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BIOLOGICAL DIVERSITY ON THE BENINESE CONTINENTAL SHELF DURING THE DEMERSAL FISH STOCK ASSESSMENT SURVEY[1]

Abstract. The global objectives of this study are to assess biodiversity composition in the tested trawling areas during the survey period. This study cannot take in account all species that can occur in the fishing areas because of the shortness of the work. To have a most complete list of species it will be better to carry out the survey covering four hydrologic periods (2 hot and 2 cold hydrologic periods) to have a chance to meet most of the species. However, the work was done during the most important period for the study. This study was conducted in terms of the demersal fish stock assessment survey initiated by the West African Economic and Monetary Union in the continental shelves of states members and neighboring countries (Côte d'Ivoire, Ghana, Togo and Benin) for the south part of Africa in order to determine fish population and abundance. In the waters of Benin, there have been listed 100 fish species including 76 demersal species (69 bony and 7 cartilaginous fish) and 13 pelagic species consisting entirely of bony specimens. Species richness, according to the reports of trawling stations, varies between 28 and 7 species. Fish abundance is the largest at the depth of 25-50 m. According to the data of station 10, species number makes 7.76% of the total, followed by station 19 with 26 taxa at the depth of 50-100 m. The lowest taxon number is registered in station 4 at a depth of 10-25 m with 4 taxa representing 1.94% of all targeted. The Simpson's index is close to 0, varying between 0 and 0.049, it shows a great diversity especially in the first stratum of 10 to 25 m. This study allows to evaluate species diversity in different fishing areas and consequences of the significant increase of fishing pressure on the stand and not only to focus on a few populations of species of commercial interest.

Key words: continental shelf, biodiversity, demersal, index, stratum.

Introduction

Biodiversity refers to variety and variability (takes into account all taxonomic levels from kingdom to subspecies or race) among the various life forms and ecological complexes in which they meet. However, biodiversity is also defined as the variability of living resources, in their relationships with the environment in which they live.

Specific diversity is generally considered to be one of the key factors in ecosystem resilience in response to anthropogenic pressures, including fisheries.

In this context, we analyzed the spatio-temporal structure and the diversity of demersal fish species on the continental shelf of Benin.

There is now a growing awareness of the role of the marine environment for the population and the imperative to maintain its balance and preserve its wealth. Face to this obligation [1], the management of the ecosystem of this environment becomes necessary.

Fishing has changed the biological and dynamic characteristics of exploited species. For example, changes in density and distribution, a decrease in the average size of individuals, or a decrease in age at first sexual maturity lead to a decrease in biomass.

Diversity index is the measure of species diversity in a given community. It is different from species richness in that unlike richness it also shows community composition and takes into account the relative abundance of species that are present in the community.

The Regional Fish Stock Assessment Project (PRESH), a component of the WAEMU Concerted Fisheries and Aquaculture Management Plan, aims to improve and strengthen the state of knowledge of the potential of the fisheries resources of the countries concerned. Scientific knowledge of fish stocks will enable decisions to be made to ensure the rational and sustainable exploitation of fisheries. Within the framework of the WAEMU Agricultural Policy (PAU), the three-year program for the development of the fisheries sector in WAEMU was adopted in Dakar in March 2003, the objective

[1] The survey was financed and organized by WAMU, which is a first in the sub-region of West Africa, except FAO survey. We would like to take this opportunity to extend our sincere thanks to the WAEMU, the Department of Animal Resources and especially its Director Mrs. Maria Luiza FEREIRA and M. N'Dong Diegane who work very hard for the success of this survey. Our thanks also go to Director of "Centre National des Sciences Halieutiques de Boussoura (CNSHB)" of Guinea.

of which is to establish a process of coordination and harmonization of the management of shared fishery resources, with a view to sustainable management of these resources and contributing to food security and the reduction of poverty in the WAEMU area. This program includes, among other things, the definition of a cooperative management plan for fisheries and aquaculture within the UEMOA, underpinned by a good knowledge of the state of the fishery resources in UEMOA countries.

The first phase of this program was conducted in 2012 with the assessment of pelagic fish stocks. During this survey in all countries, it was decided to make an assessment of the demersal stocks. For example, the Guinean research vessel N/O “General Lansana Conté” was selected to conduct demersal resource assessment surveys in Côte d'Ivoire, Ghana, Togo and Benin.

Global objective of this survey were to assess demersal resources and follow up biomass and indices.

Specific objective of this study is just to analyze biodiversity composition.

Materials and Methods

The survey is conducted onboard the CNSHB's fishing N/O research vessel, “General Lansana Conté”. This research vessel manufactured in Japan is a trawler of the rear-fishing type with the Overall length: 29.93 m, Long: 27.15 m, Breadth: 7.30 m, Gross tonnage: 198 tonnage gauge (tx) Net tonnage: 59 tx.

To estimate trawl opening size, distance measurements were made between the fishing pulleys and the spacing between the boars. These parameters are taken after trawl spinning, at each fishing operation.

This calculation method makes possible to obtain average values which differ from one stratum to another.

At the end of each trawl tow, fishes was sorted, the weight of the catches and the measurement of the fish caught are carried out.

The weighing of the catches was carried out using two scales: one digital biggest (type “Marel M1100e” with a maximum capacity of 60 kg) and the second digital small (type SPRING-DIAL HOIST CALE, of 50 kg).

The 50 kg mid-range scale was used for individual weighing of small and medium-sized specimens, while the 60 kg electronic scale was used for group weighing and large individuals.The measurement of the individuals was carried out using types of wooden graduated ichthyometers (up to 50 cm in length and 100 cm).

Each of these strata, according to depths and area, was also subdivided into squares of 3 nautical miles from each other (Fig. 1).

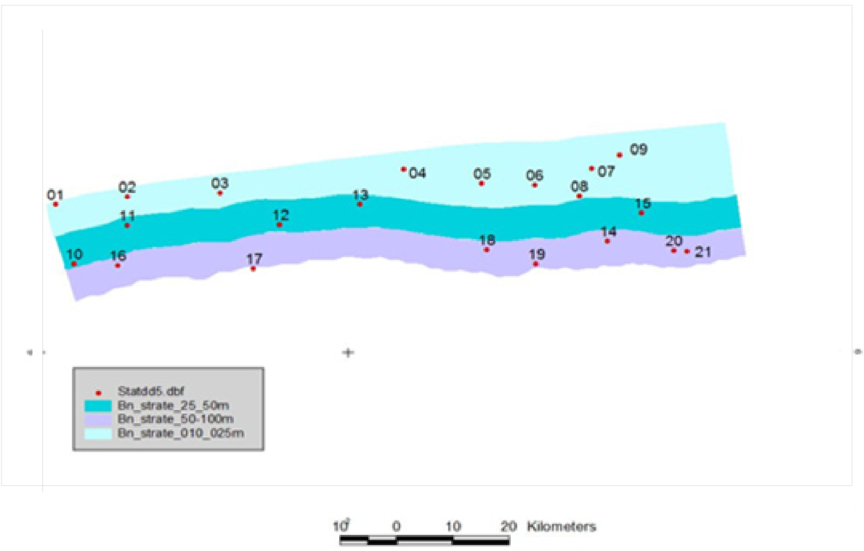

Fig. 1. Location of trawling stations in the three bathymetric strata

During the survey a Stratified Random Sampling (SRS) plan was adopted with diurnal trawling with tow duration of 30 minutes (from the complete stop of the winch).

The allocation of the stratum was carried out by weighting according to the surface area of the continental shelf (2.731 km²). The squares thus obtained were drawn at random and those retained contain a trawling station.

Twenty-one stations were programmed and realized, in 3 days, in the depths ranging from 10 to 100 m. In the coastal stratum (10-25 m), nine stations were trawled (42.95%), the intermediate zone (25-50 m) included 5 stations (29.31%) and the deep zone (50-100 m) - 7 stations (27.74%).

Fish biodiversity in most rapid assessments that have been carried out so far has been assessed as a key part of surveys which target a number of important taxa in an area.

Given the characteristics of the Beninese seabed, a map was made available to the captain in order to avoid obstacles and risk areas as much as possible.

For the purposes of this cruise, trawling on board was conducted at an average speed of 3.5 knots.

Data collected

During the survey, four (04) types of data were collected:

– meteorological data (wind speed and direction);
– environmental data (surface and bottom temperatures and surface salinity);
– catches by weight and number for all species caught;
– measurements (lengths) for some targeted species.

Data entry was done under Access where some estimates were made and other estimates in Excel.

Sampling of environmental data. The CTD probe was only used at three stations because of a failure reported by the Chief Scientist. The sea surface temperature was collected by a thermal sensor (surface thermometer) while the bottom temperature was obtained through the net attached to the trawl.

Catches sampling. After each trawling tow, the entire catch was sorted and distributed by species for a numerical and weight inventory. In the case of big catches, only a fraction is kept for sorting. This fraction, can be equal to 1/2, 1/3 or 1/4 of the total catch, is sorted and weighed, then reduced to the total catch (before capture).

This method has the advantage of providing a representative sub-sample insofar as the species present are numerous.

When in the catch, we observe a big specimen of fish, we separate them from the catch before sampling.

After the weighing and counting of the catches, the individuals in the sample belonging to groups of fish species (or other taxa) retained for size frequency monitoring were measured.

Size frequency collection was performed by total length (cm) for fish and coat length (cm) for cuttlefish. The species that were measured during this campaign are nineteen (19) including 18 species of fish and cuttlefish. These selected species are usually followed in Benin because of their commercial importance.

In this study, we are interested in data on living resources.

Estimation procedure

The formulas used to calculate the indicators provided by this demersal trawl survey were as follows.

The average catch (index of abundance) by tow ($\bar{X}$) of a species or group of species in a given area or stratum is estimated using the following formula:

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i, \tag{1}$$

where X_i – trawl catch; i and n – numbers of tows.

Average of catches or abundance indices observed and abundances presented are relative values (Catch per Unit of Effort) calculated from the ratio of the sum of total catches to the number of trawl stations in the stratum for each species caught. They are expressed in kilograms per 30 minutes of trawling.

The area swept (a) by a haul of trawl was calculated using the following formula:

$$a = d \cdot oh = v \cdot t \cdot oh,$$

where d – distance traveled by the trawl during a haul, km; oh – horizontal opening of the trawl, km; v – tow speed, km/h; t – trawl time, 0,5 h.

The biomass (B) of a species or group of species in a given area or stratum is estimated using the following formula:

$$B = \frac{\overline{X} \cdot A}{a \cdot k},$$

where $\overline{X}$ – the average catch; A – area of the area or stratum; a – area swept by the trawl; k – proportion of fish caught in the swept area (usually $0.5 \le k \le 1$, Sparre, P. & Venema, SC, 1996 [2]). For this study, the value of k is equal to 1, given that the trawl collects everything on its course. The mean length ($\overline{X}$) of a length frequency sample is estimated using the following formula:

$$\overline{X} = \frac{1}{n} \cdot \sum_{j=1}^{k} f_j \cdot X_j$$

where n – total number of individuals; k – number of length classes; f_j – number of individuals of length class j; x_j – center of the class of length j.

The density (biomass per unit area) of a species or group of species $d = B/A$, where B is biomass, kg or t, and A – swept area, km². It is the biomass per unit area. Unit: kg/km² or t/km².

Biodiversity measuring

There are many ways to measure Biodiversity on a site, but we will retain only the most used ones that answer the following questions:

– how many species are found on this site? (specific wealth);
– how important is each species on this site? (Abundance-dominance);
– do the different species have similar numbers? (digital regularity);
– how to globally quantify species Biodiversity on this site (diversity indices).

Taxonomic richness

Intuitively, our first perception of the environment tells us that the more distinct taxa (species, genera, families, ...), the greater the diversity. Taxonomic richness is simply the number of distinct taxa on an inventory list and answers the first question.

Abundance – Dominance. Abundance is the number of individuals surveyed for a given taxon. Dominance is a note indicating the proportion of area (or volume) covered by a taxon (especially for species). Indeed, a species can "dominate" a site by its coverage while its workforce on this site is low.

Diversity. To simultaneously quantify the taxonomic richness and distribution of taxa in a community, diversity indices are frequently used, the three main ones being Shannon-Weaver, Simpson's and Equitability [3].

We use here Simpson's index expressed par formula below:

$$D_{S_i} = 1 - \sum_{i=1}^{S} p_i^2$$

Shannon Weather index. Shannon Index is a commonly used diversity index that takes into account both abundance and evenness of species present in the community. It is explained by the following formula:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i,$$

where H' – biodiversity index; S is the number of taxa present in the survey and p_i is the proportion of taxon i in the survey; ln is the natural log; Σ is the sum of the calculations; $p_i = n_i/N$ where n_i is the number of individuals of the species and N is the total number of individuals, all species combined.

Shannon's equitability (E_H) measures the evenness of a community and can be easily calculated by diving the value of H with H_{max}, which equals to ln$S$ (S – number of species encountered). Its value ranges between 0 and 1, with being complete evenness:

$$E_H = H / H_{max} = H / \ln S.$$

Results and discussion

The distribution of total catches by zoological group shows that bone fish are by far the most abundant during this survey with 86.49% of total catches, followed by cartilaginous fish, 6.34% of catches (Table 1).

Table 1

Distribution of catches by zoological group

Zoological Groups	Catch, kg	Percentage, %
Osteichthyans (bone fish)	1 257,81	86,49
Chondrichthyes (cartilaginous fish)	92,2	6,34
Cephalopods	56,76	3,90
Crustaceans	47,46	3,26
Total	*1 454,23*	*100*

Cephalopods and crustaceans represent only 3.90 and 3.26% of total catches, respectively. The relative importance of these bony fish, plus cartilaginous fish (Smooth Pollock Shark, Rays and Angelfish), can be explained by the fact that the fishing gear used is a standard fish trawl.

In catches, the most abundant family is the Sparidae with 18% of the total weight followed by Polynemidae, 13% and Carangidae, 10%. The proportion of all other families is below 10%.

The first three most dominant species in the catches are the Angolan tooth (*Dentex angolensis*) with 9% of the total weight followed by the gray grouper or thiof (*Epinephelus aeneus*) and the ordinary disc (*Drepane africana*) with 8%. The proportions of all other species are below 8%. This proportion decreases gradually to 1%, if we consider the top twenty species of taxonomy (Table 2).

Table 2

First twenty taxa

Taxa	Catch, kg	Weight, %
Dentex angolensis	123.80	9
Epinephelus aeneus	119.45	8
Drepane africana	118.90	8
Polydactylus quadrifilis	96.50	7
Galeoides decadactylus	94.30	6
Pseudotolithus senegalensis	67.00	5
Chloroscombrus chrysurus	64.20	4
Sphyraena guachancho	62.40	4
Sparus caeruleostictus	56.65	4
Sepia officinalis hierredda	52.61	4
Decapterus punctatus	51.15	4
Squatina oculata	43.50	3
Dentex congoensis	41.55	3
Brachydeuterus auritus	37.88	3
Raja miraletus	30.60	2
Pseudotolithus typus	30.00	2
Dasyatis centroura	26.50	2
Balistes capriscus	23.40	2
Pagellus bellottii	23.10	2
Priacanthus arenatus	21.50	1

It should be noted that of these first twenty species, only three do not have much commercial interest; they are the triggerfish (*Balistes capriscus*), the sun-like beauclairs (*Priacanthus arenatus*) and the Ocellated Sea Angel (*Squatina oculata*), which used to be discards. Today, there are practically no more rejects because of the decline in production; all species are consumed by the population. This tendency is shown on Table 2. We observe three big classes on the dendrogram (Fig. 2).

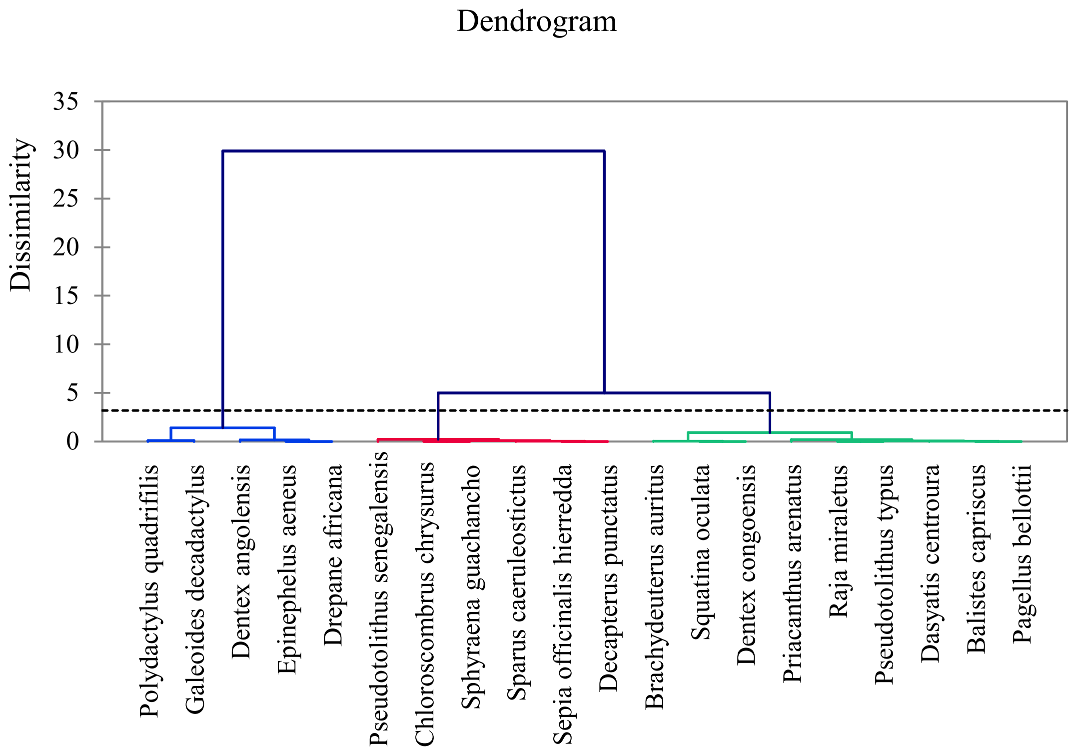

Fig. 2. First twenty taxa

The chart below is the dendrogram. It represents how the algorithm works to group the observations, then the sub groups of observations. The algorithm has successfully grouped all the observations. The dotted line represents the automatic truncation, leading to three groups. Two groups are approximately the same size, and the third one is a big size. The first two groups (displayed in blue and red color) are more homogeneous than the third one. This is confirmed when looking at the Within-class variable. It is a lot higher for the third group than for the first one (Fig. 2).

The first result to look at is the levels bar chart. The shape reveals a great deal about the structure of the data. When the increase in dissimilarity level is strong, we have reached a level where we are grouping groups that are already homogenous. Automatic truncation uses this criterion to decide when to stop aggregating observations (or groups of observations) (Fig. 3).

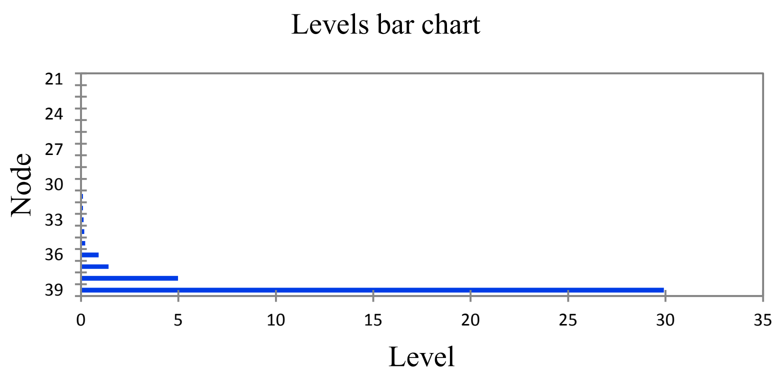

Fig. 3. Levels bar Chart

Abundance indexes

The tables below show the Catch Per Unit Effort (CPUE), the CPUE per stratum, and the abundance indexes by bathymetric strata.

The total abundance index obtained (Table 3) for all species combined is 69.25 kg/tow at 21 trawl stations (the duration of a tow is 30 minutes).

Table 3

Abundance indexes

EEZ	Total weight, kg	Number of individuals	Number of tows	CPUE, kg/tow	CPUE, individuals/tow
Values	1 454.23	415	21	69.25	20

This abundance index varies between the 3 strata as follows (Table 4):

– the 10-25 m stratum with 80.25 kg/tow;
– the 25-50 m stratum for 39.46 kg/tow;
– the 50-100 m stratum for 82.54 kg/tow.

Table 4

Average catches or abundance indexes per bathymetric strata

Stratum	10-25 m	25-50 m	50-100 m
Catchs, kg	722.24	236.75	495.22
Number of stations	09	06	06
Number of individuals	174	108	133
CPUE, kg/tow	80.25	39.46	82.54
CPUE, individuals/tow	19	18	22

Occurrence

The table below shows the most common species (Table 5).

Table 5

Species occurrences

Taxons	Number of stations where the species were found	Occurrence, %
Sepia officinalis hierredda	15	71.43
Chylomycterus reticulatus	14	66.67
Dentex canariensis	14	66.67
Sparus caeruleostictus	13	61.90
Decapterus punctatus	12	57.14
Raja miraletus	11	52.38
Sphyraena guachancho	10	47.62
Epinephelus aeneus	9	42.86
Pagellus bellottii	9	42.86
Aluterus blankerti	8	38.10
Brachydeuterus auritus	8	38.10
Dasyatis margarita	8	38.10
Fistularia petimba	8	38.10
Priacanthus arenatus	8	38.10
Torpedo torpedo	8	38.10

The occurrence of species i (n_i%) is the ratio of the number of stations where the species was caught to the total number of stations. The total number of stations is 21.

Sepia officinalis hierredda has the highest rate of occurrence (71.43%) followed by *Chylomycterus reticulatus* with (66.67%) and *Dentex canariensis* with (66.67%). Among the commercially important fish species *Dentex canariensis* has the highest rate (66.67%) followed by *Sparus caeruleostictus* (61.90%) (Table 5).

Species richness

Data collected and analyzed during the survey identified 100 taxa in the three areas surveyed.

The demersal species represent the majority of the species caught with 80.78% of the total weight whereas the pelagic species represent 15.12%.

In stratum 10-25 m there are 45 species, 39 in stratum 25-50 m and 35 in stratum 50-100 m. The total catch in the three areas explored is 1 454.23 kg for 21 952 individuals, all species combined. This catch is distributed as shown in Table 6 below.

Table 6

Total catch of different groups species

Groupe species	Nb Taxa	Catch, kg	Weight, %
Bottom	77	1174.76	80.78
Pelagic	13	219.9	15.12
Cephalopods	4	55.61	3.82
Crustaceans	6	3.96	0.27
Total	*100*	*1 454.23*	*100*

The species grouping the two categories (demersal and pelagic) represent weight of 1 394.66 kg (or 95.9% of the total catch).

Crabs are represented by 2.65 kg for 102 individuals. Shrimp are represented by a single species of 2.65 kg for 102 individuals. Sea cucumbers are represented by sea cucumber (echinoderm) of 1 kg for 1 individual found on a station. The squils total a weight of 0.15 kg for 3 individuals and lobsters, 1 kg for 6 individuals.

In general, during this survey in Benin waters, it has been listed the following specific indicators:

A hundred taxa including 76 demersal species (69 bony and 7 cartilaginous fish) and 13 pelagic species consisting entirely of bony fish.

Species richness according to the trawling stations varies between 28 and 7 species. It is maximum in stratum 25-50 m and station number 10 represents 7.76% of the total, followed by station 19 with 26 taxa in stratum 50-100 m. The lowest taxon station is station 4 on stratum 10-25m with 4 taxa representing 1.94% of all targeted taxa (Table 7).

Table 7

Taxa richness

Station number	Species number	Percentage, %	Weight, kg	Depth, m	Stratum
10	28	7.76	55.33	44.20	25-50
19	26	7.20	47.32	66.90	50-100
20	24	6.65	160.90	67.00	50-100
21	24	6.65	116.85	69.70	50-100
15	23	6.37	75.71	39.00	25-50
9	22	6.09	47.20	15.00	10-25
18	21	5.82	41.05	61.00	50-100
5	20	5.54	59.55	18.00	10-25
14	20	5.54	44.55	57.80	50-100
16	18	4.99	50.01	50.00	50-100
17	18	4.99	84.55	89.80	50-100
6	17	4.71	18.02	18.00	10-25
7	15	4.16	128.95	16.30	10-25
12	14	3.88	18.96	35.70	25-50
11	13	3.60	19.05	26.30	25-50
8	12	3.32	3.70	23.00	10-25
13	12	3.32	17.68	26.30	25-50
1	11	3.05	343.80	13.70	10-25
2	9	2.49	64.00	15.30	10-25
3	7	1.94	34.52	17.00	10-25
4	7	1.94	22.50	15.8	10-25

Shannon Weaver and Simpson index

Before discussing the stability properties of the system (here, in terms of biodiversity), it is necessary to characterize the ecological situation [4]. The level of description of this study is that of the standard coastal ichthyological.

Equitability assessment is useful for detecting changes in the structure of a community and has sometimes proven effective in detecting anthropogenic changes. The measure of equitability corresponding to the Shannon-Weaver index is carried out according to formula (1).

Generally and independently of the taxonomic group, the Shannon-Weaver index is between less than 1 and 4.5; rarely more. A value close to $H' = 0.5$ is already very weak.

H' is minimal (= 0), if all individuals in the stand belong to a single species, it is also minimal if, in a stand each species is represented by a single individual, except one species that is represented by all other individuals of the stand. The index is maximal when all individuals are evenly distributed across all species [5]. The Shannon index is often accompanied by the Piélou equitability index (1966) [6], also called equidistribution index [7], which represents the ratio of H' to the theoretical maximum index in the stand. (H_{max}). This index can vary from 0 to 1, it is maximal when the species have identical abundances in the stand and it is minimal when a single species dominates the whole population. Insensitive to specific richness, it is very useful for comparing potential dominance between stations or between sampling dates.

For each stratum, the Shannon index is less than 4.5; this means that all individuals are evenly distributed over all species [8].

The Simpson's index close to 0, varying between 0 and 0.049, shows a great diversity especially in the first stratum of 10 to 25 m this trend reinforces the results of the 2012 study [9, 10]. This result reinforces the hypothesis that the coastal zone is a spawning area where several species come to feed [11] (Table 8).

Table 8

Indexes per stratum

Stratum*	*H'*	*E*	*VarH'*	Simpson *D*
ST1	3.881 596 438	0.956 0	0.000 865	0.000 000 00
ST2	3.689 621 989	0.948 0	0.001 611	0.049 972 36
ST3	3.597 764 412	0.939 7	0.001 706	0.042 035 03
ALL STATION	4.318 616 922	0.937 8	0.000 891	0.015 202 84

* ST1 – Stratum 10-25 m ; ST2 – Stratum 25-50 m; ST3 – Stratum 50-100 m.

Shannon's specific diversity index does not evolve in the same direction as equitability. This is explained by the intense degradation of these environments where one or two species dominate by their recovery the other species present. This index therefore seems to be of little use in arid zones and is not very relevant for explaining faunal diversity in extreme cases.

Difference between stratums is not too significant according to the tab of variance analysis. (Table 9, 10). Fisher test used here explain that probability Pr associated to F is less than 0,568; this mean that we take a risk to make a mistake less than 56,8%.

Table 9

Correlation matrix

Stratum	Stratum-ALL STATION	Stratum-ST1	Stratum-ST2	Stratum-ST3	*H'*
Stratum ALL STATION	**1**	-0.333	-0.333	-0.333	0.929
Stratum-ST1	-0.333	**1**	-0.333	-0.333	0.020
Stratum-ST2	-0.333	-0.333	**1**	-0.333	-0.379
Stratum-ST3	-0.333	-0.333	-0.333	**1**	-0.570
H'	0.929	0.020	-0.379	-0.570	**1**

Table 10

Analysis of variance (*H'*)

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	3	47.331	15.777	1.219	0.568
Error	1	12.944	12.944	–	–
Corrected Total	4	60.274	–	–	–

Frequency of occurrence was determined for each species over the total 21 stations. Dominant species for each station was determined using catch rates (number of catch per haul) for each stratum, Shannon-Weather index of diversity (S-W index, *H'*), species richness (S) [12, 13].

This index will have a value of 0 to indicate the maximum diversity and a value of 1 to indicate the minimum diversity. In order to obtain "more intuitive" values, the Simpson diversity index represented by 1-D may be preferred, the diversity maximum being represented by the value 1, and the diversity minimum by the value 0 [6].

Conclusion

The study of biodiversity through synthetic indices, as we have done, consists in studying an ecosystem through emerging indicators of the state of diversity of its biocenosis. The impact of fishing on abundance (in biomass) and on species richness is quite important but it seems to be offset by an increase in numbers for most species. Use of these indexes is pertinent to evaluate richness diversity mainly Shannon index.

Such a study, although it does not seem sufficient to evaluate the "ecological state" of the system, may nonetheless be interesting in the context of a precautionary approach [2]. It makes it possible to approach the systemic aspect of the management of exploited marine resources because, as Frontier (1999) [14] points out, "taxonomic diversity does not faithfully reflect functional diversity, but still remains, from a holistic point of view, an indicator of the complexity of the system.

This study is not complete because doing just for a few days data. It's better to make the study during a long period, may be one year. This study allow just to have an overview of the stand and the consequences of the significant increase of fishing pressure on the stand and not only to focus on a few populations of species of commercial interest.

REFERENCES

1. *Convention on Biological Diversity, June 5, 1992,* 1760 UNTS 79, Can TS N° 24, 31 ILM 818 (entered into force Dec. 29, 1993) [CBD].

2. Sparre P., Venema S. C. Introduction à l'évaluation des stocks de poissons tropicaux. *Première partie. Manuel FAO.* Document technique sur les pêches numéro 306/1 Rev.1. Rome, 1996. 420 p.

3. Shannon C. E. A mathematical theory for communication. *Bell System Technical Journal*, 1948, vol. 27, pp. 379-423, 623-656.

4. Grimm V., Wissel C. Babel, or the ecological stability discussions: An inventory and analysis of terminology and a guide for avoiding confusion. *Oecologia*, 1997, no. 109 (3), pp. 323-334.

5. Frontier S. L'échantillonnage de la diversité spécifique. *Stratégie d'échantillonnage en écologie.* Paris (Coll. D'Ecologie), Frontier et Masson édit., 1983. 494 p.

6. Schlaepfer & Bütler. *Critères et indicateurs de la gestion des ressources forestières. In Ecologie des systèmes vivants: les indices de diversité*. Available at: http://btsa.gpn.free.fr/ressources/ESV.php (accessed: 13.04.18).

7. Blondel J. *Biogéographie écologie*. Paris, Masson, 1979. 173 p.

8. Frontier S. *Stratégies d'échantillonnage en écologie*. Paris, New York, Masson, Québec, Presses de l'Universite Laval, 1983. 494 p.

9. Schneider W. Field Guide to the Commercial Marine Resources of the Gulf of Guinea. *Species Identification Sheet for Fishery Purposes*. FAO, Rome, 1990. 268 p.

10. Sohou Zacharie, Sankare Yacouba, Djiman Roger. Pelagic fish resources stocks assessment in South part gulf of Guinea: Benin continental shelf. *Vestnik Astrakhanskogo gosudarstvennogo tekhnicheskogo universiteta. Seriia: Rybnoe khoziaistvo*, 2015, no. 3, pp. 53-59.

11. Sedzro K. M., Fiogbe E. D., Guerra E. B. Pêcheries maritimes artisanales togolaises: analyse des débarquements et de la Valeur commerciale des captures. *J. Rech. Sci. Univ. Lomé (Togo)*, 2017, no. 19 (2), pp. 47-69.

12. Beisel J. N., Usseglio-Polatera P., Bachmann V., Moreteau J. C. A comparative analysis of evenness index sensitivity. *International Review of Hydrobiology,* 2003, no. 88 (1), pp. 3-15.

13. Fossen I., Cotton C. F., Bergstad O. A., Dyb J. E. Species composition and distribution patterns of fishes captured by longline on the Mid-Atlantic Ridge. *Deep-Sea Research*, 2008, part II, no. 55, pp 203-217.

14. Frontier S. Les Écosystèmes. *Que sais-je?* Paris, Presse Universitaires de France, 1999. Vol. 3483. 127 p.

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БИОЛОГИЧЕСКОЕ РАЗНООБРАЗИЕ НА БЕНИНСКОМ КОНТИНЕНТАЛЬНОМ ШЕЛЬФЕ ВО ВРЕМЯ ИССЛЕДОВАНИЯ ОЦЕНКИ ЗАПАСОВ ДЕМЕРСАЛЬНЫХ РЫБ

Основная цель данного исследования – оценка количества и распределения промысловых видов рыб в обследуемых районах тралового промысла в период проведения работ. Из-за ограниченных сроков работы в исследование не вошли все виды рыб, которые могут присутствовать в районах промысла в течение года. Для более полного охвата необходимо проведение работ с возможностью облова большинства видов в течение четырех гидрологических периодов – двух теплых и двух холодных. Однако работа была проведена в наиболее важный для исследования период. Исследование было проведено в рамках работ по оценке запасов донных видов рыб, инициированных Западноафриканским экономическим и валютным Союзом на континентальных шельфах государств-членов Союза и соседних стран (Кот-д'Ивуар, Гана, Того и Бенин) для южной части Африки, в части, связанной с количеством и распределением промысловых видов рыб. В водах Бенина насчитывается около 100 видов рыб, включая 76 донных (69 костных и 7 хрящевых рыб) и 13 пелагических видов (полностью состоящих из костных рыб). По данным из разных районов тралового промысла видовое разнообразие варьируется от 28 до 7 видов. Их количество максимально на глубинах 25–50 м. По данным из района № 10 количество видов составляет 7,76 % от общего их числа, в районе № 19 насчитывается 26 видов на глубинах 50–100 м. Самое низкое количество видов – 4 (1,94 % от всех видов) – оказалось в районе № 4 на глубинах 10–25 м. Индекс Симпсона, близкий к 0, колеблется от 0 до 0,049, что означает большое разнообразие видов рыб, особенно на глубинах от 10 до 25 м. Данное исследование позволяет оценить ситуацию с видовым разнообразием рыб в разных районах промысла, а также последствия влияния промысла на все рыбное сообщество, а не только на несколько видов, представляющих коммерческий интерес.

Ключевые слова: континентальный шельф, биоразнообразие, демерсаль, индекс, страта.

СПИСОК ЛИТЕРАТУРЫ

1. *Convention* on Biological Diversity, June 5, 1992, 1760 UNTS 79, Can TS N° 24, 31 ILM 818 (entered into force Dec. 29, 1993) [CBD].

2. *Sparre P., Venema S. C.* Introduction à l'évaluation des stocks de poissons tropicaux. Première partie // Manuel FAO. Document technique sur les pêches numéro 306/1 Rev.1, Rome, 1996. 420 p.

3. *Shannon C. E.* A mathematical theory for communication // Bell System Technical Journal. 1948. Vol. 27. P. 379–423, 623–656.
4. *Grimm V., Wissel C.* Babel, or the ecological stability discussions: An inventory and analysis of terminology and a guide for avoiding confusion // Oecologia. 1997. N. 109 (3). P. 323–334.
5. *Frontier S.* L'échantillonnage de la diversité spécifique. Stratégie d'échantillonnage en écologie. Paris (Coll. D'Ecologie): Frontier et Masson édit., 1983. 494 p.
6. *Schlaepfer & Bütler*. Critères et indicateurs de la gestion des ressources forestières. In Ecologie des systèmes vivants: les indices de diversité. URL: http://btsa.gpn.free.fr/ressources/ESV.php (дата обращения: 13.04.18).
7. *Blondel J*. Biogéographie écologie. Paris: Masson, 1979. 173 p.
8. *Frontier S.* Stratégies d'échantillonnage en écologie. Paris; New York; Masson; Québec: Presses de l'Universite Laval, 1983. 494 p.
9. *Schneider W.* Field Guide to the Commercial Marine Resources of the Gulf of Guinea. Species Identification Sheet for Fishery Purposes. FAO, Rome, 1990. 268 p.
10. *Sohou Zacharie, Sankare Yacouba, Djiman Roger*. Pelagic fish resources stocks assessment in South part gulf of Guinea: Benin continental shelf // Вестн. Астрахан. гос ун-та. Сер.: Рыб. хоз-во. 2015. № 3. С. 53–59.
11. *Sedzro K. M., Fiogbe E. D., Guerra E. B.* Pêcheries maritimes artisanales togolaises: analyse des débarquements et de la Valeur commerciale des captures. // J. Rech. Sci. Univ. Lomé (Togo). 2017. N. 19 (2). P. 47–69.
12. *Beisel J. N., Usseglio-Polatera P., Bachmann V., Moreteau J. C.* A comparative analysis of evenness index sensitivity // International Review of Hydrobiology. 2003. N. 88 (1). P. 3–15.
13. *Fossen I., Cotton C. F., Bergstad O. A., Dyb J. E.* Species composition and distribution patterns of fishes captured by longline on the Mid-Atlantic Ridge // Deep-Sea Research. 2008. Part II. N. 55. P. 203–217.
14. *Frontier S.* Les Écosystèmes. Que sais-je? Paris, Presse Universitaires de France, 1999. Vol. 3483. 127 p.

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