# Wakatobi Marine National Park

# Monitoring Program

## *Summary report on changes to reef habitat quality and in the abundance and assemblage of coral reef fish*

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Information included herein represents a summary report of the scientific monitoring program implemented by the Coral Reef Research Unit, University of Essex (CRRU) and Operation Wallacea, in collaboration with RISTEK, The Wallace Foundation and the University of Hasanuddin, Makassar.

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**1.0. Background**

The coral reef monitoring programme was first implemented during 2002 by Operation Wallacea and the Coral Reef Research Unit. Reef monitoring has occurred on an annual base since 2002. A wealth of data has been collected which can be divided in to benthic community structure, economically and ecologically important fish abundance and community structure. This report, that can be considered a supplementary report of the document submitted last year, outlines key changes in habitat quality, the fish abundance and key changes to fish family assemblages.

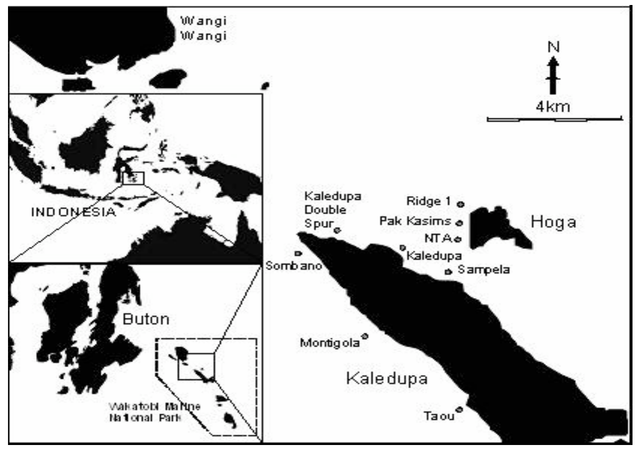
Coral reefs are in decline across the world. This decline is due too, in the main, over-exploitation and harvesting of reef based organisms. Increasing population sizes has brought about a large increase in demand and consequently fisheries effort. Importantly reef based systems exist in a dynamic ecological equilibrium and changes to one component of the system can have dramatic consequences for others. Over harvesting of fish species is key as many taxonomic groups play extremely important ecosystem services role. For examples, and in particular with the Indo-Pacific, fish tend to be the key herbivores and over extraction can competitively release macro-algae which can out-compete corals for light and space. The consequences can be dramatic with an eventual alternative stable state becoming established, for example, macro-algal rather than hermatypic coral dominated, reef systems. Any taxonomic group that competes with the key ecosystem architects i.e. corals, will lead to a decrease in topographic diversity and associated species diversity, biomass and productivity. It is therefore extremely important that we manage reef based systems with a deep understanding of how systems responded to different pressures and the consequences of disrupting the ecological balance.

Unfortunately coral reefs also face other problems other than over-exploitation. Reefs are environmentally sensitive ecosystems which are threatened by several different aspect of predicted climate change. Of most concern are increasing temperatures and acidification. Temperature will decrease coral cover through thermal induced mortality and bleaching, whereas acidification is likely to disrupt photosynthetic active and mechanisms of calcium carbonate secretion. In the near future the problems faced by reefs caused by over harvesting will be exasperated by climate change and it is therefore more important than ever to sustainably manage these important natural resources. Sustainable management initiatives are varied but there design and implementation need to be based on a detailed and expansive understanding of the quality and quantity of resource. In short appropriate management needs to be based on knowledge, understand, research and reliable data. Consequently this monitoring programme was established with the aim of feeding back detailed information to all stakeholders including, local communities, NGO's, Marine Park Authorities and also the Indonesian Government to ensure natural resource management initiatives are most appropriate and active management activities are successful .

## 2.0. Methods and Protocols

### *2.1. Sites*

The Wakatobi Marine National Park is the second largest MPA in Indonesia at 13900km$^2$ and was established in July 1996. The park is classified as IUCN Category II, a National Park managed mainly for ecosystem protection and recreation. The park consists of four main islands, Wangi Wangi, Kaledupa, Tomia and Binongko. There are also two large atolls to the west of the main island chain, Karang Kapota and Karang Kaledupa but larval flow and degrees of connectivity between the main islands and atolls is unknown. The park contains a population of approximately 98,000 who belong to two distinct ethnic groups. The Butonese people are land based farmers, traders and craftsmen and comprise about 95% of the local population. The Bajo people are traditional fishermen, living mostly in semi permanent villages erected on the reef flats. Fish is the most important protein source for local people and the Bajo provide the largest proportion of fish produce solid in local markets (Cullen 2007).




When te coral reef monitoring program was first established in 2002 108 permanent transects were laid (marked at the start, middle and end by embedding galvanised pools) at 12 sites around the study area in replicates of three at the reef flat (5m horizontal distance on the landward side from the reef crest), reef crest and upper reef slope (defined by habitat type and a depth of 10 m). For the six north-east Kaledupa sites (Ridge 1, Kaledupa Double Spur, Kaledupa, Pak Kasims, Hoga NTA and Sampela), surveys were repeated annually for six years, whereas for the west Kaledupa sites (Sombano, Montigola and Taou), the surveys were repeated after a five year interval (see Appendix 1 for complete descriptions of each site), Specifically the following data were collected as part of the monitoring program:

a. The percentage cover, diversity and community structure of hard corals as assessed by a 50 m continual line intercept transect

b. The percentage cover of soft corals as assessed by a 50m continual line intercept transects.

c. The percentage cover of macro algae as assessed by a 50m continual line intercept transect.

d. The percentage cover of dead coral and coral rubble as assessed by a 50m continual line intercept transect.

e. The density, diversity and the community and functional structure of coral reef fish as assessed by a 50 m by 5 x 5 m 25 minute restricted effort belt transect.

f. The abundance of threats present in the form of bleaching, disease and predators, such as Crown Of Thorns starfish (COTs) and Drupella.

## 2.2. Survey Methods

### *2.2.1 Benthic assemblage*

The main group studied were the hermatypic corals (Order Scleractinia); other groups of sessile reef organisms to be monitored included the soft corals (Alcyonacea), sponges (Porifera), macro algae and Crustose Coralline Algae. The area of coral rubble, dead corals and area of bare substratum available for recruitment was also recorded.

Monitoring was carried out within three "reef zones";

a) the reef flat, (1-2m depth),

b) the reef crest (2-6m depth) and

c) upper reef slope (9-12m depth).

A combination of survey methods were used to quantify spatial and temporal changes in the benthic community. The principal technique used was the continuous Line Intercept Transect (English et al., 1996), combined with belt transects (Loya, 1978). After generating species-area curves, three 50 metre long transect tapes were laid along depth contours parallel to the shoreline for each depth at each site, giving a total of nine transects per site with total length of 450m. All life forms intercepting the transect line were recorded to genus with the length intercepting the transect tape recorded to the nearest centimetre. All transect data were square root transformed to satisfy the distribution and variance assumptions of ANOVA. Data was analysed using the statistical computer package SPSS.

### *2.2.2 Fish Assemblage*

Fish community structure was assessed using a modified protocol devised by the Australian Institute of Marine Sciences. A time and distance restricted belt transect was used to characterise the fish community using standard underwater visual techniques. A 50 m by 5 (horizontal) x 5m (vertical) belt transect was used and a sampling effort of 25 mins was deemed appropriate (from preliminary studies and effort vs richness plots). The species of fish were identified and absolute abundances were recorded. Nine 50m belt transects were completed at each site (three replicates within each zone as described for the benthic intercept transects) with a horizontal gap of at least 20m between transects within a zone. This gave a total effort of 11250m3 per site. In an attempt to control natural variability in fish densities (e.g. due to diurnal influences on behaviour) sampling was limited to between 0900 and 1500 hrs.

## 3.0. Results

For purpose of clarity the following represents changes in key habitat quality and reef fish assemblage from 2007 and 2008. Data has also been included from previous years survey so that the rates of change between 07-08 can be put in to a broader context.

### *3.1. Habitat Quality*

Figure 2. The percentage cover of live coral at 6 key monitoring sites (R1: Ridge 1, KDS: Kaledupa Double Spur, KAL: Kaledupa B1, NTA: Hoga Buoy 3, PAK: Pak Kasims, and SAM: Sampela). Data collected from each zone has been combined. 2002-07.

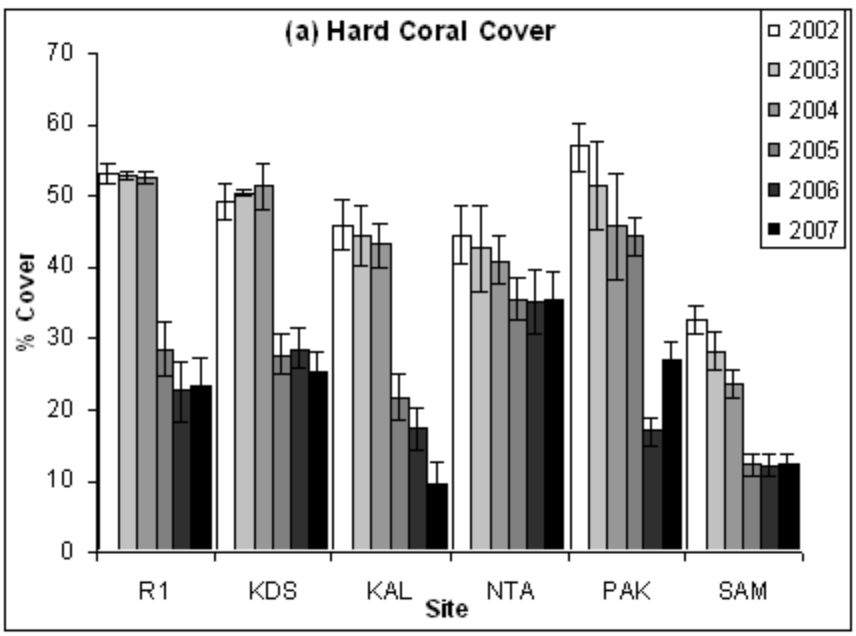
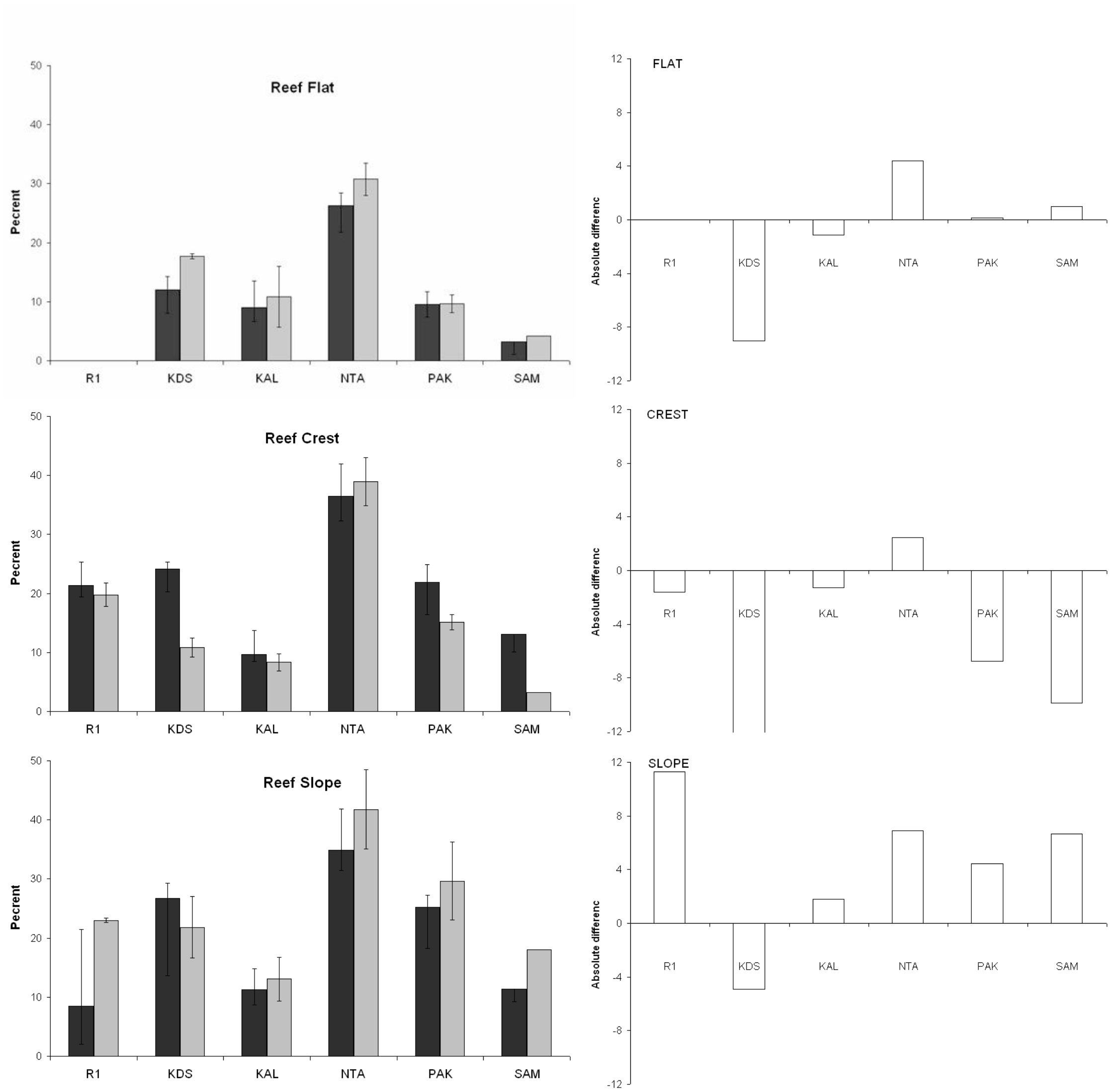


Figure 3. The percentage cover of live coral at 6 key monitoring sites (R1: Ridge 1, KDS: Kaledupa Double Spur, KAL: Kaledupa B1, NTA: Hoga Buoy 3, PAK: Pak Kasims, and SAM: Sampela) assessed during 2007 (black bars) and 08 (grey bars). a) Represents percentage of live coral recorded and b) Represents the absolute percentage change between 07-08.

**a) Percentage of live coral recorded** **b) Absolute change**



In all but one case there was a higher abundance of hard corals recorded during 2008 as compared to 2007 on reef flats however the difference was not significant (see Fig 3a). Similarly there was no difference in hard cover recorded on reef crest and reef slopes. The mean percentage cover of coral for each habitat across all sites was 14.6 %, 16.1 % and 24.6 % for the reef flat, crest and slope respectively. Across all sites there was a 0.9±2.2 % loss in corals from reef flat environments primarily due to a large decrease in abundance at the Kaledupa Double Spur (9 % loss, see fig 3b) due to a die off of a large *Acropora* stand. The only other site which had a significant change in coral abundance was the Hoga No Take Area where there was a 4 % increase in coral abundance primarily due to increases in the abundance of *Acropora*. This increase demonstrates active recovery from a relatively large die off event in 2003-04.

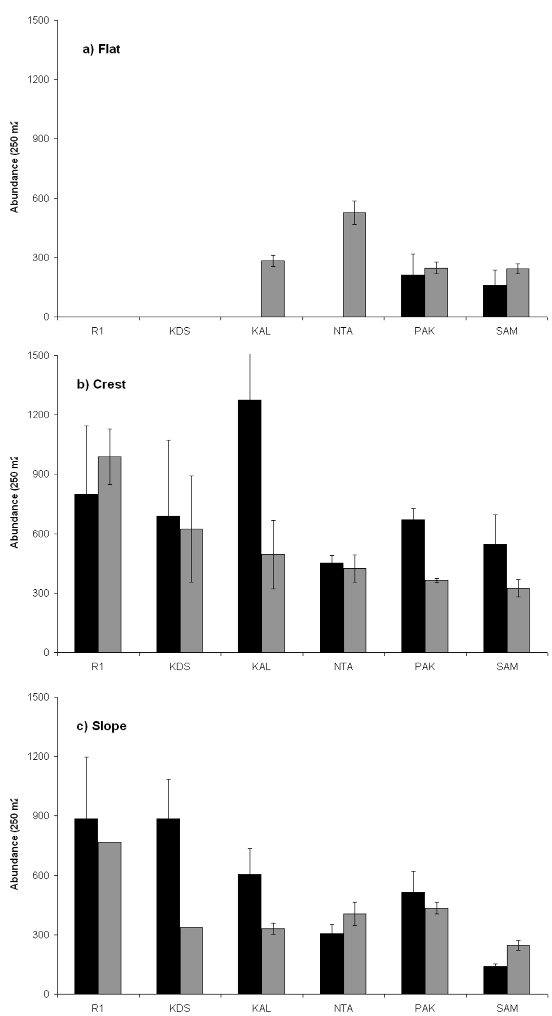
The reef crest demonstrated the greatest over loss of corals with an across site average loss of 5.1 ± 2.4 % again with the greatest loss occurring at Kaledupa Double Spur (13.3 %) although the loss at the Sampela site was also highly significant (9.9 %). Hard coral cover only increases at the Hoga No Take Area (2.5%) most probably due to the increases in *Acropora* as explained for reef flat habitats.

The reef slope was the only habitat to show an overall increase in coral cover (4.4 ± 2.3 %) but again the Kaledupa Double Spur site lost coral (4.9 %). The hard coral cover expanded at all other sites with greatest increases being observed at Ridge 1 and Hoga NTA site (11.3 % and 6.9 % respectively, see Fig 2b). Increases in coral cover at Ridge 1 can be attributed to large increases in encrusting species; this was also partially due to increases observed with the Hoga NTA although other growth forms also significantly contributed.

### *3.2. Fish Assemblage*

Figure 4: a) The total fish abundance observed at each site (underwater visual time and distant restricted transects. Data from 2007 are represented by the black bars and 2008 the grey bars. b) the relative change in percentage abundance of fish (data normalised against 2007 values). NB zero values represent no data rather than zero count / %.

**a) Total Fish Abundance**




**b) Relative percentage change (from 07)**

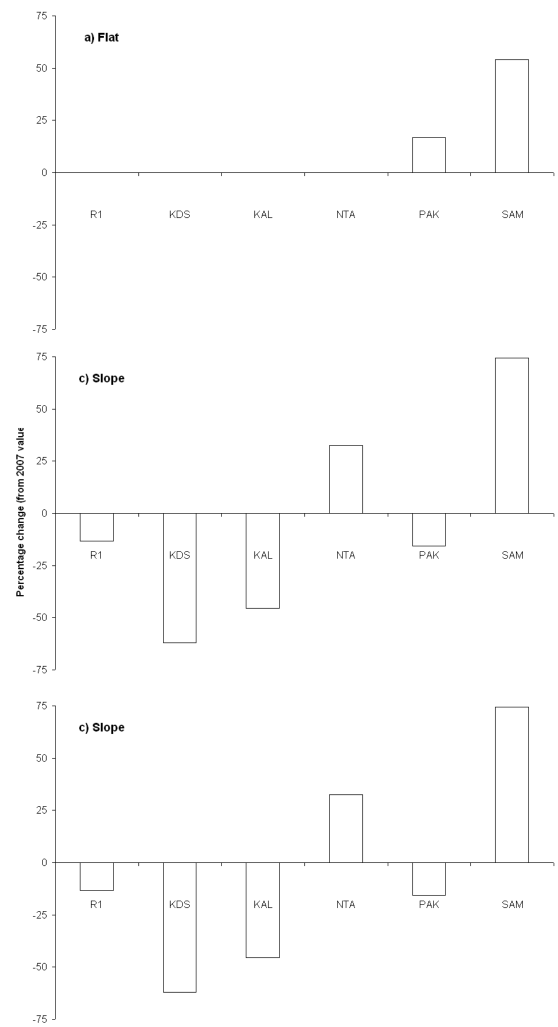
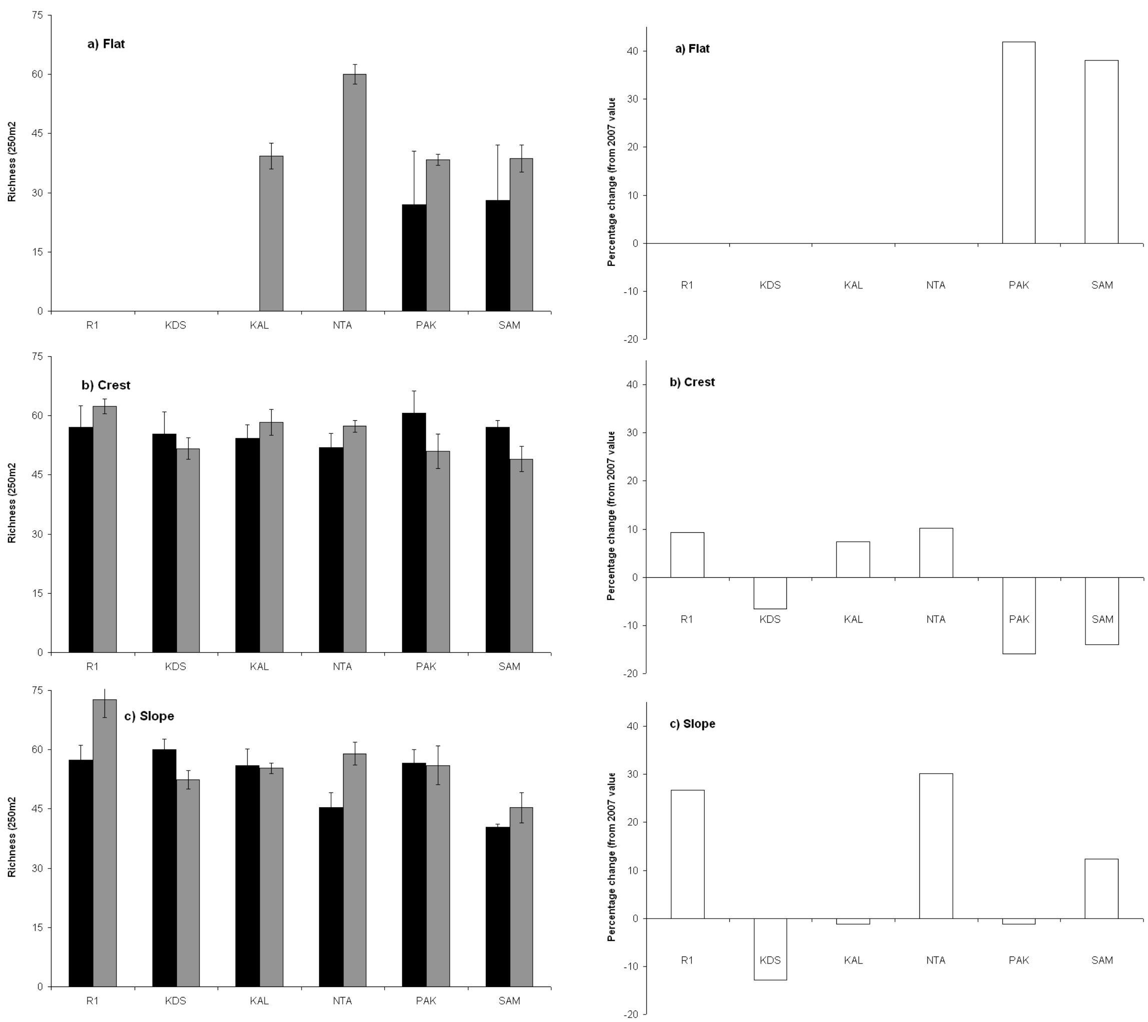


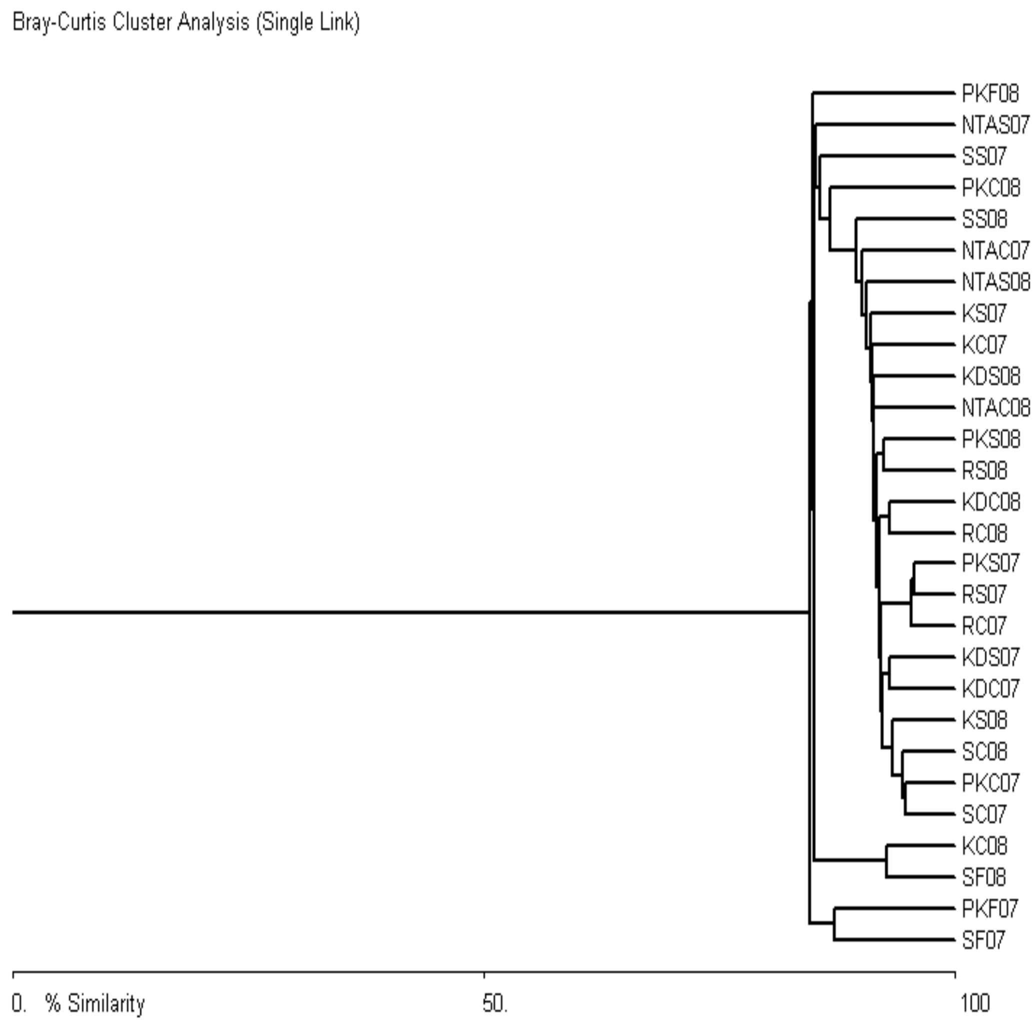
Figure 5: a) The fish species richness observed at each site (underwater visual time and distant restricted transects). Data from 2007 are represented by the black bars and 2008 the grey bars. b) The relative change in percentage abundance of fish (data normalised against 2007 values). NB zero values represent no data rather than zero count / %.

**a) Fish Species richness** **b) Relative percentage change (from 07)**



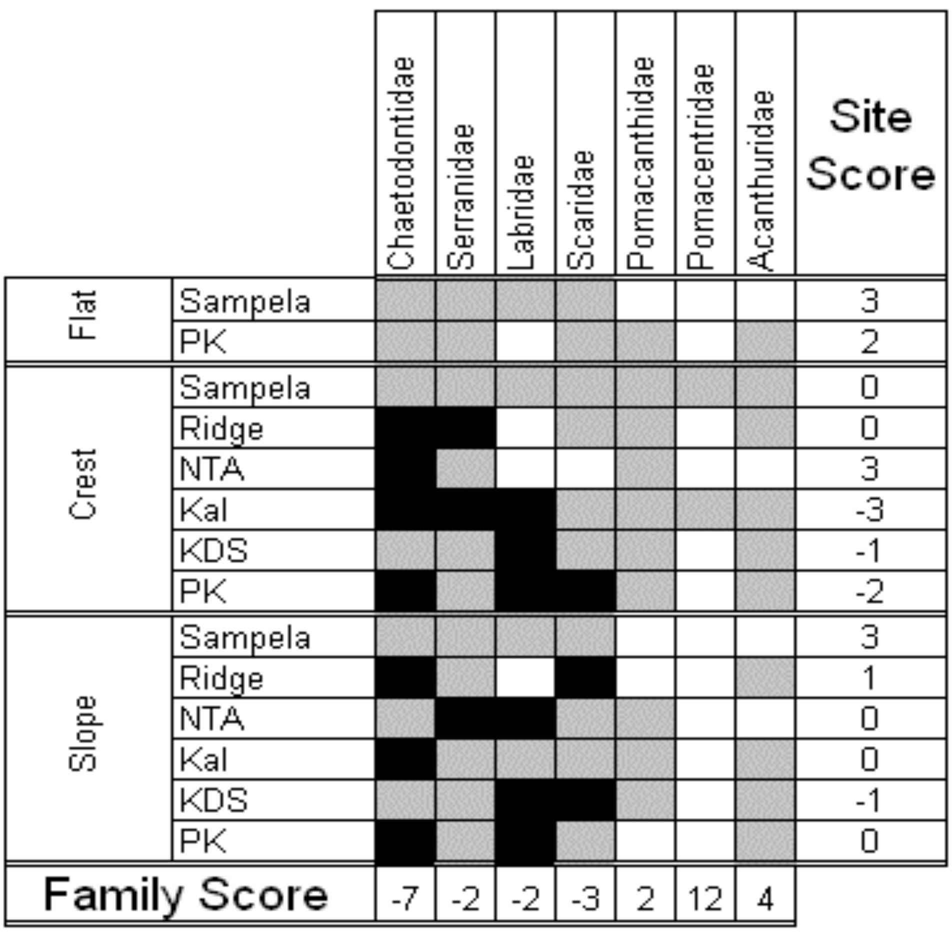

The species richness of each site and reef habitat did not vary significantly between 2007 and 2008. In general reef flat areas seem to be recovering, albeit at a moderate rate, from the 2003-04 event. The reef crest environment showed the greatest decrease in overall species richness but the loss was generally low. A healthy increase in species richness was observed within slope environments with only one site having decreased number of species.

Figure 6: Classification analysis (Bray-Curtis cluster analysis using single linked method) of fish family assemblage across all sites and habitats where annual replicated data was obtained.




The family assemblage is very similar throughout all sites. Time rather than site and habitat seems to be the most important component that separates the sites from others suggesting that temporal rather than spatial factors are key to driving changes in fish assemblage within this part of the Wakatobi. However some generalisation can be made (se Figure 7 and text thereafter).

Figure 7: Summary of key changes in the number of species belonging to the key fish families between 2007-08 across all sites and habitats. The white squares symbolises positive change (> +1.1 species on average), the grey squares represent no major changes (from -1.0 to +1.0) and the black squares represent significant loss of species (> -1.1 species loss). Description of the key changes follow. Scores indicate generalised temporal impact with positive “Site Scores” obtained for sites where, across all species, the site has gained, the opposite is true for the most impacted sites that “Site Score” negative values. ”Family Scores” follow the same principle but combines data across all sites for each fish family to indicate which fish families are most positively or negatively impacted between 2007 and 2008.



Chaetodontidae

Chaetodontidae did not vary significantly amongst reef flat habitats at different sites. However there abundance decreases markedly at reef crest habitats across the majority of sites, Sampela being the exception. The greatest reduction in Chaetodontidae species was at Kaledupa where three less species were recorded during 2008 as compared to 2007. Overall the Chaetodont species richness decreased, marginally, across slope habitats the greats reduction (of three species) being at the Kaledupa site (inline with habitat quality reductions).

**Serranidae**

The number of species of Serranidae did not vary significantly between years at any of the reef flat sites. In general richness of Serranidae did decrease by 1 or 2 species across most reef crest sites apart from the Hoga NTA where an extra species was recorded in 2008 as compared to 2007. A similar pattern was also true of reef slope environments and overall the diversity of Serrandiae has not changed significantly between 07-08.

**Labridae**

The changes in abundance of Labridae varied significantly across sites and habitat types. Labridae diversity increased within Reef flat environments. However reef crest environments varied with site some sites showing an increase whilst other sites decreased. Of note was the relative high decrease in richness at the two Kaledupa sites and the Pak Kasim site. In the main a similar pattern was observed for reef slope sites with Kaledupa Double Spur and Pak Kasims showing the worst decline in species richness. It is possible that such a decrease could be linked directly to reductions in habitat quality reported above.

**Scaridae**

No real difference in Scaridae abundance was observed between 07 and 08 at reef flat environments and limited difference was observed at reef crest environments with the exception of Pak Kasims where a number of species (2.3 species on average) were not recorded in 2008. Reef slope environments, perhaps with the exception of Kaledupa Double Spur, were not affected with Scaridae numbers and diversity remaining fairly constant of the past two years.

**Pomacanthidae**

**There were no real changes in abundance of species of Pomacanthidae across reef flat environments but there were small reductions in diversity across reef crest environments. The only reef site to show moderate decreases in Pomacanthidae species richness was the Kaledupan site, but generally the richness and assemblage of Pomacanthidae appear stable across all sites and habitat types.**

**Pomacentridae**

**Species richness of Pomacentridae increased markedly across all reef environments and across most sites. In places species richness increased by 10 (reef slope within the Hoga No Take Area) and rarely were there less species recorded in 2008 than there was in 2007. This fish family would have seem to gain dominance on many reef sites, however the damselfish are very plastic and trophically flexible consequently they cannot be used to indicate key changes to habitat quality. However they are not fished and therefore changes to abundance and richness will be as a result of inter-specific interactions (including cascade effects) or changes to habitat quality.**

**Acanthuridae**

There was a marked increase in the number of species of Acanthuridae at the Sampela reef flat and diversity remained stable within the Pak Kasims reef flats. There were no real changes in assemblage across any of the reef crest sites. Apart from the Sampela reef slope, where two extra species of Acanthuridae were recorded during 2008, the assemblage and diversity remained fairly constant.

**Concluding Remarks**

In most cases habitat quality is decreasing as observed from the lost of reef building coral. The maintenance of coral architecture must be a priority for conservation as it directly impinges of habitat availability and system carrying capacity. There were no key changes in the community structure at any habitat of reef site between 2007 and 2008. However the sites of Kaledupa, Kaledupa Double Spur and Pak Kasims, were the sites where greatest decrease in key and often targeted fish families. Interestingly these sites have in the past year, been targeted as sites to use Fish Fences and it is quite possible that the impact of fish fences in the past year has led to the less diverse fish community and loss of some key species. However the sites have also experienced a loss of coral and therefore the key driver could be habitat quality based rather than due to direct exploitative actions.

Although the monitoring programme has been designed to be sensitive enough to pick up annual changes, the inherent variability in reef fish assemblage in the short and long time scale negates the possibility of firm “short term” conclusions. However from the results obtained and presented herein, it is suggested that careful consideration is made concerning the environmental impact of fish fences and there effect on all reef habitats,; the Kaledupan sites and Pak Kasims site should be carefully monitored in the coming years and mitigating activities may be needed.

The greatest loss of species across all sites and habitat types were members of the Chaetodontidae, themselves sometimes used as an indicator reef health. However this is not entirely appropriate as although many Chaetodonts are coralivores, many are not. The important food fish family of Serranidae and Scaridae both scored negatively overall with fewer species being recorded across all sites during 2008 than during 2007 (see Figure 7). Despite these losses however overall the fish community structure, abundance and richness appears stable. Greatest loss, although still only a marginal reduction, has been seen at sites that have recently had fish fences constructed on adjacent reef flats. Reductions in fish community quality seem to be, at least in part, associated with reductions in habitat quality and worryingly several sites have loss a high percentage of coral and therefore ecosystem architecture. The cause of this loss seems to be physical rather than biological although a greater abundance of coralivores such as Crown of thorns starfish were witnessed during 2008. The cause of habitat reduction, that in the main seems localised, will be further investigated during 2009.

**Appendix 1: Descriptions of all monitoring sites**

***Hoga No Take Area***

The Hoga No Take Area is off the west coast of Pulau Hoga (GPS: 05°28.40S 123°45.45E) and falls within a voluntary No Take Area that was established in 2001. The reef crest is about 150m offshore, adjacent to sea grass beds. The reef drops vertically from the crest to a depth of just over 30metres, from where a sandy slope forms into slightly deeper waters. The site is characterized by many overhangs and small caves. Limited fishing does occur at this site as compliance with the no-take area is not total, although fishing is generally artisanal and by single hook and line.

***Pak Kasim's***

This site is located around 500 metres to the north of the No Take Area along the same stretch of the west Hoga fringing reef (GPS: 05°27.569S 123°45.179E). The reef crest is almost 200 metres offshore, again adjacent to seagrass beds. The reef aspect is not as vertical as within the NTA, and slopes at between 40 and 70 degrees. The reef bottoms out at around 50 metres into a sandy slope. There are some spur and groove formations with sandy gullies in between. Although this site is outside the NTA, it is not believed to be subject to extensive fishing. There is some evidence of fish traps and limited gleaning at low tide.

***Ridge 1***

This site is one of the least impacted within the area, situated to the north west of Hoga island on a barrier over one kilometre offshore (GPS: 05°26.565S 123°45.138E). The ridge runs from north to south with the outer slope dropping to over 100 metres and the inner slope somewhat shallower. The reef slopes at around 70 degrees on both sides with the crest remaining under several metres of water at all tides, with effectively no reef flat. This means no gleaning occurs at this site. Some artisanal line fishing occurs here and there is increasing evidence of bomb fishing along lengths of the ridge.

***Kaledupa***

The Kaledupa site is on the north eastern side of the island of Pulau Kaledupa (GPS: 05°28.22S 133°43.47E). The reef is around 300 metres offshore across a seagrass bed, with some areas of mangrove along the shoreline. There is an extensive well developed reef flat community that extends for tens of metres back from the reef crest. The reef slopes at an angle of around 50 degrees and descends past the 50 metre mark to a sloping sandy bottom. The reefs in this area are exposed to moderate levels of subsistence fishing, but again there is evidence of bomb fishing in the form of rubble craters (maximised during 2003).

***Sampela***

This site is adjacent to the Bajo village of Sama Bahari (Sampela) which is built on the reef flat (GPS: 05°28.975S 123°44.95E). The site is also subject to large sediment loads and reduced light availability due to this large sediment load (Crabbe and Smith, 2002, 2003, 2004, 2005, 2006). Adjacent intertidal mangroves and subtidal seagrass flats have been highly impacted by anthropogenic activities. The transects were located on a protected reef which slopes at 45 degrees down to a depth of around twelve metres. The geography of adjacent reef systems results in lagoonal characteristics and seasonally high resuspended sediment loads.

***Kaledupa Double Spur***

This site is located near the northern most tip of Pulau Kaledupa (GPS: 05°27.432S 123°42.412E) and has a very varied topography. There are steep walls with high benthic cover, interspersed with shallow, often rubble strewn, sandy slopes. Several spurs stick out from the main reef and descend past 50 metres seawards. Again this site experiences moderate levels of subsistence fishing, usually with hook and line gears.

***Sombano***

The reefs at Sombano are on the western side of Kaledupa island at the northern end (GPS: 05°30.117S 123°42.008E). There is a small settlement on the mainland of Kaledupa at this location separated from the reefs by extensive seagrass beds that extend for over 300m towards the steeply sloping reef that drops of into deep water. As with the Kaledupa Double Spur site, the area is known to local fisherman as a spawning ground and the villagers glean the reefs heavily at low tide, but leave other areas aside for the farming of Agar agar, which also covers large areas of the reef flat.

***Montigola***

The reefs at Montigola are adjacent to a Bajo village on the western side of Kaledupa island (GPS: 05°32.939S 123°44.600E), but of a much smaller scale than that at Sampela. The reefs are several hundred metres offshore separated from the village on the reef flat. The reefs are heavily gleaned as at Sampela and exploited in an artisanal manner with hook and line from small dugout canoes. The reefs are fairly steep slopes with areas of gentle sandy slope in between, often strewn with coral rubble. The reefs descend past 30m and then drop steeply into the depths.

***Taou***

The reefs at Taou are similar in structure and distance from shore as those to the north at Montigola. The village of Taou is on the south western side of Kaledupa island (GPS: 05°35.238S 123°45.320E), and is exploited locally using artisanal methods. There are more extensive rubble strewn areas at this site, while the reef flat is covered with seagrass beds. There are some small areas of mangrove forest along the shoreline. As at Montigola the reefs decline fairly steeply to over 30 metres in depth and then descend almost vertically into the depths.