REEF RESEARCH

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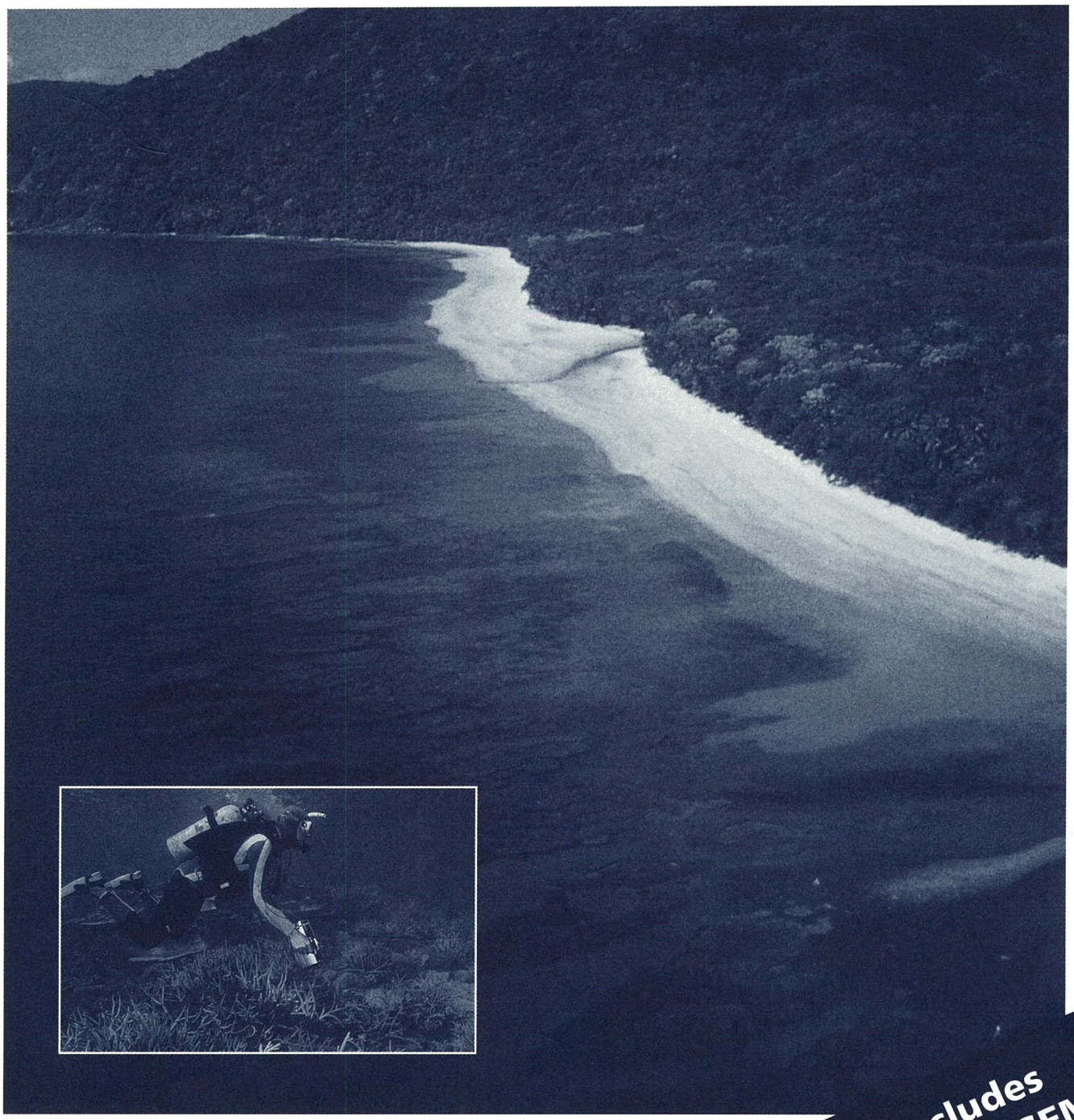

Includes REEF MANAGEMENT NEWS

Editorial

Research is the major theme for this issue. We begin with an introduction to the Authority's Research and Monitoring Coordination Unit. This introduction is followed by *What's Out There?* which looks at a study that has been undertaken by Sea Research, on behalf of the Authority, to monitor inshore fringing reefs in the Cairns Section of the Marine Park.

Ray Berkelmans provides us with details about the automatic weather stations that have been installed on the Great Barrier Reef. These weather stations will serve as early warning systems for events such as coral bleaching.

Research provides us with many answers and indeed these answers are often used in management practices. In order for scientists to carry out research on the Great Barrier Reef though, permission must be given in the way of a research permit. The Authority has developed a new system for its research permits. Paula Tomkins, Alison Green and Adam Smith report on this new system.

A summary of the six augmentative research grants the Authority awarded to students for 2000 is included. Once again a glossary is included (page 32) to assist you understand some of the terms that are used in the article.

A summary of the results of the fine-scale surveys that have been undertaken during the last five years, for the crown-of-thorns starfish, in the Cairns Section of the Great Barrier Reef Marine Park is also included. The text is mostly taken from a report which was produced by Udo Engelhardt and others for the CRC Reef Research Centre. It is reproduced here as I know many readers are interested in the crown-of-thorns starfish story.

In *Slick Talk* Steve Raaymakers reports on a global project which aims to assist developing countries implement effective measures to control the introduction of exotic marine species.

Barry Hunter of the Authority's Indigenous Cultural Liaison Unit writes about the initiatives that have been undertaken by many Indigenous communities to manage turtle and dugong.

I must offer apologies to Paige Rothenberger. In the last issue of *Reef Research*, Ms Rothenberger wrote an article on how encasement technology is being used in the restoration of mangrove forests. In that article Ms Rothenberger's e-mail address was given incorrectly. The correct e-mail address is prothen@uvi.edu.

Reef Management News

AQUACULTURE ventures and their potential impacts on the waters of the World Heritage Area adjacent to the Queensland coast are drawing increasing interest. In a major feature, we examine all aspects of the industry, including the rules and regulations and the effects of discharge from prawn ponds.

An innovative new system of video surveillance will be put in place shortly to monitor boat traffic in the Hinchinbrook area. We explain why it's being introduced and how boaties will be made aware of the transit lanes in this voluntary scheme.

The GBRMPA's Representative Areas Program is progressing with a major process of public participation including input by commercial fishermen. We detail an updated brochure being distributed to interested parties.

There's a detailed look at Acid Sulphate Soils – or the lack of them – around the Port Hinchinbrook development at Cardwell, as well as the environmental regime which has been put in place as a result of its chequered history.

The GBRMPA is being urged to press for compensation payments from shipping companies when their vessels run aground on reefs. Some overseas countries demand up-front payment before such ships are allowed to continue their journey. Should Australia be doing the same thing?

And we tell of hoppers which reduce the amount of dead bycatch from trawlers. As well as being environmentally friendly, they increase the value of the prawn catch. ■

WHAT'S IN THIS ISSUE

REEF RESEARCH:

REEF MANAGEMENT NEWS:

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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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An Update on GBRMPA's Research and Monitoring Coordination Unit

The Great Barrier Reef Marine Park Authority's Research and Monitoring Coordination Unit is responsible for coordinating a scientific basis for the management of the Great Barrier Reef Marine Park and World Heritage Area. This involves:

- identifying information needs for management (refer to article, page 4) and communicating them to research providers;
- coordinating research projects as required;
- providing technical advice to managers,
- providing scientific support for environmental impact monitoring programs; and
- developing relevant policies.

In doing so, the Unit works closely with research providers including the Cooperative Research Centre for the Great Barrier Reef World Heritage Area (Reef CRC), the Australian Institute of Marine Science (AIMS), James Cook University and other universities and research institutions. The Unit is responsible for coordinating many projects covering a variety of issues and disciplines.

The Research and Monitoring Coordination Unit has undergone quite a few changes in the last few years, and we thought it timely to provide an update to readers of *Reef Research*. For example, there has been a change in the composition of the unit. Previously, the Research and Monitoring Section comprised six program areas: water quality, crown-of-thorns starfish, fisheries, monitoring, socio-economic and section operations. Following a restructure of the Authority in 1998, in which a stronger focus was placed on critical issues, two program areas became separate Critical Issues Groups: Water Quality and Coastal Development (Jon Brodie, Director) and Fisheries Issues Group (Phil Cadwallader, Director). The remaining four program areas remain with two other changes: the internal crown-of-thorns starfish program has been greatly reduced with most of the work now being conducted by consultants via the Reef CRC, and the Unit's name has been changed to Research and Monitoring Coordination.

The Unit has also undergone quite a few staff changes. It is now made up of six full-time staff. **Dr Alison Green (Manager)** is responsible for managing the team and ensuring that the Unit fulfils its obligations. In particular, Alison is responsible for identifying research priorities, ensuring that information needs are met, providing scientific support for environmental impact monitoring programs and developing relevant policies.

Dr David Wachenfeld (Project Manager, State of the Reef Report) is responsible for the development and production of *The State of the Great Barrier Reef World Heritage Area* report and associated information products. The first report entitled *State of the Great Barrier Reef World Heritage Area 1998* was produced in 1998. David is currently developing a set of environmental indicators to be used in future State of the Reef Reports. The next report will be released in 2003. In the meantime you can access the current report on line at the Authority's web site (http://www.gbrmpa.gov.au/corp_site/info_services/publications/sotr/) or purchase a hard copy for $5 from Reef In Store (telephone +61 7 4750 0875; facsimile +61 7 4772 5281).

People, their activities, attitudes and the values they hold for the Great Barrier Reef World Heritage Area are important factors to consider as part of the management of the area. The social sciences provide information to understand this human aspect. **James Innes (Project Manager—Socioeconomics)** is responsible for this program, which includes identifying and coordinating the acquisition and dissemination of social, cultural and economic information for the Authority.

Several staff members are responsible for coordinating management needs in the natural sciences. **Ray Berkelmans (Project Manager)** has been seconded to AIMS to participate in a collaborative research program to investigate the links between global climate change and coral bleaching with AIMS and the United State's National Ocean and Atmospheric Administration. In Ray's absence, **Paul Marshall (Acting Project Manager)** is responsible for providing scientific support for environmental impact monitoring programs, as well as coordinating research projects and developing relevant policies. **Andrew Chin (Project Officer)** is responsible for the majority of the project management for natural sciences, data management and client liaison. Some of the projects Andrew is currently involved with include crown-of-thorns starfish surveys and extension, and long-term temperature and video monitoring of coral reefs. Andrew is also involved with running the Eye on the Reef Program, which is a joint monitoring program between the tourist operators, the Marine Park Authority and the Queensland Parks and Wildlife Service. The program is currently being trialed in the Cairns Section of the Marine Park. Andrew also coordinates the Authority's seminar series and provides technical advice to Reef HQ.

In addition to acting as Editor for this newsletter, **Kim Lally (Assistant Project Officer)** is responsible for preparing consultancy reports and workshop proceedings for publication in the Authority's Research Publication or Workshop Series. Kim also maintains a number of databases for the Unit and administers the Authority's Augmentative Research Grant Scheme.

Dr Zena Dinesen has been seconded to the Reef CRC to develop performance indicators for management of the Great Barrier Reef Marine Park and World Heritage Area. This research task will also contribute information for the State of the Great Barrier Reef World Heritage Area report on how key ecological, social, economic,

cultural and management objectives are being met. Three areas of research are currently involved: (1) reviewing and developing frameworks for performance reporting relevant to environmental management and conservation; (2) defining information needed to assess the success of the Representative Areas biodiversity conservation strategy; and (3) developing specific procedures and indicators to evaluate management in the Whitsundays area.

What happened to Dr Jamie Oliver?

Dr Jamie Oliver has been promoted from Manager of the Research and Monitoring Section to Director of the Authority's Information Support Group. This group is currently comprised of the following units:

- Research and Monitoring Coordination;
- Training and Advisory Services;
- Information Coordination and Analysis;
- Information Technology;
- Library; and
- Public Information and Production.

To contact any of the Research and Monitoring Coordination staff please call the Authority on +61 7 4750 0700.

Intensive Marine Pollution Course—Orpheus Island Research Station

An intensive course in marine pollution will be run at Orpheus Island Research Station from 17–23 July 2000. The course is suitable for staff from marine resorts in the Great Barrier Reef who have a strong interest in marine pollution issues, and who wish to be able to communicate this to tourists who visit the area. The course consists of lectures, tutorial sessions and field and laboratory work at Orpheus Island. Assessment is by a literature review, seminar presentation and examination in August. The maximum number of participants is 20.

For further details of the course, including costs, contact the course coordinator:

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Identifying Information Needs for Managing the Great Barrier Reef Marine Park and World Heritage Area

The Great Barrier Reef Marine Park Authority (GBRMPA) is the principal adviser to the Commonwealth Government on the care and development of the Great Barrier Reef Marine Park and is the lead agency for Great Barrier Reef World Heritage Area issues. Having the best available information for decision making is essential to high quality scientifically-based management of this important area.

Recently, GBRMPA completed a series of workshops aimed at identifying the information needs for managing the Marine Park and World Heritage Area. In particular, the workshops focussed on identifying information needs for the Authority's four critical issue groups (Conservation, Biodiversity and World Heritage; Fisheries; Tourism and Recreation; and Water Quality and Coastal Development), Day to Day Management, Program Delivery, Research and Monitoring Coordination and Reef HQ. The Authority was greatly assisted in this process by a CRC-funded consultant (Ecoconnect—science and environment communication) who facilitated the workshops, and representatives of the scientific community who were invited to participate.

The results, which will be released as a GBRMPA publication in the near future, have already played an important role in informing the Cooperative Research Centre for the Great Barrier Reef World Heritage Area of the Authority's information needs prior to the finalisation of the Centre's research program for the next year. For further information contact Dr Alison Green, Manager, Research and Monitoring Coordination, GBRMPA, on +61 7 4750 0700.

Disturbance and Recovery Cycles Long-term Monitoring on 'Unlucky' Inshore Fringing Reefs in the Cairns Section of the GBRMP

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Since 1985, the Great Barrier Reef Marine Park Authority has contracted Sea Research to conduct regular benthic surveys on the inshore fringing reefs of the Cairns Section of the Great Barrier Reef Marine Park. Initially these surveys were confined to three locations along Cape Tribulation to monitor the effects of sediment run-off from a newly constructed dirt road running through steep rainforested hills between Cape Tribulation and the Bloomfield River. There was concern that heavy sediment run-off from the unsealed road would have adverse effects on the fringing reefs (Bonham 1985). These surveys continued until 1989.

In 1994, the Authority commissioned a broad scale survey of the fringing reefs in the Cairns Section to document fringing reef communities in the region for comparison with the Cape Tribulation study. Following on from this study, long-term monitoring of additional potential human impacts began on two island fringing reefs, Snapper Island and the Frankland Islands, and monitoring re-commenced at the Cape Tribulation sites.

In the course of these surveys the reefs have been affected by two separate bleaching events, numerous cyclones, major floods and, most recently, outbreaking populations of crown-of-thorns starfish (COTS). Thus what initially began as a program to monitor the effects of sediment run-off and anthropogenic pressures has also generated very useful data on disturbance-recovery cycles for inshore fringing reefs.

Survey Techniques and Design

The three regions were surveyed during the summer months using fixed transects. Three locations were surveyed along Cape Tribulation. Sediment run-off from old and new road construction sites and from undisturbed locations was monitored. Monitoring of the Snapper and Frankland Islands was carried out at two locations on opposite sides of each island, as each side supported slightly different coral communities. The survey history is summarised in table 1. Surveys were conducted as per Ayling & Ayling 1999.

Table 1. *History of the fringing reef monitoring programs in the Cairns Section of the Marine Park*

Region: Potential impact	No. locations	No. sites per location	No. of transects per location	Survey event
Cape Tribulation: Siltation from road construction and coastal development	3 (different levels of impact)	4	5 fixed	1985–1989 1993–2000
Snapper Island: Recovery from flood damage Heavy recreational use	2 (habitats)	3	5 fixed	1994–1995 1997–2000
Frankland Islands: Heavy recreational use	2 (habitats)	3	5 fixed	1994–1995 1998–2000

To document the effect of the 1998 bleaching event on these reefs additional surveys were carried out in March–April 1998. All Frankland Island sites and selected sites of Snapper Island and Cape Tribulation were surveyed. During these surveys the condition of all coral colonies measured along each transect was recorded so the percentage of bleached corals could be calculated.

Where COTS were encountered during the 1999 surveys, densities were estimated by counting numbers of the starfish in 20 x 2 m strips along each permanent coral transect.

Disturbance and Recovery

Collectively the three survey regions have been subjected to seven major disturbances (table 2) during the period of the surveys.

Table 2. Disturbance events which coincided with surveys of Cape Tribulation, Snapper Island and Frankland Islands fringing reefs.

	Cape Tribulation	Snapper Island	Frankland Islands
Survey events	1985–1989, 1993–2000	1994–1995, 1997–2000	1994–1995, 1998–2000
Cyclone			
Manu—1986	✔		
Justin—1997		✔	
Rona—1999	✔	✔	
Bleaching			
1987 event (minor)	✔		
1998 event	✔	✔	✔
Flood			
Daintree River, 1996	✔	✔	
COTS outbreak			
1999–2000	✔		✔

Figures 1, 2 and 3 show the mean total coral cover for the three study regions during the survey period. The disturbance and recovery of these reefs in terms of overall coral cover are distinct.

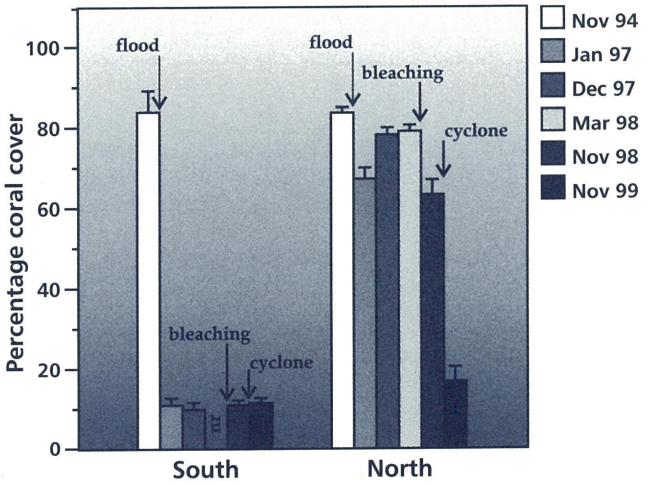

Figure 2. Total hard coral cover changes on Snapper Island reefs. Graphs show means from five transects at three sites for each location. Approximate times of major disturbances are indicated. Error bars are standard errors. nr = coral cover not recorded in south habitat at this time.

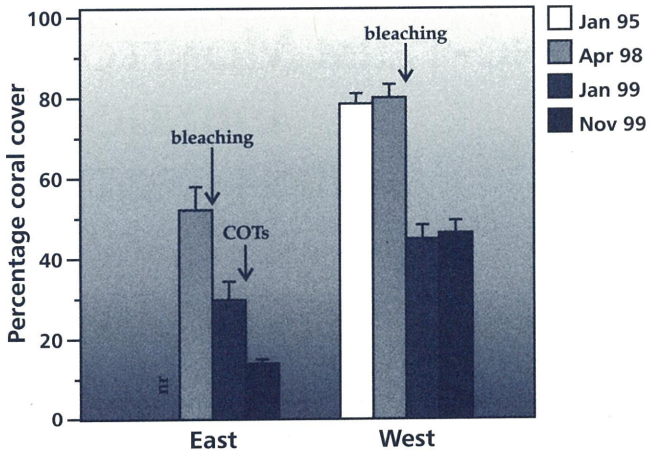

Figure 3. Total hard coral cover changes on Frankland Island reefs. Graphs show means from five transects at three sites for each location. Approximate times of major disturbances are indicated. Error bars are standard errors. nr = coral cover not recorded in east habitat at this time.

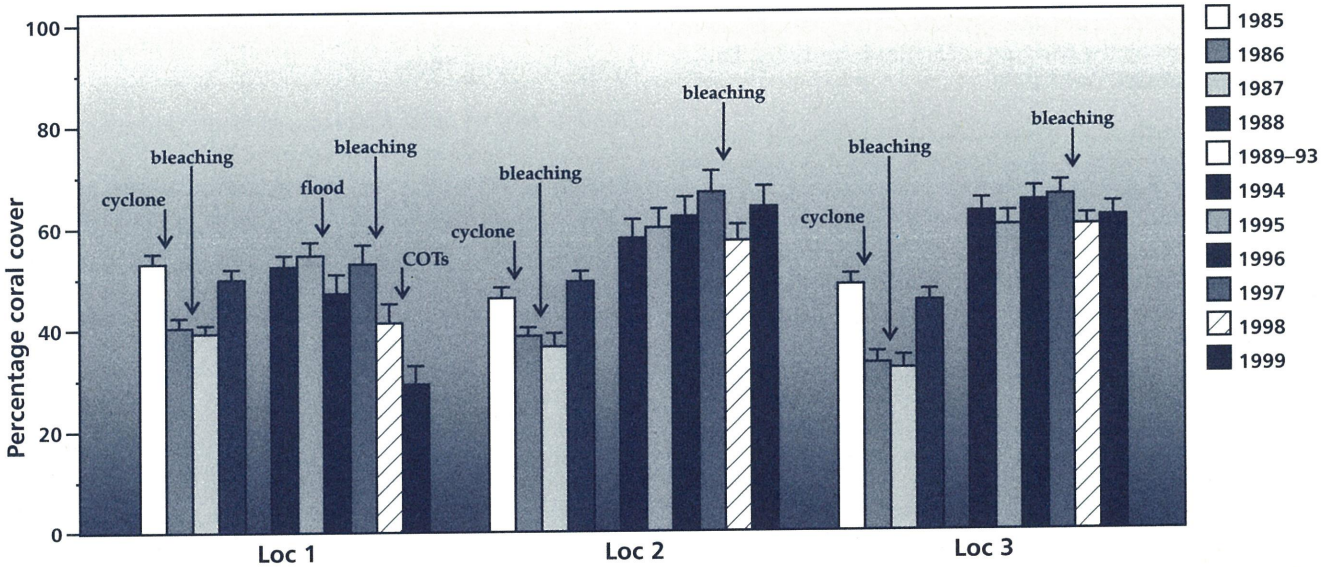

Figure 1. Total hard coral cover changes on Cape Tribulation reefs. Graphs show means from five transects at four sites for each location. Approximate times of major disturbances are indicated. Error bars are standard errors. No surveys were carried out between 1989 and 1993.

Disturbance-Recovery Case Studies

Case #1
Period: 1986–1987
Disturbance: Cyclone and minor bleaching
Location: Cape Tribulation

In April 1986, cyclone Manu crossed the coast near Cooktown generating winds between 40 and 50 knots that caused extensive coral breakage to the Cape Tribulation reefs. Coral cover at the survey locations was reduced by 25%. The affected taxa consisted mainly of the dominant *Acropora/Montipora* species. Recovery was complicated by the advent of a minor bleaching episode the following year (1987). This event bleached 33% of the remaining corals and resulted in some coral death, particularly among the pocilloporids and *Montipora* spp. Coral cover was decreased by about 4% between 1986 and 1987. However, recovery of these reefs was rapid. In the absence of further disturbances, the 1988 survey showed that overall coral cover had increased by a mean of 33% from 1987, and was similar to that of the 1985 surveys. This increase was mainly driven by rapid growth of common acroporid species.

Although the cover of *Acropora/Montipora* may be greatly reduced during a cyclone, there were many live fragments remaining in even the worst affected areas. Growth of these fragments could have led to the rapid recovery of these communities and as such, recovery to pre-disturbance levels of coral cover may not depend entirely on new recruitment.

Case #2
Period: 1996
Disturbance: Major flood event
Location: Cape Tribulation and Snapper Island

In March 1996, the Daintree region received heavy rainfall with five-day totals of around 1500 mm. This resulted in major freshwater run-off from numerous moderate-sized creeks while the Daintree River rose up to eight meters above high spring tide level. The flood plume from the Daintree River flowed north driven by the prevailing south-east winds (Ayling & Ayling 1998a). The resulting freshwater run-off inundated Snapper Island—which is situated near the mouth of the Daintree River—while Cape Tribulation sites would probably have been inundated from run-off from various coastal creeks.

Cape Tribulation: Surveys conducted in December 1996—nine months after the flood—showed that there were many dead coral colonies that evidently had been dead for quite some time. This death probably resulted directly from the flood event. Coral cover was reduced from approximately 55% (in 1995) to 47% in the southerly site (Ayling & Ayling 1998b). These sites were situated close to the mouths of coastal creeks. There were no marked differences in mortality rates between the different coral taxa (Ayling & Ayling 1998b). Recovery was rapid with many sites recovering to pre-disturbance levels within 12–24 months.

Snapper Island: In contrast to the Cape Tribulation reefs, the January 1997 survey revealed that the shallow reefs on the southern side of Snapper Island were decimated to a depth of three metres below low tide level. Coral cover had decreased from 90% (recorded in the 1994–1995 survey) to 10% and the reef displayed the characteristic signs of flood water inundation and mortality as described by van Woesik et al. (1996). The acroporids suffered almost complete mortality and most of the surviving corals were massive poritids and favids. In contrast the northern reefs only suffered a 20% reduction in coral cover. It appears that the north side of Snapper Island escaped the flood plume and it seems likely that an upwelling of seawater on the lee of the island protected the reefs from freshwater inundation (Ayling & Ayling 1998a).

Recovery on the north face of the island has occurred with a 16% increase in coral cover between the flood and January 1997, however there has been no recovery measurable by coral cover at the southern reef sites. This may be attributed to the fact that the majority of the surviving corals are slow growing poritids, and recovery of the previously dominant acroporids to pre-flood levels will rely on new recruitment and subsequent growth. The November 1999 survey identified numerous new acroporid and pocilloporid colonies suggesting that recruitment has indeed occurred and that recovery is underway.

Case #3
Period: 1998
Disturbance: Bleaching
Location: Cape Tribulation, Snapper Island and the Frankland Islands

The coral bleaching event of February and March 1998 affected large areas of the Great Barrier Reef and all of the survey regions were affected by this event. All three regions suffered bleaching of 55–60% of the coral cover and it was evident that certain coral groups appeared to be much more vulnerable to bleaching stress than others. For example, the pocilloporids were heavily bleached and subsequently suffered almost 100% mortality from this event at all sites.

Cape Tribulation: Montiporid corals at this site were significantly affected with 74% bleached. The favids fared better with 50% bleaching while only approximately 30% of the poritids and acroporids were bleached. However, eight months after the event most of the bleached *Acropora* spp. and deep water corals* appeared to have recovered with only a 10% reduction in these groups (Ayling & Ayling 1999). There were no significant changes in the percentage cover of the poritids.

Snapper Island: Pocilloporids, favids and deep water corals* showed significant levels of bleaching, and 50–65% of the acroporids were bleached. Mortality was almost complete among the pocilloporids while about half of the favids and deep water corals and < 20% of the acroporids died (Ayling & Ayling 1999). Recovery was rapid and within 24 months total coral cover was close to 1997 levels. The southern Snapper Island reef, dominated by bleaching resistant poritids, was largely unaffected.

* For this study, deep water corals are those corals found below the four-metre low tide level. These corals were typically more massive species including the genera: *Podabacia, Goniopora, Alveopora, Platygyra, Hydophora, Galaxea, Merulina, Lobophyllia, Symphyllia, Echinopora, Echinophylia, Oxypora, Mycedium* and *Pectinia.*

Frankland Islands: All coral groups with the exception of the poritids were extensively bleached at these sites. Pocilloporids were the worse affected (97% bleached). Mortality among this group, as in other locations, was almost 100%. The acroporids suffered 60% mortality and the community structure has changed from being acroporid dominated to poritid dominated. The poritids

were only slightly affected with < 10% bleaching. Recovery of these reefs in terms of coral cover has been slow, probably due to the (present) dominance of slow growing species.

Collectively, mortality from this bleaching event resulted in mean reductions in coral cover of 15% for Cape Tribulation, 19% for Snapper Island and 44% for the Frankland Islands. There were some differences in the mortality and recovery of corals of the same genus between different sites (e.g. *Acropora* between Snapper and Frankland Islands) but the reason for this is as yet, undetermined. However, numerous plausible explanations can be identified such as species specific responses to bleaching.

Case #4
Period: 1997, 1999
Disturbance: Cyclone Justin (1997), Cyclone Rona (1999)
Location: Snapper Island

Cyclone Justin crossed the coast north of Cairns in March 1997 and gave rise to 40 knot northerly winds in the vicinity of Snapper Island. This cyclone fragmented corals on the north face of Snapper Island (A.M. Ayling pers. obs.) but by the time of the next survey in December 1997 coral cover had increased by 16% over that recorded on surveys conducted in January 1997, three months before the cyclone.

Tropical cyclone Rona passed very close to Snapper Island in February 1999 generating winds of 50–70 knots. This event caused severe damage on the northern Snapper Island sites where fragile acroporid corals dominated, turning the fields of *Acropora* in the two eastern-most sites to rubble banks with around 90% mortality of living corals. The low level of live coral probably means that recovery of these sites may take at least several years. On the southern side of the island, dead standing corals (killed during the 1996 flood event) were broken into rubble and many massive *Porites* colonies knocked over. However because the corals which survived the 1996 flood were mostly these massive colonies, cyclone Rona did not reduce the overall coral cover.

Case #5
Period: 1999 – ?
Disturbance: Crown-of-thorns starfish
Location: Cape Tribulation, Frankland Islands

During the summer of the 1999–2000 survey event, COTS were recorded for the first time on Cape Tribulation and Frankland Island reefs. The density of starfish on reefs south of Cape Tribulation and the eastern Frankland Islands ranged from 50–2000 individuals per hectare and the coral communities have suffered reductions of 40–66% live coral cover.

Cape Tribulation: By the time of the February 2000 survey, very high densities of COTS in the 15–25 cm size class were found at three sites south of Cape Tribulation. There were also many feeding scars and dead standing corals evident. Coral cover at these sites had been reduced by between 40–50% from levels recorded in the 1998–1999 surveys.

Frankland Islands: Outbreaks were found on two eastern sites during the November 1999 survey. These sites supported densities of 500–2000 individuals per hectare, with diameters ranging between 10 and 20 cm. Coral cover at the south and central eastern sites was reduced by 59% and 66% respectively. The acroporids appeared to be the main target of feeding and were significantly reduced, but all other coral groups were nominally reduced.

The impact of the COTS outbreak is likely to be as severe as that of cyclone Rona or the 1996 flood event. Coral mortality is expected to be close to 100%. Subsequent recovery may take many years.

The Ups and Downs of Corals Reefs

These case studies offer a brief look into the disturbance and recovery cycles occurring on these inshore fringing reefs. Generally, they show that the effect of any particular disturbance event will depend on the nature of the disturbance and factors such as reef location and community structure. Continued monitoring of these reefs, particularly in the light of the current COTS outbreak, will make important contributions to our understanding of how reefs are affected by impacts and how they recover. At this stage, several obvious and generalised relationships are evident.

1. The effect of disturbances on coral reefs is a function of the community composition and the resilience of the corals in that community.
2. The effects of disturbances are a function the physical, hydrological and oceanographic factors occurring *at that time*.
3. The community composition of inshore fringing reefs at any one point in time may well depend on the recent ecological history. As coral cover may depend on community composition, the use of coral cover as an indicator of reef 'health' should take into account the ecological history and species flux of the reef in question.
4. Coral community composition can fluctuate dramatically from year to year. Analysis of concurrent disturbance-recovery cycles may constitute more accurate indicators of 'reef health' than absolute values of coral cover.
5. Recovery can be quite rapid depending on the surviving species. The presence of surviving coral fragments may greatly accelerate the recovery period. However, the respective contributions towards recovery from fragment re-growth and larval recruitment on these reefs is unknown.
6. These reefs may be able to support high levels of coral cover and diversity in spite of relatively frequent, large-scale disturbance events.

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Automatic Weather Stations: The New 'Smoke' Detectors on the Reef

Ray Berkelmans
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A network of weather stations and an innovative computer expert system is now in place to monitor and alert us to environmental conditions that may be stressful to corals, much as smoke alarms provide early warning of fire. This is one of the outcomes of a research collaboration between the Great Barrier Reef Marine Park Authority (GBRMPA), the Australian Institute of Marine Science (AIMS) and the United States based National Ocean and Atmospheric Administration (NOAA). As part of this collaboration, GBRMPA is installing two new automatic weather stations on the inshore Great Barrier Reef to compliment four existing weather stations on the offshore Great Barrier Reef run by AIMS. These weather stations provide near real-time feedback on weather and sea temperatures out on the reef. Data are sent every evening to NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami, Florida where the data are processed by a computer expert system. Automated warnings are sent out when given triggers, representing theorised stressful conditions, are exceeded. Such warnings will assist:

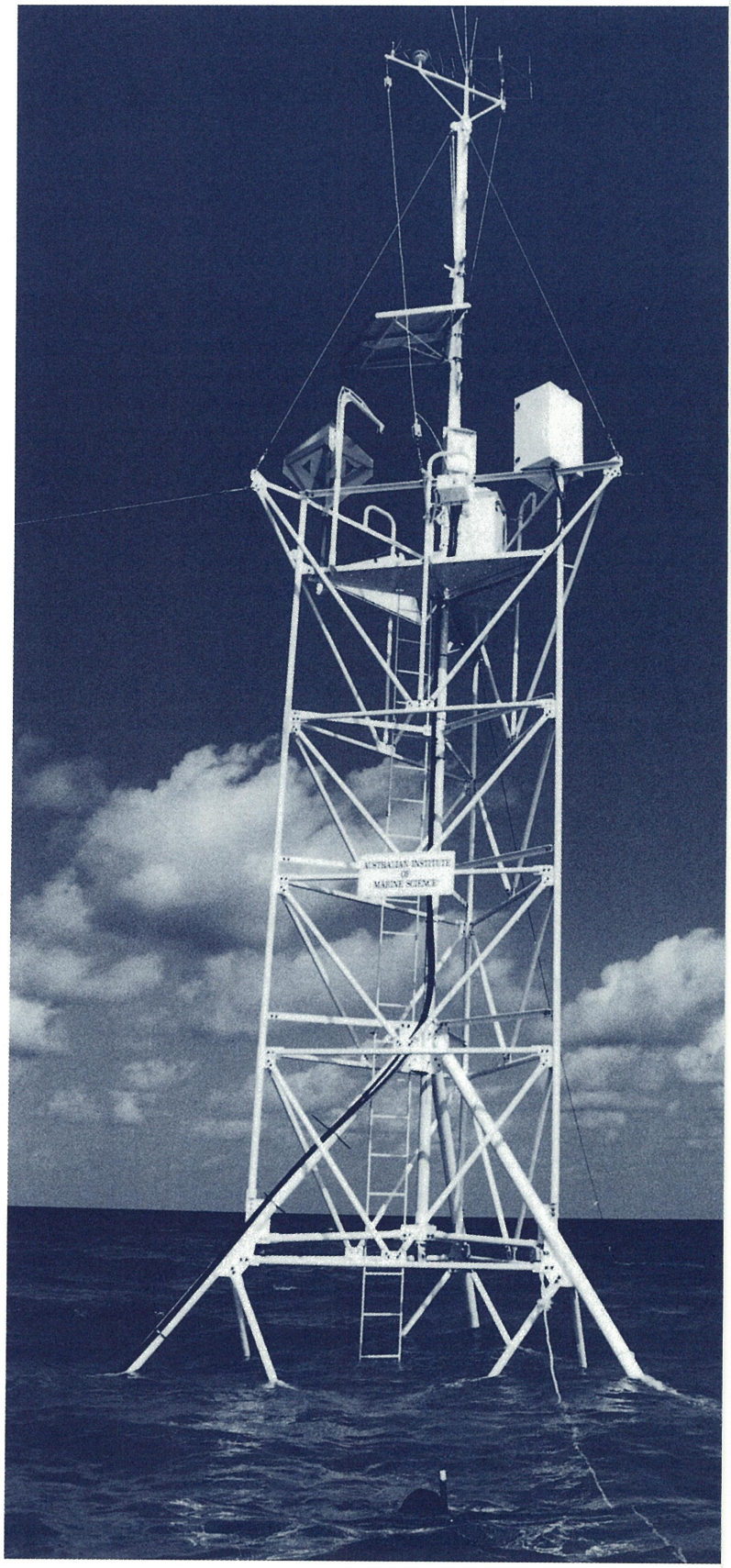
(a) Science—in the timely monitoring and improvement of our understanding of coral bleaching;

(b) Public relations—in keeping commercial operators on the Great Barrier Reef, politicians and the general public informed; and

(c) Coral reef managers—in amelioration of local-scale human impacts which might exacerbate coral bleaching.

Since the global coral bleaching event of 1998, which caused widespread coral morality particularly in the Indian Ocean, scientists are keenly aware of environmental conditions which are stressful to corals. Those conditions tend to occur when temperatures are high, winds are calm and solar radiation is high. An early warning system based on these parameters successfully predicted the onset of coral bleaching in the Florida Keys in August 1998. This encouraging achievement paved the way for the development of a similar system for the Great Barrier Reef using local weather stations and exceedence thresholds.

Preliminary thresholds were developed and implemented in an early warning system for four weather stations on the Great Barrier Reef for the 1999–2000 summer. Although still in a pilot phase, the system has already had success in alerting AIMS and GBRMPA to minor coral bleaching at Myrmidon Reef at the end of January 2000. The warm season started with unusually



Automatic weather stations such as this one at Davies Reef are used to collect weather and water temperature data. This data are used to generate near real-time warnings of coral bleaching. (Photo courtesy of the Australian Institute of Marine Science.)

cool water temperatures, overcast skies and generally strong winds in November, December and most of January. However, the last two weeks of January saw a complete turnaround in this weather pattern with clear skies and light northerly breezes resulting in a drastic warming of sea temperatures. Alerts of possible bleaching conditions were received for Myrmidon Reef near Townsville and Agincourt Reef near Port Douglas between 29 and 31 January. AIMS scientist Emre Turak visited Myrmidon Reef on 14 February and saw clear evidence of mild bleaching on the reef flat, despite temperatures having dropped from a high of 29.7°C in late January to around 28°C. Describing the bleaching he wrote:

> 'Bleaching was only partial and exclusive to a number of species. All *Acropora gemmifera* appeared to be affected with various degrees of paling or fluorescing. *Acropora digitifera* was another species which appeared affected while other species in the humilis group (*A. humilis* and *monticulosa*) and other *Acropora* spp. were not touched.'

Although this observation points to localised and mild bleaching, the early warning system at Myrmidon Reef clearly shows potential. Having this advance notice of possible bleaching allowed for a coordinated documentation of bleaching through incidental observations by scientists from a wide range of organisations. Luckily, the warm water temperatures of late January abated in February, and a more widespread bleaching event was avoided.

The bleaching alert for Agincourt Reef turned out to be a false alarm. Staff from Reef Biosearch who operate reef interpretation services at Quicksilver's pontoons at Agincourt #3 and 2d reported no unusual paling of *Acropora gemmifera* or other corals species at their sites. Alarm triggers were initially set at the same levels for both Agincourt and Myrmidon Reefs. As environmental conditions were very similar on both reefs during this period, the false alarm indicates that coral communities on these two reefs, separated by approximately 330 kilometres, may have different tolerance levels to bleaching. This is encouraging news as it implies that some coral populations may be better adapted to thermal stress than others and may therefore be more resilient to potential future climate warming. Expert system rules are currently being re-programmed for Agincourt Reef to adjust alarm triggers as a result of this feedback.

New weather stations on the inshore Great Barrier Reef in Cleveland Bay, near Townsville and Keppel Bay, near Rockhampton will complement offshore weather stations at Agincourt Reef, Myrmidon Reef, Davies Reef and Hardy Reef to provide a better representation of the Great Barrier Reef. With the weather station network in place and close collaborative links forged with NOAA, further possibilities are opened up using interpreted near real-time weather data. For example, NOAA has already developed an expert system to predict the sea state and wave height at Myrmidon Reef. In time, similar expert systems may provide predictions of underwater visibility, coral spawning, fish migration, algal blooms, etc. Data from the Great Barrier Reef automatic weather stations can be seen at http://www.aims.gov.au/pages/weather%2Dindex.html and information on the research collaborative with NOAA is available at http://coral.aoml.noaa.gov/corvil/index.html.

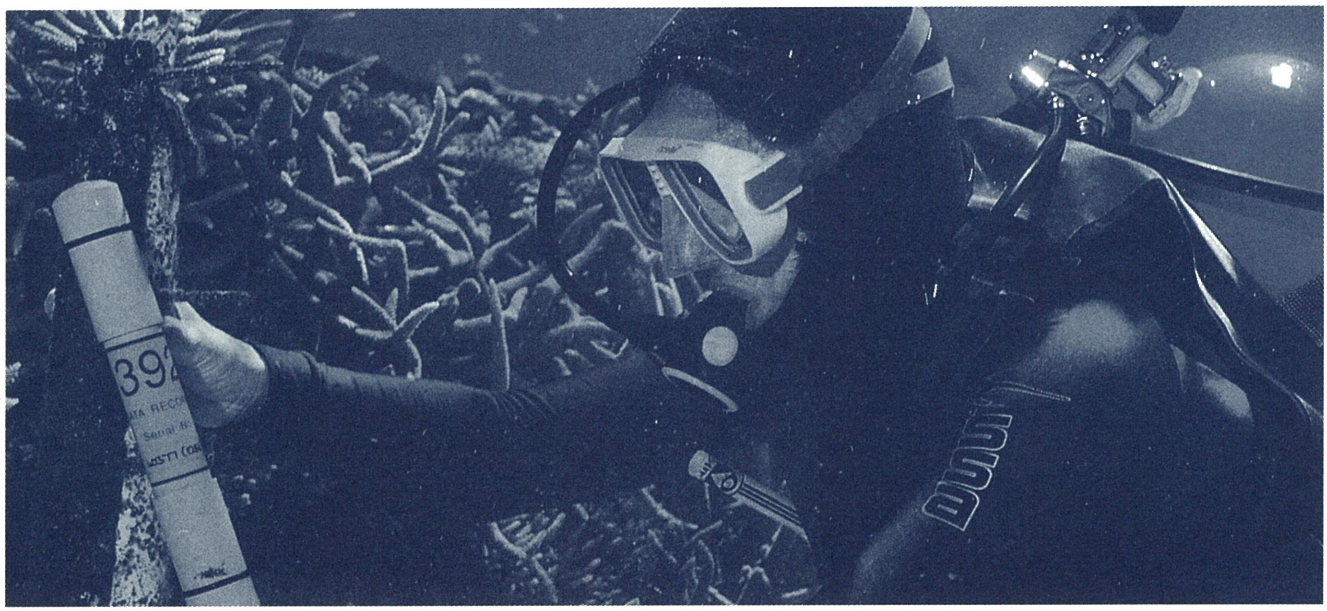
NEW PUBLICATIONS

	Price ($)
Ayling, A.M. and Ayling, A.L. 1999, *Medium-term Changes in Coral Populations of Fringing Reefs at Cape Tribulation*, Research Publication No. 59, Great Barrier Reef Marine Park Authority, Townsville, 46 pp.	n/c
Mapstone, B.D., Ayling, A.M. and Choat, J.H. 1999, *A Visual Survey of Demersal Biota in the Cairns Section of the Great Barrier Reef Marine Park*, Research Publication No. 60, Great Barrier Reef Marine Park Authority, Townsville, 42 pp.	13.70*
Ormsby, J. and Shafer, S. 2000, *Visitor Experiences, Values and Images of Whitehaven Bay: An Assessment of Perceived Conditions*, Research Publication No. 62, Great Barrier Reef Marine Park Authority, Townsville, 83 pp.	19.70*
KPMG Consulting 2000, *Economic and Financial Values of the Great Barrier Reef Marine Park*, Research Publication No. 63, Great Barrier Reef Marine Park Authority, Townsville, 42 pp.	11.60*

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

A New Research Permit System for the Great Barrier Reef

Paula Tomkins, Alison Green and Adam Smith
Great Barrier Reef Marine Park Authority



The Great Barrier Reef Marine Park Authority (GBRMPA) and the Queensland Parks and Wildlife Services (QPWS) have recently implemented a new streamlined research permit assessment process.

Research permits for both the Commonwealth and State Marine Parks are now assessed by GBRMPA in consultation with QPWS. The result is a quicker, more efficient process with more consistent assessments.

The Authority and QPWS issue approximately 150 joint research permits each year to scientists, students and consultants from government and private organisations. The majority of these are for projects based at the research stations at Lizard Island, Orpheus Island and Heron Island.

Permits are issued for most research activities undertaken in the Marine Park to reduce impacts on high use areas, protect culturally sensitive sites, separate conflicting activities and to monitor extractive activities. Results from research provides the Authority with valuable information for management.

The majority of permits issued are for limited collecting activities involving small numbers of fish, invertebrates, and plankton, or for projects that have no direct impact on the environment, such as photographic or visual surveys. A very small number of permits involve projects that could have significant impacts on the Marine Park.

Assessment of research permit applications is complex. Applications require notification to native title claimants allowing a 28-day period for comment. In addition, assessment must be made of the potential impacts of a proposal on the Marine Park and its users. Some applications are referred to Critical Issues Groups within the Authority for comment. A small number may be referred to the Environmental Research Ethics Advisory Committee if they involve:

- endangered species;
- the introduction of plants/animals, or genetically modified material to the Marine Park;
- the destruction of habitats on a large scale;
- collection of plants, animals or materials at a significant scale;
- the use of toxic or radioactive chemicals;
- work in Preservation Zones;
- new or changed zoning provisions and regulations.

The Great Barrier Reef Marine Park Authority aims to process most permits within eight weeks. Applications may take longer if they are referred to the Environmental Research Ethics Advisory Committee for consideration.

In line with the streamlined assessment process, a new Research Permit Application Form has been developed. The aim of the form is to obtain the relevant information for an assessment in the first instance, without the need to repeatedly contact the client.

The application form is essentially designed for an electronic format in an endeavour to provide researchers with ready access to the form and associated information. The new application form will be available by May 2000 on the Authority's web site at http://www.gbrmpa.gov.au.

The Authority has a goal to improve client relations and satisfaction through the achievement of a streamlined and efficient permit process.

REEF MANAGEMENT NEWS

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Video system designed to increase dugong protection

AN innovative new video system will be introduced in the Hinchinbrook region to monitor measures designed to increase protection for dugongs.

The video cameras will be located on navigation markers to monitor voluntary compliance by boat operators with transit lanes mapped out by management agencies including the Great Barrier Reef Marine Park Authority, the Environment Protection Agency and the Queensland Department of Transport.

The two time-lapse cameras will be put in place by the end of March following trials at two locations on the mainland — on the Telstra tower south of Cardwell and at the Cardwell jetty.

They will be monitored by staff from the Queensland Parks and Wildlife Service and the indigenous Girringun representative group, who are already involved with QPWS in monitoring and managing sites of cultural significance in the area.

The video equipment has been purpose designed and built to take periodic snapshots of the area with short sequences taken at pre-determined or random times each day.

The results will provide a reasonably frequent sample of vessel movements including identification of the type and size of the vessel and whether or not it is using the transit lane.

James Innes, the social, cultural and economic project manager at the GBRMPA, said the Hinchinbrook operation built on a successful trial of similar surveillance at Manta Ray Bay in the Whitsundays, which was a post-graduate research project involving the use of one mounted camera.

"We followed that up by testing one camera on the Telstra tower at Cardwell, but we found the camera on the jetty, filming at a lower angle, gave us better results," he said.

Marine Parks staffer Julie Russell points out the camera on Cardwell jetty

"It is important to carry out this monitoring because the disturbance of dugong in critical feeding areas and vessel strike have been recognised as threats to animal.

"Monitoring the use of transit lanes and continued observation of the local dugong population will tell us whether the system of voluntary compliance is working or whether they need to be enforced. It also has implications for other types of future initiatives in the Marine Park when we would want to work co-operatively with users rather than produce black and white rules."

Boat operators will be made aware of the transit lanes when an explanatory leaflet is produced and distributed at boat ramps in the Hinchinbrook region.

An A3 map will also be available with more detailed information, including co-ordinates for GPS users and line-of-site information for smaller vessels. The local Chamber of Commerce and the Hinchinbrook Local Marine Advisory Committee will also disseminate the leaflet and map. ■

Fishermen aid unique World Heritage program

THE Great Barrier Reef Marine Park Authority will begin a major process of public participation in its Representative Areas Program when an update brochure is distributed to interested parties during April.

The Representative Areas Program is a unique exercise which sets aside areas of the Great Barrier Reef World Heritage Area to protect biodiversity and habitat; its progress will be aided by business and community feedback as it develops and expands over the next year.

Discussions are being held with peak organisations including commercial fishermen to set the framework for the establishment of a network of protected areas within the GBR World Heritage Area.

The GBRMPA will be relying heavily on information supplied by fishermen for the success of the Program. Over the next nine months there will be a series of regional workshops and meetings at which the Authority will seek feedback from stakeholders about the importance of social, economic and cultural factors which affect them.

The first stage of public involvement will be when people are told about the bioregions (maps of diversity) which have been defined by marine experts, and ways in which users of the World Heritage Area may be involved in the process.

This description of diversity within a marine World Heritage Area is believed to be a world 'first'. It is unique because the GBRMPA has used a mixture of data, complex analyses and more than 220 years of combined expertise from people who have worked on marine ecosystems in the World Heritage Area.

The Representative Areas brochure spells out details of the program

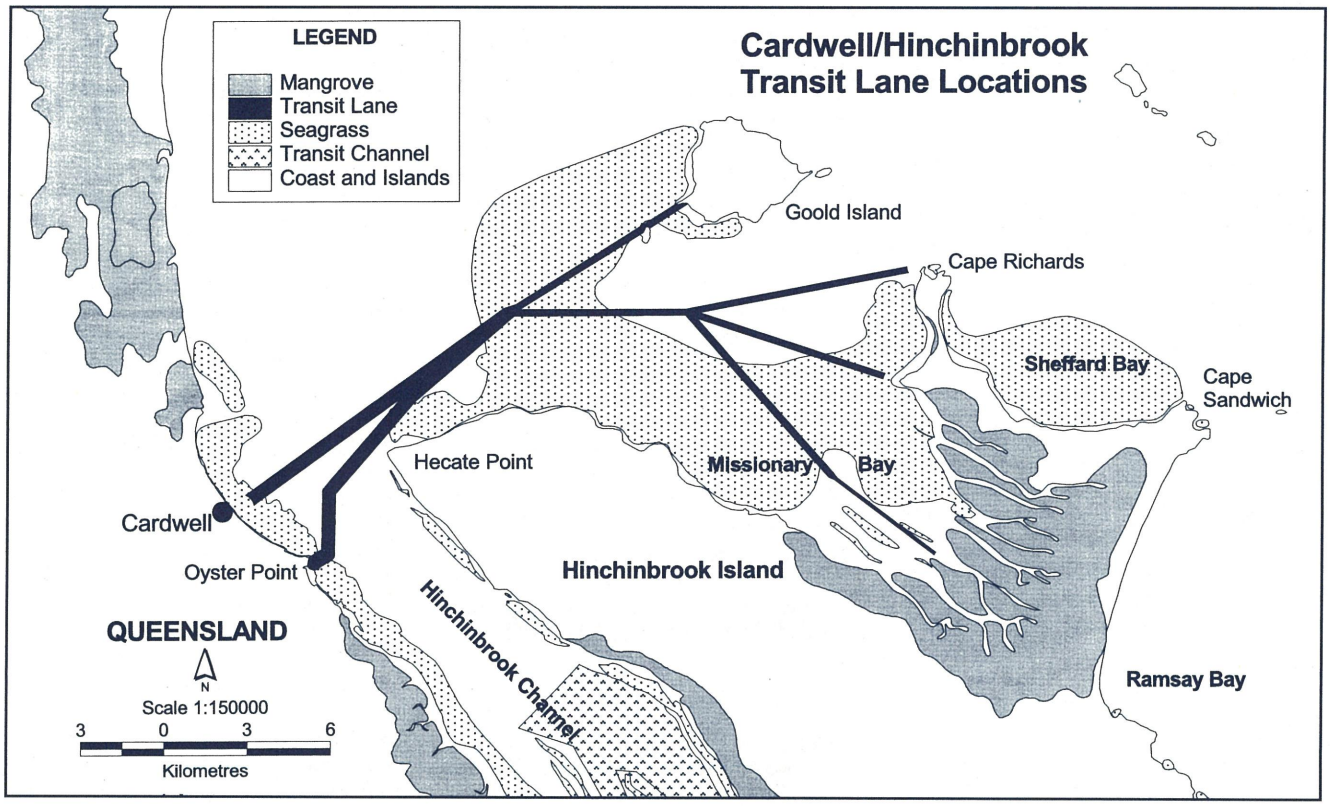
Although the map is based upon best-available information, the Authority recognises that as time goes on it will get better knowledge and more expertise, so the description of marine diversity will be updated and improved.

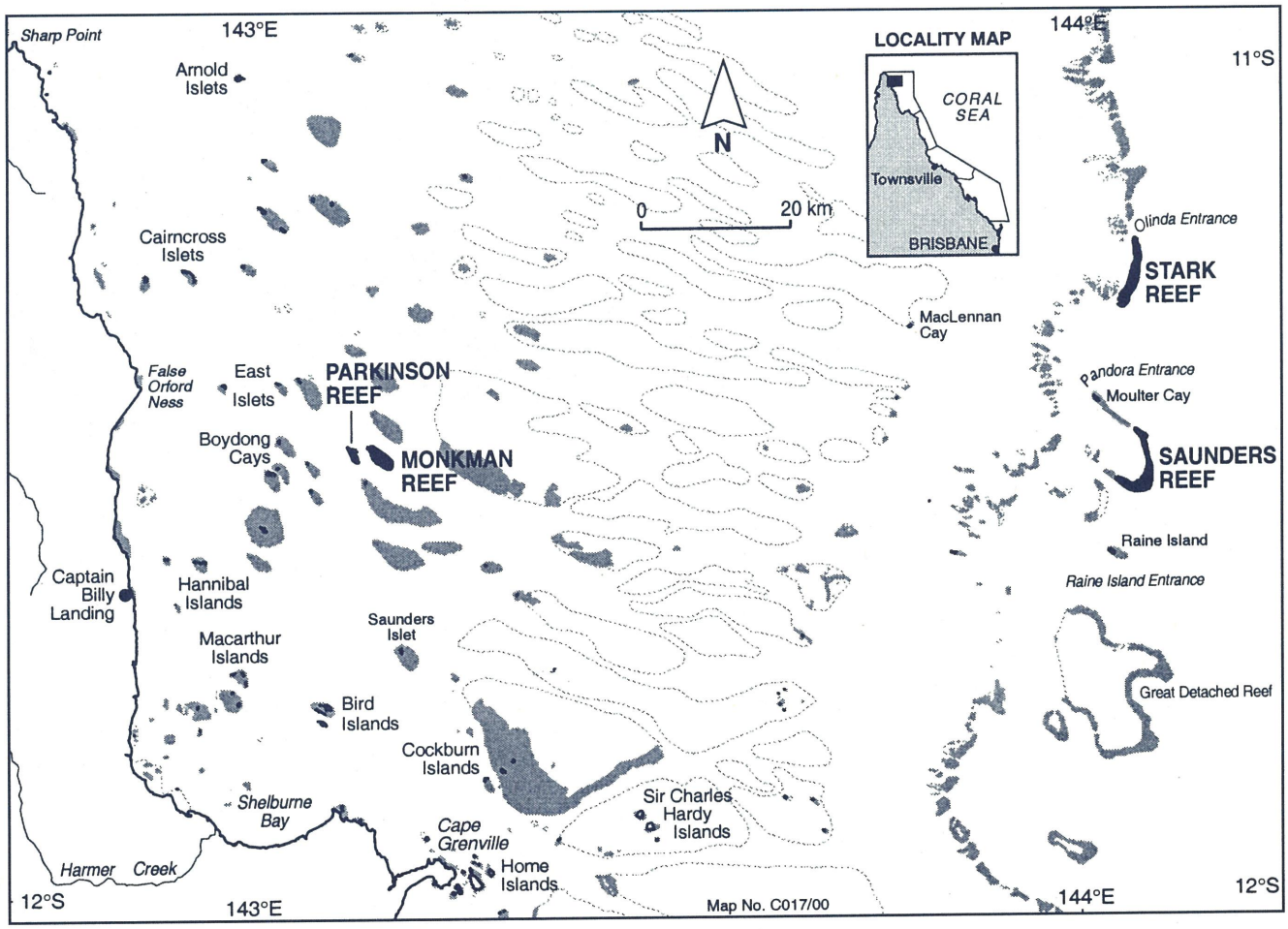
The map which will be released shows 31 different reef regions and 34 non-reef environments. Within each of those bioregions the reefs and soft-bottom areas are respectively more similar to each other than to areas outside.

The Program was launched because the Authority wants to establish the most solid scientific base possible for enhancing the protection of biodiversity of the World Heritage Area. Up to five staff members are working on it full time, with several supporting staff, and another 15 are members of an internal reference group. This will ensure all units within the organisation are co-ordinated and up to date with developments.

Experts who contributed to the map of biodiversity donated their time and included staff from the Australian Institute of Marine Science, the University of Sydney, the Australian Museum, the Queensland Museum, CSIRO, James Cook University, the Department of Primary Industries and the Queensland Parks and Wildlife Service.

The QPWS involvement will be enhanced within the next few months when it begins to contribute information about regions which are in the World Heritage Area but lie outside the Marine Park, such as creeks, wetlands, mangroves and islands. ■





New reef names to honour four Marine Park pioneers

FOUR reefs in the far northern section of the Great Barrier Reef Marine Park have been named in honour of people who gave exceptional service to the region in their lifetimes.

The four reefs were previously unnamed and were identified only by numbers. They all lie just north of Cape Grenville and the Sir Charles Hardy Islands, between 110kms and 220kms from the tip of Cape York.

The reefs have been named following a tripartite agreement between the Great Barrier Reef Marine Park Authority, the Queensland Department of Natural Resources and the Royal Australian Navy.

- **Monkman Reef** is named after a naturalist and pioneer of under-water cinematography, microscopy and "aqualunging" on the GBR. Noel Monkman was the author of the Barrier Reef book *Escape to Adventure* and produced some of Australia's early classic films. He lived on Green Island, off Cairns, and his underwater movies were among the first to bring the GBR to the attention of the world. He died in 1969, aged 73.
- **Saunders Reef**, is dedicated to Dr Graham Saunders, who was a founding member of the GBR Consultative Committee and the first director of the Queensland National Parks and Wildlife Service. Dr Saunders made a significant contribution to fostering co-operation between State and Commonwealth agencies that was vital to the establishment, zoning and management of the Marine Park. He died aged 55 in 1988.
- **Stark Reef** has been named after marine scientist and academic Professor Kevin Stark, who was a member of the original teaching staff at James Cook University and played a leading role in establishing its reputation as an internationally recognised centre of excellence in the field of marine science and technology. Prof Stark was also the chairman or a member of many scientific committees including groups which dealt with box jellyfish research, the Crown of Thorns starfish and the Reef Wonderland in Townsville. He was 56 when he died in 1989.
- **Parkinson Reef**, was nominated in honour of an artist and explorer who sailed with CaptainCook and his botanist, Joseph Banks. Sydney Parkinson was the son of a Quaker brewer who displayed a talent for drawing plants when he was apprenticed to a wool-draper. Parkinson was the natural history draughtsman who illustrated the botanical collections on the Endeavour when Cook discovered the GBR. He com-pleted nearly 1000 exquisite sketches of plants before dying of dysentry in Batavia in 1770, aged only 25. On his return to England, Banks employed five artists to complete Parkinson's work but the vast enterprise of engraving and publishing his paintings was not completed until more than 100 years later.

Virginia Chadwick, chair of the GBRMPA, paid tribute to Monkman, Saunders, Stark and Parkinson and acknowledged the cooperation of the RAN and QDNR in recognising the role all four pioneers had played in the history of the GBR.

"The naming of three of the reefs was as recognition of people who gave exceptional and outstanding service to the GBR Consultative Committee and the fourth, Sydney Parkinson, as a reminder in modern times of the exceptional value of the work of early explorers in the region," Mrs Chadwick said.

"Stark, Monkman, Saunders and Parkinson Reefs are close to areas of historical interest within the Marine Park, including the passage where the HMS Pandora foundered after hunting down some the Bounty mutineers." ■

Hoppers separate bycatch, ease effects of trawling

FISHERMEN in the east coast trawl fishery will have the opportunity to assess hoppers which separate prawns from bycatch and return the unwanted species to the sea alive, with the potential to mitigate the effects of trawling.

The use of hoppers on the rear deck of trawlers has been gathering momentum in recent years and is now extensive in the northern prawn fishery in the Gulf of Carpentaria, South Australia and Shark Bay in Western Australia.

The hoppers were originally developed by companies in Queensland and South Australia to increase the value of the prawn catch, but they have also proved to be ecologically friendly.

Up to 10 tonnes of mostly dead bycatch is thrown back into the sea for every tonne of prawns caught in the East Coast trawl fishery. However, where hoppers are used up to 70 per cent of the bycatch is returned alive and swimming.

The device enables prawns and other desired species to be sorted from bycatch quite naturally — the hopper is full of sea water and prawns sink to the bottom while other marine animals swim above them. A conveyor belt then gathers the prawns and delivers them to deck hands to be classed and packaged.

Throughout the process, the prawns are sprayed with sea water and are therefore still alive and in premium condition when packaged and snap frozen.

In the meantime the bycatch, which also remains in water throughout the procedure, is funnelled over the side or stern of the trawler and mostly escapes to swim another day.

The hoppers have caught the attention of prawn fishery fleets because of the premium prices that prime-condition prawns can demand, but the Great Barrier Reef Marine Park Authority says it is impressed by the technology because of the environmental advantages of returning the bycatch live to the ocean.

The director of the GBRMPA's Fisheries group, Phil Cadwallader, said hoppers were reported as reducing mortality of bycatch by 40–70 per cent depending on the grounds being fished and the unwanted species being caught.

"Industry and fisheries managers have come a long way with the introduction of bycatch reduction devices. However, we would like to see the managers of the Queensland fishery pursue the feasibility of using hoppers in the trawl fleet to reduce the mortality of fish and other organisms taken on board, so they can be returned to the sea alive," he said.

"The current generation of BRDs is estimated to reduce bycatch by an average 20 per cent, so if the survival of bycatch taken on board can be increased, then the overall impact of trawlers on fish and other similar animals can be decreased quite substantially.

"Hoppers were originally developed primarily as a way of enhancing commercial returns to fishers by producing high value product because it is alive as it's being snap frozen, but the effects on the survival of bycatch have also been quite remarkable.

"When the bycatch species are returned to the water alive they stand a much better chance of not being eaten by sea birds, sharks, dolphins and other predators that follow the boat feeding on discarded animals.

"If it's alive it has a much better chance of survival and the overall result of that is to reduce the impact of the industry on the biodiversity of an area. That matters to us because we have an obligation to protect the natural ecological values of a World Heritage Area and to mitigate the impacts of trawling."

The GBRMPA's enthusiasm for the environmental advantages of the hoppers is supported by Seanet, a service to the seafood industry delivered by the Fisheries Extension Network Australia funded by the Natural Heritage Trust.

Extension officer Denis Ballam said he had first noticed the advantages of hoppers when he spotted three trawlers in the Gulf of Carpentaria last year. Two of them were being followed by flocks of seabirds feeding on the dead trail of bycatch but there was a notable absence of scavengers behind the third boat which, he later discovered, had been fitted with a hopper.

Mr Ballam emphasised that he was not a lobbyist for the hopper manufacturing industry but said he was confident he would be able to organise demonstration trawls at major ports along the Queensland coast to point out their advantages despite the initial cost.

"Trawler operators are looking at paying out $50,000–$60,000 for a hopper, and that is what has put off the east coast trawl fishery so far; however, it may be possible to develop a smaller, cheaper product," he said.

"They may well be worth the initial outlay anyway, because of the increased value of the catch and the fact that the boats require one less deck hand. The industry may also consider petitioning the government for a 150 per cent tax reduction over, say, a couple of years.

"The value to the ecology of the sea bed far outweighs the relatively small cost of implementation, so it's a win-win situation for everyone concerned."

Mr Ballam stressed that the prawns harvested by trawlers with hoppers were of the highest quality because they were not crushed by tonnes of bycatch and were still alive when snap frozen in boxes ready for the market.

He estimated that the premium product commanded prices as much as 30 per cent higher than prawns trawled without the use of hoppers. ■

Deck hands sort prawns with one of the hoppers

Aquaculture regulations move to close loophole

NEW regulations covering aquaculture businesses adjacent to the Great Barrier Reef World Heritage Area have been introduced in a move to keep inshore waters as pristine as possible.

The new rules close a loophole in Queensland law which meant that some operations could be carried out adjacent to the waters of the Great Barrier Reef without an Environmental Impact Assessment being made.

The State has now adopted processes which the Great Barrier Reef Marine Park Authority believes meet Commonwealth standards and enhance protection of the World Heritage Area, satisfying the Federal Government's aim of accrediting Queensland's procedures.

'We want to ensure long-term survival'

The new regulations will not apply to established aquaculture operations, although they will be reviewed by the Queensland Environment Protection Authority to ensure the whole industry satisfies the highest standards and to ensure protection of water quality within the World Heritage Area.

The impact on water quality, particularly nutrient run-off on to seagrass beds and near-shore corals, is the primary threat from prawn farming on the coast. However, other pressures have included:

- Inadequate surveillance and monitoring of prawn diseases which could threaten the species in the wild;
- The lack of a comprehensive impact assessment process in some areas; and
- The exclusion of the Great Barrier Reef Marine Park Authority from the planning and assessment of projects which may impact on the World Heritage Area.

Over recent years the GBRMPA has become more and more concerned about threats to the Marine Park from industry based on the land, mainly agriculture. However, in recent times aquaculture and urban development have begun to contribute increasing amounts of contaminants to the waters of the Reef.

Sheridan Morris, the Authority's strategic manager for water quality, said aquaculture developments overseas had flagged the potential for coastal and marine degradation including, in some parts of the world, the complete destruction of prawn farming operations.

"The demise of prawn farms in Thailand, India, the Philippines, Taiwan and South America has also resulted in the decline of adjacent wild fisheries," she said.

"We want to ensure the long-term health and survival of the aquaculture industry, but also the continued existence of tourism and the recreational and commercial fisheries, which all rely on good water quality for their continued existence. Prawn farming is as reliant on water quality as any of these other industries and the potential for disease threatens aquaculture in particular.

"The aquaculture industry is making rapid advances. It's new and dynamic, as has the capacity to adopt technology to achieve world's best practice adjacent to the Great Barrier Reef. It's a good example of how industry can develop next to a World Heritage Area by good management."

The Australian Prawn Farmers Association gave qualified support to the new regulations when its president, Martin Breen, said they agreed with the objective to protect World Heritage values from nutrient run-off from the land.

"The industry has been supporting a major joint research project by CSIRO, the Australian Institute of Marine Science and the University of Queensland to find out, firstly, what effluent actually is," he said.

"We need to determine what happens when effluent gets into the marine environment — where it goes and how it gets distributed — and how we can better manage it.

"We strongly support the scientific approach to these questions and we are looking forward to developing technology and farming methods, techniques and practices to address the issues which have been identified by the CSIRO."

Mr Breen pointed out that the most recently established prawn farms had been able to take advantage of leading technology and practices, but "older" operations would need assistance in bringing their processes up to date.

"Historically, the industry has a very good record of willingly addressing environmental issues of concern and it is not an industry where government should find it hard to negotiate issues," he said.

"The most important thing about the industry so far is that once we have learnt from new technology, such as the effect of settlement ponds in producing nutrients and suspended solids, we have implemented the correct practices in all new farms." ■

Self-monitoring systems assess potential impacts

ALL prawn farming operations are required to have self-monitoring programs in place, primarily to assess the potential impacts on water quality and discharge water monitoring is determined on a case-by-case basis by the Queensland Environment Protection Agency.(?)

However, this system of self monitoring and self regulation does not assure environmental protection of neighbouring waters. It is not in the immediate best interest of a prawn farming operation to collect data that may result in adverse regulation of farming operations.

The effectiveness of direct pollution control strategies depends upon the ability of regulators to enforce pollution regulations.

At present, reliance on 'end of pipe' spot sampling may not reflect the true pollution loads being discharged. Recent experiments suggest nutrient concentrations in effluent vary.

For example, intensive monitoring at a field site in north Queensland indicated that the mean concentration of Total Nitrogen in effluent water had a coefficient of variation of 40 per cent within estimates taken over one week. In addition, estimates vary significantly at different times of the season.

Effluent water quality may deteriorate over the growing season as biomass, temperature and feeding regimes change, and the greatest source of nutrient and sediment from growout ponds occurs during harvest.

The typical Queensland industry method of harvesting is to drain the ponds and there is a significant increase in suspended solids late in the harvest due to resuspension of sludge at the bottom of the pond.

An estimated 30 per cent of total loadings of nitrogen, phosphorus and organic carbon are released to the environment at harvest and these factors must be accounted for in the design of monitoring programs.

Compliance is currently pursued through the submission of annual returns to QEPA by the prawn farm operators. These may be reviewed when individual licensing limits are exceeded, and prawn farming operators are also obligated to notify the QEPA if the discharge goes over its limits.

An Environmental Protection Order may be issued by the EPA if environmental harm results from an activity which is reported. ■

Morris review raises growing concerns over effects from land

IN A review of aquaculture development adjacent to the Great Barrier Reef World Heritage Area, Sheriden Morris pointed out that the region had an inter-dependent relationship with the coastal zone.

Land-based effects, predominantly from agricultural activities but also increasingly from urban development and aquaculture, are of growing concern to the Great Barrier Reef Marine Park Authority in undertaking its management role.

Ms Morris said overseas experiences of aquaculture development had flagged the potential for extensive coastal and marine degradation. Large scale clearing of mangroves and uncontrolled discharge of effluent had resulted in the polluted demises of many prawn farming operations in Thailand, India, Philippines, Taiwan and South America which, in turn, had resulted in the decline of the adjacent wild fisheries and associated coastal resources.

Ms Morris pointed out that prawn farming was the major form of aquaculture under development on the Queensland coast but that other forms of aquaculture, such as pearl oyster, scallop, mussel and oyster farming, did not demand external feed for the animals involved.

"Aquaculture without external feeding causes considerably fewer environmental effects on adjacent ecosystems than aquaculture which requires the animals to be fed — for example, prawns and fish," she said.

"While a small number of fish farms, primarily for barramundi, exist adjacent to the Great Barrier Reef, prawn aquaculture is more extensive and is developing far more rapidly."

Ms Morris' review focused almost exclusively on prawn farming that discharges effluent into the GBRWHA or waters adjoining the area.

Ms Morris said prawn farming in Queensland had developed primarily along the coast adjacent to the Great Barrier Reef. The high value placed on environmental quality in this area, together with poor environmental performance in other parts of the world, had focused attention on the prawn farming sector in Queensland.

"The ecologically destructive practice of broad-scale mangrove clearing that has characterised aquaculture industries overseas has not occurred in Australia but there is public concern regarding the sustainability of prawn farming and its potential to impact on the values of the World Heritage Area," she said."

The aim of Ms Morris' review was to identify the potential impact of prawn farming on the World Heritage Area, the jurisdictional and legislative mechanisms for licensing and managing aquaculture within and adjacent to the region and the adequacy of the mechanisms in relation to the management of the area.

There are 32 licensed prawn farms adjacent to the Great Barrier Reef, ranging from two to 127ha, with a combined total area of 400–450ha and prawn farming effluent delivers about 180 tonnes of nitrogen to the downstream environment.

Although clearly not the major contributor of nutrient to the Great Barrier Reef lagoon, there are concerns with the expansion of the industry, particularly into pristine regions.

Ms Morris reported that the primary threats to the World Heritage Area from prawn farming on the adjacent coast were:

- The impact of prawn farming effluent on water quality, in particular the nutrient enrichment of estuarine and nearshore seagrass and coral communities;
- Inadequate instruments for surveillance and monitoring of prawn diseases that carry a high risk of entry to the wild stock; and
- The introduction or translocation of species that may impact on the genetic integrity of the wild stock.

Limitations in processes for the management of prawn farming included:

- The reluctance of State regulatory agencies to pursue licence compliance for prawn farming;
- The lack of a full and transparent impact assessment process requirement for aquaculture in eight local government areas adjacent to the region — a potential area greater than 46,000ha; and
- The exclusion of the GBRMPA from the planning and assessment process for aquaculture developments adjacent to the Marine Park which may impact on the values of the World Heritage Area.

Ms Morris said technological change within the prawn farming industry was rapid and that improved management regimes could alleviate many environmental impacts. However, the main challenge was to convince the industry to adopt technology which would alleviate pollution.

Methods of regulating prawn farming to ensure the protection of the World Heritage Area included:

- Limits on total loads of nutrients discharged into the receiving waters;
- Licensing for cumulative impact;
- A dedicated compliance auditing process;
- The inclusion of mitigation technology in the licensing process;
- A cooperative operational arrangement between regulatory agencies; and
- The implementation of an 'on farm' disease surveillance program. ■

Nitrogen effluent flows from Queensland prawn farms

THERE are currently 500ha of prawn farms adjacent to the Great Barrier Reef lagoon but when compared to other land uses, such as sugar cane production, the current contribution of nutrients from prawn farming is relatively less significant.

However, the contribution of prawn farming effluent into waters already experiencing impacts can be significant. For example, around 110ha of prawn farms are situated in the Logan River catchment in southern Queensland, which produce around 45 tonnes of nitrogen effluent.

In comparison, the assigned area of cane production is around 6,000ha, so the potential total annual nitrogen load from cane farms in the area is estimated at about 240 tonnes.

A number of factors can influence the impact of prawn farming effluent, including farm management techniques and the assimilation capacity of the receiving waters.

The main source of nutrients in discharge water from prawn farms is undigested food. For example, in Thailand only 18 per cent of nitrogen in prawn feed is harvested as prawn biomass. Excreta, applied fertilisers and pond bank erosion contribute to nutrients and sediment loads to a lesser extent.

The technical efficiency of feeding is measured by the feed conversion ratio — the amount of feed required to produce an equivalent weight of fresh prawns. The ratio in intensive prawn farms in Queensland averaged 1.89 in 1996/97, which was considered a low level of efficiency compared to Taiwan and other prawn farming areas.

Extensive research is currently being conducted to quantify the value of

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Oysters, pearls, fish in wide range of activities

AQUACULTURE includes a diverse range of activities such as oyster production, pearl farming, marine and freshwater fish and crustacean production.

The aquaculture industry, which is expanding rapidly in Queensland and has significant potential for further expansion, is often considered to be environmentally positive as it has the potential to reduce harvesting pressure on wild fisheries stocks.

There are however, environmental concerns which are generally related to marine prawn production in coastal ponds where habitat destruction and effluent discharge into marine and estuarine waters occurs.

Many existing forms of aquaculture such as pearl oyster, scallop, mussel and oyster farming, do not need external feed for the animals involved, so there are considerably fewer environmental effects on adjacent ecosystems than aquaculture which requires the animals to be fed — for example prawns and fish.

There are about 30 fish farms — primarily for barramundi — adjacent to the Great Barrier Reef but most are small operations of 4–5ha. Although there are a similar number of prawn farms (32 licensed), these are more extensive (2–127ha) and the industry is developing far more rapidly.

The prawn farming industry in Queensland generates about $30m a year and employs approximately 164 people. Queensland produces the majority of farmed prawns in Australia, contributing more than 83 per cent 1996/97, and the industry is still expanding.

In a number of Asian countries there is a history of environmental problems resulting from the rapid expansion of prawn farming during the 1980s and 90s. They include:

- Increased nutrient and sediment loads in waterways;
- Chemical pollution;
- Salinisation of water supplies;
- Potential infection of native fish stocks with exotic diseases; and
- The destruction of mangroves.

There has been a plethora of scientific reviews and case studies detailing the worldwide adverse environmental impact of prawn farming and the subsequent costs to local communities when the industry has failed due to pollution and disease.

Failure is often attributed to a lack of government environmental regulation and it has been argued that the high level of pollution in effluent discharged from prawn farms has contributed to the collapse of the industry in Taiwan and China. Taiwan's production collapsed from 80,000 tonnes in 1987 to 20,000 tonnes in 1988/89.

Concern over the social costs of shrimp farming led to an Indian Supreme Court ruling against prawn farming, which included the cessation of operations in a 100,000ha region and banning of prawn farming in sensitive areas. The ruling was made on the basis of an analysis which found the social costs of prawn farming were up to four times greater than the benefits.

Unlike Asia, the development of prawn farming in Queensland has been constrained by environmental regulation. The success of this in achieving public confidence that prawn farming is ecologically sustainable and will not have a detrimental impact on the Great Barrier Reef is currently being questioned. ■

Main source of nutrients is undigested foods

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improved farm management practices on effluent loadings and discharge.

The standard prawn farming technique is to discharge directly into receiving waters and there are a range of strategies to reduce effluent, including technologies aimed at reducing waste within the production cycle and recycling effluent.

Methods for improving water management practices include:

- A reduction in water exchange to take advantage of in-pond digestion, thereby reducing the total loads of pollutants in the discharge;
- Maintenance of stocking densities and feeding rates at levels which do not exceed the supplementary aeration process or result in nutrient toxicity;
- Improvements in the quality of feeds to achieve more efficient food conversion;
- Management of sludge to minimise the need for removal and use the stored nutrients in the next crop; and
- Improved aeration technology.

Methods for 'polishing' (or recycling) effluent include:

- Eliminating effluent drainage harvesting by transferring water to other ponds or settling ponds for re-use;
- Zero or minimal water exchange;
- Fully recirculating systems;
- Settlement ponds or canals; and
- Biological treatment ponds.

The failure to develop viable alternative strategies for pond and effluent management and treatment is a major constraint to the development of an environmentally sustainable prawn farming industry in Queensland.

The impact of prawn farm effluent depends not only on the mass load and its components but also on the capacity of the receiving environment to absorb it.

A comprehensive review of the impact of prawn farming on estuary water quality in Honduras found that estuaries influenced by river discharge, particularly from draining of agricultural lands, had a limited capacity to absorb prawn farm effluent loads. This was particularly relevant during the dry season, when freshwater flows were reduced.

Where prawn farms discharged directly into estuaries, eutrophication was apparent close to shore. Estuaries influenced by rivers were more fertile and had less capacity to absorb more waste than those not influenced by rivers.

It is generally considered that gulf embayments can absorb more waste than estuaries, primarily due to nutrient dilution by larger water mass. However, circulation patterns within the gulf may allow faster accumulation of nutrients along inshore areas than previously thought.

Translocation — the movement of species or distinct genetic stock to areas outside their natural distribution — raises concerns because it presents risks to the health and genetic integrity of the World Heritage Area.

Accidental release associated with the translocation of species for use in aquaculture may result in:

- The exposure of wild populations to exotic diseases and parasites;
- Disruption of the genetic integrity of wild stock;
- Displacement of endemic species from habitat and breeding sites;
- Alteration of the food chain; and
- Direct predation on endemic species.

Current diagnostic pathology is not sufficiently sensitive to ensure freedom from all disease threats and there is insufficient information available for adequate risk assessments to be developed. ■

Exotic parasites key disease risk in World Heritage Area

THE accidental introduction of exotic parasites and pathogens to wild stock and other marine species is a key disease risk to the Great Barrier Reef World Heritage Area.

Other threats include the undetected importation of infectious products — prawns and prawn feeds, for example — and the amplification of endemic diseases associated with the intensive culturing of aquaculture species and the enrichment of adjacent receiving waters.

The Australian Quarantine and Inspection Service (AQIS) is currently conducting an import risk analysis covering all prawn and prawn products including aquaculture feeds. The importation of fish and crustacean meat to Australia is prohibited without an import permit from a director of quarantine.

Containment and management of diseases on aquaculture facilities are administered under the *Queensland Fisheries Act 1994* (Section 94), within the Aquavet Policy, a disease response protocol.

Individual disease management plans are incorporated in the applicant's development plan which is voluntary under Queensland Department of Primary Industries licence requirements. There is little structured surveillance of the presence of prawn diseases in Australia.

Producers are obliged to notify the QDPI when a disease is suspected but there is no coordinated surveillance and monitoring process for early detection. The onus is on producer notification resulting from a detection of a disease. There is a risk of disease entering the adjacent environment prior to notification of the QDPI.

There is a wide variety of pathogenic organisms on Queensland prawn farms. Currently the most significant are the virus problem Midcrop Mortality Syndrome (MCMS) and a number of pathogenic bacteria.

Definitive diagnosis of prawn diseases is difficult because detection and identification methods in many cases are unavailable or not sufficiently developed to enable large scale, low cost application.

Accurate diagnosis of farmed prawn disease is based generally on evaluation of clinical and general pathology evidence, so that in most cases the presence of disease agents is only recognised after a significant outbreak has occurred.

A review of the recent outbreaks of MCMS in Queensland prawn farms highlights the risks associated with disease. MCMS was first detected in 1995 and was active in the Queensland prawn industry for at least six months prior to recognition and the methodology for mitigation.

During this time an associated discharge of potentially infectious effluent regularly entered receiving waters. The disease is believed to be endemic to Queensland waters.

Clearly there is a requirement for an effective disease surveillance program as the current notification and management system greatly increases risks due to delays in notification.

Experience from overseas underpins concerns regarding disease management. The decline of the Taiwan prawn farming industry resulted from a rapid expansion that soon exceeded the carrying capacity of the natural resources, resulting in significant environmental degradation.

The deterioration of water quality combined with the unregulated use of antibiotics and other chemical inputs underpinned mass moralities.

In 80 per cent of prawn farms the virus White Spot Syndrome was the principle cause. In addition, bacterial infections of the hepatopancreas were promoted under the high stress condition associated with ecosystem decline.

Potential disease outbreaks are not limited to viruses. *Vibrio anguillarum, V. harveyi* and *V. alginolyticus* are the most common bacterial pathogens of Queensland farmed prawns. ■

Impact on water quality of primary concern to GBRMPA

THE Great Barrier Reef World Heritage Area has an interdependent relationship with the adjacent coastal catchment and land-based discharges, predominantly from agricultural activities, but increasingly from urban development and aquaculture, are of growing concern to the GBRMPA.

Impact on water quality is the primary concern but there are also other important potential impacts including those from prawn farm activities which could cause:

- Nutrient enrichment (eutrophication) of estuarine and nearshore ecosystems;
- Associated changes to estuarine and nearshore ecosystems due to alterations of light, salinity, nutrient, chemical and oxygen regimes;
- Risk of disease and genetic contamination of wild fisheries stocks;
- Risk of competition with and displacement of wild stock through accidental translocation; and
- Potential loss of coastal habitat for migratory (land/sea) species.

In conventional prawn farming systems, flow-through ponds are flushed with water to manage levels of production wastes. Wastes become toxic when concentrations exceed the assimilation capacity of pond flora.

Mechanical aeration adds oxygen and also assists in the instability and removal of toxic ammonia. Flushing water through the pond carries excess nutrients into the adjacent environment.

In addition to high nutrient levels, prawn pond water can be high in suspended solids and biological oxygen demand due to high concentrations of algae and bacteria.

The concentrations of these pollutants may be directly related to prawn feeding rates and other pond management practices and, when discharged, the effluent may lead to changes in the ecosystems of the receiving waters.

Eutrophication results from the supply of excessive nutrients to an aquatic ecosystem leading to enhanced plant growth, or to a change in the composition of plant and other species. The principal nutrients associated with eutrophication are nitrogen and phosphorus but others, including organic carbon, silicon, iron, molybdenum and manganese, may play a supplementary role.

It is recognised that some prawn farming operations discharge effluent into areas close to seagrass beds, for example the Hinchinbrook Channel. Increases in nutrient loading associated with eutrophication and changes in light quality can adversely affect seagrass beds, resulting in either their reduction or disappearance.

Once impacted, seagrass colonisation and regrowth can be very slow or non-existent, due to continuing impacts and poor dispersal capabilities of most seagrasses.

Loss of seagrasses can bring about a change in the marine food chain with an accompanied shift in main primary producers from benthic to planktonic, and a reduction in seagrass leaf detritus.

Continued seagrass loss can result in

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an ecosystem shift to a lagoonal system dominated by high turbidity and algal growth or bare sand and a silty floor which may remain after the decline of the seagrass beds. Such a change results in a considerable loss of biodiversity and loss of fisheries resources.

Similarly, there is clear evidence that elevated nutrients and suspended solids can impact coral communities. This is of particular concern for nearshore corals, some of which are already showing signs of environmental stress and consequent decline.

Recent experiments on corals have demonstrated the effects of eutrophication on reproductive success, coral skeletal structure and community composition.

Elevated nutrient levels significantly reduce or inhibit many critically important aspects of coral community survival, in particular the sexual reproductive processes, placing the maintenance, renewal or repair of coral communities at risk.

Eutrophication will often progress through a number of stages leading to the development of algal blooms and anoxic conditions, when anaerobic processes produce sulphides and methane.

Fish kills and changes in the benthic community structure may result, particularly where there is poor flushing. Poorly flushed estuarine areas and embayments along the Queensland coast may become eutrophic should nutrient and/or organic loadings in the area increase significantly.

Prawn pond water concern

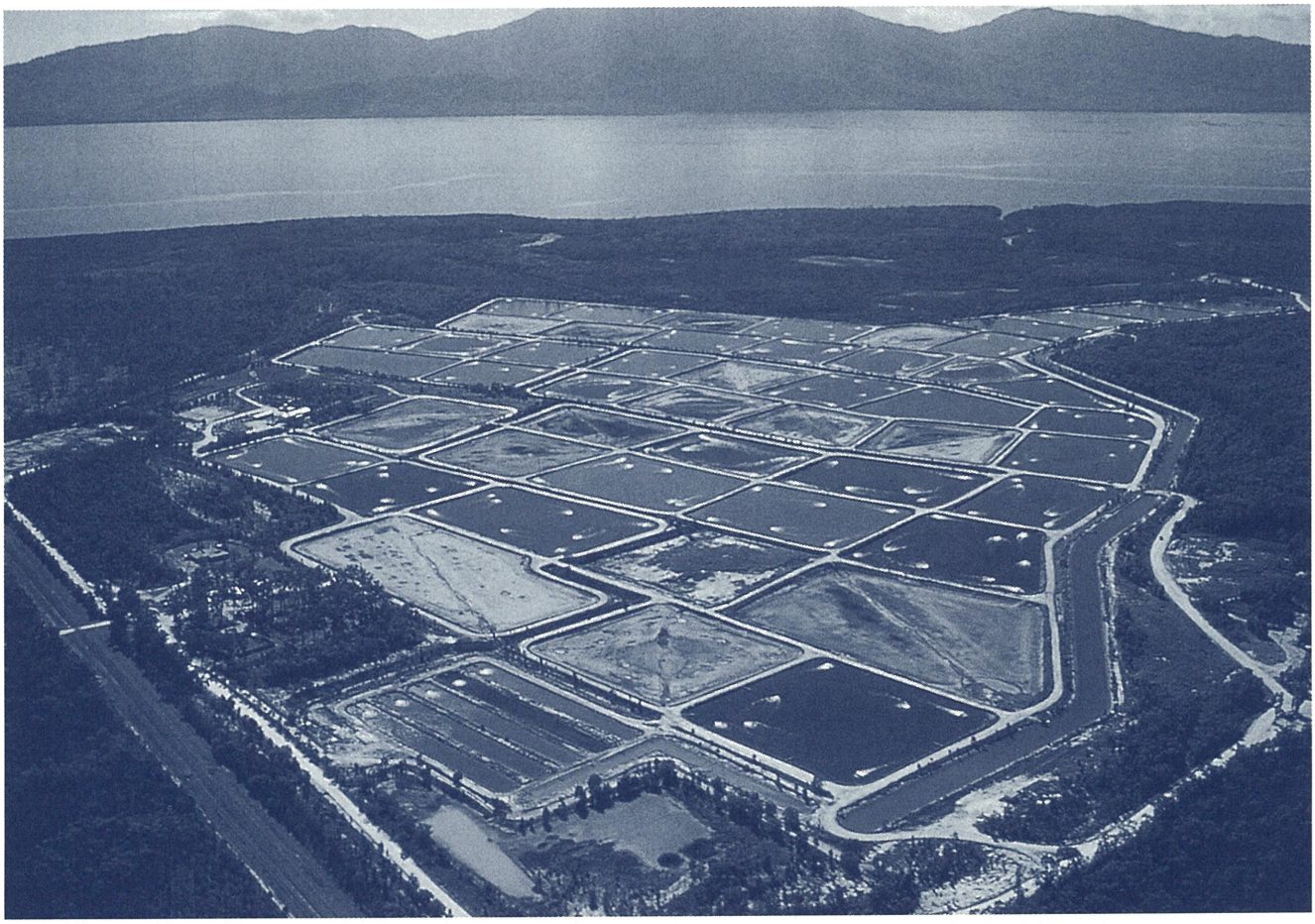
Sheriden Morris

Prawn farm effluent may have high biological or biochemical oxygen demand, which implies a high level of organic matter. The oxygen in the water is consumed by micro-organisms which feed on the organic matter, thereby reducing the dissolved oxygen concentration in the surrounding water. This may result in anoxic conditions.

Research conducted by the Cooperative Research Centre for Aquaculture has found regular discharge of high salinity effluent from prawn farms impacts upon the salinity regime in the estuarine receiving and mixing zone. The consequences of this alteration in salinity are yet to be determined.

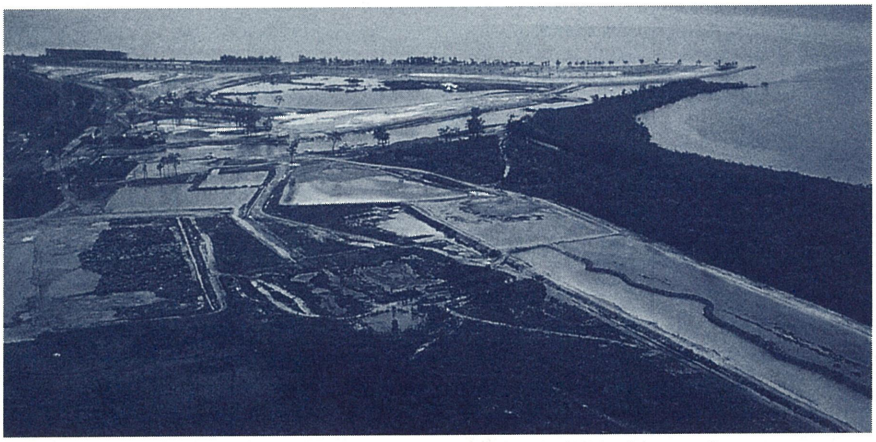
Due to the seawater access requirements of prawn farms, sites are often located in areas of potential acid sulfate soil so, during the construction of ponds and channels the risk of exposure is high. This may result in the production of sulphuric acid as leachate into the receiving environment.

Acidic soil conditions also breakdown clay and silt material to release aluminium, iron and heavy metals. At high concentrations these are toxic to aquatic life. Even using current mitigation techniques the risks from acid sulphate soils are significant in many existing and potential aquaculture areas of Queensland. ■



Aquaculture farms... land-based discharges are of growing concern to the GBRMPA

Hinchinbrook acid soils no danger to waters



Port Hinchinbrook... first tourism site planned in 1980s

Chequered history results in effective environmental regime

THE development of a large-scale tourist development and marina at Oyster Point was first proposed in the late 1980s by Resort Village Cardwell. The original proposal was for a 2000-bed resort, a 200-berth marina and associated service and commercial facilities.

Work started in 1988 but was abandoned the following year after much of the site had been cleared and major excavations for the marina basin begun. Significantly, there had been no comprehensive environmental impact assessment and the presence of acid sulphate soils at the site was not known.

The site lay abandoned until 1993 when it was bought by the current developer, Keith Williams, who set about finishing the earthworks that had been started some years earlier.

In November 1994, concern about the impact on the World Heritage values of Hinchinbrook Channel led the then Commonwealth Environment Minister, Senator John Faulkner, to use *the World Heritage Properties Conservation Act* to stop mangrove clearing on the seaward foreshore. This effectively brought a halt to the project while environmental management measures were negotiated to ensure World Heritage values were protected.

In 1996, following a change of Commonwealth government, the developer entered into a Deed of Agreement with the Commonwealth, Queensland and the Cardwell Shire Council requiring environmental management strategies to ensure the Hinchinbrook Channel would be protected.

These included the appointment of a day-to-day environmental site supervisor and an overall independent monitor responsible for overseeing and advising on the implementation of environmental management plans. Independent experts were also appointed to monitor acid sulphate soils and binding environmental management plans were put in place — including a plan for the management of acid sulphate soils.

In 1995 a study by CSIRO had identified extensive areas of 'potential acid sulphate soils' — common on the tropical Queensland coastline — at the Port Hinchinbrook site. Earthworks and clearing by the previous developer compounded by some work by Mr Williams had exposed some of these soils to the air, allowing oxidation to occur and creating the potential for acid-generating soils to develop at various locations around the site.

While the hazards were not considered critically acute, CSIRO's investigation flagged the need to develop an ASS management plan for the site as part of the 1996 Deed of Agreement. The Queensland government's Acid Sulphate Soils Investigation Team (QASSIT — a part of the Department of Natural Resources) were appointed to monitor and oversee arrangements for managing ASS.

As a result of the management plan remedial action was taken to bury or treat exposed acid sulphate soils. Water draining from the site was also directed through a drainage system to a treatment pond where it could be monitored for unacceptable acidity and treated before being discharged.

Measurements of pH were collected regularly at various locations around the site to ensure the measures in place were effective in preventing acid water entering the Hinchinbrook Channel.

This environmental management regime has been effective in ensuring that only neutral pH water flows from the excavated canal into the Hinchinbrook Channel.

The GBRMPA has, at all times, been satisfied that the values of the World Heritage-listed Hinchinbrook Channel have been protected. ■

DETAILED studies of the area around the Port Hinchinbrook development at Cardwell have revealed only small amounts of acid-producing soils which present no danger to the waters of the neighbouring channel.

The Queensland government engaged environmental consultants Woodward-Clyde to carry out the studies after concerns were raised by the Queensland government's Acid Sulphate Soil Investigation Team that some structures planned for the site might have been at risk.

Woodward-Clyde were briefed to:

- Undertake a detailed assessment of the amount of Acid Sulphate Soil (ASS) on the site;
- Advise on the engineering and health implications associated with ASS; and
- Identify remedial action for the future management of ASS material.

The consultants found that the quantities of ASS were limited in the areas where structures were planned — mainly around the marina and foreshore.

They also discovered that in the remaining areas of the development site and dredge spoil ponds there were some areas which needed remedial treatment with agricultural lime to neutralise soil acidity.

Colin Trinder, co-ordinator for the project at the Great Barrier Reef Marine Park Authority, said proven technology was available to handle, treat and manage the areas of problem soils identified by Woodward-Clyde. He said experts agreed they did not pose a significant threat to the environment, infrastructure or engineered structures.

"There has been no suggestion that impacts from ASS at Port Hinchinbrook has had a serious impact on the environment outside the site or on the Hinchinbrook Channel," he said.

"A programme was recommended by the consultants for action to remediate the minor localised problems which were identified. The consultants also proposed strategies for managing the site to minimise the likelihood of problems arising in the future.

"About 120 tonnes of neutralising agricultural lime was used to treat areas identified as having the potential to cause problems and an independent scientific monitor, who was appointed to oversee the implementation of environmental management measures, has been satisfied that the acid-producing soils have been remedied.

"Although no serious threats to World Heritage values have been identified, the GBRMPA supports the measures proposed for the future management of ASS."

Mr Trinder said intensive monitoring of outflows from the Port Hinchinbrook site over the years had always given site managers confidence that acid water was not entering the Hinchinbrook Channel, but the Woodward-Clyde study had provided additional important information on the patchy nature of acid-producing soils around the site. ■

GBRMPA urged to press for compensation

THE Great Barrier Reef Marine Park Authority is being urged to seek legislation to enable a demand for compensation for the pollution and damage caused when ships run aground on reefs in the Marine Park.

Marine biologist Len Zell, an expert in coral taxonomy who worked for GBRMPA, James Cook University and the Australian Institute of Marine Science for 15 years, became concerned about anti-fouling pollution when the refrigerated cargo vessel Peacock went aground on Piper Reef in July, 1996.

Mr Zell estimated that about a tonne of the anti-fouling agent tributyl tin (TBT) was scraped off the hull of the Peacock when it cut a 30x10m strip into the reef after its pilot fell asleep on the bridge.

He said the surface area of coral reef was ground into a concrete-like consistency, killing not only the coral but other animals including a number of giant clams.

"These ships cause significant pollution but they are allowed to sail on without paying for the costs of repairing the reef site; not only have they left toxic chemicals on the reef but they have also flattened an area of reef edge, which is usually the most spectacular and dynamic part of any reef," he said.

"Propeller wash and other activities associated with getting the ship off strip a lot of tissue from nearby colonies. If the ship sits there for more than two or three days, as the Peacock did, the anti-foulant and stagnation of the water under the hull kills a lot more coral."

Mr Zell said Australian authorities should follow the example of some overseas countries which demand compensation payments from the shipping companies before their vessels are allowed to sail on after damaging reefs.

"There is plenty of information about how to repair coral reefs, including re-seeding them," he said.

"The Peacock site was like a concrete surface after the grounding, with crushed coral anything up to a metre deep. At least the top 20–30cm should have been scraped off until no anti-fouling agent was left and then some of the colonies should have been re-seeded.

"Australia should have legislation whereby the shipping company is charged for the damage and the insurers pay for it."

David Haynes, GBRMPA's co-ordinator of water quality, research and monitoring, said he doubted whether reseeding would have been practicable following the Peacock incident, if only because the remoteness of the location would have made such action prohibitively expensive.

"You are better off not running into a reef in the first place, than relying on remedial action after the event," he said.

However, Mr Haynes agreed that massive pollution from TBT occurs when large ships run aground in the Great Barrier Reef.

Samples taken from the site of the New Reach grounding on Heath Reef in 1999 indicated that TBT concentrations scraped from the ship's hull were very high. Mr Haynes said TBT was a very toxic chemical which had a profound effect on coral reef communities when such incidents occurred.

"The TBT left on a reef will last for some time, depending on environmental conditions such as wave action, and it will kill anything that comes into contact with it," he said.

"Basically, nothing will be able to settle on that stretch of coral reef while TBT is still present. After all, an anti-settlement property has been transferred from the ship's hull to the hard substrate."

Mr Haynes said that substitutes for TBT included copper and diuron-based agents which were currently being used on small boats. However, alternatives resulted in a Catch-22 situation, because an anti-foulant which was lost too quickly would have to be reapplied too frequently to be economically viable.

"At the end of the day the best solution to the problem is that ships maintain accurate navigational procedures and do not experience a 'temporary loss of situational awareness' (sic)," he added. ■

The Peacock aground... some nations demand compensation before ships are allowed to leave

Praise for water treatment, recycling systems

Photo courtesy of The Cairns Post

Project manager Mike Basterfield at the recycling system in Port Douglas

THE Great Barrier Reef Marine Park Authority has welcomed moves by a North Queensland council to protect the Great Barrier Reef from nutrients which are brought into the region as sewage by visiting boats.

The Authority is urging communities along the Queensland coast to build water treatment and recycling systems similar to a $7.2m plant which was opened last week in Port Douglas.

The waste water, which includes nutrients such as nitrate and phosphorus, was previously dumped at sea. However, visitors to Port Douglas can now pump it into the new tertiary treatment plant from where it is used as fertiliser and to water the town's two golf courses.

The Chair of the GBRMPA, Virginia Chadwick, said the Authority fully supported the initiative by Douglas Shire Council and emphasised that the inability of many coastal plants to treat waste to tertiary standards resulted in significant quantities being discharged into the waters of the Reef.

"The new facilities at Port Douglas are in line with the Authority's water quality strategy for sewage discharge to the Marine Park," she said.

"The strategy promotes land disposal of tertiary treated effluent and the new pump-out facility meets that standard.

"The Authority encourages other councils adjacent to the Great Barrier Reef Marine Park to adopt similar standards." ■

Streamlined permit system for faster decisions

A NEW, streamlined system of assessment has been introduced by the Great Barrier Reef Marine Park Authority and the Queensland Parks and Wildlife Service to fast track permits for tourism operators and other people who need approval to make use of the Marine Park.

Four extra staff have been employed by the QPWS and the GBRMPA, which are investing more than $250,000 to ensure a faster turnaround in the time between applications and grants of permits for interested parties.

Under the new system, the GBRMPA and the QPWS are aiming to process 80 per cent of applications within eight weeks, which includes a mandatory period of 28 days for Native Title notification. Operators had previously waited an average of several months for their permits to be issued.

The Chair of the GBRMPA, Virginia Chadwick, said the applications would continue to be considered by both the State and Commonwealth governments but the system would be centralised within the Authority for faster assessment without compromising sound environmental management.

"New Plans of Management for Cairns and the Whitsundays, and new standard tourism permits have also helped to streamline the application process," she said.

"One spin-off from the new system will be economic benefits, because the standard permits now provide certainty for operators and the faster turnaround will allow assured forward planning and greater business confidence."

Six booklets have been developed by the GBRMPA which contain the standard permit conditions for vessel tours, long-range rovers, hire companies, cruise ships, aircraft tours and craftless operations such as swimming, snorkelling and diving. ■

ABC listeners hear of new funding to police Reef

Transcript of an ABC Radio interview with Peter McGinnity, director of Marine Park management, aired on Queensland Country Hour on April 6. The presenter was Mackay-based David Claughton.

A park ranger on the lookout... prosecutions are set to double

PRESENTER:

The Great Barrier Reef Marine Park Authority wants stiffer penalties imposed for illegal fishing. The call coincides with claims that illegal fishing is having a negative impact on fish stocks and could threaten the viability of industries dependent on the reef, commercial fishing included.

Recent funding has enabled the Great Barrier Reef Marine Park Authority to improve its efforts in policing the reef and double its prosecution record. But according to Peter McGinnity, director of marine park operations at the authority, the penalties imposed by the courts are too small.

PETER McGINNITY:

It's a matter that we're concerned about. The penalties at the moment are up to about $20,000–$22,000 to be exact, the maximum penalty. And we're looking at whether that shouldn't be increased. On top of that we're also looking at licence suspensions and other areas that may be used to deter these people in the future. So, those things are all currently under review.

REPORTER:

If you make a prosecution, it's up to the court to decide what kind of a penalty is imposed. What, on an average basis do you think, would be the penalty for illegally fishing in a protected area in a green zone or a yellow zone?

McGINNITY:

Most of our fines are in the order of two to three thousand dollars.

REPORTER:

Can you give us, in respect to the Great Barrier Reef, any ideas of the number of prosecutions that have been brought successfully, say in the last year?

McGINNITY:

Last financial year we had about 60 prosecutions and we usually have had in the past between about 50 and 70. In this current year, because we've got a major new program funded by the Commonwealth Government, we are hoping to double that.

We've had about 38 convictions this year, or in the first half of this year I should say, and there, at the time that we collected those figures, there is 15 matters still with the Department of Public Prosecutions to be followed through, so we're on track to doubling it at the moment.

REPORTER:

How many of those would be for illegally fishing in a protected area, say with line fishing?

McGINNITY:

The majority, something like 70 or 80 per cent because that's where we're targeting our operations. And that's the big difference at the moment, the extra $1m a year for the next three years that Senator Hill's made available, is allowing us to do, gather information and target areas and operations, and that, in combination with an increase in the number of routine patrolling we're doing out there, is really what's going to have the effect. ■

LMAC leaders provide feedback on local issues

LEADERS of community groups adjacent to the Great Barrier Reef have met for the first time to provide feedback on local marine issues to the Great Barrier Reef Marine Park Authority.

The volunteers are all members of Local Marine Advisory Committees, which were established by the GBRMPA last year to provide a two-way interface with communities to address matters of concern in the Marine Park.

The meetings held in Townsville over two days discussed forward planning for the next year. The GBRMPA's directors told the committees about developing projects and the LMAC leaders outlined how they will achieve their own objectives.

Virginia Chadwick, Chair of the GBRMPA, said subjects ranged from the Authority's Representative Areas Program and Dugong Protection Areas, which encompass the entire Marine Park, to local issues such as a push by the Cooktown LMAC to establish a Marine Parks base in their area.

"The LMACs are critically important to the GBRMPA because they represent their communities and they are able to advise us on issues which affect the marine and coastal environment in their regions," she said.

"LMACs can disseminate information among the communities about topics such as boundary issues and trawl management plans and the GBRMPA can utilise their local expertise to spread information to the communities about what we are doing and why. Equally, we can benefit from the input of local views and advice."

There are nine LMACs in communities adjacent to the Marine Park, at Cooktown, Port Douglas, Cairns, Mission Beach, Hinchinbrook, Townsville, the Whitsundays, Mackay and Gladstone. ■

SCIENCE TO SAVE AUSTRALIA'S COASTAL WATERS

Don Alcock
Communication Manager, Coastal CRC, Natural Sciences Precinct,
QCCA Building, 80 Meiers Rd, Indooroopilly Qld 4068

People (from left) are: Dr Roger Shaw, CEO, Coastal CRC; The Hon Dr Barry Jones, Chair, Coastal CRC; Olwyn Crimp, Director of Planning, Environmental Protection Agency; and Professor Gus Guthrie, Chair, Qld Innovation Council

Scientists, politicians, environmentalists and community groups have finally turned the tide to better understand and protect Australia's vast network of coastal beaches and waterways.

Dr Barry Jones, chairman of the new Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, said the nation's 36 000 kilometre long coastal zone is now well and truly in the political and scientific spotlight.

'Australians love our immense and diverse coastline and most of us live in the coastal zone. However, it has not always been studied in the right way to help decision makers conserve and manage areas impacted by industrial, agricultural or urban uses,' he said.

'Coastal development and management are now being studied by teams of researchers, resource managers and community groups to better understand and conserve our estuaries, beaches and catchments. An audit is also being undertaken to assess the health of more than 800 estuaries.'

At the official launch of the CRC in Brisbane on 15 March 2000, the former science minister said the Centre's $62 million, seven-year collaboration between government agencies, universities and the private sector is a winning formula that will help protect and wisely use Australia's dynamic coastal zone.

'The goal of the CRC is to bridge the gaps between science and the community, and between coastal researchers, decision makers and planners. Initially, knowledge will be applied to a major industrial area at Port Curtis, an agricultural region at Fitzroy River and the Brisbane River and Moreton Bay urban catchment, then will expand to other Australian catchments,' said Dr Jones.

'The CRC has forged a strong marriage between public and private organisations to integrate resource planning, infrastructure development and water management operations to keep our coastal waters healthy.'

Partners in the Coastal CRC include the Brisbane City Council, Central Queensland University, the Commonwealth Scientific and Industrial Research Organisation, Griffith University, James Cook University, the University of Queensland, and Queenslands' Environmental Protection Agency, Department of Natural Resources and Department of Primary Industries.

AUGMENTATIVE RESEARCH GRANTS SCHEME 2000

Congratulations to the six students who have been awarded augmentative research grants this year for research relevant to the management of the Great Barrier Reef Marine Park. All students are working towards a Doctorate or Masters degree. Kim Lally summarises the successful projects.

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

JAMES COOK UNIVERSITY

Rebecca Fisher / Associate Professor D. Bellwood, *The behavioural capabilities of tropical reef fish larvae: Implications for dispersal during the pelagic phase* ($1070)

Current studies have demonstrated that the pelagic stages of reef fishes have excellent swimming capabilities and are therefore capable of modifying their dispersal (Stokutzki & Bellwood 1997). A further study (Job & Bellwood in press) indicated that larval fishes have well-developed sensory abilities. These findings suggest that the way in which larvae behave can influence the way in which they disperse.

Rebecca will examine whether tropical reef fish larvae can behaviourally influence their dispersal. By investigating the development of behavioural capabilities of a diverse range of taxa, she aims to classify reef fish larvae into 'functional' groups with regards to their behavioural abilities.

Specifically Rebecca aims to:

- examine the ontogenetic development of swimming ability in the wide range of reef fish species;
- investigate how swimming speed and feeding affects sustained swimming abilities; and
- investigate developmental changes in the depth preferences of larvae and determine the proximal cues associated with vertical movements.

From a marine park management point of view the information gained from this project will be useful in developing models of connectivity among reefs.

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Job, S. & Bellwood, D.R. in press, Light sensitivity in larval fishes: implications for vertical zonation in the pelagic zone, *Limn Ocean*.

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Jane Harrington / Dr S. Greer & Dr D. Miles, *Cultural heritage management and communities: A comparative study of two world heritage areas (The Great Barrier Reef, Australia and Ayutthyah, Thailand)* ($1500)

Jane aims to address cultural heritage management practices in the context of both the Great Barrier Reef and Ayutthyah. She will give particular emphasis to the various communities of interest and their interaction and aims to:

- gain an understanding of the varying interests and values of groups who have a relationship with a 'heritage place';
- analyse how these varying interests and values create either support or conflict between groups and how these conflicts are resolved within management regimes;
- review contemporary management approaches, and address the validity of applying such approaches to places that have associations with the traditional values of non-Western cultures;
- address the validity of 1) maintaining a dichotomy between 'natural' heritage and 'cultural' heritage and 2) placing an emphasis on the protection of tangible aspects of heritage in preference to the non-tangible aspects (such as spirit or traditional practices); and
- present and discuss alternative approaches to identifying, managing and protecting places that have significance to people in terms of their association with the past.

Jane states that both Ayutthyah and the Great Barrier Reef have strong local community attachments and attract international and domestic tourists. Ayuttyhah was inscribed on the World Heritage list in 1991. It was founded in about 1350, becoming the second Siamese capital. The city was destroyed by the Burmese in the 18th century. As well as containing magnificent archaeological remains of towers and gigantic monasteries, Jane states that Ayuttyhah has sacred relevance for Buddhists.

The Great Barrier Reef was inscribed on the list of World Heritage natural properties in 1981 for its outstanding natural value, although it was recognised that the property also had significant Indigenous and non-indigenous cultural features (Benzaken et al. 1997). Benzaken et al. (1997) further states that greater emphasis on World Heritage management has resulted in a review of the 1981 listing. This review has raised the issue of protection of cultural values of natural properties.

Jane's project will provide much needed and useful information on the cultural heritage aspects of the Great Barrier Reef World Heritage Area in the context of what the area's world heritage listing means to the local community adjacent to the area. The results of the

project will also provide an opportunity for the Authority to be informed about the effects world heritage listing has upon a local community.

Reference: Benzaken, D., Smith, G. & Williams, R. 1997, A long way together: The recognition of indigenous interests in the management of the Great Barrier Reef World Heritage Area, pp. 471–495, in *State of the Great Barrier Reef World Heritage Area Workshop, Proceedings of a Technical Workshop held in Townsville, Queensland, Australia, 27–29 November 1995*, eds D. Wachenfeld, J. Oliver & K. Davis, Workshop Series No. 23, Great Barrier Reef Marine Park Authority, Townsville.

Vimoksalehi Lukoschek / Dr P. Corkeron & Professor H. Marsh, *Development and implementation of combined visual and acoustic survey techniques to estimate the sizes of populations of inshore dolphins in the Great Barrier Reef World Heritage Area* ($1300)

Developing effective techniques that derive accurate and sound estimates of the abundance of inshore dolphins is the main aim of Vimoksalehi's project. Specifically Vimaksalehi aims to derive estimates for the Pacific humpback dolphin *(Sousa chinensis)*, the Irrawaddy dolphin *(Orcaella brevirostris)* and the inshore bottlenose dolphin *(Tursiops aducans)* throughout the World Heritage Area. Through this project Vimoksalehi will endeavour to develop, test and implement combined visual and acoustic techniques for estimating population sizes of inshore dolphins in the Great Barrier Reef World Heritage Area and to estimate the population sizes of inshore dolphins in discrete areas using vessel-based line transect surveys.

Specifically Vimoksalehi hopes to:

1) develop mathematical models of visual and acoustic detectability for the abundant bottlenose dolphin (*Tursiops aducans*);
2) test these models and the suitability of combined visual and acoustic surveys on the rarer Irrawaddy and Pacific humpback dolphins;
3) compare relative abundance estimates generated by acoustic techniques with those generated by visual and mark-recapture surveys in Cleveland Bay, Townsville;
4) if necessary, develop a correction factor for line-transect estimates, from mark-recapture estimates, for use in surveys conducted elsewhere.

This project will generate baseline and ecological data relating to inshore dolphins, information which at present is somewhat lacking. Studies such as these are very important if management agencies, such as the Great Barrier Reef Marine Park Authority are to understand the status of these cetaceans.

Sarah Omundsen / Dr M. Sheaves & Dr R. Coles, *Temporal and spatial variability in recruitment and growth of juvenile fishes in tropical seagrasses* ($1520)

Seagrass meadows are a very important habitat within the Great Barrier Reef Marine Park as not only do they provide a food source for animals such as the dugong, they also provide a nursery habitat for many species. Previous studies have shown that seagrass meadows are rich and diverse in juvenile fish species, including many species of economic and social importance (Coles et al. 1993). Because the replenishment of adult populations occurs via successful recruitment, Sarah believes that understanding the role of seagrasses as nurseries is extremely important. The answers to questions such as what species use seagrass meadows in the tropics and at what time of the day do they use them are unknown.

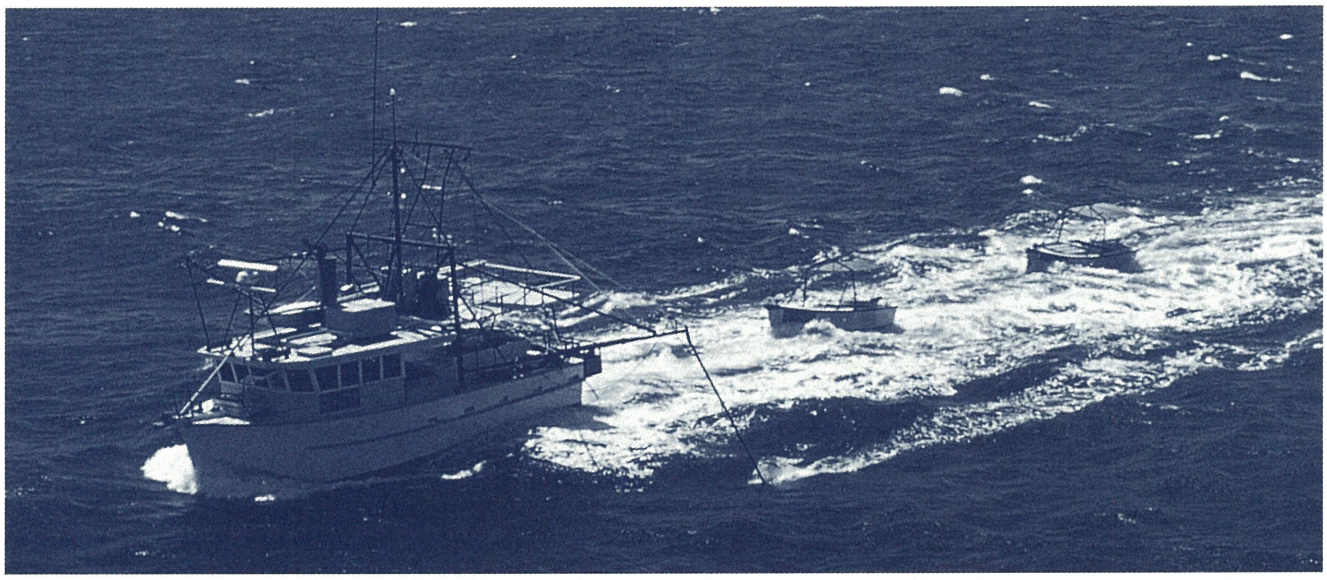
Sarah's objective is to determine how tropical seagrasses are used as nurseries by juvenile fishes. She aims to examine temporal patterns of fish recruitment to tropical seagrasses; determine how patterns in fish recruitment to tropical seagrasses vary spatially within and among seagrass systems; and investigate patterns in spatial variability of fish growth in tropical seagrasses.

Sarah was awarded a grant for this project in 1999. She reports on preliminary results which indicate that reef and coastal seagrasses are used very differently by juvenile fishes. Seagrass meadows in reef systems seem likely to have far less species and individuals than meadows found inshore. Sarah has also examined the temporal patterns of fish recruitment to tropical seagrass meadows. She describes very distinct patterns in fish recruitment during the year.

During 2000 Sarah will focus on the spatial patterns in juvenile fish recruitment and growth. This investigation will incorporate a variety of scales including recruitment and growth within and among seagrass meadows. Further investigation of recruitment patterns in coastal and reef systems will also be made.

These results will shed new light on the conservation value of seagrass meadows. For example, presently it is unknown whether fish utilise all areas and all meadows equally and thus if each meadow, or part of a meadow, is of equal conservation value.

Reference: Coles, R.G. et al. 1993, Distribution of seagrasses, and their fish and penaeid prawn communities, in Cairns harbour, Northern Queensland, Australia, *Australian Journal of Marine and Freshwater Research*, 44: 193–210.



Geoffrey Muldoon / Drs L. Fernandes, O. Stanley & C. Davies, *An ecological economic approach to determining fisheries investment where latent effort exists: Sustainability implications for the Great Barrier Reef reef-line fishery* ($1500)

Fisheries is an important management issue within the Great Barrier Reef region, and recognised by the Great Barrier Reef Marine Park Authority as one of its critical issues. While an understanding of how fishing pressure affects fish stocks is important to fisheries managers, knowledge of how changes to the management of the fishery or fishing practices impact on the financial status of the fishers is equally important. Geoffrey aims to contribute to the long-term economic and ecological sustainability of the reef-line fishery for the Great Barrier Reef by:

1. Describing economic trends and characteristics of the developing live fish industry as a component of the GBR reef-line fishery;
2. Developing measures of vessel productivity for a range of vessel sizes and technology, and on a spatial and temporal scale;
3. Investigating incentives that dictate capital investment decision-making to model impacts of latent effort on catch levels and industry sustainability;
4. Identifying the economic impacts of imposing 'natural insurance' for target stocks on capital investment, and vessel productivity and profitability; and
5. Exploring the interaction between ecological and economic sustainability under a range of 'natural insurance' constraints.

Geoffrey reports that he will use a conceptual model of fisheries management that includes the 'state of the resource' as the measure of sustainability to generate information on the socio-economic and ecological implications of alternative management strategies.

Ashley Williams / Dr C. Davies & Associate Professor G. Russ, *Habitat preference and early life history of juvenile red-throat emperor,* Lethrinus miniatus ($1600)

Ashley's project will focus on the spatial variability in the population dynamics of *Lethrinus miniatus* and forms parts of the Reef CRC's Effects of Line Fishing (ELF) project (refer to the Reef CRC's web site [http://www.reef.crc.org.au/5elf/5elf.phtml] for further information on this project). *Lethrinus miniatus* contributes more than 1000 t annually to the catch of the combined commercial and recreational reef line fishery on the Great Barrier Reef. This makes it the second most important demersal species in the fishery (Mapstone et al. 1996).

Ashley states that although some information is available on the demographic structure of adult populations of *L. miniatus* on the Great Barrier Reef, nothing in known about the early like history of juveniles. He aims to determine the spatial variability in *L. miniatus* population parameters such as age, growth, mortality, sex ratio, size/age at sex change, size/age at maturity and spawning season. The habitat of juvenile *L. miniatus* on the Great Barrier Reef will also be identified and described.

This project will utilise samples of *L. miniatus* previously collected in three regions of the Great Barrier Reef (Townsville, Mackay and Storm Cay) as part of the ELF experiment. Preliminary results indicate significant differences in demographic parameters of *L. miniatus* in the central and southern Great Barrier Reef (Williams 1997). Ashley states that these patterns may reflect regional differences in productivity or the existence of separate isolated populations.

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Mapstone, B.D., McKinlay, J.P. and Davies, C.R. 1996, A description of commercial reef line fishery logbook data held by the Queensland Fisheries Management Authority, Report to the Queensland Fisheries Management Authority.

Williams, A.J. 1997, Spatial variation in population structure of the red throat emperor, *Lethrinus miniatus*, among regions and management zones on the Great Barrier Reef, BSc (Hons) thesis, Department of Marine Biology, James Cook University.

Fine-scale Surveys of Crown-of-thorns Starfish

The following text is an excerpt from the following publication: Engelhardt, U., Hartcher, M., Cruise, J., Engelhardt, D., Russell, M., Taylor, N., Thomas, G. & Wiseman, D. 1999, 'Fine-scale Surveys of Crown-of-thorns Starfish (Acanthaster planci) in the Central Great Barrier Reef Region', CRC Reef Research Centre, Technical Report No. 30, Townsville; CRC Reef Research Centre, 97 pp. For a copy of the report please contact the Centre on +61 7 4781 4976.

Twice in the last 35 or so years, major outbreaks of the crown-of-thorns starfish (*Acanthaster planci)* on the Great Barrier Reef (GBR) have apparently originated on reefs in the Cairns Section (14°30'S–17°52'S) of the Great Barrier Reef Marine Park (GBRMP) (Kenchington 1977; Moran et al. 1992). During the two episodes recorded in the 1960s and again in the 1980s, outbreaking populations were first observed on Green Island Reef off Cairns (16°46'S) with a number of surrounding reefs also being affected at about the same time (Moran 1986). However, dedicated surveys of starfish populations were initiated only several years later, when the outbreaks had apparently progressed several hundreds of kilometres from their suggested geographic origin (Dight et al. 1990; Moran et al. 1992).

Despite a considerable research effort, particularly over the last decade, the ultimate cause(s) of *A. planci* outbreaks on the GBR and elsewhere remain unknown (Engelhardt and Lassig 1997). A lack of data on the dynamics and age structures of *A. planci* populations in particular before, during and after outbreaks has hampered efforts to more fully understand outbreak causality.

Surveys of *A. planci* populations on the GBR and in other parts of the Indo-Pacific region have employed a variety of monitoring techniques, including timed swim searches (Pearson and Endean 1969; Kenchington 1976), spot checks (Pearson 1972), manta tows (Oliver et. al. 1995; Sweatman 1997; Sweatman et al. 1998). However, few of these surveys have provided accurate estimates of population densities and age structures (Birkeland and Lucas 1990). Consequently, population field and modelling studies have suffered from the resulting lack of suitable data. Such information is, however, critical for improving our understanding of the possible factors and mechanisms that may be implicated in initiating outbreaks.

Accurately assessing low density populations or populations with substantial numbers of juvenile starfish has posed particular difficulties. Juvenile *A. planci* (< 14 cm), because of their cryptic behaviour and nocturnal feeding habits, are not easily sampled and have been rarely seen in the field (Doherty and Davidson 1988; Johnson et al. 1991). Consequently, broad-scale survey techniques such as manta towing are considered inadequate to detect the initial stages of an outbreak (Moran and De'ath 1992; Bass and Miller 1995). Ayling and Ayling (1991) showed that transect-based benthic surveys may be more suitable for accurately censusing low-density populations of the starfish. Benthic belt transects have recently been used on the GBR in an attempt to provide more reliable estimates of population densities and associated age structures (Engelhardt et al. 1997; Mapstone et al. 1998; Mapstone and Ayling 1998). Using an intensive, transect-based methodology the most recent, third recorded outbreak episode, was detected much earlier than previously possible (Engelhardt et al. 1997).

This report presents the results of intensive transect-based surveys of *A. planci* and associated hard coral cover conducted on 21 mid-shelf reefs in the Cairns and Central Sections of the Great Barrier Reef Marine Park (GBRMP) in 1998–99. Table 1 shows that status of individual reefs during the survey and the development of outbreaks is illustrated in figure 1.

The following listing is a summary of our key results:

1. We recorded a total of 4032 *A. planci* on the 21 reefs surveyed. Juvenile starfish (est. age 1) accounted for 2639 of these with a further 445 individual sub-adults and 948 adult starfish recorded inside the 800 benthic transects sampled. This is the first time in the five-year history of the surveys that juvenile starfish have dominated the sample.
2. *Juvenile starfish (est. age 1):* The average density of juvenile *A. planci* across all reefs surveyed in 1998–99 was estimated at 3.30 ± 0.20 individuals per 250 m^2, which is approximately 13.75 times the previous highest density recorded in the five years that these surveys have been carried out.

   Highest densities of juvenile *A. planci* were recorded on reefs located in the offshore Port Douglas and Cairns area. Possible Future Spot Outbreaks (FSO) were detected on nine individual survey reefs (15-070, 15-084, 16-023, 16-024, 16-057, 16-068, 16-071,

17-004 and 17-034). At each of these reefs juvenile densities above the critical threshold of 2.5 individuals per 250 m^2 were found within the exposed front reef zone. At Michaelmas Reef (16-060) both reef zones had juvenile densities above the threshold resulting in its classification as a possible Future reef-wide Outbreak (FO). Future outbreaks are expected to develop on the abovementioned reefs within the next 18–24 months.

Significant or unsustainably high juvenile densities were found in reef areas both affected and unaffected by recent *A. planci* outbreaks. In areas that had already suffered significant starfish-induced coral mortality over recent years (i.e. remnant live hard coral cover of < 10%) we noted an obvious preference of juvenile starfish for feeding on the smallest most recently recruited hard corals. These observations suggest that this latest starfish cohort has the potential to significantly impact on the onset and progress of the coral recovery phase on previously outbreaking reefs.

3. *Adult starfish (est. age 3 or older)* were significantly more abundant on reefs in the Innisfail to Townsville region compared to adult densities recorded in the more northern regions from offshore Cooktown to offshore Port Douglas and Cairns. Active Spot Outbreaks (ASO) dominated by adult starfish were detected on nine individual survey reefs (15-024, 15-070, 16-023, 16-071, 17-004, 17-023, 17-034, 17-064 and 18-031). At each of these reefs *A. planci* densities within the protected back reef zone were found to be above the upper limit of a sustainable population. At Eddy Reef (17-047) adult densities exceeded the sustainable threshold in both the back and front reef zones leading to its classification as and Active reef-wide Outbreak (AO).
4. We found significant size-specific patterns of distribution within reefs. Small juvenile starfish were significantly more abundant in exposed front reef zones. Conversely, adult starfish were more common in protected back reef zones. These findings have important implications for future monitoring studies. If the main objective is the early detection of developing outbreaks (*forecasting capability*), then it would appear that considerable effort should go into sampling reef front environments. In contrast, if the main objective is an assessment of past recruitment events on reefs (*hindcasting capability*), then back reef environments may provide a more complete insight into the probable age structure of resident starfish populations.

Our survey results clearly demonstrate the capacity of intensive transect-based surveys to reliably detect the early signs of possible future outbreaks of crown-of-thorns starfish. The high numbers of small juvenile starfish recorded in 1998–99 provide a strong indication of possible renewed outbreaks likely to develop on many reefs in the Cairns Section of the GBRMP over the next 18 to 24 months.

We still do not know to what extent COTS outbreaks are caused by human activities. However, the detailed understanding of COTS population dynamics that this study will give us may well help scientists develop new hypotheses that will lead to an answer.

GBRMPA Reef ID	Reef Name	Status 1994–95
14-116	Lizard Island Reef[1]	AO
14-143	North Direction Reef[1]	ASO(BR)
14-132b	Rocky Islets Reef (b)	IO
14-133	U/N[2]	IO
15-019	Long Reef	ASO(BR)
15-024	Mackay Reefs	ASO(BR)
15-033	Lark Reef (East)[5]	NO
15-043	U/N[2]	IO
15-070	U/N	NO
15-084	Irene Reef	ASO(BR)
15-089	Endeavour Reef (East)[5]	ASO(BR)
15-095	Evening Reef	ASO(BR)
16-015	Mackay Reef[1]	ASO(BR)
16-023	Rudder Reef (East)	NO
16-024	U/N	NO
16-026	Tongue Reef (West)[3]	NO
16-026	Tongue Reef (East)[3]	NS
16-057	Hastings Reef[4]	NO
16-060	Michaelmas Reef[6]	NS
16-064	Arlington Reef (West)[3]	ASO(FR)
16-064	Arlington Reef (East)[3]	NS
16-049	Green Island Reef[1]	NO
16-068	Thetford Reef	NO
16-071	Moore Reef[6]	NS
16-073	Elford Reef (East)	NO
17-001	Sudbury Reef[3]	NO
17-004	Scott Reef	NS
17-006	Maori Reef[3]	NO
17-011	Coates Reef	NS
17-016	McCulloch Reef[3]	NO
17-023	Cayley Reef	NS
17-034	Feather Reef	NS
17-047	Eddy Reef[4]	NS
17-064	Taylor Reef[4]	NS
18-026	U/N[3]	NS
18-030	Kelso Reef[5]	NS
18-031	Little Kelso Reef	NS
18-075	John Brewer Reef	NS
18-078	Lodestone Reef	NS

Key to codes used to indicate operational changes to the annual sampling program.

1. Reefs that were dropped from the annual sampling program due to the local introduction of *A. planci* control programs that potentially modified the natural dynamics and characteristics of the local starfish population;
2. Reefs that were dropped from the annual sampling program to accommodate the staged southward expansion of the survey area;
3. Reefs that were dropped from the annual sampling program due to logistic and/or operational difficulties such as highly patchy distribution of suitable continuous reef habitats or exceedingly large size of reef structure with a corresponding need for extended travel away from the mother ship;

Status 1995–96	Status 1996–97	Status 1997–98	Status 1998–99
NS	NS	NS	NS
AO	AO	NS	NS
AO	AO	AO	PO
AO	NS	AO	NS
AO	AO	ASO(BR) PSO(FR)	PO ISO(FR)
AO	AO	AO	ASO(BR) PSO(FR)
ASO(BR)	ASO(BR)	ASO(BR)	NS
IO	NS	NS	NS
ASO(BR)	ASO(BR)	ASO(BR)	ASO(BR)
ASO(BR)	ASO(BR)	ASO(BR)	PSO(BR)
ASO(BR)	ASO(BR)	ASO(BR)	NS
ASO(BR)	ASO(BR)	PSO(BR)	PSO(BR)
NS	NS	NS	NS
IO	AO	ASO(BR) PSO(FR)	ASO(BR) PSO(FR)
IO	AO	AO	PO FSO(FR)
NS	NS	NS	NS
ASO(BR)	NO	NS	NS
NO	NS	NS	FSO(FR)
NS	NS	NS	FO
NS	NS	NS	NS
ASO(BR)	ASO(BR)	NS	NS
IO	NS	NS	NS
NO	ASO(BR)	PSO(BR)	PSO(BR) FSO(FR)
NS	NS	NS	ASO(BR) FSO(FR)
NO	NO	NO/NS*	NS
NS	NS	NS	NS
ISO(BR)	ASO(BR)	ASO(BR)	ASO(BR) FSO(FR)
NS	NS	NS	NS
AO	AO	AO	PSO(BR) NS*
NS	NS	NS	NS
NS	AO	ASO(BR) PSO(FR)	ASO(BR) NS*
NO	NO	ISO(BR)	ASO(BR) FSO(FR)
NS	NO/NS*	NS	AO
NS	NO/NS*	NS	ASO(BR) ISO(FR)
NS	NO/NS*	NS	NS
NS	NS	ISO(BR)	NS
NS	NS	ASO(BR)	ASO(BR)
NS	NS	NO	NO
NS	NS	ASO(BR)	PSO(BR)

Table 1. *Overview of the respective status of individual reefs surveyed since 1994–95 using the* A. planci *fine-scale survey methodology. (NB: only reefs surveyed with funding from the CRC Reef Research Centre and the Great Barrier Reef Marine Park Authority as part of the CRC Reef Task 1.6.1 are shown. Reasons for the deletion or addition of individual survey reefs from the annual sampling program are also stated).*

AO—Active Outbreak; ASO—Active Spot Outbreak; BR—Back Reef zone; FO—Future Outbreak; FR—Front Reef zone; FSO—Future Spot Outbreak; IO—Incipient Outbreak; ISO—Incipient Spot Outbreak; NO—Non-outbreaking; NS—Not surveyed; PO—Post Outbreak; PSO—Post Spot Outbreak

4. Entire reef or individual reef zone not surveyed during certain years due to cyclonic activity in the survey area;
5. Reefs dropped from the annual sampling program due to financial constraints arising from operational changes to the crown-of-thorns starfish research program;
6. Additional reefs located directly offshore Cairns—opportunistic once-off surveys in 1998–99 due to the availability of limited carry over funds;

* Front reef zone not surveyed due to severe weather conditions.

Note: All reefs added to the annual sampling program in order to (i) either replace previously sampled reefs or (ii) to geographically expand the survey area were selected haphazardly.

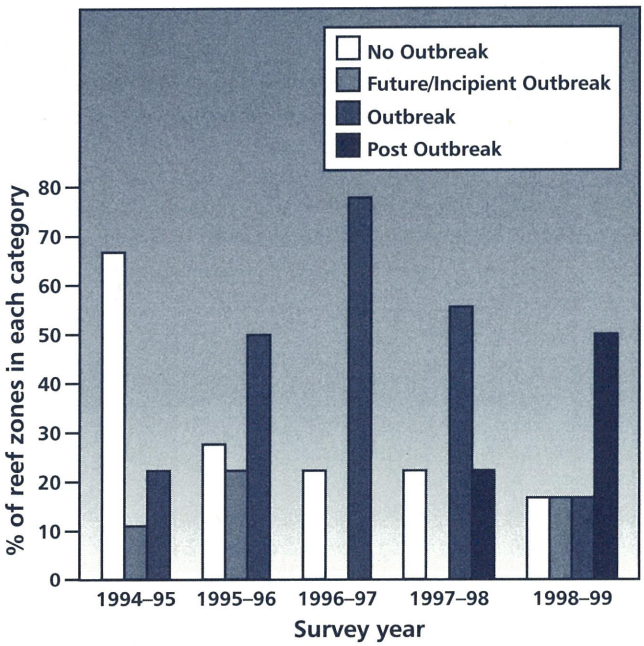

Figure 1. *Development of crown-of-thorns starfish outbreaks. This figure was developed by the Great Barrier Reef Marine Park Authority using information from table 1. Only the nine reefs that were surveyed every year were included in the analysis and each zone (back reef, front reef) is categorised separately, thereby removing the need for 'spot' categories.*

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Glossary

cetacean: means the order of mammals, primarily marine (a few freshwater species exist) with nostrils on top of their heads. Includes whales, dolphins and porpoises.

demersal: fishes (also called groundfish), cephalopods or crustaceans that spend their time on or near the bottom, although they can swim

demographic: referring to numerical characteristics of a population (e.g. population size, age structure)

dispersal: the spreading of individuals away from each other

Exclusive Economic Zone (EEZ): An area beyond and adjacent to the territorial sea, subject to the specific legal regime of a country, under which the rights and jurisdiction of that country and the rights and freedoms of other Coastal States are governed by the relevant provisions of the United Nations *Convention on the Law of the Sea.*

ontogenetic: occurring during the course of an organism's development

pelagic: of, relating to, or living in the water column of seas and oceans (as distinct to benthic)

proximal: pertaining to or situated at the inner end nearest to the point of attachment

recruitment: the influx of new members into a population by either reproduction or immigration

spatial (variability): subject to or controlled by the conditions of space

species: a group of plants, animals or micro-organisms that have a high degree of similarity and generally can interbreed only among themselves

stock: group of individuals of a species (usually genetically distinct and/or physically separated) which can be regarded as an entity for management or assessment purposes

taxon (*pl taxa*): any group of organisms or populations considered to be sufficiently distinct from other such groups to be treated as separate unit

temporal: of, related to, pertaining to, time

with Steve Raaymakers

Ballast Water Blues Still with Us

Exogenous marine species, invasive marine species, introduced marine pests, harmful aquatic organisms and pathogens, non-indigenous alien marine hitchhikers, call them what you will. The introduction of non-native marine microbes, plants and animals to new environments by shipping is widely recognised as an ecological time-bomb, threatening the world's already highly strained coastal and marine resources. The last edition of Slick Talk by Steve Hillman (*Reef Research* Vol. 9, No. 3) provided a good overview of this subject and the outcomes of the ballast water workshop held in Brisbane in May 1999.

Over the last few years *Reef Research* has featured a number of articles on this major problem, and the Summer 1999/2000 issue of *Waves*, the newsletter of the Marine and Coastal Community Network, contains a thorough treatment of latest initiatives to address introduced marine pests in Australia. Many have been spurred on by the discovery of alien striped mussels in Darwin in early 1999.

At the international level, a new global project as outlined in Slick Talk (*Reef Research*, Vol. 9, No. 2), has now commenced. Currently entitled 'Removal of Barriers to the Effective Implementation of Ballast Water Control and Management Measures in Developing Countries', this US$12 million, three-year project is being funded by the Global Environment Facility (GEF) and other parties, implemented by the United Nations Development Programme (UNDP) and executed by the International Maritime Organization (IMO), under the GEF International Waters portfolio.

This project will assist developing countries to implement effective measures to control the introduction of foreign marine species, initially through six demonstration sites. These are intended to represent the six main developing regions of the world, being Dalian/East Asia, Mumbay/South Asia, Kharg Island/ Middle East, Cape Town/Africa, Odessa/Eastern Europe and Rio De Janeiro/South America. It is planned that as these sites progress they will be replicated throughout each region. It is hoped that the project will further catalyse the development of an international regulatory regime for ballast water through galvanising action by IMO member states.

My contract at the South Pacific Regional Environment Programme (SPREP) was recently completed and I am pleased to have been recruited by IMO to work as Technical Adviser on the global ballast water project. Regular updates on the project will be provided through this column. In addition, an important feature of the project will be the establishment of a comprehensive global information clearinghouse at IMO on all matters relating to invasive marine species. Readers are invited to bookmark the IMO web site http://www.imo.org to remain abreast of international developments in this area.

South Pacific Sets Course for Cleaner Seas

It is with some reluctance that I move on from my role as Marine Pollution Adviser at SPREP and its base in Apia, Samoa, with its Beach Road and waterfront bars like "Otto's Reef", the 'Blue Marlin', "Don't Drink the Water" and 'On the Rocks', for 'civilised' London and IMO.

But it is also with a feeling of satisfaction that at least some progress has been made in getting the new regional marine pollution program up and running. Over the last two years, the SPREP member countries

have agreed to and endorsed a new five-year regional strategy and workplan to address ship-sourced marine pollution in their 200 nautical mile Exclusive Economic Zone's, an area larger than the mainlands of China, Canada and the United States of America combined.

Called the Pacific Ocean Pollution Prevention Programme, or PACPOL for short, the strategy and workplan has to date attracted over US$1.25 million in funding from a variety of sources, including the governments of Canada and Australia, the IMO and the Commonwealth Secretariat. Significant support-in-kind has also been received from France, New Zealand, the United States, SPREP island members and the international oil industry.

These resources have been deployed by PACPOL to deliver a number of benefits to SPREP island members over the last two years. These include (but are not restricted to):

- Annual training courses in oil spill response. A hundred personnel from throughout the region having now been trained at a middle-management level and planning is already underway for future annual workshops.
- The development of regional model marine pollution legislation for use as a template by Pacific island countries. This allows countries, most of which do not have effective regulatory regimes for marine pollution, to rapidly draft and pass legislation that is consistent with the international regime and harmonized across the region. The response from countries has been tremendous and several missions have been undertaken by PACPOL staff and the Regional Maritime Legal Adviser from the Secretariat of the Pacific Community (SPC), to assist countries with legislative drafting.
- A Regional Marine Spill Contingency Plan has been prepared. This sets out the mechanisms for regional cooperation and external assistance in the event of major marine pollution emergencies, and implements the multi-lateral cooperation aspects of the International Convention for Oil Pollution Preparedness and Response Cooperation 1990 (OPRC 90).
- A template has been developed for national marine spill contingency plans (NATPLANs), and assistance has been provided to several countries, including the Cook Islands, Fiji, Samoa and Tuvalu, to develop such plans.
- A comprehensive marine pollution education and awareness raising campaign has been commenced, and a variety of products primarily targeting the foreign fishing fleet have been produced and distributed.
- A training workshop has been held for regional port personnel on the planning, development, operation and maintenance of port waste reception facilities.
- Two major consultancy contracts have been awarded, one to undertake an in-depth GIS-based marine pollution risk assessment for the region and one to develop a comprehensive strategy for the provision of adequate port waste reception facilities throughout the region, in accordance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).

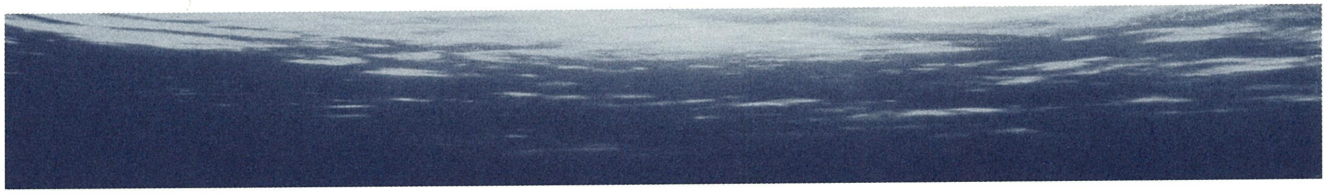
Significant efforts are continuing to secure further funding to carry out a range of additional PACPOL projects in the next three to four years, including the development and implementation of integrated marine pollution management plans at key demonstration sites in the sub-regions of Micronesia (Kosrae Island), Melanesia (Suva Harbour) and Polynesia (to be selected).

Working at SPREP to develop and commence implementation of PACPOL has served as an extremely useful lesson in the dynamics of regional, multilateral programs and the mechanics and politics of the international aid industry. Many obstacles to success are encountered in such programs, including a lack of absorbative capacity in recipient countries, which are currently being bombarded with an overwhelming multitude of environmental aid initiatives.

During my time at SPREP, a common deficiency observed in regional programs, is that the contract period of project management staff (who are mainly expatriates) is often not aligned with the project time-frame. This means staff may leave the implementing regional organisation part-way through the project, and the project crashes while bureaucracies lumber to fill the vacancy, sometimes taking six to 12 months to do so.

Avoiding this situation was identified as a high priority early on in the development of PACPOL. Resourcing was secured to employ a regional counterpart to work alongside me for a period of six months, before assuming management of the program. This simple successional and sustainability plan has ensured a smooth transition and continuation of the PACPOL programme at the end of my contract. Sefanaia Nawadra, a Fiji National with experience as a regulator in the Fiji Environment Department, in industry as the regional Environment, Health and Safety Manager for Shell Oil and in consulting with the Suva office of Sinclair Knight Merz, is now the Marine Pollution Adviser and PACPOL Programme Manager at SPREP. For further information contact Sefa at SefanaiaN@sprep.org.ws or visit the SPREP web site at http://www.sprep.org.ws.

At the time of writing I do not have my new e-mail at IMO, but their web site is given above.



Community Based Management Initiatives for Marine Turtle and Dugong

Barry Hunter
Indigenous Cultural Liaison Unit, Great Barrier Reef Marine Park Authority

Introduction

Contemporary Indigenous interests in the Great Barrier Reef World Heritage Area arise from long standing cultural association with, and use of, the coastal and marine environments of the World Heritage Area (Benzaken et al. 1997). However most external focus on Indigenous use is centred on Indigenous utilisation of critical resources such as turtle and dugong.

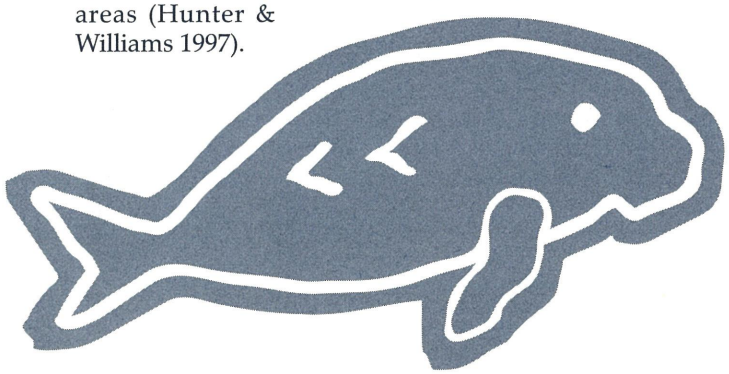
Cultural Significance

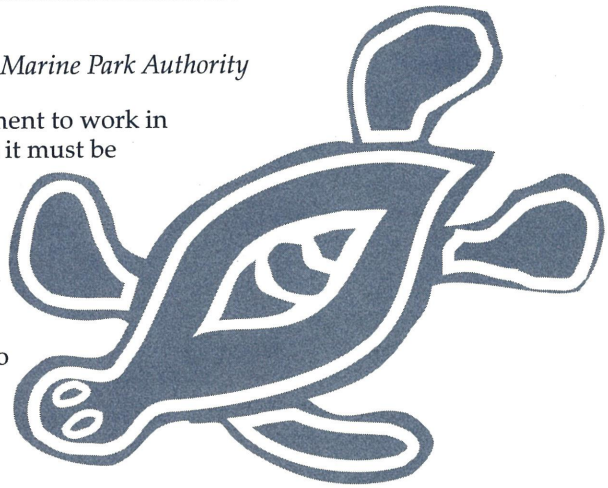
For Indigenous peoples turtle and dugong, like other traditional resources, fill different needs. Turtle and dugong have a cultural value due to tradition and keeping culture alive through the act of hunting. They also have a social value for special occasions which require traditional foods and provide subsistence for survival. These social, cultural and economic values that Indigenous peoples place upon resources such as dugong and turtle give strength to culture and demonstrate affiliation with tradition and traditional areas (Hunter & Williams 1997).

The general view held by the broader society with respect to Indigenous hunting is a negative one. This often affects the involvement of Indigenous peoples in management. There are also other relevant factors which compound the issues of management and indigenous involvement. These factors are a result of the above mentioned values of Indigenous peoples conflicting with: calls by conservation groups to mitigate hunting on conservation grounds; applied pressure upon the resource from other sectors; displacement of hunting activities by tourism; and culturally inappropriate management programs of government.

Management

Management under traditional customary law has been carried out for a long time however recent developments such as increased technology, and the disruption of culture, has affected the balance. Customary law has a role to play as a management constraint. Cultural practices enforce correct protocol such as who can catch turtles, restrictions on take numbers of turtles and eggs, seasonal closure of hunting areas and traditional owners regulating their traditional areas (Hunter & Williams 1997).





For management to work in communities it must be compatible to the needs of each individual community and these needs have to be analysed and understood, must maintain flexibility for the dynamics of Indigenous society and most importantly be initiated, monitored and maintained by the communities themselves—thus empowering Indigenous communities (Hunter & Williams 1997).

Community-based management can prove to be effective. This process provides the means for community monitoring at a grassroots level and invests control in the hands of the traditional people via a management mechanism which is community driven. Not only do traditional owners regulate who, if and where people can hunt, their role has also had a major influence on illegal hunting and the education of both Indigenous and non-indigenous communities (Hunter & Williams 1997).

The Future

Cooperative management between government and Indigenous communities is appearing as a legitimate and effective management mechanism. Effective because it offers control, monitoring and enforcement at a grassroots level. Enforcement by government management agencies can play an effective and productive part as a support to management but not necessarily as a solution. Prosecutions may only have a limited effect on people and serve to slow an individual's activities but it will not address the dugong decline or help turtle research and management. The merits of working with communities may effectively isolate individual offenders through a community monitored approach. The benefits of working with people far outweigh the difficulties associated with the big stick approach, although at times prosecutions may be necessary (Hunter & Williams 1997).

The critical component of education and information will help displace the levels of ignorance and complacency on all sides and should serve as a two-way flow. The fact remains that for people to come up with a solution they first must know and understand the problem. The outcome of an education and information program will isolate the blatant and illegal hunters and bring forward the most appropriate and effective management practices (Hunter & Williams 1997).

Management Initiatives

The following is a list of initiatives taken by various Indigenous communities in sea turtle and dugong management within the Great Barrier Reef Marine Park.

Mossman

- Kuku Yalanji: The traditional owners of the Mossman area established a Marine Resource Committee for the management of traditional hunting permits issued by the Queensland Park and Wildlife Service (QPWS) and the Great Barrier Reef Marine Park Authority (GBRMPA).
- The primary purpose of the Committee is to regulate the government permits issued for hunting of turtle within their traditional hunting area.
- The group has been engaged in turtle research and monitoring.
- The Kuku Yalanji have strongly stated that no permits for the hunting of dugong be approved off shore their traditional area. This was prior to any recognition of a decline in dugong numbers and before the Great Barrier Reef Ministerial Council decision, of June 1997, to not issue permits for traditional hunting in the Great Barrier Reef Marine Park.

Hopevale

- The Hopevale community north of Cooktown are in the process of implementing their management program for turtle and dugong with a strong focus on education, community participation and ownership of the process outcome.
- The focus of the development of management plans is to have the Marine Park Authority's and QPWS' legislative and regulative requirements fit into community law. The community's main aim is to work towards cooperative management with QPWS and GBRMPA on the community's terms.

Bowen

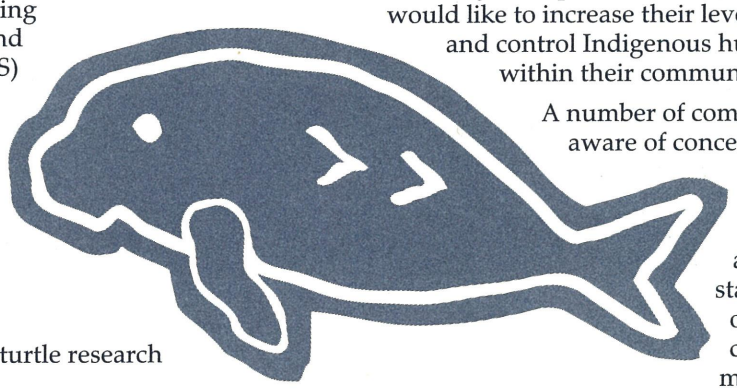
- The Girudala people of the Bowen area established a Council of Elders to manage their traditional hunting permit. This program, which has had a level of success in the past, has been stalled in recent times, mainly due to a lack of resources.

Shoalwater Bay

- The Darumbal Noolar Murree Corporation representing the people around the Shoalwater Bay region, which happens to be an important dugong habitat, have taken the initiative to enter into a formal agreement to cease traditional hunting activities until such time that the next survey is carried out and/or dugong numbers reach sustainable hunting levels. The Corporation are also looking at playing a more effective role in the day-to-day management of the area.

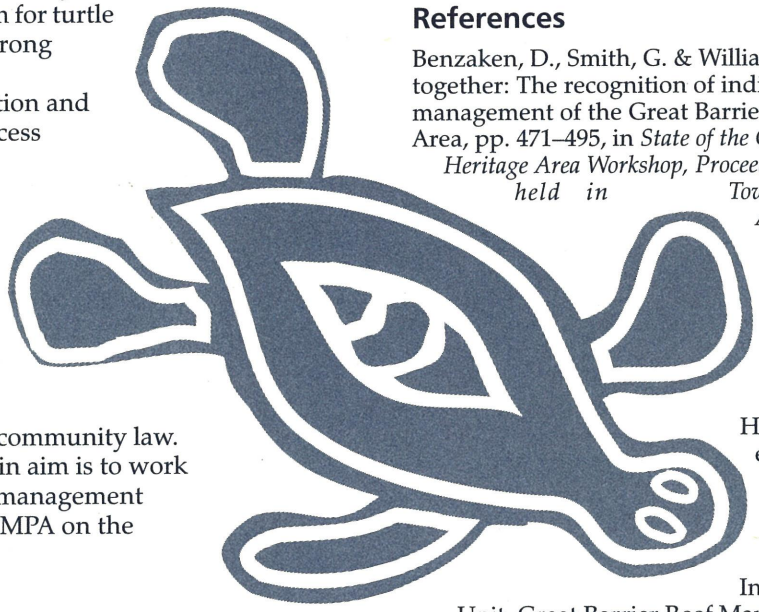
Tip of Cape York

- The Wuthathi people who represent the area around Shelbourne bay in Cape York have indicated that they would like to increase their level of monitoring and control Indigenous hunting activities within their community.



A number of communities are aware of concerns in relation to turtle and dugong management and many are starting to explore options for cooperative management.

Each region has different traditions and cultural constraints, mixed and diverse Indigenous representative groups, issues and environmental concerns. The conservation of the turtle and dugong and the management of impacts, represents the same collective goal of all interest groups. It should be understood Indigenous peoples have an obligation to be involved in management of dugong and turtle for if these animals disappear then this also means that another aspect of culture is gone (Hunter 1999).



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