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Spatial and temporal structure of the fish assemblage in Akanda National Park (Gabon), an equatorial mangrove estuary

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Abstract :

Marine spatial planning and management processes are important tools for environmental and resource management, providing effective frameworks for considering environmental, social, cultural, institutional and economic variables within a common biogeographic context. The Akanda National Park (ANP) in Gabon, almost exclusively constituted by mangroves, is part of a green belt of protected areas around the capital city of Libreville. The creation of the ANP is considered as an essential tool for the ecosystemic management of fisheries in Mondah Bay, playing nursery function for several exploited fish species. However, this role has never been documented in the mangroves of Gabon. The aim of this study is to describe the spatial and seasonal variability of fish assemblages, to assess ANP mangrove role as a nursery for fish juveniles. Fish sampling was carried out at four different sites in the four hydroclimatic seasons in Gabon using trammel gillnets with different mesh size (10, 27 and 40 mm). Fifty-nine fish species mainly estuarine and marine, first and second level predators were collected whatever the season and the site. The numerically dominant species were Pseudotolithus elongatus, Pellonula leonensis and Parachelon grandisquamis (48% of the total number of individuals), whereas P. elongatus, Chrysichthys nigrodigitatus and Plectorhinchus macrolepis represented the main biomasses (55%). The predominance in the catches of immature individuals of many species of commercial interest and in particular, P. elongatus, P. grandisquamis, C. nigrodigitatus, Eucinostomus melanopterus, Neochelon falcipinnis and Polydactylus quadrifilis, which dominate the community, highlights the importance of Akanda mangrove as a nursery for the juveniles of these species. The results of our study are a first step in understanding the fish communities of a Gabon marine protected area, which can support the decision making management plans, zonation and initiate a monitoring program for the estuarine and marine protected ecosystems.

Keywords : Diversity, Communities, Mangroves, Conservation, Nursery, Fisheries

Introduction

Mangroves are one of the most productive coastal tropical and subtropical forest ecosystems in the world (Costanza et al. 1997; MEA 2005; UNEP 2014). Together with their associated biodiversity, mangroves provide important ecosystem services that play a crucial role in the well-being of coastal human communities through climate regulation, food security, and poverty reduction (Baba et al. 2013; Benzeev et al. 2017; Carrasquilla-Henao and Juanes 2017). Among the ecosystem services associated with mangroves, ensuring the renewal of commercial fish species stocks through nursery function is of primary importance (Beck et al. 2001; Litvin et al. 2018; Carrasquilla-Henao et al. 2019). However, if in some regions of the world, this function is well documented (Nagelkerken et al. 2008; Kimirei et al. 2013), it has been scarcely addressed in Africa (France and Serafy, 2006), which hosts about 19% of the world's mangrove area (Alongi 2014; Thomas et al. 2017; Worthington and Spalding 2018).

Despite the lack of information on the nursery function, protected areas including mangroves are regularly created in Africa and used as strategic tools to preserve the renewal of fish stocks (Sheridan and Hays 2003; Kimirei et al. 2013; Litvin et al. 2018). The sustainability of the fisheries sector is highly relevant in Africa since this continent provides nearly 10% (10.5 MT) of the world's fisheries production (FAO 2020). However, the fisheries production is locally expected to decrease significantly (e.g. Gulf of Guinea) by 2050 as a consequence of climate change (Cheung et al. 2016). The productivity of Gabon coastal water is among the highest in the Gulf of Guinea, driven by the general equatorial dynamics and the input of large amounts of dissolved and particulate organic matter from Ogooué River (Nieto and Melin 2017). In the south of the Gulf of Guinea, the Akanda National Park (ANP), essentially constituted by mangroves, is one of the emblematic protected areas, showcase of the conservation policy of Gabon. ANP borders the country's largest agglomeration, Libreville, whose population density reaches nearly 3700 inhabitants.km^{-2} (Moumaneix and Nkombe 2017; Pottier et al. 2017). This large city adversely impacts the ANP aquatic ecosystem through discharge of domestic and industrial waste (Leboulanger et al. 2021).

Despite evidence of the effectiveness of national parks in Gabon, conservation objectives generate conflicts with artisanal fisheries (Ona Ona 2019). Indeed, the fishing sector is of particular importance for the country with regard to the high national consumption rate (40 kg/person/year, FAO, 2020) of fishery products. This sector is especially essential, contributing to human coastal communities livelihoods through the income generated, the provision of animal proteins and the reduction of unemployment (Egombengani 2011; Cardiec, 2021). Therefore, studying the ichthyofauna of ANP is of primary importance in order to allow sustainable management of these exploited marine resources. Despite its creation in 2002, no fish assemblage inventories or assessments in ANP have been conducted to date.

In order to alleviate to the lack of ecological baseline studies for this area, our study aims to describe the spatial and seasonal variability of fish assemblages in the mangrove of Akanda National Park in order to understand fish community structure and dynamics and to assess its role as a nursery for juveniles of exploited fish. This knowledge will also usefully contribute to the definition of the functioning of a coastal mangrove ecosystem in Central Africa, and to new comparisons with other mangrove ecosystems, particularly in the context of global change.

Materials and methods

II.1. Study zone

Gabon's coastal waters are among the most productive in the Gulf of Guinea, as a result of seasonal upwelling and the input of large quantities of dissolved and particulate organic matter from the Congo and the Ogooué Rivers (Voituriez and Herbland 1982, Le Loeuff and von Cosel 1998). Nutrient rich waters support productive food webs and abundant fisheries resources that are essential for coastal populations (McGlade et al. 2002). Akanda National Park (ANP) covers an area of approximately 53,780 hectares between the Libreville peninsula and Equatorial Guinea, some 10 to 15 km northeast and east of Libreville. It is located between 0°35 and 0°40' North longitude and between 9°26' and 9°33 East latitude (Van De Weghe 2005). ANP is part of Mondah Bay located in the southern part of Corisco Bay (Fig. 1). The whole area belongs to the estuarine system northwest of the Gabonese coast in the geographical region of the central Gulf of Guinea. Semi-enclosed Mondah Bay is a patchwork of different habitats including large mudflats and mangroves, seagrass beds, and important areas of underwater bedrock (Lebigre and Marius 1984; Van de Weghe 2005). In Akanda, mangroves cover the vast majority of the surface of the coastal banks, nevertheless, some intertidal mud banks may also act as nursery area.

The ANP climate is equatorial in transition type characterized by four seasons including a long rainy season (LRS) from April to June, a long dry season (LDS) from July to September, a short rainy season (SRS) from October to December and a short dry season (SDS) from January to March. Inter-annual rainfall, vary between 2000 and 3800 mm, the number of rainy days ranges between 170 and 200 per year. The average annual temperature varies from 25 to 26°C. The bay is protected from trade winds and swell by the Cap Esterias peninsula (Clist 1995; Van de Weghe 2005). Akanda is subject to a microtidal regime as the maximum tidal range is about 2 m. Hydrologically, Mondah Bay is of a marine nature due to the small amount of fresh water received from its tributaries, the average of all flows being estimated at between 70 and 80 $m^3.s^{-1}$. The bathymetry of Mondah Bay results in two distinct areas: the offshore area where the waters are clear and warm and depths ranging from 1 to 21 m, with abundant benthic rocky habitats and sand beds; and the coastal area, strongly influenced by the presence of large mudflats and where bathymetry does not exceed 10 m with very turbid waters. The surface water temperature is relatively high in the range of 25-30°C (Lebigre and Marius 1984). The dominant mangrove tree species in ANP are *Avicennia nitida*, *Rhizophora harrisonii* and *Rhizophora racemosa* (Lebigre 1983; 1990). Recognized as an internationally important site for birds and marine turtles, Akanda National Park has been designated a Ramsar site since 2007.

II.2. Sampling strategy

Based on their distance to Libreville, their relative distance from each other and their spatial coverage of the study area, four sampling sites located within the mangroves have been selected: Moka, Massotié, Babilone and Bambouchine (Fig 1). Within each site, three representative stations have been seasonally sampled (May 2017 (LRS), September 2017 (LDS), November 2017 (SRS) and March 2018 (SDS)).

Ichthyofauna was collected with 15 m long and 1.10 m high trammel gillnets. Each net consists of three uneven mesh netting layers (two 100 mm large mesh outer layers and one 10, 27 or 40 mm small mesh loose inner layer) made of green polyamide nylon. In order to obtain a representative sample and minimize net selectivity bias at each station, three trammel nets (10, 27 and 40 mm mesh size respectively) connected to each other were deployed. In total, three lines of three trammel nets were deployed each time within the mangrove at each sampling site during each season. The nets are set at 17h00 and visited at 7h00. the next day for night fishing. They are again visited at 16h00. for daytime fishing and lifted at 7h00 the next day, i.e. a fishing effort of about 38 hours. After each fishing session, all the individuals caught were determined to the lowest possible taxonomic level using identification keys (Stiassny et al. 2007; Carpenter 2016; Carpenter and de Angelis 2016). All fish caught were counted and the total length (TL), standard length (SL) and total weight were measured. Temperature, pH, salinity, conductivity and dissolved oxygen have been measured in the water surface with a multiparameter HANNA Hi 9828 probe.

II.3 Fish assemblages

The estuarine use functional group classification proposed by Elliott et al. (2007) and refined by Potter et al. (2015) was employed to describe the composition of the fish assemblages. This classification based on fish species defines four main categories: marine, estuarine, diadromous and freshwater divided in guilds that represent characteristics associated to the locations of spawning, feeding and/or refuge utilization. Thus, the marine category gathers Marine Straggler (MS), Marine Estuarine-Opportunist (MMO) and Marine Estuarine-Dependent (MMD), the estuarine category is divided in Estuarine Resident (ER) and Estuarine Migrant (EM), the diadromous category regroups Anadromous (AN), Semi-Anadromous (SA), Catadromous (CA), Semi-Catadromous (SC) and Amphidromous (AM), the freshwater category composed of Freshwater Migrant (FM) and Freshwater Straggler (FS). In order to estimate the occupation of the mangroves of Akanda National Park by exploited species, sampled fishes were classified into three categories of high (HCV), medium (MCV) and no commercial value (NCV) according to local market criteria.

II.4. data analysis

As a preliminary analysis of the fish assemblages, species richness (S), Shannon (H') and Pielou (J) diversity indexes, abundance and biomass were examined by sampling station and season.

The Shannon index (H') was calculated according to the following formula (Pielou 1969):

$$H' = \sum_{i=1}^{S} p_i \times \log_2 p_i$$

Where S is the species richness, i is a species, p_i is the proportion of a species i to the total number of species.

The evenness rate (J) of Pielou, which can range from 0 to 1 was calculated as:

$$J = \frac{H'}{H'max}$$

Where H'max = ln S

To estimate the species richness in the mangrove area of the ANP, the Chao-2 and Boot indices, the Jackknife 1 and 2 indices were calculated using the "vegan" R package (Gotelli and Colwell 2010).

To assess the proportion of juveniles in the fish populations, we assumed that fish smaller than the L_{50} were juveniles. The L_{50} represents the size at which 50% of the individuals in a population are mature and were obtained from the extant scientific literature (Table 4).

When the criteria of normality and homogeneity of variances were met, a one-way ANOVA was performed to compare each diversity indicator (S, H', J) between the 4 seasons and the 4 sites. Due to the non-respect of the normality and/or homogeneity of variances of the abundance, biomass and environmental factors, the non-parametric Kruskal-Wallis test was used to compare the parameters between seasons and sites. For abundance and biomass, the data were transformed into Log(x+1) in order to stabilize the variances that were too high between fishing haul. A Factorial Correspondence Analysis (FCA) was performed to explore spatio-temporal patterns of the fish assemblages. Statistical processing and graphics were made using the "vegan" library for R software (R Core Team, 2022).

Results

III.1. Environmental characteristics

No significant difference for salinity, temperature and dissolved oxygen concentration (expressed as % of saturation) was found between seasons all stations combined (Appendix 1). During the whole sampling survey, salinity ranged from 1.2 in Long Rainy Season in Massotié to 30.5 in Long Dry Season in Moka (Figure 2; Appendix 1). The average salinity was significantly different between sites (Kruskal-Wallis, p-value = 0.029) and lower in Massotié than in the 3 other sampling stations. Water temperature ranged from 20.1°C in Babilone in Short Rainy Season to 31.6°C in Bambouchine in SRS. The average temperature was also significantly different between sites (Kruskal-Wallis, p-value = 0.029) and lower in Babilone. Dissolved oxygen ranged from 11.0% of saturation in Large Rainy Season in Bambouchine to 85.7% in Short Dry Season in Massotié. The average dissolved oxygen percentage was significantly different between sites (Kruskal-Wallis, p-value = 0.00614) (Appendix 1), Massotié having the highest values.

III.2. Description of fish assemblage

Synthetic descriptors: species richness, abundance, biomass

Overall, 1580 individuals belonging to 59 species and 29 families representing a total biomass of 150.17 kg were collected (Table 2). Mugilidae (19.7%) and Sciaenidae (19.4%) were the dominant families in terms of abundance while Sciaenidae and Claroteidae (25.2 and 20.2% respectively) were the main contributors to total biomass. Three species represented 48% of the total number of fishes inventoried: *Pseudotolithus elongatus* (18%), *Pellonula leonensis* (15%) and *Parachelon grandisquamis* (15%). In terms of biomass, three species dominated the assemblage: *P. elongatus* (24%), *Chrysichthys nigrodigitatus* (21%) and *Plectorhinchus macrolepis* (11%). Sciaenidae together with Claroteidae in Massotié (60%) and together with Haemulidae in Moka (59%) dominated the biomass. In Bambouchine, Claroteidae and

Dasyatidae represented 58% of the biomass of the assemblage while in Babilone, Gerreidae, Dasyatidae, and Haemulidae were the main contributor of the fish biomass (60%).

P. grandisquamis (88% of occurrence), *Ilisha africana* (81% of occurrence), *Polydactylus quadrifilis* and *Monodactylus sebae* (75% of occurrence), *P. elongatus* (69% of occurrence), *C. nigrodigitatus* (63% of occurrence) were the most common species in the ANP. *I. africana*, *M. sebae* and *Eucinostomus melanopterus* were the most abundant in Babilone (51% of the abundance), *P. leonensis* and *E. melanopterus* in Bambouchine (48% of the abundance), *P. elongatus*, *P. grandisquamis* and *P. leonensis* (70% of the abundance) and *P. elongatus*, *I. africana* and *Neochelon falcipinnis* in Moka (60% of the abundance).

The species richness (S) varied according to season from 29 during the LDS and SDS to 37 during the LRS, and according to sampling station from 26 in Babilone to 36 species in Massotié (Table 3). While, the overall fish species richness caught in the ANP is 59, the Boot and Chao-2 indices predicted 67±4 and 88±18 species respectively, and the Jackknife 1 and Jackknife 2 indices predicted 79±7 and 91±5 species respectively. The Shannon and Pielou indexes were not significantly different between seasons and between sites (Kruskal-Wallis, p-value > 0.05; Table 3). No significant differences (Kruskal-Wallis, p-value > 0.05) were found for fish abundance and biomass between seasons or between sampling sites (Table 3).

Structure of the assemblages

The fish assemblage in Akanda National Park is dominated in terms of species richness by 39 marine species (MS, MMO, MMD) accounting for 66% of the total diversity, while estuarine and freshwater fishes species represent 17% (10 species) and 14% (8 species) of the species richness respectively (Table 2). The mean abundances were not significantly different within the 4 seasons (Kruskal-Wallis, p-value = 0.7963) and ranged from 65 individuals in LDS to 168 individuals in LRS (Fig. 3a). Species from marine origin dominated in all seasons from 45 in LDS to 53% in SRS (Fig. 3b). As for seasons, the mean abundance was not significantly different between sites (Kruskal-Wallis, p-value = 0.2859) and ranged from 37.7 in Babilone to 159.2

individuals in Massotié (Fig. 3c). Species from marine origin (MS, MMO and MME) were the most represented in Moka (64% of the abundance), Babilone (75%) and Bambouchine (49%), (Fig. 3d).

The mean fish biomass was not significantly different between seasons (Kruskal-Wallis, p-value = 0.1455) nor between sampling stations (Kruskal-Wallis, p-value = 0.3032).

The factorial correspondence analysis carried out on the faunal table produced a first factorial design explaining 26.4% of the total inertia (14.4% for axis 1 and 12% for axis 2) (Fig. 5a). Projection of the seasons onto the first factorial plan reveals an opposition between the long dry season group and the ones formed by the long rainy season, the short rainy season and the short dry season (Fig. 5c). The projection separates the 4 sampling sites on the basis of low occurrence species (Fig. 5d). The projection of ecological (Fig. 5e) did not indicate opposition on the first two axes. However, during the long dry season, Bambouchine was differentiated by the presence of freshwater stragglers.

Exploited species

The classification of the collected fish species revealed 31 species with high commercial value, 10 of medium commercial value and 18 with no commercial value. The individual sizes (TL) of fish caught in the ANP varied from 4.8 cm (*Monodactylus sebae*) to 110.2 cm (*Fontitrygon margarita*). However, the size spectrum of the species with high commercial value and for which more than 50 individuals were collected (6 species: 53% of the individuals) (Fig. 6) is uni-modal with a mode ranging from 7 to 12 cm accounting for 46% of the individuals. For these 6 species, the proportion of individuals below the L_{50} varied from 21.8% (*Chrysichthys nigrodigitatus*) to 100% (*Polydactylus quadrifilis*) (Table 4). The estuarine species from marine origin and marine estuarine species (*Eucinostomus melanopterus*, *Neochelon falcipinnis*, *Parachelon grandisquamis*, *Polydactylus quadrifilis*, *Pseudotolithus elongatus*) had more than 80% of their population below L50.

Discussion

In the marine realm, biodiversity and associated ecosystem services are threatened by numerous anthropogenic stressors, such as overfishing, pollution, climate change and biological invasions (IPBES 2019). In this context, Marine Protected Areas (MPAs) and Estuarine Protected Areas (EPAs) are promoted as tools to help conserve biodiversity heritage, maintain ecosystem processes, and favor a sustainable exploitation of living resources (Wood et al., 2008; Whitfield et al, 2020).

MPAs are currently among the main promoted strategies to mitigate the rapid loss of marine biodiversity and ecosystem services. While scientists recognize the benefits of MPAs (e.g. biomass increases, spillover, and larval export), only a very small percentage of the ocean is protected by MPAs worldwide (Wood et al. 2008, Grorud-Colvertet al. 2021). The protection of estuarine areas which are necessary ecosystems for the completion of life cycles of many fishes is complementary to MPAs.

The establishment of an efficient Estuarine or Marine Protected Area network requires the validation of three conditions, namely (i) representativeness (all species are represented in the conservation network), (ii) persistence (once established, the conservation network should promote the maintenance of natural processes by excluding all threats) and (iii) complementarity (the selected spatial units do not must be neither similar nor redundant) (Margules and Pressey 2000).

To reach these conditions, Systematic Conservation Planning (SCP) is a widely-used approach to develop efficient networks of protected areas (Margules and Pressey 2000). While huge methodological improvements have been done these last years in SCP that is increasingly being used in both marine and terrestrial ecosystems (Weeks and Jupiter 2013; Alvarez Romero et al. 2018; Chamberlain et al. 2022), there are still poor diversity data areas remaining, particularly in African coastal and estuarine ecosystems, to ensure the representativeness of basic condition.

Species assemblage's description is thus a prerequisite step towards more advanced EPA and MPA planning techniques. This is even more important in African mangroves areas where very little is known about fish assemblages that ensure biomass provision for fisheries (Blaber 2013). By giving insight into spatial and temporal structure of fish assemblages in the mangrove ecosystem of the Akanda National Park estuary in Gabon, this study provides a valuable data for a future efficient management.

Environmental parameters

The study of factors affecting the spatial distribution of species is a central issue in ecology (Wiens 1989). Understanding the determinants of the spatial distribution of species in mangroves is difficult because of the complex and dynamic nature of these ecosystems. This ecosystem complexity is due to multiple factors affecting species-habitat associations, difficulty in sampling, variation in the scales at which determinants operate and high variability of environmental parameters due to river inputs (Johnson et al. 2013).

In the mangrove area of Akanda National Park, the environmental parameters (temperature, salinity and dissolved oxygen) were stable across seasons. Environmental spatial variations were more significant within the ANP reflecting local variabilities within a season. Indeed, salinity was lower in Massotié and higher in Moka, whereas water masses were warmer in Bambouchine and more oxygenated in Massotié. As a whole, ANP mangrove waters were depleted in dissolved oxygen relative to atmospheric saturation, resulting in a moderate hypoxia during most of the survey. Dissolved oxygen levels could partly modulate fish migration in mangroves (Dubuc et al. 2019) and temporally regulate diversity and abundance of fish species. These measurements are consistent with those of Lebigre and Marius (1986) and Leboulanger et al. (2021) who reported homogeneity of salinity in the western part of the bay including Moka station. Indeed, the rivers in this area dry up for the most part during the dry seasons combined with the greater influence of the Atlantic Ocean in this area lead to the highest salinity values. Besides, in the eastern part of the bay, the salinity is much lower due to the strong inflow of fresh water from small rivers, including Massotié.

Fish species richness

In this study, we identified 59 species of fish belonging to 29 families in the mangroves area of the Akanda National Park. Based on our sampling, species richness estimators assess the number of fish species in the range of 67 to 91 for the ANP (i.e., 13 to 54% more species than sampled). An ideal species richness estimator would be unbiased (it neither overestimates nor underestimates species richness), precise, and efficient (Gotelli and Colwell, 2010). Nevertheless, the species richness registered and assessed in our study underestimate the fish species richness reported in the area based on a bibliographic synthesis of grey literature (105 fish species identified in the ANP). More, our study identified 10 additional fish species not previously inventoried in the area, which brings the total fish species richness to 115 in the area (Appendix 3). Among the 56 fish species already recorded in Akanda but not present in our study, 28 were recorded only once and 9 only twice out of the 8 studies synthesized and can be considered as rare. The 19 other species are mostly pelagic species (e.g. *Alectis alexandrina*, *Platybelone argalus*, *Megalops atlanticus*) or freshwater (*Pelmatolapia cabrae*, *Sarotherodon nigripinnis*, *Kribia kribensis*) or marine species (*Orcynopsis unicolor*, *Sphyraena guachancho*) that are difficult to capture with our sampling strategy (Appendix 3).

As the diversity of fish within the estuaries of Gabon and more generally of Central Africa is poorly documented, our study is of particular importance in benchmarking fish species diversity and richness in the region. At the scale of Gabon the fish species richness is high, 1,062 valid species of fishes are registered in Gabonese waters, with 288 of these strictly restricted to freshwaters, 592 strictly restricted to marine environments and 182 species euryhaline species (Fermon et al. 2022). At a local scale, compared to other coastal system of the Gulf of Guinea, the ANP fish species richness is higher than in Sao Tomé island mangroves (20 species, Felix et al. 2017, Cravo et al, 2021), Lake Nokoué (51 species, Benin, Lalèyè et al. 2003), Ogooué estuary (66 species, Gabon, Loubens 1966), Fatala estuary (102 species, Guinea, Baran 1995), Saloum estuary (114 species, Senegal, Diouf 1996) or Lagos lagoon (115 species, Nigeria, Oribhador and Ezenwa 2005) but lower than in Ebrié lagoon (153 species, Ivory Coast, Albaret 1994). At a more global scale, mangrove fish diversity is higher in Indo-West Pacific mangroves as in Embley (197 species, Australia, Blaber et al. 1989) or Vellar Coleroon (195 species, India Krishnamurthy and Jeyaseelam, 1981) than in Gabonese mangrove and at the level of those of West Atlantic as in Ciénaga Grande (114 species, Colombia, Leon and Racedo, 1985) and East Pacific as in Guerrero Lakes (105 species, Mexico, Yáñez-Arancibia, 1978). Biogeography (i.e. geographical location) and connectivity (Blaber, 2013) play an important role in species richness patterns. Tropical and subtropical estuaries have a higher species richness than temperate systems, mainly due to the greater richness of fauna associated with habitats closer to the equator, whether marine or riverine (Whitfield 2005). Other factors, often interdependent, can explain species distribution: the physico-chemical characteristics of the water and their spatio-temporal variations (Albaret 1999; Sosa-Lopez et al. 2007), the trophic richness and the availability of resources (Whitfield 1988), the presence, extent and state (health) of the mangrove (FAO 2007).

Fish assemblage

In ANP, fish species richness was close between the four seasons and between the four sites. The fish assemblage in the mangrove area of ANP was characterized by rare occurrence of freshwater species, and the abundance of species of marine origin (marine stragglers and marine migrants). Marine species represented more than 60% of the overall species richness and from 32% (Massotié) to 74% (Babilone) of the total abundance per site and more than 45% per season. This community composition, dominated by marine species, confirms the marine character of the ANP, which results from its strong link with the marine environment, coupled with the low input of freshwater from the watersheds. Freshwater species were confined to the oligohaline portions as in Massotié.

Parachelon grandisquamis, *Illisha africana*, *Monodactylus sebae* and *Polydactylus quadrifilis* were the most common species (occurrence>80%). These four species associated with the two most abundant species *Pseudotolithus elongatus* and *Pellonula leonensis* constituted the base of the ANP species assemblage. This assemblage is similar to the one described by Loubens (1966) in the mangroves of the Ogooué estuary (Gabon) and by Ecoutin et al. (2005) in the marine-influenced part of the Ebrié lagoon (Côte d'Ivoire). The ANP fish assemblage is directly related to the Scianidae estuary and coastal community assemblage described by Longhurst (1965) in Sierra Leone and the coastal settlement described by Durand (1967) in Congo and is typical of all desalinated coastal areas of Western Central Africa. *Pseudotolithus elongatus*, *Polydactylus quadrifilis* as well as the Mugilidae species are among the most caught species both around the ANP (Mve Beh et al. 2017) and at national level (Belhabib 2015).

Nursery role

Among the most abundant fish in the ANP, *Eucinostomus melanopterus*, *Neochelon falcipinnis*, *Parachelon grandisquamis*, *Polydactylus quadrifilis* and *Pseudotolithus elongatus* were predominantly caught at sizes below sexual maturity. Habitats that host a higher percentage of juveniles are defined as having high nursery value (Beck et al. 2001), confirming the ANP status of a habitat for the juveniles of these exploited fishes. Mangroves are known to benefit coastal resources by supporting the early stages of commercial and non-commercial fauna as fish (Tomlinson 2016). The nursery role of mangroves is mainly due to structural complexity and is driven by the structural uniqueness of mangrove microhabitats (Vorsatz et al. 2021) that provide shelter and protection against predators and availability of food (Laegdsgaard and Johnson 2001). Thus, juvenile fish benefit from these conditions in ANP that provide a favorable and safe environment for their development. However, our study did not cover first juvenile fishes settlement in the mangroves. In order to fully understand the role of the mangroves to various fish species, the study of the smallest sizes among fish assemblage requires a dedicated study, using appropriate sampling equipment.

Conclusion

Based on a systematic approach to conservation planning designed to achieve biodiversity goals while minimizing impacts on ocean resource users, Gabon created in 2017 a network of MPAs aiming at protecting 26% of the Exclusive Economic Zone, and have committed to protect 30% of their waters by 2030 (Metcalfe et al 2021). Nevertheless, filling in the gaps of scientific knowledge related to data-poor areas in order to support MPA management such as in Gabon and low-income countries is a great challenge (Metcalfe et al. 2021). The results of this study are a first step in understanding the fish communities of Akanda National Park, which can complement the management plan and initiate a monitoring program for the park taking into account the customary management by local communities and indigenous and local knowledge (ILK) which is increasingly recognized as an essential tool in ecosystem management (Loch and Riechers 2021). This study demonstrated the nursery role of the ANP for exploited species and the need to preserve it to maintain sustainable fisheries. Nevertheless, the importance of mangroves for all 0+ juveniles should be emphasized, and targeted studies to fill this research gap should be a priority. Moreover, the number of species recorded for this area may still be underestimated. The use of appropriate complementary methods to detect cryptic species (e.g., eDNA and non invasive observation systems) and long-term qualitative studies should allow for greater precision in defining and monitoring fish assemblages, especially in the context of climate change and urban constraints, including pollution, related to the vicinity of Libreville, which have a direct impact on conservation objectives. In addition, studies on other biological groups, such as benthic and pelagic invertebrates combined with trophic modeling, would provide a better understanding of the trophic functioning of the park.

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References

Ajagbe, S.O., Odulate, D.O., Ajagbe, R.O., Ariwoola, O.S., Abdulazeez, F.I., Oyewole, O.O., M.T. Ojubolamo, I.O., Arabambi, I.E. Odiaka, B.O. Fadimu, A.O. Olomola, O.A. Ganiyu, yekan, O.O. 2021. Population dynamics of *Chrysichthys nigrodigitatus* (Lacépède, 1803) in Ikere-gorge, Oyo State, Nigeria. *Ghana Journal of Agricultural Science* 56(1): 79-86.

Albaret, J.-J., 1994. Les poissons: biologie et peuplements. In: Durand J.-R., Dufour P. , Guiral D. , Zabi S.G.F. (eds.) Environnement et ressources aquatiques en Côte d'Ivoire: 2. Les milieux lagunaires, Paris: ORSTOM, p. 239-280

Albaret, J.-J., 1999. Les peuplements des estuaires et des lagunes. In: Lévêque, C. & Paugy, D. (eds.) Les poissons des eaux continentales africaines. Paris: IRD, 325-349.

Alongi, M. 2014. Present state and future of the world's mangrove forests present state and future of the world's mangrove forests. *Environmental Conservation* 29(3): 20. https://doi.org/10.1017/S0376892902000231.

Álvarez-Romero, J.G., Mills, M., Adams, V.M., Gurney, G.G., Pressey, R.L., Weeks, R., Ban, N.C., Cheok, J., Davies, T.E., Day, J.C., Hamel, M.A., Leslie, H.M., Magris, R.A., Storlie, C.J. 2018. Research advances and gaps in marine planning: towards a global database in systematic conservation planning. *Biological Conservation* 227: 369–382. https://doi:10.1016/j.biocon.2018.06.027.

Baba, S., Chan, H.T., Aksornkoae, S. 2013. Useful products from mangrove and other coastal plants. Edited by ISME Mangrove Educational Book Series No. 3. the International Society for Mangrove Ecosystems (ISME), Okinawa, Japan, and the International Tropical Timber Organization (ITTO), Yokohama, Japan. http://www.mangroverestoration.com/pdfs/Baba Chan and Aksornkoae educational-series.book3.pdf.

Baran, E. 1995. Dynamique spatio-temporelle des peuplements de poissons estuariens en Guinée: Relations avec le milieu abiotique. PhD Thesis, Université de Bretagne Occidentale, Brest. 236p. http://horiz on.docum entat ion.ird.fr/exl-doc/pleins_texte s/pleins_textes_6/TDM/42826.pdf

Beck, M.W., Heck K.L, Able K.W, Childers D.L., Eggleston D.B., Gillanders B.M., Halpern B., et al. 2001. The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates. *BioScience* 51(8): 633. https://doi.org/10.1641/0006-3568(2001)051[0633:ticamo]2.0.co;2.

Belhabib, D. 2015. Gabon fisheries between 1950 and 2010: a catch reconstructing, 11. This working paper is made available by the Fisheries Centre, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada.

Benzeev, R. Hutchinson N., Friess D.A. 2017. Quantifying fisheries ecosystem services of mangroves and tropical artificial urban shorelines. *Hydrobiologia* 803(1): 225–237.

Blaber, S.J.M. 2013. Fishes and fisheries in tropical estuaries: The last 10 years. *Estuarine, Coastal and Shelf Science* 135: 57-65. https://doi.org/10.1016/j.ecss.2012.11.002.

Blaber, S.J.M., Brewer D.T., Salini J.P. 1989. Species composition and biomasses of fishes in different habitats of a tropical northern Australian estuary: their occurrence in the adjoining sea and estuarine dependence. *Estuarine Coastal and Shelf Science* 29: 509–531. https://doi.org/10.1016/0272-7714(89)90008-5

Cardiec, F. 2021. Pêche artisanale maritime au Gabon : fonctionnement, spatialisation et aires marines protégées. PhD Thesis. Université de Bretagne Occidentale. 231 p. https://www.theses.fr/2021BRES0013

Capenter, K.E., de Angelis N., 2016. The living marine resources of the Eastern Central Atlantic. FAO species identification guide for fishery purposes 3(1): 1-859.

Carpenter, K.E. 2002. The living marine resources of the Western Central Atlantic FAO species identification guide for fishery purposes. 1: 1375–2127. https://doi.org/10.1021/cb400140u.

Carrasquilla-Henao, M., Juanes F. 2017. Mangroves enhance local fisheries catches: a global meta-analysis. *Fish and Fisheries* 18(1): 79–93. https://doi.org/10.1111/faf.12168.

Carrasquilla-Henao, M., Ban, N., Rueda, M., Juanes F. 2019. The mangrove-fishery relationship:

a local ecological knowledge perspective. *Marine Policy* 108: 103656. https://doi.org/10.1016/j.marpol.2019.103656.

Chamberlain, D.A., Possingham, H.P., Phinn, S.R. 2022. Decision-making with ecological process for coastal and marine planning: current literature and future directions. *Aquatic Ecology* 56(1): 1–19. https://doi:10.1007/s10452-021-09896-9.

Cheung, W.W.L., Jones, M.C., Reygondeau, G., Stock, C.A., Lam, V.W.Y., Frölicher, T.L., 2016. Structural uncertainty in projecting global fisheries catches under climate change, *Ecological Modelling* 325: 57-66. https://doi.org/10.1016/j.ecolmodel.2015.12.018.

Clist, B., 1995. Gabon, 100 000 ans d'histoire. Edited by Centre Culturel Français de Libreville, Gabon. 380 p.

Costanza, R., d'Arge R., de Groot R., Farber S., Grasso M., Hannon B., Limburg K., et al. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387 (6630): 253–60. https://doi.org/10.1038/387253a0.

Cravo, M., Almeida, A.J., Lima, H., Azevedo e Silva, J., Bandeira, S., Machava-António, V., Paula, J. 2021. Fish assemblages in a small mangrove system on Príncipe Island, Gulf of Guinea. *Frontiers in Marine Science* 8:721692. https://doi.org/10.3389/fmars.2021.721692

Diouf, P.S. 1996. Les peuplements de poissons des milieux estuariens de l'Afrique de l'Ouest: l'exemple de l'estuaire hyperhalin du Sine-Saloum. Thèse de Doctorat 3ème Cycle, Université de Montpellier II, p. 267. http://www.bondy.ird.fr/pleins_textes/pleins_textes_7/TDM_7/010008130.pdf

Djadji, E.L.G., Sylla, S., Zan-Bi, T.T., Atse, B.C. 2018. Reproductive biology of the mullet *Liza falcipinnis* (Valenciennes, 1836) in two african complexs lagoons (Ebrié and Grand-Llahou) (Côte d'Ivoire). *International Journal of Research – Granthaalayah* 6(5): 114-127.

Dubuc, A., Baker, R., Marchand, C., Waltham, N. J., Sheaves, M. 2019. Hypoxia in mangroves: occurrence and impact on valuable tropical fish habitat. *Biogeosciences* 16: 3959–3976, https://doi.org/10.5194/bg-16-3959-2019

Durand, J.-R. 1967. Etude des poissons benthiques du plateau continental congolais : troisième partie : étude de la répartition, de l'abondance et des variations saisonnières. *Cahiers ORSTOM Série Océanographie* 2: 3-68.

Ecoutin, J.-M., Richard, E., Simier, M., Albaret, J.-J. 2005. Spatial versus temporal patterns in fish assemblages of a tropical estuarine coastal lake: The Ebrié Lagoon (Ivory Coast). *Estuarine, Coastal and Shelf Science* 64(4): 623-635. https://doi.org/10.1016/j.ecss.2005.04.002.

Egombengani, L.B. 2011. Dynamique des changements dans l'activité de la pêche au Gabon de 1900 à nos jours. PhD Thesis. Université Victor Segalen Bordeaux 2. 425 p. https://www.theses.fr/2011BOR21897/document

Elliott, M. Whitfield, A.K., Potter, I.C., Blaber, J.M., Cyrus, D.P., Nordlie, F.G., Harrison, T.D. 2007. The guild approach to categorizing estuarine fish assemblages: a global review. *Fish and Fisheries* 8: 241-268

FAO 2007. The world's mangroves 1980-2005. FAO forestry paper 153, 89. Rome: FAO.

FAO 2020. The state of world fisheries and aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en

Faunce, C.H., Serafy, J.E. 2006. Mangroves as fish habitat : 50 years of field studies. *Marine Ecology Progress Series* 318: 1–18.

Félix, P.M., Chainho, P., Lima, R.F., Costa, J.L., Almeida, A.J., Domingos, I., Brito, A.C. 2017. Mangrove fish of São Tomé Island (Gulf of Guinea): new occurrences and habitat usage. *Marine and Freshwater Research* 68(1): 123–30. https://doi.org/10.1071/MF15392.

Fermon Y., Bailly N., Cardiec F., Causse R., Chartrain E., et al. 2022. An annotated checklist of the fishes of Gabon. *Cybium* 46(2-3): 69-317. https://doi.org/10.26028/cybium/2022-462-3-001

Gotelli, N.J., Colwell, R.K. 2010. Chapter 4: Estimating species richness. In biological diversity: frontiers in measurement and assessment. Edited by A.E. Magurran and B.J. McGill.

Oxford University Press, Oxford, U.K. pp. 39–54.

Green, A., Smith, S., Lipsett-Moore, G., Groves, C., Peterson, N., Sheppard, S., . . . Bualia, L. (2009). Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea. *Oryx* 43(4): 488-498. https://doi.org/10.1017/S0030605309990342

Grorud-Colvertet, K., Sullivan-Stack, J., Roberts, C., Constant, V., Horta e Costa, B. et al., 2021. The MPA Guide: A framework to achieveglobal goals for the ocean. *Science* 373, eabf0861

IPBES, 2019. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages. https://doi.org/10.5281/zenodo.3831673

Johnson, A.F., Jenkins, S.R., Hiddink, J.G., Hinz, H. 2013. Linking temperate demersal fish species to habitat: scales, patterns and future directions. *Fish and Fisheries* 14: 256–280.

Kimirei, I.A., Nagelkerken, I, Mgaya, Y.D., Huijbers, C.M. 2013. The mangrove nursery paradigm revisited: otolith stable isotopes support nursery-to-reef movements by Indo-Pacific fishes. *PLoS ONE* 8 (6). https://doi.org/10.1371/journal.pone.0066320.

Konan, K.S., Djadji, E.L.G., Amon, Y.N., N'da, K. 2019. Determination of the sexual maturity of Threadfins *Polydactylus quadrifilis* (Cuvier, 1829), *Galeoides decadactylus* (Bloch, 1795) and *Pentanemus quinquarius* (Linné, 1758) of the artisanal marine fishery of Grand-Lahou (Ivory Coast). *Journal of Scientific Research & Reports* 23(1): 1-9. https://doi: 10.9734/JSRR/2019/v23i130112.

Krishnamurthy, K., Jeyaseelan. M.J. 1981. Early life history of fishes from Pichavaram mangrove ecosystem of India. R*apports et Procès Verbaux des Réunions*, *Conseil Permanent International pour l'exploration de la Mer* 178: 416–423.

Laegdsgaard, P., Johnson, C. 2001. Why do juvenile fish utilise mangrove habitats? *Journal of Experimental Marine Biology and Ecology* 257 (2): 229–53. https://doi.org/10.1016/S0022-0981(00)00331-2.

Lalèyè, P., Niyonkuru, C., Moreau, J., Teugels, G.G. 2003. Spatial and seasonal distribution of the ichthyofauna of Lake Nokoué, Bénin, west Africa. *African Journal of Aquatic Science* 28(2): 151-161, DOI: 10.2989/16085910309503779

Lebigre, J.-M., 1983. Les mangroves des rias du littoral gabonais, essai de cartographie typologique. *Revue des Bois et Fôret des Tropiques* 199: 3–27.

Lebigre, J.-M., 1990. Les marais maritimes du Gabon et de Madagascar, contribution géographique à l'étude d'un milieu naturel tropical. State doctoral thesis, Bordeaux University 3, 703 p.

Lebigre, J.-M., Marius, C. 1984. Etude d'une séquence mangrove-tanne en milieu équatorial, Baie de la Mondah (Gabon). *Travaux et Documents de Géographie Tropicale* 51: 131-146.

Lebigre, J.-M., Marius, C., 1986. Etude phytopédologique des Mangroves et tannes de la Mondah (Gabon). *Etudes de Géographie Tropicale. Série Géographie Physique* 6: 1-44.

Leboulanger, C., Kolanou Biluka, L., Nzigou, A.-R., Djuidje Kenmogne, V., Happi, J.L.M., Ngohang, F.E., Eleng, A.S., Ondo Zue Abaga, N., Bouvy, M. 2021. Urban inputs of fecal bacteria to the coastal zone of Libreville, Gabon, Central Western Africa. *Marine Pollution Bulletin* 168: 112478. https://doi:10.1016/j.marpolbul.2021.112478.

León, R.A., Racedo. J.B. 1985. Composition of fish communities in the lagoon and estuarine complex of Cartagena Bay, Ciénaga de Tesca and Ciénaga Grande de Santa Marta, Colombian Caribbean. Pages 536–556 in A. Yáñez-Arancibia, ed. Fish community ecology in estuaries and coastal lagoons: towards an ecosystem integration. UNAM Press, Mexico.

Le Loeuff, P., von Cosel, R. 1998. Biodiversity patterns of the marine benthic fauna on the Atlantic coast of tropical Africa in relation to hydroclimatic conditions and paleogeographic events. *Acta Oecologica*, 19: 309-321 https://doi.org/10.1016/S1146-609X(98)80035-0.

Litvin, S.Y., Weinstein, M.P., Sheaves, M. Nagelkerken. I. 2018. What Makes Nearshore Habitats Nurseries for Nekton? An Emerging View of the Nursery Role Hypothesis. *Estuaries and Coasts* 41: 1539–1550 https://doi.org/10.1007/s12237-018-0383-x.

Loch, T.K., Riechers, M. 2021. Integrating indigenous and local knowledge in management and research on coastal ecosystems in the Global South: A literature review. *Ocean & Coastal Management* 212: 105821. https://doi:10.1016/j.ocecoaman.2021.105821.

Longhurst, A.R. 1965. A Survey of the Fish Resources of the Eastern Gulf of Guinea. *ICES Journal of Marine Science* 29(3): 302–334, https://doi.org/10.1093/icesjms/29.3.302

Loubens, G. 1966 Peuplement en poissons des eaux saumâtres et son origine. Paris (France): Faculté des Sciences, 29 p.

Margules, C.R., Pressey, R.L., 2000. Systematic conservation planning. *Nature* 405, 243–253.

McGlade, J.M., Cury, P., Koranteng, K.A., Hardmand-Mountford, N.J., 2002. The Gulf of Guinea large marine ecosystem: environmental forcing and sustainable development of marine ressources. Amsterdam, Elsevier (eds) 428p

MEA. 2005. Ecosystems and Human Well-Being : Wetlands and Water Synthesis. World Resources Institute, Washington, DC. 80p.

Metcalfe, K., White, L., Lee, M. E., Fay, J. M., Abitsi, G., Parnell, R. J., Smith, R. J., Agamboue, P. D., Bayet, J. P., Beh, J. H. M., Bongo, S., Boussamba, F., De Bruyne, G., Cardiec, F., Chartrain, E., Collins, T., Doherty, P. D., Formia, A., Gately, M., Gnandji, M. S., … Godley, B. J. 2021. Fulfilling global marine commitments; lessons learned from Gabon. *Conservation Letters* e12872. https://doi.org/10.1111/conl.12872

Moumaneix, C., Nkombe, R. 2017. Le « Gabon Vert », Pilier de l'émergence ? Exemple du Parc National de La Lopé : ressources, conflits et arrangements . *Bulletin de l'association de Géographes Français* 94(2): 330-352. https://doi.org/10.4000/bagf.1506

Mve Beh, J.-H., Yendze, C., Cardiec F., Mbega, J.-D., Le Loc'h, F. Liwouwou, J.-F. 2017. Les ressources halieutiques du Parc d'Akanda et des pêcheries périphériques. Bibliographic synthesis, Arc Emeraude project. 34 p.

Nagelkerken, I., Blaber, S.J.M., Bouillon, S., Green, P., Haywood, M., Kirton, L.G., Meynecke, J.O. et al. 2008. The habitat function of mangroves for terrestrial and marine fauna: a review. *Aquatic Botany* 89 (2): 155–85. https://doi.org/10.1016/j.aquabot.2007.12.007.

Nieto, K., Melin, F. 2017. Variability of chlorophyll-a concentration in the Gulf of Guinea and its relation to physical oceanographic variables. *Progress in Oceanography* 151: 97-115. http://dx.doi.org/10.1016/j.pocean.2016.11.009

Ona Ona, J. 2019. Gestion durable des ressources halieutiques en Afrique Atlantique Centre-Est : Cameroun-Congo-Gabon : perspective d'une politique de régulation sous-régionale. PhD Thesis, Nantes, 311p. Available from https://www.theses.fr/2019NANT2051

Oribhador, B.J, Ezenwa, B., 2005. Inventory of fisheries and fishes of the Lagos Lagoon, Lagos, Nigeria. *Tropical Freshwater Biology* 14(1): 16-36

Panfili, J., Thior, D., Ecoutin, J.-M., Ndiaye, P., Albaret, J.-J. 2006. Influence of salinity on the size at maturity for fish species reproducing in contrastingWest African estuaries. *Journal of Fish Biology* 69: 95–113

Pielou, E.C. 1969. An introduction to mathematical ecology New York: Interscience Publishers.

Potter, I.C., Tweedley, J.R., Elliott, M., Whitfield, A.K. 2015. The ways in which fish use estuaries: a refinement and expansion of the guild approach. *Fish and Fisheries* 16: 230-239

Pottier, P., Ovono, Z.M., Faure, F.E., Bignoumba, G.-S. 2017. *Les régions littorales du Gabon ; éléments de réflexion pour une planification stratégique du territoire*. Edited by LETG-Nantes Géolittomer (Nantes) & Raponda Walker. LETG-Nantes. Gabon.

R Core Team, 2022. R: a Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL. http://www.Rproject.org

Sheridan, P., Hays, C. 2003. Are mangroves nursery habitat for transient fishes and decapods ? *Wetlands* 23 (2): 449–458.

Sosa-Lopez, A., Mouillot, D., Ramos-Miranda, J., Flores-Hernandez, D., Do Chi, T. 2007. Fish species richness decreases with salinity in tropical coastal lagoons. *Journal of Biogeography* 34:52–61.

Stiassny, M.L.J., Teugels, G.G., Hopkins, C.D. 2007. The Fresh and Brackish Water Fishes of Lower Guinea, West-Central Africa. Volume I (800pp). Paris : IRD Éditions.

Thomas, N., Lucas, R., Bunting, P., Hardy, A., Rosenqvist, A., Simard, M. 2017. Distribution and drivers of global mangrove forest change, 1996–2010. *PLoS ONE* 12(6): e0179302. https://doi.org/10.1371/journal.pone.0179302

Tomlinson, P. 2016. The Botany of Mangroves, 2nd Edn. Cambridge: Cambridge University Press. doi: 10.1017/CBO9781139946575

UNEP. 2014. The importance of mangroves to people: a call to action. van Bochove, J., Sullivan, E., Nakamura, T. United Nations Environment Programme World Conservation Monitoring Centre. Cambridge. 128pp.

Van de Weghe, J.-P., 2005. Les Parcs Nationaux du Gabon. Akanda et Pongara: Plages et mangroves. Gabon Wildlife Conservation Society, Libreville, Gabon. 208 p.

Voituriez, B., Herbland, A. 1982. Comparaison des systèmes productifs de l'Atlantique tropical Est: dômes thermiques, upwelling côtier et upwelling équatorial. *Rapports et Procès-Verbaux des réunions du Conseil International pour l'Exploration de la Mer* 180: 11-130

Vorsatz, L.D., Pattrick, P., Porri, F. 2021. Ecological scaling in mangroves: The role of microhabitats for the distribution of larval assemblages. *Estuarine, Coastal and Shelf Science* 253: 107318. https://doi.org/10.1016/j.ecss.2021.107318

Weeks, R., Jupiter, S.D. 2013. Adaptive comanagement of a marine protected area network in Fiji. *Conservation Biology* 27: 1234-1244. https://doi.org/10.1111/cobi.12153

Whitfield, A.K. 1988. The fish community of the Swartvlei estuary and the influence of food availability on resource utilization. *Estuaries* 11: 160–170. https://doi.org/10.2307/1351968

Whitfield, A.K. 2005. Preliminary documentation and assessment of fish diversity in sub-Saharan African estuaries. *African Journal of Marine Science* 27(1): 307-324, https://doi.org/10.2989/18142320509504089

Whitfield, A.K., Attwood, C.G., Cowley, P.D., Lamberth, S.J., Mann, B.Q., 2020. No-take estuarine-protected areas: The missing armor for the conservation of fishes. *Koedoe* 62(1): a1648. https://doi.org/10.4102/koedoe.v62i1.1648

Wiens, J.A. 1989. Spatial scaling in ecology. *Functional Ecology* 3: 385–397. https://doi.org/10.2307/2389612

Wood, L.J., Fish, L., Laughren, J., Pauly, D. 2008. Assessing progress towards global marine protection targets: shortfalls in information and action. *Oryx* 42: 340-351. https://doi.org/10.1017/S003060530800046X

Worthington, T., Spalding, M. 2018. Mangrove restoration potential: a global map highlighting a critical opportunity. UICN, University of Cambridge, TNC report. 34 p. https://doi.org/10.17863/CAM.39153.

Yáñez-Arancibia, A. 1978. Taxonomy, ecology and structure of fish communities in coastal lagoons with ephemeral inlets on the Pacific coast of Mexico. Instituto de Ciencias del Mar y Limnologia, Universidad Nacional Autónoma de México, Publicaciones Especiales 2: 1–306.

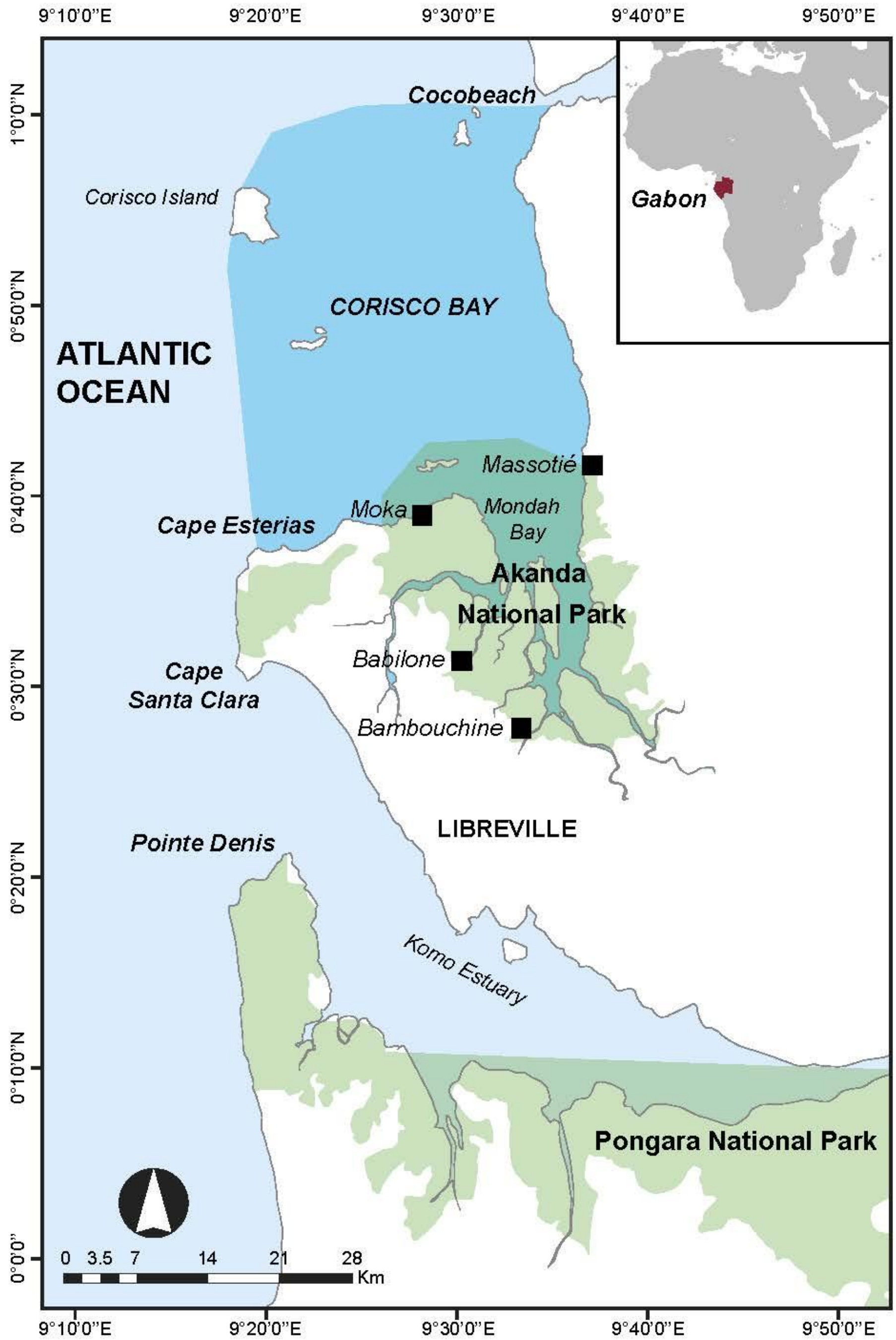

Figure 1: Location of the four sampling sites (Bambouchine, Babilone, Massotié and Moka) in the Mondah bay, in Akanda National Park. The green color corresponds to the national parks.

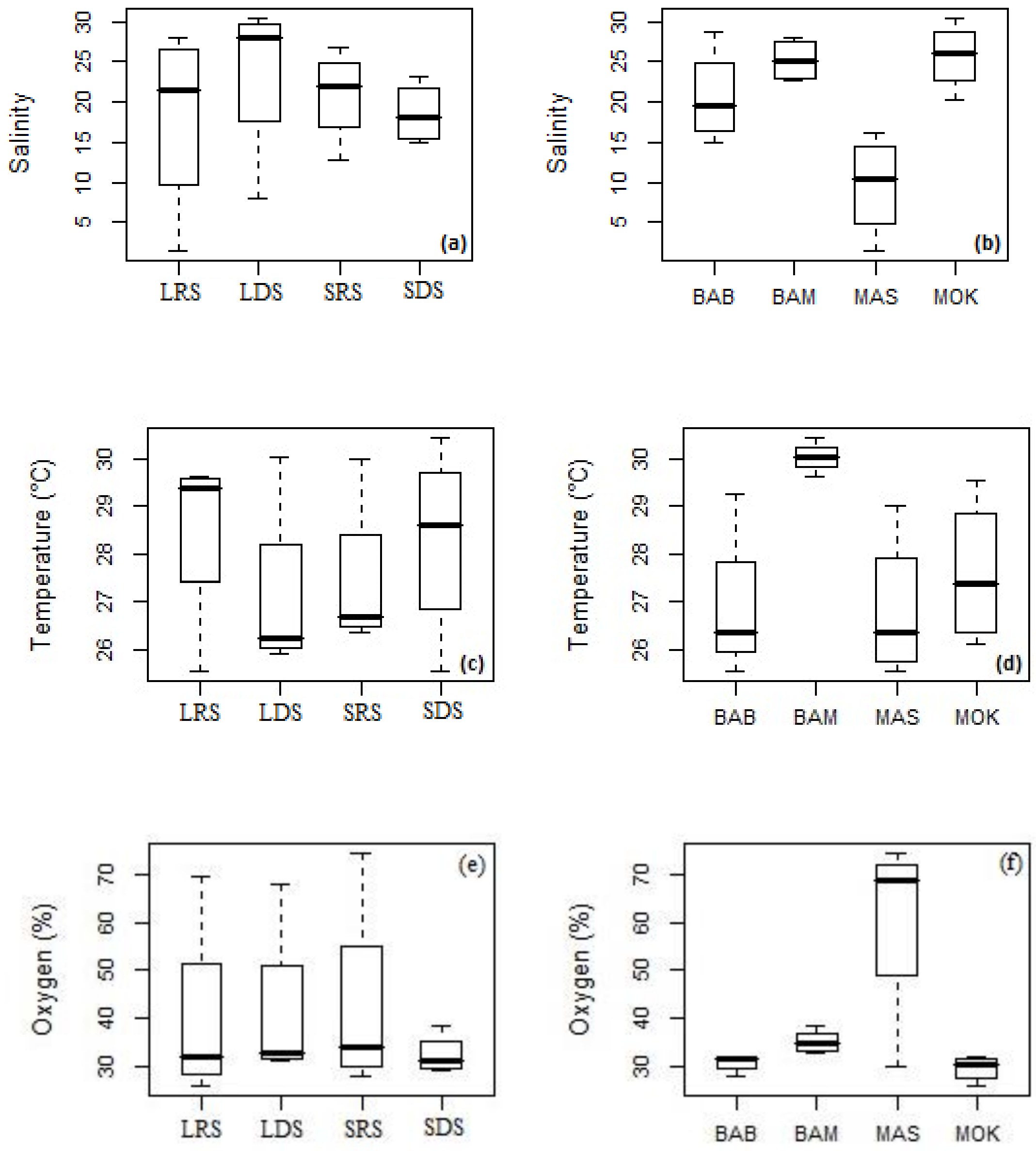

Figure 2: Box plots showing the seasonal (left) and spatial (right) variations in the main environmental parameters. The bottom and top edges of the boxes are located at the sample 25th and 75th percentiles. The center horizontal line is drawn at the 50th percentile (median). The whiskers are drawn, respectively, from the box to the 10th and 90th percentiles. (a), (b): salinity; (c), (d): temperature (°C); (e), (f): dissolved oxygen (% saturation). LRS: long rainy season, LDS: long dry season, SRS: short rainy season, SDS: short dry season (SDS), BAB: Babilone, BAM: Bambouchine, MAS: Massotié, MOK: Moka.

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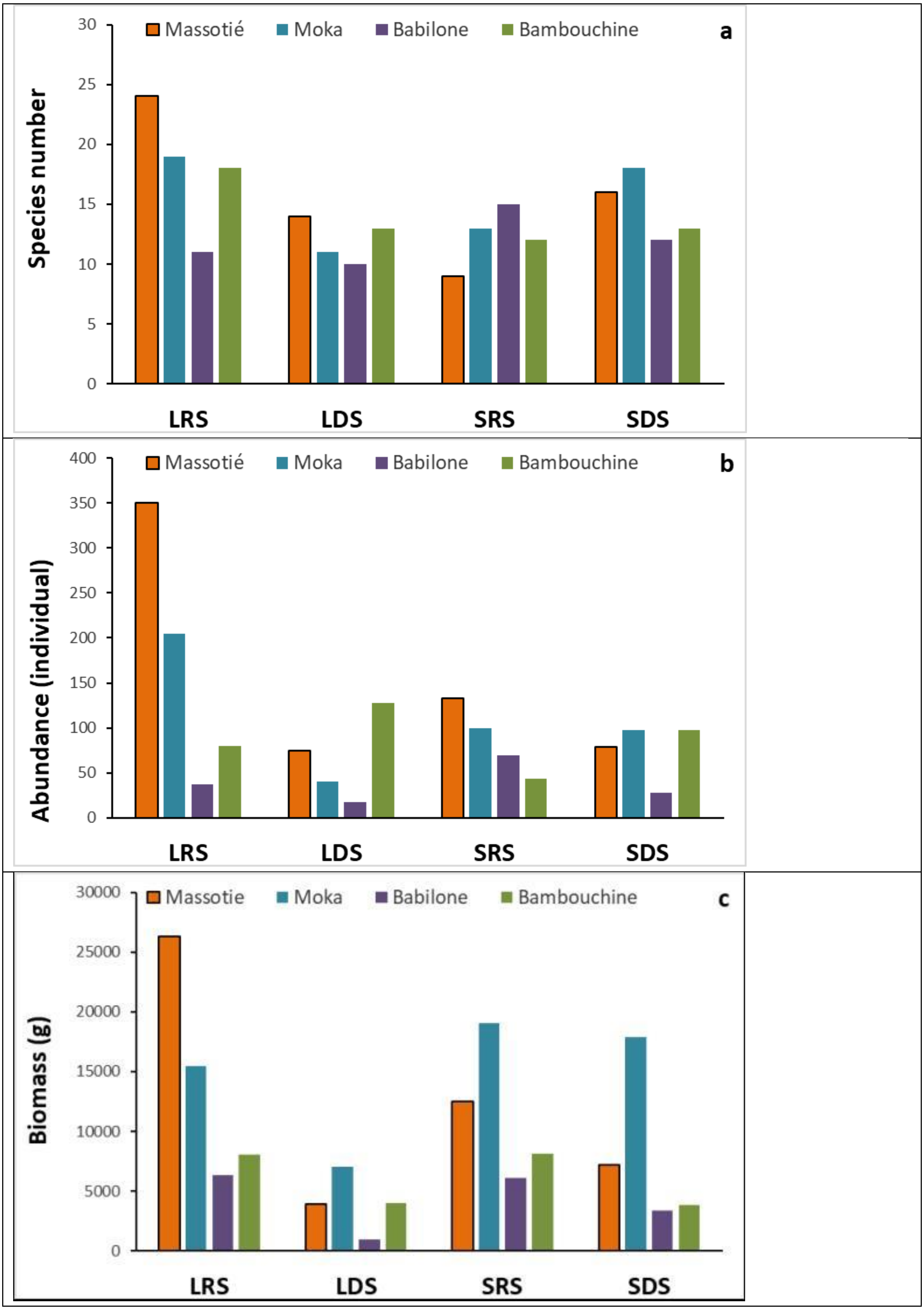
a
Species number
Massotié
Moka
Babilone
Bambouchine
0
5
10
15
20
25
30
LRS
LDS
SRS
SDS
b
Abundance (individual)
0
50
100
150
200
250
300
350
400
c
Biomass (g)
Massotie
0
5000
10000
15000
20000
25000
30000

Figure 3: number of species (a), abundance (b), and biomass (c) in function of hydroclimatic season and sampling areas. LRS: Long Rainy Season, LDS: Long Dry Season, SRS: Short Rainy Season, SDS: Short Dry Season.

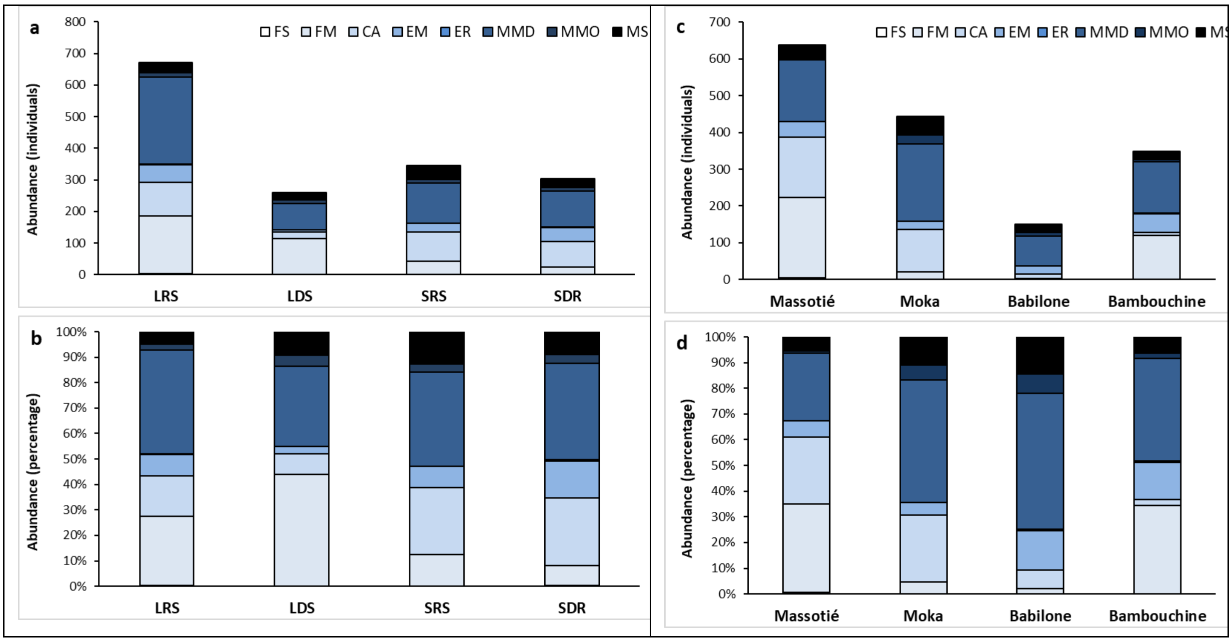

Figure 4: Mean fish abundance by ecological categories by season (absolute (a) and relative (b) abundances) and by sampling station (absolute (c) and relative (d) abundances). LRS: Long Rainy Season, LDS: Long Dry Season, SRS: Short Rainy Season, SDS: Short Dry Season. FS: Freshwater Stragglers, FM: Freshwater Migrants, CA: Catadromous, EM: Estuarine Migrants, ER: Estuarine Residents, MMD: Marine Estuarine-Dependent, MMO: Marine Estuarine-Opportunist, MS: Marine Stragglers.

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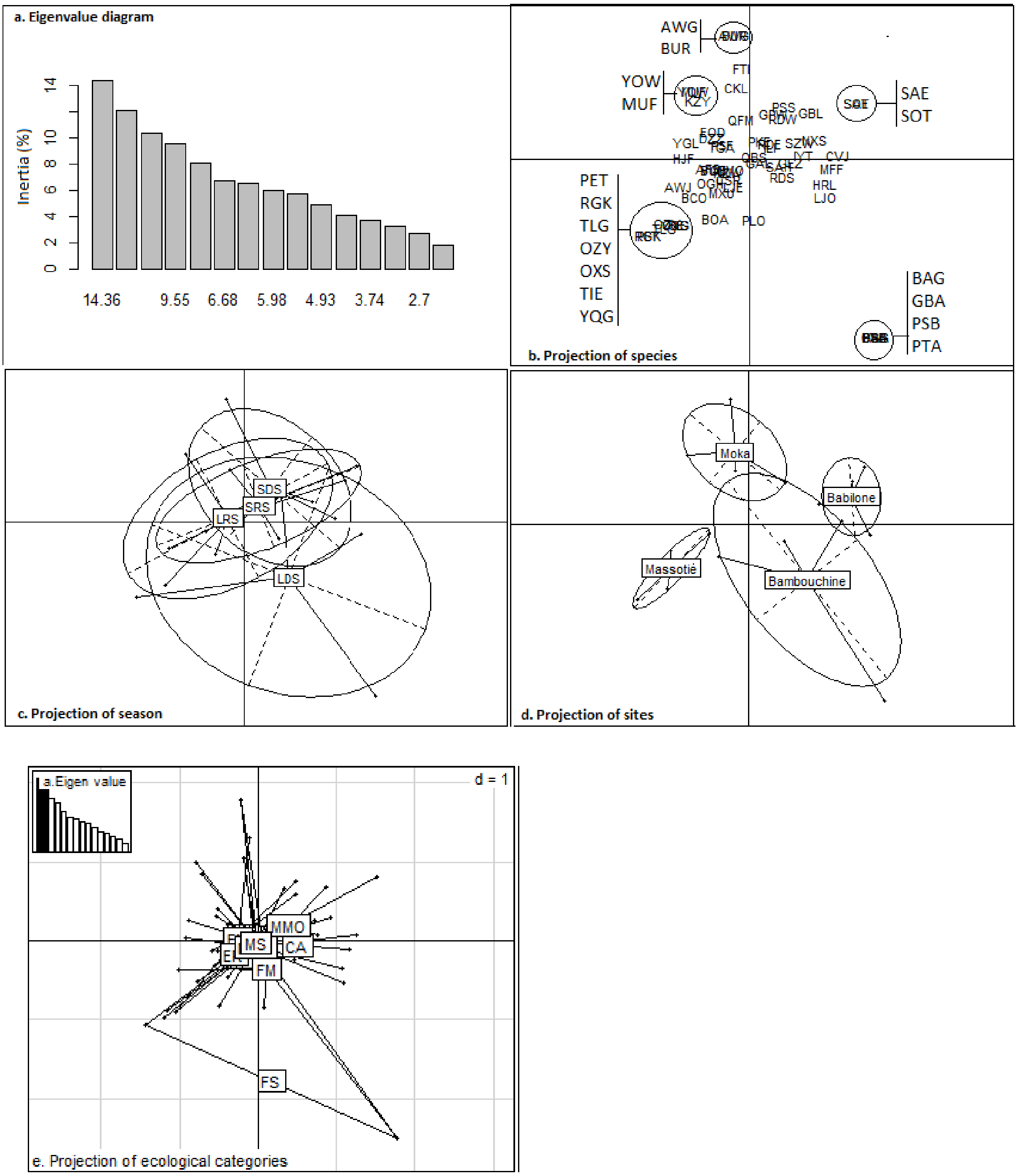

Figure 5: Correspondence analysis on the mangrove area of Akanda National Park on the factorial plane 1-2. a) projection of eigenvalues, b) projection of species (59 species, code see table 2), c) projection of seasons (LRS: long rainy season, LDS: long dry season, SRS: short rainy season, SDS: short dry season), d) projection of sites, e) projection of ecological categories FS: Freshwater Stragglers, FM: Freshwater Migrants, CA: Catadromous, EM: Estuarine

Migrants, ER: Estuarine Residents, MMD: Marine Estuarine-Dependent, MMO: Marine Estuarine-Opportunist, MS: Marine Stragglers.,

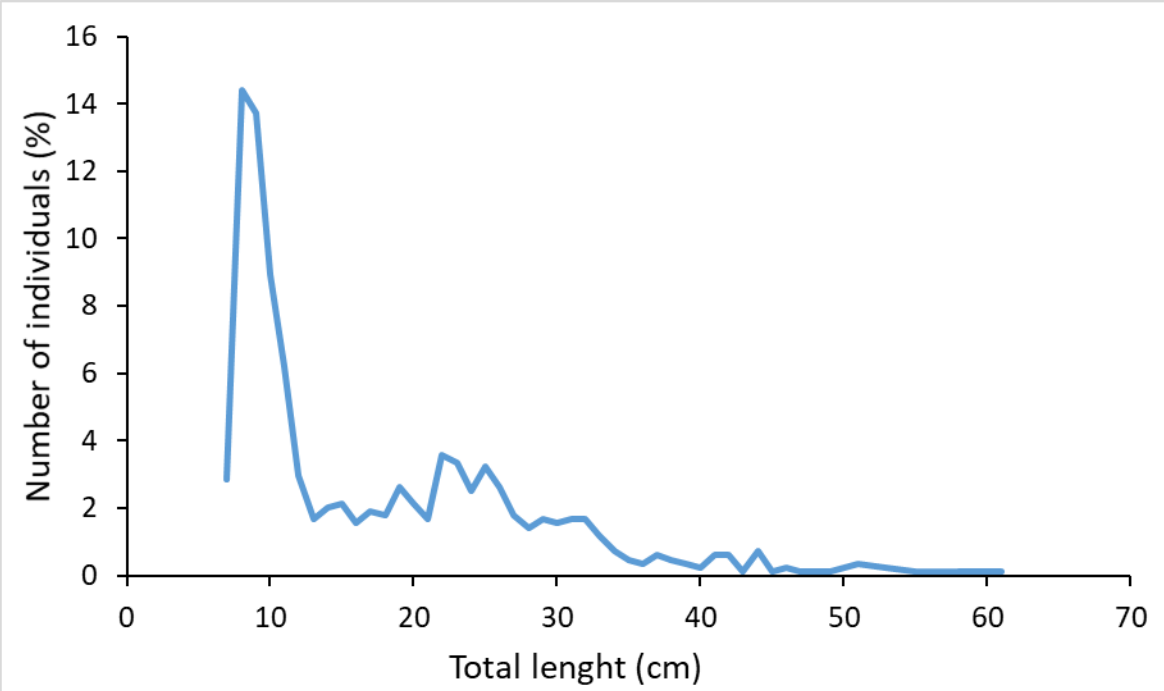

Figure 6*:* Size spectrum (percentage of individuals) of High Commercial Value species with more than 50 individuals (6 species: *Pseudotolithus elongatus*, *Parachelon grandisquamis*, *Eucinostomus melanopterus*, *Chrysichtys nigrodigitatus*, *Neochelon falcipinnis*, *Polydactylus quadrifilis*). N = 839

Table 2: List of the 59 fish species collected in the four sampling stations in Akanda at the four hydrological seasons from May 2017 to March 2018, sorted by decreasing abundance, family, FAO species code, ecological category (Ecolo), percentage of occurrence, abundance and percentage of abundance, biomass and percentage of biomass.

FS: Freshwater Stragglers, FM: Freshwater Migrants, CA: Catadromous, EM: Estuarine Migrants, ER: Estuarine Residents, MMD: Marine Estuarine-Dependent, MMO: Marine Estuarine-Opportunist, MS: Marine Stragglers.

Species	Family	Code	Ecolo		O (%)	A	A (%)	B	B (%)
Pseudotolithus elongatus	Sciaenidae	AFS	CA		69	289	18.29	36276	24.16
Pellonula leonensis	Clupeidae	PLO	FM		56	243	15.38	1777	1.18
Parachelon grandisquamis	Mugilidae	KZW	MMD		88	231	14.62	4840	3.22
Ilisha africana	Pristigasteridae	ILI	MMD		81	149	9.43	6001	4.00
Eucinostomus melanopterus	Gerreidae	MFF	MMD		50	97	6.14	5125	3.41
Chrysyscthys nigrodigitatus	Claroteidae	CSR	FM		63	87	5.51	31798	21.17
Neochelon falcipinnis	Mugilidae	KZY	MMD		25	78	4.94	637	0.42
Monodactylus sebae	Monodactylidae	QBS	EM		75	66	4.18	2490	1.66
Polydactylus quadrifilis	Polynemidae	TGA	MS		75	57	3.61	10148	6.76
Pellonula vorax	Clupeidae	OZY	FM		19	26	1.65	231	0.15
Sarotherodon melanotheron	Cichlidae	SAH	EM		19	22	1.39	927	0.62
Plectorhinchus macrolepis	Haemulidae	GBL	MMD		50	21	1.33	15874	10.57
Epinephelus aeneus	Serranidae	GPW	MMO		50	17	1.08	877	0.58
Pomadasys perotaei	Haemulidae	PKE	MMO		38	16	1.01	766	0.51
Porogobius schlegelii	Gobiidae	OGH	EM		38	14	0.89	104	0.07
Chaetodipterus lippei	Ephippidae	HRL	MS		38	13	0.82	828	0.55
Pseudotolithus senegalensis	Sciaenidae	PSS	MS		31	11	0.70	536	0.36
Ethmalosa fimbriata	Clupeidae	BOA	CA		31	10	0.63	208	0.14
Galeoides decadactylus	Polynemidae	GAL	MMO		38	9	0.57	466	0.31
Aplocheilichthys spilauchen	Poeciliidae	AFS	EM		25	8	0.51	34	0.02
Eleotris daganensis	Eleotridae	EOD	EM		19	8	0.51	393	0.26
Periophthalmus barbarus	Gobiidae	FTI	EM		19	8	0.51	76	0.05
Citharichthys stampflii	Paralichthyidae	IYT	MMD		31	7	0.44	55	0.04
Fontitrygon margaritella	Dasyatidae	RDE	MMD		31	7	0.44	8158	5.43
Lutjanus goreensis	Lutjanidae	LJO	MS		31	7	0.44	1865	1.24
Pseudotolithus senegallus	Sciaenidae	CKL	MS		13	6	0.38	1038	0.69
Lutjanus dentatus	Lutjanidae	LJE	MS		19	5	0.32	697	0.46
Nematogobius maindroni	Gobiidae	NMO	EM		25	5	0.32	29	0.02
Strongylura senegalensis	Belonidae	SZW	MS		19	5	0.32	220	0.15
Hemichromis elongatus	Cichlidae	HJF	FM		13	4	0.25	20	0.01
Lutjanus endecacanthus	Lutjanidae	QFM	MS		19	4	0.25	1447	0.96
Pomadasys jubelini	Haemulidae	BUR	MMO		6	4	0.25	796	0.53
Coptodon guineensis	Cichlidae	TLG	EM		13	3	0.19	225	0.15
Eleotris senegalensis	Eleotridae	DZZ	EM		19	3	0.19	22	0.01

Gerres nigri	Gerreidae	GEZ	ER		19	3	0.19	63	0.04
Mugil cephalus	Mugilidae	MUF	MS		6	3	0.19	21	0.01
Odaxothrissa ansorgii	Clupeidae	OXS	FS		6	3	0.19	39	0.03
Syacium guineensis	Paralichthyidae	YGL	MS		13	3	0.19	17	0.01
Bryconalestes longipinnis	Alestidae	BCO	FM		13	2	0.13	18	0.01
Caranx hippos	Carangidae	CVJ	MS		13	2	0.13	181	0.12
Carlarius parkii	Ariidae	AWJ	MMD		6	2	0.13	450	0.30
Cynoglossus senegalensis	Cynoglossidae	YOE	MMD		6	2	0.13	324	0.22
Fontitrygon margarita	Dasyatidae	RDS	MMD		13	2	0.13	2708	1.80
Sardinella maderensis	Clupeidae	SAE	MMO		6	2	0.13	18	0.01
Sphyraena afra	Sphyraenidae	BAG	MS		6	2	0.13	969	0.65
Arnoglossus capensis	Bothidae	RGK	MS		6	1	0.06	4	0.00
Caranx senegallus	Carangidae	NXS	MS		6	1	0.06	102	0.07
Cynoglossus browni	Cynoglossidae	YOW	MMD		6	1	0.06	137	0.09
Cynoglossus monodi	Cynoglossidae	YQG	MS		6	1	0.06	39	0.03
Enteromius holotaenia	Cyprinidae	BUO	FS		6	1	0.06	5	0.00
Fontitrygon ukpam	Dasyatidae	RDW	FM		6	1	0.06	2060	1.37
Gymnothorax afer	Muraenidae	AWG	MS		6	1	0.06	1310	0.87
Myrichthys pardalis	Ophichthidae	MXU	MS		6	1	0.06	284	0.19
Pentanemus quinquarius	Polynemidae	PET	MS		6	1	0.06	5	0.00
Platybelone argalus	Belonidae	PTA	MS		6	1	0.06	37	0.02
Psettodes belcheri	Psettodidae	SOT	MS		6	1	0.06	145	0.10
Psettodes bennettii	Psettodidae	PSB	MS		6	1	0.06	273	0.18
Sphyraena barracuda	Sphyraenidae	GBA	MS		6	1	0.06	380	0.25
Trachinotus teraia	Carangidae	TIE	MMD		6	1	0.06	5600	3.73

Table 3: Total fish species richness (S), mean fish species richness (Mean S), mean Shannon diversity index (mean H'), mean equitability index (mean J), mean abundance (Mean A) and mean biomass (Mean B) by season and site. Differences were tested with a one factor ANOVA tests (LRS = Long Rainy Season; GSS = Long Dry Season; SDS = Short Rainy Season; SDS = Short Dry Season).

Standard deviations are presented between brackets

	Season				**Site**			
	LRS	**LDS**	**SDS**	**SRS**	**MAS**	**MOK**	**BAB**	**BAM**
S	37	29	29	35	26	31	36	33
Mean S	19.00 (5.35)	13.00 (1.83)	13.25 (2.50)	15.75 (2.75)	16.75 (6.24)	16.25 (3.86)	13.00 (2.16)	15.00 (2.71)
ANOVA test	p = 0.091, F = 2.720, Df = 3				p = 0.582, F = 0.678, Df = 3			
Mean H'	2.037 (0.247)	1.812 (0.450)	1.965 (0.330)	1.951 (0.391)	1.851 (0.271)	2.037 (0.068)	2.075 (0.171)	1.803 (0.617)
ANOVA test	p = 0.846, F = 0.270, Df = 3				p = 0.846, F = 0.592, Df = 3			
Mean J	0.719 (0.096)	0.739 (0.216)	0.786 (0.096)	0.729 (0.149)	0.688 (0.060)	0.761 (0.092)	0.841 (0.091)	0.683 (0.220)
ANOVA test	p = 0.919, F = 0.164, Df = 3				p = 0.326, F = 1.280, Df = 3			
Mean A	168.00 (140.71)	65.00 (48.30)	86.25 (38.91)	73.75 (33.07)	159.25 (129.89)	110.75 (68.72)	37.75 (22.38)	87.25 (35.53)
chi-squared test	chi-squared = 5.393, df = 3 p-value = 0.145				chi-squared = 6.833, df = 3 p-value = 0.077			
Mean B	14.04 (9.08)	3.96 (2.50)	11.44 (5.70)	8.08 (6.72)	12.47 (9.88)	14.84 (5.40)	4.20 (2.56)	6.01 (2.41)
chi-squared test	chi-squared = 4.855, df = 3 p-value = 0.182				chi-squared = 2.103, df = 3 p-value = 0.551			

Table 4: Number of individuals, minimum and maximum total lengths, size at sexual maturity (L50) and proportion of individuals below L_{50} for the 6 high commercial value species with numbers above 50 individuals. * As no L_{50} was available for *Eucinostomus melanopterus* we approximate its L_{50} based on another gerreidae *Gerres nigri*.

Species	Number of individuals	Minimal total lenght (cm)	Maximal total lenght (cm)	L_{50}* (cm) reference	Lt < L50 (%)
Chrysichtys nigrodigitatus	87	8	62	33.4 Ajagbe et al., 2021	**57.5**
*Eucinostomus melanopterus**	97	7	13	12.1 Panfili et al 2006	**99.0**
Neochelon falcipinnis	78	8	25	27.9 Djiadji et al 2006	**100**
Parachelon grandisquamis	231	8	32	25.1 Panfili et al 2006	**98.7**
Polydactylus quadrifilis	57	12	49	67.5 Konan et al 2019	**100.0**
Pseudotolithus elongatus	289	8	53	23.8 Panfili et al 2006	**91.0**

APPENDIX

Appendix 1: Mean value, standard deviation (SD) and range are given for surface temperature (°C) and dissolved oxygen (%) in the four sampling sites of Akanda National Parc for 2017-2018 (LRS: Long Rainy Season, LDS: Long Dry Season, SDS: Short Dry Season, SRS: Short Rainy Season)

		Season				Site			
		LRS	**LDS**	**SDS**	**SRS**	**Babilone**	**Bambouchine**	**Massotié**	**Moka**
Salinity	Mean (±SD)	18.9 (±10.2)	23.7 (±9.1)	21.0 (±5.2)	18.5 (±3.5)	20.5 (±5.1)	25.3 (±2.8)	9.5 (±5.8)	25.6 (±3.8)
	Range	1.2-28.8	5.6-30.5	10.8-26.8	14.4-24.8	14.4-28.7	19.5-28.8	1.2-17.3	19.6-30.5
	chi-squared test	chi-squared = 2.3824, df = 3, p-value = 0.4969				chi-squared = 9.0221, df = 3, **p-value = 0.029**			
Temperature (°C)	Mean (±SD)	28.5 (±1.6)	27.2 (±1.8)	27.5 (±1.7)	28.2(±2.8)	27.0 (±2.4)	29.8 (±0.9)	26.8 (±1.5)	27.6 (±1.4)
	Range	25.2-29.9	25.6-30.6	28.5-30.6	20.2-31.5	20.2-29.5	28.5-31.5	25.2-29.8	26.1-29.7
	chi-squared test	chi-squared = 0.61765, df = 3, p-value = 0.8924				chi-squared = 9.0662, df = 3**, p-value = 0.02842**			
Oxygen (%)	Mean (±SD)	37.2 (±19.8)	39.5 (±18.5)	41.0 (±20.4)	32.2 (±10.9)	30.0 (±7.7)	32.5 (±14.1)	60.4 (±19.6)	29.4 (±3.8)
	Range	11.0-73.3	12.6-70.7	19.0-85.7	14.2-50.6	19.0-40.5	11.0-50.6	22.3-85.7	18.0-32.7
	chi-squared test	chi-squared = 0.28676, df = 3, p-value = 0.9625				chi-squared = 12.397, df = 3, **p-value = 0.00614**			

Appendix 2: Minimum, maximum and mean±standard deviation size (total length) of the 59 fish species caught in the mangrove area of Akanda National Park during this study. Fish commercial value: high (HCV), medium (MCV) and no commercial value (NCV)

Family	Species	Fish commercial value	Total length (cm)		
			Minimum	Maximum	Mean ± standard deviation
Poeciliidae	*Aplocheilichthys spilauchen*	NCV	7	9	7.6±0.6
Bothidae	*Arnoglossus capensis*	MCV	8	8	7.7
Alestidae	*Bryconalestes longipinnis*	NCV	9	10	9.6±0.5
Carangidae	*Caranx hippos*	HCV	19	20	19.5±1.2
Carangidae	*Caranx senegallus*	HCV	22	22	22.0
Ariidae	*Carlarius parkii*	HCV	27	32	29.6±3.6
Ephippidae	*Chaetodipterus lippei*	HCV	7	36	13.4±7.0
Claroteidae	*Chrysyscthys nigrodigitatus*	HCV	8	62	30.8±13.8
Paralichthyidae	*Citharichthys stampflii*	MCV	7	14	9.3±2.5
Cichlidae	*Coptodon guineensis*	MCV	6	22	12.2±8.6
Cynoglossidae	*Cynoglossus browni*	HCV	36	36	35.5
Cynoglossidae	*Cynoglossus monodi*	HCV	24	24	23.7
Cynoglossidae	*Cynoglossus senegalensis*	HCV	31	41	36.1±7.2
Eleotridae	*Eleotris daganensis*	NCV	9	28	12.9±6.4
Eleotridae	*Eleotris senegalensis*	NCV	9	10	9.1±0.5
Cyprinidae	*Enteromius holotaenia*	NCV	8	8	8.2
Serranidae	*Epinephelus aeneus*	HCV	9	24	14.6±4.7
Clupeidae	*Ethmalosa fimbriata*	HCV	8	19	11.8±3.8
Gerreidae	*Eucinostomus melanopterus*	MCV	7	13	8.6±0.9
Dasyatidae	*Fontitrygon margarita*	MCV	53	110	81.7±40.3
Dasyatidae	*Fontitrygon margaritella*	MCV	70	110	84.7±13.6
Dasyatidae	*Fontitrygon ukpam*	MCV	87	87	86.5
Polynemidae	*Galeoides decadactylus*	HCV	11	26	16.3±4.5
Gerreidae	*Gerres nigri*	MCV	9	16	11.3±3.7
Muraenidae	*Gymnothorax afer*	NCV	87	87	86.7
Cichlidae	*Hemichromis elongatus*	MCV	7	9	7.8±0.8
Pristigasteridae	*Ilisha africana*	MCV	9	28	17.4±3.7
Lutjanidae	*Lutjanus dentatus*	HCV	7	33	18.2±10
Lutjanidae	*Lutjanus endecacanthus*	HCV	21	36	27.1±6.1
Lutjanidae	*Lutjanus goreensis*	HCV	12	38	24.7±8.5
Monodactylidae	*Monodactylus sebae*	MCV	5	29	10.6±3.6
Mugilidae	*Mugil cephalus*	HCV	8	10	9.1±0.9
Ophichthidae	*Myrichthys pardalis*	NCV	71	71	70.8
Gobiidae	*Nematogobius maindroni*	NCV	8	10	8.8±0.8
Mugilidae	*Neochelon falcipinnis*	HCV	8	25	9.4±2.1
Clupeidae	*Odaxothrissa ansorgii*	NCV	12	13	12.0±0.4
Mugilidae	*Parachelon grandisquamis*	HCV	8	32	11.8±4.0

Clupeidae	*Pellonula leonensis*	NCV	6	13	10.0±1.2
Clupeidae	*Pellonula vorax*	NCV	9	13	10.6±0.8
Polynemidae	*Pentanemus quinquarius*	HCV	10	10	10.2
Gobiidae	*Periophthalmus barbarus*	NCV	9	14	10.9±1.8
Belonidae	*Platybelone argalus*	NCV	21	21	21.0
Haemulidae	*Plectorhinchus macrolepis*	HCV	15	53	30.4±12.5
Polynemidae	*Polydactylus quadrifilis*	HCV	12	49	27.4±8.4
Haemulidae	*Pomadasys jubelini*	HCV	19	30	23.4±5.0
Haemulidae	*Pomadasys perotaei*	HCV	7	22	14.3±5.6
Gobiidae	*Porogobius schlegelii*	NCV	9	12	10.0±0.9
Psettodidae	*Psettodes belcheri*	MCV	23	23	23.2
Psettodidae	*Psettodes bennettii*	MCV	29	29	28.9
Sciaenidae	*Pseudotolithus elongatus*	HCV	8	53	22.2±7.3
Sciaenidae	*Pseudotolithus senegalensis*	HCV	9	27	17.2±5.6
Sciaenidae	*Pseudotolithus senegallus*	HCV	17	35	25.8±6.9
Clupeidae	*Sardinella maderensis*	MCV	10	12	10.6±1.2
Cichlidae	*Sarotherodon melanotheron*	MCV	6	21	11.3±4.2
Sphyraenidae	*Sphyraena afra*	HCV	33	53	42.9±13.8
Sphyraenidae	*Sphyraena barracuda*	HCV	41	41	41.3
Belonidae	*Strongylura senegalensis*	NCV	30	38	35.0±2.8
Paralichthyidae	*Syacium guineensis*	MCV	8	11	8.8±1.7
Carangidae	*Trachinotus teraia*	HCV	43	43	42.5

Appendix 3: list of all fish species reported in the study area (see references below)

Families	Species	Bibliographic reference
ACANTHURIDAE	*Acanthurus monroviae* (Steindachner, 1876)	*g*
ALESTIDAE	*Bryconalestes longipinnis* (Günther, 1864)	*f, h*
ARIIDAE	*Carlarius gigas* (Boulenger, 1911)	*b*
	Carlarius parkii (Günther, 1864)	*g, h*
BELONIDAE	*Platybelone argalus* (Lesueur, 1821)	*a, b, f, g*
	Strongylura senegalensis (Valenciennes, 1846)	*f, h*
	Tylosurus acus rafale (Lacepède, 1803)	*b*
BOTHIDAE	*Arnoglossus capensis* Boulenger, 1898	*b, h*
CARANGIDAE	*Alectis alexandrina* (Geoffroy St. Hilaire, 1817)	*a, b, f, g*
	Alectis ciliaris (Bloch, 1787)	*b*
	Caranx hippos (Linnaeus, 1766)	*b, f, g, h*
	Caranx lugubris (Poey, 1860)	*b, g*
	Caranx senegallus Cuvier, 1833	*b, g, h*
	Chloroscombrus chrysurus (Linnaeus, 1766)	*a, c, d, e, f*
	Decapterus macarellus (Cuvier, 1833)	*a, h*
	Decapterus punctatus (Cuvier, 1829)	*a, d, e*
	Lichia amia (Linnaeus, 1758)	*a, b, f, g*
	Selene dorsalis (Gill, 1863)	*g*
	Trachinotus maxillosus (Cuvier, 1832)	*f*
	Trachinotus ovatus (Linnaeus, 1758)	*b, g*
	Trachinotus teraia (Cuvier, 1832)	*b, f, g, h*
CARCHARHINIDAE	*Galeocerdo cuvier* (Péron & Lesueur, 1822)	*e*
CICHLIDAE	*Coptodon guineensis* (Günther, 1862)	*a, c, d, e, h*
	Hemichromis elongatus (Guichenot, 1861)	*b, f, h*
	Pelmatolapia cabrae (Boulenger, 1899)	*b, f, g*
	Sarotherodon melanotheron Rüppell, 1852	*f, h*
	Sarotherodon nigripinnis (Guichenot, 1861)	*g*
CLAROTEIDAE	*Chrysichthys auratus* (Geoffroy St. Hilaire, 1809)	*f*
	Chrysichthys nigrodigitatus (Lacepède, 1803)	*a, c, d, e, h*
CLUPEIDAE	*Ethmalosa fimbriata* (Bowdich, 1825)	*h*
	Odaxothrissa ansorgii (Boulenger, 1910)	*b, h*
	Pellonula leonensis Boulenger, 1916	*f, h*
	Pellonula vorax Günther, 1868	*g, h*
	Sardinella aurita (Valenciennes, 1847)	*a, b, f, g*
	Sardinella maderensis (Lowe, 1839)	*b, f, g, h*
CONGRIDAE	*Bathyuroconger vicinus* (Vaillant, 1888)	*b, g*
CYNOGLOSSIDAE	*Cynoglossus browni* Chabanaud, 1949	*a, b, f, g, h*
	Cynoglossus monodi Chabanaud, 1949	*h*
	Cynoglossus senegalensis (Kaup, 1858)	*f, g, h*
CYPRINIDAE	*Enteromius holotaenia* (Boulenger, 1904)	*c, d, e, h*
DASYATIDAE	*Fontitrygon margarita* (Linnaeus, 1758)	*b, f, h*
	Fontitrygon margaritella (Compagno & Roberts, 1984)	*b, h*

	Fontitrygon ukpam (Smith, 1863)	*a, b, e, f, h*
DINOPERCIDAE	*Centrarchops atlanticus* (Reichenow 1877)	*g*
ELEOTRIDAE	*Bostrychus africanus* (Steindachner, 1879)	*g*
	Eleotris daganensis (Steindachner, 1870)	*a, b, h*
	Eleotris senegalensis (Steindachner, 1870)	*h*
	Kribia kribensis (Boulenger, 1907)	*b, d, f*
ELOPIDAE	*Elops lacerta* (Valenciennes, 1847)	*b, g*
	Elops senegalensis (Regan, 1909)	*a, b, c*
EPHIPPIDAE	*Chaetodipterus lippei* (Steindachner, 1895)	*g, h*
GERREIDAE	*Eucinostomus melanopterus* (Bleeker, 1863)	*f, g, h*
	Gerres nigri Günther, 1859	*a, b, e, h*
GLAUCOSTEGIDAE	*Glaucostegus cemiculus* (Geoffroy St. Hilaire, 1817)	*c, d, e*
GOBIIDAE	*Awaous lateristriga* (Duméril, 1861)	*b, f, g*
	Bathygobius soporator (Valenciennes, 1837)	*g*
	Nematogobius maindroni (Sauvage, 1880)	*g, h*
	Periophthalmus barbarus (Linnaeus, 1766)	*b, h*
	Porogobius schlegelii (Günther, 1861)	*h*
HAEMULIDAE	*Plectorhinchus macrolepis* (Boulenger, 1899)	*b, f, g, h*
	Pomadasys jubelini (Cuvier, 1830)	*g, h*
	Pomadasys perotaei (Cuvier, 1830)	*b, g, h*
	Pomadasys rogerii (Cuvier, 1830)	*g*
	Pomadasys suillus (Valenciennes, 1833)	*b, f, g*
HEMIGALEIDAE	*Paragaleus pectoralis* (Garman, 1906)	*a, f, g*
LOBOTIDAE	*Lobotes surinamensis* (Bloch, 1790)	*g*
LUTJANIDAE	*Lutjanus agennes* (Bleeker, 1863)	*g*
	Lutjanus dentatus (Duméril, 1861)	*b, c, e, f, g, h*
	Lutjanus endecacanthus (Bleeker, 1863)	*a, b, e, f, g, h*
	Lutjanus fulgens (Valenciennes, 1830)	*f*
	Lutjanus goreensis (Valenciennes, 1830)	*h*
MEGALOPIDAE	*Megalops atlanticus* (Valenciennes, 1847)	*a, b, f, g*
MONODACTYLIDAE	*Monodactylus sebae* (Cuvier, 1829)	*b, f, g, h*
MUGILIDAE	*Mugil bananensis* (Pellegrin, 1927)	*a, b, c, d, e*
	Mugil cephalus Linnaeus, 1758	*a, b, c, d, e, f, g, h*
	Mugil curema (Valenciennes, 1836)	*b, f*
	Neochelon falcipinnis (Valenciennes, 1836)	*h*
	Parachelon grandisquamis (Valenciennes, 1836)	*h*
MURAENIDAE	*Gymnothorax afer* (Bloch, 1795)	*h*
OPHICHTHIDAE	*Myrichthys pardalis* (Valenciennes, 1839)	*g, h*
PARALICHTHYIDAE	*Citharichthys stampflii* (Steindachner, 1894)	*c, d, e, h*
	Syacium guineensis (Bleeker, 1862)	*h*
POECILIIDAE	*Aplocheilichthys spilauchen* (Duméril, 1861)	*f, h*
POLYNEMIDAE	*Galeoides decadactylus* (Bloch, 1795)	*h*
	Pentanemus quinquarius (Linnaeus, 1758)	*b, f, g, h*
	Polydactylus quadrifilis (Cuvier, 1829)	*b, f, g, h*
PRISTIGASTERIDAE	*Ilisha africana* (Bloch, 1795)	*a, b, c, e, f, g, h*
PSETTODIDAE	*Psettodes belcheri* (Bennett, 1831)	*b*
	Psettodes bennettii Steindachner, 1870	*b, f, h*
RAJIDAE	*Raja miraletus* (Linnaeus, 1758)	*b*

RHINOBATIDAE	*Rhinobatos albomaculatus* (Norman, 1930)	*b*
	Rhinobatos rhinobatos (Linnaeus, 1758)	*b*
SCARIDAE	*Scarus hoefleri* (Steindachner, 1881)	*g*
SCIAENIDAE	*Pseudotolithus elongatus* (Bowdich, 1825)	*f, g, h*
	Pseudotolithus senegalensis (Valenciennes, 1833)	*b, h*
	Pseudotolithus senegallus (Cuvier, 1830)	*h*
	Pseudotolithus typus (Bleeker, 1863)	*b, g*
	Umbrina canariensis (Valenciennes, 1843)	*b, g*
	Umbrina ronchus Valenciennes, 1843	*g*
SCOMBRIDAE	*Orcynopsis unicolor* (Geoffroy St. Hilaire, 1817)	*a, d, f*
	Scomberomorus tritor (Cuvier, 1832)	*g*
SCYLORHINIDAE	*Scyliorhinus cervigoni* (Maurin & Bonnet, 1970)	*b*
SERRANIDAE	*Cephalopholis nigri* (Günther, 1859)	*a, b, f*
	Cephalopholis taeniops (Valenciennes, 1828)	*f, h*
	Epinephelus aeneus (Geoffroy St. Hilaire, 1817)	*f, h*
	Epinephelus itajara (Lichtenstein, 1822)	*b*
SPARIDAE	*Dentex congoensis* (Poll, 1954)	*a*
	Pagellus bellottii Steindachner, 1882	*c, e*
	Pagrus auriga (Valenciennes, 1843)	*a, b, f, g*
	Pagrus caeruleostictus (Valenciennes, 1830)	*b, f, g*
SPHYRAENIDAE	*Sphyraena afra* (Peters, 1844)	*a, b, f, g, h*
	Sphyraena barracuda (Edwards, 1771)	*f, g, h*
	Sphyraena guachancho (Cuvier, 1829)	*b, f, g*
STROMATEIDAE	*Stromateus fiatola* Linnaeus, 1758	*g*
TRICHIURIDAE	*Trichiurus lepturus* (Linnaeus, 1758)	*g*

a - Mbega, J.-D., Mve Beh, J.-H. 2012. Biodiversité et exploitation des peuplements piscicoles en prévision de la campagne d'acquisition sismique 2D on shore des Blocs E2 (Ntoum Cocobeach) & F3 (Kango) par la société ENI.

b- Mve Beh, J.-H., Eva M.-F. 2010. Contribution à l'étude écologique de la baie de la Mondah : caractérisation du peuplement piscicole.

c -Mve Beh, J.-H., 2012. Evaluation des peuplements ichtyologiques de la rivière Mbomo en perspective de l'aménagement d'une prise d'eau.

d - Mve Beh, J.-H., 2012. Biodiversité des peuplements ichtyologiques des rivières Nzémé, Assengo et Mbé en perspective du renforcement de la production d'eau potable.

e - Mve Beh, J.-H., 2013. Etude de la diversité ichtyologique de la rivière MEBA en perspective de l'aménagement d'une carrière de calcaire.

f - Van de Weghe, J.-P., 2005. Les Parcs Nationaux Du Gabon. Akanda et Pongara: Plages et Mangroves. Gabon Wildlife Conservation Society, Libreville, Gabon. 208 p.

g - Yendze, A.C, Mcclellan, C, Cardiec, F. 2016. Diagnostic de la pêche artisanale dans la zone du Cap Esterias et de Cocobeach.

h – Present study