ISLAMIC REPUBLIC OF MAURITANIA

Honor — Fraternity — Justice

Ministry of Economy and Finance

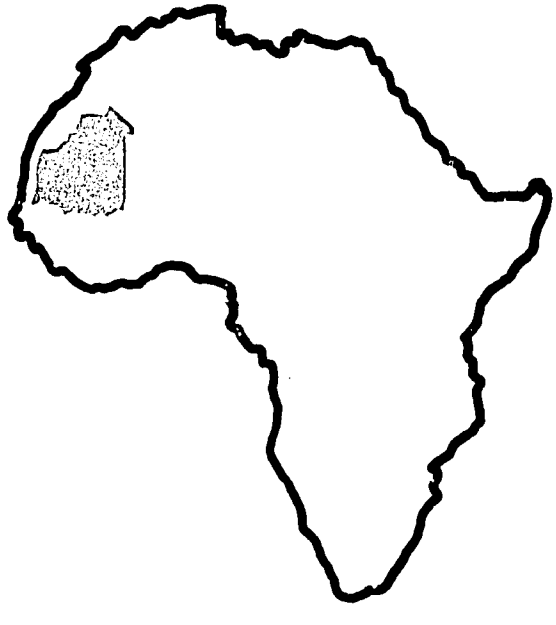
Directorate of Studies and Programming

RAMS PROJECT

Rural Assessment and Manpower Surveys

Inland Fisheries

SS-5



Financed by the U.S. Agency for International Development (USAID)

With the cooperation of:

Checchi and Company, Washington, D.C. 20036
Louis Berger International, Inc., East Orange, New Jersey 07019
Action Programs International, Santa Monica, California 90406

Table of Contents

		Page
1.	Summary and Conclusions	1
2.	Methodology	4
3.	Potentials	5
	- Abiotic Environment	5
	- Biotic Environment	19
4.	- Migrations	25
	- Reproduction	31
	- Growth and Survival of the Young	33
4.	Analysis of Production	41
	- Traditional Fisheries Services	42
	- Fishing Areas in Mauritania	48
5.	Analysis of Demand	48
6.	Policy Guidelines for the Future	52
	- Recommendations - Guidelines for Improvement	53
	- Projections to the Year 2000	57
	- Policy Guidelines	61
7.	Recommendations	62
	- Guidelines	65
	- Rationalization of Fisheries	74
	- After Completion of Development Projects	80
8.	Appendixes	
	- A. Cost Analysis of Production in Inland Fisheries	95
	- B. The Possibilities of Combining Pisciculture with Rice Growing	105
	- C. The Integrated Development Project at Paliba	109
9.	Bibliography	112

1. Summary and Conclusions

This report concerns inland fisheries along the Mauritanian bank of the Senegal River, where some 2,600 fishermen work. (The 2,362 fishermen counted in the 1977 census seem to represent a partial count.) The main characteristics of inland fisheries are that:

a) Potential catches depend upon ecological conditions and particularly on rainfall and fluctuate from one year to another. A 600,000 hectare floodplain stretches from Bakel to Dagana; another 400,000 hectares of salty soil constitute the floodplain below Rosso. Mauritania owns the third of the floodplain which lies on the right bank of the river in the valley proper and in the Delta.

The irregularity of the flow of the river varies significantly from year to year. This is due to the irregularity of rainfall in the Foula-Djalon in Guinea and can affect the area flooded which may vary from 20,000 ha. over a period of about 20 days to 600,000 ha. over a period of about 120 days. The flow of water varies between 1 and 5 (230 m^3/s in 1972 and 1,241 m^3/s in 1974).

Furthermore, the water is tetraionic, a sulphorous, achloric and has a very low mineral content, especially in Ca. One consequence of the chemical characteristics of the water is its low productivity.

b) There appear to be an adequate number of fishermen; they seem to be competent and well-equipped. Actual catches equal potential catches and sometimes over-fishing occurs.

The "shore seine" is the most commonly used type of fishing equipment and is a sign of advanced technical ability. Indeed, the use of this net indicates that the owner is able to take calculated risks and has access to substantial financial resources; it also requires leadership qualities on the part of the team captain who directs the group of fishermen who use this seine net.

River fishing is a semi-capitalistic enterprise involving the owner of the equipment and the team captain.

River fishing is also characterized by a significant level of competence on the part of the fishermen and an absence of financial bottlenecks; the overall number of canoes (1,100 on the Mauritanian bank) appears to be adequate.

Production is stimulated by a constant level of fairly high monetized demand.

c) Demand in the River Valley alone is high enough to absorb the entire volume of production without being satiated.

There is a high level of demand for fish because fish plays a central role in the food habits of the Senegal River Valley: fish is normally eaten 6 days a week. Effective demand on the Mauritanian bank varies between 7,000 and 9,000 tons a year. This demand is distributed in linear fashion along the river and corresponds to the extent of distribution.

On the other hand, the price of fish is elastic and varies according to supply and demand conditions. The value of production can reach 200 x 10^6 UM/year.

Given these demand conditions there is a tendency to overfish and there is often a lack of fish in regional markets in years of unfavorable hydraulic conditions.

d) The hydraulic development projects in the Senegal River basin will upset the natural order; fish production in the Upper Delta and at Kaedi will be increased (Diama and Gorgol projects) but will be decreased elsewhere unless positive steps are taken to correct the situation.

The retention and barrier dams (Manantali, Galougo, Gourbassi and Diama) will increase fish resources upstream and diminish them downstream. However, the

creation of Natural Development Units (N.D.U.'s) in the high water bed, which will make irrigated agriculture possible, will reduce potential catches in the river. Thus, each hectare of land that is taken away from the area that is naturally reached by the flood means that 60 kg loss of fish.

Without an adequate policy, production, employment and income will decrease.

e) Such a policy would shift inland fisheries from a natural to a controlled milieu. A comparison of potential production and demand shows that in order to improve the situation and re-establish an equilibrium of production and demand without an immediate ecological catastrophe would involve two types of policies:

-- Protection of the natural fish population and elimination of the risks of disequilibrium in the ecosystem.

-- Intensification of artificial production.

f) Measures to be taken in the context of a new policy on inland fisheries should focus on ways to protect natural stocks of fish and to rationalize production.

There must also be positive action in view of strengthening the supervision and administration of inland fisheries as well as to undertake research and training.

Ways of rationalizing fishing include the use of certain types of boats (in order to stop deforestation), restricting the use of "shore seine" nets to certain seasons of the year as well as regulating the size of the mesh. Furthermore, it is desirable to stock natural ponds with fish and to use irrigated fields for pisciculture.

g) A development plan for natural ponds provides for stocking one pond between 1980 and 1990 and two more between 1990 and the year 200. The creation of Natural

Development Units (irrigated agricultural projects) will involve improving 580 ha. between 1980 and 1990 and 3,500 ha. between 1990 and the year 2000.

Foreword

Because of the extreme aridity of the climate and the permeability of the soils which prevent any significant amount of run-off and therefore the formation of many permanent bodies of still or running water, inland fishing is limited to the southern part of Mauritania.

Thus, inland fisheries in Mauritania are all located:

-- essentially on the Senegal River itself;

-- in several residual but normally permanent ponds including

- the pond at Kankossa, on the Karakoro, a tributary of the Senegal, and

- the lake of Aleg, which is not connected to any larger body of water.

Because of its limited objectives, a lack of time and adequate documentation, this report will not treat fishing in the residual ponds. The far more important fisheries on the Senegal River are therefore the subject of this study.

2. Methodology

Fishing involves exploiting the natural environment. Its basic problem is reduced, in the final analysis, to harmonizing three inter-related factors:

-- potential, or the tonnage produced by the ecosystem;

-- production, or the tonnage actually extracted by fishing;

-- demand, or the tonnage required to satisfy the needs of consumers.

A comparison of the three factors leads to a diagnosis which can take the following forms:

-- potential	production	: under-exploitation of the stock
		: balanced exploitation
		: over-exploitation
-- production	demand	: over-supply of markets
		: adequate supply of markets
		: under-supply of markets.

The first factor is an ecological one, the second is both an ecological and an anthropic one and the third is a purely anthropic one.

3. Potentials

3.1 Research on Potentials

"Potentials" is an exclussively ecological problem, a function of a group of parameters which fall into 2 broad categories: abiotic factors on one hand and biotic factor on the other hand.

Certain parameters are by nature quite obvious: for example, the amount of land that is flooded, the physical and chemical basis of the trophic chain as well as the level of eco-biological equilibrium. Other parameters are less evident. All will be dealt with, however, because sound balanced management of a natural resource presupposes an understanding of the deepest factors which condition its ultimate potentials.

Abiotic Environment:	geography, climate, geology, hydrometry organic chemistry.
Biotic Environment:	
Biotic Environment:	vegetation, Ichthyobiology.

3.2 The Abiotic Environment

The Senegal is the second longest river in West Africa. It is both the western-most and northern-most river as well. Its bassin covers ± 340,000 km^2 between 10 degrees and 18 degrees north

latitude and longitudes 7 and 12 west of Greenwich. Its maximum length is 1,800 km between its sources in the Fouta Djalon and its mouth at Saint-Louis, Senegal.

The Senegal is actually made up of 3 large rivers: the Bafing, the Bakoye-Baoule and the Faleme. The Senegal River proper begins at the confluence of the first two at Bafoulabe.

Although there is a number of factors among which length and width play a major role, it is possible to distinguish 3 main parts of the river valley:

- the Upper Valley, upstream from Kayes on the Senegal and upstream from Gourbassi on the Faleme.

- the Middle Valley, between these places and Dagana/Rosso.

- the Lower Valley, erroneously called the Delta, which lies below Dagana/Rosso.

The Middle and Lower Valleys are the only parts of concern to Mauritania. Nevertheless, it is in these areas that fishing is a major activity. For particular reasons the river has a wide flood plain in these areas:

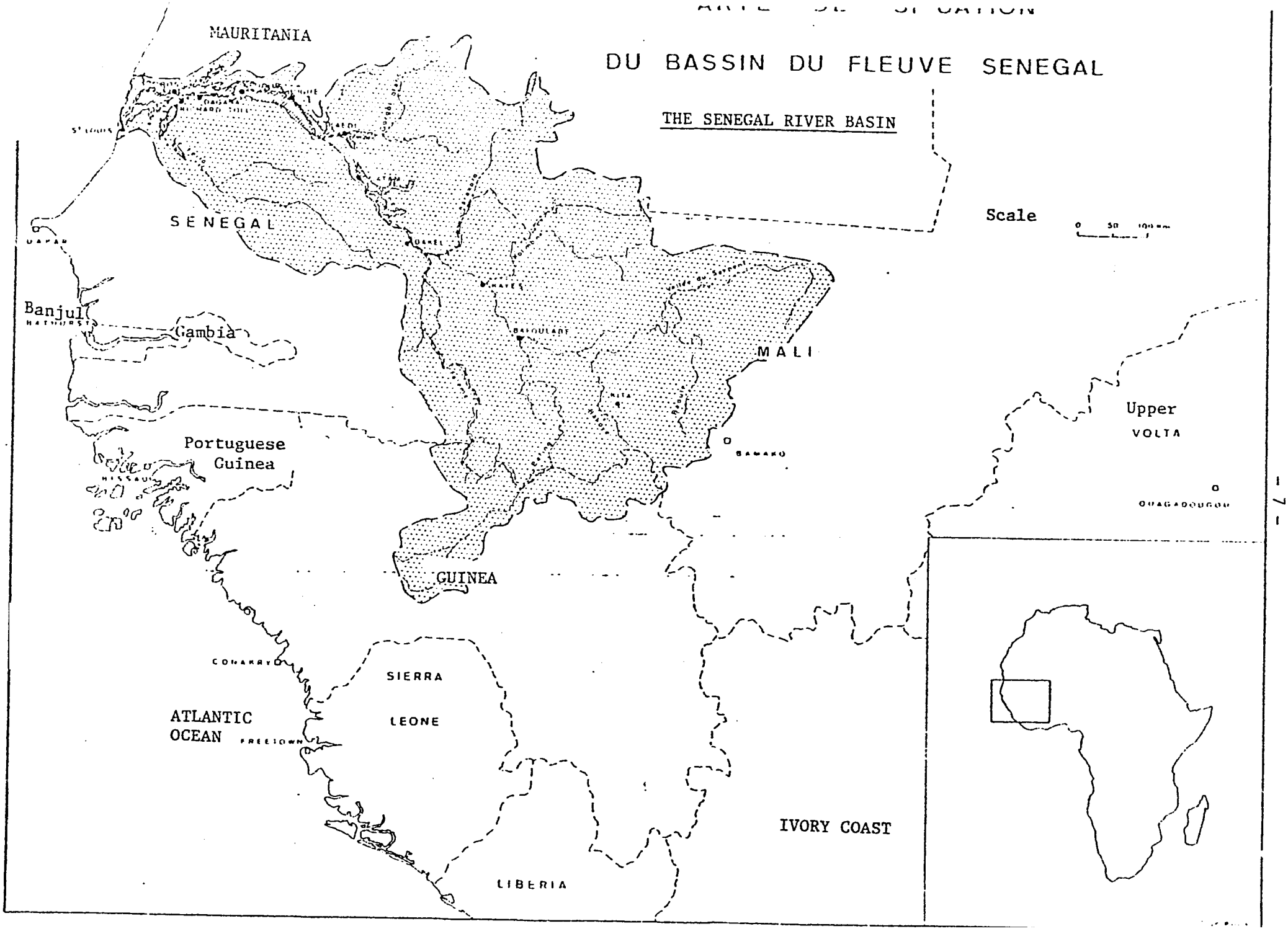
- 600,000 ha. of soft soil below Bakel-Dembancane can be flooded;

- 400,000 ha. of salty soil below Rosso can be flooded.

The river forms the boundary between Senegal and Mauritania in these two valley areas, and 1/3 of the total floodplain, which lies on the northern bank of the river, belongs to Mauritania.

- Down to Bakel, the Senegal has no high water bed and the flood waters remain confined in a single mean water bed whose banks rise 10 to 12 meters at low water. The river is about 400 meters wide at that point.

- Beginning at a point downstream from Bakel (more or less at Dembancane), there are considered to be three and even four essential parts of the river: the "Valley", the "Delta" and lakes "Guiers" and "Rkiz."


CARTE DE SITUATION
DU BASSIN DU FLEUVE SENEGAL
THE SENEGAL RIVER BASIN
Scale
0 50 100 km
MAURITANIA
SENEGAL
Banjul
Gambia
Portuguese
Guinea
MALI
BAMAKO
Upper
VOLTA
OUAGADOUGOU
GUINEA
CONAKRY
SIERRA
LEONE
ATLANTIC
OCEAN
FREETOWN
LIBERIA
IVORY COAST

-- The "Valley": The Senegal changes form completely at Dembancané: its slope becomes almost imperceptible and it meanders widely; the valley widens out to 10 to 25 km. Of course the mean water bed remains hemmed in by strong high banks but beyond these banks lie hollows cut through by the remains of former bends like small inland deltas. The river sends out winding side-channels, some of which are as large as the main river bed itself; such as the Doue, which, together with the Senegal, surrounds the Island of Mortil; the whole floodplain covers some 600,000 ha. The river has a tortuous horizontal profile because of the permanent backwaters but it is possible to establish an acceptable description of the river by following its meanwater bed lying below banks that are permanently above the high water mark. The river's profile is as follows:

— the river bed itself, which lies far below steep banks at low water,

— dune-levees along the river which may be submerged in places at times of very high water (fonde),

— annually flooded depressions (oualo), which are fed by intermittent backwaters (tiangol), which usually center around a permanent of a semi-permanent pond (vindou),

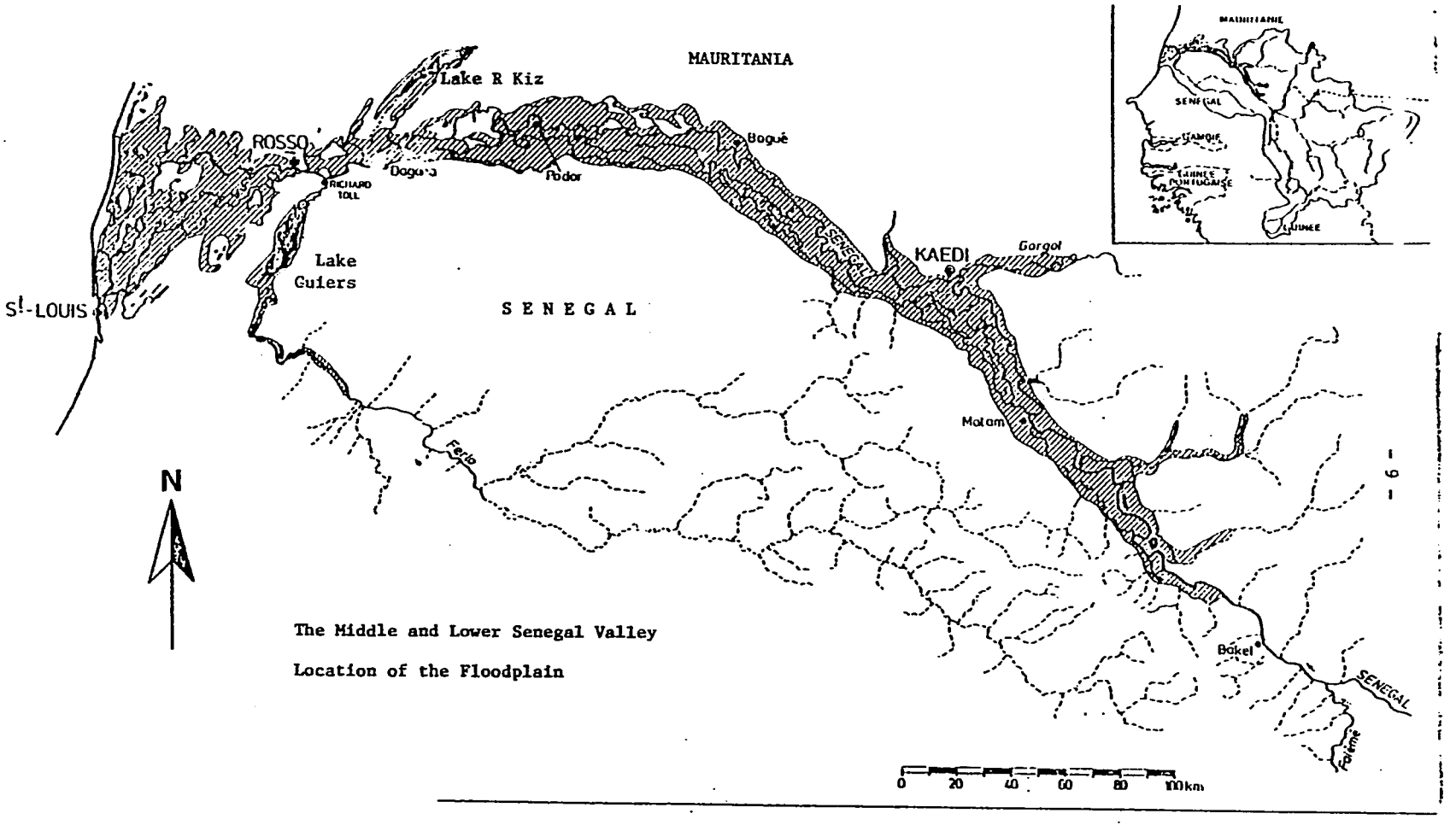
— The slope of the plateau, which is never flooded (dieri).

At low water the main river bed is criss-crossed by fordable sills as far as Boghe, some 400 km. upstream from the mouth. Fifty-three of these sills have been identified as far as the falls of the Félou.

The "Delta": The Valley narrows sharply at Richard-Toll-Dagana and then widens out again. The river sends out backwaters or side-channels which are all re-absorbed before the ocean, giving this area the appearance of a "false delta". This area is especially flat but the classical elements of the river's horizontal profile are still discernible there.

Most of the soils in this region are salty (which is its peculiarity) as far as a point a bit upstream from Dagana. The Delta covers 400,000 ha.

"Lake Guiers" and "Lake Rkiz" : Two large stretches of water lie at the head of the delta: Lake Guiers, on the left (Senegalese) bank and Lake Rkiz on the right (Mauritanian) bank.

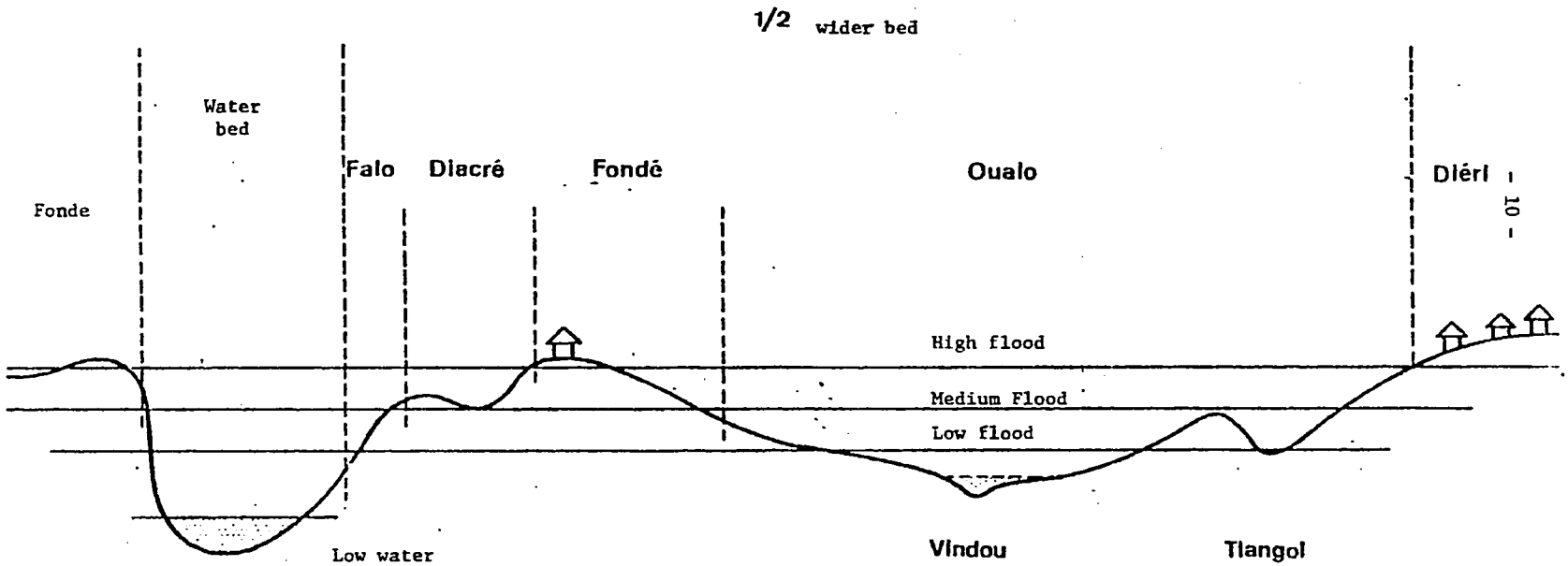


The Middle and Lower Senegal Valley

Location of the Floodplain

Cross-Section of the Valley near Podor showing the general profile

(Poular terms used)



(After J.L. Boutillier et al., 1968)

Lake Guiers is an elongated depression occupying the lower part of the fossil Ferlo River. It covers a maximum surface of 30,000 ha. and is about 80 km. long. Hydraulically, the lake is fed only from the Senegal River to which it is connected by a winding channel, the Tawey. The Tawey is thus a conveyance of water, rather than a tributary. Under normal conditions it brings water from the river to the lake at times of high water and it partially empties the lake into the river at times of low water.

Lake Rkiz is the counterpart of Lake Guiers on the right bank. Its natural hydraulic is similar although it has four channels leading out of it.

The geology of the basin is identical to that of the rest of West Africa; in the Upper Valley, the only area with sufficient rainfall to cause erosion, the geological make-up is essentially unsoluble rocks. As a result, the waters of the Senegal seem to have a low mineral content and their regime has little contrast.

The Senegal River basin lies within the tropical zone of the Northern Hemisphere, between 10 and 18 degrees of latitude, between the tropical and Saharan regions. It is therefore completely swept by the Intertropical Weather Front (I.W.F.)

Two factors govern its climate: the apparent movement of the sun and the movements of great air masses.

These last factors play a dominant role in the weather of the area which can be briefly described as follows:

1) There are three types of air masses that determine the different periods of weather:

   - the trade wind: this wind blows from the north-west brings cool air and relative humidity; it brings in the cool season.

   - the harmattan : this wind blows from the east and brings heat and dryness; it brings in the hot-dry season;

   - the monsoon : this wind blows from the south-west and brings both heat and rain; it brings in the hot-rainy season.

2) The relative proportions of these seasons vary from one location to another:

   - the farther west one goes, the more the trade wind dominates the harmattan and the longer the cool season; farthest reach: the sub-Canarian climate of Saint Louis.

   - the farther south one goes, the more the monsoon dominates the harmattan and the longer the rainy season; farthest reach: sub-equatorial climate of the Ivory Coast.

3) Because of its geographical position, Africa's climate is hot in all regions. Therefore, the essential climatic parameter is rainfall. The main dimensions of the climate are as follows:

   - there is only one rainy season per year in all parts of the Senegal River basin;

   - rainfall varies considerably from south (2,000 mm) to north (250 mm);

   - rainfall varies considerably from year to year; it is increasingly regular from south to north, corresponding to the diminishing average rainfall;

   - the floodplain of the Senegal receives an irregular rainfall that varies from 650 mm upstream to 300 at the mouth of the river.

This notion of irregularity is essential to understanding the problems of the Sahel and is better understood via a concept derived from hydrobiology: the flow of water.

The flow of water in the Senegal is of a tropical kind: it has a single annual season of high water and a high rate of flow; this season occurs between June/July and October/November.

These general characteristics are clearly marked starting at Bakel, at the confluence of the Senegal and the Faleme. These characteristics are entirely dependent on rainfall in the Fouta Djalon which make the Middle and Lower Senegal a typical allochtone river.

The extremes in the water-flow chart are striking: low-water levels are particularly evident - - the flow stops altogether in some years in the valley.

This is a result of the rock conditions of the Upper Valley and, of course, of rainfall conditions.

This rate of flow remains steady in volume in the Valley and the Delta, but the force of the flood waters diminishes on the one hand and is slightly delayed on the other.

Irregularity from year to year is considerable and is directly caused by irregular rains in the Fouta Djalon: the range (260 m^3/s in 1972 to 1,241 m^3/s in 1924). Furthermore, it seems that these water flow and rainfall deficits are periodic phenomena in the Sahel: 1860/ - 1890/1891 - 1910/1917 - 1970/1979.

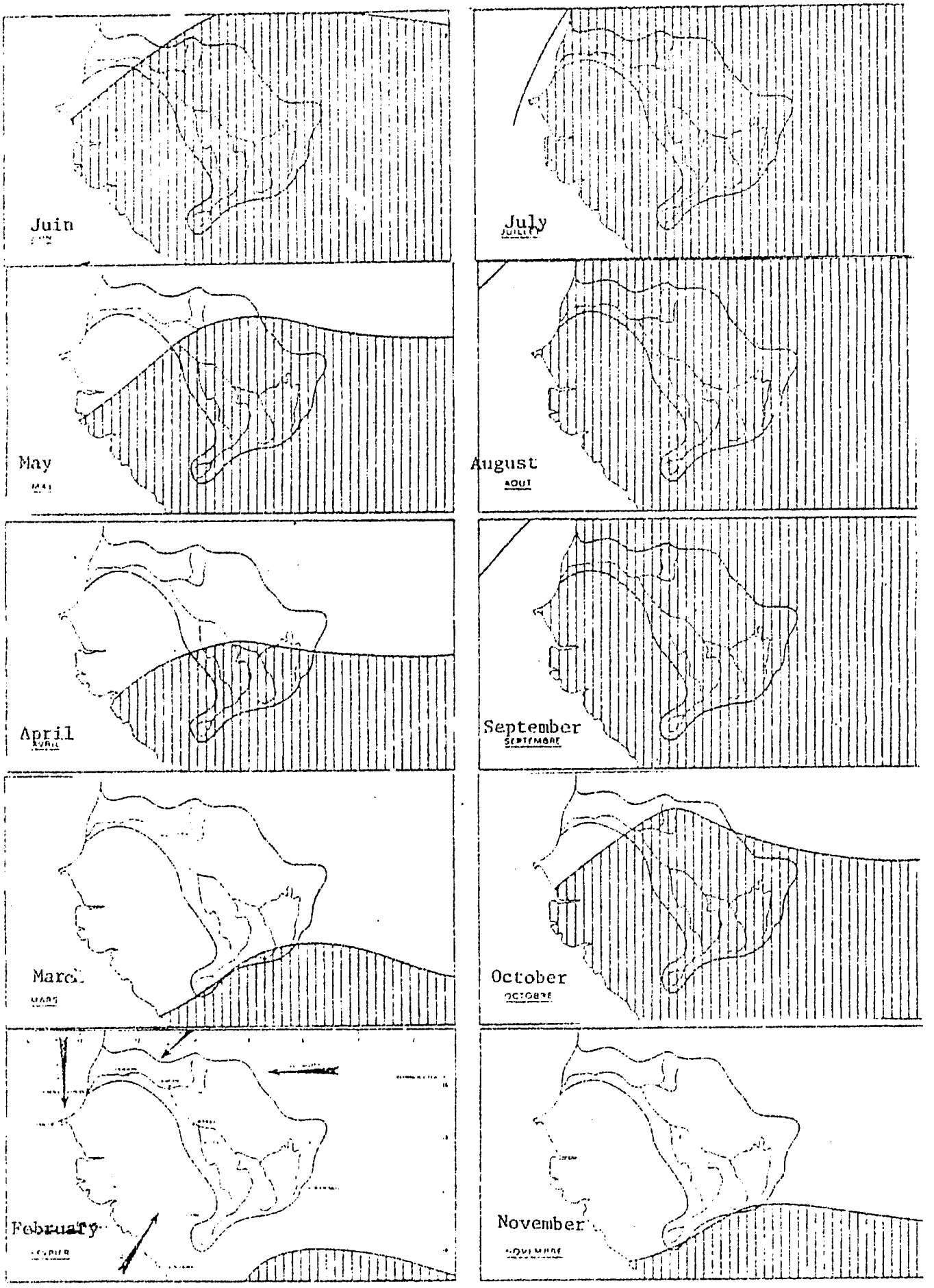
The most basic characteristics of the Middle and Lower reaches of the river is, of course, their potential flooding of high water bed of 600,000 ha. of soft soil between Bakel/Dembancane and Dagana, and of 400,000 ha. of salty soils in the Delta. The hydraulic irregularity affects the extent of flooded land in the valley, which varies between 20,000 ha. for about 20 days to 600,000 ha. for about 120 days.

Flooding is a complex phenomenon in the high water bed of the river because of its complex relief. Two factors must be mentioned:

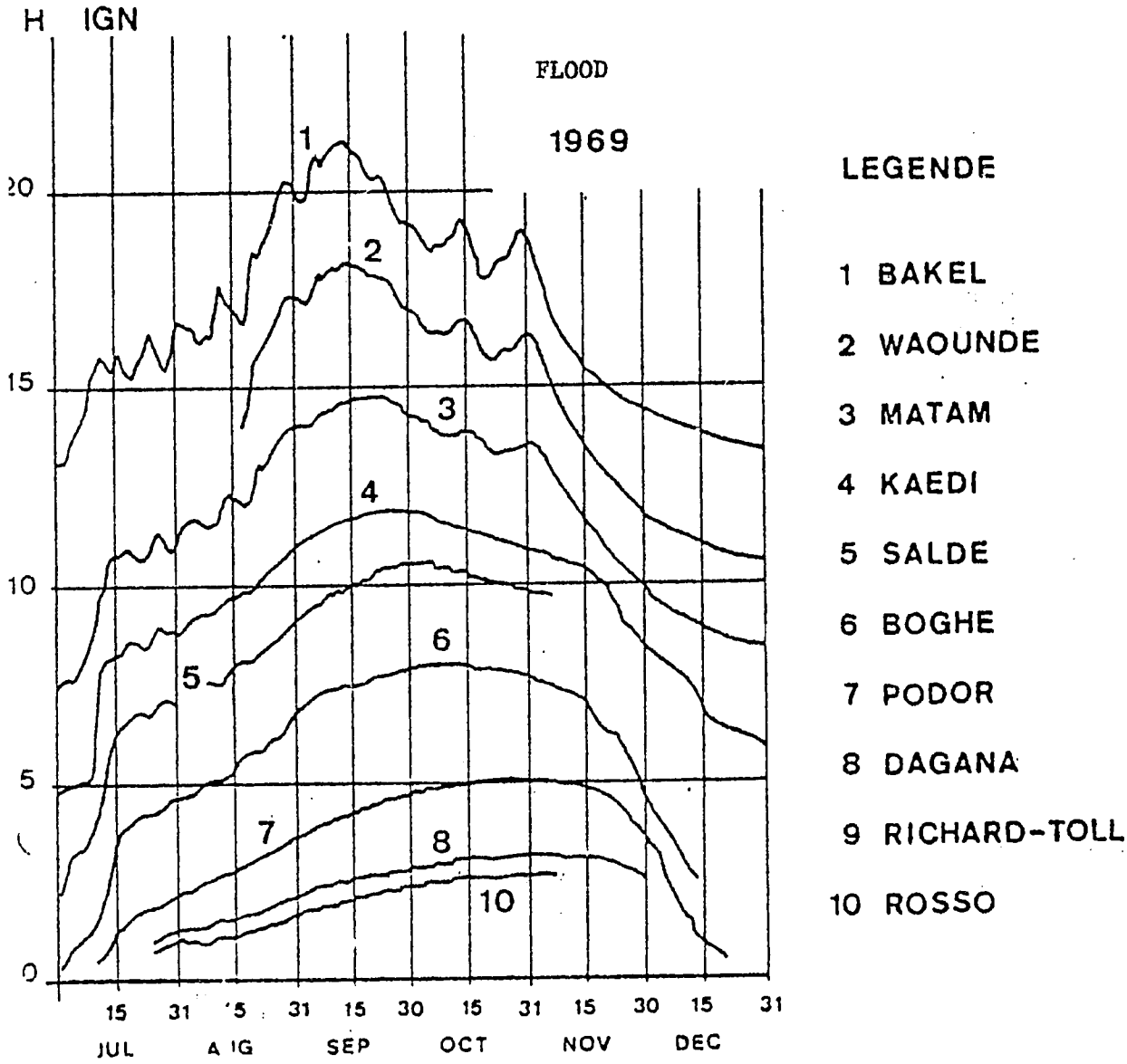
- on the one hand, the depressions remain dry as long as the flood does not reach the lowest point of the backwaters which feed them, which is why there is little flooding in years of hydraulic deficit;

- on the other hand, when the water recedes, each depression goes through three critical stages: emergence of the surrounding bank, individualization of the pond(s) that remain (s) and hydric independence of the ponds. The permanence of these residual ponds depends upon their depth at the time they become hydrically independent. Because of the rate of evaporation in the region, a pond must be more than 3 meters to remain permanent and there are few of these in the Senegal Valley.

Annual Cyclical Movement of the Inter-Tropical Weather Front in the Senegal River Basin



Evolution of the Flood of 1969 in the Valley and the Delta of the Senegal River



EVOLUTION DE LA CRUE 1969 DANS LA VALLEE ET LE DELTA DU SENEGAL

- The ratio of areas still inundated in periods of low water (the mean water bed of the river plus permanent ponds) and those inundated during the flood is 11%.

It must be mentioned that the flow during low water is so reduced as to produce non-inundated areas the most important of which are at Boghe, Cascas, and Dioulde-Diabe, in the downstream reaches.

The most important characteristics of the Delta besides the flooding of salty soils is the intrusion of salt water into the mean water bed during low water, which is firstly function of the flow of water and secondly a function of the time when the intrusion of salt water itself occurs once the flood waters have receded. This phenomenon therefore varies from year to year and its general characteristics are as follows:

- maximum length reached :140 to 210 km,
- duration :8 to 10 months,
- period :10/01 - 11/30 to 07/10 - 08/15.

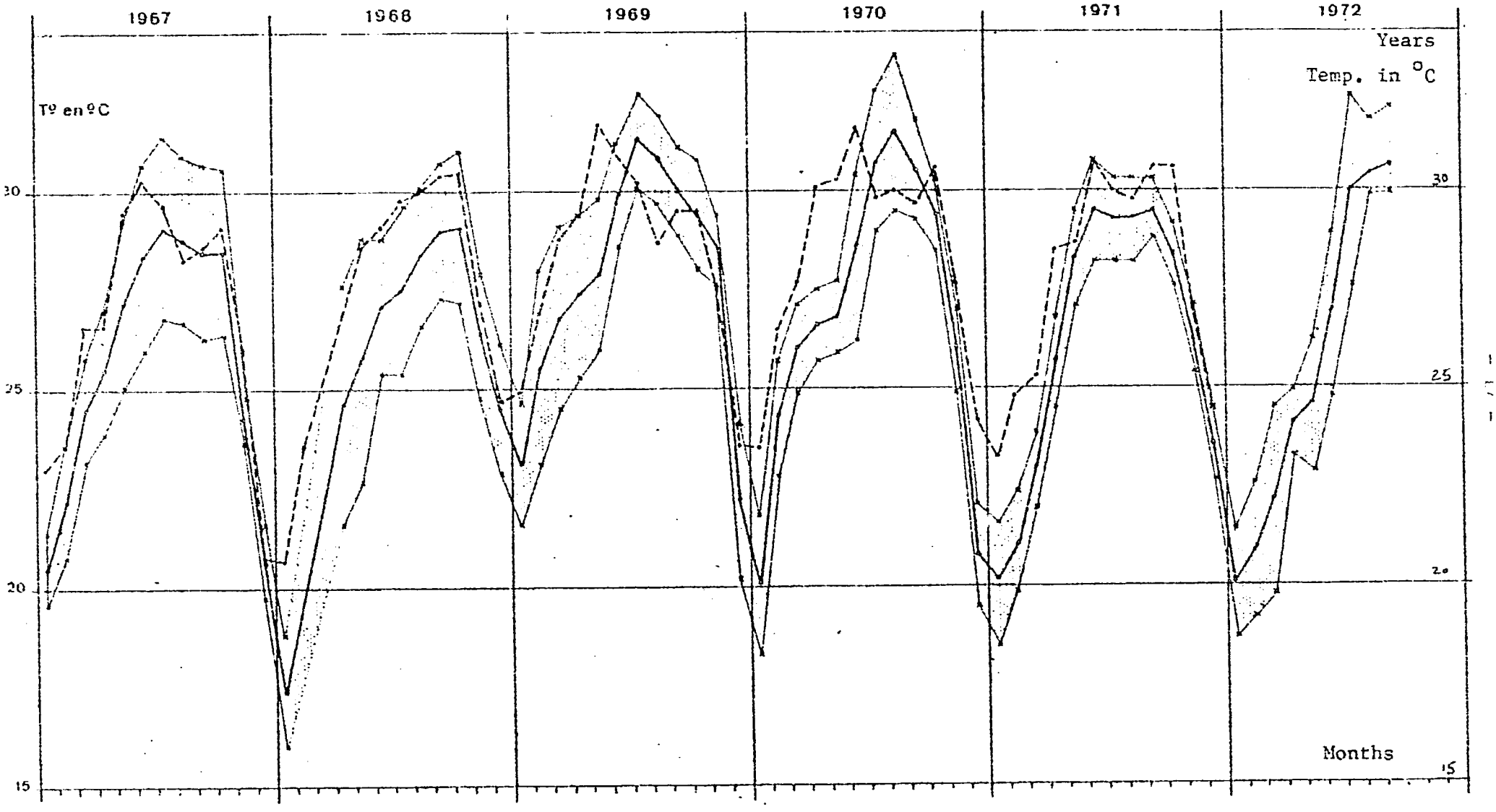
The overall range (maxima and minima) of water temperature, which are influenced by air temperatures, lies between 16 and 33 degrees C. The annual average is 21 degrees C. The average of 25 degrees is exceeded during a period of 7 1/2 months a year (April through November), whereas temperatures below 20 degrees are rarely registered (January). It is important to note that the period of maximum temperatures coincides almost exactly with the period when the high water bed is flooded, except in late November and early December.

The flow contains little in the way of solid particles: The Valley is not, therefore,"the gift of the Senegal" as Egypt was "the gift of the Nile" at least until the building of the Aswan Dam

The hydrochemical nature of the water is different in the Valley from the Delta:

In areas of the Valley, where there is fresh water year-round, the water in tetraionic, achloric and asulphurous; it therefore has a very low mineral content in general and a low calcium content

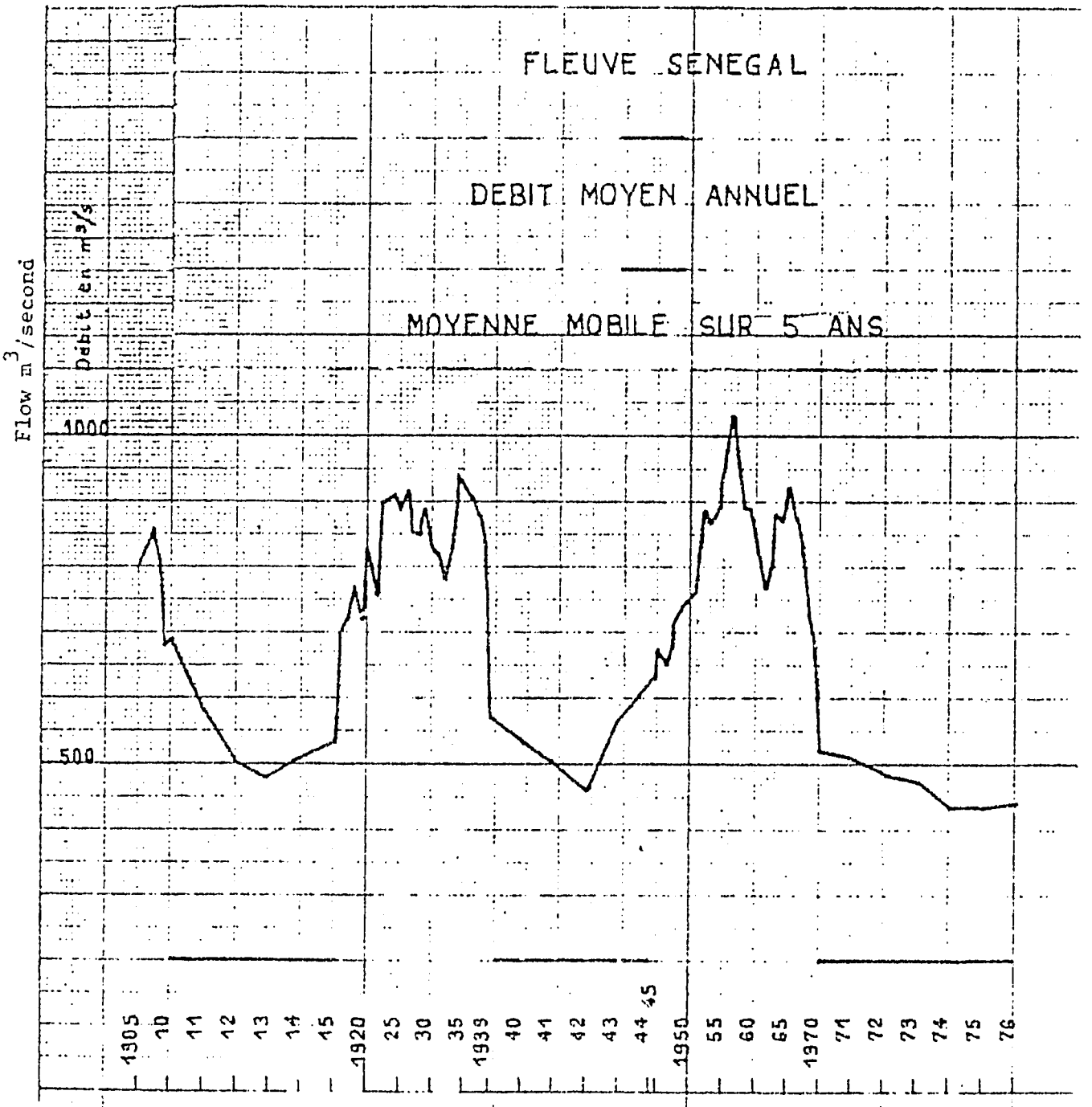
Variations in average monthly temperature over time



- aquatic: minimum, maximum and average
- air : average

Legend: aquatic minima and maxima
aquatic averages
air averages

SENEGAL RIVER - Average Annual Flow -- Changes in Average flow over 5 years



NOTA Las abscisses des SÉQUENCES SÈCHES SONT DILATÉES

N.B. The "abscisses of periods of dry years have been dilated

in particular, lacking C 1 and SO 4. This is a result of the environmental conditions in the Upper Valley (geology, rainfall and vegetation). The river water is consequently not very productive.

In the Delta, all types of water can come together over time and space as a result of the intrusion of salt water during low water. At high water, the water is typical river water, that is, tetraionic and of low mineral content, as far as the ocean. During low water, there is a gradient of decreasing salt content going from down to upstream, the sea water being of course hexaionic and highly mineralized and the fresh water being tetraionic.

- Thus, the unfavorable factors are:
  a very variable flooded area from one year to another,
  river water of low productive value,
  low water temperatures when the winter trade wind blows.
- One very favorable factor, on the other hand, is the coincidence of high water with high temperatures.

3.3 The Biotic Environment

The Senegal River basin includes three vegetation zones which are determined by rainfall : Guinean, in the south (more than 1,000 mm of rain); Sudanese as far as Bakel (1,000 to 500 mm); and Sahelian from that point on downstream.

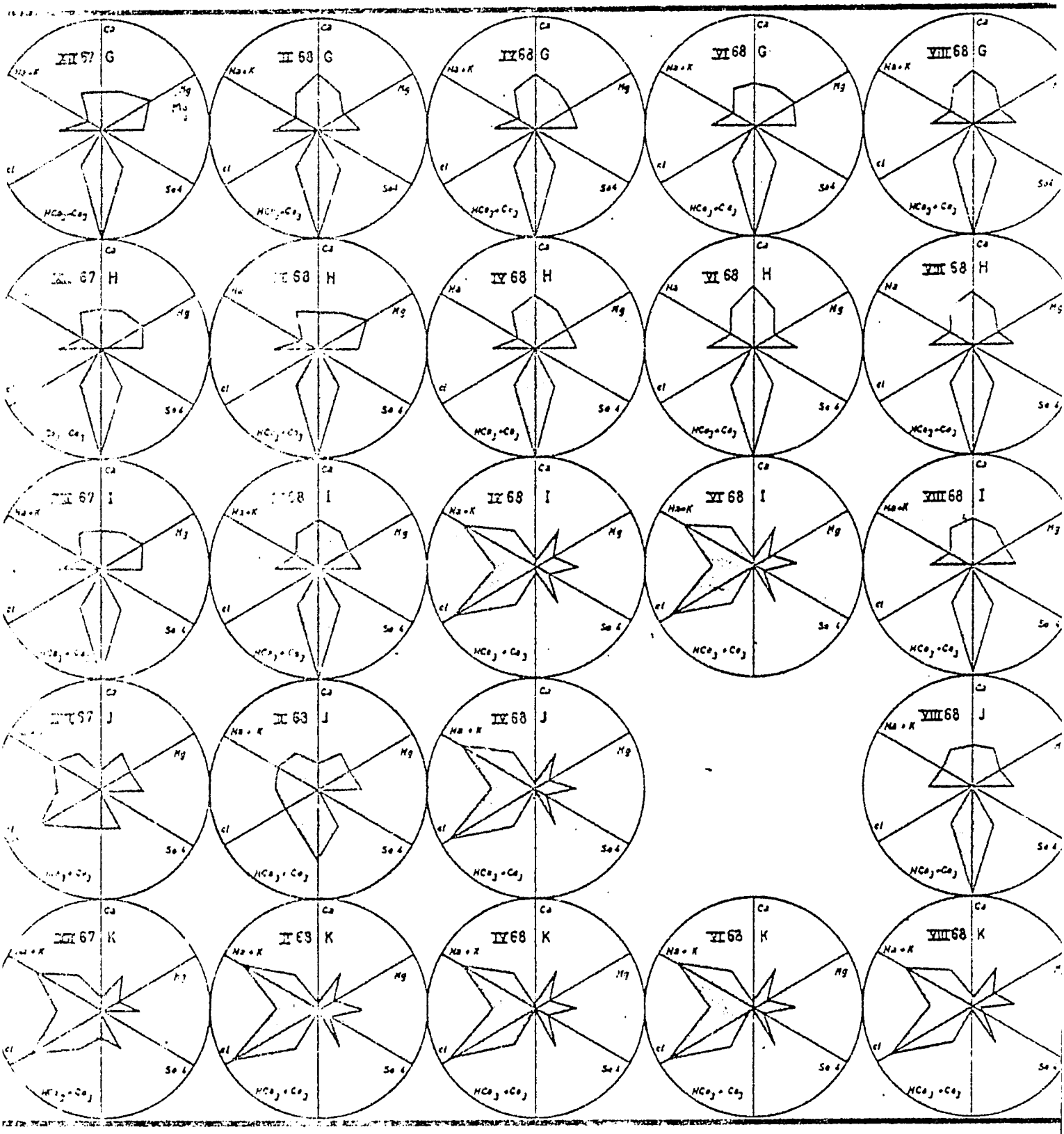
Although the Valley has a Sahelian bio-climate, there are other intervening factors, particularly the soil which is closely linked to relief and the extent and duration of submersion. In the Delta, however, the predominance of salty soils determines the presence of certain associations of vegetal species.

A transect of areas permanently above water lying in the mean water bed shows that there is a series of associated vegetation groups, either perennial or annual:

The three permanently inundated groups as well as the first group is exposed at low water are not influenced by the nature of the salinity of the soils. The dominant factors are depth and length of submersion. Associations in which Ceratophylum, Pistia, Nymphaea and Echinochloa dominate can be found in descending order of submersion.

Lower Reach of the River

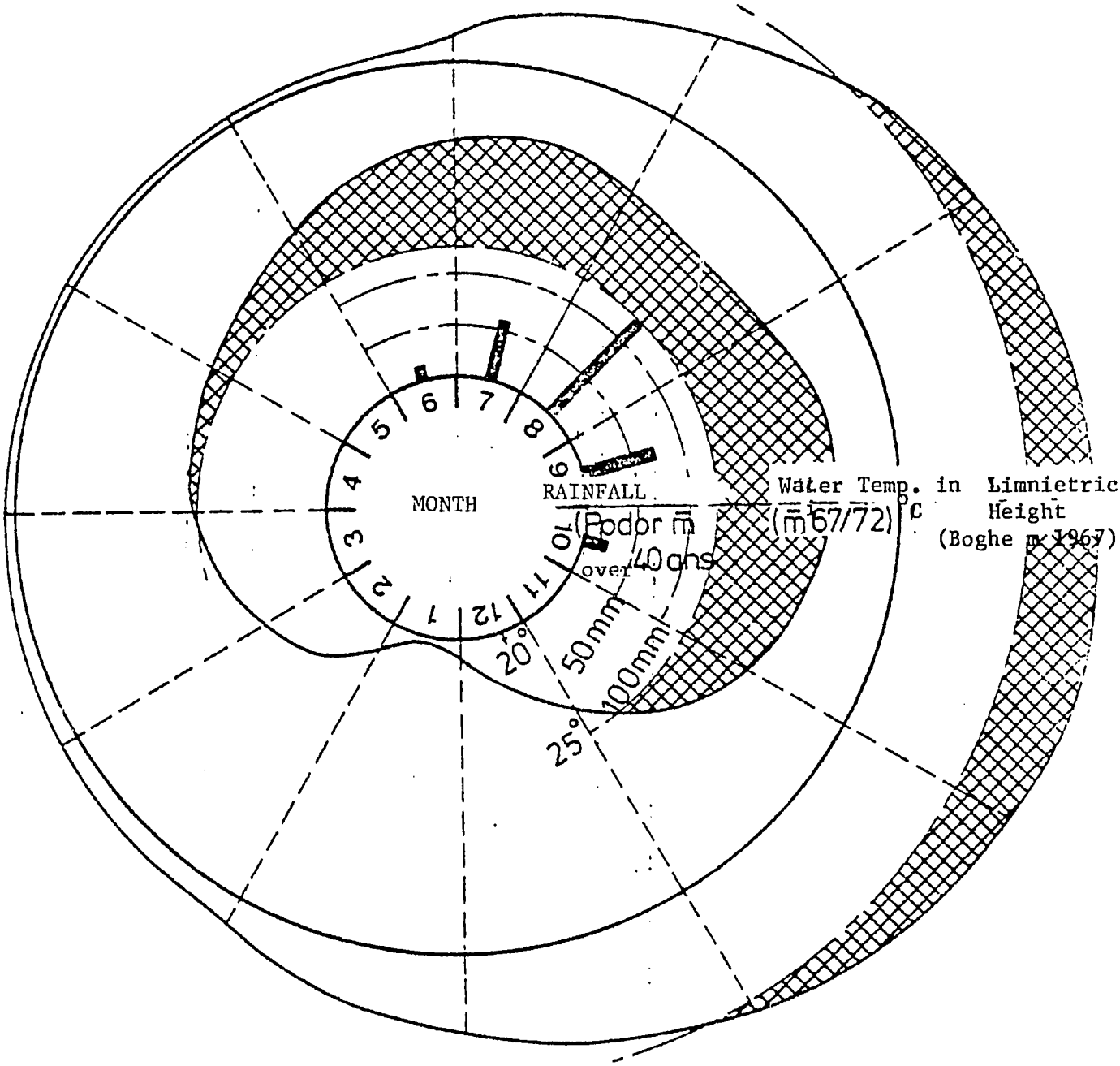
Variations in Ionic balance in time and space



FLEUVE : COURS INFERIEUR

Variations Spatio-temporelles de la balance ionique

Synoptic Graph showing the Cycle of the Main Abiotic Parameters



GRAPHIQUE SYNOPTIQUE CYCLIQUE DES PRINCIPAUX PARAMETRES ABIOTIQUES

Beyond this limit, types of associated vegetation vary according to whether there are heavy, light or salty soils. The consequences are:

- in light soils : Typha, Chrysopogon
- in heavy soils : Orysa, Acacia nilotica
- in salty soils : Phragmites, Sporobolus.

In areas above the reach of the highest waters soils with little or no salt content - - light soils by virtue of the pedological catena - - nourish the thorn scrub steppe of the regional Sahel in which Acacia seyal, raddiana and Balanites dominate. Salty soils support Tamarix in monophytic formation.

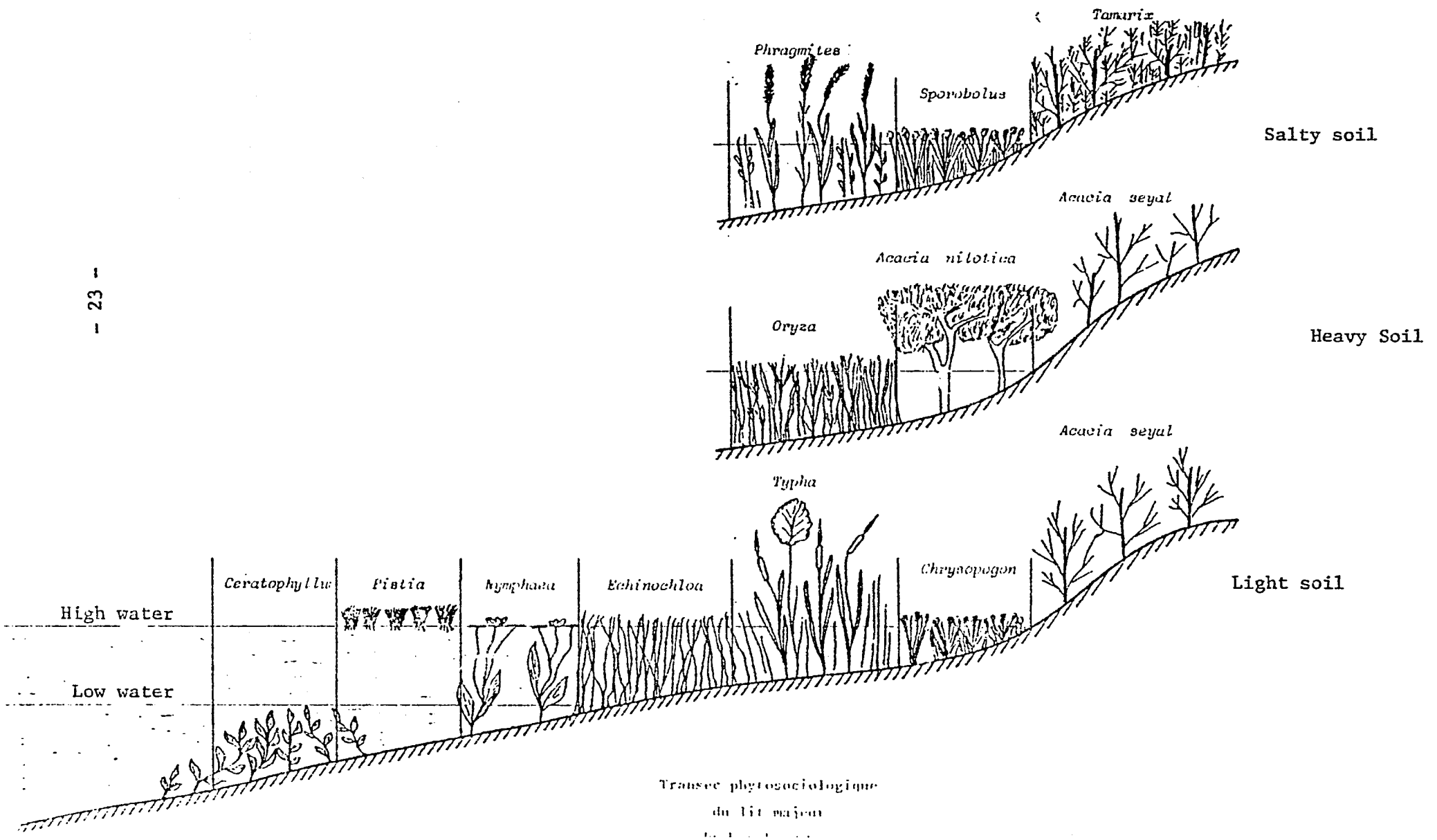
Some of these groupings are perennial: the gonakier groves, the typha groves, for example; other groupings are annual: echinochloaie groupings and the rice paddies. The former, which are significant because of their diverse possible uses, do not exist unless there is sufficient rainfall before flooding takes place. As a result of hydrometric conditions and the regional climate, the echinochloaie grouping has appeared only once in the Valley and twice in Lake Guiers between 1966 and 1972. This condition is reinforced by the ecological irregularity from year to year.

In terms of their usefulness to man, not all of these associated groups of vegetation have the same value.

- The herbaceous groups - - echinochloaie, oryzaie, sporobolaie and Vetiveraie exert a certain influence on the abiotic milieu: MICHAEL (1969) finds that they reduce the flow of water and slow down the spread of the flood. RIJKS (1972) notes a somewhat reduced thermal range in rice paddies.

- these are the most important plants in the domain of pisciculture: they provide food (directly or periphytonically), shelter (especially to the young) and places for reproduction (Gymnarchus, Heterotis, Polypterus).

Phyto-sociological Transect of the High Water bed of Lake Guiers



Transec phytosociologique
du lit majeur

- this vegetation constitutes excellent natural grazing areas for large terrestrial harbivores, especially at low water when the Sahelian praries have dried up. As a result, there is a transformation of the vegetal biomass brought about at high water by the fertilizing effect of the feces.

Unlike other river basins, the fauna of the Senegal have not been studied to any significant extent. There are thus several obscure points. However, the essential factors are known; 113 fresh water species have been definitely identified. The law of Arrhenius predicts 121, meaning that 8 species are yet to be discovered. The least explored areas are along the Upper Senegal, immdediately above the Felou and the Gouina Falls, as well as the lower reaches of the Bakoye and the Bafing. One can assume that the additional 8 species that are presumed to exist are to found here. The lack of knowledge of local fauna is significant in that the large regulatory dams to be built on the river are to be constructed in this region : Manantali, Galougo and Gourbassi. It is certain that a precise knowledge of fish life in the areas immediately upstream from the future dam sites is a prerequisite to any policy of developing fishing resources.

There are different groupings of associated fish species which correspond to the different ecological conditions of the river: there are mainly Sudanese species in the middle reach of the river and mainly Guinean species in the upper reaches. There is only one species which is unique to the Senegal: Tilapia zillii (GERVAIS, 1848). The large species exist only in the wide downstream reaches of the river: large Mormyridae, Characidae, Citharindae, Bagridae, Heterotis, Cymanarchus and Labeo are the commonest.

The fauna in the middle reaches of the river are homogenous between the end of the salt water near the mouth and the Felou falls or the Gourbassi rapids.

Lastly, the Delta is penetrated by euryphalines and even euhalins which are of course limited to the mean water bed at low water.

Pisciculture development is principally determined by the following biological parameters : migration, reproduction, growth and survival.

Migrations

Seasonal migrations can be summarized as follows:

- Fresh Water Species

Just before the intrusion of salt water (Q 700 m^3/s), the whole length of the river, including the Lower Delta, is entirely inhabited by fresh water fish. It is even quite probable that this phenomenon extends out into the ocean upon the part of the continental shelf that is influenced by the fresh water from the river. The fresh water fresh then begin a long longitudinal anadromous migration lasting during the entire period of low water. This migration is only partially determined by the intrusion of salt water because a sizeable ichthyomass moves 100 km upstream from the salt water front.

All the fresh water species are affected by this migratory movement but in a doubly differentiated way. The species which make the longest migrations are : Alestes, Mormyridae, Schilbeidae and large specimens of certain species: Citharinus, Distichodus, Labeo and Lates. It is therefore quite evident that the range of fresh water species is noticeably different from one place to another between the Upper Delta and the end of the Middle Valley during low water.

Certain shallows seem to be barriers to these movements and the sills at Dioulde-Diabe cannot be traversed by any species. These conditions therefore limit the anadromous movement of the fish.

Furthermore, in years of average hydrological conditions, at least, the maximum ichthyological biomass, originating in the Delta, does not appear to reach this point. The arrival of the flood almost always inundates the major permanent side-channels of the high water bed no matter what the hydrological conditions may be. Of course, some fresh water fish go back downstream towards the Lower Delta with the flood waters, but the greater part of the maximum biomass undertakes a lateral "flowing" migration towards the major backwaters where it remains until it is able to reach the inundated floodplain proper.

The fresh water ichthyological population which is to be found in a determined portion of the high water bed closely resembles the population to be found in the mean water bed at low water. Furthermore, the concentration of fish at low water between

Fresh Water Fish in the Senegal River

Poissons d'eau douce du fleuve Sénégal

			MV	BL	BK	BF
1.	[illegible]	Polypterus ater (GÜNTHER 1868)	x			
2.	OSTEOGLOSSIDAE	Heterotis niloticus (EHRENBERG 1829)	x	x		
3.	HYPEROPISIDAE *	Hyperopisus bebe occidentalis (LAC. GÜNTHER 1866)	x	x		
4.		Marcusenius senegalensis (VALENCIENNES 1846)	x			
5.		Marcusenius ussheri (VALENCIENNES 1846)	x			
6.		Mormyrus deliciosus (LEACH 1818)	x	x		
7.		Gymnarchus senegalensis (STEINDACHNER 1870)	x	x		
8.		Petrocephalus bane (BOULENGER 1898)				x
9.		Brienomyrus niger (GÜNTHER 1866)	x			
10.		Petrocephalus bovei (VALENCIENNES 1846)	x			
11.		Petrocephalus simus SAUVAGE 1878		x		
12.		Mormyrus tshokai (VALENCIENNES 1846)	x			
13.	GYMNARCHIDAE	Gymnarchus niloticus CUVIER 1829	x	x		
14.	PSEPHEIDAE	Pellonula afzeliusi BANDELA 1954 *	x			
15.	HETEROMYCTERIDAE	Tetrodon fahaka LINNÉ 1762	x	x		
16.	CHANNIDAE *	Ophiocephalus obscurus (BLOCH 1794)	x			
17.		Nudiceps [illegible] GÜNTHER 1864	x			
18.		Parachanna obscura CUVIER 1819	x	x		
19.		Alestes dentex senegalensis (CUVIER et VALENCIENNES 1849)	x			
20.		Brycinus macrolepidotus (LINNÉ et VALENCIENNES 1850)	x	x	x	
21.		Brycinus nurse (CUVIER et VALENCIENNES 1849)	x	x	x	
22.		Brycinus [illegible] (RUPPEL 1832)	x	x	x	
23.		Brycinus longipinnis senegalensis GÜNTHER 1867	x			
24.		Micralestes acutidens (PETERS 1852)		x	x	
25.	CITHARINIDAE	Citharinus citharus (GEOFFROY SAINT-HILAIRE 1809)	x			
26.		Distichodus rostratus (BLOCH et SCHNEIDER 1845)	x			
27.		Distichodus brevipinnis GÜNTHER 1864	x			
28.		Distichodus rostratus GÜNTHER 1864	x			
29.		Distichodus sexfasciatus GÜNTHER 1864		x	x	
30.		Hemistichodus [illegible] BOULENGER 1911		x		
31.		Hemistichodus fasciatus GÜNTHER 1867		x		
32.	CYPRINIDAE	Labeo [illegible] (PELLEGRIN 1935)		x	x	x
33.		Barbus senegalensis STEINDACHNER 1870	x	x	x	x
34.		Barbus niloticus occidentalis BLAGOE et HILTON 1960	x	x	x	
35.		Labeo senegalensis VALENCIENNES 1842	x	x	x	
36.		Barbus [illegible] RUPPEL 1832	x	x	x	
37.		Barbus parvus BOULENGER 1902		x	x	x
38.		Barbus petitjeani DAGET 1962				x
39.		Barbus [illegible] DAGET 1962				x
40.		Barbus spurelli BOULENGER 1913				x
41.		Barbus dikenensis DAGET 1962				x
42.		Barbus [illegible] (BLEEKER 1863)		x		x
43.		Barbus [illegible] DAGET 1959				x
44.		Barbus [illegible] PELLEGRIN 1933		x		x
45.		Barbus apogonoides PELLEGRIN 1913				x
46.		Barbus dialonensis DAGET 1962				x
47.		Barbus sp., cf. trispilus (BLEEKER 1863)				x
48.		Barbus occidentalis BOULENGER 1911		x	x	
49.		Barbus [illegible] DAGET 1954		x	x	
50.		Barbus [illegible] DAGET 1954		x		
51.		Barbus [illegible] DAGET 1954		x		
52.		Barbus [illegible] BOULENGER 1915	x	x		
53.	BOSMIDAE	Barbus bayad (FORSKAL 1775)		x		
54.		Barbus docmac (FORSKAL 1775)		x	x	
55.		Chrysichthys auratus (GEOFFROY SAINT-HILAIRE 1809)		x	x	
56.		Chrysichthys nigrodigitatus (LACEPEDE 1803)*		x		
57.		Chrysichthys furcatus GÜNTHER 1864		x		
58.		Chrysichthys sp.		x		
59.		Clarotes laticeps (RUPPEL 1829)		x		
60.		Auchenoglanis biscutatus (GEOFFROY SAINT-HILAIRE 1827)		x		
61.		Auchenoglanis occidentalis (VALENCIENNES 1840)		x	x	
62.	SCHILBEIDAE *	Schilbe mystus (LINNÉ 1762)		x	x	
63.		Eutropius niloticus (RUPPEL 1829)		x		
64.		Physailia pellucida BOULENGER 1901		x		
65.	MOCHOKIDAE	Brachysynodontis batensoda (RUPPEL 1832)		x		
66.		Hemisynodontis membranacea (GEOFFROY SAINT-HILAIRE 1809)		x		
67.		Synodontis schall (BLOCH SCHNEIDER 1801)		x	x	
68.		Synodontis ocellifer BOULENGER 1900		x	x	
69.		Synodontis clarias (LINNÉ 1758)		x		
70.		Synodontis violaceus PELLEGRIN 1919		x		
71.		Synodontis sorex GÜNTHER 1864		x		
72.		Synodontis nigrita CUVIER et VALENCIENNES 1840		x		
73.		Synodontis filamentosus BOULENGER 1901		x		
74.		Synodontis owaie GÜNTHER 1864		x		
75.		Synodontis dougetti BOULENGER 1911		x		
76.		Synodontis tourei DAGET 1962				x
77.		Chiloglanis niloticus [illegible] DAGET 1954			x	x	x
78.	AMPHILIIDAE	Amphilius rheophilus DAGET 1959				x
79.		Amphilius grammatophorus PELLEGRIN 1933				x
80.		Paramphilius trichomycteroides PELLEGRIN 1907				x
81.	MALAPTERURIDAE	Malapterurus electricus (GMELIN 1789)	x	x		
82.	CLARIIDAE *	Clarias senegalensis VALENCIENNES 1840	x	x		
83.		Clarias lazera VALENCIENNES 1840	x			
84.		Clarias dialonensis DAGET 1962				x
85.		Heterobranchus longifilis CUVIER et VALENCIENNES 1840		x		x
86.		Heterobranchus bidorsalis GEOFFROY SAINT-HILAIRE 1809	x			
87.	CYPRINODONTIDAE	Epiplatys senegalensis (STEINDACHNER 1870)	x			
88.		Epiplatys bifasciatus (STEINDACHNER 1881)	x	x	x	
89.		Aplocheilichthys normani ARL 1926	x			x
90.		Aplocheilichthys pfaffi DAGET 1954	x	x		
91.		Aplocheilichthys spilauchen (DUMERIL 1859)*	x			
92.		Aplocheilichthys guineensis SVENSSON 1953			x	
93.		Aplocheilichthys lemberti DAGET 1962				x
94.		Aphyosemion liberiense (BOULENGER 1908)				x
95.	CENTROPOMIDAE	Lates niloticus (LINNÉ 1762)	x	x		
96.	CICHLIDAE	Hemichromis fasciatus PETERS 1857	x	x	x	
97.		Hemichromis bimaculatus GILL 1862	x	x		x
98.		Tilapia galilaea pleurotaenia DUMERIL 1859	x	x		x
99.		Tilapia nilotica nilotica (HASSELQUIST 1757)	x			
100.		Tilapia aurea aurea (STEINDACHNER 1864)	x			
101.		Tilapia zillii (GERVAIS 1848)	x	x	x	x
102.		Tilapia heudelotii DUMERIL 1859*	x			
103.		Tilapia guineensis (BLEEKER 1862)*	x			
104.	ANABANTIDAE	Ctenopoma kingsleyae GÜNTHER 1896	x	x		
105.	OPHICEPHALIDAE	Parophiocephalus obscurus (GÜNTHER 1861)	x			
106.	ELEOTRIDAE	Krimia sp.	x			
107.		Krimia [illegible] (BOULENGER 1907)				x
108.		Krimia [illegible] chevalieri (PELLEGRIN 1921)				x
109.		Eleotris senegalensis STEINDACHNER 1870	x			
110.		Eleotris [illegible] STEINDACHNER 1870	x			
111.	POLYPTERIDAE *	Polypterus senegalus senegalus CUVIER 1829	x			
112.		Polypterus [illegible] STEINDACHNER 1869	x			
113.	LEPIDOSIRENIDAE	Protopterus annectens (OWEN 1839)	x			
			36	[illegible]	[illegible]	[illegible]

+ These species are reputed to be highly tolerant of salt water

- Barbus: There are perhaps other smaller species

- Tilapia: Thetilapia are the subject of an in-depth study by D. Thys van Den Audebaerde based on catches made in June, 1966.

MV = Middle Valley

BL = Baoule

BK = Bakoy

the salty part downstream and the shallows upstream means that the maximum high water biomass in the high water bed is to be found from Podor to Cascas.

The fish remain on the plain as long as the water continues to rise. When the current reverses, the migratory movement reverses as well and the fish return to, for the most part, the mean water bed (lateral "ebbing" migration).

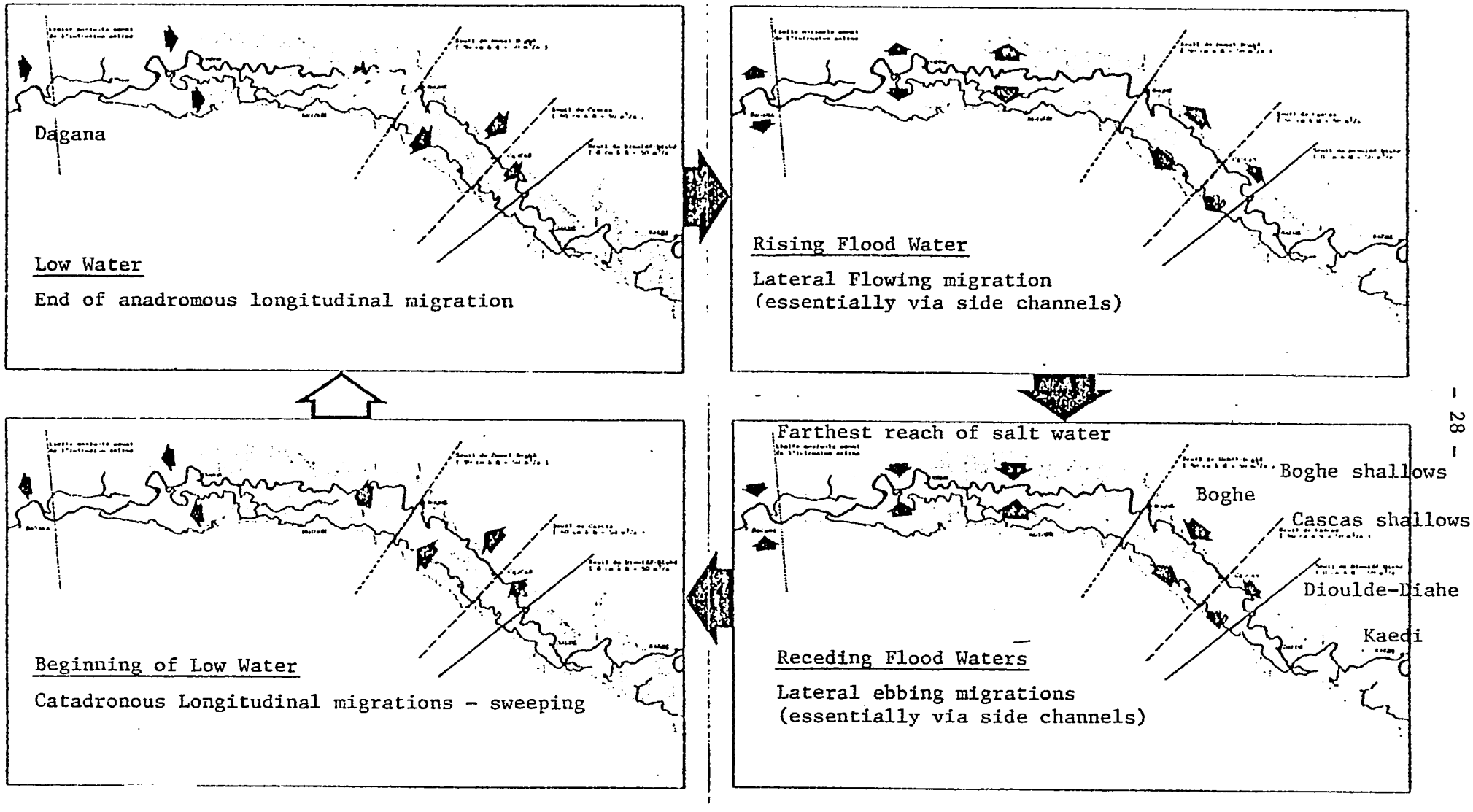
Once they have arrived in the mean water bed the fish begin a catadromous migration that takes them to the mouth of the river and beyond, from where they will again depart on an anadromous migration as part of their annual cycle. This phenomemnon of catadromous migration at the beginning of receding water seems to be more a process of being passively swept along rather than a willful migratory movement, especially for the smaller specimens. It has been noticed that the best swimmers are the first to stop their movement down the valley whether this is due to their size or to other factors. This great sweeping along of the fish by the current is in fact the mechanism by which the whole zone located downstream from Bokheul and as far as the mouth of the river is re-stocked with fresh water fish. This is how the delta ponds in particular are re-stocked.

On the whole, these movements are comparable to those of the fish in the Central Delta of the Niger, as described by J. DAGET (1960). The main features of this phenomenon in the two river complexes can be summarized as follows:

- longitudinal anadromous migrations at low water;
- lateral flowing migrations as flood waters rise;
- lateral ebbing migrations as flood waters recede;
- longitudinal catadromous migrations at the beginning of low water.

The migratory movements of fish in the large river basins of West Africa seem to be determined by the annual flow of water.

In the Senegal, however, there are certain special features of considerable importance: the space available for the fresh water fish is limited: downstream, by the salt water (the change-over to dominance by euryphalins begins at 10% salinity); upstream, by underwater sills, especially at Cascas and Dioulde-Diabe. At low water, the area available to the fish progressively shrinks as the



Cycle annuel des migrations
des poissons d'eau douce
dans la " Basse Vallée "
Basses eaux - En lit mineur

Low Water in the mean water bed

Movement of current
Annual cycle of Fresh Water
Fish Migration in the
Lower Valley

Cycle annuel des migrations
des poissons d'eau douce
dans la " Basse Vallée "
Hautes eaux - En lit majeur

High Water in the high water bed

flow of water is reduced even while the temperature of the water rises. The influence of the sills and the salt water is felt even after the period of low water because even in high water, the fish prefer to live in the high water bed, located beside the mean water bed, where they live at low water. The Lower Valley therefore seems to be a favored place for fresh water fish both at low and high water stages. During high water the availability of space is limited by the relatively small extension of the high water bed. It is near Boghe that the high water bed reaches its widest extent. Nevertheless, the maximum area accessible to fish life is only about 100,000 ha. out of a potentially flooded area of 600,000 ha. in the Valley, not counting the 400,000 ha. available in the Delta before any development work takes place. The sweeping motion of the receding waters (catadromous migration) is the means of re-stocking the fish reserves in the area where salinity exceeded 10% during the previous period of receding water by bringing in alevins recently hatched upstream. However, this sweeping motion of the receding waters has been identified only in certain years and will be discussed further on.

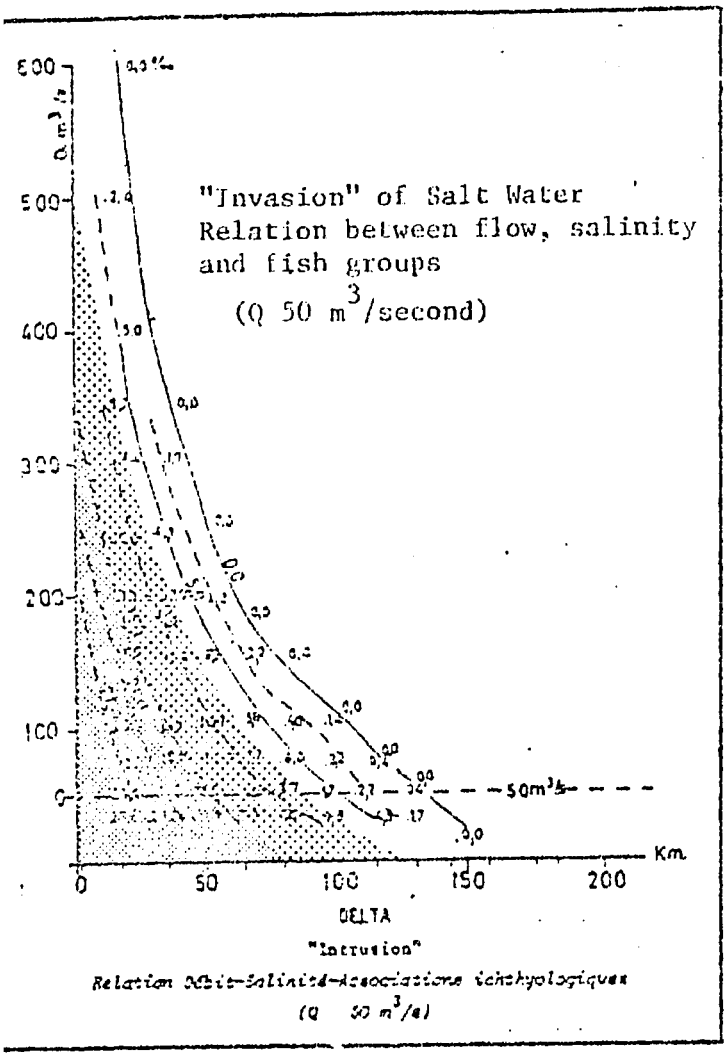
Euryphaline Fish

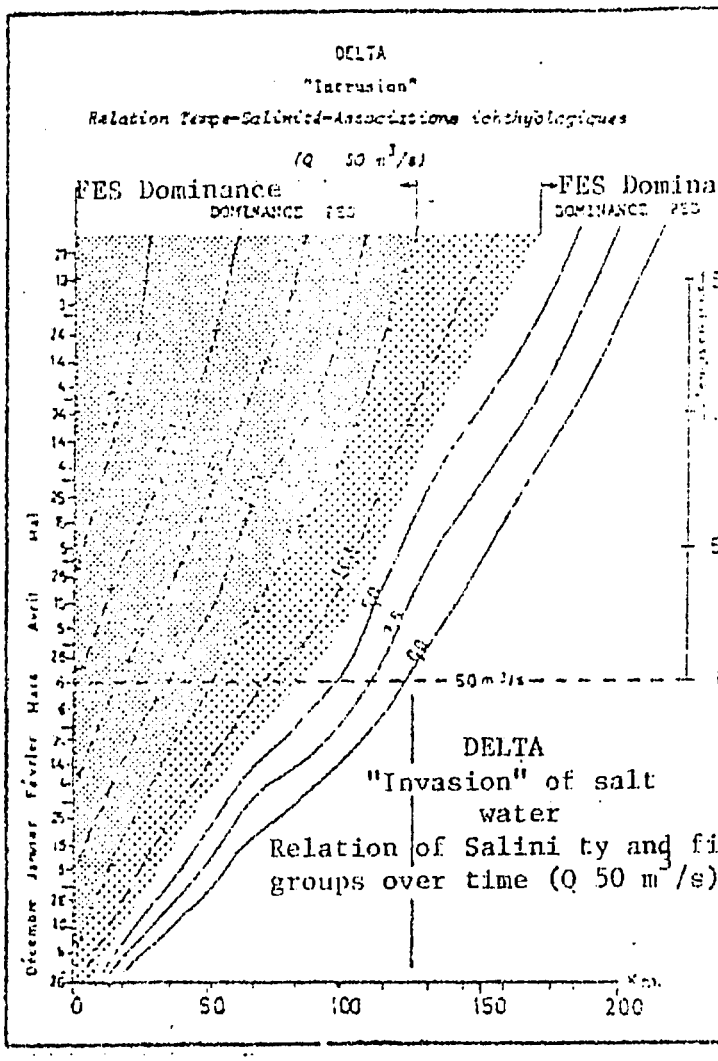
All euryphalin species have an analogous migratory behavior, which, although it may be caused by different stimuli, is always linked to the flow of water. During periods of receding and low water there are slow anadromous migration from the mouth of the river to beyond the Debi. At the beginning of high waters, they live at an unknown place on the continental shelf or in areas where the flood spreads out in the Gandio area (a pseudo-lagoonal complex) REIZER and P. LESSENT, 1972).

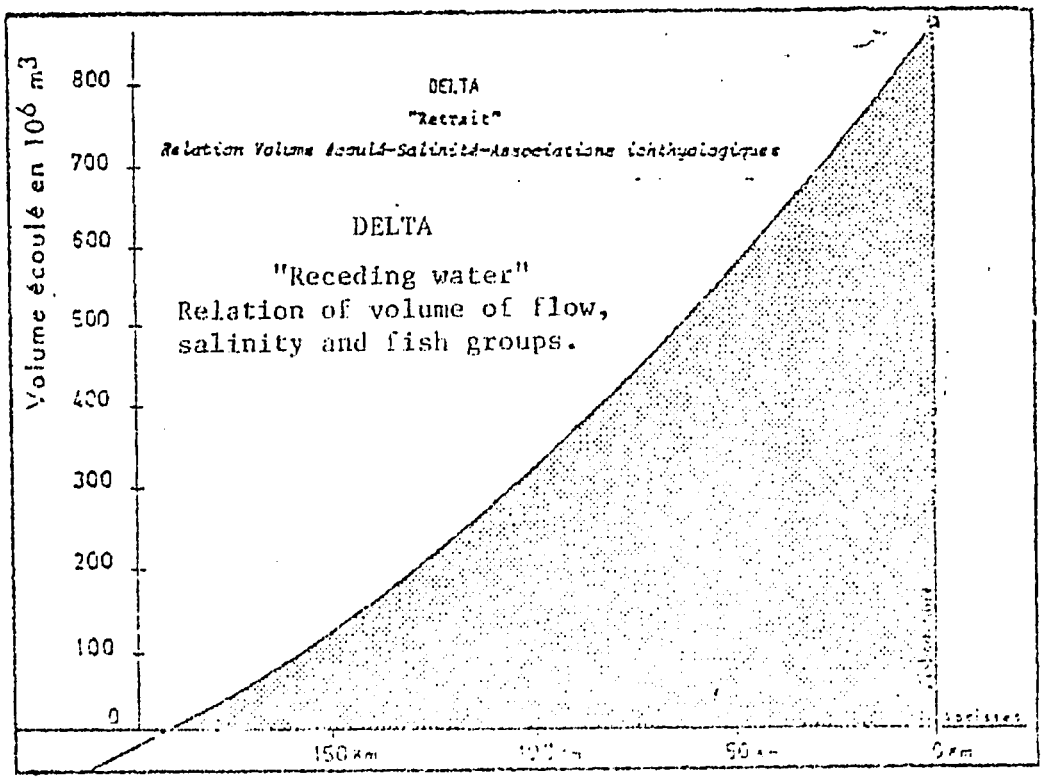
Reproduction

- The Fresh Water Species

The spawning season is during the period of rising water; it may continue during the high water period for certain species (segmented Isying); it ceases with the turn-around or falling away of the flood waters which takes the fish back to the mean water bed. If this falling away of the flood is delayed too long, as is the case in certain years in Lake Guiers, the drop in temperature will inevitably lead to a shrinking of the gonads.







MIGRATORY BEHAVIOR OF EURYHALINE FISH

Comportement migratoire des poissons euryhalins

The beginning of maturation seems, at first sight, to be caused by rising temperature which reach a satisfactory level, varying from one species to another, in April or May.

For certain species with segmented egg-laying habits, such as Heterotis and Cymnarchus, heavy rains are necessary for nest-building and egg-laying. Such rains come during the rainy season and must reach a certain intensity.

All fresh water species are able to spawn somewhere in the river, but production takes place mainly in the side-channels of the high water bed during flood stage or later, on the floodplain in the early stages of inundation. Furthermore, because of the migrations, the main biomass of mature breeding-aged fish is located in the vicinity of Podor at Cascas; in addition, certain "river" fish do spawn only upstream from Podor and mainly between Podor and Boghe (Cascas).

In conclusion, it can be said that the upper part of the Lower Valley is of great ecological importance to fish life in the Delta, the Lower Delta and the Lake Rkiz.

It must be noted that there is a concentration of mature breeding fish located and even spawning in the side channels of the high water bed of the river during rising waters which means that the fish are easily caught because they are in such a restricted area. Maximum accessibility is to be had in the Podor-Cascas region. This accessibility is even greater when one considers that the fish spend more time in the side channels when the hydraulic activity of the water is weak. Once the flood plain is covered by water the fish are much harder to catch because both adults and alevins disperse into a much greater volume and area of water.

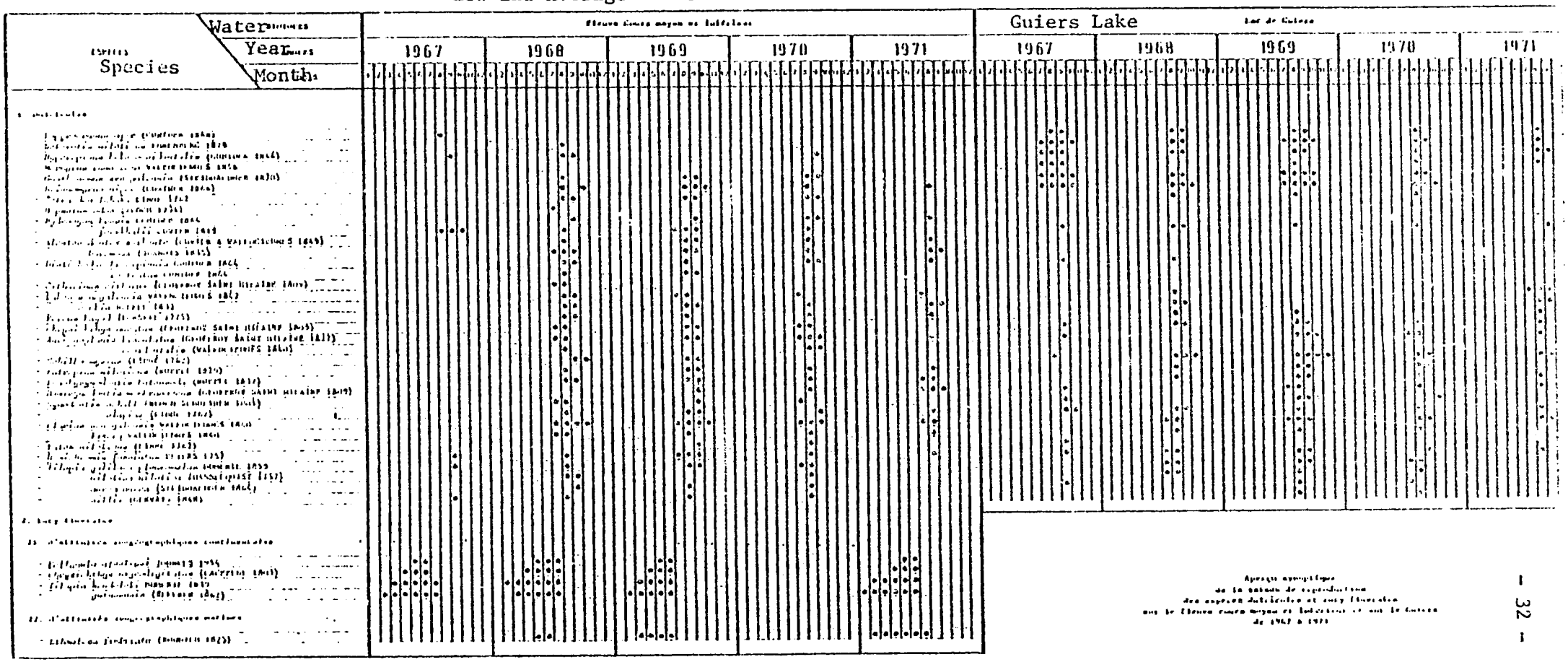
3.5 Euryphaline Fish: Reproduction

Certain species which make annual anadromous migration at low water reproduce in the river: Ethmalosa, Pellonulla, Tilapia heudoloti and guineensis in particular.

The spawning season stretches from January/February to July/August, with a net maximum in May/June. This season is quite different from that of the fresh water species, as it is independent on salinity, 5 to 15% appearing to be optimal for Ethmalosa.

Synoptic Overview of Reproductive Seasons of Selected Species 1967-1971

Low and Average River Flow



Aperçu synoptique
de la période de reproduction
des espèces halieutiques et autre faunistique
sur le fleuve cours moyen et inférieur et sur le Guiers
de 1967 à 1971

Generally speaking, as far as the Delta and the euryphaline fish are increased, Senegal has a bio-ecological link with a region, probably a coastal-marine one, in which the euryphaline fish winter (REIZER, 1971). Fishing activities on the continental shelf therefore depend on the spawning grounds of the lower Delta at least in the case of certain species.

3.6 Growth and Survival of the Young

Conclusions:

- Qualifications : the bony structures of all specimens and particularly *Citharinus citharus* (GEOFFROY SAINT-HILAIRE, 1809) have annuli that lend themselves to the study of growth.

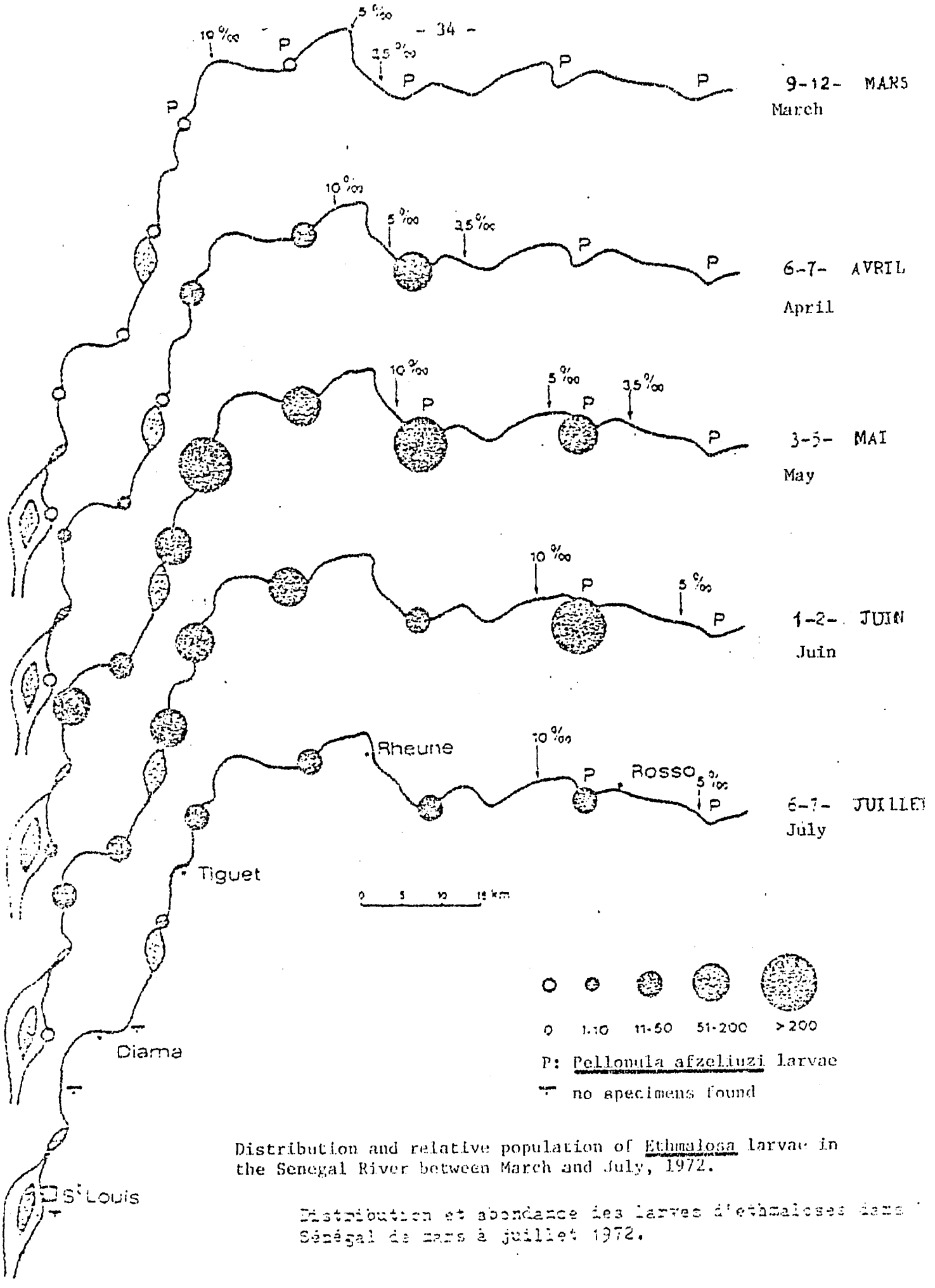
- Time factors: growth is discontinous, ceasing for a time both in the river and in Lake Guiers, and corresponds to the appearance of an annulus. This annulus becomes evident in the cold season, between December 1st and March 31st and is significant mainly, if not exclusively, during high water.

- Spatial factors : growth is 10 to 15% greater in Lake Guiers (and therefore in Lake Rkiz) as in the river.

- Causal factors : the annual cessation of growth is mainly determined by the dropping of the water level; growth begins again when thermal conditions are right. The intensity of new growth is closely linked with the extent of the annual flood. Growth can be negligible in years of hydric deficits, particularly in the river.

  Growth varies considerably from one year to another among fresh water species in the Middle and Lower Senegal Valley, particularly in the river itself. Individual growth is directly influenced by the conditions of the flood (extent and duration) and may be nil during years of hydric deficits (1968,1972, 1973). The same phenomenon exists in Lake Guiers but is less pronounced.

  It has also been noticed that the fry do not survive in years of hydric deficits (1968, 1972, 1973) among all species. This was the case in 1970 and 1971 among "fragile" species such as *Citharinus* sp.



Distribution and relative population of Ethmalosa larvae in the Senegal River between March and July, 1972.

Distribution et abondance des larves d'ethmaloses dans le Sénégal de mars à juillet 1972.

- The following hypotheses may explain these phenomena:

  - lack of food available to fry because of insufficient mineralization of the water which come exclusively from organic wastes and particularly from the feces of domestic animals;

  - major daily variations of limerimetric heights during years of unfavorable hydraulic conditions. Fish eggs are then exposed and dried out, as are the larvae and the fry.

Overall Consequence: the annual replenishing of the ecosystem is due mainly to the yearlings and does not take place in certain years.

Euryphaline Fish

The most determining ecological parameter that has appeared is salinity: it has a major influence of movement and on reproduction. Paradoxically, the name of this category of fish means that they have a high tolerance of salt water. Although euryphaline fish tolerate salt they do move about seeking ideal saline conditions. It must also be mentioned that all euryphaline species have a comparable behavior in the area of reproduction: their spawning season is the same for all of them although certain species are of continental origin - - Tilapia, Chrysichtys - - while others are of marine origin. The former's behavior is in all ways like that of the euryphalo-fluvial marine species and thus completely unlike the continental species which live only in fresh water. There is thus a perfect adaptation to the milieu.

These species are readily available to fishing in the Senegal because of the relative concentration of the biomass in a maximum area of approximately 5,000 ha (100 km x 0.5 km) and in a volume of water whose depth is not more than 5 to 10 meters. The danger of this theoretical accessibility is worsened by the fact that this biomass includes young maturing or full-grown specimens and is reduced by the fact that many species (the euryphalines) reproduce in the ocean. Given the differences between the fluvio-estuary and the coastal-marine environments, it is eury-fluvial species that theoretically run the greatest risks of being over-fished. Restrictive measures to protect the stocks of these species must therefore be taken in the river rather than in the ocean.

Potential catches of euryphaline species vary within rather narrow margins from one year to another, because of the intrusion of salt water into the river and because of the fishes' behavior patterns.

Fresh Water Fish

The most determining parameters among fresh water species are the flow of water and the temperature.

The flow of water acts upon:

- longitudinal movements by means of salt content and sills, lateral movements by means of flooding as of the high water bed;
- reproduction by inducing the annual cessation, by opening the high water bed to young adults and to fry,
- growth, whose rapidity is governed by the flow of water.

Temperature influences reproduction and growth in that it is responsible for stimulating the annual renewal of these activities which are so important to fishing.

The essential parameters of high water and high temperatures are the basis of fishing potential in spite of the particularly unfavorable factor of low mineral content of the water in the river.

The entire fresh water fishing potential of the Middle and Lower Senegal therefore depends on the duration of the annual flood of the high water bed, in other words, on the type of flood. Because the Senegal depends upon rainfall in the Fouta Djalon and therefore upon the annual movement of the Inter-Tropical Weather Front, potential river fishing depends on the same factors.

Thus, in general terms at least, the eco-biological dynamics of the Middle and Lower Senegal are similar in the area of fresh water species to those of other large fluctuating tropical river complexes: the Kafue, Lake Chad, the Benue and particularly the Middle

Niger. The Chart on the next page gives a general schematic representation of the general dynamics of the river, but it must be seen as applicable to the Middle Senegal under average conditions only.

In comparison with these other great complexes, the Senegal exists in a much more limited context. Its most important limiting factors are:

- - spatially:
  a mean water bed limited by salt water at one end and by sills at the other;

  a high water bed limited by the relative narrowness of the Valley between the estuary and the upstream sills;

- - time-wise:
  the annual flood lasts but 2 to 3 months at most, in the whole Valley, whereas the Central Delta of the Niger benefits from 6 months of flooding as the flux of water moves from Mopti to Dire;

  year to year irregularity: the hydric dynamics of the Senegal are the most irregular of any north-equatorial river.

It must always be remembered that the Senegal is a <u>medium, northern Sahelian coastal river.</u>

In these circumstances, potential fresh water fishing is : limited by - - the mineral content of the water,

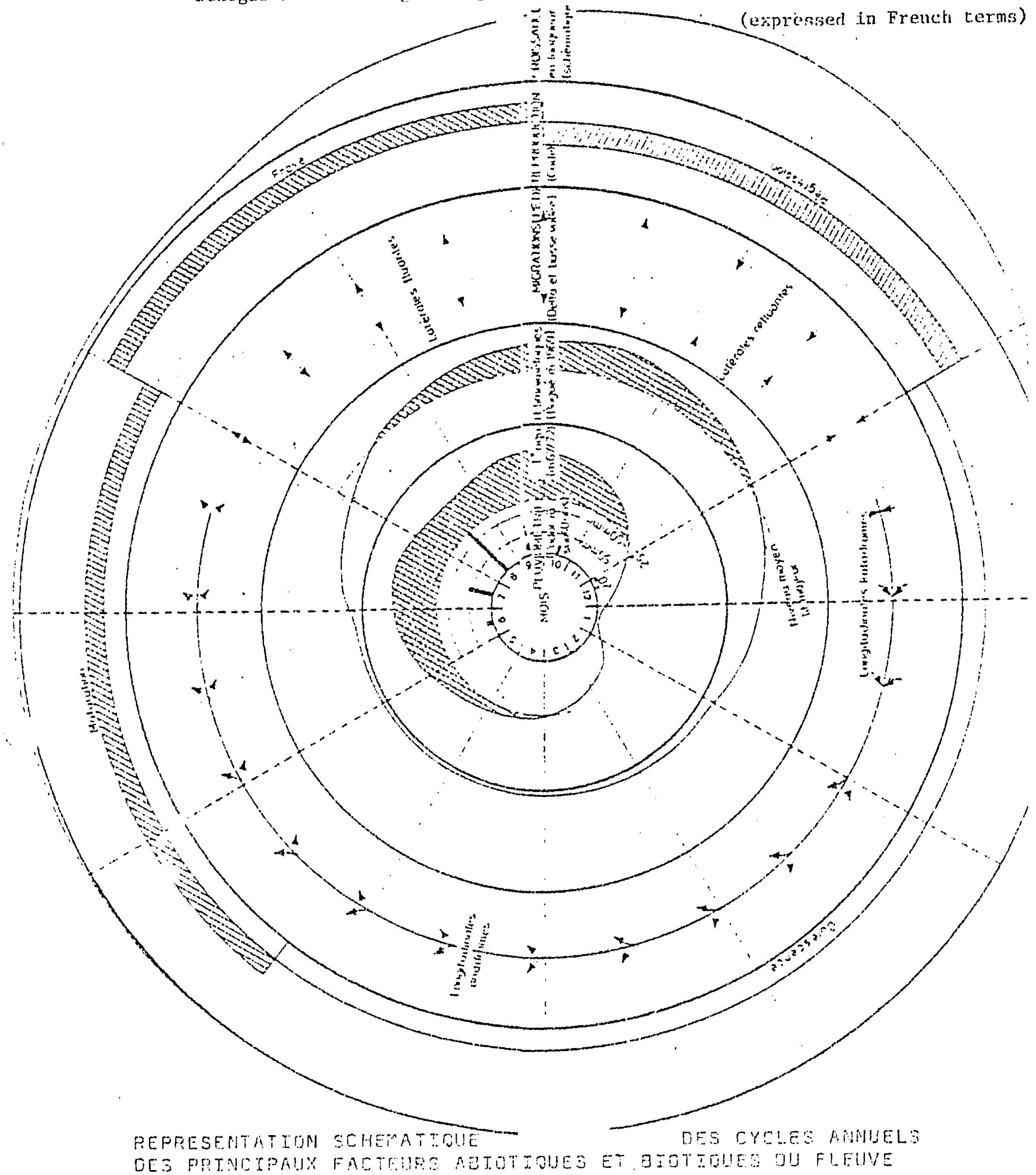
- - the amount of space actually available,

- - the effective annual duration of favorable conditions,

- - characterized by wide variations from one year to another: they can be almost nil in some years of hydric deficits which are often serious and long-lasting; these periods follow a cycle of more or less 25 years. However, given the rich variety of fish (79 species), a prompt biological recovery can be expected after these years of scarcity.

Schematic Presentation Showing Principal Biotic and Abiotic Factors of the Senegal River During Average Flow: Fresh Water Fish, Average Year

(expressed in French terms)



REPRESENTATION SCHEMATIQUE DES CYCLES ANNUELS DES PRINCIPAUX FACTEURS ABIOTIQUES ET BIOTIQUES DU FLEUVE SENEGAL COURS MOYEN : ESPECES DULCICOLES, ANNEE MOYENNE.

The primary conclusion to be drawn from these data is that otentials in fresh water fishing in the Middle and Lower Senegal are ntirely and exclusively determined by the extent and the duration f flooding in the high water bed.

It has been possible to estimate fresh water fish production n the floodplain to be more or less 60 kg/inundated hectare each year. his would yield potential catches of about 25,000 tons a year.

However, the key factor to be considered is the variations n the area of the floodplain that is actually flooded, and this is ntirely dependent on hydric conditions which in turn are dependent n rainfall in the Fouta Djalon. As a result, potential catches in this each of the river vary tremendously: 2,000 to 40,000 tons a year, 1/3 of which is in Mauritania.

It can be said that the Inter-Tropical Weather Front is what regulates the hydric cycle. If this front is subject to 25-year cycles, then fishing potential in the Senegal also corresponds to such cycles.

Basic Corollary Remark

The 1980 potential is at its minimum since the flow has been below normal since 1968.

1968	$Q\ \bar{m}$ = 394 m^3/second	
1969	765	(= $\bar{m}$ between 1903 and 1980)
1970	542	
1971	593	
1972	260	(= recordy 1903 - 1980 period)
1973	361	
1974	760	(= between 1903 and 1980)
1975	602	
1976	470	
1977	324	
1978	523	
1979	301	
1980	578	

Conclusion: 2 average and 11 below-average floods in the 1903-1980 period.

Another characteristics of the system being considered: the theoretical accessibility of the fresh water fish to fishing.

- Qualitative accessibility : adult specimens are preferred, maturing specimens dominate in the mean water bed and spawning specimens are particularly available in the side-channels.

- Spatial accessibility :

  at low water : because of the salt water intrusion and because of the upstream sills;

  at times of rising flood waters: because of lateral migrations via side channels of the river.

- Times of accessibility:

  maximum accessibility is during the month of August in the side channels;

  accessibility is facilitated during years of poor flooding because of two factors, the increased time that spawning-aged fish spend in the side channels and a greater probability that they will be caught because of the restricted area they live; the probable success of spawning is also a factor.

The human context must be studied in order to see whether the people living along the river are aware of the limitations which have been described above and whether or not they have taken any steps to regulate fishing to protect the stock of fish in view of insuring the long-term possibility of income earning.

The fragility of the ecosystem from one year to another is further complicated by the annual growth cycle of the fish themselves; the critical periods for the ichthyological biomass within the annual cycle are

- - maximum when the flood waters recede, exposing the floodplain and bringing the fish back to the mean water bed; reproduction and growth cease and it is probable that the period of greatest mortality begins;

- minimum at low water, between the time when growth and maturation of the young fry starts up again and the beginning of the next period of flooding. It would not be surprising if the biomass were constant during low water (more of less May 1 to July 1) because mortality would be made up for the renewed growth of the fish.

These remarks are speculative and of course assume an absence of human intervention.

4. Analysis of Production

Production is conditioned by a group of parameters of which the most important are the following:

- Potential production (see above)
- Demand: to be discussed below.
- General geographical anthroplogy (political, administrative, social and ethnic aspects), supervision, fishing techniques.

Production is a difficult topic to treat with any precision because in the river context there is a double dispersion of human and geographical factors.

The Senegal River basin is divided among four political entities:

Mali	155,000 Km^2 (approx.)	53% (approx.)
Mauritania	75,000 " "	26% "
Guinea	31,000 " "	11% "
Senegal	28,000 " "	10% "

Downstream from its confluence with the Faleme, the Senegal becomes the boundary between the Islamic Republic of Mauritania and Senegal. The floodplain is therefore divided between these two nations with about 1/3 of the floodplain lying on the Mauritanian shore. The border itself is actually the right bank of the mean water bed.

The floodplain is divided among the following administrative regions and departments in Senegal and Mauritania:

Country	Regions		Departments bordering on the river: Name and administrative center
	Name	Capital	
Senegal	Fleuve	Saint-Louis	Dagana
			Podor
			Matam
	Senegal Oriental	Tabacounda*	Bakel
Mauritania	VIth (Trarza)	Rosso	Keur Macene
	Vth (Brakna)	Aleg*	Boghe
			M'Bagne
			Bababe
	IVth (Gorgol)	Kaedi	Maghama
	Xthe (Guidimaka)	Selibaby*	Selibaby

* = Located outside of the Valley.

4.1 The Traditional Fisheries Service

On the national level, inland fishing has been the responsibility of several different branches of the government, which explains its present lack of organization.

1st Before 1975, inland fishing was an integral part of the Service des Eaux et Forets (nowadays, Service Protection de la Nature (Environmental Protection Service). This service was supposed to:

a) Organize and supervise the fishermen along the river and around the ponds, backwaters and lakes, count fishing equipment and boats.

b) Draw up regulations for inland fishing and enforce them.

c) Protect the fisheries while controlling forestry potential.

d) Keep production statistics.

e) Take any other technical and administrative measure that might contribute to increasing the profitability of the sub-sector and improving the standard of living of fishermen.

2nd Between 1975 and March 1980 this sub-sector was transferred to the management of the Ministry of the Economy and Finances. At this level, it was represented by the Section Head of Traditional Fisheries, who was without any logistical or technical support.

3rd Beginning in March, 1980 a ministerial reorganization took place. The Fisheries Department was upgraded and became the Ministry of Fisheries and Maritime Economy. The Fisheries Department remained as before with its two sections (see Diagram 1.1).

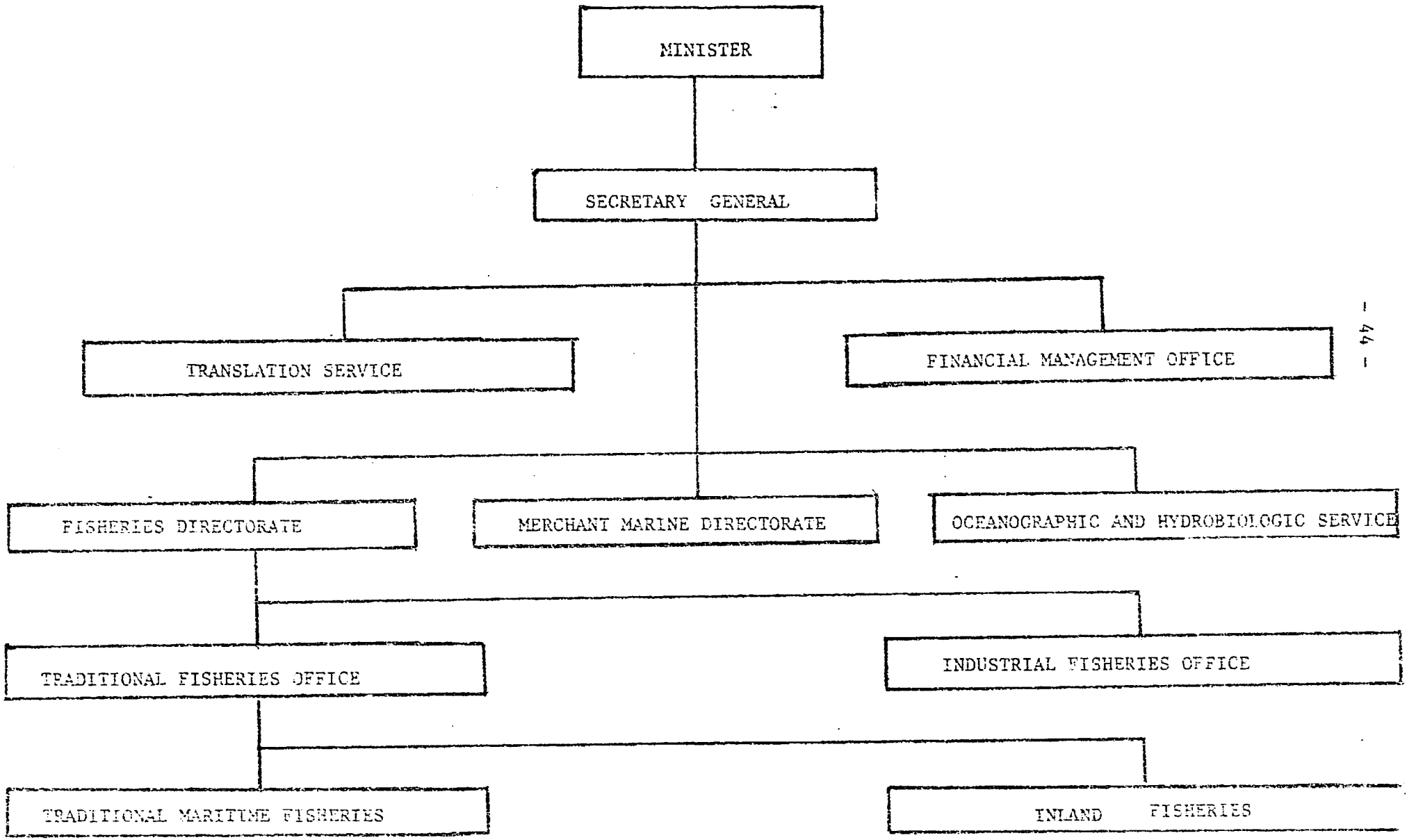
The Department composed of:

a) The Traditional Fisheries Service, with a Service Head and an Assistant Head who are concerned with the following two sub-sectors:

- Traditional (inland) fresh water fishing, which is located mainly on the Senegal River and various bodies of water situated in the south-eastern part of the country.

- Traditional maritime fishing. This is located along the Mauritanian coast from N'Diago to Nouadhibou, including numerous Imraguen fishing camps. Fishing is done either far off-shore in canoes of Senegalese origin, or on the shore with nets and fishing lines by the Imraguen. Within the last ten years, boats of Spanish origin (launches) have been used.

ORGANIZATION CHART OF MINISTRY OF FISHERIES AND MARITIME ECONOMY



b) The Commercial Fisheries Service with its Service Head, five counselors and an economist, according to the latest organizational chart of the Ministry of Fisheries and Maritime Economy in effect since March 3, 1980.

These changes show the concern of the Mauritanian Government for giving an increasingly important role to traditional fishing in particular. Nevertheless, there is still a lack of supervision.

At present, the Service is represented by its Head, an Assistant Head and two UNDP experts, two Japanese experts in Nouakchott and three in Nouadhibou. They are all concerned with traditional marine fisheries.

In Mauritania, inland fisheries are attached to the same ministry as marine fisheries. In reality, however, there is no official support for the sector because there are no qualified cadres available.

The censuses of 1972/73 indicated that there were some 10,400 river fishermen of which about 2,700 worked from the Mauritanian bank between Rosso and the mouth of the Faleme.

These fishermen are organized in seining teams and have therefore founded professional and exclusive cooperatives (approx. 400 teams of 7 to 30 workers, or 3,700) plus professional and semi-professional individuals (approx. 6,700). 7,700 of the total work on the upper Delta (above Debi) or in the Valley proper; 2,600 are on the Mauritanian bank. In addition, there are about a hundred fishermen working in Guidimaka.

The most common method of fishing is by using the shore seine. The number of seine net owners counted by the Fleuve Region's Eaux et Forets Service indicated that their number has been unchanged for a generation (last count made in 1974). About a hundred teams of approximately 10 workers each are active on the Mauritanian bank. Their mode of operation is semi-capitalistic: owner of the fishing equipment may or may not be the team captain.

The importance of seine fishing is worth a closer look. It implies that the owner of the net accepts certain risks and that he has the financial means to maintain it. It implies certain leadership qualities on the part of the fishing team's captain. The very extensive use of the seine net is an indication of the prevailing level of technology.

Without logistical personnel or financial and material means, the Head of the Traditional Fisheries Service himself can not adequately carry out his work. The Service is still as figurative as it was in the past.

Its role is nevertheless very important, since it is up to the Service to plan and to organize, supervise and train the fishermen. In addition, the Service is supposed to make available information on the traditional fisheries, draw up regulations to be approved and apply them. The Service must also coordinates all projects and activities concerning this sector. It must oversee the fisheries, the management of cooperatives, keep statistics on production and select people to train as future fishermen.

In order to do this, the service must have a complete staff at its disposal: it requires adequate technical and administrative means as well as financial autonomy.

It is advisable to upgrade this Service to become a Department of Traditional Fisheries in order to give the sub-sector the attention it requires. It has been neglected by the authorities, who are primarily concerned with commercial marine fishing.

If the goal of the government is to assure a supply of fish to the nation from traditional fisheries and to link this sub-sector with commercial fishing in the medium and long term, it is advisable to focus particular attention on it because it now has no administrative or technical infrastructure capable of giving it even a normal operating capability.

The other types of equipment (for individual use) are as follows in decreasing order of popularity: the fix sleeping net (araignee of filet maillant dormant), multiple hook fishing line without bait (diolinke, in Poular) palangre, in French when it has bait on the hooks). The dragnet is occasionally and only used in Poular areas. The casting net (epervier) is used mainly to catch bait for the multiple hook fishing lines, except at Saint-Louis. Dams, harpoons and traditional regional nets are gradually disappearing. It must be noted that all of these types of equipment are modern

(synthetic fibers are used) and they are well maintained. This is a further sign of advanced technical ability.

All of these facts indicate:

- the fishermen's competence in technical ability and knowledge of the fish;
- the high quality of the equipment;
- the absence of financial bottlenecks (especially the loans given in certain years by the BNDS (Banque Nationale pour le Developpement du Senegal) which were paid back in two years (3 years, had been originally planned), and the funds were then re-invested elsewhere).

Above Saint Louis, wooden canoes from Cassamance (Senegal) are used. There are about 3,500 of them of which about 1,000 are based on the Mauritanian bank. Given the number of seine fishermen, there are plenty of canoes available. There are no limiting factors in this domain.

Production is virtually at its maximum possible level given the continuous high level of demand; as will be seen later, however, production surpasses the reproductive capacity of the fish in years of inadequate flooding.

Example :	1968	:	35,000 tons	(after 10 years in which Q $\bar{m}$)
	1973	:	14,000 tons	(after 5 years in which Q $\bar{m}$)
	1980	:	3,000 tons	(est.-after 13 years in which Q $\bar{m}$)

On the Mauritanian bank, production was probably equal to 1/3 of total production minus that of Lake Guiers and the Lower Delta:

1968 :	10,400 tons	
1973 :	3,700 tons	
1980 :	800 tons	(est.)

This production is doubly dispersed: it is the work of 10,400 fishermen (including 2,700 Mauritanians) who bring in catches daily along 2,000 km. of river between Saint-Louis and the Faleme. At first sight, this may appear to be a disadvantge, but a closer look will show that this is actually an advantage, given the characteristics of demand.

This production is entirely monetized. Barter no longer exists in the Valley.

4.2 Fishing Areas in Mauritania

Fresh water fishing is practiced in the Senegal River and the Koundi Backwater, which stretches as far as Boghe with a series of ponds that gradually dry up after the rainy season (see Figure 1.1)

- The Gorgol, Karakoro and Grigi.
- Various lakes and ponds which contain fish when they are sufficiently full.

They are spread over several regions, particularly:

Trarza - N'Diago, Aftout es-Saheli, M'Boyo, Dieuk and Lake RKiz, closed to fishing.

Brakna - The Lake of Aleg, Dar-el-Barka, Oued Ketchi.

Gorgol - Paliba Pond.

Assaba - The ponds of Kankossa, Toya, Tanaha, Ajar and Lebkheir.

Hodh Gharbi - Oued Tamchakett, to mention only some of the most important ones, the others having been filled with sand.

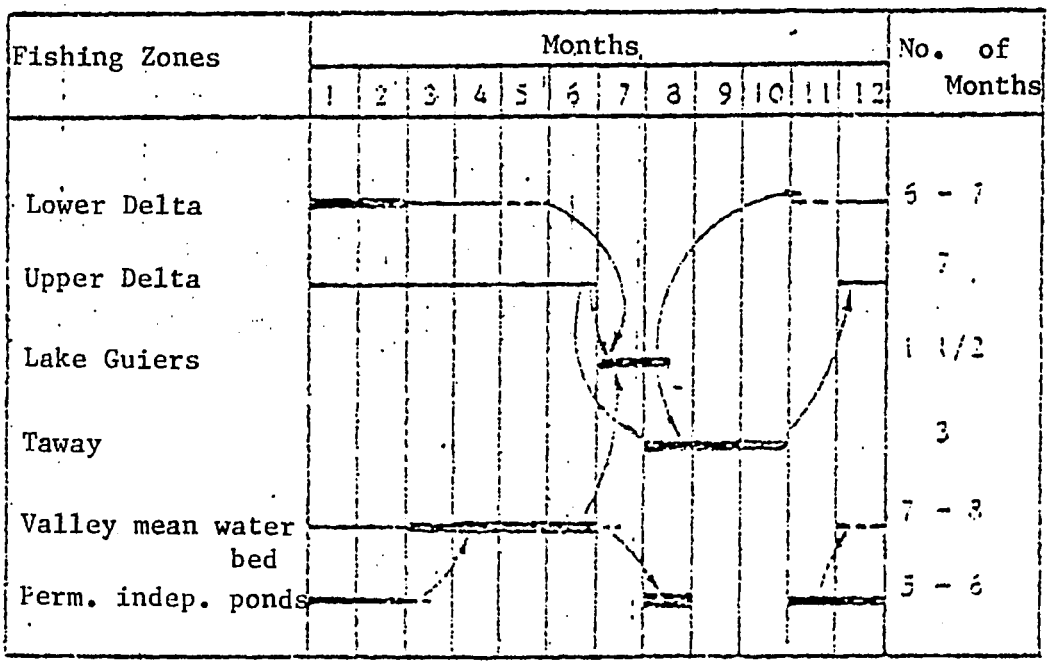
This represents approximately 850 km. of river and 3,000 square kilometers of flood plain (Lake RKiz being temporarily closed to fishing).

5. Analysis of Demand (Human Factor Problems)

Demand is entirely dependent on population factors: food habits and living conditions (housing, income, etc.)

The total population living in the Mauritanian portion of the river Valley is estimated to be 136,000 (RAMS, 1981).

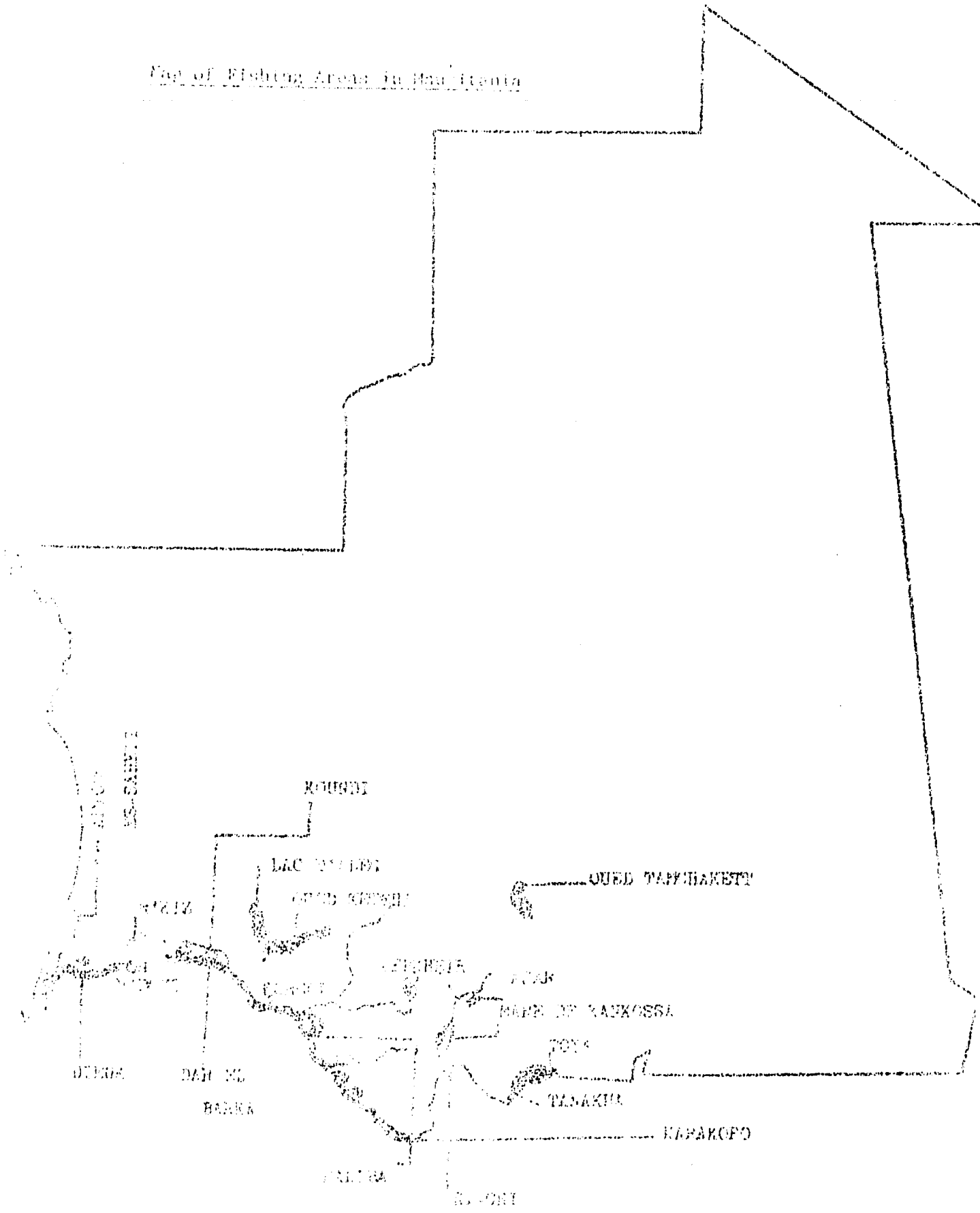
Schematic Diagram of Seine Fishing



Légende : L'épaisseur des traits est fonction de l'intensité de l'effort de pêche fourni.

egend: The thickness of the lines indicates the intensity of effort required in particular fishing seasons.

Map of Fishing Areas in Mauritania



R : 1/6,500,000

Fish plays a central role in the local diet: it is normally eaten 6 days a week. Food habits are determined by the following parameters:

- ethnic-cultural preferences. Moors eat almost no fish at all.
- socio-professional categories:
  - the fishermen eat the most fish
  - the Peulh herders eat little fish
- potential production given the time and space factors.
  - minimum consumption is 120 gr. per capita daily in Guidimaka
  - Poulars consume 150 gr. per capita daily and Wolofs consume 200 gr. per capita daily; these figures were established by the MISOES study of 1958-59.
- minimum consumption corresponds, of course, with periods of unfavorable ecological conditions.

As a result of all of these factors, demand on the Mauritanian bank was as follows in 1980:

- more or less 6,800 tons, if geo-cultural distortions are taken into account;
- more or less 9,000 tons if the Wolof level of consumption is used to calculate demand (which appears to be what people would <u>like</u> to consume).

Demand is distributed in linear fashion along the river and in "lateral proximity", corresponding to the distance which fish can be transported for marketing. Fish is easily obtainable in this area. Furthermore, the para-urban population is spread out fairly evenly, allowing the seine fishermen to market their catches continuously, The main centers of high monetary income are located approximately every 100 km: Saint-Louis, Rosso-Richard-Toll-Dagana, Podor, Boghe, Kaedi, Matam, Bakel-Gouraye, to mention only the most important places.

As a result:

- fish is a commodity with economic elasticity: its price varies directly with the distortion of supply and demand; for example:

Favorable ecological conditions 1966-68 : 25/50 Fr CFA/kg (3/6 UM)

Unfavorable ecological conditions 1970-72 : 50/100 Fr CFA/kg (6/13 UM)

Very poor ecological conditions 1980 : 400 Fr CFA/kg (80 UM)

The overall monetary value, including the fishermen's own consumption is relatively unchanging : about 200 x 10^6 UM/year or 1 x 10^9 Fr CFA. The fishermen's income remains steady, allowing them to renew their equipment annually, except in periods of very unfavorable ecological conditions when their own consumption is nearly equal to catch sizes.

The fact that producers and counsumers live close to one another means that fresh fish can be consumed within a half day of being caught. Guedj, a form of dried or fermented and dried fish, has become rare in recent years and is not made at all in years of bad ecological conditions.

6. Policy Guidelines for the Future

A comparison of Potential/Production/Demand leads to the following conclusion :

There is a tendency to over-fish which reduces the stock of fish in the river and leads to an under-supply of fish on the market; this situation is all the more serious during these years of unfavorable hydraulic conditions.

Given these conditions, it is not reasonable to propose policy guidelines whose goal it would be to satisfy demand by increasing fishing potential in a controlled environment, even without considering the impact of planned development projects in the river basin. The fishermen's level of technical ability is such that they would be able to switch to a different mode of production, provided that the innovations in production were adapted to present social conditions. An extra advantage in the form of reduced recurring socio-economic costs is also possible.

This policy is as follows:

- protecting the interest of the fishermen and of consumers in the region while ensuring full employment and a decent income to the fishermen and a desirable product at a reasonable price to the consumers;

- eliminating regional disparities in production, income and employment;

- protecting the ecosystem against the danger of over-fishing by:

  - taking general measures to protect natural stocks of wild fish;

  - devising techniques of intensifying potential and production in the over-fished areas; such techniques should be adapted to the socio-economic context.

6.1 Recommendations-Guidelines for Improvements

As just mentioned, two types of measures must be taken:

- steps to protect the natural stock of wild fish, and

- steps to intensify artificial production.

But before considering the details of this problem, it is worth studying the eventual effects on the fish environment resulting from the improvements that are projected or partially implemented in the basin of the Senegal River.

It must be remembered that at the present time the Mauritanian Senegal River fisheries are over-fished and that it is justified here and now from an ecological, economic and social point of view to go ahead with plans to intensify artificial fish production.

It must also be remembered that in this case, controlling the environment means creating ponds that can be filled and emptied, which is at least the usual practice. It cannot be forgotten that there are several environmental factors that will work against such ponds: the topography in particular, the availability of water and evaporation. The usual procedure in fish ponds is therefore inadequate *a priori*.

Special Note - - Use of the Floodplain

Before going on to study the foreseeable impact of developing river fisheries in Mauritania, the problem must be situated in the overall context of current conditions of time and space in the high water bed before consequences can be identified.

In its overall context, rural life in the Valley (especially the Middle Valley) is based on three types of economic activities: agriculture, fishing, livestock raising, and forestry, to a lesser degree.

The floodplain area is successively occupied during an annual cycle by three socio-professional groups:

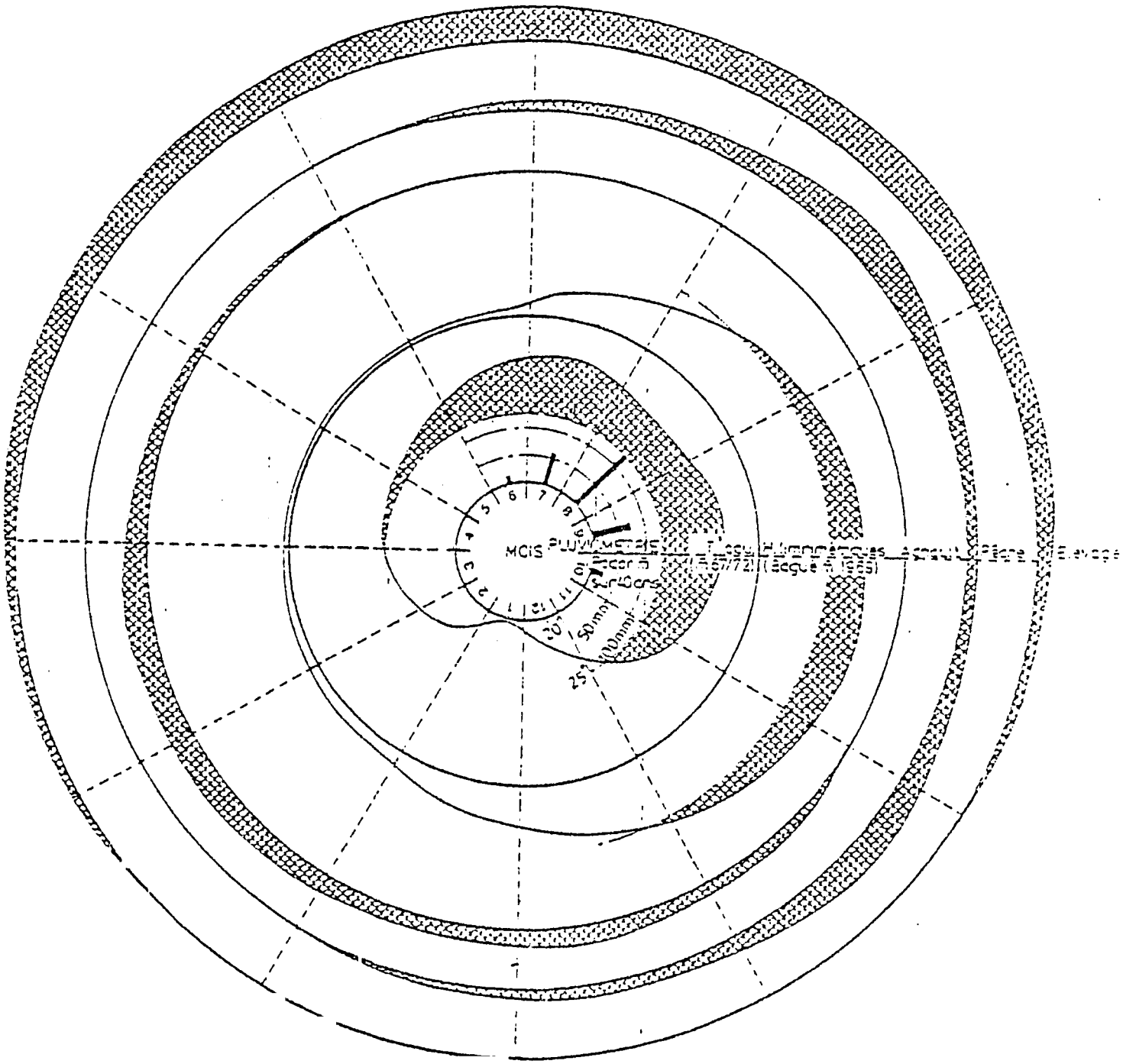
- during the flood	July-December	: fishing	Specialized Poulars
- period of receding waters	Dec.-April	: recessional agriculture	Poulars, Haratins, sedentary Peulhs
- at low water	April-July	: herding (transhumant and sedentary)	Peulhs, Poulars, Haratins

These three activities are practiced by three specialized and culturally different ethnic groups.

This system is evidence of a remarkable level of organization and shows that the basic concern of these men was to integrate themselves with their milieu. This is reminiscent of a kind of environmental climax. (Voluntary social regulations used to regulate the population according to the potential offered by the environment.) However, this dynamic is not a perfect one, to be sure.

The entire behavior of the inhabitants of the Valley therefore depends upon the rhythm of the river and the climate. It is true that at present there is only one harvest a year and production is less and less able to meet needs with each passing year. This situation is due to a climatic cycle that affects West Africa every 25 to 30 years:

Schematic Presentation showing use of the Floodplain
(expressed in French terms)



Utilisation spatio-temporelle de l'espace Floodplain

the monsoon fails to reach the basin, flooding is inadequate, most of the high water bed remains exposed, the fish do not spawn, recessional agriculture is not possible and there is no pasture land at the end of the dry season.

The regional diet is balanced and well-supplied with animal protein but with a risk of serious deficit in grains each year during the dry season and at other more widely spaced periods.

As a result of this analysis it is possible to speak of both an ecological and a human "environemntal climax". The overall dynamic mechanism of the floodplain of the Senegal indicates a certain harmony between man and nature. In fact, the Valley inhabitant uses his natural environment without modifying it very much. Instead of dominating it, he adapts himself to it : fishing and herding are based on a natural system which has never been modified while agriculture is limited to clearing land and to replacing certain associated natural species of various uses with single purpose cultivated species.

The three dominant economic activities of the primary sector are mutually enriching.

- Fishing, which is inseparably linked to the system of hydric phases, brings sediment and dissolves and activates ultra-dry animal manure, which is provided through natural grazing associations.

- Agriculture supports herding and fishing through agricultural residues, including fodder material which is either re-integrated into the hydric system or consumed by grazing animals.

- Herding enriches agriculture and fishing by adding large quantities of manure to the hydrosystem.

The elements of greatest interest to fishing are of course animal manure and, to a certain extent, agricultural residues that have not been consumed by animals.

Fish production is regulated by these three basic parameters: inundation, even though its water is chemically poor, the flood covers a high water bed of 600,000 ha. fertilized by 350 kg of animal manure per hectare, under conditions of high temperature.

As mentioned earlier, three weeks of submission are essentially to the survival of fry as well as for better crops. The basic reason could be that three weeks is the minimum time required to properly dissolve the animal manure left behind by the regional herd, on which the enrichment of the soil and the water depend.

Recessional agriculture has a slight tendency to upset the natural environmental balance; under natural conditions, the flood waters inundate vegetation-covered soil (except areas of over-grazed echinochloaie), but agriculture has the effect of stripping away vegetation and by the time the flood comes, the soil is virtually bare. There is therefore nothing to hold back the flow of the water and a reduction of direct vegetal food resources, of periphyton and of reproduction biotopes and shelter for fry results.

Herding and agriculture have led to the disappearance of wild animals, including the hippopotamus. It is true that even the best domestic animals producing large quantities of feces do not equal the hippopotamus as a means of transforming terrestrial material and adding it to the hydric system.

In closing, the system seems nearly ideal for the fishermen, given the ecological circumstances.

6.2 Projections to the Year 2000

Philosophical Basis

At the risks of over-simplifying, it is possible to define 2 types of "cultural" reactions of man to his environemnt (to the promptings of his milieu).

- Either he desires to integrate with a minimum of change, which implies a major corollary:

  since the resources of the natural milieu are limited, the number of persons who can live off them is limited. There must therefore be drastic demographic control.

- Or he seeks to change his milieu, which implies modifying it to suit human purposes. The number of people who can be supported by the environment is thereby increased and the need for demographic control is postponed.

The first solution is difficult to apply for whatever reason because the milieu and its available resources fluctuate; permanent human population would have to be kept at a minimum and extra population would be allowable only during periods of seasonal over-production. The transhumant lifestyle of the Peulh follows such a pattern in that they use surplus (but temporary) resources available during rainy season in the Sahel or in the Ferlo (Senegal).

The people of the Valley have long since adopted the option of modifying their milieu, which is the only way to survive given the cyclical deficits or water every thirty years.

The development of the river basin is a modern response to the deficits of the regional hydric ecology.

Outline of the Development Projects

The overall plan of improvements designed to control water downstream is the following:

-- Retention dams on each of the three basic tributaries:

- Manantali on the Bafing
- Galougo on the Senegal-Bakoye
- Gourbassi on the Faleme

-- Anti-salt water barrier dam in the Delta

-- Dam on the Gorgol

-- Improvements of the high water bed in the Valley and the Delta.

-- possibly a Dam on the Karakoro

Impact of these Development Projects on Potential and Production

As a general rule, the creation of retention dams leads to

- an increase in fish resources upstream in the new lake as a result of the twin factor of
  - running water that becomes still
  - an increase of submerged land.

- a decrease of fish resources downstream as a result of the twin factors of
  - an overall reduction of the flow of water which is diminished by the amount lost through evaportaion from the lake behind the dam
  - a drop in the amount of matter in suspension, which is an important factor in the life-cycle of fish.

This rule is applicable to the Senegal River.

- The upstream dams will lead to
  - an increase in production which will be of benefit to Mali (more or less 11,200 t) and Senegal (more or less 700 t)
  - reduced production downstream to the detriment of Senegal (more or less 1,400 t) and Mauritania (more or less 600 t).
- The dam in the Delta will also lead to
  - an increase upstream, depending upon the area flooded. Several hypotheses are worth considering:
    - an increase of 500 tons of fish in Mauritania (1,000 in Senegal) in the waters of the Senegal River itself
    - flooding of the Aftout es Sahel, 4,250 tons in Mauritania
    - restoration of RKiz as a lake, increase of 850 tons.

A further comment must be made about Lake RKiz. It is used in a radically different way from Lake Guiers, its companion lake on the left bank: whereas Lake Guiers is used as a fresh water reservoir to allow irrigated agriculture (at Richard-Toll), recessional crops, livestock herding and fishing, RKiz is used only for agriculture and it is a meager form of recessional farming at that. This is certainly an error .)

  - a decrease downstream, entirely to the detriment of Senegal.
- The dam at Foum Gleita, on the Gorgol, will inundate to 16,000 ha upstream form the gorge of the Oua-Oua mountains. This area - - which is entirely useful given the ecological conditions - - could produce 16,000 ha x 50 to 60 kg/ha = 800 to 960 tons/year.

Improvements in the high water bed of the river consists of dividing it up into "pseudo-polders" of Natural Development Units which would be used for irrigated crops. Water would not be brought in unless it were needed by the plants. Natural flooding of oualo lands would then come to an end.

It has been already mentioned that the fishing potential of the Valley and the Delta depends exclusively on the rype of inundation of the floodplain. It has already been stated as well that the floodplain is capable of producing 60 kg/ha fish/ha. when inundated.

As a result, for every hectare of high water bed that is put above the reach of natural flooding, there is a 60 kg. loss of fish to river fisheries as a whole.

The projected development projects - - dams, high water bed - - will not be completed for several more decades.

The most realistic time-table that can be foreseen is shown on the following page for the period of 1980 to 2000 (RAMS, 1981).

The figure used to express the impact of the Manantali Dam was derived in the following way:

The Manantali Dam is to back up the waters of the Bafing - - and therefore stop most of its useful floodwaters, which account for 5/9 of the flood of the Senegal at Bakel. Its influence on the downstream fisheries is thus estimated to be 5/9 of the 600 tons, or about 350 tons.

The figures below show that the potential/production ratio will vary depending upon the hypotheses used, particularly for the Aftout es Sahel and RKiz. (It is worth repeating that the high technical competence of the river fishermen enables production to keep up with potential)

- 1980 : 6,740 tons
- 1990 : 6 570 to 11,670 tons
- 2000 : 4,460 to 9,560 tons

The drop in tonnage is of course due to the progression of irrigated agricultural development projects in the high water bed.

There is a certain geographic distortion of potential and production that does not appear in the figures; that is, there are 2 areas that appear to be in an advantageous position: the Upper Delta on one hand and Kaedi on the other, because of the lakes to be created

there. The areas that will be in an increasingly disadvantageous position are Leqoeiba (Podor), Boghe, M'Bagne which are between the Delta and the Gorgol, and Sive (Matam), Maghama, and Gouraye, which are upstream from the confluence of the Gorgol.

6.3 Policy Guidelines

The combination of data relative to potential-production and demand leads to different conclusions under the 8 scenarios envisioned; see table below.

Of particular importance is the flooding of the Aftout es Sahel and the restitution of RKiz as a lake. In 1990, results were positive in only 2 out of 8 scenarios. In the year 2000, however, all scenarios are negative.

As a result, unless there is an adequate policy for assisting river fisheries (which has not been the case, as will be seen later in describing the NDU's), production, employment and income derived from this sector will gradually decline. It is all the worse that this is an insidious process.

The best policy to apply is one that will create a structure which will coordinate potential and production to meet demand.

Note on the Future Use of the Floodplain

The overall development of the Senegal River basin will bring about a profound change in the spatial use of the floodplain : it will be given over to a permanent specialized use (agriculture) in the place of a cyclical use (under natural conditions) combining agriculture, herding and fishing.

This is likely to lead to a paradox.

- At present the regional population's nutritional intake

  - is characterized by a temporary annual deficit in volume during the agricultural interseason, which may be prolonged during the dry years which come every 25 to 30 years,

  - but the local diet is nevertheless rich in animal proteins which are essentially supplied by fish, particularly among people living along the river, but supplemented by off-take from the regional herds (especially milk).

- The projects to develop irrigated agriculture will then

  - regularize production and provide the means to gradually raise it;
  - however, there will be a corresponding drop in the production of fish and animals, which means that the local diet will have sufficient cereals intake but a lack of protein.

The development projects will in effect replace a problem of temporary under-nourishment with a problem of permanent malnutrition.

7. Recommendations

General Conclusions

By bringing together data relating to the three elements of the parameters that condition fishing this basic problem is solved in the following way:

- Under natural conditions, that is, before the completion of the planned development projects in the river basin, there is a tendency to over-fish and deplete the stocks of fish in the river, leading to an under-supply of fish on the market.

  This situation is particularly serious in years of significant hydric deficits given a constant if not growing demand and a level of production, which, unhampered by incompetence or inadequate equipment, far over-reaches the potential.

- Potential will decline in certain areas with the completion of the various development projects but will grow in other areas, which will upset the former geographically balanced distribution mechanism. In addition, demand will continue to grow with the increase in population. There will then be a growing gap between limited and constant potential and production and rising demand.

  Another aspect of the problem, first treated in the two conditions under "current situation in 1980" and "projections to the year 2000", is the question of using the floodplain.

- Under "traditional" conditions, the environmental functioning of the floodplain system of the Senegal River integrates three important rural activities : agriculture, herding (and forestry, to a degree) by means of specialized social groups. The high water bed is thus successively given over to these three activities, resulting in a balanced nutritional intake for the people along the river, although lacking in cereals during the agricultural inter-season or periodic droughts in the Sahelian weather cycle. There is therefore a problem of general periodic under-nutrition.

Policies

Whether it be in the area of inland fisheries or in any other kind of production, the basic concern of the policy-makers bears on three factors, which can be summarized as follows: on the one hand, to assure the producers (fishermen) a satisfactory standard of living, full employment, and in doing so, offset migratory tnedencies(in Foular and Soninke areas these tendencies are very strong); on the other hand, to protect the interest of consumers by providing a desired level of protein intake at a reasonable price while taking into account population growth; finally, the policy-makers must be concerned about not over-exploiting the ecosystem.

Before going on, it must be mentioned that because fish is a staple in the daily diet and is eaten fresh, it will be recessary to respect the need for a daily supply. This will have to be done given (and even in spite of) the characteristics of the ecosystem.

By following this rule, it will be possible to avoid upsetting the food habits of the people living in the Middle and Lower Valley.

There are three critical factors in protecting the interests of the fishermen:

- to ensure full employment as professionals, especially by eliminating seasonal unemployment and disguised under-employment;

- to assure them of a decent income : as seen earlier, 40,000 UM/year in 1980 prices is an acceptable average.

- to offset the regional disparities in this income.

Protecting consumer interests requires that

- desired daily intake of fish protein be available; it is in the order of 200 gr/day per capita, or 72 kg/year per capita;

- this intake be affordable : 20 UM/kg at 1980 prices seems to be an adequate selling price;

- the rise in demand resulting from population growth be taken into account (1% a year in current socio-economic conditions, including a 2.7% annual emigration rate, which may change in the coming decade, especially after the irrigated agricultural projects get under way, transforming the Valley);

- regional disparities be eliminated (ie. the Upper versus the Lower Valley), at least in normal years.

The need to harmonize both producers' and consumers' interest in a highly perishable good that must be consumed fresh requires that production must take place in areas immediately adjacent to areas of consumption. Expensive transportation systems are therefore useless.

If the principle of a constant daily supply is accepted, the ecosystem must be able to sustain a steady volume of fishing. However, no matter what is done, the Senegal remains a typical Sahelian river in its middle and lower reaches and its flow and fishing potential are subject to wide fluctuations from one year to another. This fact is a menace to any effort to maintain a constant level of production in fishing. In addition, even in years of favorable hydraulic conditions, production tends to outstrip potential. It must therefore be accepted a priori that the ecosystem can not become significantly more productive without major intervention. Indeed, precautions are necessary to prevent over-fishing under natural conditions.

Given these conditions, two types of measures must be taken to improve the situation and to re-establish an equilibrium between production and demand without risking an ecological disaster in the short or medium terms:

- protection of the natural stock of fish in order to overcome risks of disequilibrium in the ecosystem;

- intensification of artificial production: this is both an immediate commercial necessity as well as an economic justification of facilities to be created in order to make up for at lest periodic deficits in fishing potential.

The need to overcome regional disparities requires intensifying production at certain locations before others (Middle and Upper Valley). The problem of protecting the stock of fish is, on the other hand, a regional problem affecting the Valley as a whole.

In conclusion, a policy to improve river fisheries should be as follows:

- protecting the interests of both fishermen and consumers in the region by assuring full employment and a decent income to the former and an adequate supply of fish at reasonable prices to the latter.

- elimination of regional disparities in production, income and employment.

At the same time the ecosystem must be protected from the danger of over-exploitation by:

- taking general measures to conserve the natural fish population;

- conceptualizing techniques specially designed to increase supply in over-fished areas;

- valorizing exportable tonnage from under-exploited areas.

7.1 Guidelines

Principles

Faced with such a complex situation, the environmentalist in charge of improving the milieu must logically enumerate the constraints limiting the rational development of the milieu and establish priorities to overcome them.

As seen in the preceding chapter, there are two types of measures to be taken to reach the desired goals and they are economically justified. These measures are:

- policies to protect the natural supply of fish;
- policies to intensify artificial production;

These policies must be applicable, which means that they should be:

- simple and comprehensive by the fishermen and by supervisory personnel on all levels;
- psychologically acceptable: that is, they must be consonant with the trends of social evolution; if not, they must produce the least amount of friction possible in the minds of the local people and with their habits. Whatever the case may be, no policy of limiting or banning should be established without the awareness and preferably the participation of the fishermen or at least a large majority of them.

There are two types of rules or policies, according to the areas to which they apply:

- general ones, which concern all of the fishermen;
- particular ones, which are of concern only to certain groups of fishermen in different areas. This implies a need for an "environmental subdivision plan" similar to one used in forest management. The environmental subdivisions for fisheries must have abiotic, biotic and anthropic homogeneity.

Management Subdivisions

Each "subdivision" must be based on an environmental division of the river while at the same time being connected with the administrative division of the region. This could be the following:

- Delta : the area are below Leqceiba — centered around Rosso (Trarza)
- Lower Valley : Leqceiba to M'Bagne — centered around Boghe (Brakna)

- Middle Valley	: M'Bagne to Wompou	Centered around Kaedi (Gorgol)
- Upper Valley	: above Wompou	centered Gouraye (Guidimaka)

Therefore, even after development, the zones thus defined will remain sufficiently homogenous, with Rosso being in charge of the water held back by the Mako-Diama dam and Kaedi being in charge of the lake to be created at Foum Gleita.

General Guidelines

The broad analytical perspective of this study shows that general policies should focus on:

- supervision, in the widest sense;
- rationalization of fishing as an economic activity.

Supervision

No matter what proposals may be presented by an environmentalist following a study of the natural milieu, it is indispensible to be able to count on the availability of competent and effective supervisory personnel.

If fishing is under-developed, the civil servants in charge of supervising fisheries must act as catalysts, suggesting new methods and encouraging people to enter fishing in order to bring production up to a level that is compatible with the ecosystem.

If there is a problem of over-fishing, the civil servants in charge of fisheries must see that the rules limiting or banning fishing are obeyed.

In the case of the Middle and the Lower Senegal, which are over-fished, there is an urgent need for a specialized administration exclusively concerned with fisheries. Because of the planned irrigated agricultural development, and the fragility of the ecosystem, new techniques of intensifying production must be applied. Because of these complex factors, the supervisory personnel must be as well-trained as possible, in order to give priority to imaginate leadership.

It is logical that these civil servants should be posted in well-defined locations in order to reinforce the concept of environmental subdivisions.

Finally, since fishing in the Senegal River is in effect an international affair, some kind of consulting body to take charge of harmonizing the laws on both banks of the river concerning fishing and to favor contacts between representatives of Mauritania and Senegal.

This chapter is therefore divided into the following sections:

- administration, strictly speaking,
- consulting body for inland fisheries in the Senegal River basin,
- research,
- professional training.

Administration

The study of the existing administrative body responsible for inland fisheries has already pointed out a certain number of problems. These must not be forgotten because they are barriers to effective supervision.

- There is absolutely no supervision or support for river fishing in Mauritania;
- Supervision and support are ineffective in Senegal.

Given such unfavorable factors, it appears that the first measures to be taken are to:

- create a true service, exclusively specialized in and devoted to the rational development of inland fisheries both in Mauritania and in Senegal;
- structure the 2 services in order to make the administrative boundaries match the boundaries of the environmental subdivisions as much as possible;

- give particular attention to the languages spoken by the civil servants posted in the fisheries service in Mauritania and Senegal;

- create a coordinating body to link the two services.

In applying these principles to Mauritania, the fisheries service to be created should be structured as follows:

- an inter-regional Division of Inland Fisheries, based in Kaedi and responsible for overseeing all inland waters in Mauritania;

- four regional Inland Fisheries Sectors, preferably based in the regional capitals when they are on the banks of the Senegal River or in other large towns in cases in which the regional capitals are not on the river;

- since the Lower Delta is of marginal interest to Mauritania, there is no reason not to include to two delta zones in the same management subdivision.

The organizational chart of the management subdivisioons in Mauritania is as follows:

The Organization of the Fisheries Sectors in Mauritania

Inland Fisheries Sectors	Location of Sector Administrative Centers	Region & Capital	Predominant Local Language
Upper and Lower Delta	Rosso	Trarza	Wolof
Lower Valley	Boghe	Brakna (Aleg)	Poular
Middle Valley	Kaedi	Gorgol	Poular
Upper Valley	Gouraye	Guidimaka (Selibaby)	Soninke

In order to improve its effectivenss, the Inland Fisheries Service of Mauritania should, in addition:

- separate itself from the present administrative aparatus of Marine Fisheries. In a country like Mauritania where marine fisheries are essential and constitute a major economic activity, inland fisheries are by all evidence neglected: their 7,000 tons a year are far outweighed by the 1,200,000 tons brought in to the Mauritanian coast. The Inland Fisheries Service would do well to collaborate closely with the Agricultural Extension Service and the Environmental Protection Service;

- Because the Senegal River is in fact an international boundary, the Mauritanian Inland Fisheries Service should cultivate close and continuous relations with its Senegalese counterpart;

- The Service's agents will be placed in the major towns along the river:

  - Kaedi could be the headquarters of the Service;

  - Rosso (Upper elta), Boghe (Lower Valley), Middle Valley) and Gouraye (Upper Valley) would be the headquarters of 4 environmentally homogenous fisheries sectors.

The equipment of these two hierarchical levels would be as indicated below:

- Inter-Regional Division: - 1 heavy all-terrain car, station wagon body,
  - 1 inhabitable launch (Arcachon type) stationed in Boghe or Bababe.
- Sector headquarters : - 1 light all-terrain car,
  - 1 fast launch that draws little water (type TPEI-AN2, improved model if a synthetic hulled motorized canoe is unavailable).

Consulting Committee for Inland Fisheries in the Senegal Basin

One of the most urgent measures to take after organizing the two national inland fisheries services is to concieve of a supra-national administrative structure which is needed to overcome the difficulties stemming from the international nature of the inland fisheries on the Senegal River.

Borrowing from similar experiences elsewhere, it seems that the best solution consists of creating an International Consulting Committee for Inland Fisheries in the Senegal River Basin.

The role of this committee would be:

- to first proceed with harmonizing the laws of both countries concerning inland fisheries;
- to then encourage meetings among the administrators of each of the services concerned in order to facilitate the enforcement of the laws;
- to serve as permanent intermediary between the regional research and administrative services;
- and to promote a policy of extension and diffusion of methods and techniques recommended by the Research Service.

This committe could be made up as follows:

- Permanent Secretary;
- Core Committee, to meet once a month successively in each of the Sector Headquaters; its members (no distinction of nationality) would be:
  - the Permanent Secreatry
  - the Inter-Regional Division Head : Senegal 1
    Mauritania 1
  - all of the Sector Heads in both countries 10

Total	13	members

- General Committee, to meet at least once a year, made up of:

. the Core Committee	13
. the parent ministries of the Inland Fisheries Service of Senegal and Mauritania	2
. The General-Director of Hydraulics, Forestry and Hunting (Senegal)	1
. the General-Director in charge of Inland Fisheries in Mauritania	1
. Directors of Fisheries (Senegal and Mauritania)	2
. the Director of the Research Service	1
. Assistant Director (s) of the Research Service	1
Minimum total	21 members

The Research Service

For a time, 1966-1974, Senegal was able to benefit from having a truly specialized service. Mauritania has never had one at all.

Nevertheless, the sector is an important one, particularly from the social point of view. Furthermore, if agreements in this domain were made with Senegal, Mauritania could specialize its service in certain areas of research such as the integration of pisciculture in the Natural Development Units, the management of the resources of Lakes RKiz, from Gleita and the Aftout.

Because of its central position in the Valley and its "intellectual infrastructure", Kaedi appears to be the likeliest site for establishing the Research Service.

As far as the personnel go, the staff should include

- an expert (an expatriate at first, later to be replaced by a Mauritanian);
- an associate expert;
- 2 technicians with specialized technical Baccalaureate degrees;
- junior staff: 2 employees, 6 driver-workers, etc.

In order to insure that the experts improve their work, they will remain in constant contact with the Training project (see below).

Training

Given the already high level of technical competence of the regional fishermen, the problems of training are essentially on the level of the supervisory personnel; there is no need for vocational training per se.

Ideally, the specialized civil servants from Mauritania should be on the same level as their counterparts from Senegal; the necessary contacts between the two groups would thereby be improved. That means that the technicians must have a certain level of higher education (Baccalaureate plus 2 years).

However, in this domain, Mauritania is starting from scratch.

There are two ways for the country to build up well-performing cadre of specialists:

- To train each one for a specific position to be held for his entire career; the only technical progress being a result of experience; socio-professional promotion would be almost nil;
- To allow individuals to go back to school after working for a certain amount of time; this would allow the motivated diploma-holders to attain a higher level of competence which would give them access to the next higher job category. The advantages of this "other" system are the motivation of the workers in question and the possibility of upward career mobility, enabling the workers to refine and improve their experience especially once they become aware of the limits of their knowledge. This system, however, would have to be reserved for a motivated elite.

This principle should guide policy-making:

In a society which aspires to evolve - - and a society which seeks to develop itself is necessarily an evolving one, training institutions should be adapted to needs by allowing for permanent training of individuals and their upward social mobility through increased technical ability.

Furthermore, the training of technical agents must be provided at the lowest possible cost, which means using existing infrastructure as much as possible. It is thus proposed that the National Agricultural Training and Extension School (ENFVA) in Kaedi be used as follows:

- A dozen lower secondary diploma (BEPC) - holders, preferably from fishing backgrounds, should be recruited and trained at this school; they should be able to take courses in fishing and fish raising in inland waters in the place of certain other technical courses that have little to do with fishing.

- The students should be supervised by a qualified expert (doctoral level) with substantial experience who would be posted at the school for a 4-year period: 3 years of course work and one year of field work.

- At the end of this program, the graduates should be posted as follows:

  . 5 in the specialized fisheries administration (Rosso, Boghe, Kaedi (2) and Gouraye;

  . 1 in the field service (see below);

  . 2 in the research service.

- Later on, after 3 or 4 years of practice, these technicians would be sent in turn to a post-secondary technical school where they could acquire an under-graduate-level training that would allow them to perform more competently once new needs emerge from the completion of the development projects on the river.

7.2 Rationalization of Fisheries

There are two scenarios to be considered: first of all, the present situation (before the development projects) and secondly, the situation after the development projects are completed.

The Present Situation

In general terms, in the Middle and Lower Valley, the situation of fishing is such that it is not an absence of capital limiting production. It is always possible for a fisherman, no matter how poor he is, to find the 2,000 UM necessary to make a "diolinke" and to use it as an initial investment, later allowing him to acquire more sophisticated equipment.

The areas of interest in rationalizing fishing include

- the boats (for fishing and for supervision purposes);
- equipment (how they are used in time and space, plus their physical dimensions).

It is true that the boats used by the fishermen are not one of the limiting factors in this sub-sector in terms of production, but more will be said on the subject further on.

Senegal and Mauritania are losing their forest not only in the region being studied but in all areas. Therefore, any policy that allows the use of wooden boats, even if constructed, as in Saint-Louis, contributes to further deforestation; this applies to far-off Casamance, which has become the source of wood for fishing canoes since the appropriated trees in the Senegal River Valley have long since vanished.

Furthermore, wooden canoes cost more and more because the appropriate trees for making them are becoming scarcer and scarcer and farther and farther away from the areas where the canoes are used. As a concrete example, a Casamance or a Saint-Louis-style canoe cost 4,000 UM a meter (exterior measurements) in 1980. Therefore, a 6-meter canoe cost 24,000 UM and a 10-meter canoe 40,000 UM.

The annual amortization costs are therefore increased, reducing the fishermen's income.

In the area of boats, there are two main goals:

- to slow down the process of deforestation of the Sudano-Sahelian region;
- to reduce the annual amortization costs and thereby raise the fishermen's income.

The criteria applicable to the fishermen's canoes are val for the supervisor's boats as well, with the possible exception of the Division head who may use a heavier type of boat. The Arcachon-type of fishing smack would do very well. Because of navigability problems elesewhere, the boat should be based in Boghe or, at the farthest, Bababe.

The Sector Heads, on the other hand, require a medium-weight boat with some kind of housing and storage space on board bu yet drawing little water in order to cross the underwater sills at low water.

As part of the research service activities in Senegal, a successful experimental boat was built at the Public Works Departme Industrial Naval Yard in Saint-Louis. The boat was based on the TPE AN2 model.

The boat proved to be very satisfactory and it drew only about 18 cm when loaded. It also had a cabin with a bunk. This boa could be further improved if it were made of a lighter modern mater such as fiberglass. It should have a motor (either out-or in-board of the Z-drive type).

Coincidentally, the fisheries administration is not the only governmental body that will require water transportation. Ther is easily a need for 40 boats to be used by other services that nee to used the river at low water: the gendarmerie (rural police), th health, customs, forestry and game services, etc.

Both Mauritanian and Senegalese administrators would do well to consider this issue and take action without delay.

Earlier, it was stated that spawning took place in August the "tchiali" (channels) connecting the mean water bed and the floo

It is in this season that the shore seine net, one of the most effective types of fishing equipment ever devised, is used intensively.

It has been found that as a result of migrations (at firs longitudinal, then lateral flowing ones) and the shallow sills, tha the largest concentration of adult specimens is to be found in the waters of the Podor area (Boghe, Cascas, Dioulde-Diabe), in the Balerou marshes. Studies have also shown that the replenishing of th regions dowstream (the Lower Valley, the Upper and Lower Delta, Lake Guiers and RKiz) potentially depends entirely or largely on the Pod region.

It has also been found that seine fishing in August is particularly intense, when hydrological conditions are particularly poor and ecological conditions are harmful for fishing potential.

It is evident, therefore, that one of the first measures to be taken, given the need to protect the spawning grounds and the dangers of the over-fishing that is already taking place, is to ban the use of the seine net in these vital areas. In view of the need to be simple in formulating directives, it must be stipulated t

- use of the shore seine and all dragnets for individual or group use is strictly forbidden outside of the mean water bed of the Senegal river and its main backwater, the Koundi.

  In order to reinforce the impact of this regulati a second ban must be applied because the seine is used at low water and fishermen may be allowed to extend their fishing season for 15 days to one month in the mean water bed.

- the use of the shore seine and all dragnets for indivi or group use is forbidden in all areas between the 1st of August and the 31st of October each year.

One can well imagine the need to weight the seine between the 15th of August and the 15th of October, which gives the fishermen plenty of time for any required repairs.

A further restrictive measure which usually has positive results is to establish a minimum size of the mesh of sleeping, floating, dragged and thrown nets.

In order to be effective, these regulations should derive from pre-determined bio-technical bases. In theory, in a complex biocenology, it is possible to identify the basic principle that determine whether a fish can be caught after having been able to spawn. In other words, the mesh must be large enough to let go a maximum if not all immature specimens. In the Middle and Lower Senegal, however, there is a variety of nearly 150 fresh and bracki water species and a compromise is necessary to avoid releasing adul specimens of the smaller species and catching immature specimens of certain large species (especially Citharinus).The fishermen's income must also be protected.

Based on experimental fishing carried out between 1966 and 73 on the Senegalese bank, certain data were collected concerning the minimum sizes corresponding to sexual maturity; it appears that the minmum acceptable mesh size is 30 to 40 mm from knot to knot (French measurements).

Furthermore, between 1967 and 1972, the best catches in terms of weigth were brought in with mesh of

- 30 mm in the Upper Delta
- 40 mm in the Lower Delta
- 50 mm in Lake Guiers.

Given these results, the recommended mesh sizes are 50 mm in Lake Guiers, 40 mm in the Lower Delta and 30 mm in other areas.

The Senegalese authorities have established 2 types of lower limits of mesh size: 30 mm on the river, 50 mm in Lake Guiers. Reducing the lower limit now authorized by law on Lake Guiers has more advantages than drawbacks.

- this simplifies the rules;
- nets with mesh measuring 30 to 40 mm are the only ones capable of catching the small species which sometimes swarm in the lake: Gnathomenus, Brienomyrus, Alestes, Schilbe, Eutropius, Synodontis of various sorts;
- it has been discovered that the lake fishermen adjust their mesh to catch the species they want, usually the larger ones, for economic reasons;
- by harmonizing legislation, there is every possibility for river fishermen to migrate to the shores of Lake Guiers and in the future to RKiz and the Aftout without having to modify their equipment.

Consequently, the following rule is reocmmended:

- the use of nets whose mesh measures less than 30 mm from knot to knot is forbidden in all bodies of water

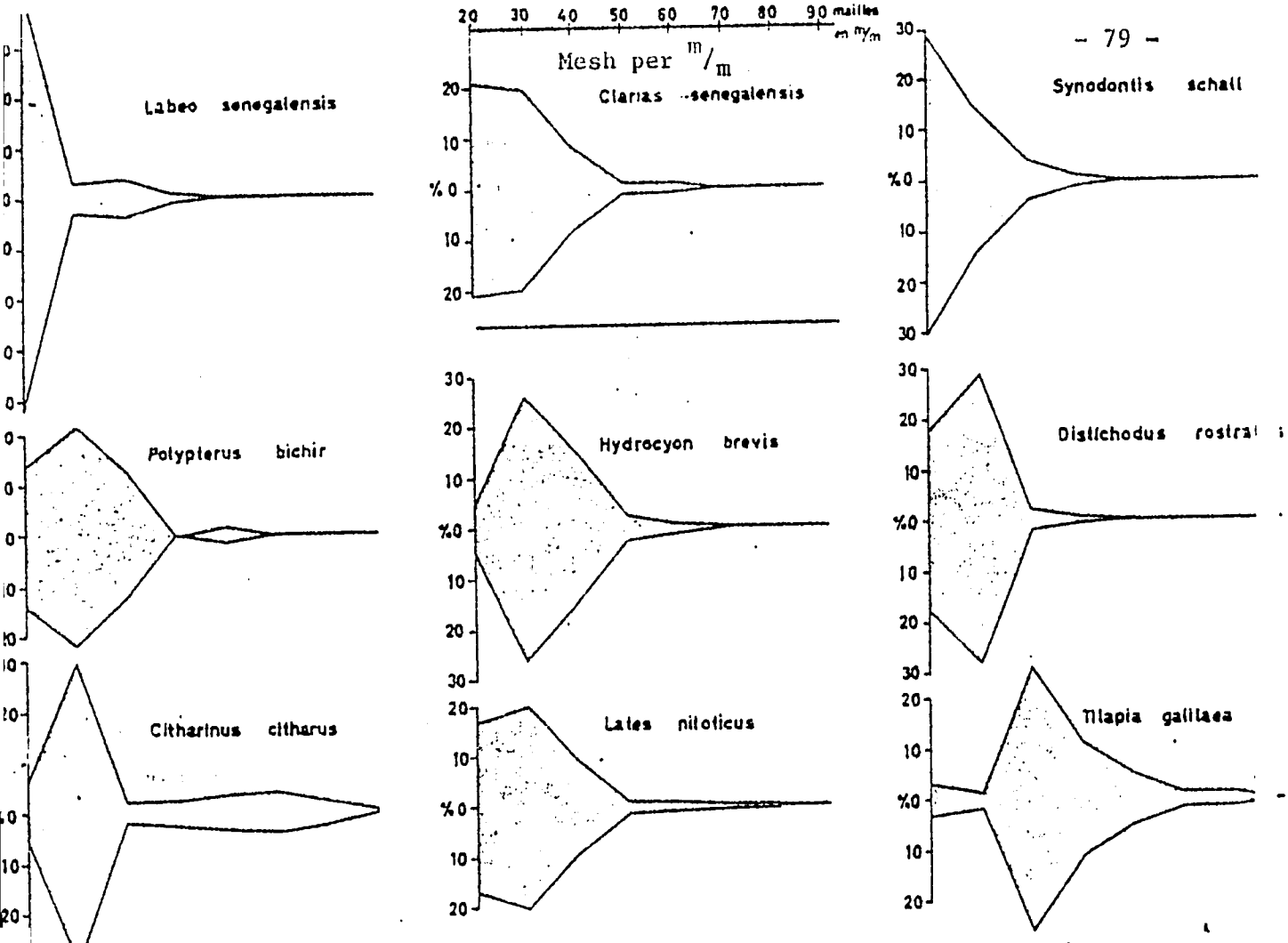
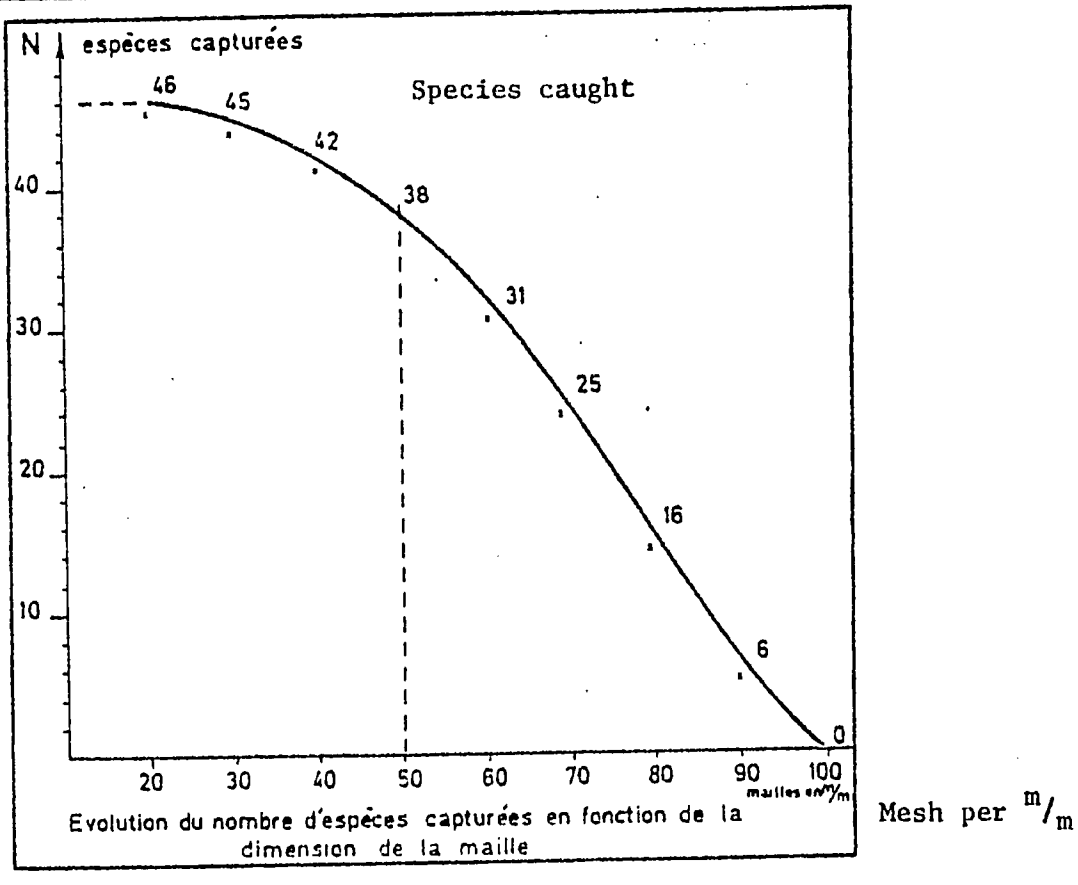


Diagram showing specific percentages of catches in relation to mesh size.

REPRESENTATION GRAPHIQUE DES POURCENTAGES SPECIFIQUES DE CAPTURE EN FONCTION DE LA DIMENSION DE LA MAILLE



Change in the number of species caught in relation to mesh size.

of the Senegal River basin whether the nets be sleeping, dragged, floating or thrown; the same applies to all kinds of hoop nets and dams used to catch fish.

The psychological aspect of these bans and limitations must not be overlooked. They have already been tested several times by means of opinion surveys carried out among the fishermen. In most cases, the professional fishermen were in agreement with the bans on condition that all fishermen obey them.

7.3 After the Completion of the Development Projects

The fishing potential of each of the four zones will change:

- the Delta: potential will increase as a result of the water held back the the Maka dam; potential will diminish because of the NDU's.
- Lower Valley : potential catches will diminish because of the NDU's.
- Middle Valley : increase because of the new lake on the Gorgol, decrease because of the NDU's.
- Upper Valley : little change.

See particular policy recommendations regarding the situations described above.

Restriction and bans on certain types of equipment, places and times will continue to be applied.

Increasing Fishing Potential

One fundamental principle of development is to use appropriate technologies for at least minimum effectiveness not only in dealing with the environment but also dealing with human beings.

Two options are possible depending on whether the situation is prior to or following the completion of the NDU's and other development projects.

Prior to Development: Development of fishing in Natural "beli".

In the first part of this report it was stated that the flood-plain of the Middle reach of the Senegal included about 600,000 ha,

Although it is complex, the lateral profile of the valley is essentially bounded by lands permanently above the high water mark (dieri) followed by oualo land, the river bank proper and the mean water bed.

There are two major types of catchment ponds lying in the center of certain oualo lands : a) the "vindou" and b) the "tiangol" types.

The fish life of these ponds was studied as part of UNDP project SF/AFR-REG 61-11/F1 (AGL). Contained in the study is paragraph 1 "La production piscicole dans les cuvettes de la Vallee", in volume II of the published results of the study (REIZER et al., 1972); the details of the findings can be found therein.

One of the important conclusions of the study was that certain "beli" could be developed as fish-breeding ponds in order to intensify fish production, assuming that a minimum number of steps was taken to overcome certain limitations.

It was discovered that in effect potential fish production in the ponds was, under normal conditions largely dependent on factors other than the area under water and its intrinsic biogenic capacity. Th se factors are the following:

- Water shortages at the end of the dry season

  This could mean a complete drying up of the pond, especially if it is of the "vindou" type. The consequences are of course significant for the possibilities of pisciculture. First of all, fish cannot live there permanently. In addition, it has been discovered that the diminishing area under water as well as the increasing shallowness of the pond at a time when rising temperature bring on a new growth cycle in other milieux prevents the fish remaining in what is left of the pond from responding to the growth stimulus of the hot season.

  It has been noticed as well that the most productive areas are the ones that are the first to be exposed by receding water: shallow areas where there is always adequat vegetation, especially the gonakaie, which produces a significant biomass of exogenous food.

Thus the perennial nature of the ponds is a key factor in their potential usefulness to fish breeding. Whether or not they are perennial depends on their depth at the time the pond becomes hydrically independent with the high water bed.

Because of climatic conditions in the Sahel, evaporation is rapid and in order to be permanent, once the hill of its "tiangol"(channel) connecting it with the river emerges and cuts of the flow of water into the pond, the pond must be at least 3 meters deep. 2 of thes meters will eventually evaporate, leaving one meter of water behind, which is enough for the residual fish population to live in perfect health.

- Date of Flooding

The date when flooding occurs has two kinds of influence: first of all an early flood could retard the effects of evaporation in the residual pond left by the flood of the previous year; finally, and most import it has been found that the fish tend to enter the "tchia (feeder channels) as soon as possible. The biomass of fish in a pond is thus determined by this factor.

Reproduction takes place in August. If spawning-ag fish are to be put into the pond before the spawning per the pond must absolutely be flooded as soon as possible. The reduced biomass of Vindou Edi is due to the fact when the flood reached the pond (second week of August, 1971), the spawning-age fish had mostly left the mean water bed. Furthermore, at the time of the disastrously low flood of 1972, the few fish that made their way into the Dialol "tiangol" which feeds the Vindou Edi had empty gonads.

- Date of hydric independence

Ponds become independent once the sills of their feeder "tiangols" emerge. If this happens at a late date the evaporation effect of the dry season is retarded; if it happens early, it reduces the fishes' chances of returning to the mean water bed because it appears that feeling the inversion of the flood is what determines the return migration.

- Geographical Location

Because of the migration phenomena linked to the sills, the ponds that are closest to the area downstream from Bababe (Dioulde-Diabe) are better stocked with adult fish. Those which are very far downstream, such as Vindou Gani, opposite Gae, tend to be stocked more by the sweep of the flood, bringing in fry from upstream.

- Water Temperature

The temperature is too low for 3 months to allow for continuous growth.

- Concentrarion of dissolved matter

The water in the ponds is the same as that in the river: it is low in minerals and lacks sulfates and is just as oligotropic.

- Improper fishing practices

As mentioned earlier, the intensity of fishing in the "tchilal" is such that in some instances the fish are unable to reach the ponds, particularly adult specimens. (Vindou Edi, 1972).

Not only that, but pond fishing is practiced until there are few if any fish left. The residual biomass at low water even in permanent bodies of water is very sparse.

Certain ones of these limiting factors can be overcome, as shown by the in-depth study of Vindou Edi: water shortage, date of flooding, date of hydric independence, residual biomass, oligotropic qualities of the water, improper fishing practices.

On the other hand, nothing can be done about the location of the pond or about the temperature.

These are the basic steps in developing the ponds:

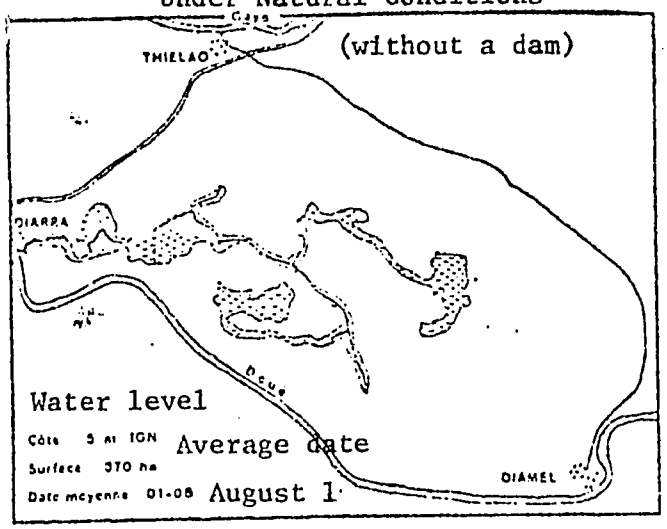
a) to assure the permanence of the pond by

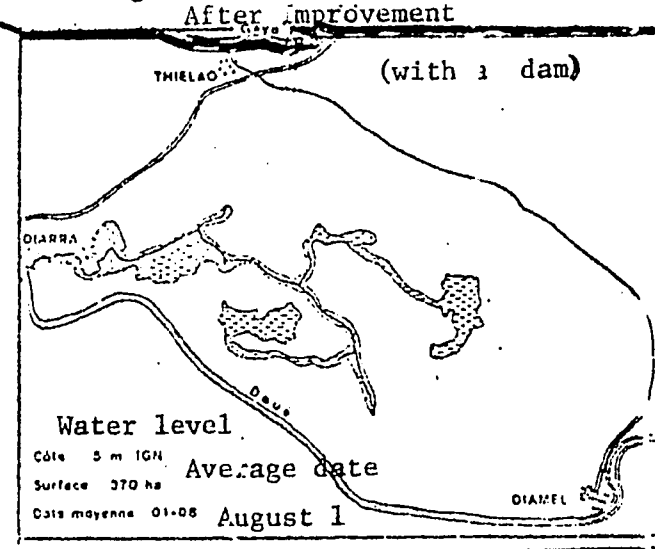
-building a dam at the confluence of the tiangol channel and the river,

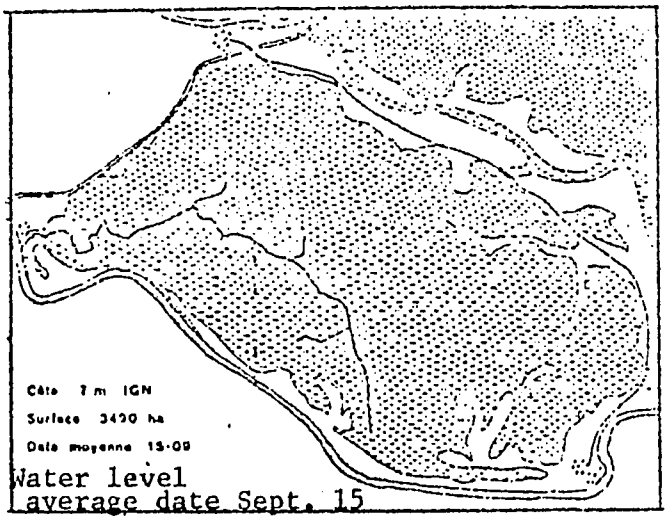
- eventually rectifying the feeder canal.

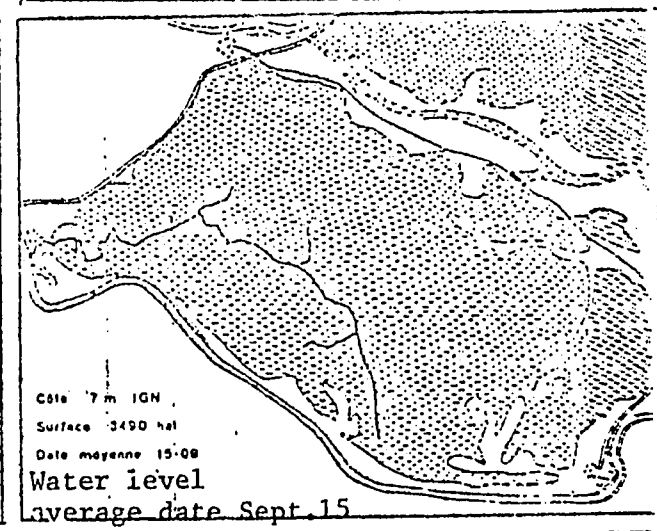
VINDOU EDI - Changes in Flooding over Time

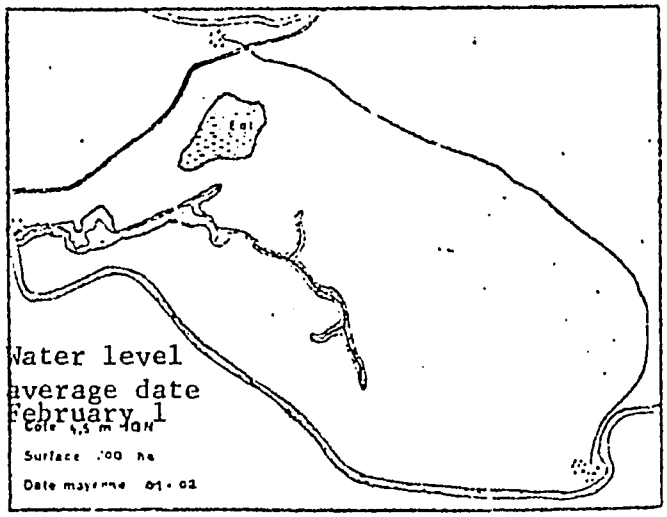
Under Natural Conditions | After Improvement

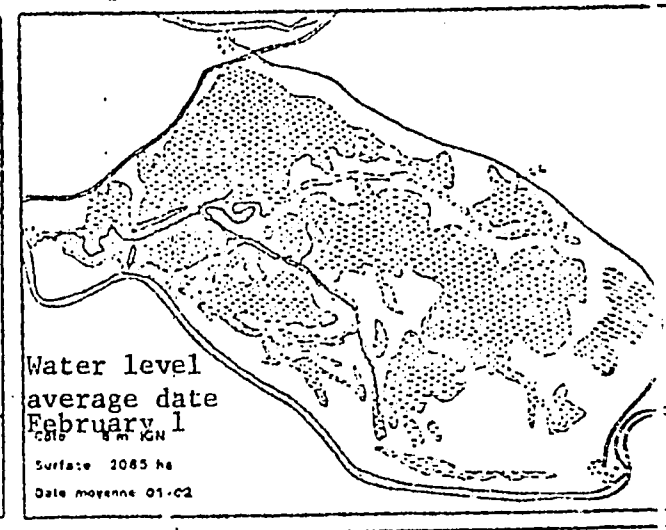


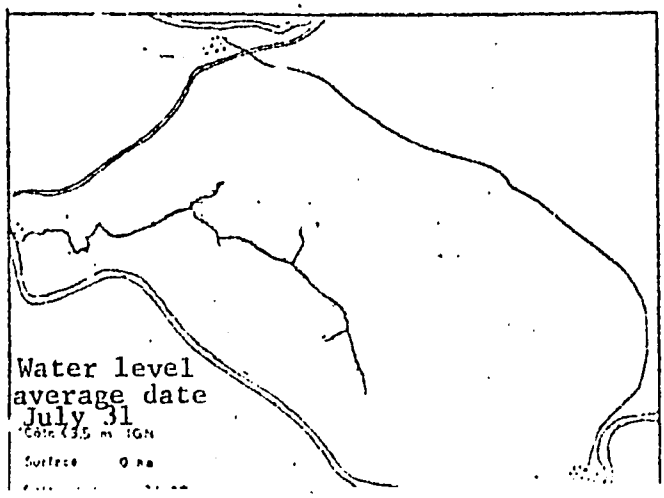


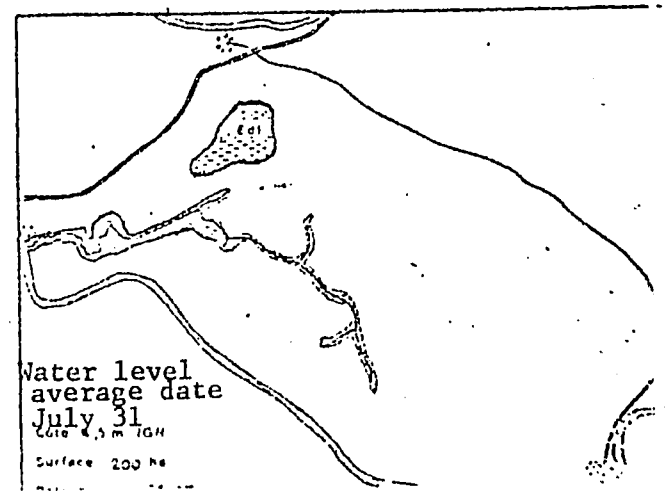












b) to increase the biogenic value of the water by

- building a dam to retard the retreat of the water,
- adding food and mineral fertilizers to the water,
- raising ducks (to provide organic fertilizer),

c) to favor the existence of a large fish biomass by

- creating a dam (to be closed when the water reaches its highest level)
- placing barriers in the channel to prevent the fish from leaving during the ebb of the flood
- banning fishing in the tiangol

d) to assure sustained daily production through a general organization of the fishery.

It must be noted that this kind of improvement cannot be applied a priori to any pond. The large backwaters, such as Guissel, Hallo or Baol will always be difficult to improve and efforts to develop them may not always pay off:

- because natural production in them is high;
- because a large portion of the fertilizer added to them would be lost during the flood mainly because of the usual inversion of the current (on the other hand, all of the fertilizer remains in the "beli" because it will never be emptied after being improved);
- because maintaining a body of water at the level of the highest floods would at most double the maximum surface, whereas damming the beli could, on the average, quadruple the surface.

"The Vindou" type of pond seems to be ideal for the kind of development being proposed (C.REIZER et al, 1972).

In order to analyze the impact of such localized improvements on the fishing potential of the Lower and Middle Valley, the example of Vindou Edi on the Senegalese bank is cited, particularly because of its hydraulic functioning.

This program would most of all allow for an inter-annual regularization of production. It may well be that pumping water (possibly by windmills) will be a viable way of maintaining the water level.

A well-chosen vindou could answer these questions if properly developed as an experimental pond.

Even without the benefit of a feasibility study (which should certainly be done), it seems a priori, that 3 beli could be used for such a project in Mauritania, which would raise the total productive surface to nearly 5,000 ha., capable of producing some 2,500 tons a year.

The development plan should call for

. 1 pond to be developed between 1981 and 1990

. 2 additional pond between 1990 and the year 2000.

The "field service" brigade, placed at first under the responsibility of the research institute and later under the administration, should be in charge of carrying out the development of the ponds and of supervising them later, once they become productive.

This field service brigade would consist of

. 1 specialized technician

. 6 workers : masons, laborers, etc.

The ponds would be chosen in relation to their adaptability to development on the one hand and their eventual integration on the other; market needs would also play a determining role.

It is difficult to estimate costs because each vindou is a special case. Of course the ones chosen will be those that can be developed at the lowest cost.

There is no example in Mauritania to be studied, so Vindou Edi on the Senegalese bank can serve as an example.

The work to be done consists essentially in raising the height of the natural dike and in installing ducts, floodgates, grills and dams.

In terms of 1980 prices, the basic cost of developing this vindou would be 10 million UM for 1,000 ha., or roughly 6,250 UM/ha.

In very general terms, the cost of developing a single 2,000 ha. vindou between 1980 and 1990 would amount to 12,500 x 10^6 UM. The cost of the 2 additional beli (3,000 ha.) to be developed between 1990 and the year 2000 comes to 18,750 x 10^6 UM.

The recurring costs are to cover to the distribution of fertilizers (S04 and P_2O_5) and the general maintenance of the dikes and the hydraulic equipment and artificial feeding, if necessary. The costs will be approximately 2,500 UM/year.

The basic calculations are as follows:

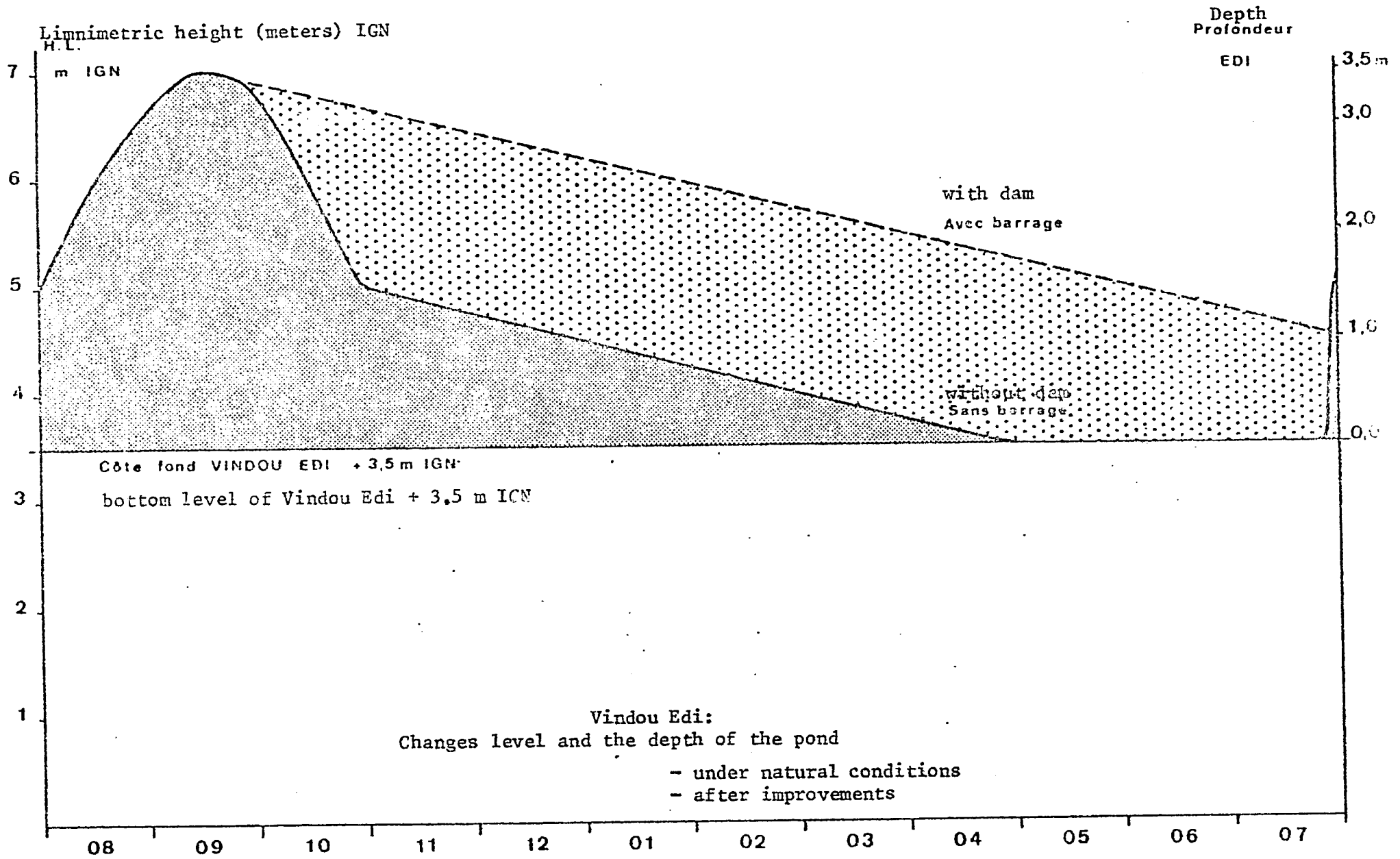
- weight of yield/ha./year	0.5 t	
- gross income/ha/year	500.0 kg. x 20 UM/kg. =	10,000 UM
- recurring costs/ha./year		2,500 UM
- net income/ha./year		7,500 UM
- number of fishing jobs/ha.	0.2 (= 5ha./fisherman)	

After Development Projects are Completed: Fisheries development in the NDU's

The impact of development projects in the basin and partilarly in the high water bed (in the form of Natural Development Units) on regional fisheries has been studied from the angle of tonnage, employment and income.

It is not a subject of immediate concern because the irrigated agricultural projects will be developed slowly; however, it cannot be ignored altogether: the productive capacity will diminish slowly and insidiously over time.

In any event the experts involved in the irrigation projects must be made aware of the problem of declining catches in the river as well as of the possibility of intensifying pisciculture in the context of the irrigation projects. Each NDU is a special case and must be studied separately.



VINDOU EDI

Variations de la côte et de la profondeur du plan d'eau
-en conditions naturelles
-après aménagement

The following principle must underly strategies of development of pisciculture.

Assuming a natural level of production of 60 kg/ha./year and 2,400 kg./ha./year in conditions of semi-intensive productivity, it will be necessary to systematically substitute 1 ha. of fish pond for each 40 ha. of area taken out of natural fish production.

The recommended economic activity, given environmental conditions, is that of fishing-pisciculture in large un-drainable ponds. This activity is a definite possibility.

In fact, it has been noticed that the space utilization plans in one of the NDU's contains areas labelled "Unuseable" located:

- in high areas where light soils and the elevation do not lend themselves to irrigation;
- in low areas where the heavier soils and the low level prevent drainage.

It seems that these two types of zones could be used for two, if not three traditional occupations.

High Ground

The higher zones are sandy and non-irrigable because of the high filtration capacity of the soil. Nevertheless, the permanent water table is not very far below the surface because of the irrigated rice fields lying in areas of medium elevation.

These higher zones could be planted with trees, possibly with species requiring a fair amount of water, but of greater value and rapidity of growth than Sahelian species (for example, species from the southern Sudanese areas): the available ground water would make up for the lack of rainfall. The luxuriance of Faidherbe Park at Richard-Toll is due to the "suspended" water table of the Tawey, which provides moisture for healthy specimens of cailcedrat tress, to mention but one species.

Forestry could thereby become a useful activity.

There is no reason to exclude the forests as grazing grounds during the 4 driest months of the year as long as goats and most sheep are kept out. Assuming a minimum amount of discipline, the forest would not suffer from the grazing. This, it is recognized, requires the consent and agreement of the Peuhl herders.

If this type of forest seems to be endangered by grazing animals, it could be the site of mixed game ranching. The major large species that could be raised there include elk, oryx, ostriches, etc.

The livestock would get back at least some of what it will lose as a result of the development projects, especially when there is nothing to prevent certain areas now used for grain cultivation from being kept free of large-scale tertiary development and being used to grow second annual forage crop. These sites could be feed lots for cattle before they are sold and would be a service for the transhumant herders in the valley.

Low-lying Ground

The low-lying zones have an irregular topography, heavy soils and are impossible to drain. They are often the sites of former natural ponds.

It is herein proposed to make them into large permanent ponds to be stocked with selected species of fish as the basis of combined pisciculture-fisheries. The ponds would also serve to acclimatize these species of fish which are generally from a different milieu. In addition to that, there is the further advantage of having less land exposed to wind erosion.

This type of "medium technoloy" has the advantage of requiring skills that are very similar if not identical to those already possessed by the river fishermen; there is really no difference between fishing in the river in its natural state and fishing in ponds that are partially hydraulically controlled.

Going from extensive (more or less 200 kg/ha./year) to semi-intensive (1,000 to 2,000 kg./ha./year) production through feeding the fish, adding fertilizer to establish a mineral balance in the water and through raising ducks would come about gradually with changes in regional demand and in the fishermen's ability to become fish raisers.

The jobs and the income of 10,000 Senegalese and Mauritanian river fishermen would thus be saved and the cultural trauma of change would be reduced to a tolerable level. In addition, this could be an excellent way of moving gradually towards more sophisticated modes of pisciculture such as raising fish in cages and in irrigation canals.

The application of these guidelines in an additional concrete example (the NDU of Nianga, on the Senegalese bank) shows that of the 1,000 ha. of the "experimental irrigation area" 200 (20%) are on high ground and 80 (¾%) on lowlying ground. It would not be wishful thinking, therefore, to imagine a restoration of pre-development production in forestry, herding and fishing, thus limiting the negative impact on the regional nutritional situation and the cultural behavior of the human groups involved.

- Thus, irrigated agriculture can be seen as a replacement for recessional farming.
- Pisciculture can then replace fishing.
- Semi-intensive forestry for productive purposes can then replace extensive use of natural forests.
- The use of feed-lots in transhumant or sedentary herding can replace extensive transhumant herding.

As in the case of factoring the development costs of a beli, estimating the development costs of a NDU is difficult because each one is a special case.

The work consists mainly of building dikes and costs are very variable, as shown by these OMVS estimates (1976):

Dagana	15,000 Fr. CFA/ha.
Boghe	44,000
Nianga	60,000
Matam	136,000
Salde-Walde	222,500

In the case of the NDU of Nianga, a small irrigated farming area, costs were estimated to be 171,428 Fr CFA/ha. in 1974; however, this area has particularly favorable conditions.

NDU	Whole area	Pond area	Cost of Ponds	Whole area	Pond area	Cost of Ponds
Boghe	2,300 ha	180 ha	9×10^6 UM	4,000 ha	320	16×10^6 UM
Koundi VIII	2,000 ha	160	8	7,000	580	28
M' Bagne	1,500	120	6	14,000	1,120	58
Koundi III	1,5000	120	6	8,500	680	34
Maghama				10,000	800	40
Totals	7,300	580	29	43,500	3,480	174

It is not unusual to produce 4 tons/ha./year in African fishponds, but it would be prudent and realistic to base production calculations on a productitivity rate of 1.5 tons/ha./year in Mauritania. This would be more in keeping with immediate production possibilities.

Raising production could be brought about by well-established methods such as:

- feeding the fish artificially, particulalry with rice by products;
- adding fertilizers to the water (such as SO4 and P_2O_5) in order to re-establish the mineral balance;
- associated duck raising.

The main point is not to aim for maximum productivity from the start but to gradually acquire the technical means to raise it gradually.

Recurring costs are for to the additional water to compensate for evaporation, for fertilizer (SO4 and P_2O_5), equipment maintenance and eventually for fish food.

These costs are estimated to be 22,500 UM/ha./year, of which 20,000 UM are for water at the rate of 1 UM/m^3.

The basic costs would then be the following:

. weight of catches /ha./year	1.5 t
. gross income/ha./year	1,000 kg x 20 UM/kg = 30,000 UM
. recurring costs/ha./year	22,500 UM
. net income/ha./year	7,500 UM
. number of fishing jobs/ha.	0.2 (= 5 ha/fisherman)

Specific Guidelines

As the title suggests, guidelines will vary according to administrative division.

- Trarza:

  Attention must be given to two important issues in the immediate future:

  - the present anarchic use of Lake RKiz;
  - the development possibilities of the brackish backwater of the right bank of the Senegal River.

In the future, attention must be given mainly to the lakes to be created from the construction of the Maka-Diama dam:

- the water of the Senegal River
- the Aftout es Sahel.

- In Brakna

  In the immediate future, the low-lying areas must be recovered and integrated in the NDU's of Boghe and M'Bagne. Avendou will be located for development.

- In Gorgol

  A preliminary study must be done on the potential of the lake to be created by the Foum Gleita dam on the Gorgol

  Eventually, the focus will shift to creating NDU's in the Maghama area.

- In Guidimaka

  Identification of 2 beli to be developed.

Appendix A

Cost Analysis of Production in Inland Fisheries

Working Assumptions

Capital = canoe, nets (used from the bank) (large, medium, small) if borrowed at an interest rate of 10 or 20%.

Salary (assuming 2 kg. a day per person)

in =

Kind (assuming 5 kg. a day per person)

Estimate of Production: based on a good, average and bad year, assuming use of each type of equipment twice a day during the fishing season or the year.

Results: see Table 4.

Average Prices at Different Times of the Year

Prices vary according to production and the season. The pric of fish can go from 20 to 35 UM for a pile of small fish to 70UM for medium-sized fish of 500 grams, depending on the species; from 40 to 55 UM per priece or per kilogram, depending on whether the fish is sold in Rosso, Boghe or Kaedi. In hard times the price can double.

Means of Transport and Cost

After being caught, the fish are transported on the heads of porters or by bicycle to nearby villages. Before the drought, they were carried by truck to Senegal and Mali and, by canoe to Kayes (Mali) during the rainy season. Transportation costs of marketing (sea) fisl in the interior of the country vary greatly. A Peugeot 404 canvas-bacl pickup truck capable of carrying one ton of cargo is expensive to ren to send fish from Nouakchott to Rosso, Boghe or Kaedi.

Principal Markets

The principal markets are: Rosso, Boghe, Bababe, M'Bagne, Kaedi, M'Bout, Dar el Barka, Maghama, Selibaby, Gouraye, Ould Yenge, Kankossa, Kiffa, Magta Lahjar, Boutilimit, Aioun el Atrouss and Nema.

Unfortunately, the absence of any statistics makes it impossible to give any figures on the relative distribution of fish among these markets.

Table 1

Average Yield of Various Types of Fishing Implements Per Fishing Season

(RAMS Estimates)

	Average Yield per Year or Season	Own Consumption 60%	Fish Marketed 40%	Price 20 UM per Kg.	Months of use per Year
Goubol	28.00 tons	16.80 +	11.20 +	224,000	5 months
Goubol	44.40 tons	26.88 +	17.92 +	358,400	4 months
Goubol	50.40 tons	30.24 +	20.16 +	604,000	3 months
Sleeping Net (Dragged)	15.00 tons	9.00 +	6.00 +	120,000	5 months
Sleeping Net (Stationary)	10.50 + X 5	6.30 +	4.20 +	84,000	7 months
Casting Net	5.11 tons	3.06 +	2.04 +	40,800	12 months
Diolinke line	33.00 + x 3	17.80 +	13.20 +	264,000	12 months
Total	1,171.81 tons	101.08	74.72 +	1,696,000	

Author's estimates, based on data gathered in the field on gross yield per type of equipment by year or by fishing season in %. These kinds of equipment are in common use everywhere along the river and its tributaries. One fisherman might own two to five kinds of equipment such as a 50 meter goubol. a stationary sleeping net and a diolinke.

Table 2

Average Selling Prices of Fishing Equipment (RAMS Estimate)

Name	Type	Length	Width	Price in Ouguiyas
Goubol (shore use)	Encircling	50 meters	5 meters	20,000 UM
Goubol (shore use)	Encircling	150 meters	10 meters	40,000 UM
Goubol (shore use)	Encircling	300 meters	15 meters	60,000 UM
Fele Fele net	Dragged	60 meters	5 meters	15,000 UM
Net	Stationary	8 meters	2.5 meters	6,000 UM
Net	Casting	2 meters	2 meters (diameter)	5,000 UM
Diolinke	Line with 1,000 hooks	150 meters	-	3,200 UM

Based on conversations with the fishermen between Rosso and Kaedi concerning the buying price or cost price of equipment frol 1968 to 1980. Average prices have been calculated, which depend on the season, on supply and demand. We have taken into account the devaluation of the ouguiya in favor of the CFA Franc (10 to 20%). The equipment has been purchased in Saint Louis or Dakar since the secession of Mauritanian from the Franc Zone.

Table 3

Factors in the Cost of Production of Fishing Equipment in the River and its Tributaries (RAMS Estimates)

Material Used	Type	Average Price	Life of Equip.	Maint. Costs	Manpower	Yield	Periods of Use	
Canoe	Casamance	33,000UM	15 yrs.	after 5 years	1	990 kg.	HW/RW	12 mos.
Goubol net	Shore use	20,000 UM	3 yrs.	10%	10 - 18	100 kg.x 4 days	HW/ RW	5 mos.
Goubol net	Shore use	40,000 UM	3 yrs.	10%	20 - 25	200 kg.x 4 days	HW/RW	4 mos.
Goubol	Shore use	60,000 UM	3 yrs.	10%	30 - 40	300 kg.x 4 days	HW/RW	3 mos.
Sleeping net	Dragged	15,000 UM	2 yrs.	10%	1	100 kg.x 1 day	HW/RW	5 mos.
Sleeping net	Sationary	6,00 UM	2 yrs.	20%	1	50 kg.x 1 day	RW	7 mos.
Casting net		5,00 UM	4 yrs.	5%	1	7 kg.x 2 days	HW/RW	12 mos.
Multiple hook line	Diolinke	3,200 UM	2 yrs.	20%	1	45 kg.x 2 days	HW/RW	12 mos.

Based on information gathered from fishermen and authorities along the river and its tributaries. Prices are an average of costs of equipment in Dakar and Nouakchott. Taking into account the life of the material and maintenance costs, yields for the periods of use have been calculated.

One must bear in mind that in a family there may be one or two canoes for 5 to 7 fishermen. The canoes usually belong, however, to the head of the family. They are used by family members without payment, either for fishing or for transporting merchandise.

HW = periods of high or rising water (= rainy season, June to September)

RW = periods of low of receding water (= dry seasons, October to June).

Table 4

Analysis of Production Costs in Traditional Inland Fishing

Kind of Equipment	Capital			Annual Capital Costs		Manpower		Salaries	
	Life of Equipment	Buying Price	Yearly maint. costs (UM)	at 10%	at 20%	Number of Employees	Days of use each year	at 2 kg/ day	at 5 kg/ day
Canoe	15 years	33,000	2,200	4,328	7,058	-			
Large net	3 years	60,000	6,000	24,127	28,483	50	50	180,000	450,000
Medium net	3 years	40,000	4,000	16,085	18,989	20	120	96,000	240,000
Small net	3 years	20,000	2,000	8,042	9,494	10	150	60,000	150,000
			14,200	52,582	64,024			336,000	840,000

Analysis of the cost of production of equipment in the inland fishing sector.

Large net at 2 kg/day : 90 days x 50 employees x 2 x 20 = 180,000 UM.
5 kg/day : 90 days x 50 employees x 5 x 20 = 450,000 UM

Med. net at 2 kg/day :120 days x 20 employees x 2 x 20 = 96,000 UM
5 kg/day :120 days x 20 employees x 5 x 20 = 240,000 UM

Small net at 2 kg/day :150 days x 10 employees x 2 x 20 = 60,000 UM
at 5 kg/day :150 days x 10 employees z 5 x 20 = 150,000 UM
2 kg/day = 336,000 UM
Total 5 kg/day = 840,000 UM

Table 5

Calculatión of Income

		Large Net	Average Net	Small Net
		UM	UM	UM
Selling price per kg. = 20 UM or 20,000 UM per tons of fresh fish	=	2,464,000	1,100,000	400,000
Total cost, at 2 kg. per day in wages if borrowed capital = 10%	=	402,782	402 782	402,782
Net income if daily wage = 2 kg. per person and capital is borrowed at 10%	=	2,061,218	697,218	2,782
Total costs at 2 kg. per day for wages if the costs of capital is borrowed at 20%	=	414,224	414,224	414,224
Net income if daily wage is 2 kg. per person and capital is borrowed at rate of 20%	=	2,049,776	685,776	14,224
Total cost at 5 kg. per day in wages if capital is borrowed at 10%	=	906,782	906,782	906,782
Net income if daily wage is 5 kg. per person and capital is borrowed at 10%	=	1,557,218	193,218	506,782
Total cost at 5 kg. per day in wages if capital is borrowed at 20%	=	918,224	918,224	918,224
Net income if daily wages is 5 kg. per person and capital is borrowed at rate of 20%	=	1,545,776	181,776	518,224

Calculation of Production

By studying the size of pre-drought catches in wet, average and dry years, one finds that a fishermen using the goubol (seine for shore use) of large, medium and small size with maximum, average and small catches, obtains the following results:

Table 6

Calculation of Production

	Wet Year	Average Year	Dry Year
Large net	50.4 tons	20 tons	5 tons
Medium net	44.8 tons	20 tons	7 tons
Small net	28.0 tons	15 tons	8 tons

By paying wages of 2 kg. or 5 kg. per day and per person, a fishermen is able to enjoy a very comfortable income in wet years, a good income in average years but he loses in all cases with a small net.

At present one of these is usable because of the low water level, unless the meshes are made smaller. This however, would decimate the fish.

It seems clear that, assuming control of water resources, only intensive fish raising will help make up for the losses to be caused by the large development projects planned for the Senegal River. The standard of living of the people will be improved by bringing in sea fish.

Table 7

Average Annual Production in Good Years in Kilograms and Monetary Value

Type of Equipment	Average Annual Production	Value in UM
Large Net	50,400 kilograms	604,800
Medium Net	44,800 kilograms	358,400
Small Net	28,000 kilograms	224,000
Total	123,200 kilograms	1,187,200

Average number of fishermen : 4,000

Source: RAMS, 1980

Table 8

Breakdown of Averag Production Costs by Type of Fishing Implement in UM

Average Maintenance Costs			(%)
Canoe	:	2,200	
Large Net	:	6,000	
Medium Net	:	4,000	
Small Net	:	2,000	
Other	:	1,400	16%
Total		15,600	
Average Investment Cost			
Cost of the canoe		7,100	
Cost of large net		28,500	
Cost of medium net		19,000	
Cost of small net		9,500	
Other		6,400	74%
Total		70,500	
Other Costs			
Other items in Total Cost		8,600	10%
Total		94,700	

Appendix B

The Possibilities of Combining Pisciculture with Rice Growing

Pisciculture must also take into account the needs of rice, and rice-growing, whcih have their own requirements.

In the Middle Valley it seems that:

- rice cultivatic is to become mechanized. Harvesting must therefore be done in a dry and absolutely flat field: it is impossible a priori to keep young fish in basins that are part of the river fields while waiting for the second crop, which would give them time to reach marketable size. A further problem is that only fairly large fish are sold in the region and selling 80 gram tilapia, as in Indonesia, is out of the question except in times of crisis. In any event, even if the fish recovered from the stress of emptying the pond once it were filled again, the lowered temperature would prevent any new growth from ocurring.

- Rice is not transplanted but is sown directly in the paddy. The paddy then becomes a kind of monophytic "lawn" that is so dense that the fish have no room in it. In the Delta, they could live only in the peripheral canals. Thus the productive water area is much less than the area given over to rice-growing.

- For various growing reasons, rice is sown fairly early in June. Under natural conditions, however, the fish spawn in August. Thus the date when the fry appear does not correspond with the rainy season crops because they appear two months after the paddies are flooded and one month before the paddies are emptied.

- Last of all, from the human point of view, the combination of rice-growing and pisciculture is even obviously more complex than rice-growing by itself. Furthermore, it is not certain that the necessary technology is appropriate at the present time.

A comparison of the requirements of rice on the one hand and fish on the other leads to the conclusion that combined rice-growing and pisciculture will not be a viable activity, strictly speaking, in the Middle Valley for a long time.

As an example it is well to keep in mind that "natural production" in the rice fields of the Delta is only 15 to 30 kg./ha. in irrigated fields and contains only 20% fish of saleable size, which comes to 3 to 6 kg./irrigated field.

If pisiciculture appears to be the ensemble of techniques for fish raising, adding irrigated rice-growing to this enterprise implies adding the necessary techniques for this crop.

The fact that many of the 600,000 ha. of irrigable land on the floodplain of the Senegal River is to be used for growing rice inevitably leads many to think about adding pisciculture to rice-growing in imitation of the techniques practiced in the Far East. This appears all the more urgent when it is perceived that the production of "natural" fish will decline significantly as development of the high water bed proceeds apace, thus reducing jobs and income for the region's fishermen.

Combining rice growing with pisciculture is sometimes proposed a little too glibly as a remedy for the growing gap between supply and demand for fish.

A closer look reveals that techniques used in the Far East are difficult if not impossible to apply in the Senegal River Valley.

The eco-icthyology of the Middle Valley has already been extensively discussed but these are its basic characteristics:

- <u>a single spawning season each year</u>, regulated by
  - hydrology (which is controllable)
  - temperature (which is not controllable).

    As a result, fry are available only during a limited period each year, which is a particularly limiting factor if one wishes to obtain them in the wild. Furthermore, not all species are suitable or even acceptable in combined rice-growing and pisciculture; it is almost impossible to sort out fry of the 80 different fish species in the Middle reach of the river. Finally, the ichthian biomass is dispersed over a gigantic area during the spawning season. Raising fingerlings does not seem to be a better solution because it requires building special ponds or basins of dubious profitability because of the brief period during which they may be used.
- <u>an annual growth cycle</u> interrupted by
  - hydrological factors (which are controllable)
  - temperature (which is not controllable).

When expressed in terms of the inundated plain, this breaks down as 500,000 ha. of which 80% is rice paddies (= 400,000 ha.)

. x 3 kg = 1,200 t/year at minimum levels of production

. x 6 kg = 2,400 t/year at maximum levels of production.

It consequently appears much more realistic - at least in the beginning, to redistribute the land according to permanent types of specialized use:

. forestry and herding in the higher parts of the NDU's,

. agriculture in the middle areas,

. piscisulture in the low-lying areas.

Appendix C

The Integrated Development Project at Paliba

The Integrated Development Project at Paliba

Funded by CARITAS Mauritanie (a Catholic agency), this project is planning to create irrigated fields around Paliba pond, in the Department of Maghama (Gorgol). With a surface of 65 hectares, this pond is permanent because its link with the river is generally broken around the 15th of April. In order to control the water, a channel could be deepened to create a permanent link and the flow of water could be controlled by a floodgate.

This project, which began in 1980, is connected with organizing farmers, growing irrigated crops, planting various kinds of vegetables, and with pisciculture.

In addition, the project is concerned with problems linked to the irrigated fields, with animal traction, improvement of traditional crops, herding and social work.

According to the head of the project, it will cover the whole department of Maghama, with a population of 10,000 inhabitants distributed in this way:

Maghama	8,000 inh.,	located 9 km. from the pond
Gourel Dieri	700 inh.,	located 5 km " " "
Dao	1,000 inh.,	located 13 km " " "
Tilionde	300 inh.,	located 2 km from the pond.

In its first phase, the project will involve the creation of 90 hectares of village rice paddies for the villages of Paliba, Dao and Taga. The 90 hectares are to be divided in the following way:

Paliba :	40 ha. for 65 heads of households
Dao and Taga:	50 ha. respectively for 80 and 50 heads of households.

The fish raising part of the project will begin in its second phase. In order to ensure a rational use of the pond, the fish raising activities should be undertaken in the following way:

a) create a permanent link between the pond and the river by digging a feeder channel which can be closed off in times of low water;

b) stock the pond and regulate fishing in it;

c) build fish ponds all around the pond in places appropri: for filling and emptying them. They can also be located not far from irrigated fields;

d) construct one or two fish breeding ponds to supply fingerlings to the pond, the river and the fish ponds. It will be simple to feed agricultural residue to the fish. In order to ensure a balanced use of the pond in combination with agriculture, the stocking of the fish ponds should be planned, and species native to the same ecological zone should be introduced. This will insure the availability of fish all year round. In addition, the creation of a marketing organization or a cooperati would facilitate the marketing of agricultural produce and fish after setting aside the quantity intended for the farmer-fishermens' own consumption.

Finally, it will be possible to raise Barbary ducks around and the fish ponds.

The management of the fish ponds could be the responsibili ›erative composed of farmers and fishermen (who are in effect people), or heads of sufficiently motivated families able, w. ·on, to obtain credit.

The group of farmer/fishermen is to be organized and :d either by local technical and administrative authorities :dit organizations.

9. Bibliography

C. REIZER

Contribution à l'étude hydrobiologique du Bas-Sénégal-Prémières recommandations d'Aménagement halieutique
CTFT, 142 pages, 106 tableaux, 19 graphiques, 4 cartes, annexe
Nogent-Sur-Marne.
1971

C. REIZER et P. LESSENT

Les pêches continentales du Bas-Sénégal
Bois et Forêts des Tropiques n° 143, 19 pages (3-21), 3 cartes, 3 photos Nogent-sur-Marne
1972

C. REIZER, JL CHEVALIER et P. LESSENT

Incidences sur la Pêche de l'Aménagement hydro-agricole du Bassin du Sénégal
Fascicule 1 : Organisation générale de la Pêche sur le fleuve Sénégal
89 pages, 68 tableaux, 4 cartes

Fascicule 2 : Influence des Travaux d'Aménagements sur les Ressources piscicoles
Recommandations
112 pages, 36 tableaux, 2 cartes

FAO - PNUD - OMVS - CTFT
Saint-Louis du Sénégal et Nogent-sur-Marne
1973

C. REIZER

Définition d'une Politique d'Aménagement des Ressources halieutiques d'un Ecosystème aquatique complexe par l'Etude de son Environnement abiotique, biotique et anthropique
Le Fleuve Sénégal Moyen et Inférieur
Tome 1 Environnement Abiotique
Tome 2 Environnement Biotique
Tome 3 Environnement Anthropique
Tome 4 Conclusions Générales et Aménagement
Tome 5 Annexes
527 pages, 160 tableaux, 77 figures
Centre Interuniversitaire des Sciences de l'Environnement FUL ARLON
1974

C. REIZER

Etude des incidences sur l'Environnement de l'Aménagement du Lac de Barrage de Manantali sur le Bafing - Sénégal
OMVS - Saint Louis du Sénégal et groupement manatali
FUL, 103 pages
ARLON Belgique
1977

C. REIZER

Assessment of Effects of Alternative uses of Floodplains on their Fisheries
1. Sénégal
FAO - FUL, 62 pages, 9 tableaux, 24 figures
ARLON Belgique
1980

C. REIZER

La place du Poisson dans les Systèmes de Production agricole de la Plaine inondée du Sénégal
FUL, 24 pages, 12 figures.
ARLON, Belgique
1981.

ANON

Consultation to promote the fishery development in the Sahel
CILSS/FAO, Rome
1978.

ANON

Report of the fishery task force, model of development program, Fishery Sector CILSS
1979.

ANON

The fishery of the Lake Chad Basin, with special reference to the fishery of the Republic of Chad. CILSS/Pêche/77/inf.5.
1977

ANON

The fisheries of the Sahelian countries prepared by Roger Aubray for the fisheries sub- group of the working party of the Club of the Sahel. CILSS/Pêche/77/inf.5.
mars 1977.

ANON

La pêche au Mali. Rapport d'ensemble CILSS/Pêche/77/inf.5 Fascicule Mali
1977.

ANON

The Fishery of Gambia, a comprehensive report CILSS/Pêche/77 inf.5 Gambia
1977.

ANON

La pêche en République de la Haute Volta, Etude Economique d'Ensemble. CILSS/Pêche/77/inf.5 Haute Volta
1977.

ANON

Deuxième réunion du Club des Amis du Sahel, Rapport de l'équipe pêche de programme sectoriel pour la pêche CILSS.
25 mai au 1 juin 1977.

ANON

Programme par pays Assistance demandée au PNUD par le gouvernement de Mauritanie pour la période janvier 1977, décembre 1981, PNUD.
1977.

Matthew amine et al, University of Rhode Island, 1979.
Artisan Fishery Technology : Ghana a Case Study of a West African Fishery Food Research Institute Accra, Ghana.

ANON

Assessment of environmental effects of Proposed Development in the Sénégal Basin
Progress Report n° , mai 1977, n°2 25 mai 77, n°3 july 77, n°4 august 77, n°5 sept. 77, n°7-8 nov./Dec. 77 n°9-10 jan./Feb. 78
OMVS/AID Nouakchott.
1977/1978.

ANON

Proceedings of the Fisheries research Planning Workshop C, the Title XII Program.
AID Contract N. AID/ah-o- 1135-12.

SGET INTERNATIONAL p. 125

Ministère de l'Industrie, des Pêches et de la Marine marchande 1978, le marché des Produits de la pêche à Nouakchott dans le sud et l'est mauritanien.
septembre 1978.

ANON

Plan National pour le Développement des Pêches Continentales du Sahel, Mauritanie CILSS : cas/Pêche/78/5.4 FAO Rome, Italie 20-21-4-1978.
1978.

ANON

Rapport sur les Assistances Extérieures en Matière de Développement République Islamique de Mauritanie 1977 PNUD Nouakchott,
1977.

ANON

Evaluation des effets sur l'environnement d'aménagement prévus dans le bassin du fleuve Sénégal (Pêche) OMVS.

ANON

Approvisionnement en viandes de l'Afrique de l'Ouest Tome I, Analyse de la situation actuelle et projection 1975-1985 pour six pays de la région OMVS.
1975.

J. CASTIAUX et J. PHILIPPE

Projet pour le Développement de la Recherche Agronomique et de ses applications dans le bassin du fleuve Sénégal. Rapport de synthèse d'enquête d'évaluation.
août 1971.

ANON

Fisheries and agriculture collaborative Research in the developping countries: A priority Planning Approach AID.
août 1978.

Ministère du Plan et des Mines

3ème Plan de Développement Economique et Social
Ministère du Plan
1976-1980.

ANON

Afrique Agriculture n°47 juillet 1979
La pêche sur la Côte Ouest.

ASSANE SYLLA

La Philosophie morale des Wolofs
SANKORE, BP 7040 Dakar, Sénégal
1978.

YAYA WANE, Ifan Dakar

Les Toucouleurs du Fouta Torro (Sénégal) Ifan Dakar.
1969.

J. BARD. J. LEMASSON, P. LESSENT

Manuel de pisciculture pour l'Afrique Tropicale Centre Technique
Forestier Tropical, 45, bis Avenue de la belle Gabrielle 94-Nogent-sur-Marne.
1971.

ANON

Développement des Pêche Maritimes Mauritanie Rapport Technique
N°1 Les Pêches Artisanales en Mauritanie Situation Actuelle et
Perspectives du développement PNUD, Rome.
1979 FI : DP/MAU/73/007.

ANDRE PHAM

La Bilharziose et les Techniques d'Irrigation et d'Agriculture en
Afrique et à Madagascar
Ecole Supérieure d'Agronome Tropicale.

Dr. SIDATT et FAN

Enquête épidémiologique effectuée dans la région de l'Assaba
Centre National d'Hygiène Mauritanie.
1979 du 5 mai au 15 avril.

J.H. SAINT PERE

Les Sarakollés du Guidimaka
Emile Larose, Librairie-Editeur, 11 Rue Victor-Cousin
110 CNRS 1979
Introduction à la Mauritanie
CNRS 15 Quai Anatole-France 75.700 Paris.
1925.

ENDA

Environnement Africain
Idep, UNEP. Sida cts BP 3.370, Dakar.
1978.