GREAT BARRIER REEF
MARINE PARK AUTHORITY

REEF RESEARCH

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NEWSLETTER OF THE RESEARCH AND MONITORING SECTION

Editorial

What a mixed bag of articles we have for you in this issue! A news-breaking story temporarily replaces the CRC Update as scientists warn that coral reefs may be threatened by rising concentrations of carbon dioxide in the atmosphere.

Steve Raaymakers reports to us from his new post in the South Pacific. Steve has taken up a position at the South Pacific Regional Environment Programme (SPREP) and I am very pleased to announce that he has agreed to continue writing *Slick Talk* for us. In this issue he outlines a program that he is developing, in consultation with SPREP member countries, to address shipping-related pollution.

In *What's Out There?* Chantal Roder, a guest writer from the Queensland Department of Primary Industries, takes a look at the seagrass resources of the Great Barrier Reef Marine Park. Chantal writes on surveys carried out in the Hinchinbrook region of the Marine Park and discusses methods for mapping seagrasses.

John Robertson reports on a workshop that was held in Hong Kong in 1997 to discuss the impacts of destructive fishing practices on the marine environment. He outlines the papers presented during the four sessions of the workshop. The sessions were impacts of destructive fishing practices, protection of the coral reef environment, promotion of environmentally friendly fishing practices, and legislation, enforcement and management strategy.

Community attitudes to wilderness-based recreation are the focus of Joan Crawford's article. Joan summarises the key findings of a study that was commissioned by the Authority entitled *Recreation use and management issues for the Great Barrier Reef Marine Park*.

In this issue I have included a paper that was written by David Lloyd and David Wachenfeld for the November–December 1997 issue of *Geo Australasia*. The paper discusses threats faced by coral reefs, with an emphasis on the Great Barrier Reef. There's also an article on the research and monitoring program which is being developed to support and assess the effectiveness of the new dugong sanctuaries. ▶

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Editorial

continued from front page

No doubt most of you are aware that this year, 1998, has been declared the UNESCO International Year of the Ocean. Events have been organised world-wide in an attempt to increase the community and government's awareness of our oceans and marine environment. One such event is the International Tropical Marine Ecosystems Management Symposium (please refer to story below for more information). This event is being hosted by the International Coral Reef Initiative which is hosted by Australia through the Authority's office.

Unfortunately this issue does not include a COTS COMMs. The Authority's COTS staff are in the middle of fine-scale surveys (both performing them and collating data) and will be in a much better position to brief us on the COTS situation next issue.

Till next time.

Kim Davis
Editor

THE INTERNATIONAL TROPICAL MARINE ECOSYSTEMS MANAGEMENT SYMPOSIUM

The International Coral Reef Initiative (ICRI) is a partnership of individual countries, non-government organisations and the private sector, along with international and regional organisations. Australia is one of the founding partners of ICRI. The International Coral Reef Initiative seeks to provide for the protection, restoration, sustainable use and understanding of coral reefs and related ecosystems. The Initiative operates through a regional structure (based on the existing United Nations Environment Programme Regional Seas Program) supported by a small Secretariat. The Secretariat is currently hosted by Australia through the office of the Great Barrier Reef Marine Park Authority.

During its term as Secretariat which concludes at the end of

1998, Australia is committed to working with other partners to strengthen and broaden the regional and national emphasis of ICRI. The aim of the Secretariat, within Australia's two-year term, is to assist in the establishment of a regional structure for the Initiative which is self-sustaining, assists individual countries and which requires a minimum of organisational support at the international level. The Secretariat is providing support and assistance to the ICRI partners in both developing their regional and national programs and improving the capacity of those countries to deliver those programs.

In November 1998 the ICRI Secretariat will host the inaugural International Tropical Marine Ecosystems Management Symposium (ITMEMS). The Symposium will serve as a major opportunity for coral reef managers from around the world to share management experience and, thereby, build international capacity for future work on successful coral reef management. The major output of the Symposium will be an action statement that will form the basis of continuing ICRI activity into the next century. It is anticipated that future ITMEMS will alternate with, and follow the successful format of, the International Coral Reef Symposium which has, since 1972, been repeated every four years at various coral reef locations around the world.

The International Tropical Marine Ecosystems Management Symposium will be a major environmental event for Australia during 1998 – the UNESCO International Year of the Ocean. It will certainly be among the premier events world-wide during the Year of the Ocean.

For further information on ITMEMS visit the ICRI Secretariat Internet site at:

http://www.gbrmpa.gov.au/~icri/secretariat/itmems

or contact John Baldwin of
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or e-mail j.baldwin@gbrmpa.gov.au

with Steve Raaymakers

SOJOURN IN THE SOUTH PACIFIC

Welcome to the first appearance of *Slick Talk* from my new position at the South Pacific Regional Environment Programme (SPREP). When I first started writing for *Reef Research* in 1991 I was working with the Great Barrier Reef Marine Park Authority. At the end of 1993 I moved to the Queensland Ports Corporation, and continued to write *Slick Talk*. With my recent assignment to SPREP, I am pleased to report that the *Reef Research* Editor has asked me to continue with this marine pollution 'news and views' column.

My current role as Marine Pollution Adviser with SPREP obviously presents an opportunity to provide a more regional perspective to *Slick Talk*, and this article outlines the new program I am developing at SPREP.

The South Pacific Regional Environment Programme (SPREP) is a regional organisation, established by international convention, which works to assist member countries to achieve ecologically sustainable development and effective protection of their natural environments

and biological resources. It consists of 26 member countries, being the Pacific Island states of American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Republic of the Marshall Islands, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Pitcairn Island, Samoa, Solomon Islands, Tokelau Islands, Tonga, Tuvalu, Vanuatu and Wallis and Futuna; and the 'metropolitan powers' of the United States of America, France, Australia and New Zealand.

SPREP is funded by member country contributions and aid donations, both from various countries and international sources such as the United Nations and the Global Environment Facility (World Bank).

SPREP headquarters are located in Apia, Samoa, which is geographically central to the region. Its programs are divided broadly into areas such as biodiversity conservation, climate change (a huge issue for low-laying island states), integrated coastal management, waste management and pollution prevention and environmental education, information and training.

As Marine Pollution Adviser I am working in the pollution prevention area. My first priority is to re-activate the SPREP/International Maritime Organization (IMO) Strategy for the Protection of the Marine Environment (SPREP/IMO Strategy). This Strategy primarily addresses shipping related pollution, a significant issue in many parts of the shipping-dependent Pacific.

This Strategy was developed by SPREP in 1993, with technical assistance from the IMO. Unfortunately, for various reasons it has not yet been implemented. Given that it is now five years old, my first task is to revise and update the Strategy, ensuring its relevance, appropriateness and acceptance and endorsement by member countries. Physical implementation is then likely to be more effective.

Without pre-empting the revision and updating process, initiatives that could be implemented under the Strategy may include:

- Assessment of shipping patterns throughout the South Pacific, including identification of high risk areas for shipping/pollution incidents.
- An assessment of the risk of foreign marine organisms being introduced to the region via ships' ballast water and hull fouling.
- A review of shipping incident/pollution prevention measures in the region, including:
  - provision of navigation aids
  - pilotage requirements
  - maritime training
  - port state control capabilities
  - provision of ships' waste reception facilities.
- Completion of regional, national and port-specific oil spill contingency plans for the region.
- Establishment of a central, regional pollution incident reporting centre and database.
- Characterisation of the biological, chemical and physical environments of each port in the region, (including presence/absence of introduced marine species) and the establishment of long-term environmental monitoring programs for these ports.
- Characterisation of hydrodynamic conditions and circulation patterns, and modeling of likely pollution dispersal scenarios, for each port and high risk shipping area in the region.
- Monitoring of ship-sourced marine debris at selected high exposure (sink) coastal sites throughout the region.
- Improving regional marine pollution surveillance and enforcement capabilities.
- A major emphasis on education, training, extension and communication.

The first two quarters of 1998 will focus on consultation with SPREP member countries, other regional organisations and international agencies to gain an understanding of their requirements and priorities. It is hoped that a revised and updated SPREP/IMO Strategy will be ready for implementation in the second half of 1998. Developments with the program will be reported in future appearances of *Slick Talk*.

For further information I can be contacted at:

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(Steve Raaymakers is currently engaged as Marine Pollution Adviser with the South Pacific Regional Environment Programme (SPREP). The views expressed by his authorship of 'Slick Talk' are not necessarily those of SPREP nor the Great Barrier Reef Marine Park Authority.)

Assessing Seagrass Resources of the Great Barrier Reef Marine Park

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Northern Fisheries Centre, PO Box 5396, Cairns Qld 4870

The Great Barrier Reef Marine Park Authority is committed to maintaining the health of seagrass ecosystems in the Great Barrier Reef region. The Authority has recognised the importance of seagrass as a food source for dugongs and turtles, a nursery ground for juvenile fish and prawns, a stabiliser of coastal sediments and as a buffer to nutrients in land run-off that can potentially harm coral reefs. Conserving seagrasses and associated marine animals while providing for reasonable use of the Marine Park is a task for the Great Barrier Reef Marine Park Authority.

With World Heritage values, fishing interests, foreshore development and the existence of a dugong protection area, the Hinchinbrook region has gained much attention from biologists, resource managers, politicians, fishers and the broad community. For efficient management of seagrass resources of the region, information on existing seagrasses is used by the Great Barrier Reef Marine Park Authority and other management agencies for regulating activities (e.g. foreshore developments and fishing practices) that can potentially harm seagrass habitats and associated fauna. To obtain baseline information on existing seagrass resources, the Great Barrier Reef Marine Park Authority contracted the Queensland Department of Primary Industries Seagrass Ecology Group to map seagrass habitats in the Hinchinbrook region (Dunk Island to Cape Cleveland) in detail.

The seagrass survey was undertaken in October 1996 with divers describing intertidal and subtidal seagrass habitats. Aerial photography was used to aid mapping of seagrass meadows in some intertidal areas. Video and satellite images have aided with mapping intertidal seagrasses elsewhere in tropical Queensland and underwater video has been used to investigate deepwater seagrasses in the Great Barrier Reef region.

A total 258 ± 30 km^2 of seagrass habitat (an area approximately five to six times larger than Magnetic Island) was mapped from Dunk Island to Cape Cleveland. Large seagrass meadows in the sheltered bays (Missionary, Shepherd and Cleveland Bays) formed the most prominent seagrass features in the region. Figure 1 shows the meadows found in the Hinchinbrook region. Other important features were dense meadows of mostly *Halophila* and *Halodule* species along the Cardwell and Townsville foreshores and in the lee of the large continental islands: Dunk, Palm and Magnetic.

The seagrass habitats mapped between Dunk Island and Cleveland Bay are likely to be regionally important to fisheries and dugong/turtle populations because the next substantial areas of seagrass habitat occur large distances to the north (Cairns) and south (Upstart Bay). The large subtidal seagrass habitat areas (e.g. Missionary Bay, Shepherd Bay, Townsville foreshore and Cleveland Bay) are probably very important alternative food sources for

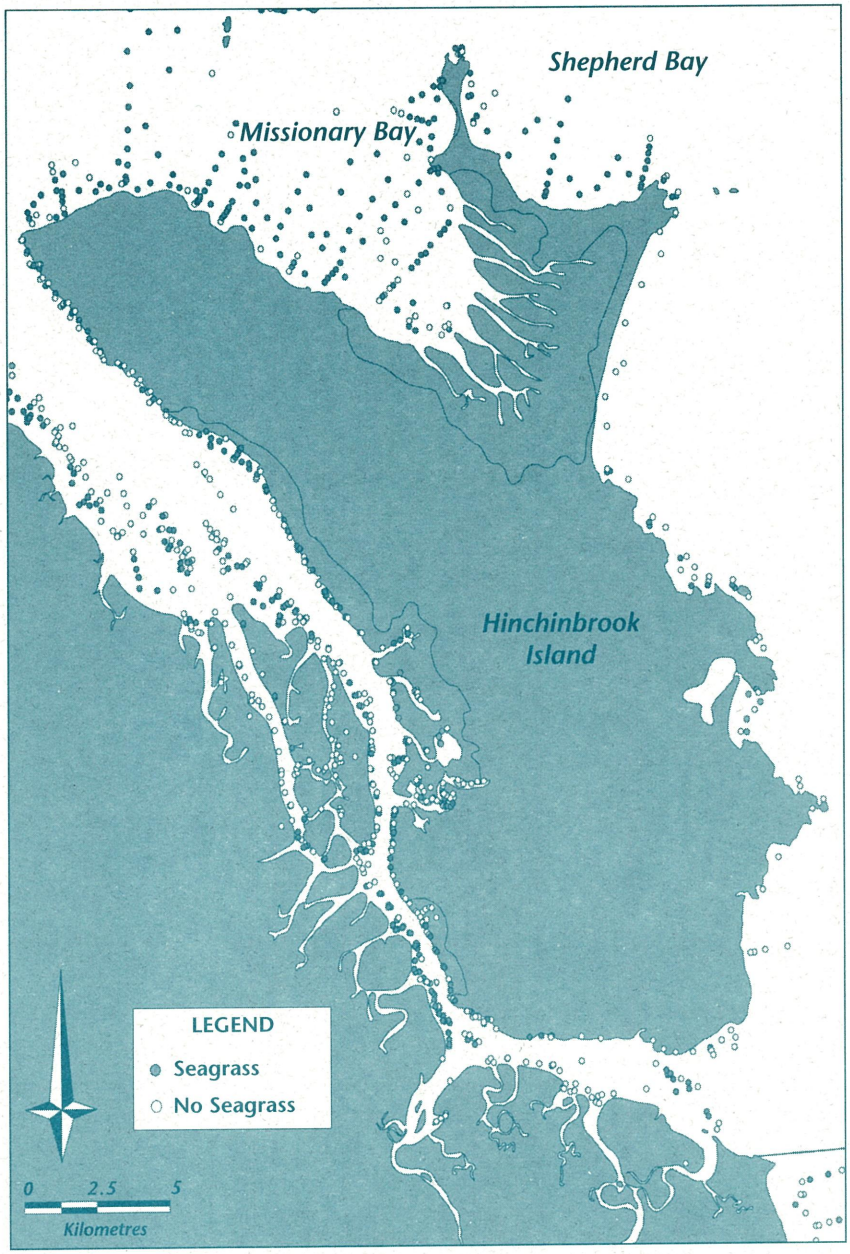


Figure 1.

Seagrass presence and absence at sites sampled during the dive survey of the Hinchinbrook region, October 1996

dugongs and sea turtles when the narrow intertidal habitat areas are inaccessible at low tides.

This survey has identified the areas of seagrass important to coastal processes in the region. The survey results will be used in developing regional management plans for a sustainable coastal system. The information was recently used directly for establishing dugong protection areas which aimed to minimise conflicts between dugong conservation and commercial fishing interests.

New methods for mapping seagrasses

While free-diving in the Hinchinbrook Channel is not recommended to the general public, it is still the most efficient method to sample seagrass in shallow, turbid coastal areas. Alternative techniques are being sought to reduce costs of surveying and to minimise risks to divers where there are dangerous marine animals, abandoned fishing nets and other diving hazards. An alternative technique using acoustic technology was trialled on seagrass habitats in Cairns Harbour during May 1996.

Acoustic survey techniques have an advantage over visual surveys and photographic remote imagery because **sound** (acoustic) signals are not affected as much as **light** is by water turbidity and depth. Data is also collected at higher spatial resolution than is usual with dive-based surveys and large areas can be surveyed quickly. Data is recorded digitally on computer in the field, and can be linked with a Global Positioning System (GPS).

Trials of acoustic techniques for mapping seagrass were carried out at three sites within Cairns Harbour, and two configurations of acoustic hardware were tested against the results obtained through a dive based survey.

A fan beam acoustic system was trialed as a technique for mapping of seagrass habitat *boundaries*. This technique uses a beam of sound that is very narrow (2°) in the horizontal plane and broad (60°–90°) in the vertical plane (figure 2). This geometry has the effect of a sonar 'sweep' of a sea-floor area typically 1 m wide by 70 m long in a direction perpendicular to the vessel track.

A conical beam acoustic system was also trialed for measuring seagrass *biomass* and sediment type. For determining seagrass biomass, the conical beam uses a very narrow beam of sound at a low grazing angle (10°) emitted from the transducer and reflected from above-ground biota (figure 2). Echo intensity (decibels) received by the transducer is affected by the density of seagrass (i.e. plant density results in higher echo amplitude).

The fan beam acoustic system successfully mapped boundaries of seagrass meadows when combined with

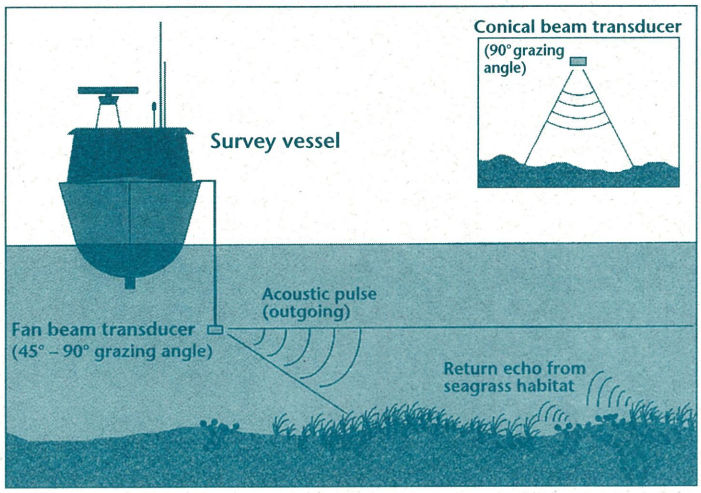


Figure 2.
Set up of fan beam and conical beam acoustic systems used for mapping seagrasses habitat boundaries

diver ground-truthed information. Meadow boundaries interpreted from fan beam data are at a higher resolution than is possible from dive-based surveys, however edges of 'patchy-cover' low-density seagrass habitat cannot be mapped with confidence.

We found that acoustic techniques can provide reliable sediment mapping information at spatial resolutions better than normally available from traditional mapping methods using sediment grabs (figure 3). Acoustic data can be used in some situations as a proxy for per cent mud – a useful sediment parameter in marine ecology studies. However, acoustic data alone cannot be used to interpret particle size composition (i.e. the proportions of each sediment fraction).

Seagrass biomass in Cairns Harbour could not be determined with any accuracy by the conical beam mapping technique in this survey (figure 4). Although correlations with biomass greater than 5 g DW m^{-2} were detected at one site, the technique could not replicate the results using identical methods at the other survey sites. The lack of any significant correlation between acoustic data and seagrass biomass data is probably the result of a combination of many sources of error. Spatial errors in the data (smearing) can be caused by GPS position-fixing and the influence of surface chop on the orientation of the transducer. Irregular bottom topography and variation (patchiness) in seagrass species composition also create 'noise' in the acoustic data and affect the ability to detect differences in seagrass biomass.

Acoustic techniques used to survey seagrass habitats will always require dive-based sampling to ground truth and interpret the acoustic signal, as well as collect information on species composition and faunal use (e.g. dugong feeding trails) of seagrass habitats.

Each seagrass survey provides only a snapshot of seagrass resources – their distribution and abundance. To understand changes in seagrass meadows over seasons and years, carefully planned monitoring programs need to be conducted. Repeated surveys which monitor the health and abundance of seagrass meadows allow us to identify impacts of natural climatic events as well as impacts from agricultural and urban land-use, foreshore developments and fishing and boating.

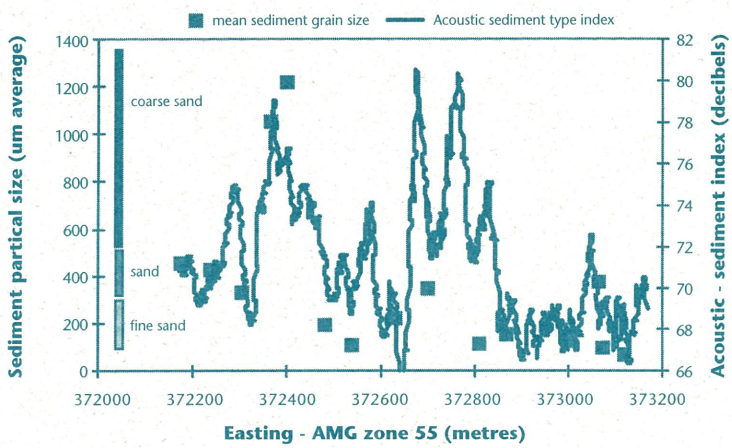


Figure 3. **Acoustic response measured in decibels (line) and mean sediment grain-size (squares) along a survey transect, Cairns Harbour, May 1996**

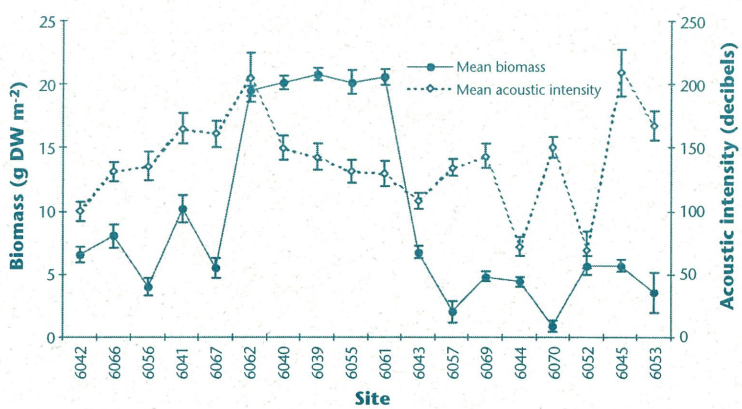
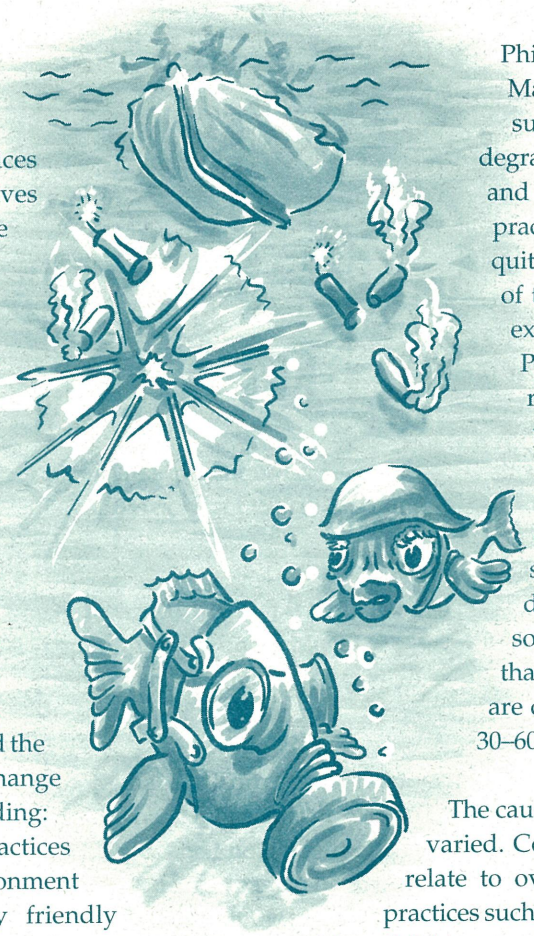


Figure 4. **Mean acoustic intensity (decibels) and ground-truthed seagrass biomass (g DW m^{-2}) examined at one survey area in Cairns Harbour, May 1996**

Workshop on the Impacts of Destructive Fishing Practices on the Marine Environment

John Robertson

Background



Destructive fishing practices such as the use of explosives and toxic substances have raised widespread concerns in the Asia-Pacific region in recent years. At its 9th meeting in Phuket, Thailand (27–29 September 1996) the Asia-Pacific Economic Cooperation Council (APEC) Marine Resources Conservation Working Group decided that a workshop should be convened to address the impacts of destructive fishing practices on the marine environment. The workshop was held on 16–18 December 1997 in Hong Kong, China. It provided a forum for government officials, scientists, environmental groups and the fishing industry to discuss and exchange information on various topics including:

- impacts of destructive fishing practices
- protection of the coral reef environment
- promotion of environmentally friendly fishing practices, and
- legislation, enforcement and management strategy

with a view to defining areas for action and regional cooperation through which the problems of destructive fishing practices could be addressed.

Themes

1. Impacts of Destructive Fishing Practices
2. Protection of the Coral Reef Environment
3. Promotion of Environmentally Friendly Fishing Practices
4. Legislation, Enforcement and Management Strategy

Impacts of Destructive Fishing Practices

Most of the papers presented comprised coral reef status reports from APEC countries such as Indonesia, Philippines, Taiwan, Hong Kong, Malaysia and China. The reports summarised the level of reef degradation, the causes of reef decline and the types of destructive fishing practices. Many areas have suffered quite alarming declines in the health of their coral reef ecosystems. For example, the status of reefs in the Philippines is that 32 per cent of reefs are in poor condition, eight per cent are in fair condition, 25 per cent are in good condition and five per cent are in excellent condition. In some areas of southern China, coral cover has declined by over 50 per cent on some reefs. It has been estimated that more than 30 per cent of reefs are degraded beyond recovery and 30–60 per cent are facing destruction.

The causes of reef decline are many and varied. Commonly, however, the causes relate to over-fishing, destructive fishing practices such as the use of explosives, sodium cyanide and fishing gear which destroys reef habitat, the harvest of rare and vulnerable species such as dugong and sea turtles, irresponsible tourism, coral mining, sedimentation and pollution. In most countries, the laws required to adequately protect coral reefs are not in place and/or enforcement is not sufficient. Additionally, there is a lack of public awareness on the significance of coral reefs and an ignorance of human impacts.

It was reported that, for many countries over-fishing and destructive fishing practices are seen as the greatest threat to sustainability of coral reef areas. In particular, explosive fishing and cyanide fishing for the aquarium fish and food fish trades severely affects reef fish abundance and reduced reef fish and coral species diversity. An interesting study compared the short-term private incentives to fisherman for using cyanide. The private incentives to fisherman were very high but the activity impacted

heavily on tourism resulting in the longer-term loss of approximately 50 times the gain received by fisherman.

There was also talks on the impact of prawn trawlers on sea bottom environments and demersal fish communities in Taiwan.

Protection of the Coral Reef Environment

Most of the talks centred on current mechanisms used by a number of countries to protect coral reefs, in particular marine protected areas. The protection of world heritage areas was discussed as well as the pros and cons of reef closures.

Many of the presentations discussed the effectiveness of community-based strategies. These strategies included the establishment of protected areas, fish sanctuaries and marine reserves, law enforcement, provision of other sources of livelihood, information and education campaigns. In the Philippines, many of the successful marine protected areas, which were established using the community-based approach, have resulted in some recovery on seriously depleted reefs. The sanctuaries improved lives of villagers by increasing catches, incomes, awareness and value systems. The Hong Kong Government is now establishing marine parks.

Promotion of Environmentally Friendly Fishing Practices

Many of the speakers discussed the success of current programs for cyanide detection technology, monitoring, inspection and sampling of live reef fish, and training of fisherman on alternative harvesting methods such as use of nets in aquarium fish capture and hook and line for food fish. The adoption of fishing technologies such as turtle excluder devices (TEDS) in trawl nets, alternative livelihoods for coastal fishing communities such as combining tourism with artisanal fisheries and promoting the sea-ranching type fishery and related technology, information and education drives and efficient law enforcement were also discussed. The need to establish these programs in some countries was also emphasised in the talks.

Programs to test aquarium and live fish for cyanide residues are already well established in the Philippines. The use of TEDS and barrier nets has been successfully adopted in fisheries in the Philippines.

Legislation, Enforcement and Management Strategy

Many of the presentations centred on the live fish trade and the growing concerns that vulnerable reef fish stocks are being rapidly over-fished. The speakers emphasised that over-fishing must be addressed in source countries. Destructive fishing practices, however, had to be dealt with through cooperation between exporting and importing nations. The influence on international trade practices by major importing nations such as the United States of America, the need for a comprehensive monitoring scheme for imports, the cyanide testing of imported fish and cyanide free documentation requirements between countries were discussed. Talks also covered the promotion of cyanide free sources for consumption and aquaria, reduced demand on wild stocks through aquaculture, education on the impact of destructive fishing and the adoption of alternative livelihoods. There was common acknowledgment that legislation must be in place to prevent the use of destructive fishing practices and that it must be consistent between adjacent countries. The Nature Conservancy explained the role that non-government organisations can play in the prevention of destructive fishing practices.

One speaker stressed that it was important to understand the socioeconomic and 'ethno-networks' of fishing communities if the strategies mentioned above were to be effective.

A report on the economic potential of the live food fish, predicted a market well in excess of US$1.0 billion. Hong Kong is still the major fishing, trading and market destination for much of the live product, although other countries such as China, Taiwan, Malaysia, Singapore and Japan are now involved. The market is mostly confined to the restaurant trade with demand being based on entertainment and consumers with a relatively high disposable income.

Prices paid for live tropical reef fish can exceed US$100 per kilogram wholesale. Premium prices are paid for species that are wild capture and/or are difficult to obtain. Species such as maori wrasse and high-finned grouper attract a significant price premium over species which are readily available.

The future of the live tropical reef fish market was stated to be firm. Major expansion was expected from other countries, in particular China. Significant expansion was predicted to also occur in some of the other Asian nations, for example Malaysia. The potential to supply this market from aquaculture operations was considered promising with significant quantities of live tropical grouper already being supplied into the Taiwan market especially. Presently the culture of reef fish species relies heavily on wild caught fingerlings for aquaculture caused by the lack of consistent success in captive breeding of coral reef fish species.

Great Barrier Reef Water Quality Monitoring and Dugong Protection Areas

David Haynes, Janet Slater, Michelle Devlin and Leane Makey

Introduction

Aerial surveys of dugong (*Dugong dugon*) within the Great Barrier World Heritage Area (GBRWHA) have indicated that there has been a dramatic decline in dugong numbers in southern Great Barrier Reef waters between 1984 and 1994 (Marsh and Corkeron 1997). It is estimated that the population decline is in the order of 50 per cent over the 10-year survey (Marsh and Corkeron 1997). This is of particular concern as the dugong has been endangered or exterminated over much of its range and the species is considered to be vulnerable to extinction (IUCN 1990). Definitive reasons for the reported decline are unclear, but are certain to include indigenous hunting and accidental capture in fishing nets, as well as loss of seagrass habitat and water quality degradation caused by coastal and hinterland development (*The condition of river catchments in Queensland: a broad overview of catchment management issues* 1993; Marsh et al. 1995; Marsh 1992; Preen et al. 1995). Current management initiatives for dugong in the GBRWHA are designed to contribute to maintenance of dugong populations at current or higher levels throughout their range (Great Barrier Reef Marine Park Authority 1994). This is to be achieved via establishment of dugong protection areas, tighter controls and bans on fish netting, and tighter controls on indigenous hunting. Research on dugong biology is being extended with scoping studies of environmental factors which may impact on dugong and their habitat such as water quality.

Dugong Protection Areas

In August 1997, the Commonwealth and Queensland Governments agreed to the establishment of a coastal sanctuary system to protect dugongs in the southern Great Barrier Reef and the Hervey Bay region (figure 1). Sanctuary establishment was seen as the most effective

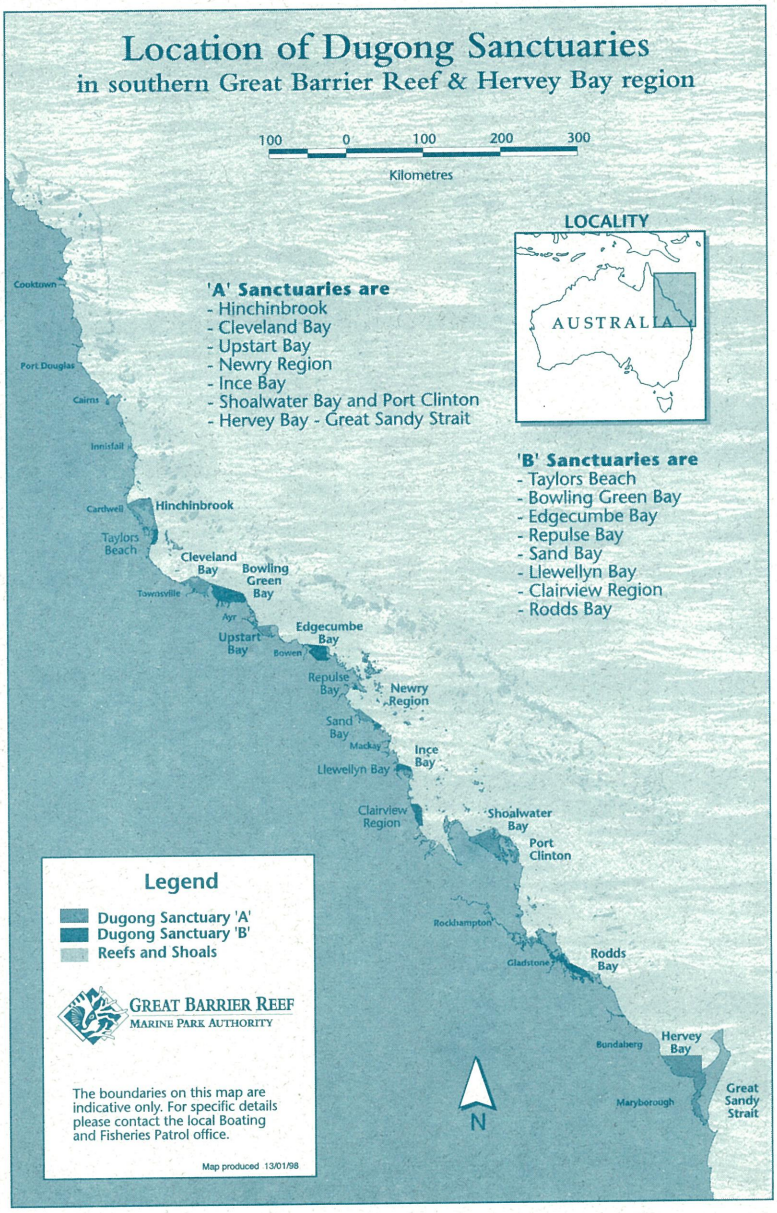


Figure 1. Dugong Protection Areas

immediate measure to address the rapid decline of the southern Great Barrier Reef dugong population.

Dugongs are threatened by both direct (e.g. entanglement in fishing nets, indigenous hunting) and indirect impacts (e.g. degradation of water quality and seagrass beds). Sanctuaries provide a focus for implementing both immediate and longer-term management measures to protect dugong populations from these types of impacts. Ultimately, a combination of these measures will promote the long-term recovery of the species.

Criteria for selecting sanctuary locations and boundaries

The location and size of the sanctuaries is based on past and current distribution of dugong populations and their seagrass habitats, as well as the recommended geographical spacing to ensure adequate genetic interchange within the species. They have also been designed to encompass areas large enough to protect a significant percentage of a typical home range.

It is essential to restore historically important habitat (even though they may not currently support large dugong numbers) in order to provide viable and protected refuges for anticipated increased populations, as well as protect existing dugong populations. For example, dugongs were historically abundant in the Newry region (figure 1), with populations large enough to support two dugong fisheries in the 1900s. In recent times, the population has been severely reduced even though the area supports substantial seagrass meadows. If managed effectively, the Newry sanctuary should be a valuable recovery area for the species.

Two tiered system of protection

A two-tiered system of 'A' and 'B' type sanctuaries has been established (figure 1). In 'A' sanctuaries, the use of offshore set nets, foreshore set nets and drift nets are prohibited. The use of river set nets will be allowed with modification in all sanctuaries except Shoalwater Bay and Hinchinbrook where they are banned. Other netting practices such as ring, seine and tunnel netting are not considered to pose a serious threat to dugong and will continue to be permitted with some modifications. In 'B' sanctuaries, mesh nets are permitted, but with more rigorous safeguards and restrictions than before (e.g. compulsory net attendance). These measures will be kept under review and strengthened if necessary.

Implementation

Sixteen dugong sanctuaries between Hinchinbrook and Hervey Bay will be implemented under the Queensland *Nature Conservation Act 1994* (figure 1). New regulations are now in place to implement netting changes in these sanctuaries under the Queensland *Fisheries Act 1995*. Additional steps to protect dugong populations completely are currently being considered and include reductions in boat speeds, traditional hunting agreements and increased enforcement and surveillance of new conservation measures.

Impacts from outside the sanctuaries

The dugong sanctuaries should provide protection from the direct human impacts of accidental death from fishing and boating but it is also important to consider indirect impacts arising from pollution.

Agriculture, public health, urban expansion and industrial activities around the world have contributed to the widespread contamination of aquatic ecosystems with organochlorine compounds, heavy metals, polycyclic aromatic hydrocarbons (PAHs) and excess nutrients (Fowler 1990; Tatsukawa et al. 1990; Brodie 1995; Connell 1995). Organochlorines and heavy metals are conservative and essentially permanent additions to the environment (Clark 1992) and are often highly toxic to biota (Richardson 1995). Polycyclic aromatic hydrocarbons and excess nutrients can also have profound environmental impacts (Grimmer 1983; Brodie 1995).

Organochlorines

Organochlorines are organic (carbon-based) chemicals which contain bound chlorine. Many of these compounds are 'man-made' and enter the environment through human activities. Chlorinated organic compounds have a wide range of industrial and agricultural applications. They include pesticides and herbicides such as DDT, lindane, diuron and 2,4-D; and polychlorinated biphenyls (PCBs) which were, and are still used in a range of industrial applications including dielectrics in electrical transformers. Polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are also chlorinated organic compounds. PCDDs and PCDFs are not produced intentionally, and have no known use. They form as unwanted bi-products of processes such as waste incineration, coal burning, metal smelting, car exhausts, cigarette smoke, pulp and paper manufacture and sugarcane and trash burning (*Dioxins in the environment: report of an interdepartmental working group on polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans* 1989; Müller et al. 1996a, b). They also occur as contaminants in a range of herbicides and in PCB mixtures (Safe and Hutzinger 1989).

Pesticides and herbicides are transported to the aquatic environment as aerosols and in overland flows and

ground leachate following rainfalls (Clendening et al. 1990). Organochlorine compounds can also enter the environment as contaminants contained in effluent discharges and in urban storm water run-off. Organochlorine compounds are highly hydrophobic, and once in the water column, tend to adsorb to fine particulates or be bioaccumulated in lipids in aquatic biota (Olsen et al. 1982). Tissue accumulation of organochlorine pesticides and PCBs have been implicated in reproductive and immunological abnormalities observed in terrestrial bird populations and in marine mammal populations (Boon et al. 1992). Many of these compounds are also suspected carcinogens (Richardson 1995), and herbicides, in particular, have the potential to adversely impact seagrasses.

Heavy metals

In contrast, heavy metals are natural constituents of rocks and soils and enter the environment through atmospheric transport of dust and through sediment movement caused by overland flows (Bryan 1971; Förstner 1989). Many metals are biologically essential, but all have the potential to be toxic to biota above certain threshold concentrations. Following industrialisation, unnaturally high quantities of metals such as arsenic, cadmium, copper, mercury, lead, nickel and zinc have been released, and continue to be released into the aquatic environment in many urban, industrial and agriculture storm-water and wastewater discharges (Förstner 1989).

Once solubilised in the water column, metals may be accumulated by marine organisms from solution via passive uptake across permeable surfaces such as gills and from food in the digestive tract (Chester and Murphy 1990; Rainbow 1990). Metal toxicity is primarily a consequence of the chemical inactivation of cellular enzymes (Förstner 1989), with organism growth, reproduction and behaviour all being potentially affected by elevated environmental metal concentrations (Langston 1990).

Polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons are derived from petroleum products and their use and enter the marine environment bound to particulates in wastewater spills and discharges, urban run-off, and during the emission of combustion exhausts. They are known carcinogens and mutagens (Clark 1992; Benlahcen et al. 1997), and have strong bio-accumulation capacities in aquatic organisms (Broman et al. 1990; Connell 1995). Polycyclic aromatic hydrocarbons have been implicated in a wide range of human health effects and disease problems in aquatic organisms (Grimmer 1983; Plesha et al. 1988).

Nutrients and sediments

Nutrients and sediments are exported to the marine environment in wind-blown dust and in water and sediments contained in overland flows and river discharges. Soil erosion and loss of nutrients is generally elevated from agricultural lands. Almost all of the catchments draining into Great Barrier Reef waters are used for agricultural purposes and have been extensively modified since European settlement (*The condition of river catchments in Queensland: a broad overview of catchment management issues* 1993). It is estimated that sediment loads discharged to the Great Barrier Reef region are now two to five times higher than loads discharged prior to settlement. As a consequence, total nutrient input into the Great Barrier Reef is estimated to have risen by about 30 per cent in the last 140 years (Moss et al. 1992; Furnas et al. 1994; Brodie 1995; Furnas and Brodie 1996; Neil and Yu 1996). A majority of land sourced sediments and nutrients are transported to reef waters during flood events (Brodie and Mitchell 1992; Brodie et al. 1996).

The modern increase in nutrient and sediment load discharge into reef waters has created a potential long-term threat to seagrasses (Preen et al. 1995; Short et al. 1996). Increased turbidity from discharged sediments may result in a shade induced reduction in seagrass photosynthesis (Shepherd et al. 1989; Walker and McComb 1992; Abal and Dennison 1996) or in extreme conditions, result in smothering of plants (Walker and McComb 1992). Increased nutrient concentrations also have the potential to cause epiphyte growth on seagrasses which reduces seagrass photosynthetic rates (Walker and McComb 1992). High nutrient concentrations may also weaken the structural integrity of seagrasses (Burkholder et al. 1992).

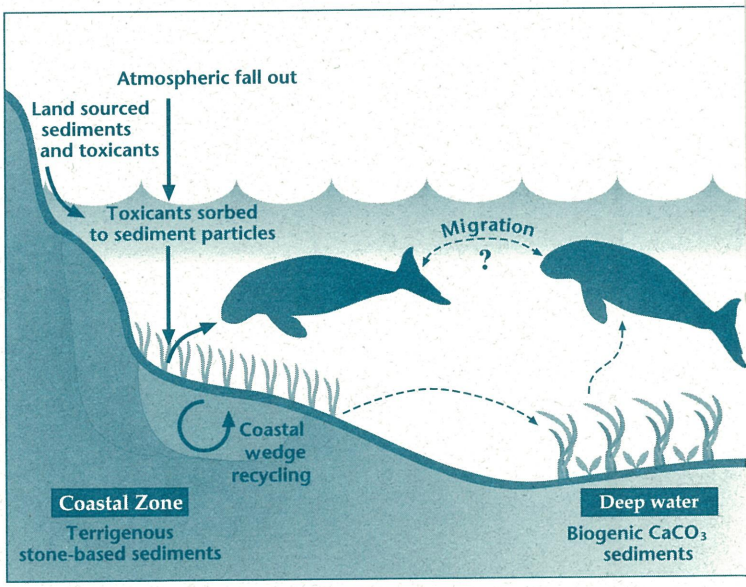


Figure 2. Pollutant transfer through the dugong food chain

Great Barrier Reef water quality research and monitoring

Water quality monitoring associated with DPAs and dugong management and conservation is based around measurement of the transfer of pollutants from the land to the nearshore marine environment and their subsequent incorporation into the dugong/seagrass food chain (figure 2). This water quality monitoring program can be divided into five broad areas of research.

a. Marine Park pollutant concentrations

In 1997, sediment and seagrass samples were collected from the intertidal zone of 15 sites between Torres Strait and Moreton Bay (figure 3). These sampling sites are under a range of urban and agricultural influences and include many of the DPAs and other critical dugong habitat. Collected sediments and seagrasses have been analysed for the presence of heavy metals, PCBs, pesticides, herbicides and polycyclic aromatic hydrocarbons (PAHs). Samples of sediments and seagrasses from selected sites have also been analysed for polychlorinated-*p*-dioxins and polychlorinated dibenzofurans (PCDD/Fs). Additional sampling of sediments from river mouths and sites further offshore will be carried out during May 1998. Atrazine and diuron (herbicides), PCBs, PAHs and PCDD/Fs have all been detected in sampled sediments and seagrasses. Detailed analysis of the data will be used to establish pollutant concentration baselines in DPAs and elsewhere, and correlations for environmental pollutant concentrations and human activity will be derived. The data will also be used to develop pollutant-partitioning models to investigate the movement of pollutants between sediments, seagrass and biota (including dugong).

b. Dugong pollutant concentrations

Tissue samples are being collected opportunistically from dugong reported stranded along the Queensland coast. Carcass recovery is being carried out in conjunction with the Department of Environment (DoE), James Cook University and the Department of Primary Industries (Queensland Boating and Fisheries Patrol). Three dugong carcasses recovered from Magnetic Island, Bowen and Mackay in late 1996 have been sampled in a pilot study. All animals were drowned or suspected to have been drowned in fishing nets. Arsenic, chromium and nickel were found to be elevated in collected tissue. Total dioxin concentrations were also elevated and dioxins were found in an unusual congener pattern compared with other marine mammals (Haynes et al. 1998). Pollutant data will continue to be collected from further animals stranded along the Queensland coast. As this occurs analyses will allow temporal and spatial variation in dugong pollutant body burdens to be examined and correlated with animal sex, age, condition and home range.

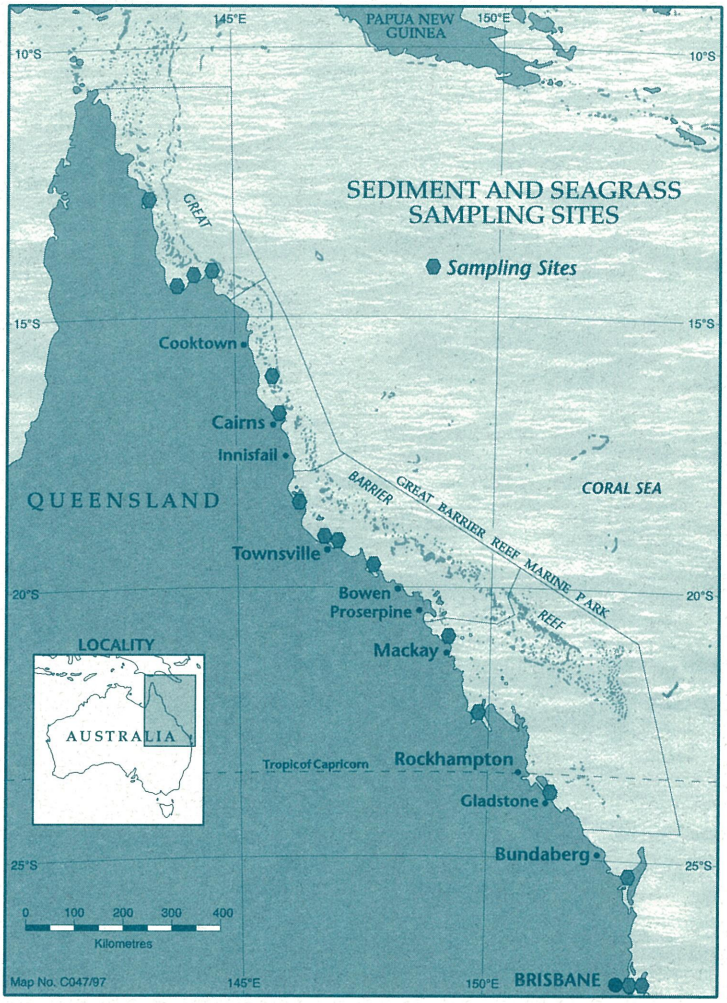


Figure 3. Intertidal sediment and seagrass sampling sites, 1997

c. Seagrass herbicide impacts

Contamination of nearshore environments by pollutants may be an additional stress on seagrass meadows and their potential role in seagrass decline in Queensland water is essentially unknown (Walker and McComb 1992; Ralph 1998). The herbicides atrazine and diuron are used extensively by the agricultural industry in Queensland (Hamilton and Haydon 1996). They are highly water-soluble and have relatively long environmental half-lives. Preliminary investigations of the toxicity of atrazine and diuron to *Halophila ovalis* have been completed (Ralph 1997, 1998). This study determined that short-term herbicide exposure resulted in reduced photosynthesis and leaf loss in this seagrass species. Toxicity trials will be continued, with the toxicity of diuron to additional species of seagrasses (*Halodule* sp., *Zostera* sp. and *Cymodocea* sp.) assessed in 1998. The exposure concentrations of the herbicide will be based on existing literature and Great Barrier Reef Marine Park Authority survey data. This information will then be combined with catchment monitoring data of herbicide concentrations to assess potential risk to seagrass meadows from current and predicted agricultural herbicide applications.

d. Chlorophyll *a* monitoring

Dissolved nutrients have a relatively short life span in reef waters as they are actively acquired by phytoplankton and benthic plants. As a consequence, chlorophyll concentration acts as a sensitive, direct integrator of phytoplankton biomass and hence, nutrient status of sampled water masses (Bell and Elmetri 1995; Brodie et al. 1996). The key objectives of the chlorophyll monitoring program are the detection and quantification of long-term trends and regional differences in the nutrient status of Great Barrier Reef waters (Brodie et al. 1996). Forty-eight stations situated along nine inshore-offshore transects are currently sampled monthly in the monitoring program (Haynes et al. 1997). The time-scale over which the monitoring program has been carried out (1992–1998) is, as yet, too short to determine whether there is evidence of eutrophication in Great Barrier Reef waters. However, data collected has confirmed that chlorophyll concentrations (and therefore nutrient concentrations) recorded from nearshore waters are significantly higher and more variable than samples collected further from the coast (Haynes et al. 1997). This chlorophyll monitoring program is complemented by a second program which collects quantitative information on the composition and spatial dynamics of flood plumes discharging to Great Barrier Reef waters. The flood monitoring program was initiated to map the distribution of phaeopigments, dissolved and particulate nutrients, suspended solids and herbicides as they are transported offshore into reef waters in river flood plumes (Devlin et al. 1997a, b).

e. Dugong habitat risk assessment

Environmental and predictive data collected during the dugong water quality monitoring program will be combined with other information to carry out a risk assessment for dugong habitat and stocks within Queensland waters. Partitioning models will be used to develop pollutant mass balances for Marine Park waters. An assessment of the health risks from consumption of contaminated dugong tissue will also be made.

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References

Abal, E.G. and Dennison, W.C. 1996, Seagrass depth, range and water quality in southern Moreton Bay, Queensland, Australia, *Marine and Freshwater Research* 47: 763–771.

Bell, P.R.F. and Elmetri, I. 1995, Ecological indicators of large scale eutrophication in the Great Barrier Reef lagoon, *Ambio* 24: 208–215.

Benlahcen, K.T., Chaoui, A., Budzinski, H., Bellocq, J. and Garrigues, P.H. 1997, Distribution and sources of polycyclic aromatic hydrocarbons in some Mediterranean coastal sediments, *Marine Pollution Bulletin* 34: 298–305.

Boon, J. P., van Arnhem, E., Jansen, S., Kannan, N., Petrick, G., Schulz, D., Duinker, J.C., Reijnders, P.J.H. and Goksoyr, A. 1992, The toxicokinetics of PCBs in marine mammals with special reference to possible interactions of individual congeners with the cytochrome P450-dependent monooxygenase system: an overview, pp. 119–60, in *Persistent Pollutants in Marine Ecosystems*, eds C.H. Walker and D.R. Livingstone, Pergamon Press, Oxford.

Brodie, J. 1995, *Nutrients and the Great Barrier Reef*, Australian State of the Environment Report, Department of Environment, Sport and Territories, Canberra, pp. 1–29.

Brodie, J. and Mitchell, A.W. 1992, Nutrient composition of the January 1991 Fitzroy River flood plume, in *Workshop on the Impacts of Flooding*, ed. G.T. Byron, Workshop Series No. 17, Great Barrier Reef Marine Park Authority, Townsville.

Brodie, J.E., Furnas, M.J., Steven, A.D.L., Trott, L.A., Pantus, F. and Wright, M. 1996, Monitoring chlorophyll in the Great Barrier Reef lagoon: trends and variability, *Proceedings of the 8th International Coral Reef Symposium, June 1996, Panama.*

Broman, D., Naf, C., Lundbergh, I. and Zebuhr, Y. 1990, An in situ study on the distribution, biotransformation and flux of polycyclic aromatic hydrocarbons (PAHs) in an aquatic food chain (*seston-Mytilus edulis L.-Somateria mollissima L.*) from the Baltic: an ecotoxicological perspective, *Environmental Toxicology and Chemistry* 9: 429–442.

Bryan, G.W. 1971, The effects of heavy metals (other than mercury) on marine and estuarine organisms, *Proceedings of the Ecological Society of London* (B) 177: 389–410.

Burkholder, J. M., Mason, K.M. and Glagow, H.B. 1992, Water column nitrate enrichment promotes decline of eelgrass *Zoster marine*: evidence from seasonal mesocosm experiments, *Marine Ecology Progress Series* 81: 163–178.

Chester, R. and Murphy, K.J.T. 1990, Metals in the marine atmosphere, pp. 27–50, in *Heavy Metals in the Marine Environment*, eds R.W. Furness and P.S. Rainbow, CRC Press Inc., Boca Raton, Florida.

Clark, R.B. 1992, *Marine Pollution*. Claredon Press, Oxford.

Clendening, L.D., Jury, W.A. and Ernst, F.F. 1990, A field mass balance study of pesticide volatilization, leaching and persistence, pp. 47–60, in *Long Range Transport of Pesticides*, ed. D.A. Kurtz, Lewis Publishers Inc., Michigan, USA.

Connell, D.W. 1995, Occurrence and effects of petroleum hydrocarbons in Australia's marine environment, pp. 47–52, in *Australian State of the Environment Report*, Department of Environment, Sport and Territories, Canberra.

Devlin, M., Haynes, D. and Brodie, J. 1997a, History of a flood plume sampling program on the Great Barrier Reef lagoon, *Proceedings of a workshop on sampling nutrients in aquatic ecosystems*, University of Canberra, April 1997.

Devlin, M., Haynes, D. and Brodie, J. 1997b, Cyclone Justin (March 1997) flood plume sampling: preliminary results, *Proceedings of the 75th Australian Coral Reef Society Conference*, October 1997, Heron Island.

Dioxins in the environment: report of an interdepartmental working group on polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), 1989, Pollution Paper No. 27, HMSO, London.

Förstner, U. 1989, *Contaminated sediments*, Springer-Verlag, Berlin.

Fowler, S.W. 1990, Critical review of selected heavy metal and chlorinated hydrocarbon concentrations in the marine environment, *Marine Environmental Research* 29: 1–64.

Furnas, M., Mitchell, A.W. and Skuza, M. 1994, *Nitrogen and Phosphorus Budgets for the Central Great Barrier Reef Shelf*, Research Publication No. 36, Great Barrier Reef Marine Park Authority, Townsville.

Furnas, M. and Brodie, J. 1996, Current status of nutrient levels and other water quality parameters in the Great Barrier Reef, pp. 9–22, in *Downstream Effects of Land Use*, eds H.M. Hunter, A.G. Eyles and G.E. Rayment, Department of Natural Resources, Brisbane.

Great Barrier Reef Marine Park Authority 1994, *Turtle and Dugong Conservation Strategy for the Great Barrier Reef Marine Park*, Great Barrier Reef Marine Park Authority, Townsville.

Grimmer, G. 1983, *Environmental Carcinogens: Polycyclic Aromatic Hydrocarbons*, CRC Press, Boca Raton, Florida.

Haynes, D., Brodie, J. and Devlin, M. 1997, Long-term monitoring of chlorophyll concentrations, Great Barrier Reef World Heritage Area, *Proceedings of a workshop on sampling nutrients in aquatic ecosystems*, University of Canberra, April 1997.

Haynes, D., Muller, J. and McLachlan, M.S., Polychloronated-p-dioxins and dibenzofurans in Great Barrier Reef (Australia) dugongs (*Dugong dugon*), (in review, *Chemosphere*).

Hamilton, D. and Haydon, G. 1996, *Pesticides and Fertilisers in the Queensland Sugar Industry – Estimates of Usage and Likely Environmental Fate*, Department of Primary Industries, Queensland.

IUCN 1990, *IUCN Red List of Threatened Animals*, International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland.

Langston, W.J. 1990, Toxic effects of metals and incidence of metal pollution in marine ecosystems, pp. 101–22, in *Heavy Metals in the Marine Environment*, eds R.W. Furness and P.S. Rainbow, CRC Press, Boca Raton, Florida.

Marsh, H. 1992, *Biological Basis for Managing Dugongs and Other Large Vertebrates in the Great Barrier Reef Marine Park*, Research Publication No. 21, Great Barrier Reef Marine Park Authority, Townsville.

Marsh, H., and Corkeron, P. 1997, The status of the dugong in the Great Barrier Reef Marine Park, pp. 231–247, in *State of the Great Barrier Reef World Heritage Area Workshop, November 1995*, eds D. Wachenfeld, J. Oliver and K. Davis, Great Barrier Reef Marine Park Authority, Townsville.

Marsh, H., Corkeron, P., Lawler, I.R., Lanyon, J.M. and Preen, A.R. 1995, *The status of the dugong in the southern Great Barrier Reef Marine Park*, Report to GBRMPA, Department of Tropical and Environmental Studies and Geography, James Cook University, Townsville.

Moss, A.J., Rayment, G.E., Reilly, N. and Best, E.K. 1992, *A Preliminary Assessment of Sediment and Nutrient Exports from Queensland Coastal Catchments*, Technical Report No. 4, Queensland Department of Environment, Brisbane.

Müller, J.F., Sutton, M., Wermuth, U.D., McLachlan, M.S., Will, S., Hawker, D.W. and Connell, D.W. 1996a, Burning sugar cane – a potential source for PAHs and PCDD/Fs, *Intersect 96*.

Müller, J. F., Sutton, M. Wermuth, U.D., McLachlan, M.S., Will, S., Hawker, D.W. and Connell, D.W. 1996b, Polychlorinated dibenzodioxins and polychlorinated dibenzofurans in topsoils from northern Queensland, with a history of different trash management practices, pp. 273–274, in *Sugarcane: Research Towards Efficient and Sustainable Production*, eds J.R. Wilson, D.M. Hogarth, J.A. Cambell and A.L. Garside, CSIRO Division of Tropical Crops and Pastures, Brisbane.

Neil, D.T. and Yu, B. 1996, Fluvial sediment yield to the Great Barrier Reef lagoon: spatial patterns and effect of land use, pp. 281–286, in *Downstream Effects of Land Use*, eds H.M. Hunter, A.G. Eyles and G.E. Rayment, Department of Natural Resources, Brisbane.

Olsen, C.R., Cutshall, N.H. and Larsen, I.L. 1982, Pollutant-particle associations and dynamics in coastal marine environments: a review, *Marine Chemistry* 11: 501–33.

Plesha, P.D., Stein, J.E., Schiewe, M.H., McCain, B.B. and Varanasi, U. 1988, Toxicity of marine sediments supplemented with mixtures of selected chlorinated and aromatic hydrocarbons to the infaunal amphipod *Rhepoxynius abronius*, *Marine Environmental Research* 25: 85–97.

Preen, A.R., Lee Long, W.J. and Coles, R.G. 1995, Flood and cyclone related loss, and partial recovery, of more than 1000 km^2 of seagrass in Hervey Bay, Queensland, Australia, *Aquatic Botany* 52: 3–17.

Rainbow, P.S. 1990, Heavy metals in marine invertebrates, pp. 67–80, in *Heavy Metals in the Marine Environment*, eds R.W. Furness and P.S. Rainbow, CRC Press, Boca Raton, Florida.

Ralph, P. 1997, *Stress physiology of* Halophila ovalis *(R.Br) Hook. f. using chlorophyll fluorescence*, Unpublished Ph.D. thesis, University of Technology, Sydney.

Ralph, P., Impact of herbicides on the photosynthesis of *Halophila ovalis*, using chlorophyll *a* fluorescence, (in review, *Marine and Freshwater Research*).

Richardson, B.J. 1995, The problem of chlorinated compounds in Australia's marine environment, pp. 53–61, in *The State of the Marine Environment Report for Australia, Technical Annex: 2*, eds L.P. Zann and D.C. Sutton, Great Barrier Reef Marine Park Authority, Townsville, Australia.

Safe, S. and Hutzinger, O. 1989, PCDDs and PCDFs: sources and environmental impact, pp. 1–20, in *Polychlorinated dibenzo-p-dioxins and -furans (PCDDs/PCDFs): Sources and environmental impact, epidemiology, mechanisms of action, health risks*, eds S. Safe, O. Hutzinger and T.A. Hill, Springer-Verlag, Berlin.

Shepherd, S., McComb, A.J., Bulthuis, D.A., Neverauskas, V., Steffensen, D.A. and West, R. 1989, Decline of seagrass, pp. 346–393, in *Biology of Seagrasses: A Treatise on the Biology of Seagrasses with Special Reference to the Australian Region*, eds A.W.D. Larkum, A.J. McComb and S. Shepherd, Elsevier, Amsterdam.

Short, F.T., Burdick, D.M., Granger, S. and Nixon, S.W. 1996, Long-term decline in eelgrass, *Zostera marina L.*, linked to increased housing development, pp. 291–298, in *Seagrass Biology: Proceedings of an international workshop.*

Tatsukawa, Ryo, Yukihiko Yamaguchi, Masahide Kawano, Narayanan Kannan and Shinsuke Tanabe 1990, Global monitoring of organochlorine insecticides – an 11-year case study (1975–1985) of HCHs and DDTs in the open ocean atmosphere and hydrosphere, pp. 127–141, in *Long Range Transport of Pesticides*, ed. D.A. Kurtz, Lewis Publishers Inc., Michigan, USA.

The condition of river catchments in Queensland: a broad overview of catchment management issues, 1993, Department of Primary Industries, Brisbane.

Walker, D. I. and McComb, A.J. 1992, Seagrass degradation in Australian coastal waters, *Marine Pollution Bulletin* 25: 191–95.

REEF MANAGEMENT NEWS

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Indigenous Initiatives in Marine Park Management

Indigenous peoples have a long association with coastal and marine environments and their management of these areas has always been inherent in cultural practices.

Over the years the Great Barrier Reef Marine Park Authority (GBRMPA) has directly attempted to involve Indigenous peoples in the formal management of the Great Barrier Reef World Heritage Area.

An Indigenous Cultural Liaison Unit was established in 1995 out of the need for the Authority to develop a more effective means to identify the interests and needs of Indigenous peoples.

Issues addressed by the unit include the recognition of cultural heritage values, hunting in the Marine Park, information sharing, cooperative management, protocols, cultural advice, and liaison.

Manager of the Unit Ross Williams said one of the goals is to provide timely and accurate information in regard to Indigenous issues in the Great Barrier Reef World Heritage Area.

'As a service provider we aim to open communication and achieve transparent management practices,' he said.

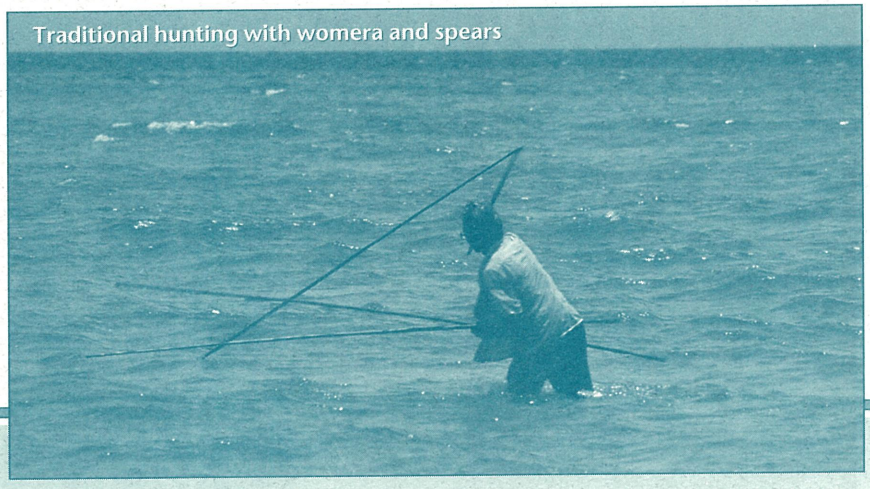
Aboriginal and Torres Strait Islander peoples have thousands of years of experience and knowledge of marine and coastal areas passed on to them that would benefit the formal management and use of the World Heritage Area and Marine Park.

'Empowering Indigenous peoples through involvement in all tiers of management will help develop effective and acceptable solutions for key Indigenous issues and is crucial for effective management of the Marine Park,' Mr Williams said.

'The starting point for this involvement is at the grass roots level. Community management gives recognition to communities, reinforces self-determination and provides benefits for all.

'These benefits include effective management of resources, such as the control and monitoring of sustainable hunting practices, and environmental protection.

'Protection of the environment can be legislated but it comes down to grass



Traditional hunting with womera and spears

roots level management, and community control, responsibility and initiative.'

Although resources are limited, the Authority through the cultural liaison unit supports Indigenous community initiatives, rather than instigates them, and assists with small based initiatives such as information sharing, and resource support.

A good example of a community initiative is that shown by the Kuku Yalanji people of Mossman. This Aboriginal group is taking responsibility and exercising their rights in areas of traditional affiliation.

An effective management initiative was the formation, by the Kuku Yalanji, of a Marine Resource Committee which is made up of, and represents, the traditional inhabitants that occupy the Mossman coastal hinterland.

The primary purpose of the committee is to regulate hunting permits, administered by the Queensland Department of Environment (DoE) and GBRMPA, issued for turtle and dugong hunting within the Mossman area.

This process enables the community to assess permit applications and monitor hunting practices in accordance with criteria that serves to invest control in the hands of the Kuku Yalanji.

The committee also stated strongly that no permits for the hunting of dugong be approved in their traditional area because of the declining numbers of dugong in areas of the Great Barrier Reef.

Not only does the committee regulate which, if, when, and where people can hunt, it also has had a major influence in deterring illegal hunting and also functions as an educator of communities both Indigenous and non-Indigenous.

Education is another issue that staff of the Indigenous Cultural Liaison Unit take seriously due to the complex and broad scope of views inherent with multi-use of the Great Barrier Reef.

The staff not only work with Indigenous groups but work closely with other government authorities, the tourism industry, fishing industry and conservation groups in order to build a greater understanding amongst all users.

'Getting Indigenous groups involved in all user-group management issues, for example tourism, coast care programs, permitting and the like allows for foundation building,' Mr Williams said.

'This allows for the development of management structures or models that involve all concerned so that effective and mutually acceptable practices can be put in place.'

Aboriginal and Torres Strait Islander peoples have become more involved and visible in the planning and management of the Great Barrier Reef due to their pro-active approach and the efforts of the Authority's Indigenous Cultural Liaison Unit.

Full participation by Indigenous groups in formal management models will be a complex long-term process. Yet, achievement of that goal will ensure Indigenous peoples of the Great Barrier Reef coastal regions will continue a long tradition of caring for country. ■

Public Support nets illegal Reef Operators

The vastness of the Great Barrier Reef and the accuracy of the on-the-spot details required for prosecution often make it hard for Reef patrols to catch illegal fishers and for courts to convict them.

With the aid of the public, however, the Great Barrier Reef Marine Park Authority had a successful record of 77 prosecutions in the 1996–97 financial year, with only three unsuccessful cases.

Darin Honchin Legal Services Unit Project Officer for the Authority said the result is a good one and he paid tribute to the public role that helps achieve such positive results.

'The Authority has an exceptional record and one it can stand by and many of the successes are the result of public reports,' he said.

Yet, the legal system often makes it hard to prosecute a case without accurate and verified information and cases can be lost on technicalities. For example, if a tourist operator is seen within a 'no fishing' zone part of the evidence needed would be to prove that the operator has or has not informed their clients that it was illegal to fish in the area.

Under a tourist operators permit, operators must tell their respective clientele of all restrictions and conditions to be adhered to in accordance with the zoning plans.

'It's not only the obligation of operators but that of every boat persons to obtain zoning information and inform all guests on board of the zones and what they mean,' Mr Honchin said.

'Whilst all reports of possible illegal activities are welcome the public should appreciate that late reports have a much reduced value due to the difficulty in gathering direct evidence.

'It's really important for inspectors to speak to everyone involved in an incident as soon as possible.'

In order to create the complete picture the Authority recommends that people record details and immediately notify the Department of Environment, or other relevant agencies if they cannot be contacted.

'Evidence is like a jigsaw puzzle. You generally need all the pieces to form the picture. Sometimes a few pieces can be missing and you can still determine the picture, but it depends on who's looking at the picture as to what they see,' Mr Honchin said.

Details that are important to record are the vessel's registration number and description, location, time, weather, number of people, what they are wearing and the activities carried out. If possible take a photo or video footage of the incident.

Mr Greg Smith, Manager of Day-to-Day Management for the Authority, said public support was much needed and appreciated.

'Patrols are limited so it is extremely important for the public to be involved. Accurate, detailed and immediate information provided by the public helps us win cases and carry out effective enforcement to protect the Reef for all to enjoy, now and in the future,' he said.
'We do caution that people take care and do not associate with people they think may be committing an offence.

'If an offence occurs contact the Queensland Department of Environment (DoE), Queensland Boating and Fisheries Patrol (QB&FP), Water Police or the Authority on call-up channel 16 VHF or phone the nearest office.'

The nearest DoE office should be contacted first, however, the QB&FP can be contacted on the free Fish Watch Hotline (1800 017 116).

Zoning plans can be obtained from the Great Barrier Reef Marine Park Authority, Department of Environment and Queensland Boating and Fisheries Patrol offices and some tackle shops, service stations and newsagents. ■

Plumes hold answers
Flood researchers follow run-off

With the recent large-scale rainfall and flooding caused by cyclones Sid and Katrina from Townsville to Cairns, plumes of floodwater spread their brown cocktail of nutrients, sediments and pollutants out into coastal waters.

The effects of this terrestrial freshwater run-off on inshore coral reefs and other near-shore communities is still only poorly understood so the Great Barrier Reef Marine Park Authority, in conjunction with other agencies, has formed a multi-institutional research team to investigate possible impacts.

Authority research team scientist Michelle Devlin indicates the floodwater concoctions originate in the hinterland, however, the relationship between water quality on the Great Barrier Reef and impact of land use in the hinterland is still a subject of debate.

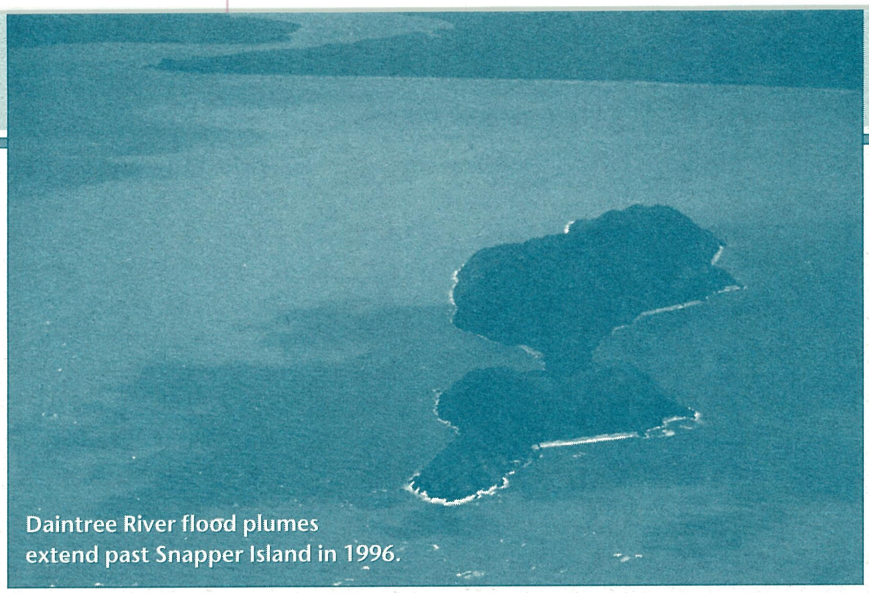
'Future research work will include further quantification of the water quality processes occurring in flood plumes and determination of relationships between the composition of the flood plumes and any impact on inshore reefs,' Ms Devlin said.

'Eventually it may be possible to link land use and catchment characteristics with the composition of the plume, and to estimate the short- and long-term effects of flood waters impinging on reef biota.'

Scientists from the Authority conducted aerial surveys several days after the peak of the Townsville floods to photograph and determine the extent and distance offshore that the floodwaters penetrated into the Marine Park.

The brown sediment plumes, distinctive from the clear blue waters, extended several kilometres out from the coast line in the Burdekin, Townsville and Cairns regions and covered inshore reef systems but did not extend to the outer reef.

David Haynes Water Quality



Daintree River flood plumes extend past Snapper Island in 1996.

Coordinator at the Authority, said that corals are particularly vulnerable when exposed to prolonged periods of fresh water and suspended sediments. Therefore, any such event may result in stress or possible death.

'Terrestrial fresh water run-off is not a new occurrence and inshore reefs have often been subject to short-term exposure to fresh water. However, prolonged and singularly massive flood events like this one can cause problems,' Mr Haynes said.

'The added dilemma is the increased sediment, nutrient and pollution problems associated with increased development of coastal areas.

'We have already initiated coral monitoring around Franklin Islands, near Cairns but it will be a while before an estimate of the impacts can be reasonably assessed.'

Although impacts from the floodwaters associated with cyclones Sid and Katrina have yet to be fully appraised, Chairperson of the Authority Dr Ian McPhail said the information gained from the surveys and ongoing research will afford a valuable contribution to furthering an understanding of the dynamics of the Reef's biology.

'This one in a hundred year event provides an opportunity to collect important information that will give scientists and Marine Park managers a more comprehensive understanding of the possible effects of terrestrial run-off on the corals and reef life,' Dr McPhail said.

'This information can be added to the database of results from other studies done on previous cyclones and associated flood waters and their effects on the Great Barrier Reef.'

To date, six Great Barrier Reef cyclones and their associated flood waters have been mapped and studied by the Authority and other agencies between 1991 and January 1998.

The effects of flood plumes vary due to factors such as duration of rainfall, wind direction and strength and land-use activities. Hence, it is important to build a database that contains records of individual flood events and their various impacts.

In 1994, floodwaters caused by cyclone Sadie impacted on coral communities at Pandora Reef. Bleaching occurred due to changes in environmental conditions such as temperature, light, nutrient and salinity levels.

The corals become white in appearance because of the stressful environmental conditions that cause them to expel endo-symbiotic micro-algae (zooxanthellae) and associated photosynthetic pigments.

Overall, recovery was rapid and there was little effect on total coral cover by April 1994 (2 months after the event).

Yet, for individual colonies and populations of several taxa, there was substantial injury and death from sediment smothering and increased turf algae due to high nutrients.

Water sampling of five northern river plumes was carried out during cyclone Violet in 1995. Analyses of the samples demonstrated that concentrations of dissolved nutrients, suspended sediments and chlorophyll were several magnitudes greater than concentrations prior to flood events.

They also demonstrated some interesting differences in nutrient and sediment concentrations, which are likely to be the result of a combination of weather and catchment differences along the coast.

Another study was conducted over a 12-month period after floodwaters, resulting from a rain depression caused by cyclone Ethel in March 1996, extended from the Daintree River to north of Snapper Island.

The south face of Snapper Island was inundated by the plume but the north face still had a large patch of clean water. Results 10 months after the event showed there had been a marked reduction in hard coral cover on the upper reef slope of the entire south face.

Total hard coral cover decreased by 85 per cent on the south face, with turf algae covering some of the dead coral. However, on the north side of the Island coral cover had only decreased by about 20 per cent.

Although studies already conducted indicate there are negative impacts on reef communities as a result of flood plumes further research and collaborative support is needed to establish the relationship between land-based development and water quality in the Great Barrier Reef. ■

Dugongs get a break
Sanctuaries now in place

A world-first rescue strategy aimed at addressing the alarming decline in dugong numbers along Australia's east coast has been introduced through a chain of sanctuaries.

The Great Barrier Reef Ministerial Council formally introduced the strategy on 12 January 1998 when changes to commercial mesh netting practices in dugong sanctuaries became law.

Chaired by Federal Environment Minister Robert Hill, the Council decided in August 1997 to create 16 dugong sanctuaries after scientific evidence and independent analysis found that dugongs are in serious decline south of Cooktown.

'Dugong are recognised as one of the values for which the Great Barrier Reef was World Heritage listed and Australia therefore has an international responsibility to protect dugong,' Senator Hill said.

Australia is believed to have the largest population left in the world but recent surveys indicate there has been a rapid decline in numbers. Some conservationists have pushed to have the dugong listed under Commonwealth legislation.

Dugongs are classified as vulnerable internationally and under Queensland legislation but are not listed under the Commonwealth Endangered Species Act.

Recently a nomination was put forward to the Commonwealth Government by a conservation group to list the dugong as a 'species that are endangered' or if those requirements were not met to list the dugong as 'vulnerable'.

The nomination was unsuccessful due to a conclusion by a scientific advisory committee that the population as a whole in Australia is stable and a population reduction of more than 20 per cent over 90 years (period of three generations) can not be demonstrated by the available data.

While dugong populations in other areas of Australia appear stable, in the southern half of the Great Barrier Reef and Hervey Bay regions dugong numbers have declined by more than 50 per cent over the last eight years.

Research conducted by leading dugong scientists indicated that in order to maintain sustainable populations no more than 3.3 dugongs per year can be killed in the southern Great Barrier Reef and 1.6 in Hervey Bay.

Carcass reports during 1997 indicate that human-related deaths continued at unsustainable levels with 21 recorded deaths in the southern Great Barrier Reef and six recorded deaths in Hervey Bay.

The causes of the deaths and dramatic decline are not certain in some cases but acknowledged threats include mesh netting, Indigenous hunting, shark nets, loss of seagrass, vessel collision, pollution, and explosions for purposes such as Defence training or marina construction.

Because the dugong is a long-lived and slow-breeding species, characteristics that put it at particular danger of becoming extinct, it was apparent an urgent strategy was needed to counteract these detrimental impacts.

The 'A' and 'B' sanctuaries (or dugong protection areas) that have been created are spread over approximately 1100 kilometres of the Queensland coast line, from Hinchinbrook Island to Hervey Bay (see map page 10).

Zone 'A' sanctuaries include high priority significant dugong habitats and have the more stringent fishing measures put in place while Zone 'B' are additional protection areas with fewer fishing restrictions. Both areas will be monitored to ensure effective protection of dugongs.

Mesh netting practices are one of the greatest direct threats to dugong survival and the Authority along with the Queensland Commercial Fishermen's Organisation, Queensland Fisheries Management

Dugong mother and calf

Authority and Department of Primary Industry, are working together to ensure future fishing practices reduce dugong mortality.

The use of offshore set, foreshore set and drift nets has been prohibited in zone 'A' sanctuaries. River set nets are allowed with modifications except in the Hinchinbrook Island region and Shoalwater Bay.

All mesh nets, except cast nets to catch bait, are banned in Shoalwater Bay while mesh netting practices are permitted in Zone 'B' sanctuaries but with restrictions such as compulsory net attendance.

Under Queensland Fisheries Regulations other netting practices such as ring, seine, tunnel and set pocket netting which are not considered to pose a serious threat to dugongs will be permitted in designated areas.

Executive Director of the Authority John Tanzer has assured the commercial fishing industry that the changes only effect the use of set and drift nets. A considerable amount of money has been injected to facilitate the removal of nets and a licence buy-back scheme.

'A great deal of negotiation has taken place to ensure mesh net fishers are adequately compensated and understand the seriousness of the dugong decline,' Mr Tanzer said.

'For further details on the new regulations fishers should obtain a copy of the amended Regulations from their local Queensland Boating and Fisheries Patrol office or the Queensland Fisheries Management Authority. Heavy penalties will be enforced if regulations are not followed.'

Concerns were raised by conservation groups who believe that mesh netting should have been banned in all the sanctuaries because of the serious nature of the decline in dugong numbers.

Tony Stokes Acting Manager of the Authority's Threatened Species Unit said modified netting practices that were not judged to be a significant threat to dugongs had been allowed to continue.

'The creation of the sanctuaries and their associated regulations was based upon the best available scientific evidence,' Mr Stokes said.

'Every effort has been made to ensure the protection of dugong in the southern Great Barrier Reef.

'The Authority, scientists and the fishing industry have worked closely with the State and Commonwealth governments to develop and implement an effective and responsible strategy.'

Although public concern has been expressed in regard to trawlers – which have not been restricted in the process – John Robertson Coordinator of the Effects of Fishing Program at the Authority believes trawlers are not a direct threat to dugong.

'Dugongs are not susceptible to being caught in trawl nets because the noise made by trawlers appears to warn the dugong off and if they are close to the nets they could out-swim the very slow-moving trawlers,' Mr Robertson said.

Under current marine park zoning in the southern Great Barrier Reef trawling is not permitted over substantial seagrass meadows. However, there are some small sparse areas of seagrass habitat that may not have been covered in current zoning.

'Trawlers generally avoid dense inshore seagrass meadows because the seagrasses clog up their nets and they would catch small prawns. Therefore, it would be a hindrance to their operation and detrimental to a sustainable prawn industry,' Mr Robertson said.

'However, there is insufficient scientific knowledge available to assess the true impact trawlers may have on sparse or deep-water seagrass meadows.'

The fishing industry has been subject to many restrictions on its activities and duly compensated. However, it is not the only group to have restrictions imposed. Indigenous hunting will not be permitted south of Cooktown.

A number of Indigenous groups in the southern Great Barrier Reef have recognised that they too may have contributed to the decline in dugong and have actively pursued community-based self-imposed moratoria on hunting until the dugong populations recover to sustainable levels.

Some Indigenous groups in conjunction with management agencies are developing community-based management plans for hunting in their regions. The plans should be supported by the agreed cooperative management arrangements, said the Authority's Manager for the Indigenous Cultural Liaison Unit, Ross Williams.

'For Indigenous peoples the decline of dugong is more than an impact on a food source. There are serious implications for the species as well as for Indigenous peoples through the loss of the cultural, social and spiritual association with the dugong,' Mr Williams said.

Although the decline in dugong is of major concern for Indigenous peoples, the other concern is for

greater recognition and/or negotiations in relation to their loss of social, cultural and economic lifestyle and well-being imposed by the restrictions.

Other impacts on dugong such as shark nets, vessel collision, explosions for purposes such as Defence training, and land-use practices are also being addressed.

A review is under way for the possible replacement of shark nets with baited drum lines. Proposals are also being considered to restrict vessel and aircraft activity, particularly in the Hinchinbrook region, and to prohibit the use of explosives in dugong sanctuaries.

Further research is needed to provide scientific information on the effects of land-use practices and coastal development on dugong populations and seagrass beds.

Most scientists agree that more research needs to be conducted in all areas of possible threat to dugongs but are confident that sanctuaries will have a positive effect. Nevertheless, turning around the dugong decline in the southern Great Barrier Reef is yet to be seen.

Information kits and brochures regarding dugongs and the sanctuaries can be obtained from the Great Barrier Reef Marine Park Authority.

Penalties for illegal take of dugong in the Marine Park will be up to $22 000 for individuals or $110 000 for a company or corporation. Illegal meshing netting in the sanctuaries can incur a maximum penalty of $75 000 and loss of nets and on conviction a loss of licence. ■

How inappropriate to call this planet Earth, when clearly it is Ocean.
Arthur. C. Clarke

Dive In – It's the International Year of the Ocean

In recognition of the importance and relevance of the world's ocean in our lives, the United Nations has declared 1998 as 'International Year of the Ocean'.

Australia, the world's largest island, with vast oceans lapping its shores, together with the internationally famous marine icon, the Great Barrier Reef, is set to play its part in a global effort to turn back the tide of degradation.

The interconnected world ocean covers 71 per cent of the planet and Australia, along with its external territories, is surrounded by three large oceans of the Southern Hemisphere – the Pacific, Indian and Southern Oceans.

Executive Director of the Great Barrier Reef Marine Park Authority Richard Kenchington believes that there are many challenges and opportunities offered by the ocean as we enter the 21st century.

'The ocean affects our climate and harbours over 4000 fish species of which many, if used sustainably, can be a continuing major food source for the world. Other marine species largely unexplored could hold the key to new medicines,' Mr Kenchington said.

'Barrier Reef research has just started to reveal secrets that will aid in the advancement of our knowledge and help us better manage marine environments.'

Among the many initiatives that Australia will undertake during the International Year of the Ocean are programs to reduce sewage and stormwater pollution, protection of threatened marine life, improvement of oil spill control programs and the release of a Commonwealth Oceans Policy.

'Initiatives such as this help us protect and conserve the Great Barrier Reef and our neighbours' coral reef systems and increase awareness of the complex issues inherent with human use and impact on the ocean and its diverse ecosystems,' Mr Kenchington said.

'Australia has led the world in efforts to achieve ecological sustainable development in marine environments. Our continued efforts to understand and manage the effects of human activity, particularly on coral reef systems, are now recognised internationally.

'Indeed, we will be in the international spotlight this year when Townsville hosts the Inaugural International Tropical Marine Ecosystems Management Symposium from 23–26 November to discuss sustainable management of coral reefs and related ecosystems.

'Through the ocean and the wonders of its diverse ecosystems we can learn how to implement management issues that could affect and enhance present and future human existence on the planet.'

Look out for special updates and articles on International Year of the Ocean in future editions. ■

And Now an Even Greater Great Barrier Reef Marine Park

Gumoo Woojabudee or 'Bigfulla Water' is the name given to the new Section of the Great Barrier Reef Marine Park. The name is derived from the Darumbal Aboriginal language group, the original inhabitants of the region.

The 350 square kilometre area includes coastal waters from Delcomyn Point to south of Corio Bay, approximately 14 kilometres north of Yeppoon. This area was not previously included in the Mackay/Capricorn Section when that Section was declared in 1986.

The Great Barrier Reef Marine Park Authority and the Queensland Department of Environment are working together to plan for and manage the new Section, which was initially proposed five years ago.

The addition of the area to the Marine Park was recommended by the Commonwealth Government inquiry into the future use of the Shoalwater Bay area. The instigation for this inquiry was a proposal to sand mine the coastal dune systems.

The Department of Defence, who train in the area and have maintained its ecological values, were opposed to any commercial operations in the region due to probable disruption to their training activities.

Declaration of Gumoo Woojabudee Section was supported by the Department of Defence, Queensland Government, conservation groups and the Darumbal Aboriginal people because of its ecological and cultural heritage values.

The new Section and its adjacent coastline possess a range of productive and diverse ecological communities including mangroves, seagrass beds, intertidal mudflats and fringing reefs. The coastal dunes have a history of Aboriginal occupation and use.

The Ramsar-listed mudflats and the coastal dunes of Port Clinton and Corio Bay provide important roosting and feeding habitat for migratory shorebirds and seabirds.

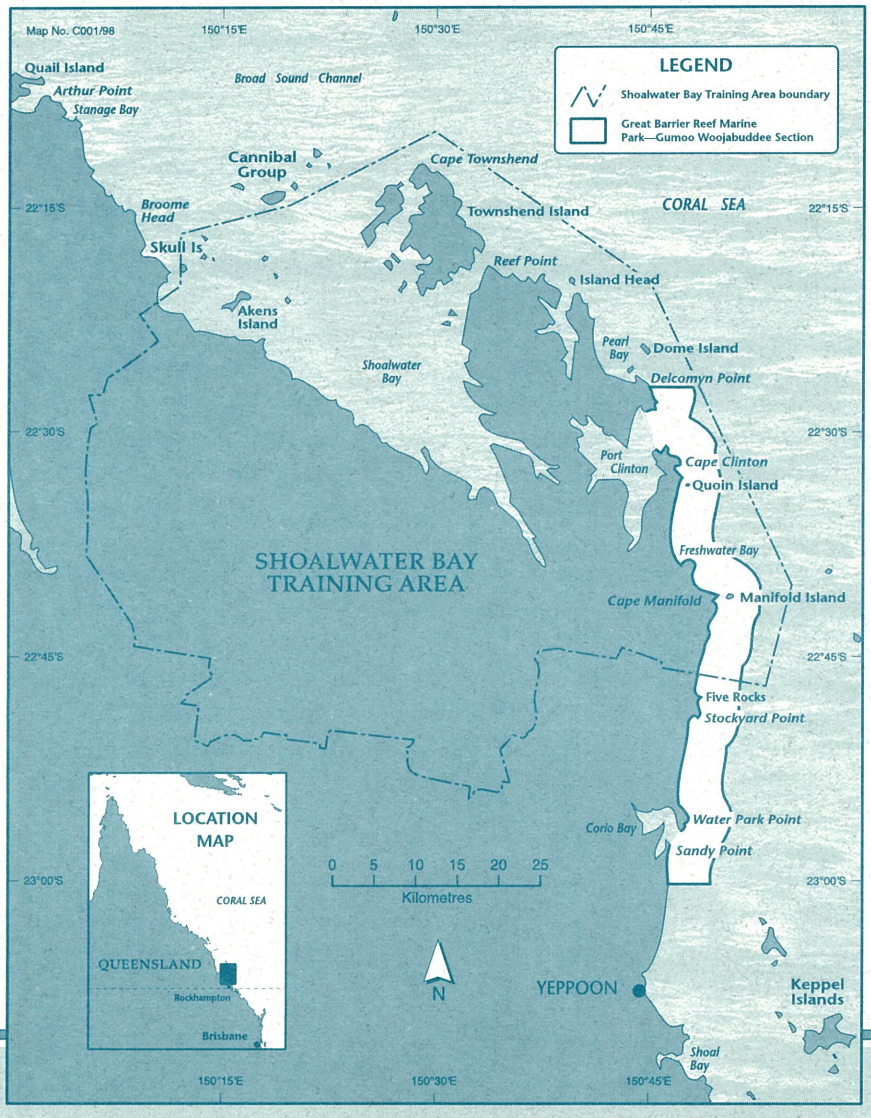
The Port Clinton area also contains considerable seagrass meadows that provide feeding areas for dugong and marine turtles, and is part of a Dugong Protection Area (Zone 'A').

The latest addition to the Marine Park will enhance the ability for managers to protect and manage the biodiversity and other conservation values of this unique region.

The Park's new Section is already part of the Great Barrier Reef World Heritage Area and preparation of a zoning plan for the new Marine Park area will begin later this year.

An information brochure calling for public submissions in the preparation of a zoning plan for the area will be released in March this year. ■

Great Barrier Reef Marine Park—Gumoo Woojabuddee Section



Working to Save Nature's Playground

David Lloyd and David Wachenfeld

With coral reefs under threat from human pressures ranging from global warming to over-fishing, the international community designated 1997 as the International Year of the Coral Reef. Australian scientists have been reviewing the condition of the Great Barrier Reef, the largest of these complex marine ecosystems.

'There is an old saying that what the eye does not see the heart does not grieve. That is, until it is too late!' says Tamarii Tutangata (Tam) sitting back in his sparsely furnished office in Apia, the capital of Samoa. As Director of the South Pacific Regional Environment Programme (SPREP), Tam has a special concern about the status of coral reefs. 'Reefs feed our families and protect our coast, without them many Pacific nations could simply wash away in the next storm or lose the fish they have relied upon for generations. We can easily see the damage to soils, forests and grasslands; unfortunately damage to our coral reefs is hidden below the surface of the water. By the time the first signs become visible the damage can be extreme.'

Similar concerns are being expressed right across the coral belt, the tropical regions which includes Southeast Asia, the Caribbean, Africa and the Middle East.

World wide, coral reefs are under threat. Over-fishing, pollution from cities, soil washed down rivers, anchor damage, coral bleaching and uncontrolled tourism are all having an effect upon the world's coral reefs. That is one of the main reasons that scientists around the world declared 1997 the International Year of the Coral Reef. During the International Year of the Reef much attention in Australia was focused on the Great Barrier Reef and the lessons learned in managing competing uses within a World Heritage Area of 35 million hectares.

'It is the sheer size and scale of the Great Barrier Reef World Heritage Area that makes it so important,' Dr Ian McPhail, the Chair of the Great Barrier Reef Marine Park Authority, said. The Authority is responsible for managing the World Heritage Area which stretches 2000 kilometres along Australia's eastern seaboard from Lady Elliot Island in the south to Australia's northern tip at Cape York. With its 2900 individual reefs, rainforests, mangrove forests, seagrass beds, 900 continental islands and coral cays, deep ocean troughs and sandy beaches, the Great Barrier Reef World Heritage Area is one of the richest natural systems on earth. For many animals such as humpback whales, dugongs and turtles, the region is a breeding area critical to their global survival. It is an area as complex and diverse as any rainforest and scientists freely admit they have only scratched the surface of what there is to know about the region.

To Ian McPhail, these are the things that make management of the reef a challenge. 'It is a huge and incredibly complex system that we are just beginning to learn about. Significant events, such as the mass spawning of coral that occurs in three days in November on the outer reef, were only discovered ten years ago.

'The possible links of El Niño and decreasing water quality to outbreaks of the crown-of-thorns starfish are still informed speculation. Overall the "outer reef" has suffered little from human impact. Australia is fortunate to have one of the few coral reef ecosystems in the world that is in good health.'

Standing waste deep in a creek that feeds the Herbert River and keeping a sharp eye out for crocodiles, Mr David Haynes, Water Quality Coordinator with the Authority, is taking samples to assess the quality of the water that will eventually find its way into the marine environment. He explained that the ocean currents, that wash across the outer reef, have travelled westerly across vast tracts of the Pacific. By the time the water reaches Australia most of the nutrients have sunk to the ocean depths. The coral communities on the outer reef have adapted to these low nutrient conditions. In comparison the inshore waters, walled-in by barrier reefs, form a shallow lagoon system. This restricts the usual flushing and dilution of contaminants that occur in open seas. The Great Barrier Reef lagoon concentrates the nutrient rich waters flowing in from towns and farms of north Queensland.

'The principal concern is the potentially negative effects of land degradation and land-based sources of pollution on adjacent coastal wetlands, mangroves, seagrasses and coral reef communities,' says Mr Haynes.

Recognising this concern the Cane Growers Association has conducted an environmental audit of their industry.

Since the 1880s the development of the sugar industry has seen the conversion of much of the wetlands into cane fields. Added to this is a major pastoral industry which has caused a great deal of vegetation clearance. 'Both these industries are absolutely important economically,' says Dr McPhail, 'but increased loads of sediment and nutrients have the greatest potential to degrade coastal ecosystems. We are also concerned about the effect of agricultural pesticides and herbicides together with heavy metals, hydrocarbons and litter, in particular plastics, coming from cities and towns', he added.

Increased loads of sediment and nutrient resulting from poorly managed land-use activities have the potential to degrade coastal wetlands, mangrove, seagrass and coral reef communities

The melaleuca wetlands and mangrove forests are areas of high biodiversity with 70 per cent of all inshore fishery species being dependent on these areas for some part of their life cycles. At the Australian Institute of Marine Science, Dr Norm Duke has been studying the mangrove environments in the World Heritage Area. 'They are in relatively good condition, although,' he adds, 'there are clear indications that pressures on them are increasing rapidly.' These pressures include the direct removal and damage of mangrove plants, conversion of mangrove lands to other uses, changing water flow and sediment distribution, chronic and catastrophic pollution and the introduction of exotic pests and pathogens.

There are good environmental and economic reasons to maintain wetland systems. Wetlands use their nutrient exchange efficiency as a filter for excess nutrients in run-off water. The limiting factor for the growth of mangrove forests is the supply of nitrogen and phosphorus, which are potentially deadly to fringing coral reefs. Mangrove forests can efficiently remove these chemicals converting the nutrient to leaf growth. The leaves drop, and as the leaves decompose they form the base of the food chain. 'This constant supply of food makes a very stable food chain. If we had no mangroves, this rich mud would wash away with the tides and floods. In its place we would have a boom or bust planktonic system dependent upon ocean tides which are simple, highly reactive and unstable', says Andrew Ballard an environmental scientist at the Authority.

Following on the findings of the State of the Great Barrier Reef Workshop, a special workshop on wetlands was organised in September 1997 at Babinda, Queensland, Australia in the heart of cane country. Participants at the workshop came from a variety of interest groups including local government, recreational and commercial fishing, conservation, agriculture, indigenous people, tourism, and local coastal communities as well as representatives from various government departments. They heard that less than 10 per cent of the freshwater wetlands remain in the Herbert river catchment and unlike mangrove systems, no controls exist to protect these critical habitats. The outcome was a resolution by all groups to protect the remaining wetlands adjacent to the Great Barrier Reef and measures were suggested to assist in rehabilitating degraded areas.

While most people think immediately of coral reefs when they think of the Great Barrier Reef World Heritage Area, the region also contains a number of other important

habitats such as mangrove and seagrass communities. There are at least 5000 square kilometres of seagrass habitat in the World Heritage Area which are important to the ecology and the economy of the region. They are an important level in the food chain, directly feeding grazing animals such as turtles and dugong, and indirectly as the decomposing leaves are eaten by invertebrates which in turn are eaten by larger organisms. Seagrasses also provide shelter for juvenile crabs, prawns and fish. They are often called the nursery of the sea. Juvenile brown tiger prawns can live nowhere else but in seagrass beds. Seagrass beds stabilise the sediment with their root and rhizone systems. Their role in converting nutrients into food for other organisms helps filter the water flowing on to the reef.

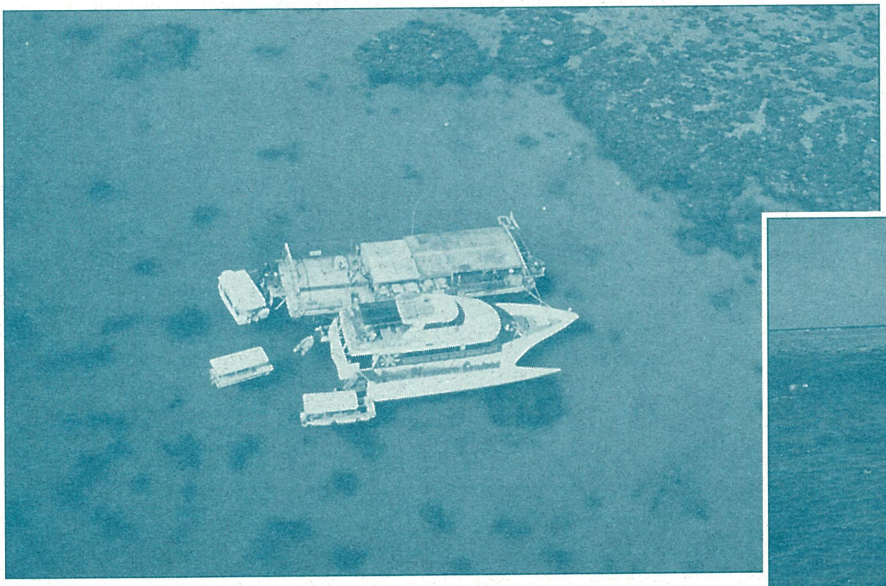
Fishing and tourism are both highly important industries in the Great Barrier Reef. Evaluating the impact of these activities on the ecology of the Reef and adopting strategies to minimise any negative effects is a major focus of scientific activity.

Recreational fishing is one of Queensland's most popular past-times. Around 882 000 people or 40 per cent of the State's population wet a line annually. In comparison, there are around 250 commercial 'reef-line' operations, supporting three or four dories each, that harvest between 3000 and 4000 tonnes annually which is roughly equivalent to the recreational catch.

Data indicates that current catch levels are sustainable, however most agree that any increased 'effort' will affect this sustainability. This does not necessarily mean that all populations of fish are 'healthy' or 'natural'. Comparisons between reefs where fishing is allowed and those where it is prohibited indicate that fishing can cause localised changes. Studies show decreases in the number and the average size of coral trout and red-throat sweetlip emperor which are specifically targeted by fishermen and heavily exploited.

Coral reefs make up only five per cent of the area of the Great Barrier Reef. The region between the edge of the continental shelf and land, that is not coral reef, is known as inter-reef area, or the Great Barrier Reef lagoon. Our knowledge and understanding of these areas is relatively poor, and so management decision making is difficult.

The inter-reef communities are an important part of the World Heritage Area with high biodiversity values. The area supports a valuable trawl fishery landing about 7000 tonnes of prawns and 1000 tonnes of scallops per year, as well as sand-crabs, lobsters and some fish. However, during trawling many tonnes of animals (known as by-catch) are caught by accident and discarded by the fishermen. High intensity trawling can have substantial impacts on the animals living on the seabed, with up to 90 per cent of biomass being removed. It is hoped that the introduction



Rapidly swelling numbers of tourists in the last decade has focused the attention of scientists and governments on the need to protect the Reef's ecology

of Bycatch Reduction Devices will reduce the impact on fish and turtles as they are introduced into the trawling fleet over the next two years.

To date the Great Barrier Reef Marine Park Authority has relied on certain 'no-take' areas or 'green zones' to separate conflicting uses such as fishing and tourism. This has coincidentally provided a refuge for many fish species. Now, the Marine Park Authority is looking at expanding this protection to populations 'representative' of varied communities found in the World Heritage Area.

Commercial and recreational fishing groups, understandably, tend to question the motives of marine park managers when valuable fishing reserves are seemingly locked away. Indeed, to outsiders it may seem as yet another case of conservation measures incompatible with industry initiatives. But to the contrary, marine reserves may benefit fisheries, according to Dr Gary Davis, from the United States National Biological Survey. He says fisheries 'refugia' could become the most important tool in the fishery manager's toolbox.

The last decade has seen a tourism industry characterised by rapid growth and changing management needs. Tourism in the region has grown from about 150 000 visitor days per year in the early 1980s to about 1.5 million visitor-days in 1994–95. It is currently the main commercial use of the reef and is estimated to generate over $1 billion annually. During this time the industry has altered significantly to meet tourists' demands.

'In 1985, boats were capable of travelling at 10 knots and could reach 20 nautical miles in two hours, which is as long as most "daytrippers" wish to travel,' says Dr McPhail. 'In 1990 they travelled to 50 nautical miles at 25 knots, in 1997 they travel to 70 nautical miles at 35 knots and it is projected that in 2001 they will be able to travel to 100 nautical miles at 50 knots. What this means is that the extent of the World Heritage Area that has become accessible over this period to the "day trip" tourist industry has increased from four per cent to a projected 81 per cent.'

Management strategies that relied on remoteness to protect wilderness qualities in some areas of the park in 1985 are not appropriate today. 'Put simply, some areas of the Reef, principally offshore Cairns and the Whitsundays, are starting to fill up and World Heritage and experience values need to be protected. Plans of Management for these areas will address issues such as competition between commercial and recreational interests and the protection of important or vulnerable sites,' Dr McPhail said. But management is also about protecting an industry. 'I think there is little we could do if a major spill occurred but the ecological impacts and effect of the negative publicity on the region's economy could be catastrophic.

'Sometimes I think that Australians forget the asset on their door step. We have one of the healthiest and best managed reefs in the world.'

Information from research lead by Professor Helene Marsh of James Cook University shows that while dugong populations in the northern part of the World Heritage Area are stable, those in the south have plummeted. 'Dugong numbers appear to have been stable over the last decade in the Great Barrier Reef Region north of Cape Bedford, however, on the urban coast south of Cooktown, dugong numbers have declined by approximately 50 per cent over the past eight years,' said Professor Marsh. As a result of this decline, Indigenous groups have decided not to hunt along the urban coast of the region and there is now no permitted traditional hunting of dugongs south of Cooktown.

Fishers have agreed to support an Endangered Species Education Program and the Queensland shark control program is being reviewed with a view to reducing by-catch. It will be necessary to introduce additional measures to decrease the incidental capture of dugongs in gill nets. Habitat deterioration remains a major unresolved threat to dugongs in the Great Barrier Reef Region. Dugong Protection Areas have been introduced in a number of significant areas along the Queensland coast in the hope of halting, and possibly eventually reversing, this decline.

But dugong are not the only marine mammals needing protection in the Great Barrier Reef. Australia is one of the very few countries where the Indo-Pacific humpback dolphin and the Irrawaddy River dolphin are found that does have an effective marine wildlife management program. It is unlikely that these species will survive into the next century outside of Australia.

In the Great Barrier Reef region management is focusing on dealing with the physical threats from gill netting and shark netting, and the reduced availability of food from over-fishing, pollution and habitat destruction affecting fish nursery areas such as seagrass and mangroves.

(David Lloyd is currently Manager, Extension Unit with the Great Barrier Reef Marine Park Authority. Dr David Wachenfeld is currently Project Officer – Monitoring with the Authority.)

This article previously appeared in 'GEO Australasia', November–December 1997. Please note, however, that some paragraphs from the original article are not included here.

NEWSFLASH

GLOBAL EMISSIONS MAY THREATEN CORAL REEFS

Coral reefs may be threatened by rising concentrations of carbon dioxide in the atmosphere, a group of scientific experts has warned. The warning comes from a report issued after a recent international meeting of experts in Boston, United States of America. (The summary of the report appears over page.) The meeting included scientists from the Australian Institute of Marine Science (AIMS), the Commonwealth Scientific Industrial and Research Organisation (CSIRO), and the Australian National University (ANU).

Dr Terry Done, of AIMS and the Cooperative Research Centre for Ecologically Sustainable Development of the Great Barrier Reef, says…'the ability of reef plants and animals to make the limestone skeletons that build reefs may be reduced by rising atmospheric carbon dioxide concentrations, which increases the acidity of surface ocean water. In the long term, it may interfere with skeleton growth by reef builders, which could pose a serious threat to the sustainability of reefs worldwide. Reefs may be less able to keep up with rising sea level, and they may be more vulnerable to cyclones, which are also predicted to increase in some areas'.

'This report represents a breakthrough in terms of recognising a previously unidentified global effect on an ocean ecosystem caused by human induced changes in atmospheric chemistry,' says Dr Barrie Pittock, of CSIRO's Division of Atmospheric Research. 'The recent Kyoto agreement on a reduction in CO_2 emissions will by itself have little effect on the magnitude of this effect over the coming century.'

The group also emphasised the importance of understanding coral reefs as parts of a whole ecosystem. Dr John Benzie from AIMS noted: 'While corals and reefs have a degree of resilience to local pressures caused by human use and natural events such as extreme storms, predation or disease, they do not survive in isolation – the recovery of any one reef depends on the nature, the health, and the history of neighbouring communities. We need to do a better job of including that in our management and conservation plans.'

According to the group's report, local damage can be isolated and managed provided that the surrounding marine ecosystem remains stable. Science's understanding of natural renewal, adaptation, and the critically important limestone creation mechanisms are all inadequate to predict detailed, local effects of the added pressure caused by increasing CO_2 emissions. However the report was confident that more atmospheric CO_2 makes reefs even more vulnerable to natural disturbances, and to stresses resulting from human population growth and development.

Dr Bradley Opdyke of ANU said 'We need to take seriously the possibility that the combination of pressures may push reef communities across some critical survival threshold. This is important to anticipate, because we can't fix it after a crash. We can re-plant some terrestrial forests and grasses, but big marine ecosystems have to rely on their own resources to regenerate and repair themselves'.

Done remarked 'The coral reef managers in Australia such as the Great Barrier Reef Marine Park Authority and Western Australia's Department of Conservation and Land Management are way out in front of the rest of the world in management philosophy and implementation. They have their hands full addressing local pollution, run-off, fishing levels, tourism, shipping and other direct human use of reefs. However, up till now they have been able to assume global climate change would be neutral or even advantageous to our coral reefs. Our report suggests that governments, managers and scientists will need to take a hard look at that assumption'.

For further information or a copy of the summary report, contact:

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List of sponsoring and supporting organisations:

Results are a report of Working Group 104 of the Scientific Committee on Oceanic Research (SCOR), which is co-sponsored by the Land–Ocean Interactions in the Coastal Zone (LOICZ) core project of the International Geosphere–Biosphere Programme (IGBP). Meeting support was provided by the United State's National Oceanographic and Atmospheric Administration's Coastal Ocean Program and the Society for Integrative

and Comparative Biology (SICB), with meeting co-sponsorship by the International Society for Reef Studies (ISRS), the Ecological Society of America (ESA) and the New England Aquarium, Boston.

Symposium participants:

BUDDEMEIER, R.W., Kansas Geol. Survey, Univ. of Kansas, Lawrence (WG-104 chair; Symposium co-organiser)
LASKER, H. R., State University of New York, Univ. at Buffalo (Symposium co-organiser)
PITTOCK, A. B., CSIRO Div. of Atmospheric Research, Aspendale, Australia
OPDYKE, B. N., Australian National University, Canberra
PANDOLFI, J. M., National Museum of Natural History, Washington
KINZIE, R.A. III, Univ. of Hawaii, Honolulu
GATES, R. D., Univ. of California, Los Angeles
YAMAZATO, K., Meio University, Okinawa, Japan (paper read; not present)
CARLSON, B. A., Waikiki Aquarium, Honolulu
BENZIE, J. A. H., Australian Inst. of Marine Science, Townsville
POTTS, D. C., Univ. of California, Santa Cruz
ROWAN, R., Marine Lab., Univ. of Guam, Mangilao
BAK, R. P. M., Netherlands Inst. of Sea Research, Texel.
DONE, T. J., Australian Inst. of Marine Science, Townsville
KARLSON, R H.., Univ. of Delaware, Newark
KLEYPAS, J., Nat. Center for Atmos. Research, Boulder
GATTUSO, J.-P., CNRS Observatoire Oceanologique, Villefranche-sur-mer, France
HATCHER, B. G., Dalhousie Univ., Halifax, Canada
SMITH, S. V., Univ. of Hawaii, Honolulu

Coral Reefs and Global Change: Adaptation, Acclimation or Extinction?

Initial report of a symposium and workshop

Dr Robert Buddemeier

Summary

Major revisions of concepts about corals and reef systems were developed by an international working group of scientific experts that met in conjunction with the Society for Integrative and Comparative Biology, the International Society for Reef Studies and the Ecological Society of America (Boston, 3–11 January 1998) to evaluate the scientific basis for growing concerns about the survival of coral reef ecosystems facing global change and local stresses. The group, sponsored by the Scientific Committee on Oceanic Research (SCOR) and the Land–Ocean Interactions in the Coastal Zone (LOICZ) core project of the International Geosphere–Biosphere Programme (IGBP), and with the support of the NOAA Coastal Ocean Program, produced an interdisciplinary synthesis with important implications for research, assessment and management.

Key conclusions were:

- The calcification rates of corals, coralline algae, and coral–algal communities depends on the calcium carbonate saturation state of surface seawater and are expected to be reduced by rising atmospheric carbon dioxide. This represents a global, systemic, climate-related threat to the functioning of reef ecosystems that will interact with the more immediate anthropogenic local stresses.

- Coral reefs and communities are products of processes operating over a wide range of interacting time and space scales, with fundamentally different controls operating at different scales. While short-term responses will be controlled by local environmental conditions and biotic responses, the longer-term sustainability of a reef system depends on the recruitment, dispersal, persistence and interactions of populations at larger scales.

- Corals, and to some extent reef communities, possess numerous mechanisms for acclimatisation and adaptation – diverse reproductive strategies, flexible symbiotic relationships, physiological acclimatization, habitat tolerance, and a range of community interactions. However, current understanding of these mechanisms, as well as of the critically important calcification mechanisms, is inadequate to explain the past success of corals and reefs or to ensure their conservation for the future.

Unlike many terrestrial ecosystems, coral reef ecosystems appear to be directly threatened by globally increasing atmospheric CO_2. Therefore, conservation or management strategies aimed at removing or mitigating only local, human-derived, or recently applied environmental stresses are likely to be inadequate. Corals and reefs are potentially robust and resilient, but realizing that potential requires the development of new approaches and greater integration of fundamental and applied research, conservation and management.

Community Attitudes to Wilderness-based Recreation on the Great Barrier Reef

Joan Crawford

As reported in the previous edition of *Reef Research*, the draft Far Northern Section Zoning Plan was released by the Great Barrier Reef Marine Park Authority (GBRMPA) on 5 December 1997 (Reef Management News, *Reef Research*, Vol. 7 No. 3–4). In terms of recreational use, the Far Northern Section is one of the more remote and less used sections of the Marine Park. One of the major steps in formulating the Far Northern Section Zoning Plan was deciding on the type and level of management to assign to this remote area. The Authority's overall management responsibility is to ensure ecologically sustainable use of the Marine Park. Achieving this charter includes maintaining a range of settings and opportunities for recreation in the Marine Park.

To aid the Authority in this decision the value Australian people place on maintaining 'wilderness' type recreation settings needed to be determined. During 1994 and 1995 GBRMPA commissioned AGB McNair to conduct two studies into community attitudes to wilderness-based recreation in the Marine Park. The first study entitled 'Community Attitudes Towards Wilderness-Based Recreation on the Great Barrier Reef' was a scoping study that identified how Queensland residents define different reef experiences. This study explored the value community's place on maintaining remote and undeveloped settings in the Marine Park. The study involved interviewing three focus groups during July 1994 in both Cairns and Brisbane. The three groups comprised different age and gender groupings to ensure representation from differing recreational patterns that may exist.

The second study entitled 'Recreation Use and Management Issues for the Great Barrier Reef Marine Park' was an Australia wide survey that was developed using the findings of the first scoping study. This second study involved AGB McNair interviewing 1081 people aged 14 years and over (Australia wide) during June 1995. Overall, 697 metropolitan residents and 384 regional residents were interviewed face to face. The report from this study measures community support for the provision of wilderness-based recreation opportunities on the Great Barrier Reef and identifies community preferences for recreation experiences in the Marine Park as well as management options for the Marine Park.

A summary of the key findings from these studies is presented below. The full reports will be published as Authority Research Publications during the first half of 1998.

Research Findings

To many respondents the term 'wilderness' was not naturally associated with a marine environment. Only a few respondents who had visited remote regions of the Reef were able to conceptualize marine 'wilderness'. These respondents interpreted wilderness in terms of marine life in its natural state, untouched or undamaged marine life as well as remoteness from signs of civilization. The perception held by many respondents was that vast areas of the Reef remained in this natural, untouched state, due to tourism being conducted in small and specific areas comparative to the size of the Great Barrier Reef system.

Knowledge of the Great Barrier Reef and Understanding of Marine Park Management

Respondents displayed only a low to medium understanding of issues affecting the Great Barrier Reef. More than half of the respondents stated that they knew only a little about the methods used for management of the Marine Park.

Visits to the Reef

Just over 40 per cent of those surveyed had visited the Great Barrier Reef some time in their life. Of these 22 per

cent had done so more than five years ago and only 10 per cent had visited the Reef within the past two years.

Return visits represent an important component of the Reef's recreation market. Two thirds of those respondents who had visited the reef within the past year indicated an intention to return to the Reef within the next two years.

Importance of Recreational Experiences to a Reef Visitor

The importance of attributes to a reef visit is reported in figure 1 below. Scenic beauty of islands and beaches, the holiday and relaxation aspect of the trip and a desire to experience a natural and unspoilt environment were the most important components for respondents. These experiences all related to the respondent's desires to be removed from their normal routine and enjoy rest and relaxation.

Recreation experiences within 'wilderness' type settings such as being far from civilisation and having access to remote areas were less important attributes of a reef visits for most respondents. Even so, all aspects received above average importance ratings.

Activities when Visiting the Great Barrier Reef

Activities undertaken when visiting the reef are reported in table 1 on right. The more popular activities revolved around passive recreational pursuits. Relaxing, sightseeing and going for island walks were the most popular. The least popular recreational activities were the physically active pursuits of scuba diving and fishing. These responses were strongly influenced by gender, age and income.

Males were more likely to undertake more physical activities such as fishing, snorkelling, scuba diving and camping. Females indicated a higher preference for glass bottom boating, island walks, picnicking and sightseeing.

Family status influenced the choice of recreational activities. Younger respondents with no children indicated a preference for more challenging and physically active experiences such as sailing, camping and snorkelling. Respondents with children indicated a preference for the more passive activities of swimming, island walks and picnicking. Respondents over the age of 40 also indicated a preference for the more passive activities of sightseeing, walking and relaxing.

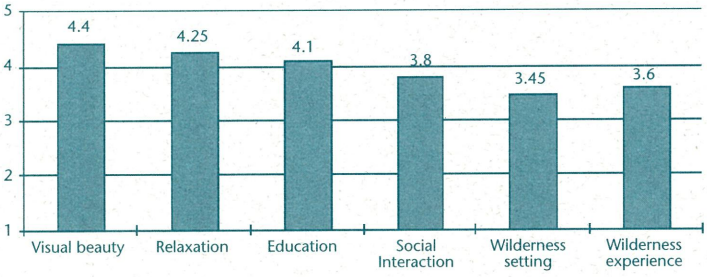

Figure 1. Importance of Recreation Experiences to a Reef Visitor ***(n=1081, based on a five point rating scale, from 'not at all important' (1) through to 'very important' (5))***

Table 1. Likely activities when visiting the Reef or islands (n=1081)

Likely Activity	Total (%)
Relaxing	81
Sightseeing	73
Go for island walks	72
Go out in a glass bottomed boat to see the Reef	69
Swimming	60
Go for Reef walks	59
Snorkeling	45
Picnicking	40
Camping	31
Sailing	31
Fishing out on the Reef	29
Fishing from one of the beaches	24
Scuba diving	23

Support for Management Options

Respondents support for management options are shown in figure 2. Respondents indicated strong support of active management for undeveloped areas in the Marine Park. The reasons given were related to importance placed on maintaining the naturalness of the Reef. Over 80 per cent of respondents agreed that areas within the Marine Park that have high natural values and few visitors are important, regardless of their personal ability to visit them.

Strong support was also recorded for limiting permanent structures and commercial access to some areas of the reef. Seventy-five per cent of respondents agreed that permanent structures, such as pontoons should be avoided in selected areas. Eighty per cent of respondents believed access by people should be limited in certain areas of the Marine Park. At the same time 67 per cent of respondents indicated they would be very interested in visiting the more remote areas of the Reef and islands in the Marine Park.

Priorities for Protecting the Great Barrier Reef

Respondents were given eight possible reasons for protecting the Great Barrier Reef and islands and

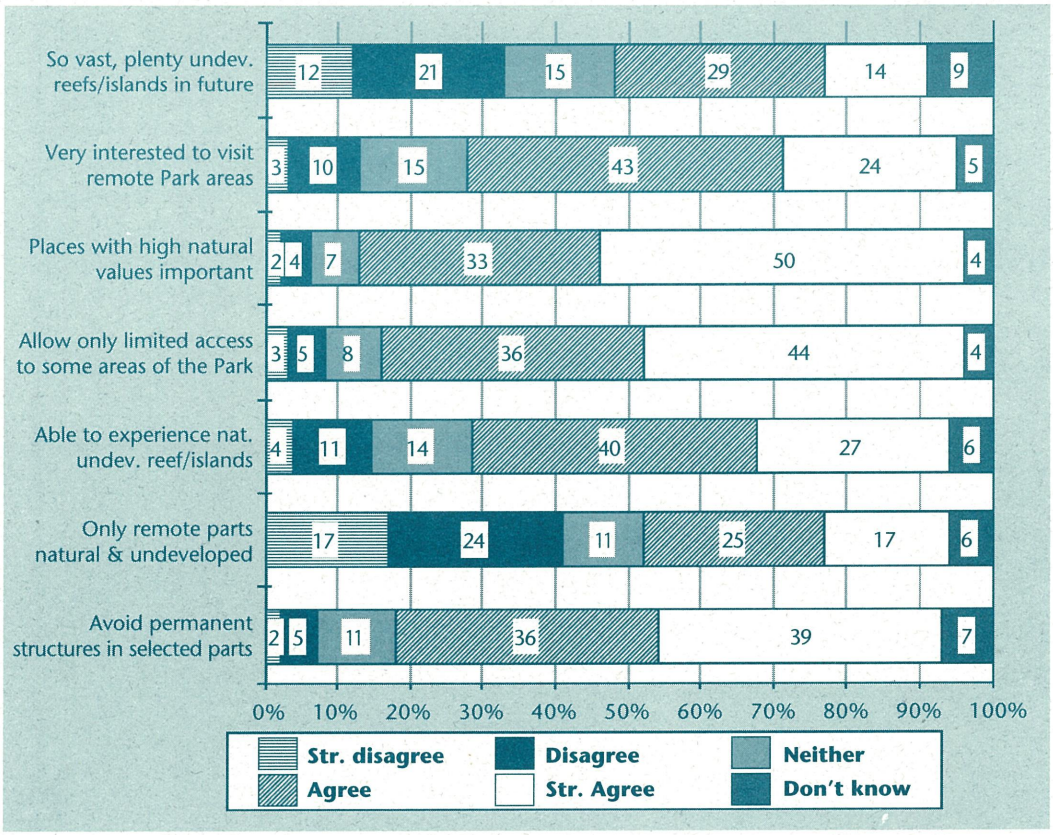

Figure 2.
Support for Marine Park management strategies

asked to rank them in order of importance. People perceived the most important reason for protecting the Reef and islands was to maintain the unique natural environment it contains. Other reasons included the fact that the area is World Heritage listed and for the recreation and enjoyment of future generations.

Respondents placed lower importance on commercial profitability of the area. The least favoured reason for protecting the Reef was due to its role as a fishing industry resource. Low importance was also placed on tourism and other economic opportunities the areas offered. The responses to these open-ended questions need further testing and clarification to support the results and conclusions drawn.

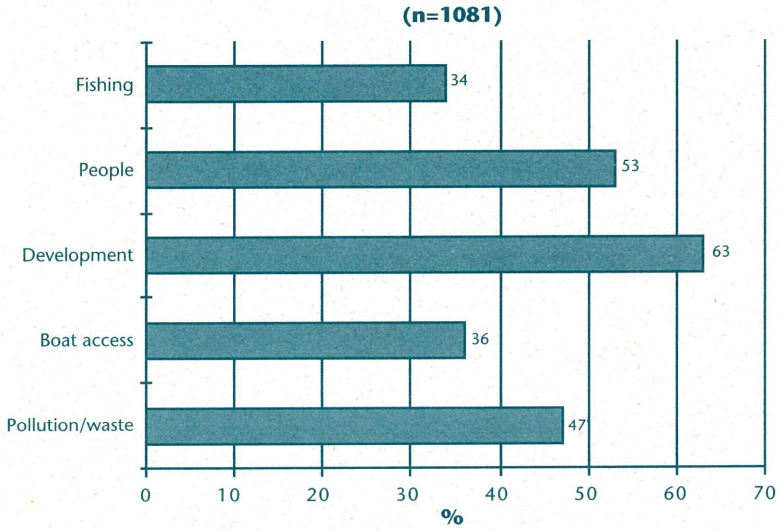

Figure 3. Issues for recreation management of the Marine Park

Issues for Recreation Management

Respondents were asked to consider issues they felt were important for the current and future recreation use of the Great Barrier Reef Marine Park. Issues for recreation management identified by respondents are detailed in figure 3. Respondents identified development issues as the major focus for Marine Park management. Respondents indicated that maintaining a balance between development and maintaining the present environment as well as limiting future developments were key areas for management intervention.

The second most important issue recorded was managing people's access to sections of the Reef and their activities in the Marine Park. Respondents stated these issues are important for the current as well as long-term enjoyment of the Marine Park.

Factors influencing these responses included place of residence, education levels and gender. Age had little influence on attitudes towards different management issues. Responses to this open-ended question cannot necessarily be taken at their face value and will need to be further tested before specific conclusions can be drawn.

The findings of these two reports were considered (along with other sources of input) when the Authority was developing the Far Northern Section Zoning Plan.

Copies of the full report can be obtained by contacting Kim Davis at the Authority on +61 7 4750 0814.