Reef research

The coral reef exhibit is a ideal research tool. Our research effort at the Aquarium is applied to determining the optimum conditions for the growth of our captive coral reef. The reputation of corals as difficult animals to keep in the home aquarium are well deserved. They are fussy about their surroundings compared to reef fish which have wider environmental tolerances. Corals are the focus of our research activities as we learn about ways to improve coral survival in our tank. Investigations completed or underway at the Aquarium have examined: development of a test for nutritional state of corals, the effects of oil on corals, the light regime in the tank[9] and a comparison of the benthic plankton community of the Great Barrier Reef with the Aquarium coral reef (Figure 15).

Conclusions

Ultimately education is the key to public support for the conservation and wise use of natural resources. The Great Barrier Reef Aquarium provides a readily accessible window on the reef and a wide range of educational experiences and interpretive services. Reproducing a section of the Great Barrier Reef on land, as a self supporting natural ecosystem, was a difficult and exacting task. Our Coral Reef Exhibit is unique in but costly to maintain in terms of skilled labour for operation, maintenance, collecting and monitoring and electricity costs. A captive coral reef ecosystem, for demonstrating and interpreting processes and issues affecting the Great Barrier Reef, is a powerful public education facility for assisting the work of the GBRMPA.

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MANGROVES IN TROPICAL REGIONS ADJACENT TO THE GREAT BARRIER REEF

Joe Baker

I speak on behalf of Alistar Robertson and his colleagues of Program 1 (Coastal Processes and Resources) of the Australian Institute of Marine Science (AIMS). They have established world leadership in understanding of the ecology of tropical mangrove ecosystems. I hope to communicate some of the excitement of this research.

Mangroves are often regarded as small and insignificant trees growing on the coastal fringe. Many people believe they are confined to the tropics. However, there are mangroves in the gulf systems of South Australia. In Western Port and other sections of southern Australia mangroves are common. As one moves up the New South Wales coast, mangroves become more plentiful and more diverse in form until we come to the North Queensland region. At our study site on Hinchinbrook Island there are more than 35 different species of mangrove trees. Mangroves are not confined to the tropical regions but the greatest diversity of mangrove species does occur in the tropics.

What are mangroves? The origin of the word “Mangroves” has been analysed by one of the leaders of mangrove research, Dr Marta Vannucci, in work conducted for UNESCO and with the International Society for Mangrove Ecology. She says:

“I finally concluded that the word mangrove would be African. The word was learned by the Portuguese on the west African coast by the early XV century. In fact, in discussing the fortifications to be made at Cacheu, which is present day Guinea-Bissao ,(Anon. Fortificacao de Cacheu, c. 1600, courtesy M.E. Bandeira Santos, C.E.H.C.A. Lisbon, pers. comm.) on the Guinea coast, “mangue sticks” (paus de mangue) are mentioned as being normally used to fence in the lands of the Portuguese to "protect them from continuous harassment by the natives". The "alagados" (flooded low lying or coastal areas or mangroves) shown on ancient Portuguese charts are marked with symbols still in use on nautical charts.

The mystery was finally solved by Dr E.S. Diop (pers. comm. 1988) who told me that in his mother language, Wolof, which is the national language of Senegal, the name for mangroves in mangue, with exactly the same pronunciations in Portuguese. The people from the "rivers of the south" (down to Guinea-Bissao, e.g. R. Geba) use the word mangle or mangli, which explains the origin of the Spanish word for the mangroves - mangle. The word mangue, therefore appears commonly in Senegal, Gambia, Casamance and Guinea; this name the Portuguese had already adopted in the XV century and spread throughout the world. Later the Spaniards learnt and adopted the words mangle and manglar that are used in all Spanish speaking cultures.

Later the words mangue and mangroves became a synonym for danger, confusion, wastelands. Mangrove swamps were in fact ill reputed areas and neither their intrinsic value nor the service they render to human kind or the role they play in the great drama of nature, were recognised. In the late 1870's a "Manual for the conversion of Wastelands" was published, where the "wastelands" were the Sunderbans, perhaps the largest single unfragmented area of mangroves in the world, on the delta of the Ganga-Brahmaputra river system. The Sunderbans (the word means "beautiful forests") are not only among the most beautiful mangroves, but are also among the most productive. Under the pretext of converting to "better use" such "bad" areas, much damage was done to an important ecosystem. All this happened because no outsider had tried to really understand the mangrove ecosystem and there had not been a local Chief Seattle to tell the invader that man is part of the ecosystem and should live in harmony with it."

Fundamentally mangroves may be regarded as plants that grow in salt water. One can have mangrove ferns, mangrove weeds, mangrove palms and mangrove trees of many different varieties. As one moves from the sea-shore environment one observes different species of mangroves which appear to have adapted to different levels of salinity of the water. The key feature of mangroves is that they can live in salt water. In this simple statement there is perhaps the potential for Australian researchers to study and develop tissue culture techniques to find the way in which other plants may be modified to grow successfully in our inland waters where we are plagued by the problems of increasing salinity. If we could develop such trees we may in the long term assist in the revitalising of the fresh water systems of our continent. Such a development could perhaps lead to allowing replanting of native trees in our inland areas as the water salinity decreases as a result of good management practices.

The mangroves of our coastal areas represent an enormous resource not only for the biological productivity (which I will explain) but also for the physical protection that they afford to our coastline. I would also like you to keep in mind that, in many countries, mangrove trees are already used as sources of energy, and as sources of timber for construction. We believe that within the next 30 years mangrove forests can be grown in Australia to produce timbers that will be suitable for cabinet making and for other domestic use. Some of the timbers on display at the Australian Institute of Marine Science, and notably the mangrove cedar, have attracted significant attention. Alistar Roberston's group has trial plantations in place for different mangrove species.

One of the coastal features of Queensland between Townsville and Port Douglas is Hinchinbrook Island, the world's largest island national park and one the richest areas of mangrove growth. Here we have a 60 square kilometre mangrove study site largely undisturbed by humans, where excellent work has been conducted by AIMS scientists over the past 14 years. The mangrove streams in the Hinchinbrook Island complex have waterways, not with distinctive visible earth banks, but with areas between the water and the land thick with trees featuring complex systems of roots. Around Townsville the mangroves become sparser but they are still of enormous significance with respect to their biological productivity. Mangroves of course are not confined to the coastal fringe. On day trips from Port Douglas to the Low Isles you will observe that one of the islands is a true coral cay and the adjacent island is a mangrove island. That itself is a distinctive feature. If one dives to inspect the coral cay it is well worthwhile moving over to the mangrove island to observe the enormous diversity of life that spawns in a mangrove ecosystem.

Looking at mangrove trees one is impressed by the rich foliage. One can also observe a certain number of dying leaves, identified by their yellow colour, and the propagules (runners) of different species.

At our study site on Hinchinbrook Island, our scientists were very fortunate that the Army built them a walkway so they did not have to struggle through the mud and root system every time they wished to conduct their research. Our scientists observed that the walkway was always covered with leaves whereas the mud around the walkway had effectively no leaves on it. At first it was thought that perhaps the leaves falling on the mud were carried out immediately by the tide but this could not always have been the case. When our scientists sat on the walkway to observe what happened they noted that if a leaf fell on the mud it was quickly taken away by a small crab, one of the sesarmid crabs which lives in the area. This feature was studied in detail by a series of AIMS scientists who observed that, in the study site of 60 square kilometres, each year up to 60,000 tonnes of leaf and litter fall from the mangroves. Of the leaf fall, some 40% is consumed by these small sesarmid crabs.

That equates to approximately 24,000 tonnes per year. Obviously there must be millions of these crabs and they, being well fed, reproduce actively. The larvae of the crabs become food for the small baitfish which accumulate in schools and move to the mouths of the rivers. On different occasions they are then moved by coastal currents to predictable areas where we subsequently observe very large fish taking advantage of this ready food supply.

Near AIMS we face from Cape Ferguson to Bowling Green Bay and thence some 50 kilometres away to Cape Bowling Green. The river systems which feed into Bowling Green Bay are principally the Haughton River and the Barratas. These rivers are mangrove lined. In one of the small mangrove creeks Alistar Robertson and his colleagues netted the mouth of the creek on an outgoing tide. They observed coming from that creek 145 different species of juvenile fish and 28 different species of juvenile crustaceans. That is not the total number of fish nor the total number of crustaceans, but the number of different species. The richness of these mangrove areas for juveniles of different species was up to ten times as great as for the offshore seagrass beds and the mudflats around. However, the numbers of adult fish in the mangroves and adult fish in the seagrass beds were about the same. This suggests that the mangroves are essential nursery areas.

One of the beauties of working at AIMS is that we do not have a departmental structure. There is no Department of Chemistry, no Department of Physics or Department of Mathematics or Department of Oceanography. The scientists work together in multi-disciplinary teams to explain how systems and processes work. If it were not for this harmony of marine research it is unlikely that we would have made the advances that the Institute has achieved in recent years. It was the biologists who observed the litter fall and the interaction with the mud crabs. They also observed that the larvae of these crabs were important as food for the baitfish and other fish. The fish, as they mature move out to the mouths of the creeks, and here the knowledge of Eric Wolanski and his colleagues on the way that waters move under different conditions, was an important factor in being able to predict where schools of baitfish would accumulate under different wind conditions.

For example, off Cape Bowling Green under the prevailing south-easters, which blow generally from March to September or October each year, we do find, (and Dr Wolanski and his colleagues can explain why), schools of baitfish up to 1.5 kilometres in diameter and 30 m deep. The larger fish such as certain, reef fish, the mangrove jack, the red emperor, the fingermark, all realise that there is good food to be obtained here with a minimum of effort. So do the sailfish and the marlin. Our scientists work together. The oceanographers explaining the way in which the living forms are carried in the currents and the biologists explaining how and why the baitfish are produced in the first place. Their combined efforts have led to a better understanding of the way the processes and systems work in the mangroves and adjacent waters. This type of study can be extended to any coastal region.

Partly as a result of the work of AIMS, the Queensland Government has declared the whole of Bowling Green Bay as a fish habitat reserve. Certainly as a result of the AIMS research and , more importantly, the communication of the results of that research to Local Government, and to potential developers, we have, to this time, been able to retain the natural vegetation of the coastal streams into Bowling Green Bay because they are the essential starting points.

The mangroves are the source. The simple facts of the leaf fall, of the crab acquiring this as good food, the reproduction of the crabs, that the crabs aerate the mud and the larvae of the crabs being the feed for the baitfish lead to the accumulation of baitfish. With their transport under different weather conditions to predictable sites it all adds up to an understanding which is essential if we are to successfully manage our marine coastal resources.

Mangroves, the trees which so few appreciate, are in fact one of the richest resources of our coastline.

When the tide comes in through unchanged mangroves it goes throughout the mangrove system. The water traverses between the complex root systems. Those who are good at mathematics could possibly make an estimate of the surface area that is there for different living forms to settle upon when their larvae have finished their free swimming stage and are ready for settlement. Contrast that with the harsh rectangular symmetry of the marina, the absolute interface of concrete with water and we can easily understand how the amount of surface for settlement of future generations of larvae is so dramatically and horrifically modified when we change from mangrove to concrete. Marina development in Florida is an extreme case. We hope that such events never occur in Queensland. But we cannot be complacent. There are many applications before the Queensland Government for major tourist developments in the coastal region. We cannot afford to have this type of development if it means the destruction of the mangrove interface between land and water.

There are many examples where humans have been smart enough to take simple steps to protect a sensitive boundary or interface. The road system used to have enormous repair bills because we would drive our cars too close to the edge of the road at the interface between the hard bitumen and the softer soil. Engineers recognised that placing a white line in from the edge to keep cars away from the sensitive area would reduce the pressure and were able to reduce maintenance costs.

Nature's "white line" in much of the coastal regions of the Pacific is the mangrove. One aspect in which we must all become more proficient is communication on the value of mangroves and of the way that their ecosystem must be preserved in order that the biological productivity of our coastline can be maintained and the physical protection offered by this complex of root systems and trees guaranteed for the benefit of future generations.

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PRODUCTION OF GEOLOGICAL STRUCTURES BY THE GREEN ALGA *HALIMEDA*

E A Drew

Introduction

Halimeda is a genus of calcareous green algae found throughout the tropics, mainly on coral reefs. One species also occurs in the subtropics and another in the Mediterranean. Twenty of the world's 30 *Halimeda* species grow, often prolifically, on the Great Barrier Reef (GBR). Most of those not found there are confined to the Caribbean, having evolved there after the closure of the Isthmus of Panama in the Miocene, 20 million years ago.

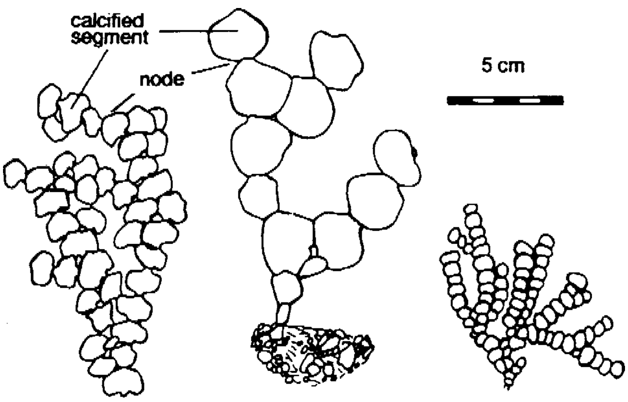

Figure 1 *Halimeda*

The appearance of *Halimeda* plants is shown in Figure 1. They are all composed of numerous flat segments between 0.5 and 3 cm wide, depending on species. These segments are calcified, sometimes very heavily, and they are joined by very short, uncalcified nodes to form branching plants. Studies of these algae have, until recently, concentrated on the prodigious amounts of coarse calcareous sediments they produce on coral reefs when they die and then quickly disintegrate at the nodes to produce piles of calcified segments. However, during the last 10 years, biologists and geologists have combined to show that *Halimeda* can grow and produce sediment even more prolifically on the seabed away from reefs. This work began in the GBR but similar phenomena are now being studied both in Indonesian waters and as far away as the Caribbean.

Between the reefs of the GBR

There are more than 2,000 individual coral reefs scattered throughout the 268,000 km^2 covered by the GBR. The reefs themselves cover only about 13,000 km^2 leaving a lot of non-reefal seabed in between. This seabed slopes gently from the shoreline to depths of 50, or occasionally 100 m, at the outer edge which can 100 km or more offshore. The outermost reefs occur at the very edge of the continental shelf where the slope of the seabed suddenly increases dramatically and rapidly descends to 1,000 m.

The coral reefs of the GBR have been studied much more than the inter-reefal water mass and seabed. Hardly any attention was paid to this enormous area until marine scientists began to suspect that individual reefs did not behave as independent entities. Intensive study of the Crown of Thorns starfish infestations, which have plagued the GBR for decades, has served to emphasise the interconnectedness of reefs over long distances. What happens in the inter-reefal water connecting the reefs has now assumed vital importance.

One researcher in particular provided fundamental information about the inter-reefal seabed well before this part of the GBR became a focus of scientific attention. Over 25 years ago Graham Maxwell, a geologist, organised a series of research cruises to sample and characterise the seabed sediments between the reefs throughout the region. This involved more than 6,000 grab sampling stations and a prodigious amount of sediment sieving and particle analysis. His work initially concentrated on the southern half of the GBR and the results were included in his Atlas of the Great Barrier Reef.[1] However, he extended his studies northwards and, in 1973, published a thorough description of the sediments of the inter-reefal seabed of the whole GBR.[2] It was his maps showing large areas of *Halimeda*-dominated coarse gravels, particularly in the northern part of the GBR (Figure 2B), which first diverted our attention away from *Halimeda* on the reefs and into this much more intriguing environment.

Behind the ribbon reefs

From about Port Douglas north, the outer edge of the GBR consists of a continuous strip of coral reef dissected