral on the front reef of Lodestone and to a lesser extent on John Brewer (personal observations).

CORAL TROUT

TABLE 3. SUMMARY OF CORAL TROUT DATA: 1983-1989

Figures show mean and standard deviation from ten replicate 50 x 20m transect counts.

Reef and Habitat	Date	*P.leopardus* mean	sd	*P.laevis* mean	sd
BACK REEF SLOPE					
John Brewer	May 83	4.4	1.8	0.2	0.4
	Feb 84	4.0	1.8	0.1	0.3
	Nov 84	3.2	1.7	0.1	0.3
	May 86	4.6	1.6	0.1	0.3
	June 89	3.5	1.1	0.1	0.3
Lodestone	May 83	2.4	1.5	0.2	0.4
	Nov 84	2.8	1.1	0.2	0.6
	May 86	3.5	1.6	0.2	0.4
	June 89	2.7	1.3	0.1	0.3
Davies	Nov 84	5.3	2.5	0.2	0.6
	May 86	6.3	3.2	0.1	0.3
	June 89	5.0	2.1	0.3	0.5
FRONT REEF SLOPE					
John Brewer	Nov 84	0.8	0.9	0.1	0.3
	May 86	3.9	1.5	0.2	0.4
	June 89	3.3	1.5	0.1	0.3
Lodestone	May 86	2.3	1.3	0.2	0.6
	June 89	2.6	1.0	-	-
Davies	Nov 84	2.7	1.4	0.3	0.9
	May 86	5.0	2.1	0.2	0.4
	June 89	3.5	1.2	0.3	0.5

A summary of coral trout density from all the surveys is shown in table 3, and the trends through time in the density of *P. leopardus* are graphed in figure 3 with 95% confidence intervals. Raw data from the June 1989 series of counts are tabulated in appendix 1. The results of the analyses of variance to test for differences among reefs, habitats and times are shown in table 4. Coral trout density on these three reefs shows a number of general patterns.

Within each reef there are more coral trout on the back reef than on the front reef, a pattern consistent on all reefs at all survey periods. However, there appeared to be a seasonal difference in this pattern: in the November survey trout numbers on the front reef were only 40% of those on the back (a significant difference), whereas in both mid-year surveys the difference was not as pronounced, with the front reef supporting an average of 80% of the back reef numbers (not significant - see table 4). Over all surveys *P. leopardus* density on the front reef was 76% of that on the back reef.

The three reefs supported consistent and significantly different numbers of coral trout (see figure 3, table 4). Lodestone had the lowest numbers, with a grand mean over all habitats and times of 27 trout per ha, followed by John Brewer (grand mean 35), with Davies the highest, having a grand mean of 46 trout per ha.

TABLE 4. ANALYSIS OF VARIANCE RESULTS FOR CORAL TROUT

A. Anova table for all three reefs, back and front reef habitats, 1986-1989 surveys.

Source of Variation	SS	df	MS	F ratio	p	Significance
Reef (R)	6.114	2	3.057	19.976	0.0477	*
Habitat (H)	1.242	1	1.242	14.508	0.1634	NS
Time (T)	1.067	1	1.067	5.881	0.0170	*
RxH	0.148	2	0.074	0.552	0.6442	NS
RxT	0.306	2	0.153	0.843	0.4331	NS
HxT	0.086	1	0.086	0.472	0.4936	NS
RxHxT	0.268	2	0.134	0.740	0.4798	NS
Residual	19.597	108	0.181			
Total	28.829	119				

B. Avova table for all three reefs, 1984-1986-1989 surveys, back reef habitat only.

Source of Variation	SS	df	MS	F ratio	p	Significance
Reef (R)	101.267	2	50.663	108.500	0.0003	***
Time (T)	22.067	2	11.033	2.951	0.0580	NS
RxT	1.867	4	0.467	0.125	0.9731	NS
Residual	302.900	81	3.740			
Total	428.100	89				

In general the changes in density over the 6 year span of these surveys were not significant for any one reef (see figure 3), with the exception of the possibly seasonal low on the November 1984 front reef surveys. In most cases the direction and extent of the small changes that were recorded were consistent over all three reefs. For example density increased at all sites between November 1984 and May 1986, and decreased at all sites except Lodestone front reef between May 1986 and June 1989. This decrease was from a

grand mean for all habitats on all reefs of 43 to a grand mean of 34 trout per ha, a 21% reduction in density, and was significant in the overall analysis (see table 4). There were no changes in density that could be related to the status of crown of thorns populations on the reefs, or to the state of the coral communities.

The TL of all *P. leopardus* counted was estimated during these surveys, and this information is summarised in Table 5. Mean length of all individuals from the 10 counts in each site is shown, along with the number of fish in the 0+ age class (this is only possible for the mid-year counts; by November the 0+ age class is not easily separable from the remainder of the population). Also listed is the number of individuals smaller than the 35cm minimum retainable size for fishermen, the number accessible to the fishery (>35cm), and the mean size of this available sub-population. The largest fish recorded in each group of counts is also shown in this table and the total number of fish larger than 50cm TL. Length frequency distributions for each group of counts are shown in figures 4 and 5.

TABLE 5. LENGTH STRUCTURE OF CORAL TROUT POPULATIONS

Numbers are total number from each group of 10 counts, ie number per ha. All lengths are total lengths (TL) in cm. Note: na = not applicable.

Reef	Date	Mean TL	No. 0+ Fish	No. < 35cm	No. > 35cm	Mean TL > 35cm	No. > 50cm	Max. TL
BACK REEF SLOPE								
John Brewer	May 83	28.9	19	27	17	42.6	2	53
	Feb 84	29.0	na	29	11	42.8	1	54
	Nov 84	34.6	na	13	19	40.7	1	52
	May 86	29.3	15	28	18	41.6	1	53
	June 89	32.3	13	16	19	40.0	0	48
Lodestone	May 83	34.8	8	10	14	43.9	3	58
	Nov 84	36.4	na	15	13	45.6	3	62
	May 86	33.7	7	19	16	42.6	2	62
	June 89	32.5	8	14	13	39.1	0	46
Davies	Nov 84	35.9	na	28	25	43.0	2	55
	May 86	34.4	7	31	32	41.3	2	53
	June 89	31.7	12	32	18	40.3	0	48
FRONT REEF SLOPE								
John Brewer	Nov 84	32.5	na	4	4	41.0	0	46
	May 86	33.7	6	20	19	41.7	1	52
	June 89	33.5	8	17	16	42.7	1	54
Lodestone	May 86	33.3	2	14	9	43.4	1	52
	June 89	32.7	8	15	11	40.5	1	55
Davies	Nov 84	34.7	na	19	8	41.5	1	54
	May 86	36.2	4	28	22	45.7	6	61
	June 89	33.2	4	20	15	39.7	0	46

There are a number of features of the length structure of coral trout on the three reefs that are of interest. Mean TL of the fish recorded in each series of counts ranged from 28.9 to 36.4 cm. Mean length was lower in the mid-year counts when there were numbers of small 0+

year class fish in the counts. The majority of these recruits initially settle from the plankton in December/January (personal observations) and were a mean TL of 14.9 cm (range from 9-20 cm) on these reefs by mid-May when the mid-year counts were made. Mean length was lowest on the John Brewer back reef slope where there were consistently more 0+ age class fish than in the other sites. With one exception there was a reduction in mean length between May 1986 and June 1989, corresponding with the overall reduction in density over the same period. This reduction was most marked on Davies Reef were there was a decrease in mean TL from 35.2 to 32.3 between 1986 and 1989.

As was mentioned above it was possible to distinguish the 0+ age class from the rest of the population in the mid-year counts. This can be confirmed by examining the length frequency graphs in appendix 1 (page 53) for surveys in February, May and November from John Brewer Reef. The growth of the 0+ age class through the year can be clearly seen. The number of 0+ fish in each series of mid-year counts is shown in Table 5. In general there were more recruits on the back reef (grand mean of 11 per ha) than on the front reef (5.3 per ha). There were consistently more recruits on John Brewer, especially on the back reef, than on the other two reefs: a mean of 16 per ha on the back reef, almost double the mean of 8.4 per ha on the other back reef sites.

In many of the sites the number of fish available to fishermen (>35cm TL) was remarkably consistent through time (with the exception of the November 1984 front reef sites where overall numbers were very low). However, on Davies Reef the number of fish in this accessible population underwent a 32% increase between November 1984 and May 1986 (back reef site only), followed by an almost 40% reduction between May 1986 and June 1989, from a mean of 27 per ha to 16.5 per ha.

In general there were very few large coral trout on these reefs; only 4% of the fish recorded in 20 series of counts were over 50cm TL. Maximum length recorded in each set of counts ranged from 46-62 cm.

CHAETODONTIDS

The combined abundance of all chaetodontid species is shown in table 6, along with the total number of hard coral feeding chaetodontids and the total number of chaetodontid species encountered in each group of counts. Time trends are graphed in figure 6, and raw data from all counts are tabulated in the appendix.

The abundance of chaetodontid fishes reflected the state of the coral community on each reef. On John Brewer and Lodestone total numbers were generally around 50-100 per ha between November 1984 to June 1989, with the mean density of hard coral feeding chaetodontids around 50 per ha. Hard coral cover was approximately 5% or less during this period; unfortunately counts of chaetodontids were not made in the May 1983 surveys before *Acanthaster* had devastated corals on these two reefs. There was a slight increase in the density of hard coral feeders on the front of Lodestone Reef between May 1986 and June 1989 that was possibly related to the noticeable recovery of plate and clumping acroporids at this site over that period (personal observations).

On Davies Reef chaetodontid density was much higher, between 200 and 400 per ha, due to the good cover of live hard coral that was maintained throughout the survey period. There was an increase between 1984 and 1986, in both front and back reef sites. The substantial decrease between 1986 and 1989 was possibly related to the reduction in hard coral cover caused by the active outbreak of *Acanthaster* present on the reef in 1989.

TABLE 6. SUMMARY OF CHAETODONTID DENSITY DATA: 1984-1989

Figures show mean and standard deviation from five replicate 50 x 20m transect counts.

Reef and Habitat	Date	Total Chaetodontids mean	sd	Hard Coral Feeders mean	sd	No. Species
BACK REEF SLOPE						
John Brewer	Nov 84	12.6	3.4	9.0	3.7	10
	May 86	10.6	1.5	6.4	2.2	9
	June 89	8.0	1.2	3.4	1.1	9
Lodestone	Nov 84	9.2	2.8	5.6	1.5	9
	May 86	8.8	3.1	4.8	3.3	8
	June 89	7.4	2.7	4.8	2.2	8
Davies	Nov 84	19.6	3.6	16.2	3.5	10
	May 86	37.0	11.6	33.2	10.6	13
	June 89	21.8	6.1	18.0	6.4	9
FRONT REEF SLOPE						
John Brewer	Nov 84	7.0	3.1	4.2	2.4	10
	May 86	8.8	3.3	4.8	2.2	10
	June 89	6.6	3.4	3.6	2.5	9
Lodestone	May 86	5.0	1.2	1.8	1.6	6
	June 89	8.4	2.3	5.0	1.9	9
Davies	Nov 84	32.0	2.8	28.2	2.4	11
	May 86	43.2	8.0	38.4	8.3	14
	June 89	25.4	5.7	21.0	2.0	13

LETHRINIDS AND LUTJANIDS

A summary of the density of all species of lethrinids and lutjanids recorded in the 1989 series of counts is shown in table 7, with the raw data listed in the appendix.

At the sampling scale used in these surveys lethrinids and lutjanids showed a high level of variance. Only 2 species were recorded in all 6 sites, and almost without exception the standard deviation was greater than the mean. No meaningful patterns in abundance can be detected using these data. Although there were nominally greater densities of both families on Davies Reef this was due to large numbers of 5 species being encountered associated with a stand of high staghorn acroporids in a single back reef count.

TABLE 7. DENSITY OF LETHRINIDS AND LUTJANIDS: JUNE 1989

Figures record mean and standard deviation from ten 50 x 20m transect counts.

Species	John Brewer mean	sd	Lodestone mean	sd	Davies mean	sd
BACK REEF SLOPE						
Lethrinus chrysostomus	0.6	1.1	0.9	1.0	0.8	1.0
Lethrinus mahsena	-	-	-	-	-	-
Lethrinus nebulosus	-	-	0.3	0.9	1.6	2.5
Lethrinus ramak	-	-	-	-	1.9	6.0
Lethrinus variegatus	-	-	0.2	0.6	-	-
Monotaxis grandoculis	2.0	2.2	0.1	0.3	-	-
Total Lethrinids	2.6	3.0	1.5	1.3	4.3	6.3
Lutjanus bohar	0.1	0.3	-	-	0.1	0.3
Lutjanus carponotatus	1.4	1.3	0.5	0.7	0.6	0.8
Lutjanus fulviflamma	-	-	-	-	2.1	5.0
Lutjanus quinquelineatus	1.5	2.2	2.9	8.1	1.1	1.7
Lutjanus russelli	-	-	0.3	0.7	1.1	2.8
Lutjanus sebae	-	-	-	-	0.6	1.3
Total Lutjanids	3.0	3.6	3.7	9.0	5.6	9.3
FRONT REEF SLOPE						
Lethrinus chrysostomus	1.3	1.3	0.5	0.7	0.5	1.0
Lethrinus mahsena	0.1	0.3	-	-	0.3	0.7
Lethrinus nebulosus	-	-	0.5	1.1	-	-
Lethrinus ramak	0.3	0.7	0.2	0.4	-	-
Lethrinus variegatus	-	-	-	-	-	-
Monotaxis grandoculis	2.2	3.3	0.4	0.7	0.7	0.8
Total Lethrinids	3.9	2.8	1.6	1.2	1.5	1.2
Lutjanus bohar	-	-	-	-	-	-
Lutjanus carponotatus	0.6	1.1	0.4	0.8	0.1	0.3
Lutjanus fulviflamma	0.2	0.6	-	-	2.3	5.0
Lutjanus quinquelineatus	0.5	0.8	-	-	0.1	0.3
Lutjanus russelli	-	-	0.4	0.7	-	-
Lutjanus sebae	-	-	-	-	-	-
Total Lutjanids	1.3	1.6	0.8	1.3	2.5	4.9