DISCUSSION

CROWN OF THORNS

There were marked differences in the pattern of crown of thorns infestation on the three reefs. On John Brewer and Lodestone crown of thorns appeared on the reef in very high numbers (over 250 per ha) in 1983 and the populations rapidly declined over the next 12 months after coral communities had been devastated. It is possible that the populations on these two reefs, and those detected on other Central Section and southern Cairns Section reefs at this time (see Ayling and Ayling; 1985) resulted from a single recruitment episode of larvae derived from aggreagations on reefs off Cairns such as Green Island in 1979/80.

On Davies Reef at this time small numbers of crown of thorns were present in deep water, probably a less successful result of the same recruitment episode. Adult individuals remained at this low density until 1989 when moderate numbers (34-64 per ha) were recorded around much of the reef. It seems possible that while Davies Reef missed receiving large numbers of crown of thorns recruits when other reefs in this area were infected, subsequent spawnings from these adjacent infected reefs in the 1983-85 period resulted in at least one moderately successful recruitment episode onto Davies Reef. As the population numbers are lower it appears to be taking longer to completely devastate Davies than either John Brewer or Lodestone.

These data suggest that the use of replicate visual transect counts of crown of thorns at a few selected sites on a reef give a good indication of the pattern and severity of any outbreak, as well as enabling the detection of low density populations such as that present in deep water on the front reef slope of Davies Reef between 1984 and 1989.

CORAL TROUT

There were consistently less common coral trout (*Plectropomus leopardus*) on the front reef than on the back reef, a pattern that has also been detected on all other GBR reefs where front and back sites have been surveyed (Ayling and Ayling, 1986b). The reason for this difference is not clear, although it may have some relationship to the water mass characteristics of the two habitats. The front reef is usually bathed in clear water with 20-30m visibility, whereas the back reef is almost invariably more silty and turbid with 10-20m visibility. In this respect the front reef habitat is similar to outer shelf reef areas where *P. leopardus* is significantly less abundant than on mid-shelf reefs (Ayling and Ayling; 1985,1986a).

The consistent differences in coral trout density between the three reefs may have several explanations. These density differences may reflect consistent patterns of fishing pressure on the reefs with the highest fishing level on Lodestone and the lowest on Davies. Another explanation may be that the reefs receive consistently different numbers of larvae, but the limited data on 0+ numbers on these reefs tends to discredit this: John Brewer apparently received consistently more recruits than the other two reefs but did not have the highest overall density. On the other hand it is possible that the differences result from features of each reef that lead to consistent differences in the normal carrying capacity for coral trout, with Davies having the highest carrying capacity and Lodestone the lowest.

We find it strange that the changes in *P. leopardus* density over a period of six years should be so small in spite of the high turnover in the populations and the fishing pressure experienced on all three reefs. As suggested above it is possible that each reef has a normal carrying capacity for populations of reef dwelling piscivores (coral trout are the most important of these piscivores: see Ayling; 1982), and that while a successful recruitment episode may increase numbers temporarily, density dependent mortality quickly reduces

numbers to around this postulated normal carrying capacity. Conversely, although fishing pressure may reduce mean size it does not necessarily cause a significant reduction in overall density because of suggested enhanced survival of juvenile fish when large adults are removed (Ayling and Ayling; 1986a). Hence although fluctuations occur due to good recruitment episodes and fishing mortality these are damped out by other factors.

In the mid-year counts it was possible to separate the 0+ size class from the remainder of the population. The number of recruits detected at each site was consistent over all three mid-year count series, and differences between habitats and between reefs were similar for all groups of counts. The John Brewer back reef site supported twice as many recruits as any other site, and back reef sites on all reefs supported more recruits than front reef sites. It seems likely that, as suggested above for overall coral trout density, the number of successful recruits supported by any site is more dependent on the physical and biological features of the site itself than on outside factors such as the number of larvae available.

As has been mentioned fishing pressure can cause a significant reduction in mean length of coral trout populations (Ayling and Ayling; 1986a). With the exception of John Brewer back reef where large numbers of recruits affected mean length, there was a reduction in mean length on all reefs between 1986 and 1989. This was especially pronounced on Davies Reef, where there was also a marked reduction in the number of fish in the population accessible to fishermen (>35cm TL) over the same period. During the survey on Davies, and during subsequent surveys in August and September 1989 several commercial line fishing boats were seen on this reef. Conversations with the fishermen showed that they had been fishing Davies and other reefs in this region more intensively over 1989 than in previous years. It seems probable that this has resulted in the large reduction in mean length and the density of fish over 35cm TL on Davies Reef between 1986 and 1989.

CHAETODONTIDS

Not surprisingly for a group of fishes that are predominantly obligate hard coral feeders the density of chaetodontids on GBR reefs is strongly positively correlated with hard coral cover (Ayling and Ayling; 1985,1986a; see graphs in appendix 1, page 54). Over all series of counts in which chaetodontids were recorded during this study there were an average of over 5x as many hard coral feeding chaetodontids on the relatively undamaged Davies Reef (258 per ha) compared with John Brewer and Lodestone Reefs (49 per ha). Although there are no pre-devastation counts of this group on John Brewer and Lodestone it is apparent that densities drop very quickly after severe hard coral damage. Densities on John Brewer in November 1984, only 9 months after the peak of the crown of thorns infestation, were 90 per ha, while on Lodestone densities were only 56 per ha 18 months after the peak.

Although there was moderate hard coral damage on Davies in June 1989 caused by the recent crown of thorns outbreak the numbers of hard coral feeding chaetodontids are still about 4x the level on adjacent devastated reefs. However, it seems likely that numbers will drop rapidly over the next 12 months.

LETHRINIDS AND LUTJANIDS

The commercially important species *Lethrinus chrysostomus* (red-throat emperor) was the most abundant lethrinid recorded on these reefs in June 1989 with a grand mean over all reefs and habitats of 7.7 per ha. It is apparent that density data on these groups collected using the same methodology that can be applied successfully to crown of thorns and coral trout can not be used to detect differences or changes with any reliability. Very high levels of variance caused by the clumping behaviour of many of these species combined with the low numbers recorded at this scale of sampling defy standard analytical methods.

However, regular observations along several 800m long sections of reef slope on Davies Reef during recent surveys have suggested that it would be possible to reduce variance in counts of these groups by markedly increasing the size of the count area. A visual search of a previously marked 400-800m length of reef, recording all lethrinids and lutjanids in a 20m wide strip from the reef crest down the slope, could be made by 2 divers using a single scuba tank. Counts along such a large transect (between 1 and 1.6 ha in area) would probably encounter several clumps of each species and reduce variance to manageable levels. Four replicate counts of this size could be searched by two observers in a day.

IMPLICATIONS FOR MANAGEMENT

The time series of strip transect counts of crown of thorns populations reported here have provided a detailed and useful picture of the history and severity of outbreaks on these reefs. If management requires more detailed estimates of the status of *Acanthaster* populations on any reef than the outbreak/non-outbreak level provided by manta tow surveys then strip transect surveys of this type can be used to provide the information.

Using this strip transect method differences in coral trout density between sites or reefs and changes in density through time can be documented. Using a suitably powerful sampling design a measured change in density of 21% was detected as significant. The length estimations that are part of this method also provide valuable data for management. For example, the number of successful recruits in a population can be recorded as well as changes in length structure of coral trout populations that may be caused by factors such as fishing pressure.

The implications for management of the ideas on carrying capacity for both juvenile and adult coral trout expressed in the discussion are worth considering. If adult coral trout density or recruit density on any reef is more dependent on the unique characteristics of the physical and biological environment of that particular reef than on the level of fishing pressure or availability of recruits then the level of this theoretical carrying capacity for each reef is an important consideration for management.

Fishing pressure is popularly supposed to have a dramatic effect on target species numbers. We have all heard how we should have seen the fish populations as they used to be before they were 'fished out'. However, at present it is impossible to get any quantitative data on the overall level of fishing on any reef so as to be able to relate this to measures of density and size of the target populations. The implementation of some form of detailed log book system for both commercial and recreational fishermen would give reef managers some real information on which to base decisions concerning changes in fish numbers and lengths.

The method used here to detect changes and differences in coral trout populations is not suitable for assessing abundance of lethrinids and lutjanids, at least in this area of the GBR. Previous surveys using similar sized transect counts in the Capricorn and Capricornia Section support this conclusion (Ayling and Ayling; 1986a). In view of the recent interest in lethrinids as possible predators of juvenile crown of thorns, the development of some method of assessing their population density would seem to be a priority for management. As has been suggested above some form of extra long strip transect count could probably be used to assess lethrinid populations, but some testing of this type of count needs to be carried out to confirm this.

It is our contention that counts of crown of thorns, coral trout and chaetodontids should be continued on these reefs annually, or at least every two years, preferably in a slightly expanded format. In the present design, where surveys are made within the same site approximately one kilometre long at each survey date, we are really only looking at differences between the individual survey sites not the reefs themselves. To get around this problem the design needs to be expanded to include at least two sites within each habitat,