ECOLOGICAL BALANCE OF BATANG LUPAR ESTUARY: POTENTIAL IMPACTS AND MITIGATIONS.

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1.0 Introduction

The Batang Lupar estuarine environment is dynamic with fast moving stream flowing through mangrove forest. The mangrove ecosystem, which encompasses the coastal tidal swamps and the numerous streams that flow through it has been widely acknowledged to play a significant role in the sustenance of the coastal marine fisheries. Ecological studies have shown those large quantities of energy, in the form of mangrove plant detritus are exported from mangrove swamps into the coastal zone (Ong *et al.* 1979).

Detritus and nutrients are exported out of the ecosystems through tidal flushing and this form the food base for marine micro-organism which in turn support the valuable estuarine and near shore fisheries (NATMANCOM 1986). It has been demonstrated that many coastal fishes have a high percentage of mangrove detritus (debris) in their gut, implying that the adjacent coastal fishery may be dependent on the export from the mangrove ecosystem. Positive correlation has been established between the real extent of mangroves and the size of fisheries yields from adjacent waters (Macnae 1974).

Estuarine animals are recruited mainly from the sea. Many species that live in the shallow water zone on the continental shelf use the estuary as a nursery ground before migrating to the open sea. Relatively few species are wholly adapted to life within this fluctuating environment.

The objective of this paper is to incorporate an environmental dimension in future project planning and implementation and to place more emphasis on prevention through conservation rather than on curative measures.

2.0 Materials and Methods

In the estuary, migrating fish populations consist in general of numerous micro-cohorts because growth is very rapid, thus sampling should be done at various localities. Seven sites, representing a range of habitats in the Batang Lupar estuary (Hadil 1991), were sampled in March, 2000. Two sampling stations with water depth of 1m and 3m were sited at the river of Sebuyau, a small mangrove creek that drained into the Batang Lupar river, were sampled from 22th to 24th March 2000. Three stations referring to Pulau Triso, Tanjong Lutong and Lingga within the main river were also sampled within the same period. The other two stations sampled within the same period were fishing stakes, one located at the mouth of the estuary, near Pulau Burong and the other at Pulau Seduku.

In sampling for different life stages of the fish, three type of sampling gears were deployed: fishing stakes, barrier and gill nets. The designs and methods of operation of these three gears were very well documented by Pang, (1989). Fishes emigrating from the estuary through the mangrove creeks were sampled using barrier net deployed at first two stations at Sungai Sebuyau. To sample bigger juvenile and adolescent fishes, a gill net was deployed at three stations (Pulau Triso, Tanjong Lutong and Lingga) within the main river. Another gear used to catch migrating fishes was the fishing stakes sited at Pulau Seduku, and at the mouth of Batang Lupar. Samplings were carried out both during the incoming and receding tides. Once the catch was landed onboard, large size fish and other specimens were sorted. All species irrespective of size were weighed and recorded.

3.0 Results and Discussion

The various fish species caught at different localities at Batang Lupar are shown in Table 1. They reflect the limited number of species found in estuary.

All of the species are of commercial important to the area and are the main food species available. Besides schools of Bombay ducks (*Harpodon neherus*), anchovies (*Coilia macrognathus; Setipinna breviceps; Setipinna taty; Stolephorus waitel*), there was pesent in these areas juvenile pufferfish, *Lagocephalus spadiceus* and big sized yellow pufferfish, *Xenopterus naritus*. Ribbonfish, *Trichirus* sp was only landed by the fishing stake at Pulau Seduku. Catfish, *Arius caelatus* was found in abundant at Sebuyau river trapped by barrier net and was common in the catches of gillnet as well as fishing stake. The common fish of the mangrove waterways, the mullets, *Liza oligolepis* were also caught by barrier net.

Other fishes which were caught in small numbers include species from families bagridae, belonidae, clupeidae, eleotridae, plotosidae, polynemidae, scatophagidae and sciaenidae.

Terubok or the big-mouthed shad (*Tenualosa toli*) is the endemic species and the most important commercial fish of Batang Lupar estuarine area. Since the migration season has just started, only a handful numbers of this shad was caught. *Tenualosa toli* is generally considered a pelagic plantivorus fish and moves into coastal rivers to spawn (anadromous). Studies by Gambang (1988), Willmann et al. (1989) and Hadil (1991) on the migration and spawning of terubok in the Batang Lupar indicate that migration into the river occurs between April and July, while the actual spawning period extends over the period between June and October. A tentative positive relationship between the presence/abundance of *Tenualosa toli* and inland rainfall and river discharge has been suggested. The other small-mouthed shad, *Tenualosa macrura* is generally found in the inshore coastal waters, especially along mangrove fringes.

Another important fish that used to be abundant in this area is the Golden Conger eel, *Muraenesox cinereus*. During the present survey not a single tail of this eel was caught. This eel is a unique fish in Sarawak. Its uniqueness lies in its swim bladder. The great demand for this organ has put a great pressure on the resource over the years. The resource was initially well distributed over the coastal waters of Sarawak but a recent survey has suggested that the traditional fishing ground around Pulau Burong has been deprived of this resource. The decline in the spawning biomass for Sarawak's conger eel has led to the drastic decline in the resource. Total landings of the fish over the years have declined from as much as 47,500 tons in 1978 (Anon.1979) to as low as 788 tons in 1995 (Anon.1996).

The habitat of this eel consists of seagrass beds within the sandy-mud bottom that form a good nursery as well a breeding ground for shrimps. There is a possibility that these eels predate upon the shrimps and other small crustaceans. Seagrass beds can be easily destroyed by siltation and by trawlers that are targetting for shrimps. Rampant logging activities up the Batang Lupar river basin has led to serious erosion and subsequently causing heavy siltation around Pulau Burong area. The habitat was adversely destroyed possibly causing serious depletion in the resource.

The famous large aquatic reptile that dwells in the area is the estuarine crocodile. There were a few reported incidents where the local people were attacked by these crocodiles.

Although most of these species were well adapted to the ever-changing estuarine environment, clearing of the ecosystem they depend on for life sustenance will bring about inherent physical, chemical and biological limits beyond which significant effects will occur. Thus sustainable development of the area should be emphasized so that ecological balance can be maintained.

Sebuyau River as a tributary to Batang Lupar also provides the fresh water inflows to the estuarine waters of Batang lupar. The upper reaches of Sungai Sebuyau River supports

few commercially important freshwater fishes and crustaceans. The dominant freshwater species sampled at Sebuyau fish market are:

Family Name	English Name/ Local Name	Scientific Name
Pangasiidae	River catfish/ Labang	*Pangasius sutchi*
Siluridae	Tapah	*Wallago dinema*
	Lajong	*Kryptopterus spp*
Cyprinidae	Carp/ Bantak	*Osteochilus vittatus*
	Harlequin fish and Scissor-tail Rasbora/ Seluang	*Rasbora elegans and Rasbora trilineata*
Belontiidae	Three-spot Gouramy/ Sepat	*Trichogaster trichopterus*
Palaemonidae	Giant freshwater prawn/ Udang Galah	*Macrobrachium rosenbergii*

All of these species are important source of protein to the indigenous people of the area. These freshwater organisms are less hardy to the changing environment especially when the water becomes turbid due to sediment runoff.

About 70% of the populace of Sebuyau, Kampong Sungai Merah, and Tebedu are involved in fishing (Anon.1996). Fishing is traditional in nature using gears like drift nets, stake net and bag nets. The high turbidity and fast flowing waters allowed the usage of these passive-fishing gears. The area of fishing is confined within the estuarine waters from Pulau Burong to as far as Pulau Seduku. Drift net is deployed mostly to target for terubok, whereas, bag nets are used to catch shrimp. Studies by Gambang (1988), Hadil (1991) and Yong (1994) have found that the Batang Lupar estuary is used as a nursery area by juvenile clupeids such as terubok and attempt have been made to culture these juveniles (Yong 1994).

Information gathered from the Fisheries Department in Sebuyau suggested that in the upper reaches (freshwater end) of Sebuyau river, illegal electric fishing and the use of cyanide for killing fish have occasionally been carried out. There were incidents where these poachers were apprehended and charged by the authority (Inland Fisheries Division

of the State Agriculture Department) under the Inland Fisheries Ordinance. These illegal fishings can have detrimental effects on the population of the fishes if left unchecked.

Farming in a mammoth scale such as the opening of new oil palm plantation involves the clearing of huge areas. Land clearing will expose the land and drainage alterations will increase erosion and sediment run-off into nearby streams during heavy downfalls. The freshwater stream would be affected of its benefial use, by the increase in turbidity, color and sediment load deposition. Erosion of the soil especially along the mangrove fringes will devoid juvenile fishes of their nursery ground and leaves them vulnerable to predators. The sediment will increase the particulate organic and inorganic material introduced to or resuspended in the environment causing increased organic enrichment. This organic load will put high demand on the concentration of the dissolved oxygen (DO), thus can lead to high biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Less dissolved oxygen concentration in the freshwater stream will kill the fishes. The complex physical and chemical properties of suspended and resuspended sediments and substratum changes associated with deposition can have both direct and indirect effects on estuarine organisms. Generally, bottom-dwelling fish species like the shrimp, catfishes-*Arius caelatus*, and croakers- *Johnius* sp. and *Ancharius brevibarbis* are tolerant to suspended solids but filter feeders like *Tenualosa toli, Setipinna sp., Coilia macrognathusi* and *Polynemus paradesius* are more sensitive. Early-life stages are more sensitive to suspended solids than adults (Sherk *et al.* 1975).

Tenualosa is generally considered a pelagic plantivorus fish, which inhabits coastal waters and estuaries, and moves into coastal rivers to spawn (anadromous). Thus, the effect of environmental conditions is probably strongest in the early estuarine phase of the life cycle of *Tenualosa toli.* As the pattern of river discharge may be influenced by human activities in the upper river catchment's areas, *Tenualosa toli* resources may be affected.

The study by the FAO team in 1988 (Willmann *et al*. 1989) have shown that the catch per unit effort (CPUE) for the mean monthly catch per trip shows a dramatic decline of

almost 50% in catch from 1979 to 1988. At the same time the numbers of fishermen has increased from 1978 to 1987 having more than doubled and in some cases tripled. Thus the decline in catches in this case can be attributed to the impact of over-fishing, though varying environmental conditions can bring about synergistic effects. Bioeconomic modelling designed to assess the impact of possible management strategies such as mesh size regulations and the reduction in fishing effort on catches, and gross and net income (Willmann *et al.*, 1989) was developed for the fishery of *Tenualosa toli* in the Batang Lupar area. The model results indicate that the single most important management measure is preventing the capture of smaller size *Tenualosa toli*, i.e below 27cm fork length. This could be achieved by introducing drift net with a minimum mesh size of 4 inches.

In mitigating the above impacts, land clearing example for oil palm plantation should be carried out in relatively dry months, just ahead of the setting up of the nursery and planting to reduce soil erosion. Clearing activities should also be worked out in stages to minimize exposure of bare land surfaces. Provide vegetative screening along perimeter of the cleared areas. Having buffer strip along the streams within the site can prevent erosion. Suitable riparian vegetation should be retain to act as buffer. Since the site is mostly covered by mangrove forest, the buffer zone or protective area as recommended by the National Mangrove Committee (NATMANCOM, 1986) should be left untouched to maintain the bio-diversity of the fishes and other fauna.

Sediment run-off into the main stream be it Sungai Sebuyau or Batang Lupar should be prevented right from it source. It is recommended that the vegetation biomass should be stacked up and burning of this biomass should be reduced in order not to expose the underlying soil to erosion. The buffer strip suggested earlier will form silt traps as well as maintaining the nursery area for aquatic animals. Provide effective temporary drainage of the work area leading to silt traps to minimize siltation of the watercourses.

The complete removal of vegetation and the completion of planting the oil palm seedlings will change the environment and leave some exposed soil. Weeds, pests and diseases are controlled with agrochemicals. During heavy downfalls, runoffs of sediment and agrochemical residuals from the plantation will pollute and will put pressure on the dissolved oxygen demands of the nearby streams causing death to aquatic life. Freshwater fishes and the giant freshwater prawn, which are more vulnerable, will be affected and will reduce the number. This polluted water will eventually reach the estuarine area and reduced plankton productivity. Plantivorous and filter feeders like *Tenualosa toli, Setipinna sp., Coilia macrognathusi, Polynemus paradesius* and their juveniles will be affected and recruitment into the fishery will be lowered. Since, the assimilation of this pollutants involved the entire plankton-based food chain, the bottom-dwelling fishes will eventually be affected.

Erosion control has to be incorporated during the construction of access roads at the site. Fast growing leguminous cover crops should be planted as soon as the site is terraced for planting. Gravel resurfacing is recommended to reduce sediment run-off along the access roads during rain.

Application of fertilizers shall be mulched into the soil, while the application of pesticides and herbicides shall be carried out by spray controlled application. The uses of these materials are to be controlled to the subscript minimal levels in order to reduce residuals that will eventually contaminate the waterways. Drainage system within the farm should first flow through sedimentation and treatment ponds before discharging the treated water into the outlet to the main stream. It is recommended that this farm should share the same outlet with Mambai quarry operating nearby. By doing so, minimal water quality interference will occur in the main stream.

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Table 1: Fishes caught in Batang Lupar river by various sampling gears used.

STATION		Sg. Sebuyau		Sg. Sebuyau		Tg. Lutong		P. Triso		Lingga		P. Seduku		P. Burong	
DATE		22-23/3/00		24/3/00		22/3/00		23/3/00		24/3/00		24/3/00		22/3/00	
GEAR		Barriernet		Barriernet		Gillnet		Gillnet		Gillnet		Fishingstake		Fishingstake	
FAMILY	***Species***	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)
ARIIDAE	*Arius caelatus*													4	292
ARIIDAE	*Arius caelatus*	190	5100			3	110	7	1880			6	510		

ARIIDAE	*Arius sagor*	1	86	2	470	1	310					3	779
ARIIDAE	*Arius sp.*	2	370	6	150					5	1100		
ARIIDAE	*Arius sumatranus*	2	70					1	150	1	146		
ARIIDAE	*Osteogeneiosus militaris*									1	120		
BAGRIDAE	*Horabagrus brachysoma*			5	100								
BELONIDAE	*Tylosorus sp.*									1	45		
CLUPEIDAE	*Ilisha sp.*									6	45		
CLUPEIDAE	*Tenualosa macrura*											1	75
CLUPEIDAE	*Tenualosa toli*					1	98	4	420				
ELEOTRIDAE	*Butis butis*											2	47
ELEOTRIDAE	*Butis melanostigma*	2	90	4	130								
ENGRAULIDAE	*Coilia macrognathus*					115	2060	29	1060	26	420	23	200	30	209
ENGRAULIDAE	*Coilia rebentischii*													44	163
ENGRAULIDAE	*Setipinna breviceps*									40	1930				
ENGRAULIDAE	*Setipinna breviceps*					1	174			6	570				
ENGRAULIDAE	*Setipinna sp.*					14	110	8	390	7	500	12	350		
ENGRAULIDAE	*Setipinna taty*											76	3215	3	270
ENGRAULIDAE	*Stolephorus waitel*											58	90		
GOBIIDAE	*Glossogobius asaro*			3	120										
HARPODONTIDAE	*Harpodon neherus*					9	215	11	230	23	720	194	2830	2	4
HEMIRHAMPHIDAE	*Hypohampus sp.*											3	20		
MUGILIDAE	*Liza oligolepis*	7	65	15	140									5	3
MUGILIDAE	*Valamugil cunnesius*														
PLOTOSIDAE	*Plotosus canius*			9	870										
POLYNEMIDAE	*Polynemus paradesius*											13	45	5	102
SCATOPHAGIDAE	*Scatophagus argus*	2	60	15	550									2	2
SCIAENIDAE	*Ancharius brevibarbis*	2	30												
SCIAENIDAE	*Johnius sp.*	3	150	3	20										
SCIAENIDAE	*Otolithoides biauritus*													4	159
TAENODIDAE	*Taenodidae*											8	25	2	1
TETRAODONTIDAE	*Chaelonodon patoca*	3	170	10	900										
TETRAODONTIDAE	*Lagocephalus spadiceus*											70	150		
TETRAODONTIDAE	*Xenopterus naritus*					5	550			1	138	12	1960		
TRICHIURIDAE	*Trichiurus sp.*											51	410		