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Spatial distribution of demersal and epibenthic communities along the northern Atlantic waters of Morocco -North West Africa-

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Abstract:
The composition and abundance of demersal and epibenthic communities along the northern Atlantic coast of Morocco were studied. Eighty two bottom trawl hauls were carried out in July 2010, at depths ranging from 20 to 800 m. One hundred forty eight species have been identified. Most of them belonged to the fish groups, followed by crustaceans, cephalopods, gastropods, echinoderms, cnidarians and bivalves. Only European hake (Merluccius merluccius) was considered frequent because this species was present in more than 75% for all depth strata. As a result of multivariate analyzes, four assemblages were defined. The group I, was located from 200 to 300 m, on the muddy-sands bottoms on the outer continental shelf and the upper slope, and characterized by high abundance and high diversity. The group II, distributed on trawlable bottoms between 100 to 200 m, limited and influenced by the rocky and coralligenous grounds. The group III, localized on the middle slope, beyond 300 m depth, on muddy bottoms and characterized by deep sea species. The group IV, situated in less than 100 m depth on sandy-muddy bottoms and characterized by typical shelf species. Each assemblage was characterized by specific species and had both qualitative and quantitative differences. Depth appeared to be the main structuring factor of demersal and epibenthic communities in the northern Atlantic coast of Morocco. The substrate type seems also, play an important role in this structuration.

Keywords: Demersal, épibenthiques, assemblages, Moroccan Atlantic waters.

Introduction

The Moroccan Atlantic coast, between Cap Spartel (35°47'N) and Sidi Ifni (29°22'N), is located on the border between three biogeographic marine regions, the Lusitanian, Mauritanian and Mediterranean regions. This is a transition zone between northeastern Atlantic warm-temperate, cold-temperate waters and Mediterranean outflow [1, 2]. This area is influenced by the Canary current [3] and characterized by the occurrence of strong upwelling during summer [4, 5]. The continental shelf is characterized by a wide range of soft bottom (sand, mud and muddy sand) and hard bottoms (rocky and coralligenous) [6, 7] and the occurrence of a *Dendrophyllia ramea* coral barrier [8]. This coralligenous is almost continuous and parallel to the coast between 120 and 180 m depth [8]. All these characteristics give to this region an important biodiversity, which includes a wide range of species, many of which are of commercial interest [9]. The most important target species in this region are *Merluccius merluccius* and *Parapenaeus longirostris* [10, 11]. Because of intense exploitation of these species by a coastal fleet and a deep sea trawl fleet, this fishery in the last decade has been characterized by a severe decline [12].

Several studies showed that fishing associated with climate variability indirectly affect community structure and functioning of marine ecosystems [13, 14, 15]. The study of the species composition and community organization has become an essential and major approach to understanding the functioning of marine ecosystems [16]. The assemblage composition and structure analysis provide a snapshot of the interactions between species and the environment [17].

The first census of the Moroccan marine life was established in the early 20th century during European shipments [8]. These surveys were designed to explore new fishing opportunities. The focus was on the coastal zone and fishing areas, leaving the most of the continental shelf and the offshore waters poorly known. From the

1980s, many bottom trawl surveys have been conducted to monitor and assess the status of the exploited fish stocks but without considering ecosystem issues as a whole [18, 9]. Studies are monospecific in nature, focused on target species of important commercial interest. Only a few have focused on the faunal composition and bathymetric distribution of communities [8, 19, 20].
The aim of this study is to contribute to the basic information on spatial distribution of the epibenthic and demersal assemblages, and the main ecological parameters that shape their structure in the northern Atlantic coast of Morocco.

2. Materials and methods

2.1. Sampling

The data used in this study was collected from 82 trawl hauls, undertaken by the Institut National de Recherche Halieutique (INRH), in July 2010, using the research vessel "R/V Charif Al Idrissi". The surveys were conducted using a stratified random sampling (Figure 1), from Cap Spartel (35°47'N) to Sidi Ifni (29°22'N) at depths ranging from 20 to 800 m.
The fishing gear used during these surveys was a locally designed bottom trawl for targeting demersal fish and shrimps. The stretched mesh sizes were 40 mm, the vertical opening (1.5 to 3 m) and the horizontal opening (18 to 22 m).
Trawling time had varied between 20 minutes (depth < 200 m) and 60 minutes (depth > 200 m) depending on the depth and speed was maintained as constant as possible during the survey (3 knots). Therefore, all catches rates were standardized per 1hour. Unusually, during these surveys, species identification has concerned the total catch (demersal and epibenthic fauna), substrate type and species number were noted. Unlike regular surveys, that was focused on commercial species and the individual number was rarely taken into consideration.

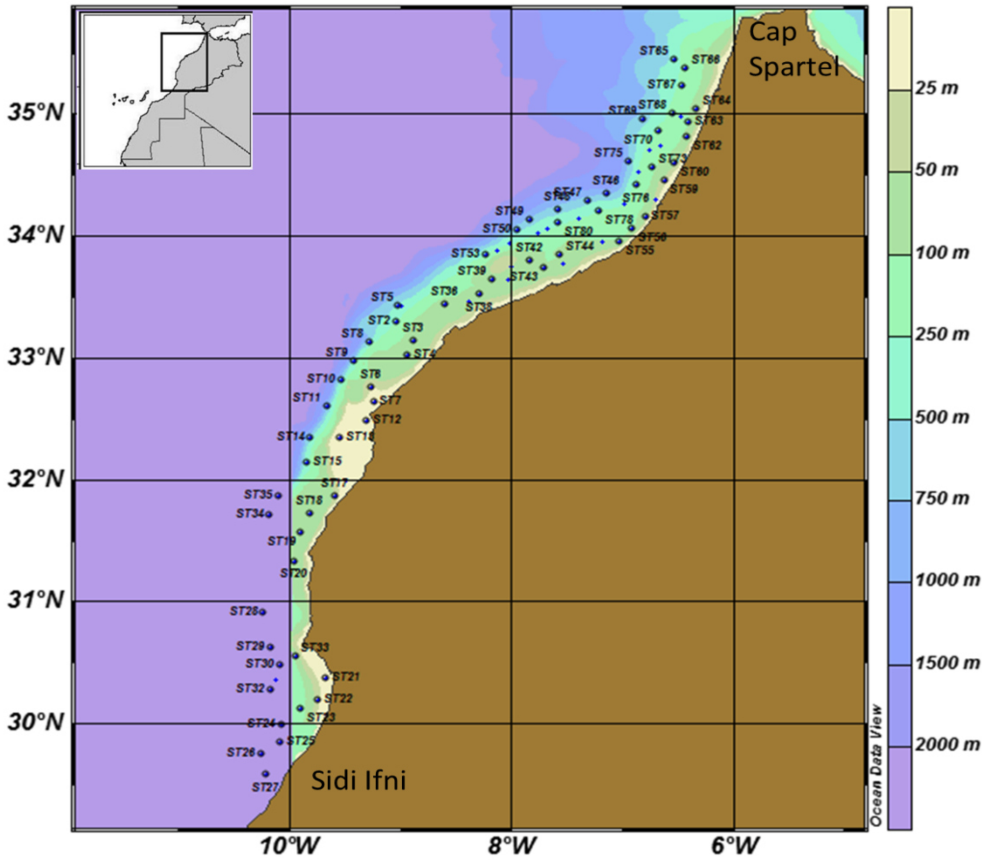

Figure1: Map of the study area and distribution of the trawl hauls in the Moroccan Atlantic coast, between Cap Spartel (35°47'N) and Sidi Ifni (29°22'N),

2.2. Data analysis

For each trawl haul, species richness (*S*) was calculated as the number of species per trawl haul and the density was expressed in number of individuals per hour. The species frequency of occurrence (*FO*) was computed for all the identified taxa and expressed in percentage : $FO = \frac{Pa}{P} * 100$; where *Pa* is the total number of trawl hauls with the considered taxa, and *P* is the total number of trawl hauls. The occurence of a taxon is considered frequent when $FO \geq 75\%$, common when $75\% > FO \geq 50\%$, occasionally when $50\% > FO \geq 25\%$, rare when $25\% > FO \geq 10\%$ and accidentally when $FO < 10\%$ following [21].

To test the effects of depth (depth strata) and substrate type (muddy, sandy, hard) on species distribution, a non-parametric Multivariate analysis of variance was conducted [22].

In order to study the spatial distribution patterns of the demersal and epibenthic fauna, two multivariate analyses were performed without considering the pelagic and endobenthic species (not accurately sampled by bottom trawling method) and the accidental species i.e. present in less than 7 trawl hauls with a frequency of occurrence lower than 10% [21].

A principal component analysis (PCA) was carried out using a 'haul x species' matrix where data were log (x_i+1) transformed (x_i: abundance of the species i) to reduce the influence of dominant species in the analysis.

For the identification of assemblage groups, a hierarchical clustering analysis [23] was conducted on the Euclidean distance matrix, calculated from the factorial coordinates of trawl hauls on the main axes of the PCA (4 axes were selected in Fig. 3). The aggregation criteria selected to create the classification dendrogram of trawl hauls was the "average linkage" (selected according to the methodological approach provided by [24]. The number of assemblage groups from the dendrogram was determined using the GAP statistical method [25]. The robustness estimates of the groups formed by the hierarchical classification were computed through a resampling process (500 bootstraps).

To characterize each identified assemblage group, the total number of individuals (N) of all the species in the assemblage, species richness per assemblage (S), the heterogeneous Shannon index specific (richness and evenness) and the Pielou *J'* evenness index were calculated. Shannon Index [26] was computed using the following formula:

$$H' = -\sum_{S}^{i=1} p_i \mathrm{Log}_2(p_i)$$

Where p_i= proportion of species $i= n_i/N$ where n_i = number of individuals of a species in the assemblage and N = total number of individuals. H' ranges from 0 (when there is one species or one predominant species) to H'_{max} = log S (when all the species have equal abundance) [27]. The Pielou evenness index [28] corresponds to $J' = H'/H'_{max}$ and ranges from 0 (when there is one predominant species) to 1 (when there is an equal distribution of individuals among all the species) [27].

Differences in each descriptor (faunal abundance and diversity indices) among assemblage groups were examined using a Kruskal-Wallis test 1-way ANOVA [29]. When significant differences were detected, we used the post-hoc multiple comparisons test Dwass-Steel-Critchlow-Flignera to identify the groups, which are responsible for such differences [30].

Furthermore, to identify indicator species for each group, we used the Indicator Value method [31]. The significance of the indicator value of each species was tested by randomization test (10 000). Only species showed an indicator value higher than 25% and were significantly different from the calculated values ($p<0.05$) were considered as characteristic of the group [31].

Besides, the k-dominance curves initiated by [32] and [33] have been plotted. These curves were used to display the cumulative abundance in relation to the rank of the species in order to compare the equitability between assemblages on the same graphic. If a given curve is always localized above another, it reflects a greater dominance. Additionally abundance-biomass comparison curves (ABC plots) allowed representing abundance and biomass of the species by superimposing all these species on the same graphic for a given group [34, 35].The comparison of cumulative dominance curves, based on the abundance and biomass of species allowed visualizing if the assemblages are dominated by individuals of low or high biomass.

All statistical analyzes were performed with the R software [36].

3. Results and discussion

3. 1. Faunal composition

A total of 148 species belonging to 9 faunal groups were identified. Most of the species belonged to the fish groups, followed by crustaceans, cephalopods, gastropods, echinoderms, cnidarians and bivalves. The predominance of bony fish in the study area, has also been observed by various authors [37, 8]. It's to note that the trawl used in this study is generally considered as more suitable for shrimp and fish sampling than for other groups of species.

In this study, 28 species were identified for the first time in the study area, in comparison with the various taxa found during the period 1981-2007 [20]. This is due to the additional systematic identification effort provided during this last survey (Appendix 2). The species identified for the first time, belong to fish groups (4 species), crustaceans (4 species), cephalopods (1 species), gastropods (6 species), echinoderms (7 species), cnidarians (4 species) and bivalves (2 species).

In term of species frequency occurrence, *Merluccius merluccius* was the only frequent species, from the coast to 800 m depth (Table 1). The importance of European hake on the northern Atlantic coast of Morocco has been, also confirmed by several authors [38, 9, 20]. It's the most important target specie in the region with a high economic value [11].

Table 1: Frequent and common species in each depth stratum

Depth strata	20-100	100-200	200-500	500 <
Number of Hauls	28	23	21	10
Fréquent species FO ≥ 75%	*Merluccius merluccius*	*Merluccius merluccius* *Parapenaeus longirostris*	*Merluccius merluccius* *Parapenaeus longirostris*	*Merluccius merluccius* *Hoplostethus mediterraneus* *Galeus melastomus* *Hymenocephalus italicus* *Nephrops norvegicus* *Nezumia aequalis*
Common species 75% > FO ≥50 %	*Sepia Officinalis* *Octopus vulgaris*	*SepiaOfficinalis,* *Octopus vulgaris* *Citharus linguatula*	*Capros aper*	*Caelorinchus caelorhincus* *Plesionika narval* *Polycheles typhlops* *Rossia macrosoma*

3. 2. Demersal and epibenthic assemblages' structure

The non-parametric multivariate analysis of variance (Table 2) showed that depth and substrate type had significant effect on species distribution ($p<0.05$).

Table 2 : The non-parametric Multivariate analysis of variance's results, to test effect of depth and substrate type on species distribution

	Df	Pillai	approx F	num Df	den Df	Pr(>F)
Depth	5	2.3040	0.3887	120	195	0.021021*
Substrate type	3	1.4874	1.5159	72	111	0.024085*

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The PCA performed on the data matrix (trawl hauls x species abundance) identified the contribution of different species (Figure 2 a, b, Appendix 1).

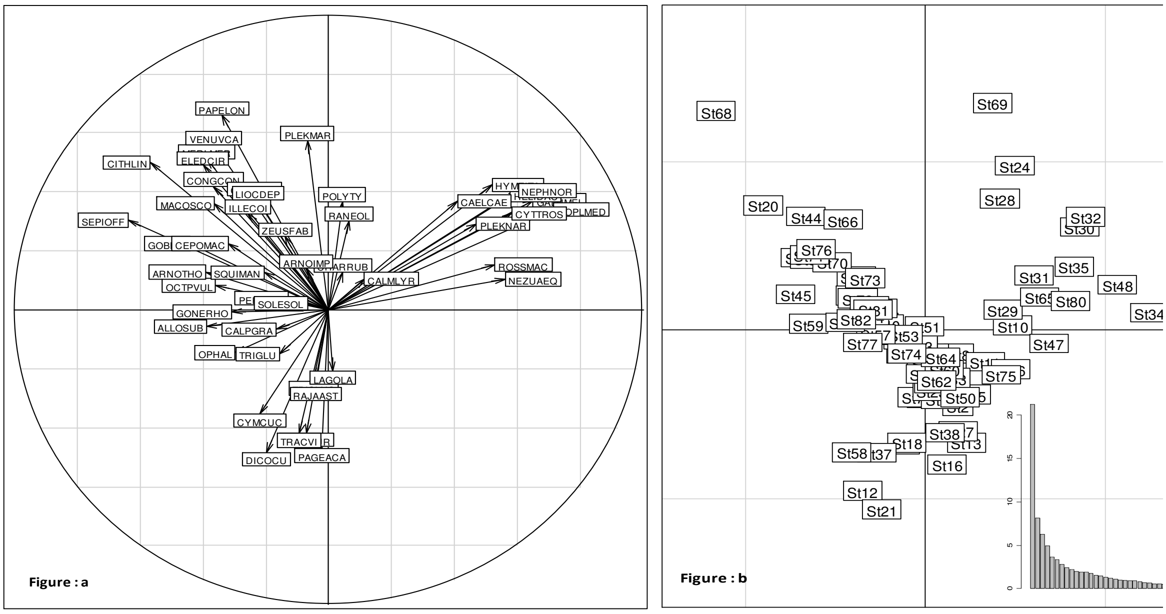

Figure 2: Factorial plane (30 % of the total inertia) of the principal component analysis. (a) The correlation circle species, (b) The projection of the trawl hauls

The first axis (21% of the total inertia) was correlated with the negative side of the offshore trawl hauls and was dominated by deep-sea species (*Nezumia aequalis*, *Rossia macrosama, Galeus melastomus*, *Hoplostethus mediterraneus*, *Nephrops norvegicus*, *Coelorhynchus coelorhynchus*, *Plesionika narva*l, *Cyttopsis rosea, Hymenocephalus italicus* and *Helicolenus dactylopterus*). At the positive side of the first axis *Sepia officinalis, Gobius arnatus*, *Alloteuthis subulata*, *Goneplax rhomboides, Citharus linguatula,* were unveiled. Other species, as well as trawl hauls, in this side of the axis, appeared under represented with a little contribution. In contrast, the second axis (9 % of the total inertia) was mainly correlated to trawl hauls, which were rich in abundance and dominated by *Parapenaeus longirostris* and *Plesionika martia*. The positive side of this axis included the coastal trawl hauls which were dominated by *Dicologoglossa cuneata*, *Pagellus acarne*, *Trachinus vipera, Cymbium cucumis* and *Raja asterias*. For the remaining trawl hauls, the second axis opposed mud to muddy-sand bottoms at varied bottom.

The cluster analysis showed four groups of trawl hauls (Figure 3). (1) group I corresponding to the hauls located from 200 to 300 m, on the muddy-sands bottoms, on the outer continental shelf and the upper slope, (2) group II, corresponding to the hauls located from 100 to 200 m, on trawlable bottoms limited and influenced by the rocky and coralligenous grounds, (3) group III corresponding to the deepest hauls located on the middle slope, beyond 300 m depth, on muddy bottoms, (4) group IV corresponding to the coastal hauls located in less than 100 m depth on sandy-muddy bottoms. In addition to those groups, two trawl hauls on muddy bottoms, characterized by their low abundance, and three separate trawl hauls were also showed but could not be considered as groups. The three last trawl hauls were very different from the others, with the dominance of some species that contributed to the second axis of the PCA.

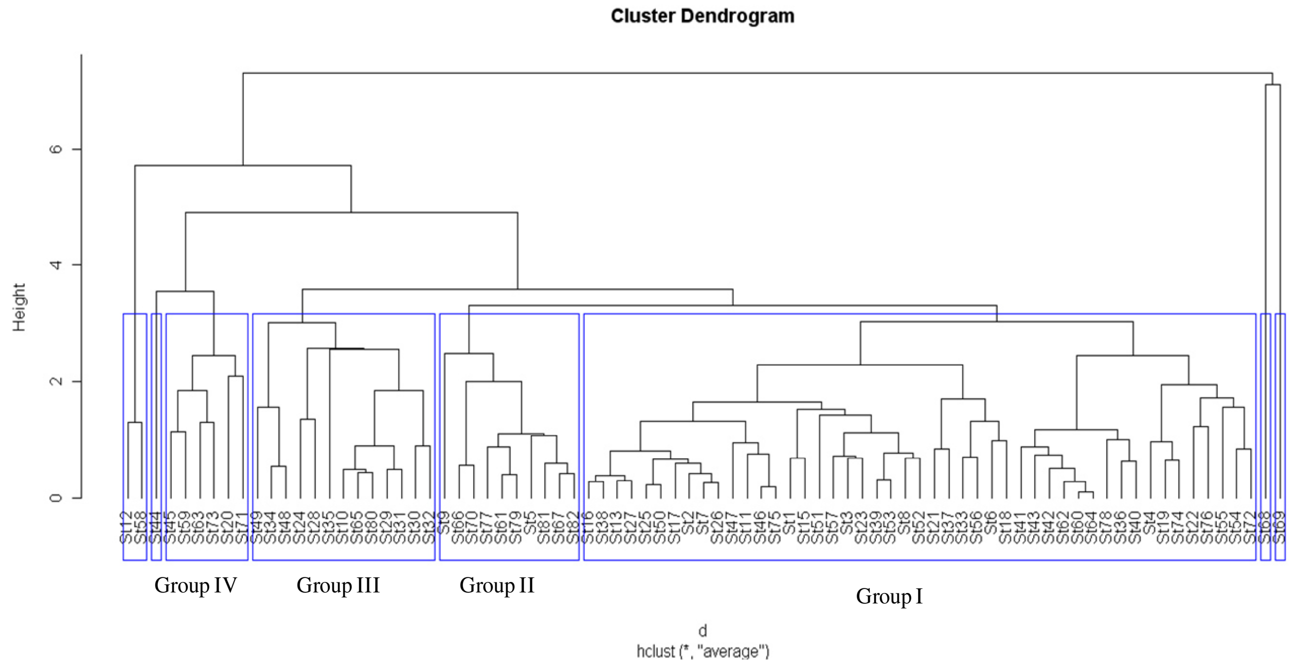

Figure 3: Hierarchical clustering (average linkage) of the trawl hauls made from the factorial coordinates of Principal Component Analysis calculated on the species abundances and groups. Number of groups determined using the GAP statistical method

In this study, the depth seemed to be an important factor revealing two main assemblages. The organization of demersal species along the bathymetric gradient was raised by various authors [39, 40, 41, 29]. For instance, in the Gulf of Lion (the Mediterranean Sea), and in the Bay of Biscay (Atlantic Ocean), three assemblages of species were highlighted: 1) coastal assemblage, from 0 to 80 m, 2) continental shelf assemblage, from 80 to 150 m and 3) continental slope assemblage, beyond 150 m [39, 40, 42]. However, it remains difficult to explicitly identify factors along the bathymetric gradient that could influence the organization of the communities. Previous studies have shown that some environmental factors such as water temperature, salinity, light, hydrological characteristics influence the structure and the organization of demersal communities [43, 44, 29].

In addition to the bathymetric factor, the analysis identified the substrate nature as another key factor structuring faunal assemblages in the study area. The nature of the substrate appeared also to play an important role by structuring the assemblages. An increased gradient in terms of biomass was highlighted with pure mud or sandy mud being highly productive [45]. The substrate type has been argued by several authors in order to explain the depth distribution of fish species, echinoderms and arthropods in New England [46] and in the Mediterranean Sea [47, 29]. However, intensive sampling would be required, to clarify the effect of the nature of substrate in structuring assemblages.

Indeed, the continental shelf of the Northern Moroccan Atlantic coasts is characterized by the presence of a coralligenous barrier (mainly dominated by Dendrophyllia species) which is almost continuous and parallel to the coast and located between120 and 180 m depth [37, 8]. This barrier extends from Cap Spartel (35°47'N) to the Sebou River (34°04'N). In the south of this region, only Dendrophyllia spots persist but without forming a continuous barrier. So the third assemblage corresponded to the sandy passages located between the coralligenous barrier.

Each identified group was characterized by specific species (indicator value higher than 25% and p<0.05) (Table 3) and had both qualitative and quantitative differences (Table 4). The rank of species changed from one group to another. In the group (I), only *Octopus vulgaris* had IndVal value more than 25% even if not significant (p= 0.31) and two species were dominated; *Parapenaeus longirostris* (28%) and *Merluccius merluccius* (15%).

Table 3: Characteristics species for each group (IndVal method)

	Species	IndVal	pValue
Group I	*Octopus vulgaris*	27,49%	ns
Group II	*Macroramphosus scolopax*	88,65%	***
	Capros aper	59,80%	**
	Illex coindetii	59,23%	***
	Sepia officinalis	36,42%	ns
	Merluccius merluccius	29,37%	ns
	Arnoglossus thori	28,52%	*
Group III	*Galeus melastomus*	76,57%	***
	Hoplostethus mediterraneus	75,92%	***
	Helicolenus dactylopterus	65,44%	***
	Nephrops norvegicus	53,75%	***
	Caelorinchus caelorhincus	53,75%	***
	Cyttopsis rosea	53,21%	***
	Nezumia aequalis	49,84%	**
	Plesionika narval	46,05%	**
	Hymenocephalus italicus	45,92%	**
	Rossia macrosoma	36,97%	***
Group IV	*Gobius arnatus*	95,06%	***
	Alloteuthis subulata	92,95%	***
	Goneplax rhomboïdes	60,14%	***
	Citharus linguatula	56,23%	**
	Conger conger	47,98%	**
	Parapenaeus longirostris	41,23%	ns
	Sepia officinalis	37,57%	ns
	Merluccius merluccius	32,02%	ns
	Squilla mantis	31,98%	**
	Arnoglossus imperialis	27,73%	*

Significance codes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, ns (no significant) : $p>0.05$

Group II was characterized by four species (IndVal>25% and $p < 0.05$): *Macroramphosus scolopax, Capros aper*, *Illex coindetii* and *Arnoglossus thori*. The two first species (*Macroramphosus scolopax, Capros aper*) were in the major part of the catches in this group (more than 60%).

Group III was characterized by 10 deep-sea species (IndVal>25% and p<0.05): *Galeus melastomus, Hoplostethus mediterraneus, Helicolenus dactylopterus*, *Nephrops norvegicus*, *Coelorhynchus coelorhynchus, Cyttopsis rosea, Nezumia aequalis*, *Plesionika narval, Hymenocephalus italicus and Rossia macrosoma.* In term of abundance the first species *Parapenaeus longirostris*, had represented 12% of the catches, followed by *Galeus melastomus* (9%). The more coastal group (IV) was characterized by 7 species (IndVal>25% and p<0.05): *Gobius arnatus*, *Alloteuthis subulata*, *Goneplax rhomboides, Citharus linguatula, Conger conger, Squilla mantis* and *Arnoglossus imperialis*. The two first species had represented 22% each of abundance in this group.

In this area, the depth seems to induce changes in substrate type and epibenthic community, which affects the distribution of demersal species. The first assemblage was distinguished by the dominance of *P. longirostris* and the top predator *M. merluccius*. The high abundance of these species on the muddy sands bottoms was reported by [8], [48] and [11]. The Penaeidae dominance indicates a planktonic origin of the trophic resources [49].

According to [10], *P. longirostris* abounds in the muddy sands bottoms, because of the presence of the increased productivity in this area, and consequently, the abundance of food. *M. merluccius* is ubiquitous species; its growth is associated with a change in feeding habit, the young feed mostly on crustaceans while fishes are the main preys of the adults [50].
Low trophic level fish such as Macroramphosus scolopax, Capros aper [29], distinguished the second assemblage. On the Portuguese coast, these species play an important role in the trophodynamics of the ecosystem [51]. They are important prey for many commercial species and, given their abundance, may have a great impact on zooplankton communities [51].
The third assemblage was characterized by typical deep-sea species, such as *Galeus melastomus*, and *C. caelorhincus* [42, 29].

Table 4: The most dominant species in different assemblage groups

Rank	Group I	% in number	Group II	% in number
1	*Parapenaeus longirostris*	27.94	*Macroramphosus scolopax*	49.36
2	*Merluccius merluccius*	15.23	*Capros aper*	11.99
3	*Gobius arnatus*	8.86	*Merluccius merluccius*	8.41
4	*Citharus linguatula*	6.76	*Plesionika martia*	5.89
5	*Alloteuthis subulata*	4.48	*Citharus linguatula*	5.66
6	*Diplodus senegalensis*	2.93	*Parapenaeus longirostris*	5.31
7	*Pagellus acarne*	2.77	*Arnoglossus thori*	3.14
8	*Ophiura albida*	2.70	*Sepia officinalis*	2.06
9	*Squilla mantis*	2.06	*Cidaris cidaris*	1.30
10	*Sepia officinalis*	2.05	*Illex coindetii*	1.02
Rank	**Group III**	**% in number**	**Group IV**	**% in number**
1	*Parapenaeus longirostris*	11.56	*Gobius arnatus*	22.40
2	*Galeus melastomus*	8.79	*Alloteuthis subulata*	21.97
3	*Capros aper*	8.19	*Munida rugosa*	7.22
4	*Hoplostethus mediterraneus*	7.94	*Citharus linguatula*	6.23
5	*Plesionika narval*	7.01	*Parapenaeus longirostris*	5.84
6	*Merluccius merluccius*	6.43	*Plesionika martia*	3.33
7	*Gadiculus argenteus*	4.94	*Merluccius merluccius*	3.01
8	*Epigonus telescopus*	4.64	*Goneplax rhomboîdes*	1.27
9	*Caelorinchus caelorhincus*	3.89	*Arnoglossus thori*	1.07
10	*Plesionika martia*	3.81	*Sepia officinalis*	0.82

The fourth assemblage was characterized by typical shelf species, most of them are benthophagous feeding habit, such as *Squilla mantis, Goneplax rhomboids, Citharus linguatula and Arnoglossus imperialis*. Similar observations were showed by in the study area [8], in French Mediterranean Sea [42] and in the northern Alboran Sea [29].
There is a close relationship between the bathymetric distributions of prey and predators [52, 17]. [53] showed that substrate type and macrofaunal communities could explain a significant part of the organization of fishes along the bathymetric gradient. Each type of sediment is characterized by a specific community of invertebrates, which are the main prey for a number of species [54]. Thus, for predators whose diet is very specialized, the disappearance of their preferred prey can lead to a limitation in their spatial distribution. Shelf fishes and crustaceans are more dependent on benthic resources and slope species had utilized plankton resources [55].

3. 3. Assemblages diversity

The total species richness was highest in group I (120 species), intermediate for the group III (80 species) and less important for groups II and IV (51 and 52 species respectively) (Table 5). The Shannon index *H'* and Pielou equitability *J'* varied respectively from 2.8 to 4.5 and from 0.49 to 0.71(Table 5). The Kruskal-Wallis test for these two indices indicated that there were no significant differences among groups. On the other hand, the difference was significant for total species richness ($p<0.0001$) and total abundance ($p<0.0001$) (Table 6).
In this study, diversity and abundance did not show any trend with depth. The lowest values were observed in the continental shelf, less than 200 m (Groups II and IV) and the highest between 200 to 300 m. In

Mediterranean Sea, [56, 40, 57] depth affect diversity of the main taxa of demersal organisms and cause a decrease in their abundance and their biomass.

Table 5: Number of trawl hauls, abundance and diversity indices in each group

	Group I	Group II	Group III	Group IV
Number of hauls	47	10	13	7
Total specific richness	120	51	80	52
Abundance N (ind/h)	18425	10178	10669	18626
Shannon indexH'	4.201	2.802	4.523	3.164
Equitability J'	0.6082	0.494	0.7155	0.555

Table 6: Dwass-steel- Critchlow-Fligner multiple comparison test per pairwise assemblage group calculated for the abundance and richness

	Abundance				Richness			
Groups	I	II	III	IV	I	II	III	IV
I	1	0.040*	0.018*	0.0003*	1	0.068	0.004*	0.283
II	0.041*	1	0.995	0.042*	0.068	1	0.733	0.991
III	0.018*	0.995	1	0.012*	0.0044*	0.733	1	0.999
IV	0.0003*	0.042*	0.012*	1	0.283	0.991	0.999	1

K-dominance curves had close profiles with the species distribution that were quite different for the first species. Their trend was consistent with the trends of the equitability index *J* (Figure 4). The comparison of cumulative frequency curves, based on the abundance and biomass of species allowed visualizing the assemblages that are dominated by individuals of low or high biomass (Figure 5). For the groups I, II and IV, the frequency distribution curve in term of species richness was higher than the distribution of biomass, which indicated a strong dominance of low biomass individuals. This could be probably the results of high fishing pressure in this region [9]. In group III, the distribution in terms of species biomass and abundance indicate a dominance of high biomass individuals.
Previous studies indicated that the oceanic circulation of water masses, which could create hydrological barriers that would limit the extent of large-scale communities, could influence the geographical distribution, of demersal species [58]. As similar situation can occur in the northern Atlantic coast of Morocco, that is part of the large canary current marine ecosystem. This area is characterized by seasonal coastal upwelling and strong localized currents, which enhance primary production and plankton biomass, in some regions. [59, 60, 5].

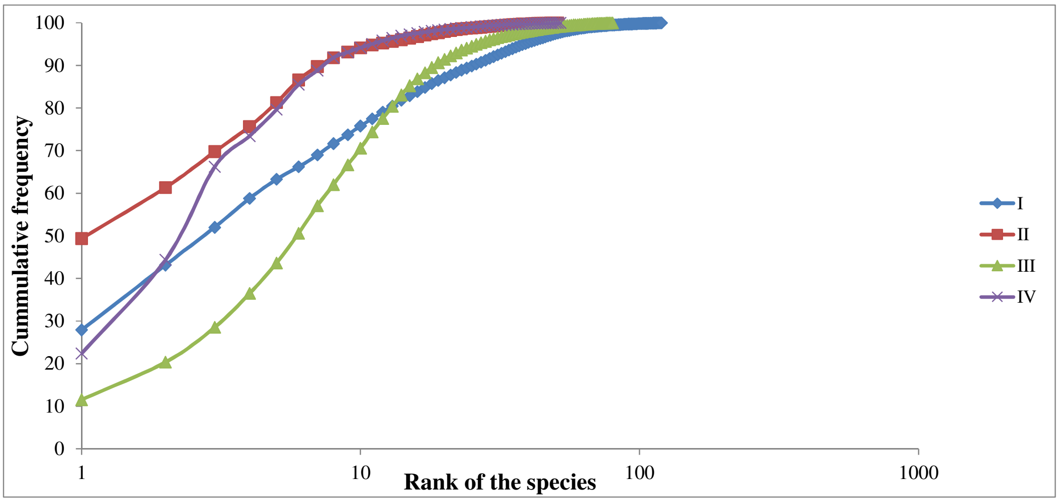

Figure 4: k-dominance curves, Based on abundance data, for each assemblages in the Northern Moroccan Atlantic area (Summer 2010)

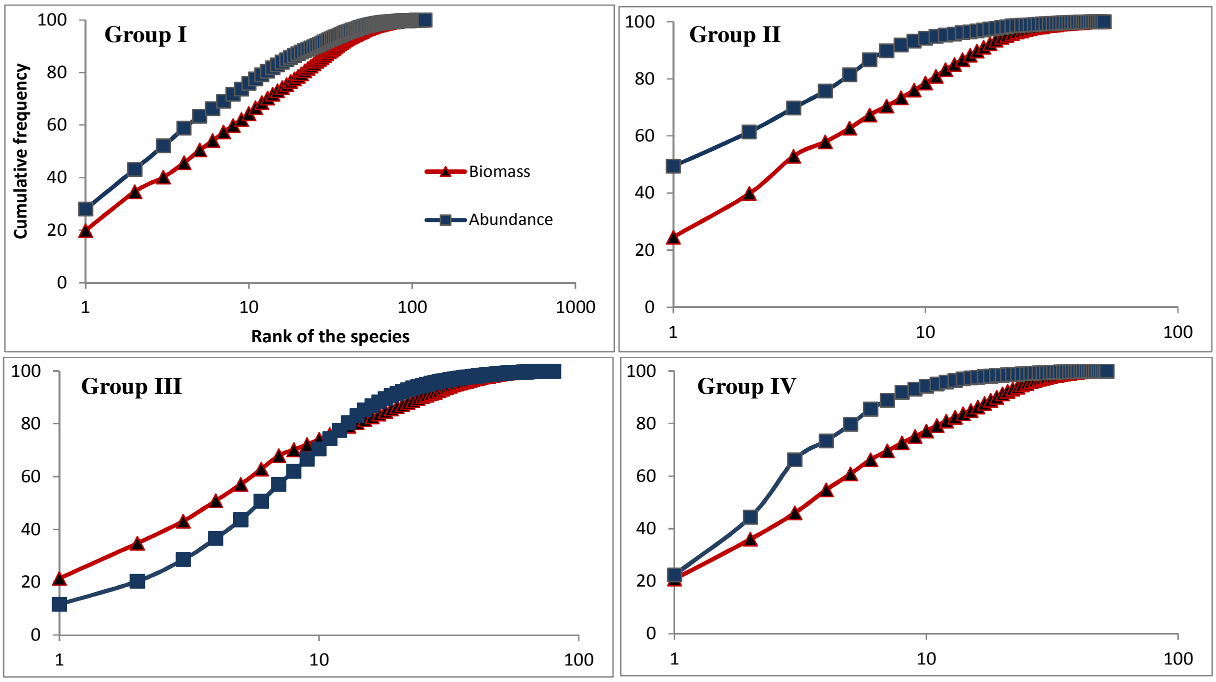

Figure 5: ABC plots based on the abundance and biomass of each assemblage group in the Northern Moroccan Atlantic area (Summer 2010)

Conclusion

This work is the first attempt to describe the spatial patterns of the epibenthic and demersal communities' structure in the northern Atlantic coast of Morocco in relation to main ecological parameters (depth, substrate nature). It points the way towards further studies, including analysis of the temporal trends of species distribution in this area. However, in order to fully understand this community structure we recommend investigating the relationship between spatial patterns in community structure and environmental factors such as water bottom temperature, salinity, indices of upwelling that are known to influence the structure and organization of demersal communities. Studies on species Age structure are needed to, in order to provide more detailed information on the structure of the assemblages and their response to various environmental parameters.

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Appendix 1: Species Code used in the principal component analysis (PCA)

Species	CODE	Species	CODE
Merluccius merluccius	MERLMER	***Pagellus acarne***	PAGEACA
Parapenaeus longirostris	PAPELON	***Galeus melastomus***	GALUMEL
Sepia Officinalis	SEPIOFF	***Goneplax rhomboîdes***	GONERHO
Citharus linguatula	CITHLIN	***Trigla lucerna***	TRIGLU
Octopus vulgaris	OCTPVUL	***Hoplostethus mediterraneus***	HOPLMED
Conger conger	CONGCON	***Squilla mantis***	SQUIMAN
Capros aper	CAPOAPE	***Callionymus lyra***	CALMLYR
Eledone cirrhosa	ELEDCIR	***Helicolenus dactylopterus***	HELIDAC
Gobius arnatus	GOBIAR	***Nezumia aequalis***	NEZUAEQ
Ophiura albida	OPHAL	***Plesionika martia***	PLEKMAR
Pagurus bernhardus	PAGUBE	***Mullus surmuletus***	MULLSUR
Alloteuthis subulata	ALLOSUB	***Peristedion cataphractum***	PERSCAT
Liocarcinus depurator	LIOCDEP	***Trachinus vipera***	TRACVI
Arnoglossus thori	ARNOTHO	***Trisopterus luscus***	TRISLUS
Illex coindetii	ILLECOI	***Plesionika narval***	PLEKNAR
Macroramphosus scolopax	MACOSCO	***Arnoglossus imperialis***	ARNOIMP
Dicolocoglossa cuneata	DENTMAR	***Coelorhynchus coelorhynchus***	CAELCAE
Zeus faber	ZEUSFAB	***Cepola macrophthalma***	CEPOMAC
Charonia rubicanda	CHARRUB	***Hymenocephalus italicus***	HYMEITA
Cymbium cucumis	CYMBMAR	***Nephrops norvegicus***	NEPHNOR
Cyttopsis rosea	CYTTROS	***Polycheles typhlops***	POLYTY
Lagocephalus laevigatus	LAGOLA	***Raja asterias***	RAJAAST
Ranella olearium	RANEOL	***Solea vulgaris***	SOLESOL
Rossia macrosoma	ROSSMAC	***Calappa granulata***	CALPGRA

Appendix 2: List of identified species in the Northern Moroccan Atlantic area (Summer 2010). Species in red and* were identified for the first time in this survey

Groupe taxonomique	Ordre	Famille	Espèce
Actinoptérygiens	Anguilliformes	Congridae	*Conger conger*
		Nemichthyidae	*Nemichtys scolopaceus**
		Ophichthidae	*Ophichthus rufus*
	Aulopiformes	Aulopidae	*Aulopus filamentosus*
	Beryciformes	Berycidae	*Beryx splendens*
		Trachichthyidae	*Hoplostethus mediterraneus*
	Chimaeriformes	Chimaeridae	*Chimaera monstrosa*
	Clupeiformes	clupeidae	*Sardina pilchardus*
		Engraulidae	*Engraulis encrasicolus*
	Gadiformes	Gadidae	*Gadiculus argenteus, Gadus poutassou, Trisopterus luscus*
		Macrouridae	*Caelorinchus caelorhincus, Hymenocephalus italicus Nezumia aequalis, Trachyrynchus trachyrynchus,*
		Merlucciidae	*Merluccius merluccius*
		Phycidae	*Phycis blennoides*
	Lophiiformes	Lophiidae	*Lophius budecassa, Lophius piscatorius*
		Melanocetidae	*Melanocetus jonsonii**
	Ophidiiformes	Ophidiidae	*Ophidion barbatum*

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	Osmeriformes	Alepocephalidae	*Rouleina attrita*
		Argentinidae	*Argentina sphyraena*
	Perciformes	Callionymidae	*Callionymus lyra, Callionymus maculatus, Synchiropus phaeton*
		Carangidae	*Trachurus trachurus*
		Cepolidae	*Cepola macrophthalma*
		Epigonidae	*Epigonus telescopus*
		Gobiidae	*Gobius arnatus*
		Mugilidae	*Mugil cephalus*
		Mullidae	*Mullus surmuletus*
		Sciaenidae	*Umbrina cirrosa*
		Scombridae	*Scomber japonicus Scomber scombrus*
		Serranidae	*Serranus cabrilla*
		Sparidae	*Boops boops, Dentex maroccanus, Diplodus cervinus, Diplodus senegalensis, Diplodus vulgaris, Lithognathus mormyrus, Pagellus erythrinus, Pagellus acarne, Pagellus bogaraveo, Spondyliosoma cantharus*
		Trachinidae	*Trachinus draco, Trachinus vipera*
		Trichiuridae	*Aphanopus carbo, Lepidopus caudatus*
	Pleuronectiformes	Bothidae	*Arnoglossus imperialis, Arnoglossus thori**
		Citharidae	*Citharus linguatula*
		Scophthalmidae	*Psetta maxima*
		Soleidae	*Pegusa lascaris, Solea vulgaris*
	Scorpaeniformes	Peristediidae	*Peristedion cataphractum*
		Scorpaenidae	*Scorpaena loppei, Scorpaena notata, Scorpaena scrofa*
		Sebastidae	*Helicolenus dactylopterus, Trachyscorpia cristulata echinata*
		Triglidae	*Aspitrigla cuculus, Lepidotrigla cuculus, Trigla lucerna, Trigla lyra*
	Stomiiformes	Sternoptychidae	*Argyropelecus aculeatus, Argyropelecus olpeisei**
	Syngnathiformes	Centriscidae	*Macroramphosus scolopax*
	Tetraodontiformes	Tetraodontidae	*Lagocephalus laevigatus*
	Zeiformes	Caproidae	*Capros aper*
		Parazenidae	*Cyttopsis rosea*
		Zeidae	*Zenopsis conchifer, Zeus faber*
Bivalves	Veneroida	Veneridae	*Ruditapes decussatus, Venus verrucosa, Venus casina**
		Cardiidae	*Acanthocardia aculeata**
Céphalopodes	Octopoda	Octopodidae	*Eledone cirrhosa, Octopus vulgaris*
	Sépioides	Sepiidae	*Sepia officinalis, Sepia orbignyana*
	Sepiolida	Sepiolidae	*Rossia macrosoma*
	Teuthida	Loliginidae	*Alloteuthis subulata, Loligo forbezi*, Loligo vulgaris*
		Ommastrephidae	*Illex coindetii, Todaropsis eblanae*
Elasmobranches	Carcharhiniformes	Scyliorhinidae	*Galeus melastomus, Scyliorhinus canicula*
	Rajiformes	Rajidae	*Raja asterias, Raja clavata, Raja miraletus, Raja naevus, Raja oxyrhynchus*
	Squaliformes	Centrophoridae	*Centrophorus squamosus, Deania calcea*
	Torpediniformes	Torpedinidae	*Torpedo marmorata, Torpedo torpedo*
Crustacés	Décapodes	Aristeidae	*Plesiopenaeus edwardsianus, Aristeus antennatus*
		Calappidae	*Calappa granulata*
		Corystidae	*Corystescas sivelaunus**
		Dorippidae	*Dorippe lanata**
		Minididae	*Munida rugosa*
		Geryonidae	*Chaceon affinis*
		Goneplacidae	*Goneplax rhomboîdes*
		Homolidae	*Paromola cuvieri*
		Majidae	*Maja squinado*

		Nephropidae	*Nephrops norvegicus*
		Pandalidae	*Chlorotocus crassicornis, Plesionika narval, Plesionika martia*
		Pasiphaeidae	*Pasiphaea multidentata, Pasiphaea sivado*
		Penaeidae	*Parapenaeus longirostris, Penaeopsis Serrata*
		Penaeoidae	*Aristaeomorpha foliacea*
		Polychelidae	*Polycheles typhlops**
		Polibiidae	*Liocarcinus depurator, Polybius henslowii, Bathynectes maravigna**
		Solenoceridae	*Solenocera membranacea*
		Paguridés	*Pagurus bernhardus*
	Stomatopodes	Squillidae	*Squilla mantis*
Gastéropodes	Neogastropoda	Volutidae	*Cymbium marmoratum*
		Buccinidae	*Buccinumhum phreysianum*, Colus gracilis*, Neptune acontraria**
	Littorinimorpha	Cassidae	*Galeodea echinophora*, Galeodea rugosa**
	Neotaenioglossa	Ranellidae	*Charonia rubicanda, Charonia lampas**
Echinodermes	Camarodonta	Echinidae	*Gracilechinus acutus**
	Cidaroida	Cidaridae	*Cidaris cidaris**
	Ophiurida	Ophiuridae	*Ophiura albida**
	Paxillosida	Astropectinidae	*Astropecten bispinosus*, Astropecten irregularis**
	Spatangoidae	Brissidae	*Brissopsis lyrifera**
	Valvatidae	Asterinidae	*Anseropoda placenta**
Cnidaires	Alcyonacea	Alcyoniidae	*Alcyonium sp**
	Antipatharia	Myriopathidae	*Antipathella subpinnata**
	Leptothecata	Sertulariidae	*Sertulariacu pressina**
	Pennatulacea	Pennatulidae	*Pennatula phosphorea**