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Biological Monitoring of Aquatic Macroinvertebrate Assemblages in the Fly River System

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Abstract

The effects of the Ok Tedi mine on the hydrology, biology and geochemistry of the Fly River system have been monitored by Ok Tedi Mining Limited since 1983. Historically, the biological monitoring program concentrated on changes in the fish fauna of the system as this constitutes a major food resource for local villagers. Macroinvertebrate assemblages were initially monitored from the early to the mid-1980's, however, further studies were deferred, with major emphasis placed on understanding and modelling the fisheries of the system. More recently the Company has implemented several new programs to monitor aquatic macroinvertebrate assemblages. This is in recognition of their likely importance in food webs and of their potential value as a tool for biological monitoring.

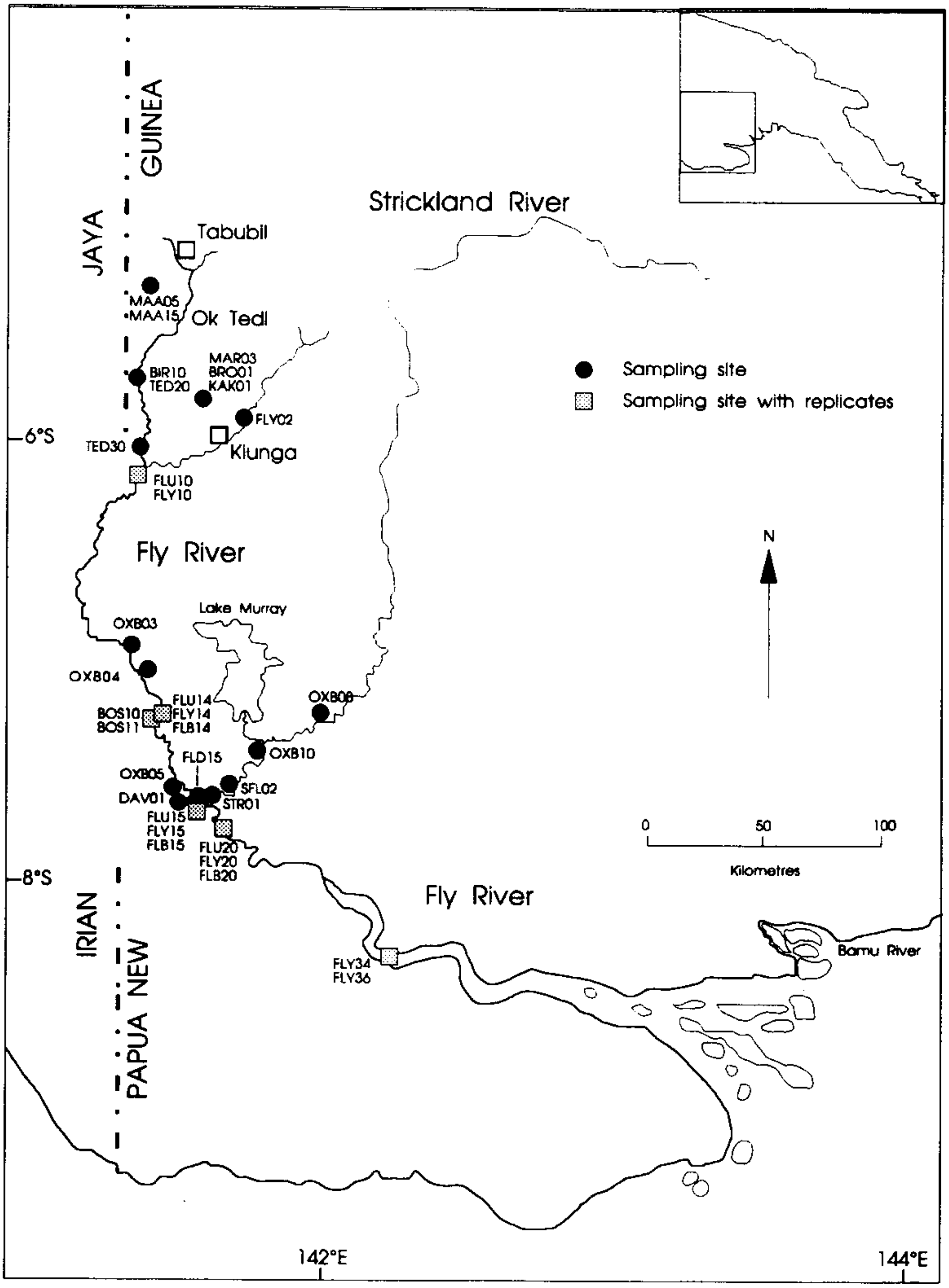
Three main programs are in progress; monitoring populations of Macrobrachium prawns in the Fly River, monitoring macroinvertebrate assemblages in off-river water bodies (oxbow lakes, blocked valley lakes and grassed floodplain sites) and examining rates of recovery of macroinvertebrate communities in upland creeks subjected to experimental disturbance.

The rationale for these studies, the methods utilised and preliminary results are presented and discussed.

Introduction

Before the commencement of environmental studies associated with the Ok Tedi mine there were no published data on the macroinvertebrate fauna of the Fly River system. The first recorded survey of freshwater macroinvertebrates in the system was by the 1974 Cambridge Expedition to the Western District of Papua New Guinea (Boyden et al., 1975). Approximately 16 taxa were recorded from the Ok Tedi at Tabubil, however, most specimens were identified only to family level (Table 1) and undoubtedly the total number of species would have been higher. The next major study was the comprehensive 'Ok Tedi Environmental Study', which commenced in 1981 (Maunsell & Partners, 1982). Biological aspects of this work focused primarily on surveying the distribution of fish species and on recording tissue metal concentrations in fish throughout the Fly River system. There was minimal sampling of aquatic invertebrates in this study, with the exception of opportunistic plankton tows in Bossett Lagoon, Middle Fly, which recorded Volvacaceae, Copepoda and Protozoa, and the determination of tissue metal concentrations in samples of mud clams, Geloina coaxans, mud crabs, Scylla serrata and a prawn, Penaeus sp. from the Fly delta (Maunsell & Partners, 1982).

Figure 1. Locations of the freshwater sampling sites in the Fly River system



The first detailed studies of aquatic macroinvertebrate assemblages in the Fly River system were two studies, in the early to mid-1980's, by Ok Tedi Mining Limited. In early 1983 a preliminary reconnaissance survey of macroinvertebrate assemblages at 15 sites in the upper Ok Tedi catchment recorded 42 taxa (Table 1), however, due to taxonomic constraints most groups were identified only to family level (OTML, 1983). Subsequent monitoring, from mid-1983 to late 1985, noted changes in the fauna of the Ok Tedi at Tabubil, with significant reductions in density, diversity and biomass of macroinvertebrates (OTML, 1986). From early 1986 to early 1987 a comprehensive survey of the benthic fauna at nine localities in the lower Ok Tedi and Fly River recorded a total of 60 taxa (Table 1) (OTML, 1987). The fauna was dominated numerically by dipteran larvae (50 % of total numbers), however nymphs of the burrowing mayfly genus, Plethogenesia and Macrobrachium prawns dominated total biomass (OTML, 1987; 1993a).

Apart from these surveys, the primary emphasis of monitoring programs throughout the 1980's was directed at fish populations. This was essentially because fish constitute a major food resource for local villagers and therefore the Company and the State are concerned with maintaining fish stocks. Aquatic macroinvertebrate studies were deferred, with major emphasis placed on understanding and modelling the fisheries of the Fly River system.

Work on the fish of the Fly River system has resulted in a comprehensive database on approximately 95 species of fish, covering a 10 year period. Currently, 40 sites, distributed throughout the system, are sampled either on a monthly, quarterly or six monthly basis to monitor fish assemblages and tissue metal levels (Figure 1). As part of this monitoring program, fluctuations in fish biomass at a range of sites are routinely reported to the State. Trends in composition of fish assemblages with time have been investigated (Smith, in press) and the relationship between fish biomass and particulate copper concentration in the river system has been modelled (Smith & Hortle, 1991).

Ok Tedi Mining Limited is now developing programs to assess the potential effects of mining on aquatic macroinvertebrates in the Fly River system, and to determine if fish assemblages maybe influenced through processes such as "bottom-up" trophic interactions (Mills & Forney, 1988; Bartell et al., 1988). Dietary studies on the fish fauna of the Fly River system have established that macroinvertebrates form an important component in the diet of many fish species (i.e. planktivores consuming zooplankton and insectivores feeding on aquatic macroinvertebrates and adult terrestrial insects, many of which originate from the aquatic environment)(Roberts, 1978; OTML, 1986; Kare, 1991). Therefore the potential exists for a change in the macroinvertebrate fauna to affect the fish fauna. The programs will also determine the overall value of aquatic macroinvertebrates as a monitoring tool in the Fly River system. In many parts of the world (i.e. Europe, North America, Australia) aquatic macroinvertebrates have been utilised to great effect over many years to monitor changes in water quality (Hellawell, 1978; Hawkes, 1979).

Three programs are currently in progress to examine different aspects of the aquatic macroinvertebrate fauna of the Fly River System; a.) monitoring populations of Macrobrachium prawns in the Fly River, b.) monitoring macroinvertebrate assemblages in off-river water bodies (oxbow lakes, blocked valley lakes and the Fly River floodplain) and c.) investigating rates of recovery of benthic macroinvertebrate communities in upland creeks subjected to experimental disturbance.

THE STUDIES

Macrobrachium *Prawn Populations in the Fly River*

Freshwater prawns of the genus Macrobrachium together with mayfly larvae of the genus Plethogenesia constitute about 80 percent of the biomass of the macroinvertebrate fauna found in the main channel of the Fly River (OTML, 1987). Dietary studies have indicated that

Macrobrachium are an important food item for many fish species within the Fly River system (Roberts, 1978; OTML, 1986; Kare, 1991) and large species of Macrobrachium are also utilised as an important food resource by the local people. Therefore, the need to establish a specific sampling program to monitor prawns has been recognised. Macrobrachium have been sampled by seine net since the inception of biological monitoring by Ok Tedi Mining Limited. These data revealed changes in the prawn populations in the Ok Tedi following commissioning of the mining operation, with reductions in numbers during the gold operating phase but with a subsequent recovery in numbers during the copper operating phase (OTML, 1991). However, because sites suitable for seine netting (i.e. river reaches with shallow/exposed sand banks) are restricted to the upper catchment, this database is of limited value for detecting potential effects of the mine throughout the remainder of the river system.

During 1991 and 1992 a sampling methodology utilising baited traps was developed to monitor Macrobrachium prawn populations throughout the Fly River system. It has been reported previously that trap design (Yamane & Flores 1989), type of bait (Harpaz *et al.* 1987), sampling site and period (Kneipp 1979), and competitive interactions between individuals or species of Macrobrachium (Peebles 1980; Harpaz *et al.* 1987) can all influence the composition of prawn catches.

Preliminary sampling in the Fly River system, with funnel traps, identified a Macrobrachium fauna consisting of six species. Analysis of these data indicated that smaller traps caught a significantly greater proportion of smaller individuals and smaller species. These differences were assumed to be related to the funnel size of the traps and to small species avoiding traps containing large specimens.

In subsequent trials two trap types were evaluated; a hinged door box trap, similar to that of Hill (1975) and a funnel trap (Figure 2).

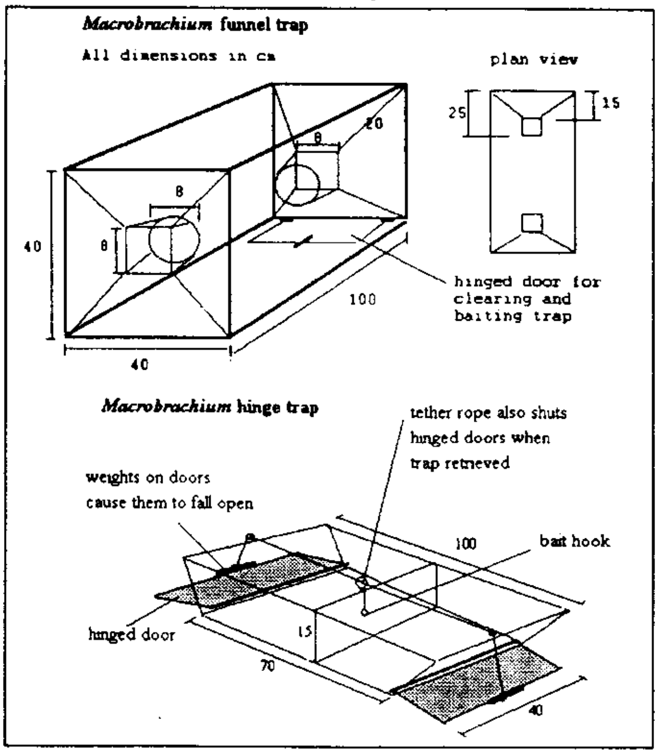


Figure 2. Schematic diagrams of the two types of prawn traps used in the study (after Tait & Bakowa, in prep.).

Five traps of each type were set alternately along the river bank at depths of 1.5 - 2.0 m. Traps were baited with freshwater herrings (Nematalosa spp.) and set for 24 hour periods. A range of trials were performed in which the frequency of checking the traps was varied from a minimum of once every 24 hours for the funnel traps to a maximum of every 45 minutes for the hinged door box traps. Trap avoidance was also tested by setting funnel traps with and without captive individuals of M. rosenbergii, a species that is known to exhibit territorial behaviour (Peebles, 1980).

The trials indicated that funnel traps, set for 24 hours and checked every 3 hours gave the optimum catches of Macrobrachium. This design increased retention of captive prawns, reduced competitive exclusion of small species and minimised logistical constraints in the field associated with frequent checking; the hinged door box traps would be effective only when checked very frequently. A detailed description of the methodology and results of this project are to be published elsewhere (Tait & Bakowa, in prep.).

A Macrobrachium monitoring program using funnel traps, modified with a 10 cm cylindrical extension to the funnel to help retain captive individuals, and based on the above methodology will be implemented at sites that are currently sampled for fish on the lower Ok Tedi, Fly and Strickland Rivers. This program will determine if the mine operation effects Macrobrachium populations at these sites.

Macroinvertebrate Assemblages in Off-River Water Bodies

The Fly River system has a catchment area of 76 000 km2 with very high rainfall, ranging from 10 000mm per annum in the upper catchment to around 3 000mm per annum near the coast. This results in a mean discharge of 6000 m3 sec-1 (OTML, 1988). Although the upper catchment extends to altitudes greater than 4000m, the majority of the catchment area is very flat. For instance, the river port of Kiunga, which is 800 river kilometres from the coast is only 20m above sea level (Smith & Bakowa, in press). The combination of high rainfall and large areas of flat land has resulted in an extensive system of wetlands. Four major habitat types are recognised in the floodplain area of the middle Fly River: blocked valley lakes, with a total area of 245km2; oxbow lakes (cut-off meander loops)(122 km2); and grassed and forested floodplain (2473 km2 combined) (Smith & Bakowa, in press).

There is little seasonality in the rainfall of the upper catchment, however the floodplain in the middle Fly is subjected to the NW monsoons (December to April) and the SE trades (May to November). As a result the water on the floodplain may be derived either from the Fly River, with associated natural and mine-derived sediments, or from local rainfall. In recent years, sites representative of the different floodplain habitats have been regularly sampled to monitor fish populations (Smith & Bakowa, in press), however, little is known of the macroinvertebrate populations in these habitats. All previous sampling of macroinvertebrate populations in the middle Fly area had been from the main river channel (OTML, 1987). Therefore, in 1993 a study was initiated to design a monitoring program that would detect any possible effects of mine-derived sediments on the macroinvertebrate fauna of floodplain habitats.

The aims of this study are to evaluate sampling methodologies for macroinvertebrates in off-river water bodies, to describe the macroinvertebrate fauna in terms of species composition, relative abundance and biomass, to determine the major habitats utilised and to develop a strategy to monitor the macroinvertebrate fauna of off-river water bodies in the Fly River system.

To achieve the stated aims, ten off-river water bodies located along the middle Fly and Strickland Rivers were selected for sampling. Replicate samples were taken from two sites within each off-river water body, providing replication between and within each waterbody. The water edge, surface and benthos were sampled using a variety of techniques: dip-net sweeps of the marginal submerged macrophytes; plankton tows in open water; Ekman-Birge grabs of the benthos in deep water; core samples of the benthos in shallow areas; and artificial substrate samples at all locations. The artificial substrates consisted of three open mesh nylon citrus bags enclosed in a coarse mesh envelope with a small rock for ballast. They were tested as a standard sampling unit which is easy to replicate and quick to process, both in the field and the laboratory. The artificial substrates were trialed over exposure periods of four, six, eight and 12 weeks to assess rates of colonization by macroinvertebrates.

This project is nearing completion of the first stage. Issues encountered so far have been the inundation or dessication of artificial substrates due to fluctuating water levels and the theft of substrates for their ropes and floats, which are an attractive resource to local villagers. At this preliminary stage 109 taxa have been identified with Coleoptera and Hemiptera as the most diverse groups. The dip-net sweep samples show a good faunal diversity but low abundances, the benthic cores and grabs reveal a patchy fauna, with low diversity and abundances and the plankton tows contained few animals. Colonization rates of the artificial substrates have yet to be examined. Once the data have been analysed an ongoing monitoring program will be initiated using the most appropriate sampling techniques for these habitats.

Benthic Macroinvertebrate Communities in Upland Creeks

During the early 1980's significant changes in the macroinvertebrate fauna of some headwater creeks in the upper Ok Tedi catchment were detected (OTML, 1986). It was postulated that sediments derived from mining activities were responsible for the observed reductions in density, diversity and biomass of macroinvertebrates in the Ok Tedi at Tabubil (OTML, 1986). Changes in the fish fauna in the Ok Tedi also have been detected, with reductions in density, diversity and biomass of fish (Smith & Morris, 1992; Smith, in press).

Mining activities, with the associated discharge of ore residues and overburden to the Ok Tedi are planned to continue into the next decade. Current modelling predicts that once mining operations cease there will be a rapid reduction in suspended sediment loads with a more gradual reduction (15-20 years) of river bed aggradation to pre-mine bed levels (OTML, 1993b). Recent sampling has demonstrated that although the number of fish species in the Ok Tedi have declined. all absent species are still found in tributary streams, or further downstream in the Fly River (Smith, in press) and it has been concluded that the fish assemblages "do not appear to have changed to compositions from which it would be difficult to return to their former states" (Smith, in press).

Similar data, however are not currently available for macroinvertebrate assemblages in the upper catchment of the Ok Tedi. Therefore, in mid-1993 a postgraduate research student from James Cook University, Queensland, Australia was funded by the Company to investigate rates of recovery of macroinvertebrate assemblages in a stream reach that was subjected to artificial disturbance. This study also would provide an inventory of the macroinvertebrate fauna in creeks unaffected by mine operations which act as refugia from which the Ok Tedi may be recolonized.

Rates of recolonization of benthic macroinvertebrates were examined by removing cobbles from the stream bed, scrubbing them clean, marking them and returning them to the same reach. This action was designed to simulate the degree of physical disturbance that occurs to a stream bed during a severe spate, with the expectation that a similar level of disturbance may result from certain mining activities. Cobbles were then removed over a period of time and the recolonization of macroinvertebrates recorded. The initial set of cobbles were removed four hours after being returned to the stream and then on every second day for an eight day period. On each occasion 'undisturbed' cobbles were also removed as a control.

Another aspect of the study looked at macroinvertebrate drift (the downstream movement of aquatic organisms in the water column) as this is recognised as a major mechanism for the recolonization of disturbed regions by macroinvertebrates (Waters, 1972). Drift samples were taken using replicate drift nets set for 24 hour periods. This would allow for the known diurnal changes in drift activity (Waters. 1969). After this period the stream bed in a 10m reach was disturbed by raking and rolling the cobbles and gravel and new drift samples were taken immediately after the disturbance and for the following 24 hour period. Cobbles were also removed from the disturbed reach and the macroinvertebrate fauna examined to gauge the magnitude of the experimental disturbance.

The field component of this project has been completed, however the identification and enumeration of the macroinvertebrate fauna has still to be completed before data analysis may commence. This initial project examined recolonization over a relatively short eight day period. In future fieldwork it is intended to examine recolonization over several months.

CONCLUSIONS

During the 1980's, studies by Ok Tedi Mining Limited on aquatic macroinvertebrates in the Fly River system were deferred in favour of intensive studies of the fish fauna. This work has been productive, both by increasing understanding of the fish fauna of the Fly River and by providing a comprehensive database which is used to manage the system. The Company is now increasing emphasis on the macroinvertebrate fauna of the system. The three research projects currently in progress will help establish effective monitoring programs to a.) detect possible effects of the Ok Tedi mine on the macroinvertebrate fauna of the Fly River system, b.) determine if the fish fauna is likely to be affected through trophic interactions and c.) provide an indication of recolonization rates for use in ecosystem management after the mine has ceased operations. This work will enhance the present understanding of the ecology of the Fly River system.

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REFERENCES

Bartell, S.M., Brenkert, A.L., O'Neill, R.V. & Gardner, R.H. (1988). Temporal variation in regulation of production in a pelagic food web model. *Complex Interactions in Lake Communities* (Ed. by S.R. Carpenter), pp. 101-118, Springer Verlag, N.Y. Inc.

Boyden, C.R., Brown, B.E., Drucker, R.F. & Tuft, S.J. (1975). Report of the 1974 Cambridge Expedition to the Western District, Papua New Guinea, Ok Tedi Environmental Study.

Harpaz, S., Kahan, D., Galun, R. & Moore, I. (1987). Responses of the freshwater prawn, Macrobrachium rosenbergii, to chemical attractants. *J. Chem. Ecol.* **13,** 1957-1965.

Hawkes, H.A. (1979). Invertebrates as indicators of river water quality. *Biological Indicators of Water Quality* (Ed. by A. James & L. Evison), John Wiley & Sons, New York.

Hellawell, J.M. (1978). *Biological Surveillance of Rivers: A Biological Monitoring Handbook.* Water Resources Handbook, Stevenage, U.K.

Hill, B.J. (1975). Abundance, breeding and growth of the crab, Scylla serrata in two South African estuaries. *Mar. Biol.* **32,** 119-126.

Kare, B.D. (1991). *Diet of selected fish species in the Fly River system, Papua New Guinea.* Post-graduate Diploma thesis, James Cook University, Queensland. pp. 41.

Kneipp, I.J. (1979). *Ecology of* Macrobrachium *species (Decapoda: Palaemonidae) in a coastal stream in North Queensland.* PhD thesis, James Cook University, Queensland.

Maunsell & Partners (1982). Ok Tedi Environmental Study: Supporting Studies, Volume 6: Ok Tedi-Fly River Aquatic Survey-Heavy Metal Review. Report to Ok Tedi Mining Limited. pp. 344.

Mills, E.L. & Forney, J.L. (1988). Trophic dynamics and development of freshwater pelagic food webs. *Complex Interactions in Lake Communities* (Ed. by S.R. Carpenter), pp.11-30, Springer-Verlag N.Y. Inc.

OTML (1983). Reconnaissance survey of macrozoobenthos in the upper Ok Tedi catchment. OTML, Biology Report No.1, pp. 7.

OTML (1986). A review of biological sampling of the Ok Tedi and Fly River systems, April 1983 to June 1986. OTML report ENV 86-9.

OTML (1987). Studies of the benthic fauna of lowland (potamon) localities of the Ok Tedi and Fly River, with reference to mining activities. OTML, report no. ENV 87-11.

OTML (1988). Sixth Supplemental Agreement Environmental Study 1986-1988. Final draft report. Ok Tedi Mining Limited.

OTML (1991). Biology Annual Report 1991. OTML report no. ENV 91-01.

OTML (1993a). Biology Annual Report: Data collected to 30 September 1992. OTML report no. ENV 93-01.

OTML (1993b). Hydrology Annual Report 1993. OTML report no. ENV 93-03.

Peebles, J.B. (1980). Competition and habitat partitioning by the giant freshwater prawn *Macrobrachium rosenbergii* (De Man)(Decapoda, Palaemonidae) *Crustaceana* **38,** 49-54.

Roberts, T.R. (1978). An ichthyological survey of the Fly River in Papua New Guinea, with description of new species. *Smithsonian Contributions to Zoology* **281**.

Smith, R.E.W. (in press). Species diversity and trends of composition of assemblages of fish in the Fly River system, Papua New Guinea.

Smith, R.E.W. & Hortle, K.G. (1991). Assessment and prediction of the impacts of the Ok Tedi copper mine on fish catches on the Fly River system, Papua New Guinea. *Env. Mon. Assess.* **18,** 41-68.

Smith, R.E.W. & Morris, T.F. (1992). The impacts of changing geochemistry on the fish assemblages of the Lower Ok Tedi and the Middle Fly River, Papua New Guinea. *Sci. Total Environ.* **125,** 321-344.

Smith, R.E.W. & Bakowa, K.A. (in press). Utilisation of floodplain water bodies by the fishes of the Fly River. Papua New Guinea. *Mitteilungen Societas Internationalis Limnologiae*

Tait, J. T. P. & Bakowa, K.A. (in prep.). Development of a methodology to quantitatively sample *Macrobrachium* prawns in the Fly River, Papua New Guinea.

Waters, T.F. (1969). Diel patterns of aquatic invertebrate drift in streams of northern Utah. *Proc. Utah Acad. Sci.* **46,** 109-130.

Waters, T.F. (1972). The drift of stream insects. *Ann. Rev. Ent.* **17,** 253-272.

Yamane, T & Flores, E.E.C. (1989). Evaluation of the catching efficiency of small pots for prawns. *Fish. Res.* **8,** 81-91.

Table 1. Systematic listing of taxa recorded in previous studies of the aquatic macroinvertebrate fauna of the Fly River system [1 = Boyden *et al.* (1975)[1] ; 2 = OTML (1983)[2]; 3 = OTML (1987)[3]]

Taxa[4] (indentation following the systematic hierarchy)						No. of Study		
NEMERTEA					Nemertea sp.			3
NEMATODA					Nematoda sp.			3
MOLLUSCA	GASTROPODA	PULMONATA			Gastropoda sp. A		2	
					Gastropoda sp. B		2	
					Gastropoda sp. C		2	
				Hydrobiidae	*Melanoides tuberculatus*			3
				Planorbidae	Planorbidae sp.			3
				Thiaridae	*Thiara scabra*			3
ANNELIDA	OLIGOCHAETA				Oligochaeta sp.		2	3
		HIRUDINEA			Hirudinea sp.			3
ARTHROPODA	ARACHNIDA	ORIBATIDA	HYDRACARINA		Hydracarina sp.			3
	CRUSTACEA	DECAPODA		Palaemonidae	*Macrobrachium* sp.		2	3
				Sundathelphusidae	Sundathelphusidae sp.			3
		AMPHOPODA			Amphipoda sp.			3
	INSECTA	COLLEMBOLA			Collembola sp.			3
		LEPIDOPTERA		Pyralidae	Pyralidae sp.A		2	3
					Pyralidae sp.B			3
					Pyralidae sp.C			3
					Nymphulinae sp.	1		
		DIPTERA		Simuliidae	Simuliidae sp.	1		
				Culicidae	*Chaoborus* sp.			3
				Chironomidae	Chironomidae sp.		2	3
				Tanypodinae	Anatopynia sp.	1		
				Orthocladiinae	*Orthocladius* sp.	1	2	
					Cricotopus sp.	1		
					Diamesa sp.	1		
					Procladius sp.			3
					Chironomus sp.			3
					Pentaneurini sp.			3
				Chironominae	*Polypedilum* sp.	1		
					Rheotanytarsus sp.	1		
					?Chironomini			3
					?Glyptotendipes sp.			3
					?Cardiocladius sp.			3
					?Dicrotendipes sp.			3
					Tanytarsini sp.			3
				Tipulidae	Tipulidae sp.A		2	3
					Alonia sp.			3
				Ceratopogonidae	Ceratopogonidae sp.			3
				Muscidae	Muscidae sp.			3
				Psychodidae	Psychodidae sp.		2	3
				Athericidae	Athericidae sp.		2	
				Blephariceridae	Blephariceridae sp.		2	
				Empididae	Empididae sp.		2	3
				?Tabanidae	?Tabanidae sp.	1		
				Thaumaleidae	Thaumaleidae sp.			3
		ODONATA	Zygoptera		Zygoptera sp.A		2	
					Zygoptera sp.B		2	
					Zygoptera sp.C		2	
					Zygoptera sp.D		2	
			Anisoptera		Anisoptera sp.A		2	
				Corduliidae	Corduliidae sp.		2	3
				Gomphidae	Gomphidae sp.		2	
				Synthemidae	Synthemidae sp.		2	3
		HEMIPTERA		Corixidae	Corixidae sp.		2	3
				Naucoridae	Naucoridae sp.			3
				Veliidae	Veliidae sp.		2	

[1] Ok Tedi at Tabubil (Boyden et al., 1975).
[2] 15 sites in the upper Ok Tedi catchment (OTML, 1983).
[3] 9 localities in the lower Ok Tedi and middle Fly River (OTML, 1987).
[4] Due to the absence of voucher specimens it was not possible to determine if taxa reported at family/genus level are the same taxon between the three studies.

EPHEMEROPTERA	Baetidae	Baetidae sp.A		2	
		Baetidae sp.B		2	
		Baetidae sp.C		2	
		Baetidae sp.D		2	
		Baetidae sp			3
		Baetis sp.	1		
	Caenidae	*Tasmanocoenis* sp.		2	
		Caenis sp.	1		
		Caenidae sp.A			3
		Caenidae sp.B			3
		Caenidae sp.C			3
	Leptophlebiidae	*Atalophlebia* sp.		2	
		Atalonella sp.		2	
		Leptophlebiid sp.A	1		3
		Leptophlebiid sp.B	1		
		Leptophlebiid sp.C	1		
	Palingeniidae	*Plethogenesia pallida*			3
		P. papuana			3
	Polymitarcidae	Polymitarcidae sp.		2	
	Prosopistomatidae	*Prosopistoma* sp.			3
TRICHOPTERA	Conoesucidae	Conoesucidae sp.A		2	3
		Conoesucidae sp.B		2	
		Costora sp.		2	
	Ecnomidae	*Ecnomus* sp.			3
	Glossosomatidae	*Agapetus* sp.		2	
	Hydropsychidae	*Cheumatopsyche* sp.		2	3
		Hydropsychidae sp.			3
		Hydropsychinae sp	1		
	Leptoceridae	Leptoceridae sp.	1	2	3
	Philopotamidae	Philopotamidae sp.A			3
		Philopotamidae sp.B			3
	Philorheithridae	Philorheithridae sp.		2	
	Rhyacophilidae	Apsilochorema sp.			3
		Rhyacophilidae sp.			3
COLEOPTERA	Curculionidae	Curculionidae sp.			3
	Dytiscidae	Dytiscidae sp.			3
	Elmidae	Elmidae sp.		2	3
		Austrolimnius sp.			3
		Notriolus sp.A			3
	Gyrinidae	Gyrinidae sp.		2	
	Hydrophilidae	Hydrophilidae sp.			3
	Noteridae	Noteridae sp.		2	
	Ptilodactylidae	Ptilodactylidae sp.		2	3
NUMBER OF TAXA			16	42	60