NEWSLETTER OF THE RESEARCH AND MONITORING SECTION

REEF RESEARCH

Great Barrier Reef Marine Park Authority

VOLUME 5 – No. 4 DECEMBER 1995

Editorial

Monitoring, mapping, corals stoic enough to live in Darwin Harbour and a look back at twenty years of research in the Great Barrier Reef region all receive consideration in the following pages. The Chairperson, Ian McPhail, draws timely attention to the progress that has been made in the cooperative arrangements that have developed both between the individual research establishments and between those establishments and the Marine Park Authority. I take this opportunity to consider some of the changes that have taken place in research arrangements in the eight or so years that I have been with the Authority.

At the time of my arrival, research priorities were largely implicit and often driven by the proposals that were put up for our consideration by the researchers themselves. Out of the proposals that arrived, those that seemed the most likely to address perceived needs were those that were funded. Considerable funds were, at the time, provided for reductionist research whereby the whole was to be determined by examination of the parts. Much of the research had limited management application. A whole host of specious 'management implications' could be gleaned from the proposals if one had the temerity to do so.

Changes were, however, in the wind. There was a much greater demand for research work to be truly management oriented and this made it imperative that the Authority think more clearly about the end products that it needed. Frameworks were set for 'needs driven' research programs and much more consultation between managers and scientists was necessary to commission work that would achieve the desired results. Scientists had to take a management perspective and managers consider the scientific difficulties that were inherent in answering many of their questions. Time-frames had to be matched, the scientific sensibility of even trying to answer some of the questions had to be assessed, the mix of reductionist and holistic work was considered, and, most importantly, talk at cross-purposes became less and less frequent. Further improvements in research program design became apparent as major streams of research, were formally established within the Authority. The latest forum for cooperation that has been established is the CRC Reef Research Centre and is proving highly successful. Whether this would be the case without the efforts (and some pain) of previous years will always remain a moot point.

I believe that the last eight years have seen a quantum leap in the mutual appreciation of the needs and abilities of the management and scientific communities. I also believe that the large number of successful projects, at differing temporal and spatial scales, have given managers and scientists the confidence that not only do they have the technical competence necessary for the work, but also the knowledge that the combination of skills they bring to a task can lead to synergistic outcomes which are to the benefit of all.

Ed.

REEF RESEARCH is published quarterly by the Research and Monitoring Section of the Great Barrier Reef Marine Park Authority (GBRMPA).

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

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Printed by .....
ISSN 1037–0692

Formatted in DTP program QuarkXPress 3.3 on Apple Macintosh. Printed on recycled paper.

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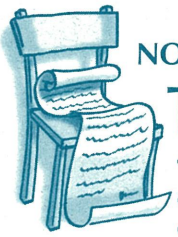


NOTES FROM THE CHAIR -

TWENTY YEARS ON

This year the Marine Park Authority celebrates twenty years of existence. Created by the first of Australia's big environmental struggles, the Great Barrier Reef Marine Park Authority was set up to provide a management regime for this extraordinary natural region. Legislation alone is no shield, a genuine sense of ownership by the community in all its complexity is the only dependable base for the long term protection of the reef. Over the last twenty years a diverse and strong set of partnerships has developed through which the management of the region is a truly shared activity. The region and its communities are dynamic, and so are these partnerships. They require ceaseless effort to maintain and refresh the commitment. In the realm of research there is a history of strong and extending partnerships.

Twenty years ago there was excellent research interest from a few individuals in a few universities, and the Australian Museum. The era of 'expeditions' to the Great Barrier Reef had only just passed. A few research stations (camps) were in place on islands; but the geographic and research gaps were vast. Nevertheless this research effort, much of it begun before the Authority started, continues as a fundamental and valuable part of the pursuit of knowledge of coral reef eco-systems.

The expansion of James Cook University, and its highly successful development of a niche in tropical marine studies, and the establishment of the Australian Institute of Marine Science brought a powerful research focus, and a critical (in every sense) mass of scientists into the region.

A little over two years ago GBRMPA, AIMS and JCU and reef industry organisations have established, through success in a highly competitive national competition, the Cooperative Research Centre into the Ecologically Sustainable Development of the Great Barrier Reef. GBRMPA itself has steadily expanded its Research & Monitoring Section, while remaining a large purchaser of research.

An interesting debate is still to be had, or is it solely a matter of balance? What should the relationship between the unfashionable systematics, and the reductionist approaches be? Can one inform the other? Can each be seen as equally valuable? Where are the heroic modellers, the cosmologists of the reef, or have the molecular biologists and the mass spectrographers found the only key to knowledge? I believe we need the results from both scales. People are the animals having the greatest impact on the reef, yet the less quantitative and controllable aspects of socio-economic research creates a scepticism amongst the 'hard' scientists. Without human demand, pressures and impacts, the need for management would not be there; should we not therefore examine far more systematically and intensively these aspects of the reef community? And a thought for the lowly 'monitors', because without their data sets and time series much of the specialised work would be comment without context.

Still enough speculation. This history of research effort, in itself, is a report of signal success in developing a research concentration to examine a highly complex and dynamic system. Somebody said studying the Great Barrier Reef is like working in an area the size of the Amazon Delta with one's head under the water. There is no shortage of topics.

But, for the Marine Park Authority, this research effort represents more than simply the extension of knowledge, and the outward movement of the research frontier. Sound management decisions can only come from good knowledge. Decisions frequently have to be made on a precautionary basis, but the more that they can be based on defensible scientific conclusions, the more that will be acknowledged by the broader community as wise and necessary.

UPDATE - *Chris Crossland*

CENTRE ACTIVITIES

The publishing output of the Centre is expanding rapidly as research results are finalised. Productions in the past three months include the Annual Report 1994/95 and the Strategic Plan 1994/98. All new research proposals to be considered by the User Advisory Group will now be judged against the criteria set down in the Strategic Plan. The free, bi-monthly CRC Reef newsletter continues to provide regular detailed updates about the Centre's research programs and will be sent to anyone on request.

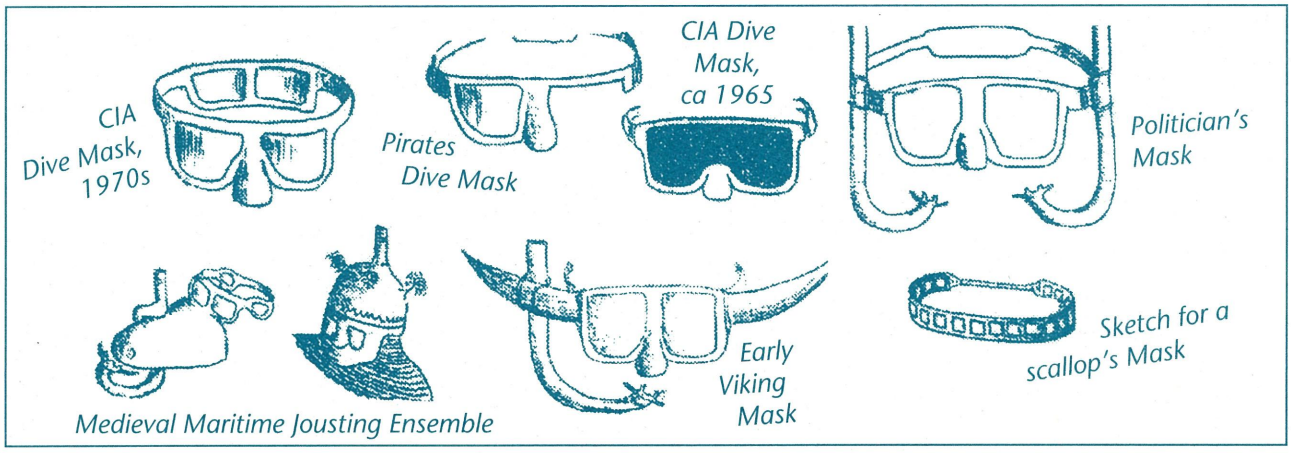
A technical report, by Garry Russ, Lou Dong and Beatrice Ferreira, on the population structure of coral trout on reefs open and closed to fishing has been published. The findings show strong fluctuations in recruitment each year which can significantly influence the abundance of coral trout populations available to anglers. The findings have important implications for managing the reef fishery. If populations can be accurately predicted three to four years in advance using yearly surveys of newly settled juveniles, then bad years could be anticipated, and Great Barrier Reef Marine Park Authority (GBRMPA) could, in future, locate reef closures for replenishment based on this technique.

The Centre has also jointly published, with the Department of Earth Sciences at James Cook University, the proceedings of a symposium, which was held in September, on Terrigenous Sediment Flux and Human Impacts. The proceedings have been edited by Piers Larcombe and Ken Woolfe.

As well as the 'hard' scientific reports, the Extension Program is also mass producing 'popular' science fliers. These are double sided sheets on particular topics, with photographs, which are intended to reduce the complexities of the research to terms which the general public can appreciate. Nine fliers are so far in wide circulation, and these have been distributed to the industries to which they are relevant. Copies of all reports and fliers are available from the Secretariat. Please call us, particularly if you have an opportunity to distribute the fliers to interested groups.

Two major fora for exchange of information between researchers have been held: the inter-agency Researcher Days in early September has now grown to include almost 50 presentations of research in progress, and in late October, 16 postgraduate students from widely different disciplines presented their research aims, directions and findings. A prize of a return airfare to Panama, to attend and present a paper at the International Coral Reef Symposium in June next year, was awarded for the outstanding presentation by Melita Samoilys from the Queensland Department of Primary Industries Northern Fisheries Centre. Her topic was Coral Trout Spawning Patterns on the

Coralations **'J' Unmasked** **Pongase**



Great Barrier Reef: more about her research findings in the next issue. All Researcher Days presentation topics have been audio-taped, and anyone can order copies of individual 15-20 minute sessions from the Secretariat. Ask for a program outline and select up to six taped sessions.

RESEARCH ACTIVITIES

Six new research tasks have been approved by the Board. They are listed below.

Vulnerable Species and their Management

(a new project with two tasks). Task One will study the ecological impacts of visitors on seabird populations. The results will provide advice to the tourism industry on options to minimise any impact visitors may have. Task Two will address strategies to reduce the impact of gill netting on dugong in the Reef region, and will include the use of aerial surveys and fishing log book returns. This project is being run from the Department of Tropical Environment Studies and Geography at James Cook University, with cooperation from GBRMPA, the Queensland Fish Management Authority, and the Queensland Department of Environment and Heritage (QDEH).

Evaluation and Design of Reef Interpretation.

This task, undertaken by the Department of Tourism at James Cook University and GBRMPA, will first go back to basics and examine how useful interpretation is as a tool in the management of protected areas, and then design new interpretive materials and field trial them.

Mercury and Heavy Metal Tracers in Coastal Sediments.

A jointly run task between JCU and AIMS, this will measure levels of mercury from agriculture and mining activities as a tracer in the detection of changes in Reef lagoon areas caused by land use.

Long-term Sea Temperature Monitoring.

This task will expand on previous sea temperature monitoring at Magnetic and Orpheus Islands, and establish stations along three cross-shelf transects and at two locations in the Far Northern Section. The results will help in predicting the future severity and duration of coral deaths from bleaching and provide an indication of climate change.

Development of Cost-effective Local COTS Control Strategies.

A cooperative activity between GBRMPA, Reef Research & Information Services and the managers of the Australian Museum's Lizard Island Research Station, the research will determine whether frequent, low level controls are more effective than periodic, high intensity efforts. This work will lead to the production of more cost-effective options and training programs for Reef tourism operators.

Allocation of Reef Sites for Future Commercial Use of Moorings.

This task, to be undertaken by GBRMPA and QDEH, will develop a better policy and legal framework to allocate sites for tourism purposes, especially those requiring moorings for commercial uses.

Finally, as the silly season approaches, all research seems to be pointing out that the marine critters out there are a great deal more sophisticated than we ever imagined. Not only do Hugh Sweatman's fish carry calendars and watches (see the last issue of *Reef Research*), but dugong, according to Helene Marsh are much cleverer than scientists. They knew where the unmapped deepwater seagrass beds were long before Rob Coles and his team from the Department of Primary Industries Northern Fisheries centre discovered them. Now comes news from Melita Samoilys of intense, communal and serial spawning activity among coral trout on certain reefs and at certain times. More next issue, when she will expound on the promiscuous and lascivious *Plectropomus leopardus*.

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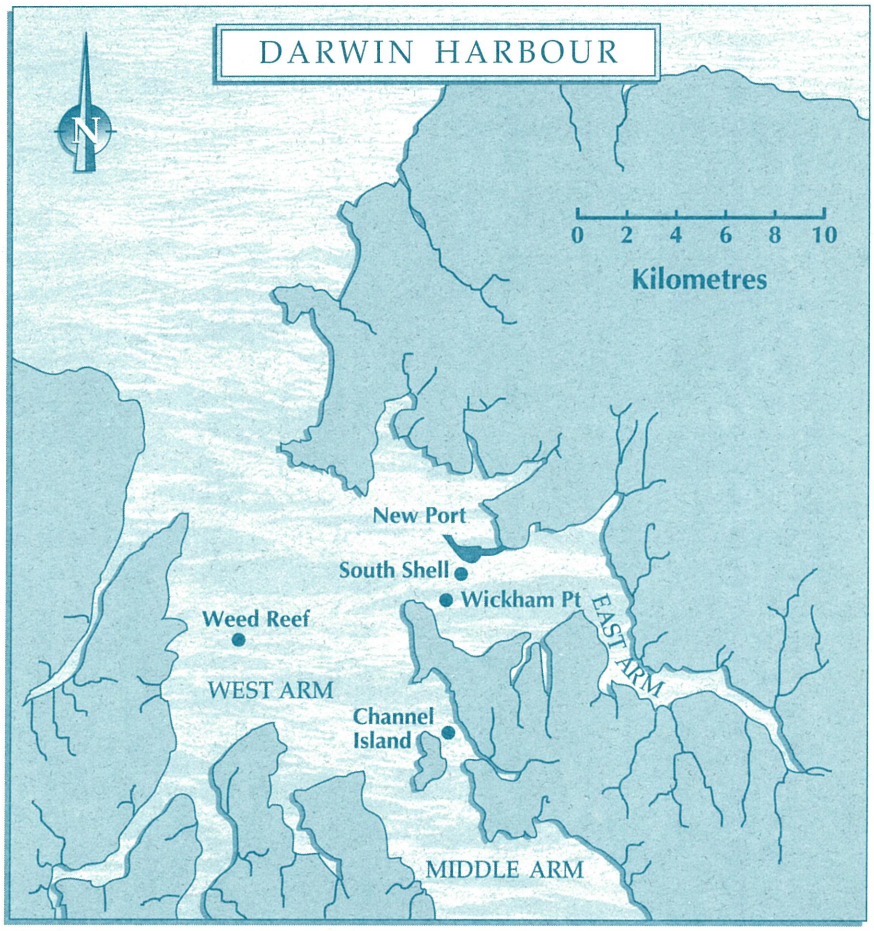
THE CORALS OF DARWIN HARBOUR

Gabi Caswell and Dr J. Russell Hanley

DARWIN HARBOUR

Darwin Harbour is a large mangrove fringed ria system of some 500 km2, formed by the last sea level rise, stabilising about 6-8000 years ago. Since that time fine sediment and silt have washed into the Harbour from the surrounding hinterland to gradually build up extensive mudbanks.



Much of the Harbour is very shallow. The deeper channels are maintained by strong macrotidal currents generated by large volumes of water moving into and out of the Harbour every six hours. Six-metre tidal exchanges occur regularly, with larger tides during the wet season (November through to March). The largest spring tides of the year usually occur in November, with a range of 0.5 to 8 m.

Semeniuk (1985) divides Darwin Harbour into three ecological zones, the first being the outer Harbour which communicates directly with the Timor Sea. The second is the middle or estuarine Harbour, and finally the arms (East, Middle and West) are classified as riverine. The ecological zones are generally descriptive of the water conditions experienced in these areas.

The combination of muddy shorelines and strong tidal movements produces very turbid waters, naturally high in suspended solids (Hanley & Caswell 1995b). In addition, turbidity is increased during the wet season when large volumes of freshwater and sediment are flushed into the Harbour. Wet season conditions produce increased sediment loads and turbidity, and decreasing salinity (Parry & Munksgaard 1995).

CORAL DISTRIBUTION AND GROWTH

Corals in Darwin Harbour are restricted to a very narrow depth range. Growth is usually confined to a few metres below zero water mark by light attenuation, and only a metre or so above chart datum by exposure to high ambient air temperatures and ultra-violet light on spring low tides (Hanley & Caswell 1995a).

The physical characteristics of Darwin Harbour exclude a large number of coral species from the small areas of suitable substrate (Hanley & Caswell 1995a). As a consequence the Harbour does not support many species of corals, and those which do grow are restricted to small patches on shallow water rocky reefs. Wolstenholme et al. (1996) recorded 111 species of corals within the Harbour. This compares to the 250-330 species recorded from 'true' coral reefs located elsewhere in tropical Australia (Veron 1986).

Some coral growth occurs in all of the ecological zones defined by Semeniuk (1985), even some which experience

almost riverine conditions during the wet season. Several genera of corals, including representatives of Fungiidae, *Acropora, Mycedium, Turbinaria, Faviidae* and *Goniopora* are relatively common. Colony sizes are usually small, with no large colonies existing within the Harbour. Growth of all species appears to be very rapid. *Herpolitha limax, Goniopora* spp. and *Mycedium elephantotus* demonstrated extremely fast growth rates during a wet season monitoring program. Hanley and Caswell (1995a) observed *Goniopora* colonies of 5cm diameter increasing to a diameter of 30 cm in 5 months, and *H. limax* specimens of 35 cm reaching a length of almost 1 m in the same period of time.

ECOLOGICAL STRESSES

The coral species present in Darwin Harbour are subjected to variable water quality and physical conditions all year round, but particularly during the wet season. We assume that the coral species which are relatively common in the Harbour are those which can cope better with the stresses imposed by the deterioration of water quality during the wet season.

The threshold tolerances of these robust corals to the changing water conditions and when these changes become lethal was not known. Hanley and Caswell (1995a) monitored several species of corals in the Harbour from October 1994 to April 1995 as part of the environmental management program for the East Arm Port Development - Stage 1. The aim of the monitoring study was to develop corals as bio-indicators to provide prompt advice on the effect of dredging and other construction activities on marine life in Darwin Harbour (Hanley & Caswell 1995a).

During the monitoring program divers often experienced low visibility of 0-10cm due to monsoonal conditions increasing suspended solids. Coral species (particularly *Turbinaria* spp., *Goniopora* spp., and *Mycedium elephantotus*) were often completely buried by moving sediment (Hanley & Caswell 1995a). Colonies of *H. limax* were often upturned and moved as much as two metres away from their original sites. Some species of *Turbinaria*, when left upside down for extended periods of time, curled over their plates and continued to grow.

During the large spring tides of early November 1994 approximately 90% of all corals lying in the shallowest part of the depth distribution in Darwin Harbour exhibited bleaching (Hanley & Caswell 1995a). This appeared to be the result of exposure, including during the middle of the day, for seven hours.

At one monitoring site the total population of *M. elephantotus* colonies (> 50 colonies) exhibited 100% bleaching after the November 1994 spring tides. However, these colonies showed an average 80% recovery per colony a few weeks after the bleaching event (Hanley & Caswell 1995a).

In conclusion, the corals of Darwin Harbour have exhibited a capacity to tolerate rapidly changing water quality and physical conditions. After a major bleaching event in November 1994 the corals demonstrated a remarkable rate of recovery (Hanley & Caswell 1995a). During the wet season, in conditions of extreme turbidity, decreased salinity and poor light attenuation several species of corals exhibited rapid growth rates. The monitoring program for the East Arm Port Development - Stage 1 is continuing.

References

Hanley, J.R. & Caswell, G.M. 1995a, East Arm Port - Stage 1: Water quality monitoring program: Report on setup phase and baseline data collection. Prepared for Darwin Port Authority, Northern Territory Department of Transport and Works, *Marine Ecology Report 95/1.*

Hanley, J.R. & Caswell, G.M. 1995b, Darwin Harbour Project: Survey of marine benthos and sediment. Prepared for the Northern Territory Government, *Marine Ecology Report 95/3.*

Parry, D.L. & Munksgaard, N.C. 1995, *Physicochemical baseline data for Darwin Harbour - East Arm Port Development,* Northern Territory University.

Semeniuk, V. 1985, Mangrove environments of Port Darwin, Northern Territory: the physical framework and habitats, *Journal of the Royal Society of Western Australia 67:* 81-97.

Wolstenholme, J., Dinesen, Z. & Alderslade, P. (in press), 'Hard corals of the Darwin region, Northern Territory, Australia', in: *Proceedings of the Sixth International Marine Biological Workshop: The Flora and Fauna of Darwin Harbour, Northern Territory Australia,* Hanley, J.R. & Caswell, G.M. (eds).

Veron, J.E.N. 1986, *Corals of Australia and the Indo-Pacific,* Angus and Robertson, North Ryde.

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SLICK TALK

with Steve Raaymakers

Report Released on Shell Conus Grounding

Slick Talk # 12 (*Reef Research* March 1995) reported on the grounding of the Shell tanker *Conus* when exiting the Port of Townsville in January 1995. That article referred to the fact that the cause of the incident was the subject of an inquiry. The Federal and Queensland Departments of Transport have now released the findings of their joint investigation.

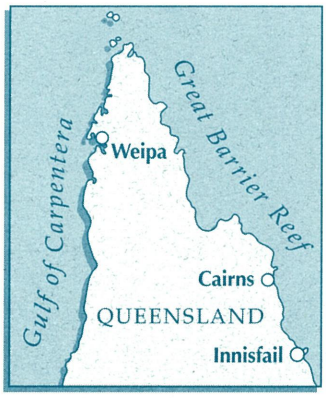
The overall conclusions of the inquiry are as follows:

- The Pilot did not take full account of the wind strength and direction when planning the departure.
- The Pilot and Master did not jointly develop a sailing plan, but relied on standard departure procedure which did not take account of the possible effect of the wind and tide conditions prevailing on the day.
- Although not severe or unusual, the prevailing wind conditions were such that the ship's position and speed at the port entrance were critical to a safe transit of the Platypus channel.
- The ship had not gained sufficient speed at the port entrance to counteract the effect of wind and tide.
- A correction for leeway and drift in increments of 2 degrees over a 3-minute period was used, when an immediate alteration of 10 degrees would have been more appropriate given the prevailing conditions; and
- No accurate assessment of tidal currents could be made as there is no real-time tide monitoring in the entrance channel to Townsville port.

It is fortunate that the incident did not result in damage to the tanker and release of oil to the environment. The seabed in the impact area is soft mud, the tanker was not travelling at great speed and was not fully laden, and a rising tide and rapid response by authorities enabled the tanker to be refloated after about 45 minutes.

At this point in time it is not clear what remedial action, such as refining departure planning procedures and installing real-time tide and current monitoring capability, might be taken to prevent similar incidents in future.

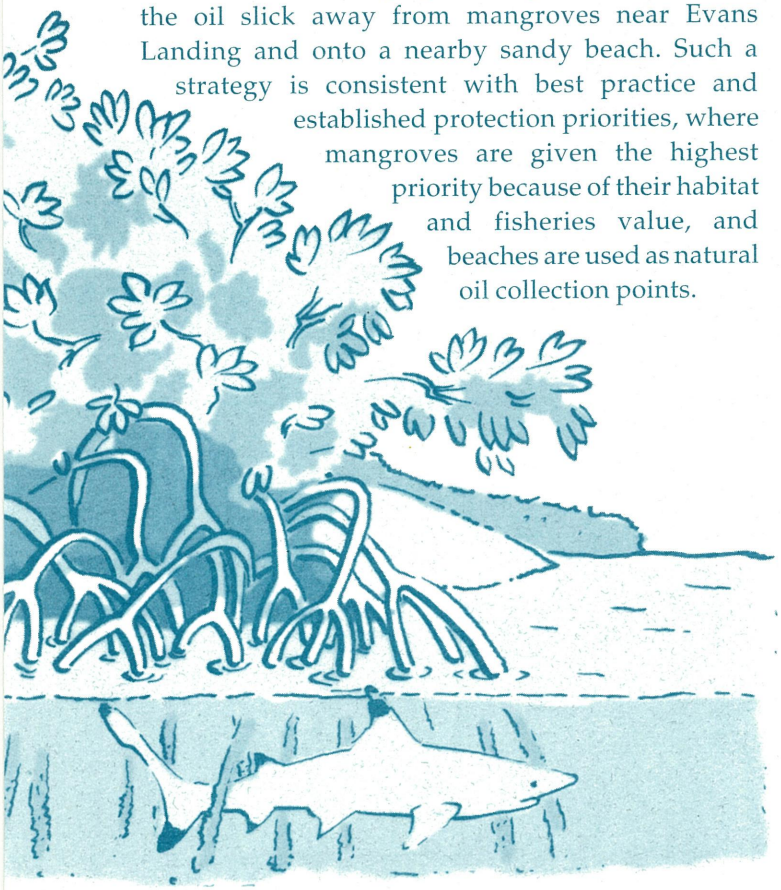
Textbook Spill Response at Weipa



At approximately 6.30 pm on Tuesday, 4 July 1995 Captain Graham Ring, Senior Marine Pilot at the Port of Weipa on the far north-west coast of Cape York Peninsula, received a report from Comalco emergency services of an oil spill within the port while he was berthing a large tanker. After

completing berthing of the vessel Captain Ring assumed the role of On Scene Coordinator (OSC), taking charge of the response to the oil spill. By 9 p.m. the source of the oil, which appeared to be Industrial Fuel Oil (IFO), was identified as being a shore-based facility, and the oil had escaped via the Lorim Point sewage treatment plant.

The Port of Weipa contains significant areas of mangroves, seagrasses and sandy beaches, and is notorious for crocodiles and sharks. Operating in darkness and within the constraints posed by the crocs and sharks, the OSC organised Comalco staff and volunteers to deploy an oil spill boom to deflect the oil slick away from mangroves near Evans Landing and onto a nearby sandy beach. Such a strategy is consistent with best practice and established protection priorities, where mangroves are given the highest priority because of their habitat and fisheries value, and beaches are used as natural oil collection points.



This operation appears to have been conducted in almost textbook fashion and proved highly effective, with only a small amount of oil escaping the boom. The mangroves were successfully protected. All available absorbent material from the joint industry/government stockpile in Weipa was placed in the catenary of the boom to absorb oil overnight, and staff retired some time after mid night.

At first light on Wednesday 5 July response operations resumed. A significant quantity of oil had been recovered by the absorbent material, and approximately 400 metres of sandy beach had become oiled in a band about 1 metre wide. It was clear that had quick action not been taken to deploy the boom during the night, the mangroves would have become oiled. Raw sewage, which had escaped with the oil, had also come ashore, complicating the clean-up.

Foreshore clean-up crews consisting primarily of Comalco staff and involving a total of 40 people as well as bob-cats, front-end loaders, dump-trucks and trailers were mobilised and the clean-up was completed by the end of the day. Three oiled birds (species unknown) were recovered and held in a treatment area, but soon died. Civil aircraft using Weipa airport and vessels using the port were asked to report any remaining oil or sheen seen on the harbour during their routine approach and departure. No further oil was reported.

A remaining problem was the oil that was still in the Lorim Point sewage treatment plant and about 4400 litres still trapped in the sewage discharge pipeline. Booms were erected around the pipeline outlet and operations commenced to clean the sewage plant and the discharge pipe of the remaining oil.

Overall, it is estimated that about 1000 litres of oil were discharged into waters of the port, about 9000 litres were recovered from the sewage treatment plant and pipeline, and about 4 tonnes of oiled debris was recovered by the clean-up.

All waste oil and oiled debris recovered during the response was held in Porta Tanks or a containment area, and subsequently transported to Cairns and Townsville for recycling and/or proper disposal. An environmental assessment determined that disposal at Weipa was unacceptable due to potential impacts on the underlying water-table, which provides domestic drinking water for Weipa.

This small spill totally depleted the entire National Plan stockpile of equipment at Weipa, although stocks were replenished by air from Brisbane by Thursday 6 July, exemplifying the ability of the National Plan to rapidly deploy equipment to areas remote from regional Resource Centres.

The Ports Corporation of Queensland, which is responsible for the Port of Weipa, is currently undertaking an investigation with a view to the prosecution of the polluter once it is identified.

(Steve Raaymakers is currently Environment and Communication Manager with the Ports Corporation of Queensland. The views expressed through his continued authorship of 'Slick Talk' are not necessarily those of the Ports Corporation nor GBRMPA).

THE NAVY'S LASER AIRBORNE DEPTH SOUNDER HYDROGRAPHIC SURVEY PROGRAM

Commodore John Leech [1] and Ralph Abbot [2]

The nautical charts produced by the Royal Australian Navy Hydrographic Service are compiled principally for navigation. However, as the Institution of Engineers Australia has observed in its monograph 'What Price Data',

> The program identifies efficiency of shipping, protection of the environment, safety of life at sea, and exploitation of resources as four applications of direct benefit, Scientists and coastal engineers would undoubtedly seek to expand this list as the hydrographic data has a wide range of uses outside those for which it is primarily intended.

Nautical charts are optimised for navigation, and much of the source data about the seabed is filtered out to avoid clutter in the navigational environment. Very often the source data have a much higher resolution than the published material. For example, published data points on a chart scale of 1:150 000 may be 2 km apart, but the source data points will probably be 250 or 125 m apart.

The nature of the source material may be obtained from the reliability diagram on the published chart. The source data for the Queensland coast are constantly being improved and added to by the Navy's flotilla of five ships based in Cairns.

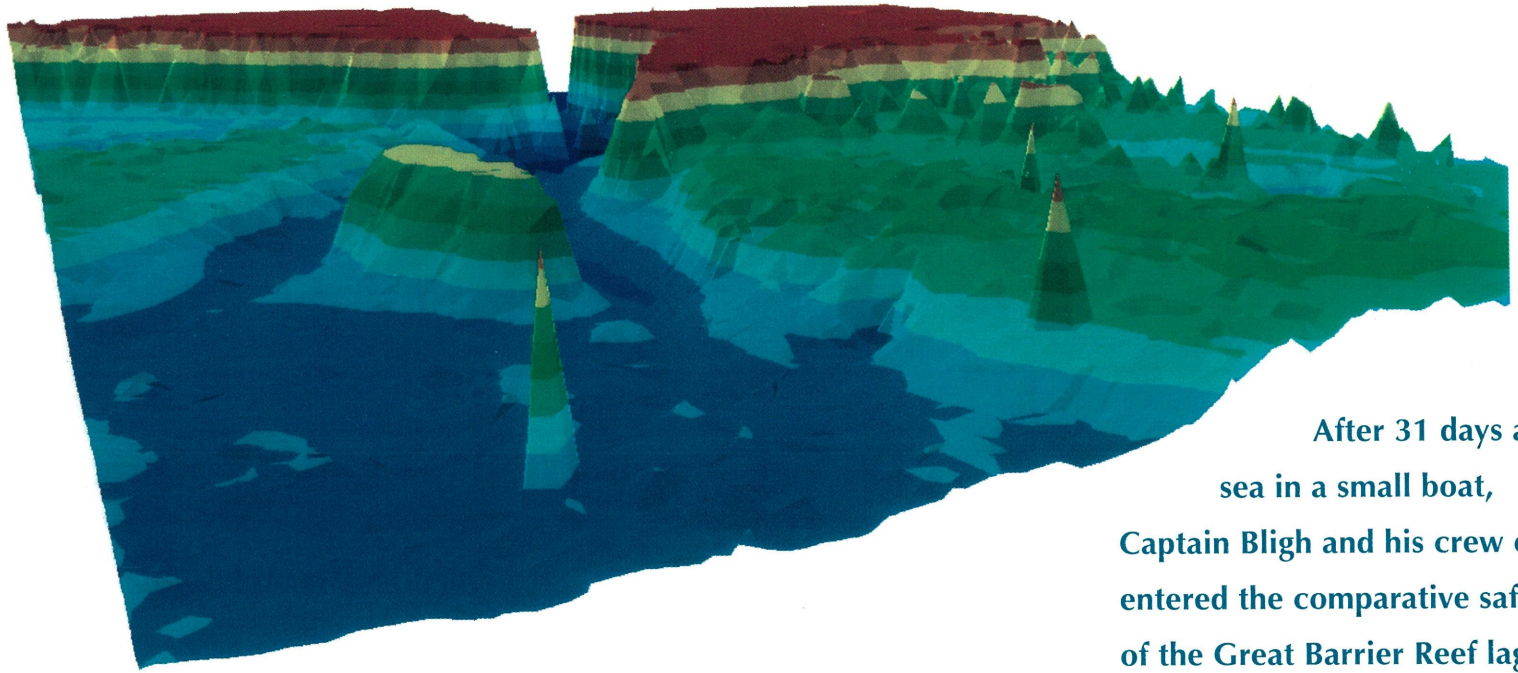
If you inspect published reliability diagrams on charts you will find that detailed survey work is generally confined to areas used for navigation. Many areas of the Great Barrier Reef are unsurveyed because carrying out surveys by traditional means is too hazardous for survey ships. Most detailed reef profiles available have been completed by the Australian Surveying and Land Information Group (AUSLIG) under contract to the Great Barrier Reef Marine Park Authority and the Australian Institute of Marine Science. AUSLIG have profiled 150 sites during the period 1977 to 1995.

The Navy has wished to survey unsurveyed areas for many years in order to improve the safety of navigation and has actively pursued a means of achieving this aim. After a decade of development, in 1993 the Navy commenced survey operations in reef strewn areas of the Great Barrier Reef Marine Park using the Laser Airborne Depth Sounder (LADS). LADS is yielding high resolution data in many areas of the Great Barrier Reef which will be of value to scientists.

LADS is a state-of-the-art laser system designed to safely and quickly chart hazardous shallow waters such as those of the Great Barrier Reef. The concept was developed at the Defence Science and Technology Organisation in South Australia in the late 1970s and early 80s. A partnership between Broken Hill Proprietary Engineering and Vision Systems saw the building of the current system for the Navy which was accepted into service in 1993. The system uses a green laser pulse in an optical radar mode to measure the depth of the water column. The timing difference between the reflections from the surface and the bottom provides the depth information. Apart from the speed and safety aspects of the aircraft when compared with a ship, the 500 m operating altitude of the Fokker F27 permits the green laser beam to be scanned from side to side as the laser is pulsed, providing a

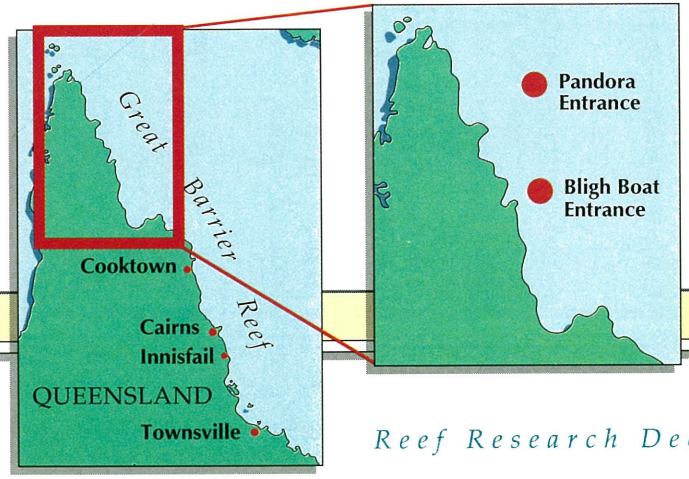
Bligh Boat Entrance

Figure 4



After 31 days at sea in a small boat, Captain Bligh and his crew of 18 entered the comparative safety of the Great Barrier Reef lagoon through this entrance.

The map on the right shows the two locations in the far northern section of the Great Barrier Reef



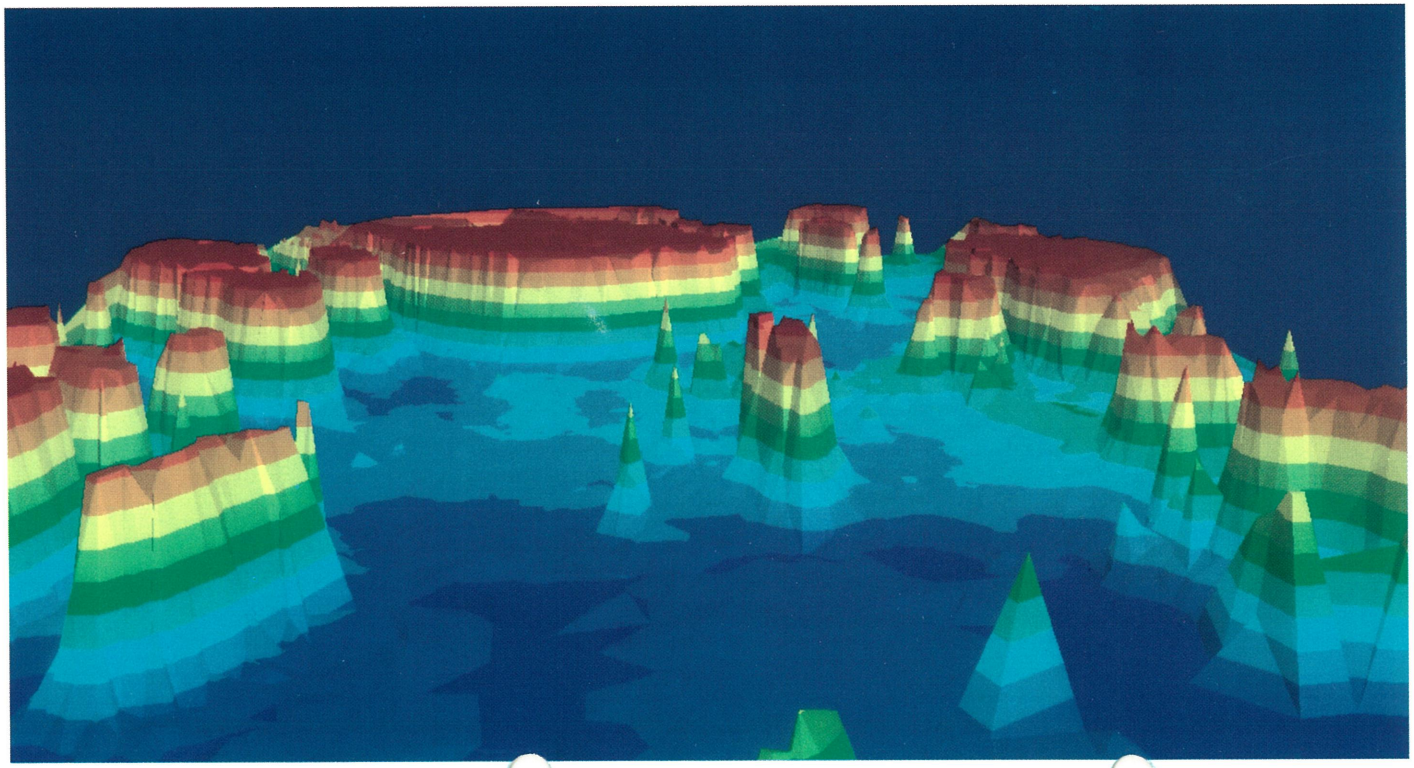
Great Barrier Reef Marine Park Authority

DSTO AUSTRALIA

THREE DIMENSIONAL IMAGES GENERATED FROM LASER AIRBORNE DEPTH SOUNDER DATA

Pandora Entrance and Reef

Figure 3



The Pandora struck the small re-topped reef in the centre. For several hours she washed across the top before finally being washed free, only to sink with the loss of 35 lives.

swath coverage 268 m wide (figure 1). There are 24 laser pulses in every scan, and the laser repetition rate of 168 Hz provides a 10 m x 10 m grid of laser soundings. In calm seas not all pulses provide a surface return, especially those towards the edges of the scan. To overcome this an infrared laser beam is directed vertically down; this provides an accurate surface reference for every sounding. The energy levels transmitted by the laser are limited to ensure that the system is eye-safe for anyone on the sea surface.

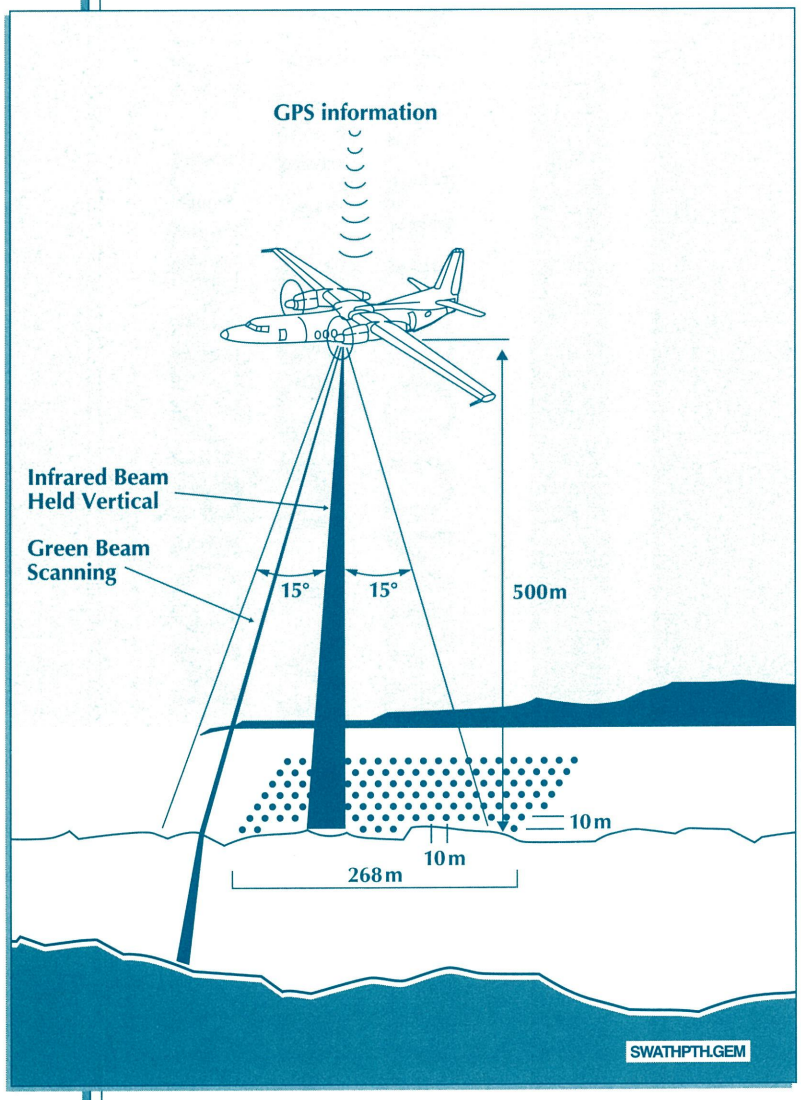


Figure 1: Scanning Pattern

As it is an optical system, LADS needs to 'see' the faint laser return from the bottom against the sunlight reflected by the water. Although it uses a very narrow optical filter to reject most of the sunlight, the system operates best once the sun has set, and for this reason most sorties are scheduled for an afternoon take-off and operation into the night. It can be a long flight with 2.5 hours transit time each way from Cairns to Torres Strait and more than 3 hours of operation. In areas closer to Cairns the sorties are not shorter, it's just that the transit times are shorter which permits up to 6 hours on task. In a recent record setter the crew surveyed 81 square nautical miles in a single sortie.

LADS records depths to 50 m, this limit being imposed by the data recording system. The depth to which LADS can measure depends strongly on the turbidity of the water. In areas of the Reef where the water is clean (and the beautiful blue colour) strong bottom returns are seen down to 50 m and deeper. In turbid water the maximum depth is reduced significantly and may be less than 10 metres in the turbid waters which often hug the north Queensland coast.

The position of the aircraft, and hence each sounding, is fixed with a GPS (global positioning system) satellite receiver operating in the Precise Positioning mode which provides aircraft position with an accuracy around 10 m. The satellite navigation is a major advance on previous ground-based positioning systems which required several ground stations to be precisely positioned and maintained, often in remote locations. A downward-looking video system enables the operators to observe the sea below and watch for shipping, reefs, islands and coastlines. This video is also used to fix the position (as determined by LADS) of known positional targets during overflights which are used to check the positional accuracy of the system.

LADS measures the depth of the water column below the aircraft, and this depth depends on the height of the tide at the time. In order to refer these depths to a tidal datum, the tide height, measured with tide gauges in the sea, is removed from each sounding depth.

The horizontal resolution of the data is 1 m, whilst that of depth is 0.1 m and the information also includes qualifying data such as the confidence in the sounding and housekeeping data. The accuracy of the horizontal position is ±20 m for 95% of all data. The accuracy of the depth is such that it meets the International Hydrographic Organisation standard

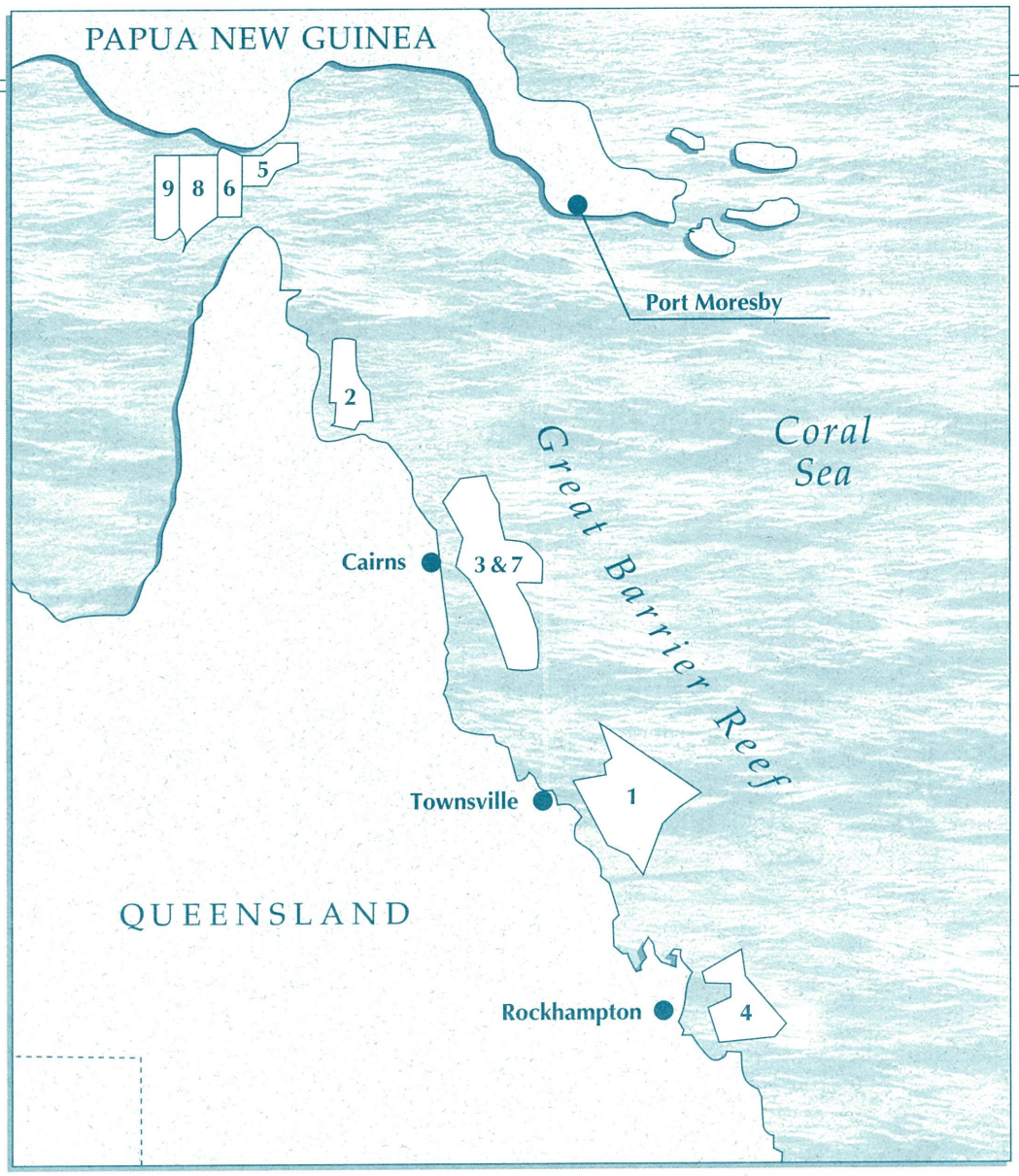
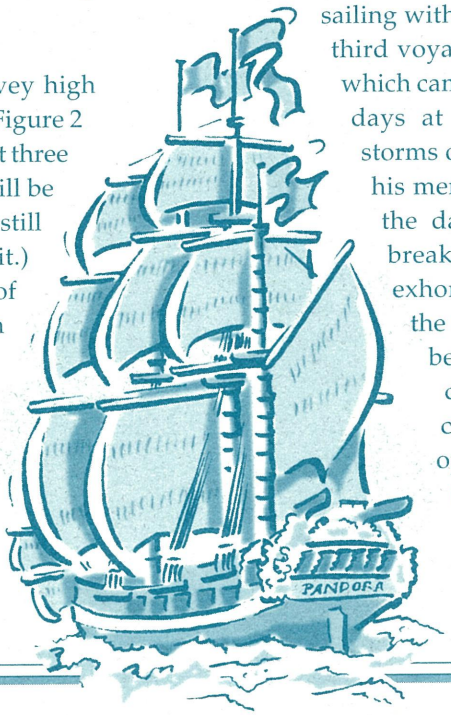


Figure 2: L.A.D.S. Missions 1993-1995

for hydrographic surveys. This is a complex standard: generally it can be stated that 95% of all soundings fall within 0.42 m at 30 m depth.

LADS has thus far been tasked to survey high priority areas in the Great Barrier Reef. Figure 2 shows the work areas for LADS in its first three years of operation. (One thing which will be obvious from the diagram is that LADS still has a very large workload in front of it.) Recent surveys have included those of several passages through the Reef which are famous in Australia's early maritime history.

It was in 1789 that Captain William Bligh with 18 of his men in a tiny longboat, following the mutiny on the *Bounty*, made his way towards Cook's Providential Passage. He knew of the existence of the Reef and this passage following his sailing with Cook on Cook's second and third voyages in the Pacific (neither of which came to Australia). Following 31 days at sea, coming through wild storms on the epic voyage, Bligh and his men kept watch for the Reef. In the dark at 1 a.m. the sound of breakers was heard and Bligh exhorted his weakened men with the cry 'Pull my lads, we shall all be swamped'. Pull away they did, and when day broke they came back through a narrow opening into the calm waters inside the Reef. Bligh had missed the channel for which he was aiming, but in a magnificent piece of



seamanship he had missed the target by a mere 15 nautical miles after 2400 miles at sea under appalling conditions. This channel, which became known as Bligh Boat Entrance, is shown in the centrespread.

Two years later the *Pandora* entered the Pacific in pursuit of the *Bounty* mutineers. After the capture of all those on Tahiti the *Pandora* headed west en route to England. A wooden cell on the deck held some of the prisoners - this was known as Pandora's box. Not long after the boat entered the Barrier Reef system it struck a reef and proceeded to sink over a period of 12 hours. The prisoners were terrified in the box as they remained captive in the floundering ship. At one stage several had broken free of their irons and the order was given for them to be re-manacled and a double guard to be posted. Two of these unfortunate wretches were still in irons in Pandora's box when she slowly slid below the reef waters where they perished: a total of 31 crew and two mutineers were lost. The ring of reefs which claimed the *Pandora* is also shown in the centrespread.

The LADS data from these two areas has been used to produce 3D images of these historic sites (figures 3 and 4). They are computer generated false colour 3D plots of the LADS soundings. They have been colour coded in 5 m depth bands, where red represents the top of the reef (0 to +5 m) which is just exposed at low tide, and deep blue represents 45-50 m deep. Other than the colour, they represent what the area would look like if the water level dropped by 50 m. These images have been generated with Maptek's Vulcan software which first produces a mesh of the data. This mesh consists of triangles formed by joining each sounding with a straight link to its neighbours. Each triangular facet is colour filled according to its depth and shaded according to its inclination to an assumed sun location, which adds realism to the 3D aspect. In the image of Bligh Boat Entrance there are unusual spikes rising from the sea floor. These are coral heads, but the realism suffers from the data reduction which occurs when LADS data is rendered to the Hydrographic Office for chart making. In this process the number of data points is reduced by about a factor of 9, and coral heads which may be 5 m in diameter become represented by a single sounding, selected to be at the shallowest depth. Whilst this is adequate for safety of shipping, it does not portray these narrow columns in the realism that would be achieved if all the soundings which occurred on the coral heads (perhaps 5 or so) were used. It is for this reason that the possibility of making available all LADS soundings is being examined.

As stated at the beginning of the article, the hydrographic data may have many uses beyond navigation. The authors, a navigator and a laser scientist, can only guess at possible applications; one major application is in the burgeoning area of coastal zone management.

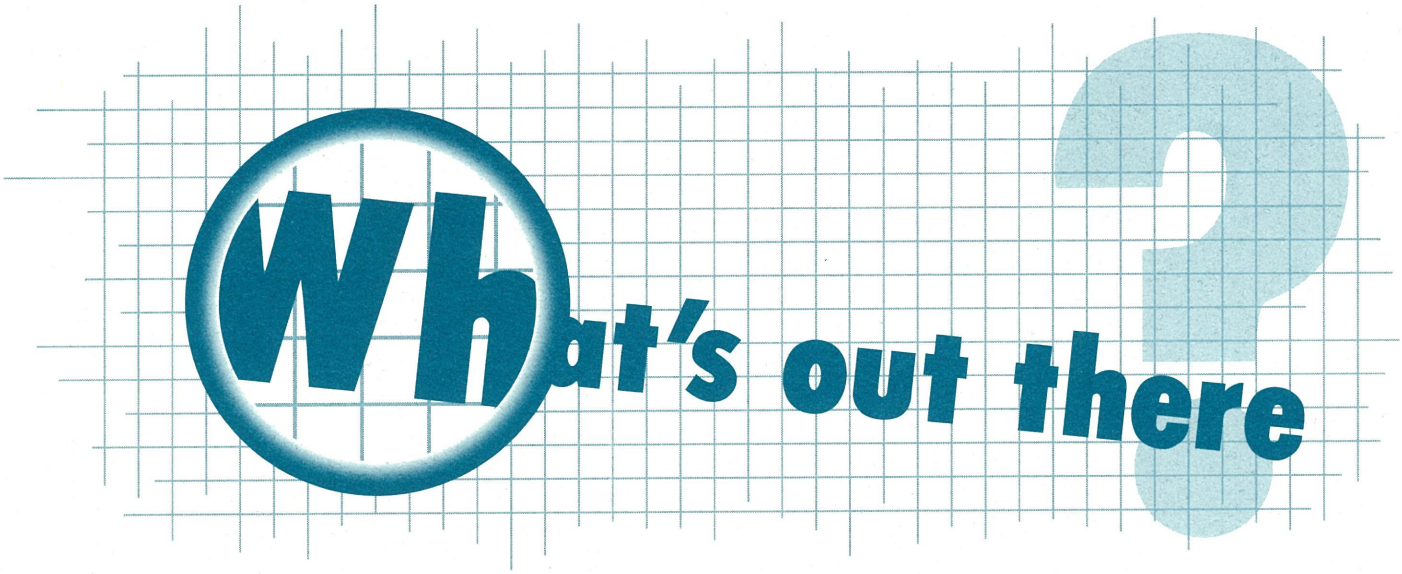
It is the Navy's intention to make both LADS and ship-surveyed data available for use by scientists. Science is a new application for the data, and arrangements for access still have to be teased out. For the time being, and to ensure some coordination of activity, requests should be made through the Geographic Information Systems Planning Officer at the Great Barrier Reef Marine Park Authority's Townsville office.

1. Hydrographer, RAN
RAN Hydrographic Office
Locked Bag 8801
South Coast Mail Centre NSW 2521

Commodore Leech was appointed head of the RAN Hydrographic Service in November 1990. A career naval officer, he has completed 25 years of naval service, ten of those in the United Kingdom. Recent senior appointments have included; Director Hydrographic Office, Deputy Director Development and Commanding Officer HMAS MORESBY.

2. Land Space and Optoelectronics Division
Defence Science and Technology Organisation,
Salisbury
PO Box 1500
Salisbury, SA 5108

Mr Ralph Abbot is one of the original team at DSTO which developed Australia's Airborne Depth Sounder, LADS, for the Royal Australian Navy. He led the trials of WRELADS, a development system, and assisted the contractors, BHP Engineering and Vision Systems, with the LADS set-to work. He is currently at DSTO providing R&D support to LADS.



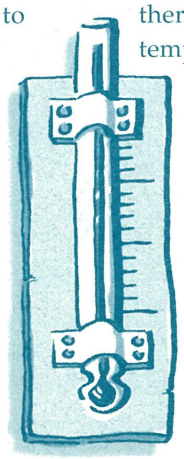
LONG-TERM MONITORING OF SEA TEMPERATURE ON THE GREAT BARRIER REEF

Ray Berkelmans

The Great Barrier Reef Marine Park Authority (GBRMPA) will shortly be embarking on a major program of monitoring sea temperature on the Great Barrier Reef. Pilot studies have been conducted at Magnetic Island and Orpheus Island for three years looking at small scale variation in sea temperature, trialling equipment and refining data handling methods. The purpose of this article is to provide some background as to why we are interested in monitoring sea temperature, where we intend to establish monitoring stations and to send a plea to readers to report any coral bleaching events to the Authority.

Background

Environmental temperature is one of the most important parameters governing the distribution, abundance and physiological function of organisms. Understanding the limits of environmental temperature within which organisms live provides insight into the physiological tolerances of the organisms and their spatial distributions. This in turn helps us to understand (and monitor) anthropogenic impacts on organisms which are at or near the limits of their thermal range.



Coral reefs are particularly sensitive to thermal stress and, during summer, many species of coral live close to their upper thermal limits. This is evident from at least five coral bleaching events which have been witnessed on the Great Barrier Reef since 1980 and a number of experimental studies. During both events, corals lose their normal pigmentation through the expulsion of their zooxanthellae leaving them pale or even bone white. If the period of thermal stress is severe and/or long enough, coral bleaching will result in death. The most severe coral bleaching event on record occurred during the 1982-83 El Niño episode in the eastern Pacific when up to 95% of all corals died, one species became extinct and two other species were virtually extirpated, eventually recruiting back in low numbers three to ten years later. Although elevated temperatures have been the cause, or have been implicated, in all major bleaching events, it is not clear exactly what temperatures and durations are sufficient to cause coral bleaching, how often these conditions occur throughout the Great Barrier Reef, or whether such occurrences are increasing in frequency as a result of global climate change. It is therefore important that a strategic long-term sea temperature monitoring network be established on the Great Barrier Reef.

Although other factors such as high light intensity, high ultra-violet light and lowered salinity have also been implicated in coral bleaching events, their effect in stressing corals is greatly exacerbated near the upper thermal limits of corals. Monitoring of sea temperature is important to managers because if anthropogenic sources of stress (e.g. elevated

sedimentation as a result of dredging) coincide with naturally warm sea water conditions then it may be unwise to grant permits for activities potentially stressful to corals near their upper thermal limits.

Long-term sea temperature records are also important to monitor the effects of global climate change. There is now strong evidence to suggest that our climate is changing at an unprecedented rate. Global average surface temperatures have increased by 0.3 - 0.6°C since the late nineteenth century and in the 20 years to 1993, the rate of change has increased dramatically. The Intergovernmental Panel on Climate Change predicts that if greenhouse emissions continue as they are, global average surface air temperatures will rise between 1.5 and 4.5°C by the year 2030. For tropical Australia, the rise is predicted to be 0 - 1.5°C by the year 2030 and 0 - 4°C by the year 2070. Hard data on the ecological effects of sea temperature increases are, however, still lacking.

Experimental design

In order to optimise sampling effort in establishing a network of temperature monitoring stations on the Great Barrier Reef, it is necessary to understand small and medium scale variability in sea temperature. A pilot study of sea temperature variability over small spatial scales (between reef-flat and reef-slope and between sites separated by 200 m - 3 km) and over medium spatial scales (between locations separated by around 75 km), showed that the differences in average daily temperatures between the reef-flat and reef-slope vary by less than 0.2°C. This small variation is despite the reef-flat temperatures varying by up to 5°C within a day and reef-slope temperatures varying by less than 1°C (figure 1).

Our data also show that variability in average daily sea temperature between sites separated by a few hundred metres to a few kilometres is generally less than 0.1°C. Between locations separated by 75 km, however, average daily temperatures varied by between 1 and 2°C (figure 2).

These data suggest that it is desirable to replicate loggers at a number of locations within a shelf position and that it is worth examining sea temperature variation at each shelf position (inshore, mid-shelf and outer-shelf). We propose setting up 3 cross-shelf transects on the Great Barrier Reef, one in the Mackay/Capricorn Section, one in the Central Section and one in the Cairns Section, and also to establish 2 monitoring stations in the Far Northern Section, one each at Lizard Island and Raine Island. At each location one reef-flat logger and one reef-slope logger will be deployed.

The specific locations for the deployment of the temperature loggers are as follows:

1. **Mackay/Capricorn transect**
   (a) Inshore: Peak Is., Divided Is., Pelican Is. (Keppels)
   (b) Mid-shelf: Heron Is., Lady Musgrave Is., One Tree Is.

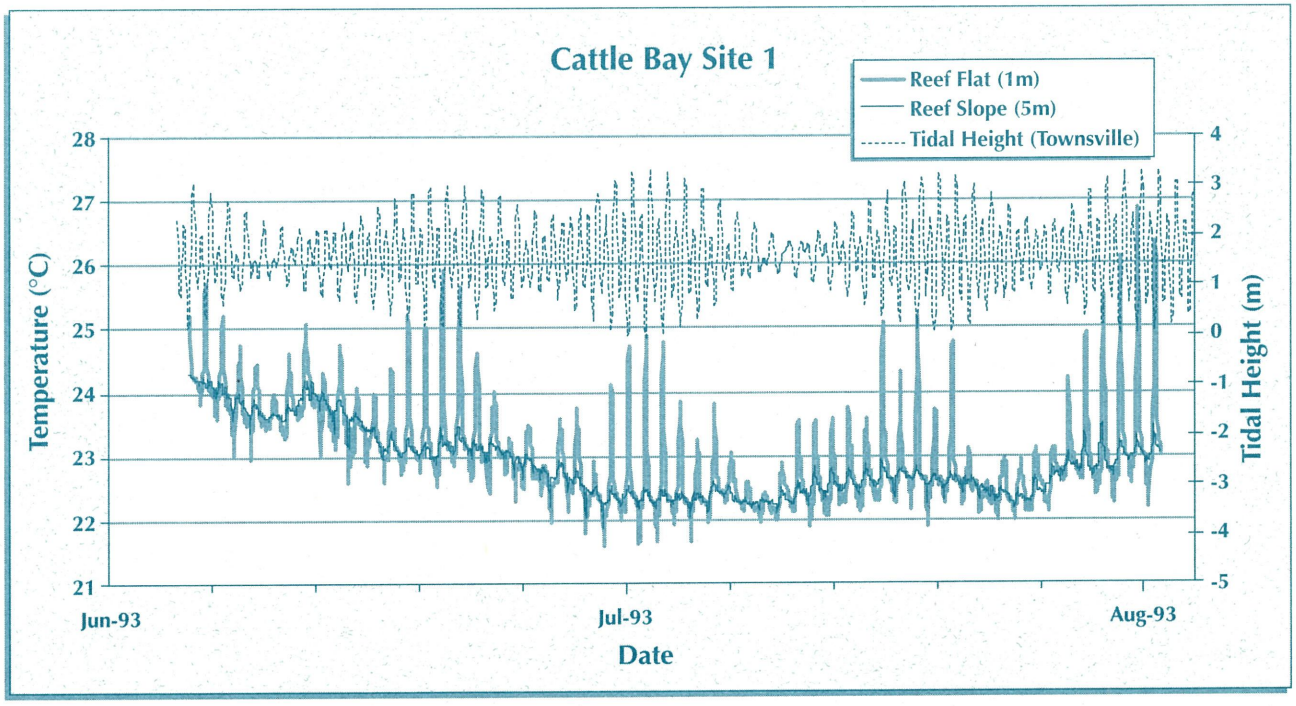


Figure 1. Variation in sea temperature between the reef-flat and reef-slope

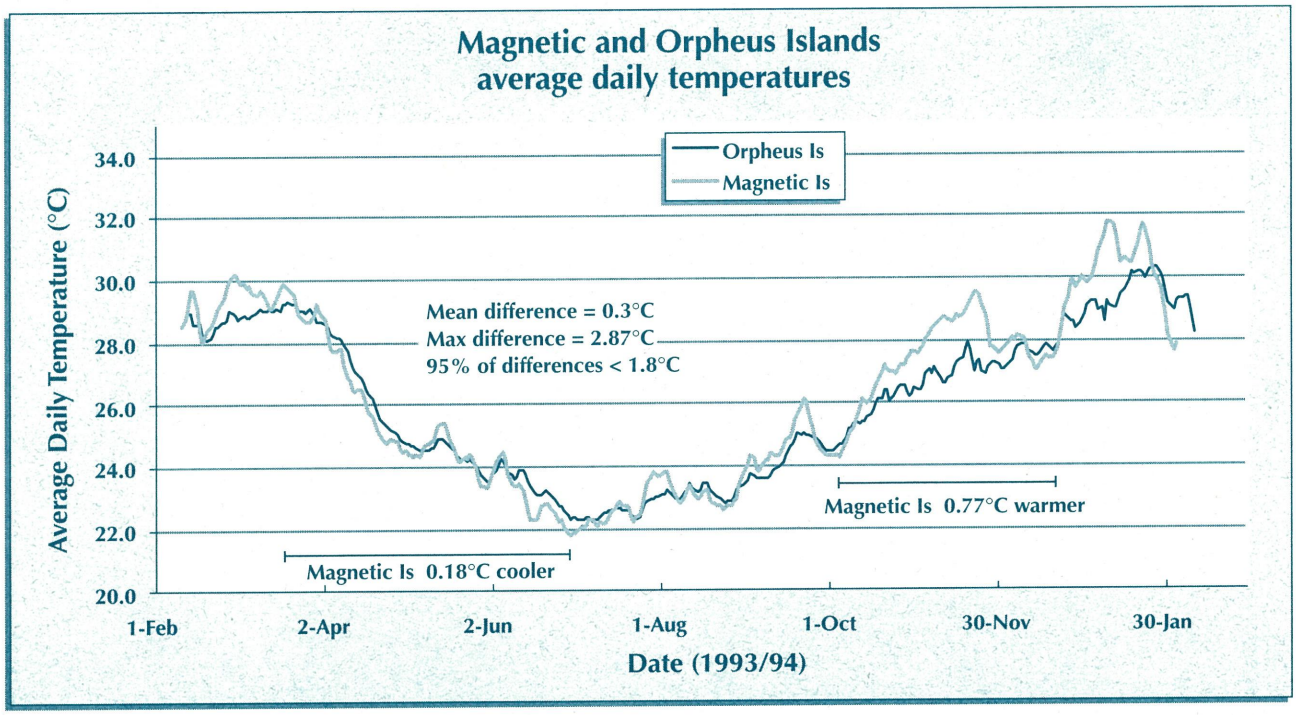


Figure 2. Variation in sea temperature between locations 75 km apart.

(c) Outer-shelf: East Cay, Turner Cay, 21-583 (outer Swains)

2. Central Section transect

(a) Inshore: Pandora Rf., Middle Rf., Magnetic Is.
(b) Mid-shelf: John Brewer Rf., Kelso Rf., Rib Rf.
(c) Outer-shelf: Myrmidon Rf., Chicken Rf., Dip Rf.

3. Cairns Section transect

(a) Inshore: Daintree fringing reefs (2 locations), Fitzroy Is.
(b) Mid-shelf: Green Is., Moore Rf., Arlington Rf.
(c) Outer-shelf: Norman Rf., Agincourt 2d Rf., Agincourt 4 Rf.

Far Northern Section: Lizard Is. and Raine Is.

We intend to make summary data in the form of average daily temperatures available on the World Wide Web through GBRMPA's home page

http://www.gbrmpa.gov.au.

and prepare yearly hardcopy summary reports for general distribution. We ask for your patience in getting access to the data as a considerable amount of work is required before we get that far.

Coral bleaching reports

Reports of coral bleaching for the 1995 summer are coming in thick and fast from the northern hemisphere including Venezuela, Belize, Mexico, Western Caribbean and Palau. Some researchers have reported moderate to heavy bleaching for example 40-60% of all Porites porites and *Millepora alcicornis* and 80-100% of all *Montastrea annularis* and *Millepora complanata* affected near Mexico. The Mexican coral bleaching event is reportedly the first on record with 60-90% of *Montastrea annularis* and other dominant species affected on some reefs. What is in store for us this coming summer on the Great Barrier Reef? If our weather follows the same pattern as these northern hemisphere locations, we may be in for another bleaching event this summer. A plea to anyone who will be in the field between December 1995 and May 1996: Please keep an eye out for coral bleaching and if you see any, report it to the Great Barrier Reef Marine Park Authority. If we get reports in this summer, we intend distributing bleaching forms and hope to have your cooperation in filling them out. We hope this will not be necessary.

Further reading:

Karl, T. & Baker, B. 1994, Global warming update: invited presentation at the 74th Annual Meeting of the American Meteorological Society, *World Wide Web. http://www.ncdc.noaa.gov//gblwrmupd/global.html*

COTS COMMS

Dr Brian Lassig

Issue Number 1 of COTS COMMS was published in February 1989. This 5-page collector's item had a circulation of 70. It looked like it was designed and produced by an amateur (it was - by me, a Mac Plus, a pair of scissors, some glue, and a photocopier). I still have regrets at not being allowed to run a competition asking readers to count the number of COTS appearing in the newsletter and estimate the amount of damage inflicted by the starfish on the newsletter's name.

The current format, content, style and distribution of COTS COMMS are very different to that yellowing first edition. Assimilation within *Reef Research* in 1992 imposed a quantum leap on the quality of production, the regularity of issues and the scale of circulation. Udo Engelhardt's involvement gave the newsletter a more personal touch and appeal to a wider audience than my own pedantry allows. The evolution of COTS COMMS will continue, accelerated by my absence from this desk for six months.

An opportunity has arisen for me to work in the Coasts and Marine Branch of the Department of Environment, Sport and Territories (DEST) in Canberra for six months. Having been the Coordinator of the Authority's Crown-of-thorns Starfish (COTS) Program for nearly six years and involved in the Program for a further two, I am keen to broaden my horizons and meet some new challenges. I'm also a bit tired of having most of my conversations opening with 'What's happening with COTS?'. I'd like to take this opportunity to thank all my colleagues and associates for their support, challenges and stimulation over the years. I look forward to resuming working relationships on my return next May.

The position of COTS Program Coordinator will be filled in my absence. *[Tony Stokes will occupy the desk from November 1995 to January 1996 and Udo Engelhardt from February to April 1996].* Of course, I will always be happy to hear from you while I'm in Canberra.

Because of my preparations for the Canberra move and Udo Engelhardt's preoccupation with getting everything organised for the coming summer of fine-scale surveys, this issue is a bit thinner than usual. The pith should return next issue.

CURRENT COTS

AIMS Surveys

Since the last issue, AIMS has provided two survey reports. In June 1995 the team surveyed reefs in the Cairns (1 reef), Innisfail (3 reefs) and Cape Upstart (4 reefs) Sectors. In September/October they surveyed reefs in the Cape Grenville (7 reefs), Princess Charlotte Bay (6 reefs) and Cooktown/Lizard Island (9 reefs) Sectors.

Only two COTS were recorded on the eight reefs surveyed in June. In contrast, COTS activity was a lot higher on the more northern reefs surveyed during the second trip. COTS were recorded on six of the seven reefs surveyed in the Cape Grenville Sector. One inner-shelf patch reef (Curd Reef) was classified as having an active outbreak. The outbreak has developed since the reef was last surveyed in 1992. Juveniles comprised a large proportion of the population.

COTS were recorded on five of the reefs surveyed in the Cooktown/Lizard Island Sector. Lizard Island was described as having an active outbreak. Most starfish were of adult size, although juveniles were also seen. COTS numbers were also reasonably high on MacGillivray, Linnet and Martin Reefs although none of these reefs were classified as having active outbreaks. At Linnet Reef, 15 COTS were recorded during manta tows and a further 52 recorded during one hour of SCUBA searches in back reef areas.

The outbreak at Lizard Island is the first active outbreak recorded by AIMS in the Cooktown/Lizard Island sector since 1985, when the surveys began. The only other active outbreak recorded within the northern Great Barrier Reef was at Sir Charles Hardy Reef (Cape Grenville Sector) in the 1991-92 survey year. A comparison of this year's data with previous years shows a definite trend of increasing COTS numbers in the entire Far Northern Section of the Great Barrier Reef Marine Park. Most of the activity appears to be in the mid-shelf area, particularly near Lizard Island.

Fine-scale Surveys

By the time you read this, a manuscript presenting the

results of the 1994-95 surveys should have been submitted to a scientific journal for publication. Udo will report on the progress of the 1995-96 fine-scale surveys in the next issue. Trips are planned for October/November 1995, December 1995, January 1996 and February 1996. It will be interesting to see if the reefs that were classified as incipient outbreaks last year qualify for an upgraded classification. From Reef-user reports and the more recent AIMS surveys it seems likely that a few extra data sheets will be needed to record the COTS numbers.

Reef-user Reports (COTSWATCH)

Judging from the rate at which Udo's in-tray fills up with completed COTSWATCH forms, the scheme continues to be very well supported. Unfortunately I can't say any more than that at this time, but Udo has promised to provide a summary report for 1995 in the next issue of *Reef Research*. Our thanks to all the COTSWATCHERS (who will remain anonymous until the next issue).

NEW COTS CONTROLS PROJECT

The development of new environmentally friendly COTS control techniques (see the March 1995 issue of *Reef Research*) answered half the question of how to cost-effectively control COTS at local scales. The other half of the question, relating to the implementation of the technique, remains unanswered. Analysis of previous COTS control efforts on the Great Barrier Reef showed that it costs between 50 cents and $30 to kill each starfish (depending on the accessibility and depth of the site, the necessity to pay divers and support personnel, vessel costs etc). Clearly, employing the most cost-effective strategy to control the starfish could save a lot of money. Conversely, badly planned and executed control operations can waste a lot of resources.

COTS controls on the Great Barrier Reef have usually relied on one of two strategies. Option one is to put all available resources into an intensive, but short-lived control exercise which is repeated every now and again (usually several months apart) when starfish densities return to pre-control levels. The second strategy is to have one or perhaps two divers inject or collect COTS for an hour or so every week or two. This high frequency but low intensity strategy is the most commonly used by tourism operators because it can be most easily accommodated within their normal operations.

While the controllers adopting either of these strategies keep records of the numbers and sizes of COTS killed, the effectiveness of the operations in protecting coral cover is not monitored because of the significant additional effort and expertise required.

The outbreak at Lizard Island has provided an ideal opportunity to study the cost-effectiveness of these two strategies. With funding from the CRC Reef Research Centre, Mr David Fisk and the Lizard Island Research Station Co-Directors (Drs Lyle Vail and Anne Hoggett) are conducting a 12-month project to compare these two strategies and contrast them with the 'do nothing' option.

While it is likely that different strategies would work better under different conditions (e.g. reef types and locations as well as the status of COTS populations), this project will provide a solid foundation for making an informed decision on the most appropriate local COTS control strategy to employ.

WHAT'S SO SPECIAL ABOUT THE CAIRNS SECTION?

Twice in the past 35 years, COTS outbreaks were initially detected in the southern part of the Cairns Section of the Great Barrier Reef Marine Park. Hydrodynamic modelling and analysis of the patterns of outbreaks suggest that the outbreaks originated on reefs to the north between about 14^{o} south and 16^{o} south. The subsequent predominantly southern progression of outbreaks into the Central Section of the Park is explained by larval transport from northern natal reefs. As we've reported in *Reef Research* over the past year or two, COTS populations are again increasing on a number of mid-shelf reefs in the Cairns Section.

The consistency of the geographical pattern of outbreak origins indicates that the Cairns Section has characteristics which predispose it to developing primary COTS outbreaks. An appreciation of these characteristics has the potential to lead to an improved understanding of the causes of COTS outbreaks.

To this end, the Authority has commissioned three reviews to gain an insight into the special features of the Cairns Section that may be responsible for outbreaks consistently

originating in this area. Professor David Hopley (JCU) is reviewing geomorphological characteristics, Drs Lance Bode (JCU) and Derek Burrage (AIMS) are looking at physical oceanography and Dr Miles Furnas (AIMS) is reviewing the chemical and biological oceanography of the Section. The reviews will describe the characteristics of the Cairns Section, compare these with those of other Sections to identify any unique features, discuss how these characteristics may influence the development of primary COTS outbreaks, identify any deficiencies in available information relevant to the question of the uniqueness of the Cairns Section and make recommendations for any additional work required to address these deficiencies.

A TIME TO SPAWN

Nearly 15 years ago Chuck Birkeland of the University of Guam hypothesised that heavy rainfall generates a significant increase in terrestrial run-off of nutrients which enhances the availability of food for COTS larvae. He postulated that these run-off events result in high larval settlement and the establishment of outbreak populations. The assumption that COTS larvae are normally limited by food availability has been supported by recent research by Dr Tenshi Ayukai and Mr Ken Okaji at AIMS.

The timing of COTS spawning and the environmental triggers of spawning activity are important pieces of information in understanding possible links between COTS outbreaks and water quality. Research into COTS reproductive biology by Drs Russ Babcock and Craig Mundy of AIMS between 1989 and 1992 provided a number of insights into this critical process. The study also raised more questions. Babcock and Mundy found that COTS fecundity (measured as the relative weight of the gonads) peaked in early December, but fertility of the eggs peaked earlier in the summer (late October). This is typically well before the onset of the wet season in the area. However, Babcock and Mundy worked on a COTS population at Davies Reef in the Central Section of the Great Barrier Reef Marine Park, and the transferability of their results to the northern Cairns Section is unknown.

A new research project by Drs Ayukai and Bandaranayake at AIMS will study a number of aspects of the reproductive biology of the Lizard Island COTS population. The project will investigate alternative ways of measuring individual starfish reproductive potential, determine the timing of spawning in this area and monitor possible environmental triggers responsible for initiating spawning activity.

Reports of any COTS spawning would make a very valuable contribution to this project. If you do observe COTS spawning events anywhere on the Great Barrier Reef or elsewhere, please pass the details on to the COTS Program Coordinator or Dr Ayukai at AIMS.

WHAT HAVE WE LEARNED ABOUT COTS?

Over the last few issues of COTS COMMS we summarised the main results of the last six years of the COTS Program. This serialisation was based on a review of COTS research undertaken between 1989 and 1995. The review was undertaken by myself, Peter Moran, Udo Engelhardt and Tenshi Ayukai. By the time you read this, the report should have been published as GBRMPA Research Publication No. 39. Contact the Editor of *Reef Research* if you would like a copy.

COTS UNDER THE SPOTLIGHT AGAIN

The controversial nature of the COTS issue has meant that it has had its fair share of reviews. The review undertaken by Professor Don Anderson in early 1989 at the request of the then Minister for the Arts, Sport, the Environment, Tourism and Territories, Senator Graham Richardson, led to the establishment of the Authority's current COTS program. Senator Richardson committed funds for the first two years of the program and asked that the program be reviewed before entering into a third year (as recommended by Anderson). Dr Bob Johannes, then of the CSIRO Division of Fisheries, conducted that review.

Both the Authority and our advisory committee on the COTS issue (the Crown-of-thorns Starfish Research Committee, COTSREC) found Johannes' review very useful. It provided independent insights into the operation of the program that those of us who are too close 'to see the forest for the trees' tend to miss. Because of the value of Johannes' review, we have asked Bob to revisit the COTS Program this year. The review is likely to occur in early December.