Science in New Guinea Vol. 27(1,2,3), 101-119, 2002

THE ARTISANAL FISHERY IN THE SEPIK-RAMU CATCHMENT AREA, PAPUA NEW GUINEA

PETER G.M VAN DER HEIJDEN

International Agricultural Centre, P.O. Box 88, 6700 AB Wageningen, The Netherlands

e-mail: p.g.m.van.der.heijden@iac.agro.nl

ABSTRACT

A survey in 25 villages in the Sepik-Ramu basin revealed that fishing was practised in all villages surveyed. The participation in catching fish decreased from 42% of the population of villages situated below 200 m altitude to 23.4% of villages at altitudes above 1,000 m, mainly as a result of the lower involvement in fishing of women and girls at higher altitudes. Females contributed half of the estimated total fish yield of respondents living below 100 m altitude, and 33% of the annual total yield of the whole catchment, which was estimated at 8,200 tons. At high (> 1000 m) and middle altitude (200 - 1000 m above sea level) most villages had only access to creeks or small rivers. At low altitudes (< 200 m above sea level) most villages surveyed had access to big rivers, swamps or lakes. Average yield/person/trip with various gears and in various waters are reported.

Eels Anguilla spp *and* Cyprinus carpio *dominated the catch of respondents living at high altitude levels. At low altitude levels half of the catch consisted of* Oreochromis mossambicus. *This species plus* C. carpio *contributed 42% of the weight of the total catch of the Sepik-Ramu area. The part of the fishing respondents that believed that the exotic species* C. carpio *and/or* O. mossambicus *had affected the numbers of native fish species decreased with increasing altitude level. At the high altitude* Gobiidae *were often mentioned to have decreased in number after the arrival of* C. carpio.

Key words: base-line survey, small-scale inland fisheries, introduced fish species, catch/effort data, catch composition, total annual fish yield, socio-economic data, catch per unit effort, contribution of women to fisheries.

INTRODUCTION

Papua New Guinea has considerable marine resources which are however not accessible to the 85% of the population who live inland (Coates 1987). The development of inland fisheries is therefore of great importance to alleviate the widespread problem of protein deficiency in the diet and to create income opportunities.

The Sepik River has one of the most important inland fisheries in Papua New Guinea. The fish yield from the floodplain region of this river is estimated at 3000 to 5000 tons/year. This yield is only 10% of what is caught on similar sized floodplains in Africa (Coates 1985). As discussed in detail by Coates (1985; 1986; 1987; 1993a) the low yield is believed to be due to the low number of indigenous fish species in the catchment area caused by species of Australasian origin, and to the limited extent of an estuarine habitat. The floodplain habitat developed only several thousand years ago (Swadling *et al.*, 1988) and only 2 indigenous fish species that are of importance to the fishery are known to migrate from the lowland river channels into the floodplain (Coates 1986).

In the 1960s the Mozambique tilapia (*Oreochromis mossambicus*, locally known as makau), the common carp *Cyprinus carpio*, the rainbow trout *Onchorynchus mykiss*, the giant gouramy *Osphronemus goramy* and several other fish species were introduced. The first 2 species have established themselves widely and are part of the fish stock of the Sepik-Ramu area. Considering the important contribution to the fish catch of especially the first 2 of these introduced species plus the discovery of significant trophic niches that were not fully used by the indigenous fish fauna Coates (1987) advocated the introduction of other, carefully selected exotic species. The Government of Papua New Guinea and the Food and Agriculture Organisation of the United Nations (FAO) embarked on the Sepik River Fish Stock Enhancement Project (1987 - 1993). This project was succeeded by the FISHAID project (1993 - 1997). The major goal of these projects was to introduce several new exotic fish species with the aim to enhance the total fish biomass of the Sepik-Ramu catchment area. It was hoped that this would increase the catch of the rural population living in the area. Introductions started in 1991 with the stocking of redbreasted tilapia *Tilapia rendalli*, followed by the giant gouramy *O. goramy* in 1993 and the silver barb or Java carp *Puntius gonionotus* in 1994. Juveniles of the golden mahseer *Tor putitora*, the chocolate mahseer *Acrossocheilus hexagonolepis*, the snow trout *Schizothorax richardsonii*, *Prochilodus margarvii* and the pacu *Colossoma bidens* were released in the period 1995-1997 (Coates 1997)

At the time the fish introductions were prepared base-line data about the Sepik-Ramu fishery were available from only a limited area in the Sepik floodplain (Coates 1985). To be able to assess the impact of the new fish introductions on the catch composition and on fisheries yield 2 base-line surveys were carried out. These surveys focused on the fishing activities taking place at all altitude levels in the Sepik-Ramu catchment area. The first survey was carried out in 1987-88 and covered 7 villages in the Sepik catchment area (Mys & van Zwieten, 1990). A second survey was carried out in 1991 - 1993. This article describes the results of the second survey. The level of participation in fishing of various groups of respondents, the daily and annual yields, the catch rates of the most common fishing methods in various types of water, and an estimate of the total fish yield from the Sepik-Ramu catchment area are reported. Also, the composition of the catch and the impact of the exotic fish species that entered the area before 1990 on native fish species as observed by the fishing respondents are presented.

THE STUDY AREA

The Sepik and Ramu rivers originate from the Central Highlands region of New Guinea. The catchment areas of these rivers are connected at the floodplain level and, from a fisheries point of view, can therefore be considered as one. Both catchment areas combined cover an area of 100,000 km^2, and the total length of the creeks and rivers found in the area is over 100,000 km (Coates 1993b). The Sepik River channel has a length of 1100 km. In the basin below an altitude of 80 m an area of approximately 7600 km^2 is flooded during the wet season. The Ramu River has a length of 650 km. During the rainy season flooding occurs below an altitude of 150 m, resulting in a floodplain of 3000 km^2. Numerous swamps and lakes are found in the floodplains of both rivers.

The total human population of the study area is approximately 785,000, of which 95% lives in small villages. Agriculture, animal husbandry (pigs and chickens), hunting and fishing are the major economic activities of the rural people. Half of the population lives at altitudes higher than 1000 m (Coates & Mys 1989). Malnutrition caused by protein deficiency is common (Coates 1987).

METHODS

Between August 1991 and January 1993 a total of 640 individuals living in 25 villages were interviewed. The villages were selected on the basis of accessibility, altitude and even distribution over the whole catchment area. Three villages were surveyed twice with an interval of 9 to 12 months. Ten villages were located in the Sepik and 15 in the Ramu catchment area. Ramu villages outnumbered those in the Sepik because the 1987-88 survey had covered only villages in the Sepik (Table 1, Figure 1). The total population of 17 villages surveyed was counted or estimated by the interviewers with the help of local informants. For 8 villages the population size as reported in the 1990 National Population Census was used (PNG National Statistics Office, pers.comm.)

Information was collected by means of structured interviews. Nine respondents were interviewed twice, all others only once. The results of the interviews included details about the demographic composition of 518 households living in 24 villages. Sex and age of the household members reported to be actively involved in catching fish were recorded. The households to which the respondents belonged ranged between 10.8% and 91% of the total number of households of the villages surveyed (average: 59.6%). No selection of the households did take place except for members being present during the time the interviewers visited the village and willing to be interviewed. These households were therefore considered to be a representative sample of all the households of the village.

Of each respondent that fished the annual fishing frequency was computed from the reported average duration of the rainy and dry season in the area, from the fishing frequency during each season as reported by the respondent, and from the frequency with which the most recent fishing trips of the respondent took place. When the dates of the most recent fishing trips did not coincide with the fishing frequency as stated by the respondent the average frequency was used to estimate the fishing frequency of the season in which the recent fishing trips took place. For example: when the respondent said to fish 2x/week during the season the interview took place but the 2 most recent fishing trips took place over a period of 2 weeks his fishing frequency was assumed to be 1.5 x/week for that particular season.

The respondents were divided in four categories: men <16 years of age (boys), men ≥ 16 years, women <16 years (girls), and women ≥ 16 years. Of each village the average yield per fishing trip and the average annual fishing frequency of each category were computed. The total annual catch of each category of each village was estimated by multiplying the average annual fishing frequency with the average yield/person/fishing trip and with the number of fishing members of each category in the village. The total annual yield of each village was estimated by adding the total annual catch of men, women, boys and girls. The average annual yield/resident of each village was computed by dividing the total annual yield of a village by the total number of residents.

Table 1. The altitude and population size of the surveyed villages, and the number of people interviewed.

Name village	Altitude	Population	Number of respondents
Sirunki	2400	1976	30
Amamonta	1600	427	31
Boro	1080	73	11
Braimba	1200	221	25
Kakopi	1820	296	31
Tibunofi	1920	336	34
Tiunka	1600	185	15
Yampu	1920	786	40
Total high altitude			**217**
Bopirumpu	550	251	21
Guria	640	115	17
Hamberauri	340	91	17
Igurue	240	154	27
Jame, Loneim	400	570	35
Neligum	260	670	42
Tauya	200	212	13
Timeru	320	82	11
Total middle altitude			**183**
Birap	40	236	32
Kesawai 1	150	163	29
Magendo 1	12	240	33
Moibu	60	183	28
Ofri	140	43	10
Palgere	80	366	35
Rebru	60	30	5
Wusema	130	68	14
Yau'umbak	20	215	54
Total low altitude			**240**
Total all villages			**640**

1. Hamberauri
2. Timeru
3. Magendo 1
4. Birap
5. Moibu
6. Rebru
7. Kakopi
8. Igurue
9. Wusema
10. Ofri
11. Tauya
12. Kesawai 1
13. Guria
14. Boro
15. Bopirumpum
16. Tiunka
17. Amamonta
18. Tibunofi
19. Braimba
20. Yampu
21. Sirunki
22. Yau'umbak
23. Palgere
24. Neligum
25. Jame & Loneim
26. Rabiawa
27. Yenkis
28. Kemeilmin
29. Avia
30. Aurump
31. Swach Ketjil
32. Pelnandu

No. 1-25: surveyed by the author

No. 26-32: surveyed by Mys & van Zwieten (1990).

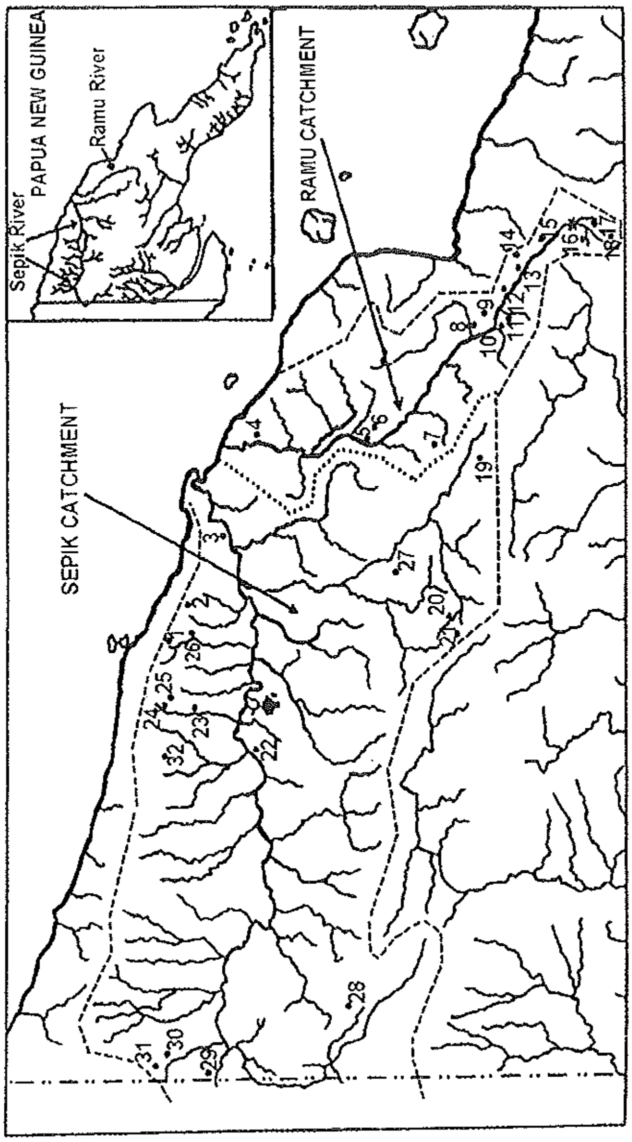


Figure 1. Sketch map of the Sepik-Ramu area.

The respondents who had tried to catch fish in the past year ("fishing respondents") were asked to describe in detail 1 to 4 most recent fishing trips they had participated in. A report of a fishing trip included information about the date, name and type of water body where the fishing took place, estimated distance of the fishing site to the village, the duration of the trip, number of participants, fishing methods used, composition of the catch and numbers of fish caught of each species, genus or family. Thirty-eight respondents living in areas where fish was scarce and fishing seldom took place described the total catch of the past year or of the past 2 years.

For identification of the fish reported to be caught coloured pictures of 18 fish species most commonly found in the catchment area were shown. When several species with a similar appearance belonging to one genus or family were known to occur in the area the picture of only one species representing that genus or family was presented. Of the following families and genera only one species of fish representing the genus or family was shown: *Ariidae*, *Gobiidae*, *Melanotaeniidae*, *Mugilidae*, *Mogurnda*, *Neosilurus* and *Oxyeleotris*. Of a species, genus or family that was known not to grow larger than 30 cm total length 3 or 4 pictures representing a small, medium or large specimen of that species were shown. Of a species, genus or family that could grow to a size over 30 cm total length 5 or 6 pictures with fish of different sizes were shown (Table 2). The respondents indicated the size of the fish caught by pointing at the picture with the fish of the size most similar to the fish they had caught. The weight of fish with the sizes shown on the pictures was estimated with length-weight relationships based on the numerous measurements of fish by project staff in an earlier phase of the project (Table 2). The length of eels *Anguilla sp* longer than 0.45 m was indicated by the respondents with their hands and measured to the nearest 0.05 m. The weight of *Anguila bicolor* specimens was estimated with the equation: $W = 7.113 \times 10^{-6} \times TL^{3.1798}$ (Weight in g, total length in mm). The weight of *Anguilla marmorata* with a length over 0.45 m was estimated with a graph based on data of R.A. Jubb showing the length-weight relationship of this species (in Tesch 1977, p 206).

Table 2. Total lenght (TL, mm) and estimated weight (W, gr) of the fish species, genera and families on the pictures used for identification of the fish.

	Size 1		Size 2		Size 3		Size 4		Size 5		Size 6	
Name	TL	W	TL	W	TL	W	TL	W	TL	W	TL	W
Anguilla bicolour	140	5	200	15	290	46	450	194				
Anguilla marmorata	140	5	200	15	290	46	450	196				
Arius sp	120	12	190	55	230	97	330	292				
Cyprinus carpio	80	8	110	24	170	65	220	182	310	150	390	1038
Glossamia sp	90	5	110	9	120	15	170	43				
Gobiidae	60	2	90	5	120	11						
Hephaestus transmontanus	90	10	100	18	120	28	170	72				
Megalops cyprinoides	120	13	210	82	270	61	400	578				
Melanotaeniidae	70	3	100	12	150	41						
Mogurnda sp	60	1	80	4	100	7	110	10				
Mugilidae sp	120	13	210	82	270	161	400	578				
Neosilurus sp	120	11	160	33	230	100						
Ophieleotris aporos	100	13	110	18	140	37	200	113				
Oreochromis mossambicus	70	5	100	19	130	42	190	115	265	335		
Osphronemus goramy	80	8	110	22	170	82	220	178	310	502	390	1005
Oxyeleotris sp	100	10	120	16	150	33	210	97	310	361		
Tilapia rendalli	70	8	100	21	130	40	180	114	270	319		
Zenarchopterus kampeni	100	3	140	8	190	22						

Of every reported fishing trip the catch per person was computed. From the reports about the total catch of one year the average yield/person/fishing trip was computed by dividing the total weight of the catch with the number of days the respondents reported to have fished during that particular year. A total of 1217 estimates of yield/person/fishing trip where thus collected (Table 3).

The various types of waters where fishing took place were divided in creeks, small rivers, big rivers, lakes, reservoirs and swamps. Creeks were defined as running waters that are less than 10 m wide. Small rivers are running waters wider than 10 m. The Sepik and Ramu below an altitude of 200 m are classified as big rivers. Swamps are mostly stagnant, shallow waters which are connected to lakes and rivers during flooding but dry up or become small, separate water bodies during the dry season. At the time the survey took place the only reservoir in the Sepik-Ramu area was Yonki Reservoir in the Upper Ramu region.

The villages and the water bodies where fishing took place were divided in three major altitude levels: Low altitude (< 200 m above sea level), Middle altitude (200 - 1000 m) and High altitude (>1000 m above sea level). The average fishing frequency, the daily and the annual yield of the population of each major altitude level were computed by averaging the data of the villages surveyed at each major altitude level. The respondents from Sirunki, the only high altitude village that was situated near a lake, had very different fisheries characteristics than the other high altitude villages which only had easy access to creeks and small rivers. In the Sepik-Ramu catchment lakes are scarce at the high altitude and only 3% of the high altitude population is living within a distance of 7 km from lakes or reservoirs bigger than 1 km^2. Because of this exceptional position the data from Sirunki are therefore presented separately and have not been included in the computations of the average yield of the high altitude level or of the whole catchment area.

The total yield of the whole Sepik-Ramu catchment area was estimated by multiplying the number of people living at each of the 4 altitude zones as defined by Coates & Mys (1989) with the average annual yield per resident of each zone. Data of Mys & van Zwieten (1990) about fishing yields of 7 Sepik villages were included in the computation of the average annual yield/resident to obtain a more complete coverage of the area.

The catch composition at each major altitude level was computed by averaging the percentage each species, genus or family contributed to the estimated total weight and to the numbers of fish in the catches of the respondents of each village that took part in the survey. The contribution of exotic species to the total annual yield of the Sepik-Ramu area was computed by multiplying their average contribution to the weight of the catch with the estimated total annual yield of the various altitude levels. When exotic fish species were present in the catches of a village the respondents were asked if they thought that the numbers of native fish had decreased since the exotic species had appeared. Only the answers of respondents from villages where exotic species made up more than 4% of the weight of the catch were considered relevant.

RESULTS

Fishing was practised in all villages surveyed but with widely different intensities. The average percentage of the village population that participated in catching fish was 23.4% at the high altitude level, 32.1% at the middle altitude level and 42.0% at the low altitude level. This increase from higher to lower altitudes is caused by the increasing participation of women and girls. Of the households surveyed in Sirunki village 53% of the members was involved in fishing, of which almost half consisted of women and girls (Table 3).

Table 3. The number of fishing respondents and reports about fishing trips collected at the villages surveyed; composition of the part of the population involved in catching fish.

Village	Fishing respondents					Fishing trips reports (N)					Composition fishing population(%)			
	Men	Boys	Women	Girls	Total	Men	Boys	Women	Girls	Total	Men	Boys	Women	Girls
Sirunki	18	4	4	2	28	43	14	9	7	73	37.7	16.7	32.5	13.2
Yampu	15	5	0	0	20	39	13	0	0	52				
Tibunofi	15	8	2	0	25	29	23	8	0	60				
Kakopi	13	4	0	0	17	28	6	0	0	34				
Amamonta	9	5	0	0	14	27	15	0	0	42				
Tiunka	10	3	0	0	13	3	12	0	0	48				
Braimba	17	5	0	0	22	44	14	0	0	58				
Boro	8	0	0	0	8	16	0	0	0	16				
Total High Altitude					147					383	64.1	32.9	2.7	0.4
Guria	7	1	0	0	8	14	1	0	0	15				
Bopirumpum	7	1	13	0	21	14	2	23	0	39				
Jame & Loneim	8	11	0	0	19	19	27	0	0	46				
Hamberauri	6	3	6	2	17	10	5	9	3	27				
Timeru	7	0	2	0	9	11	0	2	0	13				
Neligum	14	5	5	2	26	28	15	8	5	56				
Igurue	14	3	6	1	24	25	7	14	2	48				
Tauya	9	0	0	0	9	27	0	0	0	27				
Total Middle Altitude					133					271	52.7	20.1	22.7	7.0
Kesawai 1	18	1	5	1	25	38	1	10	1	50				
Ofri	5	0	2	0	7	22	0	6	0	28				
Wusema	10	1	2	0	13	34	1	3	0	38				
Palgere	9	8	1	0	18	22	13	2	0	37				
Moibu	14	3	9	1	27	38	8	25	2	73				
Rebru	1	0	2	2	5	3	0	5	5	13				
Birap	8	3	17	3	31	18	8	34	5	65				
Yau'umbak	14	3	36	1	54	42	8	110	3	163				
Magendo 1	21	1	9	0	31	64	3	29	0	96				
Total Low Altitude					211					563	38.4	14.9	39.3	7.5
Total	**277**	**78**	**121**	**15**	**491**	**691**	**196**	**297**	**33**	**1217**				

Note: Data from Sirunki are not included in average composition of the high altitude fishing population.

The average fishing frequency of female respondents increased with decreasing altitude until at low altitude women fished almost as often as men (80 and 84 times/year respectively) and girls as often as boys (45 times/year). At the high and middle altitude boys fished on an average more often than men (Table 4). In Sirunki the boys fished less often than the girls, (176 and 190 fishing trips/year respectively), but in general the children of this village fished more often than the adult respondents.

A total of 491 respondents had been involved in catching fish during the past year. Of the reported fishing trips 80% took place within a radius of 5 km, and 96% took place within a radius of 10 km from the village where the respondent lived. Within a major altitude level men had bigger daily catches than boys, and the average daily catch of women was larger than the average daily catch of girls (Table 4). The high average catch/trip of boys at the middle altitude level is an exception to this. At high altitudes the average catch/trip of men was 6 times larger than the average catch/trip of the exceptional woman that fished, but this discrepancy in the average catch/trip between men and women decreased with decreasing altitude. The difference was less than 10% at the low altitude level.

Table 4. Average number of fishing days per year of the fishing respondents, average yield/fishing trip and the average catch/person/year. (SD = standard deviation)

Altitude Level		Fishing trips/year (N, ± SD)	Catch per fishing trip (kg, ± SD)	Catch/person per year (kg, ± SD)
HIGH	Men	41.6 ± 23.8	0.31 ± 0.20	9.4 ± 3.6
	Boys	48.6 ± 31.7	0.14 ± 0.09	5.3 ± 2.3
	Women	13.8 ± 6.0	0.05 ± 0.02	0.3 ± 0.3
	Girls	0.0		
Sirunki	Men	99.5 ± 82.4	0.88 ± 1.44	87.6
	Boys	175.6 ± 46.4	0.49 ± 0.70	86.0
	Women	98.2 ± 19.1	1.03 ± 1.7	101.1
	Girls	190.5 ± 36.0	0.60 ± 0.72	114.3
MIDDLE	Men	26.2 ± 11.3	0.54 ± 0.29	15.3 ± 9.9
	Boys	64.5 ± 57.8	1.32 ± 1.54	55.2 ± 75.6
	Women	29.6 ± 27.1	0.31 ± 0.20	12.7 ± 13.6
	Girls	18.6 ± 11.5	0.11 ± 0.08	3.6 ± 1.9
LOW	Men	83.9 ± 49.9	1.15 ± 0.75	120.3 ±107.3
	Boys	44.5 ± 32.1	0.36 ± 0.36	28.1 ± 39.1
	Women	80.1 ± 68.4	1.06 ± 1.09	82.9 ± 81.7
	Girls	45.2 ± 52.9	0.14 ± 0.27	26.0 ± 41.6

The average annual yield per resident increased from 1.8 kg in high altitude villages to 27.6 kg in low altitude villages. Low altitude villages with access to lakes, swamps or big rivers had annual yields ranging from 30 to almost 75 kg per resident. Annual yields of low altitude villages without access to these types of water ranged from 0.14 to 9.1 kg per resident.

The total annual yield of the whole Sepik-Ramu area during the time of the survey was estimated at 8187 tonnes, of which 53% was caught below 100 m altitude. Women and girls contributed half of the fish caught below an altitude of 100 m and 33% of the total fish yield of the whole catchment area (Table 5).

Table 5. Population distribution, average annual fish yield per resident, the total annual yield of the Sepik-Ramu catchment area and the contribution of each category of respondents to the total yield. (Percentages in parentheses are coefficients of variation).

Population data from Coates & Mys (1989)

Altitude	Population	Number of Villages Surveyed	Annual yield per resident (kg)	Total annual yield (tons)	% Contribution of Men	Boys	Women	Girls
0-100	155,979	7	27.6 (106%)	4305	37.1	12.4	47.8	2.7
101-500	190,948	12	15.4 (139%)	2939	66.8	15.5	16.3	1.4
501-1000	40,551	4	5.8 (116%)	235	68.9	22.8	8.3	0.0
>1000	397,968	7	1.8 (40%)	708	76.1	23.8	0.1	0.0
All Levels	785,446	30	10.4	8187	52.0	14.8	31.2	1.9

At the high and middle altitudes the majority of the villages had only access to creeks and small rivers. For the small minority with access to lakes fishing in this type of water body resulted in higher average catch/person/ fishing trip than fishing in creeks and rivers. Handline was the most frequently used gear at the these altitude levels, followed by speargun at the middle altitude level and by set line at high altitudes (Table 6). Gill nets were used only by residents of one middle altitude village, but not as a stationary gear but as a seine net. This method resulted in the highest average catch/person/fishing trip of the middle altitude reports. Fishing with set lines ranked second due to the occasional catch of big eels. Of each of the following fishing gears less than 10 reports were collected: extracts of poisonous plants, bush knives, spears, bow and arrows, woven basket traps and traps made from tree bark.

Below an altitude of 200 m the majority of the surveyed villages had access to lakes and swamps. Fishing in this type of waters, and in big rivers resulted in higher average yields/person/ fishing day than fishing in creeks and small rivers (Table 6). As a consequence of the greater variety of types of water found at low altitudes a greater variety of gears was used. Gill net was the most frequently used gear at low altitudes, followed by spear and handnet (Table 6). Gill nets were used mostly in stagnant waters. After the gill nets had been set respondents of some villages used also handline or bare hands to catch fish. The average number used by the respondents who reported the use of gill nets in their recent fishing trips ranged from 1 net in Kesawai to 3.0 nets/person in Magendo 1. Depending on the type of net and the location the average yield/gill net/fishing day ranged from 0.5 kg to 1.6 kg. In most villages only monofilament nets were used (Table 7). Higher daily yields than those realised with gill nets were achieved only in swamps with other gears to catch the fish concentrated in drying pools and streams, and with basket traps placed in creeks to intercept fish migrating from the big rivers to the plains during floods. Of each of the following fishing methods less than 10 reports were collected: woven basket traps, bare hands and speargun.

Catch composition differed greatly between villages depending on the altitude and the type of water where fishing took place. At the high altitude level eels (*A. marmorata* and *A. bicolor*)

Table 6. Average estimated catch rates (kg/person/trip ± standard deviation), percentage of trips with zero catch and maximum reported catch of the most common fishing methods in various types of water at the three major altitude levels.

Altitude	Type of Water	Main fishing gears	Average catch/trip (kg, ± SD)	Reports (N)	Zero yield (%)	Maximum yield/trip (kg)
HIGH	Creek	Bare hand	0.07 ±0.17	27	18.5	0.88
		Set line	0.73 ±2.12	25	68.4	9.28
		Handline	0.21 ±0.33	16	37.5	1.10
		All methods	0.50 ±1.41	95	29.5	9.28
	Small River	Handline	0.31 ±0.71	87	51.8	3.96
		Setline	1.07 ±1.22	19	47.1	3.60
		All methods	0.44 ±1.05	144	44.5	7.85
	Lake	Handline	0.79 ±1.18	49	4.1	4.88
		All methods	0.81 ±1.17	62	11.3	4.88
	Reservoir	Handline	0.09 ±0.14	23	47.8	0.55
	All waters & methods		0.51 ±1.36	326	33.8	9.28
MIDDLE	Creek	Speargun	0.48 ±1.05	52	11.5	6.84
		Handline	0.19 ±0.23	34	5.9	1.09
		All methods	0.45 ±0.99	135	11.1	6.87
	Small River	Handline	0.21 ±0.57	55	43.9	3.60
		Speargun	0.31 ±0.48	17	15.4	1.85
		Hand net	0.58 ±0.42	10	0.0	1.65
		Seine net	1.40 ±1.81	12	0.0	6.73
		All methods	0.53 ±1.07	166	25.3	6.73
	Lake	Handline	0.72 ±0.56	14	14.3	1.70
	All waters & methods		0.50 ±1.00	319	18.5	6.87
LOW	Creek	Hand net	0.63 ±0.67	37	10.8	3.30
		Handline	0.31 ±0.48	33	17.6	2.42
		Bow & arrow	0.17 ±0.30	15	33.3	1.08
		All methods	0.47 ±0.71	105	20.0	4.48
	Small River	Handline	0.02 ±0.04	27	55.6	0.13
		All methods	0.03 ±0.07	34	52.9	0.45
	Lake	Gill net	1.09 ±1.40	144	15.4	9.20
		Spear	1.02 ±1.70	56	25.0	7.89
		Gill net + handline	1.12 ±1.08	25	24.0	3.31
		Handline	0.63 ±0.83	21	23.8	3.21
		All methods	1.06 ±1.41	288	19.4	9.20
	Big River	Handline	0.57 ±0.71	19	10.5	2.85
		All methods	1.69 ±2.72	38	10.5	11.56
	Swamp	Hand net	1.81 ±1.76	24	4.2	7.20
		Spear	0.92 ±1.10	18	33.3	4.09
		Gill net	1.60 ±2.74	15	26.7	10.05
		Handline	0.21 ±0.33	12	25.0	1.23
		Gill net + bare hands	1.48 ±0.56	15	0.0	2.23
		All methods	1.58 ±2.16	103	15.5	12.69
	All waters & methods		1.02 ±1.62	572	20.5	12.69
		TOTAL	**0.75 ±1.39**	**1217**	**23.9**	**12.69**

Notes: all estimated catch rates are based on respondents' reports (see Methods section). Not mentioned are combinations of gear and a type of water of which less than 10 reports were collected. The results of such trips however have been included in Maximum Yield/trip, and in the computations of average catch/trip for "All methods" and "All waters & methods".

were present in the catch of 7 villages. In 4 of these villages the respondents had only access to fast-flowing creeks and fast-flowing rivers and eels contributed 84.4 - 99.9% to the total weight of the catch. *C. carpio* featured in the catch of 6 high altitude villages and when villagers had access to slow-flowing rivers the contribution of this species ranged from 35 to 68% of the weight of the catch. Three other fish species or genera were reported in small quantities in 4 of the 8 high altitude villages surveyed (Figure 2). Although rainbow trout was said to be present in nearby creeks the recent fishing trips undertaken by the respondents of Sirunki village all took place along lake Iviva (2300 m above sea level). The catch of these trips consisted of 100% common carp.

A greater variety of species, genera and families was present in the catch from middle and low altitude waters (Figure 2). At the middle altitude level a clear domination of the catch by *Anguilla* spp. (over 85% of the weight) was found in only 2 villages that fished mostly in fast-flowing creeks and fast flowing rivers. The giant gouramy *O. goramy* was reported only by the respondents of one middle altitude village. This species contributed 46% of the weight and 7% of the numbers of fish in the catch.

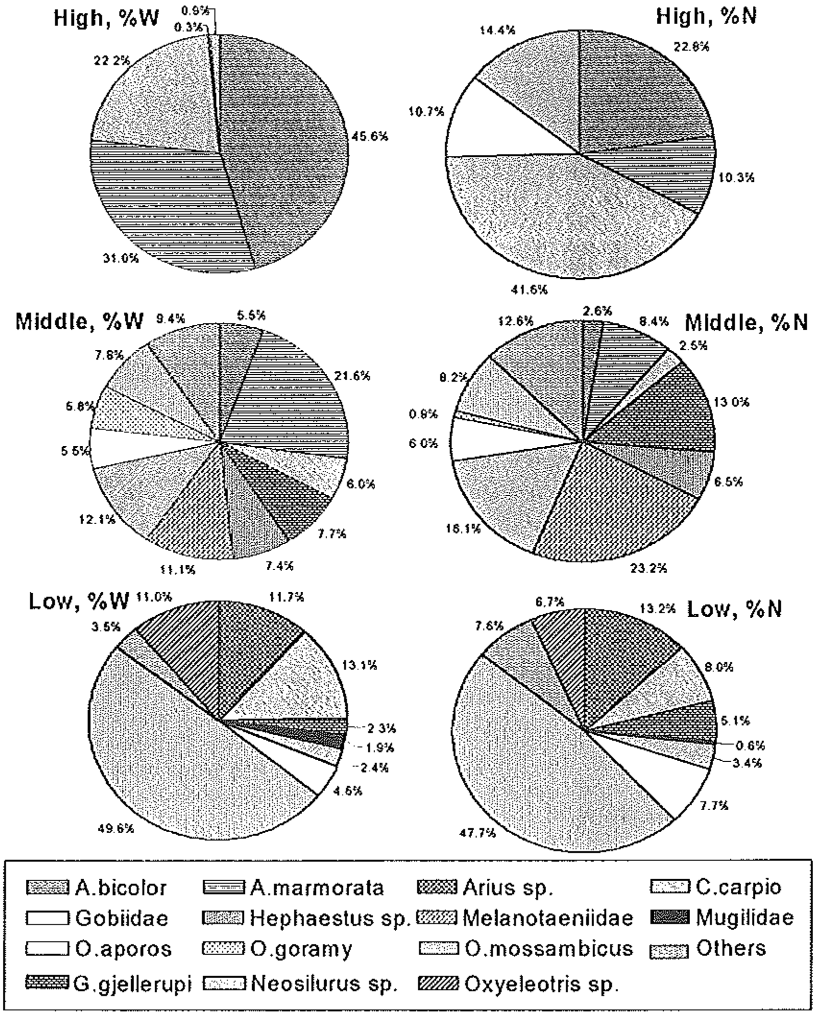
All villages at the low altitude level reported the presence of Mozambique tilapia *O. mossambicus* in the catch. Its contribution ranged from 9.9 to 79.5% of the weight of the catch. In all low altitude villages exotic fish species (*O. mossambicus* or *C. carpio*, or both) contributed at least 25% to the weight of the catch. At least one of these 2 species was present in the catch of 5 middle altitude and 6 high altitude villages. These 2 species combined contributed 42% to the estimated total yield of the whole catchment area.

The percentage of the respondents who thought that the exotic fish species (*O. mossambicus*, *C. carpio*, or both) had a negative influence on the numbers of indigenous fish decreased from 60.9% of the fishing respondents at the low altitude level to 24.4% of the fishing respondents at the high altitude level. *C. carpio* was more often thought to have a harmful effect than *O. mossambicus* (Table 8). Of the respondents at the high altitude zone who believed that the exotics had a negative influence 76% mentioned that the *Gobiidae* had decreased in number. At the middle altitude zone *Ophioleotris aporos*, *Glossamia gjellerupi* and *Mogurnda sp.* were most often mentioned to have decreased in number (by 17, 14 and 11% respectively of the respondents who thought that exotic fish species had a negative effect on numbers of native fish species). None of the respondents who fished in the lake where *O. goramy* occurred reported a negative effect of this species.

Table 7. Average catch per gill net per day (gr, ± SD) in various types of water at low altitude. SD = Standard Deviation; mono.= monofilament; multi.= multifilament)

Water body	Net type	Size(m)	Mesh sizes* (mm)	Catch/net ± SD	N
Lake	mono.	25 x 2	76, 89, 102	1343 ± 2407	98
	multi.	90 x 2.5	76, 89, 102	497 ± 801	34
Swamp	mono.	25 x 2	76, 89, 102	1599 ± 2742	15
Big river	multi.	25 x 2	76, 89, 102	279 ± 83	4

*most commonly used mesh sizes.



%W=% of the weight of the catch; %N=% of the number of fish.
Others= *M.cyprinoides*, *Mogurnda* spp., *T.rendalli*, *Z.kampeni*.

Figure 2. Composition of the catch at high, middle and low altitude levels.

Table 8. The percentage of the respondents who reported a negative effect of the exotic species *O. mossambicus* and *C. carpio* on the numbers of native fish species.

	Altitude level			
	High	Middle	Low	Total
No negative effect noticed	75.6	62.0	39.1	
Negative effect of *C. carpio*	24.4	32.9	38.5	
Negative effect of *O. mossambicus*	0	13.9	19.2	
Negative effect of *C. carpio* or *O. mossambicus*	0	0.0	11.6	
Total number of respondents	90	79	156	325

Note: percentages do not add up to 100% because some respondents thought that both exotic species influenced the numbers of native fish.

Gobiidae, *Oxyeleotris* spp. and *Melanotaeniidae* were believed to have decreased in number by 20, 13 and 10% respectively of those respondents at the low altitude level who thought that exotic species had a negative effect on the numbers of native fish species. Thirteen percent of the lowland respondents said that the exotic fish species had a negative influence on numbers of native fish thought that the arrival of common carp in lowland Sepik-Ramu had a negative effect on the numbers of Mozambique tilapia.

DISCUSSION

The part of the Sepik-Ramu population involved in catching fish appears to be greater than was thought before. One of the methods used by Coates (1985) to estimate the yield of the Sepik floodplain was based on the assumption that only men between 18 and 45 years of age were potential fishermen. The important contribution of women and boys to the low altitude catch (50% of the fish caught below 100 m) seemed to have been overlooked. In 3 low altitude villages women and girls contributed 64 to 80% of the total catch. Such a high level of female participation in catching fish is rarely reported. In his review of river fisheries world wide Welcomme (1985) reported that usually men catch the fish and the role of women is to collect, treat and market the produce. In the lowland areas of the Sepik-Ramu catchment women and girls also play a major role in fish marketing.

Local customs and tradition exclude women at high and middle altitude from the use of gears for catching eels (set line, traps). This exclusion, added to the small catches with other gears from high altitude rivers and creeks and the high chance of zero result are believed to be responsible for the low female participation in fishing in high altitude villages. In general in Papua New Guinea women and girls have a greater number of tasks in the household than male members and cannot afford to spend much time on an activity which is likely to have little or no result. When fish other than eels or gobies are present, the chances of success increase and highland women do take up fishing. Such was the case in Sirunki after Lake Iviva had been stocked with common carp in the 1960s. Women and girls in Sirunki used only handlines while fishing in this lake, and their yields were on an average 3 times higher than handline catches from high altitude creeks and rivers. Only 4% of the trips with handline at Lake Iviva resulted in zero catch.

The exceptionally high catch of boys at the middle altitude level (Table 4) is caused by the reports of 4 boys from 2 villages who claimed to fish 135 - 156 times/year and who stated that their most recent fishing trips had been very successful (2.1 to 4.7 kg/person/

trip). The average fishing frequency and annual yield of the other 20 boys interviewed at this altitude level were 24.0 times per year and 4.3 kg/person, which is close to the fishing frequency and annual yield of the other respondents at the middle altitude level.

The estimated average annual yields of fishing respondents from low altitude villages with access to lakes, big rivers and swamps ranged from 81 to 313 kg per person. This is comparable with an earlier report by Coates (1985) who, based on interviews with men from 3 Sepik floodplain villages, estimated the annual fish yields between 70 and 640 kg/man with an average of 300 kg/man. The average annual catch of the 3 floodplain villages surveyed by Coates plus the 5 floodplain villages surveyed by the author was 225 kg/fishing adult.

The estimate of the annual yield below 100 m altitude reported here is in line with an earlier estimate of 3000 to 5000 tons for the Sepik floodplain (Coates 1985). Compared with reports from other tropical rivers the yield from the Sepik-Ramu floodplain is low (Table 9). Only the yield from the Oueme River is equally low, but this estimate dates back to 1957 when modern gears made of synthetic fibers were probably not yet commonly used by the artisanal fishermen.

The difference in yield between the Sepik-Ramu and the Mahakam floodplain fishery (Table 9) does not seem to be caused by differences in total effort (expressed in persondays). From the results of the interviews in the Sepik-Ramu villages below 100 m altitude it is computed that the estimated annual yield of 4300 tons was realised with a labour input of 5.95 x 10^6 persondays (population size is 156,100; 41% involved in fishing; average fishing frequency 93 times per year). The average annual yield of the Mahakam floodplain (20,000 tons) was the result of approximately 2.55 x 10^6 persondays (5,800 full-time and 6,200 part-time fishermen, fishing frequency of full-time fishermen 287 days/year, part-timers are assumed to fish half as often; Christensen 1993a, 1993b).

Table 9. Annual catch per fisherman of the floodplain of various tropical rivers.

River	Catch·person^{-1}·year^{-1} (tons)	(Reference)
Mahakam (full-timers)	1.8 - 5.7	(Christensen, 1993b)
Mahakam (part-timers)	1.0 - 1.6	(Christensen, 1993b)
Ganges	0.9	(Welcomme, 1985)
3 South American rivers	2.2 - 5.0	(Welcomme, 1985)
11 African rivers	1.0 - 13.3	(Welcomme, 1985)
Oueme (Africa)	0.22	(Welcomme, 1985)
Senegal (Africa)	1.2 - 2.88	(Welcomme, 1985)
Sepik-Ramu	0.23	(Coates 1985, this author)

Welcomme (1979, 1986) reported that yields from Asian rivers with large floodplains are related to the maximum flooded area and attain 44.02 $\pm$ 17.88 kg/ha/yr. When this formula is applied to the Sepik-Ramu floodplain, which has an area of 10,600 km^2, the total annual fish yield is expected to range between 27,700 and 65,600 tons/year. Coates (1987, 1993a) has pointed at the recent geological history of the floodplain, the limited estuarine environment and the composition and characteristics of the indigenous fish population as major causes of the low fish biomass and consequently of the low fish yield of the Sepik-Ramu catchment.

In our survey one Sepik floodplain village (Yau'umbak) was visited twice and the interviews took place with exactly 12 months interval. The total annual yield of this village that was estimated from the reports of the first batch of interviews was only 34% of the estimate from the reports of fishing trips that took place 12 months later. Such fluctuations in yield from one year to another are the result of variations in duration and extent of yearly floods which influence the size of the fish stock in the year after the flood (Welcomme 1985). Similar fluctuations are reported from other rivers: the annual yields from the Mahakam and the Senegal River range between 12,000 tons in some years and 30,000 tons in others (Christensen 1993b; Welcomme 1979). Future surveys carried out to assess the impact of the recently introduced fish species on the composition and size of the Sepik-Ramu fish catches will have to take these natural annual fluctuations of the lowland fish biomass into account.

The short range from the homestead at which most fishing took place is explained by the fact that in the Sepik-Ramu area most fishing has to take place within the territory traditionally owned or claimed by the respondent's village. For fishing in other territories permission has to be requested from the owners and such requests seem to be made only seldom. Access to fishing grounds is thus virtually limited to the villagers claiming to be the owners of the area where the water body is located. Such limited entry to fishing areas is common in all inland and coastal areas of Papua New Guinea (Haines 1982). According to the respondents only the access to big lowland rivers and to the new Yonki Reservoir in the Upper Ramu region is open to all.

Mys and van Zwieten (1990) reported trips lasting several weeks to practically uninhabited areas by men from a very remote high altitude village in the Sepik catchment area. The trips were undertaken for both hunting and fishing. During the survey that is reported here no fishing trip that lasted longer than one day was reported.

Based on a survey among 30 fishermen from 3 Sepik floodplain villages who used gill nets to fish in lakes, Coates (1985) reported an average daily catch of 1.8 kg/person, which is 0.7 kg more than reported here. Annual fluctuations of the size of the total fish biomass in the floodplains could be a possible cause of the difference. Such fluctuations are the result of variations in size of the flooded area and of the duration of the flood in the year before (Welcomme 1985).

Much higher average catch rates of handline (1629 g/hook and per hour) were reported by Christensen (1993a) for the Mahakam floodplain in Borneo. Average catch rates with gill nets (1160 gr/net/day) at the Mahakam floodplain were close to the rates found during this survey, but lower than reported by Coates (1985), who found average catch rates for 4 Sepik floodplain villages between 1.59 and 2.83 kg/net/day. Coates (1985) reported that Sepik fishermen owned an average number of 1.6 to 2.1 nets which corresponds well with the results of our survey. Christensen (1993a, 1993b) reported an average number of 51.5 gill nets owned per Mahakam fishing household, resulting in a daily catch of 20 to 125 kg. Coates (1985, 1986, 1987, 1993a) thought that the low fish biomass of the Sepik and Ramu rivers (due to geological and biological causes) was mainly responsible for the low yield of the Sepik-Ramu fisherfolk in comparison to the results of tropical floodplain fisheries elsewhere in the world. We believe that the scarcity of efficient fishing equipment such as gill nets, and the lower fishing intensity that results from this, is another cause.

The choice of fishing methods used in a certain village is determined by water depth, strength of the current, temperature, local customs and access to factory-made fishing materials. Respondents from several high and middle altitude villages reported that the use of hand-made funnel traps to catch eels was giving way to fishing with lines made of synthetic fibers (handline and set line). Due to the increased availability of factory-made hooks and fishing lines young men in most villages surveyed did not use traps anymore and only elderly men knew how to construct and use the traps.

The catch composition of the respondents at low altitude is not much different from earlier reports. Coates (1985, 1991, 1992) reported that *O. mossambicus* accounted for 30% to 50% of the Sepik floodplain catch, *Ophioleotris aporos* and *Oxyeleotris heterodon* contributed 25 to 30%, and *Ariid* catfish approximately 25%. We found that the average contribution of *O. aporos* and *O. heterodon* to the catch of the 5 floodplain villages with access to lakes, swamps or big rivers was 30.5%, but that the contribution of *Ariid* catfish to the low altitude catch (11.8%) was approximately half of the share of this genus as estimated by Coates (1991).

During the time of the survey the lake where *O. goramy* was caught was the only place in the Sepik-Ramu area where this species was known to occur.

The results of this survey support the findings of van Zwieten (1990) who reported that the high altitude streams of the Sepik-Ramu are poor in fish species and families.

The exotic species Mozambique tilapia and common carp were found to contribute more than 40% of the total Sepik-Ramu yield. Other exotic species (*O. goramy*, *Oncorhynchus mykiss*, *Tilapia rendalli*) were only locally important and their contribution to the total catch of the catchment area at the time of survey could be considered as negligible.

The effect of exotic species on the numbers of native fish has not yet been investigated in Papua New Guinea. When a decrease in numbers of a certain fish species, genus or family is commonly reported it can be assumed to be a strong indication of what has actually occurred. A great number of respondents from high altitude villages that are far apart, reported a declining number of local species especially *Gobiidae* after *C. carpio* had appeared. This makes it likely that this species has indeed affected the numbers of *Gobiidae*. There is a significant overlap in habitat and food of common carp and gobies (Coates & Ulaiwi, 1995), and this makes it likely that the carp would be a serious competitor for the smaller gobies. Predation on eggs or fry could also have caused the decrease.

A negative effect of *C. carpio* or *O. mossambicus* on native fish species at the middle and low altitude level is less clear. Coming from the high altitude rivers and streams *C. carpio* entered lowland Sepik-Ramu about 20 years after *O. mossambicus* was introduced in this area (Ulaiwi 1990). A direct negative effect of *C. carpio* on the numbers of *O. mossambicus* is not likely. *Oreochromis* spp. protect their eggs and early fry by carrying them in their mouth and are capable of producing abundant offspring even in ponds with a dense population of common carp. It is therefore believed that predation by common carp on the eggs or fry of *O. mossambicus* is not likely to have a significant effect. A negative effect of carp on Mozambique tilapia was reported mostly by respondents from villages where gill nets were used. After it has been caught, carp often tangles the gill net which reduces the efficiency of the net to capture other fish. Such behaviour of carp may explain reduced numbers of *O. mossambicus* in the catch.

ACKNOWLEDGEMENTS

During the surveys the author was seconded to FAO/Sepik River Fish Stock Enhancement Project by the Dutch Directorate General for Development Cooperation (DGIS). The contribution of Mr H.Gumanz to the data collection is gratefully acknowledged. Thanks are also due to Dr. A.A. van Dam, Dr. M.B. van de Meer and Dr. W.L.T. van Densen for their comments on earlier versions of the manuscript.

REFERENCES

Allen G.R. & D.Coates (1990) An ichtyological survey of the Sepik River system, Papua New Guinea. *Records of the Western Australian Museum Suppl.*34:31-116.

Christensen, M.S. (1993a) The artisanal fishery of the Mahakam River floodplain in East Kalimantan, Indonesia. I Composition and prices of landing, and catch rates of various gear types including trends in ownership. *Journal of Applied Ichthyology* 9, 185-192.

Christensen, M.S. (1993b) The artisanal fishery of the Mahakam River floodplain in East Kalimantan, Indonesia. II Catch, income and labour requirements of fisher households. *Journal of Applied Ichthyology* 9, 193-201.

Coates, D. (1985) Fish yields estimates for the Sepik River, Papua New Guinea, a large floodplain system east of "Wallace's Line". *Journal of Fisheries Biology* **27**, 431-443.

Coates, D. (1986) Fisheries development of the Sepik River, Papua New Guinea: proposed fish introductions. p.367-370. In: J.L. Maclean, L.B.Dizon and L.V.Hosillos (eds.) *The First Asian Fisheries Forum*. Asian Fisheries Society, Manila. Philippines.

Coates, D. (1987) Consideration of fish introductions into the Sepik River, Papua New Guinea. *Aquaculture and Fisheries Management* 18: 231-241.

Coates, D. & B.M.F. Mys (1989) *Preliminary report on population statistics and socio-economic data for the Sepik and Ramu River Catchments*. Sepik River Fish Stock Enhancement Project, PNG/85/001 *Field Document* 4. FAO, Rome, Italy.

Coates D.(1990) Phase one final report and recommendations. Part 1 - Recommendations regarding fish stocking and alternative options. Sepik River Fish Stock Enhancement Project PNG/85/001 *Field Document* No.12/a. FAO, Rome, Italy.

Coates D.(1991) Biology of the fork-tailed catfishes from the Sepik River, Papua New Guinea. *Environmental Biology of Fish* **31**, 55-74.

Coates D.(1992) Biology of *Oxyeleotris heterodon* and its major prey, *Ophieleotris aporos*, two floodplain sleepers (Pisces: Eleotrididae) of the Sepik River fishery, northern Papua New Guinea. *Environmental Biology of Fishes* 34, 51-64.

Coates, D. (1993a) Fish ecology and management of the Sepik-Ramu, New Guinea, a large contemporary tropical river basin. *Environmental Biology of Fish* **38**: 345-368.

Coates, D. (1993b) Sepik River Fish Stock Enhancement Project FI:PNG/85/001 *Terminal Report: Project findings and recommendations*. FAO, Rome, Italy.

Coates D. & W.K. Ulaiwi (1995) A simple model for predicting ecological impacts of introduced aquatic organisms: a case study of common carp, *Cyprinus carpio* L., in the Sepik-Ramu River Basin, Papua New Guinea. *Fisheries Management and Ecology* 2, 227-242.

Coates, D. (1997) *Fish stocking activities undertaken by the Sepik River Fish Stock Enhancement Project (1987-1993) and the FISHAID project (1993-1997)*. FISHAID Project FI:PNG/93/007 *Field Document* 5. FAO, Rome, 45p

Haines, A.H.(1982) Traditional concepts and practices and inland fisheries management. pp. 279 - 291 *In*: L.Morauta, J.Pernetta & W.Heanay (Eds) *Monograph 16: Traditional conservation in Papua New Guinea: implications for today*,. Institute of Applied Social and Economic Research, Boroko, Papua New Guinea.

Mys, B.M.F. & P.A.M. van Zwieten (1990) *Subsistence fisheries in lower order streams: notes on species preference, fishing* *methods, catch composition, yield and dietary importance of fish.* Sepik River Fish Stock Enhancement Project, PNG/85/001 *Field Document* 11. FAO, Rome, Italy.

Swadling, P., B. Hauser Schäublin, P. Gorecki & F. Tiesler (1988) *The Sepik-Ramu: an introduction.* Papua New Guinea National Museum, Boroko, Papua New Guinea, 76 pp.

Tesch, F.W. (1977) *The eel.* Biology and management of Anguillid eels. Chapman and Hall, London.

Ulaiwi, W. (1990) The occurrence and spread of common carp, *Cyprinus carpio* (L.) in the Sepik River system, Papua New Guinea. pp. 765-768 *In* Hirano, R. and I. Hanyu (eds) *The second Asian Fisheries Forum.* Asian Fisheries Society, Manila, Philippines.

Welcomme R.L. (1979) *Fisheries ecology of floodplain rivers.* Longman Inc., New York, 317 pp.

Welcomme, R.L.(1985) River fisheries. *FAO Fisheries Technical Paper* **262**, 330 pp. FAO Fisheries Department, Rome, Italy.

Welcomme R.L. (1986) Considerations on fish yields in rivers. *Polish Archives Hydrobiology* **33**, 305-318.

Welcomme, R.L. (1988) International introductions of inland aquatic species. *FAO Fisheries Technical Paper* **294**, 318 pp.

Zwieten, P.A.M. van (1990) *Distribution, altitudinal range and abundance of the fish species in the lower order streams of the Sepik-Ramu catchment.* Sepik River Fish Stock Enhancement Project, PNG/85/001 *Field Document* 9. FAO, Rome, Italy.