

# Session III

## Fish and Fisheries Resources: Utilization and Conservation

Chair: Prof. Ayinla

### Resources and Constraints of West African Coastal Waters for Fish Production

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Brackish waters are regarded as some of the most productive aquatic ecosystems in the world, and are of great socio-economic importance (Kiener 1978). This paper presents the importance of resources for and constraints on for fish production in brackish waters of West Africa. It also outlines the main aspects of better management of biodiversity in brackish water ecosystems in West Africa.

In the tropical zones and particularly in West Africa, brackish waters are abundant in the Atlantic Ocean littoral, within the limits of the Gulf of Guinea. From Ivory Coast to Nigeria, their total surface area is about 3 140 km<sup>2</sup> (Table 1). Their aquatic resources are highly diversified and intensively exploited by ever growing riparian human populations (density between 3.5 inhabitants km<sup>-2</sup> near Aby Lagoon in Ivory Coast and 96.5 inhabitants km<sup>-2</sup> near Lake Aheme in Benin).

Table 1. Surface of tropical West African lagoons

Coastal lagoons	Surface (km <sup>2</sup> )
Liberia	112
Ivory Coast	1 268
Ghana	434
Togo	64
Benin	325
Nigeria	937

#### Resources of West African lagoons

The exploitation of West African coastal waters concerns mostly fish (Cichlidae, Claroteidae, Clupeidae...) and Crustaceans (Peneids Shrimps and Crabs). The fish fauna and its diversity are seasonally variable in relationship with the entrance of marine waters into the lagoons. It can be divided into three categories of fish communities according to Durand et al. (1994): (1) the littoral euryhaline marine species which come seasonally or accidentally in the lagoons; (2) the estuarine species which live usually in mixohaline inland waters; and (3) the continental or inland water species which are only scarcely recorded in the lagoons as they can enter them only when the water becomes fresh when rivers flood (Daget and Iltis 1965).

In Ivory Coast, a total of 153 species belonging to the three categories of fish indicated above have been recorded in the whole lagoon system (Albaret 1994). More than 100 species are also known from Benin lagoons (52 species in Lake Ahémé, 68 species in Lake Nokoué, 72 species in the Porto Novo Lagoon (Lalèyè et al. 1995; Lalèyè and Philippart 1997). In Nigeria, 79 species have been identified in the Lagos Lagoon. Several species are common to these lagoons. The most abundant species are: *Sarotherodon melanotheron*, *Tilapia guineensis*, *Hemichromis fasciatus*, *H. bimaculatus*, *Ethmalosa fimbriata*, *Elops lacerta*, *Mugilids* (*Mugil* spp. and *Liza*

spp.), *Chrysichthys nigrodigitatus* and *C. auratus*, *Pomadasys* spp., *Gerres nigri* and *G. melanopterus* and *Caranx hippos*.

Crustaceans are represented mostly by *Penaeus duorarum*, *Callinectes latimanus*, *Goniopsys cruentata*, *Cardiosoma amatum* and *Cliberhardius africanus* (Burgis and Symoens 1987).

## Production of West African brackish waters

Fishing techniques in the lagoons are numerous. Cast nets, drag/seine nets, gill nets of various mesh sizes, long lines and traps are commonly used (Weigel 1985; Koranteng et al. 2000). A specific production approach is the “acadja” system, which was initiated in Benin more than 100 years ago. The acadja system aims at providing additional substrata on which food for fish would develop (Welcomme 1972). Catch in acadja systems are relatively high, ranging from 86 kg/ha<sup>-1</sup> yr<sup>-1</sup> in Lekki Lagoon, Nigeria to 1 tonne ha<sup>-1</sup> yr<sup>-1</sup> in Lagoon of Benin. Table 2 shows catch and yields of fish in various West African Lagoons. The high production recorded in Benin is partly due to the development of acadjas in the country. For other countries, e.g. Senegal, Gambia, Ivory Coast, Ghana, Togo, Benin and Nigeria, the average productivity of lagoons and estuaries is around 290 kg.ha<sup>-1</sup>.yr<sup>-1</sup>. The actual catch and its composition have changed over the years in several lagoons for various reasons. When time series of catch are available, it appears that catches are highly variable from one year to the other.

## Constraints on fish production

In some lagoons such as in Ivory Coast, catches are decreasing with time not only due to overfishing but also because of prohibition of beach seine and purse seine net. In some other lagoons, actual catch is changing in relationship with the frequency of the connection with the sea.

In several cases, the number of exploited species and the average size of first capture are simultaneously decreasing because of long-term use of small mesh size net despite legislation. The recent impact on fish communities of pollution and simultaneous eutrophication has also to be considered even though they have not been documented well (Laleye et al. 1993).

## Suggestions for better management of West African brackish waters resources

Generally, collaborative strategies should be implemented for a sustainable management of the aquatic resources of the lagoons and development of the region. From this point of view, mangroves should be rehabilitated on a regional basis and fishing legislations should be harmonized in order to avoid over-exploitation of lagoons one after the other by migrating fishermen. A particular point is to manage connections with the sea so as to increase biodiversity and production. Biodiversity has also to be protected by water purification designs in order to decrease discharge of wastes coming from large cities. A sensitization-education program for

Table 2. Current information on catches of some West African lagoons (from Adite and van Thielen 1995; Durand et al. 1994; Laë 1992,1994; Laleye et al. 1995)

Water bodies	Year of reference	Catch	Yield	Main exploited species
Ebrié	1985	3 000	71	<i>Ethmalosa fimbriata</i> (33%), <i>Chrysichthys</i> (11%), <i>Elops</i> (10%), <i>Tilapias</i> (8%)
Aby	1985		215	idem
Keta Lagoon	1988	4 000		<i>Sarotherodon melanotheron</i> (90%),
Sakumo Lagoon	1995	508		<i>Sarotherodon melanotheron</i> (90%)
Togo Lagoons	1989	2 260	400	<i>Liza falcipinnis</i> (35%), <i>Caranx hippos</i> (21%), <i>Sarotherodon melanotheron</i> (10%), <i>Chrysichthys</i> (10%), <i>Ethmalosa fimbriata</i> (5%)
Lake Ahémé	1994	4 144	487	<i>Cichlids</i> (70%), <i>Gobiids</i> (10%), <i>Chrysichthys</i> (2%), <i>Ethmalosa</i> (5%)
Lake Nokoué	1944	20 000	1 330	<i>Cichlids</i> (33%), <i>Ethmalosa</i> (7%), <i>Gobiids</i> (4%), <i>Chrysichthys</i> (3%), <i>Mugilids</i> (2%),
Porto-Novo Lagoon	1994	3 442	1 147	<i>Cichlids</i> (46%), <i>Ethmalosa</i> (13%), <i>Chrysichthys</i> (11%)
Todougba and Toho Lagoon	1988	387	256	<i>Sarotherodon galilaeus</i> (73%), other <i>Cichlids</i> (12%), <i>Chrysichthys auratus</i> (7%).

rural populations on sustainable management of aquatic resources should also be elaborated.

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## Discussion

**Dr. Abban:** I would like to know if the speaker or any other participant has records on observations indicating that water development projects (e.g. creation of reservoirs along rivers) have affected brackish waters productivity.

**Dr. Laleye:** The creation of dams affects water exchange in lagoons. The reduction of freshwater flow into lagoons could lead to formation of barriers on sand bars which could limit the influx of marine fishes into lagoons and consequently reduce fish production.

**Dr. Agbleze:** In response to Dr. Abban's concern, reports from local communities indicate that the Keta Lagoon located in the coastal Savanna zone has been experiencing more frequent dry-outs after the creation of numerous dams upstream of rivers feeding the lagoon for agricultural purposes.

**Dr. Agbleze:** In Dr. Laleye's presentation, *S. melanotheron* dominates the catches, what is the patronage for *S. melanotheron* in the West African sub-region as food fish compared to other species in the catches?

**Dr. Laleye:** There is a high patronage for *S. melanotheron* all over the West African Coast.

**Dr. Pullin:** It looks as if all the fish catches in West African brackish waters are made up of native species, not alien species. There have been some introductions of alien, saline-tolerant tilapias, e.g. *Oreochromis aureus* and *O. mossambicus*, for aquaculture research development projects in the lagoon areas of Côte d'Ivoire – but these alien species did not seem to have established there. Maybe there is some difference between the numbers of alien species introductions that result in establishment in brackish waters vs. those in freshwaters. This could be checked in the introduction table in FishBase.

**Dr. Agnese:** Introduced species are typically freshwater species. With respect to lagoons there seems to be no alien species that is well adapted to brackish water conditions, hence the reason why no alien species have been introduced and established in lagoons.

**Prof. Ayinla:** What is the input of research on the Acadja system in Benin? What type of fish is being used in the Acadja system? Is there a way research can intervene to further improve production in the Acadja system by introducing a particular species?

**Dr. Laleye:** Some research has been done and the results are available in the proceedings of the previous workshop. No particular species is used in the Acadja system since it attracts all types of species. The principal fish in the lagoons is *S. melanotheron* and it forms about 60% of the catches from the Acadja system.

# Fish Resources Utilization and Conservation Measures in Niger

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Niger is a 1 276 000 km<sup>2</sup> landlocked country with 10 million inhabitants. Seventy-five per cent of the country is desert. Livestock, agriculture, and fisheries are the most important rural activities. Fisheries contributes 10 billion CFA franc to the national economy per annum.

Of the 98 fish species reported in the country, 22 are of economic importance. Fish production varies between 2 000 t and 20 000 t. These fluctuations are mainly due to variations in annual rainfall and problems of access due to water hyacinth. Tilapias represent 20% of all captures and the price per kilo varies from 500 to 1 500 FCFA. Some breeding programs for tilapia have been set up. The first trials were made in 1982 with financial help from France. Tilapias, mainly *Oreochromis niloticus*, were raised in cages. Performances were good but cost of production per kilo was high due to high cost of fish proteins imported from Côte d'Ivoire. The improvement of fish culture in Niger thus depends on the lowering of food input costs as well as the availability of water due to the severe drought that the country faces.

## Discussion

**Dr. Laleye:** In your presentation of fish production statistics, fish production is apparently still increasing. Does it mean that the resources are under exploited?

**Dr. Harouna:** Yes, because the techniques used are not developed. If the techniques become sophisticated, which cannot be ruled out with time, the resources will be over-exploited. There is also the problem of water hyacinth which can affect production.

**Dr. Kabre:** What is the role or function of intermediate agents, e.g. Forestry agents, in the production and conservation of fishes?

**Dr. Harouna:** The role of such agents have essentially to do with monitoring and the enforcement of legislation.

**Dr. Sakiti:** Is *Azolla* used in the culture of fish in Niger?

**Dr. Harouna:** Not yet but we are interested in the results of research on *Azolla* done by your laboratory.

# Development Project of Aquaculture in the Republic of Guinea

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This pilot project has been funded by the Agence Française de Développement, AFD, (750 000 Euros) and has been executed in the forest region of Guinea (Guinée Forestière) by the Directorate for Inland Fisheries (Direction Nationale de la Pêche Continentale) with technical assistance from AFD. The project aims to demonstrate the potential for aquaculture in the forest region, to enhance the food security in this region and to provide an alternative source of income for the farmers. Extensive polyculture was adopted for a three to ten-month cycle with male *Oreochromis niloticus* as the primary species (60% of the population),

*Heterotis niloticus* (20%), *Heterobranchus isopterus* (15%) and *Hemichromis fasciatus* (5%). Twenty-five farmers have been trained and equipped with necessary seed. Today, they are able to evaluate the qualities and possibilities offered by any stream and site, follow the construction of their dam, manage the water flows, determine the sex of their tilapias, improve cash income and improve the availability of fish on the local markets. Farmers now have a better knowledge of the financial management of their activities. It is intended that the project be extended by a second phase project that should start in early 2003.

## Phenotypic Variation in African Freshwater Fishes: A Geographical Scale Review

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The adaptation of fishes to environmental constraints is slower compared to some invertebrates, but the phenomenon exists in both temperate and tropical zones.

In the tropical zone, several examples showing the influence of feeding habits on morphological variations in fishes exist. The existence of dwarf populations that mature at a smaller size than usual is recorded for various tropical species and generally dwarf forms are associated with lacustrine conditions. Changes in environmental conditions may also influence the biological cycle of species. With respect to reproductive strategies, some ubiquitous species may modify their spawning period to adapt to changes in environmental conditions, mainly changes in the hydrological cycle.

The gradual development of a series of small morphological differences between neighbouring

populations of a widely distributed species, or clines, are generally responses to environmental conditions. When such populations are isolated, however, and when there is no gene flow between the populations, specialization may occur. The most famous example is that of the numerous species flocks of the Great Lakes of East Africa.

The paper shows that phenotypic variations in African fishes may exist at each geographical scale, and examples are given on morphological or biological variations covering local areas and the complete African inter-tropical zone.

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### Discussion

*Dr. Olaleye:* There were no data presented on the Niger/Benue system and I know the system has most of the species presented and more. Can you explain why there is that gap?

**Dr. Fermon:** Only a few examples were presented because of the time constraints.

**Dr. Abban:** What environmental characteristics have been considered to be associated most with the morphological or meristic variations and clines observed along a water system?

**Dr. Fermon:** It is difficult to say because there are many environmental variations – a lot of things come into play.

**Dr. Falk:** You presented several examples on morphometric variations within African fish species over a broad geographic scale, and concluded that these variations are caused by environmental conditions. However, for a variety of species it is known that they cover very distinct and differentiated genetic units. I really doubt that you can, therefore, relate morphological variations to environmental clines only. Genetic differences between different

geographical units have to be considered as well. You have to be very careful with this kind of interpretation when you are dealing with isolated, genetically distinct organisms, even if you are dealing with populations of the “same” species.

**Dr. Pullin:** Morphometrics and other techniques (such as biochemical genetics) will become increasingly important in resolving whether a given population or individual is “distinct”, in the sense of the terminology of the convention on biological diversity. For farmed species, the country in which populations or individuals acquire “distinct” characteristics is considered to be their country of origin. For wild species, distinct genetic resources (such as subspecies) are also important to the countries that own them. This suggests that taxonomic splitting has some utility in assigning ownership/benefits. But lumping clinal extremes does not help here. The important point is “genetic distinctness”.

## Thermal Influences on Sex Determination of Natural Populations of Nile Tilapia, *Oreochromis niloticus*

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Within the tilapias, species of major importance for tropical aquaculture, studies on the control of sex determination and reproduction are very important with regard to the improvement of monosexing methods. This concern includes the Nile Tilapia, *Oreochromis niloticus*, natural populations of which are widespread from the Nilo-Sudanian systems to the north of the East African Rift, and show an important ecological plasticity. Previous studies have demonstrated that in tilapia, sex is determined by major (XY or ZW) and minor (autosomal) genetic factors and influenced by environmental temperatures. High temperatures (32-36°C) applied while fishes are in their undifferentiated stage can promote masculinization in some offsprings. Under natural conditions tilapia fry may partly be exposed to such thermal conditions which may potentially influence their sex. However, previous studies were only done on aquaculture strains and under controlled conditions, so masculinization under natural conditions has never been observed. This

thermal sensitivity of sexual differentiation may represent an interesting adaptive reaction.

In this project *in situ* (in natural and semi-natural/ ponds conditions) and *ex situ* (strictly controlled ones) studies have recently been started on the potential thermo-sensibility of different natural populations of the Nile Tilapia subjected to different extreme thermal conditions: constant cold temperature habitats, constant hot temperature habitats and habitats with a large thermal range. Studies were carried out in two African countries. In Ethiopia, habitats with two extreme thermal conditions were chosen: (1) hot water springs of the Rift Valley, in which water temperature can reach 43°C, and (2) the cold water crater lakes related to the Awash system, in which the temperature is maintained below 25°C. The populations living in these two habitats are genetically closely related. Secondly, the Volta system in Ghana has been chosen to study populations living under conditions with a wide thermal range.

Because of the strong social and reproductive behaviour and the importance of spatial structuring of populations and life-stages, we are starting to analyze the genetic structure and sex ratio of fry schools in comparison with their potential population to understand the biological nature of such schools and the importance of thermal conditions on the sex ratio.

This project aims to evaluate the adaptation of different natural populations of the Nile Tilapia to extreme thermal conditions, in particular with regard to their sexual differentiation under natural conditions. Growth and reproduction strategies of individuals from these populations will be characterized to estimate the potential use of the thermal sensitivity of sexual differentiation. Finally, the present project exemplifies research and use of biodiversity which may suggest new approaches for the control of sex and thus the improvement of local aquaculture.

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## Discussion

*Dr. Falk:* What I am going to say is similar to the comment I have given to Dr. Fermon. You tried to demonstrate

that sex ratios in different populations of the Nile tilapia may be based on thermal differences only. However, as we know, several of these populations are genetically completely isolated and also very distinct. It is, therefore, not possible to conclude that temperature effects exclusively are responsible for variations in sex ratios. If you want to demonstrate such effects, you should focus your work on genetically homogenous strains, for example. Otherwise, you cannot exclude that these differences are also based on different genetic compositions of isolated populations.

*Mr. Bezault:* We did not check the genetic aspects because a lot of genetic traits are adapted to specific conditions. We want to study only the environmental aspects.

*Dr. Rezk:* Life history of each species can influence the morphology of the species. It is also important to relate genetic differences with morphometric differences.

*Mr. Kwafo Apegya:* What is the sex ratio that can be achieved at the maximum temperature of 36°C?

*Mr. Bezault:* Above 32°C, depending on the breeder, one can achieve either 100% or 50% males.

## Session III: General Discussion and Conclusions

*Dr. Olaleye:* Priorities should also be accorded to inland impoundments which could be harnessed for fish production. *S. galilaeus*, which is the dominant reservoir tilapia and endemic to inland impoundments in Nigeria, should also be considered a likely candidate for genetic improvement and subsequent culture for enhancement of tilapia fisheries in inland waters.

*Mrs. Adeogun:* I would like to see resources management policies developed which will involve all the West African Coastal stakeholders based on common property philosophy devoid of anglophone/francophone dichotomy.

*Dr. Pullin:* Plan for the future expansion of aquaculture and for addressing the new situations that this expansion will bring for conservation of biodiversity and genetic resources. The expansion of aquaculture will increase the possibilities of interactions between farmed animals and wild animals. Farmed animals become progressively genetically altered from their wild relatives, i.e. domesticated. Planning research is needed to identify approaches, institutions, costs etc. for ensuring that aquaculture expansion and

conservation of farmed and wild genetic resources proceed together with adequate funding for both.

*Dr. Rezk:* An area of great importance for research is to identify what the diversified populations we identify are good for. That is to say, it is important to relate the molecular genetic differences between populations not just to morphometric and meristic traits but to performance traits needed in different aspects that the fish can be used for, e.g. aquaculture and fisheries, or as ornamentals.

As indicated in my presentation about the situation in Egypt, there is a concern about the expansion of aquaculture and the impact of escapees from aquaculture facilities on natural populations. This is an important area, in my opinion, for future research.

*Dr. Laleye:* The problem of aquaculture is the cost of feeds for fish. Importing fish to feed fish is very expensive and costs too much for aquaculturists. The solution would be to progressively use the local resources to prepare fish food.

**Dr. Falk:** Looking at the literature and listening to the discussions here, it is very clear that only limited information is available on the biodiversity of West African fishes. Very few genetic studies on broader geographic scales have been conducted so far and the vast majority dealt with, let's say, five species with potential for fisheries and aquaculture. In fact, even most of these studies are provisory. What I would like to recommend from this point of view is to try to:

- Expand biodiversity studies on West African fish species, in particular on those with broad distributions;
- Monitor fish biodiversity in West Africa;
- Establish training opportunities and programs for West African professionals in characterizing fish genetic resources;
- Implement these data into conservation and management strategies;
- Define conservation and management strategies for West African fishes on all available biological data, including systematic and genetic knowledge on these species; and
- Include research on the socio-economical and socio-ecological aspects of conservation and management.

**Mr. Bezaul :** We can add:

- Limit as much as possible the introduction of exotic gene pools: GMO's, exotic species, sub-species, improved strains;
- Improve knowledge on the biology of fish at the local level (i.e. ecology, physiology, behaviour, morphology, parasitology and diseases resistances);
- Improve first, the development of populations adapted to local specific conditions with improvement of culture methods; and
- Develop comparative methods for analyzing physiological traits of major importance (growth, salinity tolerance, sex).

### **Recommendations for West African tilapia genetic resources research**

Future research priorities and related items:

- Expand and complete biodiversity studies on West African fish species on a broad scale, focusing on species of current importance for fisheries and aquaculture;
- Emphasize human resource capacity building and strengthening of established laboratories in the region, including international collaborations;
- Establish training opportunities and programmes for West African professionals in characterising fish genetic resources;

- Evaluate the current status of introduced alien species in West Africa and their implications with regard to biodiversity conservation;
- Improve and study populations adapted to local conditions instead of blindly using exotic populations/strains and introducing these to “new” environments;
- Expand research on the genetic basis of important traits (growth, salinity tolerance) for aquaculture;
- Extend genetic studies from cultured fish to wild populations with which they might interact;
- Determine the reaction of fish to (climatic) variation;
- Analyze the influence of structures (connections, reservoirs, dams etc.) on movements of marine and freshwater fishes and the implications on faunal changes;
- Increase the production and quality of fish (seed);
- Determine the range of market (eco-friendliness), risk assessment and ecological barriers;
- Increase the quality, availability and linkages of information; and
- Revise legislation.

### **Recommendations for Conservation:**

- Try to preserve biodiversity at all hierarchical levels (ecosystems, species, populations, genes); and
- Limit introductions of exotic gene pools.

### **General suggestions for management (sustainable utilization and conservation):**

- Improve the knowledge on biology (ecology, physiology, behaviour, morphology, genetics, parasitology, disease resistance, etc.) at the local level; and
- Preserve/protect sensitive habitats (e.g. mangroves) on a regional basis and harmonize legislation.