INTRODUCTION

The management of marine systems, or human use of them, has generally been seen in the context of management of fisheries, usually with an emphasis on maximising yield to the fishery without causing collapses of fished stocks (Russ 1991; Hilborn and Walters 1992). In recent decades, however, there has been increasing emphasis on conservation of the diversity of marine resources, and the protection of whole marine assemblages or ecological systems from ill-effects of harvesting some parts of them or ill-effects of non-harvest human impacts. Closures of areas to destructive or extractive uses has gained increasing favour as a strategy to achieve the conservation goals of marine environmental management (Alcala 1988; Alcala and Russ 1990; Bohnsack 1994; Hendee et al. 1990; Kelleher and Kenchington 1991; Kenchington 1990; McNeill 1994; Russ 1984, 1989; Russ and Alcala 1989). With relatively few exceptions, however, the enthusiasm for area-closure strategies has been based more on theory and arguments that area closures were precautionary management instruments, than on empirical evidence that such closures were effective either locally or generally. In most cases, there has been neither the prior data nor the subsequent monitoring of area closures, and comparable non-closed areas, to allow the evaluation of the area-closure management strategies (McNeill 1994; but see Russ 1989, 1991; Russ and Alcala 1989).

In 1975, the Great Barrier Reef Marine Park Act provided for the declaration of the Great Barrier Reef Marine Park (GBRMP) and its management for conservation and multiple use. Explicit in the Act was the requirement to manage the Marine Park explicitly for conservation of the biological characteristics of the Great Barrier Reef (GBR) in the context of ongoing recreational use and commercial development (*Great Barrier Reef Marine Park Act 1975*; Kenchington 1990). During the following 12 years, strategies of zoning areas of the GBR for different levels of use were implemented over the entire Marine Park. Provisions for use ranged from several forms of recreational and commercial fishing and collecting, including trawling (General Use Zones), to non-extractive uses such as recreational diving and snorkelling (Marine National Park Zones), to, in a few areas, no access at all (Preservation Zones). Though not explicit in most of the zoning plans (GBRMPA 1983, 1985, 1987, 1988), the clear intent of the zoning strategies was to protect areas of the GBR from the most obvious or likely impacts of human use on the assumption that those protected areas would come to represent near-pristine examples of the area. Presumably, it was also expected that the protected areas would act as refugia from which the offspring of abundant stocks of most organisms could re-populate areas where harvesting had reduced abundances (Bohnsack 1994; Plan Development Team 1990; Russ 1991).

In order to assess the utility of these (or other) management strategies for conservation, it is necessary that the effects on reef biota of zoning reefs for different use be thoroughly documented. This information is most efficiently provided by carefully planned quantitative descriptive studies from which the biotic status of reefs with different zoning and use histories can be compared, i.e. via a sound monitoring program. To establish whether restriction of human use of selected reefs leads to changes in the biota of those reefs, irrespective of the proximate cause of such changes, requires at its simplest the following two fundamental comparisons:

1. Comparison of the status of the reefs following closure with their status prior to closure;
2. Comparison, both before and after closure, of closed reefs with reefs having no restrictions on use.

Ideally, the comparisons should be based on relatively long-term data of the status and dynamics of closed and unrestricted reefs from before, during, and after the implementation of a zoning strategy. Clearly other data will also contribute to this evaluation, e.g. documentation of the effects of removing restrictions on reef use. In many respects, the requirements of rigorous management strategy evaluation parallel the requirements of environmental impact assessment (Fairweather 1991; Faith et al. 1995; Green 1979, 1989; Humphrey et al. 1995; Keough and Mapstone 1995; Schmitt and Osenberg 1995; Stewart-Oaten 1995; Stewart-Oaten et al. 1986;

Underwood 1991, 1993, 1995; Warwick 1993), except that the effects of management would be expected to be 'positive' compared to the background conditions (of use) whereas in impact assessment the impacts of specific actions are expected to be 'negative' compared to background conditions.

Such data, however, are not available currently for the GBR. For none of the management sections of the GBRMP were systematic, purposeful surveys of reefs with different zoning status done at, or prior to, the implementation of the first term of zoning. Any assessments of the effectiveness of management strategies to date rests entirely on the contrived use of disparate data collected for other purposes. Such data include surveys by Sea Research (Ayling 1983a, b; Ayling and Ayling 1984a, b, 1985, 1986a, b, 1991, 1992a), data from the Australian Institute of Marine Science COTS surveys and the still young Long-term Monitoring Program (Oliver et al. 1995), recruitment surveys by P. J. Doherty, D. McB. Williams and P. F. Sale (Doherty 1987, 1991; Sale et al. 1984, 1986; Williams et al. 1986), the 'Boult Reef experiment' (Beinssen 1988, 1989), and more recently tag-release-recapture studies by Davies (Davies 1995a, b), and work by Mapstone et al. (1998a, b). Although these studies have generated ample data, none provide temporal series of data specifically collected to assess the effectiveness of Marine Park zoning strategies. Only in recent years have there arisen specific attempts to test hypotheses about the effectiveness of specific management actions in the Great Barrier Reef Marine Park (Ayling and Ayling 1992b, 1993, 1994, 1995; Brown et al. 1993, 1996; Mapstone, Campbell and Smith 1996; Mapstone et al. 1996a, b).

In April 1992 the as amended zoning plan for the Cairns Section of the GBRMP became operational (GBRMPA 1992), signalling the beginning of the second iteration of management strategies for the GBR. We were asked by the Great Barrier Reef Marine Park Authority (GBRMPA) in this project to survey some elements of the macro-fauna on reefs in the Cairns Section prior to the beginning of the next period of zoning. In particular, it was considered important to survey those reefs which had been previously closed to fishing and which were to have that restriction removed in the as amended zoning plan. In so doing, we were also in a position to compare the status, in 1990–91, of reefs with different zoning histories, albeit in the absence of structured baseline data from before the then effective zoning period (1983–91).

Preliminary analyses of recent work by the authors suggested that these comparisons would have good power to detect only fairly gross differences, even with an unconventionally liberal test criterion (liberal Type I error rate, $\alpha_{crit} = 0.1$). For example, for coral trout, if we specified Type I and Type II error rates of 0.1 (i.e. power = 0.9) the *a posteriori* comparisons between zoning history categories would have been expected to detect differences in density of only 50% of existing densities on general use reefs in the north of the Cairns Section, and 100% of existing densities on general use reefs off Cairns. Our data indicated that this was a 'worst case' scenario, the results being likely to be better for other, more abundant, organisms. Clearly, in view of these preliminary results, the primary value of this project must be seen to be the provision of baseline information for the future assessment of the second zoning plan (1991 onwards).

The Authority specified a number of objectives, to which this project was principally tailored. Those objectives were:

1. To provide detailed 'baseline'[1] data on the status of selected macro-fauna (see below) on open (Marine Park Recreation/General Use) and closed (Marine National Park/Preservation Zone) reefs for comparison with data collected in the future to assess the effects of the new reef zoning strategies on the reef-associated biota;
2. To compare the status of the same suite of organisms on reefs which had a history of near continuous (~daily) use by commercial tourist operators with that on reefs with similar zoning history but without the history of consistent human use;

[1] The term baseline here refers only to future assessments of the new zoning plan. Clearly, data collected in 1991 cannot be seen as baseline date for the existing zoning plan, which was implemented in 1983.

3. To compare densities of these organisms between reefs which had been zoned over the past seven years Marine Park B, Research, or Preservation Zone (i.e. no extractive use), and others zoned either General Use A or B, or Marine Park A (extractive uses allowed);
4. To do baseline surveys of all reefs in the Cairns Section designated for use in the proposed GBRMPA Effects of Fishing Program.[2]
5. To re-survey reefs which were surveyed by Sea Research in 1983–84, as a first step toward gathering long-term data on abundances;
6. To assess the status of *Acanthaster planci* on all reefs surveyed, providing, in the event of a repeated boom in COTS populations, data to test the prediction that COTS outbreaks have their genesis in the northern Cairns Section and cascade southward with successive generations.

In addition, we sought to provide estimates, by re-survey of some of the reefs surveyed in 1989–90, of inter-annual variation in population densities and assess the utility of proposed long-term monitoring programs designed to monitor temporal changes in abundances of these organisms.

[2] Note, however, that changes in design of the Effects of Fishing experiment in 1994 meant that the reefs originally considered for such an experiment (Walters and Sainsbury 1990) were no longer relevant to the experiment. Two of six other reefs that were relevant to the revised experimental design (Mapstone, Campbell and Smith 1996) were surveyed.