Biodiversity of Estuarine Fish Faunas in West Africa

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Abstract

In West Africa (between Ivory Coast and Sénégal), estuarine environments vary from lagoons to high discharge rivers to inverse hypersaline estuaries. This results in a high diversity of estuarine fish species, with an important turnover and a core of ubiquitous species. The species richness of a given estuary depends on the combination of hydrological factors (marine or freshwater dominance) and biogeography (continental biogeographic regions). The catch rate is higher in lagoons and inverse estuaries than in normal estuaries, which can be explained by the predominance of small juveniles in the latter. Clupeids are the most abundant fishes all over the region, but different systems have different dominant species. Assessing the functioning of West-African estuaries provides useful comparisons to Asian estuarine systems.

Introduction

In West Africa the estuarine fish fauna is an important resource for local populations. In the Southern Rivers zone for instance (Southern Sénégal - Sierra Leone), the catches of the artisanal fishery, which targets mostly estuarine-related species, amounted to 150 000 tonnes/year, and to an average of 100 tonnes/year/km of coastline (Charles-Dominique 1994). On the other hand, the estuarine and coastal environment in this region is also subject to heavy human pressure, with an annual population growth rate of 4-7% and 60% of industries located in coastal cities (UNEP 1999). The coastal lagoons of Ivory Coast, the cities they support and the fish they produce are illustrative of the strong interaction between people and the environment.

Knowledge of the estuarine fish fauna, its geographic specificities and its natural driving forces, helps in the understanding and management of this resource. This paper summarises the major trends in estuarine fish biodiversity in the region.

The focus here is on coasts covering 2 800 kilometers between Sénégal and Ivory Coast (Fig. 1). The comparison of estuarine ichthyofaunas which follows is a synthesis of several local studies compiled by Baran (1995) and Diouf (1996). Three aspects are detailed: species richness, composition and abundance of regional estuarine assemblages. This comparison pictures species rich environments, whose fauna depend both on river hydrological regimes and freshwater biogeographic regions.

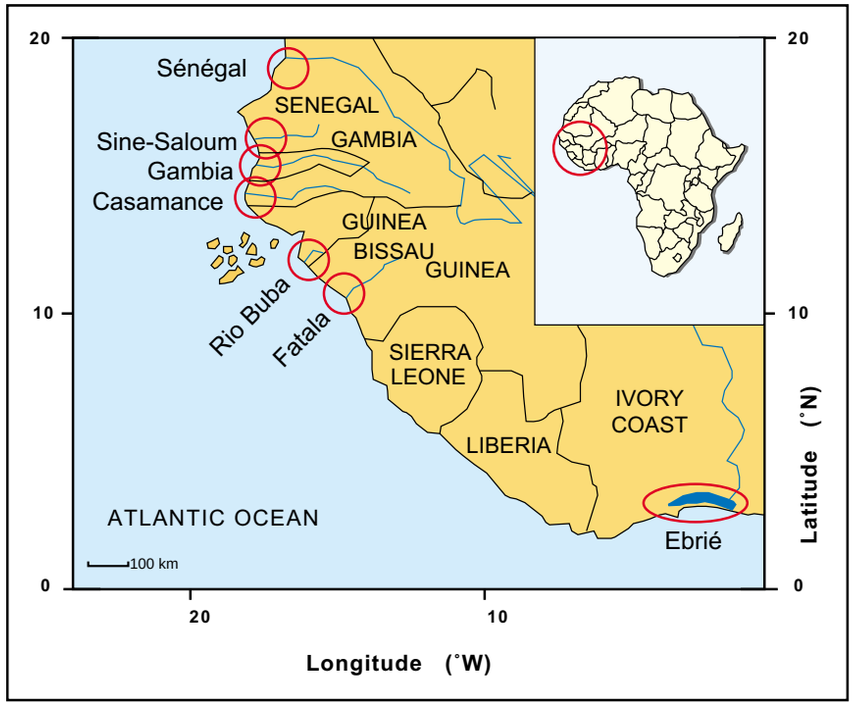

Fig. 1. Major estuaries studied in West Africa.

Species richness of regional estuarine assemblages

Species richness of estuaries and lagoons is defined here as the number of species encountered at least once within their limits. It is important to note that this definition has evolved from earlier studies to now include the openness of these systems (Albaret 1999).

When compared to other estuaries and lagoons worldwide, the species richness of West African estuaries appears to be intermediate between that of South America and that of Asia or Australia (Table 1). This fish species richness is thus lower than that around the center of aquatic biodiversity (Southeast Asia), but higher than that in the neotropics. The estuaries of West Africa exhibit a species richness close to that of the freshwater streams they are linked to, and reach on average a fourth of that of the coastal shelf. However this species richness is due mostly to a succession of species temporarily using this environment for feeding, for spawning or for shelter. In the Fatala estuary (Guinea) for instance, only 22% of any species present in a given month will still be present two months later; permanent species contribute 34% of the total richness. This turnover seems to be an essential feature of open tropical estuaries; it must be considered in biodiversity protection approaches, which should not only focus on resident estuarine species (Albaret and Diouf 1994).

Seine fishing in a West-African mangrove-fringed estuary.

Two complementary hypotheses are proposed to explain the high species richness in all West African estuaries (Fig. 2):

1) in high discharge rivers (Sénégal, Gambia, Fatala), the hydrological variability between the dry and the flood season is important; this results in a high mobility of the brackish zone. In the rainy season, the major part of the zone geographically defined as estuarine exhibits the hydrochemical characteristics of a river, and is slowly occupied by strictly freshwater species. In the dry

Table 1. Species richness (SR) in different West African estuaries and lagoons, compared to that of corresponding coastal shelves and rivers.

Name	Type	Country	Marine shelf SR	Freshwater stream SR	Estuarine SR
Sénégal	Estuary	Sénégal	292	110[e]	111[d]
Siné-Saloum	Inverse estuary	Sénégal	292[b]	-	123[f]
Gambia	Estuary	Gambia	292[b]	96	89[d]
Casamance	Inverse estuary	Sénégal	292[b]	-	86[d]
Rio Buba	Estuary	Guinea Bissau	337[a]	-	92[d]
Fatala	Estuary	Guinea	158	41	102
Ebrié	Lagoon	Ivory Coast	103	112[c]	153
Abi	Lagoon	Ivory Coast	103	75[c]	82
Lagos lagoon	Lagoon	Nigeria		-	79
Niger	Delta	Nigeria		207[e]	52*
Average estuarine species richness in West Africa (10 case studies)					97
Average estuarine species richness in South America (23 case studies)					70
Average estuarine species richness in Asia (7 case studies)					116
Average estuarine species richness in Australia (9 case studies)					113

After Baran 1995, modified according to a: Sanches 1991, b: FAO 1992; c: Paugy et al. 1994 (Comoé + Mé + Agnébi rivers for Ebrié lagoon; Tanoe + Bia rivers for Abi lagoon); d: Diouf 1996; e: Hugueny and Lévêque 1999; f: Vidy 2000.

*Species richness based on a meagre sampling and likely to be underestimated.

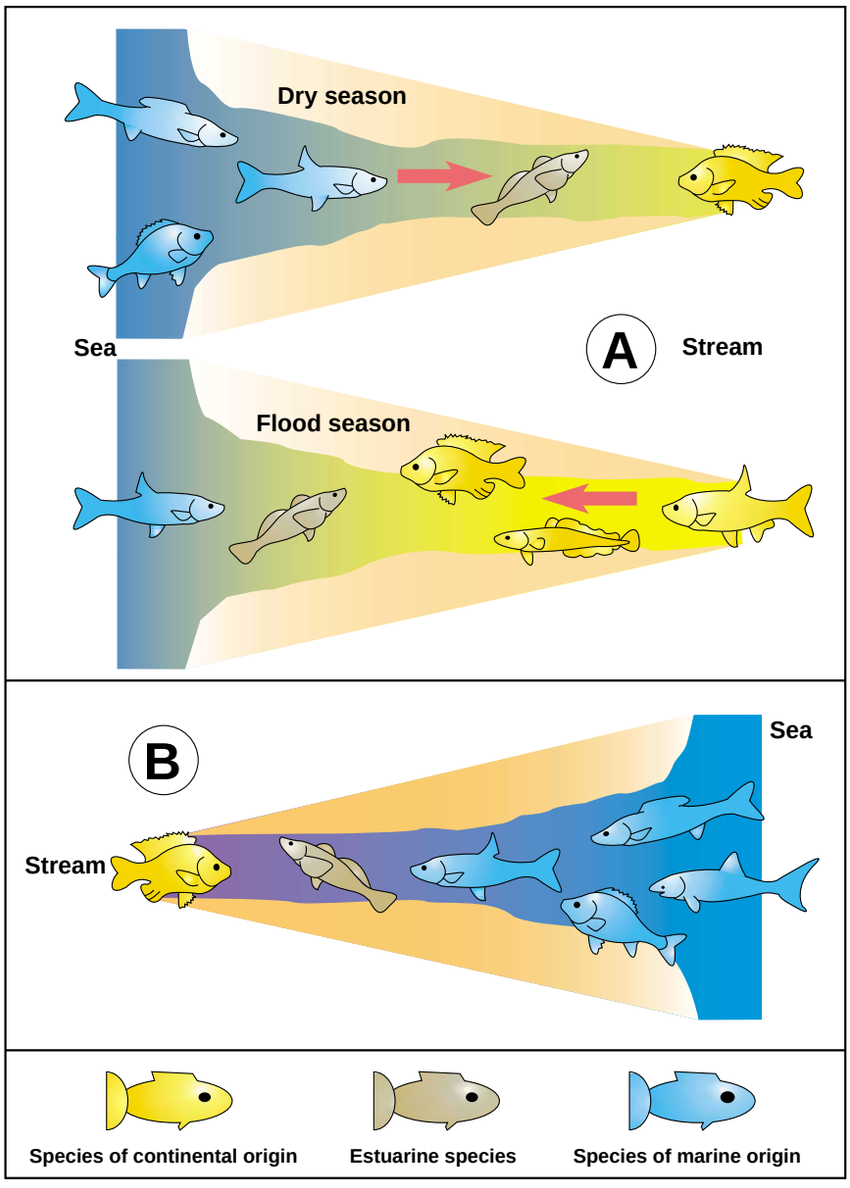

Fig. 2. Faunas and hydrological regimes in West African estuaries.
A: Normal estuaries with high hydrological variability: succession of fish faunas from marine and continential origin, depending on the season.
B: Inverse estuaries with limited freshwater input: reduced freshwater fauna but increased presence of the marine fauna.

season however the salinity at the mouth of estuaries becomes close to that of seawater, which permits the presence of marine species at juvenile or adult stages (mostly for feeding purposes). These seasonal incursions of species between the two adjacent ecosystems combine to the permanent presence of a typical estuarine community (Fig. 2A);
2) in inverse estuaries of Sénégal, the continental influence is almost nil and the population is structured according to a gradient of increasing upstream salinity. However the "deficit" of species of continental origin is compensated for by the presence of a larger number of strictly marine species, whose incursions into these rich waters are not limited by the presence of a brackish coastal zone nor by the possible competition with freshwater species (Fig. 2 B).

Composition of regional estuarine assemblages

Based on available studies and species lists, seven estuarine zones have been compared: Sénégal River, Siné-Saloum and Casamance River in Sénégal; Gambia River in Gambia; Rio Grande de Buba in Guinea-Bissau; Fatala River in Guinea and Ebrié lagoon in Ivory Coast. A multivariate Correspondence Analysis of species lists (Thioulouse et al. 1997) was made. This type of analysis projects onto a map the different estuaries, according to the species they have in common, as well as species endemic to them. Their geographical proximity on the map thus illustrates their faunal similarity. Conversely the species responsible for the similitude or difference between estuaries are also identified by the analysis (Fig. 3).

The similarity between the fish fauna in the Siné-Saloum and that in the Casamance River appears clear; these two systems are geographically close and function similarly. They exhibit a great proportion of marine species (notably rays, snappers and groupers) but the estuarine group is also well represented (croakers, threadfins, etc.). The Rio Grande de Buba fauna has strong affinities with this group, although its peculiar species demark it as the most marine of all estuaries. This can be explained by its size (20-60 m in depth, 4 km wide at the mouth) and by the absence of oversalinization as in the Siné-Saloum.

Opposite to this group of three estuaries characterised by a fauna predominantly of marine origin is the situation in the Ebrié and Sénégal estuaries, whose fauna are mainly of continental origin.

However these two latter zones also exhibit differences in their fauna, which are related to the different biogeographic origin of their freshwater species. The Sénégal River estuary is characterised by the richness of its freshwater fish fauna typical of Sahelo-Sudanese rivers (Hugueny and Lévêque 1994, Lévêque and Paugy 1999). The specificity of the Ebrié lagoon is due to freshwater species belonging to the Ivory Coast-Ghana bio-geographic region (Paugy et al. 1994).

The Fatala and Gambia estuaries are intermediate between these three poles; their faunas include many freshwater species such as mormyrids, characids, featherbacks, but also gobies living in muddy environments, particularly in the Fatala River.

Lastly the analysis clearly points out the important group of ubiquitous species, which makes "a basic assemblage present in all West African estuaries and lagoons" (Albaret and Ecoutin 1990). In this group, jacks, croakers and mullets dominate.

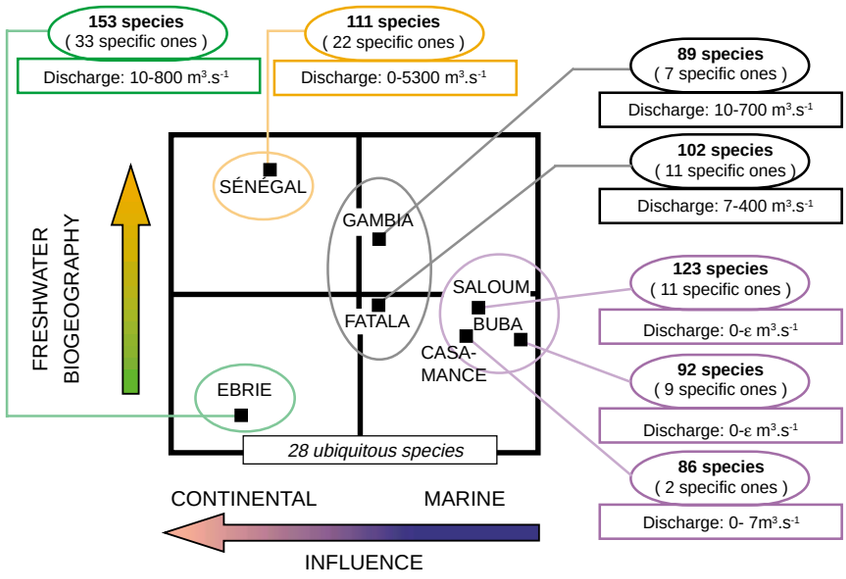

Fig. 3. Factorial map of seven West African estuaries, according to their respective fish fauna.

Abundances and biomasses of regional estuarine assemblages

In terms of primary production, estuaries and lagoons are the most productive aquatic environments after algal beds and coral reefs. This production is transferred to higher trophic levels and generally results in a similarly high fish production. The estuaries of West Africa exhibit fish production ranging around 15-16 tonnes/km^2/year (Blaber 1997). Table 2 gives some catch rates in standardised conditions in different estuaries.

These results differ from those of the coastal fisheries for which it is generally considered that the richest regions of West Africa are the Guinean and Bissau-Guinean zones of the continental shelf. The reason for the variability in catches between these estuarine zones is that both adults and juveniles are present in the more saline zones, whereas juveniles dominate in the most brackish zones and result in lower catches. The positive influence of lower salinity zones on the nursery function has recently been confirmed by Vidy (2000).

In these West African estuaries, clupeids are always numerically dominant and represent 61% to 85% of catches. However, within this family the dominant species are not always the same, depending on the estuary: in Siné-Saloum (Sénégal) the dominant species is *Ethmalosa fimbriata*, whereas in Gambia two species predominate (*E. fimbriata* and *Sardinella maderensis)* and the most abundant in the Fatala estuary (Guinea) is *Ilisha africana*. *Ethmalosa fimbriata* dominates again in Ivory Coast lagoons (Albaret 1994). Fig. 4 shows the relative importance of the five most abundant fish families in three of these estuaries.

In Senegalese hypersaline inverse estuaries (Casamance, Siné-Saloum), catfishes and croakers dominate at the mouth; they are replaced by clupeids and mullets in the middle zone, and upstream, where salinity reaches $110^0/_{00}$, tilapias proliferate. Surprisingly this replacement results in a consistency of the biomass throughout these estuaries, although the biodiversity is drastically reduced.

Table 2. Purse seine standardised catch rates in four West African estuarine zones.

	Siné Saloum	Rio Buba	Fatala	Ebrié lagoon
Average fish catches (kg/ha) and variation range	27 (8-44)	3 (2-21)	9 (0-23)	24 (14-102)

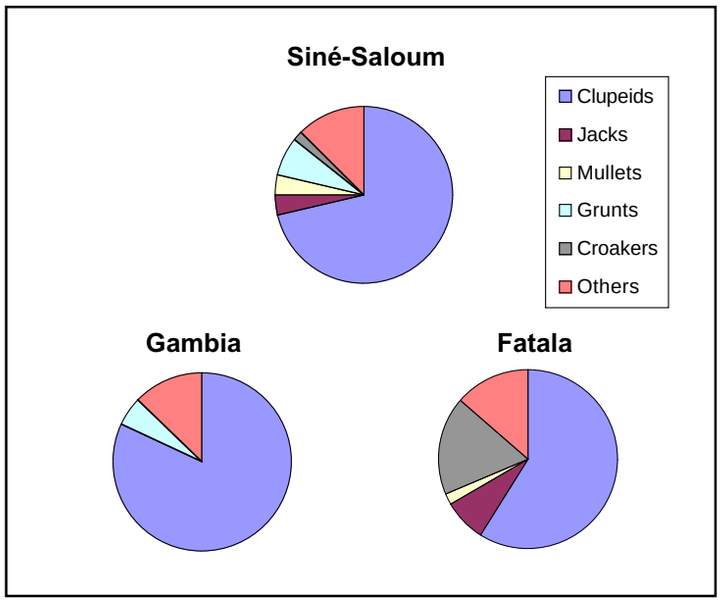

Fig. 4. Relative abundance of the five dominant families in three West African estuaries.

Conclusion

These results show the diversity of West African estuaries, in which the diversity of fishes follows that of the environment. The high species richness observed in these estuaries results mostly from two antagonistic hydrological processes, with penetration of fish faunas respectively from marine or continental origin. Although a few species only are permanent residents (but make up the bulk of catches), many others use this environment as a rich but temporary feeding ground, principally as juveniles. These major biological features are linked to the open character of estuaries, and therefore it is not justified to limit the census of estuarine species to only those species with a fully estuarine biological cycle.

Other factors superimpose on hydrology to influence species diversity, such as biogeography, size of the estuarine zone, habitat diversity and openness to adjacent ecosystems (Albaret 1999). The limited number of site studies in West Africa does not allow a quantification of these different factors; however an extension of this comparative approach to other tropical estuarine faunas would allow such a quantification. This would lead to a prioritisation of factors to be managed to ensure the sustainability of this fish resource and the protection of its diversity.

Given their ecology depending on the strength of marine and freshwater respective influence, West African estuaries and their fish species are likely to be affected by global climate change. Higher climatic variations would result in an alternation of faunas of different origins, and therefore in an increased census of species. Alternatively, a global temperature increase would result in a loss of freshwater species, in favour of species of marine origin.

Along the Guinean coast, the number of inshore streams (six in Guinea, four in Guinea-Bissau), the volume of their discharges and the heavy coastal rainfalls result in a permanent turbid brackish zone which spreads tens of kilometres offshore (Diop 1990, Cormier-Salem 1999). These factors combine to produce the physico-chemical and ecological characteristics peculiar to estuarine environments: several thousands of square kilometers of the coasts of Guinea and Guinea Bissau exhibit these characteristics (Lafrance 1994, Baran et al. 1999). This coastal zone is similar to those of the tropical Indian Ocean and South East Asia, where vast zones considered as marine exhibit the environmental and biological characteristics of estuaries (Hardenberg 1949, Blaber 1981, 1997). These shallow, turbid and brackish marine surfaces do not correspond to the classical definition of an estuary, which may require, in a river basin management approach, the notion of "coastal estuary" (Baran and Hambrey 1999). They sustain the production of considerable aquatic resources (Chullasorn and Martosubroto 1986; Silvestre and Pauly 1997) characterised by their estuarine affinities, and therefore by their dependence on freshwater and terrestrial inputs: in Southeast Asia estuarine-related capture fisheries were estimated to contribute approximately 1.4 million tonnes or 21% of the total marine capture fisheries in 1990 (Chong and Sasekumar 1994). The "relative estuarization of the continental shelf in much of the tropics" (Longhurst and Pauly 1987), although acknowledged for long, has received surprisingly very little attention from scientists and management bodies. The latter remain almost always divided into inland or coastal/marine departments, and the former have scarcely studied the quantitative and qualitative relationships between river runoffs and coastal fish production in the tropics.

Assessing these links remains an important challenge for many countries hosting the mouths of major tropical rivers such as the Brahmaputra, the Ganges, the Chao Phraya or the Mekong River.

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