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Effect of Drought, Dams and Fishing Pressure on the Fisheries of the Central Delta on the Niger River

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ABSTRACT

The fishing sector in Mali is now in a general slump. The Sahelian drought is primarily responsible for the low flooding, the decrease of floodplains and the lack of fish recruitment. During the lowest flood years, fish landings may decline by 40,000 metric tons.. Dams built for agricultural or electrical use are also playing a part in reducing floodplain area: in 1989, the decrease in production was estimated at 5,000 tons, for landings of about 45,000 metric tons. During the dry season, the stock of adults, which are particularly in danger of overfishing, is partly ensured by the releasing of water from dams which disturb fishing. The crisis which comes from a natural phenomenon has developed sociological and economical disruptions. The number of fishermen has doubled in the last 20 years and the catch per effort has reduced according to the decline of catches. Thus communal strife has increased.

Key Words: Fish production, Floodplains, Hydrology, Small-scale fisheries

INTRODUCTION

The central delta of the River Niger, Mali, is a large floodplain fed by the waters of the Niger and the Bani rivers whose sources are, respectively, in Guinea and Ivory Coast. During the high water season, flooded surfaces can reach 20,000 km² compared to 3,000 km² during the dry season. The delta is characterized by a well-defined hydrologic cycle leading to a differentiation of biotopes like rivers, lakes, ponds, fairways and floodplains (Figure 1). In this area, we have counted 150 Sudano-Sahelian fish species whose adaptation to this environmental variability appears to their capacity to undertake lateral and longitudinal migrations of great magnitude. The flood at the beginning of July is also the season for fish reproduction. For many years, this plentiful resource has been subject to an intensive fishing operation. Fishermen have adapted specific fishing techniques to different biotopes and seasons (Daget 1949a). Although there exists a large diversity of fishing gears, the bulk of the catches is made with seines, cast nets, drift and fixed mesh nets and big (diénés) and small (durankoros, papolos) traps. Fishing is a very widespread occupation involving an estimated 62,000 fishermen (Morand et al. 1990) of which one may distinguish migrant fishermen, fishermen farmers and sedentary fishermen (Laë 1988). In 1988-1989, the halieutic production was estimated at 45,000 tons (Laë and Raffray 1990).

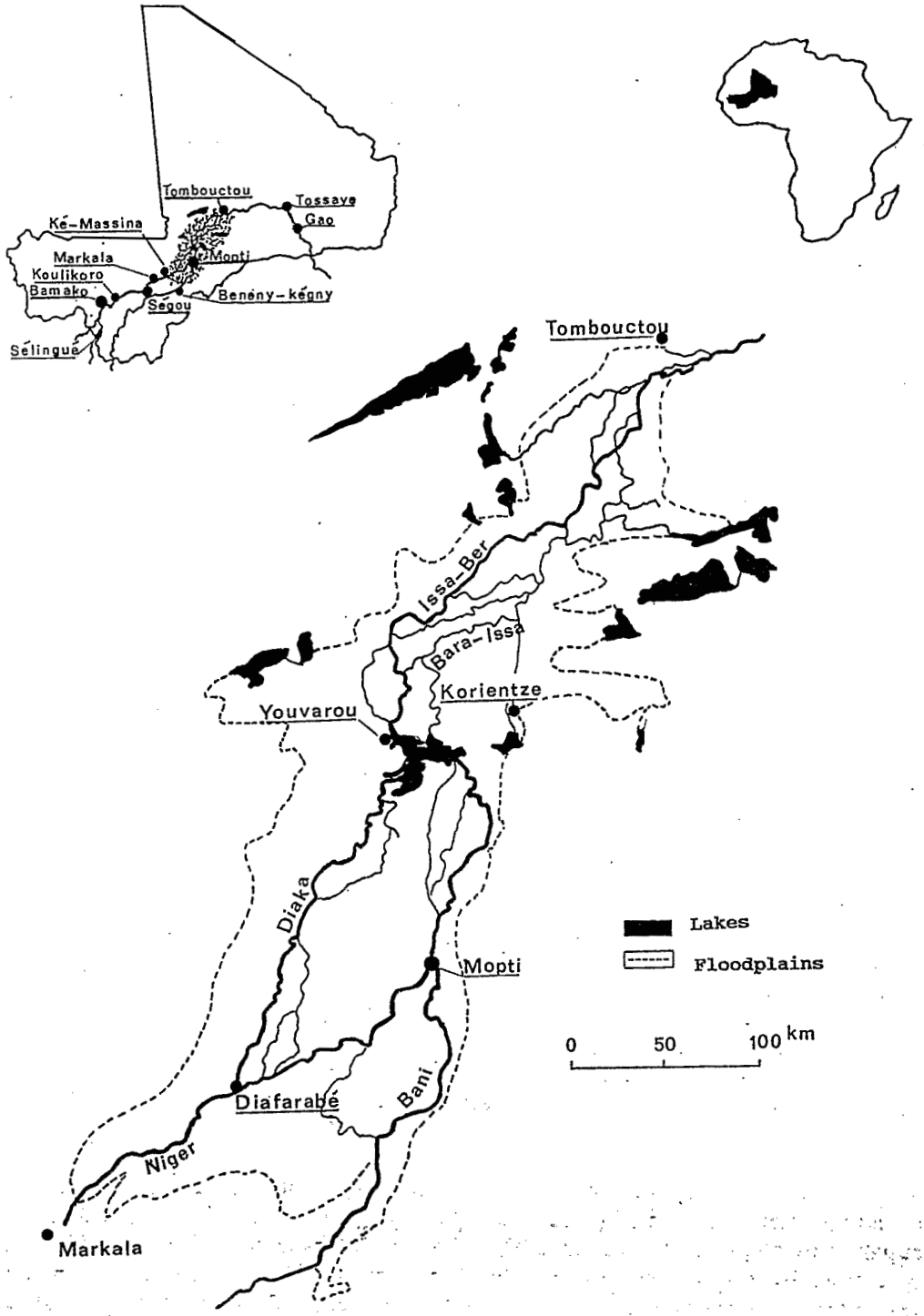

Figure 1. The central delta of the Niger and the area prone to flooding.

EFFECTS OF HYDROLOGY ON FISH CATCHES

The analysis of hydrological curves from the beginning of the century shows that there were three dry periods: one at the beginning of the century, another in 1940 and the last one since 1970 (Figure 2). The annual average flow of the two rivers is similar. The last dry period is also the longest one and since 1970 the fall has been progressive.

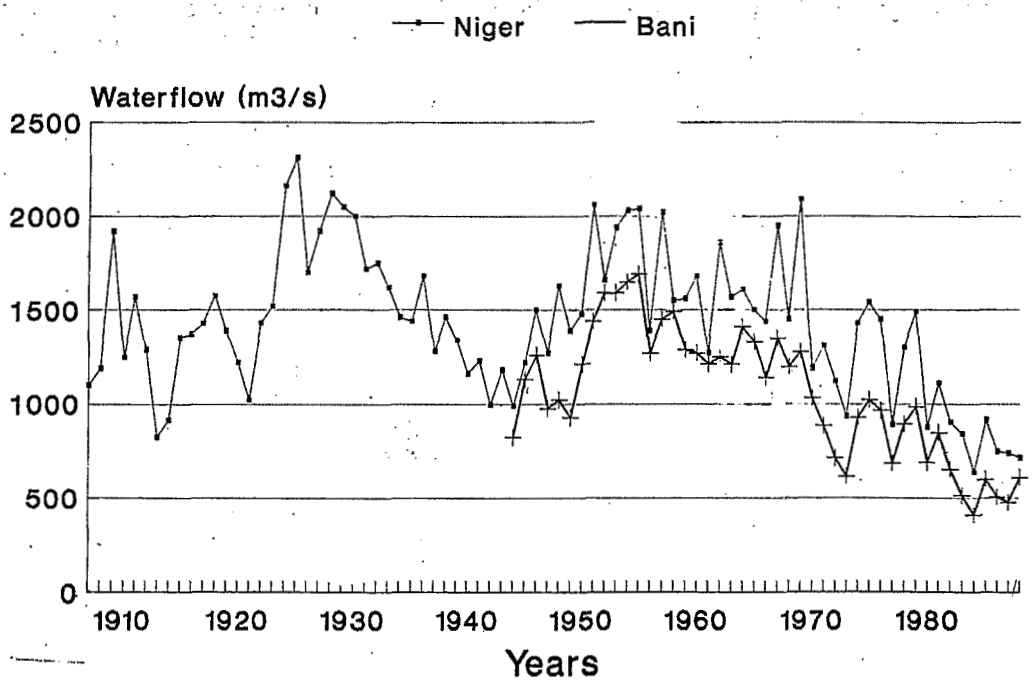

Figure 2. Average annual flow of the Niger and Bani rivers at Koulikoro and Mopti stations.

Floodplain surfaces have surely decreased during the last twenty years, but this phenomenon has never been qualified. Because it was impossible to obtain an estimation of the flooded surfaces from satellite pictures, we used hydrological data from the Malian yearbooks (Ministry of Industry, Hydraulics and Energy 1966 to 1989). The hydrological flow rate of the river is shared out between a high water season (July to December) and a low water season (January to June). We calculated the average flow rate during high-water from July to December at the entry of the delta (Bénéni Kégny on the Bani and Kémacina on the Niger) and at the exit in Tossaye after a two-month interval (September to February) corresponding to the water's flow-time (Lae 1992a). The water losses between the three stations come from evaporation and infiltration during the flood season and are proportionate to the expanse and the time length of flooded plain. They are a good index to interpret flooded areas. Estimation of flooded surfaces from evaporation values in this part of Africa shows that these surfaces vary from 20,000 km² in 1968 to 3,000 km² in 1984. In 1984, the Niger river stopped flowing during the dry season and all lakes located on right and left banks dried up.

In the same time, fish production has been steadily diminishing, dropping from 87,000 tons in 1969-70 to 37,000 tons in 1984-85. Hence, we tried to find an annual catchment pattern (July to June) based on the loss of water during the high water in proportion to the time-length and expanse of flooding. Production data stem from official statistics for fresh fish, that were smoked and dried. These fish are in a transit through the city of Mopti which constitutes the biggest trading centre in the Delta (Mopti Operation Pêche 1966—1989). Regular observations have been carried out since 1966. The total number of catches is reached after an assessment of the marketed and consumed quantities within the delta. These annual catches are calculated from the hydrological cycle during the period July to June (Lae 1992a).

The water loss curve (proportional to time length and expanse of flooding) and the catchment curve follow the same trend (Figure 3). In fact, a multiple regression analysis shows that fish production depends on the high water from the current year and from the previous year.

$$\text{Captures} = 780.95\ (\text{losses})_n + 770.71\ (\text{losses})_{n-1} + 32\ 304 \quad (R^2 = 0.93)$$

Annual catches depend for a large part on the flow of the current year (70% of the variance).

In 1980. 60 species of fishes were significant in the catches and 17 were imortant like Cichlidae, Cyprinidae, Characidae, Clariidae and Bagridae. From biological studies, we

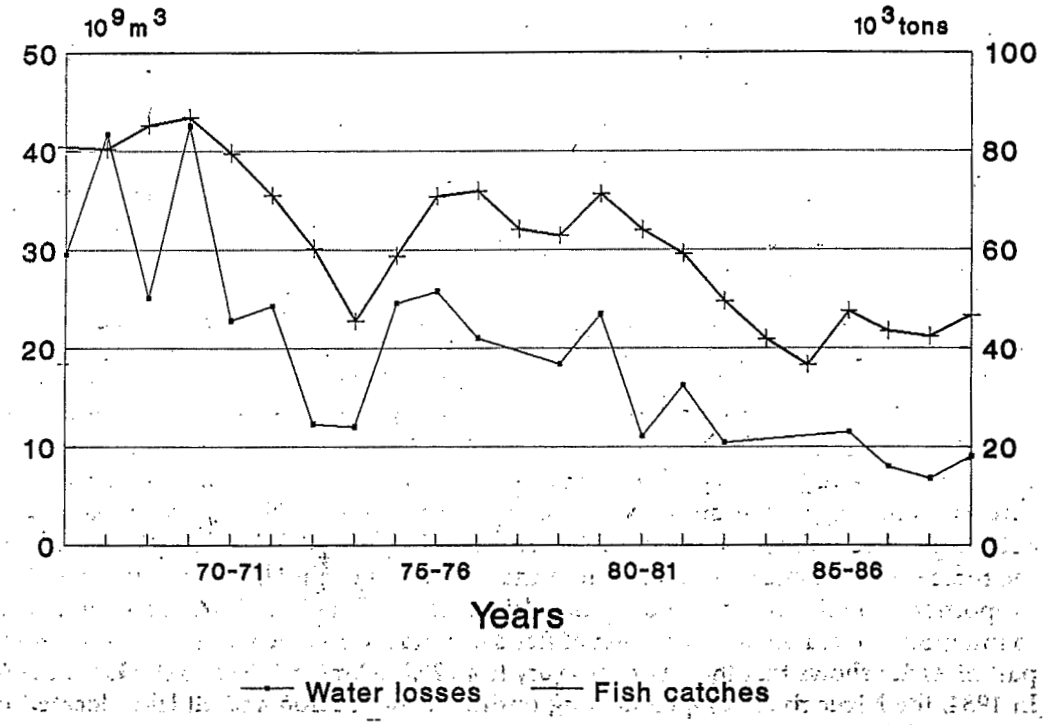

Figure 3. Annual fish catches and water losses at high water in the central delta.

estimated the average length of various fishes when they were one year old. Then we observed, in fish landings, that a large majority of fishes were under one year old (Lae 1992a). For example the catches of *Labeo senegalensis* were 15% of total landings and 86% of these fishes were caught under one year old (Figure 4). It is nearly the same situation for *brycinus, Sarotherodon* or *Tilapia*. If we add all these results to the significant catches for every species, the annual catches are made up of 69% of fishes under one year old. This fact comes from the intensive fishing operation and explains the good correlation between the flooded surfaces and fish catches.

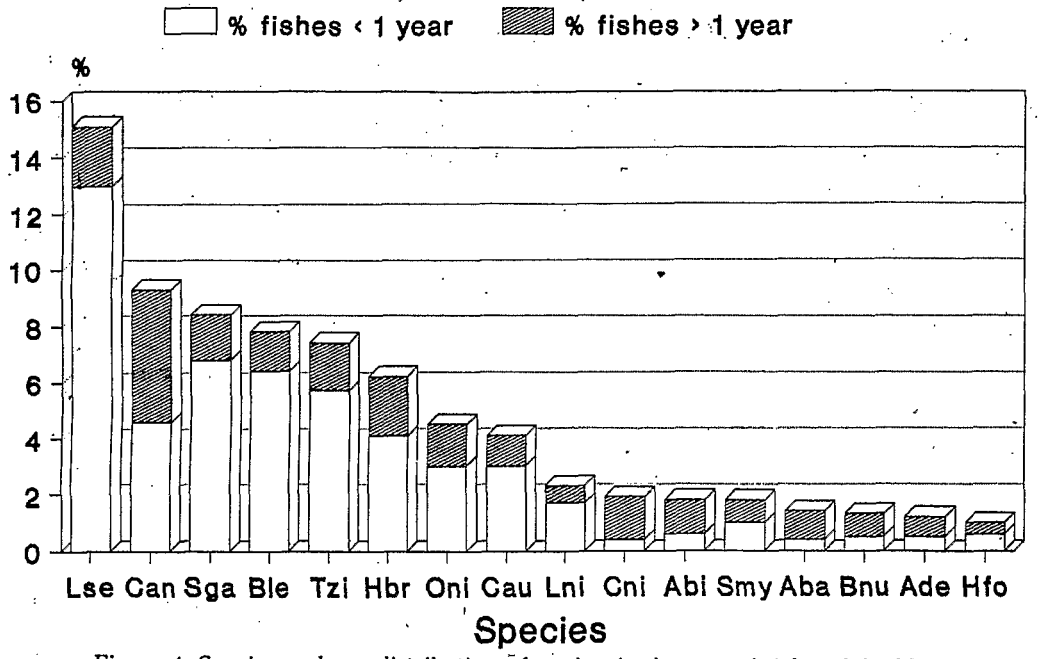

Figure 4. Species and age distribution of catches in the central delta of the Niger.
Lse - *Labeo senegalensis*, Can - *Clarias anguillaris*, Sga - *Sarotherodon galilaeus*, Ble - *Brycinus leuciscus*, Tzi - *Tilapia zillii*, Hbr - *Hydrocinus brevis*, Oni - *Oreochromis niloticus*, Cau - *Chrysichthys auratus*, Lni - *Lates niloticus*, Cni - *Chrysichthys nigrodigitatus*, Abi - *Auchenoglanis bidorsalis*, Smy - *Schilbe mystus*, Aba - *Alestes baremoze*, Bnu - *Brycinus nurse*, Ade - *Alestes dentex*, and Hfo - *Hydrocinus forskali*

Actually, it seems that fishing has few negative results on the total catch rate and that only drought is responsible for a decline in fish landings from 90,000 to 45,000 metric tons.

The disastrous drop in catches is directly linked to the decreasing flooding of the Niger (Welcomme 1986) and especially the decrease in the time-length and the expanse of flooded plains in the central delta (Lae 1992 a).

EFFECTS OF DAMS

In 1943, the construction of a water reserve in Markala upstream of the central delta allowed a considerable development of agriculture, especially rice and sugar cane. The

dam-bridge was intended to maintain the upstream water body on a hill adjacent to the high water slope, allowing irrigation to take place through gravity in the vast depresssion situated in the N-E.

Later, in 1980, the construction of a second structure was completed in selengue on the Sankarani river (the main tributary of the Niger) upstream from the city of Bamako. It was a hydro-electric dam meant to supply electricity to the Malian capital.

These changes are not without repercussions on the hydrology of the delta central on which the abundance of the ichthyological stocks depends.

Decrease in Surface and Duration of Flooding

The building of dams can have different effects, depending on the season. During high water, dam closing enables water to be kept in artifical lakes. We tried to quantify this mecanism in terms of floodplain areas and fish loss.

The effects of the Markala dam were studied over three periods (1925-39; 1951-65 and 1975-89) according to the waterflow recorded at Koulikoro and Ke Macina and listed in Brunet-Moret et al. (1986).

The water retentions and releases in Selengue were obtained from a study by SOGREAH (1985) and from Ballo (1989) on the influence of the Selengue dam on the Niger basin. The main results are the following (Lae 1990b): Markala dam's water reroutings from 1966 to 1989 fluctuated between 300 $m^3 s^{-1}$ and 100 $m^3 s^{-1}$ and the the water reserves of Selengue dam since 1984 are estimated at 123 $m^3 s^{-1}$ in the dry year period. These rerouted waterflows were added to the water entries at Ke Macina and Beneni Kegny in order to estimate waterlosses in the basin which, in turn, allows one to obtain a fish catchment estimation (Figure 5).

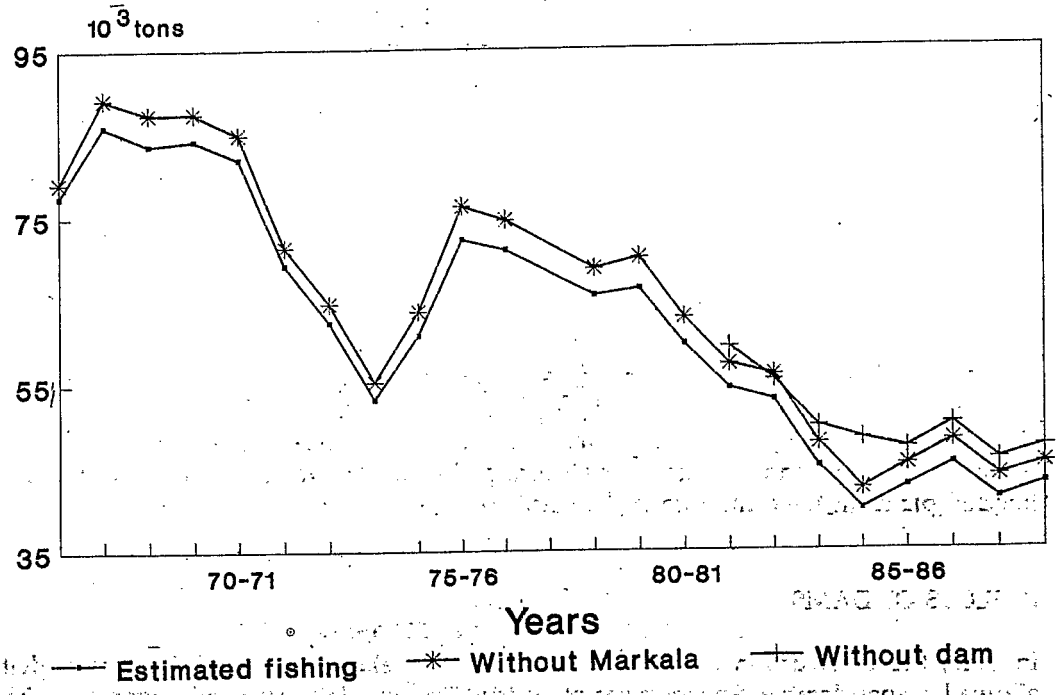

Figure 5. Fish production losses caused by the building of the Markala and Selengue dams.

Hence, the effect of the dams is felt during two key periods in the hydrological cycle. During highwater, the filling up of the two dams brings about a deterioration of the highwater at Selengue and Markala which entails a decrease in the flow entering into the delta at Ke Macina as well as in the expanse and duration of flooding. This lowers the reception capacities of the floodplains and translates into a decrease in recruitment and fish catches. Before Selengue dam started to operate, the deficit varied between 1600 and 4000 tons, depending on the water reserves made and the size of the high water. From 1980 onwards, climatic conditions were poor and the production loss was estimated at 5,000 tons, i.e. 10% of fished volume, of which 2,000 were directly attributable to the Selengue dam. Such phenomena have already been observed, the waterway regulation tending towards elimination of the natural hydrologic and geomorphologic dynamism of the system, and isolation of the river from the alluval plains. Thus Welcomme (1985) reports a fish loss of 6,000 Mg yr^{-1} due to the construction of the Kainji dam. On the Mekong river, the Pa mong dam prevents flooding for some 700 km downstream, causing an annual loss of 2500 tons (Petts et al. 1989).

Disruption of Longitudinal Migration

Longitudinal migrations play a key role in the ecology of river fish. Anadromous and catadromous fish can disappear if structures which are built across the river close it off completely; whereas, spawning fish in the plains are affected by dykes or flood regulation. One does not notice a disappearance of species in the true sense, but rather a change in stock composition (Welcomme et al. 1989). In the case of the Niger river, the Markala Dam built upstream from the flood area, must disrupt fish migrations considerably and consequently, affect upstream fish production. However, it doesn't threaten any species because the spawning areas are situated downstream. In this particular case, the halted migrations are entirely unrelated to reprodution, they are activated and kept going by external stimuli linked to the progressive and regular decrease of the given volume of water (Daget 1949 b). The construction of a fish pass in 1946 did not allow the restarting of these migrations. These passes are adapted to anadromous migrations usually intended for favouring migrations of spawners towards spawning areas, and not, as is the case here, to rapid movements of fish shoals in search of space.

Disruption of Low Water Fishing

Fishing is prohibited at certain locations on the river when the water are low. This management allows the fish, whose movement is hampered at low water, to settle down and congregate in deep areas of the minor bed without being disturbed, thus making their capture easier once the fishing ban is lifted (Daget 1956). During low water, greater volumes of water have to be turbined to ensure the electricity production Selengue, this in turn ensures a very appreciable flow during March, April and May down-stream of the dam. The waterflows observed at Koulikoro in 1987 were higher by 100 to 150 m^3/s than what they would be under natural circumstances. These extra quantities of water were used in Markala for irrigation and for the water supply to the city of Niamey in Niger. Thus, in 1989, low water maintenance was required for 8 days in the month of March, 10 in April, 26 in May and 5 in June. The river level at the Kirango power station could rise from 2 cm to 56 cm in the space of 7 days (Guigen 1988).

While raising the level of the river, these water releases perturb fishing to quite an extent, because the arrival of artifical flooding causes the fish to scatter and lowers their vulnerability to fishing gear. The fishermen are extremely sensitive to these disturbances because low water represents a turning point in time that ought to provide for the transition until the next fishing period when the water level drops (Baumann 1991). The catches, which, in fact, represent only 30% of the annual production, compared with 55% when the flood level drops (Lae and Raffray 1990), are more interesting from the nutritional point of view than from the commercial one. It explains the fishermen's concern that this low water fishing should take place under the best possible conditions.

Indirect Reproductive Stock Protection

Welcomme and Hagborg (1977) and Welcomme (1979) insist on the importance of surfaces covered with water when the water level drops. These areas would be the deciding factor in the survival stock which is responsible for reproduction during the next water level rise. In the central delta of the Niger, the relation between the expanse and the time-length of flooding on one hand and the fish catches on the other hand is so strong that fishing effort and water level drop have a lesser importance (Lae 1922 a). The water level drop conditions would therefore not be poor enough to become limiting. This is perhaps due to the water releases from Selengue which reinforce low water conditions to such an extent that they are bettter now than they were during the good high water period before the dam was built. This help from the dam should bring about a decrease in natural death and a drop in deaths from fishing.

CONCLUSIONS

The decline in fish catches from 90,000 to 45,000 metric tons is due to the advent of drought in Africa. Plots of annual catches and lost water, computed according to the hydrologic cycle of the Delta (from July to June), are highly correlated. Fished quantities are comprised of 69% of the fishes under one year old. Even if the fishing effort probably increased considerably, it seems that it has few negative results on the total of the catches. In such an unfavourable context, the Markala and selengue dams are responsible for a decrease of less importance in production caused by reduced water surfaces and low water activities. The annual fish production loss is estimated at 5,000 tons, i.e., one tenth of the annual yield. The recent construction of the Selengue dam at the same time as a worsening of the drought phenomenon, is severely criticized by the fishermen. By bringing help during low water, the dam nevertheless allows the preservation of spawner stock at a time when fishing is very intensive. In a severe low water situation, this stock could get overfished and would then be unable to assure a normal recruitment the following year. While it is impossible to apply fishing regulations by limiting the activity, prohibiting the use of fishing gear, mesh regulation, this artifical improvement of low water conditions tends to ensure a stock preservation during each pre-reproduction period.

Fishermen are now in trouble because of the decline in individual yields which dropped from 1,900 kg in 1966 to 740 kg per year in 1989. So, they had to pursue complementary activities like agriculture and one part of the family had to move to other

lakes in Mali or to other countries. The crisis which comes from a natural phenomenon, has developped sociological and economical disruptions. In fact the decrease of floodplains induced a reduction of fishing areas and the advent of troubles between villages or families. In addition, the lack of control in accessing the fishery by traditional authorities and the population increase, would involve the transition from 43,000 fishermen in 1966 to 63,000 in 1989. So the sharing of falling catches is even more difficult.

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