NEWSLETTER OF THE RESEARCH AND MONITORING SECTION

# REEF RESEARCH

Great Barrier Reef Marine Park Authority

VOLUME 2 – No. 4 DECEMBER 1992

## EDITORIAL

As promised 'Cots Comms' and 'What's out there?' have joined 'Slick Talk' as regular sections of Reef Research. Thanks to Brian Lassig, Jamie Oliver and Steve Raaymakers for the commitment that relieves the Assistant Editor, Trish Sanders, of the thankless task of soliciting the necessary material for each issue. Despite its size 'Cots Comms' is not actually making a takeover bid for the newsletter. I would also like to express my appreciation for the work done by the GBRMPA production unit who are responsible for all art work and the layout of Reef Research since, without their contribution, it would be just all words. Pongase continues to contribute his own view of reef life despite his considerable contractual obligations in parts of the world various.

The circulation of Reef Research has now grown from the initial print run of five hundred to a mailing list of thirteen hundred and seems to be continuing to grow. The Marine Park Authority is committed to the ongoing dissemination of educational material, of which Reef Research is considered an essential element, so if you require extra copies or know of other people who would be interested in receiving a copy please let me know. On the other hand, in these frugal times, costs need to be contained so if you do not wish to continue receiving the newsletter please drop me a line.

This issue covers a whole gamut of topics notwithstanding the trend towards regular program oriented sections. You can read, amongst other things, about policy development for sea dumping in the Marine Park, the European history of remote Raine Island (a fascinating place that the Editor had the good fortune to visit last year), sand sources in the Great Barrier Reef Region (there are surprisingly few), technical breakthroughs in the measurement of the interior capacity of microatolls, or even the use of mitochondrial DNA as a genetic marker in crown-of-thorns starfish. Variety's the spice of reef research so they say - enjoy.

Finally, yes, all right, I know that Septembr is really spelled with an extra suitably inserted 'e'. Hmmm.

Ed.

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Readers are invited to submit material for publication, inclusion is the decision of the Editor, all contributions or inquiries should be addressed to:

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# WHAT'S IN THIS ISSUE



## RESEARCH AND MONITORING STAFF

| | |
|---|---|
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| **Jon Brodie** | *Acting Director and Coordinator - Water Quality* |
| **Andy Steven** | *Project Manager - Water Quality* |
| **Rob McGill** | *Assistant Project Officer - Water Quality* |
| **Brian Lassig** | *Coordinator - Crown-of-thorns Starfish* |
| **Udo Engelhardt** | *Project Manager - Crown-of-thorns Starfish* |
| **David Lawrence** | *Coordinator - Torres Strait Baseline Study* |
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| **Bruce Mapstone** | *Coordinator - Effects of Fishing* |
| **John Robertson** | *Project Manager - Effects of Fishing* |
| **Janine Kuhl** | *Assistant Project Officer - Effects of Fishing* |
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| **Elaine Eager** | *Project Officer - State of the Marine Environment Report* |
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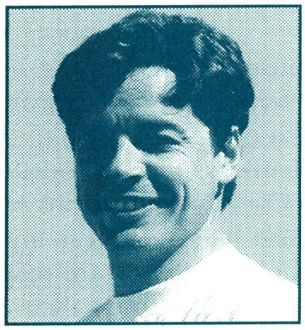
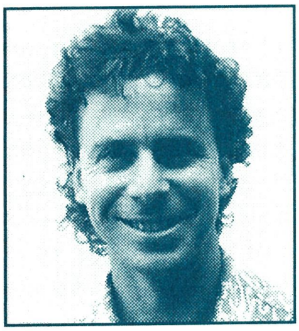
| **Trish Sanders** | *Administrative Assistant & Assistant Editor Reef Research* |



### ANDREW STEVEN

Andy has been with the Authority since September 1991 and is employed as the Project Manager of the Water Quality Program. His responsibilities include the management of some 44 research projects and coordination of a number of Authority initiatives, including ENCORE and a pesticide monitoring program. After graduating from Auckland University in 1983 with a BSc in Biology, Andy came to Australia to work at the Australian Institute of Marine Science on the crown-of-thorns starfish program. Subsequently he was involved in a variety of research programs through the James Cook University, and as a private consultant he took part in a number of monitoring and impact assessment programs. His major research interests are assessing the effects of natural and anthropogenic stresses on corals with a focus on responses to nutrient subsidy.



### JOHN ROBERTSON

John Robertson joined the GBRMPA R&M Monitoring Unit in October 1991 and became project manager for the Effects of Fishing Programme on the GBR in April 1992. After completing an honours degree in marine science at James Cook University, John worked for four years on trawl fishery research in the Gulf of Carpentaria and central Great Barrier Reef with the Dept. of Primary Industries - Northern Fisheries Unit. Attracted by the challenge of aquaculture, John worked for three years as senior biologist for a private mariculture company and specialised in the development of maturation, breeding and hatchery techniques for tropical finfish and crustacean species. During that time John completed a masters degree through the University of Queensland on the habitat requirements and coexistence of two commercially important king prawn species in the central GBR. John maintains an interest in finfish mariculture, but his major interests are natural resource management and environmental impact assessment.

# What's out there

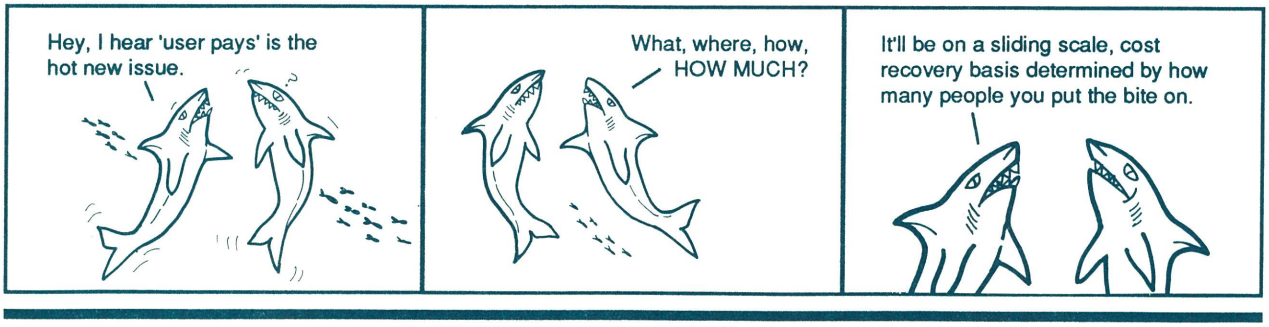
*Dr Jamie Oliver*

## Monitoring for Global Climate Change

Earlier this year R&M was successful in obtaining funds from the Climate Change Impacts Program within DASET (Department of the Arts, Sport, the Environment and Territories) for two projects which will help us to determine how global climate changes may affect the Great Barrier Reef.

The first project is being carried out in conjunction with Miles Furnas from the Australian Institute of Marine Science, and will involve the establishment of a series of long-term temperature monitoring stations. Water temperature is a physiologically important parameter which might be expected to rise significantly over the next decade or so due to the global greenhouse warming. Corals and other reef organisms may be particularly sensitive to small increases in mean sea temperature, since they already live near their upper thermal limit. The periodic, large scale coral bleaching and mortality events which occur on the GBR (see Reef Research vol. 2, no. 2) also suggest that temperature levels already reach critical levels during some summer periods, and that any increase might have serious consequences. One component of this project will involve the deployment of temperature loggers in different locations in the central and northern sections of the GBR. These loggers will collect half hourly readings of water temperature throughout the year. Before these loggers are deployed at permanent sites, an initial trial will be conducted on an inshore reef and a midshelf reef to determine how much temperature varies from site to site and at different depths on a single reef. Eventually, it is hoped that we will have a series of sites throughout the GBR where surface and sub-surface temperatures are being monitored. This will complement the

**Coralations** **No Free Lunch** **Pongase**



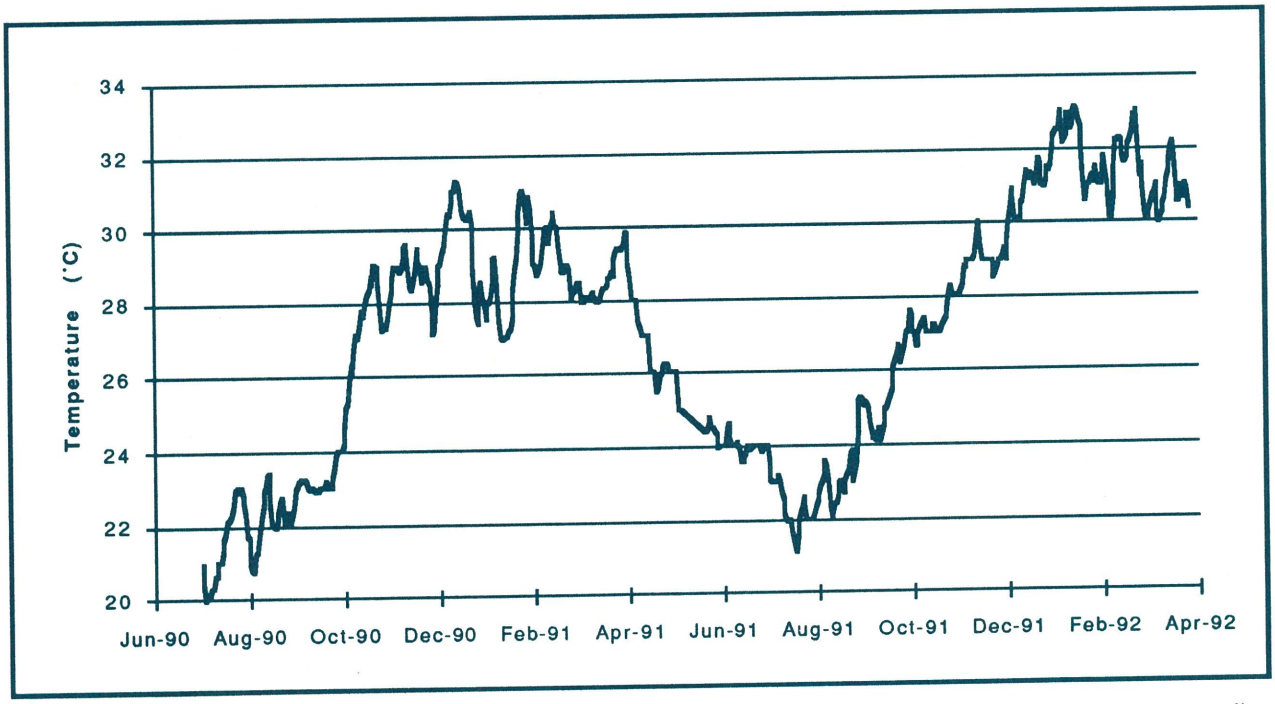
measurements already being obtained from the automatic weather stations operated by AIMS at 5 sites between the Whitsunday Region and Agincourt Reef. The resulting long-term data set will enable us to detect long-term changes in mean temperatures, or changes in the frequency or severity of extreme temperature. As it becomes available, the Authority would be pleased to make this data available to other individuals or institutions. We would also be very interested to hear from any other people who have been accumulating temperature data in the GBR region, and would be willing to incorporate such data into a larger readily accessible database on water temperatures on the GBR.

The second component of the temperature monitoring project is designed to investigate a quite different type of effect cause by global climate change. A series of oceanographic stations with high precision temperature and depth recorders will be placed near the sea bottom at the edge of the continental shelf. These loggers will be used to detect upwelling events, in which deep, cool, nutrient rich water wells up at the shelf edge and intrudes onto the continental shelf. This nutrient rich water support the growth of phytoplankton and other photosynthetic organisms and has the potential to directly and indirectly affect reefs in the vicinity of upwelling events. The instruments will be deployed in the next month or so in the southern GBR, and will provide long-term data on the frequency and duration of upwelling events in relation to changes in other global climate change indicators.

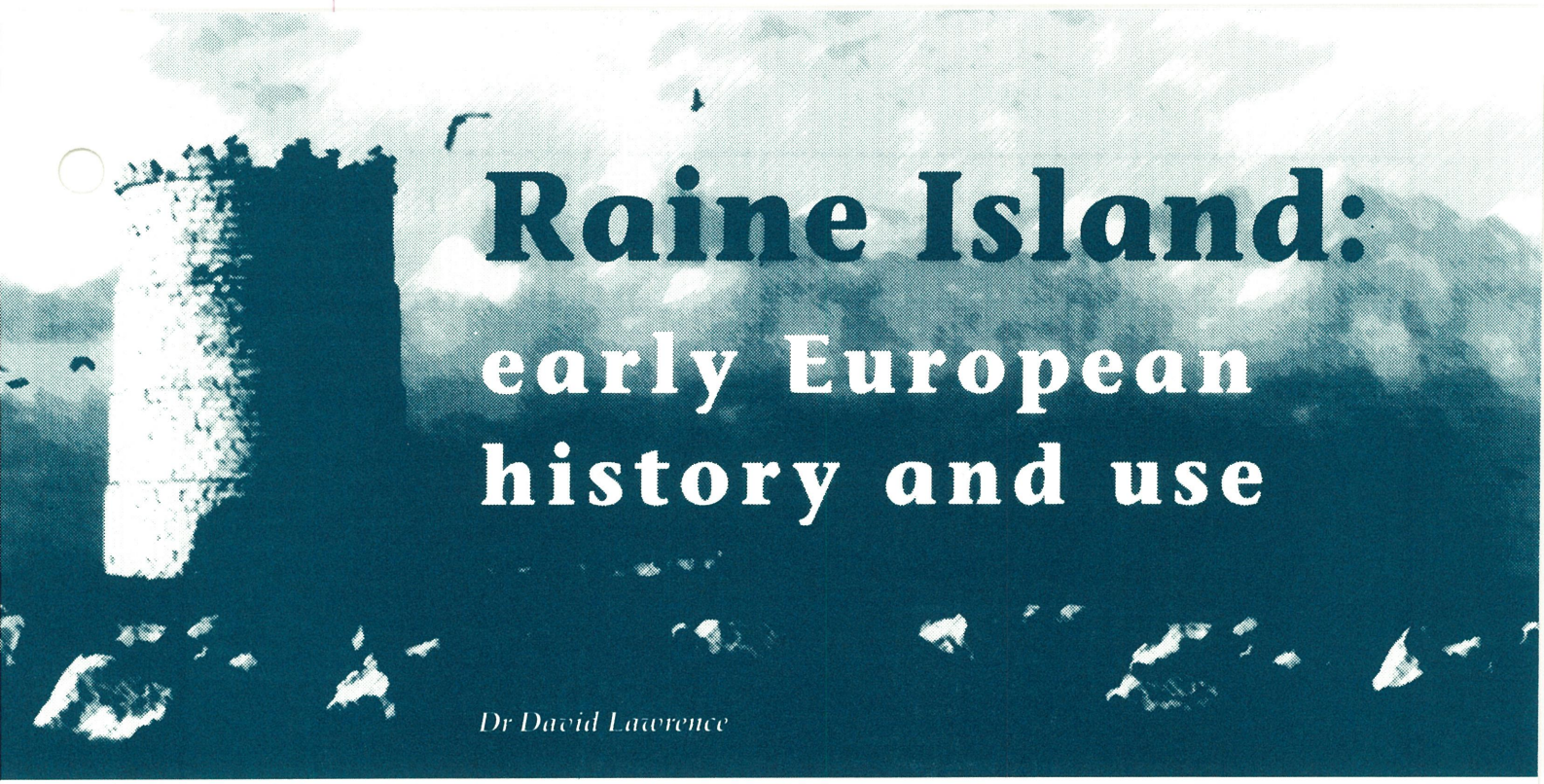
Although interesting and relevant data will begin to flow in from these projects in the next 12 months, it may take 10 years or more before a time-series has been built up which is long enough to determine if global climate change is affecting the reefs.

Next issue we will report on the progress of the second of the Global Climate Change studies: Developing techniques to monitor changes on reef flats using low level aerial photography.

R




*Daily Average Water Temperatures - Cleveland Bay. – Historical temperature from Cleveland Bay recorded by the Australian Institute of Marine Science weather station. Note the very high temperatures in Jan - Feb 1992 when coral bleaching was first observed at Magnetic Island. Data such as this from multiple stations will allow us to more rigorously relate temperature anomalies to ecological events such as bleaching.*



# Raine Island: early European history and use

*Dr David Lawrence*

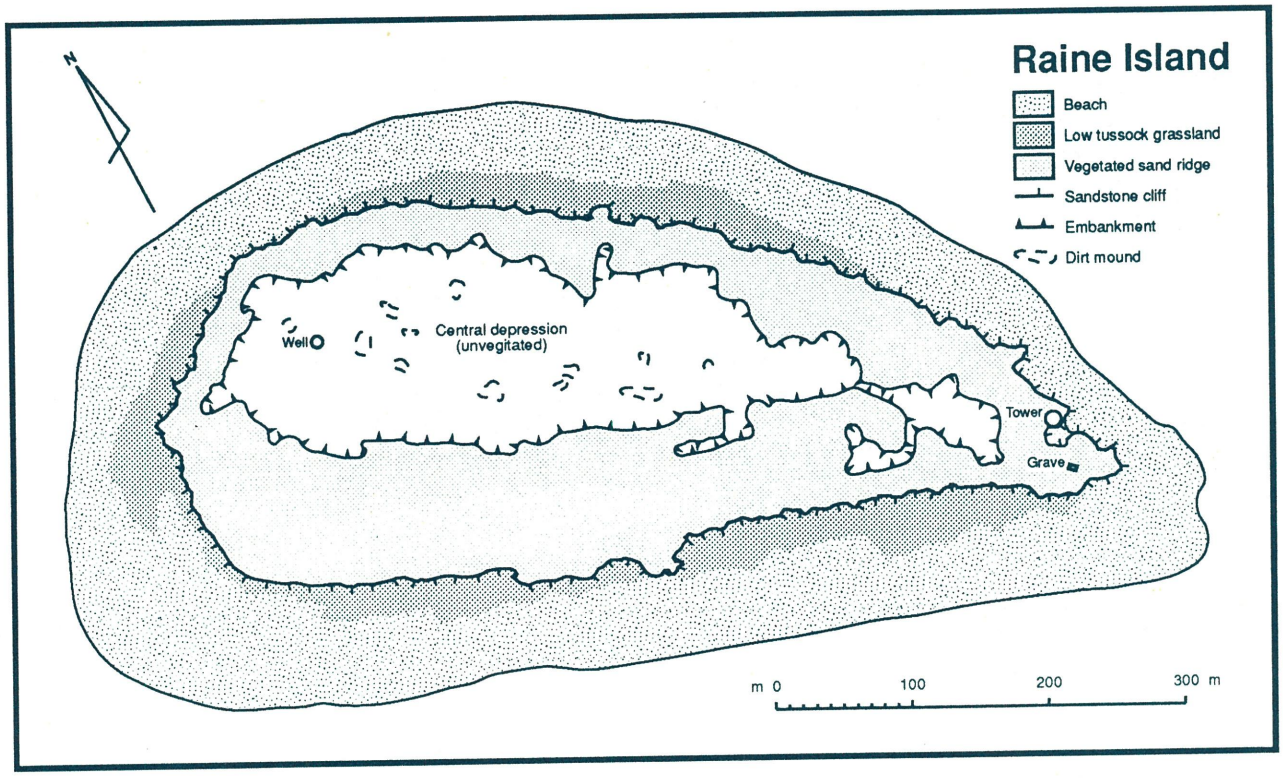
Raine Island, located in the Far Northern Section of the Great Barrier Reef Marine Park, is a declared reserve for Departmental and official purposes under the trusteeship of the Under Secretary of the Department of Family Services and Aboriginal and Islander Affairs. It is also a fauna refuge under the Fauna Conservation and National Parks and Wildlife Acts.

The first recorded European discovery of Raine Island was made in 1815 by Thomas Raine, then acting captain of the convict transport *Surrey* making a return trip to England via China. However the first scientific expedition to the island was not undertaken until 1843 when members of the surveying voyage of the *Fly* and the *Bramble* under the command of Captain Blackwood landed at the island.

Raine Island was used by passing ships during this period as a place to collect turtle, birds' eggs and birds to replenish ship stores. The treacherous waters of the northern GBR, the reefs near Raine Island, claimed many ships. The *Pandora*, wrecked in 1791 and one of Australia's most important historic shipwrecks, lies in Pandora Entrance just to the north of Raine Island and the *Martha Ridgeway* was wrecked 40 kilometres south of the island in 1841.

In 1844 the *Fly* and the *Bramble* returned to the island and landed a party of convicts sent to build a beacon to warn passing ships of the dangerous reefs. The party was under the control of Lt Ince and 19 soldiers. Captain Blackwood had recommended the construction of a beacon although the original plans differ from the completed construction. All equipment used for the construction had to be brought from the transport ships across the reefs by small boat. A quarry was opened at the eastern end of the island and lime made by burning *Tridacna* and *Hippopus* shells. Water, however, had to be brought from the Sir Charles Hardy Islands to the south and timber was obtained from the wreck of the *Martha Ridgeway*.

The beacon was commenced in June and completed by September under difficult conditions. The design by Stephen Moore, carpenter on the *Fly*, was described as a circular tower, 45 feet (13.7 m) high, 30 feet (9.1 m) in diameter at the base with walls 5 feet (1.5 m) thick. It was divided internally into three stories each partially floored in timber, and made accessible by ladders. The roof was made from a dome of timber covered in painted canvas and topped by a black ball 6 feet (1.8 m) in diameter. The beacon was painted in vertical strips, red on the south-east and black on the rest while




the dome was painted white. The beacon with dome was approximately 63 feet (19.2 m) above ground and was visible from 13 miles from the masthead of the ship at sea. A large water tank from the *Martha Ridgeway* was placed to the side to catch rainwater.

The beacon lasted in good condition for only 16 years. In 1860 it was reported that the dome had fallen in. In 1887, the Captain of the *Challenger* reported that the beams and floors had 'gone' and the tank had disintegrated. The ship's plumber was also sent ashore to carve both the name of the ship and the captain into the soft stonework which was becoming covered in graffiti. The disappearance of the dome and the timbers was attributed to the activities of bêche-de-mer fishermen who used the island after the 1870s. The boiling of the holothurians requires fuel and the platforms, timbers and ladders would have been seen as more suitable than the low growing bushes and grasses of the island.

The island was used as a phosphate mine from 1890 to 1892. J.T. Arundel and Company under the management of Albert Ellis employed about 10 Europeans and 100 Chinese labourers to dig for guano. Annie Ellis, the mother of the manager, died, and was buried on the island in 1891.

In this century the island was the subject of some sporadic scientific research. W. Macgillivray, the ornithologist, visited the island in 1910 and 1913. Since then the island has been used for scientific research notably on the turtle and seabird populations.

Small finds uncovered within the tower indicate items of short term usage such as metal boxes (Phoenix Match Co), beer, champagne and gin bottles, as well as metal straps and the remains of beche-de-mer commercial operations. The grave to the southeast of the tower (Annie Eliza Ellis) was restored in 1987 and bears the inscription:

'In Loving Memor of Annie Eliza Wife of George C. Ellis.

Entered Into Rest June 19th 1891 Aged 52 Years.

Her Last Words Were Father! Not My Will But Thine Be Done: My-God-of-Love.

Reader! Be Ye Also Ready.'

Nearby, and to the seaward of the beach rock, numerous well-tumbled ballast bricks

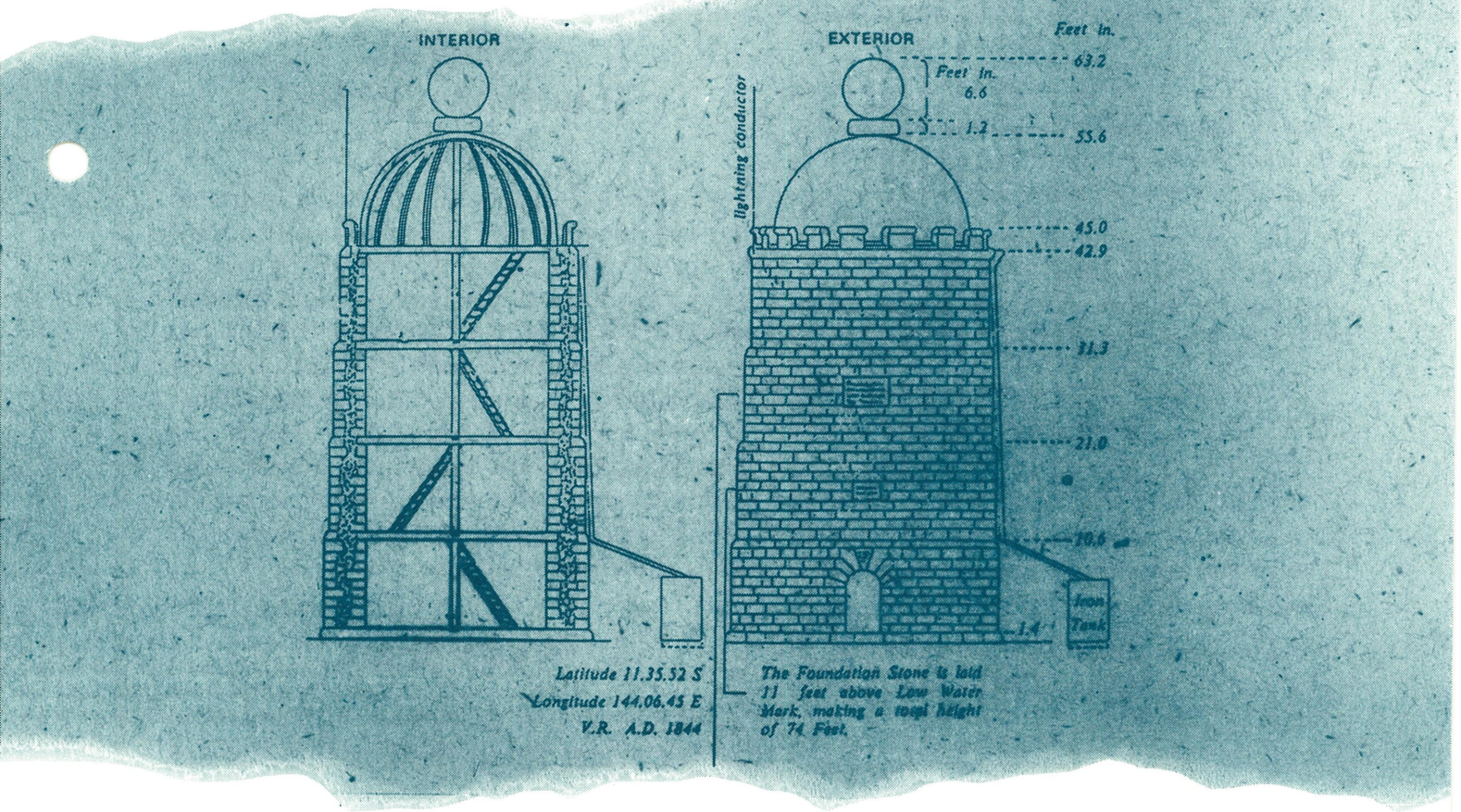
were exposed during periods of strong winds and high tides. As the actual loading of guano was done via a tramway and jetty at the opposite end of the island these bricks may represent remains of some of the two verified shipwrecks to the windward of the island. Also in the area are littered vinegar bottles which may be either the remains of ships' cargo or a more basic requirement of life on an island where turtle and seabirds formed the staple diet for both Europeans and Chinese.

The larger stone-faced depressed structure to the north-west end of the island, presumed to be a water-well, is now thought to be a reservoir for fresh water built by the guano miners, or perhaps a test site for deeper guano deposits. Virtually the whole of the north-western beach side of the island, below the scarp, has been the camping area since 1844 as it offers some protection from the prevailing strong winds. The area is so covered with artefacts that almost any temporary occupation reveals some items of interest.

Nearly 1000 examples of graffiti may be noted in and on the tower. There are approximately 966 recorded entries with 900 being legible. Of these, 53 are symbols, as distinct from initials, leaving a total of 847 names. Almost 9% of the graffiti represent Torres Strait Islander associations such as personal or family names, lugger names, mission vessel names and Papuan names. Other identifiable graffiti include Chinese inscriptions, the names of the HMAS *Gascoyne* visit in November 1961 and other European visits, possibly from private boats. Access to upper levels of the tower may reveal earlier, possibly pre-1870, graffiti.

Historically, Raine Island remains an important place. It is apparent from the above survey that the environment is certainly not pristine. Raine Island has been extensively used and the environment heavily modified. The beacon on Raine Island remains the most important historical monument in the Great Barrier Reef Marine Park.

*This article is based on a paper by David Lawrence (GBRMPA) and John Cornelius (QDEH) presented at the 1991 Raine Island Workshop.*



# COTS COMMS

*Dr Brian Lassig*

## 1992/93 Research Program

The GBRMPA's crown-of-thorns starfish (COTS) research program has moved into a new era. After three years of committed funding of around A$1 million per annum from the Australian Government the crown-of-thorns starfish research program is now less secure and less well endowed. The total research budget (including unspent funds from 1991/92) for this year is $663,000. The advisory committee to the GBRMPA (the Crown-of-thorns Starfish Research Committee - COTSREC) was faced with some very difficult decisions when recommending the program for the year and some of the details have yet to be finalised. The Committee gave priority to continuing projects, particularly those being undertaken by post-graduate students. At this stage the following projects have been approved for funding.

- *Broadscale surveys of the crown-of-thorns starfish and its effects on corals along the Great Barrier Reef* (Australian Institute of Marine Science - AIMS) $232,000
- *The role of predation in factors influencing the survival of small juvenile* Acanthaster planci *cultured in the laboratory* (Dr John Keesing of AIMS) $89,000
- *Reproductive biology of the crown-of-thorns starfish* (Dr Russell Babcock of AIMS) $33,000
- *Investigation of the trophodynamic implications of crown-of-thorns outbreaks* (Dr David Klumpp & Mr Tony Hart of AIMS) $15,000
- *Feeding ecology of the early developmental stages of* Acanthaster planci (Ken Okaji of AIMS) $22,500
- *Monitoring recruitment of* Acanthaster planci *and community changes on Suva Reef and adjacent reefs, S.E.Vitu Levu, Fiji Group* (Dr Leon Zann of GBRMPA) $1,000
- *An integrated study of hard coral regeneration and juvenile crown-of-thorns at Green Island* (Dave Fisk of Reef Research and Information Services) $20,000
- *Feeding studies on potential fish predators of post-settlement* Acanthaster planci (Hugh Sweatman of James Cook University - JCU) $50,000
- Acanthaster *feeding on coral reefs: the implications for bioerosion* (Professor Howard Choat & Ms Barbara Musso of JCU) $15,000
- *Starfish larvae: identification and capture* (Ms Katrina Roper of JCU) $7,000
- *Age determination in* Acanthaster planci (Associate Professor John Lucas & Mr Richard Stump of JCU) $6,900

## Greener (Certainly Colder) Pastures

Reflecting uncertainty over the future of funding for the COTS program and a need for income stability, we are losing two of the program's key scientists. Drs Russell Babcock and John Keesing of AIMS have found permanent employment. As an indication of their desperation in these harsh economic climes - Russ will be lecturing at Auckland University (score NZ at least 1,000; AUS 1) and John is working on abalone with the Research Section of the South Australian Department of Fisheries.

## Swan Song

The new era in the research program is characterised not only by funding changes

and the researcher departures indicated above. Professor John M. Swan, FAA FRACI, Chairman of the Crown-of-thorns Starfish Research Committee (1990-1992) and its predecessor the Crown-of-thorns Starfish Advisory Review Committee (1986-1990), has taken the opportunity of the program's mutation to stand aside from his position. John has been a tireless and enthusiastic campaigner for COTS research but personal commitments are increasingly likely to need his presence in Melbourne. John will be attending the next COTSREC meeting in Townsville in January 1993 with his successor Professor Graham Mitchell RDA BVSc PhD FTS FAA. Graham is the Director of the Royal Melbourne Zoological Gardens.

## Current COTS

The AIMS survey team has just returned from its latest trip to the Cairns Section of the Great Barrier Reef Marine Park. The team manta towed 5 reefs (Green Island, Hastings, Michaelmas, Tongue 1 and Tongue 2) and established long-term study sites at 3 (Green Island, Michaelmas and Hastings). A total of 3 COTS were seen during manta tows but close examination of areas at Green Island and Tongue Reefs using swim searches turned up 27 and 4 respectively.

Coral cover on the surveyed reefs was generally low (<10%) to moderate (<30%) and the number of starfish and coral scarring observed on Green Island Reef highlights the need for continued monitoring of the area.

## Crown-of-thorns Starfish User Surveys

Many thanks to all you reef users for sending in sighting reports for our reef-wide starfish survey. Since June 1992 the Authority's COTS team has received some 70 completed survey forms. The great majority of these

**REEFWATCH**

**Great Barrier Reef Marine Park Authority**

**CROWN-OF-THORNS STARFISH SURVEY**

"Help us to manage the Great Barrier Reef.
Simply complete this assessment for each reef you visit.
During your visit, note the condition of the coral and the presence or absence of crown-of-thorns starfish.
Count all the crown-of-thorns seen on each dive.
The information you provide will help us to follow the progress of the starfish on the Great Barrier Reef.
If you would like more information on the crown-of-thorns just tick the box on the back of this form."
**Zero Sightings : Please note that it is equally important to complete reports for reef visits during which no starfish are sighted.**

1 Name of Reef:.....
(or number from GBRMPA map)
Date of Visit:.....

2 If possible, please sketch a map of the reef in the space provided on the back of this page. Please, show your anchorage.
(You can use your GBRMPA zoning map to help you identify the exact location)

3 How did you examine the reef ?:
Scuba Diving ☐ Snorkelling ☐ Reef Walking ☐
Other :.....

4 How much of the reef did you examine ?:
Most ☐ Several sites ☐ One site ☐
(Mark on your map the site/s examined.)

5 About how long did you examine each dive site ?:

| | hr. | min. |
|---|---|---|
| Site 1 | | |
| Site 2 | | |
| Site 3 | | |

6 What proportion of the corals appears to be dead ?

A recently dead
(ie. corals are white or covered by fuzzy, green algae)

| | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| No dead coral | | | |
| Few < 1/4 | | | |
| Some <1/2 | | | |
| Much < 3/4 | | | |
| Most > 3/4 | | | |

B long dead (ie. corals entirely covered by brown algae)

| | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| No dead coral | | | |
| Few <1/4 | | | |
| Some < 1/2 | | | |
| Much < 3/4 | | | |
| Most > 3/4 | | | |

7 Did you see any Giant Triton Shells ?
Yes ☐ No ☐ if yes, how many ? ☐
anything else of interest ?
(ie. wastes, pollution, algal blooms, other?)
.....
.....
Crown-of-Thorns ? Yes ☐ No ☐

**If NO, please seal and post your survey, thank you for your assistance. If YES, please continue your survey.**

8 How many crown-of-thorns did you see on each site?
Site 1 ☐ Site 2 ☐ Site 3 ☐

9 What depth of water were they in ?
Site 1 ☐ m/ft Site 2 ☐ m/ft. Site 3 ☐ m/ft.

10 Generally, where were the crown-of-thorns seen ?
Hidden under coral ☐
On top of coral ☐
On sand ☐
Other :.....

11 Generally, how were they grouped ?

Clustered together ☐
Uniformly scattered ☐
Single individual ☐
Other :.....

12 How large were the crown-of-thorns starfish ?

Smaller than palm ☐
Size of outstretched hand ☐
Much larger than hand ☐

13 Have you visited this reef before ?
Yes ☐ No ☐ if yes,when ? ☐
Did it have similar numbers of crown-of-thorns ?
Yes ☐ No ☐

14 Other Notes :
Did you see any dead crown-of-thorns starfish ?
Yes ☐ No ☐ if yes, how many ? ☐
Any injured or diseased crown-of-thorns starfish ?
Yes ☐ No ☐ if yes, how many ? ☐
Anything eating crown-of-thorns starfish ?
Yes ☐ No ☐ if yes, what ? ☐
Any juvenile crown-of-thorns starfish ?
Yes ☐ No ☐ if yes, how many ? ☐

**Please seal and post your assessment.**
**Thank you for your assistance.**

*The crown-of-thorns starfish survey*

surveys reported small numbers of crown-of-thorns starfish. However, a few small-scale aggregations of starfish have been seen, particularly on reefs in the Swains complex in the southern parts of the Great Barrier Reef. Where relatively large numbers of starfish were reported, the information was passed on to the reef monitoring team at the Australian Institute of Marine Science. The team will be checking on these sightings during their regular survey trips within the GBR Marine Park. For interested readers who would like to become involved, we have included a copy of the user survey sheet (see previous page). These forms are available from offices of the Queensland Department of Environment and Heritage (QDEH) or directly from the Great Barrier Reef Marine Park Authority (GBRMPA) in Townsville. On your next trip to the reef, why not take a couple of these forms along and let us know what you've seen. Please note that it is equally important to complete reports for reef visits during which no starfish were sighted. Your efforts are very much appreciated.

If you require more information on this scheme please do not hesitate to contact the COTS team members Brian Lassig or Udo Engelhardt.

## Latest Research Reports

The GBRMPA recently received two final reports for research projects funded in response to recommendations made by COTSREC. Brief summaries of the main findings of these studies follow. Copies of the reports are available from the Authority.

*Assessment of the utility of mitochondrial DNA as a genetic marker in crown-of-thorns starfish* (A. planci).

Researcher: *Dr John Benzie (Australian Institute of Marine Science, Townsville)*

Previous studies into genetic differentiation among populations of crown-of-thorns starfish have often suffered from difficulties in obtaining sufficiently large sample sizes in order to detect the relatively small variations in gene frequency among outbreaking populations of *A. planci* (Benzie & Stoddart 1992). As a result, investigations into alternative methods e.g. into the utility of other genetic markers, were considered potentially useful. Identification of existing genetic variations among starfish populations could provide further insights into both the origins and subsequent spread of starfish outbreaks.

In this study, mitochondrial DNA (mtDNA) was tested for its utility in detecting genetic differentiation among populations of COTS. Previously, stock assessment studies on other types of organisms have shown the usefulness of mtDNA restriction fragment length polymorphism (RFLP) analysis (Hallerman & Beckman 1988). On theoretical grounds, the greater levels of genetic variation that exist in mtDNA as well as its maternal inheritance make mtDNA a potentially useful tool for identifying differentiation among small populations of COTS.

The research report by Dr Benzie summarises the findings of a small pilot study that aimed to establish methodologies for the extraction of mtDNA from crown-of-thorns starfish and to assess its utility as a genetic marker in *Acanthaster*.

The routine extraction of mtDNA from *A. planci* was made impossible by the activities of a strong nuclease found in its tissues. Nuclease activity was identified in a variety of different tissue types, including ovaries and spawned eggs. Benzie concluded that as a result of the nuclease's activity, the routine extraction of mtDNA from single individuals of *A. planci* is impractical. However, some mtDNA gene fragments were successfully amplified using standard procedures.

In contrast, extraction of total DNA was generally successful. Standard procedures produced high molecular weight DNA that

would be suitable to (*a*) cut using restriction enzymes and (*b*) probe with cloned *A. planci* mtDNA once available.

Dr Benzie draws the following conclusions from this pilot study:

1. Methods of assaying mtDNA variation such as end-labelling that rely on the routine extraction of mtDNA from individual samples are impractical.

2. The development of mtDNA or nuclear markers is promising where these rely on total DNA extraction and the use of either cloned probes or assaying variation from Polymerase Chain Reaction (PCR) amplified fragments.

This study has also demonstrated two key requirements for further developments:

1. That the extraction of DNA of suitable quality from the frozen collections of pyloric caecae from previous surveys can be achieved.

2. mtDNA gene fragments from these can be amplified and cut with restriction enzymes.

Although the extent of variation has to be assessed, basic approaches have been identified that could provide markers to trace dispersal patterns in *A. planci*. Frozen collections made for the protein surveys could be utilised to define patterns of dispersal at the height of the outbreak and allow a direct comparison with previous work and with the present day situation.

Benzie, J.A.H. & Stoddart, J.A. (1992) Mar. Biol. 112:119-130

Hallerman, E.M. & Beckman, J.S. (1988) Can. J. Fish. Aquatic Sci. 45:1075-1087

*Assessment of the role of dissolved organic matter and bacteria in the nutrition of crown-of-thorns starfish larvae.*

Researchers: *Dr T Ayukai (AIMS) & Dr O Hoegh-Guldberg (University of Sydney)*

The availability of energy and nutrient resources undoubtedly affects the entire larval cycle - growth, development, dispersal, survival and eventual recruitment - of crown-of-thorns starfish *Acanthaster planci*. Therefore, it can have a strong impact on the size of the adult population of *Acanthaster planci*. As yet, information on the nutrition of *A. planci* larvae is meagre and incomplete.

Phytoplankton are traditionally regarded as the major nutrient resource for *A. planci* larvae (Lucas 1982). A growing body of evidence shows the possibility of two other nutrient resources available to *A. planci* larvae - bacteria and dissolved organic matter (DOM). This study primarily aims to assess the role of these 'non-conventional' nutrient resources available to *A. planci* larvae and complements the earlier study on herbivory (Lucas 1982).

Laboratory experiments as well as a preliminary survey of DOM levels in the field were conducted in this study to quantify utilisation of bacteria and DOM by *Acanthaster planci* larvae. Key results were:

1. Heterotrophic bacteria (< 0.8 µm fraction) were not ingested by larvae in the present experiments, although utilisation of colony-forming and particle-associated bacteria remains to be investigated.

2. Larvae were able to ingest two strains of photosynthetic cyanobacteria (approx. 1-2 µm in diameter). The clearance rates (volume of water cleared per animal per time) on these small phytoplankton, however, were more than one order of magnitude lower than those on larger ones (approx. 5 µm in diameter).

3. Larvae were able to take up both the amino acid alanine, and the sugar glucose. The uptake of glucose, however, was relatively low and appears unlikely to make a significant energy contribution to the metabolism and growth of larvae.

The potential carbon intake of larvae from suspension feeding and transepidermic uptake was estimated based on the kinetic parameters obtained in this study and the preliminary data on the ambient concentrations of phytoplankton and

dissolved free amino acids (DFAA). As shown in the table below, it was then compared with the metabolic requirements of larvae.

| Stage | Resource | Ambient concentration [1] | Carbon intake ngC ind-1h-1 | % of metabolic requirements |
|---|---|---|---|---|
| Bipinnaria | Phytoplankton | 9.3 - 18 | 1.07 - 1.66 [2] | 46.7 - 72.5 |
| | DFAA | trace - 174 | 0 - 0.32 | 0 - 14.0 |
| Brachiolaria | Phytoplankton | 9.3 - 18 | 1.16 - 3.52 [2] | 14.6 - 44.3 |
| | DFAA | trace - 174 | 0 - 0.75 | 0 - 0.94 |

[1] Phytoplankton: µmC 1-1, and DFAA: nM.
[2] Phytoplankton were divided into three classes (cyanobacteria and eucaryotic algae of 1-3 µm and > 3 µm fractions). For each class, the carbon intake rate was estimated by multiplying the measured clearance rate by carbon concentration.

The estimated percentage contributions of phytoplankton and DFAA to the metabolic requirements of larvae should be regarded as approximate values, largely because the temporal and spatial variabilities of these two resources in the GBR have not been resolved. Nevertheless, this table clearly shows that the growth and development of larvae are likely to be limited by the availability of these nutrient resources. DFAA do not balance the energy budget of larvae, but are still of significance as a nutrient resource in nitrogen-limited environments typical in the tropics.

Olson (1985, 1987) has suggested that based on the results of *in situ* rearing experiments that larval starvation is unlikely to occur in the GBR and therefore is not important in explaining the fluctuation in the recruitment of *A. planci*. Results of this study contradict Olson's findings. A re-examination of the nutrition of *A. planci* larvae is recommended to fully resolve the temporal and spatial variabilities in availability of nutrient resources, particularly of phytoplankton and DFAA. Considering that there is some concern over the eutrophication of GBR waters, it is imperative to incorporate this objective into the long-term strategic plan for the management of the water quality in the GBR.

Lucas, J.S. (1982) Quantitative studies of feeding and nutrition during larval development of the coral reef asteroid *Acanthaster planci* (L.). J. Exp. Mar. Biol. Ecol. 68:53-58

Olson, R.R. (1985) *In situ* culturing of larvae of the crown-of-thorns starfish, *Acanthaster planci* (L.). Mar. Ecol. Prog. Ser. 25:207-210

Olson, R.R. (1987) *In situ* culturing as a test of the larval starvation hypothesis for the crown-of-thorns starfish, *Acanthaster planci*. Limnol. Oceanogr. 32:895-904

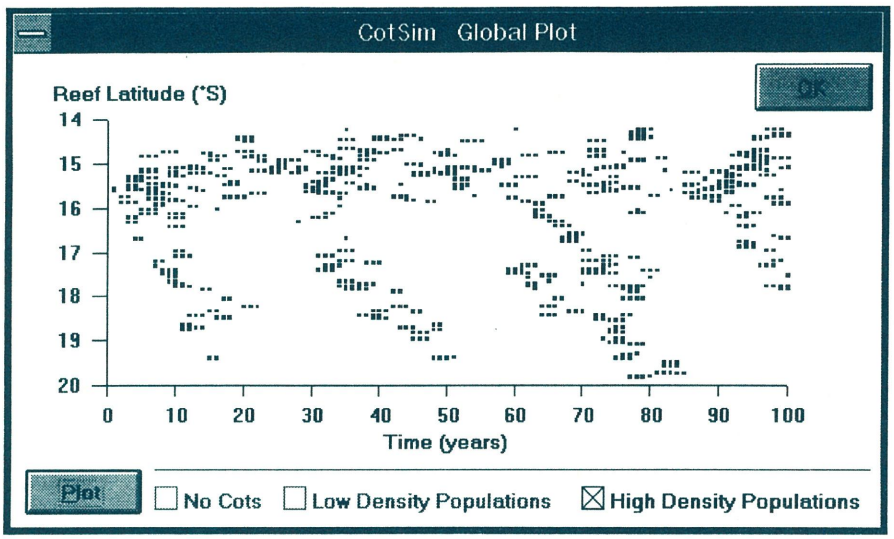
## Starfish Outbreak Hits UK!

Ever vigilent for parallels and parables, John Swan recently sent me an article from the September 1992 BBC Wildlife magazine. The article was a letter to the editor from a diver who had noted thousands of the common starfish *(Asterias rubens)* feeding on a large mussel bed. Apparently *A. rubens* occasionally occurs in immense aggregations - one in 1969 measuring 1.5km by 15km, representing several thousand tonnes of starfish. High (19°C) water temperatures contributing to successful breeding seasons of the predator and subsequently to the prey are thought to be responsible for the swarms.

## Computerised COTS

*by James Scandol, James Cook University*

As part of my research into the role of population models in *Acanthaster* management I have written a computer program for use by GBR students, scientists and managers. The program is called *CotSim* (Crown-of-thorns Simulation) and is a graphical program running under Windows 3.x on IBM compatible personal computers.




*Sample of a CotSim graph*

I have distributed *CotSim* to several institutions (listed at the bottom of this article) for evaluation. It will be available only until the end of 1992. It is hoped that interested people will find the time to have a look at *CotSim* (minimum of about half an hour). Full documentation of the system is provided. A survey is also distributed with *CotSim* for users to complete. The survey results will then be compiled so that the response to the system can be evaluated. Suggestions for modifications may also be incorporated into future versions of *CotSim*. There is little doubt that half an hour spent with *CotSim* would yield far more information and understanding of the large scale population dynamics of *Acanthaster* on the GBR than would the equivalent amount of time spent reading a paper on the subject. I would also suggest that the former process would be far more enjoyable.

The motivation for the *CotSim* project is to experiment with communication channels between the modellers and experimental scientists of the *Acanthaster* phenomenon. Rather than just static graphs of results, *CotSim* generates dynamic images of *Acanthaster* and coral dynamics. All of the model parameters and many of the processes are defined by the user, so people should not feel constricted by the model's structure. I have put considerable thought into the interface design so that users can extract large amounts of information very quickly and, dare I say, in an intuitive fashion.

For people who are not so involved in *Acanthaster* research, *CotSim* provides a generic model for appreciating large scale population dynamics on the Great Barrier Reef. It is the only multi reef population model that is easy to use and evaluate and that integrates oceanographic studies of the GBR with life history processes.

Simulation models are, and will continue to be, an important mechanism to explore data, processes and ideas. *CotSim* is the first model of GBR population dynamics to exploit gaming-simulation as suggested by adaptive management programs (Walters 1986). The *CotSim* user survey has been designed to extract information from people about the role of these sorts of models in science and management. If the survey return rate is very low it will be difficult to draw conclusions.

*CotSim* has been installed at the Australian Institute of Marine Science, Great Barrier Reef Marine Park Authority, James Cook University (Zoology, Marine Biology, Civil & Systems Engineering), University of Queensland (Dept of Zoology), University of Guam (Marine Laboratory), South Australian Department of Fisheries, The University of Sydney (School of Biological Sciences) and The University of New England (School of Resource Science and Management). If you have any queries or comments about the *CotSim* project please contact me.

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Walters, C. (1986) *Adaptive Management of Renewable Resources* Macmillan, New York.

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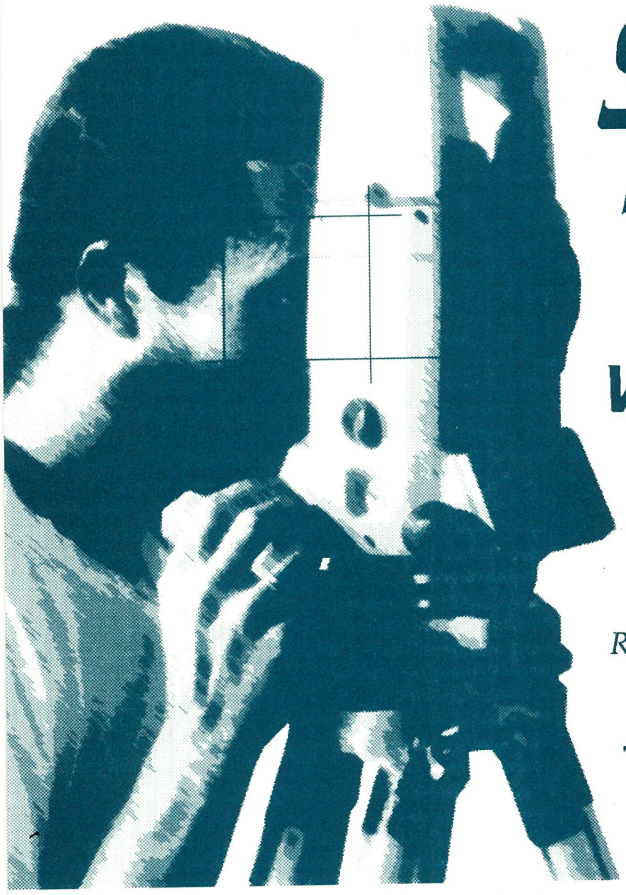

# Surveying The Reef:

## Volume Determination and Nutrient Enhancement at One Tree Island

*Rob McGill and Tony McKenna*

**The ENCORE[1] Project, based at One Tree Island in the Capricorn-Bunker Group, is designed to evaluate the effects of nutrient enrichment on a range of coral reef biota. The experiment will partition the effects of nitrogen (15 μM) and phosphorus (2 μM) separately and combined, using as sample units 12 patch reefs ('micro atolls') within the main lagoon. These fully enclosed structures vary from 12 m to 30 m in diameter, with depths of around 1 m. While water is ponded daily at low tides, measured amounts of potassium dihydrogen phosphate ($KH_2PO_4$) and/or ammonium chloride ($NH_4Cl$) will be delivered into the centre of each micro atoll subject to treatment, and the responses of organisms will be analysed. As the period during which water is ponded is quite short (around 4 hours at each low tide), automated Nutrient Dispersal Units (NDUs) have been designed and constructed to ensure the simultaneous fertilisation of all test micro atolls. One of these computer-controlled units will be moored outside each patch reef, and will be linked to the experimental area by a nutrient dispersal line.**

As the micro atolls differ in size, it has been essential to accurately determine the volume of each reef to ensure that the correct amounts of nutrient are added. These volume figures will allow the dilution rates and final concentrations of nutrients to be considered on an individual basis. Very basic calculations had been performed using formulas for cylindrical and cubic volumes, but these were clearly inadequate for reefal structures of varying size and asymmetrical shape. To provide more reliable figures, computerised surveying equipment (a TOPCON GTS - 6 'Total Station') was taken to One Tree Island in August/September of 1992, and this enabled the sighting and recording of the internal dimensions of each micro atoll. While this unit is capable of measurements within 10 mm over a distance of 3 kilometres, our utilisation was at distances of less than 40 m, well within the capabilities of the equipment.

While the patch reef tops were exposed at low tide, a series of points (approximately

1 m apart) were sighted along the internal top and bottom edges of the rim, and on the floor of each micro atoll (see figure 1). With one person operating the instrument, and another moving a sighting staff, measurement of each reef structure took between 20 and 120 minutes. Data was down-loaded daily at One Tree Island Field Station, and later processed at Parkes Instruments in Townsville. Total internal volumes and contoured graphics of all the micro atolls that will be used in the study have now been produced using surveying analysis software (see figure 2), and calculated volumes indicate a range of sizes from 27 $m^3$ to 322 $m^3$. These figures will enable customisation of individual NDUs, reducing the number of trial and error nutrient additions required to achieve accurate nutrient concentrations within each micro atoll.

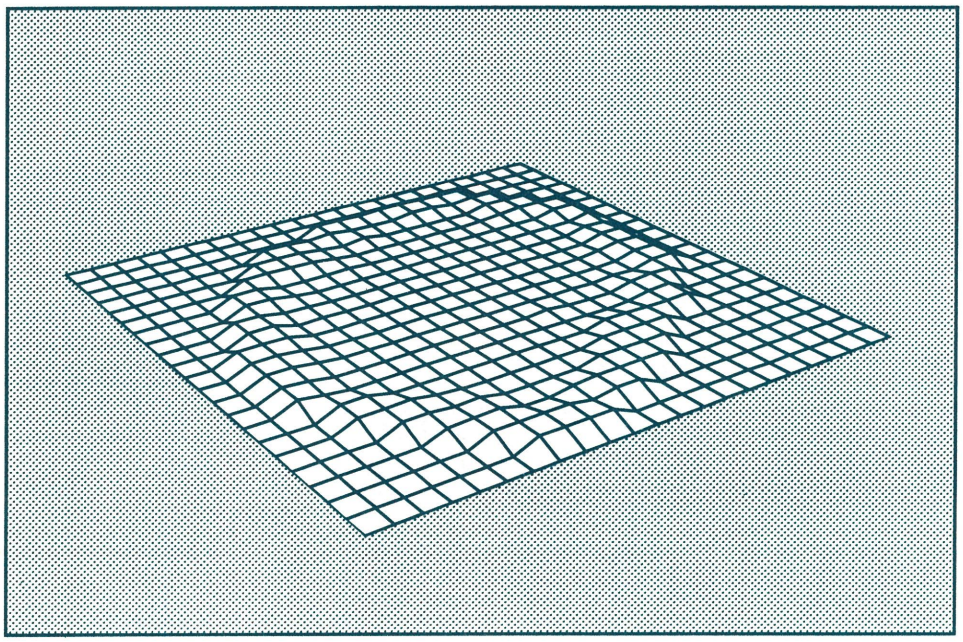

*Figure 2. Contoured graphic of a representative micro atoll, as generated from surveyed data*

Although this technology has been available for some time (it is usually employed in civil engineering fields), it has rarely been used in marine situations. The operation of the 'Total Station' at One Tree Island perhaps illustrates an increasing awareness of surveying and Computer Aided Drawing (CAD) techniques as they can be applied in the field of marine research.

[1] For a complete description of the ENCORE project, indicating location, history and experimental design, see *Reef Research* Volume 2 No. 1, March 1992, pages 6 - 7.

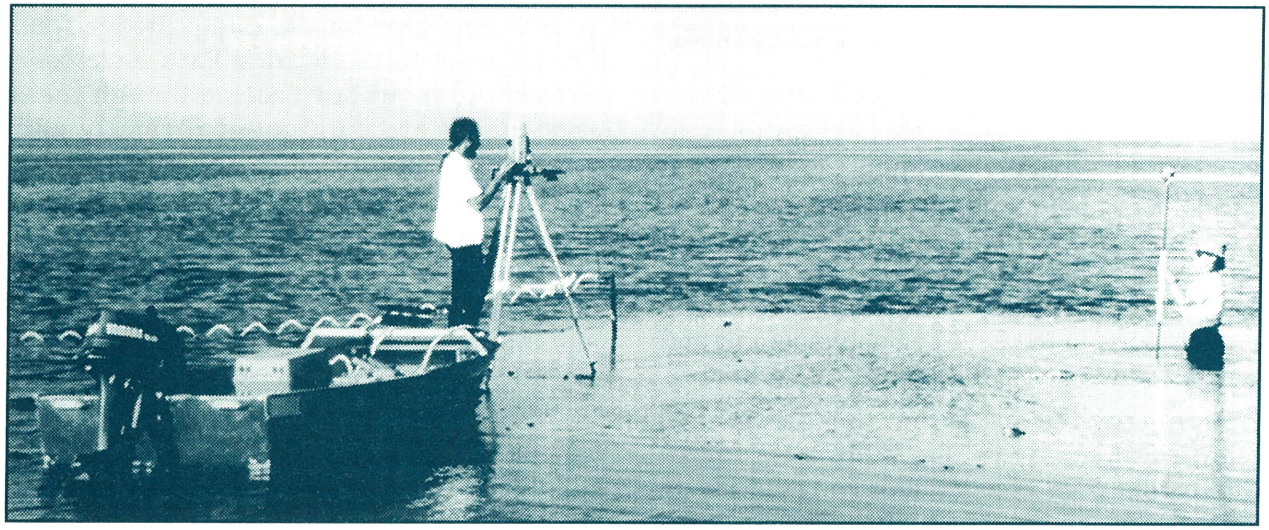

*Figure 1. Surveying the internal dimensions of a micro atoll at One Tree Island*

# GBRMPA DEVELOPS POLICY ON SEA DUMPING OF DREDGE SPOIL IN THE GREAT BARRIER REEF MARINE PARK

*Steve Raaymakers*

It is necessary for most Queensland ports to undertake dredging operations from time to time either as part of developmental works or to maintain navigable depth. Cairns and Townsville are the two main ports that undertake regular annual maintenance dredging. Dredging at other ports in the GBR Region is sporadic and generally involves small quantities of material.

Traditionally the spoil from this dredging is dumped at sea, with the dump sites for all Queensland ports except Cairns lying outside of, but adjacent to, the Great Barrier Reef Marine Park. The Cairns dump site lies within the Marine Park.

## Potential Impacts

The dumping of dredge spoil has the potential to cause impacts on the marine environment. These impacts include; smothering of part of the marine biosphere and physical disturbance to the marine substrate and its biological communities, increased water turbidity which can cause impacts on ecosystems such as coral reefs through light attenuation and increased sedimentation, release of contaminants contained in the dredge spoil causing tainting of commercial fishery species and impacts on the amenity value of beaches and other areas through loss of water clarity and deposition of muds and silts.

## Legislation And Regulation

Sea dumping inside the Great Barrier Reef Marine Park is regulated by GBRMPA through both the *Great Barrier Reef Marine Park Act 1975* and the *Environment Protection (Sea Dumping) Act 1981*. Sea dumping outside of the Marine Park is regulated by the Commonwealth Environment Protection Agency through the Environment Protection (Sea Dumping) Act. This Act implements the London Dumping Convention in Australia.

Permits are required under both Acts for sea dumping in the Marine Park and both Acts provide comprehensive guidelines for assessing permit applications and implementing permit conditions to manage and monitor any permitted dumping. The permit application assessment process involves consultation with relevant government and non-government bodies.

## Need For A Policy

Up until now proposals to dump dredge spoil in or adjacent to the Marine Park have been assessed on an ad hoc basis, although these assessments are conducted formally and thoroughly according to the requirements of the relevant legislation.

There is a current trend of development and expansion of Queensland ports, with Cairns port having undertaken a significant widening of its shipping channel in 1990; Townsville port currently undergoing a substantial expansion including deepening and lengthening of its shipping channel; Gladstone port planning a series of large scale developments over the next five years; and development plans on the drawing board for smaller single-product ports such as Hay Point, Abbot Point and Lucinda.

All of these developments involve substantial increases in dredging activity both during the actual development as well as during ongoing maintenance. The spoil from this dredging needs to be disposed of in some manner and the developments may involve proposals to dump the spoil within the Great Barrier Reef Marine Park.

Given the potential impacts of sea dumping of dredge spoil GBRMPA is seeking to reduce the use of the Marine Park as a disposal ground for dredge spoil. In response to increasing port developments in the GBR Region it has therefore been necessary to become proactive and develop an overall policy, rather than treating each proposal on an ad hoc basis. This policy seeks to prevent impacts on the Marine Park while recognising that port activities are vital to Queensland's and Australia's economy. Such an approach is consistent with the Goal and the following Aims of GBRMPA:

**Goal.**

'To provide for the protection, wise use, understanding and enjoyment of the Great Barrier Reef in perpetuity through the care and development of the Great Barrier Reef Marine Park'.

**Relevant Aims**

'To protect the natural qualities of the Great Barrier Reef, while providing for reasonable use of the Reef Region'.

'To provide for economic development consistent with meeting the goal and other aims of the Authority'.

'To minimise regulation of, and interference in, human activities, consistent with meeting the goal and other aims of the Authority'.

## The Policy

In developing its policy on sea dumping, GBRMPA has remained consistent with trends developing in the international community through the London Dumping Convention and with the Commonwealth Government's new National Waste Minimisation Strategy. These trends are towards the concept of the three Rs - Reduce, Reuse and Recycle.

In simple terms, the GBRMPA policy on sea dumping of dredge spoil in the Great Barrier Reef Marine Park requires the following:

- all opportunities to reduce or eliminate the production of dredge spoil are to be investigated and adopted if feasible.
- all productive uses of the dredge spoil, including reusing or recycling the material, are to be investigated and adopted if feasible.
- if no productive uses exist then all non-sea dumping disposal options are to be investigated and adopted if feasible.
- sea dumping is only to be considered as a last option and then in the light of a comparative environmental risk assessment involving all options.
- all relevant requirements of the Great Barrier Reef Marine Park Act, Regulations and Zoning Plans, and the Environment Protection (Sea Dumping) Act, are to be met.

This policy will apply to all new proposals to dump dredge spoil in the Marine Park as well as the current Marine Park dumping by the Cairns Port Authority. The Cairns Port Authority is currently undertaking a study of alternative spoil disposal options which is addressing the requirements of the new GBRMPA policy, and this study is now well advanced.

As dumping outside of the Marine Park is not subject to the GBRMPA policy, GBRMPA is working closely with the Commonwealth Environment Protection Agency to ensure that management of sea dumping within the Region but outside of the Marine Park is conducted in a consistent manner. As a result, the Townsville Port Authority, which currently dumps dredge spoil in Cleveland Bay, is developing a Long Term Dredge Spoil Disposal Strategy that addresses the requirements of the GBRMPA policy.

## Queensland Legislation

Queensland has developed sea dumping legislation and has applied to the Commonwealth Government for the Environment Protection (Sea Dumping) Act to be 'rolled back' in Queensland and replaced with the State legislation. Once this roll-back occurs sea dumping within Queensland State waters will be regulated by the *Queensland Marine (Sea Dumping) Act 1985* and GBRMPA will be working with the Queensland Government to ensure that this is consistent with management of sea dumping within the Great Barrier Reef Marine Park.

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# CORAL and MINERAL SAND SOURCES in the GREAT BARRIER REEF REGION

*M.C.G. Mabin*
*Department of Geography*
*James Cook University.*

For many years there has been a steady demand for small quantities of coral sand from the Great Barrier Reef (GBR) region. In more recent times there has been demand for much larger volumes of this material, and in addition a growing demand for even larger quantities of other mineral sands. Under the terms of the *Great Barrier Reef Marine Park Act 1975*, carbonate, silica and quartzose sediments (i.e. coral and mineral sands), if collected in large quantities or for commercial purposes are classed as minerals. Section 38 of the Act prohibits operations for the recovery of minerals within the Marine Park, except for small quantities collected by hand for non-commercial purposes. Given the continuing and increasing demand for coral and mineral sands there is a need to establish likely sources, and the Department of Geography, James Cook University has recently conducted a field survey to identify potential sources of these sediments that may occur within the GBR region but outside the Marine Park (GBRMP).

Carbonate, silica and quartzose sands are sought for a variety of purposes. Hobby aquarists in north Queensland have for many years collected small quantities of coral sand from the GBR. Retailers also supply sand for this market, and current demand is for about 7.5 tonnes annually. In recent years commercial aquarium operators have also sought large quantities of carbonate sediment. The Great Barrier Reef Marine Wonderland in Townsville, and the National Aquarium in Canberra each required about 300 tonnes of coral sand. Tourist operators in the Whitsunday Islands have sought large volumes of coral sand to renourish or create resort beaches. They have also considered white silica sand as an alternative to coral sand. Queensland Department of Environment and Heritage assesses this demand at about 60,000 tonnes. Quartzose sands are being sought to renourish numerous eroding beaches along the mainland coast. The Queensland Coastal Protection Unit assesses current needs at about 750,000 tonnes with an annual maintenance of more than 15,000 tonnes. These demands for coral and mineral sands have led the Great Barrier Reef Marine Park Authority to identify this as an area of resource management concern in its recent 25 year Strategic Plan draft document.

The field survey of coral and mineral sand sources investigated coastal and island sites outside the GBRMP between Mossman and Sarina and offshore in the Coral Sea Islands Territories (Flinders and Holmes Reefs). Information was also obtained from the literature on sites from Cape Flattery in the north to Moreton Bay in the South. As approximately 50% of the mainland coastline of the GBR Region lies within the GBRMP, potential sources of carbonate, silica and quartzose sands are of very limited extent. Indeed, the level of protection afforded to the GBRMP under the terms of its Act, places considerable pressure on adjoining areas, particularly as it is possible that the most environmentally sound sources of sand may well occur within the Park boundaries.

Coral sands with characteristics suitable for use in the marine aquaria trade were not found in commercial quantities in the primary field survey areas along the GBR region coastline. The only sources of suitable carbonate sands occur well outside the GBR Region on coral cays in the Holmes and Flinders reefs situated in the Coral Sea 330 and 240 km north-east of

Townsville. Combined sustainable yield is estimated to be about 115 tonnes annually. However, due to their distance offshore these sites are presently of marginal commercial viability. An alternative but expensive source of supply may be obtainable from the coral dredging operations in Moreton Bay, although this would need to be washed, crushed, graded and transported to the north Queensland demand areas. In addition, shell-grit from Hervey Bay or Broad Sound may be considered as a cheap alternative to coral sand, but this is not the preferred material of North Queensland aquarists.

White silica sands occur in several locations along the Queensland coastline, however these deposits consist of sand too fine to be useful for beach amenity or renourishment purposes. Furthermore, the introduction of silica or quartzose sand into the predominantly carbonate sediment environments of the Whitsunday resort beaches may have unacceptable impacts on nearby fringing reefs. Potential sources of quartzose sands suitable for beach renourishment purposes occur in a number of onshore and offshore environments between Cairns and Gladstone. There is now, and will continue to be a major demand for this material. However, more detailed analyses are required to fully assess both the suitability of the borrow-sands to renourish each particular beach, and the ability of the source area to withstand the removal of the sand.

This study has demonstrated that there are and will be continuing difficulties in satisfying demand for large volumes of coral sand from the GBR region although small scale non-commercial collection should remain viable. Demand for large volumes of mineral sands will undoubtedly increase, and although a number of potential sources outside the Marine Park do occur, further detailed site studies will be required. If collection of coral or mineral sands in large quantities, or for commercial purposes were to be allowed in the GBRMP, then an amendment to the Great Barrier Reef Marine Park Act would be required, and this is likely to be difficult to achieve.

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In this edition of Slick Talk we present an update on oil spill news from the Northern Territory (NT), provided by Dr Janice Warren of the Conservation Commisssion of the Northern Territory (CCNT). Janice is the nominated Scientific Support Coordinator (SSC) for oil spill response in NT and also works on a wide range of marine management and environmental policy issues.

It is hoped that this contribution to Slick Talk marks the beginning of regular updates from the SSCs in all States; many thanks to Janice for being the first cab off the rank.

## NT Coastal Resources Atlas

CCNT is currently upgrading its compendium of significant natural resources and human activities in the coastal zone of the NT, the NT Coastal Resources Atlas (CRA). Data include the nature of the coastal environment including biota (birds, crocodiles, dugong, turtles, corals and other fauna, mangroves, seagrasses and other vegetation); fossils and geomorphology (cliffs, rock platforms, coral reefs, sandy or muddy shores, dunes); recreational uses (fishing, diving, camping) and commercial uses (fishing, crabbing and prawning, aquaculture, mining, power-generation); areas with active research and education programs; and areas of cultural importance (Aboriginal, Macassan, World War II, Cyclone Tracy, shipwrecks).

In its present (1987) form, the CRA is comprised of three different volumes:

(1) MAPS: 66 x 1:100 000 or 1:50 000 scale topographic maps to which numbered resource symbols have been attached;

(2) SITE RECORD SHEETS: Descriptive information indicating precise location and significance of particular resources or uses and linked to the maps by codes relating to particular numbered symbols; and

(3) REFERENCE VOLUME: List of published and unpublished reports providing data for the CRA.

Because this paper-based system is awkward to reproduce and update, the CRA is currently being upgraded to a Geographic Information System (GIS) linked with descriptive database. This will allow users to select precisely those resources and areas desired for printing maps and accompanying reports.

Another significant advance will be site-specific information relating to vulnerability to damage by oil and chemical dispersants; priority for protection and clean-up; and detailed information on recommended, acceptable and unacceptable methods for clean-up. Because oil-spill contingency planning requires up-to-date coastal resources information, the Marine Environment Protection Unit of the Australian Maritime Safety Authority has provided funding for a substantial component of the project: development of a 'user-friendly' front-end to the complex GIS used by the CCNT (Arc/Info). This front-end, being developed by the GIS Section of the Victorian Institute of Marine Science, will also interface with the descriptive database developed by the NT Government Computing Service (NCOM).

In addition to providing essential information for oil-spill contingency planning the CRA is a valuable tool for a range of other environmental management issues, including environmental impact assessment. The target for completion of the project is during the first quarter of 1993.

## Diesel Spill From Prawn Trawler At Nhulunbuy

At approximately 6 p.m. on Saturday 3 October, a prawn trawler The Communicator went aground on rocks just 300 m off Town Beach, Nhulunbuy (Gove). The freezer compartment was breached and flooded, but none of the 6 diesel tanks were punctured; however after tides and currents on 6 October caused the vessel to resettle at a 45° angle on its starboard side, diesel began to escape through the submerged breather pipes in two of the diesel tanks.

An estimated 2,000 to 4,000 litres of diesel are thought to have escaped before all four breathers on the starboard side were plugged to prevent further release.

The resulting slick washed up on 3 km of the adjacent sandy beach, but the only ill-effects detected on the following day was a very strong diesel smell on the beach and in the town of Nhulunbuy. By the next morning (8 October) there was no trace of fumes or sheen on the beach or rock outcrops. A very thin slick (characterised by light, silvery sheen) was seen between the vessel and Town Beach, but no oily sheen or smell was detected in the sand, washed up seaweed and seagrass, or in rock pools. The light slick probably resulted from diesel leaching from the saturated absorbent boom placed around the stern of the vessel shortly after the initial diesel leak occurred.

By 9 October, the strong winds and high temperatures assisted in dissipating the remainder of the slick and other traces of diesel.

Prompt action by the salvage company and the Environmental Officer (Mr Tom Ryffel) for NABALCO (the aluminium plant at Nhulunbuy) minimised the escape of fuel into the marine environment. Further, similar to the situation with the Kirki spill off Western Australia last year, climatic conditions and the nature of the location of the spill minimised the threat of severe environmental damage. Firstly, Town Beach is a fairly exposed sandy beach and therefore of much lower biological vulnerability than mangroves and mudflats. Had a heavier fuel been spilled, damage would have been greater, but sandy beaches are easier to clean than tidal forests and tidal mud flats. Secondly, high temperatures, a 0.5 m swell and strong winds assisted in the dissipation of the slick and its associated noxious fumes. Also, two tidal creeks of Town Beach (one having mangroves) are closed to the sea during the dry season, when the mouths become heavily silted; therefore, the wetland flora and fauna in these areas were protected from impact.

This incident highlights the need for site-specific oil spill contingency plans to be prepared, especially in the areas of high risk. Tom Ryffel has already prepared a contingency plan for Melville Bay, that area most at risk from a spill at the NABALCO plant or its wharves; however, because of the mangrove creeks, turtle nesting beaches, and other vulnerable habitats along the coasts and islands east of Nhulunbuy, plans need to be made for these areas as well and necessary oil-spill management equipment and chemicals stockpiled at an appropriate site.

As Nhulunbuy is heavily used by ships serving NABALCO and fishing vessels, it is considered to be the next priority after completion of the Darwin Harbour plan.

*Dr Janice Warren*
Conservation Commission
of the Northern Territory