NEWSLETTER OF THE RESEARCH AND MONITORING SECTION

REEF RESEARCH

Great Barrier Reef Marine Park Authority

VOLUME 4 – No. 2 JUNE 1994

EDITORIAL

A large section of this issue of *Reef Research* is devoted to describing research that is being undertaken at the Great Barrier Reef Aquarium which is operated by the Great Barrier Reef Marine Park Authority. While most people appreciate the Aquarium as being a highly valuable educational facility, many would not be aware that considerable scientific research goes on behind the scenes. This research addresses issues that are both external to the Aquarium, such as the effects of oil and dispersants on corals, as well as internal, such as research on water quality in the facility. Continual research is underway to improve the conditions that the inhabitants of all displays experience and this, in turn, allows visitors to the facility to enjoy a first class experience as well as improving our understanding of natural reef processes. Other work that has taken place in the Aquarium, but not reported here, includes visitor surveys to further enhance the education of Australian and overseas visitors. *Reef Research* wishes the Aquarium continued success in its endeavours.

A list of Augmentative Research Grants awarded this year by the Authority is also included in the newsletter. This scheme has been very popular with students undertaking management related research and allows the Authority to assist with projects that are of benefit to the Marine Park. The relatively small amounts of money are for travel and/or bench fees and students who think their projects for 1995 have merit should contact the Authority towards the end of this year.

Possibly the most topical article is by Clive Cook. It describes a model of cooperation between management agencies and traditional hunters of turtle and dugong. The 'Mackay model' has been developed over a number of years to address the issues surrounding the complex legal, management and cultural aspects of the taking of protected species by members of Aboriginal or Torres Strait Islander groups. The use of scientific information, including, of course, research into social and cultural matters, in the context of traditional cultural and heritage values, is to be encouraged to the fullest.

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:

The Editor REEF RESEARCH
Great Barrier Reef Marine Park Authority
PO Box 1379
TOWNSVILLE QLD 4810
FAX:(077) 72 6093

Editor.....Steve Hillman
Assistant Editor.....Trish Drury
Design & Art.....GBRMPA Production Unit
Printed by..... Prestige Litho
ISSN 1037–0692

Formatted by the GBRMPA Production Unit in DTP program QuarkXPress 3.1 on Apple Macintosh. Printed on ESSE recycled paper.

WHAT'S IN THIS ISSUE

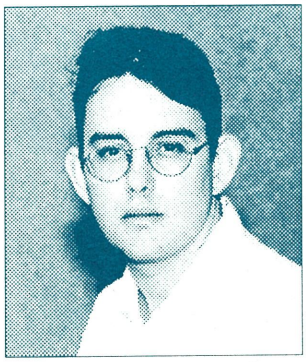
RESEARCH AND MONITORING STAFF

Simon Woodley	*Director*
Jon Brodie	*Coordinator - Water Quality*
Andy Steven	*Project Manager - Water Quality*
Rob McGill	*Assistant Project Officer - Water Quality*
Brian Lassig	*Coordinator - Crown-of-thorns Starfish*
Udo Engelhardt	*Project Manager - Crown-of-thorns Starfish*
John Robertson	*Acting Coordinator - Effects of Fishing*
Janine Kuhl	*Assistant Project Officer - Effects of Fishing*
Leon Zann	*Coordinator - State of the Marine Environment Report*
Jim Campbell	*Acting Assistant Coordinator - State of the Marine Environment Report*
Steve Hillman	*Acting Coordinator - Monitoring and Editor, Reef Research*
Ray Berkelmans	*Project Manager - Monitoring*
Hamish Malcolm	*Assistant Project Officer - Monitoring*
Dominique Benzaken	*Project Manager - Socio-economic*
Jamie Storrie	*Acting Project Officer - Effects of Shipping and Ports*
Beryl Dennis	*Administration Assistant*
Trish Drury	*Acting Assistant Project Officer and Assistant Editor, Reef Research*

Dominique Benzaken

Prior to her appointment, Dominique was a research officer with the Cape York Peninsula Land Use Strategy (CYPLUS) (Stage 1) Taskforce, based in Cairns. Her main task involved developing social, economic and cultural information collection projects (components of the Land Use Program), through the CYPLUS public participation process. Cape York Peninsula Community Groups and relevant government departments participated in the development of the terms of reference for the project. Consultants, government departments and community groups will be involved in the implementation of the strategy.

Dominique's role with the Authority will initially be to develop and implement a socio-economic program which is responsive to the planning and management needs of the Authority, and sensitive to the interests of the stakeholders in the Great Barrier Reef Marine Park.



Jamie Storrie

Specialising in the application of remote sensing and Geographic Information System technology for resource management, Jamie graduated with an honours degree in geography from James Cook University of North Queensland in 1992, and was employed by the Authority in February of the same year. Until recently Jamie worked in the Planning and Management Section of the Authority, being involved in the surveillance and enforcement program, as well as the initial development of the Authority's Geographic Information System. Recently Jamie moved to the Research and Monitoring Section as Project Officer for the Effects

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

Update

Chris Crossland

Centre Activities

Most of the Centre activities over the last three months have been directed to consolidating research activities, further developing user-researcher linkages, putting administrative mechanisms (particularly financial operations) into place, working towards extension strategies, and building wider linkages with the Centre Parties and collaborating agencies.

Over the next quarter our major focus will be to develop the first Annual Report for the Centre; review research task progress; process and promulgate the first research outputs; and establish the Extension Program.

One milestone in the Centre's development has been the recent relocation of the Centre on James Cook University campus to the new Sir George Fisher Research Building. We now have a good working space for the secretariat, conference facilities, two postgraduate laboratories and working facilities which are rapidly filling up, and rooms for visiting scientists. Researchers and members of the Centre Parties are strongly encouraged to visit and use the facilities of the Centre which is on the first floor.

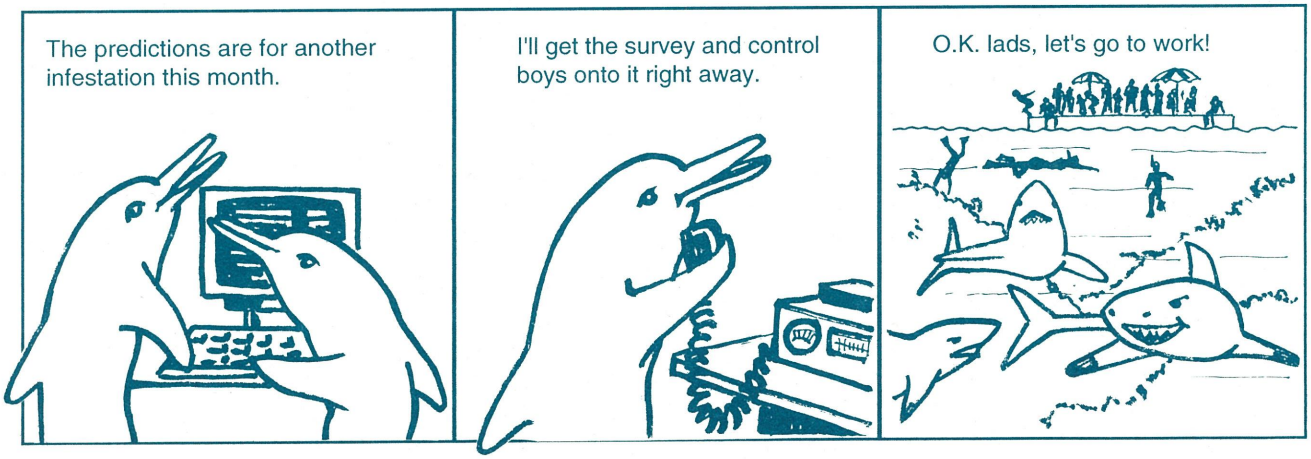
Research Activities

The research tasks (outlined in *Reef Research*, 3(4)) continue on track with a number of field activities being actively supported by various tourism operators through provision of logistic and other support.

A number of new tasks have been started over the last few months including:

a) The development of regional circulation models for the Great Barrier Reef lagoon, aimed at building further models and validating them against archival and new field data.
b) The development of scientific models which integrate the physics, chemistry and biology of the Great Barrier Reef at a regional scale,

Coralations **Not so friendly user controls** **Pongase**



taking into account external influences, for example land run-off and upwelling effects, on nutrient processes. One objective here is to integrate existing knowledge and to further build an understanding of the 'boundary conditions' which determine the growth and maintenance of coral reefs. The task aims to integrate the regional scale science information to address the 'health' of the Reef and contribute a firm foundation for risk management and planning within the Great Barrier Reef province.

c) An evaluation of the nature, severity and extent of damage from anchor and diving activities to reef benthos under different levels and types of use is underway. Management of these impacts is limited by a poor understanding of the scope of the problem and the lack of efficient techniques to quantify the impacts.

d) An analysis of Great Barrier Reef visitors to determine their attitudes, motives, socio-demographic profiles and activity preferences to provide quantitative information on the nature of Great Barrier Reef tourism and thereby give a base for the further planning and management of the industry.

e) Three engineering tasks have commenced. These will: address wave fields and water levels in coral reef areas to assist in engineering optimal structural design and operation of offshore tourism facilities, evaluate groundwater resources and their management along with wastewater discharges and effects on nutrient contributions to the Great Barrier Reef lagoon, and assist in the development of engineering guidelines for design, construction and operation of infrastructure.

A key factor in the overall CRC Program, and especially at this Centre, is the provision of 'useful information' from issues-driven research. The User Advisory Group, as part of its review of linkages between issues and research, has been looking at ways that will ensure the relevance and transfer of information.

Two major areas of tactical research - social and environmental levels of use, and effects of fishing - are being designed in close consultation with the relevant user groups. Both issues have major bearings on the ecologically sustainable development and use of resources in the Great Barrier Reef. The social/environmental use evaluation will be the first comprehensive assessment of its kind in a marine park context. The effects of fishing work is aimed at carrying out a world-first major depletion-replenishment experiment that has been the subject of considerable planning and discussion over the last few years. The Centre is working with a number of research and management agencies, including CSIRO Division of Fisheries, in developing an achievable approach.

Centre Products

Information and final reports are now starting to flow from the commissioned research tasks. A variety of publications and reports for the near future includes:

- Review of visitor use patterns (May 1994)
- Preliminary social impact assessment guidelines for the GBRMP, in the context of ecologically sustainable tourism (May 1994)
- Review and results from pilot study of restoration of coral reef habitats (July 1994)
- Evaluation of methods for effective sampling of reef fish populations (July 1994)
- Use of otolith weight for age determination in Great Barrier Reef fish populations (July 1994)
- Review of information needs from recreational fishing and boating activities (July 1994)
- Risk assessment of a major oil spill event in the Inner and Outer Routes of the Great Barrier Reef - commissioned study, Caltex/GBRMPA (July 1994).

For further information on the Centre please contact

Chris Crossland
Director
CRC: Reef Research Centre
c/- James Cook University
Post Office, Townsville Qld 4811

Great Barrier Reef Marine Park Authority

1994 Augmentative Research Grants Scheme

The Great Barrier Reef Marine Park Authority awarded 15 grants this year to students undertaking research related to management of the Marine Park.

KEY : Researcher / Supervisor, **Project title** (Grant $)

James Cook University of North Queensland

Lemnuel Aragones / Prof. H Marsh,
Ecology of seagrasses as food for dugongs and green turtles ($1000)

Vicki Hall / Dr T Hughes,
Sub-lethal damage and regeneration in reef corals ($1000)

Vicki Johnson / Dr Alastair Birtles,
Reef walking: tourist and management perspectives ($1000)

William Leggat / Assoc. Prof. D Yellowlees,
The effects of elevated nitrogen levels in sea water on plants: identification of possible bio-indicators ($580)

Jayne Ormsby / Dr C Cuff,
Perceptions of anthropogenic impacts on the Great Barrier Reef ($1000)

Kylie Pitt / Dr GP Jones,
The dynamics of larval supply: a study of the vertical distribution of pre-settlement fish larvae and an estimation of larval duration ($1000)

Anne Reynolds / Prof. H Marsh,
Investigation into the feasibility of successfully implementing the National Coastal Plan (at a local government and community level) to achieve integrated coastal zone management using the Cairns Region as a case study ($500)

Ben Stobart / Dr BL Willis,
Reproduction barriers and hybridisation in the genus *Montipora* ($734)

Jason Tanner / Dr T Hughes,
The effect of competition between macro-algae and scleractinian corals ($700)

Jamie White / Dr G Inglis,
Preliminary investigation into the feasibility of constructing coral viewing platforms on underwater observatories by coral fragment transplantation ($1127)

Dirk Zeller / Dr GR Russ,
Application of ultrasonic telemetry to the study of spawning aggregations of the coral trout *Plectropomus leopardus* (Serranidae) ($1345)

The University of Queensland

Timothy Ault / Dr C Johnson,
Metapopulation dynamics of reef fish assemblages and the importance of habitat structure, reef connectivity, and scale ($860)

Raymond King / Mr M Hockings,
Managing the traditional harvest of rare and endangered marine species ($250)

Judith O'Neil / Dr J Greenwood,
Nitrogen fixation and trophodynamic fate of the bloom-forming cyanobacteria *Trichodesmium* on the Great Barrier Reef ($830)

Deakin University

Christine Porter / Assoc. Prof. G Wescott,
A survey of marine protected area user attitudes towards and awareness of management for marine conservation ($1000)

ABORIGINAL and TORRES STRAIT ISLANDER TRADITIONAL HUNTING and NATIVE TITLE

*Clive Cook**

Recognition of Aboriginal and Torres Strait Islander interests is a major objective of the 25 year Strategic Plan for theGreat Barrier Reef World Heritage Area . This objective identifies the need to allow Aboriginal and Torres Strait Islanders to pursue their own lifestyles and culture, and exercise their responsibility for issues, areas of the Marine Park and the resources relevant to their cultural heritage, within ecologically sustainable levels.

Under the Marine Park Regulations the Great Barrier Reef Marine Park Authority can only grant permits after first assessing the impact of the proposed activity on the Marine Park. This assessment is undertaken following specific assessment criteria. In particular, one criterion [Regulation 13AC(4)(b)] requires that before a relevant permission is granted the 'need to protect the cultural and heritage values held in relation to the Marine Park by traditional inhabitants and other people' be considered. Recent advice indicates that this Regulation would include any native title holders and that cultural and heritage values held by native title holders are inextricably tied up with their rights and interests and there is substantial degree of overlap between all these factors. An important point is that Aboriginal culture does not separate the physical, cultural and spiritual association with their 'country' and one cannot be affected without the others also being affected. Consideration of an application must also take into account Regulation 13AC(5). This Regulation states:

In considering an application for permission to enter into or use a zone or designated area for the purpose of traditional fishing or for the purpose of traditional hunting and gathering, the Authority shall have regard, in addition to the matters specified in subregulation (4), to the following matters:

(a) the need for conservation of endangered species and, in particular, the capability of the relevant population of that species to sustain harvesting;
(b) the means to be employed in the proposed traditional fishing or traditional hunting and gathering;
(c) the number of animals or plants, or the amount of marine product, proposed to be taken;
(d) the purpose of the proposed taking;
(e) whether the entry and use of the area in which the activity is to take place will be in accordance with Aboriginal tradition or Islander tradition, as the case requires;
(f) the normal place of residence of the applicant;
(g) whether the applicant is a traditional inhabitant.

Much of the contemporary Aboriginal and Torres Strait Islander concern

centres on their lack of involvement in management, inadequate consultation and restrictions on traditional hunting activities, and concern regarding the lack of formal recognition of traditional clan estates. In spite of recent improvements in consultation there remains considerable dissatisfaction in relation to these matters.

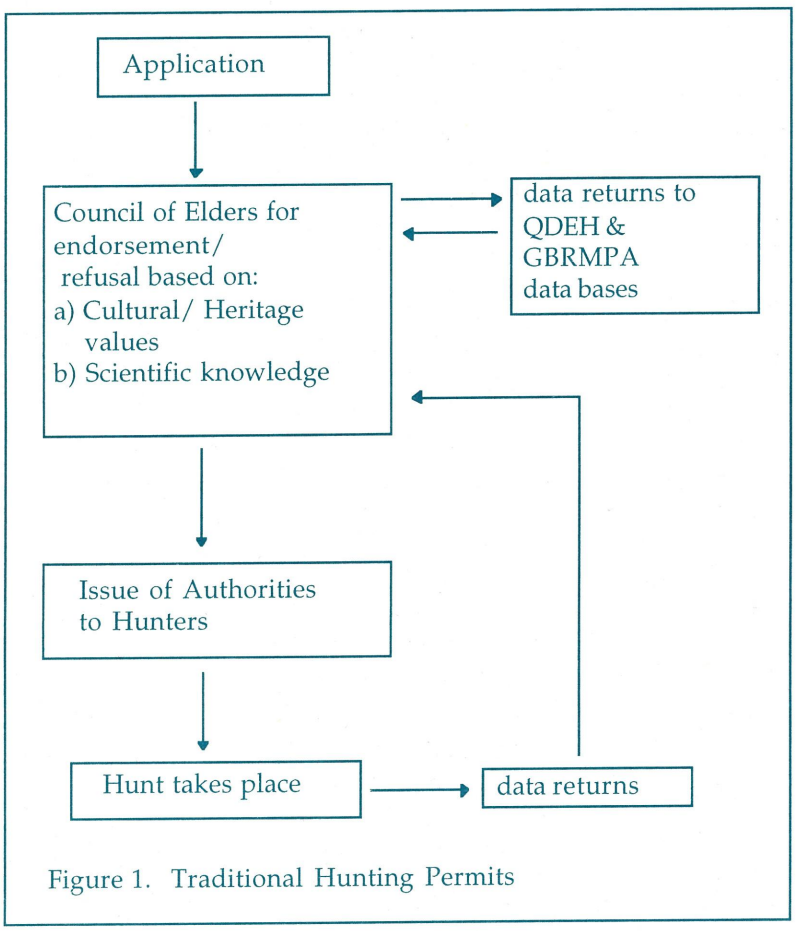


Figure 1. Traditional Hunting Permits

Permits to hunt turtle and dugong by traditional users are required and applications are assessed by staff at the Marine Park Authority. The Authority has entered into discussions with Aboriginal and Islander groups to review the procedures for issuing hunting permits. The Authority recognises that it is necessary to develop consultative and cooperative mechanisms in order to avoid or resolve conflict. It is critical, in the consultation process, to speak with the 'right' people, that is, those individuals and groups with traditional customary links and/or rights over the areas in question.

The question is: how does one assess the cultural and heritage values of traditional inhabitants and others and how does Regulation 13AC(4)(b) relate to native title?

To address this question it is necessary to identify who the traditional inhabitants are, which requires direct liaison and consultation, and to determine cultural and heritage values which can only be done by the people who speak for the particular area in question. Native title holders can only carry on the activity in exercise or enjoyment of their native title rights and interests in the area in which the native title existed for the particular group and not outside it.

Traditional hunters in the Mackay region comprise both Aboriginal (traditionally affiliated) and Torres Strait Islander (historically associated) people. A representative group has formed to become a Council of Elders and this Council represents the community as a whole. In this capacity the Council of Elders assists the Authority in assessing the cultural and heritage values held in relation to any proposed use within the Marine Park against Regulations 13AC(4)(b) and 13AC(5).

The 'Mackay model' was developed to address traditional hunting issues and it has been further refined to handle individual applications for traditional hunting of dugong and turtle and accommodate a 'community based' system of issuing permits (see figure 1).

In the context of national advances towards reconciliation and self-determination, the Mackay model is consistent with recommendation 188 of the Royal Commission into Aboriginal Deaths in Custody, which stated that governments should negotiate with appropriate Aboriginal groups to determine procedures which should be followed to ensure that the self-determination principle is applied to policies which particularly affect Aboriginal people. In addition this approach is in sympathy with other laws of the Commonwealth, for example, the *Racial Discrimination Act 1975*.

In this context the Mackay model provides a means for community agreement involving both traditional and historical hunting values.

The community recognises the culturally appropriate nature of this approach to co-management. Other coastal communities are keen to establish similar systems in their clan areas. The Aboriginal community in the Bowen region has recently been granted a similar community based traditional hunting permit.

The Mackay and Bowen models offer advantages for indigenous involvement in the management of the Marine Park. It should not be assumed, however, that the interests of the indigenous people are necessarily the same as the management or conservation values or objectives held by management agencies.

The process described here represents a positive direction along a continuum from almost no Aboriginal and Torres Strait Islander involvement in management to almost total self determination. It is reasonable to postulate that future directions lie towards self-regulation and self-determination. Permits for the conduct of traditional hunting by native title holders, in their traditional areas, may not be required in future.

Considering the wider impacts on traditional food sources and not just traditional hunting, the following questions remain:

- can the application of traditional and customary approaches continue to sustain species vulnerable to extinction?
- without empowerment can self-regulation ensure the long-term sustainability of customary foods?, and
- when will it become obvious that species are suffering a decline?

While the process of co-management through Councils of Elders in the Mackay model is a positive move towards self-determination, each particular permit application and the response by the Aboriginal or Torres Strait Islander community affected can vary. The nature of a particular permit and the native title rights will determine how the Authority should proceed in each case. The *Native Title Act 1993* (Cwlth) and the Racial Discrimination Act must also be taken into account.

There is no clear direction yet, although the way forward, I believe, is co-management; scientists can provide data, indigenous people ensure their cultural and heritage values are considered and managers help to bring it all together. The Mackay model provides a pathway towards meaningful complimentary management of the resources of the Great Barrier Reef Marine Park within the framework of the national Native Title Act.

FURTHER READING

Altman, J.C., Ginn, A. & Smith, D.E. 1993, *Existing and Potential Mechanisms for Indigenous Involvement in Coastal Zone Management: Consultancy Report*, Resource Assessment Commission Coastal Zone Inquiry, Canberra.

Bergin, A. 1991, Aboriginal Sea Claims in the Northern Territory of Australia, *Ocean & Shoreline Management* vol. 15, no. 3.

Chase, A. 1980, Which Way Now? Tradition, Continuity and Change in a North Queensland Aboriginal Community, PhD thesis, University of Queensland.

Cordell, J. 1991, *Managing Sea Country: Tenure and Sustainability of Aboriginal and Torres Strait Islander Marine Resources*, Report on Indigenous Fishing to the Ecologically Sustainable Development Fisheries Working Group.

Great Barrier Reef Marine Park Authority 1992, Draft *A 25 Year Strategic Plan for the Great Barrier Reef World Heritage Area*, GBRMPA, (Australia).

Marsh, H., Smith, A. & Kelly, G. 1984, *Dugong hunting by members of the Hopevale Aboriginal Community and the initial reaction to the Great Barrier Reef Marine Park and the dugong permit system*, (Report to the Great Barrier Reef Marine Park Authority.)

Smith, A. 1989, *Usage of Marine Resources by Aboriginal Communities on the East Coast of Cape York Peninsula*, GBRMPA, Townsville.

Smyth, D.M. 1992, *Aboriginal Maritime Culture in the Far Northern Region of the Great Barrier Reef Marine Park*, Report to the Great Barrier Reef Marine Park Authority.

Smyth, D. 1993. *A Voice in All Places: Aboriginal and Torres Strait Islander Interests in Australia's Coastal Zone: Consultancy Report*, Resource Assessment Commission Coastal Zone Inquiry, Canberra.

* Clive Cook is an Acting Senior Project Manager in the Authority's Environmental Impact Management Section.

LONG-TERM VIDEO MONITORING BY DAY-TO-DAY MANAGEMENT STAFF

R J Schneider

Information on changes in the abundance and distribution of organisms in the Great Barrier Reef Marine Park is essential for scientists and managers who wish to understand the ecological processes occurring on the reef and how these processes may be affected by human activities. While monitoring of specific installations or reefs has been occurring for some time it is only recently that a coherent and coordinated long-term monitoring strategy for the whole Great Barrier Reef has been developed. The strategy involves a number of related programs (some still being planned) being carried out by a number of organisations.

The Australian Institute of Marine Science (AIMS) and GBRMPA have jointly developed a strategy for the monitoring of long-term, regional changes on the Great Barrier Reef. A major component of this study is the monitoring of sessile benthic organisms through the use of video monitoring of fixed 50 m benthic transects.

Transects are recorded at a fixed distance (25 cm) from the substrate and at a fixed speed (12 m/min). Benthic videos are analysed through the use of a professional video player with digital freeze frame. This analysis involves stopping the tape every nine seconds and identifying the substrate beneath five fixed points on the screen. This identification is taken to the highest taxonomic level possible dependant on the quality of the image.

As an extension to this program, GBRMPA is developing a long-term video monitoring program with the day-to-day management (DDM) staff of Queensland Department of Environment and Heritage (QDEH). Additionally consultants undertaking environmental monitoring programs at tourism operations are being requested to utilise the technique. GBRMPA and DDM staff also use video for records of inspection and general reconnaissance surveys. Broadly, the aim of the QDEH study is to monitor long- and short-term changes on reefs which are not being monitored by AIMS but which are important from an environmental management perspective. An effort is being made to ensure that similar methodologies are used in all benthic monitoring activities. This has two advantages:

(i) it may allow data from AIMS long-term monitoring sites to be incorporated into management/impact studies for control or comparison, and

(ii) data gathered will contribute to a long-term monitoring database.

The aims of the video programs being carried out by DDM staff and consultants are slightly different to those of AIMS in that there is a greater emphasis on acquiring knowledge on specific reefs and tackling specific management problems.

Video transects by DDM staff and consultants are currently being recorded using two methods:

(i) perpendicular to the substrate at a distance of 25 cm - quantitative data, compatible with AIMS analysis technique, and

(ii) oblique to the substrate and at a distance of at least 1 m. This method is designed for qualitative analysis, allows a greater sense of community structure and allows impacts such as fin damage to be more easily assessed.

The default experimental design, which is based on that used by AIMS, is to use three slope sites on each surveyed reef with five

fixed 50 m transects laid at a depth of between 5 and 9 metres at each site, although this design is flexible dependant on the specific questions being asked or the area of the reef being studied. Transects are marked using rods and pickets. GPS readings and compass bearings are taken to ensure easy relocation of sites. A white board on which are recorded various details about the transect and the site, is filmed prior to transect filming. Additionally a 360 degree pan shot is taken at the beginning and end of a transect to give a general impression of the area (visibility permitting). These transects are resurveyed on an annual basis.

The video format currently used is Hi8. This format offers a reasonably high resolution relatively inexpensively. The set-up of cameras used for recording the transects is standardised to ensure compatibility and ease of analysis.

Currently six reefs in various parts of the Marine Park have sites established on them as part of the QDEH program and this number will increase in the coming year. Regular meetings are held to review objectives and techniques and it is planned to hold an annual workshop to compare and trial techniques in the field.

The first of the annual workshops was held at Orpheus Island in November 1993 where, amongst other things, a site was established, the use of plastic rather than metal starpickets was trialled and various camera set-ups were compared.

These long-term projects will offer managers and scientists a greater understanding of the ecological processes occurring on the Great Barrier Reef which will prove valuable for meaningful management, conservation initiatives or productive research in the future. The video technique is a potentially important development and may well become a standard method for ecological assessment in the future.

SHORT COMMUNUNICATION

UNIQUE CORAL REEF ISLAND

Darren Allingham

Since sea-level rose to its present position some 6500 years ago from the low level of the last great Ice Age, Mud Island (a coral reef island) has formed in central Moreton Bay. Mud Island's subtidal coralline reef flat has been dredged for 54 years by Queensland Cement Pty Ltd, reducing the island to half of its original 1200 hectare area. The mined coral has been a valuable resource for cement manufacture in Queensland. Recent research by me at the Department of Geographical Sciences, The University of Queensland, has identified Mud Island as being a relatively complex coral reef island type known as a Mangrove Island, typically forming on high reef tops in low energy environments. On the Great Barrier Reef, of 300 islands, including 110 vegetated, only 5 are classified as Mangrove Islands. All occur north of 15° south. Mud island is, therefore, a relatively rare coral reef landform and its identification as a Mangrove Island existing at 27° south almost doubles the latitudinal range over which this type is known to occur. Since 1972 coral dredging spoil has formed shingle ridges that have moved ashore to encircle 75% of the island. These ridges have restricted tidal flushing of the mangrove park and caused mangrove death by waterlogging, burial and abrasion. Continuation of dredging will totally enclose the island and cause further shingle ridges to form with the potential to destroy more mangroves. Now that 70% of the dredging lease has been mined, and in light of the latest research emphasising the geographical significance of the island, the remaining reef flat would best be preserved, and the island protected and regarded as a coral reef island unique to south-east Queensland and Australia.

This ninth appearance of 'Slick Talk' revisits and updates two topics covered previously: oiled wildlife plans and post-spill damage assessment. Also presented is news of a multi-disciplinary Great Barrier Reef Shipping Study being coordinated by the Federal Government.

Oil Spill 'Baptism' for Queensland Wildlife Rangers

'Slick Talk # 8' (*Reef Research*, 4(1)) reported on an oiled wildlife training course held by the Queensland Department of Environment and Heritage (QDEH) at Bribie Island from 23 to 25 February 1994, and the proposed development of oiled wildlife plans by QDEH.

The timing of the course could not have been better. On Saturday 26 February 1994 a diesel leakage from the Redcliffe Hospital (Brisbane) into Humpybong Creek oiled a number of water fowl that are often fed by visitors to a suburban park adjacent to the creek.

QDEH rangers who had been at the training course during the previous three days responded to the spill, and recovered more than sixty oiled wood ducks, coots, swamphens, darts and other birds. The value of their training was evident, and resulted in more than 70% of the birds surviving for return to the wild. This supports the position that, if contingency plans and proper training are in place, oiled wildlife response can be an effective and worthwhile activity, contrary to the claims by many oil spill 'authorities' that such activities are a waste of time and money. As reported in 'Slick Talk # 8', an analysis of oil spills where wildlife operations have been a dismal failure indicates that this is correlated with a lack of training and proper contingency planning.

In dealing with the Redcliffe spill, the QDEH Rangers coordinated local residents and fauna care volunteers who proved invaluable in assisting with the bird rescue.

While this small spill provided an excellent opportunity to test the training received the previous week, the task now remains for QDEH to implement oiled wildlife plans for the whole State.

US Advances in Post-Spill Damage Assessment

'Slick Talk # 6' (*Reef Research*, 3(3)) presented a summary of the findings of the Review of the National Plan to Combat Pollution of the Sea by Oil (the National Plan), and stated that an area not addressed properly by the Review is that of post-spill damage assessment. Post-spill damage assessment should be an integral and vital component of any oil spill response; to assist with the determination of damage claims and compensation, to help authorities to assess the effectiveness and effects of response operations (and therefore allow better response to future spills), and to improve scientific understanding of the effects of spills on various environments and ecosystems.

While there are a number of general principles that should be adhered to in assessing post-spill damage (for example using independent, joint industry/government monitoring teams to avoid costly duplication of studies and conflicting claims), there are many technical obstacles to accurately assessing damage and translating that assessment to a determination of compensation. For example, there are many environmental resources that may be damaged by an oil spill which have no monetary market value, but which may be of extreme value to society in non-monetary ways.

A damage assessment technique that attempts to overcome such problems is being pioneered in the United States and is known as Contingent Valuation Methodology (CVM). CVM has been used for some years in a

number of areas of natural resource management, especially management of recreation areas and national parks. It involves using public surveys to ascertain both direct and passive use values of various resources. The value of passive uses, for example the benefits an individual or group may gain from simply knowing that a resource exists and will be maintained for future generations, even though that individual or group may never directly use that resource themselves, is the most difficult to quantify.

While CVM constitutes another useful tool for post-spill damage assessment, allowing the assessment to extend to resources or resource uses that do not have readily quantifiable monetary value, reservations have been expressed about the technique from many quarters.

It is difficult for surveys of the public, who may tend to be over-emotional about oil spills, to provide strictly 'scientific' data. The shipping and oil industries are particularly concerned that the application of CVM to oil spill assessment in the United States will lead to exaggerated compensation claims against oil spill perpetrators. One can imagine the challenges presented by applying CVM to an oil spill on the Great Barrier Reef; the contingent value of this resource to society would seem to be immeasurable!

Full Steam Ahead for Barrier Reef Shipping Study

'Slick Talk # 5' (*Reef Research*, 3(2)) reported on a 'Meeting of Experts on the Prevention of Oil Spills in the Great Barrier Reef Region' held in Canberra on 14 and 15 April 1993. One of the issues that met with much discussion at that meeting was concerned with the 'pros' and 'cons' of shipping using the 'Inner Route' of the Great Barrier Reef versus the 'Outer Route' of the Coral Sea. Debate has continued on this issue for many years, with some groups such as Greenpeace calling for a complete ban on tankers through the Reef and other groups such as the Reef Pilots claiming that the Inner Route is safer. One of the recommendations to come from the Canberra meeting was that this issue should be put to rest and a definitive position arrived at by conducting a comparative risk assessment.

The Caltex Tanker Company (Australia) Pty Ltd, which ships crude oil through the Inner Route, got the ball rolling for this study by providing the Great Barrier Reef Marine Park Authority (GBRMPA) with $80 000 in December 1993. This funding is being used by GBRMPA to engage the CRC: Reef Research Centre to conduct an assessment of the comparative risks of a major spill from shipping in the Inner Route versus the Outer Route, the comparative effects of a major spill in the two routes and the comparative effectiveness and effects of the response to such a spill in the two routes. The first draft report on this study has recently been submitted by the CRC to various organisations for comment.

In addition to the Caltex/GBRMPA/CRC: Reef Research Centre risk assessment, the Australian Maritime Safety Authority (AMSA), the Commonwealth Bureau of Transport and Communications Economics (BTCE) and the Queensland Department of Transport (QDoT) have joined the study with two additional components, while the Commonwealth Department of Transport (DoT) is playing an overall coordinating role.

The BTCE component consists of a study of the economic value of shipping in the Great Barrier Reef Region, and the economics of possible alternative transport methods. BTCE have engaged consultants Travers and Morgan to conduct this component, and data collection and analysis is now well underway.

AMSA and QDoT have been charged with the third component of the study, an investigation of legislative and technical options for controlling shipping through the Reef. At the time of writing it is not clear how much progress has been made on this component.

When all three components are combined and the final report is produced, government and industry will have a much clearer, more objective picture of the environmental risks associated with shipping through the Great Barrier Reef, and of the available technical and legal management options. This will provide a more enlightened, knowledge-based platform from which appropriate shipping management measures can be developed.

COTS COMMS

Dr Brian Lassig and Udo Engelhardt

Reports of increasing numbers of crown-of-thorns starfish on reefs between Cairns and Lizard Island continue to flow in. The most recent counts are from 17 reefs between 14°40′ S and 17°10′ S where divers have reported seeing five or more starfish in a dive (see map). There are about 150 reefs in this area. It should be pointed out that the '5 COTS in a dive' is a totally arbitrary figure set without any consideration of carrying capacities, sustainability or 'normality'. Given that no reports of more than one or two starfish on reefs in the Cairns-Cooktown area had been received since the early 1980s, five seemed to be a reasonable signal of increasing numbers. It certainly doesn't mean that these reefs have outbreaks or are destined to suffer significant damage from marauding hordes! It does mean we need to maintain a close watch on as many reefs as possible in the area to record any changes in COTS populations and their effects on the Reef.

Significantly, the area of increasing numbers has been extended southwards with reports of more than five starfish on Normanby Island Reef and Flora Reef, about 30 km south of previous reports.

CURRENT COTS

AIMS Surveys

Since the March issue of *Reef Research* the AIMS monitoring team has conducted and reported on surveys in the Cairns, Innisfail, Whitsunday and Pompey sectors of the Great Barrier Reef. The overall picture from the manta tow surveys is that COTS numbers in all of the areas surveyed are low, but there are clear differences between the results of these reconnaissance surveys and more fine-scale surveys reported through the Reef User scheme COTSWATCH.

A total of seven COTS were sighted at four of the 14 reefs surveyed by manta tow in the Cairns sector, with a maximum of two starfish recorded at Michaelmas Reef, Norman Reef and Reef No. 16-017. Average coral cover for nearly all reefs surveyed was low (11 - 30%) and not significantly different to that recorded during the previous survey of this sector in mid-1993.

A total of four COTS were recorded on the seven reefs surveyed in the Innisfail sector, with no more than one starfish recorded on any reef. Average coral cover of most reefs was in the 10% to 30% range and had not changed since last year's survey.

Two COTS were sighted at one of the seven reefs surveyed by manta tow in the Whitsunday sector. An additional three COTS were recorded during swim searches at one reef. Coral cover had not changed or had increased on surveyed reefs since the last survey a year ago.

A total of eight COTS were sighted at three of the six reefs surveyed in the Pompey sector, with six of the starfish on one reef (McIntyre Reef). Coral cover was consistently higher than 30% on all of the surveyed reefs.

Reef User Reports (COTSWATCH)

COTSWATCHERS along the coast are continuing their unprecedented support of the new and modified Reef User scheme (see March 1994 edition). Reports on actual as well as zero-sightings of starfish are coming in at a steady rate.

Since the relaunch of this scheme in November last year, the COTS-team has received a total of 150 completed survey forms. Observàtions have been reported from 277 sites spread over 62 different reefs. The total count of starfish for that period now stands at 1166.

Interestingly, juvenile starfish (<20 cm diameter) were found at a fairly high proportion (34.38%) of the sites where starfish occurred. The incidence of these typically cryptic and hard to find juvenile starfish highlights the need for ongoing monitoring of the situation. COTS surveys, and in particular those for juveniles, tend to underestimate the actual number of starfish present in an area. This was highlighted during a recent local-scale control effort on Moore Reef. Surveys conducted prior to the controls recorded a maximum of 28 COTS at any one time. However, during more dedicated searches for COTS a total of 176 starfish were located and destroyed.

Starfish activity continues to focus on the area between Cairns and Cooktown. We are particularly encouraged by the support being provided by both the Queensland Department of Environment and Heritage (QDEH) and many of the local reef tourism operations. QDEH have indicated their willingness to collect additional survey information on their regular patrols out of Cairns. Tourism operations in both Cairns and Port Douglas are offering their assistance in obtaining more quantitative information on starfish numbers, and the Low Isles Preservation Society (LIPS) is discussing possible ways of getting involved in more detailed surveys of reefs in the Port Douglas area.

As always, remember that your contribution to the COTSWATCH scheme is vital. Our chances of early detection of future changes in COTS populations depends on the level of information being provided by all Reef Users. Appropriate, meaningful management actions can only be implemented if detailed information on the status of COTS is available. Therefore, the importance of your contribution can not be overstated. The COTS team at GBRMPA greatly appreciates your continued support.

We would like to acknowledge the support of the following COTSWATCHERS who have recently reported on their observations (February - May 1994):

R Vanstan / Fitzroy Island, **J Pickhaver** / Roseville, **J Anderson** / Cairns, **G Smith** / GBRMPA, **A Van Welderen** / Cairns, **G McGarry** / Cairns, **A Lloyd** / Ingham, **T Ayukai** / AIMS, **Great Adventures** / Cairns, **D Anderlini** / Cairns, **Mike Short & Jesse Low** / QDEH Cairns, **G Manahan** / Cairns, **K Larsen** / Cairns, **D St John** / Earlville, **M Schaer** / Cairns, **P Ward** / Cairns, **J Purcell** / Great Adventures, **K Roach** / Cairns, **A Lloyd-Cahill** / Smithfield, **B Knuckey** / Gladstone, **K Menkens** / Cairns, **L Lamb** / QDEH Cairns, **K Jesienowski** / Port Douglas.

Table 1. The *'COTS Top Five'* reports for February - May 1994

Reef Name / I.D.	No. of starfish	Observer
Moore Reef	176 (over six days)	J Purcell / Great Adventures
Flora Reef	40	T Ayukai / AIMS
Michaelmas Reef	9	G Manahan / Cairns
Milln Reef	7	A Van Welderen
Normanby Island Reef	5	D Anderlini / Cairns

WHAT THE EXPERTS THINK

We've reached a critical time in COTS research and perhaps in the COTS cycle. The current research program, under the guidance of the Crown-of-Thorns Starfish Research Committee (COTSREC), has been in operation for five years. The 1979-1992(?) outbreak is over and there's some interesting stirring in the suspected source area again. It seemed like an opportune time to canvas the opinions of experts with regard to the status of our current knowledge of COTS outbreaks, most productive research approaches and future prospects. We had also been wrestling with the question of what would constitute adequate proof of human activities causing or exacerbating outbreaks. A questionnaire approach to get input from the experts was a cost-effective way of getting comments from a wide and experienced audience.

We mailed a total of 101 questionnaires to potential respondents who were selected on the basis of having been involved in COTS research or management, or having a sound appreciation of coral reef ecology and long standing involvement with the GBR in either a research or management capacity. Potential respondents were asked for their views on five questions related to causes of COTS outbreaks and research directions. 'Tick-the-box' options were provided for all questions but respondents were asked to comment freely. Many did. Most (93%) of the potential respondents were (or had been until recently) based in Australia and 7% were based overseas. Seventy-three (72.3%) responded. Highlights of the survey are reported here and I hope to have the full results published in the future. I also hope to get more completed questionnaires returned so *if you are one of the outstanding 28 I'd still appreciate your comments.*

Most experts (64%) believe that evidence for human activities causing or exacerbating outbreaks does not exist, although a substantial proportion (27%) are undecided (see figure 1). Fourteen respondents (19.2%) highlighted, or commented on the use of the word 'proof' in this question. Comments related to the rarity of absolute proof in science generally, and in environmental/biological sciences in particular.

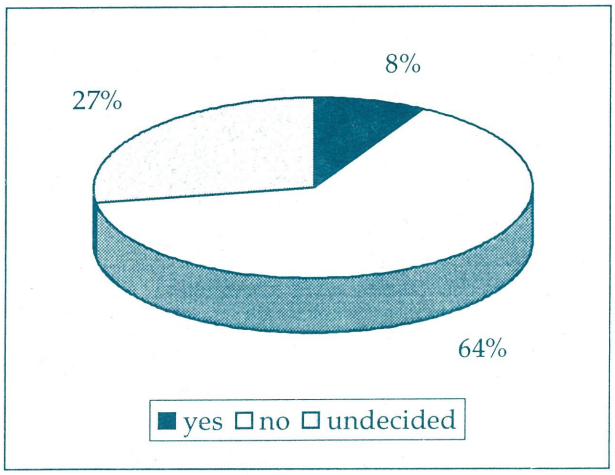


Figure 1. Responses to the question 'Does the proof that human activities cause or exacerbate COTS outbreaks already exist?'

The greatest agreement among respondents for any question was in response to the question 'Do you think that there is likely to be a single cause of COTS outbreaks or a number of factors contributing to primary outbreaks' (see figure 2). A very clear majority (87%) indicated that they thought it was likely there were multiple, rather than single, causes of outbreaks.

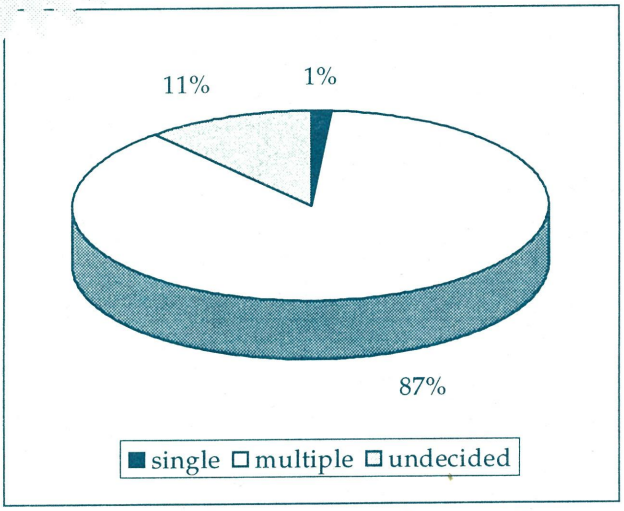


Figure 2. Responses to the question 'Do you think that there is likely to be a single cause of COTS outbreaks or a number of factors contributing to primary outbreaks?'

Of the options provided, water quality was regarded as the most likely cause of outbreaks in both natural and human influence contexts (see figure 3). Most respondents (82%) indicated that a combination of both natural and human influences was likely to be responsible for outbreaks.

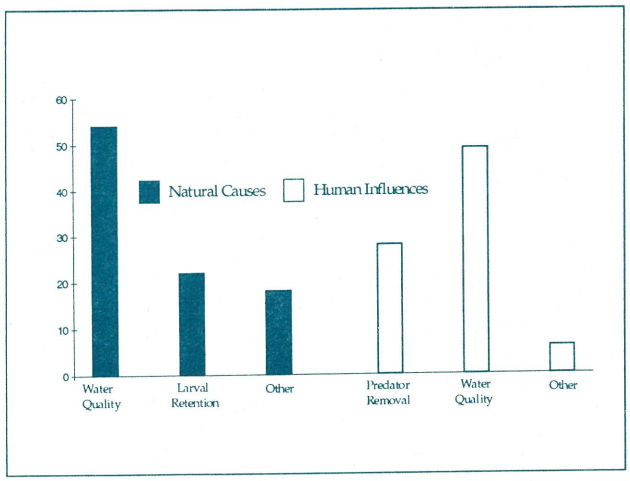
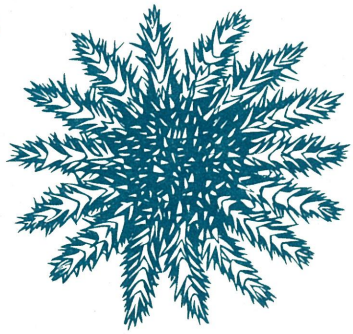
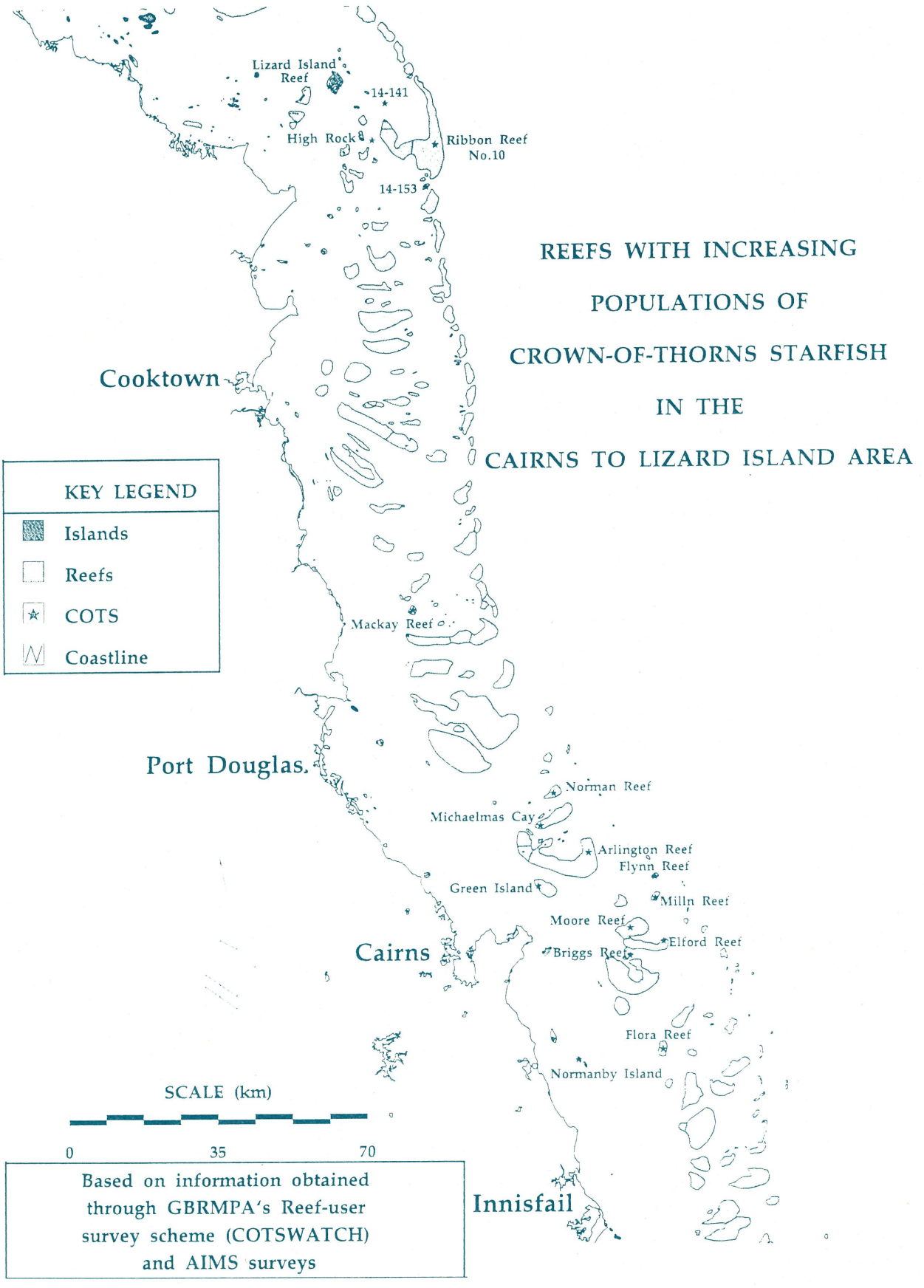


Figure 3. Responses to the question 'Based on existing evidence what do you think are the most likely causes of primary COTS outbreaks?'

Responses to the question 'What scientific approach do you think is most likely to provide generally acceptable evidence for or against the influence of human activities and COTS outbreaks?' were varied. Options provided included 'individual hypothesis testing', 'holistic research', 'modelling' and 'other'. About 60% of respondents favoured a multi-faceted approach, typically incorporating testing individual hypotheses and holistic research.

The fact that one-fifth of the respondents commented on the word 'proof' was a particularly interesting aspect of the survey that needs to be further investigated. The Authority's policy with regard to COTS is that, unless it can be proven that outbreaks are either caused or exacerbated by human activity, controls should be limited to small-scale tactical measures in areas important to tourism or science. The policy is based on cost-benefit principles where the enormous costs and low probability of success of widespread control action outweigh any potential benefits of interfering in what may be a natural process. What evidence proves human activities cause or exacerbate outbreaks? The range of comments on the topic from respondents indicate that unanimous agreement in the COTS arena (and perhaps many others) is unlikely. ***I'm interested in any comments readers might like to contribute.*** If there's enough interest in the topic of 'proof' (not just in relation to COTS) I'll pull comments together for a future issue of COTS COMMS.




REEFS WITH INCREASING
POPULATIONS OF
CROWN-OF-THORNS STARFISH
IN THE
CAIRNS TO LIZARD ISLAND AREA
KEY LEGEND
Islands
Reefs
COTS
Coastline
Lizard Island
Reef
14-141
High Rock
Ribbon Reef
No.10
14-153
Cooktown
Mackay Reef
Port Douglas
Norman Reef
Michaelmas Cay
Arlington Reef
Flynn Reef
Green Island
Milln Reef
Moore Reef
Elford Reef
Briggs Reef
Cairns
Flora Reef
Normanby Island
Innisfail
SCALE (km)
0
35
70
Based on information obtained
through GBRMPA's Reef-user
survey scheme (COTSWATCH)
and AIMS surveys

Great Barrier Reef Aquarium

RESEARCH

*Paul Hough**

The Great Barrier Reef Aquarium was opened in June 1987 and is the world's largest living coral reef exhibit. The Aquarium is an important educational facility for Australia and is operated by the Great Barrier Reef Marine Park Authority. It provides a close look at marine life that couldn't normally be seen and it allows the average person to enjoy the wonders of the Great Barrier Reef without the need for long boat trips and SCUBA or snorkelling equipment.

The main tank houses the Coral Reef Exhibit which supports more than 150 species of coral and over 200 different species of fish. The Aquarium also has a predator tank which houses sharks, turtles and large cod. As well as the two large tanks, there are many smaller tanks allowing a close look at reef animals.

Behind the scenes, the aquarium provides an ideal environment for research and monitoring and the following article outlines some of this work.

The Great Barrier Reef Aquarium, in particular the Coral Reef Exhibit, is not just a collection of fish and coral, it is a living ecosystem that is essentially an exaggerated version of the 'real' world. Although the Aquarium is primarily a public education and extension facility, its value as a research facility is beginning to be realised.

Research in the Aquarium has been undertaken since 1986. Very little was known about closed ecosystems (sometimes called mesocosms), the biological management and technology required, and almost nothing was known about the demanding needs of hard corals and other organisms. So most of the early research projects were initiated to develop existing knowledge of limits and tolerances of enclosed marine ecosystems, especially in relation to water quality and coral physiology and husbandry. The findings from those research efforts have become part of day-to-day management of the wet side of the Aquarium.

Externally funded research initiatives have been undertaken since 1990. For the sake of brevity, this article will describe only current research activities. Table 1 lists all significant research that has been undertaken but not described in this article.

The research section of the Aquarium currently manages and conducts four projects, some in collaboration with other researchers and agencies, and employs two full-time staff and two part-time staff, as well as Aquarium and specialist staff when required. The projects are:

- Improvement of the rearing technique for the larvae and juveniles of crown-of-thorns starfish. Funded by the Great Barrier Reef Marine Park Authority.
- An experimental study on the effect of water quality on the survival of acroporid corals in the GBR Aquarium. Funded by the Great Barrier Reef Marine Park Authority.
- Grow-out facility for juvenile hybrid corals. Funded by the Great Barrier Reef Marine Park Authority.
- The captive breeding of Great Barrier Reef Corals. Funded by Earthwatch.

Research in the Aquarium also nurtures future scientific talent and the Aquarium has participated in the CSIRO Student Research Scheme for the past three years. This scheme provides work experience for Year 11 and 12 secondary school students and science graduates, and funds undergraduate project work. The Rotary Science Research Scheme began in 1993 and provides financial support

Table 1. Significant research projects undertaken in the GBR Aquarium

Responses of microbial assemblages from turf farm communities to ambient levels of ultraviolet light, Deneb Karentz (University of California, Los Angeles, Australian Institute of Marine Science, United States National Science Foundation)
Photochemical activity in the GBR 'Wonderland' Aquarium, R. Szymczak (Australian Nuclear Science and Technology Organisation)
Nutrient cycling in the GBR Aquarium, J.I. Morrissey and M.S. Jones (GBR Aquarium)
Nutrient history of the GBR Aquarium, J.I. Morrissey (GBR Aquarium)
The effect of light on *Acropora formosa* survival in the GBR Aquarium Reef Tank, A.B. Keys (GBR Aquarium)
Coral lipids and environmental stress, V.J. Harriott (GBR Aquarium)
Nutrition of GBR corals, P.D. Hough (GBR Aquarium)
The effects of oil and chemical dispersant on Great Barrier Reef corals, P.D. Hough (GBR Aquarium)
Demersal zooplankton in the Coral Reef Exhibit, M.S. Jones and J.H. Carleton (GBR Aquarium, AIMS)
Ozone treatment of discoloured seawater in the GBR Aquarium Coral Reef Exhibit : An experimental investigation, P.D. Hough (GBR Aquarium)
Swimming, feeding, circulatory system, and visual ability in the Australian box jellyfish *Chironex fleckeri* (Cnidaria, Cubozoa), W.M. Hamner, M.S. Jones, P.P. Hamner (UCLA, GBR Aquarium).

to the Aquarium to employ a Year 12 matriculant or first year marine biology student to work on a short-term research project. This experience has proved invaluable to the recipients of this support and provides some willing hands to help with Aquarium projects.

CROWN-OF-THORNS STARFISH REARING

Although AIMS has been successfully mass rearing crown-of-thorns starfish (COTS) larvae for three years, poor survival (< 5%) of post-settlement juveniles has seriously affected research on COTS juvenile ecology. The purpose built facility at the Aquarium is designed to provide 2000 to 3000, six-month old, juveniles for research into stocking densities, clearance (feeding) rates of *Lithothamnion* (a coralline algae), water quality requirements and predation.

During the 1993-94 COTS season, only a few larvae survived long enough in the AIMS system to be competent post-settlement juveniles. Towards the end of the COTS spawning season, we attempted to rear larvae as a comparative, parallel study to AIMS. All attempts suffered high mortality, providing few answers to a very large problem.

The COTS facility will be restarted later this year when gravid adult COTS are available.

WATER QUALITY AND CORAL GROWTH PARAMETERS

The coral genus *Acropora* is the largest of the Scleractinia, surviving and growing in a range of habitats, yet is one of the most difficult genera to maintain in the Coral Reef Exhibit, small aquaria and experimental systems. This study aims to describe the physical, hydrodynamic and chemical conditions required for optimal growth and survival of *Acropora formosa*.

The experiments are conducted from April

to September each year which is the physically, chemically and biologically most stable time for this species. Whole colonies of *Acropora formosa* are collected and transferred to a study site at four metres depth where they are fragmented and randomly placed into trays and holders and left for one week to recover before transfer to the Aquarium. The fragments in two trays, with 10 fragments in each, are stained with alizarin red 'S' dye and secured at the study site in Nelly Bay, Magnetic Island to act as controls. The remaining fragments in 14 trays, also with 10 fragments in each, are transferred to the Aquarium and stained.

At the beginning of the experiment, each fragment is tagged and assessed using a Coral Condition Index during which the number of white tips and brown tips are counted, and videos and photographs taken before the trays of corals are placed in experimental tanks. There are 12 tanks, which are randomly assigned a treatment, in the facility and each tank has a tray of fragments. The remaining trays of fragments are used as controls: one in the Coral Reef Exhibit and another in Ross Creek, adjacent to the Aquarium.

used: six tanks supplied with water on a flow through basis from the Coral Reef Exhibit, and six tanks supplied with flow through water from Ross Creek.

Water quality parameters (temperature, pH, disolved oxygen, salinity, NO_2 and NO_3) were measured regularly throughout the experiment. At the end of the experiment, all but 8 of the fragments were dried and bleached for subsequent examination for alizarin stain. The remaining 8 fragments had their tissue removed with a fine, high pressure waterjet. Zooxanthellae cells were then counted and a sub-sample analysed for chlorophyll *a* levels. A 10-millimetre section of each fragment was also preserved and later decalcified to reveal the presence or absence of reproductive products. Irradiance levels were measured in tanks using light sensors and a logger.

THE RESULTS

Coral Condition Index

After one month, corals in water from the Coral Reef Exhibit (reef treatment) had lost greater than 50% of their zooxanthellae and a few had died. In contrast, corals receiving

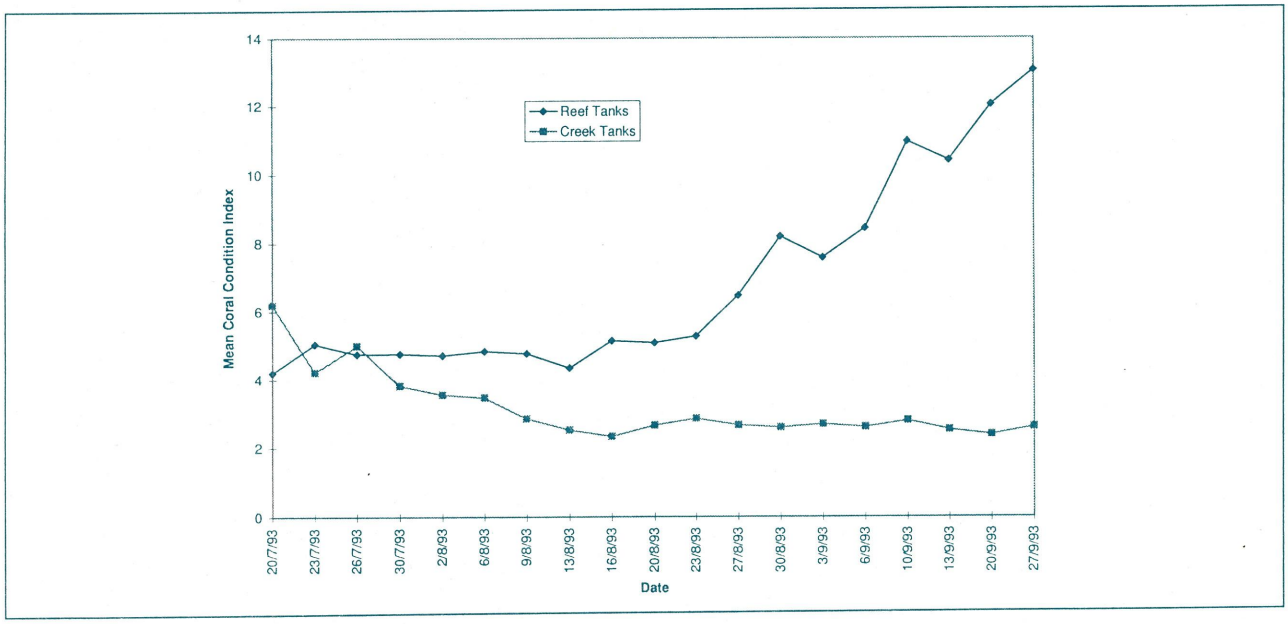


Figure 1. Coral Condition Index for Reef and Creek Tanks over Time

The first series of experiments was essentially a pilot study, the primary objective being to examine the capability of the facility to sustain 'normal' levels of growth and test the experimental methods. Two treatments were

water from Ross Creek (creek treatment) continued to exhibit growth and no loss of tissue or zooxanthellae (see figure 1). Control corals at Magnetic Island also survived well and exhibited good growth.

Alizarin staining

All growth parameters measured using alizarin staining showed a significant difference between reef and creek treatments. All fragments in the creek treatment exhibited more linear apical extension, greater initiation of new growth and more total growth per fragment than reef treatments and control. (see figure 2).

result of greater turbidity in the creek water.

Water quality

All parameters remained generally stable in the reef treatment system with more variability of salinity and $NO_2 + NO_3$ (nitrite and nitrate) evident in the creek treatment. The mean $NO_2 + NO_3$ levels in both systems was ideal: 0.3 micromolar (4.6 parts per billion

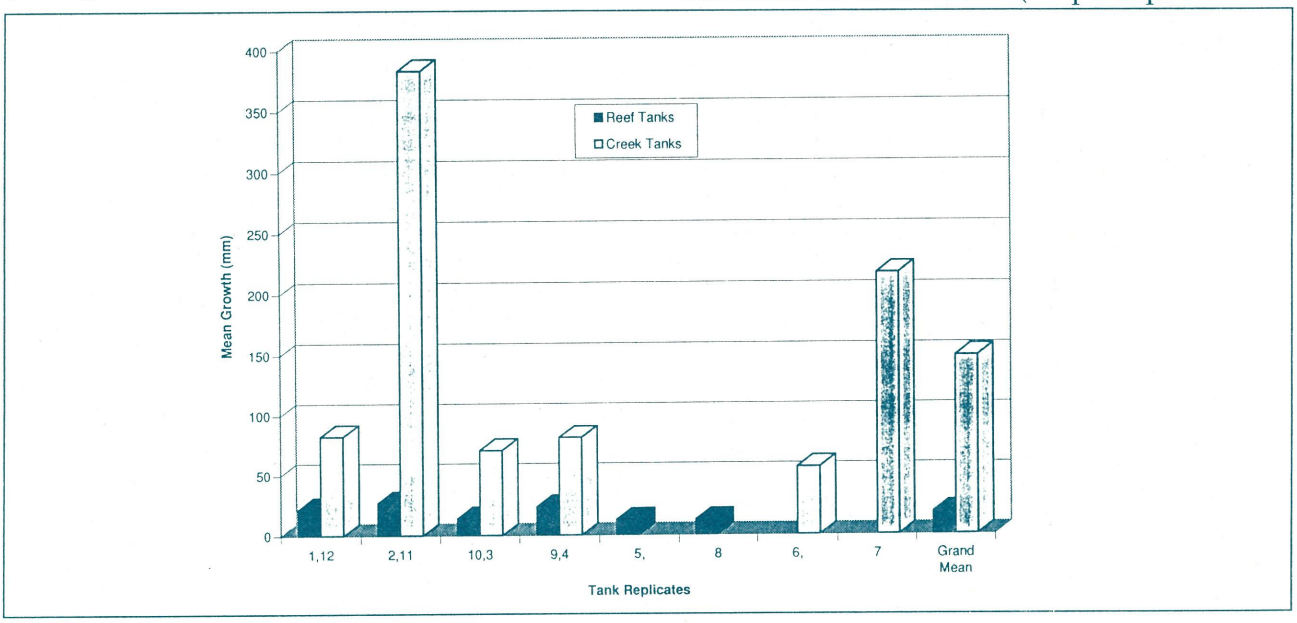


Figure 2. Mean Total Growth per Fragment for Reef and Creek Tanks

Tissue zooxanthellae density and chlorophyll *a* concentration

Creek treatment corals had up to four times the chlorophyll *a* concentration and 1.4 times the zooxanthellae densities of reef corals (see figure 3). This may be due to the 30% (compared to the reef treatment) lower irradiance levels received by creek corals as a

N). The maximum temperature variation within systems was 0.2° C. There were no significant differences in water quality that could explain the contrast in coral health and survival between reef and creek treatments.

Reproduction

Only 50% of creek treatment samples were

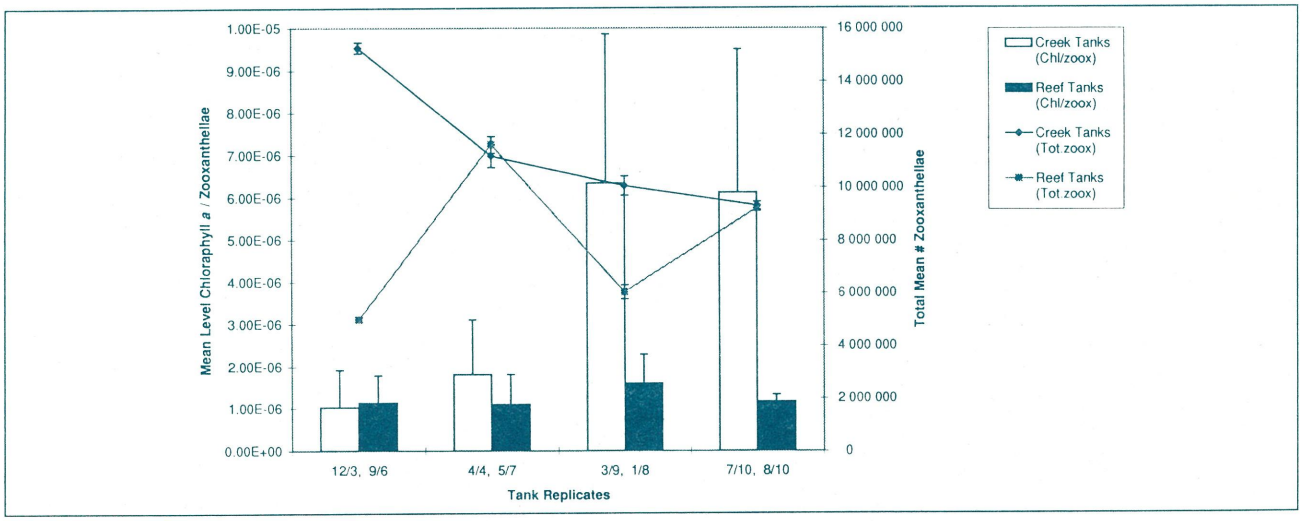


Figure 3. Comparison of Mean Levels of Chlorophyll per Zooxanthellae with Total Mean Number of Zooxanthellae per Branch

found to have eggs, though these eggs were very small. However, no eggs were found in any of the reef treatment samples.

CONCLUSIONS

The principal conclusions which may be drawn from these preliminary experiments are:

1. Corals are able to survive and grow quite well in creek water, therefore creek water is a suitable control for subsequent experiments designed to develop techniques to enhance growth and survivorship of coral in the reef exhibit.
2. The failure of corals to survive and grow in the reef exhibit appears to be associated with the quality of the water rather than any other factors such as water motion or predation in the reef exhibit.

THIS YEAR'S OBJECTIVES

Now that these corals can be sustained in the experimental system for long periods with some confidence, more detailed and manipulative experiments can be conducted. This will involve some fine tuning of the methods used in 1993, with more emphasis on analysis for phosphates, dissolved organic matter, alkalinity and secondary metabolites from the algal turf scrubbers.

GROW-OUT FACILITY FOR JUVENILE HYBRID CORALS

The Aquarium is providing a facility for growing out both within species and hybrid corals resulting from the annual mass spawning. The study is being conducted by Drs Bette Willis (JCU) and Carden Wallace (Museum of Tropical Queensland).

THE CAPTIVE BREEDING OF GREAT BARRIER REEF CORALS

Earthwatch provides research grants through a unique system of paying volunteers. In October and November 1993, 16 Earthwatch volunteers from USA, Germany, Austria and Australia assisted with experiments to mass culture acroporid corals.

To date, there has been limited success growing acroporid corals from larvae settled onto artificial substrate. Also, recruitment studies on hard corals conducted in the field have often been susceptible to many influences and possibly have given spurious results. This study aims to determine the reproductive and recruitment potential of a few species of *Acropora*.

The study was conducted at Nelly Bay, Magnetic Island during the 1993 mass spawning period in early and late October (there were 'split' spawnings last year). Different size classes of corals were selected and the colonies' size, number of tips or branches per colony and number of polyps per tip counted, and the surface areas and volumes calculated for each colony.

Four species of Acropora were studied, *Acropora millepora, Acropora tenuis, Acropora hyacinthus* and *Acropora formosa*. Six colonies of each species were collected from the study site in Nelly Bay and transferred to the makeshift laboratory late in the afternoon before spawning. At this time, the colonies' dimensions were measured and the colonies tagged. They later spawned in 300-litre tanks filled with seawater filtered to one micron.

Spawning and subsequent fertilisation of the eggs from whole colonies took place in the tanks. Samples from each tank were taken and examined at X 40 magnification to establish egg fertilisation rates, the stage of embryogenesis and larval development. When a major proportion of embryos had developed to motile larvae, they were transferred to incubators with 202 micron screened openings. The incubators were taken to the study site and secured until a majority of larvae had developed to pre-settlement stage and at this point the incubators were returned to the laboratory and emptied into clean tanks lined with unglazed terra cotta tiles and provided with seawater filtered to one micron. Generally, competent planulae settled after two days in the tanks.

Table 2. Fecundity Data

	polyps per sq.cm (mean)	eggs/sperm released per polyp (mean)	eggs/sperm released per sq.cm (mean)	eggs/sperm retained per polyp (mean)	volume of eggssperm m^3 (mean)
Acropora formosa	11.2	0.13	1.5	4.5	400000
Acropora hyacinthus	10.0	0.1	1.0	1.8	325000
Acropora tenuis	nd	nd	nd	nd	nd
Acropora millepora	22.0	0.5	10.0	3.5	440000

	Total # Eggs Released colony	Total # Eggs Retained colony	Total # Eggs Produced colony	#polyps per colony (mean)	Fecundity = Eggs/sperm released + retained per polyp
Acropora formosa	244	3440	3684	4132	0.892
Acropora hyacinthus	3785	10149	13934	63809	0.218
Acropora tenuis	nd	nd	nd	nd	nd
Acropora millepora	71175	187573	258748	120785	2.142

nd = no data

Five tips were removed from each colony (4 from the growth margins and 1 from the centre) prior to spawning and each tip placed in 200-millilitre vials for spawning. Once the tips had spawned, the egg and sperm bundles were pipetted out of the vial, tip ID number noted and the bundles counted. The eggs and sperm from this source were then mixed with products of the same species for fertilisation and incubation. Regular samples were taken from the incubators and tanks and the stage of larval development recorded and photomicrographs taken. After spawning, the tips were preserved and subsequently decalcified in acid to reveal unreleased reproductive products.

RESULTS

- Spawning began one day earlier than expected for both periods of spawning: *Acropora tenuis* spawned before collection.
- Approximately 90 000 egg and sperm bundles were released from the test colonies during the split spawning in 1993 and decalcification analysis revealed that

the retention rate (unreleased eggs) is many orders of magnitude higher (see table 2).

- After 10 days approximately 6000 settled juveniles were returned to the Aquarium.
- *Acropora millepora* is the most fecund of the three species, *Acropora formosa* the next most fecund, and *Acropora hyacinthus* the least fecund.
- Eggs produced per colony correlated to number of polyps; the colonies with the most polyps produced the most eggs.
- Fecundity increased towards the centre of the colony (away from growth margins).
- The highest number of eggs were released immediately following a decrease in water temperature, i.e. at the beginning of a rise in water temperature.
- The data showed a mean rate of fertilisation of 11% and of the fertilised eggs 69% developed through to planula and settled.
- A trial of special plankton traps to capture coral spawn proved to be very successful, alleviating stress to the colony caused by transfer.

COMMENTS

This type of study is usually very difficult and **extremely** tedious, but with 16 sets of helping hands (as well as two research assistants) rudimentary measurements involving literally hundreds of hours can be carried out during the spawning period. Several plankton tows were carried out over the spawning period and many zooplankton were observed feeding on coral spawn.

Some of the colonies studied in 1993 will be used again in 1994 and their performance compared to 'fresh' colonies. Controls for tip samples will be maintained in the field to determine the effect of sampling. Traps will be used to capture egg and sperm bundles and the resulting embryos incubated in the field.

** Paul is a research officer with the Great Barrier Reef Aquarium.*

STOP PRESS STOP PRESS

National Conference - World Heritage - Visions & Values

The joint 1994 Conference for the Australian Association of Environmental Educators and the Marine Education Society of Australasia will be held on 26-30 September 1994 in Cairns. It will explore the changing visions and values of heritage and resource management.

A call for papers has been made and abstracts are due by 30 August 1994.

For more information please contact the conference organiser:

Graham Gordon
Meetlink Conference Management
PO Box 1082 CAIRNS QLD 4870
Ph. (070) 313747
Fax (070) 312940