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# The Temporal Abundance and Distribution of Polychaete Fauna along the Shoreline of Bonny River in Nigeria

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***Abstract:*** *The Diversity and Association of Polychaete fauna collected at the shoreline of the Bonny Estuary was analyzed to assess the temporal changes in abundance and composition through a twelve month cycle. The diversity indices of Shannon-Weiner and Margalef indicated a poor to moderate environment as supported by the ecological quality assessment (EQS) which in turn was corroborated by the poor to moderate diversity values of Shannon-Weiner (1.81-2.49) and Margalef (1.9-3.79) obtained in this study.The three polychaete associations identified using average linkage cluster analyses were tightly associated with temporal co-occurrence between distributions. Thethree associations were identified as two groups of repeater species (Generalists)made up of eleven species and one group of an "assemblage of drifters" (Specialists) made up of twenty-one species. The high species turnover among the specialists which were observed with single month occurrenceswas evaluated plausibly as a result of their tendency to have low environmental tolerances since the Bonny river mouth is known to be a stable Polyhaline environment. The implications for environmental and ecological monitoring programmes are proposed in the study underscoring the need to recognize that the specialist-generalist relationship patterns may not always reflect impacts. Rather efforts to use benthic Polychaetes to monitor ecological impacts must integrate detailed species biotic interactions with the environment along with known physical and chemical variables in order to be able to understand the effects of human activities on the estuarine environment and associated management strategies.*

***Keywords:*** *Shoreline Polychaetes, Polyhaline, Bonny River, Abundance, Distribution*.

## I. Introduction

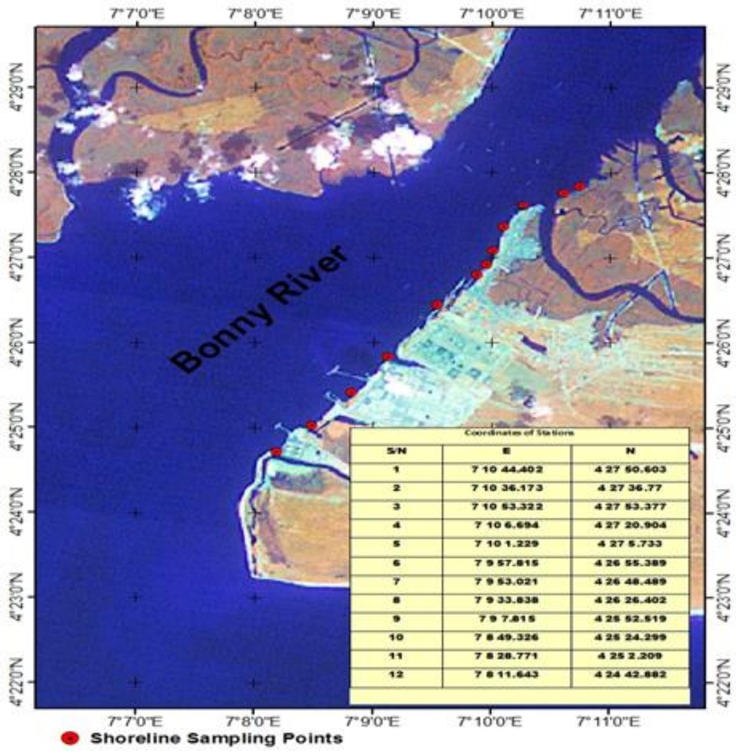
The diversity and Association of Polychaete fauna have recently received increasing attention in their ecological roles among benthic invertebrate assemblages (Gambi and Giangrande, 1986; Fresi*et al.*, 1983; Olsgard and Somerfield, 2000; Sparks-McConkey and Watling, 2001). Among benthic groups, polychaetes are, in fact, one of the best indicators of environmental disturbance, since they contain both sensitive and tolerant species in a gradient within and between habitats (Pocklington and Wells, 1992). Polychaetes which are known to constitute over seventy percent of the composition and abundance of benthic fauna provide good examples for studies that evaluate anthropogenic changes in the environment (Pocklington and Wells, 1992; Jones, andKaly, 1996; Muniz and Pires 2000; Gray *et al*., 2002; Faraco and Lana, 2003; Venturini*et al.*, 2004).

The studies of Polychaete fauna of the Bonny River are very few (Snowden and Ekweozor, 1990; Woke and Aleleye-Wokoma, 2006; Chinasa*et al.,* 2013). With the emergence of increasing oil and gas related activities, studies along the longitudinal zonation of many estuaries within the Niger Delta where over 98% of the estuaries lie, are needed for the rapid and long term monitoring of human induced alterations to the benthic habitats up and down the river. This study is aimed at describing the temporal variation of diversity and association of Polychaetes within a salinity zone on the Bonny River in order to understand the biotic changes associated with life history strategies. This study assumes that the dynamic nature of estuarine benthos can be ordered through the simple processes of immigration and extinction. Immigration of a species into a habitat and extinction of species already present will cause its species composition and arrangement to change. The rates of immigration and extinction result in a predictable or observable changes in temporal diversity effected through the types and number of polychaete species within a defined physico-chemical setting. These measurable components provide a quantitative expression of the temporal nature of the diversity and association measured in this study.

## II. Study Area

The study area is located within the mouth of the Bonny River Estuary as shown in Fig 1.0. NEDECO (1961) provides a description of the width at the mouth of the estuary to be approximately 3000 meters. The tides as published by the Nigerian Port Authority (NPA 2014) which are semi–diurnal reach a maximum height of 2.4m and 1.8 meters during spring and neap tides respectively. At the mouth of the river are the communities of Bonny on the eastern wing and Peterside on the western side. Closely located within the Bonny and Finima towns are the oil and gas facilities belonging to Shell Petroleum Development Company, Nigerian National

Petroleum Corporation and close to Finima is Mobil Producing Nigeria Unlimited. The River is described to have insignificant freshwater discharge (NEDECO 1961) and therefore have salinities at the mouth that remain at 20 parts per thousand throughout the year.




| S/N | E | N |
|---|---|---|
| 1 | 7 10 44.402 | 4 27 50.603 |
| 2 | 7 10 36.173 | 4 27 36.77 |
| 3 | 7 10 53.322 | 4 27 53.377 |
| 4 | 7 10 6.694 | 4 27 20.904 |
| 5 | 7 10 1.229 | 4 27 5.733 |
| 6 | 7 9 57.815 | 4 26 55.389 |
| 7 | 7 9 53.021 | 4 26 48.489 |
| 8 | 7 9 33.838 | 4 26 26.402 |
| 9 | 7 9 7.815 | 4 25 52.519 |
| 10 | 7 8 49.326 | 4 25 24.299 |
| 11 | 7 8 28.771 | 4 25 2.209 |
| 12 | 7 8 11.643 | 4 24 42.882 |

**Figure 1.0** Shoreline Sampling stations at the mouth of Bonny River estuary.

## III. Field Procedures

Samples at the river mouth were collected in twleve locations, upper, mid and lower areas as shown in Fig 1.0.The stations were chosen through the length of the shoreline corresponding to the Mean Low Water (MLW) mark. The stationswere spread through a distance of seven kilometers (7km) which included the shorelinesof Bonny town, Shell Terminal, Nigerian National Liquefied Gas the Bonny Natural Gas Liquid Plant (Mobil) with the last sample point terminating at the mouth of Finima river. At each location three random samples were taken by collecting with a 0.023$m^2$ Ekman grab. All samples from the sites were composited. All the locations were sampled approximately between two to three months through a 12 month period by using waypoints loaded into a GPS to collect samples from the same location as closely as possible. The grab samples were washed with water in a 45μ nitex bags, and preserved in 10% buffered formalin. Rose Bengal stain was added. Each preserved samples were hand sorted. All polychaetes were sorted, identified with stereo and compound microscope and categorized into families and generic groups. Polychaete texts used were Kierkegaard (1983), Day (1967) and Fauchald (1977).

## IV. Data Mining And Statistical Analyses

A variety of diversity indices have been used in benthic ecology to assess the community structure of benthic communities. In the present study, calculation of two diversity and Evenness indices were carried out using Shannon Wiener diversity (H'), Margalef diversity index (Da)andPielou Evenness (J'). Shannon-Wiener index is used as a quantitative measure reflecting the number of different types of species existing in a dataset, and concurrently takes into account the how evenly distributed the individuals are among those types. The two indices rely on different concepts to measure diversity. The Shannon-Wiener Index heavily relies on uncertainty. This means that the more diverse the area, the lower the probability of correctly guessing the species of a random organism from the area. This is in contrast to Simpson's index which measures the dominance in the area. This means the more diverse the area, the lower the probability of obtaining two organisms from the area which are both of the same species.

H = -SUM[(pi) × ln(pi)] SUM = summation pi = proportion of total sample represented by species

Da = (S - 1)/log lo base e N

Where Da = Margalef index, S = the number of species and N = the total number of individuals.

Evenness = E = H/Ln(S)

Where *H'* is Shannon Weiner diversity and *S* is the total number of species in a sample, across all samples in dataset.

Pielou's or species evenness (E) refers to how close in number each species in an environment.If E is close to 1.0, this means that equitability is higher (all species in the community are represented by a similar number of individuals).

An analysis of variance to fit means which test equality was performed with multiple comparison tests on means with means comparison circles and outlier box plots overlaid on each group. The box plots summarize the distribution of points at each factor level. Each multiple comparison test is represented by a comparison circles plot, which is a visual representation of group mean comparisons. The diamond plot represents the confidence interval for each group. Overlap marks for each diamond are computed as group mean shown as the horizontal line inside each diamond. Overlap marks in one diamond that are closer to the mean of another diamond than that diamond's overlap marks indicate that those two groups are not different at the 95% confidence level.The Association of polychaetes through time was analyzed with clustering method of Wards linkage.

## V. Results

### 5.1 Composition and Abundance

Table 1.0 shows the Polychaete fauna collected within the period of study. A total of 370 individuals consisting of 34 polychaete species, 26 genera and belonging to 19 families were recorded from the study area. The dominant polychaete family in terms of abundance was Lumbrineridae which had 7 genera followed in decreasing byCapitellidae (3), Nepthydae (3), Glyceridae(2) , Orbiniidae(2), Paraonidae(2) , Spionidae, (1) Cossuridae(1), Goniadidae (1), Onuphidae (1), Eunicidae (1), Sternaspidae (1), Ampharetidae (1), Hesionidae (1), Sabellidae (1) Ampharetidae (1),Maldanininae (1), and Pilargidae (1).

Five genera were the most abundant with Lumbrienerisbeing the most abundant in the study area with 6 species, followed by Aglaophamus, Scoloplos, Notomastus and Glycera with 2 species each.The species abundance showed that AglaophamusmalmgreniThéelwas the most numerous with 114 individuals followed in decreasing order by other species numbering between 11 and 50 individuals such as Scoloplos (scoloplos) armigerMüller, LumbrinerisheteropodadifficilisDay,

**Table 1. Abundance of Polychaete fauna recorded in the Polyhaline region of the Bonny (Shoreline) from June 2012 to June 2013**

| S p e c i e s | June_ 2012 | Augus t_201 2 | Octob er_20 12 | Febru ary_2 013 | April_ 2013 | June_ 2013 | Total |
|---|---|---|---|---|---|---|---|
| LumbrinerisheteropodadifficilisDay | | 6 | 4 | | 8 | 8 | 26 |
| LumbrinerisaberransDay | 1 | | | | | | 1 |
| LumbrineriopsisparadoxaSaint Joseph | 1 | | | | | | 1 |
| LumbrineriscoccineaRenier | 1 | 1 | | | | | 2 |
| LumbrinerislatreilliAudouin and Milne-Edwards | | 1 | | | | | 1 |
| LumbrineristetrauraSchmarda | | 1 | 1 | 1 | 5 | | 8 |
| NinoelagosianaAugener | | | 10 | 3 | 11 | | 24 |
| AglaophamusmalmgreniThéel | 1 | 23 | 34 | 16 | 32 | 8 | 114 |
| AglaophamuslyrochaetaFauvel | 1 | | | | 1 | | 2 |
| NephthysassimilisÖrsted | 1 | 4 | 3 | | | | 8 |
| MalacocerosindicusFauvel | 1 | | | 3 | | | 4 |
| CossuralongocirrataWebser and Benedict | | 4 | 3 | 4 | | | 11 |
| Scoloplos (scoloplos) armigerMüller | | 7 | 10 | 6 | 16 | 11 | 50 |
| Scoloplos (leodamas) johnstonei Day | | | 5 | 8 | | | 13 |
| Aricidea simplex Day | | 1 | 1 | | | | 2 |
| Paraonispygoenigmatica Jones | | 1 | | 1 | | | 2 |
| Ceratonereis (composetia) costae Grube | | 1 | | | | | 1 |
| SimplisetiaerythraeensisFauvel | 1 | 3 | 4 | 1 | | | 9 |
| Notomastusaberans Day | | | | 6 | | | 6 |
| NotomastuslatericeusSars | | | 1 | | 1 | | 2 |
| ParacapitellapettiboneaeCarrasco and Gallardo | | | | 3 | | | 3 |
| TharynxdorsobranchialisKirkegaard | | | 7 | 1 | | | 8 |
| GlyceratridactylaSchmarda | | | 5 | | 1 | 6 | 12 |
| GlyceraprashadiFauvel | | | | 6 | 3 | | 9 |
| GlycindekamerunianaAugener | | | 2 | | | 1 | 3 |
| DiopatraneapolitanaDelleChiaje | 3 | 4 | 3 | 4 | 4 | 3 | 21 |
| LysidicecollarisGrube | | | 1 | | | | 1 |
| SternaspisscutataRanzani | | | 1 | 3 | 7 | 2 | 13 |
| IsoldawhydahaensisAugener | | | | 1 | | | 1 |
| GyptisincisaBöggemann | | | | 1 | 3 | | 4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DasychoneserratibranchisGrube | | | | | 1 | | 1 |
| Melinna palmateGrube | | | | | 2 | | 2 |
| MaldanesarsiMalmgren | | | | | 4 | | 4 |
| Sigambratentaculata Treadwell | | | | | | 1 | 1 |
| Total | 11 | 57 | 95 | 68 | 99 | 40 | 370 |
| Mean | 0.324 | 1.676 | 2.794 | 2.000 | 2.912 | 1.176 | |
| Standard Deviation | 0.638 | 4.198 | 6.173 | 3.330 | 6.298 | 2.769 | |
| Coefficient of Variation | 1.973 | 2.504 | 2.209 | 1.665 | 2.163 | 2.353 | |

Ninoelagosiana Augener, Scoloplos (leodamas) johnstonei Day, Sternaspisscutata Ranzani, and Glyceratridactyla Schmarda.Six other species with total abundance between 6 and 9 individuals consisted of Lumbrineristetraura Schmarda, Nephthysassimilis Örsted, Simplisetiaerythraeensis Fauvel, Notomastusaberans Day, TharynxdorsobranchialisKirkegaard, and Glyceraprashadi Fauvel. The mean abundance of polychaetes from the study area ranged from 0.324 to 2.912. In addition, the mean values of the months of October 2012 and April 2013 were significantly different from the others.

Figure 2.0 shows the species abundance between months. Values were lowest in the months of June (2012 and 2013) and highest in the months of October 2012 and February 2013. Figure 3.0 shows the number of individuals between months with numbers highest in the months of October 2012 and April 2013. The months of June 2012 and 2013 are similar in being the lowest values.

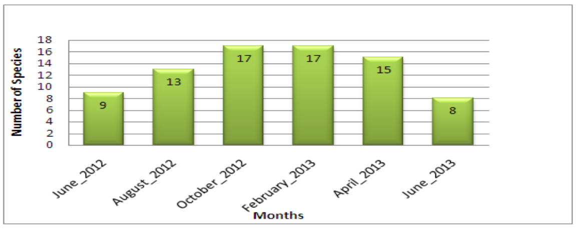



**Figure 2.0 Species abundance between months**

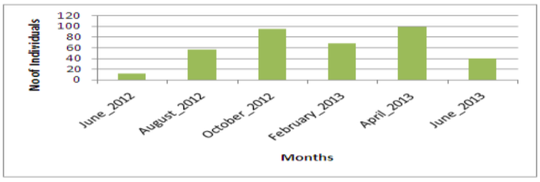



**Fig 3.0** Number of individuals between months.

**5.2 Species Diversity**

In Figure 4 and 5 the species diversity values for Shannon Weiner and Margalef indices are shown. The study area had low to moderate Shannon-Weiner diversity (1.81 to 2.49). The highest Shannon-Weiner diversity value occurred in the month of February 2013 followed in decreasing order by October 2012, April 2013, June 2012, and August 2012 with lowest diversity in June 2013. Similar values were observed for the Margalef index with values from 1.90 to 3.79. The result of this index is similar to the Shannon-Weiner with the highest value in February 2013 and lowest value in the month of June 2013. In a healthy environment, the Shannon diversity and Margalef richness are higher and in the range of 2.5–3.5. However, in the present study all the months for Shannon Weiner had values below 2.5. Only two months October 2012 and February 2013 had Margalef values above 3.5 indicating moderate diversity in these months. However the Pileouevenness(E) values indicate the highest evenness0.88 only in in June 2012 followedby a low evenness of the range of 0.45-0.50 for the months of February 2013, October 2012, August 2012, June 2013 and April 2013.

**Figure ##.MargalefDiversity index for the study period**

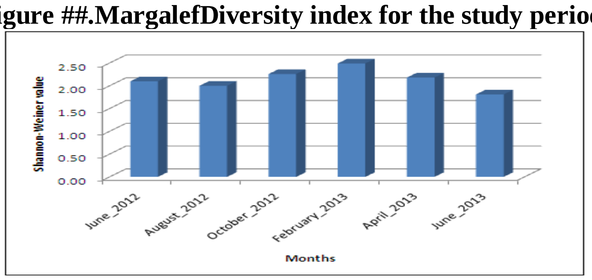



**Figure 4.0** Shannon Weiner Diversity index for the study period

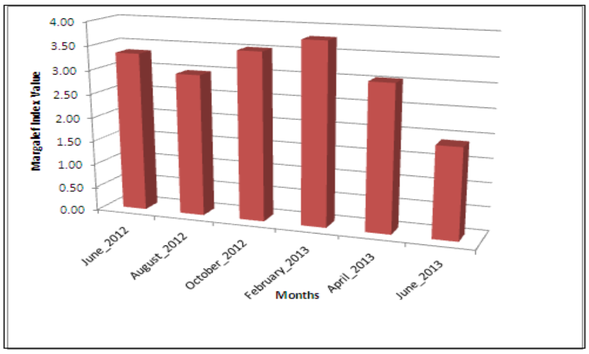



**Figure5.0** Margalef Index for the period of study


**Figure 6.0** Pieleou Evenness index of Bonny Shoreline

The one way analysis of variance of Polychaete abundance is shown in Fig 7.The graphical means diamond plot shows the abundance for each month with the X axis scaled proportional to the sample size of each month. The boxplots which compare the different months on a numeric response shows that the months clearly differ with variability highest in the months of October 2012 and April 2013 and the least in the months of June 2012 and June 2013.

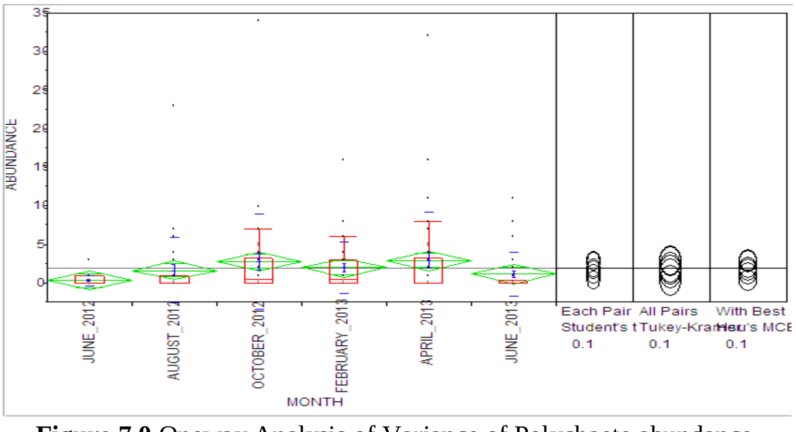



**Figure 7.0** Oneway Analysis of Variance of Polychaete abundance.

**5.3 Species Association:** The association of Polychaete species through the period is shown by the dendogram in Fig 8. The average linkage shows the hierarchical cluster of 34species grouped into three major associations of two groups of repeater species and one group of an “assemblage of drifters”. The first association is a group of repeater species made up of three species namely AglaophamusmalmgreniThéel, DiopatraneapolitanaDelleChiajeandScoloplos (scoloplos) armigerMüller. These can be characterized as generalists due to the fact that they seem to disperse and recur successfully throughout the sampling period. The second association which are also “generalists” comprise of eight species namely Lumrineris (heteropoda) difficilis Day, LumbrineristetrauraSchmarda, Glyceratridactyla Schmarda, Nephthysassimil is Örsted, SimplysetiaerythraeensisFauvel, Ninoelagosiana Augener, SternaspsisscutataRanzani, andCossuralongocirrataWebser and Benedict. This association is characterized by species that co-occurred at least three to four times out of the six sampling months. These generalists are those that seem to disperse and recur successfully throughout the year. In this group the co-occurrence is evidence of their ability at successful temporal recruitment and spatial dispersal in both wet and dry seasons.

The third association comprises of twenty-one species namely Lumbrinerisaberrans Day, Lumbrineriopsisparadoxa Saint Joseph, Lumbrineriscoccinea Renier, Aglaophamuslyrochaeta Fauvel, Malacocerosindicus Fauvel, Lumbrinerislatreilli Audouin and Milne-Ed wards, Ceratonereis (composetia) costae Grube, Aricidea simplexDay, ParaonispygoenigmaticaJones, Isoldawhyadahaensis Augener, NotomastuslatericeusSars, NotomastusaberansDay,LysidicecollarisGrube, Dasychoneserratibranchis Grube, Melinna palmate Grube, Glycindekameruniana Augener, Glyceraprashadi Fauvel Gyptisincise Böggemann, MaldanesarsiMalmgren, TharynxdorsobranchialisKirkegaard, andScoloplos (leodamas) johnstoneiDay. The third association is an assemblage of “drifters” which can be termed specialists due to the fact of their single month occurrence which is indicative evidence of an environmental effect on temporal recruitment. ,

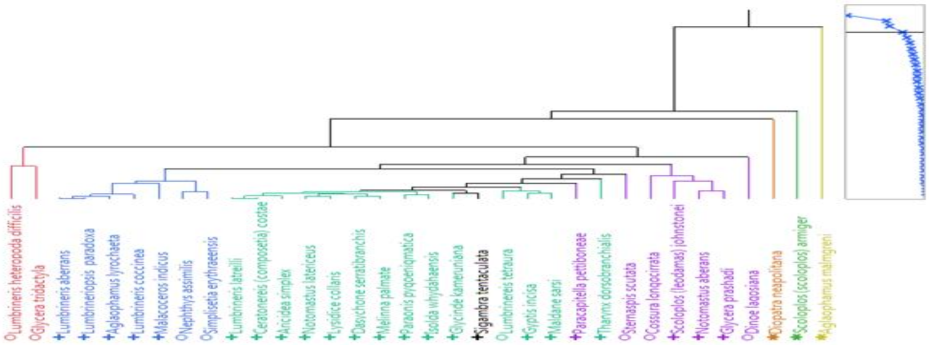



**Figure 8.0** Dendrogramof Polychaete species assemblage at the shoreline during the study.

## VI. Discussion

The results of this study provide insight to the taxonomic uniqueness of the polychaetes of the Niger Delta. Current reviews as reported by Decker et al (2003) for marine biodiversity in sub-Saharan Africa indicate that Nigeria has a total of 29 families of polychaetes of which Maldanidae had the most genera (seven genera) and the most species (seven species). The results of this study however show that additional families such as Lumbrineridae, Goniadidae, Onuphidae and Eunicidae are present to increase the number of families to thirty-three. The relative abundance of a number of species such as Aglaophamusmalmgreni Théel, Scoloplos (scoloplos) armiger Müller, Lumbrinerisheteropodadifficilis Day; Diopatraneapolitana Delle Chiaje; and Ninoelagosiana Augener provide an indication of the status of the environment as transitional. The mixed abundance of the various trophic groups such as the carnivorousand predaceous tube building species Aglaophamusmalmgreni Théel; Lumbrinerisheteropodadifficilis Day and Diopatraneapolitana Delle Chiaje; with mobile detritivore such as Scoloplos (scoloplos) armiger Müller; and deposit feeder such as Ninoelagosiana Augenercharacterizes the environment as poor to moderate quality as supported by documented ecological quality assessment (EQS) (Simbouraand Zenetos 2002) which in turn is corroborated by the poor to moderate diversity values of Shannon-Weiner (1.81-2.49) and Margalef (1.9-3.79) obtained in this study.

The three polychaete associationsidentified using cluster analyses were tightly associated with temporal co-occurrence between distributions. The three association patterns demonstrate that sometimes the mere tolerance of species to physical and chemical conditions often do not provide sufficient explanation for the observed distribution pattern (Mangum et al.,1978;Woodin, 1974;Whitlatch, 1977). In this study the similarity in seasonal occurrence was evidence of what enabled co-occurrence of the generalists who were abundant mostly throughout the sampling period. In contrast, the specialists were continuously lost and added to the habitat in a pattern that require a study of other biological variables such as spawning frequency of the females and the monitoring of new recruits in order to understand the rates of immigration and emigration.

The species turnover was observed in those Polychaetes that had single month occurrence in June 2012 (L. aberans; L. paradoxa;) August 2012(L. latereilli; C.costae); October2012 (L. collaris); February 2013 (Isoldawhydahensis; Notomastusaberans) and April 2013 (D. serratibranchis).These differences in performance ofspecialists and generalists are supported amply inthe literature. The evidence indicates that Specialists show high turnover because they tend to have low environmental tolerances (Ives and Dennis, 2003; Shurin, 2007; Panditet al., 2009), low dispersal abilities, higher mortality during dispersal, and lower colonizing efficiency due to failure to find suitable habitats (Therriaultand Kolasa, 1999; Resetarits, et al., 2005). In this study salinity and temperature does not vary (NEDECO, 1963; NNPC/RPI, 1985) which indicates that the single month occurrence turnover of the specialists with low recurrence is plausiblythe function of habitat specialization; with specialists experiencing greater constraints by local conditions and exhibiting greater responsiveness to their variation.

This study has implications for environmental and ecological monitoring programmes. The study presents evidence of an environment with stable salinity and temperature with capacity to exhibit differentiation where different species associations interact with other existing environmental variables differently. Specialists are governed by environmental processes to a greater extent than generalistswhose ability to recur throughout the sampling period is indicative that they are less restricted by local conditions. Therefore the environmental monitoring studies which often rely on ecological measures of community composition and diversity as indicators of anthropogenic change must recognize that the specialist-generalistrelationship patterns may not always reflect impacts. Any effort to use benthic Polychaetes to monitor ecological impacts must therefore focus on integrating information collected from physical, chemical and ecological monitoring into a more holistic understanding of ecosystem condition.

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