PURARI RIVER (WABO) HYDROELECTRIC SCHEME

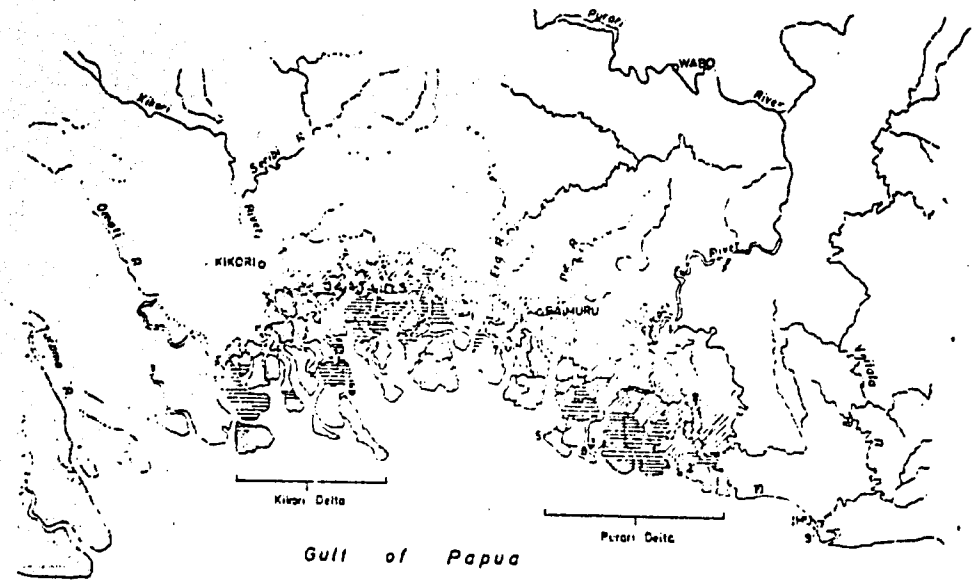
ENVIRONMENTAL STUDIES

Vol. 3

THE ECOLOGICAL SIGNIFICANCE AND ECONOMIC IMPORTANCE OF THE MANGROVE AND ESTUARINE COMMUNITIES OF THE GULF PROVINCE, PAPUA NEW GUINEA

by

David S. Liem and Allan K. Haines



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ABSTRACT

The inter-tidal forests and network of water-ways of the Purari-Kikori deltaic systems support a complex biological community.

Approximately 240 species of vertebrates have been recorded from this area, many of which are of significance to the subsistence economy. The invertebrate fauna has not been surveyed, but appears to be similar to that described for the Indo-Australian region generally. Juveniles of about 58 species of estuarine, marine and freshwater fish, and of penaeid and carid prawns have been collected from this deltaic system indicating its significance as a nursery area. Terrestrial wildlife is abundant and population densities of cuscus, Torres Strait pigeons and flying foxes seem particularly high.

At present this biological community supports a number of subsistence activities and several small scale commercial enterprises which have only a minimal effect on the environment. There is a very good potential for expanding some of these enterprises into larger scale industries.

Two large scale developments proposed for the Gulf Province could have major effects on the ecosystem and need to be carefully planned and controlled. They are the Wabo hydroelectric scheme, and a timber and woodchip industry based on mangroves.

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1. INTRODUCTION

Various aspects of mangrove swamps in Papua New Guinea have been described and reported in the past fifty years by Lane-Poole (1925), Rand and Brass (1940), Richards (1952), Hillis (1956), Taylor (1959,1964), Womersley (1960), van Royen (1963), Heyligers (1965,1972), Risdale (1968), Robbins (1968), Paijmans (1969,1971), Percival and Womersley (1975), Womersley (1975), White and White (1976) and Floyd (1977).

Paijmans (1969) and Womersley (1975) dealt with the mangrove vegetation of the Purari area, Hillis (1956) mainly considered the possible exploitation of the mangrove forest for the cutch and timber industries, White and White (1976) reported on the regeneration of mangrove forest after logging. Floyd (1977) described the zonation and distribution of mangrove vegetation in the Purari-Kikori area.

Forest types map No 2687 of the Gulf Province mangroves between the Omati and Purari rivers has been produced by the Papua New Guinea Office of Forests.

The following assessment is based on a review of available published work and on surveys conducted by the Fisheries and Wildlife Divisions between 1974 and 1977.

2. THE MANGROVE COMMUNITY OF THE GULF PROVINCE

2.1. ENVIRONMENT AND AREA

The Gulf Province deltaic system between the Kikori and Vailala rivers is interconnected by numerous anastomosing rivers and creeks of various width and depth; the major rivers are the Omati, Kikori, Era, Pie, Purari and Vailala (see Fig.1). Of these only the Kikori and Purari rivers drain a large area of the southern slopes of the highlands. A considerable amount of silt is carried out to sea forming sediment plumes. The annual sediment load carried passed the Wabo damsite by the Purari River is estimated to be 54 x 10^6 tonnes (SMEC/NK 1977, p.52-53).

The deltas are apparently built from silt carried down byrivers and deposited in the intertidal zone, forming littoral plains. The deltas are extremely unstable, with land erosion and acretion occurring continually. For example, villagers tell that Auma village, which is now separated from the sea by an extensive belt of mangroves, formerly stood on a sandy beach; and near Arehava village coconut stumps can be seen extending into the intertidal zone.

The Gulf Province has the largest expanse of mangrove forest in Papua New Guinea stretching from the Omati River in the west to the Vailala River in the east, with a frontage of about 130 km. Estimates on the extent of the mangrove forest vary e.g.Hillis (1956) estimated that the Gulf Province forest consists of about 121,500 ha of Rhizophoraceae forest, 26,730 ha of pure *Nypa* palm; PNG Forestry (1973) estimated a mangrove forest cover of about 162,000 ha. The authors, following Paijmans (1969) and Forestry Map No.1373, estimate the breakdown of vegetation cover to be:

mangrove swamps	134,400 ha
mixed mangrove swamp forest	119,800 ha
mixed mangrove/*Nypa* swamps	67,400 ha
Nypa swamps	48,500 ha
swamp forest	156,600 ha
	526,700

2.2. VEGETATION

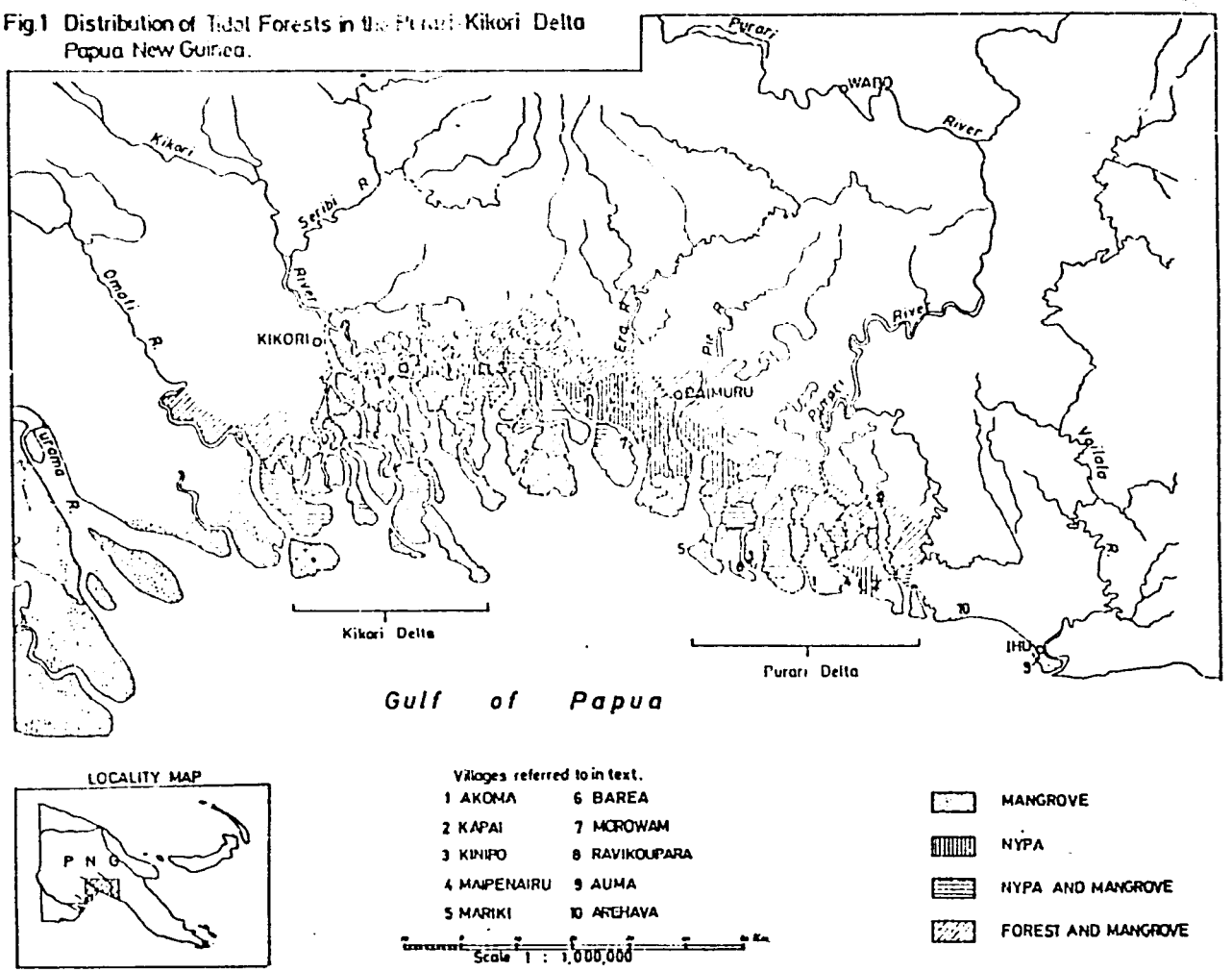
The mangrove associations described by Paijmans (1969) for the Vailala area appear typical of the region, hence his classification is used. Mangrove species present are listed in Appendix 1.

Five types of associations are recognized:

Scrub:	*Avicennia* predominate
Woodland:	Predominantly *Bruguiera* and/or *Rhizophora*, interspersed with a wide variety of other species
Nypa:	either as a pure stand or mixed with other species
Low forest:	Predominantly *Sonneratia* or *Avicennia*
Mid-height forest:	Predominantly *Rhizophora* - *Bruguiera*

Mangrove succession has been described from the Purari-Kikori deltaic system by Floyd (1977).

Fig.1 Distribution of Tidal Forests in the Purari-Kikori Delta Papua New Guinea.



2.3. FAUNA

The aquatic invertebrate fauna is dominated by crustaceans and molluscs. It has not been surveyed to date but appears essentially similar to that listed for the Indo-Australian region by Macnae (1968) and for the New Hebrides by Marshall and Medway (1976).

About 140 species of fish from 57 families have been recorded from the Purari-Kikori mangrove area.The dominant group,both in number of species and biomass is the Family Tachysuridae/Ariidae,the fork-tail catfish. The fish fauna is adapted to the sudden and large changes in salinity and the very muddy water which characterize the delta area. Many species, for example, have thick adipose eyelids, prominent snouts and/or various sensory barbels. There are no highly coloured species and only a few with conspicuous markings.

Ninety five species of tetrapods are known from this area - 12 mammals, 59 birds, 20 reptiles, 4 amphibians. Most species are arboreal or at least partly aquatic. Wildlife species are listed in Appendix 2.

3. ECOLOGICAL IMPORTANCE OF THE MANGROVE ASSOCIATION

3.1. AQUATIC ECOLOGY

The mangrove association may be considered of great importance to the Gulf region ecosystem,including the estuaries,adjacent coastal waters and the offshore Gulf of Papua, as its high productivity probably makes it the major source of organic nutrients. Rapson (1955) measured the concentrations of phytoplankton in Gulf of Papua waters. He found that "inshore in the Gulf where there is much freshwater,phytoplankton production is low". These low levels can probably be attributed to the very turbid water which would greatly limit light penetration. In this area Rapson noted large quantities of plant material which had been carried out from land. In Florida, Ray (1974) found that 90% of waterborne debris within the mangrove zone is derived from mangrove vegetation. About half of this is exported to adjacent waters in the form of fine suspended material so that about 35-60% of all suspended matter on the off-shore oolithic banks is of mangrove origin. The high productivity of associated estuaries and banks is due to such suspended matter.

In the Purari-Kikori delta studies (Haines,1976) have shown that fish utilize virtually all sources of food available
- insects and fruit from terrestrial sources (*Toxotes*, some catfish)
- detrital mud (*Scatophagus*,mullets,some catfish)
- small invertebrates (gudgeons,gobies,ambassids,anchovies etc.)

- prawns and crabs (*Polydactylus, Johnius, Lates, Kurtus, Scutengraulis, Pristia*, some catfish)
- molluscs (*Cinetodus, Acanthopagrus, Takifugu*)
- fish (*Carcharhinus, Lates, Johnius, Polydactylus*, some catfish)

Some fish are primarily estuarine, with the major portions of their populations resident in the mangrove areas. Others appear to enter the estuaries from ~~either the sea~~ or rivers mainly to forage, while others again pass through the area on breeding migrations or breed within the area or in adjacent coastal waters. Those forms which breed within the mangrove belt or in the adjacent sea frequently utilize the area as nursery grounds for juveniles during various stages of development. Marine and riverine forms penetrate the mangrove zones to varying degrees either as small peripheral populations or occasional individual stragglers.

Table 1 summarizes the data presented in Appendix 3. It gives some idea of the inter-linking of the mangrove community with the adjacent marine and riverine communities and the presence of juveniles indicates which species utilize the mangrove area for breeding or nursery grounds.

Table 1. Types of fish species recorded from Purari-Kikori mangrove estuary areas

	Estuarine species	Marine species	Riverine species	Total[1]
Adults	63	59	15	134
Juveniles[2]	35	21	5	58
Total	63	65	16	141

(1) As some species can be classified under several headings, totals given are not the sums of columns.

(2) As the specific identification of juvenile fish is frequently difficult the numbers of species given are approximate only.

Walker presented an outline of the state of Australian prawn fisheries and present knowledge of the biology of major species. He describes how the juveniles of most commercial species (*Penaeus* spp. ~~and *Metapenaeus* spp.~~) use the highly productive estuaries and adjacent coastal zones ~~as nursery grounds~~, e.g. seagrass beds in Moreton Bay, Queensland. Large numbers of juvenile penaeid prawns have

been observed and collected by the authors at various seasons within the Purari-Kikori mangrove areas and along the coast, but these have not been fully studied as yet. *Macrobrachium* spp., including the large *rosenbergii*, are the commonest prawns of the upper estuaries, whence they extend into the freshwaters above the mangrove zones. Individuals carrying eggs are found in both estuaries and rivers indicating breeding in both areas.

3.2. TERRESTRIAL ECOLOGY

Various species of wildlife are associated with Gulf Province intertidal forests. Four species of birds were found to be restricted to the mangroves i.e. two flycatchers *(Poeciledryas pulverulenta, Myiagra rufiventris)*, one mangrove *Myzomela (M. erythrocephala)*, and one mangrove kingfisher *(Halcyon chloris)*. Appendix 2 lists all species of tetrapods confirmed from this area, and gives their typical habitats.

There is a very high population density of the spotted cuscus *(Phalanger maculatus)* in the Purari mangroves, indicating that this is the species favoured habitat in this region. Cuscus scratch marks on tree trunks are regularly found, and young leaf damage from browsing cuscus is also evident. Mangrove forest is a favoured roosting place for Torres Strait pigeons *(Ducula spilorrhoa)* and flying foxes *(Pteropus macrotis, P. neohibernicus)*. Flocks consisting of thousands of Torres Strait pigeons can be observed roosting on mangrove trees and sometimes small branches break due to their weight. Young foliage is also damaged by pigeons.

The terrestrial and semi-terrestrial species such as cassowary *(Casuarius casuarius)*, bush turkey *(Talegala fuscirostris)*, wildfowl *(Megapodius freycinet)* and bandicoot *(Echymipera* sp.) are usually restricted to drier high ground or to the edges of mangroves adjoining the forested areas inland.

Migratory birds such as magpie goose *(Anseranas semipalmata)*, black duck *(Anas superciliosa)*, pelican *(Pelecanus conspicillatus)*, royal spoonbill *(Platalea regia)*, and glossy ibis *(Plegadis fascinellus)* are only found in the area during the southern winter between June and September.

There are 6 species of protected fauna in the Gulf Province mangrove area i.e. two birds of paradise *(Paradisaea raggiana, Seleucides melanoleuca)*, three egrets *(Egretta alba, E. garzetta, E. intermedia)* and one dugong *(Dugong dugon)*.

3.3. LAND ACCRETION

Mangroves are known to accelerate the process of land accretion (Hollerweger 1964, Macnae 1968), and to stabilize and protect shore-lines from erosion (Davis 1940, Savage 1972).

Coastal accretion appears to be occurring in the Purari-Kikori deltas as evidenced from old maps and village traditions, however, to date, this has not been documented.

3.4. SUMMARY

The mangrove association plays a major role in maintaining the present ecosystem of the Gulf region by:

1. Holding and settling silt carried down from watershed areas
2. Trapping inorganic nutrients carried down from the watershed, and converting them into the organic matter which forms the base of the food chains for the estuarine and Gulf of Papua communities
3. Stabilizing and protecting delta from erosion
4. Providing shelter and feeding, breeding and nursery grounds for fish, crustaceans and other marine life
5. Providing shelter and feeding and breeding grounds for various terrestrial wildlife
6. Functioning as a zone of interaction and inter-linkage with adjacent riverine, marine and terrestrial communities.

4. UTILIZATION OF RESOURCES FROM THE MANGROVE COMMUNITY

The following list summarizes the important recorded uses of resources of the mangrove community in South East Asian, African and American tropics (Watson 1928, Heyne 1950), as well as in Papua New Guinea. Those marked by asterisks are observed or recorded in the Gulf Province.

4.1. TRADITIONAL SUBSISTENCE USES

* 1 Mangrove timber for building material

* 2 *Nypa* fronds for thatching material

3 Fish stakes from mangrove timber

* 4 Firewood or charcoal from mangrove timber

5 Pneumatophore roots of *Sonneratia* for substitute cork or for floats of fishing nets

6 Mangrove bark extract for fishing net preservative or for wood stain

7 Dyes from mangrove root extract for textile and leather colouring

8 Young *Nypa* leaves for cigarette paper substitute

9 Medicinal uses: *Acanthus* fruit, exudes from *Avicennia* and *Ceriops* bark etc.

* 10 Fish poison from *Derris* root

* 11 Food, e.g. young radicales of *Bruguiera*, fruits of *Sonneratia alba*, edible fat from *Cerbera* seeds, extract of *Rhizophora mucronata* fruits for alcoholic drink

* 12 Wildlife, fish and invertebrates harvested for food. Wildlife species utilized in the Purari delta area are listed in Tables 2 and 3.

4.2. COMMERCIAL USES

* 1 Tannin extract from mangrove bark

2 Tannin extract as a source of polyhydro-phenol for glue

3 Source of dyes from mangrove bark extract

4 Mangrove timber for railway sleepers

5 Mangrove chips for paper pulp

6 Gas from mangrove wood or charcoal

7 Mangrove fibres for viscose rayon

8 Alcohol, vinegar and sugar from sap of *Nypa* flower

* 9 Crocodile skins

* 10 Estuarine fisheries

11 Aquaculture

Table 2. Numbers of vertebrate species recorded from the Purari-Kikori mangrove community and their human utilization (*)

	Total numbers	Commercial species	Subsistence species
Mammals	12	4	10
Birds	59	5	18
Reptiles	20	4	13
Frogs	4	-	-
Fish	142	60	133
TOTAL	237	73	174

) Many species are utilized to varying degrees by the local population, mainly for food. These species are defined here as "subsistence species". Species which enter the cash economy, e.g. being offered for sale in markets, are termed here "commercial species".

Table 3. Wildlife species utilized by villagers for subsistence purposes

Species are listed in decreasing order of hunting pressure and degree of utilization.

Phalanger maculatus	-	cuscus
Sus scrofa	-	bush pig
Ducula spilorrhoa	-	Torres strait pigeon
Anas superciliosa	-	black duck
Pteropus spp	-	flying foxes
Megapodius freycinet	-	common scrubfowl
Casuarius casuarius	-	double-wattled cassowary
Talegalla fuscirostris	-	black-billed brushturkey
Echymipera spp	-	bandicoot
Pelecanus conspicillatus	-	Australian pelican
Varanus indicus	-	common monitor lizard
Cacatua galerita	-	white cockatoo
Platalea regia	-	royal spoonbill
Ducula rufigaster	-	purple-tailed imperial pigeon
Plegadis falcinellus	-	glossy ibis
Dactylopsila spp	-	possum
Petaurus breviceps	-	sugar glider
Crocodylus porosus	-	salt water crocodile
Crocodylus novaeguinea	-	freshwater crocodile
Anseranas semipalmata	-	magpie goose
Hydromys chrysogaster	-	common water rat
Phalacrocorax sulcirostris	-	little black cormorant
Anhinga rufa	-	Australian darter
Dugong dugon	-	dugong
Ptilinopus superbus	-	superb fruit dove

5. ECONOMIC IMPORTANCE OF THE MANGROVE COMMUNITY

5.1. PRESENT ECONOMIC VALUES OF MANGROVE COMMUNITY EXPLOITATION

At present, there is some commercial production of crocodile skins and some commercial fishing in the Purari-Kikori deltas. The resources are also used for various subsistence purposes such as fish and wildlife for food and materials for buildings and fuel.

5.1.1. CROCODILE SKIN INDUSTRY

No accurate estimate of the wild population of crocodiles in the Gulf Province mangroves is available and neither is there any record of the quantity of crocodile skins traded from the Gulf Province. There are, however, 18 years of records of crocodile skin exports from PNG averaging about K 400,000 per year (Downes 1970, Lever 1975)(1). A very approximate estimate is that one quarter of the crocodile skins exported from Papua New Guinea comes from the Gulf Province and that half of the crocodile population occurs in the mangrove habitats. It is also estimated that, in terms of the crocodile skin industry, the mangrove swamp could be valued at 2ot/ha/year

5.1.2. SUBSISTENCE WILDLIFE UTILIZATION

It has been documented that people in rural areas of Papua New Guinea are heavily dependent on wildlife for subsistence and other purposes (Liem 1975,Liem et al 1976). An estimate of the wildlife harvest for 7 villages in the Purari delta, with a combined population of about 800, is presented in Table 4. The hunting grounds of these villages cover an area of about 100,000 hectares. Assuming that the wildlife harvested is constant throughout the year, the area surveyed may be valued at K 20,000 per year in terms of wildlife harvested, or the mangrove swamps are valued at around 20t/ha/year.

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(1) Papua New Guinea currency: 1 K(kina) = 100 t(toea). In December 1977 1 K = US $ 1.365

Table 4. Wildlife species harvested in fourteen days by villagers in the Purari delta

	Number	Est.weight (kg)	Est.value (K)
Bush pigs	21	600	500
Cuscus	50	150	250
Torres Strait pigeons	16	5	5
Wildfowl	2	2	2
Black duck	9	8	10
Pelican	6	20	20
Monitor lizard	4	16	12
Bandicoot	2	1	3
Water rat	2	1	2
Hornbill	1	1	3
Spoonbill	2	2	6
TOTAL	115	806	K 813

Data are taken from seven villages (Akoma,Kapai,Kinipo, Maipenairu, Mariki, Barea and Morowam) in the mangrove area of the Purari delta. Surveys were conducted in January/ February and July/August 1976. Cash values are estimated only.

5.1.3. BUILDING MATERIALS AND FUEL

Virtually all village houses are constructed from mangrove timber and *Nypa* palm matting. Additionally, mangrove timber is the main source of firewood. It is very difficult to put a cash value on the shelter and energy provided by mangroves to the human population and no attempt is made here. There is, however, no doubt that these resources are of considerable value to the subsistence economy.

5.1.4. SUBSISTENCE AND SMALL SCALE COMMERCIAL FISHING

A detailed analysis of subsistence fishing in the Purari delta will be presented in another report in this series (Haines in prep.). The main source of animal protein in the diet of villagers is fish and aquatic invertebrates of the mangrove zone.

The average daily catch of fish was 0.08 kg and crabs 0.04 kg per head of population. Prawns were not fully recorded

but appear to be caught in comparable quantities.

The estimated annual subsistence catch for the Purari-Kikori deltaic area is almost 600 tonnes of fish and 300 tonnes of crabs. A noteworthy point concerning fish is that a large part of the catch consists of small fish, e.g. ambassids gobies, gudgeons and small catfish.

In this paper "commercial" implies anything entering the cash economy e.g. anything sold in the market. In this sense virtually all fish, crustaceans and molluscs caught for subsistence purposes can be considered as commercial, because they are sold in markets from time to time.

The bulk of market commerce is restricted to freshly caught fish and molluscs and live crabs. Until the recent introduction of cold smoking and salting and sun-drying techniques, villagers had no efficient methods for preserving fish. These techniques are still limited to a few villages and do not appear to have altered market patterns as yet.

Because no market surveys have been carried out it is not possible to give figures. The main market species are mudcrabs (*Scylla serrata*), mullet (Mugilidae), eel-tail catfish (Plotosidae), catfish (Tachysuridae/Ariidae), jewfish (Sciaenidae) and various bivalve molluscs.

5.1.5. COMMERCIAL ESTUARINE FISHERIES

The Purari-Kikori deltaic areas are rich in estuarine fish, mudcrabs, brackish water prawns (*Macrobrachium rosenbergii*) and molluscs. Commercial development is at an early stage, with frozen fish fillets being produced for the highlands and Port Moresby markets. An estimated 8-10 tonnes mixed fish are produced annually (Anon.1976). This is only a small fraction of the potentially exploitable fish and other brackish water resources of the mangrove area.

There is considered to be good potential for developing a larger scale fishing industry based on barramundi, catfish, threadfin salmon (Polynemidae), sharks (*Carcharhinus* spp.), mudcrabs and brackish water prawns (Anon 1976).

5.1.6. PRAWNING INDUSTRY IN THE GULF OF PAPUA

Trawling for prawns (*Penaeus* spp. and *Metapenaeus* spp.) and spiny lobster (*Panulirus ornatus*) is the main commercial activity in the Gulf of Papua (Anon 1976).

The annual prawn catch varies considerably, the highest catch occurring in 1973-74 when almost 1 million kg, worth K 2,572,000 were exported (Wilson and Tatamasi 1976). It averages out at about 460,000 kg exported per year at a value of K 1,600,000.

On the basis of these figures, assuming all prawns taken use the Purari-Kikori estuaries as nursery areas, the area could be valued at around K 5.00 per hectare per year in relation to the prawn catches. The assumption is unproven to date and smaller estuaries outside the Purari-Kikori area probably also serve as nursery grounds. This figure should therefore be regarded as the maximum likely value for the area calculated on this basis.

5.1.7. OTHER FISHERIES IN THE GULF OF PAPUA

Other off-shore fisheries are at a very early stage of development. There is potential for utilizing trash fish from trawlers and for shark and tuna fisheries (Anon 1976). Nutrients carried out from the mangrove areas must make an important contribution to the fish biomass in the Gulf of Papua.

The total economic value of the Gulf Province mangrove community in relation to the existing, developing and potential fisheries dependent on it cannot be fully assessed at present. Newell and Barber (1975) estimated that estuarine dependent fish contributed 32% of the total marine fisheries production around Australia in 1971-72. In Queensland it has been estimated that the total annual value in cash, employment and kind which arises out of the exploitation of fish resources dependent on the mangrove swamps of Moreton Bay can be set at A$ 14,000,000, i.e. a net annual return in the order of A$ 750 per hectare of mangrove forest (Harrison 1967, Jones 1972).

5.2. POTENTIAL ECONOMIC VALUES OF RESOURCES OF THE MANGROVE COMMUNITY

5.2.1. TANNIN EXTRACTION FROM MANGROVE BARK

A tannin extraction industry was established at Aird Hills near Kikori in the 1950's but it closed down soon afterwards. Hillis (1956) estimated that an average yield of 37 tonnes of *Rhizophora* and *Bruguiera* fresh bark per hectare could be produced from the Gulf Province mangrove. The present cash value of this product is not available. In Papua New Guinea at present it is not economical to exploit tannin from the mangrove bark on a large scale basis, except as a by-product of timber and woodchip operations (Office of Forests, pers.comm.).

5.2.2. TIMBER FROM MANGROVE TREES

Hillis (1956) estimated that there are about 22,536,00 tonnes of harvestable mangrove timber in the Gulf Province. The present value of this resource is not available. At present there is a small scale commercial exploitation of mangroves for timber.

5.2.3. WOODCHIP FROM MANGROVE TREES

Oji Paper Co.Ltd. and Shin Asahigawa Co.Ltd. (1975) made a preliminary survey of the Gulf Province mangroves for woodchipping. It was reported that over 20 species of mangrove trees are present and 96% of the volume consists of *Rhizophora* spp., *Bruguiera* spp., and *Camptostemon* spp., with diameter of 27cm dbh (diameter breast height) or over. Out of the 230,000 ha surveyed 110,000 ha is economical forest for a woodchip industry. The total log volume in the 110,000 ha economical mangrove stand is estimated at 7,879,000 m^3. With the estimated annual production of woodchip of about 136,000 m^3 covering an annual coupe of about 2,000 ha, and royalties of 35 t/m^3, the production of this resource could be valued at K 47,600/pa in royalties.(1) Hence if used for woodchipping the mangrove forest of the Gulf Province could be valued at approximately K 7.00/ha over a period of 20 years (assumed regeneration time) or a net return of about K 0.45/ha/yr, in royalties. Additional benefits would come through employment opportunities and services. Approximately 2,300 nationals would be employed under these proposals.

The Office of Forests (pers.comm.) say there is no likelyhood of this form of development in the area in the foreseable future.

5.2.4. ALCOHOL EXTRACTION FROM NYPA PALM

The extensive pure stand of *Nypa* palm could be developed to produce alcohol, vinegar,and sugar from the sap of the flower stalk. In North Borneo (now Sabah) from a pure stand of *Nypa* palm a small scale industry could produce about 2,500 litres of 95% alcohol/ha/yr (Foxworthy and Matthews 1917) for an approximate value of K 1,000/ha/yr (1976 prices). There are about 48,500 ha of pure stand *Nypa* palm in the Gulf Province which are of potential economic importance.

5.2.5. BRACKISH WATER AQUACULTURE

In South-east Asia,patches of mangrove swamps have been developed into ponds for fish and shrimp culture. It has been estimated that the economic return on investment in fish pond development is more than in mangrove wood production,e.g. in the Philippines,there is an income advantage of about 11 to 1 or around K 100 per ha/year in favour of fish pond production (Lawas et al 1972).

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(1) The Office of Forests suggests 80 toea/m^3 to be a more realistic figure than given by the company. Consequent return in royalties would then be around K 1.00/ha/yr.

In Papua New Guinea village-based fish culture has been attempted in the highlands but has proved unviable under present social and economic conditions (Glucksman, pers.comm., West and Glucksman 1976). Considering quantities of fish naturally present and the lack of any fish culturing tradition in the villages of the Gulf Province, village-based fish culture here is considered to be both unnecessary and unviable. The only form of aquaculture with any chance of success would be the intensive culturing of a highly-priced exportable product, as with trout farming in the highlands (West and Glucksman 1976).

5.3. COMPARATIVE VALUES OF EXISTING AND POTENTIAL USAGES

Comparisons of potential monetary returns per unit area per year of the various resources of the mangrove community are given in Table 5.

Table 5. Comparative value of the mangrove forest resources

Resource	Value toea/ha/yr	Effects on ecosystem	Cost of development
subsistence building materials and fuel	n.a.	none-low	none
subsistence wildlife	20	none	none
subsistence fishing	55	none	none
subsistence crabbing	20	none	none
subsistence prawning	n.a.	none	none
crocodile skins	20	none	none
prawn trawling	500	none	high
estuarine fishing and crabbing (commercial)	n.d.	low	low
off-shore fishing (commercial)	n.d.	none	high
brackishwater aquaculture	n.d.	high-moderate	high
mangrove woodchip	45*	high	high
mangrove timber	n.d.	high-moderate	high
tannin extraction	n.d.	high-moderate	high
alcohol from *Nypa*	n.d.	none	low

n.a.: data not available n.d.: not developed

* royalties; or 100 if Office of Forests figure for royalties used

The cash value of subsistence fish is taken to be 15t per kg whole weight and of subsistence crabs 10t per kg. These figures are based on a rough average of market prices in Kikori, Baimuru and Ihu.

Values given in Table 5 are the estimated values of the resources which can be produced from the mangrove community. Other factors such as the cost of developing infrastructures, costs of exploitation, employment provided and social costs are not fully considered here. These factors should also be used in assessing the ultimate importance of the various developmental strategies.

6. LIKELY ENVIRONMENTAL IMPACTS OF LARGE SCALE DEVELOPMENT

6.1. MANGROVE HARVESTING

Large scale logging of mangrove stands for timber, wood-chipping and/or tannin extraction may have several effects on surrounding areas. The magnitude of the impact would be related to the rate, the method, and the extent of logging (see Figure 2).

(a) It could disrupt the energy and nutrient transfer from the mangroves to the estuary, and break the food chain in their area, reducing the productivity of the community.

(b) Some wildlife will be deprived of mangrove habitats.

(c) Since coastal areas are exposed to south-easterly winds for six months of the year, they would be prone to erosion by wave action if stripped of mangrove forest. The strong tides of the area would also become an important erosive force.

6.2. HYDRO-ELECTRIC DAM DEVELOPMENT AT WABO

The proposed Wabo Power Project involves the building of dam to produce hydroelectric power at Wabo 100 km inland on the Purari River, the transmission of this power to a port-site on the coast and the development of an industrial complex at this port site (Snowy Mountains Engineering Corporation - Nippon Koei Co.Ltd.,1974).

The proposed dam could affect the ecological balance of the Purari delta by altering a number of factors:

(a) the inflow of silt

(b) the inflow of nutrients

(c) the salinity regime

(d) the flood regime

These could affect the mangroves of the Purari delta quite drastically, but whether there would be any effect on the Kikori mangroves is not known (see Figure 2).

(a) Inflow of silt

An estimated 80% of the river-borne sediment of the Purari river will be trapped in the Wabo lake, resulting in a reduction of silt supply to the mangrove areas of the delta (SMEC/NK,1977). The highly unstable delta has developed because of the regular inflow of a large quantity of silt. There is at present a dynamic balance between land accretion and erosion, with an apparent favour towards accretion. The loss or reduction of silt input will alter the balance towards erosion. A lowered silt load in flowing water also increases its erosive power. As mentioned above, the delta coast is exposed to the south-easterlies for six months of the year, making it vulnerable to erosion from the sea as well as the river.

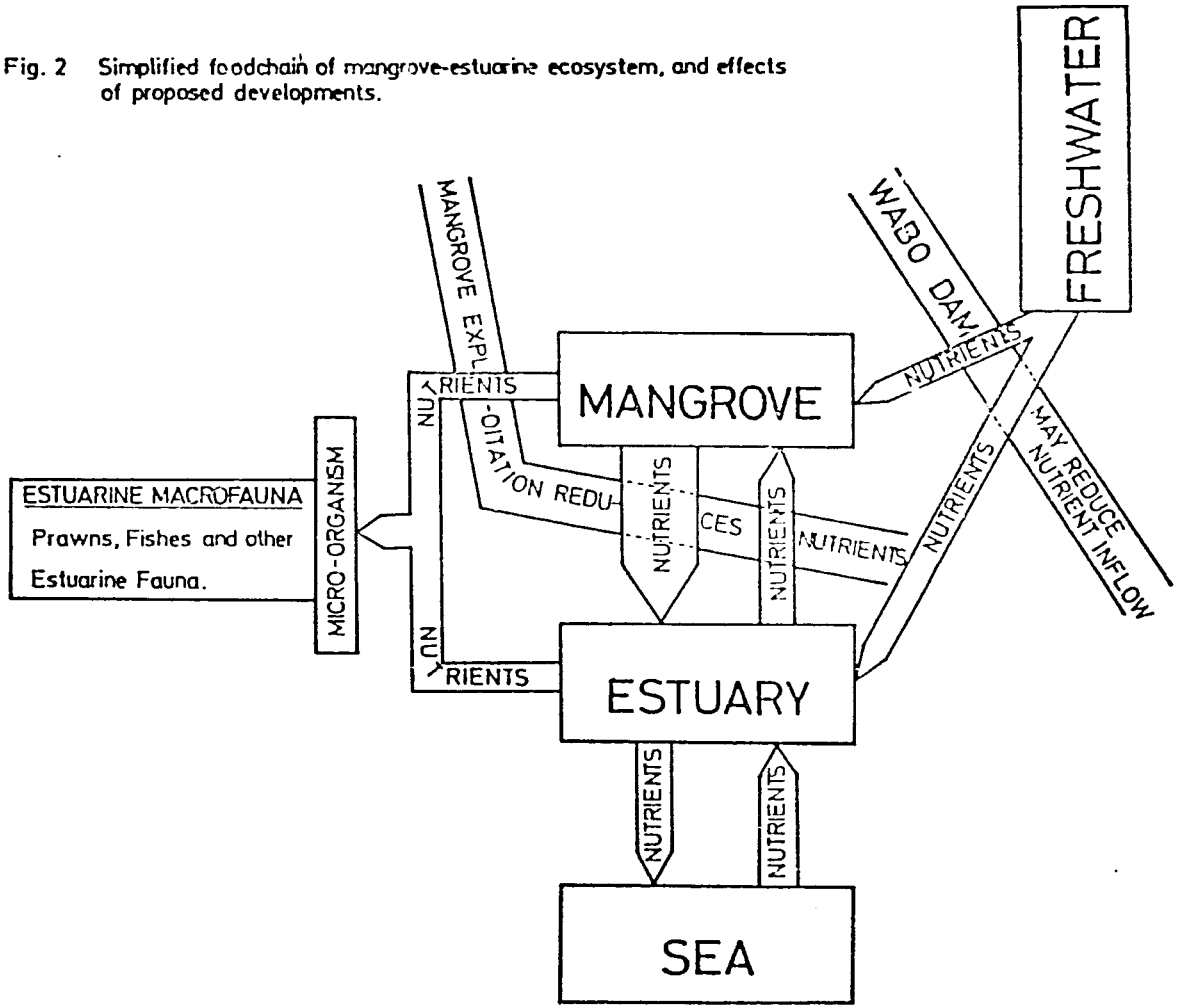
A similar situation has occurred in the Nile delta (Kassas 1972). The establishment of the Aswan High Dam has halted the delta-building process, allowing the balance to tip in favour of the erosive forces which have always been present. An active process of coastal retreat has now commenced.

The role of silt in the ecology of mangrove flora and fauna is not fully understood. A reduction of silt may affect the distribution and abundance of some animal and plant species.

(b) Inflow of nutrients

The inflow of nutrients is likely to be closely associated with silt inflow. A loss of silt-associated nutrients will reduce the nutrient cycle of the mangrove community, causing eventually an absolute reduction in biomass dependent on the mangrove association. A reduction in biomass due to reduced nutrient flow is a well-documented effect on biota downstream from artificial impoundments. Following the construction of the Tsimlyansk hydroelectric scheme in the U.S.S.R. the biomass of phytoplankton in the Sea of Azov was reduced by 2-3 times, and that of the zooplankton from 600 mg/m^3 to 24-50 mg/m^3. This had a major adverse effect on the size of fish stocks (Karpevich 1958 as cited by Nikolsky 1963,p.27). Prior to the closing of the Aswan High Dam in Egypt in 1964, the annual catch of sardines (*Sardina pilchardus*, *Sardinella aurita* and *S.maderensis*) in waters off-shore from the Nile Delta was estimated at 18,000 tons. The sardines appeared to play an important role in harvesting the burst of primary production associated with the seasonal peaks of flood-borne nutrients from the Nile. By 1972 the catch had declined to 500 tons (George 1972).

Fig. 2 Simplified foodchain of mangrove-estuarine ecosystem, and effects of proposed developments.



(c) Salinity regime

The salinity regime of water within the mangrove zone will be altered by the changed flow rates from the Purari river. While the dam is filling, flow rates in the river will fall, allowing an influx of sea water throughout the system. Adverse effects of this saline intrusion are more likely to be apparent in the adjacent swamp and sago forests than in the mangrove zone. A certain adjustment of flow rate is possible during the filling period. After filling, the same quantities of water as previously will flow down the river but seasonal fluctuations may to a certain extent be levelled out.

(d) Flood regime

Very little is known about the significance of seasonal freshwater influxes into the mangrove system. The limited information available suggests it to be of considerable importance, e.g. in Louisiana, Copeland (1966) found that parasites of mangrove oysters such as fungi and boring sponges are controlled by regular freshwater flushing. If the Wabo dam is built it may be necessary to create artificial floods at intervals to maintain the ecological balance within the mangrove community.

6.3. INDUSTRIAL POLLUTION

A decision to develop industry within the Gulf Province, whether from the Wabo Scheme or otherwise, would increase the likelihood of industrial pollution affecting the mangrove community. Such industry would need stringent controls on the disposal of wastes.

7. DISCUSSION AND RECOMMENDATIONS

The deltaic areas of the Gulf Province have considerable existing and potential importance to Papua New Guinea. They are home to approximately 20,000 people who derive their subsistence needs for food, fuel and shelter from their environment. In addition, small quantities of produce are sold outside the province, bringing in some cash income. The deltaic areas also provide nursery grounds and are a source of nutrients for important fisheries in the Gulf of Papua. With careful development the area could become a major source of protein for Papua New Guinea and of export products such as fish and timber.

There is a need for more studies so that this complex system can be better understood. Not only in Papua New Guinea, but throughout the world there is increasing interest in mangrove and estuary ecosystems. As this area contains one of the largest untouched expanses of mangroves in the world, it is a logical area for many such studies to be carried out.

It is not desirable that commercial developments be prevented while the basic research is going on as Papua New Guinea needs to develop its resources. However, commercial developments should be encouraged first in fields which have minimal effects on the environments, such as delta and off-shore fisheries and possibly small scale timber production. These operations would themselves produce valuable research data to be used in improving understanding of the system.

Certain areas requiring further research can be identified. These include detailed studies of:

1. the nutrient cycle and its mechanisms
2. microbiology
3. invertebrate faunal surveys
4. productivity
5. ecology and general biology of important species
   e.g. invertebrates: carid and penaeid prawns, mud crabs and mound building animals
   fish: threadfin salmon, catfish
   wildlife: crocodiles, cuscus
6. nutrient export to the Gulf of Papua
7. forest regeneration
8. mechanisms of land accretion
9. siltation.

8. APPENDICES

8.1. APPENDIX 1. - MANGROVE TREES OF THE PURARI DELTA

Rhizophoraceae	*Rhizophora mucronata* *R.apiculata* *R.conjugata* *Bruguiera gymnorrhiza* *B.parviflora* *B.sexangula* *B.cylindrica* *Ceriops decandra*
Sonneratiaceae	*Sonneratia caseolaris* *S.acida* var. *alba*
Verbenaceae	*Avicennia marina* var. *alba* *A.officinalis*
Meliaceae	*Xylocarpus granatum* *X.moluccensis*
Sterculiaceae	*Heritiera littoralis*
Myrsinaceae	*Aegiceras corniculatus*
Euphorbiaceae	*Excoecaria agallocha*
Plumbaginaceae	*Aegialitis annulata*
Palmae	*Nypa fruticans*
Apocynaceae	*Cerbera sp.*
Acanthaceae	*Acanthus ilicifolius*
Bombacaceae	*Camptostemon schultzei*

8.2. APPENDIX 2. - TETRAPOD FAUNA OF THE PURARI MANGROVES

* - species found only in mangrove habitat

** - species hunted

MAMMALS

a. Arboreal

**	*Dactylopsila* spp	possum
	Hipposideros diadema	common horseshoe bat
**	*Petaurus breviceps*	sugar glider
**	*Phalanger maculatus*	spotted cuscus
**	*Pteropus macrotis*	big-eared flying fox
**	*Pteropus neohibernicus*	Bismarck flying fox

b. Terrestrial

**	*Echymipera* spp	bandicoot
**	*Sus scrofa*	bush pig

c. Semi-aquatic

**	*Hydromys chrysogaster*	common water rat

d. Aquatic

	Delphinus delphis	common dolphin
**	*Dugong dugon*	dugong
**	*Orcaella brevirostris*	Irrawady dolphin

BIRDS

a. Tree/shrub birds - arboreal feeding, roosting and nesting

**	*Cacatua galerita*	white cockatoo
	Chlamydera cerviniventris	fawn breasted bower bird
	Coracina tenuirostris	long billed greybird
	Corvus orru	Papuan crow
	Domicella lory	black-capped lory
**	*Ducula mulleri*	Muller's imperial pigeon
**	*Ducula rufigaster*	purple-tailed imperial pigeon
**	*Ducula spilorrhoa*	Torres Strait imperial pigeon
	Geopelia humeralis	bar-shouldered dove
	Gerygone fusca	western gerygone warbler
	Gerygone magnarostris	swamp gerygone warbler
	Lorius roratus	eclectus lory
	Manucodia ater	glossy-mantled manucode
	Monarcha alecto	shiny flycatcher

*	*Myiagra ruficollis*	broadbill flycatcher
*	*Myzomela erythrocephala*	mangrove myzomela
	Nectarina jugularis	yellow-bellied sunbird
	Oriolus szalayi	brown oriole
	Pachycephala pectoralis	golden whistler
*	*Poecilodryas pulverulenta*	mangrove flycatcher
**	*Paradisaea raggiana*	Raggiana bird of paradise
	Ptilonopus superbus	superb fruit dove
	Rhipidura rufifrons	black-breasted rufous fantail
	Scythrops novaehollandiae	channel bill cuckoo
**	*Seleucides melanoleuca*	twelve-wired bird of paradise

b. Tree/shrub birds - aquatic feeding, arboreal roosting and nesting

**	*Anhinga rufa*	Australian darter
	Dacelo leachi	blue-winged kookaburra
*	*Halcyon chloris*	mangrove kingfisher
	Halcyon macleayii	forest kingfisher
	Halcyon sancta	sacred kingfisher
	Halcyon saurophaga	white-headed kingfisher
**	*Phalacrocorax sulcirostris*	little black cormorant

c. Shore/mudflat birds - ground feeding, roosting and nesting

	Actitis hypoleuca	common sandpiper
	Arenaria interpes	turnstones
	Charadrius leschenaulti	large sand dotterel
	Charadrius mongolus	Mongolian dotterel
	Heteroscelis incanus	wandering tattler
	Himantopus himantopus	white-headed stilt
	Limosa limosa	black-tailed godwit
	Numenius madagascariensis	whimbrel
	Numenius phaeopus	whimbrel
	Pluvialis dominica	Pacific golden plover
	Tringa hypoleucos	common sandpiper

d. Water birds - aquatic feeding, arboreal roosting and nesting

**	*Anseranas semipalmata*	magpie goose
	Buterides striatus	mangrove heron
**	*Dendrocygna guttata*	spotted tree duck
	Egretta alba	greater egret
	Egretta garzetta	snowy egret
	Egretta intermedia	lesser egret
	Nycticorax caledonicus	rufous night heron
**	*Platalea regia*	royal spoonbill
**	*Plegadis falcinellus*	glossy ibis

e. Water birds - aquatic feeding, ground roosting and nesting

**	*Anas superciliosa*	black duck
**	*Pelecanus conspicillatus*	Australian pelican

f. Ground birds - ground feeding and nesting, ground or arboreal roosting

**	*Casuarius casuarius*	double-wattled cassowary
**	*Megapodius freycinet*	common wildfowl
**	*Talegala fuscirostris*	black-billed brush turkey

g. Aerial birds- ground feeding, arboreal roosting and nesting

	Haliastur indus	brahminy kite

h. Aerial birds - aquatic feeding,ground roosting and nesting

	Sterna hirundo	common tern

REPTILES

a. Arboreal/ground dwellers

	Chondropython viridis	green python
	Boiga irregularis	common brown tree snake
	Gehyra spp	house gecko
**	*Python spp*	pythons

b. Arboreal/ground dweller/semiaquatic

**	*Varanus indicus*	common monitor lizard
	Varanus prasinus	emerald monitor lizard
**	*Varanus salvadori*	Salvadoris monitor lizard

c. Ground dwellers

	Carlia fusca	common grass skink

d. Semiaquatic

	Amphiesma spp	water snake
**	*Carettochelys insculpta*	pitted-shelled turtle
**	*Chelodina siebenrocki*	Siebenrock's snake - neck turtle
**	*Crocodylus porosus*	salt water crocodile
**	*Crocodylus novaeguinea*	freshwater crocodile
**	*Elseya novaeguinea*	New Guinea short-neck turtle
**	*Emydura subglobosa*	red short-neck turtle
**	*Pelochelys bibroni*	soft-shelled turtle

e. Aquatic

**	*Acrochordus javanicus*	file snake
	Aipysurus spp	soa snake
**	*Chelonia mydas*	green turtle
**	*Caretta caretta*	hawksbill turtle

FROGS

a. Semi-arboreal

Litoria infrofrenata	great green tree frog

b. Ground dweller

Lechriodus spp	
Litoria nasuta	rocket frog
Rana papua	

8.3. APPENDIX 3. - FISH FAUNA OF THE PURARI-KIKORI MANGROVE AREAS

These species were recorded during field work for the fisheries part of the Purari environmental studies (Haines 1976). They were identified primarily from keys and descriptions in Weber and de Beaufort (1913-1962) and Munro (1967), and from the fish reference collection at Kanudi Fisheries Research Station (Kailola 1975). Sharks were identified using an unpublished key by Filewood.

For general convenience the classification and nomenclature used here follows Munro as closely as possible, as this is the main handbook for New Guinea fishes. However, it must be recognized that many major revisions of groups have been completed since the publication of Munro.

A detailed account of the fish fauna in the Kikori-Purari deltaic system will be presented as a separate report in this series.

CODE:

- * predominantly estuarine i.e. main populations in the mangrove area
- M predominantly marine, entering or with small populations present in the mangrove area
- R predominantly riverine, entering or with small populations present in the mangrove area
- J juveniles taken from the mangrove area

Carcharhinidae

Carcharhinus leucas	river whaler shark	R
Carcharhinus gangeticus (?)	pig-eyed whaler	*
Carcharhinus glyphis	whaler shark	*

Myliobatidae

Aetobatus narinari	spotted eagle-ray	M

Dasyatidae

Himantura uar-nak	long-tailed ray	M
Dasyatis sephen	cowtail ray	M

Rhinobatidae

Rhinobatos batillum or *armatus*	shovelnose ray	M

Pristidae

Pristis microdon	sawshark	*J

Megalopidae

Megalops cyprinoides	ox-eye herring, tarpon	*M

Engraulidae

Trissocles setirostris	long-horned anchovy	MJ
Scutengraulis hamiltoni	anchovy	*J
Scutengraulis scratchleyi	freshwater anchovy	RJ
Stolephorus commersoni	anchovy	MJ
Stolephorus bataviensis	anchovy	M
Stolephorus indicus	anchovy	M

Clupeidae

Kowala macrolepis	deep-bodied herring	MJ
Macrura brevis	blackspot herring	MJ

Plotosidae

Plotosus canius	eel-tail catfish	*J

Tachysuridae/Ariidae

Hexanematichthys leptaspis	goldspot catfish	*J
Hexanematichthys latirostris(?)	broad-nosed catfish	RJ
Hexanematichthys carinatus	lesser thick-lipped catfish	R
Hexanematichthys danielsi (?)	sharp-nosed catfish	*J
Hexanematichthys proximus(?)	grey catfish	*J
Hexanematichthys stirlingi	threadfin catfish	*J
Hexanematichthys australis (?)	ridge-backed catfish	M
Hexanematichthys sp.	yellow catfish	*J
Cinetodus froggatti	high-nose catfish	*J
Pseudarius sp.	long-faced catfish	M
Pseudarius colcloughi (?)	granular-toothed catfish	M
Nedystoma sp.	long-ridged catfish	M
Netuma sagoroides	beach catfish	M
Hemipimelodus sp.	flesh-lipped catfish	*

Doiichthydae

Doiichthys novaeguineae	spoon-snouted catfish	*

Muraenidae

Gymnothorax polyuranodon	freshwater moray eel	*

Anguillidae

Anguilla interioris (?)	eel	R

Belonidae

Strongylura strongylura	long tom	*J

Hemirhamphidae (juveniles present, identification difficult) J

Zenarchopterus novaeguineae	Fly river garfish	JR
Zenarchopterus brevirostris	short-nosed river garfish	R
Zenarchopterus dunckeri (?)	river garfish	R
Labidorhamphus caudovittatus	garfish	?

Bothidae

Pseudorhombus elevatus	deep-bodied flounder	M

Soleidae

Aseraggodes klunzingeri	freshwater sole	R
Aseraggodes sp.	sole	?

Cynoglossidae

Paraplagusia bilineata	patterned tongue-sole	MJ
Cynoglossus heterolepis	tongue-sole	MJ
Cynoglossus cynoglossus (?)	tongue-sole	MJ
Cynoglossus punticeps	spotted tongue-sole	MJ

Syngnathidae

Oostethus brachyurus	short-tailed pipefish	*
Bombonia djarong	freshwater pipefish	*
Bombonia spicifer	banded freshwater pipefish	*

Mugilidae (juveniles extremely common, but difficult to identify) J

Cestraeus goldiei	Goldie river mullet	R
Rhinomugil nasutus	skip jack mullet	*J
Liza vaigiensis	diamond-scale mullet	*
Liza oligolepis	large-scaled mullet	*
Liza dussumieri	brown-banded mullet	*
Liza tade	mullet	*
Mugil cephalus	sea mullet	*M
Mugil engeli	mullet	*
Valamugil buchanani (?)	mullet	*R
Valamugil seheli (?)	blue-spot mullet	*
Liza macrolepis (?)	Troschel's mullet	*

Polynemidae

Eleutheronema tetradactylum	threadfin	*J
Polydactylus sheridani	threadfin	*J

Kurtidae

Kurtus gulliveri	nursery fish	*J

Carangidae		
Caranx sp.	trevally	MJ
Caranx sexfasciatus	great trevally	M
Caranx ignobilis	lowly trevally	M
Chorinemus lysan	leatherskin	M
Chorinemus sp.	leatherskin	MJ
Leiognathidae		
Gazza achlamys	Silver toothedponyfish	M
Secutor sp.	pug-nosed ponyfish	M
Equula equula	common ponyfish	M
Equulites berbis	ponyfish	
Apogonidae		
Apogon hyalosoma	cardinal fish	M
Kuhliidae		
Kuhlia marginata	spotted flagtail	*
Latidae/Centropomidae		
Lates calcarifer	barramundi	*R
Chandidae/Centropomidae		
Parambassis gulliveri	giant perchlet	R
Priopidichthys gymnocephalus	perchlet	*
Ambassis nalua	perchlet	*
Ambassis macracanthus	perchlet	*
Ambassis buruensis	perchlet	*
Lobotidae		
Lobotes surinamensis	dusky tripletail	M
Datnioides quadrifasciatus	four-banded tripletail	*J
Lutjanidae		
Lutjanus sp.	Papua black bass	*
Lutjanus argentimaculatus	mangrove jack	*
Pomadasyidae		
Pomadasys hasta	javelinfish	MJ
Theraponidae		
Therapon jarbua	cresent perch	MJ

Sparidae		
Acanthopagrus berda	pikey bream	*J
Mullidae		
Upeneus sulphureus	sunrise goatfish	MJ
Sciaenidae		
Johnius belengeri	lumpy jewfish	RJ
Johnius dussumieri	green-backed jewfish	*
Pseudosciaena soldado	silver jewfish	*J
Pseudosciaena sina	drab jewfish	*
Collichthys novaeguineae	paper-headed jewfish	M
Sillaginidae		
Sillago sihama	northern whiting	MJ
Pempheridae		
Leptobrama mulleri	beach salmon	M
Toxotidae		
Toxotes chatareus	Archer fish	*RJ
Epinephelidae		
Epinephelus tauvina	estuary rock-cod	M
Epinephelus fuscoguttatus	carpet cod	M
Drepanidae		
Drepane punctata	sicklefish	MJ
Scatophagidae		
Scatophagus argus	scat	*J
Selenotoca multifasciata	butterfish	MJ
Callionymidae		
Eleutherochir opercularis	flap-gilled dragonet	MJ
Callionymus sagitta	milk-spotted dragonet	MJ
Gobiidae		
Oxyurichthys jaarmani	goby	M*
Oxyurichthys tentacularis	goby	M*
Glossogobius giurus	flat-headed goby	*RJ

Apocryptidae

Scartelaos viridis	bearded goby	*

Periophthalmidae (juveniles present, identification difficult) J

Periophthalmus schlosseri	giant mudskipper	*
Periophthalmus weberi	mudskipper	*
Periophthalmus koelreuteri (?)	mudskipper	*
Periophthalmus vulgaris	mudskipper	*

Eleotridae

Prionobutis microps	gudgeon	*
Butis amboinensis	gudgeon	*
Ophiocara porocephala darwiniense	spangled gudgeon	*J
Bunaka gyrinoides	green-backed gauvina	*J
Bunaka herwerdeni	black-backed gauvina	*J
Oxyeleotris urophthalmus novaeguineae	loter	*J
Oxyeleotris lineolatus	loter	R
Mogurnda mogurnda	purple-spotted gudgeon	R

Platycephalidae

Platycephalus indicus	bar-tailed flathead	M

Lagocephalidae

Gastrophysus lunaris	silver toadfish	M
Torafugu pleurostictus (?)	toadfish	M
Takifugu meraukensis	toadfish	MJ

Tetrodontidae

Chelonodon patoca	milk-spotted toadfish	MJ
Arothron reticularis	reticulated toadfish	M

Triacanthidae

Triacanthus indicus (?)	tripodfish	MJ
Triacanthus biaculeatus	tripodfish	M

Supplementary list

These species have not been collected by the authors but have been present in earlier collections from this area. This list is prepared from Kailola (1975). Some collection localities are poorly defined.

Engraulidae		
Setipinna papuensis	hairfin anchovy	*
Thryssa (Thrissocles) mystax	anchovy	*
Harpodontidae		
Harpodon nehereus	Bombay duck	M
Antennariidae		
Lophichthys boschmai	estuarine anglerfish	M
Holocentridae		
Holocentrus spinifer	spiny squirrelfish	M
Carangidae		
Alepes kalla	herring trevally	M
Uraspis helvola		M
Zonichthys nigrofasciatus	black-banded kingfish	M
Parastromateidae		
Parastromateus niger	black pomfret	M
Cepolidae		
Acanthocepola abbreviata	band fish	M
Polynemidae		
Polynemus intermedius	threadfin	M
Periophthalmidae		
Periophthalmus cantonensis novaeguineaensis	mudskipper	*
Gobioididae		
Amphyamblyopus sp.	goby	M
Taenioides cirratus	burrowing goby	M
Scombridae		
Rastrelliger brachysoma	short-bodied mackerel	M

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