MANGROVES between Exmouth Gulf and the Eighty Mile Beach. Perth. Dept. Fisheries and Wildlife, 1975 P.Rogers

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Page

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INTRODUCTION

The word "mangrove" describes the community of trees or bushes growing between the level of high water of spring tides and a level close to but above the mean sea level. The word mangrove, can be used to describe a community of trees, or an individual species such as Avicennia marina (Macnae, 1968).

Mangrove trees are found on sheltered shorelines of bays and gulfs, and on the banks of river estuaries where salt water penetrates from tropical and sometimes temperate oceans.

In Australia, extensive mangroves occur around the northern shores at all suitable localities between Houtman Abrolhos and Shark Bay in Western Australia and the Queensland-New South Wales border. Isolated mangroves also occur in southern Australia, at Western Port Bay near Melbourne, St. Vincents and Spencer's Gulfs, South Australia, and on the Leschenault estuary near Bunbury, Western Australia (Morrissy, 1972).

Beard (1967) also discovered an inland occurrence of mangroves on a saline inland creek along the Eighty Mile Beach, Western Australia.

Along the coastline between Exmouth Gulf and the Eighty Mile Beach, mangrove swamps cover an area ranging between 115,000 and 120,000 acres. Thirteen mangrove species have been recorded to date from Western Australia (Wilson - pers. comm.). The following seven species have been recorded between Exmouth Gulf and Broome:

1.	Camptostemon schultzii	Broome
2.	Sonneratia alba	Broome
3.	Rhizophora stylosa	Port Hedland, Pt. Samson, Broome, Yardie Creek.
4.	Ceriops tagal	Dolphin Is., Pt. Samson, Dampier Archipelago, Broome
5.	Bruguiera conjugata	Broome, Dolphin Is.
6.	Aegiceras corniculatum	Broome
7.	Avicennia sp.	Roebuck Bay, Roebourne, Gales Bay, Exmouth Gulf, Port Hedland

Information on the relative abundance of each of these species is not readily available. However, it is thought that the two most prominent mangroves in this area are Avicennia and Rhizophora spp. The four tree-plant species, of Carallia brachiata, Xylocarpus granatum, Camptostemon schultzii and Pemphis acidula are also found at some localities, in close association with the mangrove swamps near the high tide mark.

The coastal swampland between Exmouth and the Eighty Mile Beach is typical of arid warm sub tropical coastlines. The shore exposed between tide marks in regions where the tides are considerable includes two distinct sections:

(i) a portion exposed at low tides never colonized by mangroves

(ii) a portion entirely covered by water only at high spring tide commonly called a "salt marsh".

The salt marsh along the dry coastline north of Exmouth Gulf is often divided into two levels. The "low marsh" tends to be occupied by a more or less well developed mangrove community and the "high marsh" consists of either bared saline mudflats or is occupied by a variety of halophytes. Mangrove species zonation tends to be more developed in the proximity of creeks and tidal estuaries.

The seasonal conditions between Exmouth Gulf and the Eighty Mile Beach are characteristic of the semi-arid sub-tropical climate. The numerous river systems which drain the coastal hinterland are dry for the greater part of the year with seasonal flows occurring from cyclonic rains in January and February or from infrequent winter rains in June or July. The only river along this section of coastline with continuity of flow is the Fortescue River. The perennial flow of this river is due to inland artesian springs which supplement seasonal rainfall runoff.

Despite the numerous rivers and creeks draining the coastal hinterland between Exmouth and the Eighty Mile Beach, there are no extensive estuarine areas as found in the south west of Western Australia such as the Swan estuary, Peel Inlet, Leschenault Inlet, Walpole Inlet, Wilson Inlet and others.

IMPORTANCE OF MANGROVES

The establishment of mining industries between Exmouth and Broome will result in several coastal land developments which are likely to affect present areas of mangrove swamps; these are:

1. Areas of mangroves and swamp flat land will be requested for industrial sites, harbours, marinas, aircraft runways and town installations.
2. Mangrove waterways and creeks will be requested as sites for sewage and refuse disposal.
3. Mangrove waterways and creeks will be utilized for purposes of aquatic recreation and sport fishing. These areas may similarly be utilised commercially to supply fresh fish as new population centres develop in the Pilbara region.
4. The existing creeks and rivers have a water supply potential and some may be dammed to provide reservoirs for mining development.
5. Pollution from industrial development is likely to have detrimental effects on mangroves.

The ecological importance of mangroves has only recently been recognised by scientists. It appears that mangroves have two important roles:

(i) as a primary source of energy for marine life and (ii) as shoreline stabilizers. The role mangroves exert as shoreline stabilizers has been recognised for a long time.

(i) Mangrove Detritus

Through photosynthesis and other metabolic activities characteristic of holophytic nutrition, these plants are able to build plant tissues using the complex organic compounds characteristic of living organisms (i.e. carbohydrates, proteins, fats, vitamins, etc.), synthesized from simple inorganic compounds such as water, carbon dioxide, nitrates, etc. These plant tissues form the base energy substrate from which herbivores and subsequently carnivores and detritus consumers in the food chain are able to grow and reproduce. In a coastal-estuarine aquatic environment debris from plants and animal waste may come from outside the aquatic system; allochthonous, in the case of mangroves and land plants, or autochthanous from within the aquatic system as for sea grasses, algae, etc.

Mangrove debris is a source of energy input into the aquatic system. Dead leaves, twigs and other plant debris fall directly into the water or may reside for a time on the bank before being swept into the ocean by streams or tidal movement.

The leaching of water soluble organic and inorganic compounds supplies nutrients for micro-organisms and possibly other animals also (Stephens, 1967 The means of degradation of debris include chemical dissolution, autolysis, hydrolysis, oxidation, mechanical attrition and fragmentation, enzymatic lysi by bacteria and fungi and the activity of scavenging organisms.

The time taken for degradation will depend on the relative importance of material agents of wind, water, wave action and the abundance of deposit feeders and suspension feeders. The temperature of the environment is also likely to affect degradation rates due to its influence on the rate of chemical reactions, enzyme activity and the metabolism of organisms.

Leaves lying in brackish water may be "grazed" far more heavily than leaves in fresh water or dry conditions. This condition observed by Heald in a Florida Estuary, was due to the onset of heavy grazing by two amphipods, Metita mitida and Corophium lacustre (Heald, 1971).

Fragmented mangrove debris or detritus is eaten by amphipods and by xanthid crab populations and converted directly to animal protein or reduced to particulate detritus in faecal material.

Colonisation of mangrove detritus during decomposition by fungi and bacteria was observed within the first two months and became extensive in brackish water within four months (Heald 1967). As its populations of fungi and bacteria increased, the leaf debris acquired a large complex of protozoa, nematodes and rotifers. These feed on the fungi and algae. It is uncertain whether amphipods gain nutrients from plant debris itself or from the associated micro flora. Experiments by Siki et al (1968) showed that Artemia were unable to survive until an inoculum of Pseudomonas had colonized the plant debris converting it into

/4. ...

a bacterial detritus. Starr (1956) found vitamin B_{12} was produced as a result of the activities of micro-organisms. Heald (1971) suggested that the micro-organisms contribute to the diet of detritus scavengers which may ingest them accidentally or intentionally.

The organic detritus particle, that is, the plant debris and its associated microbiota, constitutes a relatively protein rich food source for suspension or deposit feeders. Heald (1971) demonstrated that leaf material of 6% protein from the mangrove, Rhizophora mangle increased to 20.5% protein after 11 months as a consequence of micro flora attached to the mangrove leaf susstrate.

Odum (1968) demonstrated that the striped mullet (Mugil cephalus) ingests large quantities of detritus and utilised the attached organisms on the particle surfaces. He subsequently suggested that the ingested particles, whether organic or inorganic, are excreted by mullet virtually unchanged except for the loss of the attached micro flora. These excreted particles soon acquire a new micro flora or fauna.

Investigation of stomach contents of the majority of fish and crustaceans in the Florida estuaries by Heald and Odum (1970) demonstrated the presence of particulate detritus in pink shrimp, two species of mysids, numerous molluscs, striped mullet, sheepshead minnow and goby fish.

In the North River estuary of the Everglades, detritus accounted for 80-90% of the nutrition of a number of species of crabs, worms, insect larvae, shrimps and small forage fish. The detritus eaters are the prey of over sixty species of juvenile fish which live in the mangrove bordered estuaries for varying periods of their lives. Among these are tarpon, snook, snapper, sheepshead minnow, spotted sea trout, jew fish and crevalle jack. The juveniles feed on amphipod and insect larvae, and as they grow larger, on shrimps, crabs and fishes which are themselves all detritus eaters (Heald and Odum 1970; Austin and Austin 1971).

In a similar manner the mangroves on Western Australia's north west coast are thought to provide a short food chain based on allochthonous plant detritus providing a source of energy to many commercial and game fish species.

Studies on penaeid prawns in the Gulf of Carpentaria by C.S.I.R.O. show that the banana prawns use mangrove swamps as nursery areas. Investigations of mangrove creeks in the Mermaid Strait and Southern Nickol Bay, Western Australia by Slack-Smith (1967), proved these areas to be banana prawn nurseries.

However, investigation of the literature fails to demonstrate to what degree there is an association between mangroves and juvenile development of banana prawns. In some instances, some mangrove bordered tidal creeks do not support banana prawn nurseries for reasons unknown (Robins pers. comm.). To date no documented survey has been published on the location of the more important fish and banana prawn nurseries that exist between Exmouth Gulf and the Eighty Mile Beach. From evidence

/5. ...

presented by Florida research workers it is apparent that mangroves lining tidal creeks and shorelines provide energy as allochthonous detritus for juvenile prawn growth and are prawn nursery areas. This association between mangroves and prawn nurseries in Florida may similarly apply to the mangroves fringing the Pilbara coastline and banana prawns.

Other evidence suggesting the usefulness of mangroves can be found. The clearing of mangroves and marsh flats at Useless Loop on a part of the Shark Bay foreshore was associated with a decline in whiting juvenile abundance (Lenanton 1970). This decline may be partly due to the decline in the local availability of detritus or primary detritus feeders and reduced food supply for the whiting juveniles.

The abundance of the mullet species Mugil dobula, Mugil peronii and Mugil waigiensis feeding in close proximity to mangroves fringing tidal creeks and bays at One Arm Point, south of Derby (Bramley 1973), may be due to the availability of detritus and attached algae and fungi for food.

The importance of the coastal mangrove fringes on the coast between Exmouth Gulf and the Eighty Mile Beach, is enhanced by the lack of river flow and estuarine waters as a source of nutrients and a nutrient trap respectively, compared to the less arid coastlines of Australia.

Thus mangrove debris may be a major source of energy in the total food chain in these coastal waters. The total importance of mangroves for the maintenance of the existing fish population along this coastline will depend on the relative abundance of seagrasses and benthic algae as primary energy sources to the food chain.

It may be sufficient to say that no extensive areas of underwater sea grasses along this part of the continental shelf have been recorded. Furthermore, tidal movements of between 6 and 10 feet and greater requires sea grass beds to grow at depths where they would not be as productive, because of the lack of light for photosynthesis, as in a shallow estuarine environment. Also coastal waters are turbid due to tidal movement reducing light penetration.

American research workers have estimated that a mangrove swamp can be valued, through the annual return of fish landed, at $380 per acre (Robas, 1970).

A paper given by G. Harrison, Chief Inspector of Fisheries and Senior Biologist of the Department of Harbours and Marine, Queensland, established a total annual return from "useless" Morten Bay mangrove land of $300 per acre (Serventy 1968).

These values have been computed for dense mangrove swamps in tropical regions. It is unlikely that the annual fall of debris from the "Pilbara" coastal mangroves would be as high or as productive per unit area as tropical mangrove areas. However, if these mangrove areas along this north western coastline are 25% as productive as tropical rain-forest mangroves, the potential value of the annual catch of fish for 120,000 acres of mangrove in this region may be in the order of $8-9m, assuming constant prices.

/6.

(ii) Mangroves as Shoreline Stabilizers

Mangroves act as land builders on coastlines where they trap sediment and build up a stable depositional terrain that would otherwise not develop because of wave action, tidal current scouring, etc. One viewpoint suggests that mangroves aid the advance of shorelines by spreading forward over the mud flats in the intertidal zone (Davis 1940; Richards 1952).

Scholl (1968) suggested that mangrove advance occurs only after the intertidal zone has been raised by sedimentation to allow colonisation. Bird (1971) from evidence at Yaringa, showed that the pneumatophores and root system of Avicennia marina assisted the deposition of fine silt and mud within the mangrove fringe. In contrast, adjacent mudflats did not demonstrate a continual role of accretion but an irregular cycle of erosion and accretion. Bird (1971) also suggested that mangroves act indirectly as agents in the advance of shorelines by sheltering the near shore zone at high tide from the effects of offshore winds, and facilitating the vertical deposition of sediment and organic material and subsequently permitting shoreline advance.

The role of mangrove colonies as land agents also assists in shore stabilisation and the minimisation of erosion (Bird 1971; Macnae 1968). Where mangroves have died back or have been cut away, the shore is often sandy rather than muddy, and there may be active erosion of the sediment that had been built up under the former mangrove cover.

The removal of mangroves in Jervis Bay, N.S.W. has resulted in erosion and forced local authorities to dump car bodies to check bankerosion. Hutching's suggestion is that the continual removal of mangroves from Jervis Bay could lead to active erosion of the river banks and silting with subsequent damage to existing oyster leases (Hutchings 1973).

Silting and heavy deposition of mud and sand on mangroves resulting from erosion can drown these plants by smothering their pneumatophores, preventing and blocking the plants air-respiration channels. Sand and shell bars can move into and drown mangroves as has been demonstrated in New Zealand (Chapman and Donaldson, 1958).

Chapman suggested that the removal of mangroves from the Ganges Delta in the Bay of Bengal may have been a significant factor in causing the high death toll of 300,0000 - 500,000 people during the hurricane on November 13, 1970. He suggested that the removal of the mangrove barrier for agricultural purposes enabled "tidal" waves to penetrate further inland and with greater devastation (Chapman 1971).

Florida workers recognising the role mangrove colonies exert in shore stabilisation and the minimisation of erosion, have undertaken the cultivation and transplatation of Avicennia germinans and Rhizophora mangle with a view to stabilising existing shorelines (Savage 1972).

Mangrove shorelines in the "Pilbara" region exert a similar stabilising influence on the coastal shorelines. The clearing of mangroves on creek and river shorelines will result in increased silting and decreased productivity of adjoining bays and creeks as a consequence of increased water turbidity. In the extreme, large scale shoreline removal of mangroves may result in massive shoreline erosion and deaths of adjoining mangrove areas from silting.

LEGISLATION ON MANGROVE SWAMP RECLAMATION

A comprehensive act on the prohibition of clearing wetlands is the Massachussett's Wetlands Protective Act of 1965. This Act provides that no person may "remove, fill, dredge any bank, flat, marsh, meadow, or swamp bordering on the coastal waters" without a hearing, a state license and a biological investigation.

In Western Australia, the protection of inland and tidal waters and wetlands comes under the provision of three Acts, The Fisheries Act, the Fauna Conservation Act and Rights in Water and Irrigation Act and respective regulations.

1. Fisheries Act and Regulations

(It should be noted that, in this section, "fish" means and includes all or any of the varieties of marine or fresh water fishes and crustacea or marine animal life).

"(a) Regulation 17 No person shall deposit any filth, refuse, or other deleterious matter in any tidal or inland waters or into any watercourse whether dry or not, leading into any tidal or inland waters where fish are or are likely to be.

(b) Regulation 18 No person shall deposit any filth, refuse, or other deleterious matter, or discharge any matter from mining works, sawmills, gasworks or other manufactories or boiling-down or wool-washing establishments in any place in a manner which will cause or be likely to cause the destruction of fish in waters near or adjacent to the place in which the matter aforesaid is deposited or discharged or injury to any fishing grounds.

(c) Section 26

(1) It shall not be lawful by the explosion of dynamite or any explosive substance, or by means of any poisonous or noxious thing, to destroy or take fish in any Western Australian waters: And if any person shall explode any dynamite or any explosive susbstance in or under such waters, or place or cause to flow thereinto any poisonous or noxious thing, such person and all other persons assisting or being at the time in company of such persons shall, for every such offence, be severally liable to a penalty not exceeding one hundred dollars and not less than twenty dollars; But nothing herein contained shall apply to any person duly authorised by the persons and in the manner to be prescribed by the regulations to explode torpedoes or dynamite in any such waters.

/8. ...

(2) If any person is found in possession of, or has in his boat, any dynamite or other explosive substance immediately after such explosion, it shall be prima facie evidence that such person caused such explosion."

2. Fauna Conservation Act

"Regulation 46 Except as the Chief Warden of Fauna may authorise in pursuance of a management scheme or working plan or in the administration of the Act and these regulations, a person shall not, in respect of any sanctuary -

(a) remove or disturb any humus, leaf mould, rotting vegetation, soil, stone, sand, rock or gravel;

(b) cut, pick, pull, break, remove, injure, poison, strip or destroy any tree, shrub, herb, grass or other plant thereof, whether living or dead;

(e) interfere in any manner with the water level or water supply in any sanctuary including any lake, swamp, watercourse, river, drainage flow, well, water hole, or dam, whether natural or artificial, or use any water therefrom.

(n) introduce, place, drop, pour, spray, fog, mist or otherwise use or discharge any dangerous, poisonous or noxious substance."

3. Rights in Water and Irrigation Act - Section 13

"(1) The Minister shall be entitled, in the name and on behalf of the Crown, to institute and maintain by any person empowered for that purpose by the Minister any proceeding in any Court of Justice, whether such proceeding be for any civil remedy or for the recovery or enforcement of any penalty against any person for illegally diverting or taking or for polluting the water of any water-course, or of any lake, lagoon, swamp or marsh, or for unlawfully interfering with the bed thereof.

(2) In suchproceedings it shall not be necessary for the Minister to show that either the Crown or the Minister or any person has sustained damage by such illegal diversion or taking or pollution of water or unlawful interference with such bed; nor that the Crown or the Minister is a riparian owner or otherwise entitled to the use or to the protection of the water-course, or of the lake, lagoon, swamp or marsh from which water is illegally diverted or taken, or the water whereof is polluted, or whose bed is unlawfully interfered with; but the Minister shall be entitled to judgement in his favour if it be proved that the water has been illegally diverted or taken or polluted, or that the bed has been unlawfully interfered with; and the Minister shall, in the discretion of the Court, be entitled to the costs and expenses of the proceedings against the person by whom the Court in its discretion shall order such costs and expenses to be paid.

In Western Australia, tidal mangrove swamps are, for the purposes of the Land Act, 1933-67, Crown Land.

If protection of mangrove swamp areas is required it appears, with existing regulations and legislation, regulation 46 from the Fauna Conservation Act would be more effective.

This would require the creation of mangrove reserves with sanctuary status.

The Fisheries Act and Rights in Water and Irrigation Act provides further powers regulating the illegal dumping of refuse on mangrove sites. However, the obvious problems associated with the policing of the respective sections of these Acts are; obtaining up to date factual evidence, and naming the offender against these sections during or soon after the offence. The inability to obtain this type of information especially in the north for the purposes of implementing the respective laws, results in no enforcible powers.

Offenders doing damage to mangrove swamps on land known as Crown Land can also be prosecuted for the low maximum penalty, under Section 164 of the Land Act, of $50.

Further powers for the protection of mangrove areas also currently exist under the Forest Act, providing the need is recognised by the Conservator of Forests, under section 43 of the Act, regulation 7.

" The Governor, on the recommendation of the Conservator may make regulations for all and any of the following purposes.

(7) The management of State forests, timber reserves, and forests on Crown Lands, and the regulation of cutting, removal, hewing, and sawing of timber and the cutting, hewing, stripping, tapping and removal of other forest produce."

The maximum penalty for an offence against this section of the Act is 6 months jail or a fine of $200. The definition of "forest produce", also includes shells, indigenous animals and birds (not being game within the meaning of the Game Act, 1912-1913)".

Further protection of mangrove areas could be implemented within the bounds of the Forest Act by declaring certain regions as State Forests. However, the Conservator of Forests may be unwilling politically to use the Forest Act for conservation purposes, given that the mangrove areas on the Pilbara coastline are not suitable for commercial timber production and increased costs would be incurred policing and administering unproductive "forest" areas for conservation.

In the proposed legislation amending the Fisheries Act, powers exist for the creation of aquatic reserves or national parks. The protection of mangroves up to the high water mark at spring tide could be implemented under these powers. However, if these powers were used, there is a need to allow for certain fish species and/or vegetation to be protected without preventing these areas being used for sport fishing.

/10. ...

The protection of mangrove areas by the creation of aquatic reserves close to population centres where the pressures for clearing mangrove areas for development are greatest, would be politically unfavourable if they also exclude public usage for aquatic recreation, sport fishing and perhaps commercial net wetfishing, on the Pilbara coastline. Small areas of fully protected aquatic reserves with no access by the sporting public would not be as effective in terms of coastline - mangrove protection as would larger regions, accessible to the sporting public but still maintaining the status of aquatic reserves.

SUMMARY

Evidence from the literature cited suggests that mangroves have an important ecological role as a source of food energy, as well as a geological-geographical role in shore stabilisation.

However, with pressures for urban and industrial development in the Pilbara, complete protection of mangrove swampland is unlikely. Firstly, if priorities for the conservation of mangroves swamps close to urban developments on the Pilbara coastline are to be made, delineation of the more important marine fish nursery areas may be required. Secondly, consideration of the effects of clearing mangroves on the stability of adjoining sediments will be required. It is probable some sediment regions of mangroves swamps are less prone to erosion than others because a tendency for erosion and subsequent sediment deposition elsewhere is likely to be affected by local topography and ocean-tidal current patterns. Changes in sediment patterns bought about by the removal of mangroves and subsequent erosion, can result in the silting of boat and shipping channels, with subsequent dredging costs recurring over a number of years.

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