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REEF RESEARCH

NEWSLETTER OF THE RESEARCH AND MONITORING SECTION

Great Barrier Reef Marine Park Authority

VOLUME 6 No. 2 JUNE 1996

Editorial

Technology gets to all of us in the end so *Reef Research* is finally going electronic. Yes! the Marine Park Authority now has its own page on the World Wide Web and *Reef Research* will be a part of the offerings to the information hungry community sitting behind servers and modems everywhere. The address for the Authority home page is http://www.gbrmpa.gov.au/ so come and surf the reef. Next issue I will include a flyer to ask readers if, now a Web version is available, they would like to discontinue receiving the hard copy version of *Reef Research*.

Still on computer stuff, for technophiles our Geographic Information System gurus have written about the sometimes painful process of establishing an operational and relevant GIS. As with all technology, there is no easy path to its incorporation and there are a number of lessons that the writers bring to our attention. Hopefully some of the less productive paths can be avoided by other GIS developers that are out there in our readership circle. Probably the take home message is that it is imperative to adequately resource the development from day one.

This issue of the newsletter further examines the state of the Great Barrier Reef World Heritage Area from values, experiences and tourist impacts perspectives. As with the ecological summary that was presented in the March issue most uses of the Park by tourists appear to be relatively benign although there is no room for complacency and some questions exist with regard to the quality of the experiences that some visitors expect.

Not so benign is the subject of 'Slick Talk', which describes an almost unbelievable series of events leading to the grounding of the vessel *'Sanko Harvest'* off the coast of Western Australia. I hesitate to think too long about the danger to the Great Barrier Reef if similarly crewed and operated vessels are traversing the inner route to various ports on the coast of Queensland. One can only hope that efforts such as those in train as a result of the Great Barrier Reef and Torres Strait Shipping Study provide for ever increasing protection of one of the jewels in the Australian environmental crown.

Ed.

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CRC Reef Research Centre

UPDATE - *Chris Crossland*

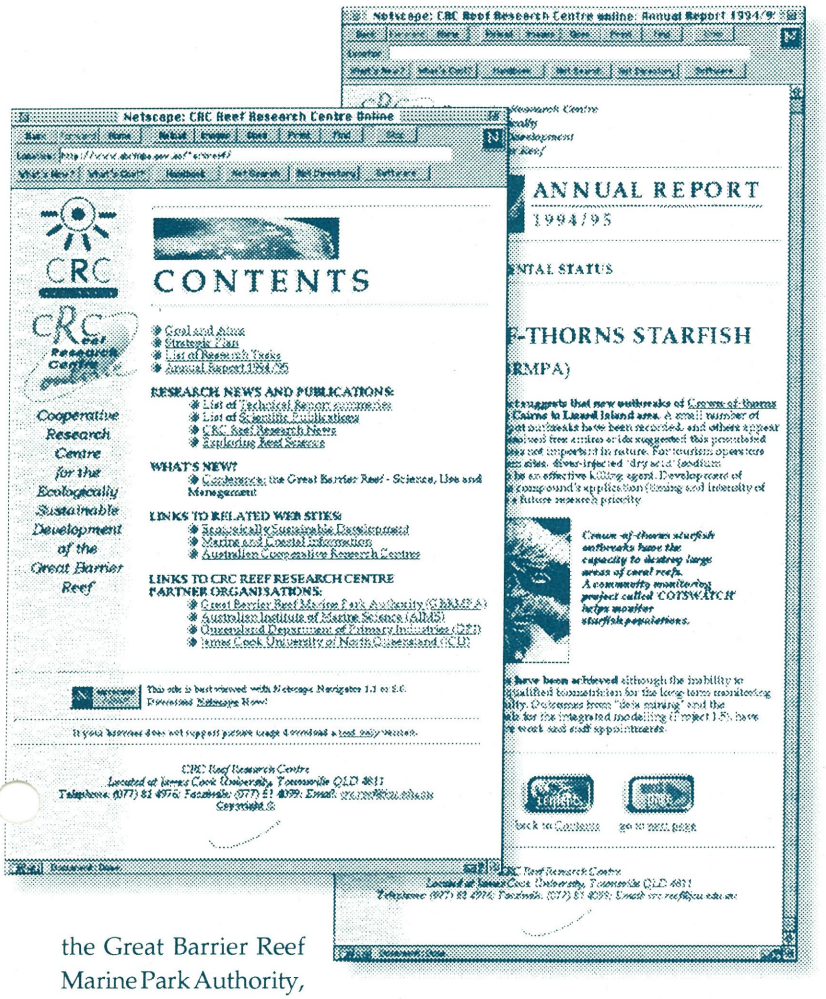
CENTRE ACTIVITIES

The third-year review of the Centre will take place in February 1997. In preparation for this, a committee of eminent researchers will visit Townsville in November to evaluate research and extension activities and will report to the national CRC Program Review Committee. This body will then assess the Centre's administration, management and the achievements of its goals. Professor Michael Pitman, previously the Australian Government's Chief Scientist, remains this Centre's Visitor. The visitor is external advisor and mentor to the Centre linking it with the CRC program as a whole.

Among other things, the four-day May Board meeting looked at strategic planning to the year 2000 and considered requirements if the Centre is to continue beyond that date.

In June Ms Jenni Metcalfe, formerly of CSIRO and now with the environmental communications company 'Econnect', commenced an independent review of the Extension and Training Program which will take into account the views of researchers and managers from all our partner organisations, and those of our major stakeholders. While it is notoriously difficult to measure the success or shortcomings of a communications strategy, the attempt will hopefully shed some light and provide suggestions for the future.

By the time of publication, CRC Reef will have its own page on the Internet. It will contain information about the research programs, a list of research tasks, technical reports and other publications, and Ecologically Sustainable Development information. The homepage will also link to the national CRC Program and



the Great Barrier Reef Marine Park Authority, the Australian Institute of Marine Science, the Queensland Department of Primary Industries and James Cook University.

RESEARCH ACTIVITIES

New tasks approved by the Board include:

- socioeconomic implications of crown-of-thorns starfish outbreaks,
- dugong management in the Great Barrier Reef, and
- developing reliable monitoring programs for use by marine tourism operators and community volunteers.

The last has received a National Ecotourism grant of $60 000 from the Federal Department of Tourism and will receive in-kind assistance from operators Rum Runner and Undersea Explorer and from the Order of Underwater Coral Heroes (OUCH). The objectives of the project are to develop simple, low-cost environmental monitoring programs for coral reefs that can be carried out by visitors as part of a dive-tourism experience or by volunteer community groups. It will evaluate the reliability and quality of data collected by 'non expert' researchers and produce a package of instructional materials for use by operators and volunteers.

Once a working model has been produced with adequate quality controls, these monitoring programs will be available over a broader scale. Operators and community groups have wanted to become involved in research programs for a long time, and this project is expected to find useful ways in which they can do so. Operators visit parts of the Reef that scientists don't necessarily get to, and they go there frequently. If their monitoring is successful, they will provide information that can be achieved in no other way. For further information contact Ms Barbara Musso on (077) 81 5243.

TECHNICAL REPORTS

Recent publications include:

Sweatman, H 1996 *Impact of tourist pontoons on fish assemblages on the Great Barrier Reef*, CRC Reef Research Centre Technical Report No. 5, CRC Reef Research Centre, Townsville.

Cappo, M and Brown, I 1996 *Evaluation of sampling methods for reef fish populations of commercial and recreational interest*, CRC Reef Research Centre Technical Report No. 6, CRC Reef Research Centre, Townsville.

Mapstone, BD, Campbell, RA, and Smith, ADM 1996 *Design of experimental investigations of the effects of line and spear fishing on the Great Barrier Reef*, CRC Reef Research Centre Technical Report No. 7, CRC Reef Research Centre, Townsville.

In press or in peer review are:

Dissolved free amino acids (DFAA) and crown-of-thorns starfish (T. Ayuki), The estimation of visitor use in the Great Barrier Reef (P. Valentine), and A review of environmental impact monitoring of pontoon installations (V. Nelson & B. Mapstone).

CRC Reef Research Centre

An unincorporated joint venture between:

Association of Marine Park Tourism Operators
Australian Institute of Marine Science
Great Barrier Reef Marine Park Authority
James Cook University
Department of Primary Industries

established under the

Cooperative Research Centres Program

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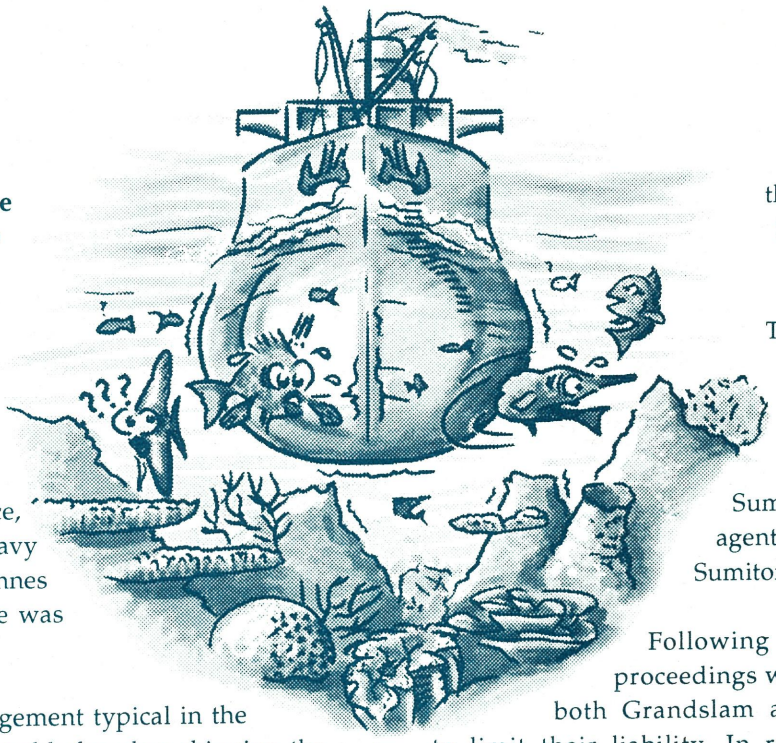
SLICK TALK 17

with Steve Raaymakers

'HEINOUS, SHOCKING NAVIGATION,' RULES JUDGE



In February 1991 the bulk carrier *Sanko Harvest,* en route from Tampa, Florida, to Esperance, Western Australia, slammed into submerged rocks and broke apart in the Archipelago of the Recherche near Esperance, spilling 700 tonnes of heavy fuel oil and 30 000 tonnes of phosphate which she was carrying as cargo.

Under a complex arrangement typical in the murky and convoluted world of modern shipping, the *Sanko Harvest* was:

- bareboat chartered (i.e. crew not included) to a company called Grandslam Enterprise Corporation,
- managed on behalf of Grandslam by Eastern Shipping Company Limited of Japan,
- crewed by Eastern through a crewing agent, Hanjoo Maritime Company of Korea,
- thence time-chartered to Sanko Steamship Company Limited,
- who in turn issued a voyage charter to the owner of the phosphate cargo, Sumitomo Australia Limited.

Two separate bills of lading were issued (relating to two types of phosphate on board) naming Sumitomo's US buying agents as consignor and Sumitomo as consignee.

Following the incident, court proceedings were commenced by both Grandslam and Sanko seeking to limit their liability. In response Sumitomo brought a cross-claim against Grandslam and Sanko for the value of the lost cargo, which was agreed at $8 900 000.

The case was heard by the Admiralty Division of the Federal Court of Australia. On 29 November 1995 the judgement was handed down by Justice Sheppard. In doing so Justice Sheppard made a number of what one might describe as colourful statements about the incident, which could potentially apply equally to shipping through the Great Barrier Reef.

A summary of Justice Sheppard's findings provides a sobering reminder of the potential for similar incidents in Reef waters. The need for Reef management agencies to continually review and upgrade shipping management measures, and the need for the research community to continue to seek to develop new and improved incident prevention and response capabilities, are highlighted by this tragic case.

Without going into the convoluted details of the specifics of the case under maritime law, the central issues regarding who was liable were whether Sumitomo could prove that the ship was unseaworthy or not properly crewed or equipped, and whether Sanko and Grandslam could then establish that any such unseaworthiness was not caused by want of due diligence on their part.

Justice Sheppard held that the ship was unseaworthy because it was sailing on uncorrected charts. The ship did not have the current edition of the local Pilot, which contained warnings that 'the Archipelago of the Recherche is inadequately surveyed, vessels without local knowledge should not traverse the area, and passage should not be attempted at night.'!

Justice Sheppard also found that the charts used for laying off a course to Esperance had large unsounded areas. The Second Officer on the *Sanko Harvest* gave evidence that he thought that the absence of soundings indicated deep water. The course that he had laid took the vessel straight through the 'o' of the second 'not' in the instruction 'Portions not sounded should NOT be traversed.'!

The charts had 'Dangerous to Navigation' markings and stickers in the area of the Archipelago of the Recherche.

Justice Sheppard described the conduct of the Master and the Second Officer as 'grossly negligent' and said that it was 'necessary to emphasise the heinousness of the shocking piece of navigation which led the vessel to the rock on which it eventually foundered'. Justice Sheppard referred to a 'frontal assault' on the Archipelago, and said that the course chosen was 'perilous enough in the daytime. At night it was folly bordering on madness!'.

A safe, clearly marked channel was available, albeit involving an additional 60 nautical miles sailing.

Justice Sheppard found that no effective system was in place on board the vessel for correcting charts. A British Admiralty Notice to Mariners was on board the vessel at the time of the incident. This required corrections to the three charts relating to the approach to Esperance, including insertion of the symbol for underwater rocks exactly in the position where the vessel grounded!

Justice Sheppard also found that the vessel was unseaworthy because it was crewed by incompetent officers:

- The Captain was on his first voyage as a Master and his first voyage on the *Sanko Harvest*. Two years previously he had been reported as 'somehow having a bit of rashness, needs guidance to cultivate serious and calm judgement ability'.
- The Chief Officer was also on his first cruise on the *Sanko Harvest* and had a history of 'low grade to average rating'.
- The Second Officer had spent the previous three years shorebound running a private business.
- The Third Officer was on his first voyage after completing conscript service in the Korean Navy.

In summing up Justice Sheppard stated that '... no competent team of bridge officers would have taken this vessel on the course it took ... the totality of the behaviour of the deck officers reeks of incompetence ... the procedures adopted for crew appointment, evaluation, record keeping and selection for promotion were gravely inadequate'.

Justice Sheppard noted that in 1985 Sanko and its Japanese subsidiaries encountered financial difficulty. He said that 'it would appear that ... after 1985 ... steps must have been taken to cut expenditure and return the group to more profitable trading. This is probably the root cause of the problems which existed ... the findings I have made demonstrate the shoddiness and slackness pervading the whole organisation'.

In the result, Sumitomo succeeded in defeating the application by Sanko and Grandslam to limit their liability, and recovered the whole of its agreed $8 900 000 together with interest. The spilt oil however, has long since done its damage on Western Australia's coast. This damage included 200 oiled fur seals, 13 of which died, many dead oiled birds being recovered and over 100 kilometres of coastline, much of it pristine National Park, becoming oiled.

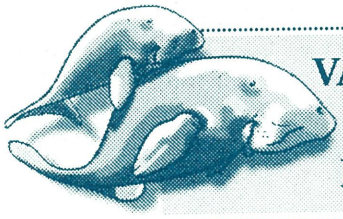
Case details courtesy of Peter Murrell of Murrell Stephenson, Solicitors and Attorneys.

(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).

What's out there

The last issue of *Reef Research* summarised some of the findings of the State of the Great Barrier Reef World Heritage Area Workshop held in November 1995. That article focused on ecological findings of the workshop and foreshadowed looking at other aspects in future issues. This issue will look at some other issues such as values and experiences as well as tourism and its impacts on the Great Barrier Reef World Heritage Area.

Steve Hillman



VALUES OF THE GREAT BARRIER REEF WORLD HERITAGE AREA

As Dominique Benzaken (Socioeconomic research coordinator at the Marine Park Authority) writes '(values) are social constructs arising from beliefs systems which provide individuals and society with a framework for organising and interpreting their surroundings and for acting according to agreed social norms. Valuing selected aspects of the natural or social environment is giving those aspects special significance according to shared beliefs about their importance. Environmental values therefore are not properties of the environment per se, but rather a statement by the beholder (individuals, groups, cultures, society) of their importance. In environmental management, "values" are defined as valued attributes of the natural environment for their ecological, social, economic and cultural significance'.

So what are the 'values' of the Great Barrier Reef World Heritage Area and how do we develop an inventory of them? The simplistic approach is to just list those attributes that are, on face value, valuable. This list might include dugongs, turtles, special places and so on. While not arguing for one moment that these are not valuable attributes, it seems to me that if they are of outstanding value, for any number of reasons, then there will be considerable pressure to protect them by other means, whether a World Heritage Area exists or not. That said, there are a number of ways of valuing the Great Barrier Reef World Heritage Area. The current status of knowledge has been acquired through various research studies and the public participation process as well as information that has been compiled regarding such things as tourism, recreation, other human uses and economics.

The information base that we have to work with is incomplete, particularly as it relates to values associated with indirect or vicarious use and values of those not associated with the participatory process. An integrated approach is required to build a better

time-series of information at a range of scales regarding recreation and tourism, indigenous use, economics and other things that people consider necessary to protect world heritage status.

In my view, the true value of the Great Barrier Reef World Heritage Area is that it is a complex but integrated assemblage of species, communities, habitats and ecosystems that is unique in the world. To try and tease out individual items that are of value is a simplistic and anti-intellectual consideration of values and ignores the relationships that exist in the Great Barrier Reef World Heritage Area and that fact that the whole is necessary for the flora and fauna to continue to live in a relatively undisturbed and pristine area.

TOURISM IMPACTS

Tourism is a major use of the Great Barrier Reef World Heritage Area and is estimated to be worth well over one billion dollars annually. Tourism impacts have been studied in the context of the ecological, social and cultural values of the area.

Generally speaking the ecological impacts of tourism have been demonstrated to be minimal and very localised and have been well managed. Where structures are part of a tourism project, the Marine Park Authority requires rigorous assessment, particularly with regard to the effects on the ecology of the site. To date, predictions about changes to the fauna and flora of areas that have been developed have been quite reliable and the Authority is now in a position to accurately assess developments and put in place monitoring programs that will detect any environmental changes before they become a problem. Monitoring programs are funded by the developer but managed by staff in the Research and Monitoring Section. These programs are carried out by independent consultants to ensure impartiality. It is likely that monitoring of structures will be reduced in scale in the future.

Much less information is available about the impacts of tourist and recreational activities where monitoring has not been possible, and the effect of cumulative impacts have not been satisfactorily addressed. Management plans are in various stages of development for a number of heavily used sites and regions. Little work has been carried out on the impacts on amenity or social values associated with tourism but this is receiving greater attention now that the Authority has gained a good understanding of ecological impacts.

Anchor damage has been identified as an impact that needs to be addressed, and moorings have been established in the Whitsundays and around various reefs in the Cairns Section. The effectiveness of these moorings has yet to be properly assessed however.

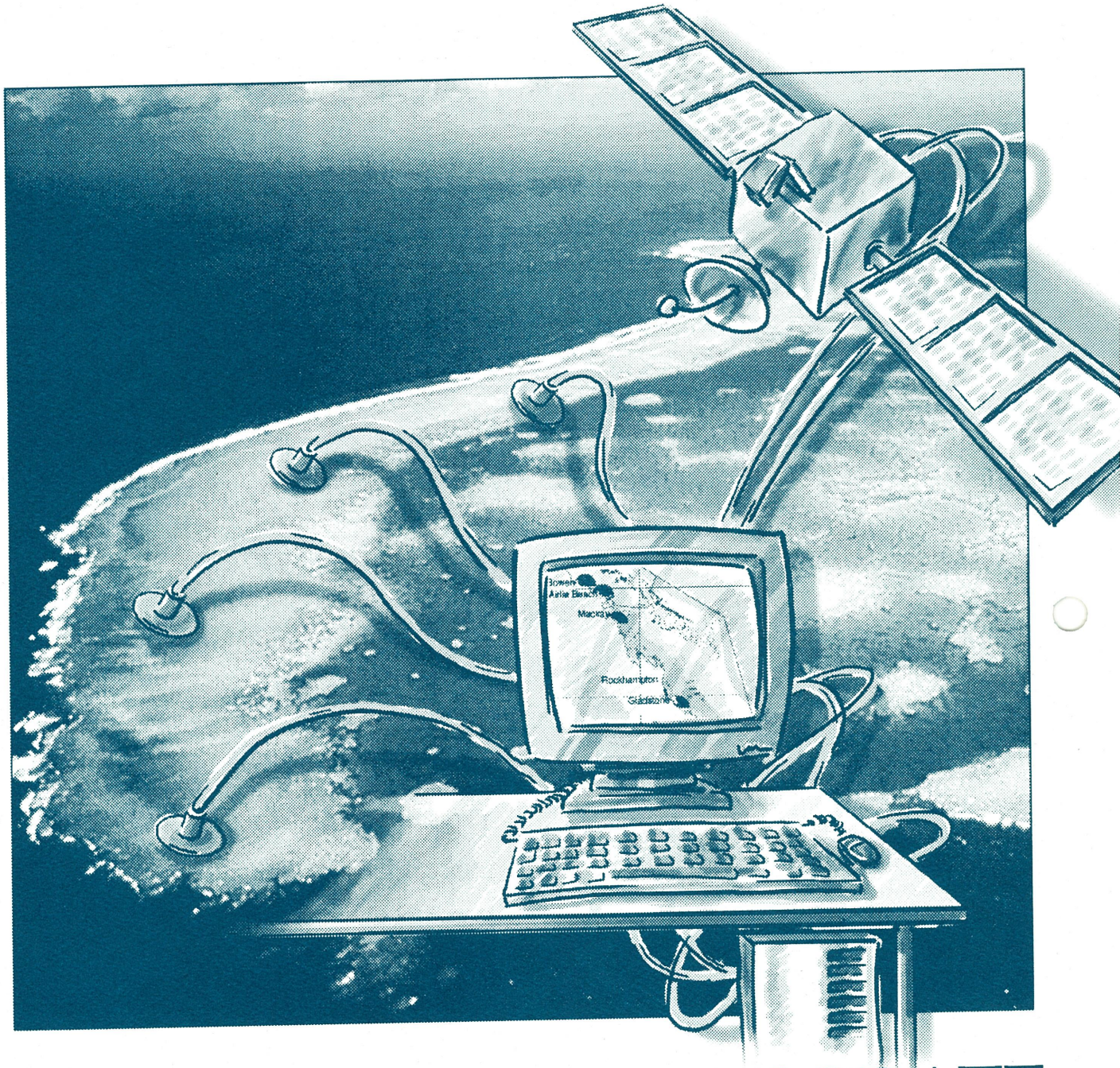
Probably the greatest threat to the Reef comes from adjacent terrestrial tourist developments which can impact on water quality, mangroves and seagrass beds.

EXPERIENCES

Work to date that has examined the experiences that people have and what they expect has been limited to a detailed study at Lady Musgrave Island, a study at a pontoon at Norman Reef, some work done in the Whitsundays and occasional point data. A number of new studies, especially associated with diving and snorkelling, will expand on this knowledge base.

Work to date indicates that:

- there are a wide range of experiences sought by visitors,
- interactions between users has received little attention,
- nature is the most important part of the experience desired by visitors visiting the Reef,
- the experiences of many visitors are dominated by excitement and novelty and these are regarded as of high quality,
- crowding is seen to be a negative experience by many visitors,
- different users often resent other users and their impact on experiences that are sought after, and
- the allocation of specific sites for particular purposes is perceived by many to be degrading reefs that they are possessive about - this is particularly the case with regard to some forms of intensive tourism.



DEVELOPING A CORPORATE WIDE NETWORK FOR GIS

Michael Hartcher and Jeff Shearin

Introduction

The use of Geographic Information Systems (GIS) at the Great Barrier Reef Marine Park Authority has steadily increased since their inception in 1992. Throughout the development there have been various problems encountered and 'blind alleys' entered, as well as a number of significant improvements and major achievements. The purpose of this article is to briefly outline the Authority's GIS experiences, suggest how such a system could be implemented less painfully, and highlight our current situation, particularly the role of GIS in decision making, and the importance of data coordination and management.

When one considers that the Great Barrier Reef contains about 3000 reefs and around 1000 islands; includes vast lengths of coastline with critical habitats such as mangroves and seagrasses (also found in deep water);

furnishes sites for endangered species such as turtle and dugong; supports a plethora of commercial activities including trawling and line fishing, tourist daytrip and dive operations; is used for the collection of marine fauna for sale; and is used for a myriad of recreational activities, it becomes apparent that the information required to plan and subsequently zone is mind-boggling and potentially one huge mess! Enter spatial analysis with information technology to the rescue.

The development of GIS has been less than ideal in the Great Barrier Reef Marine Park Authority in terms of staffing and infrastructure, however, we have managed to develop a system which is available on-line throughout the Authority to virtually any user, and which contains a wide variety of data sets pertaining to topography, natural resources, jurisdictional boundaries, socioeconomic issues and aerial surveillance, as well as a variety of scanned aerial photographs and satellite images and many cartographic and modelling tools.

Pilot study 1991 and onwards

The initial emphasis for developing a GIS was for zoning of the Great Barrier Reef Marine Park. The overlaying of significant natural resources with trends in usage can provide a means for evaluating the management requirements of an area. Prior to automated methods, which utilise GIS, planners had used hand-drawn maps and plastic overlay sheets to analyse resource and activity patterns to convey information. Such methods were quite time consuming, lacked real precision, had no capacity for future updating, and had no provision for linking to databases.

The initial pilot study into developing a GIS at the Authority, carried out by the Australian Survey and Land Information Group (AUSLIG) in 1990-91, was the result of a gathering impetus created by the birth of a series of new hardware and software technologies which were making spatial analysis and mapping with computers a literal reality. A variety of recommendations came out of the study including the proposed hardware and software structure and staff requirements. The study recommended that two additional staff would be required to establish and maintain a GIS in the Authority, composed of one GIS Manager with expertise in the operation of GIS systems, and one GIS project officer as support.

Unfortunately the funding approval did not cover the whole structure and we were left with a technician but no GIS Manager. This was to prove a stumbling block for development in the years to come although progress was still quite evident. In the early stages development was very much focused on map products, where staff were approached regarding possible GIS mapping needs and it was attempted to produce a useable product in a timely manner. Data acquisition was very much a 'grab what you can' exercise where we sought to load our hard disks with as much useful, valid, and 'corrected' data sets as we could find. Fortunately the main base entities (e.g. reefs, islands, coastline, etc.) had been digitised through a contract with AUSLIG so we had a topographic base to work with. These base coverages required quite a lot of editing, however, having been supplied in 11 separate map sheets for each theme and containing a great deal of overlap making edge-matching of the maps impossible.

The focus for the next couple of years was on establishing a database which contained information relevant to planning and management and in correcting errors in the main base layers. Because zoning is primarily the responsibility of the Planning and Environmental Management Section in the Authority, the database development was primarily focused on planning and management needs. Over the 2-3 years of initial development the GIS was confined to a small working group with only two workstations available running ArcInfo and ArcView licences.

This situation continued during the development stages, however, once requests started increasing and as staff started to observe the utility of the system, demand became too high for the group to maintain timely supply of desired products. Also, the number of people in the Authority with GIS needs and skills to use the system was increasing significantly with as many as 8-12 staff wanting to use the system at any one time! The significant bottleneck of ongoing requests made it very difficult to undertake development work and modelling. It was apparent that the system needed to decentralise so that the bottleneck would be relieved and also to provide access for a variety of staff.

Before and after network

By 1995, the sheer amount of GIS data generated, and thus requiring hard disk storage, was tending to stretch the limits of available disk resources. The machines being used for GIS processing were being overloaded by having to handle increasing volumes of data requests from network users. The situation was further exacerbated by the use of older technology (SUN IPX) for the main GIS data server, which was being utilised as an operating terminal, while a SUN sparc 10 was being used as the main operating terminal relying on data retrieval from the 'slower' server (see figure 1). Clearly some level of upgrade was required and the tasks allocated to each machine needed to change in

order to facilitate throughput of jobs and projects.

Further, there was a perception that the efficiency of the Authority's computing network was being compromised by the volume of data traffic allegedly emanating from GIS sources. While the validity of this suggestion was difficult to quantify, due to ongoing developments within the corporate network itself, the magnitude of existing GIS data transfer across the network was seen to be sufficient to prompt thoughts of partitioning the network to create a GIS sub-network. The sub-network has effectively removed direct GIS network traffic from the mainstream corporate network.

How it was done

The networking of GIS throughout the Authority has involved a variety of skills from a number of different staff. The system had to be designed, quoted, approved, purchased, installed, formatted, tested and manipulated further.

The process has proceeded as follows:

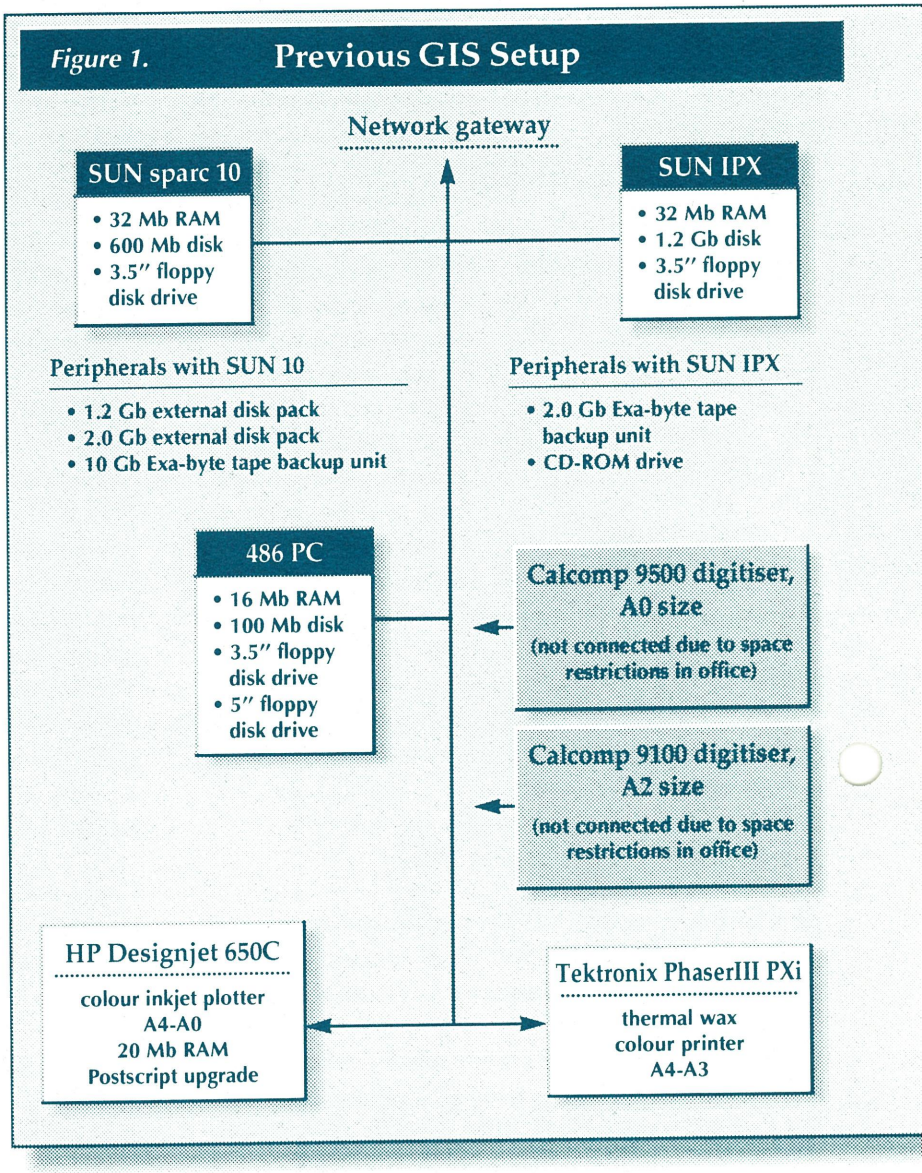
Step 1 Design of network
Step 2 Obtain quotes for all components of a range of possible network scenarios
Step 3 Budget approval
Step 4 Purchase hardware and software
Step 5 Install hardware and software
Step 6 Implementation and troubleshooting
Step 7 Testing of links, etc.
Step 8 Follow-up on problems (we are currently at this step)
Step 9 Fully consolidate network

The main alterations to the network were as summarised below:

1. An existing fileserver was utilised to carry extra hard disks specifically for GIS data and projects.
Three new 4 Gb hard disks were procured for individual roles of:

- storage of base GIS coverages,
- storage of images from satellite and photo-scanning sources, and
- provision of GIS user workspace areas and cartographic tools.

Figure 1. **Previous GIS Setup**



2. A hard disk controller card was attached to the GIS disks. This disk controller card has dual output slots with one slot connecting to the main network and the second slot connecting to the GIS sub-network.

3. New purchases and upgrades of existing GIS workstations included:

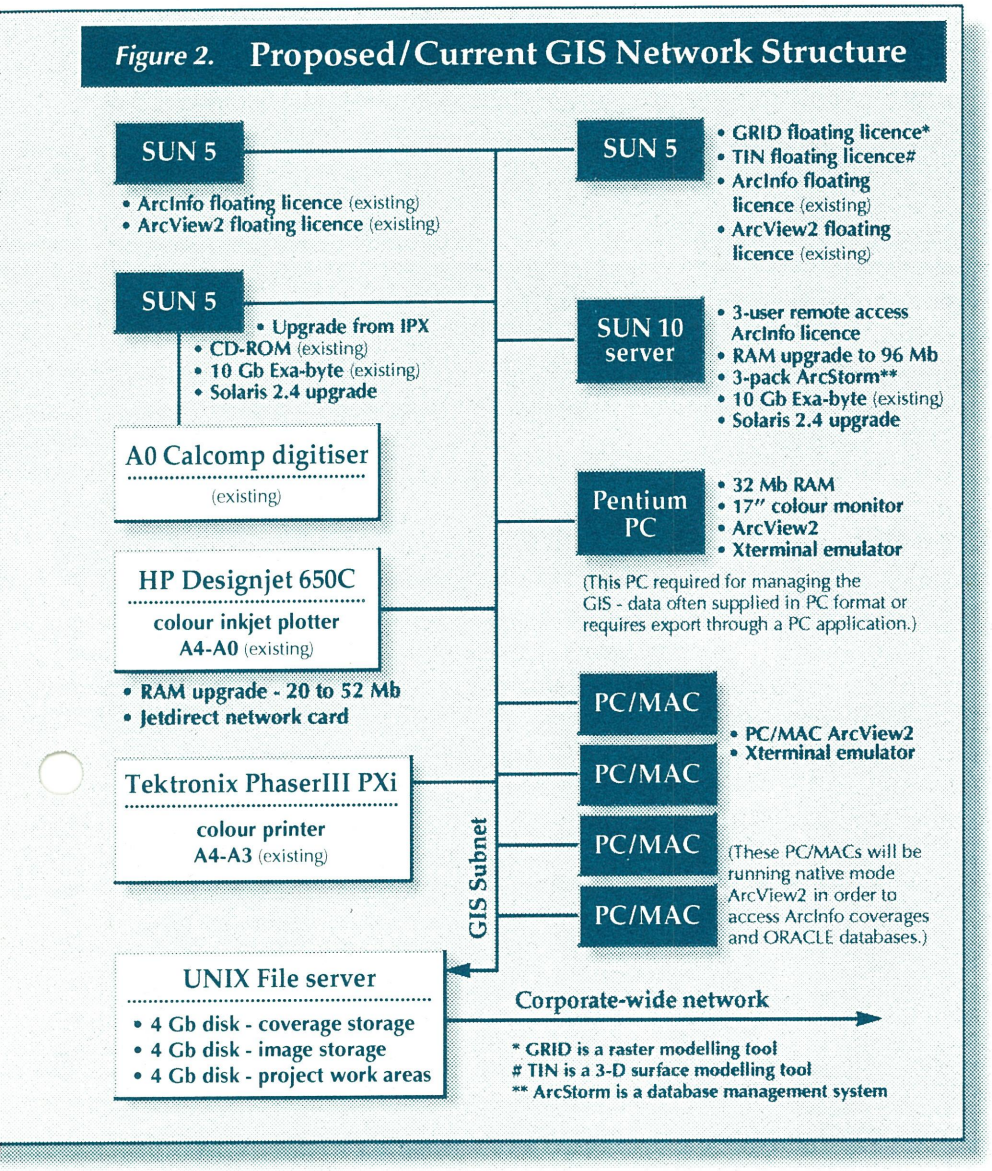
- memory upgrade for the node-lock server that allows remote access,
- new workstations, and
- an upgrade to the aging IPX workstation.

4. A new hub to handle GIS users' connections was added as was additional wiring for the sub-network.

5. Changes were made to the ArcInfo and ArcView licence structure. These were:

- the existing floating licence was converted to a node-lock arrangement to allow for remote connections from PCs, Macs and workstations,
- a new floating licence for the new workstation was purchased, and
- the existing floating licence was relocated to the newly acquired workstation.

Figure 2. **Proposed/Current GIS Network Structure**



The present network is depicted in figure 2.

Blind alleys and burnt fingers!

It is absolutely essential that when new software versions become available there is time allocated to identify any problems that may occur with your own specific network and/or methods of data access. Performance tests and scenario tests can help to pin-point trouble spots in the network, particularly where a specific task is required on a regular basis.

It would be worth suggesting, or even insisting, that acquisitions for untried hardware/software platforms be subjected to extensive trials to avoid any contorted workarounds where incompatibility is concerned. In our haste to produce a system with access from various platforms, we accepted assertions of compatibility from end users and vague suggestions from certain vendors. Subsequent operational problems revealed that the desired, fully operational system could not be configured for particular platform/network combinations, such as using Mac ArcView 2.1 to access GIS coverages directly from a Unix server.

The good bits so far

Some of the achievements include customisation for easier use of the GIS and automation of repetitive tasks, development of standards for mapping with the Authority cartographer, faster turn-around for GIS requests, a more centralised GIS unit with adequate resources and room for demonstrations, and stronger links to other agencies' GIS, such as the Australian Institute of Marine Science, James Cook University, the Queensland Department of Primary Industries, Commonwealth Scientific and Industrial Research Organisation, and the Queensland Department of Environment.

An outstanding inventory of data has been acquired, especially when one considers that the original staff structure was never implemented. This has been facilitated by the development of a sound network of contacts and good communication between agencies. It is difficult to maintain regular contacts at times due to work loads and different focus of agencies, however, there appears to be a fairly strong commitment by GIS users to develop coordination and standards.

The outcome of all this work has been a dramatic increase in the use of information to guide decision making. Many projects within the Authority, including the Far Northern Section zoning review, Whitsunday Islands management planning, endangered species planning, Aboriginal and Torres Strait Islander liaison, the Shoalwater Bay plan, the Effects of Fishing Program, crown-of-thorns starfish research and water quality monitoring have incorporated the use of GIS to perform analysis/modelling and create output maps. As a result quite a few staff have become competent in their ability to enter, edit, manipulate, analyse, and plot information of relevance to the projects for which they are responsible. More importantly, the level of conceptual understanding of GIS and spatial analysis/geography has risen to the level where most GIS users can develop methods for solutions to 'spatial problems'.

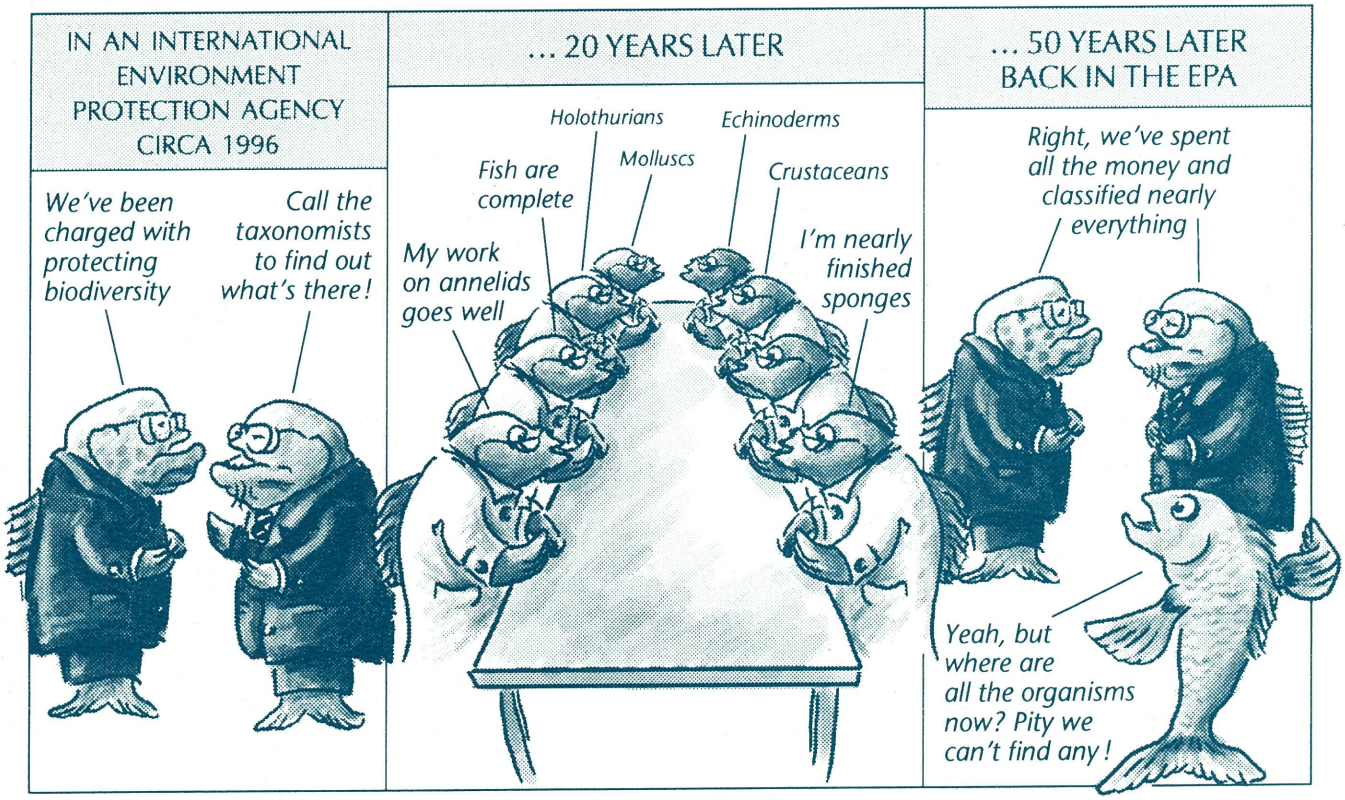
Current value and future directions

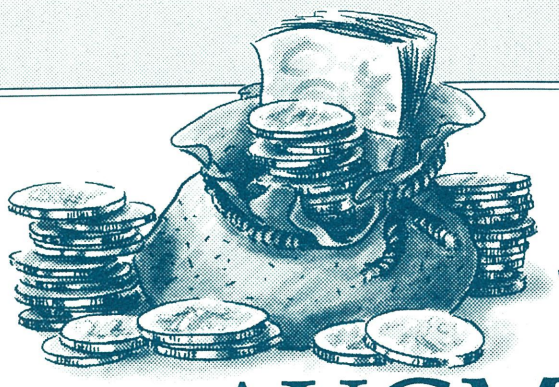
The value of a GIS has been spelled out in many texts highlighting the 'power' of GIS and the utility of digital systems. The current value of the Authority GIS is that it contains a sound base inventory of data sets necessary for project development, and it is openly accessible by virtually all staff within the Authority. Further improvements such as larger scale data sets, development of a users' manual, completion of documentation and associated meta-data, along with links to the world wide web, will make the system a lot more coherent and more sensitive to varying needs. A team environment has been created among GIS users, in which the overall information strategy is being approached and in which cross-fertilisation of knowledge and ideas is encouraged.

The focus for the future of GIS in the Great Barrier Reef Marine Park Authority should be on the coordination of data needs, modelling, and reporting systems. Admittedly the coordination of data has been less than ideal due to a variety of circumstances, but mainly being an artefact of the failure to provide the proposed staff structure from the beginning. This situation may be improved if a central data coordination role is developed to oversee data acquisition, analytical needs and modelling. Also, the roles of staff who are administering the GIS in terms of computing support and management of the system need to be clearly defined and staff given adequate credibility. Many organisations have more competent GIS systems due to their commitment to adequate staff structures and by investing in expertise which can guide development and help to avoid wasted effort.

The GIS coordinator role in the computing section has proven to be essential to the daily operation of the GIS system. There are many different components incorporated in the GIS network and it is essential to have somebody to be available to troubleshoot any problems with hardware and/or software. The role of the position has also involved organising any software and hardware quotes and purchases, as well as organising training in GIS for staff. Data management and coordination ARE distinctly separate roles which MUST be given a high priority if a system is to be utilised in an efficient and cost effective manner. At present the position of the GIS 'unit' within the corporate structure needs to be better defined and possibly altered with demarcation made apparent for the separate roles of the team and to further enhance the cohesive nature of the overall information and strategy.

Coralations **'Protecting' Biodiversity** **Pongase**





1996 AUGMENTATIVE RESEARCH GRANTS SCHEME

The Great Barrier Reef Marine Park Authority awarded ten grants this year to students undertaking research related to management of the Marine Park. Kim Davis reports.

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

James Cook University of North Queensland

Ken Anthony / Dr Bette Willis,

The role of particulate feeding on energy budgets in reef corals, ($1000) This study will investigate the importance of sediment (particulate matter) as a food source for corals and as a factor influencing growth and reproduction. By using a range of sediment concentrations, Ken will detect thresholds where sedimentation shifts from being an energy source to a stress factor. He concludes that if a given sediment load represents an energy source to some species but a stress factor to others, increased levels of sedimentation over inshore reefs will have the potential to alter the structure of the coral community towards a dominance of species with high heterotrophic capabilities.

Naniel Aragones / Dr Graeme Inglis,

Restoration ecology of seagrass beds: improving the efficiency of seagrass transplantation, ($1000) Naniel will examine biological and methodological factors which affect attempts to restore seagrass beds through active transplantation. He will develop an efficient species-specific technique for transplanting seagrasses in the intertidal zone, determine the impacts of transplantation on donor populations and study the survival and growth of seagrasses transplanted from one habitat type to another. The results of this project will be extremely useful for future restoration of seagrass beds.

Daniel Breen / Dr Geoff Jones,

Modelling biological survey techniques in marine park management (Section 2. Small coral reef fish surveys), ($1500) In his research Daniel will focus on extending an existing project which measures changes in small reef fish communities associated with a large tourist pontoon located at Agincourt Reef. On completion of the fish censuses, the effectiveness of sampling and monitoring techniques will be assessed using computer simulations and field data, and an assessment carried out of how simulated patterns model real field distributions of organisms. Daniel will also examine how this information can be integrated into resource management models and strategies.

Andrew Broadbent / Dr Graham Jones,

Assessment of the potential of clams as bio-indicators of water quality, ($1200) This project will interface between a compliance monitoring program being conducted at Kelso Reef, and a reef-wide project (commenced in mid-1995)

commissioned by the Authority to assess the potential of clams as bio-indicators of water quality. Fortnightly measurements of water quality parameters (such as nutrients, sediment flux and chlorophyll) are currently being taken at Kelso Reef. In addition, Andrew will collect samples of clam haemolymph and analyse them for ammonia, nitrate, glutamate and glutamine. These findings could provide key information on the potential of clams as long-term bio-indicators of water quality.

Julie Lahn / Dr Sandra Pannell and Dr Maureen Fuary,
Customary marine tenure in Torres Strait, ($960). This project will focus on cultural principles and beliefs that the people of Warraber and Poruma Islands have about the sea. An appraisal of the current use of marine resources by these people will be carried out so that family and community sea boundaries of these islands can be mapped. Julie also hopes to gain an insight into Islander perceptions of the current state of the reefs and other users of the reefs in the Torres Strait. The outcomes of this project may prove useful in future planning and management of the Great Barrier Reef in the region of these islands.

Alex Peachey / Acting Professor Owen Stanley,
The economic value of commercial, recreational and indigenous fisheries on Bramble Reef, ($800). Alex aims to determine economic impacts associated with the reopening of Bramble Reef and derive economic values for various fisheries (commercial, recreational and indigenous) for Bramble Reef and the offshore Ingham area. In addition to surveying users, Alex also plans to gain an insight into the recreational and indigenous non-market values associated with fishing in these areas.

Michael Rasheed / Dr Graeme Inglis and Dr Robert Coles,
Investigations of recovery and succession in north Queensland tropical seagrass communities, ($1600) This research is aimed at establishing and comparing mechanisms of recovery for tropical seagrass communities at an inshore intertidal and an offshore subtidal site in the Great Barrier Reef region. Mr Rasheed will describe colonisation and subsequent succession of seagrass species following loss, examine the relative importance of sexual and asexual reproduction to seagrass recovery and investigate the effects of ambient light on seagrass recovery and succession. This information will assist management in identifying seagrass areas that are particularly vulnerable to loss and strategies to enhance their rapid recovery.

Jacqueline Wolstenholme / Dr Carden Wallace and Dr Bette Willis,
Delimination of species boundaries within mosaics of the *Acropora humilis* ***species complex: a contribution to resolving problems encountered in management programs and ecological studies of coral reefs***, ($1500) This project will clarify species boundaries within *Acropora* by combining recently discovered breeding and genetic techniques with traditional morphological characters. As *Acropora* is one of the largest and most taxonomically complex coral groups, the results of this project will contribute significantly to understanding the extent to which hybridisation, reticulate evolution and sibling species confound species descriptions in corals.

The University of Queensland

Ben Diggles and Ingo Ernst / Professor R Lester, Dr I Whittington and Dr M Jones,
Effect of recreational fishing on the mortality of released fish on the Great Barrier Reef, ($900) The researchers aim to determine the effects of specific angling techniques on the mortality of the wire netting cod, *Epinephelus quoyanus*, and the yellow stripey, *Lutjanus carponotatus*. The relationship between methods of capture and variables such as handling time, location of injury, water temperature and fish length will be examined. This project is anticipated as a pilot investigation which may lead to a more extensive study of hooking mortality in Australian fish species.

Michelle Heupel / Dr Mike Bennett,
Biology of two reef-living sharks: the blacktip reef shark, *Carcharhinus melanopterus* ***and the Epaulette Shark,*** *Hemiscyllium ocellatum*, ($784) Michelle will examine various aspects of the biology (e.g. reproduction, host-parasite interactions) and behaviour (e.g. habitat use, foraging behaviour) of two reef-dwelling sharks at Heron Island Reef. Various tagging techniques will be used in an attempt to gather information on long-term movements over the reef flat and occupancy of the environment. Michelle believes this study, in addition to studies on other elasmobranch species, will assist future management decisions regarding elasmobranch fishes.

COTS COMMS

Udo Engelhardt

Every now and then there comes a time when one should sit back, feel comfortable and relaxed, and have a good close look at where 'things' are going. The crown-of-thorns starfish program is no exception to this rule, and in this issue of COTS COMMS I am pleased to report on a series of reviews that have been carried out over the last few months. Reviews, reviews, reviews ... absolutely everything (*well, nearly everything*) was looked at in an effort to assess program operations and to give us new leads and directions for the future. The results, I believe, are quite interesting and informative. The following summaries will hopefully give you a good overview of what is going on in the 'Wonderful World of COTS'. Happy Reading !

INDEPENDENT COTSREC PROGRAM REVIEW

Eminent marine scientist, Dr Bob Johannes, was asked to review the performance and effectiveness of the Crown-of-thorns Starfish Research Committee COTSREC Program from 1992 to 1995. Dr Johannes, who had previously reviewed the program in 1991, was also asked to make recommendations for any changes to the operation, management, content and scope of the Program, as well as for the level of funding for the Program in the future. Here is a brief summary of some of his main conclusions and recommendations.

'The goals of the Great Barrier Reef Marine Park Authority's (GBRMPA) crown-of-thorns starfish research program are to understand more fully the causes of crown-of-thorns starfish outbreaks, to provide public forewarning of, and education concerning, outbreaks and to provide advice on appropriate control procedures where required. COTSREC provides independent expert advice to the GBRMPA on the running and directions of the research program.

'The GBRMPA/COTSREC program has operated in a highly efficient and productive manner during 1992-95 within the limits imposed by inadequate and uncertain funding. It has contributed significantly to the knowledge required for the use and enjoyment of the Great Barrier Reef in an ecologically sustainable manner. COTSREC has also significantly improved its communication with the public, the media and the tourism industry as well as its program for controlling COTS outbreaks on priority reefs.

'COTS outbreaks present invaluable research opportunities that are unavailable at other times. They also require expanded communication with the public and the media, as well as starfish control activities on priority reefs. Lags in funding during both previous outbreaks significantly constrained GBRMPA's ability to respond to these challenges and to capitalise on the vital opportunities outbreaks provide for obtaining a better scientific understanding of the phenomenon and its cause(s).'

Specific recommendations from this review were (not in any order of priority):

- Seek supplementary funding to enhance the program's abilities to carry out communication and research activities during the current outbreak.
- Expand research on the effects of COTS on the population characteristics of massive corals to answer some important and worrisome questions concerning the future of these corals in the event that outbreaks continue to occur at roughly 15-year intervals.
- Initiate studies into pre-settlement factors relating to COTS outbreaks using field applications suitable for

studying COTS larvae in the plankton. Studies of this nature may assist to identify outbreaks earlier and link larval dispersion and recruitment with hydrodynamic factors.

- Support valuable research that can only be pursued effectively during outbreaks such as studies of predation on small juvenile starfish, movements of adult starfish populations and mechanisms for the ultimate termination of outbreaks.

- Make available funds for additional fine-scale monitoring north and south of the Cairns Section in order to track the apparently expanding area of the outbreak.

- Seek means of reinstituting multi-year guaranteed budget arrangements, such as those operating during the period of 1989-1992.

- Obtain a contingency fund to be able to respond fully to the scientific opportunities and communication and control responsibilities that new outbreaks create.

CAIRNS SECTION REVIEWS

Three times in the last 35 years major outbreaks of COTS have started somewhere on reefs in the Cairns Section of the Marine Park. Rather than assuming that this pattern was simply the result of some chance events, it would seem likely that one or several factors may be responsible for making this area particularly prone to COTS outbreaks. In an effort to pinpoint some of the factors that are possibly unique or amplified in this region, the COTS program commissioned three reviews. The following paragraphs summarise what is currently known about the geomorphological, physical and biological characteristics of this critical area. The key to understanding the ultimate causes of the COTS phenomenon may be found somewhere in this maze of information!

'Review of the uniqueness of the Cairns Section of the Great Barrier Reef Marine Park in reference to the possible predisposition of the area to developing primary outbreaks of the crown-of-thorns starfish (COTS)'

by Prof. David Hopley, Director - Sir George Fisher Centre, James Cook University

An examination of the geomorphology and related factors in the Cairns Section of the Great Barrier Reef Marine Park suggests that there are many features which would favour a pattern of outbreaks of crown-of-thorns starfish similar to that recorded. This is a part of the Great Barrier Reef in which mainland influence is probably greatest. The reef is adjacent to a mainland of high relief and high rainfall with the reefs in close proximity to this mainland. These effects would be aggravated by human activities which extend at least half way up the Cairns Section. In this area, there is also a high density of population and extensive agriculture, utilising practices which may lead to accelerated soil erosion and the possibility of nutrient flux from the mainland to the Reef lagoon. Further, the influence of the El Niño-Southern Oscillation (ENSO) phenomenon with periods of low rainfall interspersed with periods of flood with a 10-14 year cycle is likely to create a pulsatory temporal pattern which may also be related to crown-of-thorns starfish outbreaks.

The following features appear to coincide within the area that has been regarded as that from which crown-of-thorns starfish originate:

- The southernmost extent of narrow shelf width,
- The southernmost extent of the reef being close to the mainland and all its influences,
- The southernmost extent of extensive Halimeda banks,
- The southernmost extent of domination by crescentic reefs, and
- The southernmost extent of ribbon reefs and low wooded islands.

The northern boundary to the region is distinguished by:

- The northernmost extent of dominance by crescentic reefs,
- The northernmost extent of high rainfall on the adjacent mainland,

- The northernmost extent of coastal ranges exceeding 1000 metres in height,
- The northernmost extent of dense and long settled human populations,
- The northernmost extent of extensive agricultural areas, and
- The northernmost extent of dead, submerged shelf edge reefs.

No other area of the Great Barrier Reef is comparable with respect to these features.

Recommendations for further investigation

Crescentic reefs appear to be integral to the understanding of crown-of-thorns starfish outbreaks. Insufficient is known about the hydrodynamics related to this reef type, particularly in summer months when the major flow of water may be from north to south. Research into the flow of water over and around crescentic reefs is recommended. The residence time of water due to the constraining influence of the ribbon-reefs also merits further investigation.

Although extensive work over the last twenty years has provided information on the Halimeda banks, the part they play in total nutrient cycling over the continental shelf is not fully known. Incorporation of the banks into the nutrient budgets of the shelf needs to be undertaken.

Oceanic influx is known to affect the distribution of Halimeda banks. It is also related to ENSO events. Further investigations are required as to the scale of oceanic influence on the outer edge of the shelf and the extent to which it extends across the shelf.

Terrigenous influence on this sector of the Great Barrier Reef is clearly indicated and has been illustrated by numerous, though isolated studies. A study needs to be undertaken to determine the zone affected by mainland runoff and whether or not this has changed in historical times. A suggested strategy would be to carry out a systematic shallow coral core program which could establish the pattern and extent of terrigenous influence through the application of numerous techniques e.g. fluorescence, geochemistry etc.

Relationships between ENSO and crown-of-thorns starfish outbreaks have been suggested. Further work is required on shelf hydrodynamics during contrasting El Niño and anti-El Niño (La Niña) phases.

'Physical oceanography of the Cairns Section of the Great Barrier Reef Marine Park, in the context of COTS outbreaks'

by Drs Lance Bode (James Cook University) and Derek M Burrage (Australian Institute of Marine Science)

This report surveys the physical oceanography of the Cairns Section of the Great Barrier Reef Marine Park, against a background of the potential influences of the current regime on the crown-of-thorns starfish phenomenon. The various field studies which have been carried out on the shelf, as well as relevant work in the adjacent Coral Sea, are discussed and evaluated. Also treated are a number of theoretical and numerical modelling studies of the current regime.

The ongoing COTS surveys point to a recent but continuing upsurge in the numbers of starfish in the northern portion of the Cairns Section. This raises the question of whether such populations are a likely precursor to further COTS outbreak episodes. The last outbreak stimulated considerable research on the COTS phenomenon, a novel aspect of which was the combined role played by physical oceanographic field studies and numerical modelling.

The models of Dight and co-workers at that time linked larval transport processes with the currents on the continental shelf. This demonstrated the general southward trend of starfish activity. Further modelling work by Black and Burrage has revealed the variability in the extent of larval transport, due largely to the influences of the East Australian Current on continental shelf circulation.

Improvements in computational facilities now allow these early models to be upgraded in a number of ways, through increased spatial resolution, improved model physics and particle release strategies, and the assimilation of real data into the process of model forcing. Such advances need to be accompanied by the acquisition of improved data sets, so that the models can be more comprehensively verified against physical reality. However, the disappearance of large COTS numbers throughout the Great Barrier Reef has been mirrored by a reduction in research support, which now needs to be redressed. The only available long-term current observations come from the Transport of the East

Australian Current System (TEACS) current mooring array. This has provided invaluable information about oceanic influences on the continental shelf edge and slope, near the northern and southern extremities of the Cairns Section. Apart from several current measuring programs discussed in the report, which were set up independently of TEACS, no correspondingly long-term data on currents have been collected from the inner and middle shelf. Such data are crucial for a proper quantitative evaluation, calibration, and further refinement of the various numerical models. This would enhance their use in COTS larval transport modelling and in related studies, and thereby develop their potential use for management decision making in the Great Barrier Reef Marine Park.

A key feature influencing low frequency ('mean') currents in the Great Barrier Reef Region is the position at the shelf edge of the bifurcation point for the inflowing South Equatorial Current, where it separates into the East Australian Current and the northward flowing Hiri Current. This generally tends to be located in the northern part of the Cairns Section, but its position also exhibits considerable variability. The relationship between the bifurcation and other physical factors (e.g. winds, oceanic current regime, and other influences such as ENSO), quite apart from the possible effects on shelf currents and larval transport processes, is essentially unknown. The situation in the Cairns Section contrasts with that in both the neighbouring Sections, Central and Far Northern, where much more relevant research has been effected. An improved understanding of the region's circulation will require a more concerted effort than has been made to date, not only in data collection and analysis, but also in various types of numerical modelling.

'Biological and chemical oceanographic features of the Cairns-Cooktown region relevant to crown-of-thorns starfish outbreaks'

by Dr Miles J Furnas
(Australian Institute of Marine Science)

Existing biological, oceanographic, water quality and environmental data for the Cairns-Cooktown region (14°30'S to 16°55'S) have been reviewed with regard to the contribution of regional features, processes and dynamics to the preferential development of primary crown-of-thorns starfish outbreaks in this region.

In terms of its regional and time-averaged water quality characteristics, the Cairns-Cooktown region does not differ greatly from the Great Barrier Reef shelf as a whole. Taking due regard for systematic differences between data sets, an examination of extant water quality and nutrient data sets shows no clear evidence for widespread eutrophication in the region from natural or anthropogenic sources. Time and spatially-averaged, depth-weighted chlorophyll concentrations are on the order of 0.4 to 0.5 μg L^{-1} , close to the larval development/starvation threshold suggested by Lucas (1982). Under low-rainfall, low-runoff conditions, chlorophyll concentrations in lagoon waters may only be half this value. A significant proportion (40-80 per cent) of this phytoplankton biomass is in the form of picoplankton (> 2 μm size fraction) which are not optimal food for *Acanthaster* larvae. Higher persistent chlorophyll concentrations (as an indicator of phytoplankton standing crop) are found elsewhere in the southern Great Barrier Reef (Pompey Reefs 20°S). Resident phytoplankton populations have real primary production rates similar to the Great Barrier Reef as a whole and are characterised by relatively high in-situ growth rates. While blooms of *Trichodesmium* are regularly observed in the region, *Trichodesmium* is unlikely to be a significant food source for *Acanthaster* larvae.

Significant, shelf-scale, but episodic upwelling occurs in the Cairns region and can contribute significantly to shelf nutrient stocks. No large-scale upwelling events have been observed in the Cooktown region to date. Shelfbreak upwelling in the Cooktown region is constrained by the local reef topography and direct effects are most likely limited to the outer shelf.

There is circumstantial evidence supportive of the terrestrial runoff hypothesis for the generation of past primary crown-of-thorns starfish outbreaks in the region. Both the mid-1980s and current (incipient) outbreak were preceded 3-4 years by significant inputs of freshwater to the Cairns-Cooktown shelf from river runoff and rainfall. This freshwater input is presumed to contain substantial dissolved and particulate nutrients. The largest river floods in the region since the late 1950s occurred in 1979 after several 'wet' years (1974, 1977). The major floods of 1981 also appear to have affected the region. Low salinity waters were observed in the Cairns—Cooktown region

and it is likely they persisted for several weeks during the likely time for *Acanthaster* larval development. Widespread distribution of low salinity water and elevated nutrient and chlorophyll levels, which also were likely to have persisted for more than one month, were noted during a prolonged (December-March) monsoonal rain depression which followed cyclone Joy in 1991. Post-cyclone Joy chlorophyll concentrations (ca. 0.5 µg L^{-1}) were above the threshold for successful larval development.

The importance of terrestrial nutrient inputs is likely to be strongly influenced by the retention time of water, nutrients and plankton within the semi-enclosed section of shelf between the Howick Islands (14°30'S) and Cape Tribulation (16°05'S). It is likely that the dense structure of shelfbreak and cross-shelf reefs in the Cooktown region inhibit lateral exchange of shelf waters. However, there is no data or other information regarding water residence times in this region. A program of hydrodynamic modelling is needed to examine flushing in this region and its relation to other environmental forcing factors (e.g. wind stress, tides, floods).

FINE-SCALE SURVEYS 1995-96 - SUMMARY REPORT AND CURRENT STATUS

Just as a brief reminder, this section includes a summary of the 1994-95 results. The two plots for 1994-95 and 1995-96 should help readers to appreciate the dramatic trends in starfish numbers that we are currently seeing in this part of the Reef.

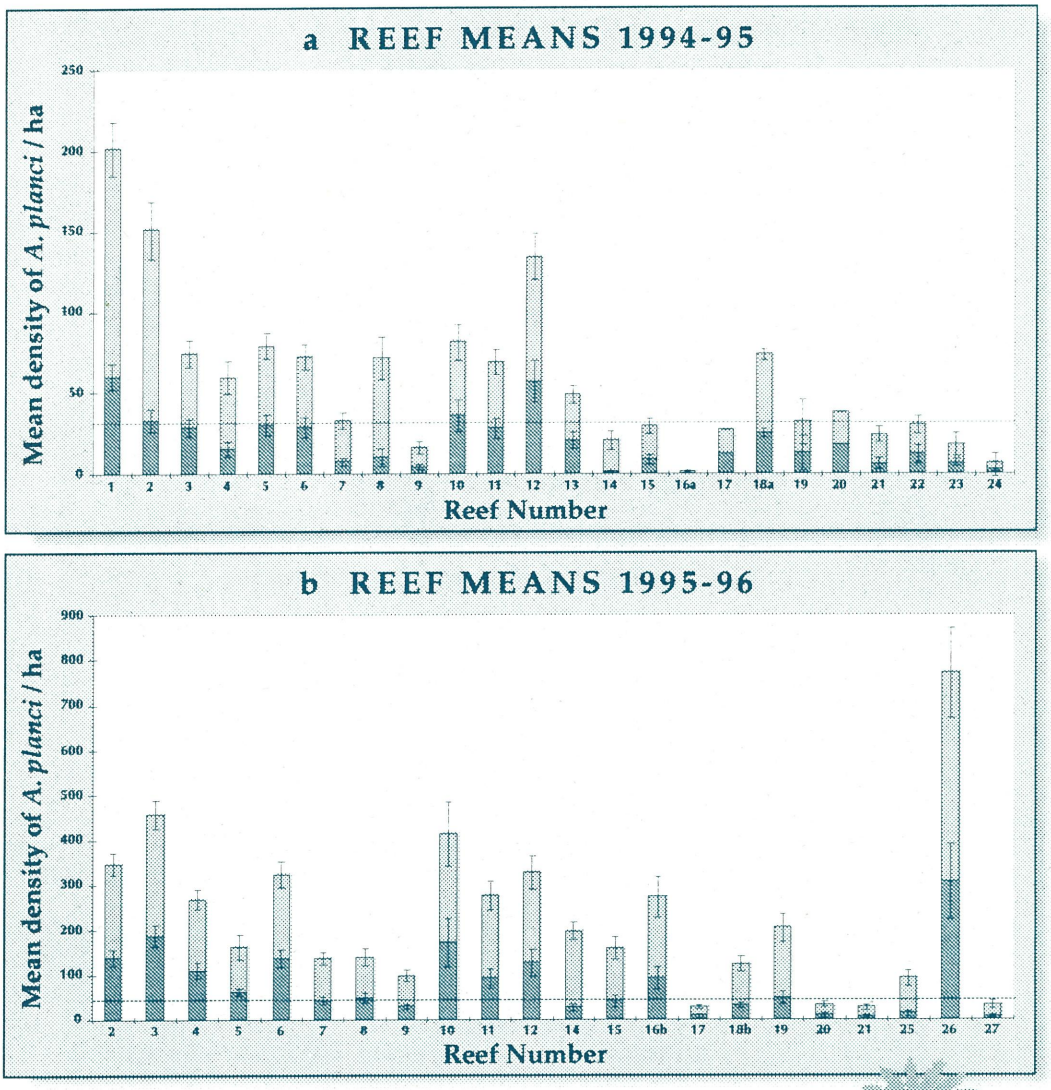


Figure 1. Histograms showing density distributions of COTS (*Acanthaster planci*) across survey reefs in 1994-95 (a) and 1995-96 (b). Reefs are arranged in order of increasing latitude. ***Dark grey bars*** show the density of mature COTS only (*3 years and older, active outbreaks*), ***light and dark grey bars*** combined show density estimates as determined for the total population observed (*all ages, incipient outbreaks*). Horizontal lines at 30 starfish per hectare indicate the upper limit of what is considered to be a sustainable population density. Error bars show +/- 1 standard error (SE).

1994-95

Densities of mature COTS were found to be markedly higher on reefs in the central and northern parts of the Cairns Section, with two reefs (8.33%) classified as having active reef-wide outbreaks (AO) (Figure 1a, dark grey bars). The same year, active spot outbreaks (ASO) were observed on another seven reefs (29.17%). Substantial numbers of juvenile and sub-adult starfish were located, particularly in the Cooktown to Lizard Island area and on reefs between Port Douglas and Cairns. Based on the 1994-95 results, and assuming relatively low mortality rates for late juvenile (5-15 cm) and sub-adult (15-25 cm) starfish, further widespread increases in densities of mature *A. planci* appeared highly likely. Consequently, eight reefs (33.33%) were classified as incipient outbreaks (IO) (Figure 1a, light grey bars).

1995-96

As predicted, densities of mature starfish have continued to increase markedly. At the end of the 1995-96 survey season, seven reefs (31.82%) were classified as having active outbreaks (AO) * (Figure 1b, dark grey bars) with a further nine reefs (40.91%) supporting active spot outbreaks (ASO) #. Again, the fine-scale surveys detected high densities of juvenile starfish on many of the reefs surveyed, indicating a strong likelihood of further population increases. This is reflected in the high proportion (eight reefs; 36.36%) of new incipient outbreaks (IO) now predicted for 1996-97 (Figure 1b, light grey bars).

** Note that outbreaking densities on reef numbers 10-12 were restricted to a single habitat only. Hence they were classified as active spot outbreaks (ASO).*
 # Includes reef numbers 10-12.

The observed trends indicate that by summer 1996-97 many mid-shelf reefs in the survey area will have between 10 to 15 times the number of mature COTS that could really be sustained by the coral community. It appears that the situation is still getting worse with significant local losses in coral cover to be expected over the next few years. Ongoing surveys will continue to monitor the situation and attempt to detect possible new outbreaks at the earliest possible time.

COTSWATCH - REEF-USER SURVEY SCHEME

Given the trends of increasing COTS numbers just described, the contributions from COTSWATCHERS are more important than ever. It is critical for us to get complementary information on the status of COTS from other reefs and regions throughout the Great Barrier Reef Marine Park. Clearly, our surveys can only cover a relatively small proportion of reefs and the additional information from Reef-users is needed to give us a more complete picture of the situation. And remember, zero records are still important to us. If you have run out of survey forms, please let us know so that we can send you another pile. (*There is no shortage of blank forms here in the office!*) My sincere thanks goes to all COTSWATCHERS who have been sending their information to us over the last three months. As usual, your efforts are greatly appreciated.

COTSWATCHERS (FEBRUARY-MAY 1996)

R Aiello / Great Adventures, Cairns; **M Allen** / Cairns; **D Blackshaw** / Great Adventures, Cairns; **R Braley** / 'Aquasearch'; **C Briggs** / Great Adventures, Cairns; **A Brown** / Cairns; **F Chapman** / QDEH Cardwell; **Coral Princess Cruises** / Townsville; **G Elliott** / Borneo Sea Adventures, Malaysia; **I Fleetwood** / Gladstone; **T Geddes** / Port Douglas; **S Goodhew** / Cairns; **K Hoppe** / Kiel, Germany; **P Heatherwick** / Port Douglas; **C Honchin** / Townsville; **W Legg** / Rockhampton; **H Malcolm** / QDEH Pallarenda; **R Mau** / Lismore; **S Martin** / QDEH Cairns; **P Mc Ginnity** / Townsvile; **S Mordes** / Cairns; **J Moxham** / Port Douglas; **J Purcell** / Great Adventures, Cairns; **C Purdon** / QDEH Townsville; **S Richards** / Cairns; **O Schapendonk** / Great Adventures, Cairns; **R Schutte** / Great Adventures, Cairns; **S Simpson** / Port Douglas; **E Suzuki** / Vatulele Island Resort, Fiji; **K Thomas** / Cairns; **J Wells** / Great Adventures, Cairns; **C Williams** / Queensland Department of Environment Cairns; **M Short** / Queensland Department of Environment Cairns; **M Wilson** / Airlie Beach; **D Wiseman** / Brinsmead.