NEWSLETTER OF THE RESEARCH AND MONITORING SECTION

REEF RESEARCH

Great Barrier Reef Marine Park Authority

VOLUME 5 - No. 2 JUNE 1995

EDITORIAL

In this issue, I extend a belated welcome to Ian McPhail, the new chairperson of the Marine Park Authority. He has shared with us some of his thoughts on the role of research and monitoring in the management of the Park and the need to proceed, as far as is possible, from a solid information base. As the editor of the newsletter that draws attention (one hopes) to the needs for research as well as the outputs that come from it, I lend my wholehearted support to these views.

There are many other interesting articles in this issue as well. James Aston, who has recently joined the monitoring group, tells us what happens to a reef when 11 000 tonnes of container ship hits it at speed (circumspectly, he doesn't tell us why it hit it), Glenn Shield from our Aquarium describes the process of designing effective exhibits and a contribution from Julian Cribb encourages scientists to be better communicators.

Frankly, I think that communication of science to non-scientists should be a number one priority for all of us. We do interesting and useful things and we should be telling the world just that. In these days of frugal necessity it could be said that it is only fair that the taxpayer, whose hard-earned dollar we spend, has a right to know what the outcomes of our endeavours are. I urge all readers who engage in research to concentrate on telling the world the what and why of their work.

Mistakes are a part of life, and I must now apologise for errors that appeared in the last issue of Reef Research. Firstly, Siriol Giffney was accredited with the article on coral transplantation when in fact it was written by the researcher, Ursula Kaly. To add insult to injury, Siriol's surname was misspelled. Sorry to both of you, it never rains but it pours.

Ed

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

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

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WHAT'S IN THIS ISSUE

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Notes from the Chairman

Understanding complex natural systems is difficult enough; comprehending a system as large as the Great Barrier Reef is an even greater task; and understanding a system subject to so many external physical and human forces is daunting in the extreme.

Management authorities can legitimately rely on the precautionary principle when faced with decisions about human activity, but a steadily expanding knowledge base is the only sure foundation for defensible decision making.

The Great Barrier Reef Marine Park Authority (GBRMPA) has invested heavily in research over its short history. As well, sister institutions such as the Australian Institute of Marine Science (AIMS) and James Cook University of North Queensland (JCU) have concentrated efforts in the physical and biological realms in particular. The Australian Museum, the University of Sydney and a range of individual workers have all added to the sum of knowledge. The advent of the Cooperative Research Centre further concentrates the research focus for the Reef, while at the same time creating the potential to develop a more systematic agenda, and fill the gaps.

It is interesting that the major set of issues, particularly those associated with land-based sources of pollution, are to a significant extent outside the management capacity of the Authority. To be effective contributors to the debate GBRMPA must ensure that the necessary understanding of the physical and chemical processes is developed. We can only be heard in these debates if we are well informed.

There is a certain irony in that we know a fair amount about the reaction of natural systems to anthropogenic impact but it is only relatively recently that we have sought to develop an appreciation and understanding of the impactors. Tourism and urbanisation trends are necessary baseline information. Added to this knowledge, there is a need to understand the behaviour, aspirations and expectations of the wide category of users of the region. Further, as indigenous aspirations are made more explicit, there is an urgent need to document and analyse thoroughly the pattern of contact of indigenous peoples within this region and their cultural perspective on its resources.

All this represents a major task for the Authority to systemise, interpret and translate data into informed policy making. It is challenging, to use an overworked phrase, but it is stimulating and intellectually demanding. The Research and Monitoring Section has a vital role to play in these processes, and helps connect the Authority to the thinking of the scientific community.

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

Several more tasks have been completed and reports have been received by the Secretariat and are in the process of peer review. For readers who are not professional research scientists, this involves the findings and methodology being scrutinised by at least two, often three, other scientists of equal standing in the particular field of research. Reviewers may come from institutions unconnected in any formal way with CRC Reef, or from management agencies who will put the results to use. Researchers may dispute any criticisms of their work, and re-argue their case until it is resolved by mutual agreement. It is very rare for a report not to be queried in some way. It may need substantial revision, significant amendment, or a simple adjustment in its emphasis.

This is a particularly rigorous process, but a vital one if research is to be of uniform excellence and relevance across the spectrum of tasks. The Centre will only proceed to publication of a technical report after proper scrutiny of results according to a program of quality assurance. With that caveat, there are a number of tasks which, although in the process of peer review, have findings which can be disseminated at once.

Research Update

Master Reef Monitoring Directory

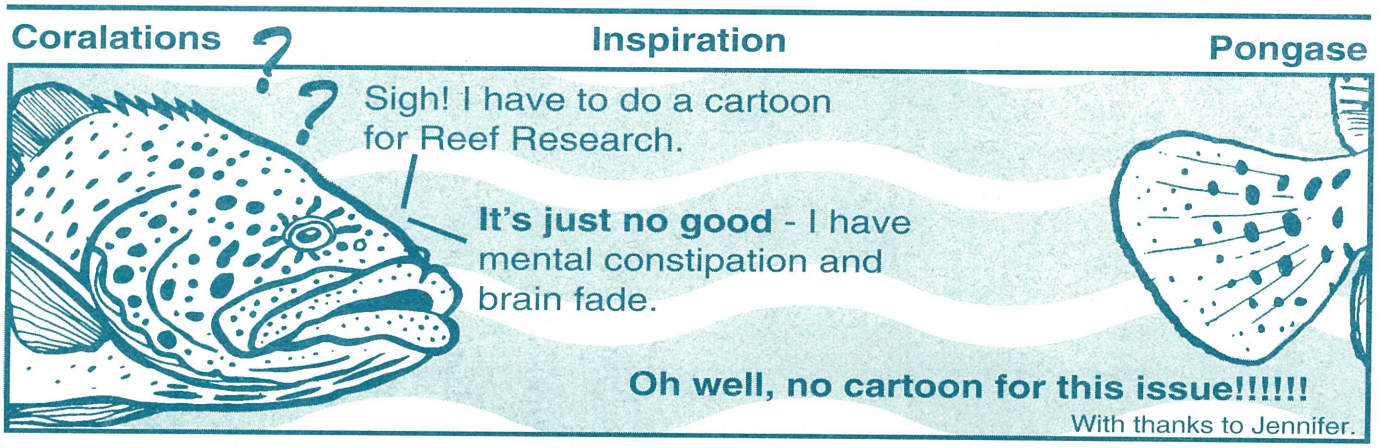
A consolidated directory of biological monitoring programs has now been completed, creating better access to various scientific databases developed since 1975. James Cook University post graduate student Rahim Gor Yaman has compiled information on more than 100 major monitoring programs about fishes, benthos, marine mammals, sea turtles, water quality and oceanographic studies.

The database will become a useful tool to help managers, particularly from GMRMPA, the Department of Environment and Heritage and the Department of Primary Industries determine their research and monitoring priorities and needs.

The most significant finding is the geographical imbalance of monitoring effort. While 30 per cent of all reefs off Cairns have been the subject of various monitoring studies during the past 20 years, only four to five per cent of reefs in the far northern and southern Capricorn sectors have been subject to the same level of scrutiny.

This survey, which has been completed in only six months, will provide a reference for other scientists to fill in gaps in existing knowledge. It lists 700 published papers and unpublished reports about significant monitoring projects in the Marine Park with a duration of more than three years. The Program Leaders are listed with the institution at which they carried out the work, so that other Australian and overseas researchers can contact them.

It will also help tourist operators, who pay their own



environmental monitoring costs, to better plan their budgets with GBRMPA and independent environmental consultants whom they may employ.

After peer review, this research will proceed to technical report stage and become a public document. Subsequently, it will be maintained and updated on a computer network and may be distributed via the Internet. Suggestions about the most effective means of disseminating this information are welcome. Please telephone the CRC Reef Secretariat with your views.

Bramble Reef Reopening

Given the opportunity offered by the reopening of Bramble Reef to line fishing after three and a half years closure, the Centre, working closely with the Reef management authorities, has established a number of new research tasks which were stepped up in intensity during May. There are four groups of integrated tasks; visual surveys of fish on Bramble and nearby reefs (an extension of research begun before closure in September 1991), fishing trips supported by recreational fishing clubs and commercial fishermen, surveys of recreational and commercial fishers and their catches, and a study of the social and economic impact on the Herbert River district, a definably discreet geographical community, of the reopening.

Researchers will be on board commercial and recreational boats both before and after the official opening to fish the deeper waters around Bramble and Trunk Reefs, outside the depth range where underwater visual counts can be made. Two Townsville angling clubs are assisting by targeting their normal trips to locations where researchers want information. Monitoring of catch, effort and stock structure is essential in assessing the effectiveness of the closure for the fishery and the consequences of its reopening for both fish stocks and catch rates, and will provide valuable information about the age structure of fish populations protected from fishing, and how that changes as a result of resumed fishing.

All coral trout and sweetlip will be identified, counted, sorted and labelled by research staff on the vessels, and the frames will be frozen and transported to James Cook University for dissection and analysis.

All together, there are seven components to the survey of fishers:

- traditional boat ramp surveys;
- bus route surveys (modified boat ramp surveys that cover a large number of ramps in a single day);
- voluntary boating log books;
- club boats with researchers on board to fish deeper waters;
- commercial boats with researchers on board;
- voluntary commercial fishers logbook recording catch and effort; and
- surface patrols conducted by management agencies.

These research components fit into a wider research program being conducted by telephone and by face to face interviews by GBRMPA staff with the help of volunteers from the Tourism Department of James Cook University. These surveys have been designed to gather information from a wide community base, including commercial skippers and crew, recreational fishers, divers, small boat owners, clubs and associations, charter operators and their clients, and the residents of the Ingham area who may never even set to sea, but whose life has been affected in some way by the closure of Bramble Reef.

Some questions in the socio-economic survey are quite specific, relating to expenditure on boat maintenance, fuel, rods, nets and other tackle. Others will be related to people's opinions about the future management of Bramble Reef.

This is the first time such large scientific and socio-economic research programs have been integrated in the Great Barrier Reef region. All surveys and questionnaires have been approved by the Ethics Committee of JCU, and researchers have given the Herbert River community a firm undertaking to publish their results within an agreed time.

The Impact of Tourist Pontoons on Fish Assemblages on the Great Barrier Reef

Researcher Hugh Sweatman will publish the results of his research on the behaviour of the fish fed by tourist operators at Kelso and Agincourt Reefs in the September issue of *Reef Research*. Preliminary findings however, are too interesting to keep back. Fish arrive at the pontoons shortly before the boats, and leave very soon after the tourists who feed them depart. So they know what time of day it is. They also arrive at the pontoon when a boat is scheduled to arrive, even if the trip is cancelled for such reasons as rough weather. However, on days when the tourist operators do not have trips scheduled to visit the pontoon, the fish do not show up either, which implies that not only do they carry watches, they know what the date is too. The question is, do fish know when it's Friday?

THINGS THAT GO BUMP IN THE NIGHT

James Aston

It's 5 a.m. on 30 March 1995. It is still dark and the MV *Carola*, an 11 000 tonne container ship, is steaming up the northern sector of the Great Barrier Reef inner shipping route. The ship fails to alter course to port to maintain its passage inside the main shipping channel. Suddenly, an almighty crunch - the MV *Carola* has run into South Ledge Reef, at the northern tip of the Great Barrier Reef Marine Park!

This is the stuff sailors' nightmares are made of, but around 2000 ships transit the Great Barrier Reef every year and every year around one to three of these run aground in the Great Barrier Reef region. Some are never refloated and are added to the 200 known wrecks on the Great Barrier Reef.

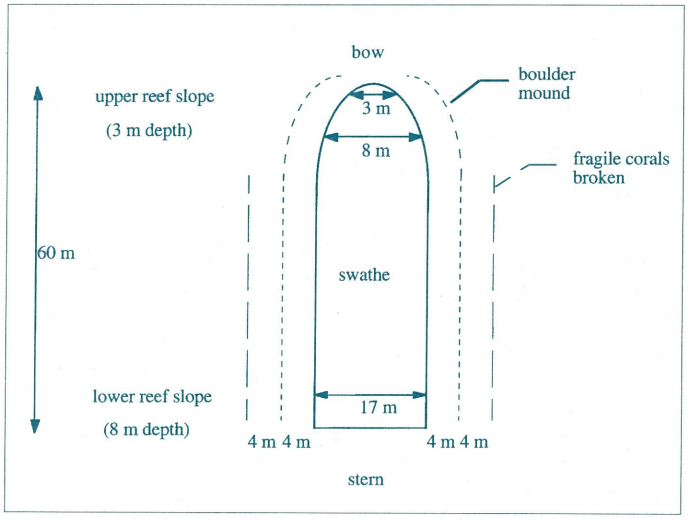


Figure 1 - Sketch of vessel grounding impact swathe

Luckily, the MV *Carola* went aground at low tide and refloated as the tide came in later in the day. No fuel or oil spillages were reported although minor damage was sustained to the hull. The grounding of the MV *Carola* presented a unique opportunity to examine the impacts of a large vessel grounding, particularly in relation to:

- extent of damage to coral colonies and habitat along the grounding swathe and adjacent areas;
- percentage cover and species composition of coral communities along the swathe and adjacent areas; and
- rates of coral regeneration and recovery.

As the grounding was in Torres Strait, the window of opportunity to inspect the site was very small due to the prevalence of strong currents and strong winds in the region. Within a few days of the grounding a monitoring team comprising Ray Berkelmans, Rachelle Ninio and James Aston visited the site during a period that coincided with weak currents and unusually calm weather.

The site was located using a Global Positioning System although the swathe was spotted only while snorkelling while being manta towed. The MV *Carola* had left quite an impression - 60 m long, 17 m wide and 3 m deep! The area of impact extended from the lower reef slope to the upper reef slope at the south-eastern end of the reef (see figure 1).

Within the swathe, the substrate was reduced to rubble, shingle and fine sands. Large bommies and broken bits of the reef matrix up to 3 m in size were fractured and dislodged and pushed out to form a mound along the sides of the swathe (see photo 1).

This mound was up to 4 m wide and 1.5 m in height. There was little left to recognise in terms of the types of corals affected within the swathe or the mound of boulders, although remnants of favids, porites, *Merulina* and *Hydnophora* spp were evident (see photo 2). There was no coral damage from propeller wash up to 100 m seaward of the swathe where the substrate was predominantly sand.

Numerous patches of antifouling paint up to 0.5 m in length were found within the swathe. Samples of the paint were collected and are being tested for levels of tribuytal tin (TBT). TBT is known to be lethal to organisms at very low concentrations (within the order of 1 part per billion).

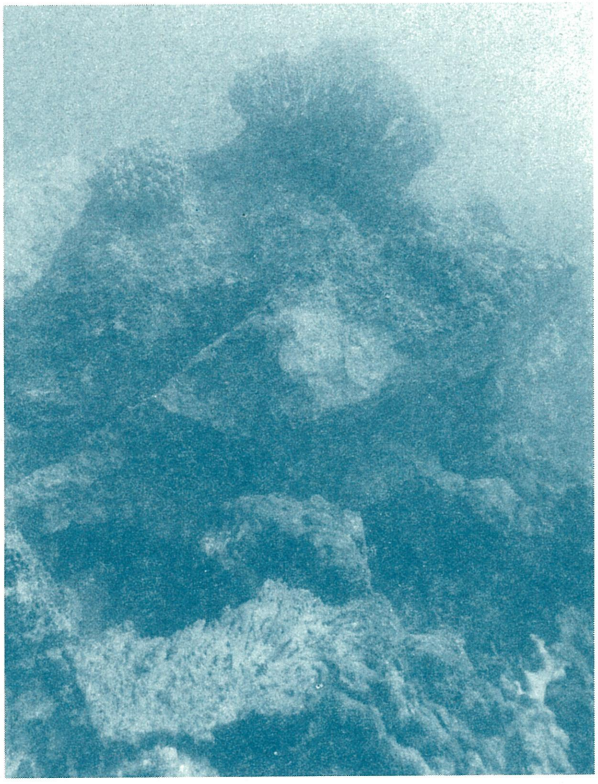


Photo 1. Fractured and dislodged corals and reef matrix

The percentage cover and species composition of coral was estimated adjacent to the impacted area on both sides of the swathe to allow interpolation of the coral community in the impact zone prior to the grounding and to serve as a baseline for future recovery monitoring. The impact site at South Ledge Reef has a relatively high percentage of hard coral cover and a high diversity of corals generally. The mean percentage hard coral cover on the lower reef slope was 50% and mainly comprised acroporas and favids. Permanent transects were established and videoed.

The monitoring team found that the impacts from the grounding were mainly structural and would not be expected to have any effect on the ecology of the reef except at a very localised scale. It is intended that a monitoring team will revisit the site on an annual basis, if possible, to monitor the recovery of the corals at the impact site and adjacent areas. TBT levels in the benthos may also be monitored pending expert advice.

Recent advances in navigational technology and efforts by shipping companies and government agencies have helped to minimise the risks of shipping incidents in the Great Barrier Reef. The range of factors which contribute to shipping accidents and specific mechanisms to reduce shipping incidents are documented in the Great Barrier Reef and Torres Strait Shipping Study (March 1995) and the Australian Maritime Safety Authority and others are committed to implementing the recommendations from this study.

Any significant shipping incidents should continue to be investigated. This information could be used to develop management strategies such as vessel speed restrictions or modifications, or establishment of shipping areas, if the incremental impacts or extent and types of impacts are judged to be unacceptable for particularly sensitive areas of the Great Barrier Reef.

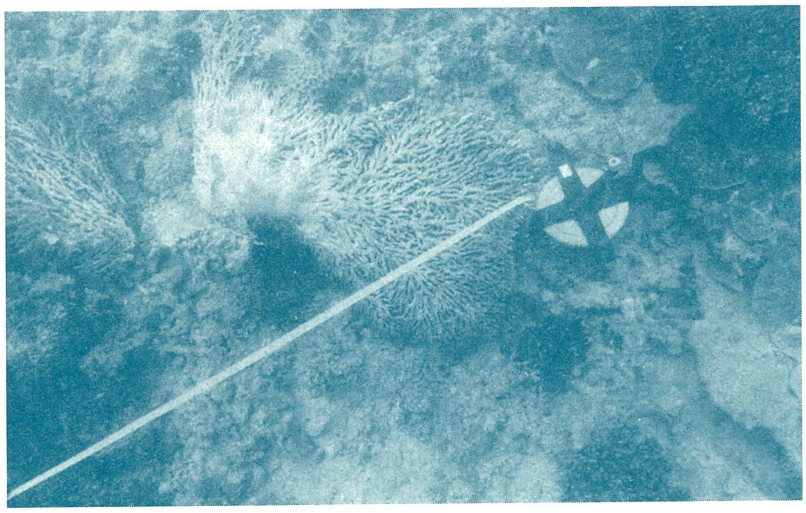


Photo 2. Damaged corals up to 4 m from the swathe

Scientists Have Let Australians Down!

COMMUNICATING SCIENCE TO NON-SCIENTISTS

Julian Cribb*

Scientists, I suggest, have let Australia down.

Not, I hasten to add, as scientists. In fact, I suspect that part of the explanation for the brilliance for Australian science may lie in the fact that its practitioners are outcasts - and must thus strive all the harder against a tide of disinterest and suspicion to prove themselves. Like good wines, great science sometimes flourishes in stony ground.

But scientists have let Australia down because they have not told it what they are doing. They have been so wrapped up in their work and their discoveries, they have forgotten to explain them to the society that pays their miserable wages. They have omitted to put their work into language that ordinary people can understand. They have failed to explain its relevance to our daily lives - our health, wealth and well being as a nation - and how to put it into practice in our industries. The scientific communications job in Australia has been botched - and as a result the political hounds have thundered off in full cry after other priorities.

The penalty for this was a decade of cuts, lost talent and lost opportunity in Australian science. It can still be seen in the demoralised and scandalously under-resourced conditions in our universities. It will take far more than a decade to rectify and win back Australia's brightest youth to the profession of research. The penalties for not communicating with society and industry about the products and progress of science and technology exact a very high price indeed - one that generations of Australians yet unborn will have the privilege of repaying.

The main reasons that I see for effective communication are:

- To transfer to society or industry the benefits of research;
- To inform policy-makers and leaders about progress that can advance the interests of the community;
- To prepare the public for the advent of new technologies and technological change;
- To share with industry, other scientists and users the findings of research and experience, so they may be combined into workable technologies;
- To bolster economic competitiveness and lower reliance on imported technology solutions;
- To remedy and if possible avert environmental damage caused by unwise use of technology and resources; and
- To involve the next generation in technological progress appropriate to their evolving society.

Target audiences that should be involved are:

- The public, via the media;
- Political leaders, through personal communication and well-prepared policy documentation, and via the media;
- Industry, via specialist publications and first-hand contact, and the media;
- Peers, via scientific journals and personal communication - but also through the general media; and
- Young Australians - through special schools publications, teaching kits, science clubs and the media.

The conclusion is obvious. The only form of communication which reaches EVERY part of society is the general media - and a well-planned communication strategy must take this into account.

Many scientists still seem to think that the media is somehow responsible for many of society's ills, an object to be avoided and disdained, frequently abused and criticised, but at best kept at a careful arms-length and told only those things considered good for it to know. Journalists are often mistrusted by scientists. Sometimes this mistrust arises because scientists do not understand the kind of journalist they are dealing with and fear their arguments may be misunderstood or, worse, misreported. This in turn may discredit them among their peers. Where this does occur, it may often be due to researchers not having taken sufficient pains to

explain clearly and simply the nature of their work.

The media - newspapers, television, radio and magazines - are the means by which our society exchanges and evaluates new ideas. As such, they are the natural public outlet for scientific discovery and progress. If you can't get your views and ideas across to the media clearly, concisely and with impact, then you have failed a key test of communication.

Role of communications

Good communications is not an adjunct to scientific policy or industry progress - it is a physical part of it. A scientific body which relegates communications to a secondary role, excludes it from policy discussion and denies it access to vital information, is guilty of gross neglect of its responsibility to its researchers and the industry it serves.

Too often the 'wheel-trim' syndrome applies to public relations. That is, communicators are kept in the dark about key developments and asked to clear up the mess only after one occurs. When communicators are excluded from policy formulation, policy is made without any proper advice as to how it will be perceived by the public, media or by political leaders. The result will be policies which may be acceptable inside a science body, but which end up being public disasters. Communications and public relations must be an integral part of policy formulation. No policy change should be made without some consideration of how its results are to be publicised and disseminated - and how they will be received. By involving a communicator in policy-making, the process of obtaining favourable publicity will by mightily facilitated.

Conclusion

Learning to be a skilled and effective communicator is no easier than learning to be a skilled or effective researcher. It can take a lifetime of developing your abilities and contacts. But it is absolutely central to the role and responsibility of a good scientist, and will become more so as time goes by. Furthermore, if science is ever to achieve its true potential in Australia, and industry or society to fully recognise its worth and contribution, the task of communicating its needs and achievements is absolutely vital.

I wish you good fortune in it.

* Julian Cribb, Science Writer for *The Australian* (based on a seminar to the Bureau of Rural Resources, July 1992, Working Paper No. WP/11/92)

AUSTRALIAN SCIENCE COMMUNICATORS (ASC)

Would you be interested in joining an association of people who communicate science? A broad-based association to promote national awareness and understanding of science and technology in Australia?

ASC includes science communicators from media, government-funded research organisations, museums, universities, education and industry. Scientists, teachers, students and interested persons are welcome to join.

It aims to:

- provide a forum and meeting place;
- promote awareness of science and technology;
- lift professional standards;
- encourage debate on ethical, economic and social issues;
- publish a journal; and
- organise exchanges and scholarships.

If you are interested please write to us care of: GPO Box 2265, Canberra ACT 2601.

For further information, phone, fax or write to the Secretary: 06 282 2026 (ph); 06 246 5560 (fax); toss@enmech.csiro.au (e-mail)

Julian Cribb, *President*

Great Barrier Reef Marine Park Authority Dispersant Policy Endorsed by Expert

The use of chemical dispersants to treat oil slicks at sea remains a controversial issue amongst oil spill response professionals, scientists and environmentalists interested in oil pollution, particularly in relation to coral reef areas. In 'Slick Talk #13' we take a look at GBRMPA's policy and guidelines on the use of dispersants in the Great Barrier Reef Marine Park.

When dealing with an oil slick on the sea's surface, there are basically three options available to response personnel:

- monitor the slick and leave it to degrade naturally;
- physically contain the slick and recover the oil using mechanical devices; and/or
- break down the slick by applying chemical dispersants.

Alternative techniques, such as in situ burning, are currently the subject of various research and development efforts, particularly in North America. However, many would argue that, as it is necessary to physically contain the oil to achieve the oil thickness required to sustain combustion, this method is really no different from the second option above. The only difference is that the contained oil is 'disposed of' by burning it in situ, rather than recovering it and disposing of it on shore.

In many oil spill scenarios, the first point above is often the most environmentally sound option, so long as the oil slick does not threaten to impact on coastal resources. However, under wind and tidal influences, coastal impact may be imminent and action must be taken to try and prevent as much oil as possible from coming ashore. As oil spill booms and similar containment and recovery devices are generally ineffective in open-water situations, the application of chemical dispersants is often the only option available.

Throughout the Great Barrier Reef region there are large areas of deep, open water where physical response techniques would not be effective and which provide opportunities to treat an oil slick with dispersants. Chemical dispersants therefore constitute a significant component of the 'armoury' of tools available to combat oil spills in the region.

Because dispersants are toxic chemicals in themselves, and because dispersed oil is more toxic in the short-term than undispersed oil, due to the increased surface area to volume ratio of the dispersed oil droplets, the inappropriate use of dispersants can be environmentally damaging in itself.

It is, therefore, vital to ensure that appropriate guidelines and procedures are in place and are followed when making the decision to use dispersants. Often, the decision to use dispersants means accepting impacts on one resource (i.e. in the area where the oil is being dispersed) in order to prevent impacts on another resource which would be impacted if the oil were not dispersed. This requires a system of prioritisation, under which environmental resources are allocated value rankings.

Oils are only amenable to dispersion while they are still fresh and the application of dispersant must be conducted as soon as possible after the spill has

occurred. Once they have become weathered over the first two days (depending on variables such as sea and air temperature, sea state and type of oil), oils become less and less amenable to dispersion. This means that it is vital to have decision-making processes clearly established prior to spills occurring, and ideally to have dispersant use/non-use zones predesignated. Unfortunately, because of the huge size of the Great Barrier Reef region (>350 000 km^2), detailed assessment of all environmental resources and predesignation of dispersant use zones throughout the whole region would be a major task. While dispersant use zones are being predesignated for particular areas within the Great Barrier Reef region, GBRMPA has opted for a general policy and set of detailed guidelines governing the use of dispersants throughout the Marine Park. They are officially referred to as Interim Guidelines, allowing for the fact that as further research information becomes available they may be modified and updated accordingly.

Development of the policy and guidelines was commenced in-house by GBRMPA staff in 1991 and was based on an extensive literature review of the effects of dispersants and dispersed oil on tropical marine systems such as coral reefs, seagrasses and mangroves. They were sent in draft form for comment to other relevant bodies, such as the Queensland Department of Environment and Heritage, and were formally approved by the Marine Park Authority at its 142nd meeting on 23 June 1993. A central element of the policy is the requirement for the On Scene Coordinator (OSC), who is predesignated as being the relevant Regional Harbour Master from the Queensland Department of Transport, to obtain advice from the Scientific Support Coordinator (SSC), who is provided by GBRMPA, prior to any use of dispersant. Under the policy the OSC must also adhere to the guidelines and any dispersant use/non-use zones designated by the SSC.

Fortunately, the GBRMPA policy and guidelines have not yet been tested in a major oil spill, and hopefully they never will be. However, they have been subject to scientific review and comment. At a recent oil spill dispersant workshop held in Melbourne, Dr Ken Trudel of S.L. Ross Environmental Research Ltd, a recognised international expert on dispersants, praised and endorsed the approach taken by GBRMPA through its guidelines and stated that they provided a practical, workable model which, if adhered to properly, would help minimise the environmental impacts of an oil spill in the Great Barrier Reef region. The challenge remaining is ensuring that should a spill occur, the use or non-use of dispersant is not driven by uninformed opinion from either extreme of the camp, but rather by the guidelines which have been developed based on a comprehensive review of the best scientific information available.

This means that all personnel potentially involved in spill response decision making, including senior members of Government who may intervene in a spill response, are aware of the policy and guidelines and the importance of sticking to them.

The full policy and guidelines are reproduced below.

Policy and Interim Guidelines for the Use of Oil Spill Dispersants Within the Great Barrier Reef Marine Park

(Approved by the Marine Park Authority, 142nd Meeting, 23 June 1993)

Policy

The appointed On Scene Coordinator, after consultation with the appointed Scientific Support Coordinator, may authorise the use of chemical dispersants in strict accordance with the guidelines below. GBRMPA will designate dispersant use/non-use zones for the REEFPLAN area and these are to be adhered to as advised by the appointed Scientific Support Coordinator.

Where there is a risk of fire or explosion, the On Scene Coordinator is empowered to use dispersants irrespective of all other considerations or advice from the Scientific Support Coordinator.

Interim Guidelines

General

- The oil type must be amenable to dispersant use.
- Oil weathered for more than two days is generally not amenable to dispersant use. This may vary with oil type and physical conditions.

- The area must have adequate depth of water over sensitive resources. This varies according to the resource, the oil and dispersant types and weather conditions, but will not generally be less than ten metres.

- The area should preferably be one of high energy input and have an active water exchange rate.

- The area should preferably not contain eggs and larvae of ecologically important species (e.g. corals), commercial fisheries species or aquaculture.

- The decision to use dispersant must be based on an evaluation of the impacts that will occur if dispersant is used compared to the impacts that will occur if dispersant is not used. It may be necessary to accept impacts on one resource in order to minimise impacts on a more valuable resource.

- Decisions should be based primarily on ecological considerations, with aesthetic/amenity considerations being adhered to secondarily.

Coral Reefs

- Generally, dispersed oil is more damaging to coral reefs than undispersed oil.

- Use of dispersant to prevent oil reaching a reef is recommended only if the upstream site is less sensitive than the coral reef itself and sufficiently distant to ensure that oil does not reach the coral reef once it is dispersed (i.e. while it is desirable to prevent undispersed oil reaching a reef it is more desirable to prevent dispersed oil reaching a reef).

- Use of dispersant on oil already over coral reefs is recommended ONLY if the alternative is to allow the oil to impact on mangroves downstream (i.e. the impact of dispersed oil on reefs is preferred to the impact of undispersed oil on mangroves).

Seagrasses

- Generally, dispersed oil is more damaging to seagrasses than undispersed oil.

- Use of dispersant to prevent oil reaching seagrass beds is recommended only if the upstream site is less sensitive than the seagrass beds themselves.

- Use of dispersant on oil already over seagrass beds is recommended ONLY if the alternative is to allow the oil to impact on mangroves downstream, and only if the area is well flushed.

Mangroves

- Generally, dispersed oil is less damaging to mangroves than undispersed oil.

- Use of dispersant to prevent oil reaching mangroves is recommended.

- Use of dispersant on oil already in mangroves is recommended only if it can be applied manually in a controlled manner as dispersants on vegetation can cause defoliation and mortality.

Beaches/Rocky Shores

- Ecologically, it may be more desirable to allow oil to beach where it can be cleaned up mechanically rather than to disperse it at sea where it enters the water column. However, aesthetic/amenity impacts may tempt the use of dispersants to prevent oil from beaching. Ecological considerations should be taken into account in this situation.

- Use of dispersant on oil that is already beached is dependent on the shoreline type. The possibility of causing the oil to sink into the substrate creating the potential for long-term impacts should be considered.

Bird and Turtle Rookeries

- Undispersed oil can have severe effects on bird life and nesting or hatching turtles.

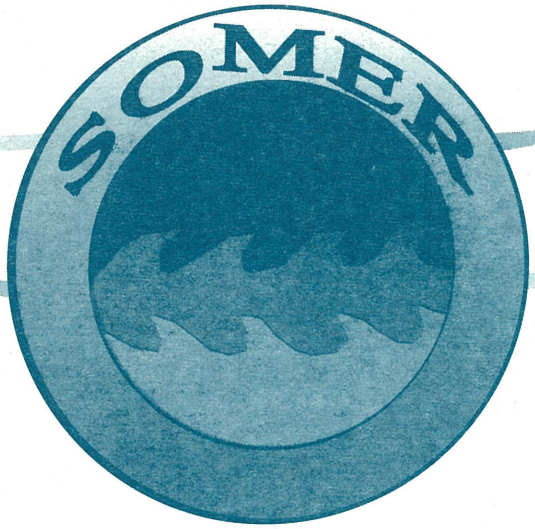
- Use of dispersant to prevent oil from reaching bird or turtle rookeries is recommended.

Physical Structures

- It may be possible to use dispersants to remove oil from physical structures such as rock walls, wharfs, buoys and boat hulls.

- However, a number of non-toxic, biodegradable de-oilers are now available that are more effective and less harmful than dispersants for this purpose.

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



The State of the Marine Environment Report for Australia

Jim Campbell

The State of the Marine Environment Report for Australia (SOMER), the first comprehensive, scientific description of Australia's marine environment, was released on 13 February 1995. SOMER was undertaken primarily to provide baseline information for Australia's 'Ocean Rescue 2000 program', a national, long-term initiative for the management of its marine environment. SOMER covers the vast area of Australia and its external territories, from the coral reefs of the tropical north to the shores of Australia's Antarctic Territory. Its major focus is the coastal waters around the Australian continent, particularly near the most heavily populated areas.

SOMER describes:

- the major marine ecosystems;
- the uses of the marine environment and their effects;
- the issues and threats affecting the marine environment;
- the condition or health of the marine environment; and
- marine environmental management and conservation.

SOMER is based on some 83 commissioned papers, which have been subjected to extensive open peer

review, prepared by 134 scientists. Two volumes (*Technical Annex 1: The Marine Environment* and *Technical Annex 2: Pollution*) of selected papers are now in press and a third volume representing state issues will be published soon. The papers were summarised by Dr Leon Zann, the SOMER Coordinator, as a 'Technical Summary' and this is currently being prepared for publication. It is hoped that it will be available in June. The main report *Our Sea, Our Future* describes the general findings and identifies major issues. Because this main report is to be used in the preparation of a national marine conservation plan, it has been extensively reviewed by Australian federal and state governments.

SOMER describes Australia's marine environment as vast in area with a very rich biodiversity. Australia's Exclusive Economic Zone is over 11 million square kilometres (one of the largest in the world); its legal continental shelf is 14.8 million square kilometres in area; its continental coastline, including that of its major islands, is almost 70 000 kilometres long; and it has over 12 000 islands.

Northern Australia has the largest areas of coral reefs in the world, and amongst the largest areas of tropical seagrasses and mangroves. It has some of the world's last secure populations of endangered and threatened species such as giant clams, turtles and dugongs.

The southern coastline has the largest areas of temperate seagrasses in the world, and the highest species diversity of seagrass and marine algae. Because of the long geological and climatic isolation of its marine flora and fauna, the south has a very high proportion of endemic species (around 90% of species in most marine groups).

However, the south is generally far more densely populated and developed than the north, and is under greater environmental pressure. Despite Australia's great size, around 85% of its population live in the coastal zone, largely in cities in the south-east.

Major findings

A great number and variety of issues and problems were identified. While it is difficult to compare diverse environmental, social, management and scientific issues, the most serious general issues were considered to be:

- declining marine and coastal water/sediment quality, particularly as a result of inappropriate catchment land use practices;
- loss of marine and coastal habitat;
- unsustainable use of marine and coastal resources;
- lack of a coherent national marine science policy and lack of long-term research and monitoring of the marine environment; and
- lack of strategic, integrated planning in the marine and coastal environments.

A conference on the state of the marine environments of Australasia and Oceania was held at the University of Queensland in Brisbane on 14-17 February 1995 to discuss the major findings of SOMER and consider future directions in coastal research and monitoring in the region. The findings of the workshop have not yet been published but principal recommendations based on the issues raised in SOMER were agreed to by the conference and include:

- the need for immediate action to address the major findings;
- Australia's marine environments should be managed as a series of large marine ecosystems whose boundaries are determined on biological and not political criteria;
- the establishment of a national coordinating body - key responsibilities of which would include coordinating a national, integrated and strategic approach to managing coastal and marine regions; and
- that community groups be better resourced to improve their input and role in decision making and information exchange.

THE ART OF RESEARCH

Concept, Design and Construction of Exhibits at the Great Barrier Reef Aquarium

Glenn Shield

What is an exhibit?

Since the term exhibit can be used to cover such a broad range of things, it is probably easier to answer this question by asking another. What does an exhibit at the Aquarium do?

We aim to produce something that informs, interests, entertains, involves and enlightens the general public. It is important that they enjoy their visit and it is equally important that they take something away with them. This 'take home' element could be a whole new attitude or a revitalised concern and love of the reef environment.

On a broader scale, exhibits should make the Aquarium look attractive so that visitors have the most pleasant and stimulating aesthetic experience possible while they are in our watery world. It is also important that even though exhibits are quite separate they all fit together in some way so that the Aquarium can be considered as a whole.

Is it possible to do all this? Well, perfection is always a good aim and in aiming for it we have to ask and answer many questions. It is this process of questioning that forms the basis of the research in exhibit production. The questions, however, are many and varied taking in technical, theoretical, aesthetic and educational considerations. Furthermore, there is never one right answer and for every answer there is always a better one just out of sight.

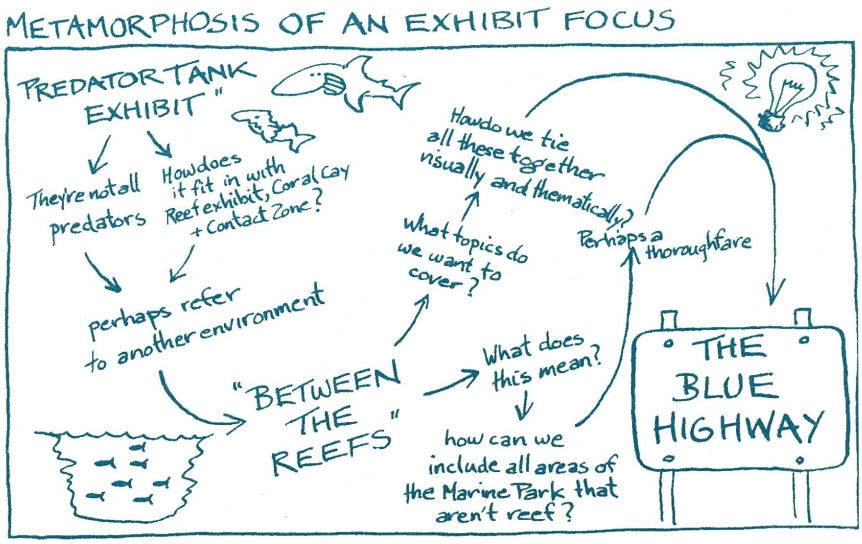
Below are some examples of the big questions involved in the process of exhibit production as well as some of the answers we have used.

What is it all about?

All exhibits have a starting brief. These briefs are defined by a need for the Aquarium or by a particular grant of money. In order to begin designing the exhibit this brief has to be redefined in terms of a focus or clear direction for the exhibit. This focus comes out of a process of asking and re-asking what the exhibit is all about.

Our latest exhibit is called the Blue Highway. It began as an exhibit about the Aquarium's predator tank and was tentatively called the Predator Exhibit. After a number of discussions, the term predator seemed too limiting and the focus changed to an exhibit about the deeper water of the Marine Park and was tentatively called Between the Reefs. This was also found to be limiting and the focus was again changed to an exhibit about the ninety or more per cent of the Great Barrier Reef Marine Park that isn't reef.

So where did the Blue Highway come from? To tell



you the truth it was something somebody said as a joke in one of our brainstorming sessions. It may have been said as a joke but in subsequent meetings it became apparent that this was actually a very relevant answer to our search for a focus to hang the exhibit on.

Brainstorming is one of the most important forms of research at these early stages as it brings everybody's attitudes, understandings and feelings about a particular topic out into the open. By looking at all these as a group it is possible to see common threads which can become a clear focus. The Blue Highway was the end of a process of moving from the idea of an exhibit about the animals in a particular tank to one about the largest, most unknown part of the Marine Park.

What does it look like?

The most important piece of research here is aimed at gaining an understanding of the space the exhibit is going into. This includes looking at the dimensions, the available light, and the feeling created by the shapes present. It also includes talking to the engineering staff about what major changes are possible. Often, walls can be moved, added onto or removed entirely.

These major changes can be scary. In the case of the Stone Fishtrap Exhibit (an exhibit about Aboriginal and Torres Strait Islanders' knowledge of marine resources) we cut and moved a wall, removed a large section of railing from the stairwell and wheeled some 30 wheelbarrow loads of concrete up in the elevator and dumped it over a set of stairs to turn them into a more aesthetically pleasing ramp.

As far as the style and look of the exhibit is concerned this involves looking through art books, photographs and exhibit books to get ideas, and then maybe hiring local artists with particular styles to create the look.

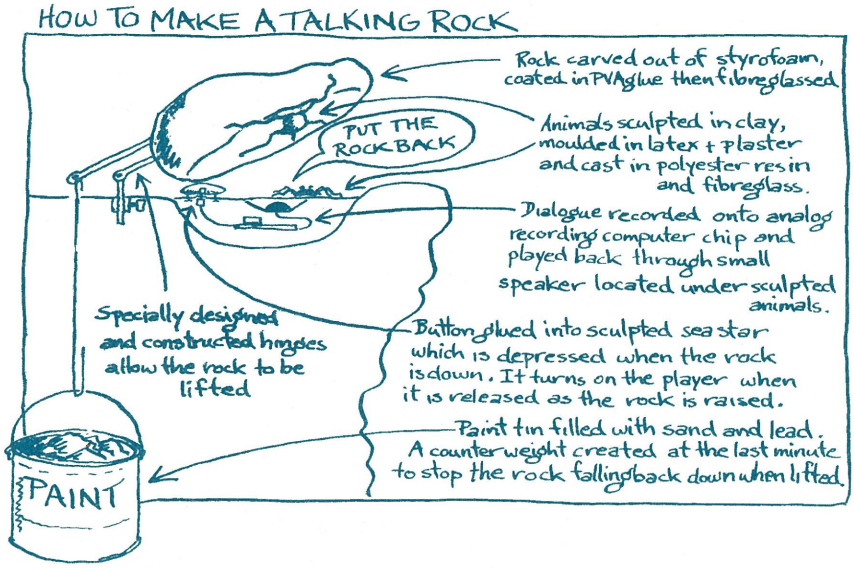
The Contact Zone is an exhibit designed to complement the Touch Pool on the upstairs floor of the Aquarium. The main aims are to brighten the area and to add interpretive material about the invertebrates that could be encountered in the pool. The title of the exhibit was created to represent all the shallow areas of the reef at which people can easily come in contact with sea life.

The look created for the 'Contact Zone' had its origin in a photograph of light playing on the wall of the reef exhibit downstairs in the Aquarium. This was given to local artist Michael Murphy who transformed it into a pattern of white and yellow lines dancing over a number of shades of blue and green. This is the pattern that now brightens the area around the touch pool.

How does it work?

This is where things get technical and where trial and error is one of the most important research tools. Research is needed to work out what materials can be used for a particular task and what technologies are available. This is also where the study of the cost of materials and technologies comes into play. It is not always a case of researching the technology itself as much as researching the people who know something about it and using them.

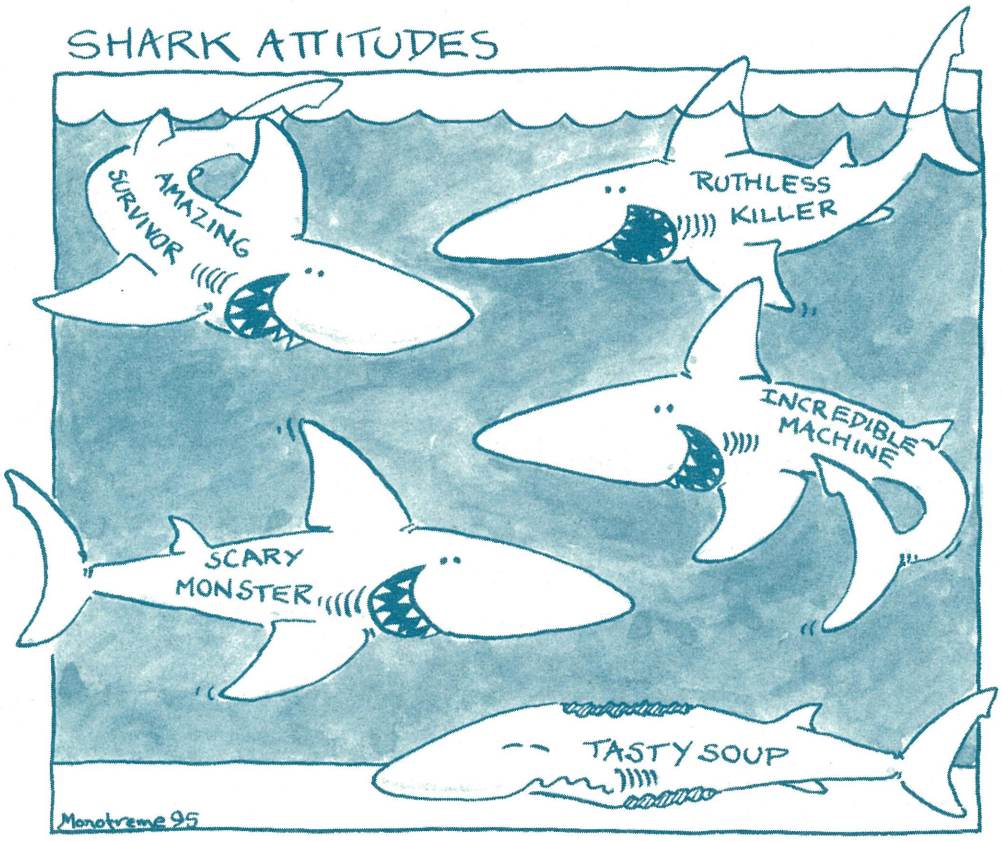
The talking rock in the Contact Zone is a case in point. It uses both modern technology and some old-fashioned ingenuity. How do you make a rock talk?



What does it say?

If there aren't already enough questions, you also have to work out what your information is going to be. It can be any, or all of, words, images, diagrams, objects or live displays. A great deal of this information comes from people in the know within the Aquarium and the Marine Park Authority. Much comes from books, articles and videos and some from personal observation.

Information gathering is one thing but presenting this information in a way that can affect attitudes is quite another. To do this, an understanding of attitudes is needed. So far, the easiest way to source this sort of information is to talk to the volunteers and interpreters here but there is a need in the future to do some attitudinal testing of visitors to improve our understanding of the effects of exhibits.



In designing the new Blue Highway shark display we had to look at people's attitudes to the sharks in our tank and sharks in general. The most commonly asked questions by visitors were tabled and examined. Questions, like: Why are your sharks so small? How dangerous are they? and Why don't they eat the other fish in the tank? can give a feeling for the attitude of the visitors. It was decided to replace the big, killing, eating everything in sight attitude to sharks with an entirely different one. In our display sharks will be sleek, stylish, powerful and exciting, much like a top of the range sports car. This also fits in with the theme of the Blue Highway.

How is it finished?

The simple answer to this is, it isn't. For every question you answer in creating exhibits there is always a better answer around the corner and there are always many more questions born out of the process. As soon as an exhibit is finished the real testing begins. Do the colours fade? In the case of the colour magenta from the colour printer the answer is 'yes'. Does the tank leak? This was a big 'yes' for the Stone Fishtrap in its first year. Will children crack their head open on it? This has not happened but the possibility has been pointed out a number of times leading to subtle design changes. Most importantly, are people getting the intended message?

Hopefully in this brief outline I have given an impression of the thought processes and practices behind the way we produce exhibits in the Aquarium. The most difficult and most exciting thing about the process is that it is so varied that it is impossible to become pigeonholed into one field of study. How these processes compare to other institutions is as yet unknown and an excellent topic for yet more research.

1995 Augmentative Research Grants Scheme

The Great Barrier Reef Marine Park Authority awarded 16 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

Ross Jones / Dr D Barnes & Dr G Jones
Sublethal stress assessment in hermatypic corals ($1000)

Vincent Hilomen / Dr G Russ
Inter-habitat movement patterns and population dynamics of small commercial reef fishes from Lizard Island lagoon, Great Barrier Reef ($695)

Ab Rahim Gor Yaman / Dr G Inglis
An examination of the recovery of coral reefs following removal of tourist pontoons ($1200)

Nick Buzza / Dr P Catt
Subtidal reef mapping with digitised aerial photography ($1200)

Carolyn Smith / Dr BL Willis
Coral population genetics: a molecular approach to determining clonal population structure ($1000)

David Prince / Dr G Woods
Automatic generation of Sea Surface Temperature maps from NOAA satellite data ($600)

James True / Dr BL Willis & Dr DJ Barnes
Variation in tissue thickness of massive porities corals (*Scleractinia: Poritidae*): implications for new methods of monitoring coral health ($1000)

Tony Rouphael / Dr G Inglis & Dr J Oliver
Assessing the effects of underwater photographers on coral assemblages within the Great Barrier Reef Marine Park ($516)

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

Kenneth Melchert / J Monaghan & Dr S Smithers
The effects of water-level changes on the geomorphology of Heron Island reef platform ($804)

Seiji Nakaya / Dr CS Shafer, Dr B Mapstone & Dr G Inglis
Intensity and distribution of spearfishing activities in the Great Barrier Reef and demographics of spearfishers ($800)

Coleman Doyle / Dr P Veth
Magnetic Island shipwreck project ($475)

Ilona Stobutzki / Dr D Bellwood
How pre-settlement reef fish find reefs: swimming abilities and behavioural responses ($900)

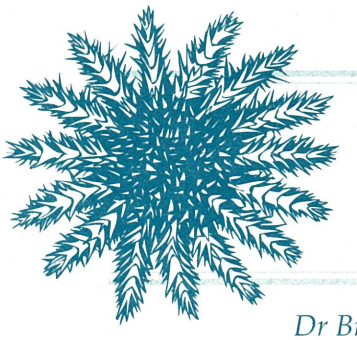
The University of Queensland

Timothy Ault / Dr C Johnson
Metapopulation dynamics of coral reef fish communities ($1060)

Petra Ringeltaube / Dr C Johnson
Community dynamics of nongeniculate coralline algae (NCA) on Heron Island, Great Barrier Reef ($360)

Southern Cross University

Peter Davies / Dr B Eyre
Comparison of nutrient behaviour in two pristine tropical estuaries ($1000)



COTS COMMS

Dr Brian Lassig and Udo Engelhardt

How many COTS doth an outbreak make? Like many apparently straight-forward questions to do with the COTS phenomenon, there is no simple answer. Various proposed definitions of so-called normal populations (as opposed to outbreaking populations) range from anywhere between about 6 COTS per km^2 of reef to about 1500 COTS per km^2. The definitions are also generally specific to the survey method used (e.g. timed swim searches, manta tow or measured transects) and are no doubt strongly influenced by the experience of the person doing the classifying.

The bottom line on what constitutes an outbreak is really the density of COTS in an area that can be sustained by the amount of coral present. In normal densities, coral growth and recruitment should balance the amount of coral eaten by the starfish so there is no overall loss in coral cover. More COTS should be sustained in areas with 50% coral cover than in areas where coral cover is say 20%.

Research into the feeding biology of COTS by Dr John Keesing (formerly of the Australian Institute of Marine Science) led to the conclusion that about 1000 COTS per km^2 (about 10 COTS per hectare) was about the upper limit of normal population densities. Dr Peter Moran (AIMS) and Mr Glenn De'ath (AIMS and James Cook University) analysed manta and SCUBA search survey data of outbreaking and non-outbreaking reefs and came to a similar conclusion that an upper limit of around 1500 COTS per km^2 or 15 COTS per hectare is normal.

But to complicate the picture, COTS outbreaks are extremely variable in their nature. At the one extreme (Green Island in the early 1980s is a good example), there may be over a million starfish spread over a large area of the reef. At the other extreme, there may be very localised high densities of starfish that may either 'disappear' or gradually work their way around the reef perimeter and ultimately cause widespread coral mortality.

The Macquarie Dictionary doesn't help. It describes an outbreak as, '1. a breaking out; an outburst. 2. a sudden and active manifestation. 3. a public disturbance; a riot; an insurrection.' None of these seem to be good descriptions of COTS behaviour.

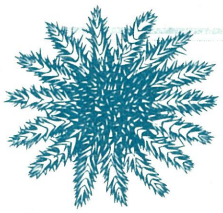
In the past, AIMS has classified reefs as active outbreak, no recent outbreak or recovering. No distinction was made between major, reef-wide events and localised starfish aggregations, although there are clearly distinct qualitative and quantitative differences between the two extremes.

With the introduction of the fine-scale surveys we realised that the existing AIMS classification system (which was based on the manta tow technique) wasn't going to work. Although we haven't finalised the new system, we're looking at adding two additional categories that will better reflect the variability of COTS populations.

Obvious large outbreaks, that have COTS densities above about 35 per hectare averaged over the reef, will remain classified as active outbreaks. Densities below about 10

COTS per hectare will be classified as non-outbreaking. The grey area in between these two densities is a new category (as yet unnamed) that is suggestive of higher than normal starfish densities, but not an outbreak. Reefs in this category will warrant closer monitoring to see how the COTS populations develop.

The final new category will be devised for the localised high-density unsustainable populations. Drawing on an analogy with fires, these will be called spot outbreaks for which we must acknowledge the creativity of Dr Terry Done of AIMS.



REEF PROMOTIONS / CONSERVATION EDUCATION DIVING ARCHEOLOGY MUSEUM - COTS EXPEDITION REPORT

As we all know, when it comes to funding for marine research, it never seems quite enough to do the wonderful and, of course, urgently needed, bit of research that one wants to do. The COTS program is no exception and so it came as a very pleasant surprise when Whitsunday-based adventure travel company Reef Promotions approached us about the possibility of organising a COTS research trip at no cost to our program. Clearly an opportunity not to be missed. Udo Engelhardt reports on the trip.

Well, just a few months later I found myself on board the 'research vessel' MV *Pacific Adventure* steaming out of Port Douglas for a 9-day trip to selected mid-shelf reefs in the Cairns Section of the Marine Park. With me were staff from Reef Promotions and a dozen or so keen volunteer research assistants from the United States. This all-American volunteer crew was made up of members from CEDAM - an association of scientifically minded divers who don't mind spending some of their hard-earned cash travelling around the world supporting reef research projects. Thanks to Reef Promotions' efforts, COTS research featured as an exciting and worthwhile venture on their travel itinerary.

Little did the CEDAM divers know about the hardships that lay ahead of them. Several hours a day diving in the not exactly crystal clear waters of some of the local mid-shelf reefs, sticking their heads into caves and under overhangs in search of the elusive COTS, or carefully cutting off COTS spines for subsequent ageing of starfish - the menu of activities was, literally, exhausting. The work schedule did take its toll on expedition members. After 9 p.m. each night, one would not find too many divers sitting on deck chatting about the day's diving. At that time, most of them preferred to listen to what their pillows had to say.

After having gone through an intensive one-day training program, they were ready to get involved in both the fine-scale surveys using benthic transects and the collection of COTS spines. The team ended up visiting 7 reefs in the Lizard Island to Daintree region. The trip went extremely well thanks to the dedication and commitment of everyone involved. Nearly 200 sets of spine samples were collected and more than 150 benthic transects laid out. Not a bad effort for a holiday on the Reef!

My experience with this expedition highlights the very useful contributions that the tourism

industry and volunteer assistants can make, not only to the overall success of an existing research project, but also in providing additional opportunities. The benefits are there for all parties involved, let's hope that we are going to see more of these activities in the future. Again, many thanks to both Reef Promotions and CEDAM for the fantastic support given to our program.

COTSWATCH Update

And here it is, the latest from our dedicated field team of COTSWATCHERS including **J Purcell** / Great Adventures, **M Schaer** / Cairns, **S Moon** / Ocean Spirit Cruises, **S Richards** /Cairns,**I Stapleton**/ Port Douglas, **V Travers** / Deep Sea Divers Den, **Aquamarine Industries** / Stratford, **W Kibble** / Cairns, **S Singleton** / Earlville, **C Hopkins** / Deep Sea Divers Den, **G Bennett** / Cairns, **D Gribble**/ Cairns, **K Green** / Cairns, **T Waldron** / QDEH Pallarenda, **C Williams** / QDEH Cairns, **R Barnard** / Red Hill, **B Woodlouse** / Red Hill, **C Henzen** / Wyh (NL).

In the period from March to April 1995, a total of 69 individual site reports from 19 different reefs were received. The situation remains pretty much unchanged, with a number of reports providing information on a small number of localised aggregations of COTS on reefs in the Cairns area. Within this region, the pattern of COTS distribution also appears quite stable, with mid-shelf reefs generally recording higher numbers of starfish than outer-shelf reefs. Local control efforts continue at three of the reefs, with encouraging signs being reported by field staff. The numbers of starfish still encountered at these control sites reinforces the need for repeat efforts and ongoing vigilance. However, coral mortality is generally being kept at acceptable levels and there is not any obvious degradation of the sites.

As usual, a big thankyou to all contributors to the COTSWATCH scheme. Keep up the good work. Over the next few months we will, as part of our ongoing extension activities, provide the various Reef-user groups with more detailed feedback on the current status of COTS. So stay tuned for the very latest on the issue.

PROGRAM OVERVIEW

This section concludes the serialisation of the COTS Program review that was started in the September 1994 issue of *Reef Research*. It deals with one of the oldest theories on COTS outbreaks - that humans have over-collected or over-fished COTS predators and upset a natural balance between starfish populations and their coral food resources.

While the view that over-collection or over-fishing of COTS predators has caused or exacerbated outbreaks has been strongly advocated by some scientists, support from research remains scant. Research has approached the testing of this hypothesis from a variety of angles:

- feeding trials and gut content analysis to identify predators of COTS;
- surveys of marine experts for anecdotal information on the identity of COTS predators and the incidence of predation;
- analysis of fish catch records

to assess possible effects of fishing on putative COTS predators;

- comparisons of putative predator densities on reefs that have been affected by outbreaks with densities on reefs that haven't;
- modelling the effects of predation on COTS populations; and
- experimental manipulations to measure predation rates of juveniles in the field.

Identification of COTS predators is fundamental to many of these approaches. Although feeding trials have demonstrated that a variety of fish species will eat large juvenile and adult COTS under artificial conditions, extrapolation of the results to natural conditions is debatable. As anyone who has visited a pontoon site on the Great Barrier Reef will testify, fish will eagerly swallow chicken bones and tabouli salad, but this observation does not make snapper or red bass significant predators of battery hens and parsley.

Preliminary experiments on predation on small juvenile COTS were conducted by Dr Hugh Sweatman of James Cook University. Laboratory-reared, small juvenile COTS presented to fish predators in the field showed that lethrinids (a likely fish predator of COTS that is targeted by commercial and recreational anglers) will eat juvenile starfish, but they are not a preferred food. Dr Sweatman also analysed gut contents of harvested fish species from reefs with high COTS densities. In a sample of 95 red-throat emperor, *Lethrinus miniatus*, he found no evidence that this fish species preys on adult COTS.

Observations of predation on COTS in the field by marine scientists and other experts identified a number of predators, some of which are, or have been, targeted by commercial and recreational anglers and collectors. The giant triton, *Charonia tritonis*, was the most commonly observed predator (accounting for nearly half of all observations), however this high proportion of observed predation events may be attributed to the long duration of such events compared with other predators. Fish predators included maori wrasse, *Cheilinus undulatus*, and several species of lethrinids. The rarity of observed predation events highlighted the impracticality of using direct observation as a means of measuring predation in the field.

Analysis of Queensland Fish Board landings, records from sample charter operations and recreational spearfishing competitions, to address the question of fishing pressure on putative COTS predators, proved fruitless because of inadequate and confused record keeping. Reporting systems changed over the 25-year period, taxonomy and common names of fish were inconsistent and no effort statistics were included to allow any assessment of fishing pressure. The lack of confirmed predator identities further limited the value of this study in understanding the effects of fishing on COTS predators.

Because of a lack of detailed COTS life history information, such as larval survivorship and settlement rates, and a lack of knowledge of critical predation parameters, including feeding rates and feeding behaviour, Dr Hamish McCallum of the University of Queensland concluded that computer modelling cannot establish a minimum predation level that would prevent outbreaks. However, his models predict that any predator capable of increasing starfish mortality by 1% per day would be important and that predator densities of 10 per hectare are sufficient to have a substantial impact on starfish numbers. His models also indicate

that the searching behaviour of predators is critical for the prevention of primary outbreaks, while the maximum rate of prey consumption is more important in preventing secondary outbreaks. The sorts of predators that have significant impacts in these two situations are therefore likely to be different. The observations of Mr Lyle Squire, formerly of the Queensland Department of Primary Industries Northern Fisheries Centre, are interesting in this regard. He noted several occurrences of COTS in the stomachs of maori wrasse, *Cheilinus undulatus*, fished from northern Great Barrier Reef reefs where COTS were rare. The suggestion is that this species, which is targeted by commercial and recreational anglers, was actively searching for COTS when the starfish was rare.

Other models have also been hampered by a lack of critical information on predators and COTS' life history information, but they have provided some useful insights into possible mechanisms of outbreak causality and highlighted critical areas for further research. A model developed by Dr Rupert Ormond of the University of York and others concluded that predator densities of 5-20 per 2000 m^2 of reef front would be sufficient to prevent outbreaks, providing larval recruitment was not exceptionally high. Such predator densities were found on Red Sea reefs and on sampled Great Barrier Reef reefs that had not been affected by outbreaks. Lower predator densities occurred on sampled Great Barrier Reef reefs that had experienced outbreaks.

The estimated predator density predicted by Ormond and others to regulate COTS populations is two to ten times higher than that estimated by other modellers. This difference highlights the need for more information on key parameters to be able to more realistically scope model assumptions.

Juvenile starfish are likely to be more vulnerable to predation because of their small size and because their spines are less well developed than those of adults. Because large numbers of juvenile COTS have not been located in the field in recent years it has been necessary to rear starfish for experimental work. Two projects have used these starfish to look at aspects of predation.

Dr John Keesing (formerly of AIMS) placed small reared juvenile starfish in the field under a variety of experimental conditions. He found that COTS juveniles experienced very high mortality rates due to predation, probably by worms and crustaceans living in the coral rubble habitat where juveniles are found. Predation rates were size-dependent, reducing from around 8% per day for newly settled starfish (less than 1 mm diameter) to around 1% per day for 6-month old starfish (approximately 13 mm diameter). Based on these figures, Dr Keesing concluded that mortality during the first year of life is likely to account for the most important influence on eventual COTS population size.

Predation rates on larger juveniles (1.5-7.9 cm diameter) were lower (0.34% per day) and insignificant in a single trial of caged and uncaged starfish conducted by Dr Sweatman. This rate of predation is lower than the suggested requirement (Dr McCallum's model) if population regulation by predators is to be achieved. However, the average mortality rate from predation in the first year may come close to the critical predation rate.

So, while the predation hypothesis remains a reasonable explanation of how human activities could cause outbreaks, or make them bigger or more frequent, supporting evidence from natural field conditions is hard to come by. Predation on minute recently settled juveniles appears to be significant, but these predators (including worms and small crustaceans) are not fished or collected. The only known predators on adult COTS appear to be quite specialised animals such as the giant triton (collection of which has been banned on the Great Barrier Reef since 1969), and a number of fish species (such as triggerfishes and toadfishes) which, again, are not targeted by commercial or recreational anglers. The one exception, the maori wrasse, could bear some closer investigation. Small juveniles of COTS of about one year of age are likely to be the most susceptible to predation by harvested fish species. At smaller sizes these starfish don't have well developed spines, they are emerging from their rubble habitat to feed on corals, and they are about 'bite-size' for a number of 'fishable' fish species.

Ironically, or perhaps predictably given Murphy's Third Law of Marine Biology, starfish at about this size or age are the most difficult to find in the field. Over the past couple of years scientists at AIMS and the Great Barrier Reef Aquarium have tried, unsuccessfully, to produce juveniles so that the experiments of Dr Sweatman could be repeated on reefs subject to differing fishing pressures. If we could find, or grow, a few hundred starfish of this age we might be in the position to cross off one of the many unanswered questions surrounding the COTS debate.

PUBLISH AND PERISH

In the last edition of *Reef Research* we mentioned that two new manuals (*Planning for Crown-of-thorns Starfish Population Increases* and *Controlling Crown-of-thorns Starfish*) were about to be published. At the time of writing these were with the printers and they should be available by the time you read this article. The planning manual covers:

- communication and information links (between GBRMPA, tourist operators, QDEH and AIMS);
- surveys;
- local controls;
- research directions;
- media;
- GBRMPA policy on controls; and
- contacts for information.

The control manual gives detailed descriptions about:

- when are controls necessary;
- success of controls;
- costs of controls;
- labour and organisation;
- control techniques;
- search procedures;
- survey techniques;
- permits;
- reporting; and
- first aid.

Give us a call or drop us a line if you'd like a copy of either of these publications.

LETTERS TO THE EDITOR

In Steve Raaymakers' Slick Talk column in the December 1994 edition of Reef Research he made reference to the significant quantities of oil spill response equipment purchased by the Queensland Department of Transport (QDoT) to complement National Plan holdings. Steve then commented that QDoT should be applauded for this initiative since most other State Governments in Australia rely on the oil industry and the National Plan to provide oil spill response equipment in their States.

I agree that QDoT's role in providing additional amounts of equipment should be acknowledged and applauded, however, it also needs to be acknowledged that a number of other States and the Northern Territory are in fact providing significant amounts of equipment and services in addition to that provided under National Plan arrangements.

Port authorities in NSW have purchased specialist oil spill response equipment valued at over $1million in recent years. The Maritime Services Board Sydney Ports Authority alone has purchased equipment valued at over $700,000 in the past eighteen months with more on order, including 100 tonne capacity oil recovery barges. Several Victorian port authorities have purchased booms, skimmers and other response equipment, as has the Fremantle Port Authority (FPA) in Western Australia. FPA is currently purchasing additional equipment. The Dampier Port Authority provided funds to build a large storage shed for oil spill response equipment. South Australia provided funds to build storage facilities and to purchase equipment designed to assist in the transport and deployment of specialist oil spill control and recovery devices, including State owned equipment. In the Northern Territory the Nabalco company in Gove provided funds to purchase a significant quantity of equipment, including booms, a heavy duty skimmer and a helicopter borne dispersant spray bucket.

The above shows that, in addition to Queensland, State and Northern Territory governments, port and marine authorities and individual companies are not wholly reliant on the National Plan or the oil industry for oil spill response equipment as appears to be implied in Steve Raaymakers' article.

Ray Lipscombe

Manager Operations
Marine Environment Protection Services
Australian Maritime Safety Authority

RESEARCHER DAYS
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This year the researcher days will be held at the Sheraton Breakwater Casino-Hotel on the 11th and 12th of September 1995

The themes for this year are:

- Status of the Reef
- Water Quality
- Effects of Fishing
- Engineering
- Reef Use

For any further information contact Zoe Deluca on (077) 818723