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JCBPS; Section B; February 2019 – April 2019, Vol. 9, No. 2; 201-215, E- ISSN: 2249 –1929
[DOI: 10.24214/jcbps.B.9.2.20115.]

Journal of Chemical, Biological and Physical Sciences

An International Peer Review E-3 Journal of Sciences

*Available online at*www.jcbsc.org

Section B: Biological Sciences

CODEN (USA): JCBPAT Research Article

Demersal fish assemblages of trawlable grounds in the Côte d'Ivoire continental shelf (West Africa)

Kouadio Fréderic KOUAKOU[1,2], Soumaïla SYLLA[1]*, Stanislas Silvain Yao[2], & Stanislas Arra[3]

[1] Centre de Recherches Océanologiques (CRO), B.P.V 18 Abidjan, Côte d'Ivoire, Fax (225) 21 35 11 55
[2] UFR Biosciences, Université Félix Houphouët Boigny Abidjan, 22 B.P. 582 Abidjan 2, Côte d'Ivoire

[3] UFR SGE Université Nangui Abrogoua, Laboratoire d'Environnement et de Biologie Aquatique; 02 BP 801 Abidjan 02, Côte d'Ivoire

Received: 06 **February** 2019**; Revised:** 12 February 2019; **Accepted:** 18 February 2019

Abstract: Data from bottom trawl surveys off Côte d'Ivoire were analysed to examine patterns on Côte d'Ivoire's continental shelf of groundfish assemblage structure and diversity in relation to depth. The 31 hauls from the shelf surveys spanned between 10 and 100 m in depth. A total of 82 demersal fish species belonging to 44 families were caught. Based on Classification and ordination method, fish fauna can be grouped into three assemblages: shallow, intermediate and deep assemblage. Assemblage I (Shallow) comprises the strata with depths 10 and 25 m include *Selene dorsalis, Pseudotolithus senegalensis, Trichiurus lepturus and Grammoplites gruveli.* Assemblage II (intermediate) includes the strata with depths between 25 and 50 m, characterised by *Pagellus bellottii, Epinephelus aeneus, Raja miraletus* and *Grammoplites gruveli*. Assemblage III (deep shelf) contains the depth strata between 50 and 100 m, characterised by *Pagellus bellottii, Pseudupeneus prayensis, Selene dorsalis, Raja miraletus and Grammoplites gruveli*. *Grammoplites gruveli and Raja miraletus* was relatively abundant throughout the depth range sampled. The stratum of 25 to 50 m appeared to be a transition zone between shallow and deep shelf fish fauna. Different statistics were used to assess diversity of the demersal fish assemblages on the continental shelf.

The analysis of bottom trawls revealed that, in general, species diversity, richness and evenness more or less uniform at shallow and deep shelf but marked at intermediate shelf.

Keywords: Demersal fish, Community structure, Indices of diversity, Continental shelf, Côte d'Ivoire.

1. INTRODUCTION

In fisheries, defining the aggregation of species in the ecosystem is the basis for managing species by the management unit approach [1]. Even though most of the research is focused on stock assessment, descriptions of fish communities have been made, both of the fish assemblages [2, 3] and of the human impact on these [4,5,6].The structure of species assemblages for several exploited fish stocks around the world has been established. Examples are in the northern Alboran Sea (western Mediterranean) [7] in the central Mediterranean sea [8]; Congo, Gabon and Angola in south-west Africa [9], Faroe Bank [10], central and Southern California [11]. Although, information on demersal fish assemblages is particularly scarce in the Gulf of Guinea, where demersal fish are heavily exploited as principal targets or as by-catch. The Gulf of Guinea is a very important area for fisheries. Artisanal fisheries have traditionally dominated the area and this is still the case, with over 70% of the catch coming from the artisanal sector [12], however, the impact of industrial fleets in the area is increasing [13]. A number of foreign fleets have been present in these waters on a large scale since the 1960's, most notably from the European Union, Korean Republic, Japan, Russia and ex-eastern bloc countries. European countries represent the largest fleet in the region and have fishing agreements with many of the nations [12]. Understanding the natural dynamics of this region is, therefore, of vital importance if the fisheries resources of this productive area are to be sustainably managed and not exhausted as with so many other fish populations throughout the world. Côte d'Ivoire's, coastal demersal resources of the continental shelf are subjected to an intensive fishery carried out by trawl, gillnet and longline fleets whose effects on the marine community as a whole are poorly understood. The gillnets and longlines catch a small number of species, whereas the trawl fleet exploits a multi-species fishery targeting several demersal and benthic species. These resources are exploited by artisanal and industrial fleets (national and foreign).

Integrated assessment of fisheries requires studies that focus on the whole ecosystem and not only on single species, and that consider fishing activities as key pressures affecting several ecosystem components [14]; [15]. Therefore, it is highly necessary to develop studies like these, which identify the components, assemblage structure and functioning of ecosystems at a regional scale like Gulf of Guinea.Recent work has demonstrated changes in species composition and size structure of demersal fish communities in response to fishing [16]; [17]. It appears that a key challenge is to incorporate ecosystem objectives within fisheries management including measurable indicators such as ecosystem diversity, species diversity and ecologically depended species [18]. Despite the ecological and economic interest of the region, from the Gulf of Guinea there is a lack of studies on demersal fishes, with the exception of a few studies dating a since some ten years ago.

The intention of this paper is to give a general description of the demersal fish assemblages on the continental shelf off Côte d'Ivoire including species composition and interactions, as well as diversity.

2. MATERIAL AND METHODS

2.1 Study area and sampling procedure: The Ivorian oceanic zone is bordered to the north by the Gulf Of Guinea shoreline stretching from the Cape of Palmes (7°30W) and the Cape of Three Points (2° W).

The shoreline is 566 km long and is characterized by a series of beaches forming a wide arch opened to the Atlantic Ocean. The continental shelf, with an area of 12 000 km², has two types of bottom sediments, sandy bottoms in the eastern part and rocky bottoms in the western part. It is narrow, with a width that varies between 9 and 18 miles, with a mean of 13 miles**.**

The study is based on a set of abundance indices estimated along the continental shelf off Côte d'Ivoire (Figure 1). The study area included Côte d'Ivoire continental shelf between 10 m and 100 m depth, stratified in three depth strata. Data collected from a bottom trawl survey performed over the continental shelf off Côte d'Ivoire within the framework of the UEMOA PRESH project are analysed. A total of 31 hauls were taken during experimental bottom trawl survey cruise during ten days from March to April 2015. For survey, a single randomly stratified design was used, based on depth (bathymetry). The study area was divided into three depth strata: 10 - 25; 25 - 50 and 50-100 m according to traditional fishing grounds. Locations of sample units were selected randomly within each stratum. Allocation of hauls in each depth strata was roughly proportional to the surface of the corresponding stratum. The hauls were carried out during daylight hours on board of the research vessel R/V ‘‘Général Lansana Conté" (length: 29.93 m; engine power: 750 CV), with an average towing speed of 3 knots. The standard device was a bottom trawl with 25 mm cod-end mesh size (stretched mesh).The horizontal and vertical openings of the net (16 m and 2 m on average, respectively). During the survey, the catch from each haul was identified to species level, and each species was enumerated and weighed separately on board. A part of the catch was frozen or preserved in formalin for later study. Specimens were identified on board following the nomenclature reported in [19]; [20].and [21].

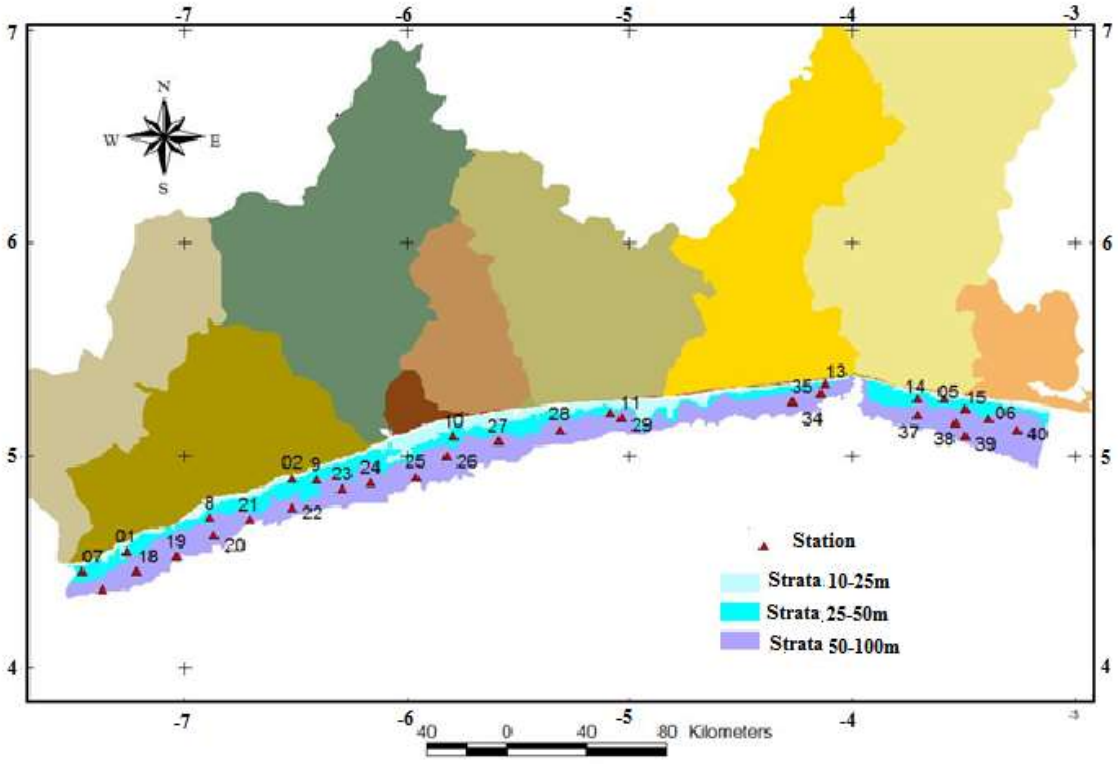


Figure1: Sampling stations on the continental shelf of the study area

2.2 Data analysis

2.2.1 Ecological diversity indices: We analysed groundfish diversity separately on the basis of three bathymetric strata: the coastal strata (ranging from 10 to 25 m; 4 hauls), the middle strata (ranging from

25 to 50 m; 9 tows) and the deeper strata (ranging from 50 to 100 m; 18 hauls). Otherwise, each of these three strata were characterized by a specific species composition in ground fishes [22]. Species abundances were calculated for each haul after standardization of the data to a 30.min $^{-1}$, making it possible to allow comparisons between sampling stations. Those species regarded as markedly pelagic in behaviour were excluded from the analyses, since they had not been quantitatively sampled. For each of these three bathymetric strata, we investigated the diversity patterns of demersal fish assemblages through the analysis of four ecological parameters of abundance, number of species (*S*), species diversity, Shannon-Wiener index [23]:

$$H' = -\sum_{i=1}^{s} Pi \times \log_2 Pi$$

species richness [24]:

$$d = \frac{(S-1)}{\log N}$$

evenness [25]:

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

and dominance, Simpson's index[26]:

$$\lambda = \sum_{i=1}^{s} p_i^2$$

They were calculated for each of the station-groups defined by cluster analysis, where P_i = proportion of total sample belonging to *i*th species, N = the number of individuals of the entire sample and H_{max} = log (*S*).

2.2 Demersal assemblage structure: Prior to the cluster analysis, species with pelagic behaviour were removed. In order to identify the different assemblages of demersal fish, multivariate analyses were performed after species removal and accidental species present in less than 4 tows (frequency of occurrence less than 10%, [27]. All the above criteria enabled to work with 38 species belonging to 26 families.

To identify zonation patterns cluster analysis was applied to the species abundance matrix. Cluster analysis (group average), employing the Bray-Curtis similarity index [28], was applied to the standardized abundance values of the species using the PRIMER algorithms (Plymouth Marine Laboratory). In order to normalize the data and avoid skew, a fourth-root transformation was applied to the abundance data prior to cluster analysis [28]. Non-metric Multidimensional scaling (MDS) ordination analysis was also performed with the same configuration as in cluster analysis with respect to similarity index and transformation. The stress value (s) of the MDS ordination indicates excellent representation (s < 0.05), good ordination (s <0.1), still useful ordination (s<0.2) or close to arbitrariness (s >0.3). The interpretation was supported by cluster analysis (group average) on identically transformed data. The typifying and discriminating species of the cluster of stations were determined using the SIMPER procedure [29]. This procedure indicates the average contribution (% Cum.) of each species to the similarity (typifying species) and dissimilarity (discriminating species) between groups of samples. The observed community differences between depth ranges were tested using an analysis of similarity

randomization test (ANOSIM) [29]. Variation in species relative abundance was also examined by using the graphical representations of species cumulative frequency distributions (k-dominance curves) [30].

3. RESULTS

3.1. Overall catch

A total of 82 demersal fish species belonging to 44 families were collected from 31 trawls and are listed in Table 1. 38 species were found at depths less than 25 m, as were 46 and 59 species respectively in the bathymetric range of 25 - 50 m and 50 - 100 m from the continental shelf. *S. dorsalis* was the most abundant species in the three strata (Table 1), followed by *P. bellottii* in two of the three strata. At depth ranging from 10 to 25 m the dominant species were *S. dorsalis* (37%), *Pteroscion peli* (10%) and *P. senegalensis* (9%). In the middle strata (ranging from 25 to 50 m) the dominant species were *P. bellottii* (24 %), *Decapterus punctatus* (22 %) and *Selene dorsalis* (13 %). In the deeper strata (ranging from 50 to 100 m), *Priacanthus arenatus* (40 %), *Dentex angolensis, S. dorsalis (15*%) *and P. bellottii* (11%) were the most abundant fish species. The deeper strata showed the highest total abundance (39 184 ind. 30 mn^{-1}) followed by middle strata (9 117 ind.30 mn^{-1}), and Coastal strata (801 ind. 30 mn^{-1}).

Table 1: List of demersal fish species arranged by families, indicating the number of individuals collected, depth (m) of capture.

Family	Species	Depth		
		10 – 25 m	25 – 50 m	50 – 100 m
ANTENNARIIDAE	*Antennarius senegalensis*	0	37	0
ARIIDAE	*Arius heudelotii*	7	0	1
ARIOMMATIDAE	*Ariomma bondi*	0	0	290
BALISTIDAE	*Balistes capriscus*	41	17	13
BATRACHOIDIDAE	*Batrachoides liberiensis*	0	4	4
	Halobatrachus didactylus	0	0	27
BOTHIDAE	*Arnoglossus imperialis*	0	0	7
	Bothus podas	8	7	0
CARANGIDAE	*Decapterus punctatus*	3	2030	124
	Selene dorsalis	294	1214	5752
CHAETODONTIDAE	*Chaetodon hoefleri*	0	2	32
	Chaetodon marcellae	0	0	13
CITHARIDAE	*Citharus linguatula*	0	0	52
CYNOGLOSSIDAE	*Cynoglossus canariensis*	6	49	39
	Cynoglossus monodi	5	68	329
	Cynoglossus senegalensis	1	69	52
DACTYLOPTERIDAE	*Dactylopterus volitans*	0	24	49
DASYATIDAE	*Dasyatis margarita*	1	19	0
	Dasyatis marmorata	0	11	0
DIODONTIDAE	*Chilomycterus reticulatus*	0	2	1
DREPANEIDAE	*Drepane africana*	30	10	0
EPHIPPIDAE	*Chaetodipterus goreensis*	1	0	0
EPHIPPIDAE	*Chaetodipterus lippei*	3	0	0

FISTULARIIDAE	*Fistularia petimba*	14	690	273
HAEMULIDAE	*Pomadasys jubelini*	7	20	0
	Pomadasys rogeri	0	17	0
HOLOCENTRIDAE	*Sargocentrodon hastatus*	0	4	0
LETHRINIDAE	*Lethrinus atlanticus*	1	0	0
MALACANTHIDAE	*Branchiostegus semifasciatus*	0	0	9
MORIDAE	*Laemonema laureysi*	2	0	0
MULLIDAE	*Pseudupeneus prayensis*	36	172	2121
MURAENESOCIDAE	*Cynoponticus ferox*	0	4	8
OPHIDIIDAE	*Brotula barbata*	0	5	17
PARALICHTHYIDAE	*Citharichthys stampflii*	0	30	734
	Syacium micrurum	9	62	99
PLATYCEPHALIDAE	*Grammoplites gruveli*	9	295	120
POLYNEMIDAE	*Galeoides decadactylus*	36	584	0
	Pentanemus quinquarius	9	0	0
PRIACANTHIDAE	*Priacanthus arenatus*	0	42	15233
PSETTODIDAE	*Psettodes belcheri*	1	0	0
RAJIDAE	*Raja miraletus*	8	130	244
SCIAENIDAE	*Pentheroscion mbizi*	0	0	50
	Pseudotolithus epipercus	1	0	0
	Pseudotolithus senegalensis	72	174	7
	Pseudotolithus typus	22	0	0
	Pteroscion peli	79	504	0
	Unbrina canariensis	0	10	593
SCORPAENIDAE	*Pontinus accraensis*	0	0	3
	Scorpaena laevis	0	0	9
	Scorpaena maderensis	0	1	0
	Scorpaena stephanica	0	0	2
SERRANIDAE	*Epinephelus aeneus*	8	14	4
	Mycteroperca rubra	1	1	0
	Rypticus saponaceus	2	0	0
	Serranus accraensis	0	42	95
	Serranus cabrilla	0	0	51
SOLEIDAE	*Dicologoglossa cuneata*	0	0	3
	Dicologoglossa hexophthalma	0	0	12
	Solea hexophtalma	0	0	4
SPARIDAE	*Boops boops*	0	0	505
	Dentex angolensis	6	72	5876
	Dentex barnardi	0	0	30
	Dentex canariensis	0	3	250
	Dentex congoensis	0	0	10
	Dentex filosus	24	0	9
	Pagellus bellottii	34	2177	4215
	Sparus caeruleostictus	10	44	172
SYNODONTIDAE	*Saurida brasiliensis*	0	0	190

	Synodus saurus	1	0	0
	Trachynocephalus myops	0	1	7
TETRAODONTIDAE	*Ephippion guttifer*	6	6	0
	Sphoeroides spengleri	0	1	19
TORPEDINIDAE	*Torpedo torpedo*	0	58	7
TRIAKIDAE	*Mustelus mustelus*	0	0	12
TRICHIURIDAE	*Trichiurus lepturus*	3	365	830
TRIGLIDAE	*Trigla gabonensis*	0	10	4
	Trigla lyra	0	16	536
	Trigla spp	0	0	20
URANOSCOPIDAE	*Uranoscopus albesca*	0	0	1
	Uranoscopus polli	0	0	10
ZEIDAE	*Zeus faber*	0	0	5
Total 44	82	801	9 117	39 184

3.2. Demersal fish assemblages: The cluster analysis showed a depth-dependent grouping pattern. Classification of the trawl catch data in terms of species abundance revealed the existence of three groups associated with the continental shelf **(Figure 2).** Those groups appeared at a similarity level of 40%. Based on cluster analyses, the fish fauna on the Côte d'Ivoire continental shelf falls into 3 assemblages: a shallow, a deeper and an intermediate assemblage in-between. The first correspond of samples taken the stations covering the depth range between 10 and 50 m. This assemblage (group I) includes two and four stations from depths between 10 to 25 m and 25 to 50 m respectively in two zones. It was from Tabou to Sassandra (five stations) and Sassandra to Abidjan (one station).

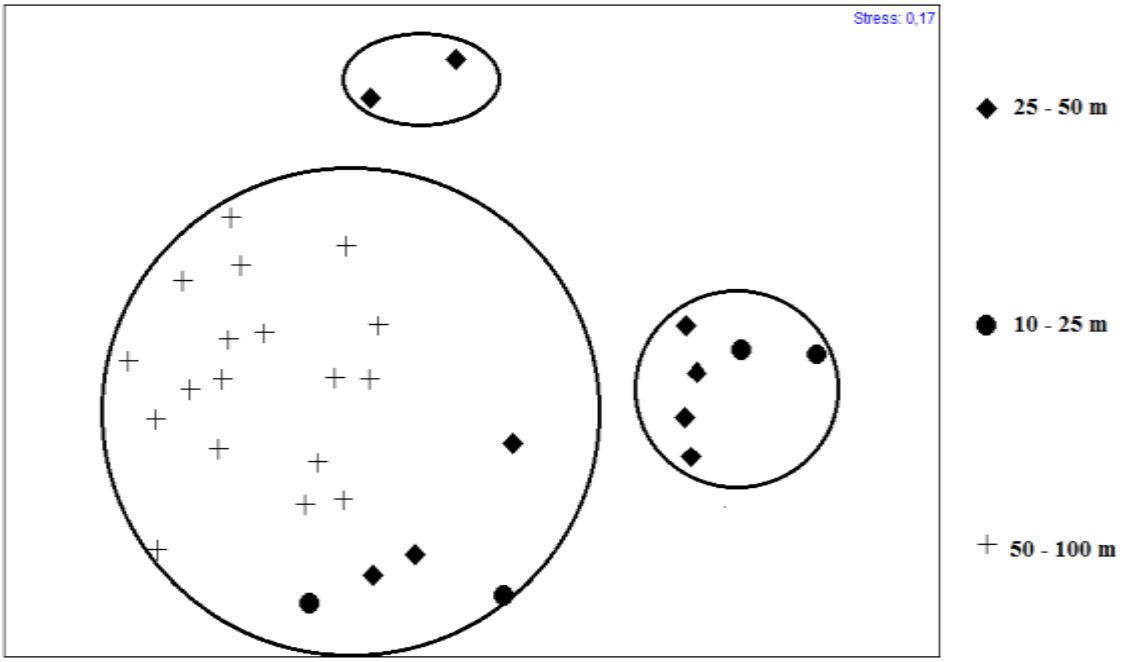
The second concerned three stations covering the depth range between 25 and 50 m. This assemblage (group II) includes three stations in two zones from Sassandra to Abidjan (two stations) and Abidjan to Assinie (one station).

A third group was made up of the stations investigated between 50 and 100 m in all three areas or zones. This assemblage (group III) includes 22 stations: 18 stations covering the depth range between 50 and 100 m; three stations covering the depth range 25 - 50 m and one station to 10 - 25 m depth. The stress value 0.2 indicated that the ordination was sufficiently consistent to infer useful results [31].

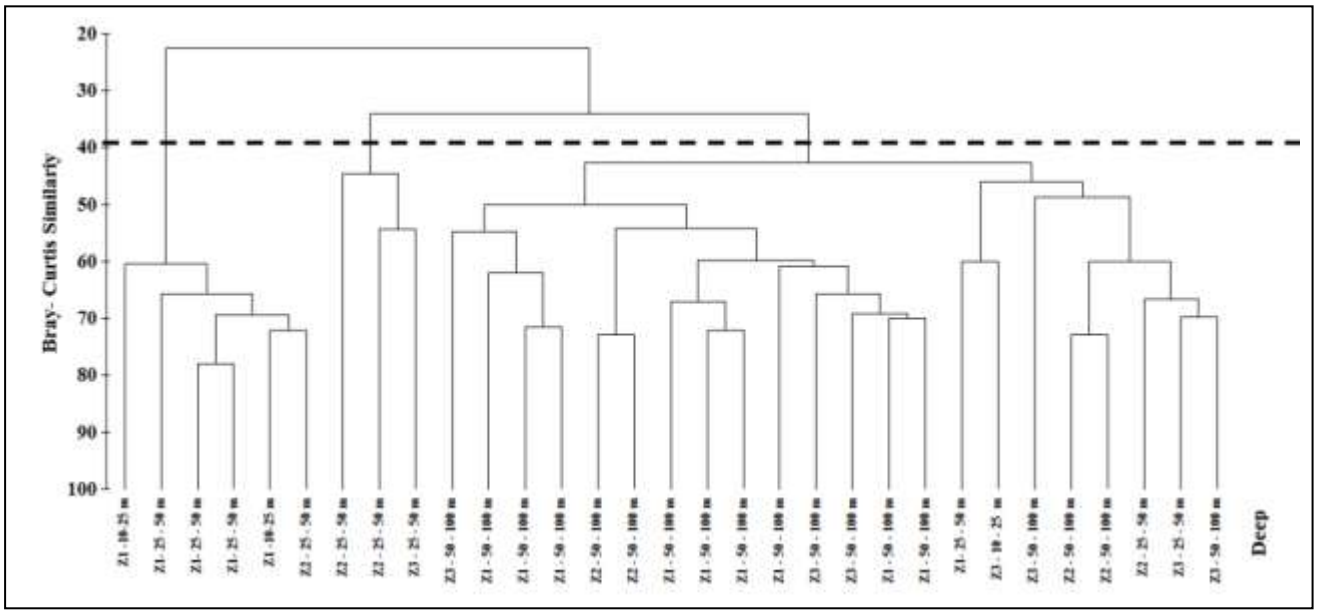
In the area, MDS showed two not well-defined assemblages that basically aggregated as a function of the strata bathymetric. Each assemblage is formed by the hauls made on at all depths strata **(Figure 2)**.The MDS plot did not show high separation (degree of dissimilarity) among the assemblages.

The results of the SIMPER analysis revealed the most important species contributing to the similarity among group. A relatively small number of species contributed most to the similarity of each group, but their relative abundances varied between adjacent groups (i.e. groups I-II, **Table 2**).The group I was characterised by *S. dorsalis, G. decadactylus, P. senegalensis, P. peli, D. africana, T. lepturus, R. miraletus, C. monodi, P. jubelini* and *G gruveli* which contributing to 91.05 % of the average similarity of 66.16 for this group. In The group II, middle shelf assemblage, *P. bellottii, C. monodi, E. aeneus, R. miraletus* contributed 75% of the similarity between samples. *P. bellottii , P. prayensis ,D. angolensis, S. dorsalis , R. miraletus, G. gruveli , B. podas, C. linguatula, B. boops, T. lyra* and *S. caeruleostictus* were the key species contributing 90 % to the average similarity of 49,00 within the group III, deeper shelf assemblage. However, some of those dominant taxa in group I such as, *C. monodi, R. miraletus* were species provided the major contribution for defining the assemblages at depths for group II. Examination

of the species that dominated in each group and contributed highly to the similarity indicates that most of the species presented a wide distribution range, implying that species differences between each group are quantitative rather than qualitative. Some species appeared in all the groups, although with very different abundances. This was the case for *G. gruveli* and *R. miraletus*, since both had a wide bathymetric distribution range.



(a)



(b)

Figure 2(a): Cluster dendrogram of Bray-Curtis similarity for 31 coastal locations sampled.Cut-off level is indicated by dashed horizontal line; Z1: from Tabou to Sassandra'zone ; Z2: from Sassandra to Abidjan'zone ; Z3 : from Abidjan to Assinie'zone. **(b):** Non-parametric multidimensional scaling ordination plot (Bray-Curtis similarity) with cluster groups

Table 2: Dominant fish species by area based on abundance rank for each station group identified by cluster analysis over all samples in each group. % Cum: average contribution to the similarity in each group.

Species	Av.Abund	Av.Sim	Contrib%	Cum.%
Group coastal shelf (I): Average similarity= 66.16				
Selene dorsalis	199.33	12.02	18.17	18.17
Galeoides decadactylus	78.33	9.82	14.85	33.02
Pseudotolithus senegalensis	40.33	7.81	11.8	44.82
Pteroscion peli	97.17	7.3	11.03	55.85
Drepane africana	6.47	4.53	6.85	62.7
Trichiurus lepturus	61.17	4.12	6.23	68.92
Raja miraletus	7.83	4.04	6.11	75,03
Cynoglossus monodi	9.33	3.9	5.89	80.92
Pomadasys jubelini	3.67	3.88	5.86	86.78
Grammoplites gruveli	37.83	2.82	4.26	91.05
Group middle shelf (II) Average similarity: 47.90				
Pagellus bellottii	24.67	12.32	25.73	25.73
Cynoglossus monodi	5.67	10.2	21.29	47.02
Epinephelus aeneus	2	8.21	17.14	64,16
Raja miraletus	19.33	5.09	10.62	74.78
Grammoplites gruveli	11.67	3,83	7.99	82.77
Bothus podas	2.33	3.77	7.88	90.65
Group deeper shelf III : Average similarity= 49.00				
Pagellus bellottii	288.73	9.62	19.63	19.63
Pseudupeneus prayensis	105.73	8.36	17.06	36.69
Dentex angolensis	267.09	7.45	15.2	51.89
Selene dorsalis	247.77	4.91	10.02	61.91
Raja miraletus	12.59	3.48	7.11	69.02
Grammoplites gruveli	7.36	3.01	6.15	75.17
Bothus podas	23.32	1.89	3.86	79.04
Citharus linguatula	33.36	1.68	3.44	82.47
Boops boops	22.95	1.48	3.03	85.5
Trigla lyra	24.95	1.25	2.54	88.04
Sparus caeruleostictus	8.59	1.02	2.07	90.12

Av.Abund : average abundance; Av.Sim :average similarity; Contrib: contribution; Cum. : cumulative

Analysis of similarity (ANOSIM) revealed that for the global test of three depth strata, there were statistically significant differences within structure from the assemblage between these site (Global R= 0.835 p< 0.001). Similarly values of R (slightly higher, at 0.96 and 0.92) for the Group I versus Group II and Group I versus Group III comparisons, contrasted with a lower value (of 0.68) for Group II versus Group III, imply that the explanation for the global test result is that Group II differs from both Group I and Group III, but the latter sites are not distinguishable.

3.3. Community dominance: Differentiation between station-groups in area was evident by the graphical descriptors (*k*-dominance curves), for numerical abundance **(Figure 3).** Stations corresponding to the deeper shelf (group III) showed more diversified and less dominated communities than those from the middle shelf (group II). The coastal stations (group I) had an intermediate position, while the curves were more elevated for group II, suggesting that depths between 25 and 50 m were dominated by fewer species. Pairwise k-dominance curve comparison between groups were significant in the areas, while the pairwise R values, which give an absolute measure of how separated the groups are, in all cases were R comprised in the range of 0.67 to 0.96 suggesting that the groups were well separated **(Table 3).**

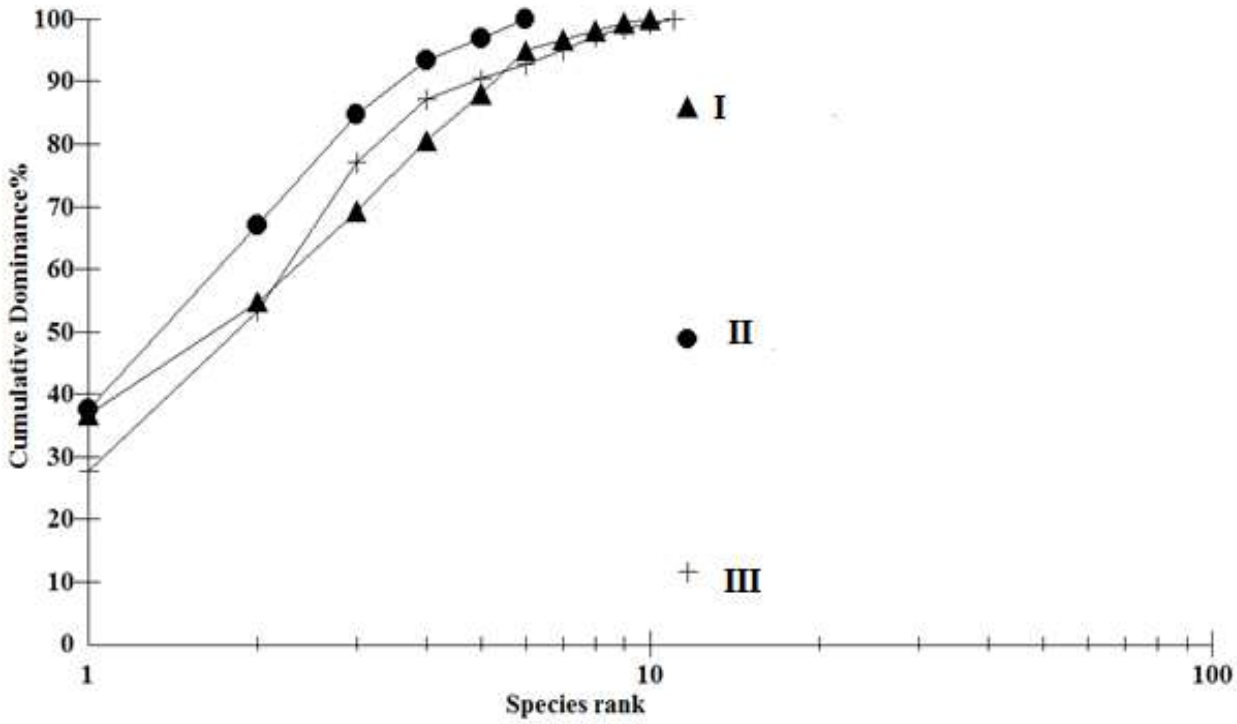


Figure 3: *K*- dominance curves for the demersal fish communities between the three station-groups from Côte d'Ivoire's continental shelf.

Table 3: Results of ANOSIM tests about depth group (R values). In all cases P<0.001

Groups	II	III
I	0.963	0.922
II		0.677

3.4. Patterns in abundance and species diversity with depth: The total species richness was similar in samples from the coastal shelf (group I), and from deeper shelf (group III), but less important for middle (group II) (Table 4). The values of ecological parameters such as the species diversity (H'), dominance (D), richness (d) appeared to be more or less uniform at groups I and III.

[DOI:10.24214/jcbps.B.9.2.20115]

Table 4: Ecological parameters by depth zone for the demersal fish communities in Côte d'Ivoire continental shelf

Depth zone	Mean depth	Number of species (S)	Abundance fish30.mn^{-1}	Richeness (d)	Diversity (H')	Evenness (J')	Dominance (D)
Coastal (I)	30.83 (20 – 41.6)	10	541	1.43	2.60	0.78	0.21
Middle (II)	37.50 (25 – 50)	6	66	1.20	2.12	0.82	0.27
deeper (III)	68.63 (45.2 – 92)	11	1042	1.44	2.56	0.74	0.21

4. DISCUSSION

Three main assemblages of Côte d'Ivoire continental shelf corresponding to the following bathymetric ranges: Shallow-water assemblages or coastal shelf (10-25 m), Intermediate shelf or middle shelf (25–50 m), deeper shelf (50-100 m) have identified. The three continental shelf assemblages exhibit greater abundance and contain species of commercial interest such as: *S. dorsalis* (Carangidae), *G. decadactylus* (Polynemidae), *P. senegalensis* (Scianidae), *P. peli* (Scianidae), *D. africana* (Drepaneidae), *T. lepturus* (Trichiuridae), *C. monodi* (cynoglossidae*), P. jubelini* (Haemulidae), *G. gruveli (platycephalidae), R. miraletus* (Rajidae), *P. bellottii* (Sparidae), *P. prayensis* (Mullidae), *D. angolensis* (Sparidae). The main determining feature associated with the structure of the demersal fish assemblages is depth [32,33,34,35,36]. Nevertheless, other bottom and oceanographic characteristics play a role, at least for structuring assemblages on the continental shelf.

Several factors appear to contribute to this geographical differentiation. These include the gradient in eutrophy, fresh/brackish water runoff, temperature and differences in the extent and the bottom type of the continental shelf. Indeed, Côte d'Ivoire's coastline includes a 1200 km^2 coastal lagoon systems composed of the Aby, Ebrié and Grand - Lahou lagoons. These three systems communicate by artificial canal: Asagny canal links Grand – Lahou and the Ebrié lagoon, while Assinie canal links Ebrié and Aby lagoons. In fact, Changes in relation to depth were probably related to change in temperature and oxygen levels ([36]. Physical characteristics of water masses, as well as bottom type, light intensity, pressure, etc., are mostly depth-dependent, and depth obviously reflects the combined effects of these factors [32].

These demersal fish assemblages (groups) identified in this work correspond partly to the following assemblages (called by Longhurst [37]. : Group 1: Sciaenidae; Group 2: Sparidae (shallow part); Group 3: Sparidae (deep part). The group of species referred to as eurybathic or thermocline species by Longhurst [37] is not isolated in this work; these are generally included in the second assemblage. Also, the estuarine sciaenid community described by Longhurst [37], is not represented in these results considering the range of depths (especially the minimum depth) covered in the surveys used in this study. Their limits are not strict and often overlap, probably influenced by differences between geographic locations. Despite continuous faunal renewal along the bathymetric gradient, many marine environmental studies have established zonation models with boundaries along this gradient and resulting in different groups of species [38,33,39]. However, groups do not usually overlap within a given locality ([40]

In other areas, as, on the slope of the eastern Norwegian Sea [41], Mediterranean Sea [39]. and Gulf of Cadiz (SW Spain) [42] separate fish assemblages were identified, each characterised by specific depth, temperature and species composition. On Côte d'Ivoire continental shelf, the identification of assemblages was not always so clear. The structure of the cluster was not always so well defined and has relative many intermediate-scale linkages, indicating more gradual changes in species composition. This was also confirmed by Non-parametric multidimensional scaling ordination analysis performed on fish abundance along the continental shelf in the area (Figure 2) and ecological parameters by depth zone,

which shows shallow-water assemblages and a deep assemblage, each with relatively modest variance in depth distribution, and an intermediate assemblage of species with broad and overlapping depth ranges. In fact, only few species, such as *G. gruveli* and *R. miraletus*, had a depth distribution that covered the coastal shelf to the deep shelf. This pattern is probably explained by the homogeneous hydrographical conditions on the shelf. The boundaries of fish assemblages may shift as environmental conditions change. This has been seen e.g. on the continental shelf and upper slope of Angola [9] and the northeast Newfoundland/Labrador Shelf [43].

In this study, diversity did not show, in general, any trend with depth. However, the low value observed at stratum level 25 to 50 m could be explained by the thermocline situated at these depths.In addition, evenness did not change with depth, indicating little variability in the numerical codominance of species over the depth range examined. The *k*-dominance analysis suggested that the spatial trend in diversity and dominance was a strong feature of the species assemblages under study, with dominance being the highest in group II [44], who investigated whether changes in diversity and dominance could be related to fishing, concluded that the largest changes in diversity appeared to be due to changes in evenness or species richness, or both, often leading to an increase in diversity in response to heavy exploitation.

5. CONCLUSION

The present study has shown that although Côte d'Ivoire's shelf is a small area, its species richness is high, but only a few species make up most of the abundance. The fish species are not evenly distributed, neither horizontally nor vertically. Additionally, the complex; hydrographic conditions with mixed water masses on the continental shelf have no major influence on the biogeography of the demersal fish assemblages, where the water masses are relatively homogeneous. Species diversity for the demersal fish assemblages is low on Côte d'Ivoire's shelf as compared to other areas. The observed three fish assemblages on the continental shelf seem to be strongly linked to the depth gradient.
The results of the present work should be taken into account for future assessment and management of trawl fisheries.

ACKNOWLEDGEMENTS

The authors express their gratitude to the participants of the surveys, and to the crew of the R/V "Général Lansana Conté" for their help. Special thanks also go to Dr. Sylla Soumaïla, Diaha N'guessan Constance and Joanny Tapé G. for providing oceanographic data, to Dr. Yao silvain for his valuable comments on the manuscript. This work was financially supported by the UEMOA, through the PRESH project ''Projet Régional d'Evaluation des Stocks Halieutiques''

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Corresponding author: Soumaïla SYLLA

Centre de Recherches Océanologiques (CRO), B.P.V 18 Abidjan,
Côte d'Ivoire, Fax (225) 21 35 11 55

Online publication Date: 18.02.2019

View publication stats