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REEF RESEARCH

GREAT BARRIER REEF
MARINE PARK AUTHORITY

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Editorial

Well, another year has come and gone and what a busy one it was.

In 2000, Reef HQ and the Authority's Public Information and Production and Media and Public Affairs units were consolidated into a communication and Education Group. Part of this new group's brief will be to review the products that the Authority currently produces and this newsletter will be among those that are reviewed.

There is no Reef Management News in this issue of *Reef Research* so for those of you who were looking forward to it I offer my apologies. There is however, a mixed bag of other interesting stories that may grab your attention.

The occurrence and impact of herbicides in the Great Barrier Reef, particularly in relation to seagrasses, is discussed in *What's out there?* The research described in this article will greatly assist managers and the like understand the effects of herbicide runoff on seagrasses.

Kirsten Michalek-Wagner and others provide a brief update on a monitoring project that is being carried out in the Torres Strait on heavy metals. A baseline study was initiated in 1990 — with a more comprehensive study being undertaken in 1992–93 — which showed that high levels of various trace metals were found in some of the seafoods eaten in the Torres Strait Islands. Funding was granted in 1998 for further monitoring of these heavy metals and as Kirsten reports the data is currently being analysed.

A light-hearted look at spawning is the focus of Martin Russel's story entitled 'Do fish doing the tango have protection?' Martin attended the American Society of Ichthyologists and Herpetologists Annual Meeting in Mexico and presented a paper on protecting fish spawning aggregations in the Marine Park. He kindly provides us with a report on that meeting.

Focusing on the social sciences for a moment, Gianna Moscardo, from the CRC Reef Research Centre, gives an overview of a project which looks at understanding tourists' knowledge and perceptions of the World Heritage status of the Great Barrier Reef. Overall, it appears that tourists visiting the Reef are concerned about it but really don't know why the area is important or what activities threaten it.

Bryony Barnett provides an update on the Authority's Representative Areas Program and encourages everyone with an interest in the program to have input.

I join with David Haynes to provide our readers with a brief overview on the Strategic Partnerships with Industry–Research and Training (SPIRT) grants the Authority is supporting as an industry partner. This article was written some months ago and since then an additional SPIRT grant, where the Authority is an industry partner, has been awarded. The project is entitled 'Change in the coastal habitats of the Great Barrier Reef region since European settlement: implications for contemporary management'.

WHAT'S IN THIS ISSUE

REEF RESEARCH:

Adam Smith, Colin Trinder and Paul Marshall present a brief overview of the environmental management of defence activities in the Great Barrier Reef World Heritage Area. Last but not least there is an article on site planning in the Great Barrier Reef Marine Park by Johanna Johnson and co-workers.

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Views expressed in *REEF RESEARCH* are not necessarily those of GBRMPA.

Readers are invited to submit material for publication. Inclusion is the decision of the Editor. All contributions or inquiries should be addressed to:

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The Occurrence and Impact of Herbicides in the Great Barrier Reef, Australia

David Haynes[1], Peter Ralph[2], Jochen Müller[3], Joelle Prange[3], Kirsten Michalek-Wagner[1] and Jane Waterhouse[1]

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Background

Australia's 32 000 km of coastline contains the largest and most diverse seagrass assemblages in the world (Kuo & McKomb 1989; Walker et al. 1999). These seagrasses are significant primary producers (Walker et al. 1999) and play an important role in the cycling of marine nutrients and as stabilisers of the coastal seabed (Fonesca & Kenworthy 1987). Seagrasses also create habitats with high biodiversity and productivity which provide nursery grounds for many juvenile invertebrates and vertebrates (Edgar & Shaw 1995). The importance of seagrass beds for commercial and recreational fisheries is well established (Bell & Pollard 1989). Seagrasses are also of great ecological importance as food sources for species such as green turtles and dugongs (Wachenfeld et al. 1998).

Seagrass Meadow Decline

Seagrasses have received considerable attention during recent years following the significant decline of seagrass beds both in Australia and elsewhere (Walker & McComb 1992; Preen et al. 1995; Short et al. 1996; Kirkman 1997). Approximately 1450 km^2 of seagrass beds have been lost in Australia over the last 10 years (Kirkman 1997). This loss has been attributed to natural causes as well as human impacts. The general hypothesis related to seagrass loss is that increased turbidity in coastal zones has decreased the amount of light reaching submerged plants (Walker et al. 1999). As a consequence, the photosynthetic output of affected plants is reduced, which ultimately has the potential to lead to the death of the plant.

There are, however, alternative factors which may contribute to decline in seagrass meadows. These include the impact of herbicide run-off from adjacent agricultural lands. To examine the potential risk of herbicide run-off on the Great Barrier Reef, two studies were carried out in 1998 and 1999. The first study comprehensively surveyed concentrations of herbicides in the nearshore marine environment along the Queensland coast; and the second assessed whether the levels of any detected herbicides had the potential to harm local seagrass meadows.

Sediment Herbicide Concentrations

Marine sediment samples were collected from 51 subtidal locations between Torres Strait and Gladstone in 1998 and 1999 (figure 1). All sampling sites were located in shallow water in major estuaries and northward facing bays (sediment accumulation areas) along the northern and central Queensland coast. Collected sediment samples were analysed for a range of herbicides at the laboratories of Queensland Health and Scientific Services. The herbicide diuron was detected at nearly all sampling sites between Townsville

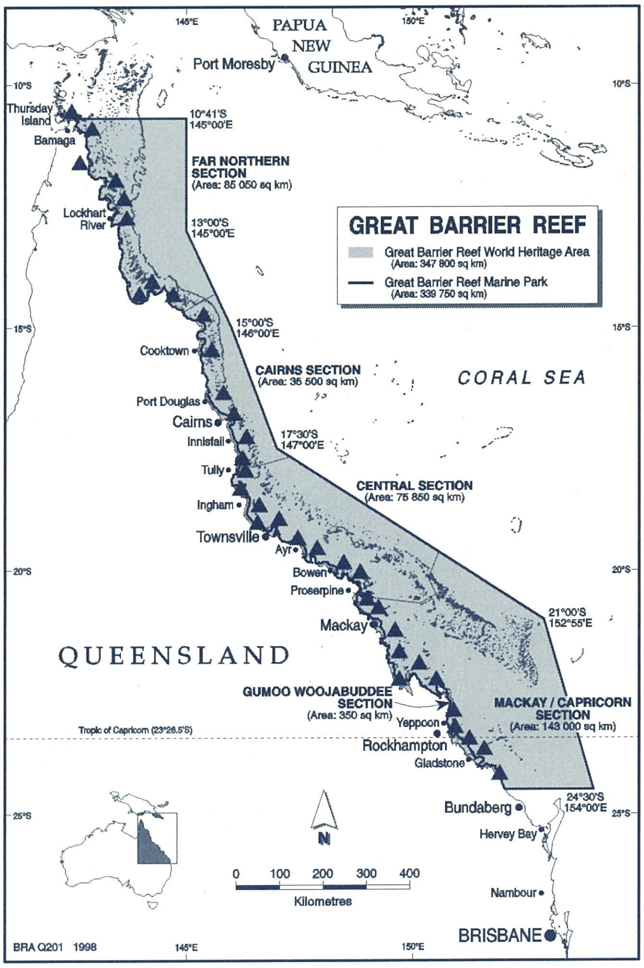

Figure 1. Approximate locations of subtidal sediment sampling sites, 1998 and 1999.

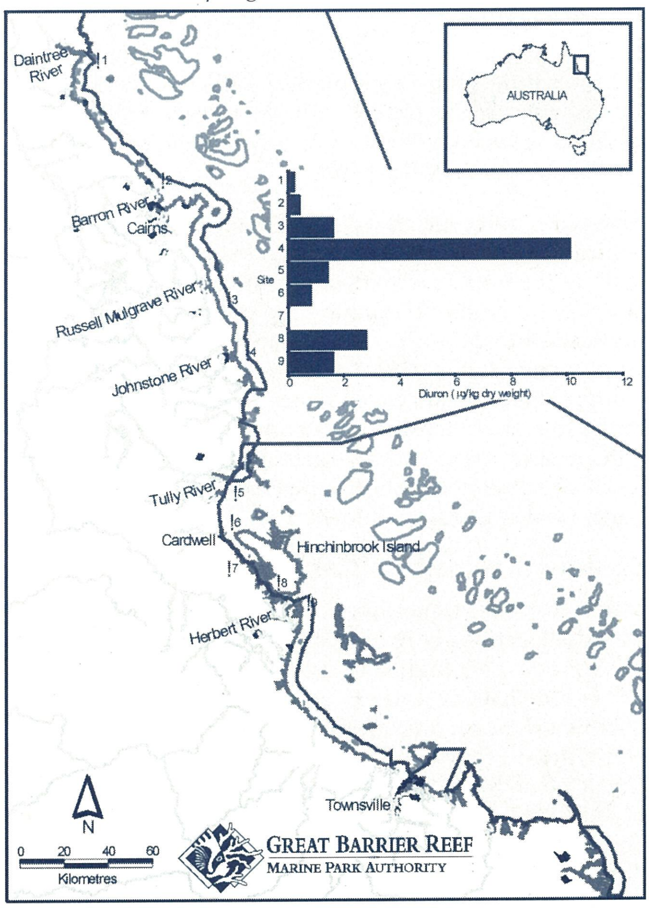

Figure 2. Subtidal diuron concentrations (µg kg^{-1}), Wet Tropics region, Queensland.

and Cairns (figure 2) and in Repulse Bay, Whitsundays, and at the mouth of the Fitzroy River (Haynes et al. in press). When detected, diuron concentrations ranged from 0.2 to 10.1 µg kg^{-1}. Highest concentrations of diuron were detected adjacent to the mouths of the Herbert and Johnstone Rivers. High agricultural usage of diuron by the sugar cane industry occurs in these two river catchments (Hamilton & Haydon 1996).

Seagrass Herbicide Toxicity Trials

To assess whether environmental levels of diuron detected in the sediments were high enough to affect seagrass health, a toxicity trial was carried out. Three tropical seagrass species (*Halophila ovalis*, *Cymodocea serrulata* and *Zostera capricorni*) were exposed to diuron and the impact assessed using Pulse Amplitude Modulated fluorometry (Schrieber et al. 1994). This technique rapidly measures stress response in seagrass (and other plants) by detecting changes in photosynthetic rate (Dawson & Dennison 1996; Ralph 2000). Seagrasses were exposed to a range of diuron concentrations over a five-day period (Haynes et al. in press). Diuron exposure concentrations were based on concentrations detected during the nearshore marine sediment survey. Seagrass were placed in fresh seawater after the five-day exposure period, and their photosynthetic ability monitored over a further five-day recovery period.

The Effects of Diuron on Seagrass Photosynthesis

All concentrations of diuron showed some degree of toxicity to one or more of the seagrass species, as indicated by a decline in photosynthetic capacity over the exposure period. In all three seagrass species, exposure to 10 and 100 µg L^{-1} of diuron resulted in a decline in photosynthesis within two hours. Photosynthesis in *H. ovalis* also declined over the first 24 hours at even lower diuron concentrations (0.1 and 1.0 µg L^{-1}) (figure 3). Photosynthetic rates in *H. ovalis* and *Z. capricorni* was significantly decreased at all diuron concentrations after five days exposure, whereas photosynthesis in *C. serrulata* was only significantly lower in plants exposed to the highest diuron concentrations. Photosynthetic rate depression was still present in plants exposed to 10 and 100 µg L^{-1} diuron at the end of the five day recovery period (figure 3).

What Does it Mean for Seagrass Health?

The immediate toxicity of diuron to seagrass indicates that herbicide concentrations present in nearshore Queensland sediments present a potential risk to Great Barrier Reef seagrass. Partitioning models indicate that seawater in the vicinity of contaminated sediments can reach the concentrations shown here to be high enough to impact seagrass photosynthesis (Haynes et al. in press). The three seagrass species which were tested are abundant along the Queensland coast (Lee Long et al. 1993; Kirkman 1997) and form one of the major ecological components of the Great Barrier Reef World Heritage Area. In addition, *Cymodocea* and *Halophila* are both important food resources for the threatened dugong (*Dugong dugon*). The potential of diuron to impact Great Barrier Reef phytoplankton and to inhibit photosynthesis and growth of coral zooxanthellae (which produce food for coral via photosynthesis) also

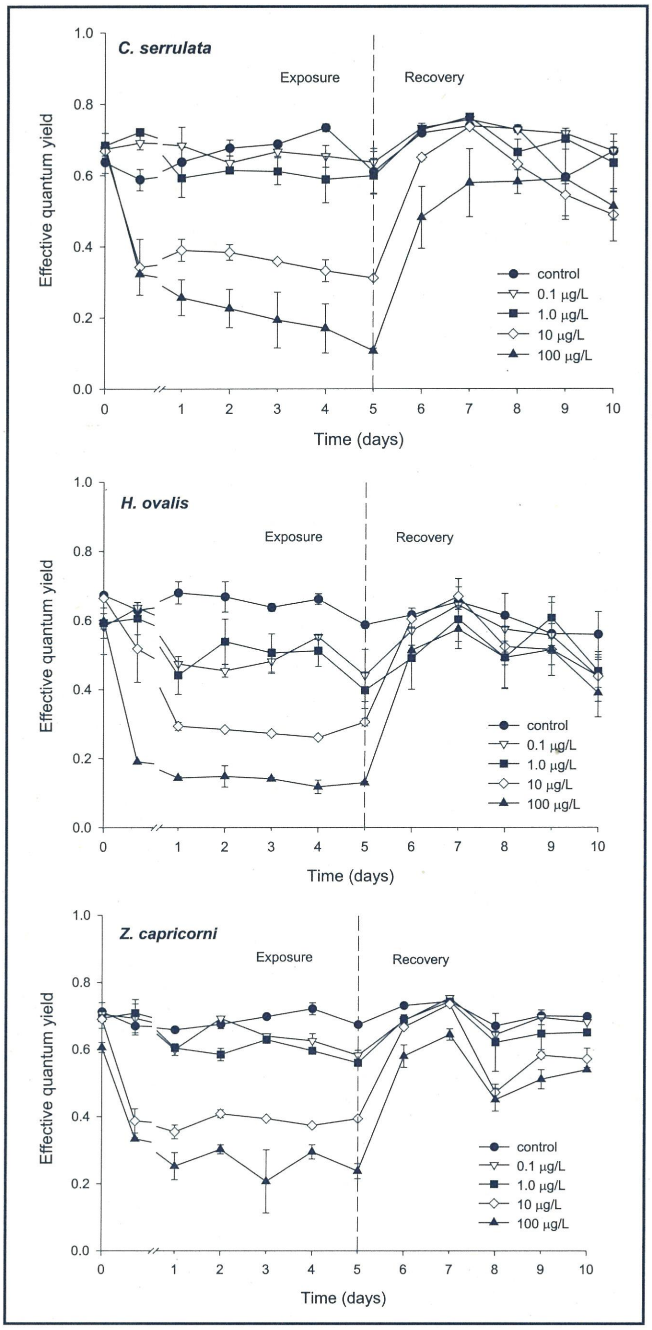

Figure 3. *Photosynthetic rates of* Halophila ovalis *exposed to diuron*

exists. Diuron is not the only type of stressor that seagrasses are exposed to. Many other stress-factors such as increased water turbidity and high temperatures can affect seagrass health at the same time, and potential synergistic effects have to be taken into consideration. The combined effects of these impacts on seagrass health are presently unknown and will be the subject of future research efforts.

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The Torres Strait Heavy Metal Monitoring Project — Background and Update

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Background

The Torres Strait Baseline Study (TSBS) was initiated in 1990 in response to concerns, particularly by Torres Strait Islanders, about the possible effects on the adjacent marine environment from mining operations in the Fly River catchment of southern Papua New Guinea. In response to the results of a pilot study, which determined the levels of trace metals in selected marine organisms, sediments and seagrass (Dight & Gladstone 1993) a more comprehensive main study was subsequently undertaken in 1992–93 (Gladstone 1996).

The 1992–93 study indicated the influence of the Fly River on the trace metal levels in sediments and selected indicator organisms and was largely limited to north-eastern Torres Strait. The trace metal content of marine sediment of the central section of Torres Strait was influenced by smaller coastal rivers of Papua New Guinea. High levels of some trace metals including cadmium — which exceed current recommended safe levels — were found in a number of seafoods commonly eaten in the Torres Strait Islands. However, high levels of trace metals were considered unlikely to be related to anthropogenic factors. The TSBS recommended long-term monitoring for trace metal levels in sediments and selected indicator organisms of the Torres Strait marine environment (Gladstone 1996).

Rationale for Present Study

The high levels of cadmium reported in crayfish heads and in the muscle, intestines, liver and kidney of green turtle and dugong continues to be of concern to Torres Strait Islanders as these are staple foods in traditional diets. Widespread community awareness of high heavy metals content in traditional foods has limited the consumption of liver and kidney of dugong and green turtle by some Torres Strait Islanders. However, there is some scepticism about the results from the TSBS as these are regarded inconclusive because they were based on a low number of samples. Moreover, strong concerns remain amongst Torres Strait Islanders of possible heavy metals contamination of their environment as a result of Ok Tedi mining activities.

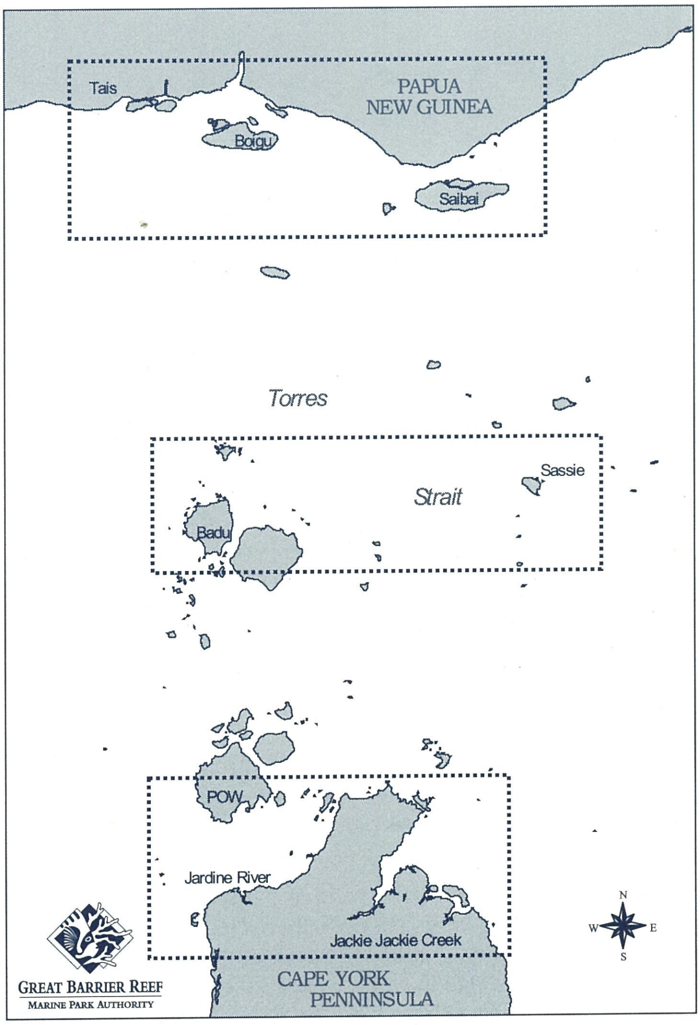

Figure 1. *Map of Torres Strait and northern Great Barrier Reef identifying the sampling regions in which mangrove cockles were collected. Circled areas represent the southern, central and northern sampling regions respectively.*

In 1998, in response to requests from the Torres Strait Regional Authority funding was allocated by the Australian Government (Environment Australia) for further monitoring of heavy metals in the marine environment of Torres Strait.

The main aims of the current study are:

1. To accurately determine the levels of heavy metal pollutants in tissues of the traditional food sources of dugong and green turtle.
2. To develop sampling strategies and to test the use of the mangrove cockle *Polymesoda erosa* as an appropriate indicator organism to allow temporal and spatial comparisons of levels of trace metals. The ultimate aim is to use these analyses as an estimate trace metal variability in the Torres Strait.
3. To assess implications of these results for the marine environment in Torres Strait and the health of its traditional inhabitants.
4. To contribute to capacity building for community based management strategies for natural resources in Torres Strait by providing training to Islanders in sampling and processing techniques and furthering knowledge.
5. To investigate the potential to use cost-effective long-term monitoring strategies, using novel techniques such as the Semi-Permeable Membrane Devices, which could ultimately be used as an alternative to conventional bio-monitoring.

Samples of mangrove cockle have been collected with the assistance of local communities at a number of regular sample locations in northern, central and southern Torres Strait (figure 1). The samples have been collected over the last two years before and after each wet season (figure 2).

Tissues of dugong and green turtle from different regions of the Torres Strait have been donated by Indigenous hunters, and like mangrove cockle, analysed for a suite of metals including arsenic, copper, chromium, lead, mercury, nickel, selenium and zinc.

While the final data analysis is still under way, this project should be considered as a success already, given the unprecedented high level of collaboration between the Torres Strait Islanders, the Torres Strait Regional Authority, the Great Barrier Reef Marine Park Authority, the Australian Institute of Marine Science and James Cook University.

A total of 136 dugong and 31 turtle samples have been donated by Indigenous hunters and subsequently examined for this study, making it the most extensive analysis of trace metal pollutants for these groups in northern Australian waters.

Moreover, the samples will also be used within an Australian-wide monitoring program of dugong, which will include analyses for organochlorines such as dioxins and a number of pesticides and herbicides.

The study is expected to be completed by the end of 2000 and is intended to form the framework for a continuing pollutant assessment of the Torres Straits tailored to meet the information needs of Torres Strait Islanders, the Torres Strait Regional Authority and the Great Barrier Reef Marine Park Authority.

Figure 2. *Collection of mangrove cockles in collaboration with Torres Strait Islander communities (photo courtesy of Donna Kwan)*

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The Fish Tango —
Protection of the Fish Dance

Martin Russell
Fisheries Issues Group, Great Barrier Reef Marine Park Authority

As she amorously looks with inquisitive eyes at the potential prospects for a one-night stand, she thinks to herself 'This is not what the brochures look like. The guys just aren't as big as they used to be. I remember just a while ago when there were so many guys on the dance floor that I could go all night'. Her once in a year chance for romance proved to be a flop. Maybe she will have more success next time when she comes back as a guy, provided she lives that long.

Her stage name is coral trout and her real name is *Plectropomus leopardus*. Once a year she and the other mature fish known by the same name get the chance to go to a special part of a reef for an amatory liaison with the opposite sex. Unfortunately, the increased abundance of spawning fish doing the tango in localised areas at predictable times makes fish spawning aggregation sites (FSAS) particularly vulnerable to overexploitation and disturbance by anthropogenic impacts such as fishing, tourism and research activities. Consequently, the fish tango can be a precarious dance.

Many species of tropical fish that inhabit coral reefs aggregate at specific times and locations to spawn. These aggregations are influenced by season, lunar phase and possibly temperature. They commonly form at traditional spawning sites, i.e. dance floors conducive to hot romance. The types of fish that aggregate to spawn range from predatory cods, groupers, trevallies and snappers to herbivorous parrotfishes and surgeonfishes. Spawning aggregations occur in at least 21 different families of tropical reef fish worldwide, and most of these produce pelagic eggs.

There are many possible reasons why fish aggregate to spawn at specific reef dance floors. Spawning aggregations typically form at sites where water movements will transport eggs and larvae into the water column and offshore for the open water phase of development. Large numbers of eggs released simultaneously might overwhelm the feeding capacity of egg predators, allowing a proportion of eggs to survive this peril. Aggregations might also offer better prospects to find mates and to synchronise physiological readiness to spawn.

Spawning aggregations of fish can vary considerably both within and between fish species. Spawning aggregations can form on a daily basis with associated movements over short distances or on a seasonal basis as a result of large-scale migrations.

For some time the Great Barrier Reef Marine Park Authority has been aware of the need to protect FSAS in the Great Barrier Reef Marine Park from human activities — particularly fishing, tourism and research — that might be impacting on these aggregation sites and the aggregations of the fish themselves. However, implementing appropriate protective management strategies has been limited by a lack of biological, physical and case study information. The Authority's Fisheries Issues Group is currently preparing a report entitled *Spawning aggregations of tropical reef fish: Implications for management,* which includes recommendations on strategies to protect fish spawning aggregations from human impacts in the Great Barrier Reef Marine Park.

Fishing on FSAS has resulted in severe stock depletion of fish around the world, and there is concern that commercial and recreational fishers are targeting FSAS in the Marine Park. Tourism activities in the Marine Park occur in areas where several FSAS are known to occur, and there is concern that fish feeding, the presence of divers and physical damage to corals caused by anchoring and divers can affect the formation of aggregations and the normal spawning behaviour of fish at these sites. Some research activities also have the potential for impacts similar to those caused by fishing and tourism. The Great Barrier Reef Marine Park Authority is working to mitigate the impacts of these activities to ensure the maintenance of FSAS and the aggregating fish that depend on them.

The Fisheries Issues Group is working closely with the Queensland Fisheries Service to minimise target fishing on spawning aggregations of reef fish. The introduction of seasonal closures in the peak spawning months is

American Society of Ichthyologists and Herpetologists (ASIH) Annual Meeting in Mexico

Martin Russell travelled to Mexico to present the talk
'Fish spawning aggregation protection in the Great Barrier Reef Marine Park'
to the ASIH meeting. Here is his report on that meeting.

In June 2000, Martin Russell, Project Officer for the Great Barrier Reef Marine Park Authority's Fisheries Issues Group, attended the 80th annual meeting of the American Society of Ichthyologists and Herpetologists (ASIH), hosted by Universidad Autonoma de Baja California Sur, La Paz, Mexico.

968 presentations on research and management of teleosts, elasmobranchs and reptiles were made by some 900 delegates. The ASIH meeting was held over one week in La Paz, a coastal fishing and tourism town in southern Baja California, Mexico.

As part of this meeting, a symposium on *The importance of spawning aggregations in the lives of reef fishes* was organised by Dr Yvonne Sadovy, Associate Professor at the Department of Ecology and Biodiversity of the University of Hong Kong and Dr Michael Domeier, Pfleger Institute of Environmental Research California.

Martin Russell was invited as one of 16 speakers from throughout the world working on fish spawning aggregation research and/or management.

This was the first opportunity in many years for scientists and managers working on fish spawning aggregations to gather and share their knowledge. This gathering proved to be a catalyst for these experts to voice their collective concern for the need to better manage reef fish spawning aggregations.

There was a great deal of interest from the ASIH delegates in when, where, why and how fish aggregate to spawn, and what should and is being done to protect these spawning aggregations from human impacts. The main issue discussed was that fisheries throughout the world are targeting fish spawning aggregations and there is an urgent need to ensure protection is afforded to these aggregations. It was emphasised that fish spawning aggregations form a particularly easy target for fishers and are potentially vulnerable to over-exploitation. The vulnerability depends on the biology of the species, the intensity and selectivity of fishing and the responses of aggregating individuals to selective removals. Grouper species throughout the world are known to form large spawning aggregations at certain times of the year. Commercial and recreational fishers often heavily exploit these aggregations, and the removal of the larger more aggressive males on the spawning grounds will cause a change in sex ratios, and these changes could lead to reductions in effective population sizes and loss of genetic variation.

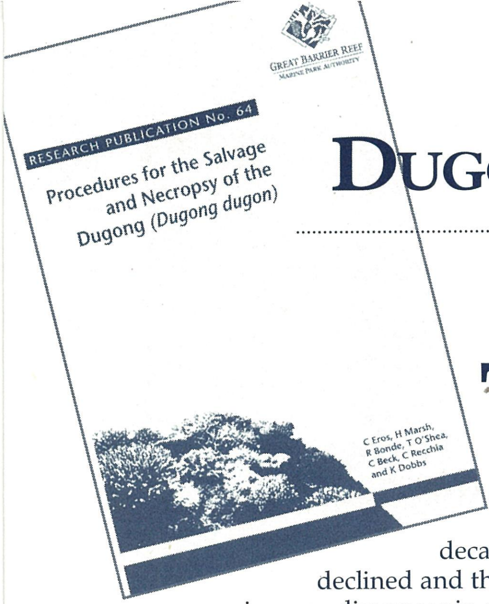
The presentation given by Martin on the Authority's initiatives to protect fish spawning aggregations in the Great Barrier Reef Marine Park was received with great interest. The delegates observed that the Marine Park is a very large marine protected area relative to other marine protected areas throughout the world, and the initiatives to protect fish spawning aggregation sites are broad scale across the entire reef area. Most initiatives in other coral reefs throughout the world are small scale, dealing with individual reefs.

Martin is a founding member of a new international group formed to raise awareness and take steps to better manage fish spawning aggregations as a valuable and irreplaceable resource. This new group, called the Society for the Conservation of Reef Fish Aggregations, will strive towards influencing and facilitating marine resource conservation, research and management agencies to implement international conservation and management initiatives for the protection of reef fish spawning aggregations. The Great Barrier Reef Marine Park Authority's initiatives to protect fish spawning aggregations in the Great Barrier Reef Marine Park will feed into the strategies developed by the Society.

proposed to allow reef fish to spawn without interference from fishing pressure.

Fish spawning aggregation sites are being considered during the reef-wide rezoning exercise under the Authority's Representative Areas Program. Marine Park Authority officers and Queensland Parks and Wildlife Service field staff are being trained to identify fish spawning aggregation sites and the locations of mooring, pontoon and anchoring sites are being carefully considered to protect FSAS and aggregating fish from tourist activities.

The Great Barrier Reef Marine Park Authority aims to ensure that the anthropogenic perils of the fish dance are minimised, and that successful fish tangos continue to produce reef fish for the future.



Dugong Necropsy Manual

Kirstin Dobbs
Great Barrier Reef Marine Park Authority

The Great Barrier Reef World Heritage Area supports a population of about 12 000 dugongs. However, over the last decade or so, the number has declined and there is concern that the species may disappear in certain areas of its range.

To minimise this risk, many initiatives have been implemented to reduce the impacts on dugongs. These include the establishment of 16 Dugong Protection Areas (DPAs) and the funding of an education campaign urging boaties to 'Slow down for Dugong, Turtles and Dolphins — less than planing speed preferred'. In addition, the Marine Animal Hotline (**1300 360 898**) — which is the cost of a local call — has been widely promoted so that live stranded and dead carcasses of marine mammals and turtles can be reported quickly and recovered to determine, where possible, the cause of death.

The Great Barrier Reef Marine Park Authority recently published a technical manual on the *Procedures for the Salvage and Necropsy of the Dugong (Dugong dugon)* (Eros et al. 2000). Limited copies of the necropsy manual are available from the Great Barrier Reef Marine Park Authority. It is envisaged that the manual will also be available on the Authority's web site (http://www.gbrmpa.gov.au) in early 2001.

The manual is for use as a resource and training guide for people responding to dugong carcass incidents to identify the cause of death. While the manual is useful for incidents occurring in Australia, and Queensland in particular, it will also be a useful reference for agencies and researchers in other areas where dugongs are found (such as Malaysia, Thailand and Papua New Guinea).

Day-to-day management staff of the Great Barrier Reef Marine Park operate a program for the salvage and necropsy of dugongs on the Great Barrier Reef. The program trains local veterinarians and Marine Parks staff to deal with reports of carcasses. The production of a manual of procedures for the salvage and necropsy of dugong carcasses provides a standard guide for the conduct of necropsy techniques, and establishes a foundation for improving these techniques. This information will enable us to determine the cause of dugong deaths and thereby act as a catalyst for management actions.

The Great Barrier Reef Marine Park Authority contracted a world-renowned expert on dugongs, Professor Helene Marsh from James Cook University, to produce the dugong necropsy manual based upon a similar instruction manual issued for use with Florida manatees (Bonde et al. 1983). The dugong necropsy manual was written by a research assistant of Professor Marsh's, Carole Eros, in consultation with the authors of the Florida manatee manual and Great Barrier Reef Marine Park Authority biologists. Draft copies of the manual were extensively reviewed by Marine Parks and Queensland Parks and Wildlife Service field staff, Queensland Department of Primary Industries veterinarians, private veterinarians, Park management staff and marine mammal biologists.

The manual comprises eight sections:

- 1. Introduction, which explains the reason for performing necropsies and provides a brief summary of life history characteristics of dugongs.
- 2. Elements of a Stranding Network, which uses the Great Barrier Reef Marine Parks arrangements as an example and provides information on the elements needed for an effective network.
- 3. Incident Response Procedures, which covers issues such as safety, and a standard methodology for documentation including sample data sheets and photographs that should be taken during an incident.
- 4. Necropsy Technique, which describes how to conduct a necropsy and the samples that should be taken together with in-depth descriptions of the major organ and tissue groups. The section includes many figures, showing line drawings and photographs to explain techniques and to describe organ locations.
- 5. Specimen Collection and Preservation, which lists techniques to collect and preserve tissue samples.
- 6. Transportation of Specimens, which describes material to be contained in a necropsy kit and methods for transporting tissue samples, using Queensland regulations as an example.
- 7. Determination of Causes of Death, which describes various causes of death (diseases, vessel strikes, starvation, human-related actions) determined from dugong carcasses in Queensland and elsewhere. Case studies for disease and accidental entanglement are provided.
- 8. Glossary, which defines technical and medical terms used in the text.

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How Great is the Great Barrier Reef?

Tourists' Knowledge and Understanding of the World Heritage Status of the Great Barrier Reef

Gianna Moscardo
CRC Reef Research Centre, James Cook University, Townsville Qld 4810

The CRC Reef Research Centre tourism team has been investigating a number of different aspects of reef tourism including visitor satisfaction, expenditure and motivations for reef visits. The team has also been conducting a series of surveys of both visitors and residents. These surveys are focussed on understanding perceptions of the health of the Great Barrier Reef and threats to its wellbeing. A technical report has been produced reporting on the resident surveys conducted in 1997 (Green et al. 1999) and several new reports are currently being prepared on the 1998 resident surveys. The team has also been working on understanding visitor perceptions of these same issues.

It has been suggested that resource managers and researchers often discuss at length the potential or actual damage resulting from tourism assuming that the visitors themselves are aware of this damage and/or that they do not care about any damage done to the visited destination. There is, however, very little evidence on either what visitors do know about negative impacts or about their levels of concern over these impacts. The CRC Reef Research Centre tourism team decided to investigate this issue with Great Barrier Reef tourists. Specifically they looked at what levels of awareness of threats and impacts on the Great Barrier Reef existed amongst visitors and how concerned these visitors were about the health of this environment.

Method

Two studies provided the data for the analyses reported here. The first was a telephone survey of residents of the eastern state capitals and the major residential centres adjacent to the Great Barrier Reef World Heritage Area. This survey was completed by 1003 people with a response rate of 58%. Of these 1003 respondents, 242 had visited the area for recreation, leisure or a holiday within the last two years. Responses from this sample of visitors were analysed further.

A second study was conducted with visitors on reef day-tour boats. Data in this part of the research was collected from 328 visitors with a response rate of 86%. The second sample included both Australian (23%) and international visitors (77%).

Results

In both samples there were very high levels of recognition of the World Heritage status of the area with 93% of the first sample and 90% of the second sample correctly identifying the Great Barrier Reef as a World Heritage Area*. In addition to awareness of World Heritage status the researchers were also concerned with whether or not visitors understood why the area was listed or what its critical values or features were. In both surveys one measurement of this was an open-ended question asking for words or phrases to describe the Great Barrier Reef. The key results are summarised in table 1.

Table 1. *Words and phrases used to describe the Great Barrier Reef*

Survey 1
Awesome, amazing, fantastic, magnificent (36%) Beautiful, lovely, scenic (20%) Unique (9%) Colourful (8%) Large, big, huge (5%)
Pristine/untouched (3%) Valuable/important to the whole world (2%) In need of protection (2%) Diverse/varied (3%)
Survey 2
Awesome, amazing, fantastic, magnificent (32%) Beautiful, lovely, scenic (18%) Interesting (6%) Colourful (5%) Large, big, huge (4%)
Unique (3%) Pristine/untouched (3%) Valuable/important to the whole world (5%) In need of protection (2%)

The first section in this table lists the five most common words/phrases used and there is marked similarity between the two sets of responses. The second section lists any words/phrases which are related to the values of the Great Barrier Reef or its reasons for listing. As can be seen generally there is a low level of spontaneous use of phrases such as unique, fragile, varied, diverse, or pristine.

Table 2. *Reasons why the Great Barrier Reef is a World Heritage Area*

Reasons for listing	% of second sample
Coral reefs	34%
The marine life	34%
Needs it be protected/preserved	23%
The whole thing	18%
Unique place	10%
Cleanliness/water quality	9%
Research resource	8%
Diversity of life	7%
Tourism resource	7%
So use can be managed	4%

To investigate this further the second survey included a question that asked for two reasons why the Great Barrier Reef was a World Heritage Area. Answers to this question are given in table 2. Even with a more specific question it did not appear that many visitors have much of an understanding of the importance of the area in terms of its size, diversity, uniqueness or its role as habitat for rare and endangered species. It appears that visitors in general believe that World Heritage listing provides protection for an

* In recognition of its outstanding universal value, the Great Barrier Reef World Heritage Area was inscribed on the World Heritage List in 1981 (Wachenfeld et al. 1998).

environment that is important, even though they do not appear to know why it is important.

In both surveys visitors were asked to list three major threats to the Great Barrier Reef. The top three answers in each case were the same: pollution, human impact and tourism. In each sample approximately 30% of the visitors surveyed listed tourism as a major threat. This open-ended question was designed to determine general awareness of different kinds of threats.

The surveys also asked visitors to rate the severity of impacts of some specific threats of concern to the management agencies (see table 3). The second survey split one item, industrial/residential activity, into three components: the activities of residents, residential development and industrial activity. In both cases agricultural run-off gave the most negative rating. The first sample of Australians gave much more negative ratings to the activities of tourists and to tourism infrastructure than did the sample of mostly international visitors interviewed on reef tours. This latter group gave more negative ratings to industrial activity along the coast.

Table 3. *Ratings of severity of impacts of identified threats*

Threat	% of sample which rated the threat as having a very negative impact	
	% of Survey 1	% of Survey 2
Agricultural run-off	43%	56%
Industrial/residential activity on the coast	35%	—
Commercial fishing	32%	29%
Crown-of-thorns starfish	31%	9%
The activities of tourists	20%	6%
Tourism infrastructure	16%	10%
Recreational fishing	5%	8%
Activities of residents	—	12%
Industrial activity on the coast	—	44%
Residential development on the coast	—	14%

Both groups appear to be overestimating the severity of impacts from industrial activity on this environment given that there is very little industrial activity in this region. It is interesting to note that the Australian sample gave a more severe rating to the activities of tourists than did those in the second, more international, survey. It is possible that Australians are less likely to define themselves as tourists and so find it easier to be critical of the activities of a group seen as made up of 'others'. This is consistent with the pattern of results for the second sample. In the open-ended question 28% of this group listed tourism as a threat but only 16% rated either the activities of tourists or tourism infrastructure as having a very negative impact. In other words there is some recognition that tourism may be a threat to the Great Barrier Reef but this may not translate into personal responsibility.

Finally the visitors in the second survey were asked what two questions they would most like answered about the Great Barrier Reef (table 4). Many of the questions that were asked were about the management and protection of the Reef. More than a quarter of the sample wanted to know about conservation and management in general, with 22% concerned about the future survival of this World Heritage Area, 12% specifically asking about tourism impacts and a further 7% concerned with threats in general.

Implications and Conclusions

Three major themes can be identified from the results of these analyses.

Table 4. *Most common questions visitors had about the Great Barrier Reef*

Question	% of Survey 2
More information on protection/management	27%
Questions about specific animals/plants	22%
What about it's future survival?	22%
History and development	18%
What are the effects of tourism?	12%
How big is it?	9%
Is it changing?	8%
How does it work?	7%
What things are threatening it?	7%
What research is done?	4%

1. Visitors to the Great Barrier Reef do appear concerned about the protection and conservation of this World Heritage Area. Protection, management, threats and survival dominate the questions that visitors have about this environment. They are, however, not very clear about why the area is important and needs protection and what the area needs protection from. Few respondents in either study provided more than general answers to the questions about why the area is World Heritage listed or what things threaten the area.
2. There is some recognition that tourism in general has the potential to have negative impacts on the Great Barrier Reef World Heritage Area. Again this appears to be a general perception with little apparent understanding of the actual ways in which tourism might be a problem. Further, there seems to be a tendency for the respondents to downplay their own personal impacts. In the case of Australian respondents it can be suggested that this happens by labelling tourists as 'others'. In the case of international respondents this may be achieved by downplaying the impacts of tourism when compared to the impacts of residents of the area.
3. There are low levels of awareness of the potential long-term and widespread impacts of factors such as coastal development associated with tourism and residential development. There does not appear to be a strong connection in the mind of visitors between their activities on the adjacent coast and impacts on the Great Barrier Reef.

Overall it can be suggested that visitors to the Great Barrier Reef do care about this environment and some are aware that tourism may be a threat to it. Most, however, do not appear to have any detailed knowledge about why the area is important and what activities threaten it. This more detailed knowledge is necessary if visitors are to be able to change their behaviours to minimise impacts.

References

Green, D. et al. 1999, *Understanding Public Perceptions of the Great Barrier Reef and its Management*, CRC Reef Research Centre, Technical Report No. 29, Townsville; CRC Reef Research Centre, 64 pp.

Wachenfeld, D.R, Oliver, J.K. & Morrissey, J.I. 1998, *State of the Great Barrier Reef World Heritage Area 1998*, Great Barrier Reef Marine Park Authority, Townsville.

Note: Some of the issues raised in this article are addressed in a brochure entitled '*Protecting the Great Barrier Reef World Heritage Area*' which was produced by the Great Barrier Reef Marine Park Authority. The brochure outlines threats to the World Heritage Area and the steps taken by the Australian Government and/or the Authority to address these threats. If you would like copies of the brochure please call the Authority on +61 7 4750 0700 or visit our web site (http://www.gbrmpa.gov.au/corp_site/info_services/publications/brochures/protecting_biodiversity) (*Ed.*)

An Update on the Authority's Representative Areas Program

*Bryony Barnett**

More than just Coral Reefs

The Great Barrier Reef is well known worldwide for it's 2900 coral reefs and its huge variety of wildlife, but there's more to it than just coral reefs. The Great Barrier Reef World Heritage Area (GBRWHA) includes many different community types — groups of animals and plants — which live together in habitats such as sponge or soft coral gardens, mangroves, seagrass beds, sandbanks, mudflats, estuaries and reef drop-offs. This is the 'biodiversity' of the GBRWHA, which has evolved over millions of years. It is an important part of Australia's natural heritage, and is recognised as a World Heritage Area for its outstanding universal values. In many ways we depend on this biodiversity for our enjoyment, livelihood, food, medicine and inspiration.

The Great Barrier Reef Marine Park Authority's Representative Areas Program (RAP) will help protect the biodiversity of the GBRWHA through establishing a comprehensive, adequate and representative network of highly protected areas. Specific aims of RAP are to help:

- maintain biological diversity
- allow species to function undisturbed
- provide an ecological safety margin against human-induced and natural disasters
- provide a solid ecological base from which threatened species or habitats can recover or repair themselves and
- maintain ecological processes and systems.

There are five phases to the RAP:

1. Classification of the biodiversity
2. Review of the existing zoning
3. Identification of potential areas for protection
4. Selection of areas to be incorporated into the network of highly protected areas
5. Development of a draft zoning plan for public review.

Understanding the Biodiversity of the GBRWHA

The first phase of the RAP, the classification phase, has improved our understanding of the GBRWHA. A map showing the diversity of the whole area has been produced and can be found on the Authority's web site (http://www.gbrmpa.gov.au) under 'Hot Issues'.

How was the biodiversity classified?

In the past 30 years, our knowledge of the Great Barrier Reef Region has increased considerably. As a first step to the RAP classification, more than 40 layers of biological and physical data for the GBRWHA were mapped using a Geographic Information System (GIS). This included information on fish, hard and soft corals, seaweeds, seagrass, sediments and depth. This is the best available information the Authority currently has.

Two groups of scientific experts analysed all of the information and used their combined experience to classify the whole of the GBRWHA as 72 different broad scale 'bioregions' (generally at the scale of hundreds of kilometres). Twenty-nine different bioregions were described for the reef areas and 34 for the non-reef areas. A further eight areas, mostly in the deep water offshore areas, were classified but not described due to insufficient information.

What is a bioregion?

A bioregion is an area where the groups of plants and animals, and the physical features (e.g. depth, sediment type) are sufficiently distinct from the surroundings and the rest of the GBRWHA. What makes one bioregion different from another is the combination and structure of animals and plants, and the physical features which make up that region. Reef bioregions are easier to distinguish than non-reef as they generally represent just reef habitat. By comparison, a non-reef bioregion may comprise a number of smaller scale habitats, such as patches of seagrass within a broader area of mudflats. The types of seagrass and mud-living animals found in a northern bioregion are different from those in a southern coastal bioregion. The resulting map of bioregions is complex, but it is clear that there is distinct variation from north to south, from inshore to offshore, and between reef and non-reef areas. The different bioregions are illustrated by different colours (note that the colours on the bioregion map do not represent Marine Park zoning).

What is a 'fuzzy boundary'?

The bioregion map shows the boundaries between the different colours as sharp lines. In reality the boundaries between most bioregions are rarely that sharp. Except for some clearly defined edges of reefs, in most cases the boundaries are more gradual or 'fuzzy'. This may be due to a gradual change in nature (e.g. as the water gets deeper the sediments and animals will change gradually until there is a different community from that closer inshore). Or it may be due to less detailed information about the animal and plant life in some areas. Eighty-three per cent (83%) of the boundaries for the reef bioregions are clearly defined and 13% are 'fuzzy'. Most of the boundaries for the non-reef bioregions have been classified as 'fuzzy'.

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* Formerly of Great Barrier Reef Marine Park Authority, now Extension Manager, Cooperative Research Centre for the Great Barrier Reef World Heritage Area.

Reviewing the existing network of highly protected areas

The Great Barrier Reef Marine Park is zoned for different uses, with some areas being highly protected. These are shown on the zoning maps as small patches of pink 'no go' zones, and larger areas of green 'no take' zones. In terms of extractive activities, only 4.5% of the total Marine Park is currently highly protected. A review of the existing zoning shows that some bioregions have no highly protected areas at all, whilst others have only small areas of high protection, particularly in the non-reef areas. Of the bioregions that have some high level protection, many have only one location which is highly protected. To ensure adequate levels of protection, there is likely to be some future changes in zoning in the Marine Park.

Where to Next in the Representative Areas Program?

Having defined the different bioregions and reviewed the existing zoning, the next stage of the RAP involves identification of options ('candidate areas') within each bioregion which may be zoned 'highly protected'.

While the main aim of the RAP is to protect the biodiversity of the GBRWHA, the Authority hopes to achieve this while minimising the impacts on existing users. This will be done by considering available information on how people use and value the GBRWHA, including information from Indigenous groups, fishers, tourist operators, conservationists and 'locals'.

How does the Authority know which areas are important to you?

The Authority already has some information — you may have contributed to this — but more is needed. The following mapped data has been compiled by social scientists and managers:

- aggregate data on commercial fishing locations (including trawling, line fishing, netting, crabbing, harvest fishing);
- aggregate data on charter boat fishing;
- recreational fishing locations;
- areas of, and publicly available information on, Native Title claims;
- tourism locations and activities;
- recreational collecting sites;
- shipping channels;
- shipwrecks;
- defence activities;
- research activities;
- locally collected data on use (Whitsundays, Cooktown);
- Aboriginal and Torres Strait Islander Heritage database; and
- Historic Heritage database.

In addition to this information the Authority is also gathering information from local people and other experts to ensure that the data is as comprehensive as possible. The Great Barrier Reef Marine Park Authority is keen to ensure that everyone who wants to have input has opportunity to do so.

Further Information

If you have any queries about this Update contact a member of the Representative Areas Program by using the contact details below.

A detailed overview document on the RAP, which answers commonly asked questions, is also available from the Authority. All information, including the new RAP timelines, is available on the Authority's web site.

Contact details:
Representative Areas Program, GBRMPA
PO Box 1379, Townsville Qld 4810
Phone: +61 7 4750 0700
Facsimile: +61 7 4772 6093
E-mail: rap@gbrmpa.gov.au
Web site: http://www.gbrmpa.gov.au

FOUR KEY MESSAGES

1. The Representative Areas Program (RAP) is about protecting the entire variety of plants and animals across the Great Barrier Reef Marine Park.
2. Ensuring examples of the entire diversity of habitats in the Great Barrier Reef Marine Park are protected from extractive activities will bring benefits to our society, our economy as well as future generations.
3. RAP will ultimately mean more highly protected areas ('no-take' zones) in the Great Barrier Reef, especially in those bioregions which are currently unprotected (e.g. many non-reef areas).
4. Anyone who uses the Marine Park needs to be involved with RAP. Unless the Authority knows what areas users want to keep for fishing, collecting etc., we may inadvertently make it a highly protected ('no-take') area.

Supporting Research on the Great Barrier Reef — SPIRT Grants

David Haynes & Kim Lally
Great Barrier Reef Marine Park Authority

Through the Australian Research Council's competitive grants system the Commonwealth Government offers a number of grants to researchers, universities and the like. One such grant is offered through the *Strategic Partnerships with Industry-Research and Training* (SPIRT) scheme. The SPIRT scheme supports research of a high quality that encourages collaboration between higher education organisations and industry and has the potential to benefit Australia socially. Proposals for the grants must contain an industry contribution, whether it is in cash or in kind. Funding is provided on a dollar-for-dollar matching basis with the industry partner(s).

The Great Barrier Reef Marine Park Authority (GBRMPA) has been approached by a number of researchers to support their projects as an industry partner. The Authority sees collaborative arrangements such as those offered by the SPIRT scheme as an effective way of encouraging focused, cost-effective and mutually beneficial research. A brief overview of the projects GBRMPA is currently supporting as an industry partner is given below.

Ecologically sustainable community-based management of dugongs

Researcher: Helene Marsh (James Cook University)
Industry partner organisation: Great Barrier Reef Marine Park Authority, Hope Vale Aboriginal Council

The dugong is the one of the most significant traditional food sources for Indigenous peoples who live in coastal areas of tropical Australia (Marsh et al. 1997). Dugong are also important in many aspects of Aboriginal and Torres Strait Island culture.

Indigenous peoples have a very good knowledge of dugongs and their habitat. Many communities have noticed that dugongs are no longer found in areas where they were once seen in great numbers. These communities are very concerned about the wellbeing of the dugong population (GBRMPA 1999). Many Indigenous groups in coastal Queensland have agreed to stop hunting dugong in their local areas and there is now no permitted hunting of dugong in the southern Great Barrier Reef, south of Cooktown (GBRMPA 1999).

The aim of this project is to provide information that will assist Indigenous communities and natural resource management agencies develop community-based management of dugongs. The Hope Vale Aboriginal Community, situated near Cooktown, will be used as a case study. The researchers will:

- assist the traditional owners to document Aboriginal knowledge of dugong ecology and behaviour; and
- develop a means of estimating the absolute abundance of dugongs.

This will then enable an estimate of a sustainable annual catch to be calculated.

The information gained from this project will be used to inform the Turtle and Dugong Hunting Management Plan for Hope Vale which has been developed jointly by the Hope Vale Aboriginal Community, GBRMPA and the Queensland Parks and Wildlife Service. It will also be useful for managing dugongs elsewhere in the Great Barrier Reef Marine Park.

References

GBRMPA 1999, *Dugong Information Kit*, 3rd edition, Great Barrier Reef Marine Park Authority, Townsville.

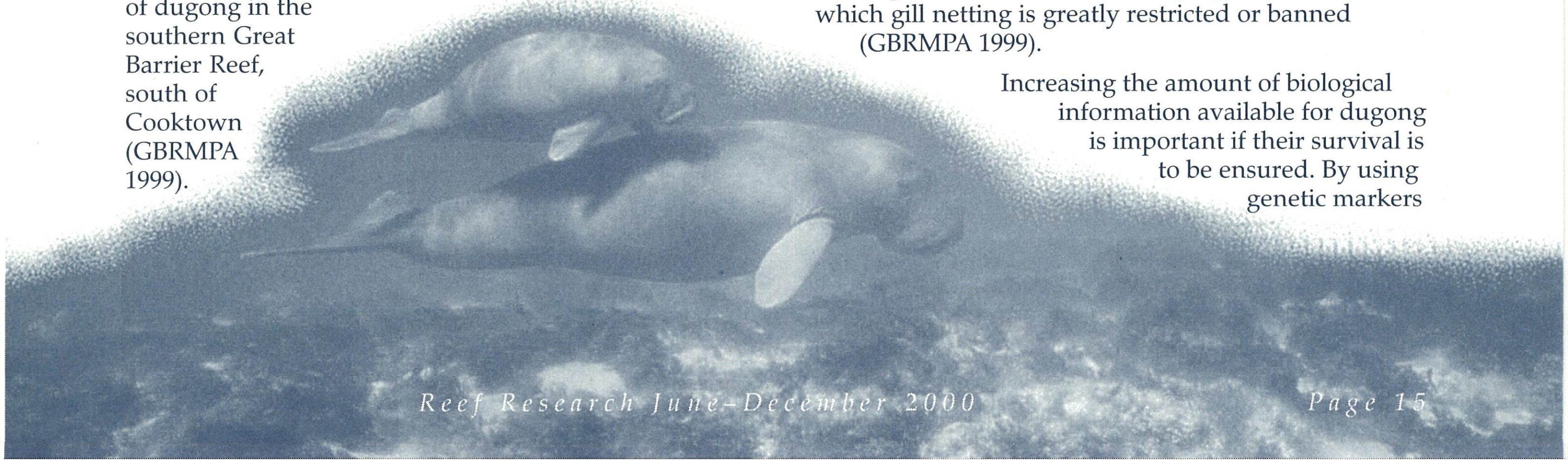
Marsh, H., Harris, A.N.M. & Lawler, I.R. 1997, The sustainability of the Indigenous dugong fishery in Torres Strait, Australia/Papua New Guinea, *Conservation Biology*, 11: 1375–1386.

Genetic structure of Australian dugong populations: a tool for management planning

Researchers: David Blair and Helene Marsh (JCU)
Industry partner organisation: Great Barrier Reef Marine Park Authority, Queensland Environmental Protection Agency

The Great Barrier Reef World Heritage Area (GBRWHA) contains an estimated 15% of Australia's known populations of dugongs (Berkelmans & Oliver 1999). However, the reported number of dugongs in the southern region of the GBRWHA has declined recently. In response to this decline, the Great Barrier Reef Ministerial Council instigated a number of actions including the establishment of dugong sanctuaries in which gill netting is greatly restricted or banned (GBRMPA 1999).

Increasing the amount of biological information available for dugong is important if their survival is to be ensured. By using genetic markers



to provide estimates of gene flow and migration rates in dugong populations, this project aims to supplement the methods that are currently deployed to assess population sizes.

Tikel (1998) states that Mitochondrial DNA sequences from 105 dugongs primarily from eastern Australia have revealed some fascinating patterns. This project aims to extend this data set from 105 to 250 dugongs.

References

Berkelmans, R. & Oliver, J. 1999, *A Dugong Research Strategy for the Great Barrier Reef World Heritage Area*, Research Publication No. 58, Great Barrier Reef Marine Park Authority, Townsville.

GBRMPA 1999, *Dugong Information Kit*, 3rd edition, Great Barrier Reef Marine Park Authority, Townsville.

Tikel, D. 1998, Using a genetic approach to optimise dugong (*Dugong dugon*) conservation management, Unpublished PhD thesis to James Cook University.

The impact of environmental perturbations and changes to water quality on coral reproduction

Researchers: Ove Hoegh-Guldberg and Ross Jones (University of Sydney) and Peter Harrison and Selina Ward (Southern Cross University)
Industry partner organisation: Great Barrier Reef Marine Park Authority

Corals are very sensitive to variations in water temperature and the impact of global climate change on coral health has become an important area of research. It has been suggested that global seawater warming is currently posing, and will continue to pose, a major stress on coral reefs.

This project is comprehensively investigating the impact of increased seawater temperatures and nutrient concentrations on a number of important coral species of the Great Barrier Reef.

Specifically the project aims to:

- clarify the mechanism of coral bleaching;
- investigate the effect coral bleaching has on coral physiology (such as the ability of corals to manufacture their own sunscreen-like compounds);
- examine the combined impact of elevated nutrients and elevated seawater temperature on coral reproductive success; and
- investigate the impact of small temperature changes on coral reproductive success.

The project is assessing impact on corals maintained in aquaria as well as on corals living on reefs.

Role of benthic microalgae in nutrient cycling, primary production and aquatic food webs: Coastal marine ecosystems

Researcher: Bill Dennison (University of Queensland)
Industry partner organisation: Queensland Environmental Protection Agency, Queensland Commercial Fishermen's Organisation*, Brisbane River and Moreton Bay Water Quality Management Strategy, Great Barrier Reef Marine Park Authority

The sediments of nearshore coastal waters of Australia contain a thin layer of microscopic algae. This benthic microalgal community is composed of a variety of different types of organisms (mostly diatoms, dinoflagellates and blue-green algae) that live on or near the surface of the sediment. Microalgae require light for photosynthesis (as do terrestrial plants) and are therefore restricted to the first few millimetres of sediment. Recent results indicate that benthic microalgae in Australian waters are widespread and photosynthetically active (Harris et al. 1996; Dennison et al. 1997). Very few scientific studies have been carried out on benthic microalgae and the role they play in ecological processes is largely unknown.

University of Queensland researchers plan to develop ways to assess the ecological role and quantitative importance of benthic microalgae to coastal marine ecosystems of Queensland. Specially, they aim to assess:

- the role benthic microalgae plays as a benthic biological indicator of light and nutrient availability;
- the importance of benthic microalgae as a fisheries resource, especially to prawns; and
- the significance of benthic microalgae in sediment nutrient processes (e.g. denitrification, nitrogen fixation and sediment nutrient flux).

The study will be conducted in Moreton Bay and the Great Barrier Reef in inter-reefal areas offshore from developed catchments.

References

Dennison, W.C., et al. 1997, *Benthic flora dynamics phase II* , Report submitted to the Brisbane River & Moreton Bay Wastewater Study, University of Queensland Marine Botany, 33 p.

Harris, G. et al. 1996, *Port Phillip Bay Environmental Study Final Report*, CSIRO, Canberra, Australia.

The development of Pulse Amplitude Modulated chlorophyll fluorometry as a management tool for the non-intrusive sublethal stress assessment in corals in the Great Barrier Reef

Researchers: Ross Jones and Ove Hoegh-Guldberg (University of Queensland)
Industry partner organisation: Great Barrier Reef Marine Park Authority

Considerable research effort has been directed into assessing the impact of elevated sediments and nutrients on coral reef health. However, little is known about the effects that other pollutants such as herbicides and ship antifoulants have on corals. There is also a lack of suitable and rapid techniques to assess sublethal stress in corals.

During the last few decades there has been considerable progress in the use of chlorophyll fluorescence techniques for measurement of photosynthetic activity in plants. In particular, researchers have made recent progress in the use of Pulse Amplitude Modulated (PAM) fluorometry to determine sublethal stress in corals (Jones et al. 1998, 1999). This technique measures change in the fluorescence characteristics of the

* The Queensland Commercial Fishermen's Organisation is now known as the Queensland Seafood Industry Association Inc. (*Ed.*)

photosynthetic activity of the symbiotic algae (zooxanthellae) that live within a healthy coral's tissues. Photosynthesis carried out by these zooxanthellae is very important to coral health as it produces over 90% of the coral's food requirements.

The researchers aim to use this technique to investigate the impact of water quality stress on corals from the Great Barrier Reef. Specifically they aim to demonstrate, calibrate and evaluate PAM fluorometry as a tool for assessing the effects of herbicides, antifouling paints and contaminated sediments on corals using standard ecotoxicological stress assessment protocols. The researchers will also investigate the long-term effects of suspended particulate matter concentrations on corals and the potential use of the PAM technique as an *in situ* reactive management tool.

References

Jones, R.J. et al. 1998, Temperature induced bleaching of corals begins with impairment of dark metabolism in zooxanthellae, *Plant, Cell and Environment,* 21: 1219–1230.

Jones, R.J., Kildea, T. & Hoegh-Guldberg, O. 1999, Assessing the environmental impacts of cyanide fishing on hard corals, measured in situ using modulated chlorophyll fluorescence techniques, *Marine Pollution Bulletin*, 38: 864–874.

Dioxins are some of the most toxic compounds yet identified. The primary known sources of dioxins are:

- *chemical reactions in industrial processes which result in contaminated products and waste (e.g. pesticide and paper production); and*
- *high-temperature reactions such as those in incinerators, metal smelting furnaces and in motor car exhaust gases.*

Little is known about the sources and occurrence of dioxins in the Great Barrier Reef ecosystem. These toxicants, or more correctly polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), are the focus of two current GBRMPA collaborative research projects. High concentrations of PCDDs have been detected in soils from agricultural areas in northern Queensland (Müller et al. 1996), in the marine environment in dugongs (Haynes et al. 1999) and sediments from the Great Barrier Reef Marine Park (Müller et al. 1999; Gaus et al. in press).

Origins of dioxins in Queensland

Researchers: Des Connell (Griffith University) and Jochen Müller (University of Queensland)
Industry partner organisation: Queensland Health Scientific Services, Queensland Environmental Protection Agency, Great Barrier Reef Marine Park Authority, ERGO Forschungsgesellschaft mbH

Studies on toxicants in Queensland coastal environments have demonstrated that an unknown process has led to contamination of soils, sediments and marine biota with polychlorinated dibenzodioxins (PCDDs) along the Queensland coast (Müller et al. 1999) and contamination appears to be widespread (Gaus et al. in press). The project consists of three stages with the aims of:

- identifying areas in Queensland in which PCDD concentrations are elevated;
- determining the specific process(es) which resulted in the formation of the PCDDs; and
- assessing and/or developing innovative intervention strategies to minimise future PCDD pollution.

The results of this study are anticipated to provide strategies which will minimise the movement of dioxins into the Great Barrier Reef environment.

Sources and bioaccumulation on toxicants in the water-seagrass-dugong turtle system

Researchers: Des Connell (Griffith University) and Jochen Müller (University of Queensland)
Industry partner organisation: Great Barrier Reef Marine Park Authority, ERGO Forschungsgesellschaft mbH

The dugong is listed as 'vulnerable' and the green turtle as 'endangered' on the 1996 IUCN Red List of Threatened Animals. Both species are under threat and populations are in decline in the Great Barrier Reef region. Reasons for the decline of dugong populations are unclear but it is known that certain human influences threaten dugong and green turtle populations.

Recently, fat tissues from dugong carcasses stranded at three sites along the Great Barrier Reef were analysed for PCDD/Fs. All three samples showed high levels of PCDDs. These levels were higher than those found in most other marine mammals which have been analysed anywhere in the world (Haynes et al. 1999). The reasons for this high level of contaminants in dugong are presently unknown. This project aims to address many of these unanswered questions. Specifically it will seek to:

- establish dioxin concentrations in sediment, suspended sediments, water and seagrass in dugong-green turtle habitats along the Queensland coast;
- identify compartments and key factors which govern the distribution of the toxicants;
- identify animal specific factors (sex, age etc.) and regional factors which may be linked to the concentration of dioxins in dugong tissues; and
- develop a model for the movement and distribution of dioxins from sources to the marine environment.

The results of this study are expected to provide information on sources and exposure pathways of toxicants to dugong and green turtle which will allow the implementation of evaluated management procedures to protect these threatened populations.

References

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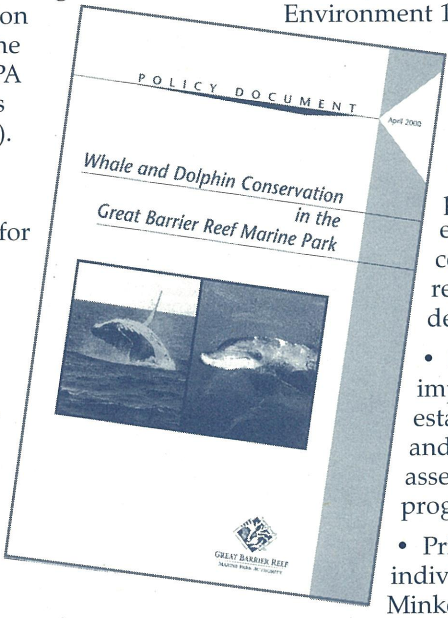
Whale and Dolphin Conservation

Conservation, Biodiversity and World Heritage Critical Issues Group

In February 2000, the Great Barrier Reef Marine Park Authority (GBRMPA) finalised a *Whale and Dolphin Conservation Policy* for the Great Barrier Reef Marine Park. Attached to the Policy is a supporting document providing background and justification for the policy provisions. Copies of the policy may be obtained from GBRMPA or, in early 2001, from the Authority's web site (http://www.gbrmpa.gov.au). The policy provisions relate to:



- Improving information by establishing information priorities for key species, identification of key habitats and assessment of threats (e.g. contaminants, noise, entanglement, vessel strikes, prey abundance); and supporting data collection and reporting programs.
- Developing and disseminating education program materials and information, and developing and reviewing codes of practice and monitoring compliance of these codes.
- Managing vessels and aircraft by instituting regulations on approach distances, prohibited vessels for whalewatching and definitions for commercial whalewatching and swimming-with-whales programs; issuing permits for approaches closer than allowed under regulations; and managing traffic in key habitats (e.g. through voluntary or mandatory speed limits, transit lanes or limited access).
- Managing whalewatching and swimming-with-whales activities. This is to be accomplished for recreational users and incidental commercial whalewatching and swimming activities by ensuring they abide by regulations and GBRMPA's *Best Environmental Practices for Whale Watching*. Dedicated commercial whalewatching and swimming-with-whales programs will be considered through normal permit assessment processes, and will include assessment against the Queensland commercial guidelines described in the *Nature Conservation (Whales and Dolphins) Conservation Plan 1997* (Department of Environment 1997). The Authority will also develop in collaboration with the Queensland Government a long-term strategy for managing commercial whalewatching and swimming-with-whales programs.
- Other human activities including a prohibition on feeding cetaceans, ensuring that effects on cetaceans are considered in permit assessments and relevant GBRMPA programs, and in developing regulations as required.
- Protection of key habitats by implementing specific measures and establishing protection areas as required, and considering key habitats in permit assessments and relevant GBRMPA programs.
- Priority species, populations and individual animals: For example, Dwarf Minke whales are considered a separate species for management purposes; data collecting and management efforts will focus on listed threatened species; and on protecting individual or groups of special interest.

The *Whale and Dolphin Conservation Policy* also contains an addendum, approved by the Authority in March 2000, to manage swimming with Dwarf Minke Whales in the vicinity of the Ribbon Reefs. Management will include issuing a limited number of permits based on specified eligibility criteria.

Reference

Department of Environment 1997, *Conservation and Management of Whales and Dolphins in Queensland 1997–2001*, Department of Environment, Brisbane, 36 pp.

NEW PUBLICATIONS

Publication	Price ($)
Davies, C.R. 2000, *Inter-reef Movement of the Common Coral Trout, Plectropomus leopardus*, Research Publication No. 61, Great Barrier Reef Marine Park Authority, Townsville, 50 pp.	16.30*
Eros, C., Marsh, H., Bonde, R., O'Shea, T., Beck, C., Recchia, C. and Dobbs, K. 2000, *Procedures for the Salvage and Necropsy of the Dugong (Dugong dugon), April 2000, First Edition*, Research Publication No. 64, Great Barrier Reef Marine Park Authority, Townsville, 74 pp.	n/c
Sherl, L.M., Valentine, P.S. and Millard, M. 2000, *Recreation and Tourism Experience in the Great Barrier Reef Marine Park and Implications for Management*, Research Publication No. 65, Great Barrier Reef Marine Park Authority, Townsville, 162 pp.	38.40*

* Price includes postage within Australia by surface mail and the Goods and Services Tax (GST). Copies of these reports are available from Reef In Store (telephone +61 7 4750 0875).

Environmental Management of Defence Activities in the GBRWHA

Adam Smith, Colin Trinder and Paul Marshall
Great Barrier Reef Marine Park Authority

The controlled detonation of a recently discovered bomb in the Great Barrier Reef resulted in many dead fish being collected fom the surface

The Department of Defence has seven training areas in the Great Barrier Reef Marine Park. The largest are at Shoalwater Bay (between Yeppoon and Mackay) and Halifax Bay (offshore from Townsville). These training areas are regularly used by the Defence forces of Australia and occasionally by other countries for land and sea-based exercises including tactical manoeuvres, target firings, amphibious operations, mine hunting and support operations. The military training areas are 'designated areas' in Great Barrier Reef Marine Park zoning plans. The management arrangements for designated areas provide for control, use and entry into areas of the Marine Park used for the conduct of defence operations.

A range of political, social, economic and environmental issues are associated with Defence activities in the Great Barrier Reef World Heritage Area. Some of these issues, including security, economics, employment, research and navigation, are important for humans. In contrast, some environmental issues including the impact of high explosives on marine life such as mammals, reptiles, fish and birds; clean-up of unexploded ordinance; boat strike of endangered species or sensitive habitats; and pollution from rubbish, sewage discharge and oil spills have resulted in community concern.

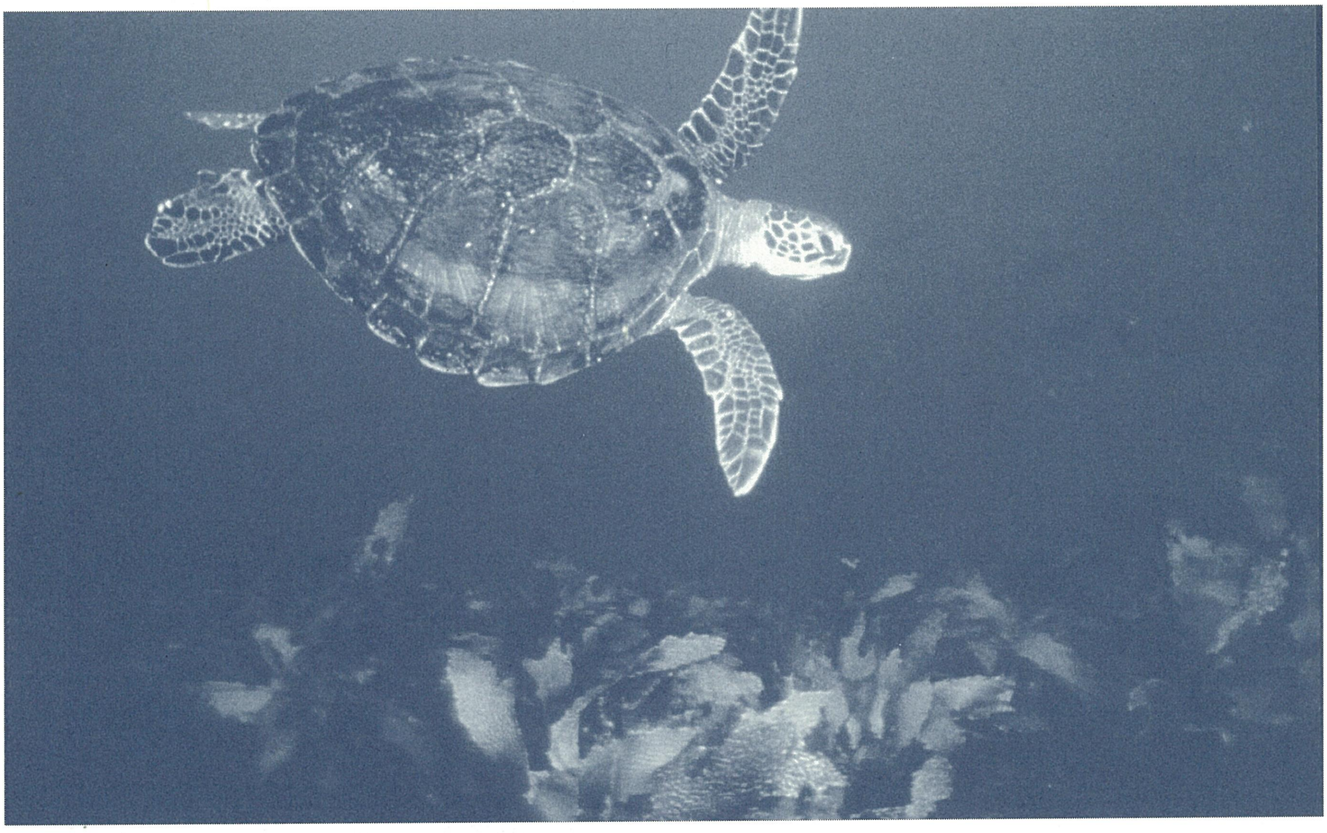
The Department of Defence is working closely with the Great Barrier Reef Marine Park Authority, the Queensland Parks and Wildlife Service and the public to ensure that their activities are managed in accordance with principles of ecological sustainability. A three-phase approach has been adopted to ensure appropriate management: (1) consultation, (2) research, and (3) environmental impact management. Consultation is occurring at local, state and national levels with a focus on the management and use of high explosives in the Halifax Bay training area and notification of environmentally significant incidents. Marine research is focussing on dugongs.

Environmental impact management of Defence activities considers the location, scale and risk of potential impacts and options and alternatives. Large-scale or high risk activities, while essential to training a modern military force, must also comply with relevant federal and state legislation. Preparation of an initial environmental review, environmental management plan and environmental certificates of compliance are used to manage routine or low risk activities.

An example of improvements in consultation, research and environmental impact management of Defence matters in the Great Barrier Reef is the recent discovery of a 2000 lb unexploded bomb in 10 metres of water at Cordelia Rocks in the Halifax Bay training area. Dealing with this ordnance involved joint site inspection and monitoring, preventative actions to minimise impacts of explosion on marine life, media and post-impact monitoring. The results of the controlled detonation of the bomb caused about 300 dead fish on the surface, a large turbid plume and damage to the seabed within a 40 metre radius of the blast. This result will contribute to discussions of the future use of high explosives in the Great Barrier Reef World Heritage Area.

Augmentative Research Grants Scheme 2000

In addition to the six augmentative research grant projects detailed in the last issue of Reef Research *(Vol. 10, No. 1), the Authority has also awarded a grant to the following student from the University of Queensland. Kim Lally reports.*



KEY: **Researcher** / Supervisor, *Project title* ($ awarded) Description of project

Kendra Coufal / Dr J. Whittier, *A survey of endocrine disruptors in marine turtles* ($1000)

A growing body of scientific research indicates that a number of man-made chemicals may affect the health of humans and wildlife by interfering with the normal functioning of their endocrine systems. These endocrine disruptors may cause a variety of problems with development, behaviour and reproduction (US EPA 1997). The United States Environmental Protection Agency (US EPA) is very concerned about these findings and is directing a great deal of resources into learning how, and to what extent, these chemicals may be adversely affecting the health of humans and wildlife (US EPA 1997). The Agency has begun screening all pesticides and herbicides for potential endocrine disruptive activity. This action has taken place in response to reports of environmental chemicals affecting embryonic development of wildlife.

Kendra states that information about these substances in Australian animals such as marine turtles is lacking and, through this project, she aims to outline the natural and man-made estrogens found in four species of marine turtles. The estrogens Kendra plans to test for will include chemicals used in catchment areas of the Great Barrier Reef Marine Park. Some of these chemicals have been found to be endocrine disrupters in studies conducted for the United States Environmental Protection Agency.

Existing samples that have been collected in the last five years will be tested along with supplementary samples taken from turtles at nesting and feeding areas from several sites in eastern Australian waters. This study will provide new information about an emerging wildlife health problem and will establish a baseline for the monitoring of marine turtle reproductive health in Australia.

Reference

United States Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances, *EPA Activities on Endocrine Disruptors, Background Paper*, 10 September 1997, available from Internet: URL: http://www.epa.gov/oscpmont/oscpendo/history/endo2_2.htm

SITE PLANNING IN THE GREAT BARRIER REEF MARINE PARK

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Introduction

The Great Barrier Reef Marine Park (GBRMP) lies within the Great Barrier Reef World Heritage Area. Management of the GBRMP requires agencies such as the Great Barrier Reef Marine Park Authority (GBRMPA) and the Queensland Parks and Wildlife Service (QPWS) to actively consider the values that led to World Heritage listing, when implementing policy. There is an obligation to identify, protect, conserve, present, and transmit to future generations the outstanding universal values of the Great Barrier Reef, while recognising the multiple use nature of the Marine Park (Lucas et al. 1997). This obligation extends from, and is incorporated in, the highest levels of decision-making right down to detailed site specific planning.

Planning frameworks exist at different levels. Zoning plans, for example, which represent the highest planning framework level for the GBRMP, have been the primary mechanism employed to manage use. These large scale mechanisms work well when levels of use are relatively low, but do not necessarily provide sufficiently robust means to manage the cumulative impacts of many users, especially in intensively used areas, such as offshore Cairns and the Whitsundays. Increasing user pressure in these areas led Marine Park management agencies to develop area-specific site plans to balance conservation goals while allowing for reasonable use.

In developing these types of second order plans it was recognised that managing certain uses would also require GBRMPA to plan at an even finer scale. Focus on site specific issues such as anchor damage, displacement of existing users, protection of cultural and heritage values, and improved site allocation mechanisms was needed (Honchin 1996). Since recognising this requirement, site planning has developed into an integral management tool for specific areas throughout the GBRMP, including those where an overarching Plan of Management may not yet have been developed.

The most recent examples of site planning in the GBRMP can be found at Hardy Reef in the Whitsundays, Fitzroy Reef in the Capricorn-Bunker group, and in various locations throughout the Cairns area.

Hardy Reef background

Hardy Reef is located in the mid-shelf complex of reefs in the Whitsunday Region known as the Hardy Unit, covered by the Central Section Zoning Plan. The Hardy Unit is also in the Whitsunday Planning Area under GBRMPA's Whitsundays Plan of Management (WPOM). Under the Central Section Zoning Plan Hardy Reef is a Marine National Park B Zone and under the WPOM designated a *Setting* 2 location, which are areas with a '...natural setting that may have high levels of visitation'.

Hardy Reef is recognised as having a wide range of values and is identified as a key presentation area for public appreciation and understanding of the Great Barrier Reef. It is a popular site for structures-based tourist operators, vessel-based tourist operators and recreational visitors. The inner lagoon is a safe anchorage area, and the northern outer edge a popular location for commercial and recreational scuba divers. It has significant cultural values for Indigenous peoples, and a wide range of natural and scientific values that contribute to it being a site of major management interest.

A range of activities, such as pontoon based snorkelling, are provided at Hardy Reef

Tourist use of Hardy Reef is high with approximately 80 000 people visiting it each year. There are currently a number of commercial tourist operators who provide a variety of experiences at Hardy Reef for visitors. These activities range from pontoon based snorkelling, diving and glass-bottom boat reef observation, similar vessel based activities and scenic flights on helicopters and airplanes that take visitors to specific sites to snorkel and dive. The northern part of the lagoon is used by recreational boaters as a day anchorage and an overnight anchorage in fair weather. It is reasonably protected from all directions and offers comfortable anchoring in up to 15–knot winds.

Hardy Reef is a long-term monitoring site for the Australian Institute of Marine Science (AIMS) who have conducted annual surveys of the entire perimeter for crown-of-thorns starfish and coral cover since 1986. AIMS have also conducted detailed monitoring of fish and coral communities. Results of this long-term monitoring show that Hardy Reef has high benthic diversity, with generally moderate to high coral cover. More recent research shows a general decline in coral cover, which is more dramatic and pronounced in the south, attributed to the effects of recent cyclones (Sweatman et al. 1998).

Large and varied populations of fish, particularly in the north, inhabit Hardy Reef with a range of pelagic fish also present in southern areas. Different types of sharks are known, such as white tips, black tips, and occasionally whalers, hammerheads and tigers, with crustaceans (such as crayfish), common in deeper waters and dark recesses (Colfelt & Colfelt 2000). Commercial and recreational fishing is not allowed in Hardy Reef, however, commercial fishers in particular frequently use adjacent reefs such as Line, Hook and Bait Reefs. Hardy Reef, as with other reefs in the area, hold significant cultural values for Indigenous peoples.

Outcomes

With the range of competing interests and values at Hardy Reef there is a need to balance the variety of user needs and provide for equitable and transparent management of what is a high use, but sensitive site.

A draft site plan has been prepared. It aims to achieve balanced outcomes, with the site planning process revealing a need to more actively manage structure-based and facility-based use at Hardy Reef to ensure its values are not inadvertently lost. The site plan proposes management strategies that complement existing WPOM strategies, and allows the management agencies to permit growth in certain types of use in a sustainable manner.

The site plan establishes three different 'management areas' to:

- focus varying types and levels of permitted facility-based use;
- provide for access to, and anchoring in, some areas free from permitted structures and facilities;
- preserve the recreational opportunity spectrum; and
- establish a 'no-structures' policy outside of the management areas to ensure that nature conservation values are adequately protected and that future management options are not diminished.

New strategies for issues not explicitly dealt with in the WPOM, such as the identification and protection of fish spawning aggregation sites (FSAS), are also addressed. As an emerging reef-wide issue, the management agencies are enthusiastic about protecting FSAS because of their biological, fisheries, tourism, cultural and recreational values.

Additionally, the site plan establishes strategies that permit the management agencies to respond promptly to emerging issues and to implement new management policies and procedures quickly. It also ensures that agreed strategies are in place so that dedicated users share some of the responsibility for protecting known, and potential, values at the site.

Fitzroy background

Fitzroy Reef is a drying, closed ring (platform) reef located at latitude 23 37.5° S, longitude 152 9.5° E. Fitzroy Reef lies within the Capricorn-Bunker group of reefs and is covered by the Mackay/Capricorn Section Zoning Plan. The reef encloses a large lagoon that occupies about 30% of the reef top surface. The lagoon is open to the sea at its northern edge (Jell & Flood 1978; GBRMPA 2000).

The lagoon exhibits well-developed coral communities interspersed with 'barren' rubble slopes, dense platforms of branching corals such as *Acropora* and *Porites*, massive *Porites* heads, thickets of *Pocillopora* and vase-shaped colonies such as *Montipora* and *Echinopora* (Marine Bio Logic 1988). The reef flat and lagoon are important feeding areas for green, hawksbill and loggerhead turtles (C. Limpus, QPWS, pers. comm., August 2000).

Fitzroy Reef is presently used for roving tourism operations only. Between 1994 and 1998 Environmental Management Charge data indicates that the number of commercial tourist passengers visiting Fitzroy Reef is about 1.5% of the total number of tourist passengers visiting reefs in the Mackay/Capricorn Section of the GBRMP. This figure translates to about 0.1% of total tourist passengers visiting reefs along the entire Great Barrier Reef. Recent interest in increasing the use of Fitzroy lagoon as a tourist destination included a proposal for a pontoon and fixed-railing semi-submarine operation (Taylor 2000) and prompted the development of a site plan.

In a regional context, Fitzroy Reef is one of only two reefs in the Capricorn-Bunker group with a lagoon that is accessible to vessels. The other reef, Lady Musgrave Reef, is already well used by tourist operators and includes permanent structures in the form of two permitted pontoons. Fitzroy Reef remains in an undeveloped state. The lagoon is a popular anchorage for commercial fishing, tourist and recreational vessels and is considered a major safe anchorage area for the region (The commercial fishing industry in the Capricorn/Bunker Area 1979; Kenchington 1984; Lucas 1998; GBRMPA 2000).

Outcomes

Although the Fitzroy lagoon is fairly large, much of it is too shallow for large vessels. In addition, the southern margin of the lagoon, which faces the prevailing wind and sea, is susceptible to turbidity during strong winds. Calm, deeper waters (6–10 metres) with coral features occur largely in the centre of the northern margin of the lagoon. This suggests that tourist operators will focus their operations in and around this centre.

Based on the size of this preferred tourism area, and experience with existing tourist pontoon operations at

Site plans have been completed for two locations at Lizard Island

other reefs throughout the GBRMP, it is considered that the area is of adequate size for only one major structure-based tourist operation. Additional secondary mooring sites may be available, although siting these moorings will require careful site selection and supervision.

However, the fact that there are only two of these types of reefs that occur in the Capricorn-Bunker group is an important regional factor. The value of the reef for anchorage, the General Use zoning, and its presently low level of commercial tourism use would indicate that the lagoon should not be utilised for major structure-based operations as an outcome of this site planning exercise.

Cairns background

In recent years, intense tourism use of popular reefs easily accessible from the ports of Cairns and Port Douglas has resulted in high numbers of mooring installations and user conflicts at many sites. QPWS Marine Parks staff have had ongoing difficulty in monitoring the permitted status of installations due to the complexity of identifying precise mooring ownership in the field.

In late 1997, a database was completed containing all mooring and pontoon information on permit files, which was linked to a Geographic Information System (GIS) to provide baseline information on the physical location of permitted installations in the Cairns Section of the GBRMP. QPWS officers started to fix positions of installations found at reefs using Differential Geographical Positioning System (DGPS) in 1998 on an opportunistic basis, and in 1999 high priority was given to verifying mooring installations in the Cairns Section.

The site planning process in the Cairns Section has naturally grown out of this process and from the requirements of the Cairns Area Plan of Management (CAPOM). Site plans were prepared in response to the increasing use of many reefs in the Cairns Section, to ensure that the values of the area were protected and conserved, while allowing for a range of use opportunities. Amongst other strategies, the CAPOM limits the number of permitted moorings and pontoons that may be installed in each location, as well as limiting the installation of other structures.

Outcomes

The site planning and mooring allocation process in the Cairns Section is an extensive one. To date site plans have been completed for Lizard Island Localities 2 and 3, while a further 16 site plans are underway for other locations. Site assessments for many reefs have been completed and eight site plans are currently in the process of being drafted based on site assessment material. A period of public consultation involving marine industry groups, Local Marine Advisory Committees and other interested parties will follow.

The site assessment process in the Cairns Section generally involved:

- desktop compilation of information relevant to the site (values, past studies, permits etc.);
- developing GIS layers for permitted moorings, 50 m/ 200 m no anchoring buffers, preferred reef anchorages, designated reef anchorages, and fish spawning aggregation sites, which were placed on rectified aerial imagery of specific site planning locations;
- identification of sites for field assessment which did not conflict with existing permitted moorings and/or pontoon no anchoring buffers, designated reef anchorages and fish spawning aggregations sites;
- field assessments, by snorkelling if the site was small with good visibility, by manta tows for larger areas, or by scuba if visibility was low, to record reef structure, dominant biota, general diversity, aesthetics, anchoring or mooring suitability, access and egress consideration, and other relevant issues (e.g. crown-of-thorn starfish impacts).

The site planning research and assessment process in the Cairns Area has reinforced the view that good quality, accurate GIS base maps or rectified photos are integral to facilitate comprehensive site planning. Furthermore, achieving the appropriate balance between conservation and multiple-use requires accurate resource information, such as the spatial and temporal distribution of FSAS and an understanding of the impact of tourism activities.

Conclusions

Management of a multiple use Marine Park is a complex and challenging process. As managers we need to be responsive to changes in the way that increasingly scarce resources are used by the diversity of stakeholder groups. We must simultaneously be responsive to community needs and still meet our obligations to conserve the Great Barrier Reef for future generations. To do this, our planning processes must be innovative and dynamic.

In the Cairns and Whitsunday areas site planning lies within a framework provided by Plans of Management. This framework does not exist for some areas such as the Capricorn-Bunker group. Zoning plans (e.g. Mackay/Capricorn Section Zoning Plan) therefore provide the planning context for site planning at areas such as Fitzroy Reef that do not have these overarching Plans of Management.

Site planning, in conjunction with these planning frameworks and a process involving detailed impact assessment, focuses management attention at a fine scale. This allows managers to make informed assessments of proposals to install private moorings, pontoons, and other structures. Site plans have proven to be beneficial because they are flexible working documents which retain their currency as valuable management tools. They allow the incorporation of new management strategies and policies as they are developed.

Due to the many and varied values of specific reefs in the GBRMP, and the increasing demand for access by some users, a number of site plans have been developed. At present there are draft site plans for Hardy Reef and Fitzroy Reef, 14 site plans prepared for the Cairns Area by QPWS, and a number of bays and reefs identified as future site planning priorities.

Site plans also provide certainty for commercial and recreational users of the GBRMP. By creating a framework for equitable and transparent management, and identifying acceptable and sustainable activities relative to a sites' biological and conservation values, there can be no unrealistic expectations on permissible levels of use or access by the public or proponents. As such, site plans are a valuable guide for managers undertaking environmental impact assessment of proposed activities.

To ensure that site planning strategies consistently provide the best outcomes possible, they will require ongoing monitoring and adaptation as needs of both managers and users are identified, and will no doubt form an important part of the future management of the Great Barrier Reef.

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