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**THE TIDAL FLATS OF THE CAIRNS ESPLANADE
WITH REFERENCE TO OTHER MARINE ECOSYSTEMS**
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(From a paper presented to the Youth Ecological Seminar of the Cairns Branch of the Wildlife Preservation Society of Queensland, 4 . 3 . 72)

Introduction:

The muddy shores of our estuaries might seem to be exceedingly undesirable places for animal (particularly *Homo sapiens*) and plant life, but at certain points a passing glance would quickly correct this opinion. I set out to investigate, if I could, the following points:

1. That the productivity of the region could equal or even exceed that of the most fertile land in the world;
2. That the mangrove-tidal-mud environment provides a vital link in the great marine food-chains of the Cairns region;
3. That the preservation of the above areas is justified in all but the most minor aspects

Between 11 December 1971 and 6 February 1972, the collection of data for the report required approximately 40 hours of field work and a further 30 hours spent in the analysis of the information obtained. I believe that the evidence which I collected during the various phases of my field work fully supports the hypothesis which first motivated me to do such a piece of pure research. In my report I shall discuss the geographical factors which affect this area; the special stability of this type of environment; the animals which dwell in the tidal mud; and most importantly, the relationship of the tidal-mud-mangrove area to the marine ecosystems and the economy of the Cairns area.

TOPOLOGY OF THE SPECIFIC AREA UNDER STUDY:

The majority of estuarine muds on the Cairns Esplanade are extremely viscous and this poses a serious problem of access. I set out to walk the entire length of the foreshore to find which area would combine both ease of access and diversity of life forms. From this preliminary survey I also gained much information on how man's activities affect the tidal mud environment. Opposite the Cairns Base Hospital the surface was like a liquid to walk on, and the mud remained viscous until I reached the northern end of the fore-shore where the mangrove forest begins. Here a shallow layer of sand projected to about 400 feet from the shore. This was the best area for my study.

Basically, the region which I studied is one of marked contrasts. Looking along the sandy beach, one immediately notices the goat's-foot vine (*Ipomoea pes-caprea*), so characteristic of the transition between terrestrial sand and semi-marine environment. This belt is approximately 20 feet wide and is dotted here and there with grouped tussocks of couch-grass. As one moves from the area of maximum growth the abundance of the vine dwindles so quickly that a sharp dividing line is formed between it and the sandy beach. The area of sand extends for 38 feet with an average gradient of 1 in 2. At this point the actual beach ends at a channel about 5 feet wide and 4 inches deep. The sand spit is now reached which extends out into the tidal muds. As one progresses out onto this area, which lies between the mangroves and the exposed mud community, the proportion of mud gradually increases until a transition zone is reached. The surface here is dirty brown in colour and one can walk on it with few mishaps occurring. Beyond this transition zone are the viscous grey and brown estuarine muds. From this point onwards penetration was, for me at any rate, impossible. Basically the same pattern emerges if one walks along parallel to the shore.

A physical factor of major importance is that two storm drains empty out into my region. During my first few visits they were dry and partially blocked by sand, because there had been no substantial rain for many months. However, from 6th to 9th January, over 20 inches fell in Cairns. The resulting flow from the drains forged two channels at right angles to the shore and these passed directly through the sandy spit. Two large pools were formed just below their outlets, in which many thousands of small fish of a variety of species seemed to be thriving. A week later the flow of fresh water from the outlets had almost ceased.

To the north of the sandy area is the mangrove forest. Seedling pioneer species of *Avicennia* and *Rhizophora* have invaded the edge of my region and the succession of species can quite easily be seen. I found by counting that the *Avicennia* seedlings are outnumbered by about 3 to 1, even though they are much larger and at first glance appear to be the dominant group.

One of the most important features is the extreme flatness of the estuarine mud. Apart from the beach, almost the entire region is horizontal. This means that a difference of only a few inches in the depth of the water can expose hundreds of yards of sea-front in a short period of time. The currents in the area are gentle, barely rapid enough to be observed. As the tide is receding, a flow is established towards the mangrove region; as the tide rises, the reverse occurs. This would allow for the

exchange of material between the two areas and would tend to cause a slow spreading of the surface sand layer.

THE EFFECTS OF RAINFALL, WIND SPEED AND TEMPERATURE VARIATION:

One factor which alone makes the mudflat environment unique is the extreme variation in the salt concentration which is periodically experienced. To alleviate such varying conditions, most of the inhabitants are found below the surface. The mangroves, those strange plants which live in a semi-marine environment, cannot survive without periodic inundations of fresh water. Thus rainfall is the major physical factor which influences the tidal region. I was caught in three sudden monsoonal rainstorms, so characteristic of December and January in North Queensland, and know this to be true.

As the storm clouds approach and the wind speed/increases, a sudden lull occurs in the activities on the mud-flat. All species of crabs retreat into their burrows, the sea-birds fly away to shelter, and the area becomes strangely quiet. One no longer hears the cracking of the pistol prawns and the popping of the mud as another crab emerges from its burrow. During the period of rainfall the tidal mud region is quickly drenched by an inch or so of fresh water. This is due to its extreme flatness and lack of vegetation. If enough falls then the storm drains will begin to flow, thus adding their quota. After the storm is over life quickly returns to normal, but this is not the case if rain falls for several weeks. At these times tremendous volumes of water come from the mouths of the Barron and Trinity inlets, thus resulting in the formation of virtually a fresh water lake over the estuarine muds (i.e. at high tide.) Unfortunately, I was not able to observe the effects of such prolonged exposure to water of low ion concentration because I had a time limit on my survey. Such a study would be very interesting.

I was able to observe the effects of 3 days of continued rain, in which 20 ins fell. I was surprised to find that this period of rainfall did little to affect the numbers of organisms which lived below the surface. However, one species (*Telescopium telescopium*) which lives on the surface was notably distressed. Many of them were lying point downwards in the sand and some were partly buried. It was obvious that if the rain had continued then the numbers of this and other species could have been seriously depleted. Therefore I believe that there is a cycle in the abundance of the organisms which is controlled by the amount of rainfall received. In the late summer months the number would be at its lowest due to the almost continuous inundation. The numbers would again build up in autumn and winter but would reach a peak in the spring and early summer months. It was during the peak that I believe I carried out my survey.

Our tropical environment can also be linked to the winds which blow over the Cairns region. Low pressure systems and cyclones are prevalent during the summer months and so influence the wind speed and direction. During the morning the winds usually blow from the S.E. but towards evening the temperature is reduced by the cool north easterly sea breezes. The S.E. winds have very little effect on the exposed tidal muds.

Even though the evaporation rate must be tremendous, a thin film of surface water is being continually replaced from below. Therefore dehydration is not a major physical factor influencing the inhabitants of the estuaries. The same applies with temperature variation, even though on hot sunny days only crabs and certain univalves are found on the surface. The water can become reasonably warm but this does not seem to affect the myriads of fish fry and plankton which live in it. So we see that in many ways this environment favours the settling and development of life forms much more than on the rock faces of the sea-shore or the mountains and dry plains of terrestrial earth.

METHODS USED FOR THE COLLECTION OF DATA.

The inhabitants of the mudflats are extremely shy and even the slightest movement near their burrows causes them to disappear immediately. As one is

approaching the area under study thousands of crabs of different species will be seen busily foraging for food or trying to catch the attention of a female. However as soon as one disturbs the ground they quickly retreat into their holes, often 3 or more together in their haste. This makes direct observations of the behavioural patterns and foraging techniques of the denizens of the tidal muds extremely time consuming and somewhat hard on the back! By far the best technique is to kneel down on the surface of the area in which one knows there is a large population of macroscopic species and try to remain perfectly motionless.

At first one will see nothing but suddenly a single crab will come to the surface of its burrow to cautiously look around. Finally it will emerge and suddenly one is surrounded by dozens of crabs of a number of species. It is as though the emergence of one individual acts as a signal to all the others. Sea birds will also come quite close if one uses this technique. I found that after about half an hour of repeating the same action, e.g. walking to and fro while digging a quadrat, the fiddler crabs in particular become used to one's actions and will continue their activities nearby. If, however, one comes too close to where some have been foraging while another is being examined then they will retreat immediately. The conditioning seems to be short-lived because on the next day the crabs still require the same time to become accustomed to one's activities.

I found that quadrats provide far more information than transects about the numbers of species inhabiting the mudflats and why certain species are found in certain locations. However transects are vital to obtain an accurate map of the topography of the area and which surface species inhabit which zone of land. I stress surface activity because most of the species and activities of the estuarine tidal flats are found below the surface. In my survey I used quadrats of 9 cubic feet in volume (3ft. x 3ft. x 1ft.), combined with small random samples and transects of varying lengths. This method allowed me to compare the data from different locations in the section of the Cairns Esplanade under study.

For preserving most specimens, a solution of formalin in seawater (1 in 20) was effective. Creatures with a limey exterior were best preserved in a solution of 75 parts methylated spirits to 25 parts tap-water. Formalin solution can be used to preserve mangrove seeds, but is not successful for actual plants as the green pigments diffuse out, leaving a brown, dead-looking mass. To estimate the proportions of different soil components in each quadrat, samples were placed in uniform containers with water, shaken well and allowed to settle; then the thickness of each layer of sediment was measured.

As mentioned before, the flatness of the region largely determines the amount of exposure suffered by the soil. Most of the organisms come to the surface just as the tide is receding and enjoy a brief period of activity, before retreating again due to the increase in light and heat intensity. Therefore the best method for the collection of many species of fauna is to follow the out-going tide. One or two hours before low tide, when the water is about 7 inches deep on the flats, an examination can be made of the sandy beach. Then, as the tide allows, one can follow it out. However, once it reaches a certain point, almost the entire flat is exposed in about 25 minutes. In contrast, the best time for examining the sloping rock-face on the sea-shore is at the lowest of low tides. Temperate, overcast days are best for collecting purposes.

DATA FROM THE QUADRAT AND TRANSECTS

To gain an accurate picture of the mudflat region one must investigate the variation in physical factors with depth and locality, and their relationship to the numbers and types of organisms found there. From three quadrats and three transects I tested samples for the variation in chloride and sulphate concentrations and pH in depth, and analysed for the percentages of various soil components particularly the amount of organic matter.

Several interesting and important regularities emerged. Firstly, the variation

in stratigraphy was almost the same in every quadrat and transect studied, the only variable being the thickness and depth at which each layer occurred. The layers appeared in order, beginning at the surface:

1. A layer of fine, medium and coarse grained sand;
2. Fine grained sand and grey mud;
3. Black mud with much organic matter;
4. Viscous grey mud with fine sand;
5. A solid layer of fine sand with mud or the compressed shells of dead animals.

The black mud layer is the most productive of all for it constitutes the region of decay. 95% of it consists of organic matter which is of mangrove origin. Here we see one of the most important links between the mangrove forest and the tidal muds; the basic food materials of the Cairns Esplanade originate in the mangrove mud. This is also the reason for the tremendous number of crabs because they can utilise directly organic matter in this form. In this layer of decay, the greatest activity on the mudflat is found. It is literally teeming with zooplankton, protozoans and diatoms in an amazing variety of form and structure. The ciliates and flagellates are by far the most common representatives of the protozoa. Shrimp, crab, bristleworm and amphipod larvae and copepods make up the astronomical numbers of the zooplankton.

Secondly, a relationship was found which linked the pH of the soil and the chloride and sulphate concentrations to the number of life forms existing at different levels. Peaks occurred in both of the ion concentrations in the decay layer and this correlated with an acid pH and, most importantly, a peak in the amount of organic matter and the number of life forms.

A feature which must surely impress anyone who visits the tidal region is the increase in the numbers and diversity of organisms as one progresses from sandy beach onto the tidal and mangrove muds. The sand, where only amphipods, soldier crabs and bristleworms are to be found, is virtually a desert when compared with the other regions. The muds of the mangrove forests, which are bound together by tens of thousands of miles of the fine roots of *Avicennia* and *Rhizophora*, are inhabited by thousands of crabs and billions of planktonic organisms. A similar situation is found on the exposed tidal flats, but here there is no interlacing network of mangrove root systems. It is here that the growth and development of planktonic organisms occur, and it is here that the crabs reach their greatest abundance and diversity. From my quadrats and transects I was able to determine the distribution of crabs, plankton, mangrove species, and bristle worms, with regard to soil composition.

Clearly the tidal muds of the estuaries are really vast biological decay areas, where the pieces of organic matter are broken down into their components so that once again another cycle of life and death may begin.

COMMENT ON THE ACCOMPANYING SPECIES LIST

There are two outstanding conditions that make life on the shore flats of estuaries different from that on the ocean and coral cay beaches. Firstly, the water is, as already noted, usually still. Even a strong wind scarcely raises small waves to disturb the stillness of the shallow sea bottom, and the quiet current distributes a rich store of rotting debris from the mangrove woodlands, covering all surfaces with a deposit of organic matter. It is this special stability of the tidal flats which makes them unique. Captain Yeasely of the dredge "Trinity Bay" showed me a chart of the Cairns Esplanade compiled in 1905; not one major topographical feature had changed in over 60 years. The muddy shores thus have great riches in the way of food. Secondly, the sea-water is at all times, likely to be subject to great changes in salinity and may always be less saline than on the ocean shores, since there will always be some rain water draining down from the land. At times this amount of fresh-water is great, as previously described.

Whilst these conditions may provide a barrier to the inward migration of most

of the sea creatures of the nearby ocean beaches, they have resulted in the evolution of species specially adapted to the mudflat environment. And since, as indicated, the estuarine muds are very rich in organic matter, the individuals of those few adapted species are often exceedingly numerous. When comparing the number of species that I found and identified with those in a survey of Michaelmas Cay one can see that the mudflats are unique in that the comparatively few macroscopic species exist in tremendous numbers, whereas a coral cay is unique in the diversity of its flora and fauna.

— LIST OF SPECIES IDENTIFIED —

CRABS:

Uca marionis var: *vomeris* (Fiddler crab)
Macrothalamus carinimonus.
Sesarma erythroductyla.
Scopimera inflata (Sand-bubbler crab)
Paragrapsus laevis.
Mitrys longicarpus (Soldier crab)
Scylla serrata (Mud crab)
Ocypode cordinara, (Ghost crab)
Ocypode ceratophthalma.
Diogenes custos. Hermit crab)

PRAWNS:

Squilla laevis (Mantis Shrimp or Prawn Killer)
Alpheus audouini (Snapping Prawn)

BRISTLE WORMS:

Perinereis nuntia.
Glycera
Australonereis chleria.
 Aphroditidae (Family only)
 Four unidentified species.

WORMS:

Bright orange-red ribbon worm (Class Nemertea)
 Peanut worm (Class Sipunculoidae)
 Shipworm (Genus *Teredo*)
Phascolosoma noduliferum.

SAND HOPPERS AND SEA LICE:

Ligia australiensis (Sea Slater Order Isopoda)
Talochaetia novae-hollandiae (A Sand Hopper Order Amphipoda)

UNIVALVES:

Pyrazus ebeninus (Hercules club shell)
Telescopium telescopium ("Cone" shaped shell)
Melarapha scabra (Periwinkle)
Bullina lineata (Bubble shell)

SEA SLUGS:

Onchidium danelii (Order pulmonata)

BIVALVES:

Eunarcia fumigata.

BIRDS

Larus novae-hollandiae (Silver Sea gull)
Ardea sumatrana (Great-billed Heron)
Notophayx novae-hollandiae (White Faced Heron)
Sterna bergii (Crested Heron)
Erclia testacea (Curlew Sandpiper)

FISH:

Osteogobius australis (Brown Speckled Goby)
Arenigobius semifrenatus (Bridled Goby)

PLANKTON:

Copepods (Order Copepods)
Phronimella elongata (Planktonic Amphipod)
 As well as the above there were shrimp, prawn, crab and bristle worm larvae.

PLANTS:

Zostera (Eel Grass)
Avicennia marina (Mangrove)
Rhizophora stylosa (Mangrove)
Ipomoea pes-caprea (Goat's Foot Vine)
Sonneratia alba (Mangrove)
 A type of hardy couch grass.
 Unidentified Algae.

WHAT WOULD HAPPEN TO THE CAIRNS TIDAL FLATS IF LEFT IN THEIR NATURAL CONDITION:

Where Mudbanks of river silt are formed in sheltered areas along the shore and are exposed at low tide, seeds of pioneer mangroves find a root-hold. When fully developed, the intricate maze of their roots and pneumatophores slows down the tide movements and traps floating debris and silt which gradually builds up the level of the forest floor. Conditions become suitable for the non-pioneer species to establish and form a mangrove forest. Finally an extension of the shore itself is created, which is submerged only at the highest high tides. Conditions are now suitable for grasses to begin to grow and the mangrove forest is slowly replaced by species of *Acacia*. Thus a slow process of succession results in the natural reclamation of the tidal mud area.

This process has been halted on the Cairns Esplanade by the regular removal of young mangroves as they become established. However, in my area at the northern end, there is a wide band of mangrove forest. It shows a marked transition of zones from its outer edges, as can be seen in the height, age and population density of the various mangrove species.

THE EFFECT OF MAN ON THIS ENVIRONMENT:

From my preliminary survey when I walked the length of the Esplanade I was able to gauge the amount of visual pollution of that part of the mud flats nearest the shore. I found that the maximum pollution occurred near the centre of the city where the park benches look out over Trinity Bay. On the sandy shore and in the mud directly in front of the benches the number of intact and fragmented beer bottles was astounding. Aluminium and steel beer and soft drink cans were also abundant, as were other residues, particularly newspaper, polythene bags and the inner tubes of car tyres. Progressing north to the suburban area I found the amount of glass and cans quickly fell off. However the amount of paper and plastic, rotting sugar bags and tyres remained constant. As expected, the number of discarded soft

drink cans reached a small peak in front of the Base Hospital. A new feature in the suburban area was the amount of garden and kitchen refuse deposited by the house owners opposite the foreshore.

I do not believe that a moderate amount of such visual pollution will have any effect on the ecology of the area.

What I am greatly concerned about is the kind and concentration of pollutant which comes from the wharves, the bulk sugar terminal, and particularly waste fertiliser and insecticides running off from Trinity Inlet and the Cairns fertiliser works. Unfortunately I could not make any measurements of these.

Of far greater importance to the environment of the Cairns mud flats is the proposed reclamation of a large area of the fore-shore for commercial and tourism interests.

CONCLUSIONS:

Immeasurable damage is being done to the life support systems of our planet by the "quick dollar" development of rainforest, mangrove woodland and tidal flats.

I believe that the mangrove woodlands and tidal muds and the life forms of the Great Barrier Reef form a great interdependent ecosystem in which the removal of one link could result in the collapse of the others. The waters of the Reef are notorious for their under-productivity, so the plankton which supports the great food chains must be coming from regions close to the shore. My detailed study of the tidal region found in every sample teeming multitudes of protozoans and planktonic organisms, most of which were immature stages in their life-cycle - the fry of fish and the larvae of shrimps, amphipods, crabs and many others. This region of few extremes provides a stable environment in which the young can develop.

The mangrove forest supplies the basic organic material necessary for the development of the diatoms, which provide food for the copepods, which fall victim to the young shrimps, which are in turn devoured by the fry of fish. At high tide the large predatory species such as sardine move in. These in turn attract even larger species, which fall victim to the enthusiastic Esplanade angler. Crabs, too, are taken by those brave enough to venture out onto the tidal muds.

The great cycle of eat or be eaten does not end here. Currents sweeping out from Trinity Inlet wash over the tidal flats and carry the plankton and young fish out to sea, where the coral polyps in their millions feed on the tiny organisms and the larger species of reef fish devour the young of others. One might ask why the reef around Green Island became established in that position. Coral polyps not only require comparatively shallow water to settle and develop, but also an abundant food supply consisting mainly of zooplankton. Michaelmas Cay also is on the receiving end of an abundant food supply from the Cairns region. For the coral cay to support such a large bird population, the number of fish in the surrounding waters must be exceedingly great. Mangrove seeds found washed up on the shore of this cay could only have originated from the coastal mangrove woodlands, so we see that a current does exist which could serve as a transport medium for the phyto- and zooplankton.

From this one can see how vital is the link between the coastal and the reef environments. Destroy the Great Barrier Reef and the tidal muds and mangrove woodlands still remain, yet remove these areas and one may create repercussions which are so great as to lead to the extinction of the reef as we know it today.

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