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Upper Meta River Fisheries Investigations

Part I

MANAGEMENT OF THE UPPER META RIVER FOOD-FISH FISHERY

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SUMMARY

A. Catch assessment surveys

Based on an initial frame survey of the fishery in 1977, 1252 metric tons of fish were captured by 211,979 canoe days of fishing effort. Eighty percent of the catch and 40% of the fishing effort occurred during the low water season. Average number of canoes fishing daily was slightly greater in the low water season than during high water, 627 and 548 respectively. Catch per unit of effort (CPE) was 10.58 kg and 2.13 kg per canoe-day in low and high water seasons, respectively. Annual CPE was 5.91 kg/canoe-day.

Based on knowledge gained during the 1977 frame survey, an improved survey was designed which reduced the number of sampling zones; and probabilities of sampling each zone was assigned proportional to the importance of the zone to the total fishery.

The 1978 catch assessment survey (CAS) produced the following information:

total catch = 071.4 metric tons, RSE* = 25.1%

fishing effor = 126,334 canoe-days, RSE = 9.8%

catch per unit effort = 8.10 kg, RSE = 19.6%

The high and low water catches were nearly equal, 538 mt for high water and 534 mt, for low water. However, since the low water season is much shorter than the high water (151 days and 214 days, respectively) catch per day was much greater during low water than high water (3.5 and 2.5 mt, respectively).

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*The relative standard error indicates the relative precision of the estimate. Twenty percent or less are considered acceptable.

Welcomme (1975) proposed that catch from African rivers is a function of drainage basin area such that Catch = 0.1326 (area in kms^2) $^{0.8533}$. To see if this formula might be useful for South American river fisheries we compared our catch estimate with Welcomme's prediction. For the main channel fishery which is the estimate used by Welcomme, we found 751 mt and the equation predicts 620 mt. The 17.5% difference in estimates is acceptable. Thus the Upper Meta River appears to be exploited at a similar intensity to many other tropical rivers.

Catch per unit effort (CPE) in the areas of commercial exploitation is large enough to provide fishermen with a good income. In the upper, middle and lower 100 km sections of the Upper Meta River annual profit for a fishing unit (potential income minus costs for equipment, investment and labor) averages 67,000, 14,600, and 35,500 pesos, respectively. These values divided by 1.8 are the profits per fisherman. However, since nearly all fishing units (89%) are composed of members from single households, fishing unit income is nearly equal to family income.

Profits are highest in the upper 100 km section due to its nearness to the markets of Villavicencio and Bogota resulting in competition for fish between many buyers. Higher prices appear to stimulate fishermen to use more fishing gear. Fishermen in this upper section could catch enough fish to cover all expenses including labor costs if the CPE were 2.15 kg/canoe-day. Thus the present CPE of 8.1 kg is 3.8 times greater than necessary to sustain a subsistence fishery.

Even in the middle 100 km section, CPE is 1.7 times greater than need be to maintain a subsistence fishery. The fishery appears to be underexploited economically in the sense that more effort by more fishermen could be expended

and all would still make a profit. If the fishery is presently underexploited biologically which we believe it is, an increase in effort will produce a sustainable increase in total catch.

We estimate 1217 and 1778 fishermen fish in the high and low water seasons respectively. The large difference in numbers between seasons is probably because many fishermen farm during the high water season. Also some fishing canoes are taken from the water for repair during high water or are relocated up canos where they are not visable to the surveyor.

Density of fishing units is greatest along the Meta River (1.89/km during low water) and least along the Manacacias-Yucao tributaries (0.24/km during low water). Colonization along the Meta River may be limited by number of home sites. Presently most homes are flooded at least temporarily each year. Houses on stilts may be necessary. Along the Manacacias River, colonization may be limited by availability of land. Presently most potential home sites are enclosed in large cattle ranches and riverside colonization is discouraged. A poorly developed marketing system in the lower tributaries provided little incentive to increase fishing effort beyond that required for home consumption.

B. The Commercial Fishery

Six of the 25 species of commercial food-fish make up 80% of the annual catch. These are Amarillo, Rayado, Baboso and Valenton, all Pimelodid catfish and Cachama and Cherma, both Characids of the genus *Colossoma*.

The catch is very seasonal, Rayado and Baboso are dominant species during the receding and low water months of November through January and the *Colossoma spp.* dominate the catch during the rising water months of April and May. These five months are by far the most important in the fishery (Figure 1). The large

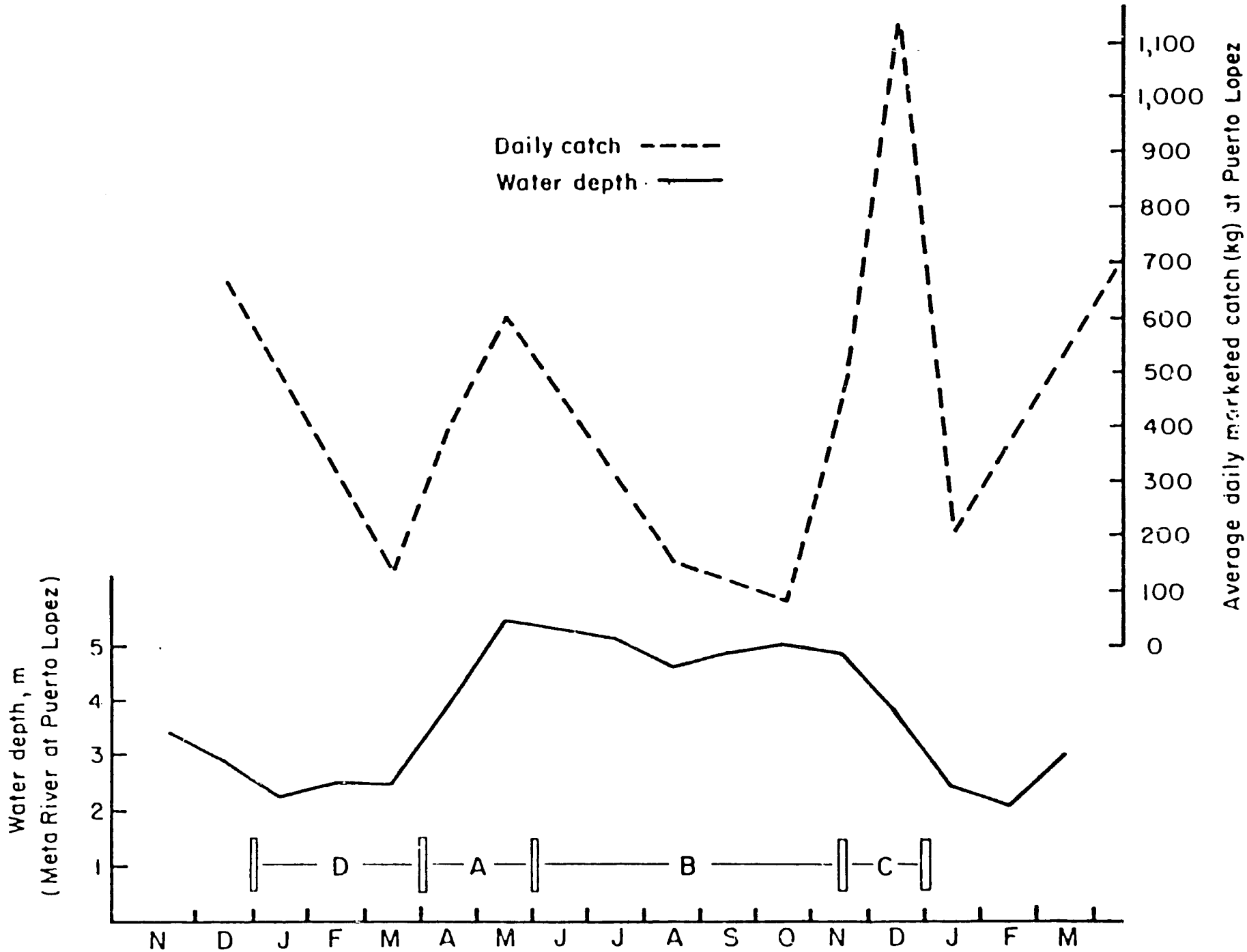

Figure 1. Relation of Meta River Water Depth at Puerto Lopez and quantity of marketed fish (Nov. 1977–April 1979). Proposed time blocks (A-D) for fishery surveys are

catfish, Valenton and Amarillo are important all year but the peaks of their catches are during the rising water period.

Nineteen species are individually of small importance in the commercial catch. Some species do not grow large enough to be caught in most gears, some are relatively scarce, some are generally not sold but are eaten by the fishermen and others are considered undesirable and fishermen try not to catch them.

Length frequency distributions (LFD) for commerically exploited food fish have been constructed. Their value lies in interpreting population changes which take place through time.

Methods are proposed for interpreting changes in LFD's and their implication for management. Separate interpretations are considered for species with only one age class represented in the catch and for species represented by several age classes.

Detailed interpretation of LFD's are given for the six most important species in the commercial catch. These include LFD's for data accumulated over an entire year, separated for high and low water seasons, and separated by sex. Where enough data is available, LFD's are presented for mature fish. These distributions represent catch characteristics in 1977-78 and should be used for comparison to future catch characteristics.

Species characteristics are presented including maximum, minimum, and average size in the catch, season of abundance, size range by sex, stomach contents, length at maturity, length-weight and length-length conversion equations and suggestions are given for their use in management.

We propose that only standard length need be recorded for catch statistics for most commercial species since we have adequate data to establish conversion equations for standard length (SL) to eviscerated weight, SL to total length (TL)

and SL to fork length (FL). Thus weights can be calculated from known lengths for analysis of the catch. This will save much time and reduce costs of field equipment.

C. Fishing Gear.

Gears most commonly used in the Meta River system are setlines, gill nets and cast nets. Setlines are of single or multiple hooks. Single hook setlines vary in strength and hook size depending on the target species. Gears of lesser importance include harpoons, hand gaffs, beach seines and bow and arrow. Poisoning and dynamiting are rarely used in the study area.

Drift gill netting, a very effective fishing method, is becoming popular among fish buyers who travel the rivers nightly in motorized canoes. These nets are generally fished during fish migrations.

Cast nets of small mesh are used to catch bait for setlines. Large mesh cast nets are used during the low water season (9% of all gears) and are very effective for a wide variety of species accounting for 22% of the low water catch.

The most commonly used but least effective gear is the Cachamero setline. Fifty-three percent of gears fished are Cachameros and they account for about 9% of the total catch.

The Amarillero setline accounts for 18-20% of the gears in use and for about 30% of the total catch. This gear is very selective for Amarillo catfish.

Longlines are about 10% of all gears in use and account for about 15% of total catch. Longlines and Amarilleros are about 0.7 times as efficient (kg of fish caught per unit of effort) as the stationary gill net.

Eight to nine percent of all gears are gill nets and these account for 20% of the total catch. The gill net is less selective in relation to feeding habits

than hook gears and its effect is divided among many species. Thus, the gill net is not "ruining the fishery" as is commonly believed and is an effective way to exploit a wide range of species.

Tables are presented showing the percent catch of each species by each gear. The fisheries manager may consider modification of the gear composition or a change in mesh or hook size to effect a change in the catch composition.

Young of major commercial species, i.e., catfishes and the Colossoma species, were not represented in the experimental multimesh monofilament gill net catches. We believe the juveniles do not normally inhabit the Upper Meta River.

Catch per unit effort was better in traditional multifilament gill nets than monofilament gill nets for 15 cm (6 inch) stretched mesh. Multifilament gill nets were more effective in rivers than in the clear waters of lagoons and canos.

Thirty-six species were represented in multimesh monofilament gill nets catches. Eleven of these were commercial food fish and ten were ornamental fish. Thus, 15 species were not exploited by the fishery. Of these, nine species, Pavon (Peacock bass), Descarnador, Capitan, Cucharo, Dorada, Platanote, Dormilon, Payarin, Pirana are abundant and grow to 0.3 kg or larger and would be acceptable in a subsistence fishery. Small mesh gill nets, especially if fished in lagoons would increase the harvest of fish and have very little negative effect on the species presently exploited.*

Most species captured in a 3 or 4 inch mesh gill net do not grow large enough to be caught in traditional gears. Also, most of the fish, 82.9% and 64% by

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*A fishery employing small mesh gill nets during high water would be beneficial in the many small lagoons which deoxygenate or otherwise become toxic to fish as they decrease in volume during the low water season.

weight, caught in the 3 and 4 inch mesh gill nets respectively are piscivorous. A significant capture of these fish could have a positive effect on fry survival of food fish and all life history stages of ornamental fish.

Almost all gill nets in use on the Upper Meta River are of 20 cm (8 inch) stretched mesh, a size which selects for mature fish of most species.

Experimentally, 15 cm and 20 cm mesh gill nets had nearly the same catch per unit effort (CPE) by weight. The 15 cm mesh caught more, but smaller fish, than the 20 cm mesh nets. Twenty-five cm mesh gill nets caught much less than the smaller meshes. Holes in the netting indicated that fish were too strong to be retained.

Experimental longlines captured several commercial species, mainly catfish. Traditional type fish hooks were about three times more effective than circle hooks according to our data.

A wooden box trap made of slats was found effective for catching loricariids and several other small species. The catch could be used for subsistence food or more likely as bait for setlines. Such a trap would be useful to Meta River fishermen.

Nylon mesh hoop trap net experiments were inconclusive. Catches were poor before adding wings to direct fish into the trap. Many Meta River fish have teeth and they easily rip the netting and escape from the trap. Wire mesh would be necessary for the trap to be effective.

1.0 INTRODUCTION

1.1 Background

The Upper Meta River fishery (Figure 2) was studied in several aspects, all directed at providing information for rational management of the food and ornamental fish stocks This fishery is the most intensively exploited and most likely to be expanded within Colombia's Orinoco system. Methods developed during the present "pilot" study are suggested for use in all the nation's Orinocian Fisheries. Objectives of the integrated studies agree well with priorities in fisheries investigations defined by INDERENA (Herazo et al, 1977) in their five-year development plan.

Project objectives include:

1. Develop an efficient catch assessment survey (CAS) program to estimate harvest, fishing effort and eventually maximum sustainable yield and optimum fishing effort.
2. Develop a set of base-line data from the commercial catch:
   a. length frequency distributions
   b. relative abundance within the species composition
   c. minimum spawning sizes and length frequency distributions of spawning stocks
3. Evaluate fishing gears as to their catch composition and relative efficiencies.
4. Define the socio-economic status of fishermen and estimate the economic value of the fisheries resources.

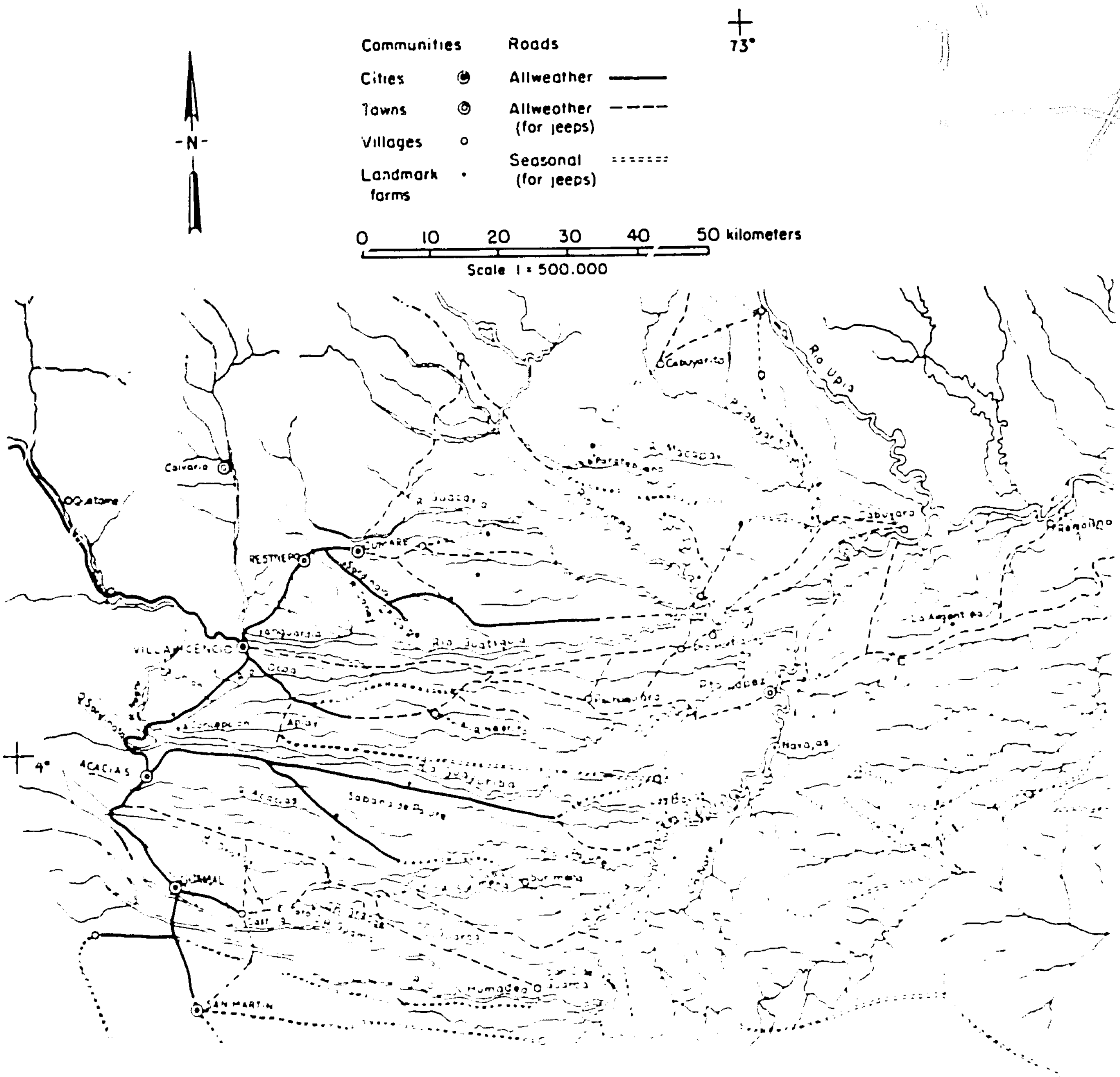
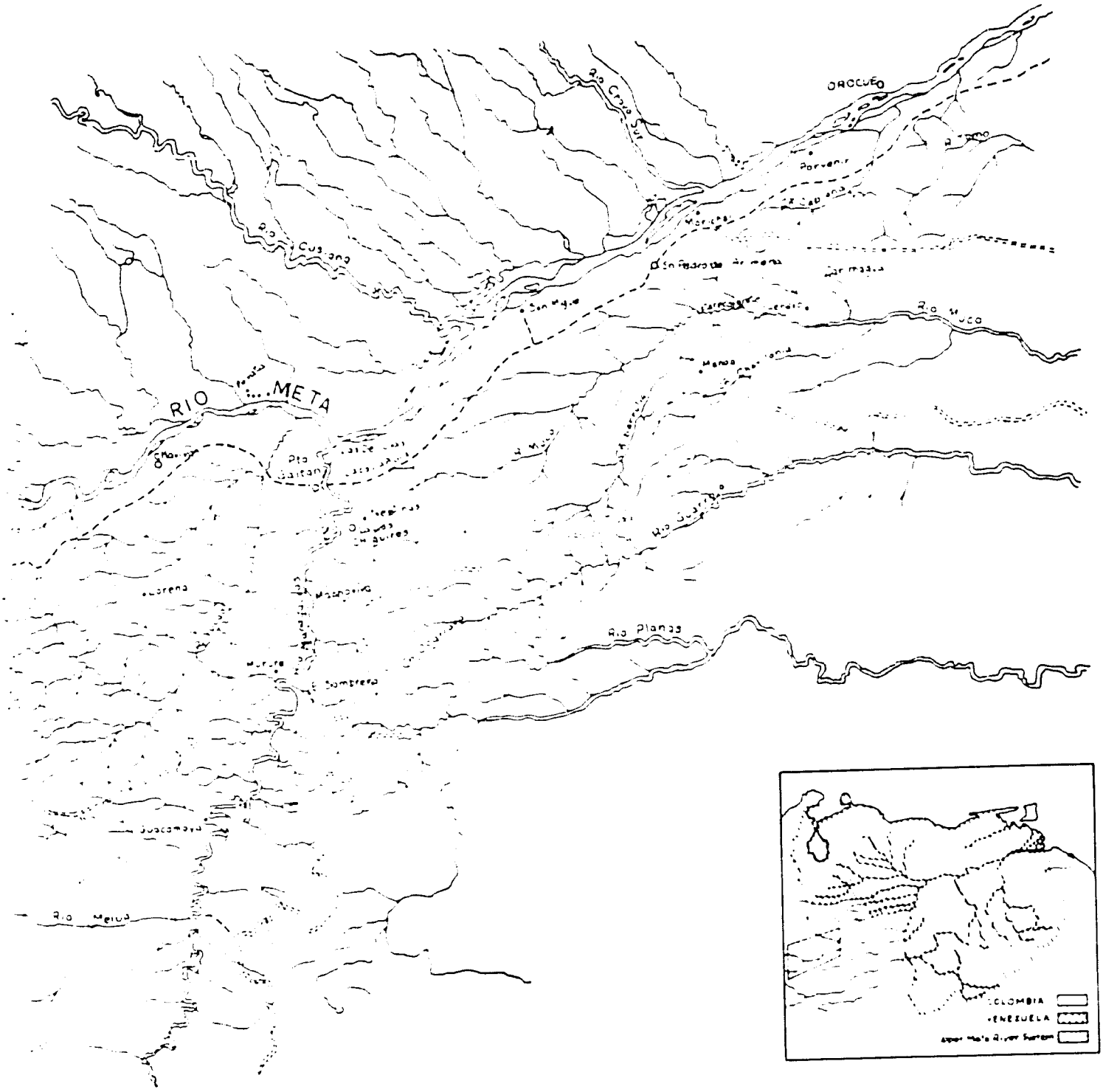


Figure 2. Upper Meta River System


OROCUÉ
Porvenir
Río Cusiana
Río Muco
RIO META
Pto Gaitan
Río Planas
Sombrero
Río Melua
COLOMBIA
VENEZUELA

5. Define the ornamental fishery and evaluate it in terms of species composition in the catch, areas of exploitation, socio-economic condition of the fishermen and trends in annual catch.

6. Recommend species from the Orinoco system for aquaculture studies.

7. Describe water quality in the study area.

The present report will cover the first three topics as a unit designed to evaluate, for management purposes, the food fish stocks* The CAS (topic 1) provides estimates of the amount of fishing, the average catch per unit of fishing effort and the total catch from the fishery. Number and density of fisherme are also estimated. These data show the contribution of the fishery to the populace in terms of fish harvested and employment provided.

Information from the CAS, gathered during at least two years, at spaced intervals of three or more years, will be used to satisfy a surplus yield model as described by Ricker, sect. 13.4 (1975) and discussed by Malvestuto et al (1979). The model is designed to provide estimates of the maximum sustainable harvest and the optimum number of fishermen (in terms of fishing effort) that should exploit the fish stocks.

Baseline catch data (topic 2) were collected in 1977-78. Future descriptions of the catch in terms of length frequency distributions and relative species composition can be compared to the baseline data. Changes in size distribution and relative abundance can be analyzed to see if significant shifts in population structure have occurred on a species by species basis. Authenticated changes, when found, can be considered in relation to minimum spawning size and trends in total weight of capture on an annual basis. From this, decisions for modifying the capture can be made.

*Topics 4 and 5 are presented as separate reports, i.e., Upper Meta River Fisheries Investigations, Parts 2 and 3.

Knowledge of fishing gear effectiveness (topic 3) allows fisheries managers to recommend gears which select for underutilized species and against those too heavily harvested. Also, before detrimental changes occur, projections of species composition changes can be made assuming changes in the relative abundance of fishing gear types. These estimates can aid fisheries managers in suggesting gear compositions which would best utilize the multispecies stock.

1.2 Description of the Study Area

The Upper Meta River as defined here includes the main river, (316 km) and navigable tributaries (700 km) from the headwaters downstream to the town of Orocure. This area was chosen from the 5000 km of rivers in Colombia's Orinoco system since it is the most developed and the most likely area for rapid advances in development. This unique status is mainly due to the area's proximity to the only large population center, Villavicencio (population 200,000) and to the road system from the mountain cities. Detailed descriptions of the area are given in Guerrero (1964); Blydenstein (1967); Sodeic and Consultan Itda (1974) and Anonymous (1975). The study area is in Colombia's Eastern Plains, the western 100 km of area are piedmont and the eastern 200 kms are low land (about 200-300 m MSL) Savanna. Annual rainfall generally comes during the eight months of April through November followed by four months of little or no rainfall. Annual rainfall ranges from 2000-4000 mm with the amount increasing from east to west. The Plains are consistently warm. Mean monthly temperatures range from 25 to 28°C.

The extreme difference in seasonal rainfall results in a pronounced flood and drought cycle with the high water season here defined as the 214-day period from 10 April to 9 November and the following 151-day dry season from 10 November

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to 9 April. Sampling programs were based on this hydrological year beginning on 10 April. There is of course considerable year to year variation in the end points of these seasons (see Appendix I for more details). At some point during the wet season the Meta River will reach a level 4-5 meters above the low water minimum. At this time considerable riparian habitat is flooded and both permanent and temporary lagoons are brought in connection with the river.

It is generally assumed that here as well as other tropical flood plain systems (Kapetski et al, 1975, Kelley, 1968) that spawning of most species occurs near the time of rising water (April through May) and that the 0-age fish utilize the flood plain and lagoons as nursery areas (Figure 3). At the height of the Meta River flood season, fish are difficult to catch due to their low density and the problems of fishing in flooded gallery forest habitat. As water receeds, juvenile fish must move to the river channel or to the few permanent lagoon basins. Prey for large fish is abundant and they feed actively. During the low water season a large mortality on young fish occurs. As the river begins to rise again adult fish migrate to their spawning areas and the cycle is repeated. This cycle should be remembered when considering seasonal catch per unit effort, species composition, location of fishing effort, types of gear in use, etc.

2.0 METHODS

2.1 Catch Assessment Surveys

Data for estimating fishing effort (f) and catch per unit effort (CPE) are collected during field surveys. The product of f and CPE is the daily catch (C) of the surveyed section.

Fishing effort from a survey section is calculated by:

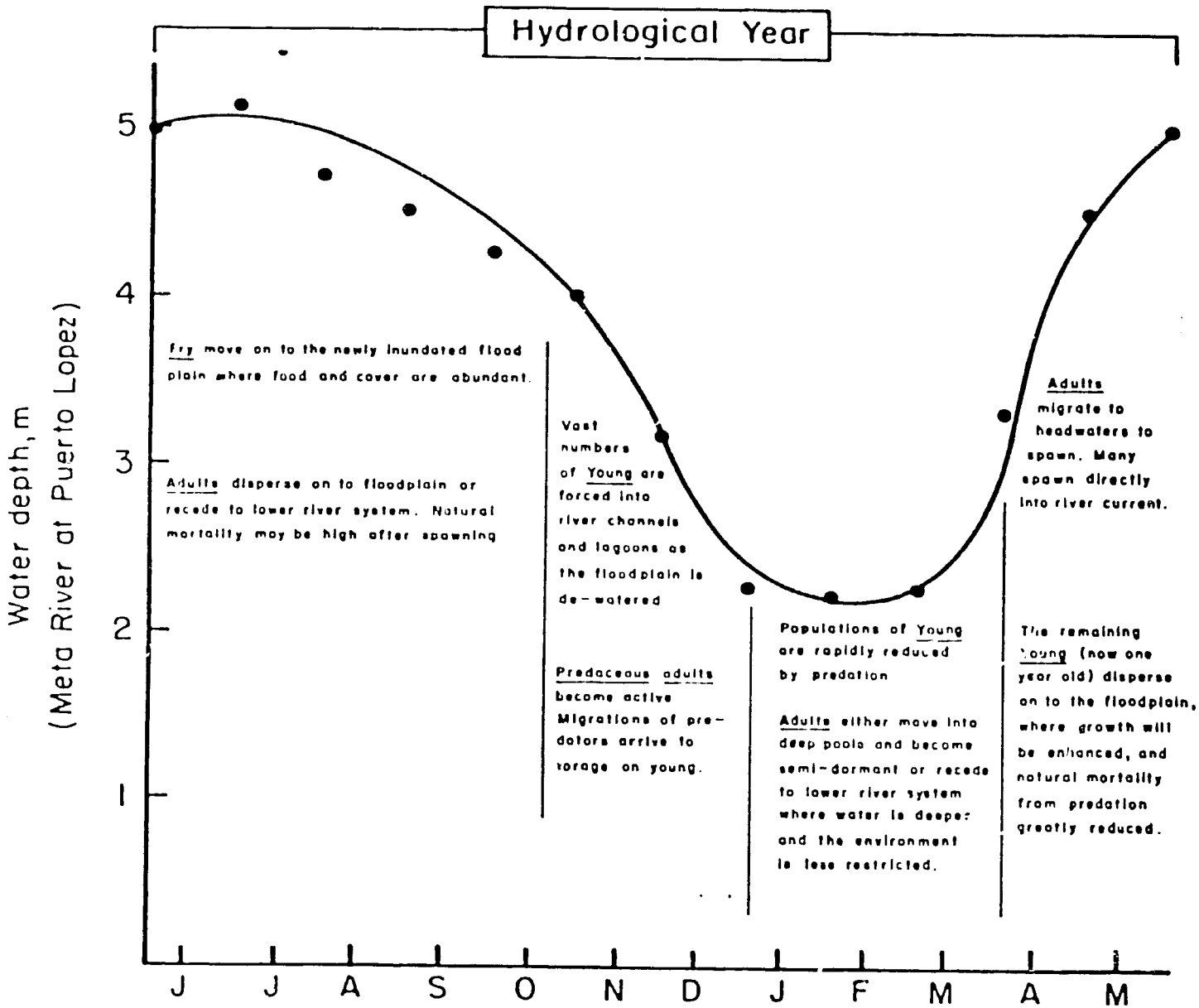

Figure 3. Annual water-depth cycle based on six years of data 1972-78 at Puerto Lopez. The hypothetical effects on the fish community are described under the curve at the respective phases of the hydrological cycle.

1. Counting all canoes.

2. Calculating the fraction of canoes that are for fishing.

3. Determining the average frequency of fishing trips per canoe. For details of calculating fishing effort see Appendix 2. Both 2. and 3. are obtained by interviewing riverside dwellers. Effort in this report is expressed as canoe-days where a canoe is a fishing unit including the fishing crew and the gear they fish. Catch per unit effort (CPE) is the average weight of catch per canoe-day of the sampled fishermen. Daily catches used for calculating CPE were those from the most recent fishing trip of interviewees.

In the 1977 frame survey, daily C and f estimates in a given surveyed section were expanded to seasonal estimates by multiplying the estimates by the number of days in the season. Estimates for each zone in a given season were added together for the total seasonal C and f over the study area.

The 1978 CAS estimates require more calculations but produce estimates with known levels of precisionin terms of relative standard errors. Each sampling stratum in time and space (two time-strata, for high and low water and three geographical strata) was sampled in proportion to sampling need as determined from data obtained in the 1977 frame survey. Malvestuto et al (1979) contains a detailed description of expanding Upper Meta River CAS survey data to annual estimates with associated variances.

Accuracy of canoe counts made from the survey boat was checked by counting canoes in the same sections from a low flying (60-150 meters) aircraft (Appendix 3).

2.2 Sampling the Commercial Catch

We weighed and measured fish brought to riverside collection points (generally at Puerto Lopez but some data are from San Miguel, Puerto Gaitan, Cebuyaro, Las Bocas and Puerto Guadulupe). When there were few fish we weighed and measured each individual. When many were landed, we subsampled, but always made a complete count by species. Data were used to demonstrate the distribution by size (length frequency distribution) in the catch of each species and the relative abundance of each species in the catch by weight and by number. Also length-weight and length-length conversions were made.

All weights in this report are eviscerated weight, about 90% of total weight. This parameter is used since fishermen eviscerate fish before selling it and whole fish are rarely available for study. When whole fish were encountered, we collected data on sex, stage of maturity and stomach contents.

Data were collected during each CAS field trip, about once a month from April 1977 until March 1979.

2.3 Evaluation of Fishing Gear

During interviews, we determined quantity and kind of gears in use. Also we inquired as to the kind of fish caught and their weight for each gear employed. From these data we determined the average catch by weight of each gear and the relative species composition from each gear.

We fished various gears, traditional and exotic to examine catch compositions in a search for efficient gears and ones which select for unexploited species. Experimental gears included traditional multifilament nylon gill nets of three different mesh sizes, multi-mesh-sized monofilament gill nets, and long lines with both traditional and circle hooks. Some data are also available on experimental catches with single hook setlines and traps.

3.0 Results and Discussion

3.1 Catch and fishing effort (Topic 1)

3.1.1 The 1977 Frame Survey: Results and Application to the 1978 Catch Assessment Survey.

During the hydrological year 10 April 1977 to 9 April 1978 we sampled fishermen to obtain estimates of catch (c) and fishing effort (f) in the Upper Meta River system allocating one survey trip to the high water, and one to the low water season within each of 10 zones (figure 4) that encompassed the study area. We estimated an annual harvest at 1252 metric tons captured by 211,979 canoe days of effort. Eighty percent of the catch and 45% of the fishing effort occurred during the low water season. Daily fishing effort during low water was slightly greater than during high water, (627 verses 548 fishing canoes, respectively) but the respective CPE was much different (10.58 and 2.13 kg/canoe day). Annual CPE was 5.91 kg/canoe day. (Table 1)

The frame survey provided insights into the distribution of fishing effort of the Upper Meta fishery. The main river and upper tributaries were the most heavily fished, experienced the greatest variety of fishing gears and were the main areas of commercial exploitation. Quantity of gears fished per canoe was greater here than in lower tributary zones. Seasonally, daily f and CPE increased during low water, but this change was not consistent throughout the zones as low water fishing effort decreasing in tributaries.

An understanding of the internal variation, both geographical and seasonal, was one objective of the frame survey. Based on this knowledge an improved survey was designed with a reduced number of sample zones (combining those with homogeneous characteristics) and with probabilities for sampling each zone in proportion to the importance of the zone to the total fishery. We defined four

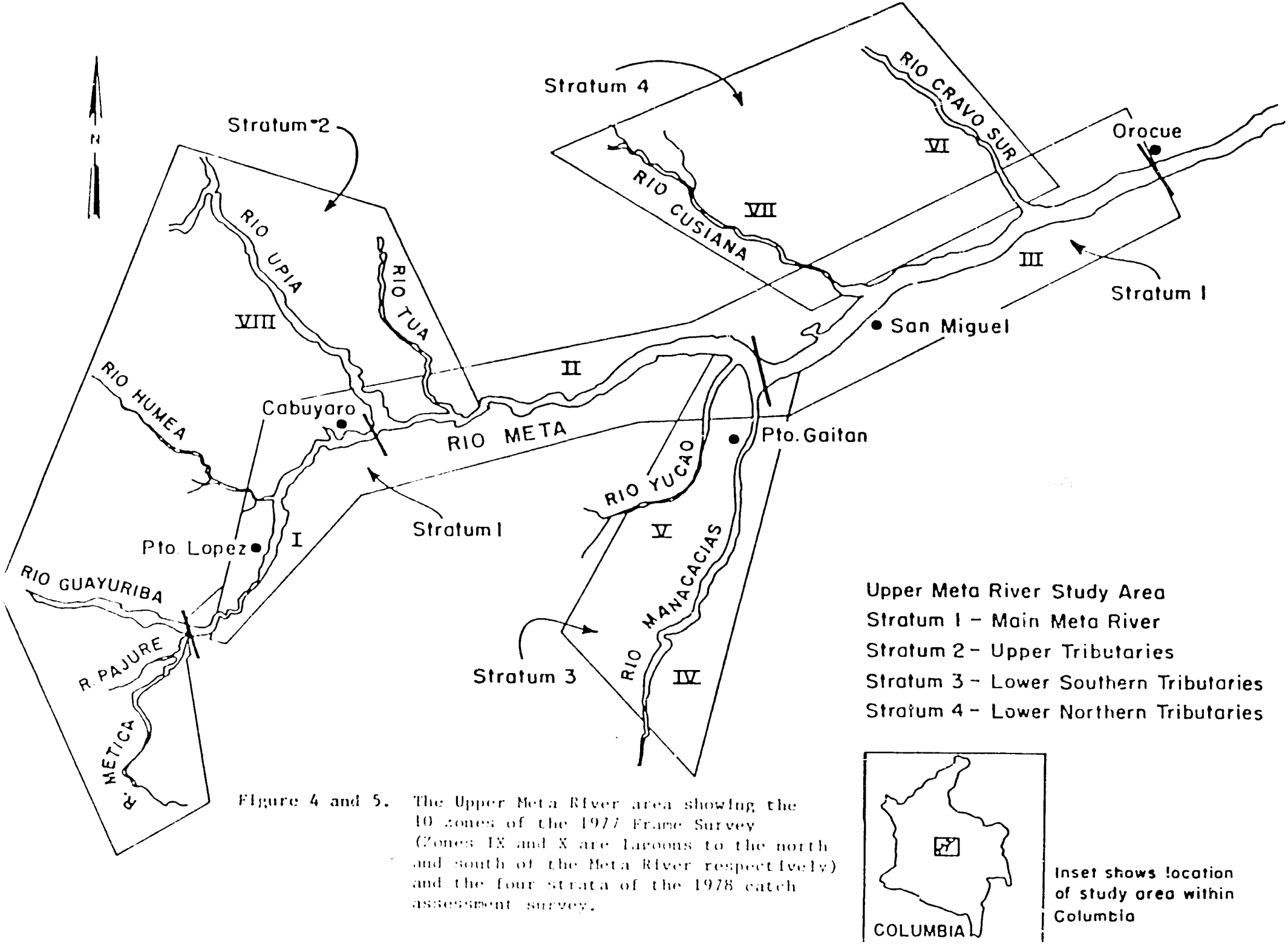

Figure 4 and 5. The Upper Meta River area showing the 10 zones of the 1977 Frame Survey (Zones IX and X are lagoons to the north and south of the Meta River respectively) and the four strata of the 1978 catch assessment survey.

Table 1. Catch and fishing effort from the Upper Meta River system during the 1977 hydrological year

Zones	High Water			Low Water		
	CPE in kg/ canoe-day	Canoes Fishing Daily	Seasonal Catch (kg)	CPE in kg/ canoe-day	Canoes Fishing Daily	Seasonal Catch*(kg)
1. Meta River-Upper 100 km	2.80	102	61118	13.17	160	318187
2. Meta River-Central 100 km	3.15	70	47187	5.80	90	78822
3. Meta River-Lower 100 km	2.53	75	40607	22.75	81	278255
4. UPIA River (and other upper tributaries)	1.59	146	49678	7.67	141	163362
5. Yucao River	1.00	13	2782	4.84	17	12424
6. Manacacias River	1.00	31	6634	4.65	46	32299
7. Cusiana River	1.45	80	24824	7.00	66	69762
8. Cravo Sur River	2.65	31	17580	12.80	26	50253
9-10 Lagoons	No data	0	0	No data	0	0
		548	250410 kg (250.4 tons)		627	1003304 kg (1000 3.3 tons)

*Seasonal catch is from: 214 days during high water
151 days during low water

TOTAL ANNUAL CATCH: 1253.7 metric tons
Total annual effort = 211949 Fishing canoe days
Annual average catch per unit effort = 5.91 kg/ fishing unit day.

homogeneous zones, henceforth called strata, from the original ten zones of the 1977 frame survey. These are: (1) the main Meta River; (2) the upper tributaries; (3) the lower southern tributaries; and (4) the lower northern tributaries. See Appendix 4 for strata descriptions.

3.1.2 Allocation of Sampling Effort for the 1978 Catch Assessment Survey

We considered several statistics tabulated from the frame survey information as possible important criteria in determining the allocation of sampling effort to individual strata. Four of these criteria were selected and each was given equal importance in the allocation of sampling effort. Quantitative, then qualitative criteria were used in the determination. Perhaps no two people would interpret the data equally, nor use the same system for allocating sampling effort, but the sampling program for 1978 had a logical basis and has provided more reliable estimates of catch and fishing effort than was possible from the frame survey.

3.1.3 The 1978 Catch Assessment Survey (CAS)

The 1978 CAS was statified by time into high water (Block A) and low water (Block B) seasons as defined in the 1977 frame survey and especially into the four strata defined above in Section 3.1.1 (figure 5). Sampling units within each stratum were assigned equal sampling probabilities. (See Malvestuto et al, 1979)

We sampled in strata 1, 2 and 3 and catch and effort statistics are presented for these three strata in table 2 (a-c). Since the Cusiana-Cravo Sur tributaries were not sampled during the 1978 CAS, the estimates of f and C presented in Table 2 must be expanded to account for the missing tributaries.

Table 2a. Catch and fishing effort from the highwater season of 10 April to 9 Nobember 1978.

	Daily in strata			Totals	
	1	2	3	daily	seasonal
fishing effort (canoe-days)	198.8	52.6	14.0	265.4	56,796 (SE = 4,924) (RSE = 8.7)
Catch per unit effort (kg/canoe-day)	8.4(.71)*	7.31(.24)	3.75(.05)	7.91	7.91
Catch (kg)	1722	480	54	2261	483,982 (SE = 108,579) (RSE = 22.4)

*numbers in parentheses are probabilities associated with quantity of fishing effort in each stratum.

SE = standard error
RSE = Relative standard error (percent)

****

Table 2b. Catch and fishing effort from the low water season of 10 November 1978 to 9 April 1979.

	Daily in strata			Totals	
	1	2	3	daily	seasonal
fishing effort (canoe-days)	311.0	65.7	8.0	384.7	58085 (SE = 10238) (RSE = 17.6)
Catch per unit effort (kg/canoe-day)	8.14 (.71)*	10.39 (.24)	2.12 (.05)	8.38	8.38 (SE = 3.40) (RSE = 40.6)
Catch (kg)	2531	813	17	3361	571,461 (SE = 225,292) (RSE = 44.4)

*numbers in parentheses are probabilities associated with quantity of fishing effort in each stratum.

SE = standard error
RSE = Relative standard error (percent)

Table 2c. Catch and effort for the hydrological year 10 April 1978 to 9 April 1979.

High Water		Low Water		Total Year
Annual fishing effort in fishing unit days				
265.4 (.59)*	+	384.7 (.41)*	=	3[illegible]
	Total for 365 days SE = 11292 RSE = 9.8%		=	114720
Annual catch per unit effort in kg/fishing unit day				
7.91 (.59)	+	8.38 (.41)	=	8.1
	SE = 1.59 RSE = 19.6%			
Annual catch in kg				
2261.6 (.59)	+	3360.7 (.41)	=	2712.2
	Total for 365 days SE = 248576 RSE = 25.1%		=	989960

*numbers in parenthesis are probabilities associated with the number of days per stratum to days in the year.

The 1977 frame survey indicated that for high water these two tributaries contributed 12% of total effort and 10% of total catch, and for low water, 6% of total effort and 5% of total catch. Expanding the 1978 time block estimates of catch and effort upward by these percentages give the total effort and total catch for the two seasons (table 3).

The standard errors associated with the 1978 estimeates are expanded upward by the same percentages so that the RSE's previously given remain the same. The annual estimate of CPE as previously calculated will be accepted as a representative value for the entire system.

3.1.4 Compatability of the Upper Meta River CAS estimate

Welcomme (1975) found that when the annual catch (C) in tons from various African rivers for which data are available, is plotted against basin area (A) in square kilometers, an exponential relationship is obtained.

$$C = 0.11326\ A^{0.8533}\ (r^2 = 0.90)$$

Assuming tropical river systems in Africa and South America have many similarities, we evaluated this equation for use on the Upper Meta River. Our annual catch for 1978 was 1071 tons of which 751 tons came from the Main River Stratum. Welcomme assumed that "production" or harvest estimates from the African rivers were from those areas "sufficiently intense to attract the attention of fisheries administrators and biologists", probably meaning the main river channels.

The Meta River watershed upstream from Orocue (the Upper Meta River) is 20,000 km^2 (Geurrero, 1964). Thus:

$$C = 0.1326\ (20000)^{0.8533} = 620 \text{ tons}$$

This is within 20% of our main river estimate of 751 tons; thus, our catch estimate is reasonably compatable with the model.

Table 3. Estimates of total effort (E), total catch (C) and catch per unit of effort CPE by time blocks and for the entire year. Relative standard errors (RSE) are also given.

		High Water	Low Water	Annual
C (kg)	=	537,758	533,608	1,071,366
(RSE)		(22.4%)	(44.4%)	(25.1%)
E (FEU-days)	=	64,541	61,793	126,334
(RSE)		(8.7%)	(17.6%)	(9.8%)
CPE (kg/FEU/day)	=	7.91	8.38	8.10
(RSE)		(16.2%)	(40.6%)	(19.6%)

Welcomme states that the majority of river length is concentrated in the lower order streams where sampling is seldom possible and that these streams inevitably support subsistence fishing albiet at a low level of intensity.

Therefore, Welcomme proposed "that the estimates of production based on major African River fisheries are low and undervalue the importance of river fish as a component of the food of the people". Catch from lower order streams (generally those less than 100 km in length) is considered to be near 40% of the total for the system for African rivers.

If the Upper Meta River main channel provided 60% of total catch and its tributaries 40%, then the predicted total catch would be 1252 tons. This over estimates our main river and navigable tributary estimate by 17%, but since we did not consider the catch from the remaining non-navigable streams the predicted catch approximates the CAS estimates.

The similarity in estimates does not in itself validate our results however it does indicate that they are reasonable relative to catches from several other tropical rivers.

3.1.5 Present state of the fishery

Catch per unit effort is proportional to mean stock size at the time of fishing (Ricker, 1975). As fishing effort increases stock size decreases. Thus, as effort increases, catch per unit effort will decrease.

Presently, the catch per unit effort in the areas of commercial exploitation (Strata 1 and 2) is large enough to provide fishermen with a good income, especially in the upper 100 km of the Meta River, where the average fishing unit (1.8 fishermen, usually members of a single family) has a net annual profit potential* of 67,000 pesos.** This amount decreases in areas farther down river

*potential because all fish are not sold; about 25% are consumed by the fishermen families or traded locally.
**41 Colombian pesos = US $1.00 in 1978.

where annual profits for fishing units between the Upia and Manacacias tributaries is 14,600 pesos and between the Manacacias tributary and the town of Orocue is 35,900 pesos (details are inpart 2, the socio-economic report).

Profitability is greatest in the upper 100 kms mainly becuase prices for fish is highest there. Increased price also stimulates fishermen to set out more gear per fishing unit.

Gross income per fishing canoe (GI) in the upper 100 km section was 91,273 pesos; GI - 8.1 kg/canoe-day (the annual estimated catch per effort) reveals that 1 kg. of a fisherman's CPE accounts for 11,268 pesos of income. Annual fishing unit investment in this section is 24,251 pesos. This value divided by the income provided by one kilogram of CPE demonstrates that an annual CPE of 2.15 kg would allow a fisherman to exactly recover his costs for materials, minimum wage (12.5 pesos per hour) and investments. Thus the present CPE of 8.1 kg is 3.8 times greater than necessary to sustain a subsistence fishery. Since CPE is proportional to stock size, economically the fishery appears to be greatly underfished. If fishing effort were increased by recruitment of fishermen to the fishery, decreased average income but continued profit would result. Increased fishing effort could also be achieved if existing fishermen set out more gear or could use more efficient gears.

Profit in the Meta River section between the tributaries Upia and Manacacias was lowest. Gross income per fishing canoe was 36390 pesos and costs were 21813 pesos. Considering 8.1 kg for CPE in 1978, a CPE of 4.85 kg would have balanced a fishermen's expenses including minimum wage. Thus, even in this area, 8.1 kg is 1.7 times greater than necessary to sustain the present fishery.

Based on the above analysis we recommend a 10-20% increase in fishing effort: After the fishery has stabilized at a new level of effort, all the data necessary for a surplus yield model will be available. Results from the model will provide

an estimate of state of the fishery in relation to its biological potential.

3.1.6 The Surplus Yield Model (SYM)

In section 3.2 management considerations are given for individual species, based on trends observed in commercial catch statistics. However, the question of what is the potential yield from the Upper Meta River is best dealt with on a community basis (Turner 1977).

Although yield models, both the surplus yield and dynamic pool type were designed for the analysis of single species populations, the former is also applicable to analyses of multispecies (Gulland, 1977) fish communities, with the community considered a single stock while the dynamic pool model requires data on rates of growth and mortality for each species in the fishery, the surplus yield model depends only on the community response to increased mortality, i.e. its attempt to increase biomass by increasing growth, survival and reproduction.

The model assumes that unfished populations are not productive and that as stock size is reduced by fishing, the remaining stock attempts to fill the void by increasing production. In this way, a fishery, by thinning out a fish population , creates the production by which it is maintained. Generally, a population is most productive when it has been reduced to about one-half of its unfished biomass. It follows, that under conditions of increasing f, CPE decreases proportional to decreased stock size, but total catch increases in proportion to increased surplus production, until the population is near one-half the unfished biomass. A further reduction in biomass will result in both CPE and total catch decreasing. At this point the fishery, by definition, is biologically over-fished.

To complete an SYM on the Upper Meta River system, two sets of data on annual effort and CPE are needed. The first set is from the 1978 catch assesment survey i.e., 126334 canoe-days and 8.10 kg/canoe-day , the second set could be generated in 1984. The two sets of data must come from different stages of development, i.e., different amounts of fishing effort. Also, they should come from years when effort has been stable for long enough such that existing stock abundance is in equilibrium with the new effort expended. Three years of stable fishing effort is probably a minimum time interval before annual CPE and fishing effort should be estimated again on the Upper Meta system because of the many large species suggesting slow-turn-over rate.

Ricker (1975) sect 13.4 describes a simple SYM where CPE = a-bf and a and b are unknowns. (CPE and f are as previously defined). When CPE and f are known for two different levels of a fishery, a and b can be solved by the method of simultaneous equations or by linear regression of CPE on f. Maximum sustained yield is equivalent to $a^2/4b$ and the optimum fishing effort for this catch equals a/2b. Fox (1970) proposed a more sophisticated "exponential surplus yield model" which incorporates several years of CPE and f data in an attempt to eliminate the effect of compensatory lag. The model that is ultimately utilized will depend on the manner in which the fishery develops. We found no indication that any significant change in the fishery had taken place in the three or more years prior to 1978 and we feel that our estimates of CPUE and E represent the fishery in equilibrium condition.

A good rule of thumb for economic development is "if you want to develop an area, build a road to it". Although there has been a road from Villavicencio to the port of Puerto Popez for many years, 70 Km of it is mostly a bed of large unprocessed river rock alternating with sections of dirt and gravel. Torrential rainfall and poor runoff, due to roadside rice fields, also contribute to the difficulty of maintaining a dependable and economically sound fish transport

system from the Meta River to Villavicencio and Bogota. In 1978, Columbia initiated a project to pave this 70 km section. Completion of pavement is scheduled for 1980. We assume that fishing effort will increase after completion of the road as a response to more rapid, economical and dependable transportation to markets. In approximately 1984 measures of f and CPE should represent equilibrium conditions, reflecting development of the fishery.

It will be possible to estimate maximum sustainable yield for the Upper Meta River fishery and the optimum effort needed for the harvest when the second data set for the SYM is available. The information will assist managers in making long range development decisions.

3.1.7 Distributions of Fishing Units Seasonally and Geographically

We estimated 1217 and 1778 fishermen were in the study area during the high and low water seasons respectively. We believe there is no seasonal migration of fishermen and that the large difference in the number of fishermen between seasons is partially due to seasonal changes in occupation i.e., more farming during the high water season and more fishing during the low water season. Also it is more difficult to count fishing canoes during the high water season when the shoreline extends into tall grass or forest. Thus, the best estimate of fishermen whether full or part time in the Upper Meta system is calculated during the low water season.

Eighty-nine percent of the fishing units were owned and operated by members of one family. Thus the number of families involved in fishing is 1097 (988+109) (table 4).

Density of fishing units is greatest along the Meta River and least along the Manacacias-Yucao tributaries. The number of fishermen along the Meta River may be limited by the availability of home sites. Even at the present density, many homes are inundated annually to depths up to one meter. Some fishermen

have built their homes on stilts to prevent flood damage, but the inconvenience of flooding may inhibit colonization on lower ground.

The Cravo Sur-Cusiana tributaries are well colonized. However, due to their distance from fish markets, frequent low water periods when the river is unnavigable, and to the inhabitants preference to work as small-scale cattle ranchers, people expend little effort in fishing. The reduction in the number of canoes here from the high water to low water season may indicate that fishermen leave these tributaries before the water gets too shallow for navigation and spend the low water season along the Meta River.

People living along the upper tributaries are farmers and fishermen. This area, like that of the Meta River, is an area of commercial fishing. Fishermen density, however, is about half that of the main river (table 4).

Table 4. Fishing units and their density in the four geographical strata of the Upper Meta River system.

	Fishing Units	Fishing units/km
Low Water 1977-78		
Upper Meta River	595	1.89
Upper tributaries	153	0.89
Manacacias-Yucao tributaries	63	0.24
Cravos-Cusiana tributaries	177	0.70
	988	
High Water 1978		
Upper Meta River	301	0.95
Upper tributaries	132	0.55
Manacacias-Yucao tributaries	33	0.12
Cravo S.-Cusiana tributaries	210	0.83
	676	

3.2 The Commercial Fishery (Topic 2)

The Commercial catch is described in terms of (1) relative abundance in the species composition and (2) length frequency distribution (LFD) by species. Biological information for each major species is presented after the LFD for that species to enhance the readers appreciation of the commercially harvested species.

3.2.1 Species Composition and Relative Abundance in the Commercial Catch

The Meta River food fish fishery can be visualized by considering the number of species involved and their relative abundance by weight and numbers (Figures 6-7). Since the fishery changes considerably with season, it is most revealing to examine catches from the high and low water fisheries separately.

Weight rather than number is the most important parameter in a food fish fishery, since monetary and food value from the fishery are functions of weight. Six of the 25 species in the commercial catch account for 75-80% of the annual harvest by weight. These are the Amarillo*, Rayado, Baboso and Valenton, all Pimelodid catfishes and the Cachama and Cherna, Characids of the genus Colossoma (Figure 8).

The Rayado and Baboso catfish are abundant mainly during the low water season when their combined catch is about 40% of commercial harvest. The Colossama species dominate the high water catch, their combined weight also being near 40% of that seasons total.

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*Common and scientific names are shown in table 12.

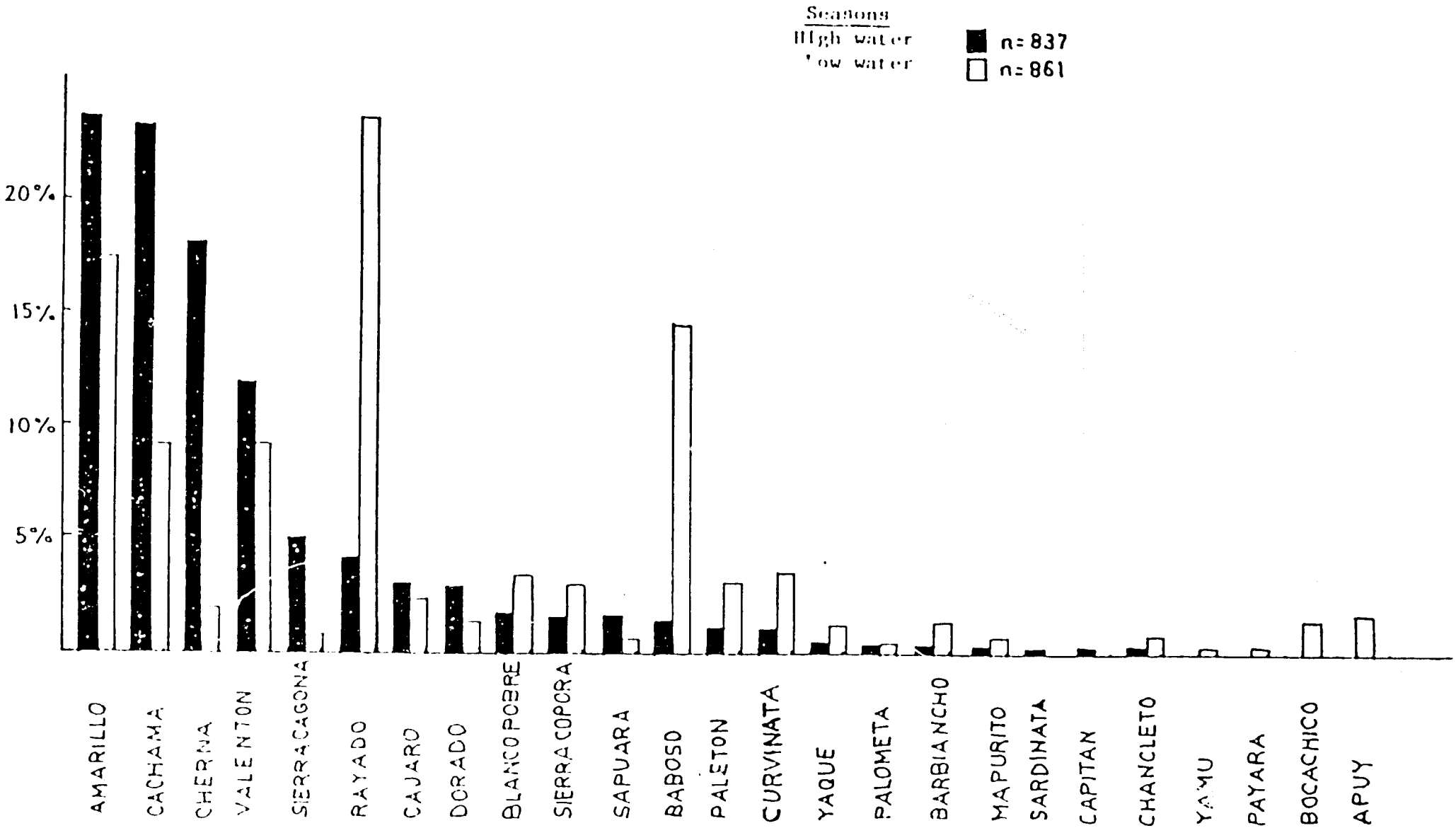


Figure 6. Percent total weight of each species in the commercial catch of 1977-1978 separated by high and low water seasons.

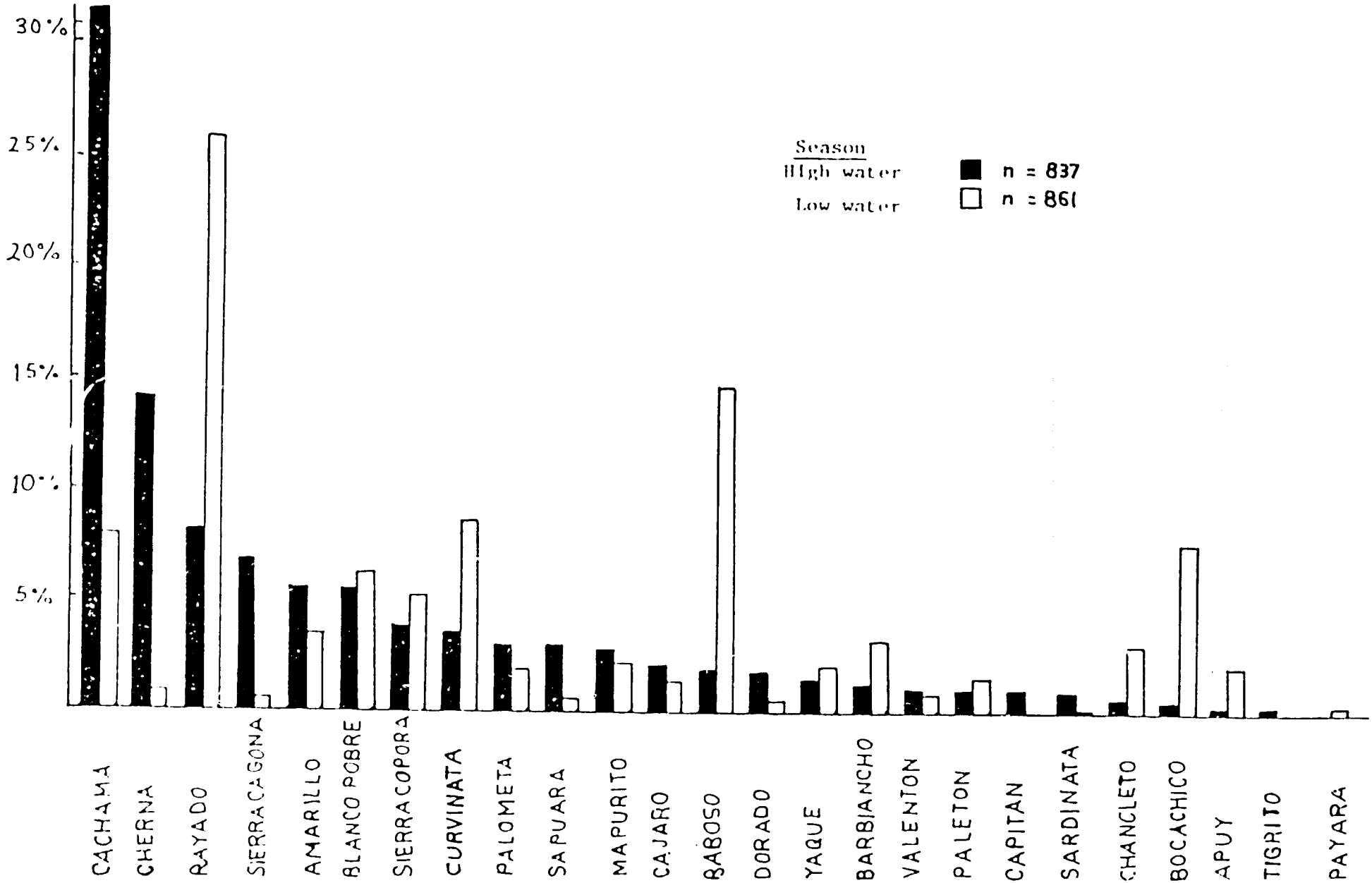


Figure 7 Percent by number of each species in the commercial catch of 1977 and 1978 separated by high and low water seasons.

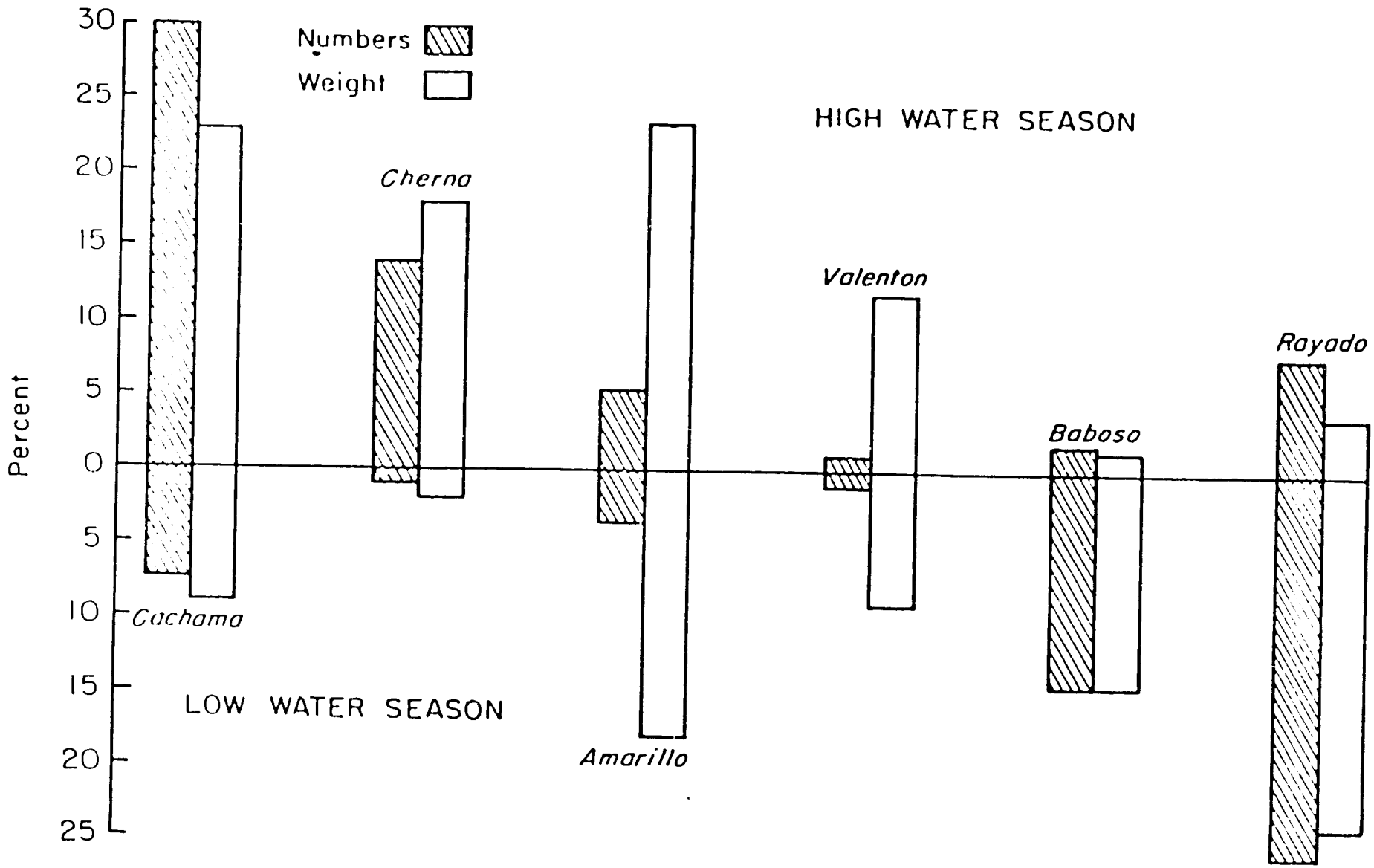


Figure 8. Percent of the commerical catch by numbers and weight for the six most important species. Their combined weight is about 80% of all (25) commercial species. Cachama and Cherna are abundant during high water, Baboso and Rayado during low water, while the catch of Valenton and Amarillo are more evenly distributed between the seasons.

Valenton and Amarillo contribute about 10% and 20%, respectively, to the commercial catch throughout the year, with their importance being slightly greater during high water season.

The remaining 19 species in the commercial catch each contributes three percent or less to the commercial catch on an annual basis. Reasons for their slight importance vary. Some species are small, thus even though many are caught, their weight contribution is small. Also, most gears in the fishery select for large fish. Small species include Curimata, Palometa, Sapuara, Sardinata, Chancleto, Bocachico and Capitan. The Dorado, Tigrito, Cajaro and Paleton are relatively scarce in the catch. There is no past history of their large catches, thus they probably do not suffer from overfishing. The environment is probably not amenable to large population growth of these species.

Other species are relatively common in the catch but are usually consumed by fishermen rather than sold. These include the Blanco Pobre, Mapurito, Yaque, Barbiancho and Apuy.

Still others are considered undesirable species. Fishermen would rather not eat them and fish buyers either will not accept them or pay only a fraction (about 25%) of what is paid for preferred species.

When numbers are compared rather than weight, large species are less important than small species. The Baboso and Rayado, which approach average size in the mixed species catch, have numerical relative abundances that approximate their abundance by weight.

3.2.2 Individual Species Characteristics in the Commercial Catch

The Upper Meta River will experience a catch assessment survey biannually, at least until 1988 and the commercial catch will be sampled annually. The CAS

will produce estimates of total catch and amount of fishing effort for the fishery as a whole. Commercial catch sampling will provide descriptions of each species' relative importance and population structure. The following discussion describes how to use these descriptors to manage the fishery on a species by species basis.

Length Frequency Distributions (LFD) and their Interpretation.

The LFD is a graphical representation of relative abundance of size classes of a given species in the commerical catch. However, the LFD does not accurately represent the size distribution in the actual population due to size and species selectivities of the fishing gears. Nevertheless, the value of the LFD is in evaluating changes which occur in time and as long as the relative composition of fishing gears (gillnets, castnets, longlines, etc.) remain unchanged, the effects of fishing will often be manifested in the LFD.

Changes in abundance of size classes can be attributed to the effects of fishing or to changes in environmental conditions. Assuming that the latter remains relatively constant (or if we determine which changes were influenced by fluctuation of environmental variables) then other population changes can be attributed to changes in fishing effort.

The effect of fishing on the abundance and productivity of a population was discussed in section 3.1.6. Increasing fishing effort decreases survival in the fishable stock and increases production, at least until the population is reduced to about one-half of its unfished biomass; further reduction results in over-fishing. These population changes are manifested in LFDs, eg. comparison of a species' LFD high and from low levels of fishing effort would show that under the higher rate of exploitation the LFD contains fewer large (old) fish and more small (young) fish than does the LFD recorded when fishing effort was less.

As long as annual catch continues to increase during the period of increasing effort, the harvestable surplus in the population has increased. Once annual catch begins to decrease, the population is overfished. Commerical catch monitoring will keep fisheries mangers abreast of such occurrances.

There is a time lag associated with the adjustment of age structure to a new rate of fishing. The lag will approximate the time interval between explitation of the parent stock and recruitment of their young to the fishery. Thus population changes may occur without being immediately recognized (Gulland, ibid). Thus, we should consider the LFD in relation to length at first production We assume that not all individuals need to spawn to maintain a healthy population, but as a precatutionary measure we would like to see at least half of the commercial catch be of fish which have had the opportunity to spawn at least once. Besides ensuring adequate reproduction, most fish in the catch would be composed of individuals which have passed the phase of life when maximum growth efficiency occurs. A minimum size limit such that the minimum length at reproduction is equal to or less than the mean length in the commerical catch would serve this purpose. If no restrictive size limit is composed, and if the mean length in the commerical catch continues to be less than minimum size for spawning, the hypothesis of overfishing will be verified (or denied) by examining future annual catches to see if catch for the species in question has decreased, or increased when the stock comes to equilibrium with the level of fishing effort.

A decrease in effort, which would occur as a result of restrictive regulations, would cause an immediate decrease in annual catch followed by a proportional increase of larger fish in the LFD. If the species had been under fished, a decrease in recruitment would occur, causing reduced CPE in the youngest harvestable size group (after a lag of at least one generation interval). If the species had been over-harvested, reduced effort would result in temporarily reduced catch followed by increased catch per effort and increased prominence

of the younger fish in the commercial catch LFD.

Environmental modification and pollution may result in a decreased carrying capacity and annual catch. Recruitment would probably be affected most which would result indecreased representation of small fish in the LFD. This would be followed (after a lag of one generation time) by a return to the original LFD shape but with an associated reduction in total catch.

The forgoing discussion describes LFDs where multiple age-classes are exploited. Some species, due to their uni-model LFDs, appear to be exploited in only a single age-class. Either the gears are very selective for a narrow size range (unlikely in the multigear Upper Meta River fishery) or smaller and larger individuals are not present in the area where the fishery occurs. Thus a change in fishing effort will not result in a shift in the LFD as occurs in a multiple age-class fishery. However, compensatory mechanisms are still in effect and catch will increase in response to increased fishing effort until the maximum sustainableyield stock size is achieved, after which an increase in effort will affect a decreased total catch.

Thus, interpretation of population changes which occur for species exploited in only a single age class is mainly dependent on recognizing valid changes in total catch which are related to changes in fishing effort. In addition, the single exploited age class may be entirely of mature fish, so no shift will occur toward immature fish in the catch as exploitation increases.

It should be remembered that the Upper Meta River is actually a tributary headwater of a very large river system; it's not unreasonable to think that a species such as the Baboso could spend most of its life in the lower Meta or Orinoco River and only come the the Upper Meta for a brief feeding period followed by spawning, after which they leave the area and possibly die before

the following year's spawning season. Godoy (1967) in a study involving tagged fish in the River Parana, found that many Characids and Pimelodids migrate upstream to breed and downstream to feed, covering distances of 1200-1400 km. in one year. Bayley (1973) found similar phenomena in the Pilcomayo River of the upper Parana, where the main feeding grounds for many large fish appeared to be in the swamps of the lower Charo and these fish migrated to the Andean reaches of the river to spawn.

As well as LFD's, other biological information can be used to assess the status of the fish stocks:

(1) Identification of mature fish

Fish were considered mature if visual observation of the gonads indicated that spawning would occur within 3 to 4 months, i.e., maturity stages 4, 5, 6 and 7 of Kesteven (Ricker 1968, page 162). These observations provided estimates of minimum spawning sizes, by sex; thus, fish were classified as immature or mature and differences in size ranges of mature fish by sex were documented.

(2) Spawning season

When most mature sized fish are found in spawning condition, a peak in spawning is assumed to be at that time or soon afterwards. Spawning often follows a period of migration and/or intensified feeding activity. These are times of increased vulnerability to fishing.

(3) Stomach contents

In a mixed-species fishery, as that of the Upper Meta River, the relative importance of a species in the catch depends largely on its competitiveness in the fish community. Knowledge of the food which a species prefers allows fisheries managers to classify species as prey or predator, carnivore or herbivore, etc. This assists decision-making about the relative amount of

exploitation which should be directed towards a species and about protection of food sources of commercial species.

(4) Length and weight relationships

For most species a linear relation exists between logarithms of weight and length (table 5). Thus, once a large number of individuals have been weighed and measured, a weight-length relationship can be calculated. This allows a reliable estimate of weight to be computed for a given fish when its length is known. Both weighing and measuring fish in the field are time consuming. Weighing requires more time than measuring and is done with expensive, delicate instruments, easily damaged and cumbersome to transport in the field. Thus utilization of the weight-length conversion can save time and money in field operations.

The most consistent length to record is standard length (SL) since it does not depend on undamaged caudal fin rays, nor on uniform compressing of lobes and selection of longer lobes, as pointed out by Balon (1974). Also, in South America, caudal rays are often damaged by Pirana.

Nevertheless, measurements of total length (TL) and fork length (FL) as well as standard length are common in fisheries literature. Thus, we measured the three types of length on a large sample of fish and present equations of the linear relationships of SL to TL and SL to FL (tables 6-7). These conversion equations will facilitate investigators in their use of literature involving the Orinocian commercial fish species.

Table 5. Equations predicting eviscerated weight (EWT) in kg from standard length (SL) in cm for various commercially exploited species (n = number of fish used to determine the equation).

SPECIES	EQUATION	r^2*	n
Amarillo	Log EWT = 3.088 Log SL - 4.87	0.96	113
Apuy	Log EWT = 2.644 Log SL - 4.64	0.72	56
Baboso	Log EWT = 3.038 Log SL - 5.00	0.82	188
Blanco Pobre	Log EWT = 3.015 Log SL - 4.80	0.91	129
Bocachico	Log EWT = 2.278 Log SL - 3.546	0.81	67
Barbiancho	Log EWT = 3.005 Log SL - 4.862	0.90	78
Burra	Log EWT = 2.941 Log SL - 4.561	0.84	122
Chachama	Log EWT = 2.521 Log SL - 3.681	0.78	227
Cajaro	Log EWT = 2.905 Log SL - 4.504	0.99	21
Curimata	Log EWT = 3.393 Log SL - 5.159	0.77	26
Chancleto	Log EWT = 3.289 Log SL - 5.246	0.84	28
Cherna	Log EWT = 1.698 Log SL - 2.111	0.69	57
Mapurito	Log EWT = 2.942 Log SL - 4.749	0.83	52
Dorado	Log EWT = 3.400 Log SL - 5.607	0.77	27
Payara	Log EWT = 2.527 Log SL - 3.958	0.70	39
Palometa	Log EWT = 3.207 Log SL - 4.733	0.61	42
Paleton	Log EWT = 3.298 Log SL - 5.546	0.91	39
Rayado	Log EWT = 2.882 Log SL - 4.711	0.95	403
Sardinata	Log EWT = 1.799 Log SL - 2.983	0.86	9
Sierra cagona	Log EWT = 2.917 Log SL - 4.481	0.88	34
Sierra copora	Log EWT = 2.137 Log SL - 3.302	0.65	30
Sapuara	Log EWT = 2.142 Log SL - 3.087	0.69	17
Valenton (<140cm)	Log EWT = 1.4215 Log SL-1.693	0.65	12
(>140cm)	Log EWT = 2.157 LogSL-5.174	0.91	13
Yamu	Log EWT = 3.718 Log SL - 5.816	0.95	17
Yaque	Log EWT = 3.085 Log SL - 4.935	0.85	60

* r is the coefficient of linear correlation between SL and EWT. The strength of the relationship is best indicated by r^2, the proportion of the variance of EWT "explained by linear regression on SL. (Remington and Schork, 1970) r^2 range from 0 to /1/.

Table 6. Equations predicting total length (TL) in cm from standard length (SL) in cm for various commercially exploited species (n = number of fish used to determine the equation).

SPECIES	EQUATION	r^2	n
Amarillo	TL = 1.104 SL + 5.680	.97	136
Apuy	TL = 1.116 SL + 4.725	.93	69
Baboso	TL = 1.175 SL + 3.516	.91	215
Blanco Pobre	TL = 1.100 SL + 7.569	.96	160
Bocochico	TL = 1.083 SL + 3.255	.92	118
Barbrancho	TL + 1.066 SL + 6.957	.95	87
Curvinata	TL = 1.137 SL + 2.259	.92	152
Cachama	TL = 1.080 SL + 8.098	.84	370
Cajaro	TL = 1.097 SL + 3.947	.99	27
Curimata	TL = 1.113 SL + 1.803	.85	26
Chancleto	TL = 1.017 SL + 5.521	.94	40
Cherna	TL = 1.006 SL + 14.907	.81	126
Comagente	TL = 1.059 SL + 6.101	.94	75
Dorado	TL = 1.179 SL + 4.225	.92	37
Payara	TL = 0.90 SL + 12.612	.94	24
Palometa	TL = 1.054 SL + 5.012	.82	50
Paleton	TL = 1.107 SL + 7.965	.98	52
Rayado	TL = 1.137 SL + 1.868	.99	486
Sardinata	TL = 1.152 SL + 3.444	.99	11
Sierra Cigena	TL = 1.131 SL + 5.070	.92	63
Sierra Copora	TL = 1.000 SL + 8.552	.90	78
Sapura	TL = 1.197 SL + 1.282	.99	40
Valenton	TL = 0.984 SL + 27.915	.94	28
Yama	TL = 1.159 SL + 0.573	.93	18
Yaque	TL = 1.174 SL + 0.782	.95	66

Table 7. Equations predicting fork length (FL) in cm from standard length (SL) in cm for various commercially exploited species (n = number of fish used to determine the equation).

SPECIES	EQUATION	r^2	n
Amarillo	FL = 1.076 SL + 2.305	.99	132
Apuy	FL = 1.043 SL + 1.821	.95	69
Baboso	FL = 1.042 SL + 2.22	.95	218
Blanco Pobre	FL = 1.040 SL + 1.986	.99	160
Bocachico	FL = 1.012 SL + 2.401	.99	114
Barbiancho	FL = 0.997 SL + 5.398	.96	88
Curvinata	There is no fork		
Cachama	FL = 1.005 SL + 6.612	.89	363
Cajaro	FL = 1.075 SL + 3.083	.99	18
Curimata	FL = 1.120 SL + 0.534	.86	26
Chancleto	FL = 1.105 SL + 0.648	.94	33
Cherna	FL = 1.000 SL + 7.990	.93	124
Mapurito	FL = 1.044 SL + 2.375	.97	75
Dorado	FL = 1.098 SL - 0.592	.92	37
Payara	FL = 1.050 SL + 4.558	.95	46
Palometa	FL = 1.274 SL - 1.843	.24	50
Pateton	FL = 1.033 SL + 4.080	.99	52
Rayado	FL = 1.0[illegible]3 SL + 0.526	.99	480
Sardinata	FL = 1.067 SL + 0.775	.99	11
Sierra Cabona	FL = 1.038 SL + 2.648	.92	63
Sierra Copora	FL = 0.981 SL + 5.858	.93	78
Sapuara	FL = 1.081 SL + 0.831	.99	39
Valenton	FL = 1.064 SL + 0.701	.94	28
Yamu	FL = 1.104 SL + 0.529	.95	21
Yaque	FL = 1.057 SL + 2.094	.97	67

The following section provides specific information concerning the six most important species in the commercial fishery. LFDs, biology, comments related to the fishery, and management recommendations are given.

The Yellow Catfish - El Bagre Amarillo

Common name: Sagre Amarillo

English name: Yellow catfish

Scientific name: ___?_____, (fam. Pimelodidae)

Amarillo were captured from 40 cm (1.2 kg) to 150 cm (71 kg) and averaged 98 cm (24.7 kg) standard length.

Conversion equations for length and weight relationships are:

1. Log EVWT = 3.088 Log SL - 4.87 (r^2 = .96, n = 113)
2. FL = 1.1076 SL + 2.305 (r^2 = .99, n = 132)
3. TL = 1.104 SL + 5.680 (r^2 = .97, n = 136)

where EVWT = eviscerated weight in kgs: and SL, FL and TL = standard, fork and total lengths in cm respectively.

Length frequency distribution analyses (LFD)

Annual LFD has two prominent modes at 65 cm (A) and 120 cm (B). The majority (62%) are >90 cm. A t-test with unequal variances shows the high water (117 cm) and low water (89 cm) means to be different ($P < .01$). Smaller fish are not evident in the high water catch LFD. In contrast, a majority (58%) of the low water catch is of smaller size fish.

Although we have little data on length frequency differences by sex, figure 9 d and e indicate that a majority of the smaller fish are males, and females probably grow larger than males (these features are typical among Meta River Pimelodid catfishes). We encountered only three ripe fish, two females (118 and 122 cms) with eggs and one male flowing milt (128 cm). It is possible that the Amarillo does not mature until it is attains length greater than 95 cms SL. More fish should be examined to clarify this. The two ripe females were captured in January and March.

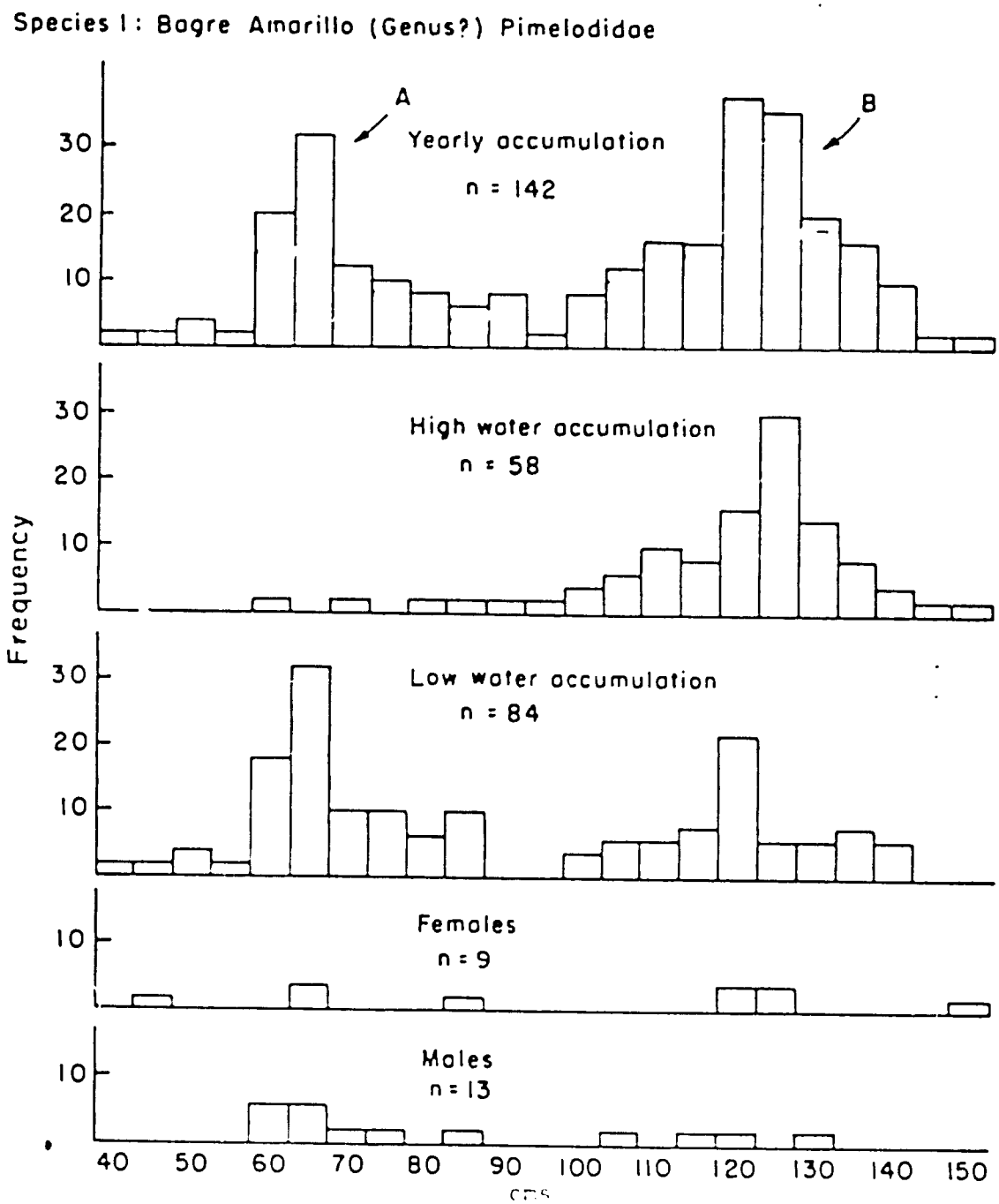


Figure 9. Annual, seasonal, and sex characteristics of length frequency distributions for Bagre Amarillo.

Spawning season may be during these low water months, or come during the onset of rising water in April.

We believe that the Amarillo is piscivorous. The only full Amarillo stomach we encountered contained fish. Fishermen generally use fish as Amarillo bait although large earthworms are also used. Amarillos are generally captured around sunken trees in deep pools, or in deep water near steep mud banks. They are more likely to be captured in areas of slight current. It is believed that Amarillos often feed on subterranian organisms that fall into the river as the riverbanks cave in, a common occurrence during rising and falling water seasons.

Amarillos are caught with many gears. Small individuals are caught on hooks and in nets set mainly for Rayado and Cachama. Large Amarillos are the target species for fishermen using large hooks tied on strong set lines. Many Amarillos also are harpooned while swimming in shallow floodplain waters. During low water, they are also caught with castnets and hand gaffs; the latter method requires that fishermen dive around sunken trees and jab a large hook into the fish. The hook is attached to a rope by which the Amarillo is retrieved. The Amarillo is the target species for hand gaffing.

Comments

The Amarillo stocks in the Upper Meta River are important culturally as well as economically. This species is a prominent feature in any description of the Meta River fishery. The success of fishery management in this river will, in part, be measured by the success of the Amarillo fishery, and the stock itself, as the Llains are developed and the fishery expands.

We have no direct evidence of overfishing on this species but several features lead us to believe that Amarillo might be one of the first to be

adversely affected by increased fishing effort.

1. Amarillo grow very large and large fish usually have small yield potentials due to slow growth to maturity and small numerical abundance.

2. Fishing for this species began in earnest only recently i.e., within the last ten years according to Marco T. Romero, fish buyer in Puerto Lopez. Thus the large catches during 1977-78 may be from a build up of old fish and may actually be excessive in relation to the stocks ability to compensate by increased recruitment and growth.

3. The Amarillo is captured in most of the gear types used on the Meta system and two gears have been developed specifically for Amarillo, i.e. the large hook set line and diving with hand gaffs. The latter method allows the fisherman to enter the aquatic environment when fish are concentrated in a few deep water pools and actively pursue the fish. When the dry season is long, the rivers become very low and many large Amarillos are removed from the Upper Meta River and its tributaries.

4. This species is the most desirable to sport fishermen who come in increasing numbers from all parts of Columbia during the low water months. It's interesting to speculate on their contribution to the Amarillo catch. Consider that about 75% of the total Upper Meta River catch is sold and almost all Amarillos, due to their large size, are among the marketed portion. Twenty percent of the commercial catch is Amarillo i.e., about 6,428 fish in 1978. From observation and discussion with sport fishing club members, it is plausable that 100 to 300 Amarillos i.e., 1.5% to 4.5% of their present annual catch, come from sport fishing. As the road systems to the Plains improve, the impact of sport fishermen will undoubtedly increase dramatically. Sport fishermen are an important factor in the Amarillo catch and they have a vested and increasingly

vocal interest in management of the Upper Meta River fishery.

Management recommendations

In consideration of the above discussion and of the catch data presented in figure 9 we feel that a precautionary minimum size of capture regulation of 95 cm SL would possibly benefit the Amarillo stocks and cause very little inconvenience to fishermen.

Larger fish, those >95 cm are thought to be of reproductive age and account for 54% of the Amarillos caught numerically; due to their relative large size this group amounts to 90% of the catch by weight. Reduced fishing mortality on the smaller fish may result in increased abundance of larger fish thus increasing reproductive potential. The regulation would not affect effort directed at the larger fish now harvested.

The Amazon Catfish - El Bagre Valenton

Common name: Valenton (Plumito - males only)

English name: Amazon catfish

Scientific name: Brachyplatystoma vaillantii (fam. Pimelodidae)

Conversion equations for length and weight relationships are:

$$\text{Log EVWT} = 1.422 \text{ Log SL} - 1.693 \quad (r^2 = .65,\ n = 12)$$

for fish smaller than 140 cms SL.

$$\text{Log EVWT} = 3.157 \text{ Log SL} - 5.174 \quad (r^2 = .91,\ n = 13)$$

for fish equal to and larger than 140 cms SL.

$$\text{FL} = 1.064 \text{ SL} + 0.701 \quad (r^2 = .99,\ n = 28)$$

$$\text{TL} = 1.099 \text{ SL} + 9.920 \quad (r^2 = .99,\ n = 28)$$

where EVWT = eviscerated weight in kg and SL, FL and TL equal standard, fork and total lengths in cms, respectively.

Length frequency distribution analysis

There appears to be no difference in the distribution by size between high and low water periods ($\alpha = .05$). Females grow much larger than males.

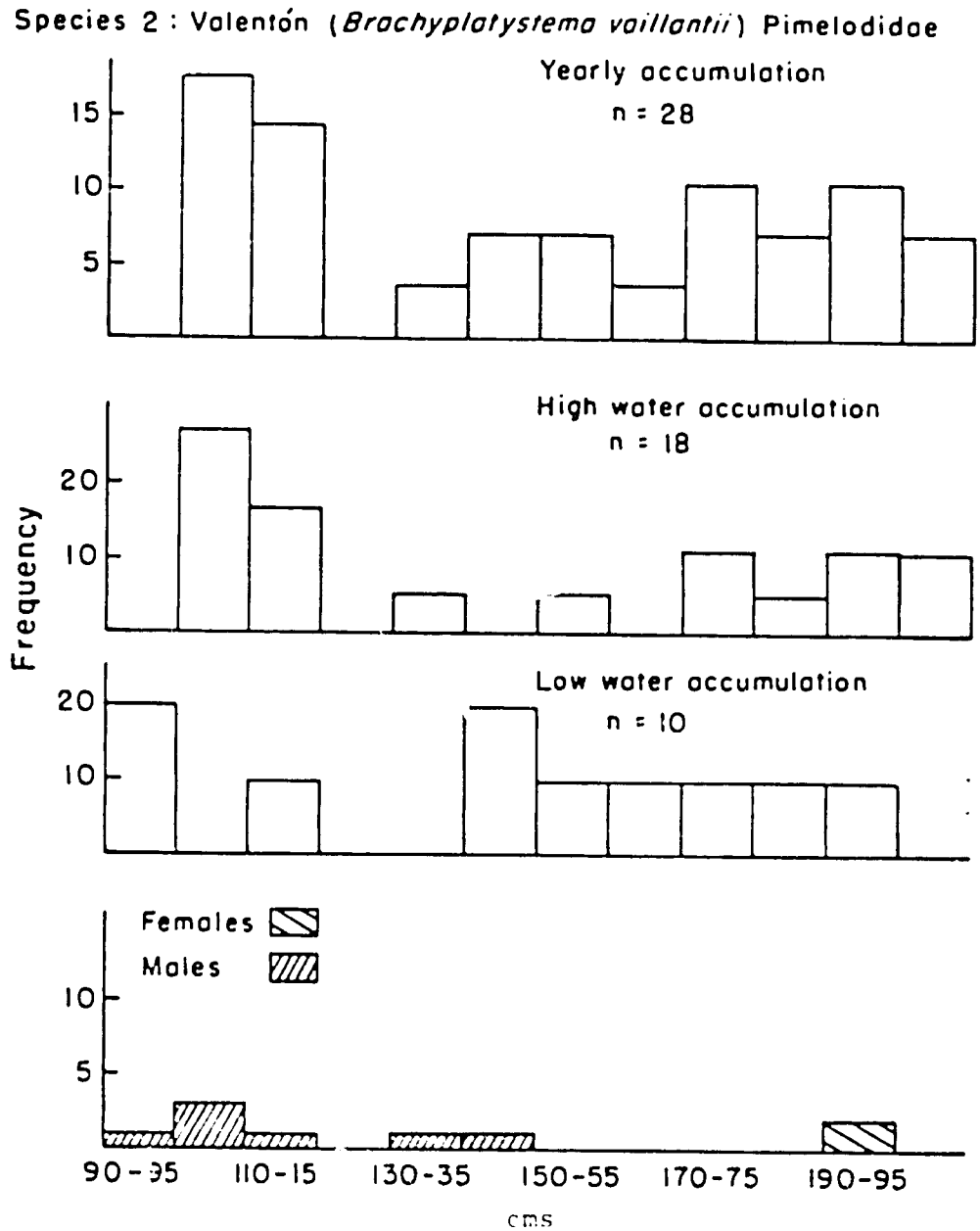


Figure 10. Annual, seasonal, and sex characteristics of length frequency distributions for Valenton.

Generally, any Valenton larger than 145 cm SL is a female and they can grow to over 200 cm SL. This difference is so obvious to fishermen that the male and female have different names, i.e., Valenton refers only to the female, while males are called "Plumito".

Four mature males were observed in April and May, ranging from 101 to 126 cm SL. Only one mature female was examined, a 190-kg fish captured in June 1977. The ovaries were developed but flacid indicating that some spawning had already taken place. We assume that spawning begins at the onset of rising water in April and May.

Stomach contents

No full stomachs were observed. However, the only successful method of catching large Valenton is with hooks baited with 0.5 - to 1-kg fish, preferably alive. We assume the Valenton is generally piscivorous.

Comments

Although this giant river catfish, rumored to reach a maximum weight of 200-250 kg, is a valuable fish, its appearance in the commercial catch was not common in 1977-78. Total annual harvest of Valenton was probably less than 400 individuals from the Upper Meta system and about 45% of these were small, i.e., less than 140 cm SL.

Small Valenton (generally males) are caught incidental to the fisheries for Bayago, Cachama and Baboso. Large females are rarely captured in any gear except the "Valentenero". This gear is a single "shark hook", number 6/0 on a strong rope. The rope is anchored to a heavy weight at midriver in strong current and at some point along the line a large calabash float is attached which

provides some movement to the bait. The calabash also allows the fishermen to find the gear which may be moved a considerable distance if a Valenton takes the hook. The habitat of the large Valenton, unlike that of large Amarillos, is deep swift water at the center of the channel. Thus, due to the additional cost of a Valentenero, the Valenton's central current habitat where few other commercial species are fished, and the small probability of catching a Valenton (low CPE), very little effort is directed toward this species.

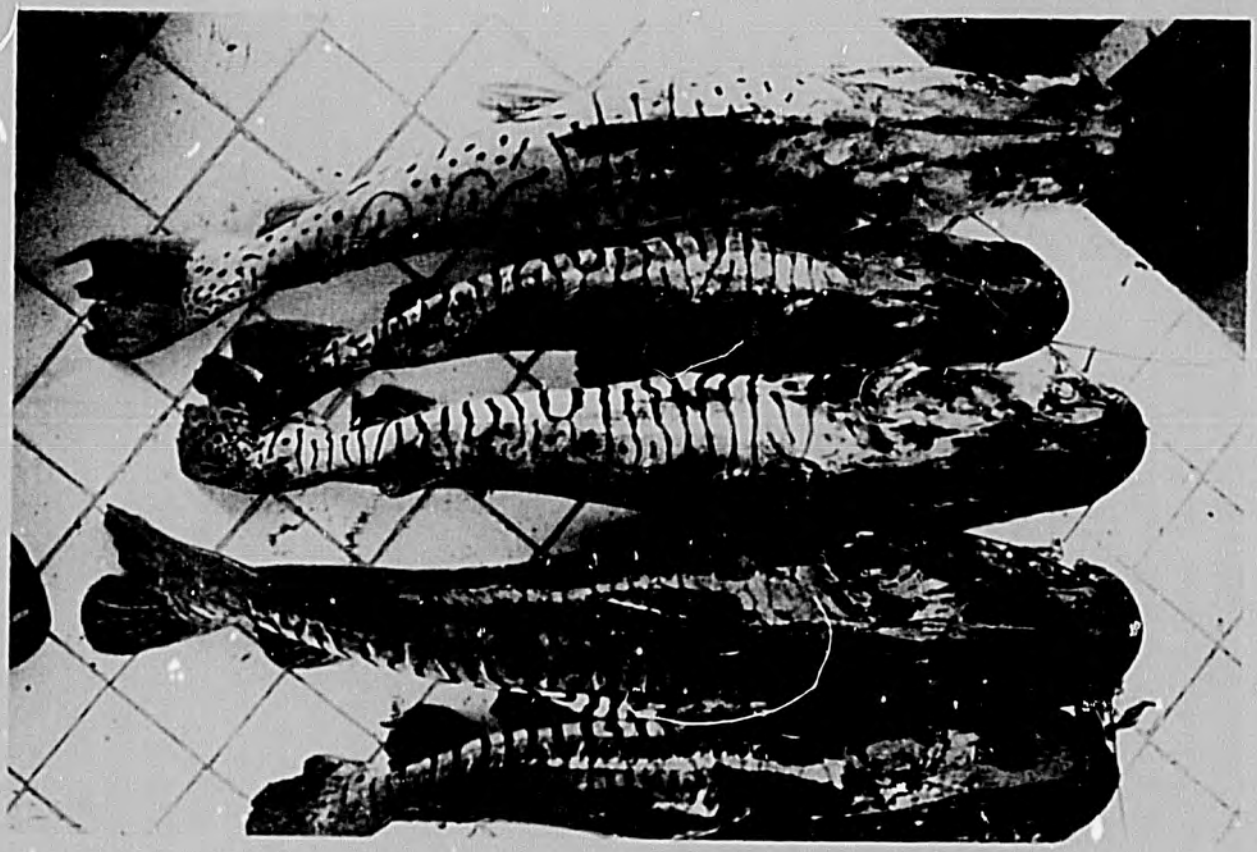
Management recommendations

There are no reliable catch records from earlier years of the Meta River fishery. Fishermen claim that Valenton used to be more abundant in the catch and that larger specimens used to be common. The Valenton may require several years to reach sexual maturity. Those species with the greatest generation time will be at a competitive disadvantage under exploitation.

However, due to the small amount of interest shown by fishermen in exploiting the Valenton, its stocks are probably in equilibrium with fishing effort and no drastic reduction in abundance will occur in the near future. Also, it is generally beneficial to the fishery as a whole if standing crop of large piscivorous species are not too high since these large fish are generally inefficient converters of energy. Large standing crop could cause reduced abundance and catch of other species. Therefore, no regulation is recommended at this time. LFD and total catch should be evaluated on a yearly or biyearly basis to check for changes in the population size structure.

When recommendations are required, a "slot limit" would be most practical, prohibiting the capture of fish between 130 and 180 cms. This would allow continued exploitation on most males and a protected size group of mature females which would ensure adequate reproduction.

Tiger Shovel-nose Catfish - El Bagre Rayado



Rayados landed at Puerto Lopez showing variability in striations.
Los Bagre Rayados traidos ol Puerto Lopez presentan variabilidad en sus estrigaciones

Common name: Bagre Rayado

English name: Tiger shovel nose

Scientific name: Pseudoplatystomas fasciatum (fam. Pimelodidae)

The Rayado ranges from 43 cm (1.0 kg) to 112 cm (15.7 kg) and averages 69 cm (4.7 kg) standard lengths.

Conversion equations for length and weight relationships are:

1. Log EVWT = 2.882 Log SL - 4.711 (r^2 = .95, n - 403)
2. FL = 1.063 SL + 0.526 (r^2 = .99, n = 486)
3. TL = 1.137 SL + 1.868 (r^2 = .99, n = 486)

where EVWT = eviscerated weight in kgs, SL, FL and TL = standard, fork and total lengths in cms.

Length frequency distribution analyses

Both the high and low water LFD's are similar to that for the entire year indicating that the entire exploitable size range is present and vulnerable in the Upper Meta River throughout the year. Also, a "t" test indicated no difference in the high and low water LFDs (α = .05).

Rayados recruit to the fishery in appreciable numbers at 50 cm SL. There is an obvious difference in size ranges between sexes. Males are rarely encountered larger than 80 cm SL while females commonly exceed 100 cm SL.

Eight Rayados in near-spawning condition were examined, four females (one 65 cm* and three 100 cm size group fish) and four males (55, 60, 70 and 80 cm size groups). This small sample at least indicates that the majority of the Rayado catch is of mature fish. One male was from June, the other seven ripe fish were caught in April. Spawning probably begins in April with the rising

*More mature females should be examined before determining minimum spawning size.

Species 3: Bagre Rayado (*Pseudoplatystoma fasciatum*), Pimelodidae

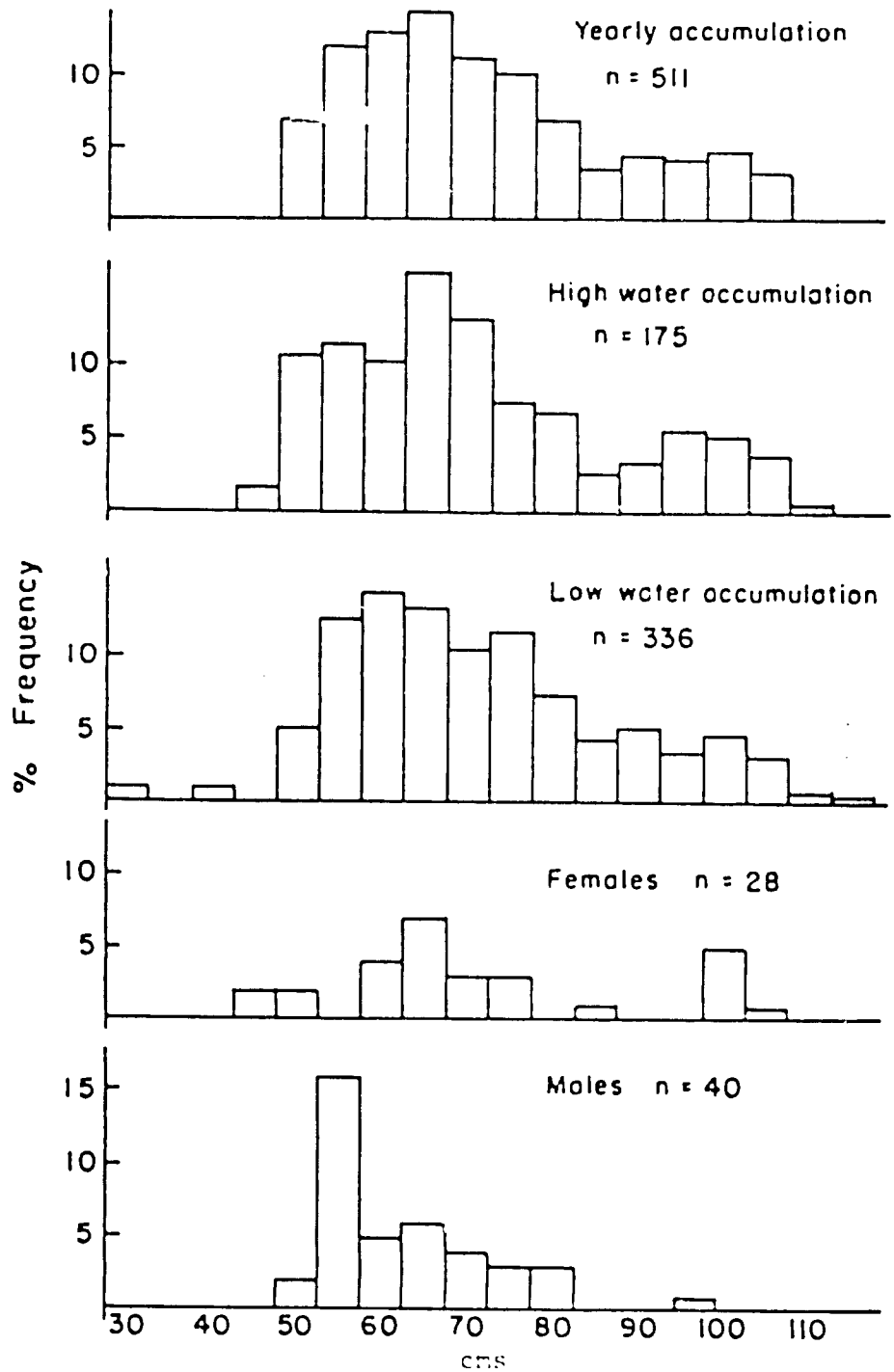


Figure 11. Annual, seasonal, and sex characteristics of length frequency distributions for Bagre Rayado.

flood waters.

Stomach contents

Five Rayados were found with full stomachs, all containing fish, specifically young Bocachico. However, these samples were from November and December, the months when large quantities of young Bocachico are forced to the rivers as flood plain water diminishes thus they are easy prey. It's generally believed that Rayado is piscivorous, however they are caught as easily on hooks baited with earthworms as with fish.

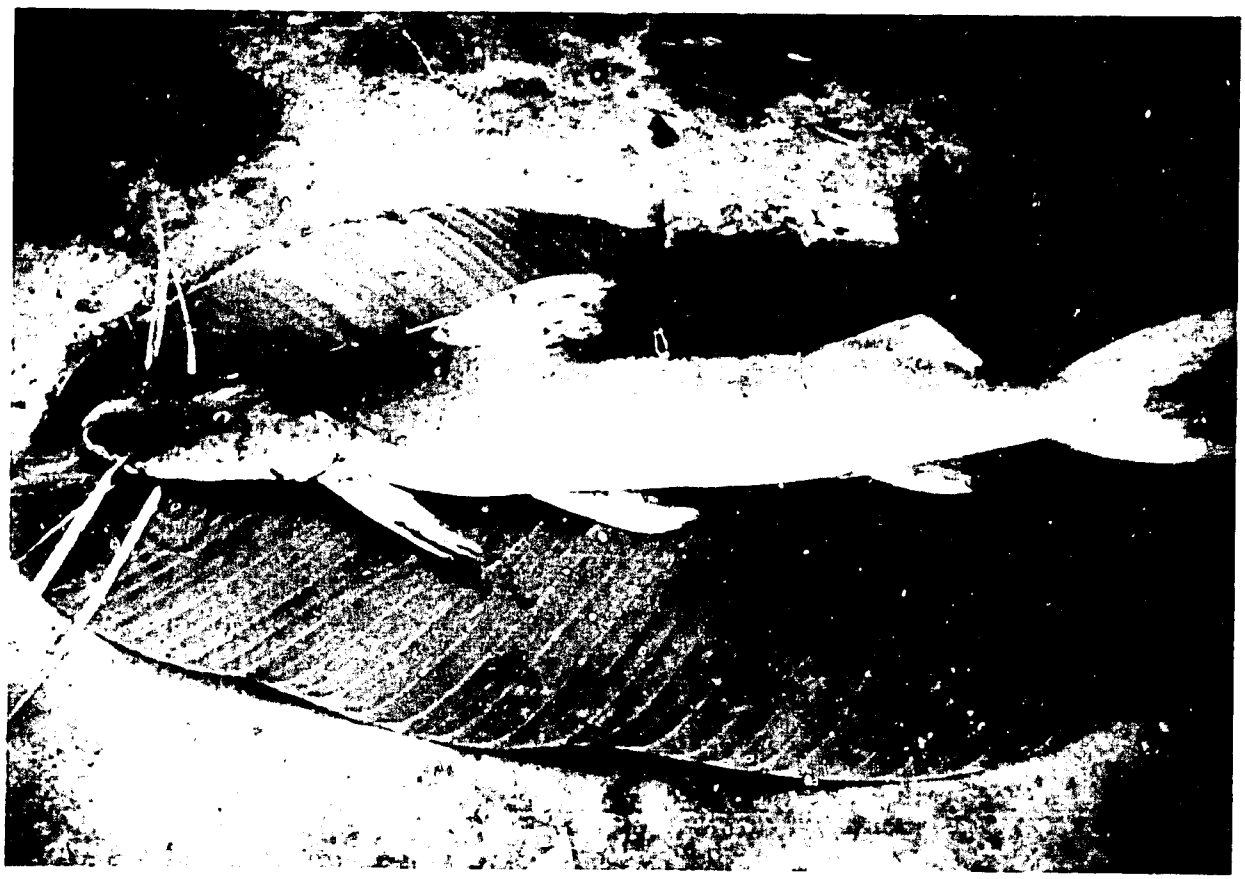
Comments

The Rayado is captured in all gears except those using very large h[illegible]s. Good catches of Rayado come from longlines set in streams connecting rivers to lagoons and with castnets over sand bars during the low water season. Hooks and gillnets fished near sunken trees are also effective for catching Rayado.

Management recommendations

The majority of the catch is of mature fish and most of those that are not are probably males. Even though fish are fully recruited to the catch at 50 cms, 18% of the catch is of fish larger than 90 cms, most of which are mature females. Thus, there appears to be adaquate survival for spawning.

Fishermen have expressed a desire for official minimum size regulations for commerical species, especially for those of importace. Thus we recommend a minimum legal size for capture of 50 cm SL (about 60 cm total length). Presently this would cause no hardship as it would only exclude 2.5% of the numerical catch and virtually none of the catch by weight.



The White Catfish - El Bagre Baboso o Blanco

Common name: Bagre "Baboso" or Bagre "Blanco"

English name: White catfish

Scientific name: ?? _____ (fam. Pimelodidae)

*The Baboso is similar in appearance to species of the genus Brachyplatystoma, but the Baboso's wide flat barbles do not conform to the definition of this genus.

Baboso are caught in a narrow size range between 55 cm (1.9 kg) and 86 cm (7.5 kg) and average 74 cm (4.2 kg).

Conversion equations for length and weight relationships are:

1. Log EVWT = 3.038 Log SL - 5.00 (r^2 = .82, n = 188)
2. FL = 1.042 SL + 2.22 (r^2 = .95, n = 218)
3. TL = 1.175 SL + 3.516 (r^2 = .91, n = 215)

where EVWT = eviscerated weight in kg , and SL, FL and TL equal standard, fork and total lengths in cm respectively.

Length frequency distribution (LFD) analyses

High water and low water LFDs approach that of the yearly accumulation. However, relatively more large fish (70 cms) were caught during high water (.01). Sample size was relatively small in the high water season as Baboso

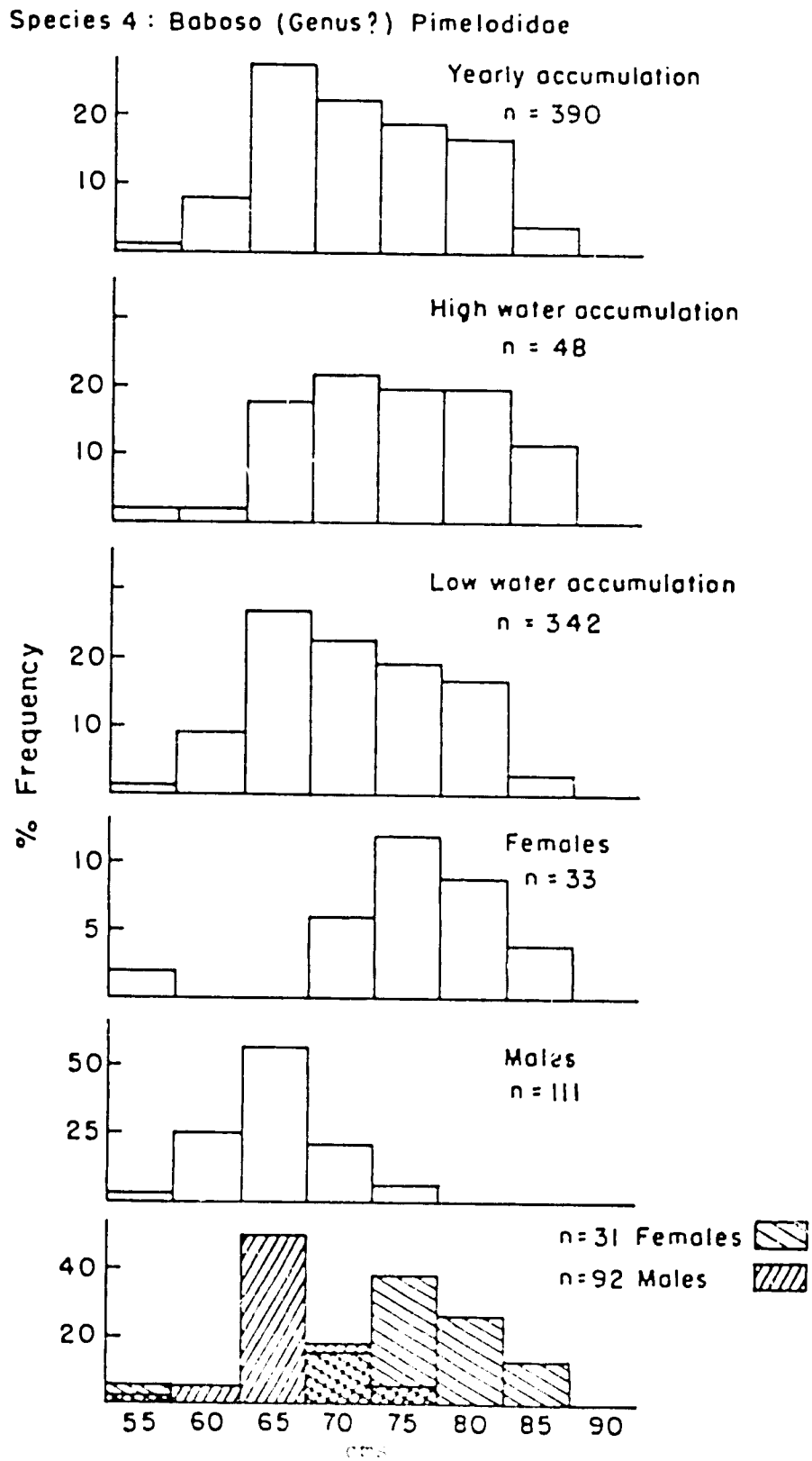


Figure 12. Annual, seasonal, and sex characteristics of length frequency distributions for Baboso.

are scarce at this time. About 90% of the catch appears to occur during the low water season and the majority of this, during the month of December.

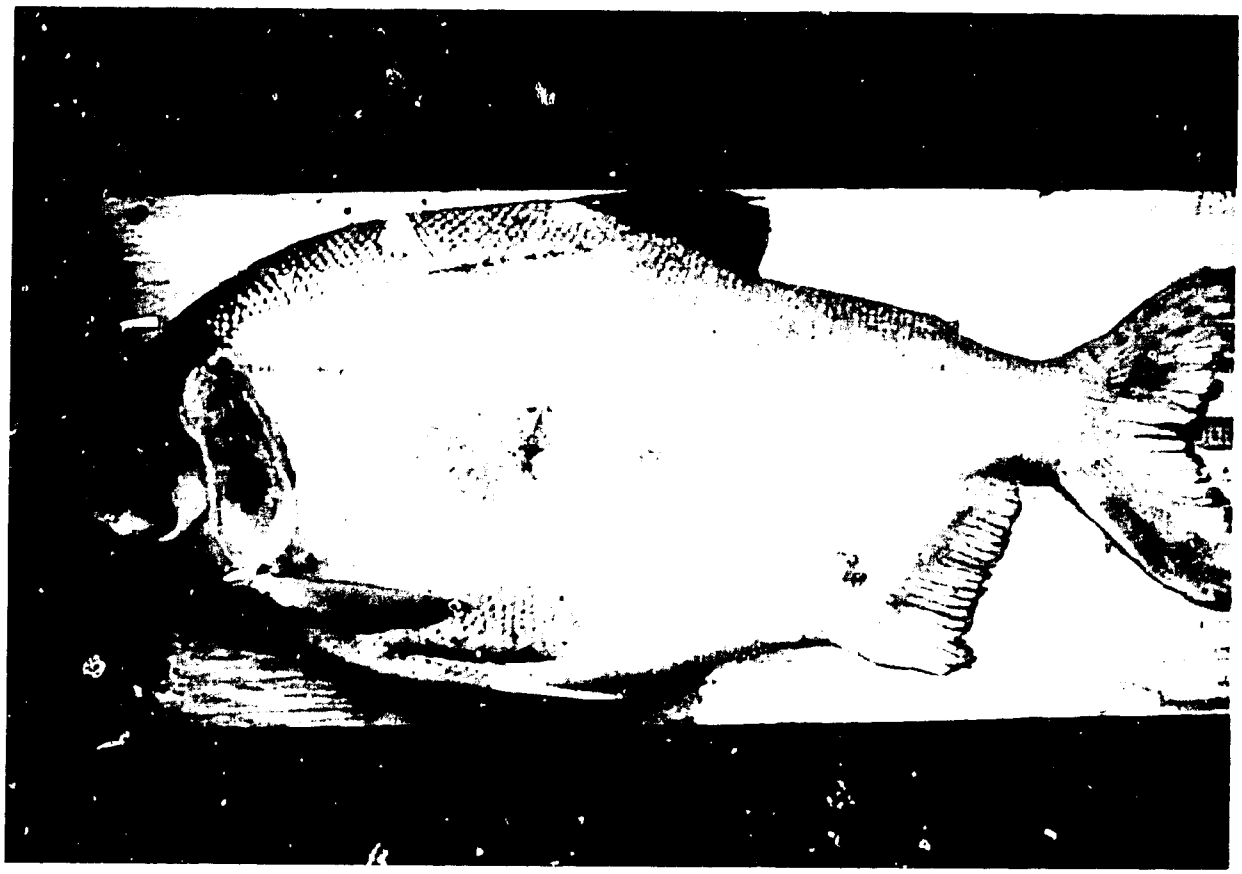
Although the seasonal and annual LFDs appear unimodal, figure 12 d and e reveal that the catch contains large females (66-85 cm) and smaller males (55-75 cm). Figure 12 f further demonstrates that these fish are all of mature sizes and the independent LFDs for mature fish of each sex appear to form single modal distributions indicative of single age classes.

Thus, we hypothesize that the Baboso fishery is entirely for one age class of mature fish. The Baboso is not exploited as juveniles and may not be present in the Upper Meta system for this part of their life cycle.

Only one Baboso was found with a full stomach and it contained fish. We assume Baboso are generally piscivorous and that the reason for their great abundance in the Upper Meta in December is to feed on young Bocachico being flushed into the rivers as water level recedes. However, more stomach samples are needed to verify this.

Management recommendations

Due to the short season of exploitation and short period during the life cycle that fishing mortality affects this species, it is thought unlikely that they could be easily over-exploited. No restrictive measure is necessary, however, a legal minimum size limit of 50 cm could be initiated to satisfy fishermen's request for a definition of legally exploitable fish.



Pacu - La Cachama o Morocoto

Common name: Cachama, Cachama blanca, Morocoto

English name: "Pacu"

Scientific name: Colossoma bidens (fam. Characidae)

The Cachama ranges from 44 cm (2.9 kg) to 66 cm (8.1 kg) and average 54 cm (4.9 kg) standard length.

Conversion equations for length and weight relationships are:

1. Log EWWT = 2.521 Log SL - 3.681 (r^2 = .78, n = 227)
2. FL = 1.005 SL + 6.612 (r^2 = .89, n = 363)
3. TL = 1.080 SL + 8.098 (r^2 = .84, n = 370)

Length fre uency distribution analyses

High and low water LFDs approximate the yearly distribution but are different (= .01) with fish being generally smaller during low water. The size range is narrow and only one mode is obvious, that being at 55 cm and probably only one age class is being exploited. However it appears that proportionately more males grow to 60 - 65 cm than females. LFDs of mature fish by sex show that the exploited population is entirely mature.

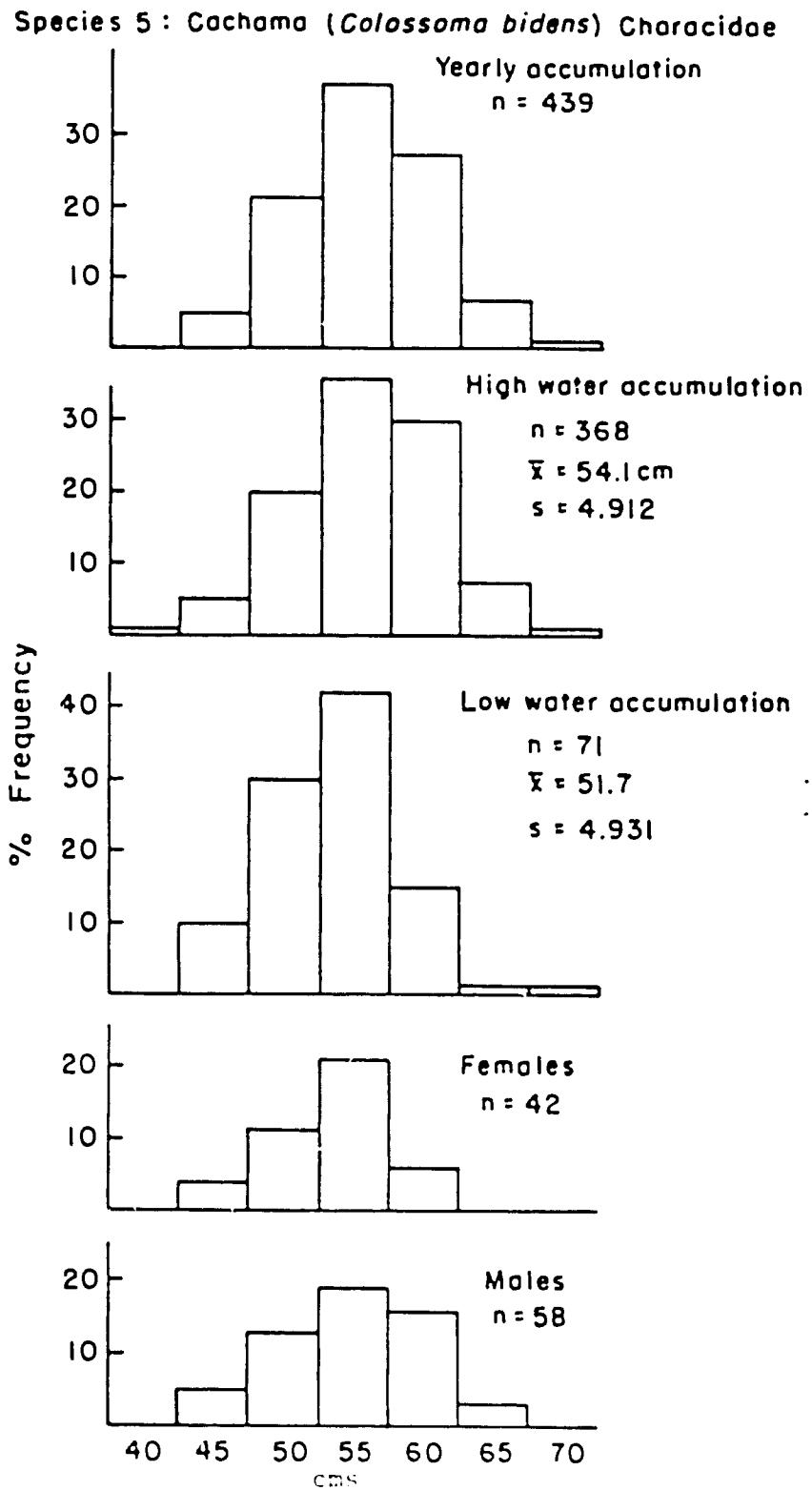


Figure 13a. Annual, seasonal, and sex characteristics of length frequency distributions for Cachama.

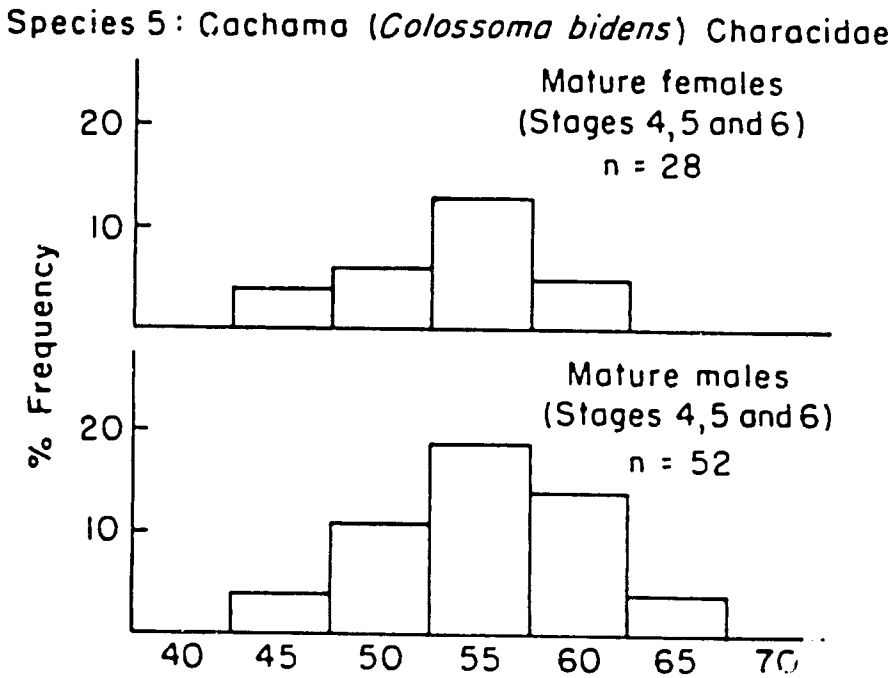


Figure 13b. Length frequency distributions of sexually mature Cachama.

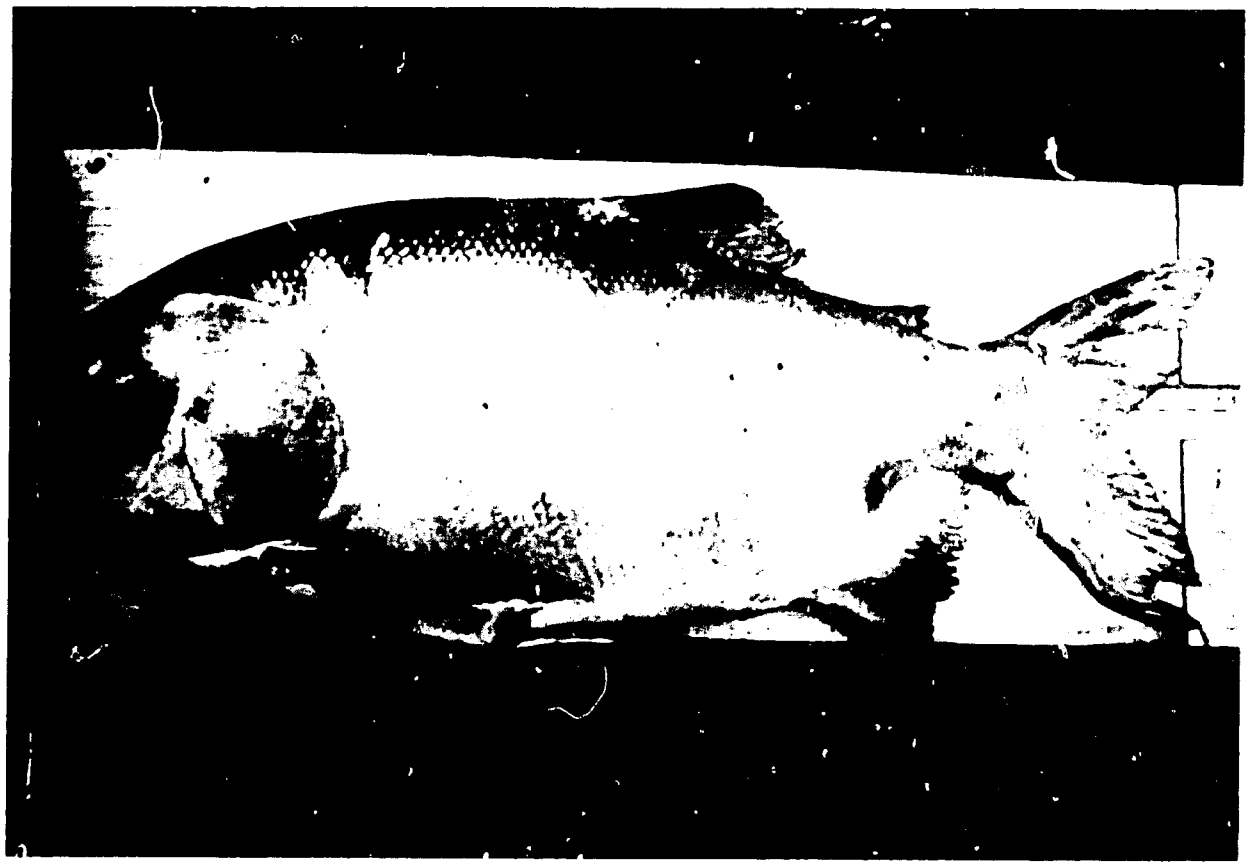
We examined 19 full Cachama stomachs and found leaves in 18 i.e., in 94%. Material considered fruit or fruit seeds including palm nuts were in 4 stomachs (21%). Successful bait for Cachama include Grava or similar wild fruits from flood plain trees, earthworms and fish. This diet indicates that the Cachama is omniverous.

Comments

In the Upper Meta River, the majority of Cachama are caught in April and May as water is rising. Fish at this time are ripe and large catches are made with drift gillnets indicating an upward migration. The migration also brings fish to the Upper Meta in preparation to move onto the flood plain as it is inundated. A rich food source of fruits, leaves and palm nuts is available on th flood plain.

Cachama eggs are semi-bouyant and no doubt require some degree of turbulence to keep them from sinking. Thus its likely that eggs are released into the river current in upper areas of the system. Eggs then float down stream possibly leaving the Upper Meta River area before alevins develop and move to nursery areas. We made several unsuccessful attempts to procure Cachama fingerlings from ornamental fishermen in Puerto Gaitan. Apparently fingerlings are in this area but at very low abundance. Biologists in Venezuela have found Cachama fingerlings in the lower Orinoco and its possible that the young stages of the Cachama life cycle are passed in areas other than the Upper Meta.

During low water, Cachama are caught in castnets, gillnets and on hooks as they concentrate in deep water pools. During high water, hooks and gillnets are still used. Hooks are often fished near the surface for Cachama during this season.



Pacu - La Cherna o Cachama Negra.

Common name: Cherna, Cachama Negra

English name: "Pacu"

Scientific anme: Colossoma macropomus (fam. Characidae)

Cherna ranged from 48 cm (60 kg) to 80 cm (13.0 kg) and averaged 63 cm (9.3 kg) standard length in the commercial catch. A specimen of 19 kg, caught by sport fishermen was seen by the authors.

Conversion equations for length and weight relationships are:

1. Log EWT = 1.698 Log SL - 2.111 (r^2 = .69, n= 57)
2. FL = 1.000 SL + 7.99 (r^2 = .93, n = 124)
3. TL = 1.006 SL + 14,907 (r^2 = .81- n = 126)

Length frequency distributions (LFD)

The annual LFD is unimodal. Ninety-seven percent of the 127 Chernas measured were caught during the high water season.

Thus, high and low water comparisons are not available.

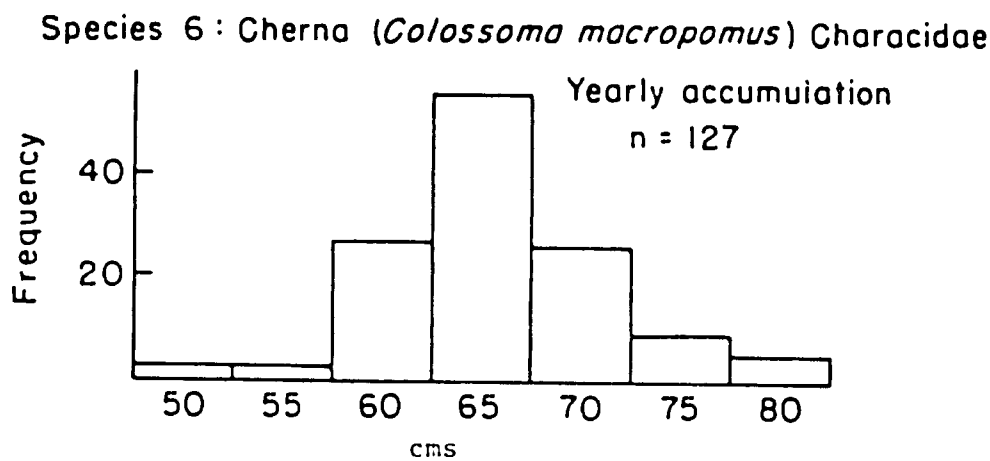


Figure 14. Length frequency distribution of Cherna in the commercial catch. Most of the sample is from April.

Eight mature Cherna (six males and two females) were observed. Seven were caught in April-May but one was from December. We believe that Chernas, although ripe during the low water season, do not spawn until the onset of rising water in April-May. These data do not indicate size differences by sex but since the sample is small we are uncertain of this.

Only one full stomach was observed and it contained seeds of a hard fruit. Sport fishermen catch Cherna on earthworms, chicken hearts and fish and commercial fishermen often use Plantain or Guav' 'ruits as bait. Cherna is reported to successfully feed on zooplankton when available.

Cherna is much less abundant in the catch than the Cachama. Cherna may be too large to be selected by the typical 20 cm stretched mesh gillnet or too strong to be contained by the net. It is common that gillnets are badly damaged by large fish which usually escape afterwards.

No restrictive measures are recommended for Cherna. Minimum legal size of capture should be 50 cm SL i.e., 65 cm TL.

3.2.3 Lesser exploited commercial species

Nineteen species make up about 20 percent of the commerical catch. Species from this group are either scarce, small, not marketed, not wanted or a combination of these factors. Thus, individually these species contribute very little to the total catch.

Summary statistics for these species as well as the six major species are presented in table 8. These include average size, mean size, size range by sex in the commercial catch, length and weight conversions and length frequency statistics (mean, standard deviation and sample size) from yearly and seasonal accumulations. Mean lengths by seasons are in appendix V. Photographs of most species are in appendix VII.

Specific data are not available for the lesser exploited species. However, some useful observations are presented below.

Blanco Pobre and Mapurito are the most common of the lesser exploited species. They are caught using a variety of baits and gears especially in the widely used subsistence gear, the cachamero hook and line. During low water the Bocachico, Curvinata and Curimata are frequently caught, mostly in castnets and beach seines. Dorado and Valenton "Plumito" males are never common, but their greatest catch comes as the high water season begins and they are most easily caught in drift gillnets.

Considering feeding habits, the Pimelodid catfish are generally carnivorous (table 9), mostly eating fish. Yaque and Mapurito stomachs contained crabs, the latter species also ate insects and seeds.

Table 8: Descriptive statistics for 25 species in the commercial catch

	standard length (cms)			Eviscerated weight (kgs)		(females) - standard length - (males)					
	n	mean	range	mean	n	mean	range	n	mean	range	n
Amarillo	(141)	100.2	43-147	24.7	(114)	98	43-147	(9)	81	56-128	(13)
Apuy	(69)	59.7	41-70	3.2	(56)	62	55-68	(7)	58	50-66	(12)
Baboso	(386)	69.2	55-86	4.2	(192)	74	66-85	(31)	63	55-75	(110)
Blanco Pebre	(165)	48.7	33-81	2.0	(129)	48	35-62	(22)	41	38-47	(10)
Bocachico	(118)	24.5	-40	0.65	(67)	* Insufficient data					
Barbiancho	(92)	50.5	35.0-75.0	2.1	(80)	58	51-65	(6)	42	35-62	(13)
Curvinata	(152)	41.3	16-58	1.9	(122)	35	22-47	(15)	31	22-46	(15)
Cachama	(437)	53.7	40-66	4.9	(227)	52	43-60	(42)	53	42-65	(56)
Cajaro	(28)	75.7	42-106	8.6	(23)	*					
Curimata	(26)	20.5	18-23	0.2	(26)	*					
Chancleto	(45)	37.0	23-46	1.0	(40)	38	30-45	(4)	34	23-44	(13)
Cherna	(127)	64.3	48-80	9.3	(63)	65	58-77	(6)	62	58-69	(7)
Mapurito	(76)	38.9	23-51	1.1	(52)	35	23-47	(7)	35	26-43	(4)
Dorado	(37)	81.4	4[illegible]-101	8.4	(27)	*92	84-100	(2)	79	79	(1)
Payara	(53)	60.4	43-92	3.9	(39)	60	50-75	(7)	57	43-75	(3)
Palometa	(55)	26.9	13-32	0.76	(42)	28	27-31	(6)	26	23-30	(5)
Paleton	(52)	96.2	62-141	6.3	(40)	112	90-134	(4)	81	67-105	(6)
Rayado	(507)	69.3	31-112	4.7	(404)	70	43-105	(28)	61	47-95	(40)
Sardinata	(11)	49.2	34-60	1.4	(10)	47	38-60	(5)	34	no data	(1)
Sierra Cagena	(63)	61.0	40-74	5.2	(34)	64	62-69	(6)	61	57-69	(5)
Sierra Copera	(73)	54.9	40-78	3.1	(30)	60	50-78	(8)	56	54-58	(4)
Sapuara	(40)	33.0	-51	3.2	(35)	*					
Valenton	(28)	138.6	87-205	50.8	(26)	187	186-188	(2)	112	95-145	(7)
Yamu	(21)	39.9	28-51	1.5	(18)	39	34-49	(4)	37	28-45	(2)
Yaque	(68)	51.8	34-65	2.4	(60)	52	37-62	(6)	47	44-52	(3)

Table 9: Food from stomachs of the 19 lesser important species of the Upper Meta River commercial fishery.

Full Stomachs In Sample		Fish	Crus-taceans	Detritus	Insects	Seeds	Leaves	Grass	Fruit-Nuts	Un-Known
0	Apuy									?
3	Blanco Pobre	X								
2	Bocachico			X						
0	Barbiancho									?
5	Curvinata	X	X			X				
0	Cajero									?
0	Curbata									?
2	Chaucleto	X								
3	Comagenti		X	X	X	X				
0	Dorado									?
2	Payara	X								
4	Palometa					X	X	X	X	
1	Paleton	X								
1	Sardinata	X								
6	Sierra Cagona						X	X	X	
3	Sierra Copora									
5	Sapuara			X			X			
0	Yamu									?
5	Yaque		X			X				

3.3 Fishing gears. (Topic 3)

3.3.1 Gears presently used for the capture of food-fish.

Meta River fishermen use several types of gear. This probably stems from fishermen's varied backgrounds and to the array of exploited species and variety of habitats in the flood plain river system. Gears include gillnets, castnets, several sizes of single hook and line gears, longlines, harpoons, hand gaffs and beach seines. Bow and arrow and poisoning with rotenone "Barbasco" are rare in the Upper Meta as these methods are mainly used by indigenous fishermen, few of who live in this area. Dynamiting fish is practiced in the low water season, mainly in small tributaries and usually by tourists who are in the area only a short while.

Gears most commonly used in the commercial fishery are setlines, gillnets and castnets. Set lines can be classified as either single or multiple hook lines. The former is further divided into 'chorrosqueros' for small 0.5-2.0 kg sized fish (Mapurito, Blanco Pobre, etc), the Cachamero for averaged size 3-15 kg fish (Cachamas, Rayados, etc), the Amarillero which catches mostly Amarillo and the Valentonero designed for Valenton. Multiple hook lines generally have Cachamero size hooks (Figure 15).

Gillnets are of the 'shirtail' type, i.e., they have no bottom line and generally weights are not used. Traditionally gillnets have been fished stationary, but recently, especially among fish buyers who travel the rivers in motorized canoes, drift gillnetting has become popular. Driftnetting intensifies during the migration seasons of November-December and April-May.

Large mesh castnets are efficient gears for catching food-fish during the dry season when water is shallow and fish are concentrated. (Throughout the year small mesh castnets are used for catching setline bait).

Table 10 and 11 show the effectiveness of each gear in relation to the standard (average sized) stationary fished gillnet, which is 20 cm stretched mesh, 3.7 meters deep and 18.5 meters long.

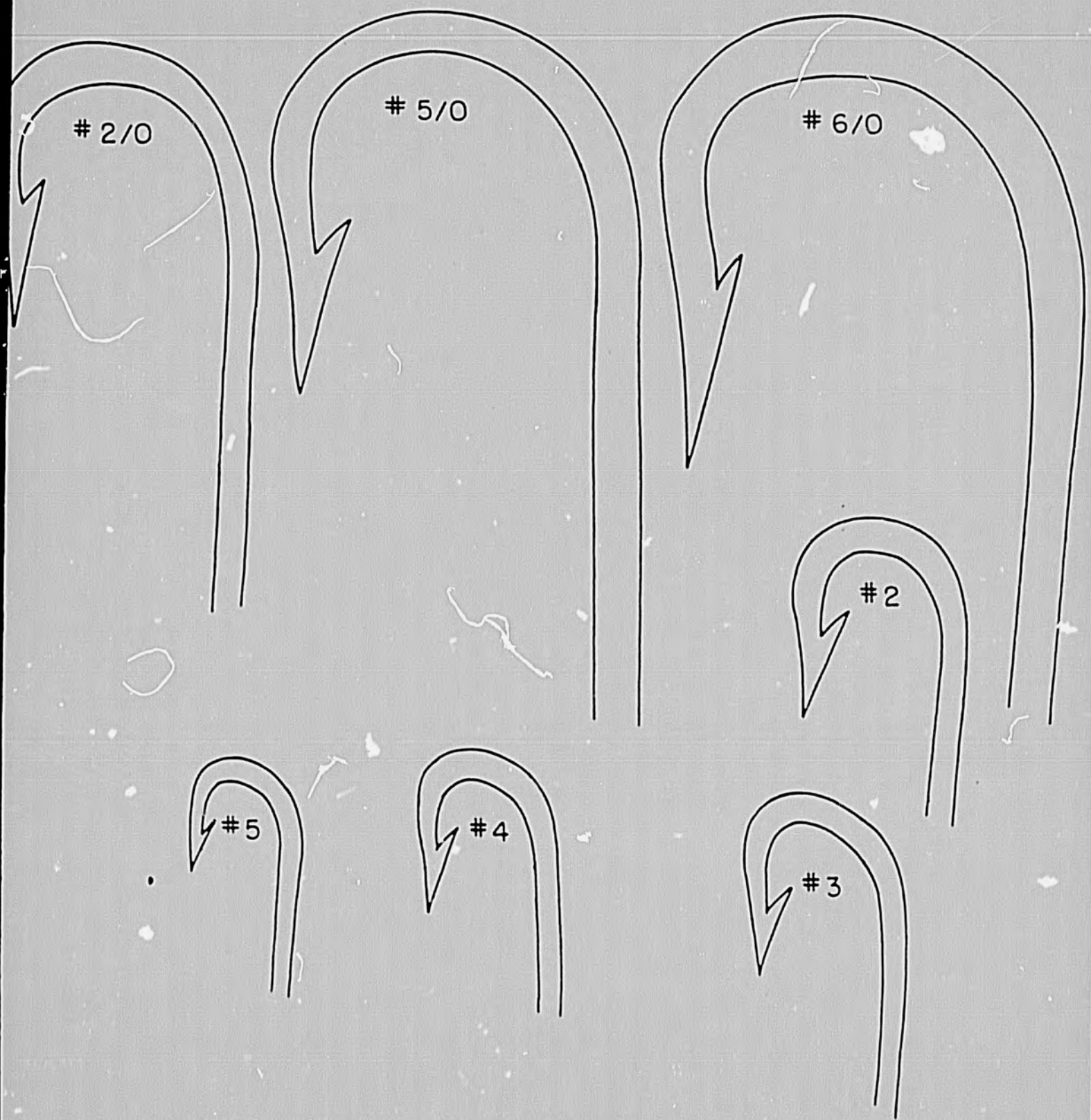


Figure 15. Hook sizes used in the Upper Meta River fishery. #5/0 and #6/0 are for Valenton, #2/0 for Amarillo and #'s 2, 3, 4, and 5 are for various catfish and Cachama. Smaller hooks are generally used for baitfish. (Actual hook sizes).

Table 10. Contribution of fishing gears to the Upper Meta River fishery during the 1978 high water season.

	Numerical % of gears in use	% by weight of total catch	Catch per unit effort (kg)	Relative efficiency*	No. of gears in the sample
Cachamero	51	12	0.5	0.12	252
Amarillero	18	27	3.2	0.76	88
Valentonero	1	-	-	-	4
Chorosquero	2	-	0.2	0.05	10
Longline	13	19	2.9	0.70	66
Gillnet	9	19	4.2	1.00	46
Castnet	3	2	1.7	0.40	13
Bow and arrow	1	1	4.2	0.99	3
Harpoon**	2	19	19.2	4	10

* The efficiency of each gear in relation to the catch per effort of a stationary gillnet which was arbitrarily assigned an efficiency of 1.00.

** We believe the actual catch per unit effort for the harpoon is much lower than our data indicated, and that although most fishermen carry a harpoon in their canoe while fishing other gears, they only report use of the harpoon when it was used successfully.

Table 11. Contribution of fishing gears to the Upper Meta River fishery during the 1977-78 low water season.

	Numerical % of gears in use	% by weight of total catch	Catch per unit effort (kgs)	Relative Efficiency*	No. of gears in the sample
Cachamero	55	6	0.3	0.04	83
Amarillero	20	34	4.7	0.70	30
Valentonero	1	7	14.0**	2.07	2
Chorrosquero	-	-	-	-	-
Longline	7	10	3.7	0.65	11
Gillnet	8	21	7.3	1.00	12
Castnet	9	22	7.0	1.03	13
Bow and arrow	-	-	-	-	-
Hand gaff	-	-	-	-	-
	1	-	-	-	1

* The efficiency of each gear in relation to the catch per effort of a stationary gillnet which was arbitrarily assigned an efficiency of 1.00.

** We are skeptical about this large value; more samples are needed.

Below is a summary of the relative quantities and efficiencies of fishing gears:

Cachamero: About 53% of all gears fished are cachameros, since they are inexpensive and easy to fish and maintain. Their CPE is the lowest of the commonly used gears being about 0.4 kg per night. However since they are very numerous they account for 12% and 6% of the total catch for the high and low water seasons respectively.

Amarillero: This gear accounts for 18-20% of all gears in use. Catch per unit effort (3.2 to 4.2 kg) is good, but actual frequency of catch is small since the average sized fish per catch is about 25 kg. About 30% of the fishery's catch comes from the Amarillero.

Long-line: 13% (highwater) and 7% (lowwater) of gears are long-lines, and they account for 19 and 10% (high and low water) of the total catch. Although both longlines and Amarilleros have efficiencies relative to the gillnet of about 0.7, the longline is less common.

Gillnets: 8-9% of gears in use are stationary-set gillnets. They are about 1.4 times as efficient as longlines and Amarilleros. However, since relatively few gillnets are in use they account for only about 20% of the total catch. The gillnet captures many species, several of which are herbivorous and are not caught on hooks. Thus the gillnets effect is divided among many species and without it some species would be seldom exploited.

Castnets: During the high water season castnets are not efficient (0.4) and are seldom used (3% of total gears) for food-fish. In contrast they are common (9% of gears in use) and contribute significantly (22% of total catch) to the low water catch. A commercial castnet fishery for Prochilodus in flood water lagoons has not developed in the Meta system. This may be due to the abundance of larger fish or to the abundance of pirana and sunken trees in the lagoons which can severely damage a castnet.

We have very little data on Chorrosqueros, Valentoneros, harpoons, hand gaffs, and beach seines. This is, in some cases, related to the small amount of effort expended using these gears, their short season of use, or in the case of seines, reluctance of fishermen to admit using an illegal gear. Data on these gears, presented in tables 12 and 13 in section 3.3.1, should be viewed in this light.

Most food fish species may be captured in any of several gears. The gear most selective, for which we have sufficient data, is the Amarillero. It captures mostly Amarillo, Cajaro and Valenton with the former accounting for nearly the total catch. Gears least selectivethroughout the year are the gillnet and longline. The castnet accounts for nearly all the catch of Bocachico and Curvinata and nearly 100% of Apuy, 70% of Payara, 50% of Rayado and 30% of Baboso during the low water season.

Knowledge of the gears being used to exploit the commercial species has several uses for the fisheries manager. It will be evident for instance that no single gear is having a major effect on the fishery. This disproves a popular theory that the gillnet is ruining the fishery. Also, some gears select a wide range of species, thus one should be caucious about prohibiting a gear such as the gillnet or longline as a method of reducing the catch of one or two heavily exploited species. It would be better to restrict the sale of the species as a method of reducing effort.

At the same time, it may be possible to use the gear selectivity analyses to promote the catch of underharvested species. For example, the expanded use of castnets in lagoons during high water might provide increased catches of Bocachico, Sapuara, etc. and in this way promote an alternative catch to fishermen rather than simply a restriction of effort.

Some species such as the Amarillo and Valenton are caught by gears designed specifically for these species. Thus if one wished to reduce the Amarillo catch,

a prohibition of the use of this class of setline would be effective and have virtually no direct effect on the catch of other species. The same would be true of putting a ban on the use of hand gaffs.

Results in tables 12 and 13 are based on data from fishermen interviews. For many species and gears little data were available. The 1980 CAS will provide additional data which can be used to improve the accuracy of the estimates.

Table 12. Percentage catch for each species accounted for by each type of fishing gear, high water season, 1978.

	Cachamero	Amarillero	Chorrosquero	Longline	Gillnet	Castnet	Bow	Harpoon	n	% of sample by weight
Clupeidae										
Sardinata (*Pellona flavipinnis*)				100					(2)	-
Characidae										
Cachama (*Colossoma bidens*)	26			36	37	2			(29)	9.4
Cherna (*Colossoma brachypomus*)					100				(8)	4.9
Palometa (*Mylossoma duriventris*)	5				29	48	10	10	(14)	0.7
Caribe (*Serrasalmus spp.*)			11				89		(45)	1.5
Cynodontidae										
Payara (*Hydrolicus scomberoides*)	9				41			50	(7)	1.8

	Cachamero	Amarillero	Chorresquero	Longline	Gillnet	Castnet	Bow	Harpoon	n	% of sample by weight
Prochilodontidae										
Bocachico (*Prochilodus mariae*)			1			27	72		(26)	1.1
Sapuara (*Semaprocilodus laticeps*)					88			13	(3)	0.5
Doradidae										
Sierra coporo (*Oxydoras niger*)	46			23	26	5			(13)	2.7
Sierra cagona(?)	68			5	27				(12)	2.4
Pimelodidae										
Valenton (*Brachyplatystoma vaillantii*)		100							(1)	2.4
Apuy (*Brachyplatystoma juruense*)				80		20			(2)	-
Dorado (*Brachyplatystoma sp. I.*)	25			48				27	(5)	2.4
Baboso (?)	26				42			32	(2)	0.6
Blanco pobre (*Brachyplatystoma sp. II*)	63			32	1	4			(20)	2.6
Mapurito (*Cillophysus macropterus*)	100								(3)	-

	Cachamero	Amarillero	Chorrosquero	Longline	Gillnet	Castnet	Bow	Harpoon	n	% of sample by weight
Cajaro (*Phractocephalus hemilioptcrus*)	28	72							(2)	1.5
Bagre Rayado (*Pseudoplatystoma fasciatum*)	18	2		45	20	10	0	4	(64)	20
Cucharo (*Sorubim lima*)				100					(1)	-
Paleton (*Sorubimichthys planiceps*)		100							(1)	-
Pimelodidae										
Yaque (*Sciates marmoratus*)	100								(6)	1
Amarillo (?)	7	62		1	11			14	(26)	1.9
Barbiancho (?)	71			29					(3)	-
Tigrito (*Pauliicea lutkeni*)				76		24			(4)	1.7
Agenjosidae										
Chancleto (*Agenjosus sp.*)										
Sciaenidae										
Curvinata or Burra (*Plagioscion squamosissimus*)				33	44	22			(3)	0.3

sample number = 302 fish sample weight = 1519 kg

Table 13. Percentage catch for each species accounted for by each type of fishing gear, low water season, 1977-78.

	Cachamero	Amarillero	Longline	Gillnet	Castnet	No. of fish in sample	% of sample by weight
Clupeidae				100		(1)	-
Sardinata (*pellona flavipinnis*)							
Characidae							
Cachama (*Colossoma bidens*)	27		35		39	(4)	3
Cherna (*Colossoma brachypomus*)							
Palometa (*Mylossoma duriventris*)							
Pirana (*Serrasalmus spp.*)	100					(1)	
Cynodontidae							
Payara (*Hydrolicus scomberoides*)				29	71	(2)	1
Prochilodontidae							
Bocachico (*Prochilodus mariae*)					100	(2)	0
Sapuara (*Semaprochilodus laticeps*)							
Doradidae							
Sierra Gopora (*Oxydonas niger*)				100		(1)	0
Sierra Pagona (?)	100					(2)	1

	Cachamero	Amarillero	Longline	Gillnet	Castnet	No. of fish in sample	% of sample by weight
Pimelodidae							
Valenton (*Brachyplatystoma vaillantii*)							
Apuy (*Brachyplatystoma juruense*)					100	(1)	0
Dorado (*Brachyplatystoma sp. I.*)				100		(1)	1
Baboso (?)	10		3	60	27	(15)	10
Blanco Pobre (*Brachyplatystoma sp. II.*)	27		27	45		(3)	1
Mapurito or Comagente (*Callophysus macropterus*)							
Cajaro (*Phractocephalus hemiliopterus*)		53	47			(4)	9
Bagre rayado (*Pseudoplatystoma fasciatum*)	15		28	3	54	(17)	13
Paleton (*Serubimichthys planiceps*)							
Pimelodidae							
Yaque (*Sciates marmoratus*)							
Amarillo		81	19			(14)	56
Barbiancho	42		58			(5)	2
Tigrito (*Paulicea lutkeni*)			100			(1)	-

	Cachamero	Amarillero	Longline	Gillnet	Castnet	No. of fish in sample	% of sample by weight
Agenlosidae							
Chancleto (*Agenlosis sp.*)							
Sclaenidae							
Curvinata (*Plagioscion squamossissimus*)					100	(3)	1

sample number 77 fish

sample weight 601 kg

3.3.2 Experimental gears

During each CAS field trip we fished experimental gears. The type of gears used depended on water conditions, availability of baits and the proximity of fishable habitat. The purposes of experimental fishing were many:

1. To determine if exotic gears could make useful contributions to the existing catch or would be useful sampling gears for research purposes. Our exotic gears included monofilament gillnets in a wide range of mesh sizes, circle hooks, hoop nets and box traps.
2. To determine what the species composition of the catch would be from traditional gears. Gears being tested were multifilament 'shirt tail', gillnets, longlines, single hook lines and beach seines.
3. To determine the size composition of the catch from larger and smaller mesh sizes than the standard 20 cm (8 inch) stretched mesh presently used by Meta River fishermen.
4. To examine fresh whole fish, collect ovaries and stomachs for analyses, determine stage of sexual maturity and evaluate degree of parasitism in the body cavity.
5. To obtain specimens for taxonomic analyses and as a reference collection.

3.3.2.1 Multifilament gillnets.

Gillnets used by Meta River fishermen are hand made from multifilament nylon twine. Almost all nets are 20-cm stretch mesh and are of the 'shirt tail' type, i.e., they have no bottomline. This prevents any serious entaglements with submerged tree limbs, etc.

We fished 15-cm, 20-cm, and 25-cm mesh nets to see what changes in catch would occur by increasing or decreasing mesh size from the standard 20-cm mesh. Fifteen - cm and 20-cm meshes had nearly the same catch rates, i.e., 1.10 and 0.91 kg/net respectively. Catch in 25-cm mesh nets was much less, i.e., 0.11 kg/net.

Catches in rivers were better than from still water, especially for the 20-cm mesh. Possibly there are relatively more small fish in lagoons than rivers. Numerically CPE was better in 15-cm nets, but average size was larger in 20-cm nets.

We found no significant difference in the 15 cm and 20 cm mesh catches. However, the 15-cm mesh did catch some species which usually do not grow large enough to be caught in 20-cm meshes such as the Sapuara and Yamu. Thus, although there is no advantage in CPE by weight, the 15-cm mesh would be a method of catching species which until now have been only marginally exploited.

Table 14. Species composition and catch per unit effort in multifilament gillnets of three different mesh sizes (a,b, and c). Dimensions of the gillnets were approximately 18.5 m x 3.7 meters, i.e., the average size of commercial nets.

(a) 15 cm mesh

	Rivers (15 nets)			Lagoons and canos (13 nets)		
		means			means	
	n	length	weight	n	length	weight
Yamu	1	46	2.33			
Payara				2	56	2.82
Sapuara				1	41	2.33
Rayado	3	68	3.72			
Cucharo				1	--	0.30
Panaque	1	26	0.50			
Curvinata	3	44	1.42			
Pavon				2	40	0.85
	fish/net = 0.53			fish/net = 0.46		
	wt/net = 1.22 kg			wt/net = 0.77 kg		

- - - - - -

(b) 20 cm mesh

	Rivers (26 nets)			Lagoons and canos (9 nets)		
		means			means	
	n	length	weight	n	length	weight
Sardinata	1	--	4.8			
Cachama	5		3.21			
Palometa	1	29	0.91	2	27	0.72
Dorado	1	84	8.60			
	fish/net = 0.31			fish/net = 0.22		
	wt/net = 1.17 kg			wt/net = 0.16 kg		

- - - - - -

(c) 25 cm mesh

	Rivers (17 nets)			Lagoons and canos (9 nets)		
		means			means	
	n	length	weight	n	length	weight
Cachama	1	44	2.90	no catch		
	fish/net = 0.06					
	wt/net = 0.17 kg					

3.3.2.2 Multimesh monofilament gillnets (MMG)

Eleven commercial species appeared in the MMG catch (Table 15) i.e., Sardinata, Palometa, Yamu, Payara, Sapuara, Bocachico, Sierra Copora, Sierra Cagona, Apuy, Chancleto and Curvinata. However, this represents only 44% of the 25 species present in the commerical catch; none of the six primary species which make up 80% of the commercial catch by weight were represented in the MMG catch (See sect. 2.33). We fished the MMG in many habitats and during all seasons of the year; it's unlikely that species which are selected by gillnets as adults would be completely resistant to capture when small and more abundant. We believe that many commercial species spend their juvenile lives in areas other than the Upper Meta River system. Bayley (ibid) and Godoy, (ibid) found that many species of South American Characids and Pimelodids migrate great distances (600-700 km in one direction) in river systems and spend much of their lives in lower reaches, returning upstream mainly to spawn.

A total of thirty-six species were represented in MMG catches; 11 of these are commercial species and another 11 are ornamental. Thus 14 species in the catch are presently not exploited. Many of these are small, however, the Pavon (Peacock Bass), Descarnador, Capitan, Cucharo, Dorada, Platanote, Dormilon, Payarin and Pirahna are abundant and grow to 0.5 kg or larger and would be acceptable in a subsistence fishery.

The amount of commerical food and ornamental fish in the MMG catch is small and generally of species of minor importance to existing fisheries. The exception is the Sapuara, which is exploited both for food and ornamental purposes. Its catch is small in both fisheries, however. As a means of increasing the harvest from the Upper Meta system the introduction of small mesh nets, i.e., 10-15 cm meshes would be a possible way. A broader representation of the fish community would then be exploited which should have a stabilizing effect on the community.

Table 15. Species composition in experimental monofilament gillnets fished overnight in standing water (lagoons and canos) and moving water (rivers) habitats. Mean weights, mean lengths and standard deviations of mean lengths are also presented. Data are from 24 gillnets fished in standing water and 21 gillnets fished in moving water. The gillnets have an area of 13.9 square meters.

a. 2" stretched mesh

Species	numerical catch lagoons and canos	numerical catch Rivers	means weight in kg.	means length in cm.	standard deviation of mean length
(Clupeidae)					
Sardinata	1	-	1.20	42	
(Characidae)					
Arenca	9	4	0.10	15.1	0.38
Cateprion	8	-	0.10	8.8	0.45
Moneda	1	-	0.05	13.0	
Palometa	1	-	0.05	23.0	
Pirana	4	-	0.10	11.0	
(Erythrinidae)					
Dormilon	3	-	0.15	21.0	1.41
(Ctenoluciidae)					
Agujon	4	-	0.35	36.3	2.87
(Cynodontidae)					
Payara (Cynodon)	23	5	0.20	19.2	1.47
(Prochilodontidae)					
Sapuara	7	2	0.10	15.0	
Bocachico	15	-	0.10	14.3	3.37
(Anostomidae)					
Leporino	5	-	0.20	19.5	
Platanote	3	-	0.30	27.5	
Botella	1		0.20	18.0	
(Hemiodontidae)					
Tijero	1	-	0.15	17.0	
(Doradidae)					
Dora	1	-	0.10	20.0	
(Pimelodidae)					
Dorada	1	-	0.10	20.0	
Cucharo	1	-	0.33	36.0	
Nicuro	-	1	0.10	14.0	
Platysilurus malarmo	-	1	0.10	22.0	
(Ageneiosidae)					
Descarnador	-	5	0.15	22.3	5.5
(Loricariidae)					
Cucha	2	-	0.10	11.5	
Alcalde	13	-	0.08	24.3	1.67
(Sciaenidae)					
Curvinata	-	3	0.20		
TOTAL	104	21			
CPE (fish/net-night)	4.33	1.00			
(kg/net-night)	0.67	0.15			

Table 15(b). 3" stretched mesh

Species	numerical catch lagoons and canos	numerical catch rivers	means weight in kg.	means length in cm.	standard deviation of mean length
(Clupeidae)					
Sardinata	1	-	0.50	43.0	
(Characidae)					
Moneda	7	-	0.20	14.8	0.50
Pirana	15	-	0.19	16.3	2.67
Catoprion	1	-	0.15	14.0	
(Erythrinidae)					
Dormilon	4	-	0.40	28.5	1.29
(Cynoluciidae)					
Agujon	2	-	0.38	37.0	4.24
(Cynodontidae)					
Payara (Cynodon)	14	1	0.30	28.1	4.22
Payarin	14	-	0.40	37.9	2.71
(Prochilodontidae)					
Bocachico	2	-	0.25	17.5	4.95
Sapuara	8	-	0.20	19.0	1.83
(Anostomidae)					
Leporino	1	-	0.40	27.0	
Platanote	-	1	0.70	33.0	
(Hemiodontidae)					
Tijero	7	-	0.30	27.0	1.41
(Gymnotidae)					
Cuchillo	1	-	0.20		
(Pimelodidae)					
Barbiancho	-	1	0.58		
(Ageneiosidae)					
Descarnador	3	-	0.25	25.7	8.69
Chancleto	5	-	0.30	26.0	3.39
(Sciaenidae)					
Curvinata	3	17	0.70	27.4	4.44
TOTAL	88	20			
CPE (fish/net-night)	3.67	0.95			
(kg/net-night)	1.08	0.64			

Table 15(c). 4" stretched mesh

Species	numerical catch lagoons and canos	numerical catch rivers	means weight/length in kg.	means weight/length in cm.	standard deviation of mean length
(Clupeidae)					
Sardinata	2	-	0.75	37.5	
(Characidae)					
Yamu	1	-	0.50	28.0	
Pirana	3	-	0.35	18.4	2.79
(Ctenoluciidae)					
Agujon	-	1	0.45	41.0	
(Cynodentidae)					
Payarin	1	-	0.50	39.0	
Payara	2	1	0.99	41.3	4.79
(Prochilodontidae)					
Sapuara	1	-	0.40	26.0	
(Doradidae)					
Sierra Copora	1	1	2.40	49.0	12.7
(Pimelodidae)					
Capitan	1	1	0.25	35.0	8.49
(Ageneiosidae)					
Chancleto	3	-	0.68	35.0	2.65
(Loricariidae)					
Cucha	1	1	0.25	27.0	5.66
(Sciaenidae)					
Curvinata	1	-	0.70	33.3	2.31
(Cichlidae)					
Pavon	2	-	0.70	29.5	
TOTAL	19	5			
CPE (fish/net-night)	0.79	0.24			
(kg/net-night)	0.54	0.21			

Table 15(d). 5" stretched mesh

Species	numerical catch lagoons and canos	numerical catch rivers	means weight in kg.	means length in cm.	standard deviation of mean length
(Characidae)					
Palometa	2	-	0.50	24.5	
Pirana	3	-	0.52	24.5	0.71
(Ctenoluciidae)					
Agujon	1	-	1.00	46.0	
(Cynodontidae)					
Payara	1	-	0.70	30.0	
Payarin	2	-	0.45	42.5	4.95
(Prochilodontidae)					
Sapuara	1	-	1.00	32.0	
(Doradidae)					
Sierra Cagona	1	-	8.60	72.0	
(Pimelodidae)					
Apuy	-	1	0.75	51.0	
(Ageneiosidae)					
Chancleto	2	-	1.20	42.5	2.12
(Loricariidae)					
Cucha	2	-	0.40	22.5	
Cucha Real	-	1	0.70	28.0	
TOTAL	15	2			
CPE (fish/net-night)	0.63	0.10			
(kg/net-night)	0.79	0.07			

Table 15(e). 6" stretched mesh

Species	numerical catch		means		standard
	lagoons and canos	rivers	weight/lenght in kg.	in cm.	deviation of mean length
(Characidae)					
Palometa	2	1	0.50	24.3	
(Cynodontidae)					
Payara	1	-	1.75	51.0	7.07
Payarin	1	-	0.53	41	
(Doradidae)					
Sierra Copora	3	-	2.04	49	
(Loricariidae)					
Cucha	1	2	0.40	24.3	3.21
TOTAL	8	3			

CPE (fish/net-night)	0.33	0.14
(kg/net-night)	0.41	0.06

The decreasing number of species in the catch as mesh size increases, i.e., 24, 18, 13, 11, and 5 species for 2, 3, 4, 5, and 6 inch meshes respectively, indicates that most species don't grow large enough to be caught in the present commercial fishery which generally selects for fish larger than one kilogram.

A large percentage of the catch in small mesh nets is of piscivorous predators, with 82%, 64%, and 36% of the catch by weight from 3", 4", and 5" meshes respectively being piscivorous. (Table 16).

Payara*, Payarin, Curvinata and Chancleto are the main predators in these mesh sizes. Payarin form dense schools in the lower reaches of canos and prey heavily on young of the year as they move from lagoons to rivers in the latter part of high water season. Marten (1979) has shown that reduction of predators by harvest should be considered a potential tool in fisheries management and this may be practical for the Upper Meta system.

Description of the catches from 45 MMG nights fished over a two year period are given in table Catches are much better from lagoons and canos (standing water environments) than from rivers and more individuals of a great variety were captured there. The only species which was noticably most important in river catches was the Curvinata (Drum) in 3 inch mesh.

The panels used in the MMG are 6 ft. deep by 25 feet long which presents an area 20.37% that of a standard Meta River commercial fishing net (3.7 m by 18.5 m). Thus if the CPUE for the MMG nets is multiplied by 4.91, an estimate of what catches would be if the MMG nets were of equal area to traditional nets can be determined (Table 17). MMG catches are generally a little less than the catch from commercial gillnet (See sect. 3.3.1). We would expect catches in small mesh nets by experienced fishermen to compare favorably with catches from tradtional gears.

*Generally not young Scombroides, but adult Cynodon sp.

Table 16. Percent predators by weight of total catch in experimental gillnets.

	Mesh sizes of monofilament gillnets				
	2"	3"	4"	5"	6"
Sardinata	6%	1	9	--	--
Pirana	2%	7	6	8	--
Dormillon	2%	4	--	--	--
Agujeta	7	2	3	5	--
Payara (Cynodon)	29	11	17	3	16
Payarin	--	14	3	4	5
Cuchillo	--	1	--	--	--
Barbiancho	--	1	--	--	--
Cucharo	2	--	--	--	--
Capitan	--	--	3	--	--
Apuy	--	--	--	4	--
Descarnador	4	2	--	--	--
Chancleto	--	4	11	12	--
Curvinata	3	36	4	--	--
Pavon	--	--	8	--	--
TOTALS	55%	82%	64%	36%	21%

Table 17. Predicted weight of fish which would be caught per net night if the monofilament panels had the same area (68.5 m^2) as an average gill-net used by Meta River fishermen. The conversion is one commerical net equals 4.91 experimental panels.

Mesh Size	Lagoons and canos	River
2"	3.29 kg	0.74 kgs
3"	5.30 kg	3.14 kgs
4"	2.65 kg	1.03 kgs
5"	3.88 kg	0.34 kgs
6"	2.01 kg	0.29 kgs

Since monofilament gillnets are expensive, unavailable in most of Colombia, and difficult to repair, a small mesh fishery using small diameter multifilament nylon might be more practical.

Date in Table 14 can be considered a baseline for future comparisons to estimate effects of fishing or of evnironmental modification. Also they should be used for fisheries extension officers to show potential small-mesh fishermen what catches they can expect with such gears.

3.323 Fishing hooks

During the 1978 high water season we fished 43 traditional and 27 circle hooks on long lines and caught no fish. However, overall catch per effort for traditional long lines (10 hooks each) including all 1977-1978 sets was 0.26 fish or 0.94 kg (n = 42.7 lines); and for circle hooks 0.13 fish or 0.38 kg (n = 7.9 lines). Table 18 a and b show statistics of the catches prior to the 1978 high water season.

Long lines baited with fish or earth worms caught a variety of catfish species as well as the Cachama. During the rising water season of April-May, we baited some hooks with wild fruits but caught nothing. In a field trip to the Guaviare River in 1979, we were able to capture Cherna using plantain as long line bait.

Experimental catch per unit effort by weight for long lines is similar to that for traditional gillnets. Species compositions differ, however, since long line catches are dependent on feeding habits, while selection in gillnets is not. Thus the Sapuara, Yamu and Panaque, which are generally considered to be herbivorous or detritus eaters, would not be expected in the long line catch.

A fisherman owning both long lines and gillnets can fish a wide variety of habitats and take advantage of more conditions in the hydrological cycle, as well as the seasonal availability of bait.

Table 18. Experimental catches from long lines

(a)	Traditional hooks			Circle hooks
Highwater 1977	292 hooks			
	n	$\bar{x}$sl	$\bar{x}$wt (kgs)	No data
Blanco Pobre	2	44.5	1.48	
Cachama	2	59.5	6.2	
Barbiancho	1	56	2.46	
Bagre Rayado	2	65	3.26	

(b)	Fish/10 hook line = 0.24			
	wt/10 hook line = 0.83 kg			
Lowwater 1977-78	92 hooks			52 hooks
	n	$\bar{x}$sl	$\bar{x}$wt (kg)	n $\bar{x}$sl $\bar{x}$wt (kg)
Amarillo	1	85	12.25	
Blanco Pobre	2	39	0.99	
Chancleto	1	45	1.55	
Yaque				1 57 3.03
	Fish/10 hook line = 0.43			Fish/10 hook line = 0.19
	wt/10 hook line = 1.72 kg			wt/10 hook line = 0.58kg

Single hook setlines include the Cachamero, Amarillero and Valentonero (Table 19). We fished Cachameros baited with earth worms or fish; all catches were made with earth worms. The Cachamero is the simplest and least costly and is commonly used for subsistence fishing.

Amarilleros and Valentoneros are expensive, require live fish or pieces of large fish for bait and have a very low numerical catch per unit effort. Sampling with the larger hook gears is time consuming and is not likely to produce meaningful information.

Table 19. Experimental catch from three types of hook and line gears.

	Single hook set lines		
Cachameros		(13 hooks fished) means	
		length (km)	weight (kg)
	n		
Blanco Pobre	1	55	2.80
Nicuro	1	23	.25
Sierra Cagona	1	62	5.59
	fish/hook = 0.23		
	wt/hook = 0.66 kg		
Amarilleros	(4 hooks fished)		
	no catch		
Valentonero	(1 hook fished)		
	no catch		

3.3.2.4 Box traps

We fished a box trap (4 ft x 15 in. x 15 in.) made of wooden slats spaced wide enough apart to allow movement of water through the trap, but retain most fish larger than 10 cm SL. Fish were removed daily for 31 consecutive days

beginning February 1, 1978. Forty-eight fish from six families, mostly loricariids, were captured (Table 20). Size ranged from 10 to 25 cm. Although these fish are large enough to be eaten, they are also the sizes used to bait Amarillo and Cachamero setlines. Thus the box trap could be useful to Meta River fishermen.

3.3.2.5 Hoop-trap nets

We fished a 9-hoop, 5-foot diameter hoop trap twice in 1977 during high water phase in the Manaccaias River and the Cano Mirriba, but caught no fish. Fish had entered the trap, but they escaped by ripping hopes in the nylon netting. During the falling water phase, we fished the trap in a cano near La Pollata. Our catch was two large Pirana and a Rayado which had been reduced to a skeleton by Piranas. Fish had again cut holes in the netting. We fished two traps in the Manaccaias in February 1978 (low water), but caught nothing.

We then built two 10 by 1m wings of 10-cm mesh and attached them to the trap. We fished the trap with wings in a cano near the Manaccaias River and captured a Pavon of 0.6 kg and a Sapuara of 0.3 kg.

Hoop traps could be a good sampling gear if they had wings made with lead core bottom lines and if wire mesh was used rather than nylon netting. The weights on the wings we fished entangled badly, so that we needed about one hour to set the trap.

Table 20. Experimental catch from a 4 foot long slat-box trap fished for 34 consecutive days during low water season, February 1 - March 5, 1978.

	n	mean length (cm)	number/day
Characidae			
Pirana	1	--	0.03
Anostomidae			
Platanote	1	25	0.03
Pimelodidae			
Nicuro	1	20	0.03
Ageneiosidae			
Descarnador	4	--	0.12
Loricariidae			
Cucha	40	13	1,18
Cichlidae			
Bocon	1	10	0.03
TOTAL:	48		1.42 fish/day

4.0 RECOMMENDATIONS

A. Liberalize restrictions on use of fishing gears.

Presently only gears using fishing hooks or cast nets with a stretched mesh of 7 cm or larger are permitted. Besides fishing hooks, we advocate the use of: (1) gillnets with stretched mesh size 18cm. These nets should not block more than one half of any waterway whether it be a large river or small stream; (2) castnets of any mesh size. Small mesh nets are used to catch bait fish for hook and line gears; (3) The harpoon and bow and arrow should be declared legal gears; and (4) The hand gaff, used by skin divers to capture large catfish should also be legalized, but an analysis of its catch composition and relative efficiency in relation to other gears should be done. The legality of the hand gaff should then be based on the results of that analysis.

The use of the beach seine for food fish should not be permitted until its catch composition is known and its overall effects on the catch of other gears and on the well being of the fishery as a whole is determined. If enforcement in the future is sufficient to eliminate illegal seining, comparisons of catch per effort of fishing gears for the species most selected by beach seines should be made between 1978 and the years to come when no seining occurs.
The reason for this and for the proposed sanctioning of the seine is more social than biological since nearly all fishermen believe that illegal beach seining is the cause of decreased catches during the low water season. This hypothesis should be validated or disproved and appropriate legislation for the use of beach seines then should be based on the investigation results. Beach seine research should be done with the aid of experienced beach seine fishermen who would be hired on a daily basis by INDERENA.

B. Improve the collection of commercial catch statistics.

A data sheet should accompany each fish transport permit (salvoconducto) and transporters should be required to write the number of each species and the total weight of all fish in the shipment. Date of transport, source area and shipment destination would also be recorded. The data sheet should be given to the last road checkstation ("reten") before reaching the destination or to an INDERENA office when requesting a new transport permit. Periodically an INDERENA inspector should accompany transporters from the "reten" to the unloading site to check on the validity of the data presented. To assist transporters, more liberal time limits should be put on the duration of a salvoconducto. Fish transporters complained that since salvoconductos are only valid for three days, many are out dated before fish are available for transport.

C. Regulation of the Commercial Catch.

The present species composition is mostly large predatory species which may be considered inefficient converters of the basic productivity in the Meta system. Many South American river fisheries, such as the Magdalena, are based on Prochilodus spp., algae and detritous feeders. In the Meta River, the Prochilodus and various less desirable (as food fish) herbivores are generally considered bait fish for the catfish fishery.

However, due to the relative scarcity of suitable habitat in the Upper Meta system for detritavores, it is uncertain that a large reduction in predacious fish would result in a corresponding increase in the abundance of Bocachico and Sapuara (family prochilodontidae). It is just as likely that the numerous small Loricariids, Characids, and Pimelodids which feed on algae and detritus would inherit the system and no great fishery resource would remain. Another reason for maintaining the existing catch composition (and community structure) is that the large and varied food fish species (25 in all) as well as the varied prey

species which evolved in the system are probably using all available food sources and are presently providing adequate return on the fishermen's investment. Also to be considered is the large and increasing number of Colombians who vacation in the Eastern Plains primarily to participate in the sport fishery. They especially would be disappointed by a marked reduction in the populations of large catfish and characids.

In consideration of the above discussion, we propose that on the basis of the length frequency distributions and relative species abundance as defined for data collected during the time interval February 1977 - March 1979, comparisons be made with future catches to determine when significant deteriorations occur in any given species. Management will be done on a species by species basis. The following assumptions should be considered when interpreting changes in the catch:

1) It is characteristic of a fished population that as fishing mortality increases the population structure attains a decreased average age (size)
2) Total catch, although requiring an increased amount of fishing effort, would increase as long as the population is below its maximum sustainable yield.

When a reduction in the mean length in the catch of a species is observed, the new mean length should be compared to the mean length of the 1977-78 base line data. A statistical (Student's t) test will reveal if probable that a real difference exists or if such a reduction is typical considering the variability in lengths which naturally exists in the samples.

If a significant difference exists, and yet the mean length is still greater than the minimum spawning length (MSL), defined as the length at which at least 50% of females are in mature sexual condition, just prior to spawning season, no catch restrictions are necessary. Some reduction in average length should indicate that an increased total catch is forthcoming.

If the average size has been reduced to a length less than the MSL, restrictions may be in order to prevent overfishing. Restrictions would be better justified if it were also known that total catch (weight) of the species was also decreasing. Suggested management actions are: (1) Legislate a minimum legal length of capture (ML_c) which would move the mean length of capture upward above the minimum length at spawning (MSL); (2) The ML_c's should be published in an INDERENA bulletin which should be adequately dispersed to fishermen and fish traders; and (3) INDERENA inspectors should monitor the marketed catch frequently in Villavicencio, Bogota and when possible at fish landing sites along the rivers. Illegal-sized fish should be confiscated, violators summoned to court or at a minimum they should have to appear at an INDERENA fisheries office to discuss the necessity of the minimum size restrictions.

Many species in the Upper Meta River catch are not encountered when immature (for example, the Cachama, Cherna and Baboso) and it is likely that the early life history stages are passed in areas distant from the fishery. In this case the fishery exploits very few age classes and the population response to increased harvest is not likely to manifest itself as an increased proportion of small size fish in the catch. Rather, an increase in total catch caused by increasing fishing effort would persist until recruitment to harvestable size had been reduced by insufficient reproduction. An indication that management inputs are needed would be rapid reduction in total catch of the species and corresponding sharp decreases in its catch per unit effort.

To reduce the catch in such a case, an ML_c could be legislated, possibly at the existing mean length of capture. This would ensure that an increased percentage of the stock was protected from fishing mortality.

An alternative protective measure would be to prohibit harvest of the endangered population during a specified season. Data is available showing the seasons

when fish are most vulnerable to capture. A closure during the vulnerable period would effectively reduce catch.

Marketed catch can be controlled since these fish pass through concentration points such as the Puerto Lopez landing, and the Villavicencio and Bogota markets. INDERENA inspectors can easily sample these catches to see if laws are being violated. Fishermen compliance with minimum size or closed season regulations depends on whether or not fish are to be marketed and whether the fishermen needs the fish for home consumption. If the latter is the case an illegal fish probably would not be released. However, if a fisherman also catches legal-sized fish and if he believes in the basis for the law, the small fish may be released. Thus, it is important that the fishing community be made aware of the principles on which management decisions are made. Possibly public meetings sponsored by INDERENA would provide fishermen the opportunity to contribute to management decisions.

If restrictions on some species are legislated, INDERENA should suggest alternative species which are less exploited and tell fishermen which gears are most useful for the catch of these species.

D. Future management potential - the surplus yield model.

The CAS can in a short time (1-2 years) provide estimates of harvest and fishing effort However, it is intended to ultimately provide an estimate of maximum sustainable yield (MSY) of the fishable stocks. To arrive at this estimate, and that of the corresponding optimum level of fishing effort, annual catch and fishing effort must be estimated from two distinct stages in the development of a fishery. Most useful estimates of catch and effort would be from times when the fishing effort had remained constant for at least three years. Stable effort intervals allow the compensatory mechanism in popluation growth to respond to a particular effort level and effect a stable recruitment and catch per unit effort.

When MSY and optimum effort are estimated they can be compared to the existing harvest and fishing effort to evaluate the existing fishery.

If the fishery is underfished, increased effort can be applied by:

(1) Permitting existing fishermen to use more effective gears such as beach seines, improved synthetic materials for gill nets and possibly traps or circle hooks, or

(2) Through the news media, inform people that a respectable living can be made by fishing and farming along the Plains rivers and that the present density of fishermen is low in relation to that which the system can support. Government loans for relocating and purchase of fishing gears should be considered.

If the existing level of effort is found to be excessive, resulting in a reduced total catch as effort increases, immigration to the fishery should be discouraged, and minimum and possibly maximum length limits should be set to allow adequate spawning. Existing effort should be directed toward the least exploited and less affected species such as (in the Meta system) the Doradid catfishes, the Payara and the Bocachico.

If fishing effort is found to be correct for achieving MSY, immigration to the fishery should again be discouraged and careful monitoring should be maintained to ensure that all species are being exploited and that a few species are not being over-exploited while others are lightly fished. This would be done through analyses of length frequencies and relative abundance in species composition.

Management of a fishery is like maintaining an automobile, it requires periodic checks, repairs and especially tune ups, in the form of increasing or decreasing effort through length limits, season and species regulations.

We presently believe that the Meta River fishery, although fishing has undoubtably existed for a least the last 30 to 40 years, is still underfished. Our beliefs are based on the following considerations:

(1) Presently most of the important species are large and exploited at mature sizes. If the community were overharvested, and large species would be reduced in importance, as they are the most easily overharvested, and small species would dominate the catch.

(2) Available species, which are important in the capture of other river fisheries, such as the Bocachico and Pacora (Curvinata) in the Magdalena River, are almost neglected in the Meta River fishery.

(3) Hooks and mesh sizes are very large indicating that small fish, including many species which do not grow large enough to be caught in the gear, are unexploited.

(4) Density of fishing units is generally less than 1 per kilometer of river.

(5) The average fishing economic unit invests less than 4 hours per day in fishing and maintaining gear, fishes less than 5 days per week and uses a small amount of fishing gear, e.g. generally less than 10 hooks or two small gill nets per day.

(6) Out of the entire Meta River system, about 1000 km in length, only the upper 300-400 km are regularly fished commercially. However, due to the regular annual appearance of large populations of fish in the Upper Meta River fishery, it is likely that this area enjoys migrations of fish produced in the lower system.

Since we believe that exploitation is low, (although a complete set of data for the calculation of MSY and optimum effort will not be available for

several years) the Meta River and probably all Eastern Plains River fisheries appear to be underfished and short-term management schemes based on total catch, length frequency distributions and relative abundance of the species composition will provide adequate information for rational management in the present and near future.

E. Protection of the ecosystem.

We strongly warn that agricultural practices in the Eastern Plains, mainly confined to the Piedmont, are having an increasing detrimental effect on the fisheries resources, especially in the Upper Meta system and in the drainage of the Ariari, a main artery of the Guaviare River. Active participation by INDERENA should be initiated to: travel extensively and personally examine environmental modifications such as clearing of riparian vegetation for cultivation of rice, cotton, etc. or changing drainage patterns to construct ditches for rice irrigation; inact strong legislation to protect riparian habitat; reforest damaged areas; pump water from natural water sources rather than making irrigation canals. The natural drainage patterns should not be modified in any way.

Fumigation practices should be carefully scrutinized "in the field" by INDERENA chiefs with inspectors. Strong regulations should be enacted against careless spraying on windy days and at any time near streams, lagoons or their buffering riparian vegetation.

Joint studies by ICA and INDERENA should be carried out with the ultimate goal of minimizing the negative effects to the environment from pesticide application. It is likely that the results of this study would reduce farming costs of pesticides and their aerial application. Objectives of these studies should be to determine: (1) the minimum pesticide dosage necessary; (2) which of the many available pesticides has the least ill effects, both immediate and delayed; and

(3) methods to limit the escape of pesticides from cultivated fields to the aquatic environment.

Colombia's river fish populations are renewable natural resources which if exploited rationally and protected from environmental pillage will perpetually provide thousands of tons of high protein fish annually, income to thousands of fishermen, and food and recreation for Colombians from all parts of the nation.

Costs of research into environmental protection and restoration should be paid by those who are causing the damage. Legislation authorizing such payment would seriously inhibit further environmental degredation by others.

F. Continuing research.

(1) Follow the CAS schedule as described by Malvestuto, el al (1979).

(2) Continue to accumulate data on the minimum spawning sizes, length frequencies of spawning stocks, and the time and areas of spawning.

(3) Monitor, on a regular basis, the commercial catch of the most intense eastern plains fisheries to keep abreast of changes in the fishable stocks.

(4) The economic condition of the fisheries should be assessed periodically (every 3 to 5 years).

Finally, it was our impression that there exists an abundance of laws to protect Colombia's natural resources but that some laws are of questionable value and none are seriously enforced. Laws with a biological basis which people believe in, would be an improvement. Also, for laws to be taken seriously, conscientious, educated enforcement officers should be supported in the field with vehicles, boats, gasoline and travel allowances. Without enforcement, the value of studies and resulting regulations is minimal.

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6.0 APPENDICES

6.1 Hydrological Cycle

The Plains have mean monthly temperature ranging from 25° to 28° C. Relative humidity is in the range of 60-80%. The annual hydrological cycle, however, is pronounced and strongly influences the activities of both fish and fishermen. Migrations and spawning of many species occur during the rising water phase of April and May. The long high water season provides an expanded nutrient rich nursery area on a moderate flood plain. Receeding waters in November-December force all fish back to the river channels or into the few permanent water lagoons. Predators probably enter the Upper Meta at this time and feed on abundant young fish. Fish concentrate in the few deep water pools during the dry months of January through March. Young of the year are rapidly reduced by predation as well as by competition for limited resources.

Catch, as indicated by commercial landings at Puerto Lopez (see Figure 1), is greatest during the rising and falling water periods April-May and November-December, respectively, and is probably a result of increased activity and/or abundance of fishable stocks in the Upper Meta system during these seasons. During high water, catch is lowest; stocks have just passed a time of heavy fishing mortality; volume of water has increased five to eight times, thus decreasing the density of fish, and the flooded habitat is often forested and therefore difficult to exploit.

During the low water months of January-March, catch is less than during the transition water phases on each side of it. Low water stocks are somewhat reduced by large catches in November-December. Water is at its clearest level of the year (secchi disc visability 50-60 cm) and fish may successfully avoid gillnets. Fish may migrate down river below the Upper Meta River study area. Warm water, decreased prey availability, high visability and decreased water volume may result in fish becoming semi-dormant in the few deep pools, hiding

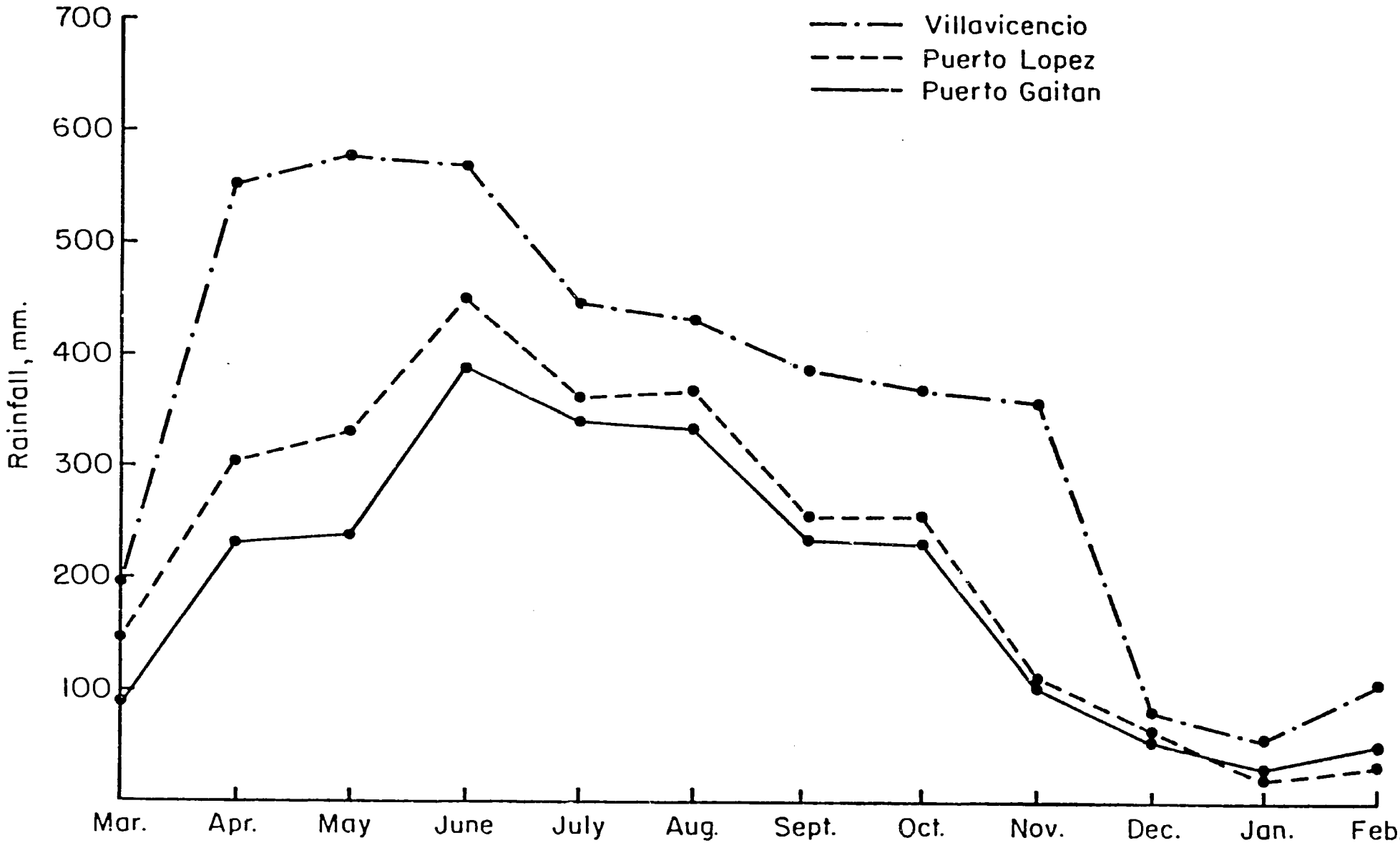


Figure 16. Average monthly rainfall at Villavicencio (upper piedmont) and two savanna locations in the Upper Meta River system study area. Point estimates are averages over the years 1972-1978. Data were provided by the Colombian Hydrometrological Service ("Himat").

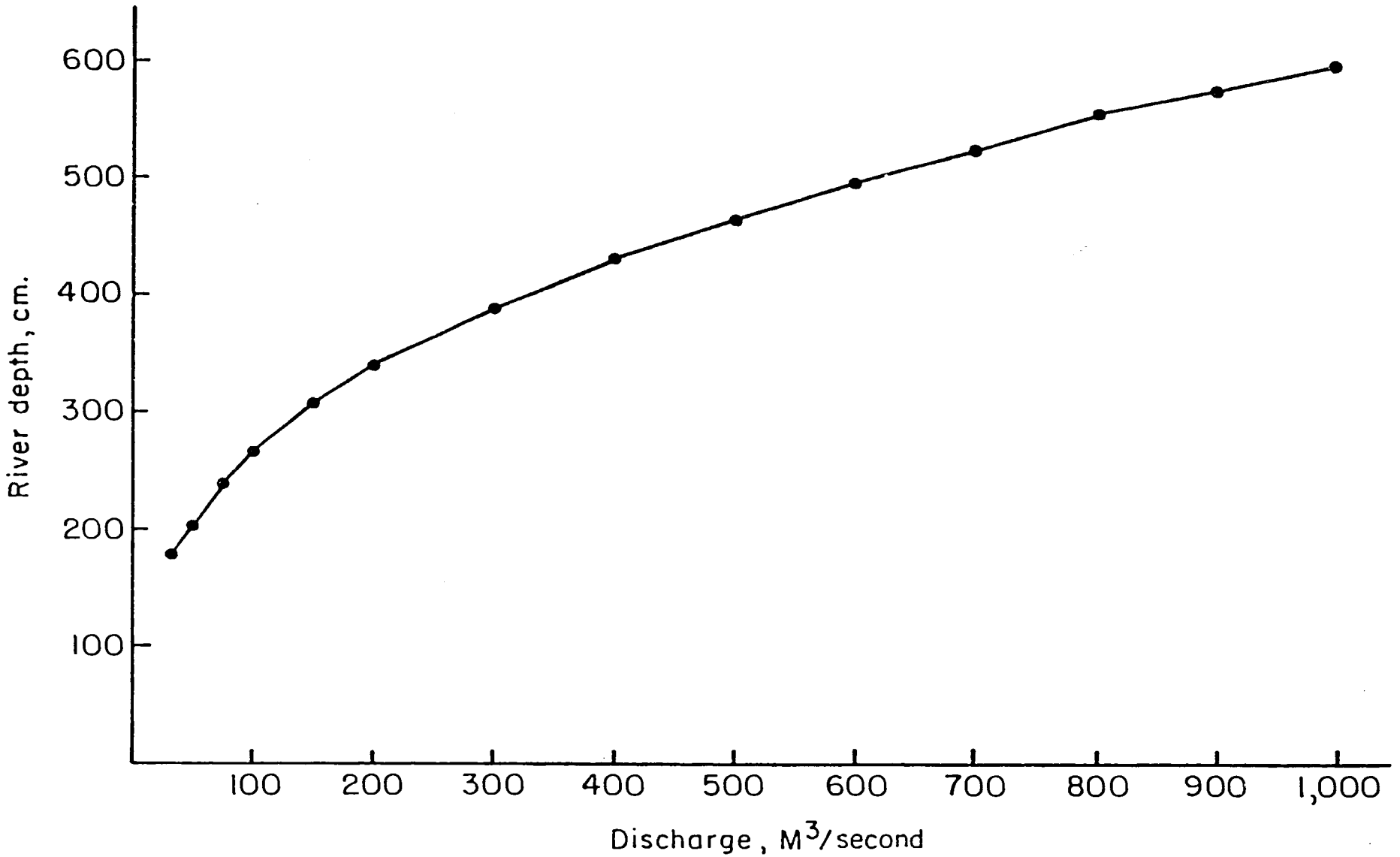


Figure 17. The relation of river depth and volume for the Meta River and Puerto Lopez. Data were provided by the Colombian Hydrometrological Service ("Himat").

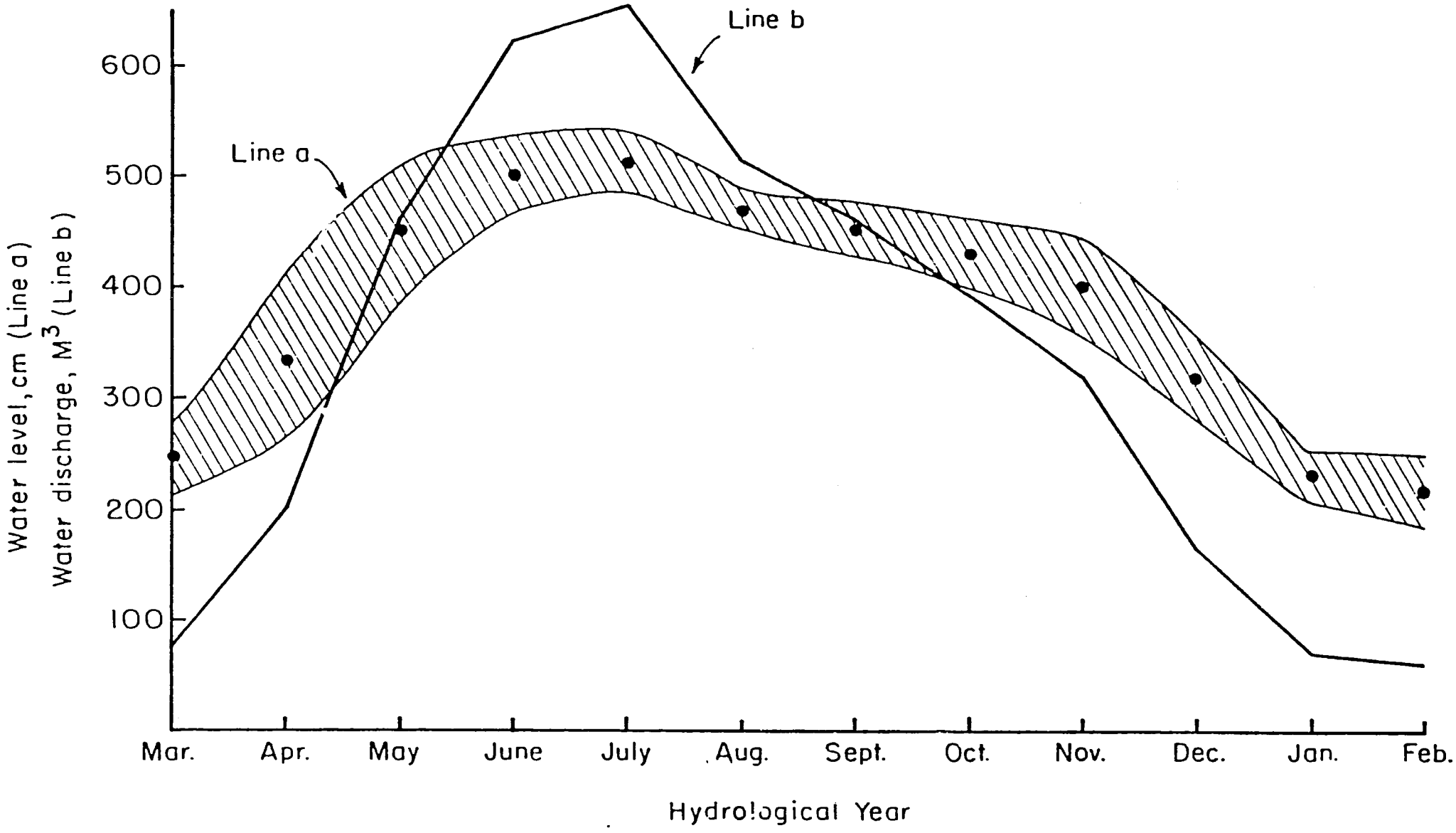


Figure 18. Line a: Average monthly water levels in cm, and the 90% confidence interval for the estimated line. Line b: Average monthly water volumes in cubic meters. Data is for the Meta River at Puerto Lopez bridge for the time interval 1972-1978. Data were provided by the Colombian Hydrometrological Service ("Himat").

among numerous sunken tree trunks. Fishermen who skin dive to gaff Amarillo catfish during the low water season claim this is the case. Many fishermen blame beachseine fishermen for the low catches in this season.

The hydrological year begins in April with heavy rainfall in the mountains. The rainy season on the plain is less intense; it begins later, ends earlier, and is about 60% of rainfall in the upper piedmont.

By May, the Meta is near the general high water level. Volume, however, increases considerably until July. Apparently increases in height above about 450 cm results in an increase in flood plain area rather than water height.

Rainfall decreases in September and October; however, little decrease in water depth occurs until mid-December when water has drained off the plain.

6.2 Unit of Effort; the Canoe-Day

Almost all fishing is done from canoes, but all canoes are not used for fishing. Many are used solely for transportation of people and cargo. Also, if a fisherman owns two or more canoes, although he may alternate in his use of each for fishing, he can only use one at a time; so, we consider that he only has one fishing canoe.

The count of canoes is the first requirement in estimating fishing effort. Through interviews at riverside dwellers' homes, we found what fraction of canoes were for fishing. Then we asked how frequently they fished to find out how many fishing canoes were in use on an average day.

Counting canoes can be done rapidly in a river boat, and for practical purposes, instantaneously from an airplane. Interviews are the time-consuming part of surveys. Linear regressions between (1) canoe count and fishing units and (2) canoe count and fishing units in operation per day, for 19 sets of data provide predictive equations for preliminary estimates of fishing effort without conducting survey interviews.

Data for regression analyses were separated for main river and tributaries as we felt these two areas had substantially different relationships. Generally, for main river sections, fishing units and fishing units operating daily are 79% and 49% of canoe counts while the same respective relations along the tributaries are 86% and 57%.

Main River sections

$Y = 0.99x - 36.0$; Y = fishing units ($r^2 = .94$, $n = 8$)

$Y = 0.48x + 2.15$; Y = fishing units operating daily ($r^2 = .76$, $n = 8$)

Tributary sections

$Y = 0.91x - 216$; Y = fishing units ($r^2 = .98$, $n = 11$)

$Y = 0.59x - 2.15$; Y = fishing units operating daily ($r^2 = .76$, $n = 8$)

All x's = number of canoes counted.

6.3 Canoe Counts

Canoes were counted from an airplane and also from a boat once during high water and again during low water in HY 1977. The largest count in each section was taken as the best estimate.

Both counts were, for practical purposes, identical. The totals for all sets of paired data were 1168 and 1179 canoes for counts from boat and airplane, respectively. Differences occurred in individual pairs of data and are probably due to local movement of canoes (counts from air and water were often several weeks apart). The results reassure us of two things. One, that counts from a boat or airplane are equally valid, and two, that at least within a time block (season) there is virtually no change in the number of canoes found along the Llanos rivers. These conclusions indicate that (1) very little replication in sampling is necessary to estimate canoe abundance with precision, and that (2) canoe counts along Llanos rivers from a boat or an airplane, whichever best fits the requirements of the investigation, need not be validated by counting with a second method. These findings should lead to considerable savings in research time and funds.

There were 31% more canoes counted in the low water season than during high water. Dugout canoes without motors are not likely to move far and it is unlikely that canoes move in and out of the Upper Meta River system with the seasons. It is likely that during high water, some canoes are kept along ephemerol streams and lagoons out of sight of the surveyor, and like the fish in the system, are compelled to move to the main river channel during the low water season.

Canoe counts in 1978 were made from a survey boat. Routine aerial counts were discontinued in the Upper Meta River system.

	Canoe Counts			
	High Water 1977		Low water 1977-78	
	From Boat	From Airplane	From Boat	From Airplane
Rio Meta				
Rio Guayuriba-Puerto Lopez	85	82	125	114
Puerto Lopez-Rio Upia	97	70	163	124
Subtotal	182	152	288	238
Rio Upia-Puerto Guadalupe	--	101	73	94
Puerto Guadalupe-Rio Manacacias	--	101	124	76
Subtotal			197	170
Rio Manacacias-San Miguel	31	27	32	34
San Miguel-San Pedro de Arimena	29	30	50	41
San Pedro de A.-Porvenir	39	26	47	51
Porvenir-Orocue	30	39	36	98
Subtotal	129	122	165	224
Tributaries				
Rio Upia	--	66	--	64
Rio Yucao	11	10	--	14
Rio Manacacias	11*	31	24	34
Rio Cusiana	98	131	--	108
Rio Cravo Sur	74	98	--	82
		749		1101
Other upper navigable tributaries estimated considering fishable kilometers of river and canoes per kiometer in the Rio Upia.		(100)		(114)
Sums where pairs are available	494	513	674	666

Air Counts = 1.04 and 0.99 boat counts.

The linear relation between counts from an airplane (x) and counts from a boat (Y)

$(n = 18, r^2 = .64)$

$Y = 5.6 + 0.91X$

Best estimates of total canoes in the study area	849	1225

* this pair not used in regression since a canoe landing was not seen during count from the boat.

6.4 Strata descriptions

Stratum 1 (the main river) includes the three main river zones of the frame survey. This stratum contains a high intensity of fishing effort, a wide variety of fishing gears, and a large and variable CPE. It is uniformly composed of mixed commercial and subsistence fishermen, contains fish buyers in all seasons and has a large annual catch per kilometer. Apart from these statistics, this stratum is one continuous river segment uniformly affected by seasonal and daily fluctuations in water level, turbidity, etc. Also fish migrations appear to pass completely through the stratum.

Stratum 2 contains the six upper tributary rivers: Pajure, Metica, Guayuriba, Humea, Upia, and Tua. These rivers, although each having unique properties of water quality and being uniquely affected by weather, have in common a high catch per unit of effort, commerical and subsistence fishery segments, and fish buyers at least during the high water season in the lower segment of each river. CPE is relatively stable and annual catch per kilometer is relatively high for tributary rivers. However, there are substantial differences among the six rivers which may warrant further division, or deletions, in the future. The Tua, Metica, and Pajure are relatively deep and occupy narrow mud and sand basins. The Guayuriba, Upia and Upper Humea are wide valleyed, shallow streams with rocky bottoms. Another factor is the extent of agricultural development in each river's watershed which often modifies riparian habitat and introduces toxic chemicals to watersheds. The Tua, is the only river which appeared to have no more than subsistence farming activity within its watershed.

Stratum 3 is the lower southern tributaries, the Manacacias and Yucao Rivers. These rivers originate in the plains from spring-fed streams. They meander considerably and their flood plains are characterized by an abundance of oxbow lagoons. Unlike other strata, waters are acid and depth of visability is

relatively high. Commerical fishing is mostly limited to the exploitation of ornamental fish for which an extensive fishery exists, mainly in flooded back waters and in adjacent lagoons and connecting streams. Density of riverside homes is low and consequently very little fishing takes place for food fish. Most ornamental fishermen have residences in Puerto Gaitan. Fishing gears include gillnets, long lines, and single hook lines.

Stratum 4 (the Cusiana and Cravo Sur Rivers) enter the Meta River from the north and originate in the mountains. This stratum is the most distant from markets and is generally without roads. During the dry season, the rivers are not navigable. These factors, and the fact that most residents are employed in cattle ranching, result in a lack of commercial fishing. All fishermen interviewed fished with one or two single hook lines, a gear which has a relatively low catch per unit effort.

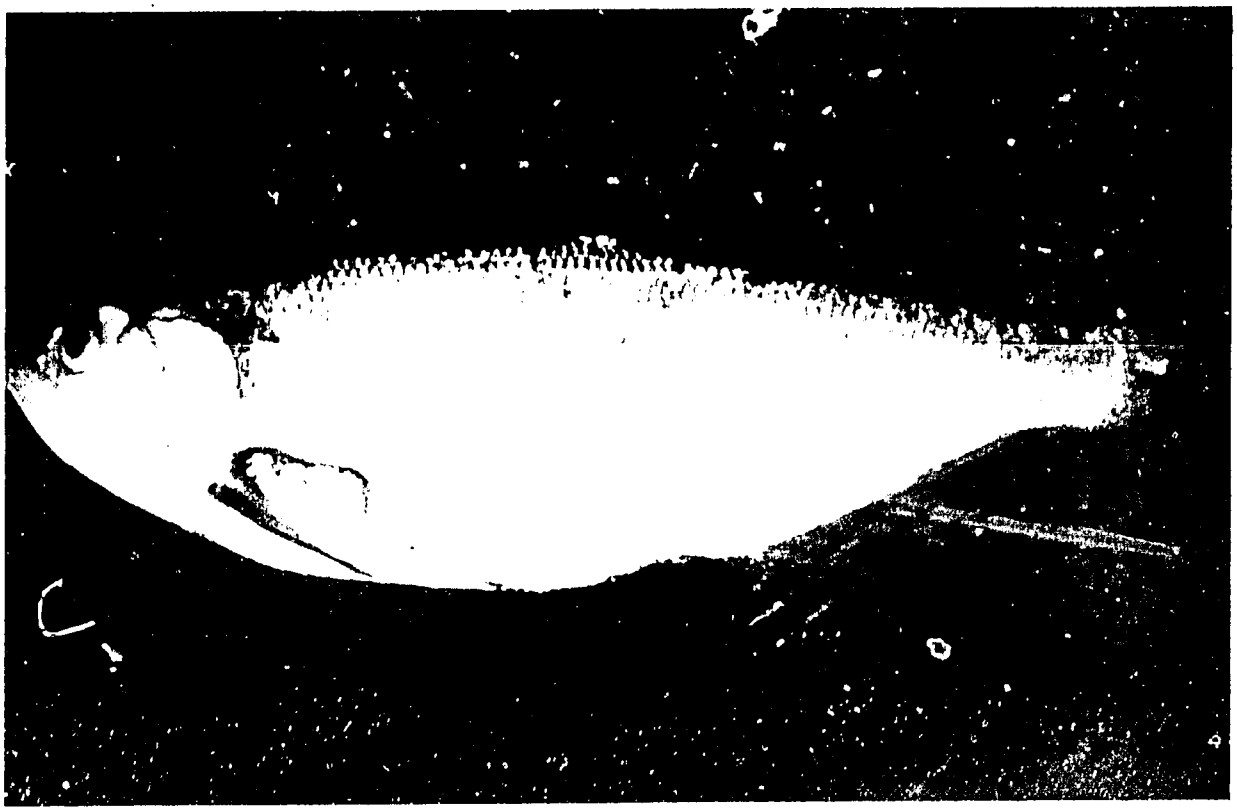
We encountered no fishermen in the lagoons zone adjacent to the rivers, and the number of people fishing this habitat appears low in relation to the fishable area. Lagoons in the Meta River system are generally old river channels which became isolated lakes as the river changed course. Food-fish fishermen have homes along riverbanks. They may fish river, cano or lagoon depending on water conditions and availability of fish. Thus, interviews at riverbank homes provide information from both riverine and lagoon segments of the fishery. For these reasons, we have removed lagoons as a seperate stratum from the survey scheme.

6.5 Annual (An), high water (HW) and Low water (LW) descriptive statistics of Length frequency distributions for 25 commercial fish species. Data is from commercial catches. A t-test was used to evaluate differences between means of low and high water LFDs. In species where seasonal means differ significantly, t-test comparisons between those b seline data and future samples should use baseline data which is specific for the season of the new sample. If no significant difference exists, use the annual statistics in the comparison.

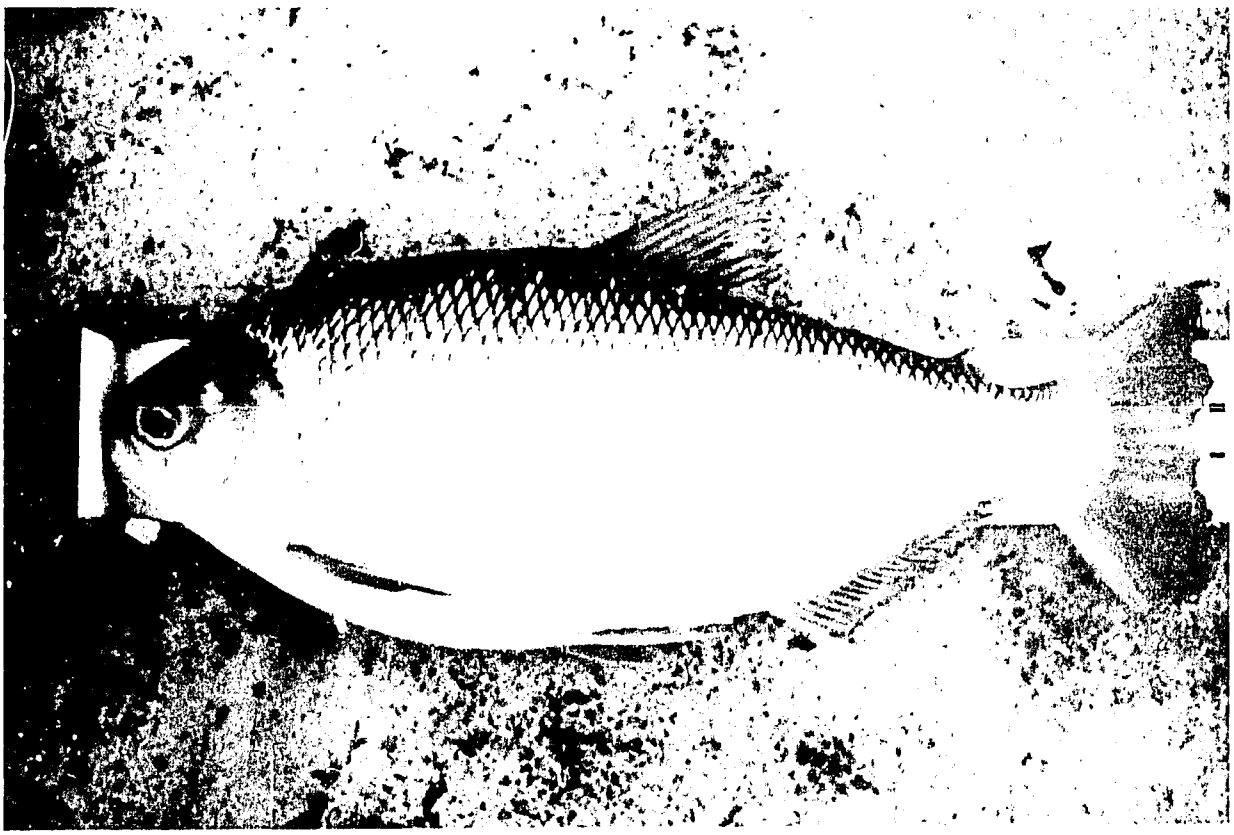
		n	mean(cms)	St. Dev.	
Amarillo	Annual (An)	141	100.2	28.002	
	High water (HW)	58	116.6	2.231	means are different
	Low water (LW)	83	88.8	3.143	α = .01
Apuy	AN	69	59.7	5.992	
	HW	5*	60.0		
	LW	63	59.9	6.074	
Baboso	An	386	69.2	6.790	
	HW	47	72.0	6.892	means are different
	LW	339	68.8	6.694	α = .01
Blanco Robre	An	165	48.7	8.522	
	HW	61	50.9	6.757	means are different
	LW	104	47.4	9.190	α = .01
Bocachico	An	118	24.5	7.8525	
	HW	3*	36.3		means are different
	LW	111	24.5	0.724	α = .01
Curvinata	An	152	41.3	8.567	
	HW	46	38.0	10.311	means are different
	LW	106	42.7	7.293	α = .01
Cachama	An	437	53.7	4.991	
	HW	366	54.1	4.912	means are different
	LW	71	51.7	4.931	α = .01
Cajaro	An	28	75.7	17.720	
	HW	15	78.7	18.188	means are different
	LW	13	72.2	17.220	α = .01
Curimata	An	26	20.5	17.220	
Chancleto	An	45	37.0	5.291	
	HW	23	34.7	5.570	means are different
	LW	22	39.3	3.894	α = .01
Cherna	An	127	64.3	5.321	
	HW	123	64.1	5.136	
	LW	4*	71.0		

		n	mean(cms)	St. Dev.	
Mapurito	An	76	38.9	6.584	
	HW	33	36.2	7.279	means are different
	LW	43	41.0	5.201	α = .01
Dorado	An	37	81.7	8.823	
	HW	26	82.1	7.488	no difference at
	LW	11	79.6	11.638	α = .01
Payara	An	53	60.4	11.389	
	HW	8*	67.1		
	LW	45	59.2	10.390	
Palometa	An	55	26.9	3.200	
	HW	34	26.2	3.346	means are different
	LW	21	28.1	2.594	α = .01
Paleton	An	52	96.2	22.524	
	HW	14	101.7	23.799	no difference
	LW	38	94.2	22.015	α = .01
Rayado	An	507	69.3	16.122	
	HW	175	68.7	16.302	no difference
	LW	332	69.6	16.043	α = .01
Sardinata	An	11	49.2	9.261	
	HW	8*	51.3	7.285	
	LW	2*	48.5		
Sierra Cagona	An	63	61.0	7.848	
	HW	57	61.8	6.779	no difference
	LW	6*	52.8		α = .01
Sierra Copora	An	78	54.9	7.848	
	HW	32	55.7	7.863	no difference
	LW	46	54.3	7.871	α = .01
Sapuara	An	40	33.0	13.169	
	HW	14	43.1	3.92	no difference
	LW	11	41.5	6.88	α = .01
Valenton	An	28	138.6	41.327	
	HW	18	136.1	45.347	no difference
	LW	10	143.0	34.724	α = .01
Yamu	An	21	39.9	6.526	
	HW	5*	43.8		
	LW	16	38.7	5.275	
Yaque	An	68	51.8	5.807	
	HW	20	50.5	6.065	no difference
	LW	48	52.3	5.676	α = .01

6.6 Photographs of 17 of the lesser exploited commercial fish species.

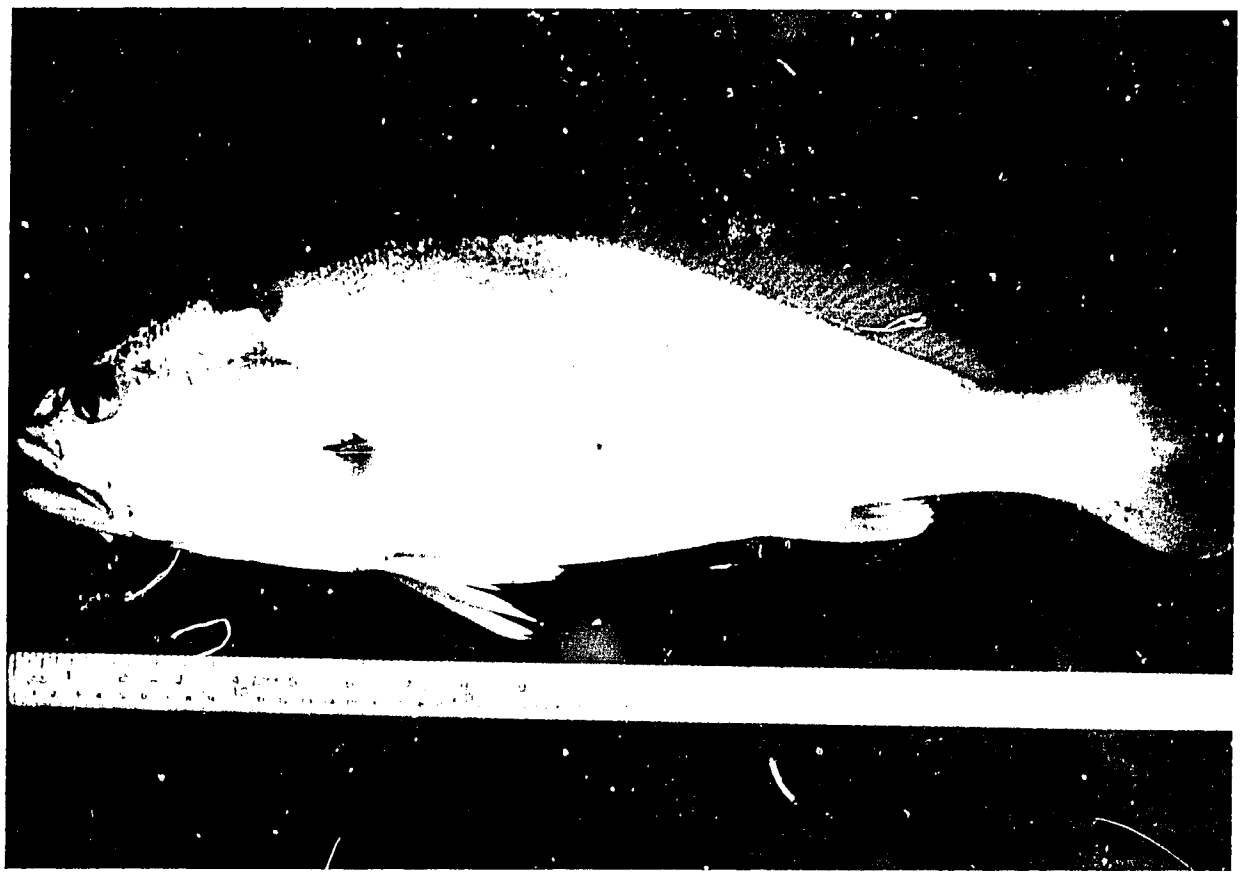


La Sardinata (Pellona flavipinnis) Family Clupeidae



El Yamu (Brycon ____?____) Family Characidae

El Agujon (Boulengerella lucius) Family Ctenoluciidae

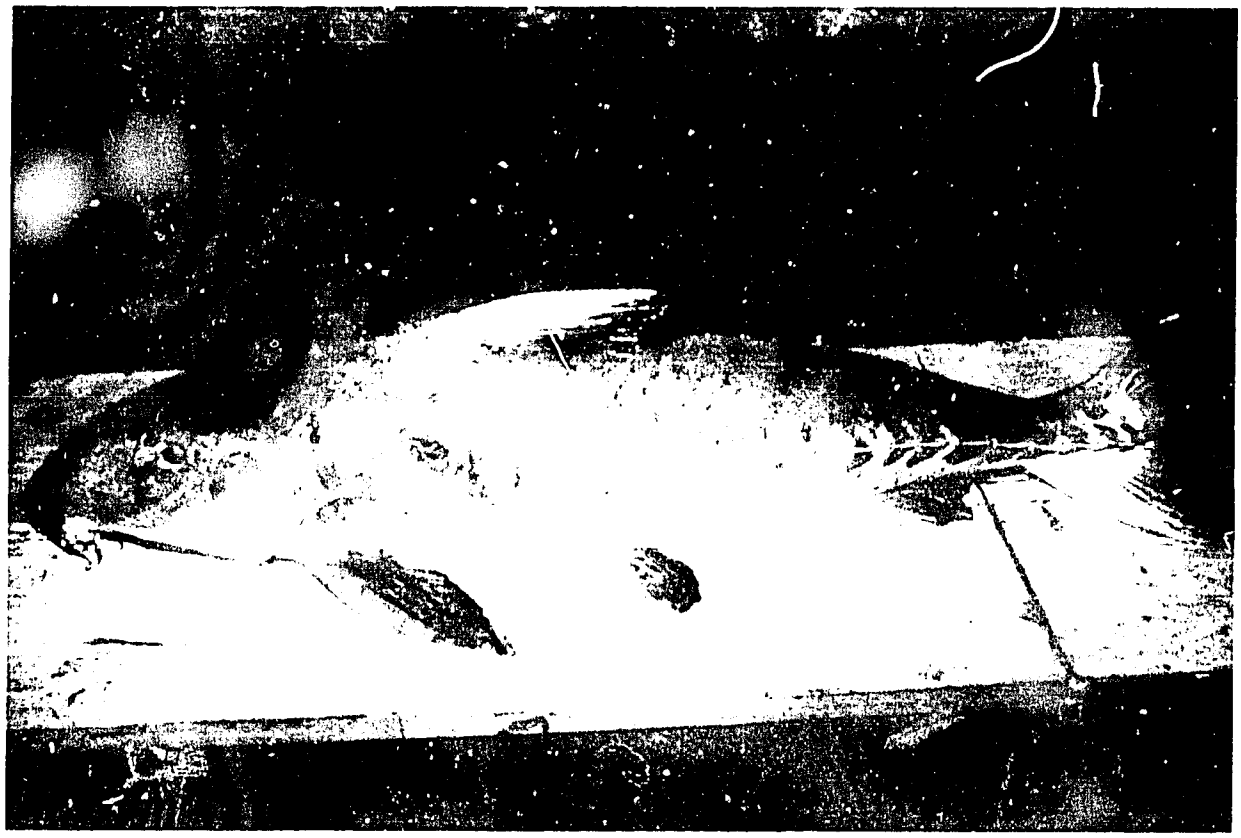


La Curvinata (Plagioscion squamosissimus) Family Sciaenidae

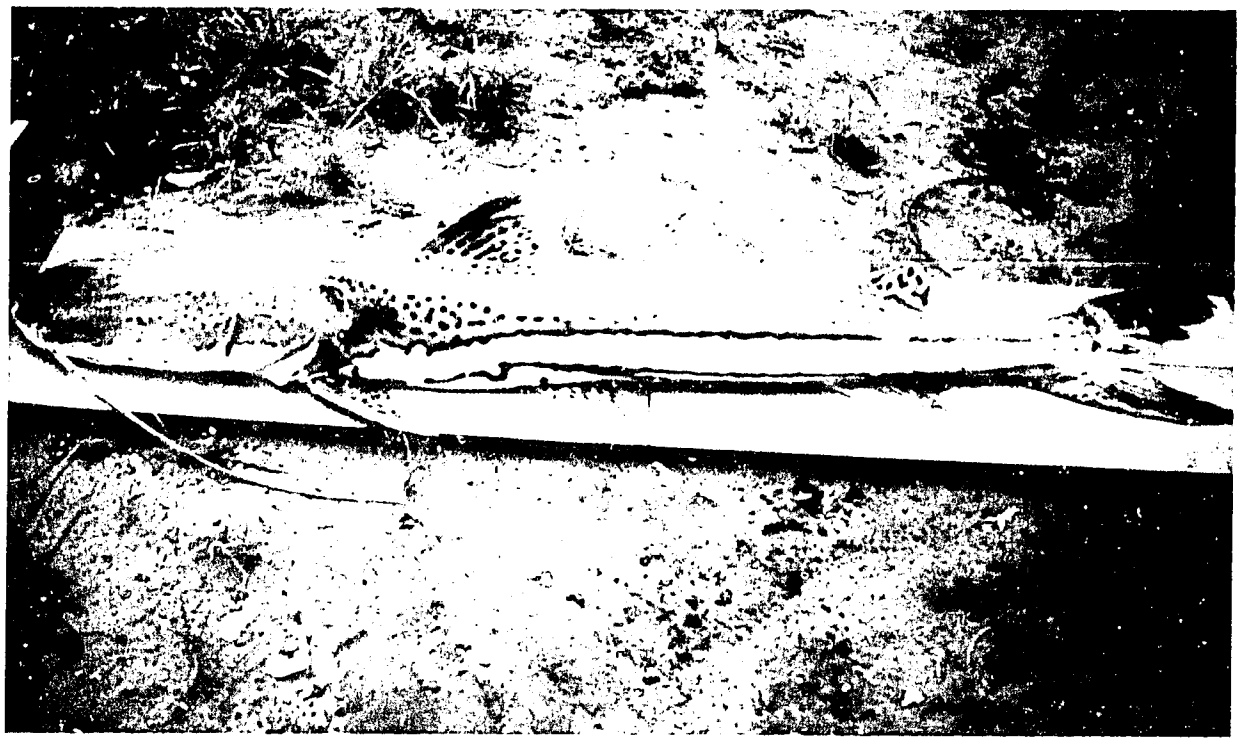
La Payara (Hydrolicus scomberoides) Family Cynodontidae

The upper and lower fish are Sapuara (Semaprochilodus Laticeps) Family Prochilodontidae. The center fish is Dormilon (Hoplias malabaricus) Family Erythrinidae. The latter species does not enter the commercial catch.

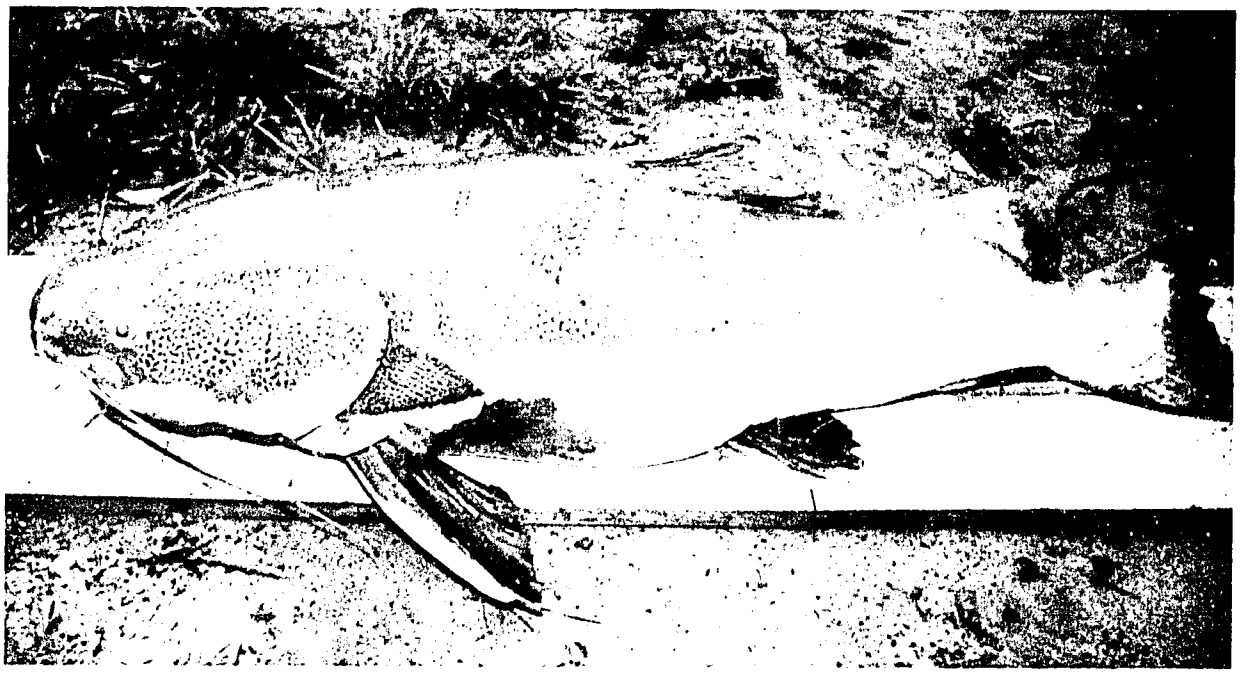
La Sierra Cagona (__?___) Family Doradidae



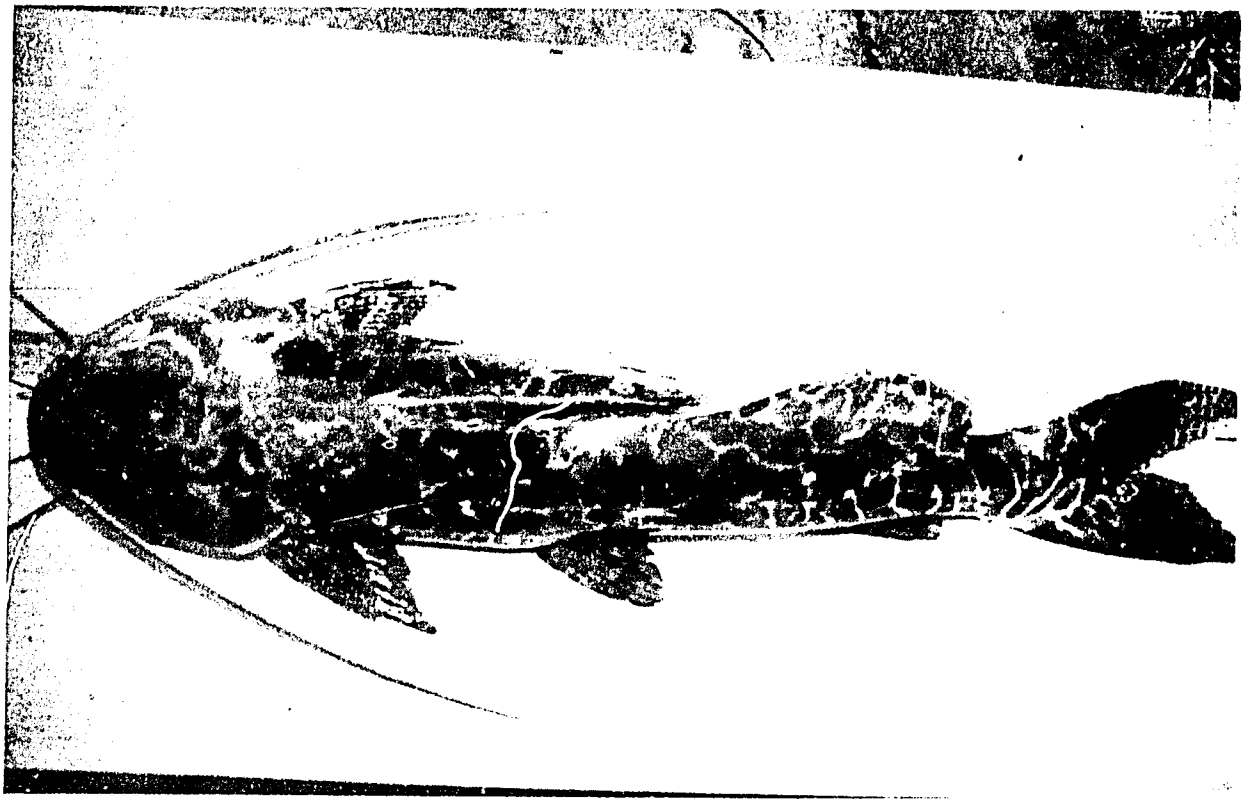
La Sieria Copora (*Oxydoras niger*) Family Doradidae



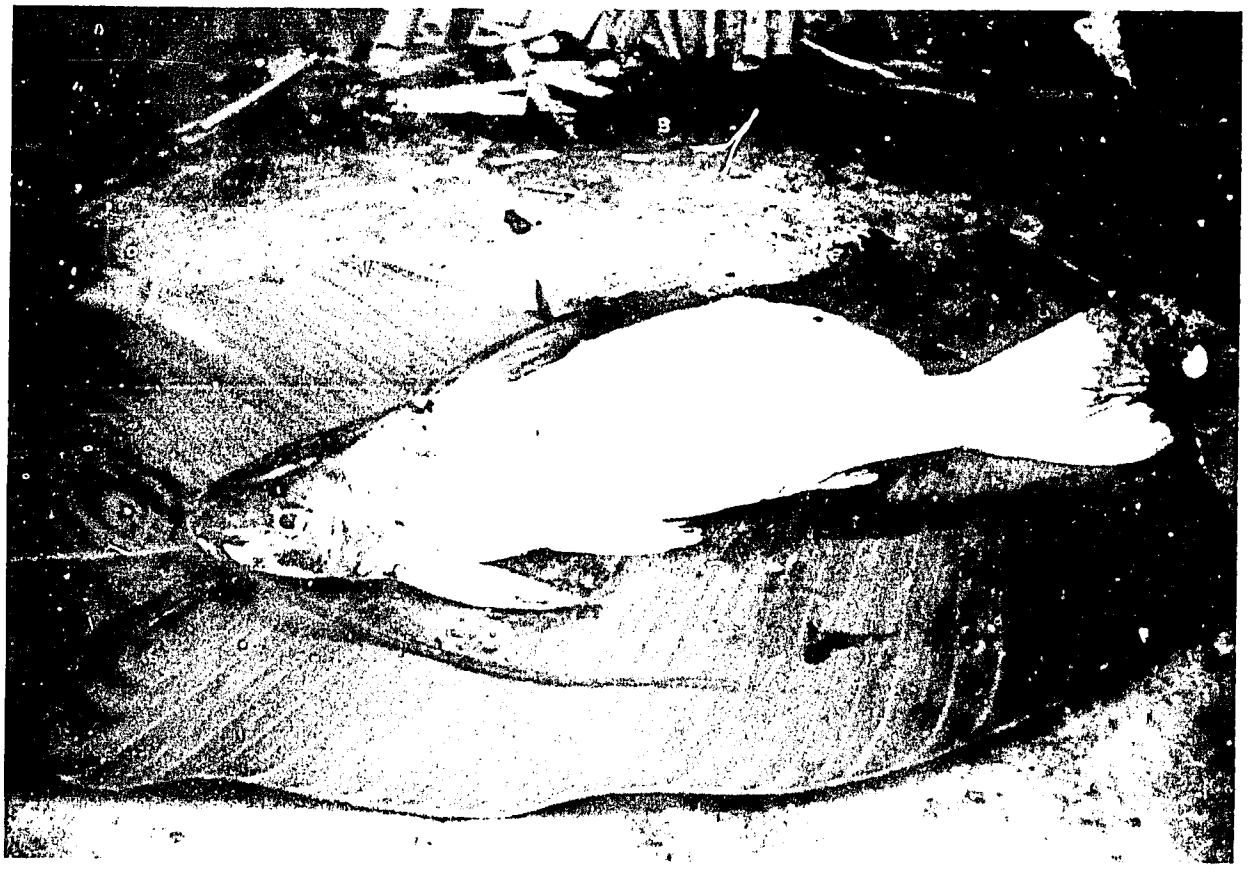
El Paleton (Sorubimichthys planiceps) Family Pimelodidae



El Cajaro (Phractocephalus hemiliopterus) Family Pimelodidae



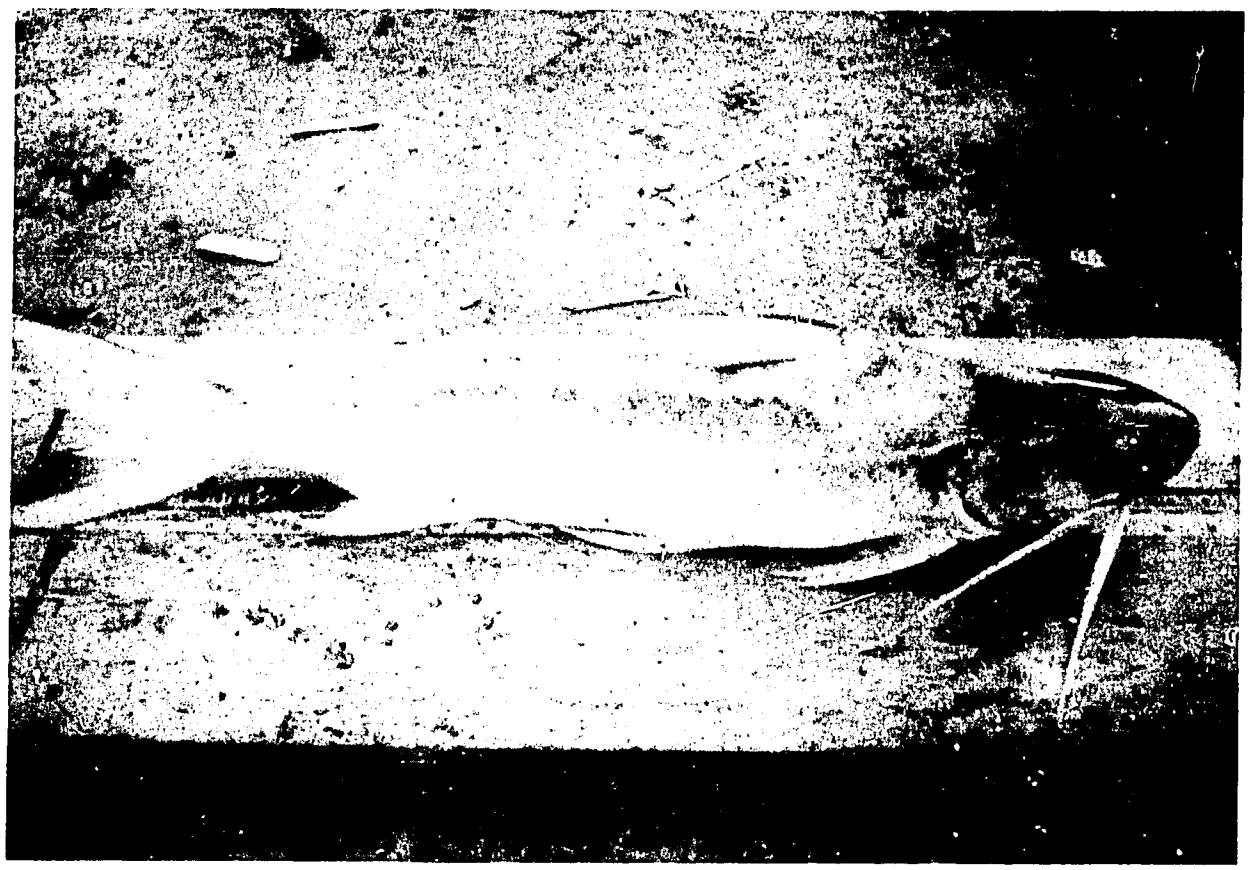
El Yaque (Sciates marmorates) Family Pimelodidae



El Barbiancho (Pinirampus pinirampu) Family Pimeodidae

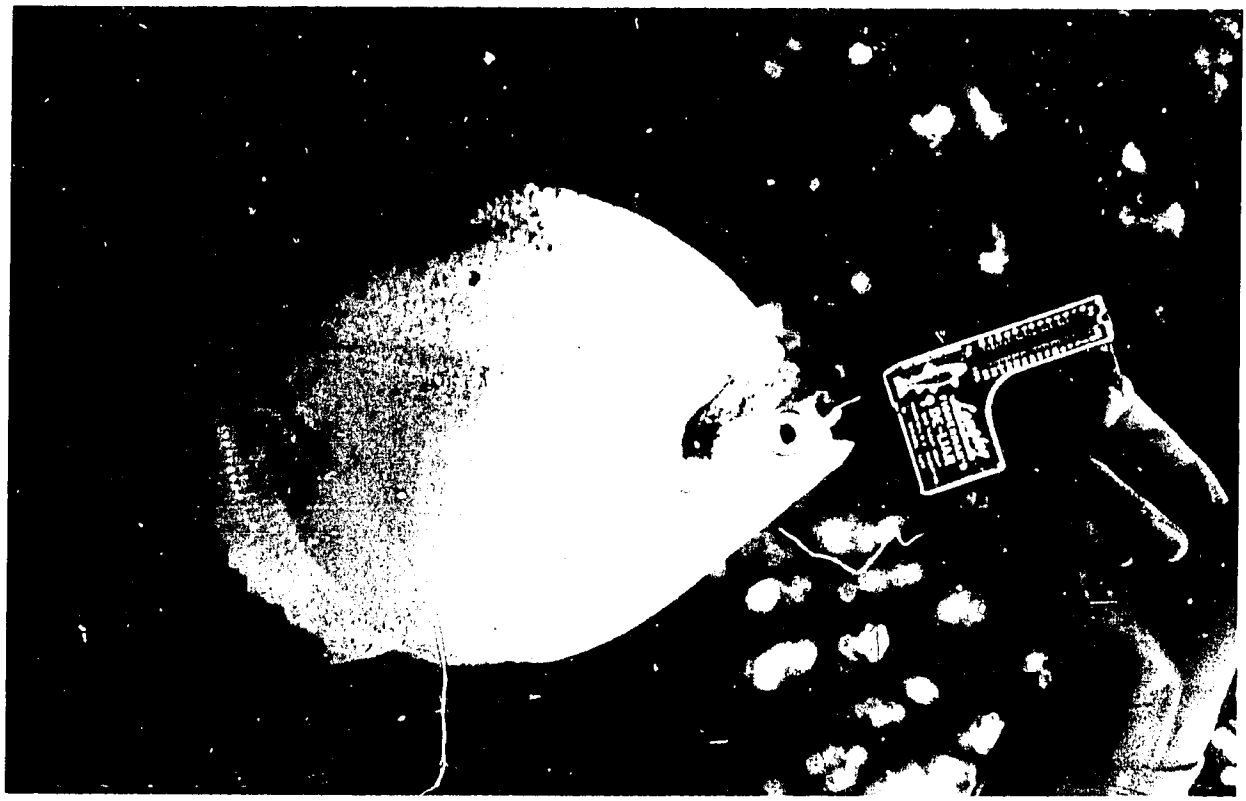
El Apuy (Brachyplatystoma juruense) Family Pimelodidae
(Note the long caudal filaments)

Mapurito o Camagente (Callophysus macropterus)
Family Pimelodidae



El Tigrito (*Paulicia lutkeni*) Family Pimelodidae

El Chancleto o Boca Sin Hueso (Ageneiosus sp.) Family Ageneiosidae

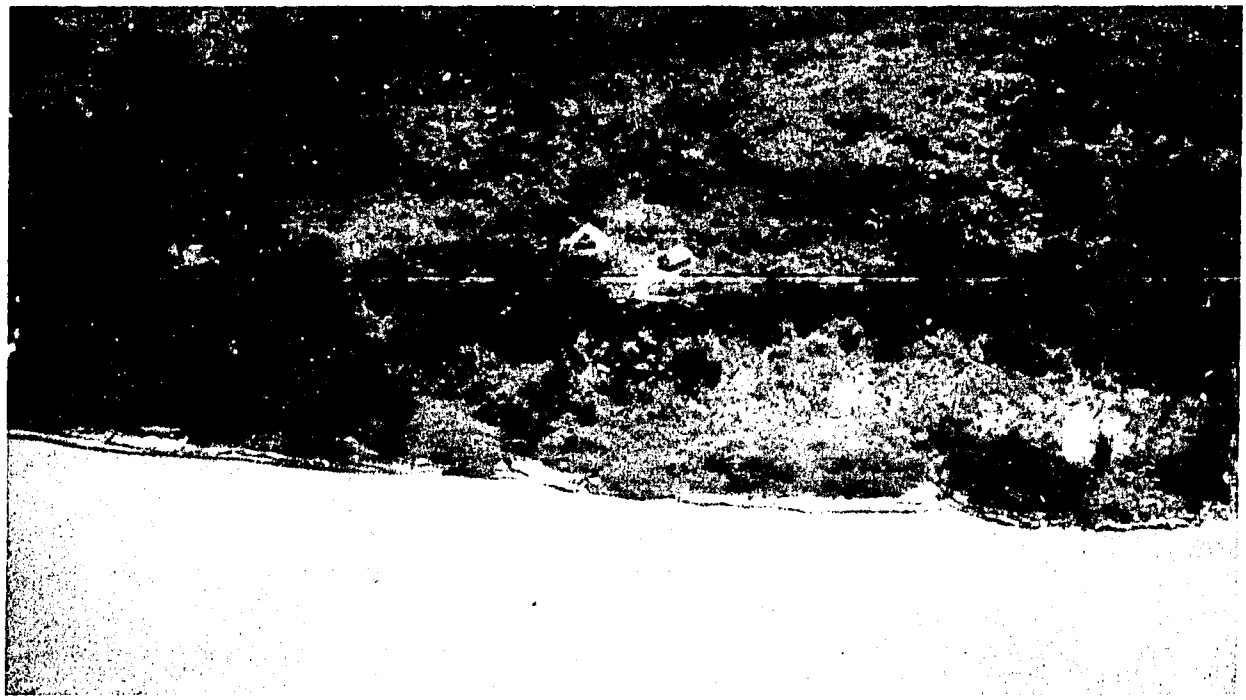


La Palometa (Mylossoma duriventris) Family Characidae

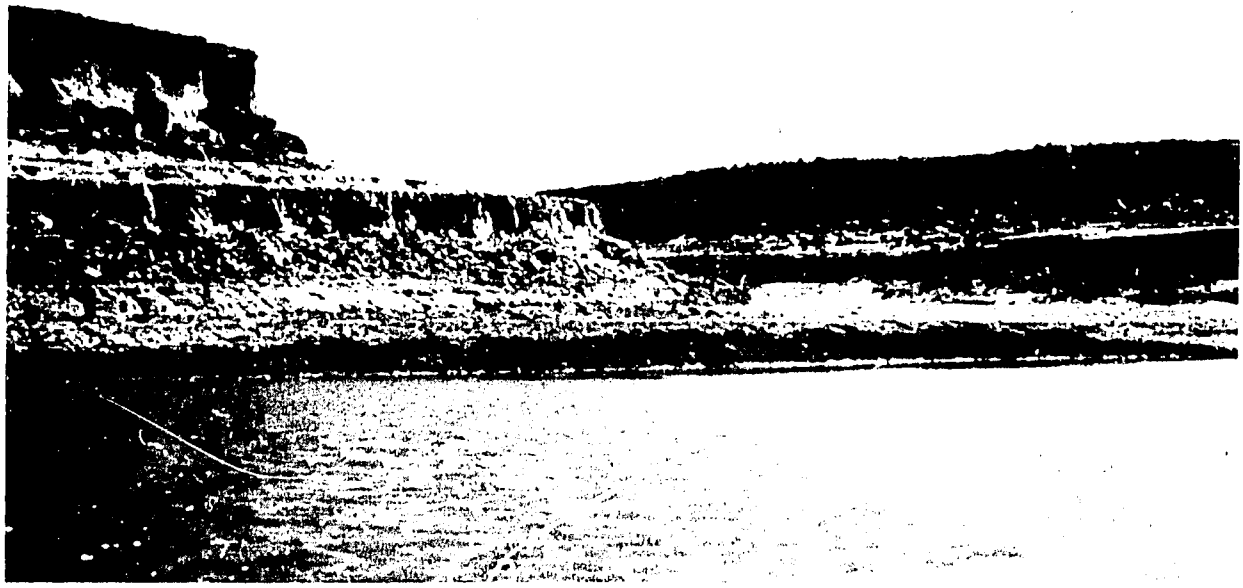
6.7 A pictòral description of the Upper Meta River and its food-fish fishery

Most Eastern Plains rivers originate in the Andes Mountains
La gran mayoria de los rios de los llanos Orientales se Originan en la Cordillera Oriental.

The Meta River during high water season at Puerto Guadalupe, near the center of the Upper Meta River study area. River width is about 300 meters.
El rio Meta durante la epoca de aguas altas en Puerto Guadalupe. El ancho del rio es de 300 mts aproximadamente.



The southern shore of the Meta River is generally elevated, thus limiting flood plain formation.
La orilla sur del rio Meta presenta, generalmente, elevaciones que limitan la formacion de inundaciones en los llanos.

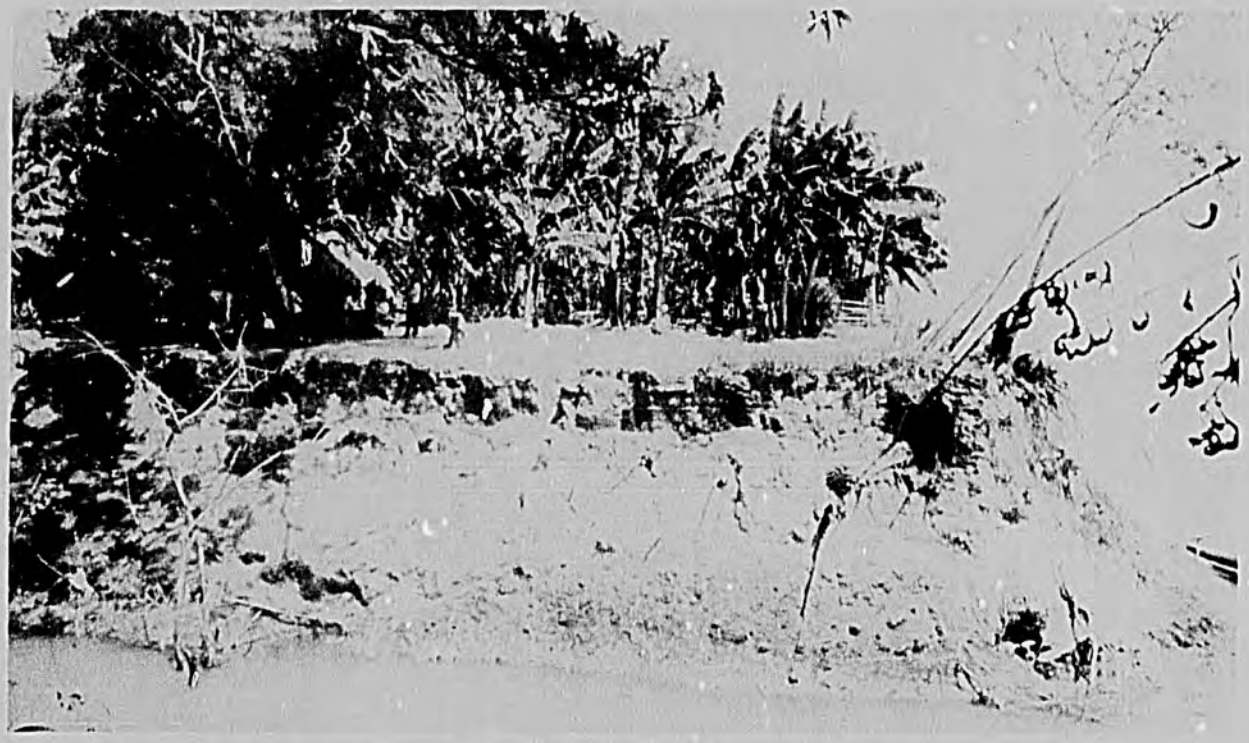


During the dry season, the aquatic system is reduced to narrow river channels and isolated lagoons.
Durante la estacion seca, el sistema acuatico es reducido a rios angostos, arroyos y Lagunas apartadas.

Small oxbow lagoons are common along the Manacacias and Yucao Rivers, tributaries of the Meta River.
Pequenas lagunas se forman comunmente a lo largo de los rios Manacacias y Yucao, los cuales son tributarios del rio Meta.

During the high water season, rivers and lagoons are connected by channels called canos.
Durante la epoca de las aguas altas, los rios y lagunas estan conectadas por canales llamados canos.

During the high water season, elevated shoreline, suitable for home sites is limited (Photo from June 1977)
Durante la epoca de aguas altas, los sitios disponibles para vivienda, en las orillas del rio, son escasos (Foto tomada en junio 1977)



In the low water season, river depth is reduced by as much as five meters from high water levels. (Photo from March 1978) Note that both photos are of the same riverside home.
En la epoca de aguas bajas el nivel del rio baja hasta cinco metros del nivel alcansado en la epoca de aguas atlas. (Foto tomada en Marzo de 1978). Notese que ameas. Fotos pertenecen al mismo sitio.

Bagre Rayado is the most common fish in the Upper Meta River fishery, and is an important part of the catch during all seasons.
El bagre rayado es el pez mas comun en la pesqueria del alto Meta, y su captura es un renglon importante en todas las estaciones.

Fish transporters arrive at ports between 6:00 and 8:00 a.m. Fish are rapidly sold to intermediaries who then either sell the fish to the public, store it on ice or truck it to larger markets in Villavicencio or Bogota.
Los tranportadores de peces llegan a los puertos entre las 6:00 y las 8:00 a.m. Los peces son vendidos rapidamente por los intermediarios, a otros intermediarios que lo venden en los mercados de Villavicencio o Bogota.

The municipality of Puerto Lopez has provided a large ceramic-topped table, protected against sun and rain to facilitate wholesale fish marketing.
El municipio de Pto Lopez esta proveido de ona mesa de baldocin, protegida de la llovia, para facilitar la venta del pescado.

INDERENA biologist and assistants record lengths and weights of fish in the commercial catch at Puerto Lopez. Species composition and length-frequency distribution are determined from these data.
Biologos del INDERENA y assistentes recolectan datos de longitud y peso de los peces, que se venden en Puerto. Lopez. La composicion de especies, distribucion y longitud de frecuencia son determinados de estos datos.

Fish transporters also carry people and farm products to ports. On return trips they carry manufactured qood requested by fishermen.
These varied services increase the probability that costs associated with opertaion of a motorized boat can be made.
Los transportadores de peces tambien llevan gente y productos agricolas.

Upper Meta River food-fish are also sought after by a growing family of sport fishermen. The large size of many Meta River fishes make this sport especially exciting.
En elalto Meta los peces de consumo tambien son solicitados en la pesca deportiva. La gran tamana de los peces hace este deporte mas excitante.