NEWSLETTER OF THE RESEARCH AND MONITORING SECTION

REEF RESEARCH

Great Barrier Reef Marine Park Authority

VOLUME 5 – No. 3 September 1995

Editorial

This issue of *Reef Research* is a real mixture of interesting information. The COTS continue their apparent increases, anchors are hydraulically screwed into a concrete substrate of their own making, fish seem to know what day of the week it is when a free feed is available at a pontoon, what to do with no-longer needed oil rigs and crashed bulk carriers is considered, the use of historical photographs as a tool for monitoring change is discussed and a summary of the usage of fertiliser in the catchments adjacent to the Marine Park is given. Oh, and there is movement on the ballast water research front, Shoalwater Bay is to become a Marine Park and the Chairman says good-bye to the Executive Officer. I, who have worked with Wendy over a number of years, also take this opportunity to wish her all the best in her new position in chilly Canberra.

The variety of work that is reported is testimony to the broad spectrum of research needs in the Great Barrier Reef region, and the ever increasing number of reports that are flowing from the CRC Reef Research Centre is demonstrating that it is now coming of age despite being in existence for less than three years. As projects reach conclusion it is hoped that as many as possible will be reported here in *Reef Research* so that readers know what is available and useful to them.

Variety of research is all very well but the pressing need, in this writer's opinion, is to invest resources in the synthesis of the information that is flowing from all this good work. For example, it would be useful to take all the information that has been gathered in relation to pontoons, biological, physical and social, and put together a 'pontoons' report that spells out clearly the what, why and how of all we know about these structures. Similar reports could be put together for any number of 'issues' areas as opposed to 'research' areas.

To carry out these kinds of syntheses will not be a simple matter and will require significant resources. However, I think it is an essential challenge that needs to be taken up if we research people are to more effectively demonstrate the validity and usefulness of our endeavours.

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:

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

Editor.....Steve Hillman
Assistant Editor.....Kim Davis
Design & Art.....Andreas Wagner
Printed by.....
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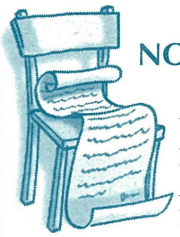
WHAT'S IN THIS ISSUE

RESEARCH AND MONITORING STAFF

Jon Brodie	*Director*
Andy Steven	*Acting Coordinator - Water Quality*
Brian Lassig	*Coordinator - Crown-of-thorns Starfish*
Udo Engelhardt	*Project Manager - Crown-of-thorns Starfish*
John Robertson	*Coordinator - Effects of Fishing*
Janine Kuhl	*Assistant Project Officer - Effects of Fishing*
Michele Owen	*Administration Assistant - Effects of Fishing*
Jamie Oliver	*Coordinator - Monitoring*
Steve Hillman	*Project Manager - Monitoring and Editor, Reef Research*
Ray Berkelmans	*Acting Project Manager - Monitoring (Shoalwater Bay)*
James Aston	*Project Manager - Monitoring*
David Wachenfeld	*Project Officer - Monitoring*
Rachelle Ninio	*Assistant Project Officer- Monitoring*
Dominique Benzaken	*Project Manager - Socio-economic*
Judy Anderson	*Assistant Project Officer - Socio-economic*
Kim Davis	*Acting Assistant Project Officer - Administration and Assistant Editor, Reef Research*
Jon Ive	*Administration Assistant*



NOTES FROM THE CHAIR

By the time of publication of this issue, Dr Wendy Craik, Executive Officer of the Great Barrier Reef Marine Park Authority, will have taken up her appointment as Executive Director of the National Farmers' Federation. To have achieved such an appointment is a testament to Wendy's wide background and close contact with rural industries in her seventeen years with the Great Barrier Reef Marine Park Authority.

Wendy has a PhD in Zoology, as a fish biologist. (She also has the distinction of not eating her research interest!). She holds a Graduate Diploma in Management.

During Wendy's time with the Great Barrier Reef Marine Park Authority, she has been involved in a range of administrative and supervisory activities. Amongst these, she is credited with having established the development of fish studies in the Great Barrier Reef, and having established excellent contact with the fishing industry. Both the public service and industry aspects of commercial fishing are vigorous defenders of their activity and for Wendy to have established a position of such high credibility reflects her knowledge base, her genuineness as a person and her skill as a negotiator.

Dr Wendy Craik

In recent years, Wendy has been part of the discussions that led to the establishment of the CRC Reef Research Centre, and to the increasing systemisation of monitoring and research on the Great Barrier Reef.

In her time in the Planning and Management Section, Wendy participated in the introduction and the completion of zoning plans and the establishment of operational management systems for the Marine Park.

Certainly, the crowning achievement of this history of service to the Marine Park Authority was the 25 Year Strategic Plan for the Great Barrier Reef World Heritage Area, which has been recognised internationally as an outstanding example of community involvement in the establishment of agreed management outcomes. The finished document does not tell the story of the endless hours of negotiation, consultation and plain hard work that went into its completion.

A recent *Bulletin* article referred to Wendy as the General Manager of the Marine Park Authority and because Graeme Kelleher was located in Canberra, it is in fact a largely accurate description.Wendy has been the Executive Officer, the General Manager, the motivator and has contributed to the intellectual strength of the Marine Park Authority.

Wendy's contribution has been great. She will leave an enormous gap but she is going on to a further career step which has an extremely high profile and which represents a very great achievement, and, I suspect, another milestone in an illustrious career.

UPDATE - *Chris Crossland*

CENTRE ACTIVITIES

Two new task reports are currently being printed. Peter Valentine and Gail Broome of James Cook University's Department of Tropical Environment Studies and Geography (TESAG) have completed 'Principles of Social Impact Assessment and its Application to Managing the Great Barrier Reef'. Hugh Sweatman, formerly with the Department of Marine Biology at James Cook University, and now with the long-term monitoring program at the Australian Institute of Marine Science, has finished his study on the impacts of fish feeding on tourist pontoons, and presents his findings in this issue of *Reef Research*.

RESEARCH ACTIVITIES

Seagrass Surveys - New Findings

The Department of Primary Industries research team, working from the Northern Fisheries Centre in Cairns, have discovered vast, previously unknown seagrass meadows. Dr Rob Coles, Warren Lee Long and Len Mckenzie found the new seagrass beds, with a total area of 4000 square kilometres, between Cairns and Cape Weymouth. In two intensive field trips, they examined 300 deep water sites - deeper than 15 metres - and 17 reef platforms. Most of the meadows were concentrated south of Princess Charlotte Bay, with only small meadows further north. They were found on most inshore and mid-shelf coral reefs, but proved to be uncommon on reef platforms on the outer edge of the Great Barrier Reef.

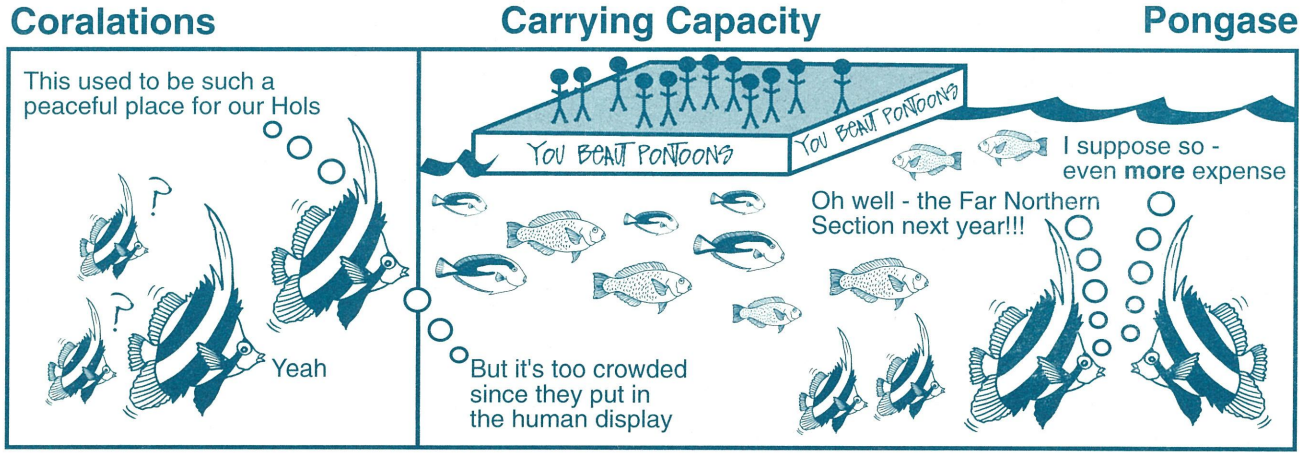
Each deep water site is video recorded and the reef tops are examined by spot dives and manta tow surveys. In both reef top and deep dive surveys, seagrass species and abundance are noted along with the amount of algae and other details of the benthos.

The Department of Primary Industries Northern Fisheries Seagrass Group has been conducting seagrass surveys for more than ten years, and the injection of funds from the Centre has enabled them to search in deeper waters. As well as the constraints of diving at 15 to 20 metres, the team has had to contend with the remoteness of the sites and the unpredictability of the weather. They plan to spend another 20 days at sea at the end of this year when the weather is expected to be most favourable.

Mapping the far northern sector of the Reef is the Centre's first major seagrass project. Only about ten percent of these reefs have been surveyed so far, so there is considerable work ahead.

Moorings and Anchor Research

The impacts of anchors, anchor chains, and pontoon mooring systems are the subjects of several separate but interconnected tasks within the Centre. Paul Marshall of the CRC Reef Research Centre and James Cook University's TESAG is studying the consequences of anchoring on coral reefs. He will use underwater video monitoring and small scale experiments to gain a more comprehensive understanding of the effects of anchoring, using the situation in the Whitsundays as a case study. The aims of



the task are to develop indicators of anchor damage; determine the susceptibility to damage of various species and growth forms, and to monitor the recovery of corals from anchor damage. A model will be developed to help managers assess site vulnerability and acceptable levels of use. A series of consultative meetings have been held in the Whitsundays to gather input from bareboat operators, tourist industry representatives, dive companies, PADI and the Order of Underwater Coral Heroes (OUCH) (a local volunteer group). Hayman Island Resort has provided logistical support for field trips, and other local operators have also offered support.

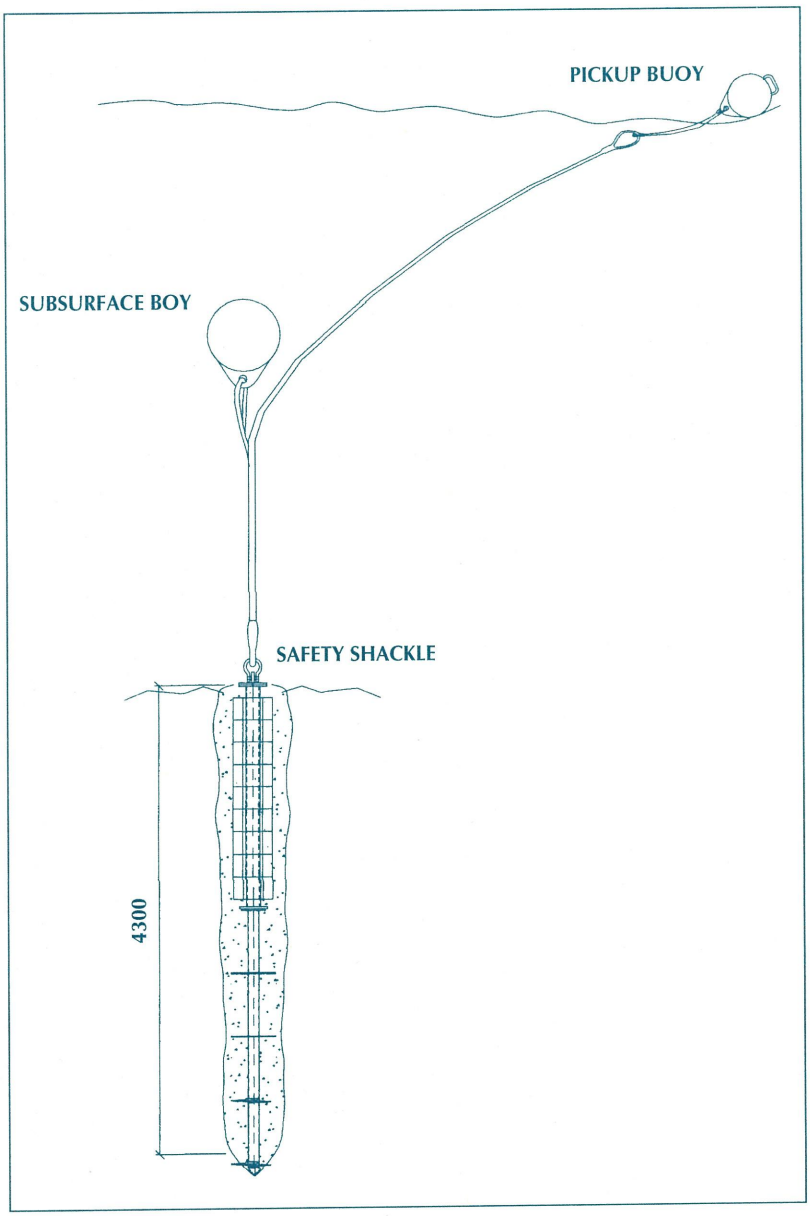


Figure 1: General arrangement of a grouted screw anchor (drawing courtesy of Pacific Marine Group Pty Ltd.)

In the Department of Civil and Systems Engineering at James Cook University, Barrie Greensill heads a team testing the performance of grouted screw anchors to see how much force they can withstand. Nine anchors, each consisting of a 100-millimetre steel shaft with two screw flights, were sunk into a simulated testbed on land using a custom designed underwater hydraulic drilling rig. Cement slurry was pumped through the anchor shaft during installation which in reality sets in the sea bed in about three weeks, forming a 500-millimetre thick concrete shaft (see figure 1). The anchors, manufactured by Pacific Marine Group Pty Ltd in Townsville held up to design specifications and passed all the load tests. Although the final report is not due until the end of the year, indications are that these anchors will become an acceptable alternative to large, concrete blocks, and can be used in various configurations to secure pontoons up to 50 metres long or cruise ships up to 600 tonnes via a catenary line tied to a buoy on the surface.

Tourist operators who have already installed concrete block anchors weighing up to 20 tonnes, or who may prefer the option of being able to move pontoons in the future, will benefit from another task within the Engineering Program. Researchers Mark Britton and Troy Tesolin are testing the performance of pontoon anchor chains in simulated category four cyclone conditions and assessing the influence of currents by forcing thousands of litres of water past a scaled anchor setup in a 25-metre flume tank. Little is known about the specifics of pontoon movements during severe cyclones, and in response, marine engineers have designed mooring systems with six to eight backup five-tonne dumper blocks, which lift as the pontoon shifts. A computer model is being developed to see how large dumper blocks can be expected to move, and to assess the tension in the cable under cyclonic conditions. This task fits into the wider review of engineering guidelines for structures being built or located in the shallow Reef lagoons, ensuring that such structures are safe, both for the Reef and for people, and to provide economic confidence for the tourist operators.

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

THE IMPACT OF TOURIST PONTOONS ON FISH ASSEMBLAGES

_Dr Hugh Sweatman_* has just completed his study of pontoon effects on fish assemblages which contains matters of general interest and implications for management. Here Hugh reports:

For many tourists, observing large fishes at close range is a fascinating experience, and it is an aspect of a daytrip to the Reef which tourist operators are keen to promote. Quite properly, Reef managers were concerned that this activity may have unknown consequences. Aggregations of carnivores might have a deleterious effect on local populations of smaller fishes and invertebrates that are their prey; they might deplete the populations of the aggregating species on adjacent reefs; feeding fishes non-natural supplementary food may also affect their health; and they could be wounded in the competition to eat it. On these assumptions, operators have been required to carry out fish censuses at pontoons on a regular basis.

While no two pontoons attract identical aggregations of fishes, it is clear that Spangled Emperor and Red Bass are the prevalent species. I chose to work at the two pontoons operated by Quicksilver Connections at Agincourt Reef off Port Douglas, and the pontoon at Kelso Reef near Townsville operated by Pure Pleasure Cruises. I am grateful to both companies for their support, which greatly facilitated the research.

AT KELSO REEF

Pure Pleasure Cruises have operated a daytrip since mid-1990. Initially the catamaran was simply moored at a site in the lagoon and used as a base for the normal range of activities including SCUBA diving, snorkelling, and fish feeding. The 10 m x 30 m steel pontoon was moored permanently in December that year. My initial approach was to observe the behaviour of the fishes at the pontoon to try to determine the potential for an impact on prey species. A secondary concern, expressed by Reef managers and the company itself, was that the relatively tame fish, used to being fed, would themselves become easy food if targeted by fishermen once the catamaran left.

Fishes in the aggregation were counted by divers using hand tally counters. The number of Spangled Emperors at the pontoon varied among visits from 50 to 150. On the basis of wounds and distinctive patterns of fin damage it was clear that some of the same individuals were present on successive days. Divers swam a transect under the pontoon and boat and counted the Spangled Emperors that were in feeding pose - hovering about one metre from the bottom with their heads inclined slightly downwards, or actually in the process of taking bites from the sand. Their feeding rates were estimated by following individuals and recording their bite rates.

Forty-one observations lasting from one to 22 minutes were made during visits. Faeces were collected from the sand under the rear of the boat, where members of the aggregation spend most of their time, and were found to contain broken remains of burrowing sea urchins, bivalves and gastropods.

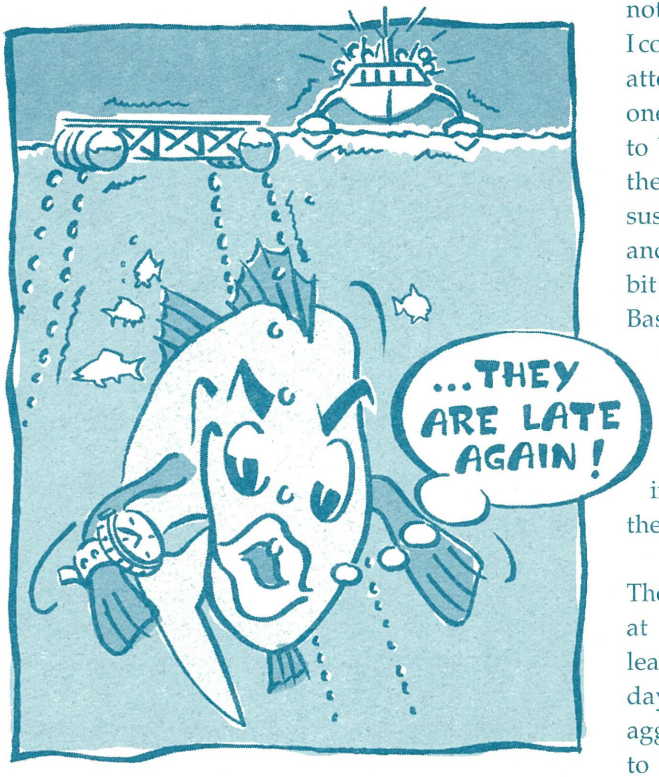
Observations from before the tourist boat arrived until after it left show that the Spangled Emperors arrive when the boat does, and disperse shortly after the boat leaves. This means that they are not tame catches for fishermen. However, the cues that draw fishes to the pontoon are not clear, although they may be responding to propeller noise. On 1 June 1994 the daytrip was cancelled, but a number of fish came to the pontoon on time, presumably in expectation of its arrival. On 3 June 1994, counts were made around arrival time. This was a Friday when the boat was not scheduled to come. No fish were seen.

Fishes at Kelso are fed at the end of the trip at 3.00 p.m. when all of the tourists have returned to the boat. Fresh pilchards are thrown one at a time off the port side of the boat, bringing the whole aggregation thrashing to the surface in competition.

The fish are clearly keenly interested in handouts of food. This appears to be the principal cause of aggregation, but a proportion of them do feed on natural prey while at the

pontoon. Less than 10% of the aggregation was in feeding pose at any one time, and bite rates of these fish were also variable. I estimated that an average aggregation of 100 fish would take about 1.5 bites per square metre of sand under the pontoon in a day.

To look at the effects of their feeding, I used cages to prevent large fish from feeding on animals in the sand in experimental plots beneath the Kelso Reef pontoon site and at two control sites away from the aggregation for a period of four months. When I compared the change in total numbers of all prey, of all bivalves and of four individual species in caged and uncaged plots, I found no statistical evidence for an effect attributable to feeding by fish. An analysis of the direction of changes in density, rather than their magnitude, gave the same result. Looking at the size frequency distributions of bivalves in caged and uncaged plots, there was no indication that the pontoon site (i.e. the fish aggregation site) was any different to elsewhere. Thus, there was no evidence of changes due to the feeding activity of the fish.



AT AGINCOURT REEF

Quicksilver Connections have had pontoons at Agincourt Reef since 1984. Fish have been fed and Red Bass have been recorded in aggregations at the pontoons since at least 1989. Although they fight vigorously when hooked, anglers do not seek them as they have a reputation for being ciguatoxic.

The same methods of observation were used as at Kelso Reef. Fishes were counted opportunistically by snorkellers using hand tally counters, and on some occasions through the windows of the underwater observatories, though these were discarded if there was doubt that the whole aggregation was visible. Particular attention was paid to any predatory behaviour, visits to cleaner fishes (*Labroides spp.*) and obvious interactions with conspecifics.

As at Kelso Reef, the members of the aggregation were not always at the pontoon. Nonetheless, counts in the middle of the day were high and those at dawn and dusk were zero. Small groups of bass could be seen moving across the snorkelling area to the pontoon as the aggregation began to build up around 8.00 a.m. The boats arrive at 11.30 a.m. and depart at 3.00 p.m. so, unlike the Spangled Emperors at Kelso, the aggregations at Agincourt begin to form some hours before the tourist boat and persist after the boat's departure. Scars and fin damage of individuals show that a number of the same fish come to the pontoons each day.

Quicksilver staff feed the fish several times, either by hand to lure them up on to the submerged snorkelling platform or by throwing pilchards into the water nearby.

In more than ten hours of intensive observations under the pontoons or in the adjacent snorkelling areas, I did not see any behaviour that I could interpret as a predation attempt on natural prey. On one occasion a fish was seen to bite the ropes attached to the divers' access platform suspended under the pontoon and another time the fish bit the platform itself. Since Bass do not take encrusting organisms it seems unlikely that this was an example of feeding. The number of natural prey consumed in the immediate vicinity of the pontoon is low.

The presence of an aggregation at the pontoon may not lead to an increase in daytime predation, but if the aggregation disperses at night to feed, the probability of a prey organism encountering a Red Bass is possibly higher for prey closer to the source of the dispersal: the pontoon. To determine this would require extensive time in the field because large sample sizes would be necessary and sources of variation in survival other than predation by Red Bass would be numerous. Like all survivorship studies it would be important to measure emigration as well as mortality. The scope for the necessary manipulations, such as moving coral to make discreet habitat units, was restricted by the fact that the area was a working tourist facility within the Marine Park.

CONCLUSION

In conclusion, while there may be no evidence that the formation of aggregations at pontoons causes any measurable depletion from local populations, their formations at those locations is clearly a result of human activities that would be very unlikely to occur otherwise.

I would suggest that the impact is inconsequential. Aggregations occur naturally, so, in the case of aggregations at a pontoon, it is only the particular location that is influenced by man. If the tourist operators were not feeding fish at their pontoons, the fish would aggregate naturally at different sites.

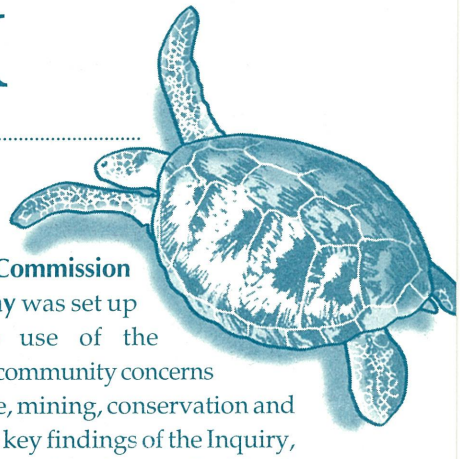
In current schemes, counts of fish at pontoon sites where there are aggregations are compared with control sites nearby, with no aggregations. These comparisons are hard to interpret. The management requirements for monitoring at pontoon sites may well be re-defined to eliminate such counts and concentrate on the quantity and quality of the feed itself. If the natural daily ration is being significantly augmented by manipulated feeding, two kinds of impacts can be foreseen. Increased food intakes could lead to increased survival rates and hence higher local population levels. The additional food intake may also lead to increased reproductive output. Since natural prey are available and given the intense physical competition among members of the aggregation for extra food, the second alternative is more likely. The aggregations represent only a small proportion of the population on reefs the size of Kelso or Agincourt and considering the likely dispersal trajectories of planktonic larvae, any such increase in reproduction will be diluted over regions rather than reefs and so will be vanishingly small.

Tourists undoubtedly appreciate the opportunity to see large fishes at close range, particularly when a large Maori Wrasse comes right up to the snorkelling platform. The feeding of fish at pontoon sites may be creating a zoo-like experience rather than an undisturbed observation of the natural ecosystem. If, in the future, the tourism industry becomes more wilderness orientated, the cessation of fish feeding seems very likely to remove the main motivation for large carnivorous fishes to aggregate at pontoons. They will aggregate somewhere else instead.

** At the time this research was conducted, Dr Hugh Sweatman was in the Department of Marine Biology at James Cook University of North Queensland. He is now with the long-term monitoring program at the Australian Institute of Marine Science.*

Shoalwater Bay: PLANNING FOR A NEW MARINE PARK

Ray Berkelmans



The Shoalwater Bay region, just north of Rockhampton, was once considered a backwater suitable only for conducting army exercises. Now it is seen by many as one of the highest priority conservation areas along the Queensland coast. This is in part due to the fact that exclusive defence use has kept development out of this area of 274 000 hectares of wilderness, leaving its high quality, natural features relatively free from human impact. The purpose of this article is to explain the Great Barrier Reef Marine Park Authority's interest in the area and to point out the substantial opportunities available to the scientific community for research and monitoring and the application of scientific knowledge in environmental planning and conservation.

In 1993 the Commonwealth Commission of Inquiry into Shoalwater Bay was set up to investigate appropriate use of the Shoalwater Bay area following community concerns over conflicts between defence, mining, conservation and traditional use of the area. The key findings of the Inquiry, made public in May 1994, were that the area had high ecological value and that defence use of the area had generally been well managed. It also found that the area was important for fishing, as a water catchment and that it had important traditional attributes. There was uncertainty, however, about the commercial viability of mineral sand mining. The Commission recommended that conservation be elevated to equal importance with Defence use of the

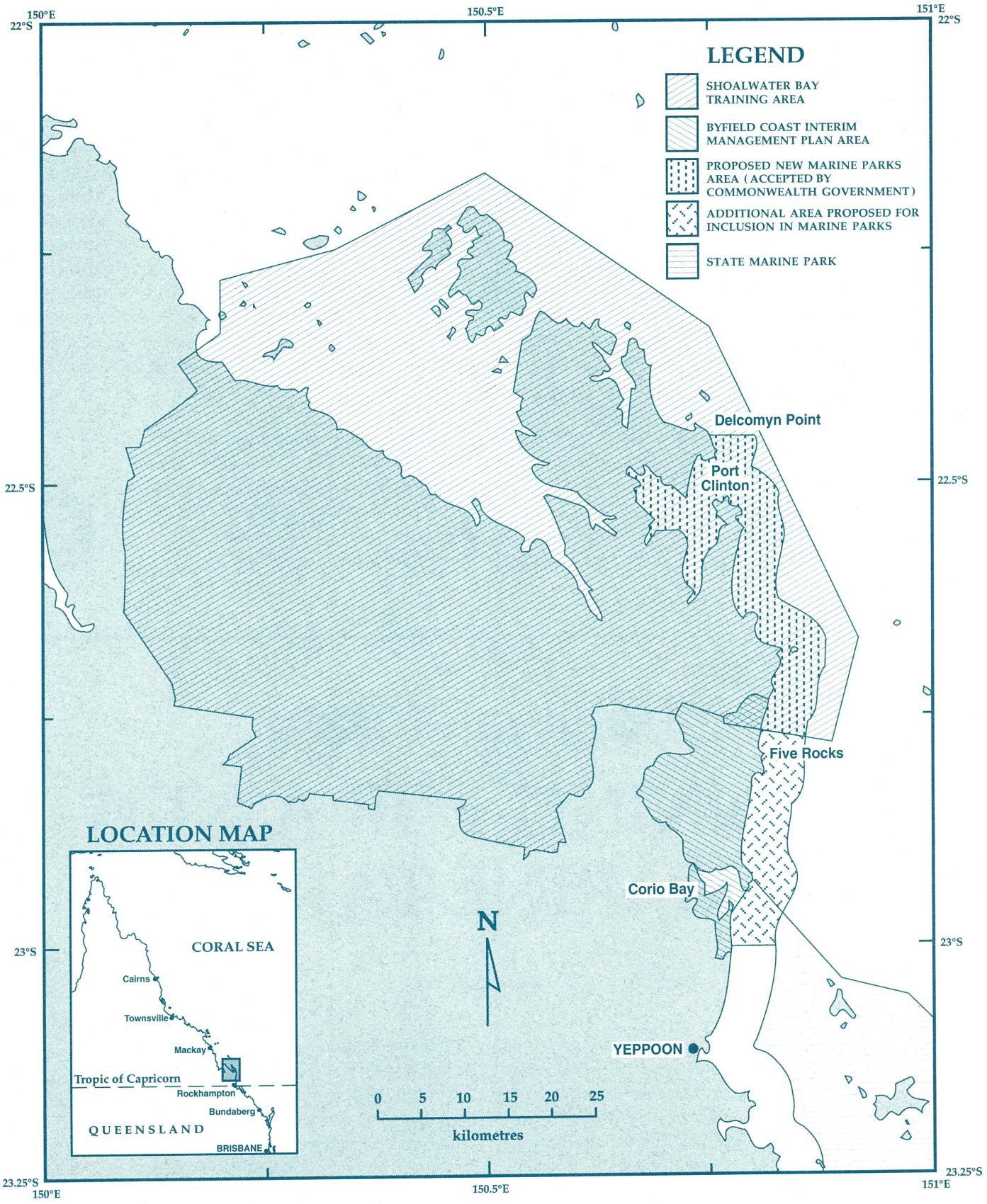


Figure 1. Shoalwater Bay planning process (Conceptual Diagram)

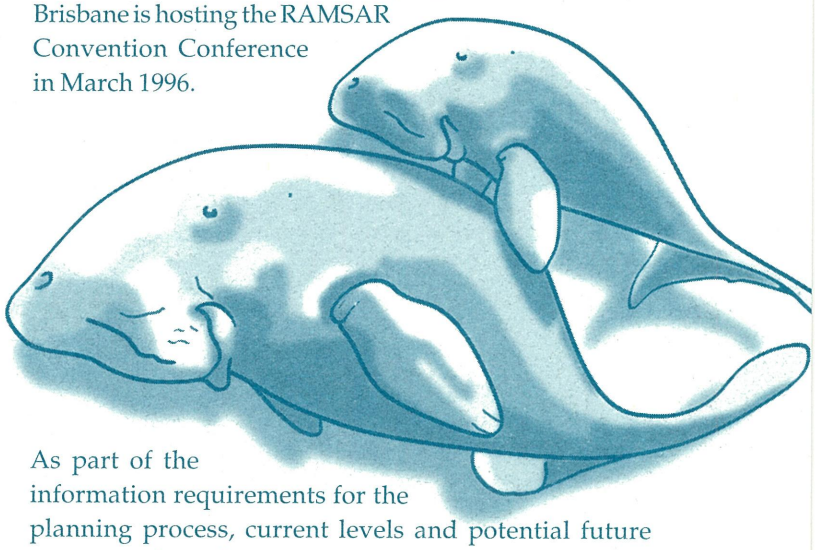
area, but that mining for sand and other minerals should not take place. It also recommended that a strategic plan and management plans, for the terrestrial and marine environments, be developed and integrated between the principle management agencies, namely the Department of Defence, the Great Barrier Reef Marine Park Authority (GBRMPA) and the Queensland Department of Environment and Heritage (QDEH). For the conservation movement, the Inquiry findings were a major win because it formally recognised the value of the area as a scientific reference site and recommended that management of the coastal waters which are currently not in the Marine Park, be handed over to GBRMPA for inclusion in the Great Barrier Reef Marine Park.

The Commonwealth Government endorsed the findings of the Inquiry in early 1995 and provided funding to implement the Inquiry recommendations. The Authority is currently preparing a submission, in collaboration with QDEH, for complementary declaration and management of the waters in the Port Clinton to Corio Bay area as Commonwealth and State Marine Parks (figure 1). A zoning plan will then be developed and, in the spirit of integrated catchment management, management strategies will be developed for the new declared section of the Marine Park and all other waters around the Shoalwater Bay Training Area (figure 1).

A substantial program is being designed to acquire the resource data needed to support the zoning and management planning and a review of existing data is currently under way. Currently, the biggest issue facing managers is the apparent conflict between the gill net fishery (mainly for barramundi and king salmon) and dugong conservation. Shoalwater Bay is an important dugong habitat and dugong populations have declined substantially since 1987, as they have all along the Queensland coast south of Cooktown. To identify appropriate management options, research will concentrate on movement of the dugongs within Shoalwater Bay and between adjacent wetlands using satellite tracking. The Shoalwater Bay area is also home to very large turtle populations, especially green turtles. Research will concentrate on population monitoring and movement of turtles.

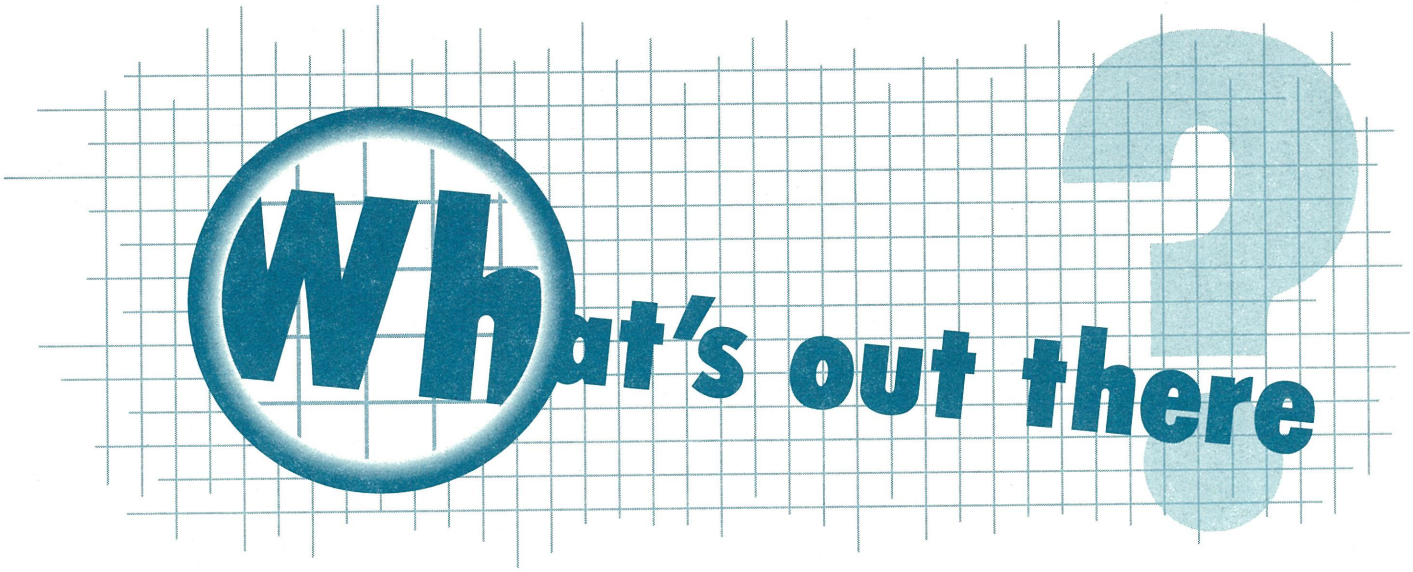
Dugong and turtle populations are supported by extensive seagrass beds which grow in the shallow and protected waters of the Shoalwater Bay area and its many tidal creeks and inlets. These beds will be surveyed by helicopter in the intertidal areas and by boat in the deeper areas and their maximum and minimum seasonal extent mapped. Species composition, abundance and the value of these beds for large herbivores and for juvenile fish and prawns will be established. The sustainability of the fisheries, especially mud crabs, barramundi and the trawl fishery was a major concern of the Inquiry and will be the subject of cooperative work with the Queensland Department of Primary Industries.

Other components of the research program will involve mapping and baseline surveys of the fringing and shoaling reefs around the 54 islands and exposed rocks in the area. Innovative technology is planned for the mapping of inter-reefal areas using acoustic survey techniques. Shoalwater Bay and adjacent areas also have extensive mangrove forests which need to be mapped and have the species identified. The extensive wetlands also support important wading bird and seabird populations which will be surveyed. These data will support not only the zoning and a Marine Park management plan, but also the nomination of the Shoalwater Bay area under the RAMSAR Convention for the protection of internationally significant wetlands. Brisbane is hosting the RAMSAR Convention Conference in March 1996.



As part of the information requirements for the planning process, current levels and potential future commercial and recreational use of the marine environments will also be important research areas. Tourism and recreational use of the terrestrial areas will remain prohibited within the military training area, although boat access to beaches will still be possible at times when military exercises are not being conducted.

A draft zoning and management plan for the new park area will be released for two phases of public comment, the first expected in early 1996 and, all going well, the plan will be finalised in the second half of 1996. The zoning plan and management strategies for the existing Marine Park in the area will conform as far as possible with a Strategic Plan for Shoalwater Bay being developed by the Department of Defence in collaboration with the Great Barrier Reef Marine Park Authority, the Queensland Department of Environment and Heritage and the general public. Funding commitments have been made by the Commonwealth Government for a further three years to monitor key natural resources.



A CENTURY OF CHANGE ON CORAL REEF-FLATS: OR NOT?

the historical photographs project

David Wachenfeld

Our ability to understand long-term dynamics of coral reef communities has been limited by human memory and scarce long-term scientific data. The aim of the Historical Photographs Project has been to document long-term changes on coral reef-flats using historical photographs. In order to be used in the project, historical photos had to fulfil two criteria:

- the photo had to be taken by someone on or near a coral reef-flat during an extreme low tide (so that the benthic community is visible), and
- the photo had to contain a recognisable landmark.

So far, we have collected 88 historical photographs from 21 different locations ranging from Heron Island in the south to Thursday Island in the north. The photographs date from as far back as 1890. These photographs offer an unrivalled opportunity to compare reef-flats as they are today with the same reef-flats as they were many years ago.

Comparisons between historical and modern photographs can provide information that is useful in the management of the Great Barrier Reef Marine Park. Such comparisons can be used to distinguish between reef-flats that should be of concern to managers and others that may require less attention. However, using comparisons between modern and historical photographs as a measure of reef-flat health is a coarse tool with several important limitations. These limitations must be considered when analysing photographic comparisons.

- Firstly, historical photographs only show reef-flats. Irrespective of the degree of change observed on the reef-flat, conclusions about the state of any other part of the reef cannot be drawn. In addition, only photographs of reefs that are within sight of a significant landmark can be used in this project. Thus all reefs studied in this way will be close to the mainland, a continental island or a coral cay.

- Clearly, a collection of historical photographs from a particular location does not represent results of a sampling design incorporating random sampling. Most photographers will have been attempting to illustrate a particular point when taking a photograph and it is impossible for us to know how representative any single photograph is of the whole reef-flat. This problem is worst when only one photograph from a reef-flat exists and is reduced when several photographs from one reef-flat at one time are available for study.

- Photographs taken at an oblique angle to the substratum do not allow the substratum to be quantified easily. Without complicated geometric analysis of the photograph, the best that can be achieved is a qualitative, subjective impression of the substratum shown in the photograph.

- Comparison of historical and modern photographs only provides two snap-shots of a continuous process

of reef change. The comparison provides no information about the state of the reef-flat in the years between the two photographs. Thus, when interpreting two apparently identical photographs of the same reef-flat that are separated by 100 years, it is equally possible to conclude that the reef-flat has remained unchanged over the last 100 years or that the reef-flat has changed but that in recent years it has returned to the state of 100 years ago. In addition, if comparison of modern and historical photographs does show a change in the reef-flat, this supplies no information as to the cause(s) of the observed change.

These problems of photographic comparisons should be considered when reading the following accounts of individual locations.

Over the last two years, on each day with suitably extreme low tides Andrew Elliott and I have been revisiting the sites of the historical photos and taking new photos for comparison, using the landmarks in the photos to relocate the sites.

In total, twelve sites have been revisited. At eight of these, given the limitations of the technique described above, there is little or no evidence of any change in the reef-flat benthic community.

For three sites in the Palm Islands, Little Pioneer Bay on Orpheus Island, Juno Bay on Fantome Island and Coolgaree Bay on Great Palm Island, photographs from around 1890 show reef-flat communities of soft corals and massive hard corals. These sites were revisited in 1994 and the modern reef-flats appeared identical to those in the photos from over 100 years ago.

A photo of Geoffrey Bay on Magnetic Island from 1952 shows large colonies of branching hard corals. This site was revisited in 1995 and similar coral colonies were found at the extreme south end of the bay. Thus comparison with the historical photo provides no evidence of change. However, these colonies were far from typical of the reef-flat community, with most of Geoffrey Bay's reef-flat comprising coral rubble and algae with very little living coral. It is not possible to tell from the historical photo whether or not this was also the case in 1952.

During the 1928-29 expedition to Low Isles many photographs were taken. Most of these depict banks of coral rubble and similar banks still exist today, although not necessarily in the same places. Other photos from the expedition show massive hard coral colonies on the reef-flat to the south of the sand cay and branching hard coral at the extreme southern edge of the reef-flat. The reports from the expedition also contain written descriptions of this area of the reef-flat. During a visit in 1995 all features of this area of the reef-flat photographed and/or described by the 1928-29 expedition were observed and photographed (see figure 1). However, in their 1993 study of reefs to the north-east of the cay, Bell and Elmetri (1995) found that there was a markedly lower density of hard coral colonies than was measured during the 1928-29 expedition.

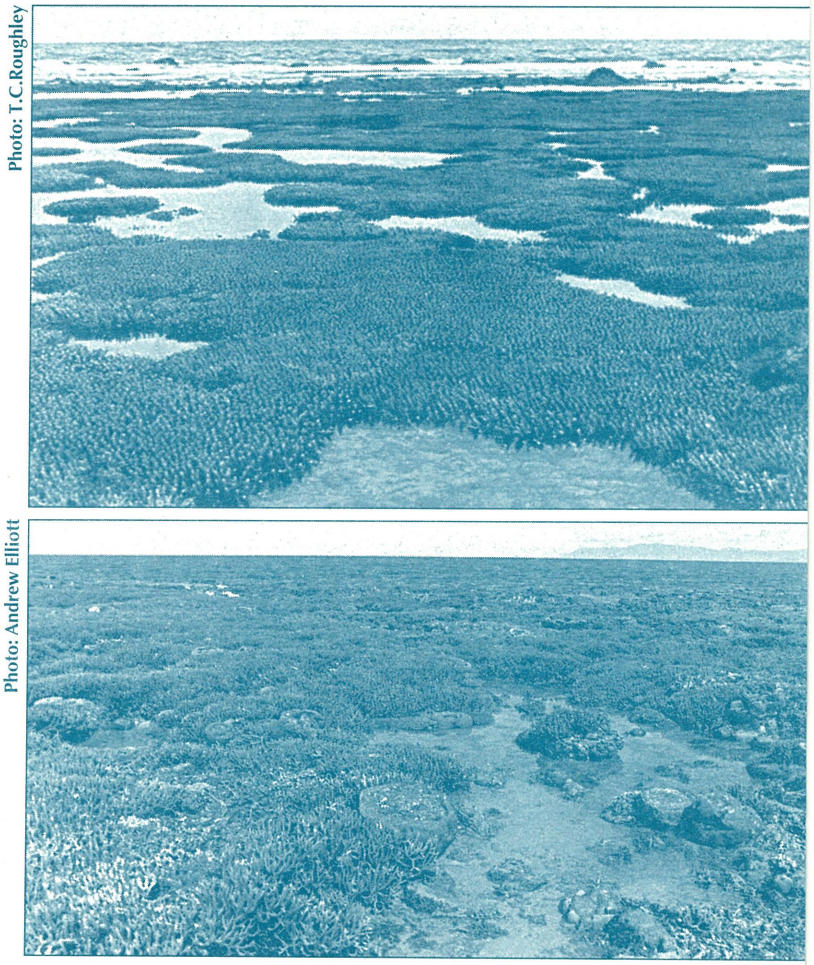


Figure 1. The edge of the reef-flat at the southern edge of Low Isles reef in 1928 (top) and 1995 (bottom). Note the high cover of branching hard corals in both photos.

Three photographs from Pickersgill Reef, north of Port Douglas, taken in the late 1960s and early 1970s show diverse reef-flat communities of soft corals, sturdy branching hard corals and smaller numbers of massive hard corals. When visited in 1995 this reef-flat showed large areas of almost identical benthic communities. However, there were also very large areas covered exclusively in much finer branching hard corals.

One photo from Daydream Island taken prior to 1950 shows well developed colonies of branching hard corals. Although preliminary photographs taken of the area in 1994 indicated that no such corals remained on this reef, a more extensive search on an extreme low tide in 1995 revealed that branching hard corals are still present on this reef-flat.

On Hayman Island reef-flat the cover of branching hard corals no longer extends onto the area where the historical photographs were taken in 1946. However, extensive areas of this reef-flat are covered in such corals and there is no reason to believe that conditions for coral growth have significantly changed.

At the four remaining sites evidence of significant change in reef-flat communities has been found.

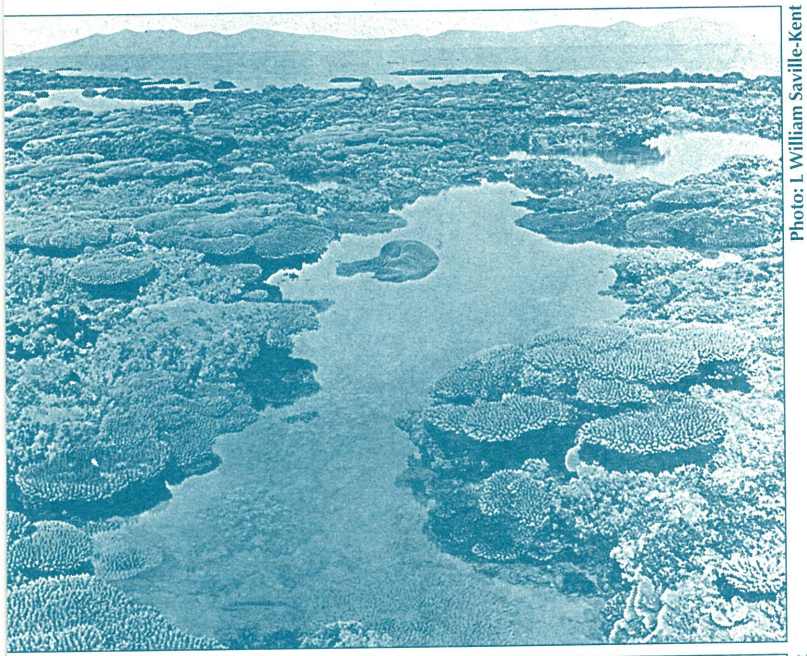


Photo: L William Saville-Kent

Photo: Andrew Elliott

Figure 2. The reef flat to the south of Stone Island around 1890 (top) and in 1994 (bottom). The cover of branching hard corals in 1890 was much higher than that in 1994.

Two sites near Bowen have both shown significant declines in cover of hard corals. Photographs of Stone Island taken between 1890 and 1910 show extensive cover of branching and massive hard corals. However, in 1994 only a very small number of very small coral colonies were found (see figure 2). In 1918 very heavy rainfall caused the death of corals on the reef-flat at Stone Island (Hedley 1925; Rainford 1925), however, anecdotal reports from long-term Bowen residents suggests that the reef reef-flat thirty years ago resembled the photos from the turn of the century. Photos from Bramston Reef, just south of Bowen, taken around 1890 show large numbers of massive hard coral colonies and also some branching hard corals. In 1994, no similar branching hard corals were found and all large massive hard corals were dead although their skeletons were still in place. As at Stone Island, the only hard coral colonies present were very small.

One photo, taken in 1958, from the reef-flat to the north of Green Island shows an extensive cover of branching hard corals, however another photo of the same area from the early 1960s shows only soft corals. The timing of this change in benthic community structure coincides with the reports of the first crown-of-thorns starfish (COTS) outbreaks at Green Island in 1961-62, and predation by COTS seems a likely explanation for the decline in cover of branching hard corals. Interestingly, this area of reef-flat was still dominated by soft corals in 1994. Three photographs from the reef-flat to the south of Michaelmas Cay taken sometime prior to 1958 show mixed communities of branching hard corals and soft corals. Today, the cover of branching hard corals appears to have greatly diminished and the reef-flat benthic community is completely dominated by soft corals.

Overall, the reef-flats of most of the reefs studied so far show little or no change from the historical photographs. However, on the four reef-flats where change has been observed, the changes are very great. On each reef where change was seen the change took the form of reduced cover of living hard coral. Potential causes of hard coral mortality on reef-flats that need to be considered include cyclones, predation by crown-of-thorns starfish, water quality, freshwater from storms, reef-walking, anchor damage and climate change.

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A GBRMPA Research Publication on the Historical Photographs Project is currently being prepared. It will contain photographs from all the sites revisited so far and will document the technical details of the project. It should be available at the end of the year.

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The successful action of Greenpeace in reversing the decision of Shell and the British Government to dump the offshore oil installation 'Brent Spar' in the North Atlantic this June has focused attention worldwide on the issue of decommissioning similar infrastructure, including in Australia. In this edition of Slick Talk we explore this issue in the Australian context.

Images of orange jumpsuit clad eco-heroes in high speed Zodiac inflatables mounting daring raids against the demons of industry returned to world television screens in June this year, as Greenpeace took direct action against plans by Shell to dump the obsolete offshore oil storage and transfer facility 'Brent Spar' at sea. European public reaction to the proposal was even more fierce than against France's proposed renewal of nuclear testing. The reaction included boycotts against Shell products across Europe and even fire bombings and shootings at German petrol stations.

The massive negative publicity generated by the Greenpeace campaign, combined with political pressure exerted by European leaders at the G-7 summit in Canada resulted in the scuttling plan being abandoned. The 'Brent Spar' was instead towed to a Norwegian fiord to await dismantling and scrapping on land, probably back in the United Kingdom.

A purely scientific assessment of the situation may indicate that sinking the huge structure in water that is more than 2 kilometres deep and at least 250 kilometres from the nearest land is actually the best net environmental solution. Some groups, including the fishing industry, are concerned that towing the structure to shore and dismantling it poses the threat of pollution of sensitive coastal areas, as oily sludges and other wastes still on board may be released in the event of an accident.

However, the precedent that would be set by allowing the dumping to go ahead, which Ritt Bjerregaard, environment commissioner at the European Union said 'will send a political signal that the sea may be used as a rubbish dump', outweighed purely technical considerations. There are currently over 400 offshore facilities in the North Sea alone. In the next 10 years, 50 large British platforms will be decommissioned (Pearce 1995). Developments in relation to the 'Brent Spar' will obviously influence how future decommissionings are handled.

The Australian offshore petroleum industry is small and relatively young by international standards. There are a range of production facilities spread over 23 producing fields, currently restricted to Bass Strait, the North West Shelf and the Timor Sea. These facilities include simple wellheads and manifold systems which sit on the ocean floor (known as Subsea Completions), unmanned monotowers, and the larger platforms with permanent workforces that are more representative of the general public's image of the offshore oil industry. Despite its relatively small size by world standards, the industry is extremely significant to Australia, with net self sufficiency in crude oil alone being 86% and petroleum exports earning $10.5 billion in 1990-91.

Significant and ambitious offshore exploration and development efforts continue, especially in the North West Shelf area and Bass Strait. As reserves decline, the decommissioning issue will become a significant one for Australia.

The level of consideration given to the potential impacts of decommissioning, prior to the 'Brent Spar' affair, may be reflected by the recent review of the environmental implications of offshore oil and gas development in Australia (Swan et al. 1994). This comprehensive 695 page report contained only five brief paragraphs on the negative impacts of decommissioning, and these related mainly to the socio-economic effects of coastal centres closing down after production ceases. It did contain a small section on the potential positive opportunities for creating artificial reefs, but nothing on the other potential negative impacts of decommissioning.

Current Australian policy on the decommissioning of offshore oil facilities encompasses the guidelines of the International Maritime Organization (IMO), with each case considered on its merits under the provision of the *Petroleum (Submerged Lands) Act 1967*. The IMO guidelines (which also applied to the 'Brent Spar'), state that disused facilities should ideally be removed, although partial removal or non-removal may be allowed on a case by case basis depending on age and size of the facility, depth of water and impacts of removal.

Should the facility, or part of the facility, be removed and disposed of by dumping at sea, such dumping will be

assessed and regulated under the London Dumping Convention and the Australian legislation which implements that convention, the Environment Protection (Sea Dumping) Act 1981. This Act is administered by the Commonwealth Environment Protection Agency. Before a sea dumping permit is approved, the proponent must demonstrate that no unacceptable environmental impacts or impacts on other marine resource users will occur. Sea Dumping Permits will normally require all contaminants, including oil and oil sludges, to be removed prior to dumping. However, the stricken BHP bulk carrier 'Iron Baron' was recently dumped off Tasmania with about 70 tonnes of oil and 26 000 tonnes of manganese ore still on board.

To date, only two offshore oil facilities in Commonwealth waters have been decommissioned. These are the Cobia 2 Subsea Completion in Bass Strait, and the Talisman Floating Production and Storage Operation (FPSO) off Western Australia. In the case of the Talisman facility, the FPSO, which is essentially a ship, simply sailed off to another use. Underwater structures (including gravity boxes, buoyancy tanks and flow lines) were towed into deep water for dumping. The rationale behind this decision was primarily to preserve safety of navigation and prevent snarling of fishing trawlers.

It seems sensible and prudent to consider the decommissioning of each facility on a case by case basis, as each situation may result in different environmental impacts and will require a different management response to prevent or reduce these impacts. However, it is vital that the decommissioning and the end use of the site should be predetermined and pre-agreed in the design phase and constitute a condition of approval prior to the project even commencing. Design of the facilities can then incorporate the necessary features to allow more cost-effective decommissioning.

Like the mining industry, the offshore petroleum industry deals with decommissioning issues in development applications and plans, project design and financial planning. In addition, the offshore industry may face further options at the time of decommissioning which may be 30 or 40 years from project commencement. Unlike the mining industry, there are limited opportunities for progressive decommissioning of offshore projects as they proceed.

In determining the pre-agreed decommissioning option, a comparative environmental risk analysis which assesses all options, including removing the facility completely, leaving it in place or dumping it at sea, should be conducted. The option which results in the best net environmental benefit and which includes consideration of economic viability and technical feasibility can then be selected.

The system needs to allow some flexibility, as decades may pass between determining the pre-agreed decommissioning option and decommissioning actually occurring, during which time advances in science and technology may provide more optimal solutions. The Australian offshore petroleum industry argues that this approach, with decommissioning options firming as projects near their decommissioning date, allows governments and industry the capacity to accommodate changing requirements and opportunities. Notwithstanding this flexibility, the Petroleum (Submerged Lands) Act specifies that at the discretion of the Designated Authority, all property will be removed at the expiration of the permit, licence or lease, with due regard to the protection of the area's natural resources.

Some interesting possible decommissioning options proposed by John Gray of the University of Oslo (Pearce 1995) are to leave the rigs in place and use them as research platforms with excellent accommodation and other facilities, or use them as fish aggregation devices and bases for fishing operations, or better still ban fishing around them and use them as management bases for marine protected areas and as fisheries refugea.

In the United States of America, the fishing industry enthusiastically embraces and promotes the 'rigs to reefs' program which manages the toppling or placement of decommissioned platforms as artificial reefs and fish habitats. As it is difficult for governments and industry to foresee rehabilitation demands and determine what additional options may be appropriate a few decades hence, the industry necessarily incorporates some flexibility into decommissioning plans.

While the Australian offshore industry and Government regulators discuss decommissioning options from inception, the 'Brent Spar' episode has certainly concentrated the minds of all parties. Let's just hope that the reactionary activities seen in Europe this year are avoided here through sound pre-planning and pre-emptive management during the design phase.

Thanks must go to Peter Cochrane of the Australian Petroleum Exploration Association and Tim Gentle of the Western Australian Department of Environmental Protection for providing information for this article.

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(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 or GBRMPA).

BALLAST WATER IN QUEENSLAND

Queensland Ports to Undertake Ballast Water Risk Assessment

The Ports Corporation of Queensland which is responsible for 7 bulk export ports, together with the individual Port Authorities of Cairns, Townsville, Mackay, Rockhampton and Bundaberg, has called for tenders to conduct a Ballast Water Risk Assessment for 12 Queensland ports.

The Risk Assessment will be a desk-top study involving extensive searching of literature and shipping records. The main outputs of the assessment will be:

- identification of all source ports from which ballast water is imported to the participating Queensland ports,
- characterisation of physical, chemical and biological environments at the source ports,
- development of an Environmental Similarity Matrix for each participating Queensland port and its set of source ports, and
- an assessment of the risk of foreign marine organisms being introduced and establishing in Queensland via the participating ports based on the Environmental Similarity Matrices, the life history and environmental requirements of likely risk species and all stages of the ballast water cycle.

The Risk Assessment has been developed in consultation with the National Ballast Water Research Advisory Group and the CSIRO Centre for Research on Introduced Marine Pests. The results of the study will be made available to government and industry to assist development of ballast water management measures, and will also be publicly available.

Ports Corporation of Queensland Funds Treatment Research

In addition to undertaking its Ballast Water Risk Assessment, the Ports Corporation of Queensland believes that a high priority must be given to the research and development of viable methods for killing foreign marine organisms in ballast water, in order to develop a practical solution to this problem.

To this end the Ports Corporation has provided $92 000 over three years to the Cooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef (CRC Reef Research Centre), in Townsville, for an engineering PhD student, Mr Darren Oemcke, to undertake such research. Mr Oemcke will be testing the effectiveness of conventional waste water treatment technology, such as ozonation and UV treatment, on organisms found in ballast water. His research stems directly from the recommendations of the Australian Quarantine Inspection Service Ballast Water Research Series Report No. 1, *Ballast Water Treatment for the Removal of Marine Organisms*.

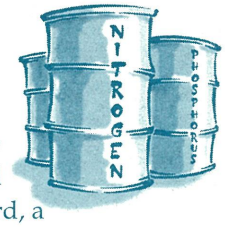
Mr Oemcke hopes that an end result will be the design of a pilot plant for either a ship-board or shore-based treatment facility which complies with the requirements of the Draft Australian Ballast Water Management Strategy, in that it must be safe, practicable, cost-effective and environmentally acceptable.

Mr Oemcke is seeking collaboration with other researchers in this area and also additional support for the project. The Townsville Port Authority and Dalrymple Bay Coal Terminal at the Port of Hay Point have already come forward with an offer to assist with access to ships in their ports and other in-kind support.

For further information contact:
Steve Raaymakers, Ph. 07 3225; 1035 Darren Oemcke, Ph. 077 81 5081

Historical Fertiliser Usage in Catchments Adjacent to the Great Barrier Reef Marine Park

Andy Steven



One major objective of the Great Barrier Reef Marine Park Authority's Water Quality Program is to quantify the potential downstream effects of agricultural practices on the Great Barrier Reef. Jim Pulsford, a consultant with a long involvement with the fertiliser industry, was commissioned by the Authority to collate historical data on nutrient applications of nitrogen and phosphorus in fertilisers and stock feed supplements, for each of the river catchments adjacent to the reef. His report *Historical nutrient usage in coastal Queensland river catchments adjacent to the Great Barrier Reef Marine Park* will soon be published by the Authority.

BACKGROUND

The land catchments adjacent to the Great Barrier Reef occupy 423 725 km^2, about 20% larger than the Great Barrier Reef Marine Park (349 000 km^2). They vary considerably in rainfall, topography and the proportion of rainfall which runs off the catchment. From the Daintree River to Cardwell more than half of the average rainfall runs off, whereas in the central and southern areas the proportion of rainfall which runs off is much lower.

Land-use practices in these catchments depend on landform, climate, availability of irrigation, soil types and the economics of adapting natural conditions to produce various horticultural and agricultural crops. Agricultural crops, mostly sugarcane, comprise 3% of the total catchment area, improved pastures containing sown species account for 8% and the remainder is mostly devoted to pastoral use or forestry.

As most of the soils of the region are naturally deficient in the major elements, nitrogen, phosphorus and potassium, addition of these has been necessary for large-scale crop production, particularly sugarcane, fruit and vegetables.

A combination of high runoff potential and high rates of fertiliser use provides an opportunity for leaching, erosion of topsoil and hence nutrient losses from agricultural areas to streams and rivers and eventually to the coastal zone.

It has been estimated that present day exports of nutrients and sediment from catchments to the coastal zone are 3-5 times higher than could be expected from conditions prior to European settlement (Moss et al. 1992; Gourlay & Hacker 1986). Much of this increased nutrient export has occurred in the last 40 years from rapid deforestation, followed by agricultural development and urbanisation.

THE REPORT

The report covers 28 catchments from the Daintree River (16°S) to the Mary River (25°S), for the period from 1910, when records of the first fertiliser applications were made in north Queensland, to 1990. It provides, for each catchment, a summary of major land uses and some details of fertiliser-use practices. The area, mean annual runoff and rainfall data are tabulated for each catchment, as are historical usages of phosphorus and nitrogen.

For 1990, tables are provided to show the total quantities of the nutrients applied to the main groupings of crops and pastures, the average rates for the catchment and ratios of nutrient applications to mean annual runoff volume.

The information relies heavily on fertiliser industry sources for details of the products supplied at various times to agricultural areas. The data were modified to allow for changing nutrient content of fertiliser products with time, and for differences in the groups of products for which statistics were obtained.

Allocation of nutrient applications to catchments presented difficulties, as local authority areas in Queensland rarely relate to boundaries of river catchments. As sugarcane production constitutes the bulk of fertiliser usage

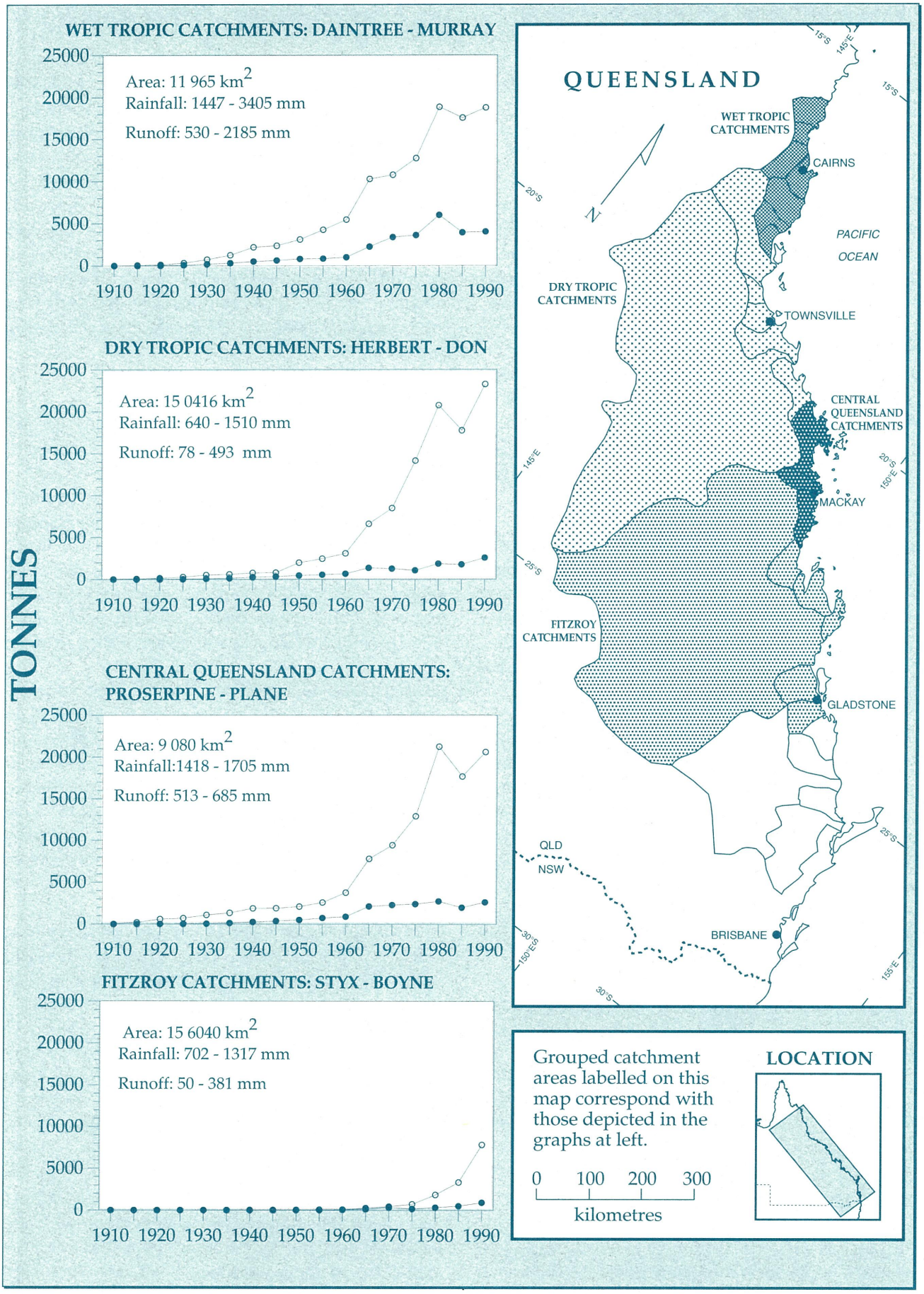


Figure 1. Tonnes of nitrogen and phosphorus applied in five year intervals (1910 - 1990) to four regional catchment groups.

(70% of the total nitrogen and 55% of the phosphorus in 1990), and since there have been changes in fertiliser products supplied, a detailed study of changes in the areas and production of sugarcane at the catchment level was essestial.

MAJOR FINDINGS

Figure 1 displays tonnages of nitrogen and phosphorus applications in 5-yearly intervals for four regional groups of catchments from 1910 through to 1990. Figure 2 indicates the average rates of nitrogen and phosphorus applied per hectare in 1990 for each of the 28 catchments.

Nutrient application

Application of nitrogenous and phosphatic fertilisers to crops and pastures increased dramatically following World War II, largely due to increasing areas of sugarcane production. The greatest increases in fertiliser use occurred in the dry tropic and central Queensland catchments.

In 1990 approximately 83 000 tonnes of nitrogen were applied in fertiliser to crops and pastures. This is about the same quantity as had been applied, cumulatively, in the period to 1945. Cumulative nitrogen applications in the period up to 1990 were about 2 million tonnes, equivalent to 53 kilograms nitrogen/hectare for the whole area adjacent to the Great Barrier Reef.

Of the 83 000 tonnes of nitrogen used in 1990, sugarcane accounts for about 71%, field crops over 13%, pastures 8% and all fruit and vegetable crops 8%. A reduction in nitrogen use on sugarcane since a peak in 1980, has been offset by an increase in nitrogen use on irrigated crops, especially cotton. The reduction in the share of nitrogen applied to sugarcane is due largely to reduced rates of application following lower sugar prices and the increasing adoption of green cane harvesting in higher rainfall areas of north Queensland.

The intensity of nitrogen use varies considerably between catchments, with higher rates where rain-grown sugarcane production is the dominant land use (figure 2). Six catchments in north Queensland, where average annual runoff exceeds 50% of rainfall, occupy 2.6% of the total area and accounted for 20% of 1990 nitrogen use. High application rates of nitrogen occur notably in the Pioneer, Plane, Haughton, Johnstone and Russell-Mulgrave catchments.

Phosphorus applications to crops and pastures and for livestock supplementation were about 13 500 tonnes in 1990; about the same amount as had been applied, cumulatively up to 1940. Cumulative phosphorus applications in the period to 1990 were about 400 000 tonnes, equivalent to about 10 kilograms/hectare for the whole area.

Sugarcane accounted for 55% of phosphorus use in 1990, pastures 19%, field crops nearly 14% and all fruit and vegetable crops over 12%. The intensity of phosphorus use varies considerable between catchments, with the Johnstone, Mossman and Pioneer catchments receiving above 4 kilograms/hectare in 1990 (figure 2). However, twelve of the basins, occupying 86% of the total area, had average application rates of less than 1 kg/ha in 1990. The six north Queensland catchments, where average annual runoff exceeds 50% of average rainfall, occupy 2.6% of the total area and accounted for 25% of the total phosphorus applied in 1990.

Potential nutrient losses

Of the 80-85 000 tonnes of nitrogen being applied annually in fertiliser, 20-30 000 tonnes are contained in the products sold from the farm. Most of the remaining 50-65 000 tonnes is lost to the atmosphere, and to runoff and leaching from the site of application. This residual nitrogen has the potential to enter the water cycle via runoff of soluble products such as urea, dissolved ammonium and nitrate or in sediment and organic matter to streams and rivers, and by percolation to underground water resources which may subsequently enter streams.

Annual losses to runoff and leaching are variable, depending mainly on rainfall amount and intensity, on density of ground cover and on fertiliser application methods and timing. Losses are likely to be greater in the higher rainfall areas where runoff as a proportion of rainfall is high. Highest losses are likely to occur in the Haughton, Plane, Pioneer, Burrum and Kolan catchments (> 3 kilograms of nitrogen applied per 1000 megalitres of runoff).

Of the 13 000 tonnes of phosphorus applied annually in fertiliser, 1-2 000 tonnes are contained in the products sold from the farm. Most of the remainder, together with similar proportions of phosphorus applied previously, accumulates in the soil in forms which are of low availability to plants. As with nitrogen, there is a high potential in some areas for loss of phosphorus from agricultural systems to streams, rivers and aquifers. Such losses are likely to be higher where rainfall and runoff are highest and where residual soil phosphorus levels are high. Greater losses are likely to occur in the Burrum, Haughton, Kolan and Plane (> 0.6 kilograms of phosphorus applied per 1000 megalitres of runoff). These losses are mediated by the soil characteristics and the application methods and rates. It is likely that a high proportion of this phosphorus is still contained in the topsoils of the 600 000 hectares of land to which it has been applied over the last 70 years.

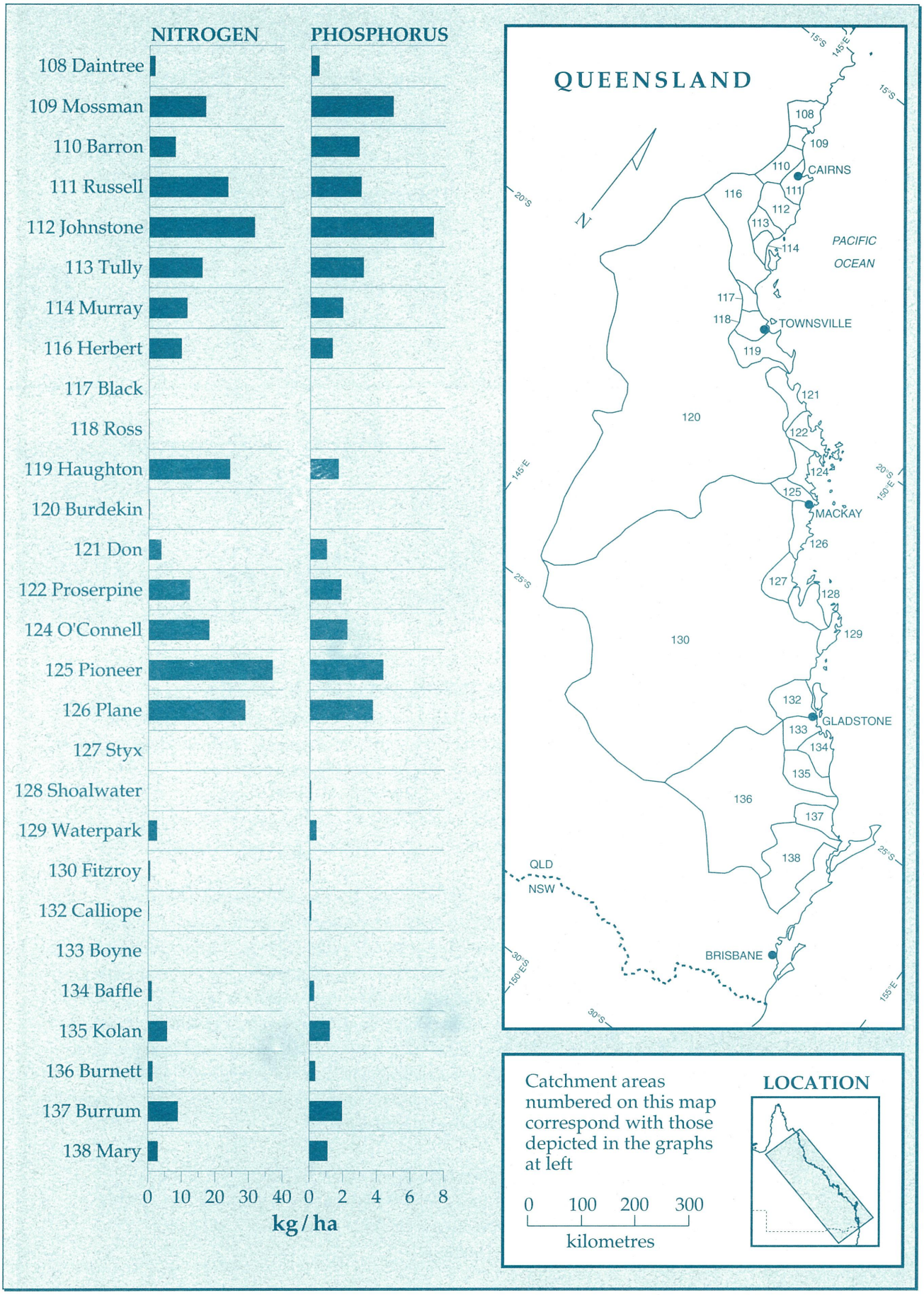


Figure 2. Average application rates of nitrogen and phosphorus (kilograms per hectare) for 1990 in catchment areas adjacent to the Great Barrier Reef

CONCLUSION

The report details, at a catchment level, applications of nitrogen and phosphorus in fertilisers and stock feed supplements. The historical data provide a time series which may be of use in relating soil applications to stream nutrient contents and, in the case of phosphorus, perhaps to sediment compositions.

The report highlights the complexity of factors of importance in studying actual losses and the mechanisms of loss from agricultural and pastoral areas. It calls for the adoption of land-use practices which maximise nutrient use efficiency, so as to minimise any adverse impacts, particularly those directly related to the Great Barrier Reef ecosystem.

References

Gourlay, M.R. & Hacker, L.F., 1986, *Pioneer River Estuary: Sedimentation studies*, Dept of Civil Engineering, University of Queensland, Brisbane, 207p.

Moss, A.J., Rayment, G.E, Reilly, N. & Best E.K., 1992, *A preliminary assessment of sediment and nutrient exports from Queensland coastal catchments.* Report of the Queensland Department of Environment and Heritage and the Department of Primary Industries, Brisbane.

Special Announcement:
NEW JOURNAL TO BE PUBLISHED

MANGROVES AND SALT MARSHES, an international journal concerned with the science and management issues of tidal wetlands, particularly mangroves and salt marshes, is due to be released about November 1996. This journal will be published in Holland and will include research and discussion papers, short reports and, occasionally, invited review papers on topical subjects.

Mangroves and Salt Marshes will cover pure and applied science in biological, chemical and physical oceanography as well as fisheries, forestry, siltation, aquaculture and the sustainable use of mangroves and salt marshes. Papers describing multi-disciplinary studies on mangroves and salt marsh ecosystems, and on their interaction with the land, sea and man, will also be considered. Linked adjacent ecosystems such as seagrasses, coastal waters and land will also be addressed.

Mangroves and Salt Marshes will be published quarterly and is aimed at all those actively engaged in the scientific research, management or commercial exploitation of tidal wetlands.

For further information please contact Dr Eric Wolanski at the Australian Institute of Marine Science, Townsville on (077) 53 4243.

COTS COMMS

Dr Brian Lassig and Udo Engelhardt

In the December 1994 issue of *Reef Research* we mentioned that we'd received reports of increasing numbers of COTS on quite a few Indo-Pacific reefs from South Africa to the Cook Islands. We asked overseas readers and local globe-trotters for any information on the current and historical status of COTS populations throughout the Indo-Pacific region. Since then we've pleaded for this information across the Internet and at a number of conferences and seminars. The response has not been overwhelming. In fact we've had one. Dr Russ Babcock of Leigh Marine Laboratory recorded a spot (localised) outbreak in the Kermadec Islands (roughly 30°S 175°W) to the north east of New Zealand. Russ commented that although COTS have been reported at the Kermadecs since the 1970s, this was the first report of an outbreak. The low coral cover (<5% below 2 m depth) means that the starfish are likely to have a significant effect on the area (before they die of starvation).

So we'll try again. Our focus is logically on our own doorstep, but we can learn an enormous amount from information on the current and historical status of COTS populations in other areas. If this can be combined with local information on human use and local environmental conditions we may be able to tease apart some of the complexities of the issue. ***Reports of no or very few COTS are just as important as observations of outbreaks.***

If you do have (or could get or know of anyone in the position to provide) information on COTS from anywhere in the Indo-Pacific region, we'd very much appreciate hearing from you. All contributions will be cheerfully acknowledged.

CURRENT COTS

Reef-user Reports (COTSWATCH)

Thanks to our dedicated bunch of volunteer observers, the COTSWATCH program is going from strength to strength. The program's ,vital statistics' of 158:231:68 for the period from May to early August 1995 are impressive by anybody's standards. The 158 reports received over the two month period provided details on 231 individual sites on 68 different reefs. For obvious reasons (COTS activity and efforts in promoting the scheme), the focus has again been on reefs in the Cairns Section of the Marine Park. A great number of reports from outer shelf reefs in this Section (e.g. Ribbon reefs) confirmed that current starfish activity is pretty much restricted to mid-shelf reefs.

A particularly encouraging trend is seen in the quality of reporting provided by COTSWATCHERS. More and more reports include detailed maps and descriptions of the sites and locations where observations were made. Also, the number of zero-sighting returns clearly indicates an appreciation of the usefulness of this type of information. Well done everyone and keep up the good work! And remember, if you are running low on survey forms, just give us a call so we can maintain the current strong flow of information. As you can imagine, we have stacks and stacks of forms sitting here waiting to be completed by keen Reef-users.

Finally, a brief reminder that the COTSWATCH scheme aims to provide for a two-way flow of information. If there is a related topic that you would like some feedback on, please make a note on the back of a completed form and we will try to respond to your needs.

Many thanks to the following COTSWATCHERS (*May - early August 1995*):

T Waldron / QDEH Pallarenda, **C Williams** / QDEH Cairns, **J Purcell** / Great Adventures Cruises, **S Moon** / Ocean Spirit Cruises, **J Curtin** / QDEH Cairns, **J Haig** /

QDEH Cairns, **S Whelan** / Cairns, **Pro Dive** / Cairns, **M Wilson** / Airlie Beach, **S Richards** / Cairns, **M Schaer** / ProDive Cairns, **D Wachenfeld** / Townsville, **J Cruise** / QDEH Airlie Beach, **R Fitzpatrick** / Townsville, **A Schneider** / Townsville, **G Patterson** / Kuranda, **Great Adventures** / Cairns, **I Stapleton** / Port Douglas, **W McFarlane** / Cairns, **R Schutte** / Great Adventures, **C Williams** / QDEH Cairns, **J Cowie** / Cairns, **P Hough** / Townsville, **B Jewell** / Great Adventures Cruises, **H Sweatman** / AIMS, **W Legg** / Rockhampton, **G McGarry** / Cairns, **S Woodford** / Great Adventures.

AIMS Surveys

Since the March issue of *Reef Research*, the AIMS Monitoring team has surveyed reefs in the Cairns, Innisfail, Townsville, Cape Upstart, Whitsunday and Pompey Sectors. Although reefs in the Cairns Sector topped the COTS count, very few starfish were recorded during any of the surveys. No reefs came close to being classified as outbreaks.

Sector	No. Reefs Surveyed	Max. No. COTS on Any Reef	Total No. COTS
Pompey	4	1	2
Whitsunday	11	1	1
Cape Upstart	6	1	1
Townsville	8	0	0
Innisfail	3	1	2
Cairns	12	5	10

THE 1995-96 COTS PROGRAM

This year is going to be something of a loaves and fishes act. With the lowest level of funding for the COTS Program in 10 years (see figure on the right) we're having to focus efforts even more than in previous years. It's a critical time for COTS research with rare opportunities to investigate the causes and dynamics of outbreaks in their early stages. It's also an opportune time to conduct baseline surveys and collect reference material prior to the possible onset of another outbreak episode.

Some of the details of the 1995-96 COTS Program have not yet been determined, but we will focus on two main areas:

- COTS dynamics; and
- COTS and water quality.

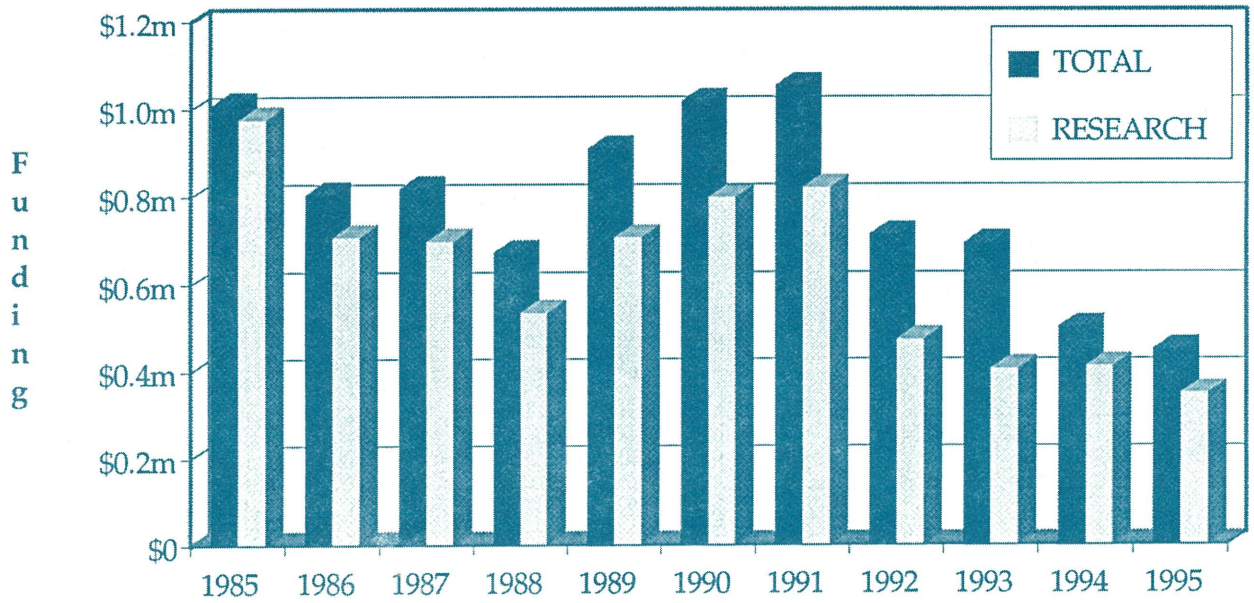
COTS Dynamics

The AIMS broadscale COTS surveys (incorporated into the AIMS Long-term Monitoring Program) provide a GBR-wide perspective of the COTS phenomenon. Against this background, the fine-scale COTS surveys in the Cairns Section of the Marine Park provide a greater level of detail on the populations in this critical area. As reported in previous issues of *Reef Research*, they have the potential to allow us to hindcast and forecast changes to the COTS populations in this area. At an even finer level of resolution, population dynamics studies on particular reefs give us information on key processes such as starfish movement, growth and mortality. This suite of techniques allows investigation of the issue at the variety of scales necessary to understanding the causes of outbreaks.

The fine-scale COTS surveys will continue in the coming year with funding from the CRC Reef Research Centre. Preliminary results of the surveys last summer were reported in the March edition of *Reef Research*. Further analyses of the data indicate that of the 24 mid-shelf reefs in the Cairns Section surveyed, 12 either have, or are likely to have within the next 6-18 months, COTS outbreaks of various scales. The latter group of reefs are characterised by high densities of juvenile starfish that are likely to grow, become more conspicuous and cause obvious coral damage. We refer to them as incipient outbreaks. Two reefs currently have active reef-wide outbreaks, 9 have active spot (localised) outbreaks (7 of these are incipient reef-wide outbreaks) and 1 reef which is currently classified as non-outbreaking is likely to have an active outbreak.

Additional years of data from these surveys will greatly improve our abilities to both hindcast (to detect previous starfish recruitment patterns in time and space) and to make more reliable projections of the dynamics of COTS populations.

As part of both the broad-scale and fine-scale surveys we will be collecting starfish spines for ageing as well as tissue samples for genetic analyses.



Total (research and monitoring) and research (only) funding for the GBRMPA COTS Program from the 1985-86 to 1995-96 financial years

These analyses could help to unravel the mechanisms of outbreak origins. The geographic spread of outbreak origins has significant management implications.

COTS and Water Quality

The COTS - Water Quality Working Group recommended three high priority project areas that will be funded in 1995-96:

1 Identification of peak spawning times and environmental triggers responsible for initiating spawning activity in COTS populations in the Cairns Section of the Great Barrier Reef Marine Park

Research into the reproduction of COTS by Dr Russ Babcock significantly enhanced our understanding of the reproductive biology and behaviour of the starfish, at least in the Central Section of the Great Barrier Reef. However, results of the COTS rearing project at AIMS over the last couple of years have indicated that individual starfish differ enormously in their potential to produce healthy, viable gametes. Gonad chemicals may provide a much more accurate measure of the reproductive potential of mature COTS. Drs Ayukai and Bandaranayake at AIMS will be evaluating the reliability of endogenous chemical contents in COTS gonads as a measure of individual reproductive potential and using this technique to determine peak spawning times and possible environmental triggers. Research will be done at Lizard Island, and comparisons will be made with populations from more southern reefs. Better information on this critical area will assist in determining the timing of spawning and facilitate correlative studies of prevailing environmental conditions that might be associated with outbreaks.

2 Desktop studies into the possible uniqueness of the Cairns Section

The last two recorded COTS outbreak episodes and the current increase in populations originated in the Cairns Section of the Marine Park. It has been suggested that the northern origin is forced by the time taken for coral to recover on reefs (i.e. because northern reefs were affected first, they are the first to recover sufficiently to support large COTS populations again). However, outbreaks are extremely patchy and variable in effects. Only a small proportion of reefs were, seriously' affected in the last outbreak and on the majority of reefs sufficient coral cover should have remained to sustain COTS populations. An alternative explanation of the consistency in outbreak origins is that there is something special about the Cairns Section that predisposes it to originating COTS outbreaks. A series of desktop studies to review information on a variety of aspects relevant to COTS will be conducted to provide clues

to this possible uniqueness. The list of aspects to be reviewed currently includes:

- hydrodynamics,
- geomorphology,
- water quality,
- phytoplankton community composition, and
- anecdotal information.

3 A review of available recruitment data for coral reef species in the Cairns Section over the past 30 years

COTS larvae derive most of their nutritional requirements from relatively large phytoplankton (>2 µm). They are probably not unique in this regard. If the hypothesised connection between water quality and COTS outbreaks holds, other species with similar dietary requirements should also experience highly successful recruitment events when conditions are favourable. We plan to conduct a desktop study to review available recruitment data to determine whether or not this has occurred in the past, and if there is any concurrence with COTS population changes.

Beyond these two major areas, we are hopeful of initiating a project to determine the most cost effective local control strategies (with funding from the CRC Reef Research Centre) using techniques developed over the last couple of years. We've budgeted a small amount to have an independent review of the program conducted this year. The last review was undertaken by Dr Bob Johannes in 1991 and it would certainly be useful to have a measure of our progress over the last 4 years and a different perspective on future directions for the program.

The COTS extension program will continue to keep managers, researchers and the general public informed of the status of COTS populations and or research into the issue. COTS COMMS lives!

THE FUTURE OF COTS RESEARCH

As we've mentioned in a couple of previous issues of COTS COMMS, we've been working on a review of the COTSREC program from its birth in 1989 to the present (well June 1995 anyway). As part of the process, the review identifies a number of areas of research that need to be addressed when the financial and environmental conditions are favourable. Later in the year we'll be asking experts in the identified areas for their assistance in outlining research projects and in providing estimates of project costs. A collation of these outlines will form the basis of a COTS Research Contingency Plan. We thought that it would be useful at this stage to advertise the identified research needs and to ask for input from anyone with interests in these areas. The future directions we've identified include:

- monitoring of massive coral communities to provide information on population dynamics before, during and after COTS outbreaks,
- genetic and hydrodynamic model studies to determine the degree of connectivity among increasing COTS populations in the Cairns Section,
- research into the food sources and dietary requirements of COTS larvae in the field (in particular the effects of naturally occurring nutrient levels and short-term pulses on food sources and larval health and survival),
- research into factors other than nutrition affecting COTS reproduction, larval development, survival and settlement,
- research into the predation on COTS in the field, and
- modelling of COTS population dynamics.

The input we're seeking for each of these directions (and others if you believe we've missed any key research areas) is an outline of possible projects including objectives, duration, methods and notional total cost. Please forward outlines to us ASAP or give us a call to talk further about your suggestions.

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