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# Research proposal for the Wakatobi Marine National Park, Sulawesi Indonesia 2009-2011

*“Survey of the Marine Biodiversity, Ecology and Natural  
Resource Management of the Wakatobi Marine  
National Park, South East Sulawesi, Indonesia”*

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## Abstract

The Coral Reef Research Unit (CRRU) undertakes trans-disciplinary research into coral reef and associated systems and has worked within the WMNP since 2002. It is proposed that the research continues for the period of 2009-2011 during June to August. The following represents a summary of the proposed activities section specific research themes for clarity:

1. **Coral Reef Dynamics:** monitoring of rates of change in the abundance and diversity of key coral reef functional taxa such as hard corals, fish and invertebrate species will take place across transects located at key sites within the Northern WMNP. Inter-annual comparisons of rates of change will be calculated at all sites and vulnerable locations identified. Permanent quadrats located in key since 2005 will be used to assess coral growth and recruitment rates. Global comparisons will be possible through the use of Reef Check surveys across a large area.
2. **Coral Reef Biodiversity:** the diversity, and importantly rates of change, in biodiversity will be ascertained through research theme 1. Research theme 2 will focus on the specifics and examine how different environmental conditions such as light availability and other environmental stressors (i.e. sub-optimal conditions e.g. in mangrove and shallow lagoon patch reefs), impact on coral community diversity. Further research will be implemented to try to increase our understanding of the processes and mechanisms that control / influence community diversity and functional redundancy.
3. **Mangrove ecology:** coral reefs cannot be considered in isolation and the diversity and productivity of reef systems is greatly affected by the health and productivity of linked systems (e.g. mangrove and seagrass beds). Consequently the ecology of mangrove forest around the WMNP will be examined in detail and research will also include in-depth surveys aimed at understanding the process of between-system connectivity.
4. **Seagrass and intertidal ecology:** for the purposes outlined for research theme 3 it is also important that we understand the factors that affect and drive seagrass community structure. Consequently a series of studies will be implemented to characterise the key factors that drive seagrass and intertidal diversity.
5. **Fisheries:** WMNP fisheries are an extremely, locally important, natural resource and evidence suggest that fisheries productivity in the region is declining. Therefore a series of studies will be established to examine and collect simple fisheries parameters to enable us to detail the current status of fisheries in the northern WMNP and highlight specific practises that are having a disproportionate detrimental impact.
6. **Ecotourism:** this is one of the fastest growing industries in the world and this proposed research programme and operation represents a case study. The characteristics of the operation, from a tourism stand point, will be examined and importantly the benefits and possible impacts of tourism (social and economic) will be identified.
7. **Social and Cultural Change:** conservation science and management is truly cross-disciplinary and it is most important that research activities integrate the natural and social sciences. Within this research theme we propose to characterise the key social components of local coastal communities and identify the drivers of change. The social science outputs will be integrated with those produced by the natural science programme so that coral reef managers can utilise a more holistic view when identifying natural resource issues and when considering management interventions.

It is proposed that the research project be run each year for a total of three years, all results obtained each year will be reported on within an annual report. It is envisaged that the field component of the research will take approximately 2-4 months per year requiring 1 or 2 visits to the site. It is also expected that the research will continue to enable the production of high quality publications aimed at increasing our understanding of tropical marine biodiversity, ecology and natural resource management whilst also highlighting and raising the scientific awareness of, the Wakatobi Marine National Park. Awareness will also be increased by results being presented at both national and international conferences.

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### **Proposed composition of the research team**

The proposed research will be coordinated by Dr David Smith. In collaboration with Dr Smith other researchers will help deliver the programme. Tentative research collaborators are:

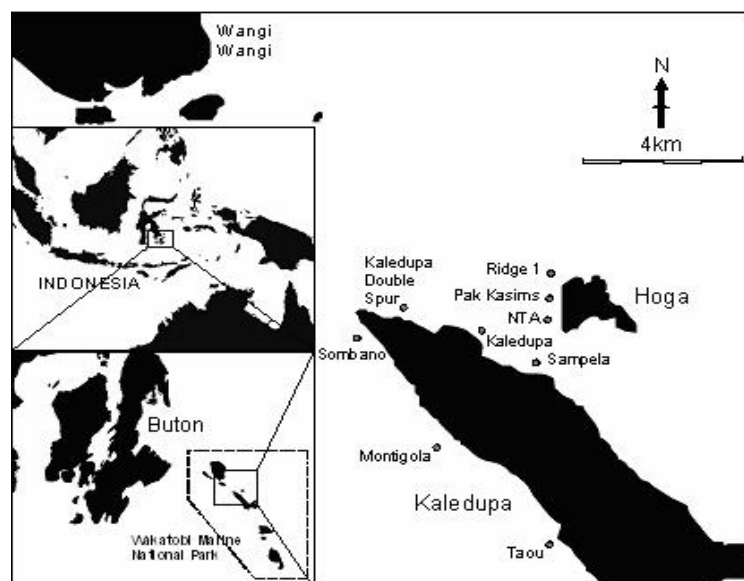
Prof Jamal Jompa	UNHAS and The Wallacea Foundation, Indonesia
Dr James Bell	University of Wellington, New Zealand
Dr David Suggett	University of Essex, UK
Dr Richard Barnes	University of Cambridge, UK
Dr Simon Cragg	University of Portsmouth, UK
Dr Herawati Sudoyo	Eijkman Institute, Indonesia.

## Background

The Coral Reef Research Unit (CRRU) is a UK based research body that undertakes trans-disciplinary research into coral reef and associated systems both in respect to the natural and social sciences. The CRRU is administered at the University of Essex, UK one of the UK top research institutes, is under the direction of the author and encompasses an advisory board of some 40 academics, mostly from the UK but also from Indonesia (e.g. UNHAS, The Wallacea Foundation), Australia, USA, Egypt, Seychelles and Honduras. The CRRU directs and implements the marine research initiatives of Operation Wallacea.

The primary focus of the CRRU and Operation Wallacea activities within the Wakatobi is to examine and evaluate conservation strategies and to gain a better understanding of coral reef ecology, biology, ecosystem dynamics, architecture and services and importantly ecosystem connectivity, exploitation and sustainable utilisation. The research undertaken within the Wakatobi (see figure 1) is unique within the region and utilises a truly cross-disciplinary approach. Marine science research is mainly focused on the island of Hoga at the Hoga research centre but some of the social and fisheries aspects will require visits to nearby communities. For clarity and focus the research activities can be divided in to separate research themes but in reality there is much linkage between themes. During 2009 through till 2011 we aim to continue the high level research and to address key questions. We aim to produce quality outputs which will continue to be submitted to top flight international journals (See Appendix 1 for publications stemming from the 2007-2008 research). No specific research timetable is given for the three years because the research is continuous and no distinction can be made between each year.

**Figure 1: The location of the Wakatobi Marine National Park and the key sampling sites**



## 1.0. Coral Reef Dynamics

### 1.1. Coral Reef Monitoring Programme.

The Coral Reef Monitoring Programme (CRMP) was established in 2002 and since that time repeated annual surveys have taken place at key designated sites within the northern Wakatobi. The 2009-2011 CRMP will continue the annual time series data collection so that rates of change in habitat quality as well as changes in key taxa can be determined. The data collected thus far have supported many publications and help identify key trends in coral reef status in the region. The CRMP returns a very large amount of high quality data that can be used to address many subsidiary research questions. The main aims of the 2009-2011 programme is as documented previously:

- 1). To determine the quality of benthic habitats of specific reef sites subjected to different environmental conditions, management practises and exploitation rates.*
- 2). To determine the abundance and in cases, the size frequency distribution, of economically or ecologically important invertebrate species at specific reef sites subjected to different environmental conditions, management practises and exploitation rates*
- 3). To determine the abundance of coral reef fish within specific reef sites subjected to different environmental conditions, management practises and exploitation rates.*
- 4). To quantify the rates of change in key coral reef organisms (coral, invertebrates and fish) over a 7 year period and to relate rates of change to varying environmental conditions, management practises and rates of exploitation.*

#### 1.1.1. Survey design and study sites

Three replicated transects will be located within three reef zones: a) upper reef slope (10 m), b) reef crest and c) reef flat 10 m horizontal distance on the landward side of the reef crest. Due to the methodologies used, which are resolute and robust, in previous years the number of sites that could be observed and studied over an 8-week research period was restricted to 6. This restriction is mostly due to the technique used to accurately and precisely assess the benthic features of reef systems. 50 m continual line transects will be used and a high definition underwater video camera will be used to record, at a fixed distance from the benthos, each transect line. The video footage, which will be of high quality will then be analysed back at the field facilities.

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The proposed sites (conditions and time depending) are:

1. Hoga home reef No Take Area (B 3)
2. Hoga home reef unmanaged (Pak Kasims)
3. Sampela reef (Sampela B1 light limited)
4. Kaledupa Reef (Kaledupa B1 – moderately exposed reef)
5. Kaledupa Double Spur (exposed reef)
6. Ridge reef system (Ridge 1- unimpacted exposed reef system)
7. Sumbarno (heavily exploited reef system)
8. Mentigola (Southern reef system)
9. Tomea (protected reef system)
10. Wanci atoll (isolated reef system)

### 1.1.2. Data collection

*The sample unit:* 50m transect tapes will be laid at each depth in replicates of three. Each transect (replicate) will be separated by at least 20 m. The transects will be established at least 15 min before commencement of the surveys. The starting point of each transect will be marked using GPS to enable data to be entered in to a GIS database.

*Benthic habitat quality:* High definition video footage will be taken of each transect. The surveyor will keep a fixed distance of 1 m above the transect tape ensuring the angle of the camera is kept at a constant 90°. The footage will be analysed back at the field facilities and kept for future reference. Analysis of the footage will involve identification of the benthic life form (to at least genus level in all cases) and the distance along the transect line that the life form changes. This continued line intercept technique provides the most resolute and sensitive data. Seventeen categories of benthic life form will be recorded along with taxonomic identification to genus, and where possible, species level. The percentage cover and abundance of each coral genus along the 50 m replicated transects will be recorded. Rates of change in the key benthic features (e.g. coral cover) will be determined by interannual comparisons of the data sets. Vulnerable sites will be identified as those sites showing significant declines in habitat quality.

*Fish Abundance, population structure and diversity:* Time and distance restricted transects will be used to characterise the fish community of each monitoring transect. The sample unit will be the same as explained above and therefore the transect length will be 50 m. A belt transect, of standardised effort (20 mins per transect) will be used as a moving box technique. The number of fish (to a minimum of family level, but to species level wherever possible) 5 m either side of the transect line and 5 m above the transect line will be recorded along the transect length. Inter site (horizontal data) and inter annual (longitudinal data) comparisons will enable sensitive sites and vulnerable fish taxa to be identified.

*Invertebrates*: Ecologically and economically important invertebrate species will be examined along the same transect lines. A belt transect of 1.5 m either side of the central transect line will be used to assess selected invertebrate groups using a standardised effort of 20 mins survey time per transect. The size frequency distribution of key groups such as Holothuroidea and commercially exploited molluscs (e.g. *Tridacna* spp), and ecologically important taxa such as *Acanthaster planci* (Crown of Thorns Starfish) will also be recorded. Other taxa to be recorded include the coralivorous *Drupella* and ecologically important *Diadema*.

### 1.2. Research Activity: Reef Check Surveys

The CRMP protocols require a great deal of expertise and resources. The procedures have been specifically designed for the Wakatobi MNP around the key objective of detecting annual rates of change, which could be small and thus required a very precise and accurate methodology. Such detailed and resolute long-term programmes are rare. Global programmes do exist that require a lower skill level and amount of resources whilst at the same time allowing broad scale comparisons between different reef sites over large bioregional scales. Such a global programme is Reef Check. Therefore Reef Check surveys will be carried out throughout the Wakatobi MNP during 2009-2011. The specific aim of our reef check surveys are two fold:

1. *To know how the health of reef systems of the Wakatobi compare to reefs within the Indo-Pacific region.*
2. *To enable results obtained from the Wakatobi to be fed in to a global data base of reef check sites.*

The procedures used are standardised (see [www.reefcheck.org](http://www.reefcheck.org)). The main objective of the Operation Wallacea Reef Check programme is to survey as many sites as possible over as wide a geographical range as possible throughout the course of the 10-week research season. During 2006-2007 over 60 sites were surveyed around the islands of Wanci, Kaledupa and Tomia, a similar level of sampling effort is envisaged for the next 3 years (Prevailing conditions and resources dependent). Reef Check surveys will also be carried out at least 5 of the Monitoring stations to allow comparisons between the two procedures.

### 1.3. Research Activity: Coral Reef Growth and Recruitment

Since 2005 three replicated quadrats, each of 10 m long and 2 m wide have been permanently fixed to the substratum at a depth of 10 m (to the central point) at Hoga B3, Sampela B1, Pak Kasims, Kaledupa B1 and Ridge 1. The species composition of all corals has been recorded in each of the quadrats along with the maximum width, length and height of all massive coral colonies. During the next three years the quadrats will be re-assessed and the linear extension rates of each massive coral colonies will be calculated so that the growth rates of massive corals can be

determined at the five contrasting sites and annual growth compared over the years. New coral recruits will be identified and recruitment rates per unit area at the five sites will be calculated and again compared between years to determine long terms inter annual variability. Consequently this research activity aims to:

1. *Evaluate rates of massive coral species growth and recruitment within contrasting reef sites of the Wakatobi MNP to enable inter-annual comparisons to be made between sites.*

## **2.0. Theme 2: Coral Reef Biodiversity**

### **2.1. Research Activity: Light-limited Coral Reef Systems and reefs of marginal habitats**

One of the key factors that impact reef systems is reduced water quality. Reduced water quality, and in particular, increased sediment load with a concomitant reduction of light penetration, can reduced species diversity, productivity and the physical integrity of coral reef systems. Consequently during the next three years, detailed studies examination of the diversity, ecology and physiology of a light limited reef will be undertaken. It is likely that as costal populations expand, many more reefs will be impacted to the same extent as the light-limited site in the Wakatobi and therefore information obtained from this research activity is particularly important. Data concerning the growth and recruitment of corals within a light-limited system, coupled with rates of change will be obtained from the fixed quadrats and CRMP respectively. The specific aim of this research task is to:

1. *Determine how coral reefs are affected by reduced light and to gain an understanding of why some species can tolerant low light environments whilst others cannot.*

Specifically this research activity will build on previous work that examined how corals (further partitioned into coral host and symbiotic zooxanthellae) acclimate to different light environments and how photoautrophy:heterotrophy (metabolic plasticity) is modified. Interspecific comparisons will be made to determine the impact of light (and therefore sediment) on coral distribution / success. Specimens and results obtained from reef habitat will be compared to the physiological characteristics of corals found in marginal habitats. Corals of marginal habitats can be considered robust and detailed understanding of their physiology may allow us to identify mechanisms of tolerance and sensitivity within the context of climate change scenarios and other human impact. It would be very advantageous if samples of the microalgae, from the coral, could by taken back to the CRRU laboratories for identification which requires specific expertise and equipment not available at the site.

Generally the photophysiology of selected corals species (those abundant in light-limited conditions compared to otherwise dominant species not found on light-limited reefs) will be investigated through non-invasive fluorometric techniques. It is envisaged that corals (different tolerant and non-tolerant species) will be sampled along a depth gradient across reef systems characterised by different ambient light environments (from optimal to sub-optimal (marginal)). Other physiological variables and parameters will also be measured and obtained thereby giving us a more complete idea of how coral species will be affected as environments reduce in quality.

## 2.2. Research Activity: Diversity of Shallow Water Patch Reefs

Situated within lagoon systems are numerous patches of corals of various sizes and degrees of isolation. These patch reefs have high conservation value as they harbour many more species than the surrounding vegetated or non-vegetated habitats. Furthermore, where there is strong ecosystem connectivity between reef and mangrove, which is known to have an increase in overall system diversity, patch reefs could be essential as refuge for migrating species. The relationships between the physical and biological characteristics of these patch reefs and the diversity of the associated fauna is unknown. These coral patches also exist in areas that are most often characterised by high light and fluctuations in temperature. In many cases they therefore represent quite harsh environments that are susceptible to damaging environmental conditions. They have also in the past, been heavily exploited by the local coral mining trade. This research activity is therefore aimed at gaining

1. *Understandings of the importance of these patch reefs to system diversity whilst also identifying the characteristics that are important in sculpturing the structure of the associated resident as well as transient community.*

Because the patches, or coral bommies, are isolated from the source of the majority of the associated species, the coral bommies also make an ideal system to examine theories of Island Biogeography, a theory which was first discovered in Wallacea.

The density of coral bommies, their size and benthic characteristics will be examined in three different zones: near reef, mid lagoon and far reef. The associated community structure (including identification of fish cryptic species through collaborative institutes) will be determined through time-restricted surveys. The fish community structure of the coral bommies will be ascertained along with the fish community structure of adjacent vegetated and non-vegetated (as a gradient) habitats. The degree of permanency as compared to transience of associated fish on coral bommies located in the different zones will be determined by repeated surveys of a minimum 10 coral bommies in each zone. The effects of size and physical complexity on the degree of permanence and transience will be determined. The main output will be detailed information concerning the importance of coral

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bommies to ecosystem diversity, identification of the key physical and biological factors that drive patch reef diversity and their relative conservation value.

### **2.3. Research Activity: The abundance and diversity of exploited fish species within a previous No Take Area**

During 2002 a social and biological experiment was set up on the Hoga home reef adjacent to the marine research facility. Through a series of participatory approaches, a small scale No Take Area (NTA) 500 m long and 30 m beyond the reef crest and back to the shoreline was established. Continued monitoring of the NTA as compared to sites immediately adjacent and with increasing distance from the NTA have been carried in the years since. During 2006 the NTA was once again open to fishing and therefore this research activity aims to continue detailed assessment of the effects of renewed fishing within the area and to compare changes in fish abundance and population structure before, during and after fisheries exclusion. Consequently this research activity aims to:

1. *Determine the biological success of small scale NTA's and the consequences of changing management practises*

A series of transects will be established within the NTA, immediately outside the NTA and at least two other sites with increasing distance from the NTA. Time and distance restricted belt transects (as explained for the CRMP) will be used to assess the abundance and size frequency distribution of economically important fish including Grouper, Snapper, Trevally and Emperors. Comparisons between years, both of the overall abundance and size frequency distribution will enable us to identify whether or not populations are expanding or contracting, whether the mature population is increasing or decreasing and therefore whether the NTA is successful in protecting otherwise heavily exploited species even though fisheries activity as resumed. During 2009-2011 the data collected will be relayed back to government and park authorities and rates of change in abundance during exclusion and post exclusion used to demonstrate the benefits of strictly protected areas.

### **2.4. Research Activity: Resource utilisation and partitioning amongst key coral reef fish Taxa**

Coral reefs are the most diverse of marine systems and are characterised by extreme species richness. One of the main question facing reef ecologists is why coral reefs are so diverse and if habitats become impacted, as is increasingly the case, what species are most likely to loose out? This research activity is focused on trying to gain an understanding of how different fish taxa, seemingly utilising similar resources, co-exist in an extremely competitive environment. The research activity also aims at addressing the issue of environmental degradation and its relative affect on different

coral reef fish the main question being which species will win out in environments where available resources have been reduced. This is particularly important as there will be a critical threshold of loss that will result in reduced functional redundancy. Functional redundancy represents the capacity of a system to maintain its current stable state. Once it reduces past a pivotal point an alternative stable state is reached (e.g. from coral to an algal or sponge dominated system) often with a mass loss of diversity and productivity. The threshold redundancy levels of Indo-Pacific reefs have not yet been calculated and with impending climate change predicted to have a large effect on functional groups, it is extremely important that we gain a better understanding of the functionality of reef systems and the critical biomass of functional groups that are needed to maintain the diversity and productivity of coral reef systems. Therefore the overall aim of this research activity is to gain an:

- 1. Understanding of resource utilisation by model fish taxa and how patterns of utilisation vary across reef systems of different qualities.*
- 2. Levels of functional redundancy of reefs of different habitat qualities and predicted levels needed to maintain ecological stability.*

The research activity will focus most on changes in feeding behaviour and space utilisation in key taxonomic groups of reef fish, namely Butterflyfish, Parrotfish, Damselfish, Cleaner fish and Angelfish. The relative abundance of these fish taxa will be determined as part of the monitoring programme as will differences in habitat quality amongst the reef sites. To assess functionality, detailed information will be obtained on key ecological processes such as algal removal through feeding.

Surveys of the behavioural characteristics of each taxa will first include the production of an ethogram. Each taxa will be observed for at least 10 hrs (on different reef systems) and behavioural traits identified and characterised. Individuals (replicated at least 10 times on different reef systems) will then be observed at different times of the day for a minimum of 30 mins. Time budget analysis will be carried out to determine differences in behaviour between the different reef sites. As part of the behavioural studies, feeding behaviour will be examined in detail. Feeding behaviour, and hence resource utilisation and functionality, will be characterised for each of the taxa using representing species as test / model species. Specifically the food item of the species as well as feeding strategy (diffuse vs. focus feeding) will be examined and compared to the availability of this food item within the environment. Species which are seen to be abundant on reefs of different qualities as compared to those species whose abundance varies to the great extent will be selected. It is hypothesised that those species with a more cosmopolitan distribution will alter their behavioural characteristics to best suit the environment. This degree of “behavioural plasticity” will be compared within species, across species and specifically across functional feeding guilds to help address the question of what species will be able to exist on reefs with reduced habitat quality and resource availability.

Specialised fish groups will also be examined to determine how specific behavioural responses change. Cleaner fish play a very important role of reef systems and provide a service to other fish (termed clients) by removing ectoparasites and organic debris from their skin. Cellular debris and ectoparasites reduce the fitness of clients. Studies will be carried out to determine the density of cleaner stations across reefs of different habitat quality. The types of clients and selectivity of clients will also be assessed. In particular differences in selectivity of the cleaners between species and sites will be examined to determine the behavioural response of cleaners to a reduced quality environment. Mathematical models will be used, based on cuing theory, to identify client strategies, the question being do these change on reefs of different quality.

As cleaners play such an integral role and are characterised by complex behavioural interactions, this groups can be consider a model taxa to investigation the complex behavioural traits of coral reef fish.

## **2.5. Research Activity: The importance of individual coral colonies in supporting coral reef fish**

One of the key features of coral reefs that are important in influencing system diversity is topographic diversity or spatial heterogeneity. That is, a more complex physical habitat increases microhabitat availability with a concomitant increase in species richness. On a smaller scale, many coral colonies have different topographies. Many of these physically complex coral genera are sensitive to environmental change e.g. Acroporids and Pocilliporids. They are therefore often the first species to be lost from a system when it has been perturbed. What is not known is what this loss means to overall reef diversity as a direct result of the loss of physical structure, microhabitat availability and consequently the diversity of future reef systems that have negatively been impacted by climate change. Therefore this study is aimed at gaining an understanding of what species utilise different coral colony types (e.g. branching, tabulate, foliose and massive growth forms) and what are the physical features of these coral taxa that increase associated fish community richness . More generally the research task aims to increase our:

1. *Understanding of the importance of individual coral colonies in supporting coral reef fish diversity.*

At least 30 coral colonies of each type will be examined on a degraded and less impacted reef system. The physical characteristics of each colony will be fully described (size, area, depth from substratum, inter-branch spaces). The species present within or adjacent to the coral colony will be determined and their relative

position to the coral ascertained e.g. within branches, above colony, below colony. It is possible that the relative importance of individual coral colonies will vary between sites and therefore inter-site comparisons will be made based on the percentage of overall fish species richness associated with coral colonies (using data obtained from the CRMP). It is quite possible that some species will utilise colonies on a temporary basis only. Therefore at least 5 colonies of each type and of specified size classes will be reassessed at each site to examine whether colony communities are mostly permanent or transient and whether this varies with reef quality.

## **2.6. Research Activity: Benthic competition on coral reefs**

Corals reef are highly competitive environments and three functional groups actively compete for the limited resource, space. The outcomes of competitive interaction are dependent on prevailing environmental conditions. Such conditions include light environment, temperature and relative levels of disturbances. Environmental conditions are predicted to change radically over the next century which will also serve to influence the competitive ability of the different functional groups. The main space competitors on reefs are hard corals, soft corals, sponges and macroalgae. This research activity will examine the dynamics of the functional groups and how their relative abundance and biological structure changes with environment. Consequently sponge skeletons will be extracted and spicules used for identification purposes through collaborative institutes. This research activity therefore aims to:

- 1. Increase our understanding of competitive interactions amongst key functional groups of coral reef based organisms and how success is affected by a changing environment.*

## **2.7. Biological characteristics of the Gorgonian community**

Gorgonian corals (Cnidaria: Anthozoa: Octocorallia) are conspicuous, diverse and often dominant components of polar to equatorial benthic marine habitats. They provide secondary space to other organisms, enhancing habitat structural complexity and biodiversity. Gorgonian abundance, diversity and distribution depend upon environmental factors such as substratum type, light, temperature, current regime and flow rates, which have been shown to induce intra- and interspecific morphological differences both within and between individual colonies. In the advent of global climate change, however, understanding patterns of gorgonian variation in response to such environmental parameters is becoming increasingly important in management and remedial conservation efforts. Yet little is known of the ecology, biology and variable responses of gorgonian taxa relative to environmental parameters, particularly in the Indo-Pacific, despite their high regional abundance and diversity. Consequently this research activity (in collaboration) aims:

1. *To assess the distribution, abundance and morphological variations of gorgonian species across sites of varying natural and anthropogenic exposure and recovery;*
2. *To examine the genetic structure of gorgonian populations*

### **3.0. Theme 3: Mangrove Ecology**

Previous studies have demonstrated that a high degree of connectivity exists between coral reefs and adjacent habitats. Seagrass studies previously carried out in the Wakatobi have shown that coral reef fish utilise seagrass beds at different stages of their life cycle (ontogenetic shifts), during certain tidal stages and at different stages of the diurnal cycle (see Appendix 1 for recent publications). Seagrass beds are therefore paramount in defining the diversity and productivity of coral reef systems. However the relative importance of mangroves, although known in other bioregions and theorised within the Indo-pacific, has not been examined using this underlying hypothesis of habitat connectivity.

#### **3.1. Research Activity: Importance of mangrove habitats in supporting adult as well juvenile fish populations and the degree of connectivity between adjacent systems.**

In 2009-2011, intensive surveys will be carried out on mangroves that are associated with a) seagrass only, and b) associated with seagrass and coral reef, as well as c) of different habitat quality (e.g. different levels of mangrove exploitation).

1. *To identify the degree of connectivity within and between mangroves, seagrass beds and coral reefs.*

#### **3.2. Research Activity: Importance of mangrove in supporting model invertebrate groups.**

Apart from supporting fish, mangrove also support many invertebrate species both within associated sediments (e.g. burrowing crustacea) and attached to mangrove roots. Decaying mangrove wood is an important habitat and samples will be analysed to examine decomposition characteristics (through collaborative institutes as technology does not exist within the field). During 2009-2011 and beyond detailed surveys will take place to examine the ecology and diversity of invertebrates associated with mangrove using a series of permanent plots located in different areas of the mangrove (relative to tidal height) and within mangroves from different areas (and characterised by different levels of exploitation). Within these areas the abundance of invertebrates and floristic characteristics of mangrove plants will be determined. The plots will be permanently marked allowing successive years sampling and therefore a) the rates of change in mangrove invertebrate populations as well as b) changes in floristic characteristics, to be determined. By examining

markings of mangrove trees coupled with information on the floristic change, it is also possible that the exploitation of mangrove, primarily for firewood, could also be ascertained in future years. The aim of this research task is therefore:

1. *To establish permanent mangrove monitoring plots and to obtain baseline data on mangrove invertebrate populations and mangrove floristic characteristics to which future assessment can be compared.*

#### **4.0. Theme 4: Seagrass and Intertidal Ecology**

Aspects of seagrass ecology will be characterised as part of earlier research themes e.g. Theme 2 *Coral Reef Biodiversity: Research activity Diversity of Shallow Water Patch Reefs* – will also include data collection of seagrass fish and vegetation characteristics through a number of replicated belt (fish and invertebrates) and line (benthic characteristics) intercept transects (as explained previously). During 2006-08 a number of papers were published or submitted that examined herbivore as well as habitat connectivity (see Appendix 1), within the seagrass beds and this will be built upon in 2009-2011 and beyond by examining the three-way interaction between seagrass, mangrove and coral reefs as explained in the Mangrove Theme above.

Agar farming is now common place within the Wakatobi but we still have a limited understanding of how Agar farms affect local fauna and flora. Several preliminary studies have demonstrated a positive role whilst others have actually demonstrated a negative role and we have to conclude that the impacts of agar farming is dependent on the location at which the agar beds are placed and the way in which they are placed. This will form the basis's of the hypothesis tested between 209-2011. Therefore the aim of this study is:

1. *To determine the effects of agar farming on the abundance, diversity and community structure of shallow coastal species and to determine if agar beds located in different places and in different ways have different relative impacts on associated FAUNA AND FLORA.*

#### **5.0. Theme 5: Fisheries**

The Wakatobi, despite being a Marine National Park, is a working reef and studies carried out by Cullen during 2005-2006 clearly demonstrated that local communities are most often 100 % dependent on marine resources as a source of subsistence and / or economics. A number of exploitative activities occur but by far the most important, both in terms of local economics and system degradation, is fisheries. Fisheries in the Wakatobi MNP are seasonally and although a large proportion of the fisheries effort is pelagic based, there is still high exploitation of coral reef fish particularly by local Bajo communities. There is a continual need to assess the characteristics of natural resource exploitation and to undertake inter annual comparisons on catch and exploitation rates. This information is fed directly back to

authorities. Human populations cannot be excluded from ecosystem ecology and are integral components of the system. Therefore during 2009 – 2011 this research aims:

1. *Increase our understanding of natural exploitation rates and the effects on affected species and habitats*

### **6.0 Theme 6: Ecotourism**

The research ecotourism run by Operation Wallacea functions as an important generator of income within the Kaledupa Area through the supplies and services which are sourced from local communities, as well as the direct economic impact through employment, rental of houses for volunteers and other income streams. Conservation of biodiversity has to be balanced with the economic requirements of local communities. There is a great demand from local communities for the level of ecotourism activity within the Kaledupa area to keep on increasing however increased levels of tourism will bring its own problems and one of the key questions to address is what is the carrying capacity of the area after which time the key attractor (i.e. high quality environment and cultural diversity) is lost. Part of this research theme will be focused on identifying limits to ecotourism growth whilst the second part will focus on identify potential social, cultural and environmental impacts in a balanced and neutral manner. The research aim is therefore general and all encompassing:

1. *To understand the advantages and disadvantages of eco-tourism and the potential for sustainable tourism growth.*

### **7.0 Theme 7: Social and Cultural Changes**

The communities within the Wakatobi are subject to change from a variety of pressures: increasing economic input, education, change in the way their natural resources are managed, access to media and the presence in the area of western visitors and Kaledupans who have lived and worked in other parts of the country or overseas. Through a series of questionnaires, interviews and semi structured issues this research theme examines how these social changes are affecting the communities.

1. *To understand the rates of change in key community social, cultural and economic attributes and to identify the causes of change*

Throughout the study period the vulnerability , adaptability and economic diversity of different communities will also be examined.



## Appendix 1:

### Examples of Journal papers published during from the Wakatobi 2007-2008

1. Hennige SJ, Suggett DJ, , McDougall K, Warner M. **Smith DJ** (2008). Photoacclimation of symbiotic dinoflagellates revisited: Bio-optical and biophysical signatures. *Coral Reefs*. DOI 10.1007/s00338-008-0444-x
2. Unsworth RKF, De León PS, Garrard SL, Jompa J, **Smith DJ**, Bell, J. (2008). High connectivity of Indo-Pacific seagrass fish assemblages with mangrove and coral reef habitats. *Marine Ecology Progress Series*.353: 213-224.
3. Hennige SJ, **Smith DJ**, Perkins R, Consalvey M, Patterson DM, Suggett DJ. (2008). Photoacclimation, growth and distribution of massive corals in clear and turbid waters. *Marine Ecology Progress Series*. 369: 77-88.
4. Suggett DJ, Warner M, **Smith DJ**, Davey P, Hennige S, Baker NR. (2008) Photosynthesis and production of hydrogen peroxide by symbiotic dinoflagellates during short-term heat stress. *J. Phycology* 44. 948-956
5. Pilgrim, S.E., **Smith, D.J.** and Pretty, J. (2008) A cross-regional quantitative assessment of the factors affecting ecoliteracy: Policy and practice implications. *Ecological Applications*. 17, 1742-1751.
6. Pilgrim, S., **Smith, D. J.**, Pretty, J. and Cullen, L. (2008). The Loss of Local Ecological Knowledge as a Consequence of Livelihood Diversification in Indonesia: Implications for Natural Resource Management. *Environment, Science and Technology*. 17: 1742-1751.
7. **Smith DJ**, Etienne, M, Spring N and Suggett DJ (In press). Duel mechanisms of coral bleaching. *Proceedings of the International Society of Coral Reefs*. Florida.
8. Unsworth, R. F. K., Jompa, J., DeGrave, S., Bell, J and **Smith, D. J.** (2007). The role of habitat complexity in structuring seagrass faunal communities. *Marine and Freshwater Research*.58 (11).
9. Cullen, L., Pretty, J. **Smith, DJ**, Pilgrim, SP. (2007) 'Links Between Local Ecological Knowledge and Wealth in Indigenous Communities of Indonesia: Implications for Conservation of Marine Resources. *The International Journal of Interdisciplinary Social Sciences*.2 (1) pp 289-299
10. Unsworth RKF, Wylie E, **Smith DJ**, Bell JJ, (2007). Diel trophic structuring of seagrass bed fish assemblages in the Wakatobi Marine National Park, Indonesia. *Estuarine, Coastal and Shelf Science*. 72: 81-88.
11. Unsworth RKF, Taylor, JD., Powell, A., Bell, J. and **Smith, D. J.** (2007). The contribution of scarid herbivory to seagrass ecosystem dynamics in the Indo-Pacific. *Estuarine, Coastal and Shelf Science*.74: 53-62
12. Unsworth R.K.F, Powell, A., Hukom, F., **Smith D.J.** (2007). The effectiveness of small scale 'No-take Areas' as tools in conservation management of locally exploited coral reef fisheries. *Marine Biology*.1152: 243-254
13. Pilgrim, S, E., Cullen, L., **Smith, D. J.** and Pretty, J. (2007). Hidden Harvest or Hidden Revenue? The effect of economic development pressures on local resource use in a remote region of southeast Sulawesi, Indonesia. *Indian Journal of Traditional Knowledge*. Volume6: 150-159.
14. **Smith DJ**, Pilgrim S, Cullen L, (2007) *Coral Reefs and People*. Chapter 35. In Pretty, J., Ball, A., Benton, T., Guivant, J., Lee, D., Orr, D., Pfeffer, M., Ward, H. (Eds.), *SAGE Handbook on Environment and Society*. SAGE, London.
15. Haapkyla, J., Seymour, A.S., Trebilco, J., **Smith, D.J.** (2007). Coral disease prevalence and coral health in the Wakatobi Marine Park, South-East Sulawesi, Indonesia. *Journal of the Marine Biology Association of the UK*. 87, 5582: 1-12.

Four other papers are currently In review

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