REEF RESEARCH

NEWSLETTER OF THE RESEARCH AND MONITORING SECTION

Great Barrier Reef Marine Park Authority

VOLUME 5 - No. 1 MARCH 1995

EDITORIAL

It is pleasing to see that cooperation rates highly in this issue of *Reef Research*. Not only do we have the usual list of helpers for COTSWATCH, we also have information on a project on bioremediation funded by the Energy Research and Development Council, the Australian Institute of Petroleum, the Australian Maritime Safety Authority and the Commonwealth Environment Protection Agency. The Marine Park Authority will provide substantial in-kind support for this task. There is also a report from our External Services Section that describes some of the work that is carried out with our international counterparts, 'What's out there' reports on the developer-funded monitoring at Hardy Reef and the collaborative work at Bramble Reef is described.

Bramble Reef was closed at the request of the local community and has been so since the beginning of 1992. It is an encouraging sign of our more enlightened times that users are now increasingly involved in the management of our common resources. Considerable interaction between interested parties has taken place over the intervening three years and the Authority has funded surveys to assess the stocks of fish on Bramble Reef, as well as several other reefs that have acted as controls.

The closure has been compromised to some extent by the vagaries of nature, in that a large coral trout recruitment episode took place on all monitored reefs in 1992. This, and the ability of coral trout to quickly re-stock reefs when conditions are right, has masked most of the effects of the closure since stocks increased on all the reefs. Despite this, there has been a very noticeable improvement in the stocks of legal size coral trout that will be available to fishers when Bramble Reef re-opens to fishing on 1 July of this year. Continuing support from the users of this particular reef after it re-opens will greatly assist in the assessment of management techniques that can be employed in the future and in other areas. The take-home message is, of course, that cooperative management is sensible, common-sense management.

Ed.

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

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STAFFING NEWS

Since the beginning of time, or in this case, since the beginning of *Reef Research*, we have seen many faces come and go in the Research and Monitoring Section.

Simon Woodley, Rob McGill, Christine Dalliston and Jamie Storrie have left the Research and Monitoring Section to pursue their interests in other areas of the Authority.

Bruce Mapstone is currently working with the CRC Reef Research Centre, Hamish Malcolm has left the Authority to join forces with Land Use and Fisheries (DPI), and Jamie Oliver is spending some time out at the Australian Institute of Marine Science. Elaine Eager has moved to Brisbane to work with QDEH, Trish Drury has left sunny Townsville for Perth and Beryl Dennis has retired from the working life. William Gladstone has gone and come back (and will no doubt be off again soon).

New faces include Jim Campbell, who is working on the State Of the Marine Environment Report, Zoë deLuca, our new assistant project officer and Michael Baer, who is working with the water quality team. Rachelle Ninio has joined Ray Berkelmans in the monitoring team, Gayle Jennings is working with Dominique Benzaken on social and economic research, Nicky Turia is editing and preparing reports for publication and Kim Davis is the new administration assistant for the section and the assistant editor for *Reef Research*.

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

The first set of results from a number of research tasks are in the process of peer review, and staff of the Centre have spent much time in establishing the most effective ways of communicating those findings. It is essential to the success of the CRC that research produces useful results which are relevant to Reef industries, and to this end the User Advisory Group, which has a major input into the topics to be researched, will also be closely involved in the dissemination of information. The User Advisory Group's members are made up of personnel from AMPTO, DPI, GBRMPA and QDEH.

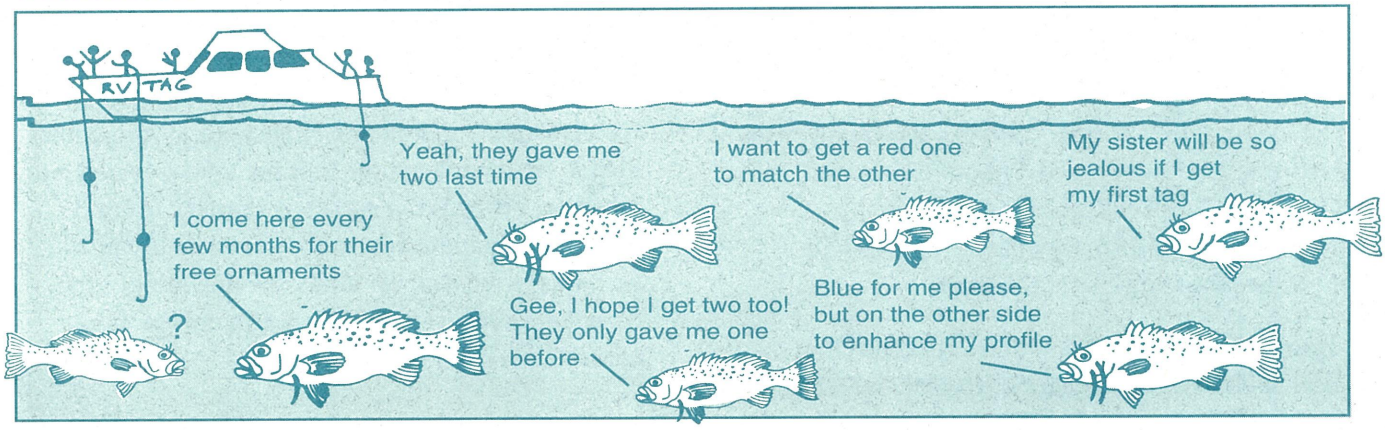
As tasks are completed, a Technical Report will be published and the advisers will assist in identifying target groups who will put the findings to use. They will also consider the best modes of information transfer, whether this be by brochure, video, full reports or wider general dissemination. Projects that are presently undergoing peer review, and which will provide reports shortly are:

- Coral Transplants: Pilot Project (reported elsewhere in this issue)
- Experimental Design: Effects of Line and Spear Fishing
- The Population Structure of Coral Trout on Reefs Open and Closed to Fishing
- Principles of Social Impact Assessment
- Age Determination in Fish: Otoliths
- Abnormal Coral Growth Formations

In addition, the Centre has received from its Chief Investigators their half yearly annual reports on more than fifty tasks and will consider the 'slow release' of results obtained while research is in progress, so that end users are kept informed about the trends being discovered.

Last November I attended the Second International Conference on Oceanography held in Lisbon (the

Coralations **Tagging Biases** **Pongase**



first was held in 1960 and resulted in the formation of the Intergovernmental Oceanographic Commission in UNESCO). It emerged that Australian coastal science and management are well integrated and managed in comparison with the rest of the world, especially with regard to the tropics. Within the limited resource base allocated to Australian oceanography, the small cadre of scientists and government managers is well regarded internationally. Discussion was initiated with the US State Department about possible linkages between the Centre and the US Coral Reef Initiative.

Still in Portugal, I attended a conference on 'Sustainable Tourism for the 21st Century', at which it emerged that Australian models addressing quality tourism such as the 25 Year Strategic Plan for the Great Barrier Reef World Heritage Area, are being copied internationally. Issues which the Great Barrier Reef tourism industry and managers need to keep under close review are essentially the social questions: mainland accommodation developments and the implication for local populations, regional dependence on mass tourism, and a single region of origin for inbound tourists. The Centre in now involved in the planning for a further international meeting dealing with environmental impact assessment and monitoring targeted at the Asian region.

Heritage and Interpretive Training Course

The Extension program has given a boost to private eco-tourism operators throughout Queensland by designing a Heritage and Interpretative Training Course which will produce accredited graduates to take up positions in the industry. The course is being offered by regional colleges of Technical and Further Education (TAFE) to train young people for jobs associated with national parks, World Heritage areas and Aboriginal communities. It is also intended to raise the professionalism of staff already employed as environmental tour guides.

The five-month, full-time course is also available in part-time modules offered by both Cairns and Townsville TAFE colleges. Airlie Beach, Rockhampton and Hervey Bay campuses will introduce the course later this year.

'Trainee guides' choose modules concentrating on local habitats and ecosystems, coastal and marine studies, plants, animals, reef interpretation and an independent study project, and then apply what they learn each week in real work situations.

The course has the full support of GBRMPA, the Wet Tropics Management Agency and QDEH, and is an important component of the CRC's brief to initiate training and extension activities about the Reef.

Research Activities

a) Postgraduate Research Scholarships were advertised nationally in September and offers have been made to applicants to carry out research for either a Ph.D or Masters degree in the following marine biology or engineering areas:

- reef nutrients,
- coral reef ecology,
- responses of corals to anchor damage,
- the influence of groundwater and surfacewater discharges on the water quality of the Great Barrier Reef lagoon,
- innovative design relevant to reef infrastructure, and
- the effects of elevated nutrients and sediments on the structures of corals.

b) AIMS researchers, with financial contributions from the CRC, have developed a new transmissometer (an instrument to measure suspended sediment) which is self cleaning and can be left in place for up to three months. Four have been placed in the Tully, Herbert, Burdekin and Fitzroy Rivers which will measure turbidity during flood events.

c) The Department of Tourism at James Cook University has spent considerable time observing divers at the Yongala wreck. Other CRC researchers, with the full cooperation of Quicksilver Diving Services and Quicksilver Connections at Agincourt Reef, have completed the first phase of research into whether certified divers do any damage to coral. First findings indicate that 84% of those divers did no damage whatsoever and, overwhelmingly, the damage was caused to branching corals by fin contact (see *Reef Research* 4(4)).

A Global Issue

Michelle Morrison, Program Officer, External Services Section

The Great Barrier Reef Marine Park Authority has been working on managing the balance between conflicting uses of the Great Barrier Reef Marine Park since 1975.

In pursuit of this challenge - ecological sustainable development - the Authority has adopted a philosophy which incorporates strong environmental considerations with sensible controlled development.

The Great Barrier Reef Marine Park Authority has developed a system of multiple-use zoning principles that attempts to strike a balance between users. These principles have been refined into a management technique which can be applied broadly anywhere, and which are flexible enough to allow for specific local variations. This approach has appealed to many other national and international environmental agencies, and demand for Authority expertise is increasing.

The Authority's management approaches have been applied elsewhere and include the zoning scheme introduced in the United Kingdom's Lundy Marine Nature Reserve, where English Nature have adopted principles of multiple-use planning. Development of the plan included a public participation phase and education program to complement the marine reserve zoning scheme.

We have also been working with the Ras Mohammed National Park Sector agency in Egypt, which has sent staff at the Park Manager to Ranger level on work placement training programs with the Authority. These programs last 10 to 12 weeks.

These programs involve an initial orientation with Authority operations and day-to-day management agencies. This includes field visits and short two-week placements with regional offices of the Queensland Department of Environment and Heritage to examine park management in action. All programs offered are undertaken on a cost recovery basis and are individually designed to meet specific training needs.

Usually the trainees are assigned a placement supervisor with whom they work on projects Authority staff are dealing with at the time. For example, area management planning, tourism infrastructure impact assessments, monitoring of impacts, community education programs and surveillance and enforcement are some of the projects in which the trainees have been involved.

This type of training offers the opportunity to become involved in the real and complex demands of operational programs at the Great Barrier Reef Marine Park Authority and to learn to seek out practical and culturally appropriate solutions.

Authority staff have worked on numerous international projects over recent years, particularly in the Asia/Pacific region. If we can assist in environmental challenges, the External Services Section facilitates Authority involvement on a cost recovery basis.

Is the Hardy Reef, Hardy?

Rachelle Ninio

Some time today, thousands of tourists will converge onto snorkelling areas across the Great Barrier Reef. Many of these 'punters' have never snorkelled before and some are not even confident swimmers. Nevertheless, the Great Barrier Reef proves irresistible and many take the plunge.

Overwhelmed by a new environment, they soon forget the warnings of enthusiastic crew. Some snorkellers cling onto coral outcrops, as if hanging on for their lives. Others injure coral with their fins, and those who feel particularly insecure may resort to reef walking.

The more adventurous are armed with scuba gear and in great anticipation they sink to the bottom, scarcely noticing the corals below. Gaining buoyancy control is hard for a first timer, and many rise and sink like yo-yos. During this 'yo-yo' stage weights have been known to accidentally fall into giant clams.

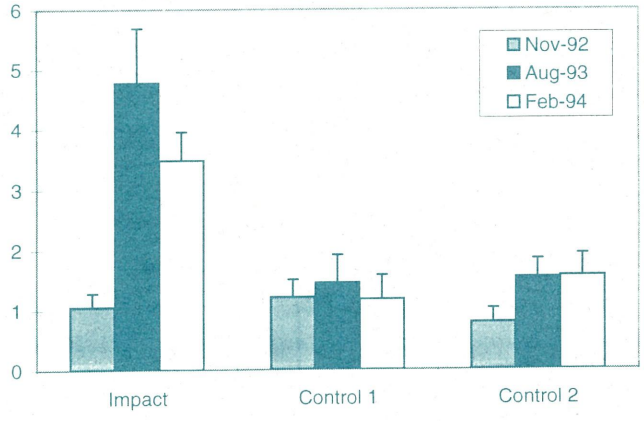


Figure 1a. Damge levels on the reef-slope at the Hardy Reef new pontoon site (data from Ayling 1994)

At the Hardy Reef snorkelling area, the area available to snorkellers is limited because the reef-flat in front of the pontoon dries on low tides and the reef-slope is very steep underneath the pontoon. As a result, the impact of snorkelling is concentrated in a small area. In the snorkelling area, the reef is shallow, increasing the likelihood of damaging delicate branching corals below. Currents are sometimes strong and can overpower the inexperienced snorkeller who may panic and struggle to regain control. Any observer who

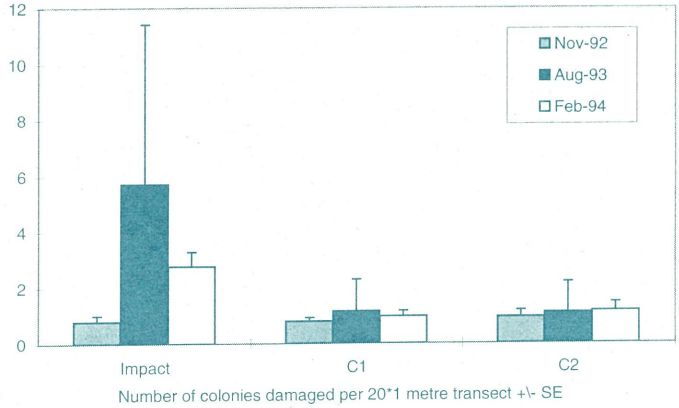


Figure 1b. Damage levels on the reef-flat at the Hardy Reef new pontoon site (data from Ayling 1994)

believes that the reef is a fragile ecosystem, might suspect that these tourists could have a detrimental effect on the reef.

The Hardy Reef pontoon provides us with a particularly interesting case study. The original Hardy Reef pontoon (owned by Hamilton Island Enterprises) was one of the earliest pontoons installed on the Great Barrier Reef, having been on site since 1984. In 1992, a new pontoon was installed, approximately 200 metres south of the old site. Dr Tony Ayling of Sea Research, monitored the effects of the new pontoon and the recovery of the old pontoon site.

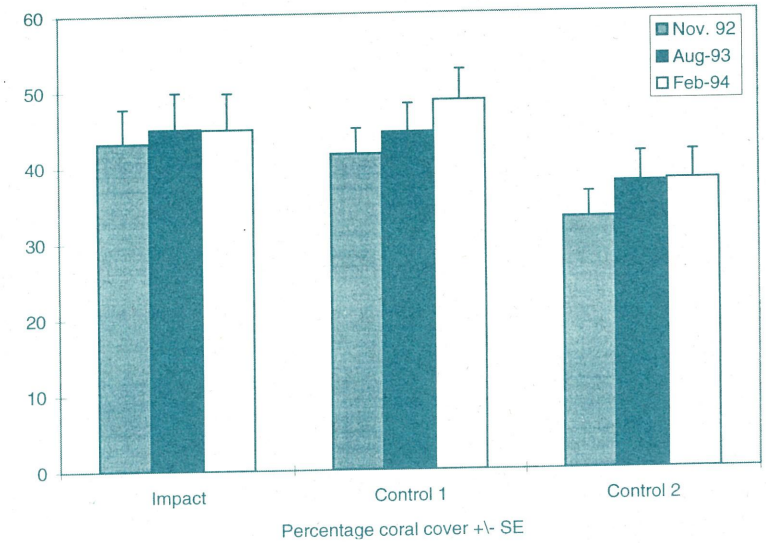


Figure 2a. Percentage coral cover at Hardy Reef new pontoon reef-flat sites (data from Ayling 1994)

Monitoring results

While the amount of coral damage recorded by the monitoring program at the new pontoon site was high soon after installation (see figures 1a and 1b), 12 months after the installation, damage levels had

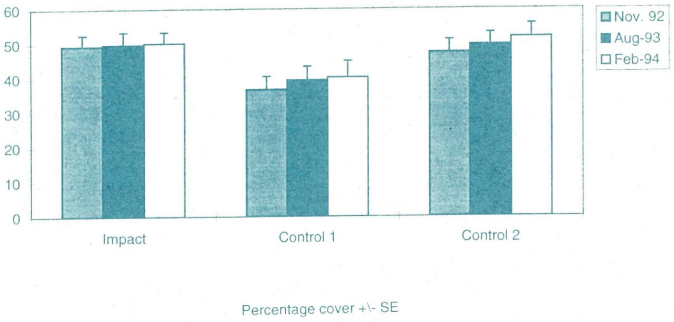


Figure 2b. Percentagecoral cover at Hardy Reef new pontoon reef-slope sites (data from Ayling 1994)

declined at the site. This indicates that the recorded levels of damage were not necessarily all due to fin damage but may be partially due to coral breakage during installation. Most of the injured corals were fragile branching corals. High levels of coral breakage did not appear to affect the corals longevity, as no damaged colony ever died. Despite the high rates of coral injury, total coral cover was not measurably affected (see figure 2a and 2b).

At the original pontoon site, levels of coral damage were also high compared to control sites (see figure 3). However, after eight years of operation, increased damage levels at the old pontoon site did not appear to have affected coral cover (see figure 4). Total coral cover was actually higher at the original pontoon site than on the surrounding reef (see figure 4). Twelve months after the relocation of the pontoon, injury levels at the original site had declined and were equivalent to those at control sites (see figure 3). In fact, it was hard to tell that there had ever been a pontoon there at all. Many believe that these findings can only point to the overall sustainability of the commercial tourist operation.

But what about the fish?

Intensive fish feeding at the old pontoon site had resulted in many large fish living underneath the pontoon. At the time of the baseline study, the fish aggregation included several hundred trevallys and over 800 fusiliers. These fish all took part in daily fish feeding episodes, competing for food or scraps. In addition there were about 50 large grazing fishes associated with the pontoon, which were either attracted to the pontoon itself or grazed on the pontoon and its mooring chains.

When the pontoon was relocated the entire aggregation of fish simply shifted with the pontoon. Fish feeding was not continued at the new pontoon and the feeding aggregation at the pontoon declined rapidly. At the time of the final survey, about a year after the pontoon's relocation, there were about 12 large predatory fishes and 400 fusiliers found underneath the pontoon. Grazing fish increased in number to about 80 fish, possibly because of the larger size of the new pontoon. The study provided no evidence that the aggregation of large predatory fish affected small, coral-associated fish densities in the area next to the pontoon, however, the secondary effects on other animal groups such as invertebrates were not measured.

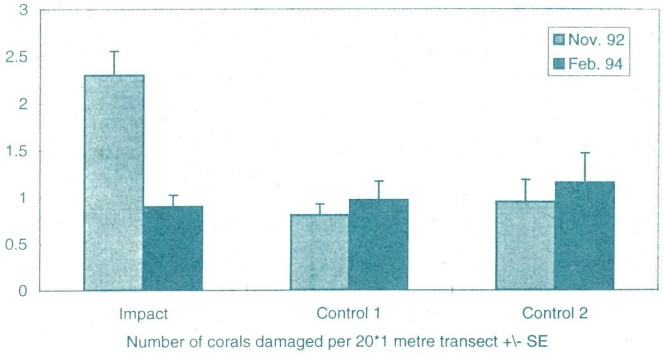


Figure 3. Coral damage at the old pontoon site (data form Ayling 1994)

The moral of this scenario

At face value, these results indicate that this pontoon operation is sustainable over the long term and that monitoring could be scaled down. However, the Hardy Reef monitoring program, like most other pontoon monitoring programs, has focused on gross changes in only a few environmental variables, such as coral cover and coral damage rates and these variables have almost always been analysed one factor at a time. These univariate analyses are unlikely to detect gradual changes at a community level. Other techniques allow the combined trends in many animal and plant populations to be taken into consideration at the same time and are much more sensitive to community level changes than conventional statistical techniques. Although the Hardy Reef monitoring program was not designed with such multivariate statistics in mind, a re-analysis of the data may show more subtle changes happening in the community.

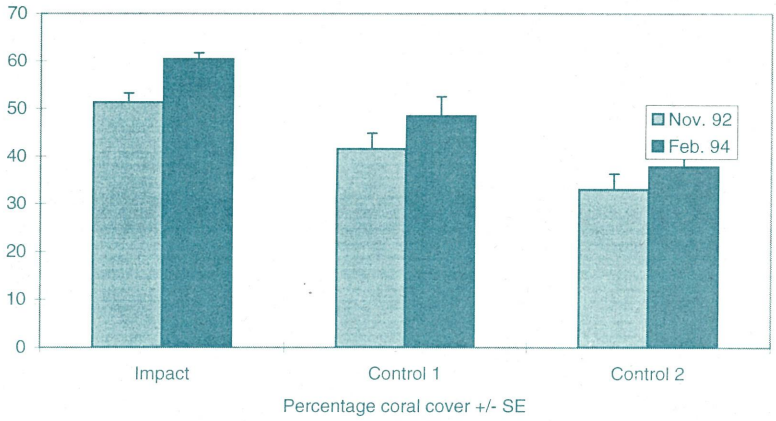


Figure 4. Changes in coral cover at the old Hardy Reef site (data form Ayling 1994)

So, while we can be reasonably sure that our intrepid snorkellers are not ruining Hardy Reef, there remains some doubt about community-wide and longer-term changes. For this reason, monitoring programs which indicate that Hardy Reef is robust should not be used as a panacea for proper education and adequate supervision of visitors to the reef.

Where do we go from here?

A study is currently being designed under the auspices of the CRC Reef Research Centre to look at the recovery of a number of vacated pontoon sites, including the old site at Hardy Reef. This information will help us to decide whether pontoons should remain where they were installed or be allowed to be repositioned from time to time. At present, the Authority believes that fixed pontoons are desirable because they encourage operators to be responsible for the reef around their pontoon. However, if damage to an area is quickly restored there may be an argument for occasionally relocating pontoons. Such studies are particularly relevant as more tourist operators are requesting to shift their pontoons to new locations on the Great Barrier Reef.

We now have the results from about 20 monitoring programs, looking at the environmental impact of about 12 different pontoons. Dr Bruce Mapstone of the CRC Reef Research Centre is currently reviewing and synthesising data from environmental impact monitoring of pontoons moored on the Great Barrier Reef (up to June 1994). Using this data, he may be able to identify consistent ecological impacts of pontoons and recommend strategies for future pontoon monitoring programs.

The more information we obtain, the closer we come to predicting the extent of environmental impacts before they occur. In the future we may be able to incorporate knowledge of coral communities at a site and that site's topography into these predictions. Visiting a site before development occurs, for the purpose of predicting the extent of an impact, and then revisiting the site after development in order to test our predictions will enable us to increase the accuracy of our predictions. Using this information we will be in a far better position to minimise and manage impacts on the Great Barrier Reef.

Reference

Ayling, A.M. & A.L. 1994, Hardy Reef - Monitoring of the impact of the new Fantasea Cruises pontoon, Unpublished final report for the Great Barrier Reef Marine Park Authority.

REEF REJUVENATION

Siriol Gifney

As significant milestones are reached within individual CRC funded tasks, a summary of results to date will be published in *Reef Research*. The first task completed is a pilot project: Experimental Test of the Effects of Methods of Attachment and Handling on the Rapid Transplantation of Corals. The researcher is Dr Ursula Kaly of the Department of Marine Biology, James Cook University of North Queensland, with assistance from Geoffrey Jones and Rohan Pratt.

Coral transportation in the sea, much like revegetation programs on land, has the potential to benefit significant Reef sites that have been damaged by weather, crown-of-thorns starfish, boat anchors or heavy recreational use.

Research into the restoration of coral reef habitats is in its early stages. Previous attempts to rehabilitate reefs have often used a 'stab-in-the-dark' approach and met with variable and unexplained success. There is a need to develop methods of restoring coral reef habitats in areas affected by development if coastal diversity, productivity and aesthetic values are to be maintained. The research also provides additional management options in dealing with naturally destructive events, such as a cyclone passing over a pontoon site.

The aim of this pilot study was to examine some of the methods which might be used in small to moderate scale rehabilitation projects on the Great Barrier Reef. Methods of transportation which were previously found to be costly in time and money, or caused damage to the source communities, were discarded. Only techniques with the potential for rapid, relatively inexpensive reintroductions of corals into a damaged area were tested.

The main emphasis of this work was to methodically derive the best techniques for relocation of habitat-forming species with an emphasis on cost-effectiveness and the ability to place very large numbers of fragments. The pilot project was carried out so that future research on the effects and success of rehabilitation could be undertaken without problems of poor replacement technique. Most attempts at restoration to date have tended to ignore this step - a factor which could explain some of the mixed and unaccountable rates of success.

Specifically the study was designed to determine whether:

- corals of a variety of types, including soft corals, branching, corymbose, encrusting, and massive forms can be successfully reintroduced into a damaged area,
- any particular technique is more successful than others,
- the suitability of the technique varies with species, and
- the survivorship and growth rate of manipulated corals is similar to that observed in naturally occurring colonies in the same area.

The study was carried out at Lizard Island between March and July 1994. Two bommies near the mouth of Lizard Island lagoon were used as both sources and sites for attachment. Coral fragments were transplanted only within the area that they were found as any effects of translocation were not included in the scope of the pilot study.

Forty fragments around 5-10 cm in maximum dimension were collected for each of five coral species at each bommie. An additional 10 fragments of each species were marked in situ at each bommie to serve as controls. These were branches of similar size as the fragments used in the experiment, and were marked with plastic-coated wire at the position at which they would have been cut had they been detached from the colony. Only colonies from which no fragments had been taken were used to provide controls.

This was a multifactorial experiment, designed to examine the effects of handling corals exposed to air versus unexposed corals, and two different methods of attachment. Some corals were taken to the surface and stored under wet tarpaulins for two hours to simulate conditions in which they might in reality be transported, while others were

never exposed to air. Some corals were attached using cable-ties to masonry nails hammered into the substratum, and others were attached to freshly drilled and chiselled holes in the substratum using 'Expandacrete', an underwater epoxy cement.

Five species of coral were all subjected to each treatment combination. They were the hard corals, *Stylophora pistillata, Acropora gemmifera, Favia stelligera, Echinopora lamellosa* and the gorgonian coral, *Rumphella* sp., chosen because they represent the wide diversity of coral types expected to be included in any rehabilitation.

At the end of the study the number of tagged fragments and controls that were recovered, across all treatments and coral species, varied between 91% and 98%. Of these between 71% and 90% were alive, with only 2-4% found dead in most species. Almost all the corals responded best to being firmly attached to the substratum with epoxy cement - with the exception of *Favia stelligera* which showed no differences among any of the methods of attachment or handling, and did not show any evidence of growth in the time of the study.

The corals responded better to cement for two reasons; firstly, the nails and cable ties allowed the base of the corals to shift constantly with water movement, probably making it difficult for fragments to grow down onto the substratum and secondly because coral fragments could move around they appeared to become abraded on the rock and sometimes came into contact with other corals. In one instance a neighbouring *Platygyra* sp. digested a fragment of *F. stelligera* which had twisted on its nail and come into contact with it.

Abrasion was a particular problem in *Rumphella* sp. Many of the fragments attached to nails and even some of the controls which had plastic coated wire wrapped around them suffered damage at the point of contact, often exposing the coral's skeleton.

The best and worst method of transplanting fragments was then calculated for all coral species. For *Stylophora pistillata* the best was cement and the worst nails and cables. For *Acropora gemmifera* the best appeared to be cement but the response to the method of attachment may be site specific. For *Favia stelligera* there was no differences between methods used. For *Echinopora lamellosa* cement appears to be the best method, but with regard to exposure to air, this species, along with *Stylophora pistillata* showed a measurable negative response. It became clear that if these two species of corals require transport to a rehabilitation site, they need to be kept submerged.

In contrast, *Acropora gemmifera* and *Favia stelligera* were unaffected by the exposure treatment and it should be possible to move them from site to site in a boat covered by a wet tarpaulin, provided the operation takes less than two hours.

The results of this experiment suggest that for some species any exposure to air will significantly affect their ability to survive and grow. *Echinopora lamellosa* was borderline in its response to exposure, and so should probably be kept submerged.

If the decision to go ahead with the rehabilitation of a reef is taken, it is likely to be costly. Preliminary calculations on a full per hectare basis, put the cost of restoring either of the bommies with a target density of 245 000 fragments per hectare in the order of $580 000 plus ship time. This assumes shallow water diving, and includes all consumables required for each method and a four-person dive team collectively able to place 500 corals per day. Costs of access to the site, regional travel and living costs are so variable that they were excluded from calculations.

Complete replacement of full density does not seem viable for such high density communities. But in the case of the Lizard Island bommies, replacement of 10% of the target density over the same area might cost around $58 000 plus ship time, a figure which would be more justifiable in a medium-scale restoration of a site.

The CRC Reef Research Centre is continuing to support and fund this research. The corals on Lizard Island were examined again in December 1994, and further experiments are needed to determine which species are amenable to transplantation and what proportion of target densities are required to achieve enhanced recovery of a damaged area.

Technical Reports will be published on the completion of each task, and will be available from the Centre's Secretariat.

More spills and shipping incidents in the Great Barrier Reef region, encouraging developments in oil spill research funding and an audit of Australia's national oil spill plan feature in this appearance of Slick Talk, which has now been a part of *Reef Research* for 3 years.

Tanker grounds in Reef region

The risks presented to the Great Barrier Reef from shipping accidents were highlighted in January 1995 when the *Shell Conus*, a 24 000 tonne petroleum tanker, which supplies Queensland coastal cities, ran aground while departing the Port of Townsville.

At around 5 p.m. on Thursday 12 January 1995 the 171-metre tanker veered out of the port entrance channel in rough seas and strong winds, colliding with a channel marker and running aground on soft mud and sand on the northern side of the channel. The port entrance channel at Townsville runs adjacent to Magnetic Island, which is within the Great Barrier Reef Marine Park and supports intertidal fringing reefs, seagrass beds, mangrove areas and significant recreational beaches. An oil spill under the wrong conditions in this area has the potential to cause considerable environmental and economic impacts.

Fortunately, the tanker had discharged 30 000 tonnes of petroleum products in Townsville, and was carrying only a small amount of cargo. This, combined with the soft nature of the seabed in the area, meant that there was little chance of damage to the vessel or oil being spilt. However, the incident did demonstrate the fact that shipping accidents involving oil tankers in the Great Barrier Reef region can, and do, happen.

Although the cause of the accident is subject to an inquiry, it appears to have been related to the fact that there is a 90 degree angle for ships to navigate when leaving the harbour at Townsville. Larger ships such as the *Conus* are unable to gain sufficient speed for precise steerage, and can be blown out of the channel in high winds when in a light condition and high in the water. An ex-Harbour Master from Townsville claims that similar incidents have occurred at Townsville in the past.

A rapid response was mounted to the incident with two tugs and a pilot launch being dispatched to assist. Fortunately, there was a rising tide and after 50 minutes the tanker was refloated and towed back into the channel.

The fact that such an incident can occur to a professionally operated Australian ship, close to port and with an experienced pilot on board, highlights the even greater risk presented by 'flag of convenience' ships which may be operated by sub-standard crews in open reef waters and non-pilotage areas, and reinforces the need for constant review of shipping management practices in the Great Barrier Reef region.

Illegal 'operational' discharges continue

The regular occurrence of illegal, so-called 'operational' discharges of oil from ships in the Great Barrier Reef region has been the subject of articles in Slick Talk in the past, and despite numerous, ongoing calls from a number of areas for a more concerted effort on behalf of regulators and the shipping industry to address this problem, they keep on occurring.

This was highlighted between 3 and 6 January 1995 when five kilometres of pristine mainland beach near Dunk Island in north Queensland was impacted by tarry oil residue which almost certainly came from a passing ship using the Inner Route of the Great Barrier Reef. The oiled areas were Mission Beach and Wongaling Beach, both important tourist areas in their own right. Mission Beach is of particular importance as a resort area and a transfer point to the resorts on the offshore islands, including world famous Dunk and Bedarra Islands.

While the oiling has had minimal ecological impact, it certainly interfered with the amenity of the beaches, causing them to be closed for three days while crews from the Cardwell and Johnstone Shire Councils and the Queensland Department of Environment and Heritage (QDEH) effected a clean-up.

Both beaches have Wet Tropics World Heritage rainforest as an immediate backdrop and the Great Barrier Reef World Heritage Area lapping at their low-tide marks. The fact that they are no less susceptible to oil pollution than any average Australian beach can not help but raise doubts about the practical effectiveness of the 'paper protection' afforded by World Heritage listing.

Australian authorities have a dismal record of successfully apprehending and prosecuting the perpetrators of such pollution, although it is acknowledged that prosecution is particularly difficult. A contributing factor is possibly the fact that the main regulatory agency for ship sourced oil pollution, the Australian Maritime Safety Authority (AMSA), conducts its operations from faraway Canberra. Neither Marine Parks Rangers from QDEH or Boating and Fisheries Officers from the Queensland Department of Primary Industries (QDPI), who both regularly patrol the Reef in fast patrol vessels, have bases along the Reef region coastline and who are professionally trained in maritime law enforcement, have appropriate delegations under either State or Commonwealth marine pollution legislation. Such powers are restricted largely to Harbour Masters and AMSA surveyors, both of whom are generally port-bound.

Pollution enforcement and prosecution capabilities in the Reef region could be vastly improved through appropriate delegation of both State and Commonwealth legislative powers to all relevant agencies with a field presence in the area, including QDEH, QDPI and the Queensland Water Police, and through the formation of a multi-agency 'flying squad' of appropriately trained and equipped officers who are based in Queensland and who have a greater appreciation of the Reef and local conditions.

Bucks for bugs

For the last five years the Great Barrier Reef Marine Park Authority (GBRMPA) has been trying to secure funds to conduct research into the use of oil degrading microbes as an oil spill clean-up tool in tropical Australia. Referred to as bioremediation, the technique has become standard practice in the clean-up of land sites contaminated with various organic pollutants, and was used successfully on an experimental basis to treat oiled shorelines in the *Exxon Valdez* spill. However, very little is known about the effectiveness and side-effects of the technique in tropical marine and coastal environments. Given that bioremediation is likely to be more effective in tropical areas, due to high ambient temperatures, GBRMPA has recognised that the technique could be extremely useful should a significant oil spill occur in the Great Barrier Reef region.

Because of the extreme logistical obstacles presented by the remoteness of much of the Reef region and the fact that the sensitive and complex nature of tropical marine environments such as mangroves, seagrasses and coral reefs limit the scope for the use of chemical dispersants and mechanical methods, the development of alternative and more efficient response technologies such as bioremediation must be a high priority. With the help of the Queensland National Plan Oil Pollution Committee, GBRMPA has at last been successful in securing total funding of $247 000 for a bioremediation research program. The Energy Research and Development Council, a Commonwealth fund established to promote energy industry related research and development, has made $123 000 available; the oil industry through the Australian Institute of Petroleum, $47 000; AMSA using funds from the National Plan, $47 000 and the Commonwealth Environment Protection Agency, $15 000. In addition, GBRMPA is contributing $30 000 worth of support-in-kind and will be acting as the research coordinator. The project will fall under the overall auspices of the National Plan Advisory Committee, with AMSA, as the National Plan managing agency, administering the funds. The research task will be put out for tender, with proposals being accepted from both the industrial and academic research communities.

The research will concentrate on direct fertilisation techniques, where fertilisers are used to stimulate naturally occurring bacteria, as opposed to culturing and/or inoculation techniques which have not proved particularly successful overseas. Both laboratory and field trials, including a range of habitats, oil types and controls, will be utilised. The objectives of the research program are as follows:

- Determine the effectiveness of bioremediation across a range of tropical coastal habitats on a range of common oil types transported in tropical Australia.
- Determine the potential negative impacts that may result from the use of bioremediation within each of the tropical coastal habitats studied.
- Investigate the methods and techniques currently available for the bioremediation of waste oil and opportunities for their use in tropical Australia.
- Appraise the usefulness of bioremediation techniques in cleaning up oil spills in comparison with conventional methods.

At the time of writing (February 1995) the project was scheduled to commence in early 1995 and run for three years.

Australia does not have a particularly rich history of Research and Development of oil spill response and clean-up techniques, especially in relation to new and alternative approaches. This project therefore represents a major step forward for oil spill Research and Development in this country and will hopefully mark the beginning of a new commitment from industry and government to continue to seek further improvements in our capability to deal effectively with this significant environmental threat. The contributions from the participating organisations are to be commended and the results of the program will be of extreme interest not only to oil spill responders throughout tropical Australia but also in South-East Asia and other tropical areas, where very little is currently known about the use of bioremediation to treat oil spills.

National Plan subject of audit

In November 1994 the Australian National Audit Office (ANAO) released its report on an audit of Australia's National Plan to Combat Pollution of the Sea by Oil (the National Plan), entitled *Is Australia ready to respond to a major oil spill?*

The audit came close on the heels of the comprehensive Review of the National Plan conducted between November 1991 and June 1993, and picked up a number of issues that were not addressed by that review.

The ANAO audit generally found that since management of the National Plan was assumed by

the Australian Maritime Safety Authority (AMSA) in 1991, there has been a significant improvement in communication and technical support for state and industry bodies. The audit also found that even with the best plans and levels of response capability, prevention of environmental and economic damage can not be guaranteed in the event of a major spill and the best that can be hoped for is to recover around 10% of the spilled oil. This is a reflection of the nature of oil on water and the practical limitations of oil spill response operations, and not any deficiencies in response capabilities. However, the audit also found that there are a number of areas where further improvements could be made with the National Plan. The main finding of the audit report is that there is no clear definition of AMSA's role as the National Plan managing agency, with AMSA focusing too much on maritime operational matters, which should be left to the states and industry, and that AMSA should assume a more strategic leadership role, including the establishment of truly national standards, guidelines and policies.

This finding of the audit report tends to confirm my own experiences with AMSA and the opinions of others with whom I have dealt in the oil spill response community. In my view AMSA should address the following issues.

- The lack of any clear, formalised national standard on the use of contentious and poorly understood oil spill response techniques such as bioremediation, in situ burning and use of chemical dispersants. Decisions on these techniques are presently largely left to the states on an ad hoc, spill by spill basis (although some states and other agencies such as GBRMPA have developed their own policies and standards on some of these issues).

- The lack of national standards for the testing, approval and registration of off-the-shelf bioremediation products that come onto the market from time to time, with many potentially environmentally dangerous products being freely available with little information on their effectiveness and side-effects.

- The lack of a rigorous and scientifically meaningful national testing and approval procedure for new chemical dispersants that come onto the market from time to time, with the current simplistic, effectiveness test forcing scientific support personnel to provide advice on dispersant use without adequate information on toxicity and environmental effects.

- The lack of clear and regionally relevant standards and guidelines for the conduct of post-spill damage assessment and monitoring, with some parts of industry being more advanced than government in this area. There are no formal, pre-agreed mechanisms in place to ensure joint industry/government monitoring effort and this raises the spectre of *Exxon Valdez* style contradictions in findings and conflicts over compensation claims.

- The lack of a national oil spill response research and development program with clearly established priorities, overall direction and formalised funding structure.

Many of these issues have been identified through various forums for several years now, and it can only be hoped that the release of the ANAO audit report will add to the impetus to address these types of issues before the big spill occurs.

Reference

Smith, D and Luck, I. 1994, **Is Australia ready to respond to a major oil spill? Australian Maritime Safety Authority,** Audit Report (Australian National Audit Office) No. 9, 194-95, 64p.

(Steve Raaymakers is currently Manager, Environment and Communication with the Ports Corporation of Queensland. The views expressed through his continued authorship of 'Slick Talk' are not necessarily those of the Ports Corporation or GBRMPA).

A study of fish stock replenishment

Michelle Gist and John Robertson

BRAMBLE REEF

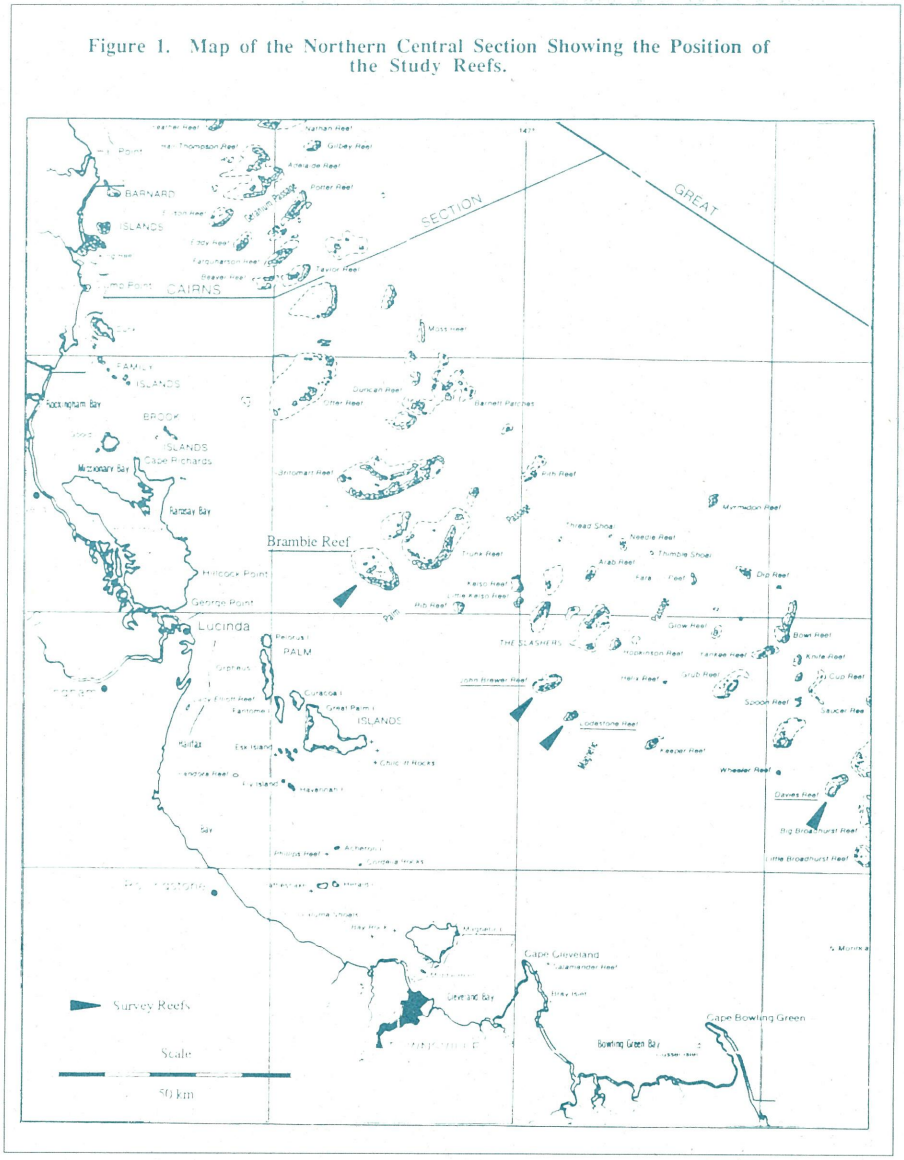
Bramble Reef is an inshore reef off the coast of Ingham (figure 1) in the northern Central Section of the Great Barrier Reef Marine Park (18°25'S, 146°43'E). The events that have occurred on Bramble Reef in the last few years have attracted a lot of attention from management agencies, the fishing industry and local community groups.

At the request of the local community, the Great Barrier Reef Marine Park Authority declared Bramble Reef as a replenishment area on 1 January 1992. The community was concerned that the reef was being over-fished. The closure applied to both commercial and recreational bottom line fishing. To monitor the effectiveness of the closure, the most important of the recreationally and commercially targeted fish species (coral trout and red-throat emperor) were monitored annually by underwater fish surveys. These surveys were carried out by Tony Ayling of Sea Research. The first survey was conducted in September 1991, just prior to the closure of Bramble Reef. Three other reefs, which were open to fishing (John Brewer, Lodestone and Davies), were also surveyed, as controls, to compare their fish populations with Bramble Reef. After Bramble Reef was closed, fish surveys on the four reefs were conducted each year for the next three years until 1994. The number of reefs surveyed was increased in 1993 and 1994 after fishers expressed concern that fishing pressure was being transferred from Bramble to three adjacent reefs, Britomart, Trunk and Little Trunk.

A community advisory committee (Bramble Reef Replenishment Area Advisory Committee) was established soon after the closure of Bramble Reef. This Advisory Committee was set up to provide regular communication between managers and community groups, and to advise on management of the replenishment area and re-opening issues. The committee meets every six months. It is comprised of representatives of recreational fishing interests, tourism charter operators, the Palm Island Aboriginal community, Queensland Commercial Fishermen's Organisation, and other government agencies (GBRMPA, Queensland Department of Environment and Heritage, Queensland Boating and Fisheries Patrol and Queensland Department of Primary Industries).

The results of the annual surveys are very interesting. After 2.5 years of replenishment closure at Bramble Reef, the density of catchable common coral trout

Figure 1. Map of the Northern Central Section Showing the Position of the Study Reefs.



(those over 38 cm length) had increased (figure 4) while the total population of coral trout had increased as much as threefold (figure 2) (all data for figures supplied by Ayling and Ayling 1994). The primary cause of this increase was due to a high level of recruitment of juvenile trout. This was particularly evident in 1992 (figure 3) and illustrates the incredible ability of coral trout to re-stock reefs under favourable conditions. The subsequent growth of these juvenile trout through to legal size has masked any effects that the closure may have provided.

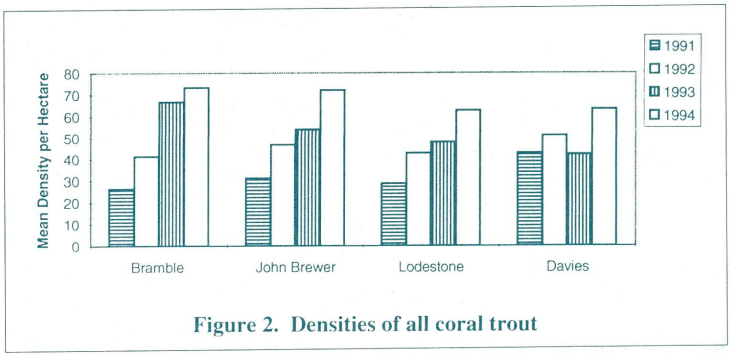


Figure 2. Densities of all coral trout

The study has been very valuable in itself as it shows how quickly reef fish populations can recover under favourable conditions. The closure may have been very appropriate and effective in its own right if the conditions for recruitment were not as good.

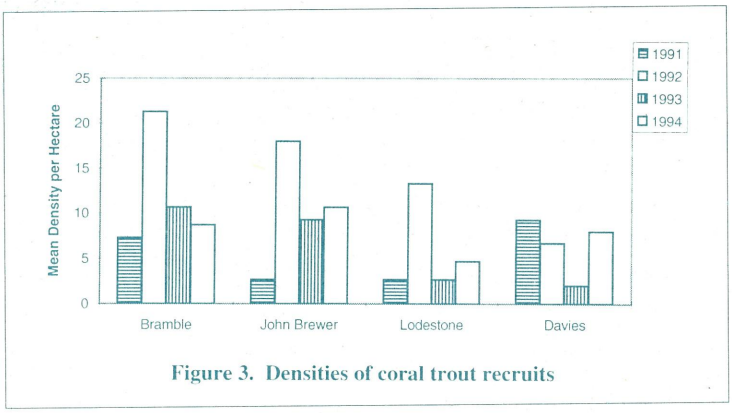


Figure 3. Densities of coral trout recruits

The red-throat sweetlip showed a similar density pattern over the survey period with the stocks remaining very low (figure 5). Although there was an observed density increase on Bramble Reef over the survey period, it was still 3.5 times lower than on the control reefs. Whether red-throat sweetlip are more susceptible to fishing and less resilient than coral trout is unknown. Little is known about the species biology, particularly the whereabouts of juveniles. The species is also more difficult to visually survey as they are far more mobile than coral trout. There has been no significant increase in the density of other fishing target species on Bramble Reef since the closure.

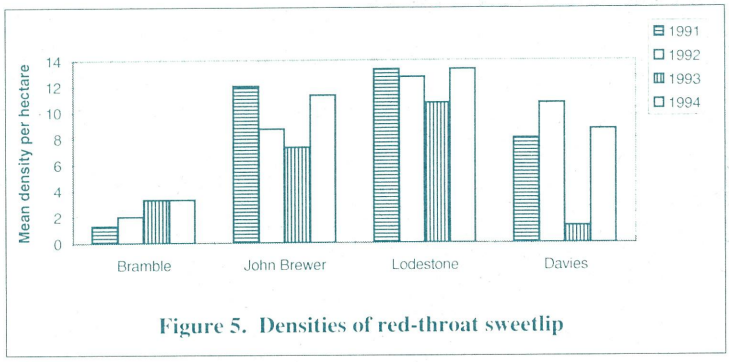


Figure 5. Densities of red-throat sweetlip

On recommendation by the Advisory Committee, Bramble Reef will be re-opened on 1 July 1995. There are a number of advantages to opening on this date. It will allow for a further fish survey to be conducted and will also allow time for further growth in the coral trout. It is expected that by this date about 70% of the trout population will be of a catchable size (>38 cm). The initial fishing activity expected when Bramble Reef is re-opened will be diminished due to the poor weather conditions experienced in July. This will result in a staggered start to the resumption of fishing. Annual surveys of fish stocks at Bramble Reef and nearby reefs will continue for at least another three years.

Apart from utilising the mid-year poor weather, the Advisory Committee are still developing a number of other short-term re-opening strategies to allocate fishing effort between commercial and recreational fishers. Concerns have been raised over whether the fish stocks will be able to sustain the intensive fishing pressure. Both amateur and professional fishers will need to come together in order to benefit from the closure and to also ensure that the rapid decline of fish stocks that occurred three years ago is not repeated.

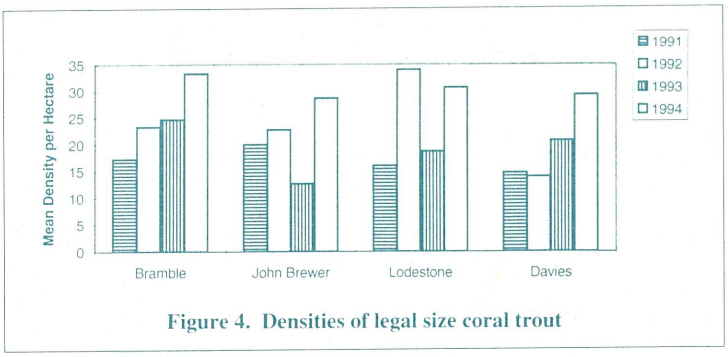


Figure 4. Densities of legal size coral trout

Reference

Ayling, A.M. & A.L. 1994, Bramble Reef replenishment area - 1993 and 1994 surveys, Unpublished final report to the Great Barrier Reef Marine Park Authority.

COTS COMMS

Dr Brian Lassig and Udo Engelhardt

I want to add a new certainty to life. We now have death, taxes and criticism of the Great Barrier Reef Marine Park Authority for inaction over perceived life-threatening issues. In the COTS context, a few *but vocal* opponents have said (and will continue to say) GBRMPA hasn't acted responsibly in dealing with outbreaks of COTS on the Great Barrier Reef. With increasing numbers of starfish on the GBR and elsewhere (see the last few issues of *Reef Research*) we expect renewed criticism and trumpet-blowing. So I thought it timely to highlight just some of the things we've done over the past couple of years to keep on top of the COTS situation. Previous issues of *Reef Research* have described some of these initiatives, but it's worth presenting an overview of the complete package to show how comprehensive and strategically designed our activities have been. We are not good fiddlers.

Our activities over the past year or so fall into six basic areas:

- Contingency Planning
- Controls
- Monitoring
- Extension and Information
- Program Review
- Industry and Institutional Collaboration.

Contingency Planning

In 1992 GBRMPA COTS staff and AIMS personnel worked up a basic plan to be initiated in the event of increasing numbers of starfish on the Great Barrier Reef. The contingency plan focuses on scientific aspects with a high priority being to establish the extent of any population increases. During previous outbreaks a serious catch-22 developed and resulted in substantial delays in getting appropriate funding for research into the causes of outbreaks. Without knowledge of the seriousness of the situation we couldn't get funds for surveys and research. Without adequate funding we couldn't undertake the surveys to assess the seriousness of the situation.

We have followed the plan over the past couple of years and have now instituted fine-scale surveys (as specified by the plan) to provide more detailed information on the changes in COTS numbers in critical areas on the Reef. This has only been possible because of continuity in funding for the program during times when starfish were relatively rare - a unique situation that means we can be pro-active.

Discussions with representatives from industry, scientific institutions and management organisations have resulted in the development of a more hands-on version of the contingency plan that dovetails into the science-based contingency plan. All the key players are now aware of their roles and responsibilities, who to contact, what information is necessary for management and what to expect from the other players.

Controls

Previous issues have described the development of new environmentally-friendly techniques for local control of COTS. Injection with sodium bisulphate (Dry Acid) is now being used successfully in a number of areas where localised increases in COTS numbers are causing some concern. A manual detailing local control techniques is being published.

We have reviewed the policy of COTS control to remove some of the uncertainty over the application of controls and to be consistent with the fact that COTS are natural inhabitants of coral reefs. Because experience has shown that local controls are most successful in protecting corals when they have been started as soon as possible we, in conjunction with GBRMPA's Environmental Impact Management Section, have streamlined the permit assessment process to minimise delays. Response times now should be measured in days rather than months.

Monitoring

As previous issues of *Reef Research* have described, our knowledge of the status of COTS populations on the GBR is leap years ahead of where we were at the time of the last outbreak. The three COTS monitoring programs - AIMS' broadscale surveys, the CRC/GBRMPA fine-scale surveys and the COTSWATCH program are providing us with an unprecedented quantity and quality of information. This means that for the first time we can closely monitor fairly subtle changes in COTS populations while at the same time keep track of the big picture. Greater attention to the COTS situation overseas is also helping to keep the current changes in perspective and to provide further insight into the causes of outbreaks.

Extension and Information

Recognising that ignorance is one of our greatest enemies, we have put considerable effort into keeping Reef-users and the general community informed of the status of COTS on the Great Barrier Reef and on the results of current research. Extension efforts have taken many forms including *Reef Research*, publications, videos, targeted presentations in regional areas, magazines as well as interviews with the printed and electronic media. Over the last year, few months have passed without us initiating some media communication about the program.

Program Review

As we mentioned in the last issue, we've been working on a scientific review of the last five years of the program. Parts of the review have been serialised and popularised for *COTS COMMS*. The printing of the official publication has been put on the backburner for a short time because of higher priorities, but the exercise has helped to establish and consolidate our current knowledge and identify gaps that need to be addressed. Regular reviews of the program (in 1989 and 1992 by external reviewers, and annually by the COTSREC) have meant that research has been much more focused in recent years. Research has strongly emphasised an hypothesis-testing approach with specific attention being paid to establishing the causes of outbreaks. The COTSREC has recommended that the program be externally reviewed in 1996 to ensure that research funds are used in the most cost-effective manner.

Industry and Institutional Collaboration

Although GBRMPA is responsible for the management aspects of the COTS issue, we are not the only organisation (or people) concerned about it. We have worked closely with scientists, day-to-day managers and tourism/dive industry representatives in our contingency planning activities and in developing the new control techniques. The high return rate of completed COTSWATCH forms provides us with a measure of the high degree of successful collaboration with industry and other Reef-users. The CRC Reef Research Centre has established a COTS program and is currently supporting a number of projects of immediate benefit to management and the tourism industry.

CURRENT COTS

AIMS Surveys

Since the last issue, AIMS has provided reports of their surveys in the Cairns, Cooktown/Lizard Island, Innisfail, Swains and Capricorn/Bunker Sectors of the Great Barrier Reef. Two reefs were classified as having active outbreaks (Reef 22-088 and Horseshoe Reef in the Swains Sector). There were few COTS elsewhere in the southern sectors. The outbreak on Gannet Cay in the Swains Sector is over and the reef is now classified as 'Recovering'. Median live coral cover is variable, ranging from 5% to 30%.

High numbers of COTS were recorded on four reefs in the Cooktown/Lizard Island Sector (Lizard Island, MacGillivray, Mackay and North Direction Island). None were classified as having active outbreaks, but there are indications that at least Lizard Island and Mackay Reefs may be in the early stages of outbreaks. Scuba searches at North Direction Island suggested that there could be quite a large population of juveniles on this reef. Median live coral cover in the sector ranged from 5% to 65%.

Only a handful of COTS were observed on the six reefs surveyed in the Cairns Sector (Reef Nos 15-092, 16-013A, 16-013B, 16-013C, Undine and Upolu Reefs) and on the four reefs in the Innisfail Sector (Feather Reef, Hutchinson Island Reef, Jessie & Kent Islands reefs and Scott Reef). Additional surveys in the Cairns Sector are scheduled for April.

Reef-User Reports (COTSWATCH)

Reef-users continue to strongly support the Authority's COTSWATCH scheme, breaking a number of records along the way. In the period from mid-November 1994 to mid-February 1995 an amazing **200!** individual site reports were received. The reports provide detailed information on some 613 COTS seen. There still is a nice balance between the zero returns and the actual counts or observations. It is probably safe to assume that the steadily increasing number of completed COTSWATCH forms reflects the increased interest and commitment by Reef-users, as well as the fruits of our recent efforts in promoting the scheme in the Cairns to Port Douglas area. The fact that starfish numbers in this area are on the increase may also explain some of the success of the current scheme. In any case, many thanks to all you COTSWATCHERS out there and in particular to our 'regulars' who, in some cases, have been with the scheme for the last twelve months. Your efforts are very much appreciated and we will continue to meet our end of the bargain by providing feedback to you on this important issue.

COTSWATCHERS 11/94 - 2/95

I Drayton / Lizard Island Lodge,

W Davis / Dallas USA,

I Stapleton / Port Douglas,

G Byron / QDEH Rockhampton,

B Knuckey / QDEH Gladstone,

K Steinbeck / Holloways Beach,

G Leeon / Cairns,

J Purcell / Great Adventures,

S Martin / QDEH Cairns,

S Moon / Ocean Spirit Cruises,

J Olds / QDEH Gladstone,

K Burns / Sunlover Cruises,

S Richards / Manunda,

C Dunk / Coral Princess Cruises,

K Roach / Cairns,

J Richardson / Pro Dive Cairns,

S Wood / Friendship Cruises,

M Baer / Townsville,

G Rochester / Cairns,

P Harvey / Mission Beach,

C Hopkins / Deep Sea Divers Den,

L Cahill / Smithfield,

B Heinrich / Proserpine,

J Haig / QDEH Cairns,

S Whelan / Cairns,

S Sammon / New York USA,

J Stoddart / Cremorne,

M Hartcher / Townsville,

J Barrett / Townsville,

M Turner / Townsville,

A Frisch / JCU,

R Buck / QDEH Mackay,

B Kahn & G Johnstone / Port Douglas,

P Pilkington / Lizard Island Lodge,

C Hulley / Seaforth NSW,

Mr & Mrs Allderdice / Denver USA,

R Toff / Cairns,

D Sinclair / ACT,

Aquamarine Industries / Stratford,

D Anderlini / Cairns,

B McCormack / Cairns,

G Smith / Townsville,

M Schaer / Cairns,

J Richter / QDEH Rockhampton

Fine-scaleSurveys: Preliminary results 1994-95

A total of 24 mid-shelf reefs have been surveyed for COTS in the Cairns Section of the Marine Park using an intensive transect-based methodology. The technique has been shown to be highly suitable for detecting starfish of all size classes including small juveniles (<10 cm). This is the first time that such a wide geographic area, covering three degrees of latitude, has been intensively surveyed in this manner during a non-outbreak period. Preliminary analyses reveal some interesting trends:

1. There are pronounced latitudinal differences in the distribution of both juvenile and mature COTS, with reefs north of the Daintree area generally supporting higher numbers of COTS than reefs to the south of Port Douglas.

2. A number of reefs in the Daintree to Cooktown area are currently experiencing localised high density populations (spot-outbreaks) of starfish, with two additionalweeks now being considered as active outbreaks.

3. Reefs in the Lizard Island area are characterised by the presence of substantial numbers of 2+ year old COTS. These starfish are currently 18-26 cm in size and are quickly becoming a more conspicuous part of the population. Unless the 2+ age class experiences high levels of mortality over the next 6 to 8 months a number of reefs in this area are likely to experience localised outbreaks within the next 12 months.

4. The relatively wide geographic spread of mature COTS (3+/4+ age classes) throughout the northern parts of the study area indicates that the population structure observed is largely the result of regional rather than localised phenomena.

5. The situation in the area off Cairns and south to Innisfail differs markedly from the one in the north. Although a number of localised high density populations were found on reefs off Cairns, the starfish are generally more patchily distributed. However, the GBRMPA/CRC fine-scale surveys and the COTSWATCH Reef-user reporting scheme have also identified several areas where substantial recruitment of COTS has now occurred for at least four consecutive years. These areas will have to be monitored very closely in order to retain an early warning capacity.

6. Generally, reefs located south off 17°S had lower numbers of COTS. Furthermore, there were few signs of recent recruitment of starfish.

7. On a couple of reefs off Cairns, the surveys identified sites that appear to be supporting relatively high numbers of small juveniles (1+ age class). Assuming that the area off Cairns will follow trends currently seen further north, our findings suggest that reefs in the Cairns area are lagging behind the Lizard Island area by approximately 1 - 2 years.

8. However, it is possible that starfish densities will increase further throughout the Cairns Section. Should the current El Niño episode come to an end (as is now predicted) the resulting strengthening of the East Australia Current (EAC) has the potential to transport COTS larvae from the high density populations found in the north down to reefs off Cairns. There is a high degree of uncertainty as to the likely behaviour of the EAC and the great number of factors influencing water currents make it impossible to predict future recruitment events with any degree of certainty.

9. The above trends are generally supported by the findings of complementary survey schemes such as the GBRMPA COTSWATCH scheme and the AIMS Long-term Monitoring Project.

It should be noted that interpretation of the survey results is by no means a trivial task. We simply do not have any baseline information collected in years preceding an outbreak. Reefwide monitoring was only initiated in the mid-1980s when the second wave of outbreaks on the GBR was well under way. We are also reviewing the process by which reefs are classified into either outsbreaking or non-outbreaking reefs. Our ability to make more reliable projections will hopefully improve in years to come as repeat surveys start to shed light on the behaviour of starfish populations in the Cairns Section of the Marine Park.

PROGRAM OVERVIEW

Hydrodynamics, Recruitment and Terrestrial Inputs Because of the extreme logistical difficulties associated with trying to monitor the dispersal of COTS larvae in water currents, computers have been used to simulate the movement of larvae between reefs. Much of the computer modelling has centred around the development of numerical hydrodynamic models for resolving the dispersal pattern of COTS larvae on large and small spatial scales. These models

seem based on robust modelling techniques, and general patterns predicted by the models match fairly well with the observed pattern of outbreaks on the GBR. However, the models require a number of critical assumptions and simplifications. Until assumptions are validated against reliable field data the Crown-of-thorns Starfish Research Committee has recommended that models be used only for limited and prescribed purposes. An urgent need was felt for a set standard for the use of hydrodynamic models for management decision making. This need is currently being addressed by the Authority.

Studies have identified hydrodynamic processes which play a prominent role in the dispersal of larvae. These include:

- low frequency current flows associated with the East Australian Current,
- essentially low frequency, wind forced flows, and
- relatively high frequency tidal flows.

The hydrodynamic model SURG1E was modified by the Marine Modelling Unit at James Cook University and used for examining the scale and relative importance of these processes for the Cairns Section where the past two major COTS outbreaks were first recorded. This model predicts that:

- EAC associated flows are relatively weak in the north, but intensify farther to the south away from the EAC bifurcation,
- the dense reef matrix significantly reduces the development of wind forced flows,
- the amplitude of tides is relatively large in the south, and
- flows within the reef matrix follow natural passages, resulting in a degree of phase retardation in tidal flows.

The model seems successful in demonstrating that the hydrodynamic regime in the north behind the Ribbon Reefs is markedly different from that in the south.

A current 'best-use' model for simulating the large scale dispersal of COTS larvae is based on three transport component outputs from SURGE (East Australia Current, winds and tides) and runs under time-dependent tidal flows and a randomly varying wind field that is typical during the spawning season of COTS. This model is capable of generating outputs that are qualitatively consistent with observations made for the past two major COTS outbreaks e.g. the southward movement of COTS outbreaks to the south of Cairns and the high incidence of COTS outbreaks in mid-shelf reefs. However, the consistency between the results of dispersal simulations and observed outbreaks at the level of individual reefs is less convincing. Resolution at this scale is vital to the identification and validation of individual source and sink reefs. There are a number of reasons why this level of detail is unachievable at this stage. The model assumes that COTS larvae behave as neutrally buoyant, passive particles (which has not been proven); it runs under 'average' conditions; and does not take into account the role of fine-scale hydrodynamic processes on the movement of COTS larvae in close proximity to reefs and their possible retention on reefs. There are also a number of shortcomings associated with records of outbreaks on the Great Barrier Reef (for comparison with simulations) with incomplete data on affected reefs and the uncertainty over when outbreaks on particular reefs started.

The model developed for fine-scale resolution of dispersal around reefs predicts much longer residence times of COTS larvae than previously thought and suggests the potential importance of self-seeding as a mechanism for COTS outbreaks. This model is highly sophisticated, but still suffers from a degree of uncertainty due to assumptions that have not been validated against field data.

A hindcasting model for low frequency currents along the Great Barrier Reef by Dr Kerry Black of the Victorian Institute of Marine Science successfully explained how the southward movement of COTS outbreaks occurred in a wave of secondary outbreaks. It also provided an interesting view that the initiation of the last major outbreak coincided with a period of slow currents. This model was calibrated against current meter data and proven to be statistically efficient. The model, however, is essentially applicable only to the central Great Barrier Reef and its relevance to the Cairns Section may be questionable, since the physics of the Cairns Section is different from that in other parts of the Great Barrier Reef. There is a possibility that the dispersal of COTS larvae in the Cairns Section is under the strong influence of high frequency tidal flows rather than the East Australia Current as well as low frequency flows and wind forced flows.

The number of COTS larvae settling on individual reefs is affected by a number of physical and biological factors. Temperature is one of these factors. The data on the sea surface temperature along the Great Barrier Reef during the spawning season of COTS over the past 30 years was statistically analysed and viewed in relation to the reported range of temperature for larval survival by Dr Black. Interestingly, the optimum temperature of 28°C for larval survival occurred at 16°S, which had been identified as the initial epicentre of COTS outbreaks. This coincidence, however, needs to be interpreted carefully. Firstly, the analysis does not take the horizontal and vertical variations in temperature into consideration. Secondly, Lucas' results indicate that the optimum temperature is around 28°C, but not exactly at 28°C. It is, therefore, more appropriate to say that the temperature in most parts of the Cairns Section during the spawning season of COTS is generally suitable for larval survival.

It has often been assumed that COTS recruitment in the Great Barrier Reef occurs in isolation from terrestrial influences, as their habitat is away from the mainland. A study by Dr Cecily Rasmussen of James Cook University, of environmental records in the skeletons of long-living massive corals on Green Island, however, suggests that this is not always the case. The highlight of this study is a positive correlation between agricultural fertiliser usage on the nearby mainland and skeletal magnesium concentration, which has been suggested to increase with increasing concentration of organic matter in seawater. However, a possibility that the observed change in skeletal magnesium concentration is due to the natural change in ocean productivity is not precluded.

Most controversial debates on COTS recruitment primarily stem from the fact that both larval and juvenile COTS are rarely seen in the field. COTS larvae closely resemble larvae of other starfish. Monoclonal antibodies for COTS larvae have been developed, and some appear to be sufficiently specific to identify COTS. This process is being refined by Ms Katrina Roper of James Cook University with a view to developing an assay system that can be used in the field.

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