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FISH SPECIES ABUNDANCE AND DISTRIBUTION IN THE GAMBIA ESTUARY

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ABSTRACT

The area covered by this study extends from the mouth of the Gambia estuary to about 250 km inland. In this stretch of the estuary, about 43 seining sampling stations were operated. The purpose of this study is to look closely at the fish resources of the estuary with the view of improving understanding of existing patterns that determine periodic yields as a prerequisite for rational and sustainable management, which has to be based on sound scientific findings. Understanding the fish resource patterns and trends of factors that affect it would facilitate review and enable proper formulation of legislation governing its sustainable exploitation. The results are expected to help explain past, present and future yield patterns as well as provide a basis for planning and implementation of future estuarine-related projects. In the report, environmental parameters such as water temperature, salinity, dissolved oxygen, water transparency and depth are observed as well as fish species occurrence within the estuary. In sum, during the five surveys conducted throughout the estuary, surface water temperatures did not differ much from bottom temperatures. The small difference between mean surface temperature and bottom temperature (0.68^{o}C) indicates an absence of a thermocline in the Gambia estuary even during the rainy season. Records of salinity throughout the surveys indicate a negative upstream gradient with slopes differing from survey to survey depending on the volume of down stream flow of freshwater. The results of the study indicate surface and bottom concentration of dissolved oxygen in a parallel pattern of oscillation throughout the estuary with a mean difference of only about 0.29 mg/l. On the whole, the lower estuarine waters were observed to be relatively more turbid from September to May, while the upper estuarine turbidity was observed to be highest in April to September. Turbidity appears closely linked to river discharge regime. About 80 fish and shellfish species were encountered in the Gambia estuarine system belonging to more than 40 families. Salinity seems to be the main factor controlling the occurrence of species throughout the Gambia estuary.

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1 INTRODUCTION

The Gambia, one of the smallest countries in Africa, lies between longitudes 16º50' W and 13º45' W and latitudes 13º00' N and 13º50' N. The country is 480 km long and nowhere more than 50 km wide. Its total surface area is little more than 11,000 km^2. Most of the country is low-lying with only a few points above 50-m elevation (Mott and MacDonald 1992).

The main topographical feature is the River Gambia, which runs through the country for almost 500 km (Figure 1). A significant dilution of seawater by fresh water takes place at the lower part of the river forming an estuary which during the dry season occupies up to about half (250 km) of the Gambia part of the river.

This vast stretch of estuary provides excellent conditions for concentration and development of a variety of fish species and their supportive ecosystems. These have been exploited by small-scale fishermen settling along the estuary for generations with little if any form of control.

In recent years, the quest for producing food for a growing population, among other reasons, has increased the importance of the fisheries of the estuary. While it is not reflected in this study, the estuary is currently under exploitation pressure. Lack of understanding of the structure of the population *vis-à-vis* species distribution, richness and abundance, as well as *in situ* physico-chemical factors that support them and their periodicity could pose challenges to any kind of resource management regime in the future.

Already, periodical oscillations of yield are visible due in some part to inappropriate exploitation strategies by fishermen, resulting from the lack of understanding of the population and ecosystem structure of the estuary. Notwithstanding, estuarine fisheries continue to provide the bulk of fish for semi-urban consumption and in recent years contributed significantly to the export market by providing the bulk of shrimps to export-oriented processing plants in the country.

Fisheries of the estuary, apart from playing the noble role of providing a relatively cheap source of animal protein, also provide employment and to some extent reduce the rural-urban drift.

As a result, the government provides some support to the sub-sector in the form of introducing the concept of Community Fisheries Centres (CFC), encouraging the formation of associations in order for these associations to benefit from government credit schemes.

Another importance of the Gambia estuary is that it provides support, protection and nursery to the early life cycle stages of almost all commercially and ecologically important marine fish species particularly shrimps.

Fisheries catches of the Gambia estuary include multiple species of finfish, crustaceans and shellfish (shrimps, oysters and cockles). These are annually harvested using out-dated and in some cases destructive fishing gear and methods. Catches are evacuated to local markets by middlemen in smoked, fresh or salt-dried forms.

Shrimp harvests are purchased by the few processing plants in the country by special arrangement to supplement oceanic catches for export, mainly to EU countries for much needed foreign exchange.

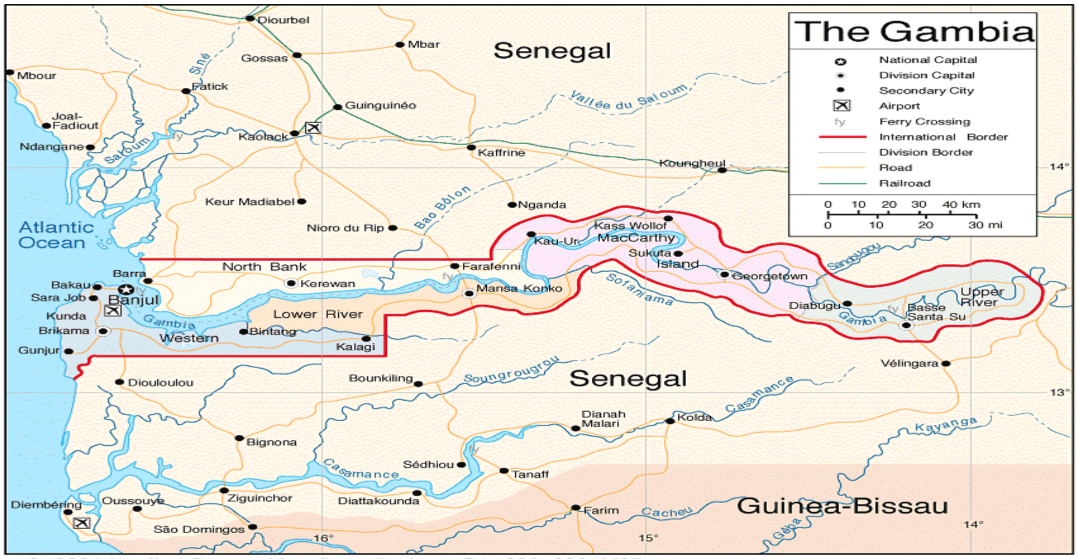

Figure 1: Map of the Gambia.

The purpose of this study is to look closely at the fish resources of the estuary in view of improving understanding of existing patterns that determine periodic yields as a prerequisite for rational and sustainable management, which has to be based on sound scientific findings. Very limited research effort has been applied in this area. The few appreciable efforts include the study conducted in the early 1980s (Moll 1983) by the University of Michigan for/on behalf of the Organisation for the Development of the Gambia River basin (OMVG). The time lapse since this study is so great (20 years) that it is deemed necessary to replicate the study in order to update existing ecosystem and exploitation patterns. Understanding the fish resource patterns and trends of factors that affect it would facilitate review and enable proper formulation of legislation governing its sustainable exploitation. The results are expected to help explain past, present and future yield patterns as well as provide a basis for planning and implementation of future estuarine-related projects.

1.1 Objectives

- To improve understanding of the general fish distribution pattern of the Gambia estuary.

- To establish and describe fish species abundance and diversity in the Gambia estuary.

It is expected that the present study will give answers to the question as to whether fish population and distribution in the Gambia estuary have definite patterns and if so what are the *in-situ* factors that determine those patterns. Attainment of these objectives will enable the Government, through the Fisheries Department, to give periodic advice to small-scale fishermen and to adopt regulatory fishing measures for maximum productivity with minimum costs.

1.2 Goals

- To identify the indicator (most frequent/ecologically important) species in the estuarine system.

- To utilise indicator species to identify highly productive areas in-terms of overall species composition.

- To describe physico-chemical parameters of the estuary.

- To relate and assess the impact of the parameters on distribution and other behaviours of fish.

1.3 Inception of the study

Under the umbrella of the Franco-Gambian technical co-operation, this study, vested in the Institute for Research and Development (IRD), was funded through the Embassy of the Republic of France in the Republic of Senegal. The present study represents one of the components to be jointly implemented by the Institute and the Department of Fisheries of the Gambia. The scientific team in this component is composed of one Gambian marine ecologist, four French fisheries researchers and one Senegalese Eco-sounding technician. The Fisheries Department is fully represented in the implementation of other components, all geared towards improving the much-needed capacity of the Department to conduct applied research.

2 LITERATURE REVIEW

2.1 General description of estuaries

The word estuary was derived from the Latin word “aestus” meaning “tide” and the adjective “aestuarum”, which means “tidal”. The more common definition in literature was given by Cameron and Pritchard (1963) as: “a semi-enclosed body of water which has a free connection with the open sea and within which seawater is measurably diluted with freshwater derived from drainage”.

This definition however is often considered limiting since it will not include those water bodies that are intermittently disconnected with the open sea due to sand bars that emerge during the dry season when rain and river runoff are greatly reduced. This gave rise to an expanded definition by Hopkinson and Hoffman (1983)“...has a free connection with the open sea at least intermittently...”.

A common categorisation of an estuary lies in its being either positive (normal) or negative (inverse). An estuary is considered negative or inverse when evaporation from it exceeds inflow of fresh water from rivers or local rainfall into it causing water in the estuary to become more saline than the adjacent seawater. The phenomenon was observed in the South Senegalese river of Casamance (Albaret 1987), which is situated in the same geographic area as the Gambia estuary. The opposite scenario is therefore an estuary in which annual freshwater loss through evaporation does not exceed the annual gain in freshwater from rain and rivers. An upstream rise of the salinity gradient could have far reaching consequences on the ichthyofauna of the estuary. Albaret, considering species richness as one of the fundamental parameters in the study of the fish community in the Casamance River, observed that the parameter decreased with an increase in salinity during all of the three periods of his study. However, he could not rule out the possibility of incidences of high fish mortality resulting from emigration and osmo-regulatory problems of the fish encountered.

The influence of extreme salinity on the fish community of estuaries was also reported by Young and Palter (2001). The authors, working on the Wellstead estuary in West Australia reported that a marked increase in the mean monthly salinities in the lower estuary from 53 to 112 ppt was accompanied by a decline in the number of fish species. In their comparison with the upper estuary during the same period, where salinities did not undergo such an extreme rise, the authors could not observe any such decline in the number of species. Instead they observed a rise in the fish community density. The comparison suggests that, as a result of exceptionally high salinities, some freshwater fish species could have suffered mortality in the lower estuary or moved into the upper estuary where salinities are lower.

Among the most emphasised aspects in estuarine and other fish community studies is species richness (Albaret 1987) and Baran 2000). The former expanded the definition of species richness in estuaries and lagoons as the number of species encountered at least once within their open systems. Baran (2000) compared the species richness of West African estuaries with that of world estuaries and positioned West African estuaries as intermediate between those of South America and Australia or Asia. From the authors’ modified table of species richness, Diouf (1996) gave the species richness of the Gambia estuary an 86, which was considered high, similar to other West African rivers.

There are two likely reasons for this. Firstly, in high discharge rivers (for instance Senegal, Gambia, Fatala), the hydrological variability between dry and the flood seasons is considered very important in producing mobility of the brackish zones of these rivers. In the rainy season, the major part of the zone, geographically defined as estuarine, exhibits the hydro-chemical characteristics of a river, and is slowly occupied by freshwater species. In the dry 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 add to the permanent presence of a typical estuarine community.

Secondly, in the inverse estuaries of Senegal, the continental influence is almost none 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 waters are not limited by the presence of a brackish coastal zone or of course by possible competition with freshwater species.

2.2 Abundance and biomass in estuaries

In terms of primary production, estuaries and lagoons are the most productive aquatic environments after algal beds and coral reefs (Baran 2000). 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 (Baran 2000). In some West African estuaries (Saloume in Senegal, Rio Buba in Guinea Bissau, Fatala in Guinea and Ebrie lagoon in the Ivory Coast) Clupeids are found to be numerically abundant and represent up to 61-85% of catches. However, within this family the dominant species are not always the same depending on the estuary. (Albaret 1994) reported the Gambia estuary as being dominated by two species of clupeids, *Ethmalosa fimbriata* and *Sardinella maderensis*, whereas in other regional estuaries (Saloume, Fatala and the lagoons of the Ivory Coast), the dominant species are *Ethmalosa fimbriata*, *Ilisha africana* and *Ethmalosa fimbriata* respectively. In the hyperhaline inverse Senegalese rivers of Casamance and Sine Saloume, catfishes and croakers dominate at the mouth; they are replaced by clupeids and mullets in the middle zone and upstream. Where salinity reaches up to 110 ppt, tilapia proliferates. It is fairly surprising that replacement results in relative consistency of biomass throughout these estuaries, although the biodiversity is drastically reduced. The relationship between abundance and size distribution in a community is a fundamental aspect of population ecology that has been the subject of considerable work in recent years (Macpherson *et al*. 2001).

3 MATERIALS AND METHODS

3.1 Organisation and composition of the survey missions

An IRD river vessel "Diassanga" was used in all the cruise missions along the estuary. In most cases, the vessel sailed from the Senegalese delta village of Tubakuta with six Senegalese fishermen, an IRD marine engineer and a participating Gambian marine ecologist who travelled to Dakar to receive and jointly endorse relevant documents pertaining to the respective mission at the IRD headquarters in Dakar. The signatures symbolically validated the contract for the conduct of the mission in the Gambia estuary. A more formal authorisation was usually provided by the Ministry of Fisheries through the Department of Fisheries. Each mission was well equipped in terms of researchers and equipment. The IRD research team joined the following day in Banjul to begin at Chitabong bolong (Station 1). Two other Gambian fishermen join their six Senegalese counterparts on the arrival of Diassanga in Banjul to jointly conduct all sampling operations. On the whole, a team of six fisheries scientists/ecologists conducted the study led by a renowned French researcher, Dr. Albaret who conducted several studies in the West African region particularly in the SeneGambia sub-region. Three other French researchers, a Senegalese specialist in Eco-sounding and a Gambian fisheries ecologist, as stated earlier, conducted the five surveys. Each survey usually took about 12 days and not more than five seining operations were conducted daily.

3.2 Sampling method

One important aim during sampling was to collect fish samples from the mouth to the farthest extent of the estuary. Therefore, the operation started around Chitabong bolong near Banjul, which was designated in most of the five surveys as station 1. The stations, which numbered to about 43, were established randomly hence do not show any definite pattern of distribution (Figure 2). However, some skewness was allowed in the location of some stations, usually in or at the mouth of tributaries to allow capture of more diverse fish species. Sampling missions were conducted at different times reflecting marked hydrological periods of the year (rainy season, dry season, peak discharge period). Sampling was done using a purse seine measuring 250 x 25 m with a stretched mesh size of 14 mm. Fish samples were sorted, identified to species level and recorded. The total numbers of individuals, as well as the total weights of the species in the samples, and in some cases individual weights, were recorded to the nearest 1 gm. In cases where the volume of the sample was too large, a random sub-sample of about 30-50 sorted individuals was taken for treatment. Treatment of individual species in each sample included recording of sexes, maturation stages of gonads and observation of stomach contents. Each species was given a three-letter codification (FAO 1996).

At each sampling station, physico-chemical parameters such as dissolved oxygen (DO), water temperature (T˚C), salinity (‰), station depth, and water transparency were taken using oxygen meters, thermometers, refractometers, depth gauges, secchi disc and other equipment respectively.

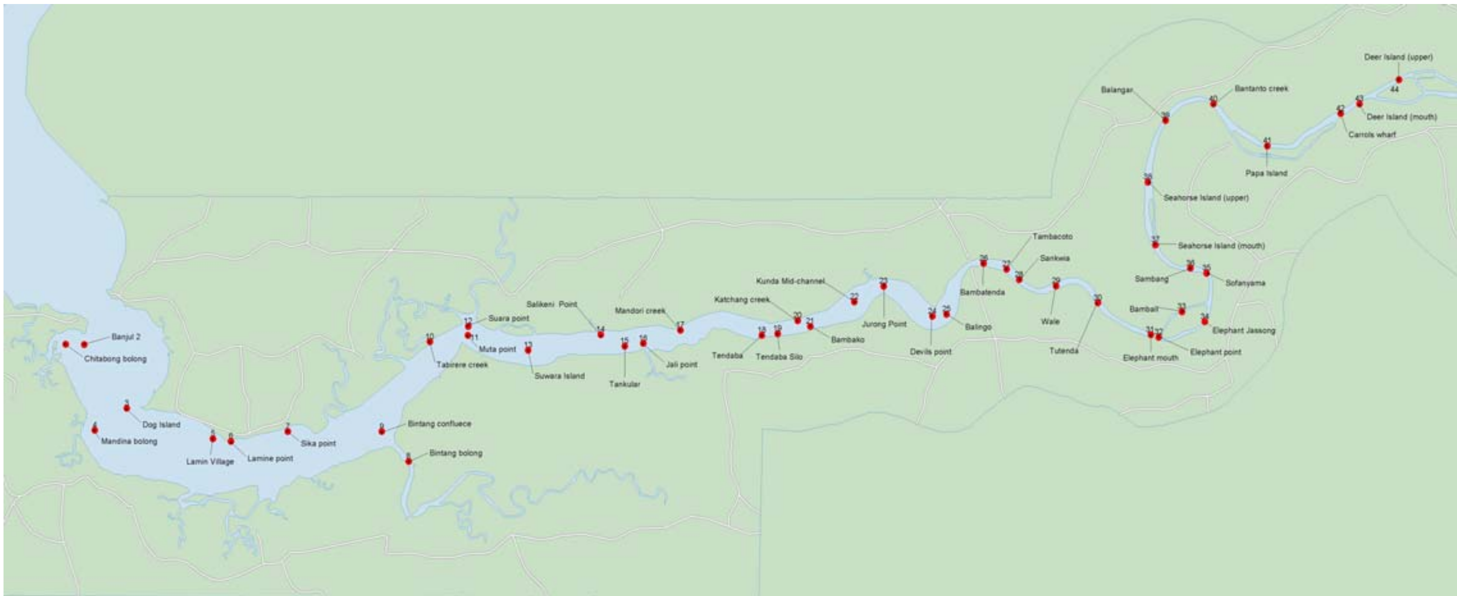

Figure 2: Map of the Gambia estuary showing sampling stations.

Results of these environmental factors as well as those from biological treatment mentioned above could be plotted against each station and time, and for closer observations. This study is intended to be more descriptive of practical outcomes and to find determinant factors that affect fish yields and productivity in the estuary, rather than venturing into detailed, complicated and highly theoretical statistical analysis, which is often not appreciated by policy makers.

4 RESULTS

The area covered by this study extends from the mouth of the Gambia estuary to about 250 km inland. In this stretch of estuary, about 43 seining operations were conducted. Positions of the sampling stations are given in Figure 2 in the previous section.

4.1 Environmental parameters

4.1.1 Water temperature

Water temperature is known to impact on live functions of fish even in the tropics. During all the five surveys and throughout the estuary, surface water temperatures did not differ much from bottom values of the parameter. In all the surveys, values ranged between 32.0°C and 23.3°C with a mean of 29.5°C ± 0.9. Bottom temperature ranged from between 30.0°C and 23.1°C with a mean of 26.85°C.

During Survey 2, 2–12 June 2001, temperature readings were taken between stations 1 and 43 (Chitabong bolong and Deer Island).

Surface temperatures throughout this survey ranged from between 32.2°C and 26.6°C with a mean value of 29.12°C ± 0.74°C. The highest temperature was recorded at the mouth of Sofanyama creek (station 35) in the upper estuary and the lowest at Dog Island in the lower estuary. Bottom temperatures, the mean of which do not differ markedly from surface temperatures, ranged between 29.8°C and 24.6°C in the upper estuary. These were recorded at Elephant Island and Dog Island respectively. On the whole, the mean bottom temperature recorded during the survey was 28.69°C ± 0.72°C .The low bottom temperature at Dog Island could be attributed to the considerable dept at that station (Figure 3) while Sofanyama's high surface temperature could be attributed to the influx of tributary water from the continent. Sharper temperature oscillations were observed during the mission of 16 – 25 September 2001 than in the previous surveys (between 31°C and 23.3°C). The highest temperature was recorded at the surface at the confluence of Bintang bolong tributary with the main channel while the lowest was recorded at Elephant point (station 32). The mean of the surface temperatures between Chitabong and Papa Island was 29.5°C ± 0.91°C. With the exception of the third survey, temperature readings along the estuary indicate a general slight upstream increase characterised by slight oscillations (Figure 3).

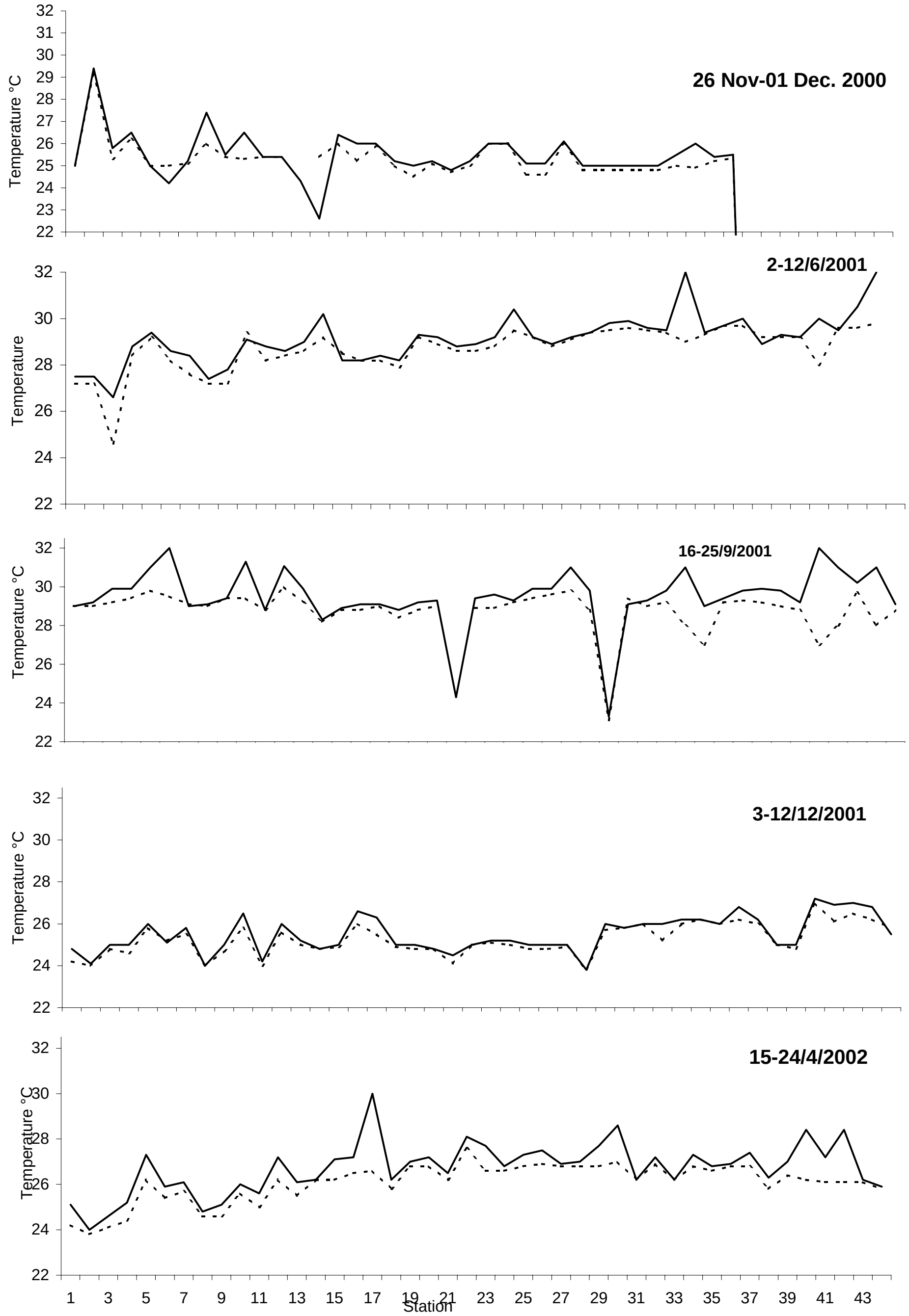

Figure 3: Surface and bottom water temperatures from the five surveys of the Gambia estuary.

During survey 4 (3 – 12 December 2001), recorded temperatures ranged between 27.2^{o}C (station 40, Bantanto Creek) in the upper estuary and 24.0^{o}C (station 6, Lamin point in the upper estuary with a mean temperature of 25.48^{o}C ± 0.7285^{o}C. The bottom readings followed a similar pattern with slightly lower values. The mean recorded was 25.24^{o}C ± 0.63^{o}C.

The mean surface temperature readings in survey 5,15-24 April 2002, was 26.71^{o}C ± 0.87^{o}C with the highest temperature of 30.0^{o}C being recorded at station 15(Tankular) and the lowest, 23.8^{o}C, at station 2(Banjul). Only slight oscillations were observed at the rest of the stations with a bottom mean temperature of 26.07^{o}C ± 0.66^{o}C.

4.1.2 Salinity

Both surface and bottom salinity readings were taken. Records of this parameter during all the surveys indicate low upstream values (Figure 3). The slope however differed from survey to survey. During the survey in June (survey 2) the surface values recorded ranged from between 38.5 and 2.5 ppt, between Sika point (station 7) and Deer Island (station 43). In June (at the end of the dry season and beginning of the rainy season), the influence of Oceanic tide extended the estuarine condition furthest inland. A scenario of contracting estuary was observed during the following survey in the third month of the rainy season 16-25 September 2001 (survey 3), when both bottom and surface salinity read zero at the mouth of Katchang creek (station 20).

In December 2000 (survey 4) an upstream movement of the saline front was observed reaching station 23. The highest value recorded, 32 ppt, was at station 2 (Banjul). It appeared that December-January marked the beginning of reducing fresh water discharge into the estuary. Salinity recorded in April, four months later did not only indicate an increase in value and elaboration of estuary conditions further inland, but an extreme value of 40 ppt (which is higher than the mean ocean salinity) around stations 1 – 3 at the mouth of the estuary. The economic importance of this high salinity at the lower estuary will be further discussed in later sections.

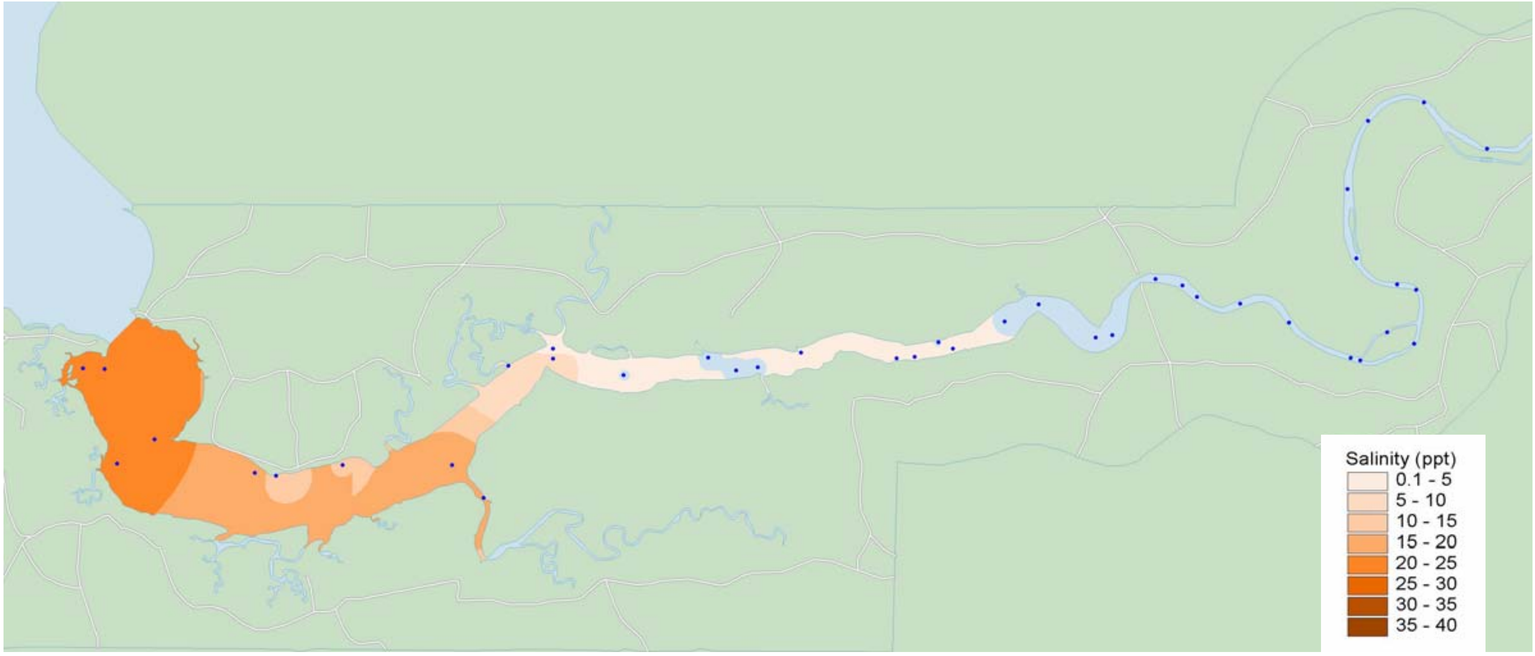

Figure 4: Salinity profile of the Gambia estuary from survey 3, September 2001. (The salinity distribution is representative of a high flow period in the Gambia River.)

Figure 5: Salinity profile of the Gambia estuary from survey 2, June 2001. (The profile is representative of a low flow period in the Gambia River.)

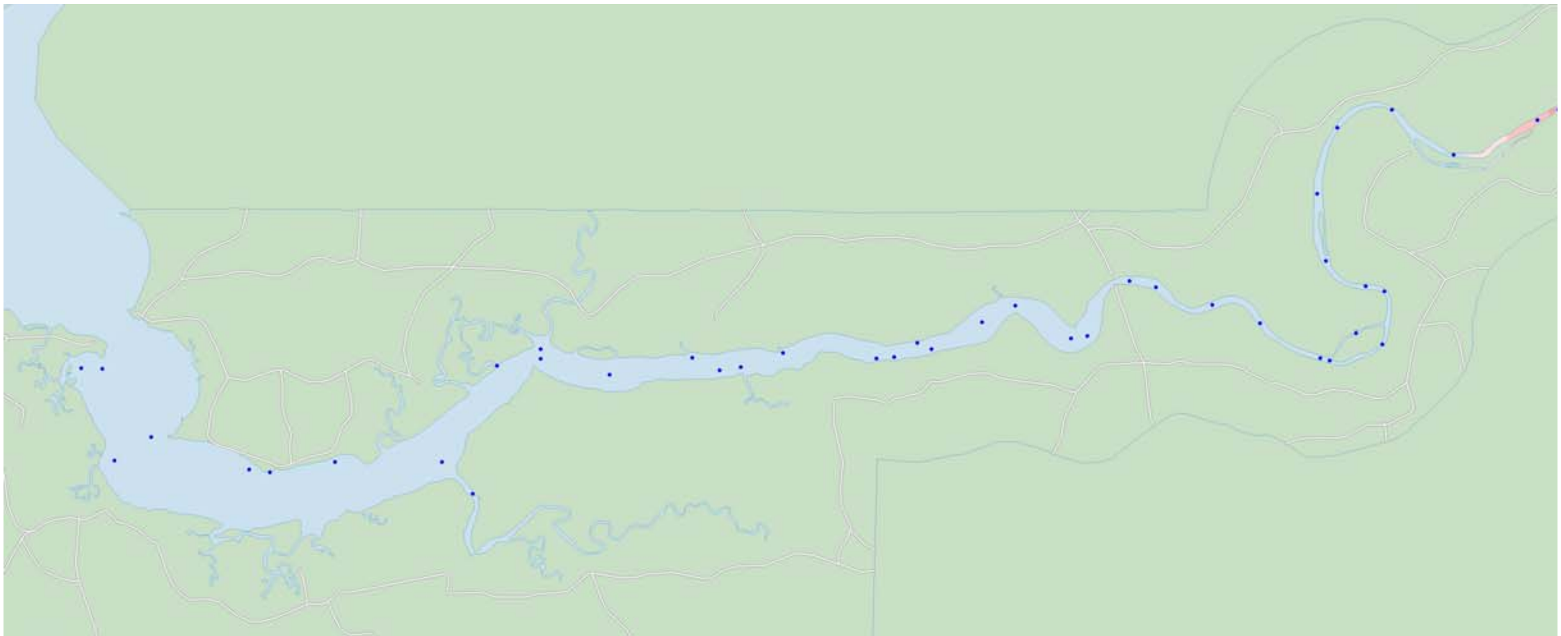

Figure 6: Distribution of *Synodontis gambiensis* during survey 2. (This is representative of freshwater spp during the low flow period.)

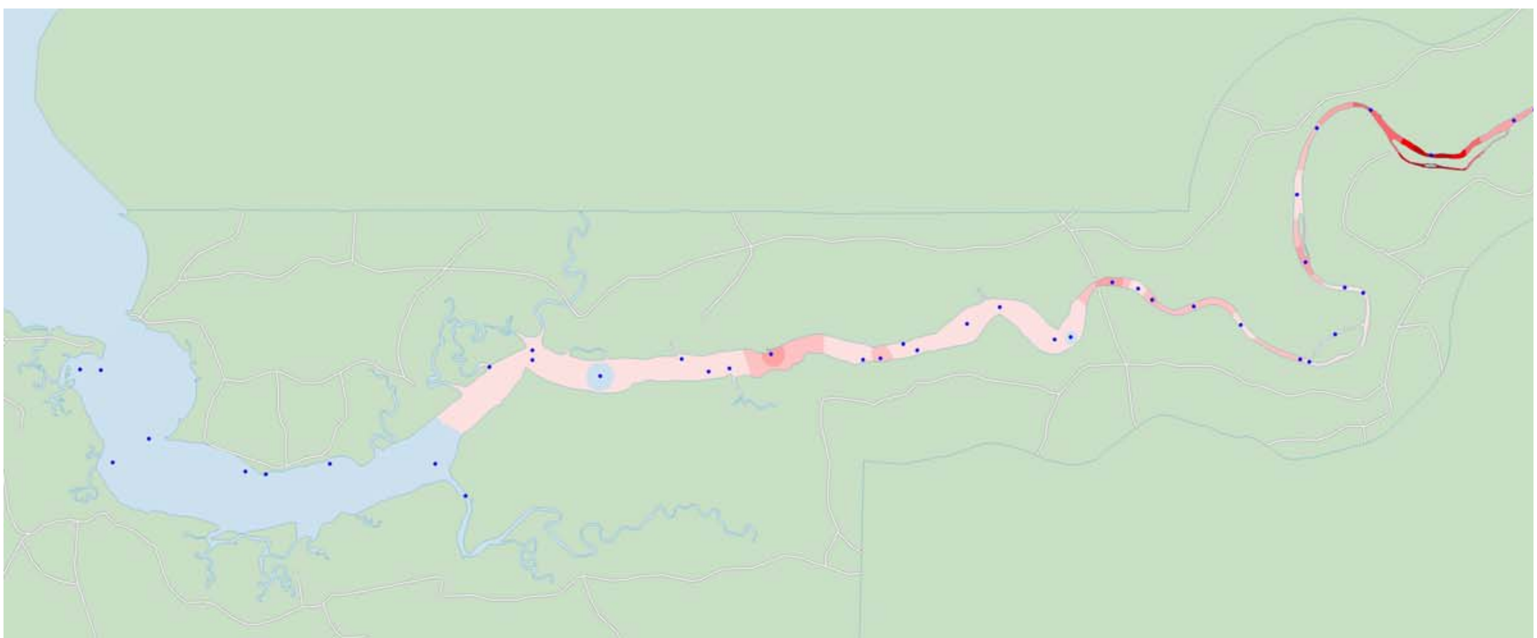

Figure 7: Distribution of *Synodontis gambiensis* in December 2001.

4.1.3 Dissolved oxygen

Oxygen is among the important factors that affect the distribution of fish. Fish tend to avoid waters deficient in dissolved oxygen. During high discharge periods the tendency for areas with very low transparency to be anoxic could be high due to high concentration of suspended mud particles that could not only impede photosynthetic processes but could also increase biological oxygen demand (BOD) in the processes of decomposition of organic matter

The results of the study indicate both surface and bottom concentration of dissolved oxygen following similar patterns of oscillation throughout the estuary (Figure 8). The highest measurement of (8.1mg/l) was recorded at the mouth of Katchang creek in April (survey 5) while the lowest (2.84 mg/l) was recorded in Bintang bolong tributary in November 2000. In the context of the whole estuary, a slight upstream increase of dissolved oxygen concentration was observed.

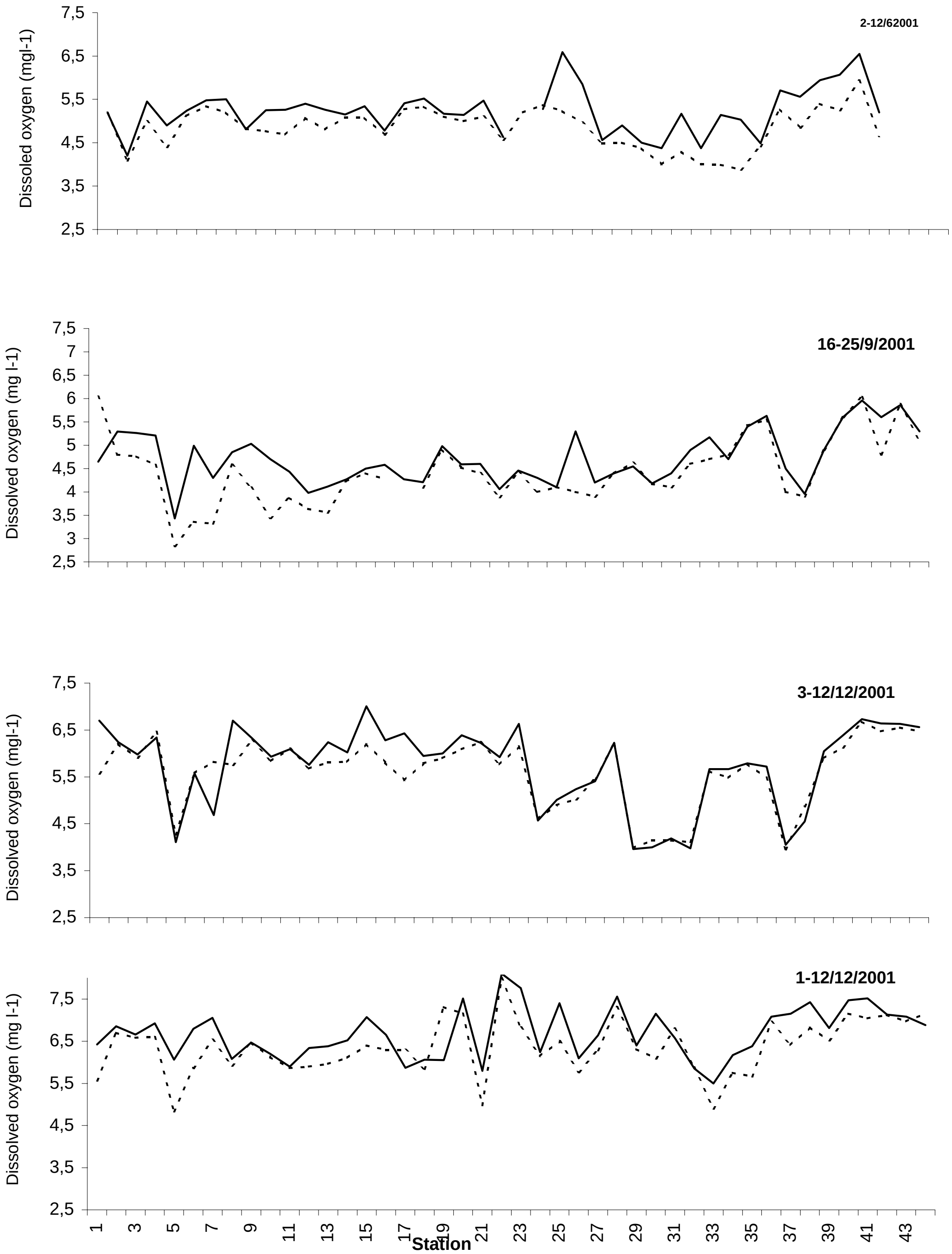

Figure 8: Dissolved oxygen measurements recorded in the Gambia estuary during the five surveys (November 2000 to April 2002).

4.1.4 Water transparency

This parameter is important, particularly in estuaries where the dominant species belong to filter-feeding pelagic fish species such as clupeidae. It is indeed equally important to predatory species that require optimum transparency in search of prey (FAO 1996). The lowest values of transparency (0.1 m) throughout the estuary were recorded at stations 17 and 16 in September (survey 3) and 14 in April i.e. at the mouth of Mandori creek, Jali point and Salikeni point respectively (Figure 9). Two of the stations (Salikeni and Mandori are confluence stations where tributaries discharge into the main channel. The concentration of suspended particles (mud) and nutrients could suitably explain the high turbidity. The highest transparency of 1.9 was recorded at station 31 at the entrance to Elephant Island. On the whole, the lower estuarine waters were observed to be relatively more turbid from September to May while the upper estuarine turbidity was observed to be highest from April to September.

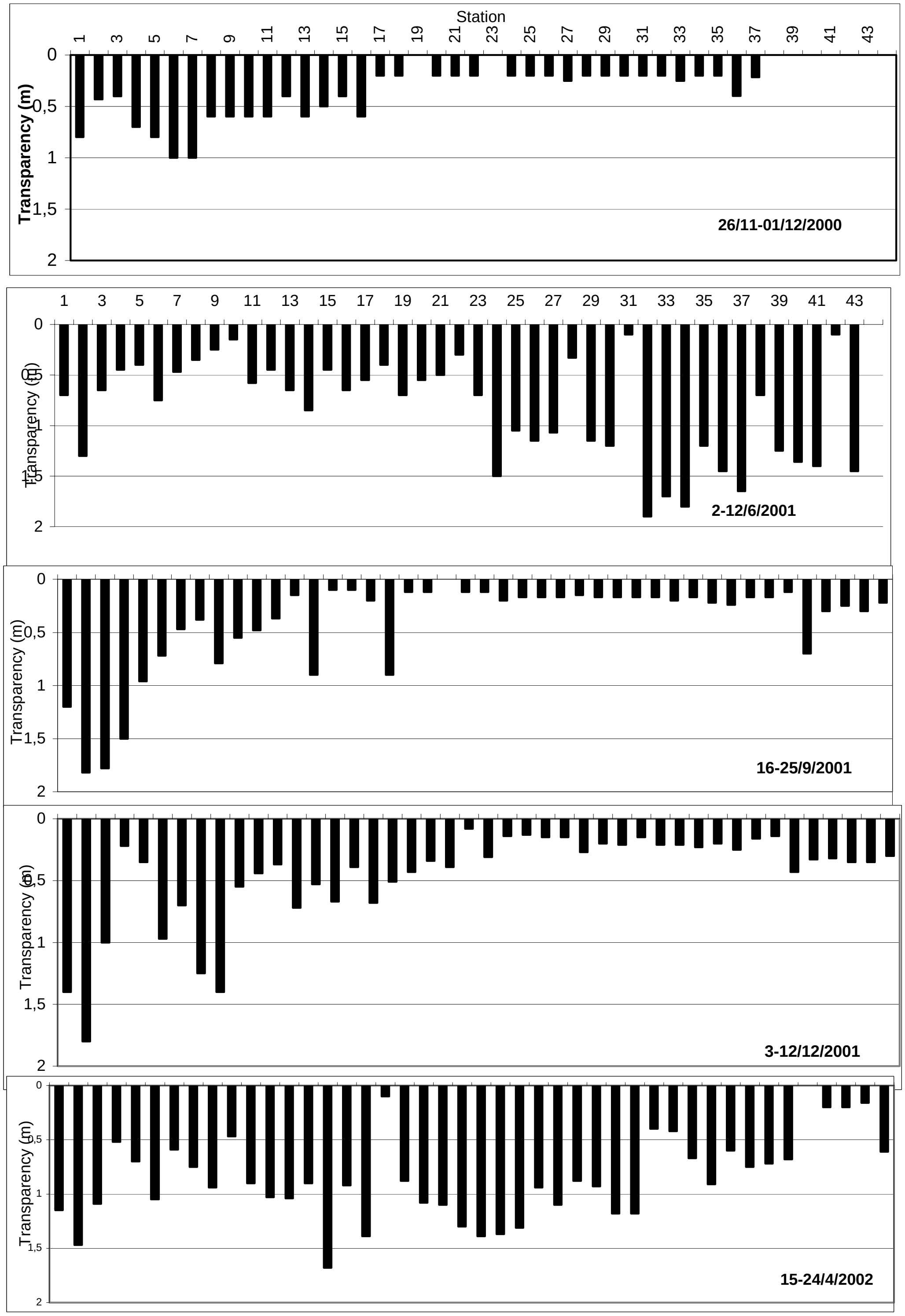

Figure 9: Water transparency profiles from the five surveys of the Gambia estuary.

4.1.5 Depth

The means of the five depth measurements of the study area are shown in Figure 10. Measurements indicate the existence of few relatively deep trenches below 10.0 m in Banjul (11.18 m ± 2.02 m), Sambang (10.12 m ± 4.86 m), Elephant mouth (10.88 m ± 3.62 m), and Sofanyama (11.12 m ± 2.42 m). The lowest mean depths recorded were at Mandina bolong (3.34 m ± 1.0 m) and Tendaba (3.18 m ± 0.46 m). On the whole, a more continuous mean depth of over 6 m was observed in the upper estuary above Bamba Tenda (station 26). The bottom of the lower estuary appeared more undulated.

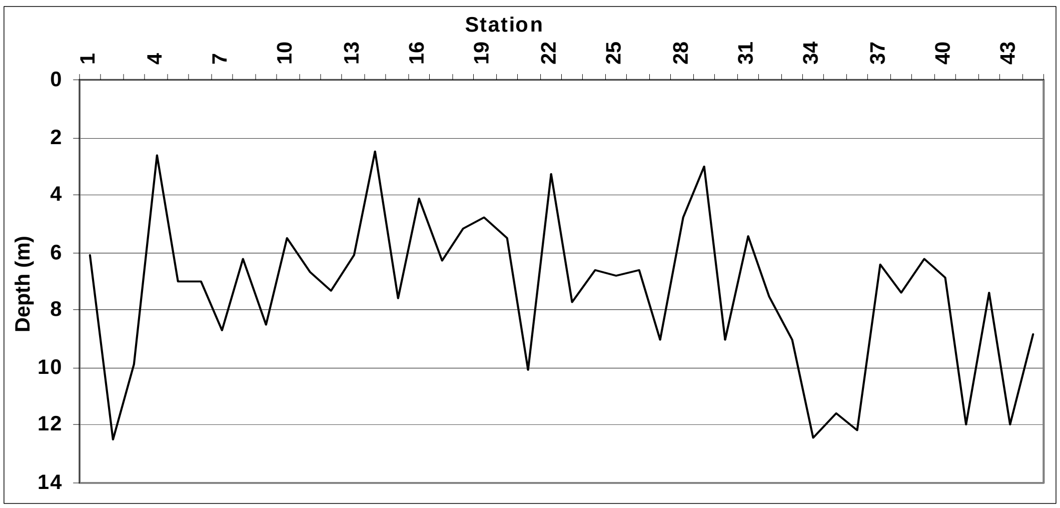

Figure 10: Depth profile of the Gambia estuary, 15-24 April 2002.

4.2 Fish species occurrence in the Gambia estuary

As earlier stated, about 80 fish and shellfish species were encountered in the Gambia estuarine system belonging to more than 40 families (see Table 8 in the Appendix). Depending on their various life history characteristics and environmental tolerance limits these species, though estuarine, were found distributed along the estuary at varying degrees of occurrence and at different hydrological periods reviewed. However, certain species such as *Pseudotholithus elongatus* (PEL) and *Callinectes latimanus* (CAA) appear rather ubiquitous. The latter (crustacean) has very limited economic importance but its trophic role cannot be over-emphasised as it has been found in the stomach content of many commercially important species including *P. elongatus*. Occurrence of species at different zones and time appears to be salinity-driven.

During a high flow period in December 2000, about 28 species were recorded between Chitabong bolong (station 1) in the lower estuary and Sambang (station 36) in the upper estuary (Figure 11). The species with the widest distribution included *Callinectes latimanus* (CAA), *Cynoglossus senegalensis* (CYS), *Chrysichthys maurus* (CWA), *P. elongatus* (PEL) and *C. nigrodigitatus* (CNI). The results indicate that *S. gambiensis* and *E. fimbriata* over-lapped between Salikeni point and Sankwia (stations 14-28). Since both species have a relatively narrower range of salinity tolerance (by virtue of their patterns of distributions in relation to salinity changes in other surveys), the zone of their overlap could be indicative of optimum saline conditions for many species of a wider eury-halinity. This is evidenced by the fact that the zone appears intermediary in terms of the number of species present.

During a very reduced discharge period in June 2001, the number of species encountered in the estuary totalled about 44, more than 75% of the total number of species found throughout the five study missions (Figure 11). Among these, *P. elongatus*, *P. notialis* (PDU), *Cynoglossus senegalensis* (CYS), *C. latimanus*, *Ethmalosa fimbriata* and *Sardinella maderensis* were encountered at almost all stations*.* *Polydactylus quadrifilis* (POQ), *Pentanemous quinquarius* (PQQ) and *Ilisha africana* intermittently appear throughout the study area seemingly unrestricted by the slight lowering of salinity upstream. However, species such as those of the family Ariidae tend to be restricted at the lower estuary between stations Chitabong bolong and Balingo. *Ilisha africana*, a member of the family pristgastridae, also exhibits similar restricted distribution. During this period, all Bagridae (*Chriysichtys nigrodigitatus*, *C. maurus* etc.) were confined to the mid and upper estuarine zones. In terms of concentration, more species were observed between Mandina bolong and the confluence of Bintang bolong with the main estuary though very low concentration was observed opposite Lamin village within this range. The high concentration at Mandina bolong is attributed to the shelf-like nature of the station. Although the station is situated at the mouth of creeks, turbidity at the station is relatively low but the high presence of phytoplankton, feeding *E. fimbriata, S. maderensis* and other species as well as an optimum daytime oxygen level (5.1 mg L-1) are indicative of the station having high primary production.

The survey conducted during the rainy season (16-25 September 2001) and a very high discharge period, reduced the salinity level and its extent down stream was observed to have influenced the distribution of some species particularly *E. fimbriata, I. africana, P. notialis, Arius latiscutatus* and *S. maderensis* (Figures 12-14). Areal distribution of all of the above mentioned species shrank towards the lower estuary between Chitabong bolong and Tankular, although a few individuals of *A. latiscutatus* could still be found up to Jurong point in the mid estuary. Again during this period more species were concentrated between the Chitabong and Bintang confluence with the exception of the deep channel stations of Banjul and Dog Island where species occurrence appears very scanty. The considerable depth at both stations may create seining problems ranging from fish escaping from the seine bottom to avoidance of the gear before encircling. Extensive incursion into the mid estuarine zone by relatively low salinity tolerant “freshwater” species was observed in *Synodontis gambiensis*, which was encountered downstream at up to Tabiere creek (station 10) and *Schilbe intermedius* at Tendaba. Despite the low salinity in the mid estuary during this period certain environmentally sensitive species such as *Mormyrus anguillaris* (MAN) and *Alestes baremose* held back at the upper estuary.

Salinity measurements during the survey mission from 3-12 December 2001 indicate a moderate discharge from the river, which had created a weakly saline environment in both the mid and upper estuary (Figure 4-7), with salinities ranging from 0 – 5.5 ppt. The weak salinity appears to be quite favourable to *E. fimbriata, P. notialis* and *I. africana,* all of which had expanded their presence in the river distribution. Though few individuals of *I. africana* in particular which, during the previous survey in September, restricted its distribution within stations not above Tankular, were encountered as far up as Papa Island. The distribution of *S. gambiensis* shrank by about nine stations from around Bintang confluence to Tendaba while *S. intermedius* retreated from Tendaba to around Jurong and Devils points. On the whole, during the survey the highest recording of species occurrence was made in the lower estuary with the exception of Banjul (station 2), and Lamin village (station 5). In this zone the highest was recorded at Lamin point, Chitabong, Mandina bolong, Tabiere creek and Muta point and the bulk of the species that formed this included *P. elongatus*, *I. afrcana, E. fimbriata, S. maderensis*, species of the *Ariidae* family and the crab *Callinectae latimanus*. Climatically, the month of April is considered one of the hottest months in the Gambia with mean atmospheric temperatures reaching up to39.3°C. Results of the present study also characterised that month as a period of weak freshwater discharge into the estuary (Figure 3). Fish samples taken from the estuary in April 2002 indicate ubiquitous distribution of some commercially important species such as *P. elongatus, P. notialis. E. fimbriata* and *Polydactylus quadrifili (POQ), Liza grandisquamis* and *L. Falcipinnis.* It is during this survey that the concentration of species throughout the estuary appears almost even with occurrence in the upper estuary almost equating with those of the lower and mid estuarine zones.

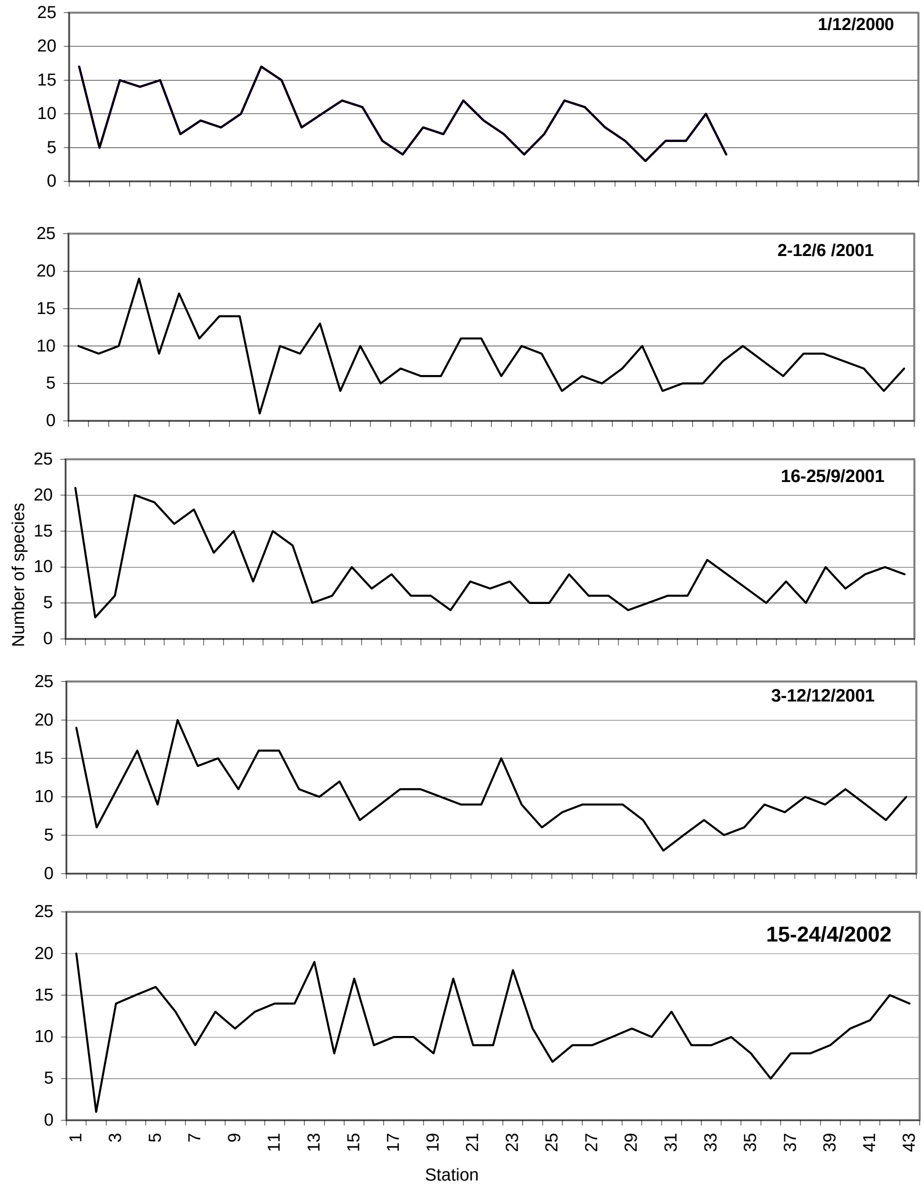

Figure 11: Number of species for each sampling station in the five surveys of the Gambia estuary.

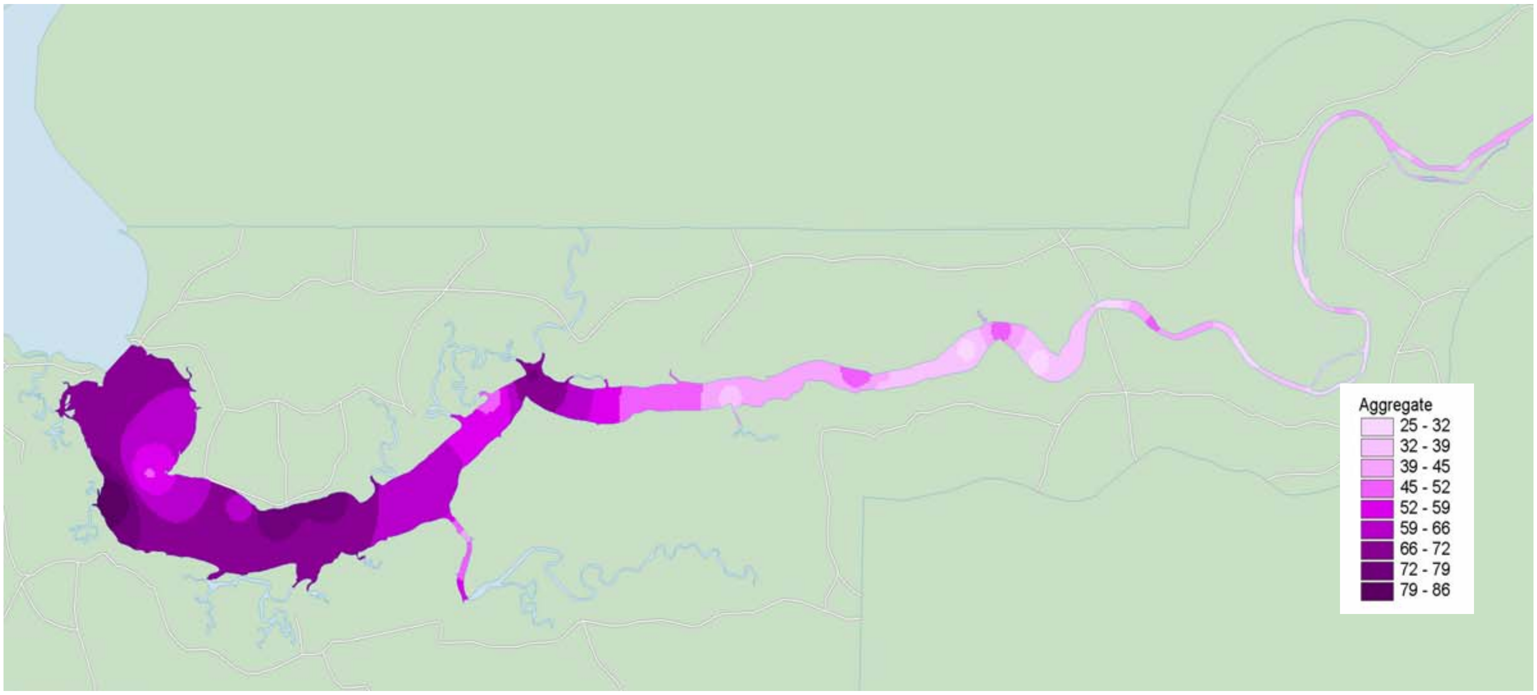

Figure 12: Aggregate number of species recorded at stations during the five surveys, November 2000 to April 2002.

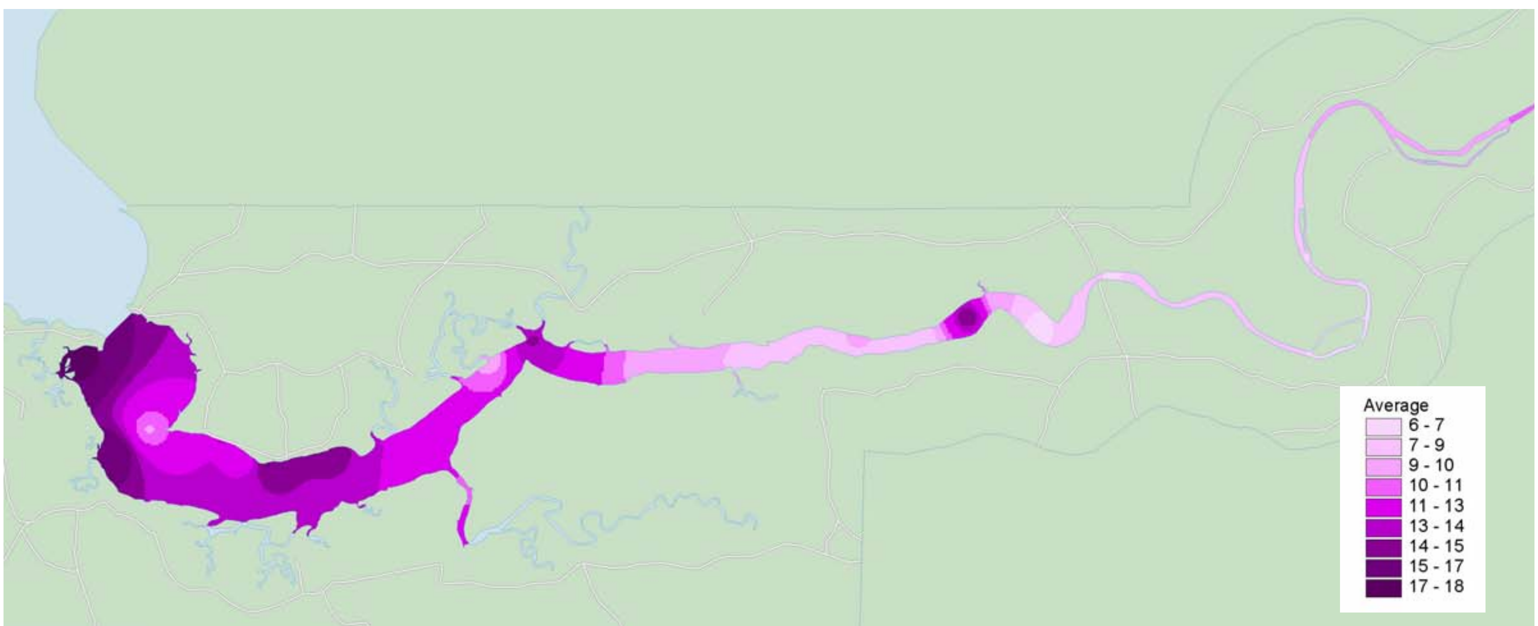

Figure 13: Average number of species recorded at stations during the five surveys, November 2000 to April 2002.

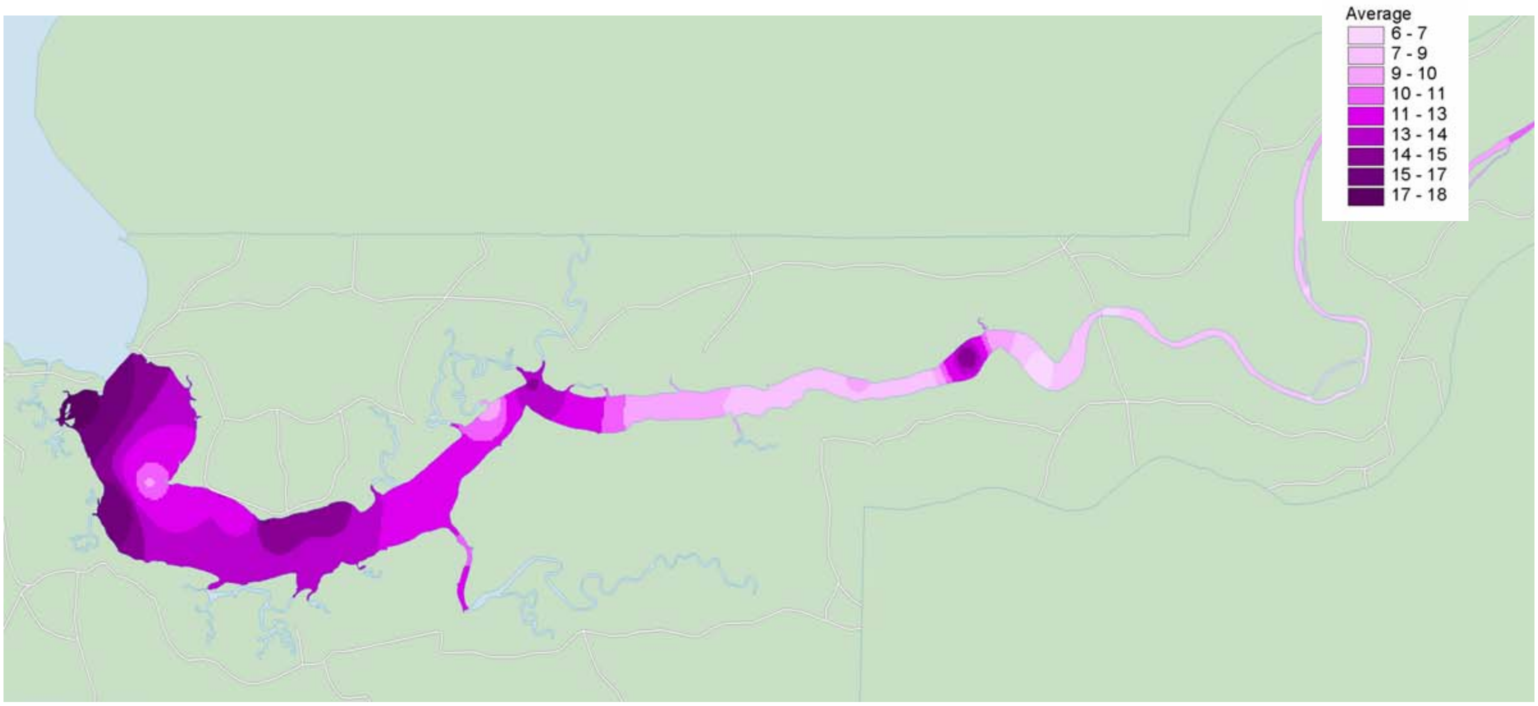

Figure 14: Aggregated number of species at stations during all five surveys.

5 DISCUSSION

5.1 Environmental factors

Higher salinity at the mouth of the Gambia estuary caused by reduction of freshwater sources may impede the entry of larvae and juveniles of many marine species into the estuary, particularly the shrimp (*Penaeus notialis),* to complete their earlier lifecycle processes. Salinities lower than in the adjacent ocean was known to be required by larvae and juveniles of *P. notialis* in maintaining an osmo-regulatory balance with the environment during development (Perkins 1974). After completion of metamorphosis in the estuary, the pre-adult shrimp require a higher salinity for the same osmo-regulatory purpose and therefore move towards the ocean for feeding and growth (Perkins 1974). Higher salinity in the upper estuary than in the lower estuary could direct these movements and the fisheries upstream, which would be tantamount to the oceanic industrial shrimp fishery giving way to the estuarine artisanal fishery. Shrimps are a highly valued fishery product in the Gambia (Fisheries Department) and one of the most important foreign exchange earners per unit volume of product in the country.

Reversal or a similar phenomenon of the estuary may have far-reaching consequences on the finfish community as well. Albaret 1987 reported a fish community in the South Senegalese river of Casamance as having suffered from heavy mortality, adaptation changes, as well as shift from the normal pattern of distribution of species, all resulting from a salinity increase due to a prolonged drought in the region.

Unlike the salinity regime, the water temperature regime in the estuary does not vary much vertically or horizontally. Although a very slight upstream increase is evident, the gradient at all times during the study period appeared quite insufficient to make a direct link to fish species' abundance and distribution patterns (Figure 3). The role of temperature of surface waters is quite important in that it is one of the factors that determines solubility and volume of dissolved oxygen (DO) in water (Perkins 1974). The impact of dependence of oxygen solubility on temperature becomes more important as the range of mean seasonal temperature variations widens that characteristic of temperate regions. However, in tropical regions like the Gambia, where climate and aquatic species are stenothermal (narrow range of temperature variation and tolerance), behavioural response to temperature is often minimal. Water temperature in the tropics would become more of a concern in deep and poorly mixed estuaries in which a less dense surface layer over-lies the denser bottom layer. This formation, referred to as stratification, often results in anoxic conditions in the bottom layer rendering it an unsuitable habitat for fish and other aquatic organisms (Baklashova 1980). Water temperature structure in the Gambia estuary at all times during the study period does not conform to anything near to stratification as both surface and bottom values throughout appear almost equal (the mean difference being only 0.68^{o}C*).*

The greatest opportunity that unstratified water offers is to allow vertical mixing that brings nutrients to the surface to enhance primary productivity. The slight difference in surface and bottom temperatures and dissolved oxygen indicate that the relatively uniform and constant temperature does not influence oxygen concentration. The trends in oxygen concentration appear to be more in response to trends in salinity. The explanation for low oxygen concentration in the tributary of Bintang bolong could be that the tributary in recent years, has suffered massive mangrove die-off, which must have increased the BOD from decomposing organic matter. This is furthermore evidenced by the very low values of transparency in the tributary.

Before closing this section on temperature relations in the Gambia estuary it would be necessary to hypothetically assess the expected scenario of its extreme rise as theoretically assumed in the event of global warming and climate change. The Gambia is one of the countries listed as vulnerable to certain impacts of climate change (Jallow 1995). According to published literature (Izrael 1991), a 1-2°C rise in global air temperature, accompanied by a 10% reduction in precipitation may cause a 40-70% drop in mean annual river run-offs. In the event of the above scenario and according to results of these surveys there may be a complete change in the hydrological and salinity balance of the Gambia estuary, which would in turn affect fish species abundance, composition and distribution. This would be the elaboration of the situation observed from the results of survey 2 in June 2001 when a salinity of 40 ppt was recorded at the mouth of the estuary

The Gambia estuary is nowhere considered eutrophic as indicated by results of the present study. Isolated records of low oxygen readings such as in Bintang bolong tributaries were attributed to high BOD from organic matter decomposition. Conditions in the tributary could reach threshold levels for aquatic organisms in the future particularly if mangrove leaves fall and die-off progressed and accompanied by a rise in mean annual temperatures. Already the oyster fishery had collapsed not only due to due to substrate loss (mangrove roots) but also deteriorating environmental conditions.

There are no recent reports of fish killed due to anoxic conditions in the Gambia estuary. However, in 1993 an urgent alarm was raised in the rural areas of the River Gambia because of the water changing colour to black causing fish kills in the freshwater zone. This prompted an urgent multi-disciplinary scientific investigation in view of finding the root cause of the so-called “strange black water”. The report, produced by the Department of Fisheries, implicated high BOD and anoxia as being the cause after the river had received a large volume of organic-laden surface run-off from a heavy down pour.

5.2 Fish communities

The results of this study have identified salinity as the most important factor affecting the fish community structure in the estuarine system. In terms of the number of different species (species richness), high river discharge and the contraction of the estuary concentrate species at the lower estuary and marine species form the most significant part of the fish community there. On the other hand, during the same period, the increased freshwater character of the mid estuarine zone leaves species of more euryhaline nature in the upper estuary together with some freshwater species, which take advantage of the retreat of ”marine” species to occupy the rich vacant niches. During low discharge periods and expansion of the estuary, distribution becomes more even and the density of species in any particular zone is reduced. In the mid estuarine zone during low discharge periods, species diversity is slightly reduced perhaps due to the retreat of some stenohaline freshwater species. The numbers of spp at stations indicate the highest species richness between stations 19 and 26 during the relatively high discharge period in April at a salinity range of 10- 22 ppt and an average of 16.20 ppt. This falls more within the optimum salinity range and average of typically estuarine species than the lower estuary between stations 1 and 18 where salinity during the same period ranged between 29 and 40 with an average of 29.8 ppt. This could serve as a suitable explanation for the evolution of peaks in the lower estuary.

Total biomass (weight in a unit area) and fish abundance (number of individuals) in the estuary show two distinct identifiable peaks at lower estuarine stations 1-17 (Chitabong bolong and Mandori creek) and mid estuarine stations 17-29 (Mandori Creek to Wale). The former mainly represent species of the family Sciaenidae (*Pseudotholithus elongatus* etc.), Clupeidae (*Ethmalosa fimbriata, Sardinella maderensis*), Pristigastridae (*Ilisha africana*), and Ariidae (*Arius heudoloti* etc), which are pure estuarine species and have a relatively narrow range of salinity tolerance. The latter include species of the family Polynemidae (*Polydactylus quadrifilis*, *Pentanemus quinquarius* etc), Mugilidae (*Liza grandisquamis, L. falcipinnis etc.*), Bagridae (*Chrysichthys nigrodigitatus, C. Maurus and C. Johnelsi*), Mochokidae (*Synodontis gambiensis, Synodontis batensoda*) and Schilbeidae (*Schilbe intermedius*).

6 CONCLUSION

Understanding the fish community structure in the Gambia estuary could be an important tool in the management of the fisheries of the estuary. Despite all the positive attributes in the estuary in terms of species richness, biomass etc., estuarine fisheries remain unattractive to many. The numerous government calls to people to take up fishing did not yield the much-desired results, at least among indigenous Gambians. It is, therefore, a challenging task for the Department of Fisheries to strive to bring about an attitudinal change of people towards fishing. One way to do this, in my view, is to make fishing a more profitable venture. An important element in achieving such a goal is to increase Catch Per Unit Effort by an average estuarine fisherman through mapping of distribution patterns of commercially important species as they relate to time, place and environmental factors. The species occurrence matrix, presented in this study could serve as a prototype for such mapping. Such information would be required in almost every estuarine-related project in the future. The project that immediately comes to mind here was an earlier proposed multi-purpose impoundment project at Bambatenda in the mid estuary by shareholding nations of the river (the Gambia, Senegal and Guinea). It is reasonable to believe that one day, attempts would be made to fulfil this impoundment ambition of our Governments. Therefore, it is urgently necessary on the part of the Department of Fisheries of the Gambia to intensify applied research on the estuary in view of increasing the role the estuary fisheries in the socio-economic development of the country. Under such circumstances, implementation of any future proposal that could be detrimental to continuous development of fish and fisheries of the estuary will be given a second thought.

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APPENDIX : TABLES OF DATA RECORDED

Table 1: Records of environmental factors taken during the survey, 26 November- 01 December 2000.

St. ID	Depth (M)	Secchi (M) T°C	S. T°C	B.T°C	S.Sal. (ppt)	B.Sal. (ppt)
1	7	0.8	25	25	27	
2	8.4	0.43	29.4	29.2	22	20
3	5.7	0.4	25.8	25.3	23	23
5	6.6	0.7	26.5	26.2	17	19
6	4.2	0.8	25	25	18	18
7	5.6	1	24.2	25	15	15
8	5.8	1	25.2	25.1	17	19
9	6.1	0.6	27.4	26	12	15
10	4.7	0.6	25.5	25.4	15	16
11	9.1	0.6	26.5	25.3	7	9
12	6.6	0.6	25.4	25.4	7	9
13	6.6	0.4	25.4	25.4	7	8
14	2.7	0.6	24.3		8	9
15	4.4	0.5	22.6	25.4	3.5	3.5
17	7	0.4	26.4	26	4	
18	4.3	0.6	26	25.2	7	8
19	8	0.2	26	25.9	1.5	
20	5	0.2	25.2	25	1.5	
21	6.7	0	25	24.5	1.5	1.6
22	3.9	0.2	25.2	25.1	1.5	2
23	8.26	0.2	24.8	24.7	0	0
24	5.5	0.2	25.2	25		
25	5.4		26	26		
26	4	0.2	26	26	0	0
27	3	0.2	25.1	24.6	0	0
28	5.9	0.2	25.1	24.6	0	0
29	6.2	0.25	26.1	26	0	0
30	8.9	0.2	25	24.8	0	0
31	11.8	0.2	25	24.8	0	0
32	13.8	0.2	25	24.8	0	0
33	13.8	0.2	25	24.8	0	0
34	8	0.2	25	24.8	0	0
35	5.4	0.25	25.5	25	0	0
38	7	0.2	26	24.9	0	0
39	4	0.2	25.4	25.2	0	0
Mean	6.553143	0.397941	25.49143	25.33529		
SD	1.869127	0.215467	0.698286	0.522145		

Table 2: Records of environmental factors taken during the survey, 2 - 12 June 2001.

Station no.	Depth (M)	Secchi (M)	S. T°C	B.T°C	S.Sal. (ppt)	B.Sal. (ppt)	SOx. (Mg/l)	B.Ox. (Mg/l)
1	6.2	0.7	27.5	27.2	38	38		
2	10.3	1.3	27.5	27.2	38	38		
3	10.2	0.65	26.6	24.6	39	39		
4	2.4	0.45	28.8	28.4	38	38	5.19	5.19
5	8.4	0.4	29.4	29.2	37	38	4.2	4.09
6	8.8	0.75	28.6	28.2	37	37	5.45	4.99
7	9.2	0.47	28.4	27.6	38.5	39	4.9	4.4
8	5.2	0.35	27.4	27.2	39	39	5.24	5.12
9	9.8	0.25	27.8	27.2	39	39	5.48	5.34
10	3.2	0.15	29.1	29.4	34	35	5.5	5.2
11	6.8	0.58	28.8	28.2	37	37	4.81	4.82
12	8.6	0.45	28.6	28.4	37	37	5.25	4.77
14	7.6	0.65	29	28.6	36	36	5.26	4.69
15	3.4	0.85	30.2	29.2	29	30	5.4	5.07
16	7	0.45	28.2	28.5	32.5	33	5.26	4.81
17	4.8	0.65	28.2	28.2	34	34	5.15	5.08
18	7.1	0.55	28.4	28.2	36	35	5.34	5.08
19	4.2	0.4	28.2	27.9	35	36	4.78	4.69
20	5.1	0.7	29.3	29.2	25	26	5.41	5.27
21	6.6	0.55	29.2	28.9	26	28	5.52	5.33
22	9.5	0.5	28.8	28.6	31	31	5.17	5.1
23	2.7	0.3	28.9	28.6	27	28	5.14	5
24	8.4	0.7	29.2	28.8	27.5	29	5.47	5.1
25	9.5	1.5	30.4	29.5	17	19	4.63	4.57
26	5.4	1.05	29.2	29.2	19	20		5.2
27	8.4	1.15	28.9	28.8	26	28	5.28	5.37
28	9.7	1.07	29.2	29.1	25	25	6.59	5.23
29	4.9	0.33	29.4	29.4	22	22	5.85	4.96
30	8.4	1.15	29.8	29.5	17	18	4.56	4.49
31	8.4	1.2	29.9	29.6	14	14	4.9	4.5
32	15.1	0.1	29.6	29.5	19	19	4.5	4.37
33	9.7	1.9	29.5	29.4	17	17.5	4.37	4
34	13.8	1.7	32	29	11	12	5.17	4.29
35	20	1.8	29.4	29.3	16	17.5	4.37	4
36	7.1	1.2	29.7	29.7	13.1	14.4	5.14	3.99
37	7.7	1.45	30	29.7	12	15.5	5.03	3.88
38	7	1.65	28.9	29.2	16	17.5	4.49	4.42
40	5.1	0.7	29.3	29.2	2.5	5	5.71	5.27
41	8.1	1.25	29.2	29.2	4	5	5.56	4.85
42	6.6	1.36	30	28	8	9	5.94	5.4
43	8.8	1.4	29.5	29.6	8	9	6.07	5.25
Mean	7.78837209	0.8444186	29.1279	28.693			5.22641026	4.844
Deviation	2.21135749	0.429324	0.74224	0.729			0.38983563	0.3881

Table 3: Records of environmental factors taken during the survey, 26 November - 01 December 2000.

Station no.	Depth (M)	Secchi (M)	S. T°C	B.T°C	S.Sal. (ppt)	B.Sal. (ppt)	SOx. (Mg/l)	B.Ox. (Mg/l)
1	6.4	1.2	29	29	25	26	4.65	6.04
2	12.1	1.82	29.2	29	24	30	5.29	4.8
3	11.2	1.78	29.9	29.2	23	30	5.26	4.76
4	3.5	1.5	29.9	29.4	21	22	5.21	4.58
5	7.2	0.96	31	29.8	16	18	3.43	2.84
6	8.7	0.72	32	29.5	14	15	4.99	3.36
7	5.1	0.47	29	29.1	15	17	4.3	3.32
8	5.1	0.38	29.1	29	18	18	4.85	4.58
9	8.4	0.79	29.4	29.4	18	22	5.03	4.09
10	4.8	0.55	31.3	29.4	5	8	4.7	3.44
11	6.3	0.48	28.8	28.8	10	11	4.43	3.87
12	8.4	0.37	31.06	30	0	4	3.98	3.64
14	5.9	0.15	29.9	29.2	0	1	4.11	3.56
15	3.9	0.9	28.3	28.2	0	0	4.27	4.23
16	7	0.1	28.9	28.8	0	0	4.5	4.4
17	4.8	0.1	29.1	28.8	0	0	4.58	4.27
18	7.9	0.2	29.1	29	2	1	4.27	
19	4.6	0.9	28.8	28.4	1	1	4.21	4.09
20	4.4	0.12	29.2	28.8	0.2	0.2	4.98	4.91
21	6.3	0.12	29.3	29	0	0	4.59	4.52
22	6.7	0	24.3		1.5	0	4.6	4.4
23	4.1	0.12	29.4	28.9	0	0	4.06	3.89
24	9.6	0.12	29.6	28.9	0	0	4.46	4.42
25	6.3	0.2	29.3	29.2	0	0	4.3	4
26	7	0.17	29.9	29.4	0	0	4.1	4.1
27	5.6	0.17	29.9	29.6	0	0	5.3	4
28	11	0.17	31	29.8	0	0	4.2	3.9
29	12	0.15	29.8	28.8	0	0	4.4	4.4
30	8.8	0.17	23.3	23.1	0	0	4.55	4.62
31	11.2	0.17	29.1	29.4	0	0	4.18	4.17
32	12.8	0.17	29.3	29	0	0	4.4	4.1
33	11.5	0.17	29.8	29.2	0.1	0.1	4.9	4.6
34	14.5	0.2	31	28	0	0	5.17	4.7
35	7.4	0.17	29	27	0	0	4.7	4.8
36	5.2	0.22	29.4	29.2	0	0	5.4	5.42
37	3.7	0.24	29.8	29.3	0	0	5.63	5.55
38	6.3	0.17	29.9	29.2	0	0	4.5	4
39	8	0.17	29.8	29	0	0	3.96	3.9
40	5.5	0.12	29.2	28.8	0	0	4.9	4.9
41	6.4	0.7	32	27	0	0	5.6	5.6
42	5.6	0.3	31	28	0	0	5.96	6.03
43	6.9	0.25	30.2	29.7	0	0	5.6	4.8
Mean	7.33636364	0.4193182	29.5082	28.816			4.71954545	4.43209
Deviation	2.12190083	0.3326756	0.9131	0.6021			0.46719008	0.55722

Table 4: Species occurrence at stations in the Gambia estuary, November - December 2000.

Station number	Station name	Number of species
1	Chitabong bolong	17
2	Banjul	5
5	Lamin Village	15
6	Lamin point	14
7	Sika point	15
8	Bintang bolong	7
9	Bintang confluence	9
10	Tabiere creek	8
11	Muta point	10
12	Suara point	17
13	Swara Island	15
14	Salikeni point	8
15	Tankular	10
16	Jali point	12
18	Tendaba	11
19	Tendaba silo	6
20	Katchang creek	4
21	Bambako	8
22	Kunda mid channel	7
23	Jurong point	12
24	Devils point	9
25	Balingo	7
26	Bamba tenda	4
27	Tambakoto	7
28	Sankwia	12
29	Wale	11
30	Tutenda	8
31	Elephant mouth	6
32	Elephant point	3
33	Bambali	6
34	Elephant Jassong	6
35	Sofanyama	10
36	Sambang	4

Table 5: Species occurrence at stations in the Gambia estuary, June 2001.

Station number	Station name	Number of Species
1	Chitabong bolong	21
2	Banjul	3
3	Dog Island	6
4	Mandina bolong	20
5	Lamin village	19
6	Lamin point	16
7	Sika point	18
8	Bintang bolong	12
9	Bintang confluence	15
10	Tabiere creek	8
11	Muta point	15
12	Suara point	13
13	Suara Island	5
14	Salikeni point	6
15	Tankular	10
16	Jali point	7
17	Mandori creek	9
18	Tendaba	6
19	tendaba silo	6
20	Katchang creek	4
21	Bambako	8
22	Kunda mid channel	7
23	Krule point	8
24	Devels point	5
25	Balingo	5
26	Bambatenda	9
27	Tambakoto	6
28	Sankwia	6
29	Wale	4
30	Tutenda	5
31	Elephant mouth	6
32	Elephant point	6
33	Bambali	11
34	Elephant jassong	9
35	Sofanyama	7
36	Sambang	5
37	Seahorse Island (mouth)	8
38	Seahorse Island (upper)	5
39	Balangar	10
40	Bantanto creek	7
41	Papa Island	9
42	Carols wharf	10
43	Deer Island	9

Table 6: Species occurrence at stations in the Gambia estuary, September 2001.

Statation Number	Station Name	Number of spp
1	Chitabong bolong	20
2	Banjul	1
3	Dog Island	14
4	Mandina bolong	15
5	Lamin village	16
6	Lamin point	13
7	Sika point	9
8	Bintang bolong	13
9	Bintang confluence	11
10	Tabiere creek	13
11	Muta point	14
12	Suara point	14
13	Swara Island	19
14	Salikeni point	8
15	Tankular	17
16	Jali point	9
17	Mandori creek	10
18	Tendaba	10
19	Tendaba silo	8
20	Katchang creek	17
21	Bambako	9
22	kunda mid channel	9
23	Jurong point	18
24	Devils point	11
25	Balingo	7
26	Bamba tenda	9
27	Tambakoto	9
28	Sankwia	10
29	Wale	11
30	Tutenda	10
31	Elephant mouth	13
32	Elephant point	9
33	Bambali	9
34	Elephant Jassong	10
35	Sofanyama	8
36	Sambang	5
37	Seahorse Island (mouth)	8
38	Seahorse Island (upper)	8
39	Balangar	9
40	Bantanto creek	11
41	Papa Island	12
42	Carrols wharf	15
43	Deer Island (Mouth)	14

Table 7: Species occurrence at stations in the Gambia estuary, December 2000.

Station number	Station	Number of species
1	Chitabong	10
2	Banjul	9
3	Dog Island	10
4	Mandina Bolong	19
5	Lamin Village	9
6	Lamin point	17
7	Sika point	11
8	Bintang bolong	14
9	Bintang confluence	14
10	Tbaiere creek	1
11	Muta point	10
12	Suara point	9
13	Swara Island	13
14	Salikeni point	4
15	Tankular	10
16	Jali point	5
17	Mandori creek	7
18	Tendaba	6
19	Tendaba silo	6
20	Katchang creek	11
21	Bambako	11
22	Kunda mid channel	6
23	Jurong point	10
24	Devils point	9
25	Balingo	4
26	Bamba tenda	6
27	Tambakoto	5
29	Wale	7
30	Tutenda	10
31	Elephant mouth	4
32	Elephant point	5
33	Bambali	5
34	Elephant Lassong	8
35	Sofanyama	10
36	Sambang	8
37	Seahorse Island (mouth)	6
38	Seahorse Island (upper)	9
39	Balangar	9
40	Bantanto creek	8
41	Papa Island	7
42	Carrols wharf	4
43	Deer Island Mouth	7

Table 8: Species occurrence at stations in the Gambia estuary, April 2002.

Statation number	Station	Number of Species
1	Chitabong bolong	19
2	Banjul	6
3	Dog Island	11
4	Mandina bolong	16
5	Lamin village	9
6	Lamin point	20
7	Sika point	14
9	Bintang confluence	15
10	Tabiere creek	11
11	Muta point	16
12	Suara piont	16
13	Swara Island	11
14	Salikeni point	10
15	Tankular	12
16	Jali point	7
17	Mandori creek	9
18	Tendaba	11
19	Tendaba silo	11
20	Katchang creek	10
21	Bambako	9
22	Kunda mid channel	9
23	Krule point	15
24	Devils point	9
25	Balingo	6
26	Bambatenda	8
27	Tambakoto	9
28	Sankwia	9
29	Wale	9
30	Tutenda	7
31	Elephant Mouth	3
32	Elephant point	5
33	Bambali	7
34	Elephant Jassong	5
35	Sofanyama	6
36	Sambang	9
37	Seahorse Island (mouth)	8
38	Heahorse Island (upper)	10
39	Balangar	9
40	Bantanto creek	11
41	Papa Island	9
42	Carols wharf	7
43	Deer Island	10

Table 9: List of fish epecies found in the Gambia estuary during the period November/December 2000 to April 2002.

Family	Species	FAO/Personal code
Gobiidae	Acentogobius schlegelii	ACS
Characidae	Alestes baremose	ABA
Ariidae	Ariu latiscuttatus	AGA
Ariidae	Arius hedeuloti	AHE
Ariidae	Arius parkii	ARP
	Batrachoides liberiensis	BLI
	Big-claw shrimp (undetermined)	
Eleotridae	Bostrichus africanus	HAF
Haemulidae	Brachydeuterus auritus	BAU
Characidae	Brycinus nurse	BNU
	Callinectes latimanus	CAA
Carangidae	Caranx hippos	CHI
Carangidae	Caranx senegallus	CSE
	Cer? mal?	
	Ces. mel?	
	Chaetodipterus lippei	CLI
Carangidae	Chloroscombrus chrysurus	CHL
Bagridae	Chrusichthys maurus	CWA
Bagridae	Chrysichthys johnelsi	CJO
Bagridae	Chrysichthys nigrodigattus	CNI
Bothidae	Citarichthys stampfilii	CST
Claire	Clarias anguilaris	CLS
Cynoglossidae	Cynglossus senegalensis	CYS
Dasyatidae	Dasyatis magarita	DMA
Dasyatidae	Dasyatis ukpam	DUK
Monodactylidae	Drepane africana	DAF
Clupeidae	Ehtmalosa fimbriata	EFI
Elopidae	Elops lacerta	ELA
Tetraodontidae	Ephipion guttifer	EGU
Polynemidae	Galeodes decadactylus	GDE
Gerreidae	Gerres melanopterus	GEM
Gerreidae	Gerres nigri	GNI
	Gymnura micrura	GYM
Carangidae	Hemicaranx bicolor	HBI
Mormyridae	Heperopisius bebe occidentalis	HBO
Characidae	Hydrocynus brevis	HYB
Pristigastridae	Ilisha africana	IAF
Carangidae	Lichia amia	LAM
Mugilidae	Liza grandisquamis	LGR
Mugilidae	Liza falcipinis	LFA
Monodactylidae	Monodactytus sebae	PSB
Mormyridae	Mormyrops angiulloides	MAN
Mugilidae	Mugil bananensis	MBA
Mugilidae	Mugil cephalus	MCE
	Nematopalaemon hastatusNEH	NEH
Penaeidae	Parapenaeopsis attanticus	PAT
Clupeidae	Pellonua leonensis	PEF
	Pen. gui.	
Penaeidae	Penaeus monodo	PMO
Penaeidae	Penaeus notialis	PDU
Polynemidae	Pentanemus quinquarius	PQQ
Sciaenidae	Pesudotholithus elongatus	PEL
Ophichthyidae	Pisodonophis semicinotus	PIS

Haemulidae	Plectorhinchus macrolepis	PLM
Polynemidae	Polynemus quadrifilis	POQ
Haemulidae	Pomadasys jubelini	PJU
Haemulidae	Pomadasys peroteti	POP
Sciaenidae	Psedotholithus brachygnatus	PBR
Sciaenidae	Pseudotholihtus senegalensis	PSN
Sciaenidae	Pseudotholithus typus	PTY
	Pterocion peli	PPE
Clupeidae	Sadinella maderensis	SEB
Cichlidae	Sarotherodon melanotheron	THE
Shilbeidae	Schilbe intermedius	SIN
	Sepia	
Sphyraenidae	Sphyraena afra	SPA
Sphyraenidae	Sphyraena guachancho	SGU
	Squilla sp	
Belonidae	Strongyla senegalensis	SSE
Soleidae	Synaptura cadenati	SCA
Mochokidae	Synodontis batensoda	BBA
Mochokidae	Synodontis gambiensis	SYG
Cichlidae	Tilapia guineensis	TGU
Carangidae	Trachinotus maxillosus	TMA
Carangidae	Trachinotus teraia	TFA
	Tri. marga.	
Trichiuridae	Trichiurus lepturus	TLE
Cichlidae	Tylochromis jentinki	THE
	UCA crab	
Sciaenidae	Umbrina ronchus	URO