Australian Government
Department of the Environment, Water, Heritage and the Arts

# Marine and Tropical Sciences Research Facility Milestone Report, June 2007

**Program 8:** **Sustainable use and management of marine resources of the Great Barrier Reef**

**Project 4.8.2:** **Influence of the GBR Zoning Plan on inshore habitats and biodiversity, of which fish and corals are indicators: reefs and shoals**

**Project Leaders:** **Dr Peter Doherty, Australian Institute of Marine Science**

**Report By:** **Garry Russ, David Williamson and Richard Evans, School of Marine and Tropical Biology, James Cook University**

## Project Update

### *Data collection during 2006 and 2007*

In 2006, with funding from the CRC Reef transition funds and the Marine and Tropical Sciences Research Facility, we surveyed 32 Representative Area Program (RAP) sites (Palms – 6, August 2006; Whitsundays – 18, March 2006; and Keppels – 8, October 2006) and 12 long-term sites (old zoning effects) in the Keppels (October 2006). During the first half of 2007, we surveyed 10 RAP sites (Palms – 6, April 2007; and Magnetic – 4, May 2007) and 30 long-term sites (Palms – 24, April 2007; and Magnetic – 4, May 2007). Thus in the year 2006/2007 the James Cook University research group surveyed a total of 74 sites. An attempt to re-survey the Whitsunday Island group long-term green zone sites and their corresponding fished sites in March 2007 was postponed due to poor underwater visibility from heavy run-off of fresh water and sediments in early 2007. We have rescheduled the Whitsunday trip for three weeks during October 2007. It is expected that the complete compliment of all long-term monitoring sites (old zoning effects) in the four island groups will be completed by late 2007. The long-term monitoring data will be reported on during the first half of 2008.

This report focuses on the effects of the 2004 Great Barrier Reef Marine Park (GBRMP) Zoning Plan on two fishery target species on inshore fringing reefs of the GBRMP, coral trout (*Plectropomus* spp.) and the stripey sea perch (*Lutjanus carponotatus)* and a non-targeted group, the butterfly fishes (Chaetodontidae). The data presented here are collected from green zone sites in the Palm, Magnetic, Whitsunday and Keppel Island groups which were closed to fishing in July 2004, and corresponding sites which have remained open to fishing. The figures and analysis summarise baseline data collected prior to the 2004 rezoning and repeat survey data collected during 2006 and early 2007 (two to three years after the rezoning). This project update report builds on previous reports submitted to the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) during 2006 and early 2007 (refer to Evans *et al.* 2006; Russ *et al.* 2007).

### *Methods*

Five replicate transects were surveyed within each site using an underwater visual census (UVC) technique. Approximately 160 species of fish from within fifteen Families (Acanthuridae, Balistidae, Chaetodontidae, Haemulidae, Labridae, Lethrinidae, Lutjanidae, Mullidae, Nemipteridae, Pomacanthidae, Pomacentridae, Scaridae, Serranidae, Siganidae and Zanclidae) were counted by two observers who swam side by side along a fifty-metre transect line observing fish three metres either side (total search area per transect = 300m²). A third diver swam directly behind observers one and two, rolling out the transect tape to measure the distance covered. This UVC technique reduced diver-negative behaviour of several of the surveyed fish species. To ensure accuracy of the fish counts the species list was divided between the observers. The grouping of different families of fish depended on their abundance, behaviour and how conspicuous they were.

Observer 1 surveyed the fish families Acanthuridae, Balistidae, Chaetodontidae, Pomacanthidae, Pomacentridae, Scaridae, Siganidae, Zanclidae and small 'non-targeted' species of Labridae. Observer 2 surveyed the families Haemulidae, Lethrinidae, Lutjanidae, Mullidae, Nemipteridae, Serranidae and the larger 'targeted' species of Labridae. To avoid any bias in counts and size estimation of the different families, observers 1 and 2 alternated roles within protected and fished areas. Size estimation training was carried out at the start of each day, using wooden fish models.

Two methods were used to assess the sessile benthic community. Structural complexity was estimated every ten metres along each transect by a simple index combining categorical estimates (five levels) of slope and rugosity. Diver 1 recorded this information during return transect swims, while Diver 3 used a line intercept method to record a benthic point sample every metre along each transect tape (fifty samples per transect). Categories sampled were live hard coral (for example branching, solitary, tabular, massive, foliose, encrusting), soft coral, sponge, clams (*Tridacna* spp.), other invertebrates (such as ascidians and anemones), macro-algae and turf algae, dead coral, rock, rubble or sand. All transects were carried out within a depth range of two to nine metres, with an average depth of six metres. Visibility was recorded on each transect and typically ranged from six to twelve metres. Surveys did not proceed if visibility was less than four metres.

This data report focuses on the effects of the new zoning plan on coral trout (*Plectropomus* spp.), stripey sea perch (*Lutjanus carponotatus*) and a butterfly fish group (Chaetodontidae) comprised of four abundant species in the family *Chaetodon aureofasciatus, C. melannotus, C. rainfordi* and *Chelmon rostratus*. The Chaetodontidae group was chosen as a control group because they are not targeted or captured by hook and line or spear fishers. Furthermore, chaetodontid abundance is known to be closely associated with live coral cover and their population dynamics may reflect habitat changes which are operating independently of zoning management (Pratchett *et al.* 2006). Estimates of mean live hard coral cover and habitat structural complexity are also provided in this report. Statistical analyses of all data were conducted using univariate repeated measures ANOVA.

### *Results and Discussion*

Studies before the implementation of the new zoning plan in 2004 detected no significant differences between fished and protected reefs on the mid- to outer-shelf (Adams *et al.* 2000, Mapstone *et al.* 2003). However, high fishing pressure and increased levels of surveillance on the inshore reefs are seen as the likely reasons for observable differences between fished and protected areas on the inshore reefs (Davis *et al.* 2004, Evans and Russ 2004, Williamson *et al.* 2004). Since 2004, the Australian Institute of Marine Science Long-term Monitoring Program has detected differences between fished and protected areas at all five regional areas on the mid- and outer-shelf of the Great Barrier Reef (Cairns to Capricorn Bunker Group) and inshore biomass of target fish species is also greater in protected than fished areas (Evans *et al.* 2006; Russ *et al.* 2007). At this early stage, it is not possible to state unequivocally that these results are caused by the new zoning plan directly, but the overall spatial patterns are encouraging.

Total mean biomass estimates of target fish species in fished and newly protected zones of all four inshore island groups combined are presented in Figure 1. Between 2004 and 2006/2007 the mean biomass of *Plectropomus* spp. (coral trout) across all island groups increased in recently protected green zones from 5.8kg to 8.2kg per 1,000m$^2$. In the fished areas however, the overall mean biomass of *Plectropomus* spp. decreased from 5.7kg to 3.9kg / 1,000m$^2$ (Figure 1). Furthermore, the overall mean biomass of *L. carponotatus* increased from 2.5kg to 3.9kg / 1,000m$^2$ in new green zones while remaining stable at approximately 2.5kg / 1,000m$^2$ in areas which have remained open to fishing (Figure 1). Neither of these results were statistically significant (Table 1). The general pattern of increased biomass for two target species is encouraging, but must be interpreted with caution because of the short temporal scale of the monitoring and large site level variation within and between island groups. Greater resolution in the data is achieved by examining zoning effects within each island group independently.

**Table 1:** Results of repeated measure ANOVAs comparing protected and fished sites of the Palm, Magnetic, Whitsunday and Keppel Island groups before and after the rezoning in 2004. LHC = Live Hard Coral; SC = Structural Complexity. *** = P<0.001; ** = P<0.01; * = P<0.05; NS = Not Significant. Numerical figures are *f* values.

| Source of Variation | Year*zone *Island (2,26df) | Year* Island (2,26df) | Year* Zone (1,26df) | Year (1,26df) | Zone* Island (1,26df) | Island (2,26df) | Zone (1,26df) |
|---|---|---|---|---|---|---|---|
| ***Plectropomus* spp.** | 1.32 NS | 0.41 NS | 3.31 NS | <0.01 NS | 0.42 NS | 2.17 NS | 0.42 NS |
| ***L. carponotatus*** | 1.07 NS | 1.24 NS | 1.46 NS | 1.86 NS | 0.42 NS | 0.79 NS | 0.29 NS |
| ***Chaetodon spp.*** | 0.84 NS | 4.60 ** | 2.30 NS | 6.43 * | 1.25 NS | 3.37 * | 8.78 ** |
| **LHC** | 0.52 NS | 3.71 * | 0.29 NS | 16.06 *** | 0.25 NS | 5.52 ** | 3.03 NS |
| **SC** | 0.51 NS | 1.77 NS | 0.11 NS | 0.84 NS | 0.34 NS | 9.72 *** | 0.36 NS |

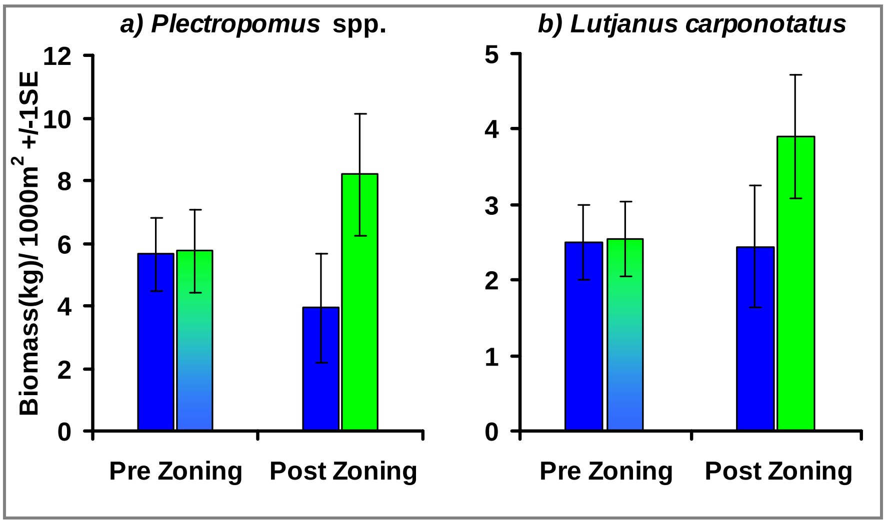


**Figure 1:** Mean biomass (+/- 1SE) of *Plectropomus* spp. and *Lutjanus carponotatus* in fished (blue bars) and protected areas (green bars) in the Palm, Magnetic, Whitsunday and Keppel Island groups, before and two to three years after rezoning.

In the newly protected green zone of the Palm Island group (Curacao Island), the mean biomass of *Plectropomus* spp. increased from 4.9kg to 7.4kg / 1,000m² between 2004 and 2006. During the same period however, the mean biomass of *Plectropomus* spp. decreased from 4.5kg to 2.9kg / 1,000m2 in the corresponding fished zone. Furthermore, *L. carponotatus* mean biomass increased from 1.7kg to 4.0kg / 1,000m² in the new protected zone and decreased from 3.1kg to 2.7kg / 1,000m$^2$ in the fished zone (Figures 2(a) and 3(a)).

At Magnetic Island the biomass of *Plectropomus* spp. increased in newly protected green zones between 2004 and 2007 from 0.8kg to 1.9 kg / 1,000m$^2$ and decreased from 4kg to 2.6kg / 1,000m$^2$ in areas which remained open to fishing. The mean biomass of *L. carponotatus* increased from 2.1kg to 3.0kg / 1,000m$^2$ in newly protected areas of Magnetic Island. However, similar increases were also detected in fished areas, where mean biomass increased by from 2.3kg to 2.9kg / 1,000m$^2$ (Figures 2(b) and 3(b)).

Similarly, in the Whitsunday Island group, between 2004 and 2006 *Plectropomus* spp. mean biomass increased from 7.6kg to 13.5kg / 1,000m² in protected areas while decreasing from 8.3kg to 6.3kg / 1,000m2 in the corresponding fished areas (Figure 2(c). The mean biomass of *L. carponotatus* increased from 2.6kg to 5.3kg / 1,000m² in new protected zones and to a lesser degree, from 2.8kg to 3.1kg / 1,000m$^2$ in fished zones (Figure 3(c)).

In the Keppel Island group, between 2004 and 2006, the mean biomass of *Plectropomus* spp. remained stable at approximately 9.6kg (pre-zoning) and 9.9kg (post-zoning) / 1,000m$^2$ in the protected areas but fell from 5.5kg to 3.9kg / 1,000m$^2$ in the fished areas (Figure 2(d)). Over the same period, the mean biomass of *L. carponotatus* decreased slightly in both protected and fished areas of the Keppel Island group (Figures 2(d) and 3(d)).

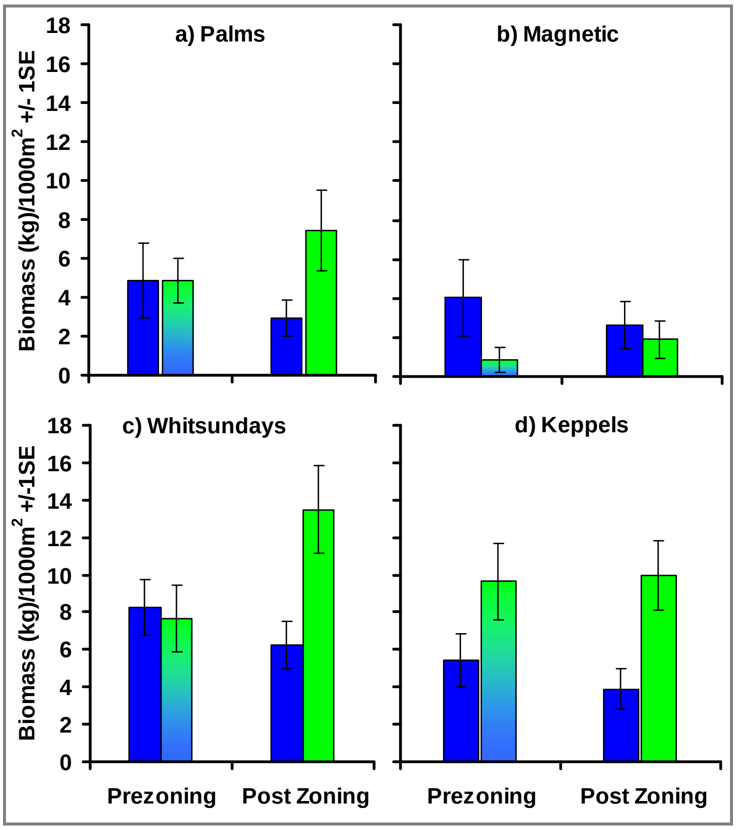


**Figure 2:** Mean biomass (+/-1SE) of *Plectropomus* spp. in fished (blue bars) and protected areas (green bars) in the Palm, Magnetic, Whitsunday and Keppel Island groups, before and two to three years after rezoning.

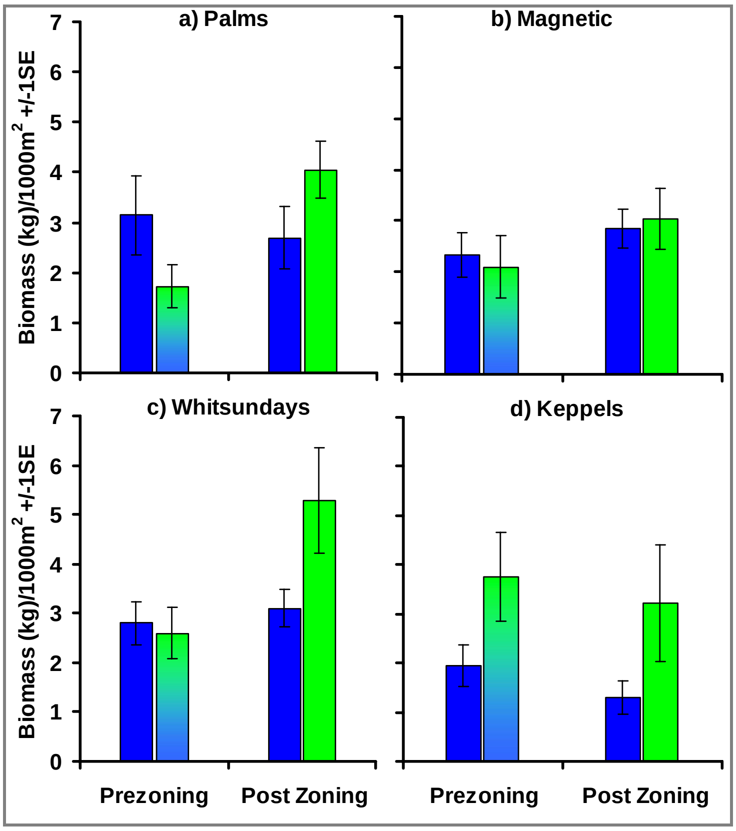


**Figure 3:** Mean biomass (+/-1SE) of *Litjanus carponotatus* in fished (blue bars) and protected areas (green bars) in the Palm, Magnetic, Whitsunday and Keppel Island groups, before and two to three years after rezoning.

Between 2003/2004 and 2006, the mean population density of the Chaetodontidae group declined in the Palm, Whitsunday and Keppel Island groups in both protected and fished zones. Mean Chaetodontidae abundance declined by 66.7% in fished areas of the Palm Island group and in the Keppel Island group by 69.5% and 52.5% in the fished and protected areas respectively. However, the only statistically significant decline occurred in the fished areas of the Keppel Island group (Tukeys: $p = 0.0145$). Such declines in the abundance of Chaetodontids may be due to the large reductions in live hard coral cover observed in both the Palm and Keppel Island groups (Figure 5) (Berumen *et al*. 2005; Pratchett *et al.* 2006). At Magnetic Island, the mean density of chaetodontids increased in both protected and fished zones, however this result was not statistically significant (Figure 4, Tukeys: $p = 0.91$). Overall increases in the abundance of Chaetodontids at Magnetic Island are probably related to a recruitment pulse of these fish, as changes in coral cover varied between fished and protected areas.

A general decline in live hard coral cover was observed in both fished and protected areas of the Palm, Whitsunday and Keppel Island groups. A slight increase in hard coral cover was recorded in protected zones of Magnetic Island, but a decline was seen in the fished zones. The most dramatic reductions in live hard coral cover were observed in the Palm and Keppel Island groups where overall (combined fished and protected areas) mean live hard coral cover decreased by approximately 49% and 40% respectively (Figure 5). However, significant declines in live hard coral cover were observed only in the Keppel Island group between 2004 and 2006 (Tukeys: $p = 0.0039$). No significant changes were observed in the structural complexity of the benthos between 2003/2004 and 2006 (Figure 6, Table 1). Importantly, there were no significant differences detected in either live hard coral cover or habitat structural complexity between protected and fished zones of any island group (Table 1).

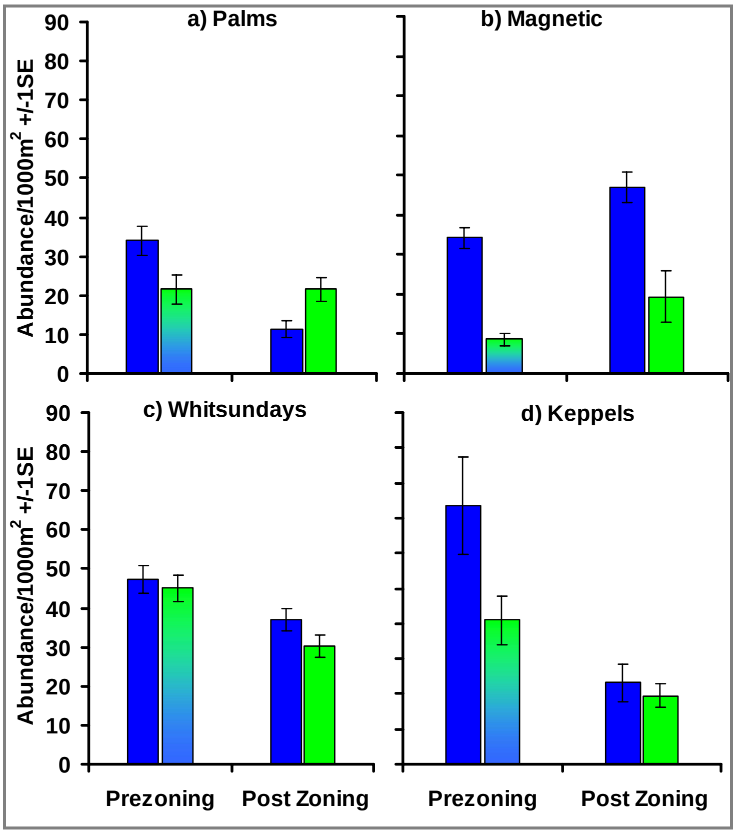


**Figure 4:** Mean population density per 1,000m2 (+/- 1SE) of four species of Chaetodontid (*Chaetodon aureofasciatus*, *C. melannotus*, *C. rainfordi* and *Chelmon rostratus*) in fished (blue bars) and protected areas (green bars) of the Palm, Magnetic, Whitsunday and Keppel Island groups, before and approximately two to three years after rezoning.

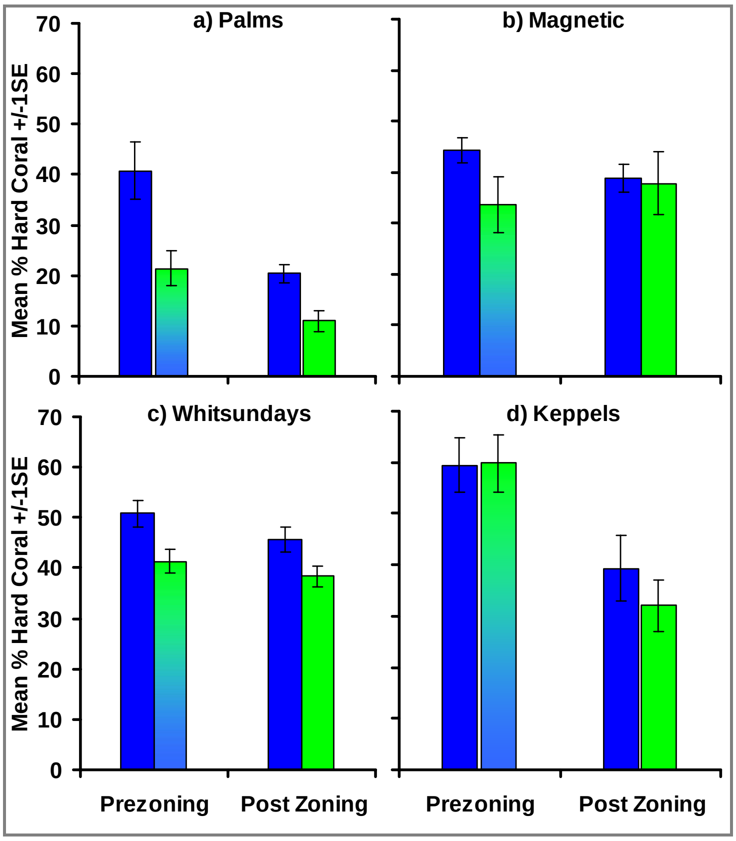


**Figure 5:** Mean percentage (+/- 1SE) of live hard coral cover in fished (blue bars) and protected areas (green bars) in the Palm, Magnetic, Whitsunday and Keppel Island groups, before and two to three years after rezoning.

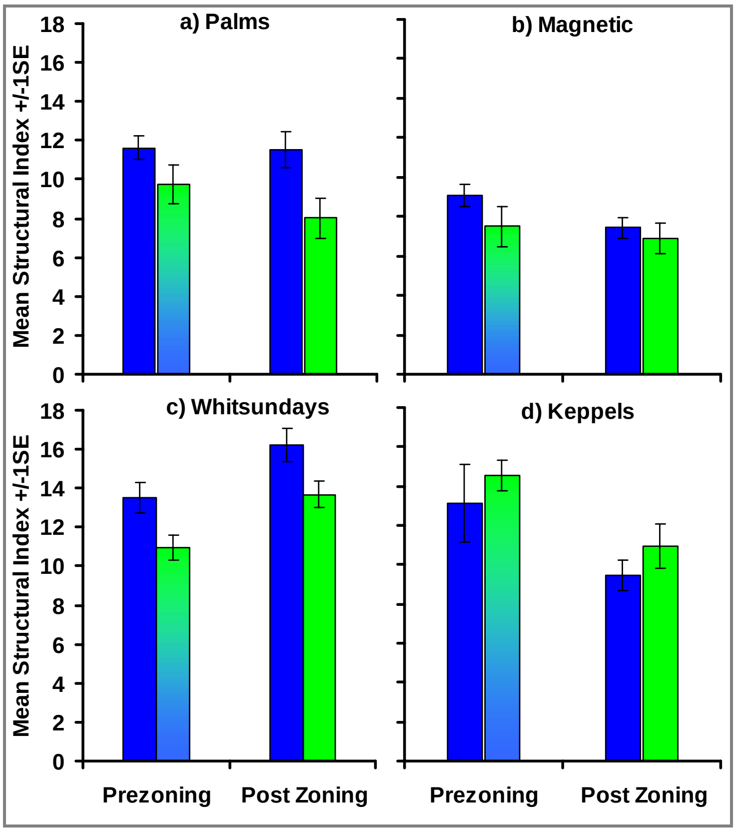


**Figure 6:** Mean structural complexity (+/- 1SE) of the reef habitat in fished (blue bars) and protected areas (green bars) in the Palm, Magnetic, Whitsunday and Keppel Island groups, before and two to three years after rezoning.

Fringing reefs of the Keppel Island group underwent two severe coral bleaching events during 2006, the first in February/March due to thermal stress and the second in October from freshwater inundation of shallow reef flat corals (Authors pers. obs. and AIMS unpublished data). Proliferation of the brown algae *Lobophora* sp. has occurred since the March 2006 bleaching event on many of the reef slopes which were previously dominated by the branching hard coral *Acropora formosa*. However, at this stage, it would be premature to suggest that there has been a significant and persistent phase shift from coral dominated to algal dominated fringing reefs in the Keppel Island group. Continued annual monitoring will shed light on the future decline or recovery of these fringing reefs.

In the shorter term however, the data suggests that there has been rapid and dramatic impacts of these bleaching events on the fish community of the Keppel Island group. It is already clear that there is likely a strong effect of coral cover decline on the mean abundance of chaetodontids. However, reductions in the abundance of prey fish species due to loss of live coral cover and subsequent habitat deterioration, may ultimately lead to a reduction in the abundance of predatory fish species on these reefs (Graham *et al.* 2003). The decrease of *Plectropomus* spp. stocks in the fished areas of the Keppel Island group and their stability within the protected areas, suggests that no-take protection status may be buffering against a potential decline of *Plectropomus* spp. stocks within the protected areas.

It is evident that environmental impacts such as mass coral bleaching events, coral disease, or outbreaks of crown of thorns starfish (*Acanthaster planci*) may confound the potential benefits of assigning no-take reserve protection on coral reefs. Longer term monitoring data generated from this project will provide insight into the contribution, if any, of no-take marine reserves to buffering against the effects of environmental impacts and/or enhancing recovery of benthic and fish communities following severe impacts.

### *Conclusion*

The observed increases in the biomass of target species within newly protected areas are encouraging, but this data needs to be interpreted with caution due to the high level of variation within and between island groups. Although preliminary, the data presented here suggests that we may be witnessing the beginning of a rapid and sustained response in populations of target fish species to the implementation of new no-take protected areas on inshore reefs of the GBRMP. These results were obtained after a short duration of closure to fishing (two to three years from 1 July 2004) and the speed of change detected in these fish populations was largely unexpected. However, such rapid responses to zoning changes are not unprecedented. Halpern and Warner (2002) reviewed the effects of eighty reserves using 112 independent studies to find that mean levels of average density may be reached after a short period of time (one to three years). Furthermore, the data presented here also suggest that there may be some effect on stocks of target fish species of concentration of fishing effort into areas which have remained open to fishing. This project has now developed a well defined baseline and continued monitoring of these locations will yield great insight into the dynamics of fish populations and the effects of management zoning on these high use reefs.

### *Acknowledgements*

The authors would like to thank the Department of the Environment, Water, Heritage and the Arts, the Marine and Tropical Sciences Research Facility and CRC Reef Research Centre for providing the funds for this phase of the project. The collection and processing of baseline data from the near-shore reefs was funded by an Australian Research Council (ARC) grant (DPO209086).

James Cook University staff would also like to thank the staff of the Queensland Parks and Wildlife Service at Conway National Park and Rosslyn Bay Harbour, the Orpheus Island Research Station, Hayman Island Resort, Keppel Reef Scuba Adventures and Keppel Haven Resort.

Thanks also to research assistants Jody Krueger, Philippa Mantel, Kathryn Markey, Will Robbins and the volunteers Melissa Cowlishaw, David Feary, Alison Jones, Peter Venables and Stefan Walker.

### *References*

Adams S., Mapstone B.D., Russ G.R. and Davies C.R. 2000. Geographic variation in the sex ratio, sex specific size, and age structure of *Plectropomus leopardus* (Serranidae) populations between reefs open and closed to fishing on the Great Barrier Reef. *Canadian Journal of Fisheries and Aquatic Sciences* 57: 1448-1458.

Berumen M.L., Pratchett M.S. and McCormick, M.I. 2005. Within reef differences in diet and body condition of coral feeding butterflyfishes (Chaetodontidae). *Marine Ecology Progress Series*. 287: 217-277.

Davis K.L.F., Russ G.R., Williamson D.H., Evans R.D. 2004. Surveillance and enforcement in the Great Barrier Reef Marine Park: a study of illegal fishing around Orpheus and Magnetic islands. *Coastal Management* 32(4): 373-387.

Evans R.D., and Russ G.R. 2004. Larger biomass of targeted reef fish in no-take marine reserves on the Great Barrier Reef, Australia. *Aquatic Conservation: Marine and Freshwater Ecosystems* 18(4):1021-1031.

Evans R.D., Williamson D.H., Sweatman H., Russ G.R., Emslie M., Cheal A. and Miller I. 2006. *Surveys of the effects of rezoning of the GBR Marine Park in 2004 on some fish species – preliminary findings*. Unpublished report to the Australian Government Department of the Environment and Heritage. 18pp.

Graham N.A.J., Evans R.D. and Russ G.R. 2003. The effects of marine reserve protection on the trophic relationships of reef fishes on the Great Barrier Reef. *Environmental Conservation* 30: 200-208.

Halpern B. and Warner R.R. 2002. Marine reserves have rapid and lasting effects. *Ecology Letters* 5: 361-366.

Mapstone B.D., Davies C.R., Little L.R., Punt A.E., Smith A.D.M., Pantus F., Lou D.C., Williams A.J., Jones A., Russ G.R. and MacDonald A.D. 2003. *The effects of line fishing on the Great Barrier Reef and evaluation of alternative potential management strategies.* CRC Reef Research Centre Technical Report No. 52, Townsville, QLD 4811, Australia: 205 pp.

Pratchett M.S., Wilson S.K. and Baird A.H. 2006. Declines in the abundance of Chaetodon butterflyfishes following extensive coral depletion. *Journal of Fish Biology* 69: 1269-1280.

Russ G.R., Williamson D.H. and Evans R.D. 2007. MTSRF Report 2: March 2007. Project 4.8.2: Effects of GBR Zoning plan on inshore habitats and biodiversity: reefs and shoals.

Williamson D.H., Russ G.R., Ayling A.M. 2004. The effectiveness of marine reserves in protecting fish stocks on fringing reefs of the Great Barrier Reef Marine Park. *Environmental Conservation* 31(2): 145-159.

### *Appendix 1: Public presentations of project data*

- **June 2007:** Garry Russ gave a community presentation in Townsville as part of an Inaugural Professorial Lecture, which included a brief overview of the results presented in this report.
- **November 2006:** David Williamson gave a presentation to the Great Barrier Reef Marine Park Authority for the Keppel Islands Management Response Meeting. Reported on the status of fish and coral populations on Keppel fringing reefs following two bleaching events in 2006.
- **August 2006:** Australian Coral Reef Society 82nd Annual Conference in Mission Beach. Richard Evans presented the data from the Whitsundays results. Received third place student award for presentation.
- **June 2006:** David Williamson addressed a Local Marine Advisory Committee (LMAC) meeting in Yeppoon. The presentation focused on the status of fish and coral communities on Keppel Island group reefs and included a briefing on the proposed larval marking experiment for the Keppel Island group.
- **June 2006:** David Williamson and Richard Evans gave a presentation to tourism industry representatives at the "Eye on the Reef" Workshop in Cairns (GBRMPA), on monitoring program and proposed larval marking experiment.
- **March 2006:** David Williamson gave presentation in Yeppoon to CapReef, GBRMPA, QPWS and local industry representatives on the proposed larval making experiment in the Keppel Islands.
- **November 2005:** David Williamson gave presentation in Yeppoon to CapReef, GBRMPA, QPWS and local industry representatives on the monitoring program we have underway for the GBRMP with focus on the Keppel Island group and an overview of the proposed larval making experiment in the Keppel Islands.

*Proposed public presentations of data*

- **August 2007:** Richard Evans to present a talk on the effects of zoning on inshore reefs at the State Conference of the Australian National Sports fishing Association in Yeppoon.
- **September 2007:** Richard Evans to present results of current report at European Marine Protected Areas Conference in Murcia, Spain.
- **October 2007:** Richard Evans and David Williamson to present results of the inshore monitoring program at ACRS conference in Fremantle, Western Australia.

### *Appendix 2: Fieldwork schedule for 2007/2008*

- **October / November 2007:** Whitsunday Island group. Surveys of long-term and RAP monitoring sites.
- **November / December 2007:** Keppel Island group. Surveys of long-term and RAP monitoring sites.
- **March 2008:** Palm Island group. Surveys of RAP monitoring sites.
- **May 2008:** Magnetic Island. Surveys of long-term and RAP monitoring sites.