The Taxa Structure and Composition of Zooplankton Communities of Bonny Estuary: A Bio-indication of Anthropogenic Activities.

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ABSTRACT

This study was aimed at ascertaining the zooplankton taxa structure and composition as a way of assessing the environmental quality of the Bonny estuary. The plankton net of 55 µm mesh-size was towed vertically, preserved in well-labeled 250 ml polyethylene bottles, and fixed with 10% formalin. In all, 2,928 zooplankton specimens were collected: Calanoid copepods were the most abundant constituting 55.3% of all collections, followed by Cyclopoida (10.2%), Harpacticoida (5.8%), Copepod larvae (17.0%); Annelida/Polychaeta larvae (1.9%); Chaetognatha (2.3%); Appendicularia (2.2%); Pisces larvae (2.6%); Tunicate larvae (0.6%); Cnidaria (0.1%); Ctenophora (0.1%); Echinodermata larvae (0.9%); Mollusca larvae (1.2%); Copepoda /Cladocera (0.03%); and Malacostraca (0.1%). A total of 119 species was collected, and Margalef's diversity index ranged from 1.54 to 7.58. There was relatively higher abundance and diversity of zooplankton in the offshore sampling stations than in the near-shore sampling stations, probably due to impacts of natural, ecological, and anthropogenic factors. Mitigation measures to significantly check these anthropogenic activities among inhabitants of near-shore areas are recommended.

(Keywords: zooplankton, relative abundance, diversity, species composition, estuary, anthropogenic impact, Nigeria)

INTRODUCTION

Plankton is essentially non-motile relative to the water mass, but drifts with it. The plankton community in rivers is usually dominated by a small number of taxa (Admiraal et al., 1994).

Zooplankton comprises a large variety of different organisms with sizes ranging from tiny flagellates, a few mm large, up to giant jellyfish of 2m diameter. They are composed of the permanent members whose entire life-cycles are spent as plankton (holoplankton); and the temporary members, which comprise mostly of the egg and larval stages of benthic organisms (meroplankton). Zooplankton are small animals and float freely in the water column of rivers, lakes, and oceans and whose distribution is primarily determined by water currents among other factors.

Zooplankton occupies a central position in the trophic link between primary producers and higher trophic levels (Iloba, 2002); they are also good bio-indicators of the aquatic environmental conditions (Uttah et al., 2008; Uttah and Uttah, 2009) that precursor changes in the zooplankton composition and also influence their densities (Hillbricht-Ilkowska, 1977; Karabin, 1985; Matveeva, 1991). The zooplankton species composition, distribution, diversity and relative abundance in an aquatic ecosystem could have an important impact on fisheries and public health of the river and its users (Jafari et al., 2011). A typical zooplankton assemblage frequently differs in diversity and abundance spatially from river to river, and even from site to site within each river, from geographical region to region and also temporally, and it is structured by fish predation, competition, aquatic macrophytes (Jackson and Schmitz, 1987) and physical, chemical and biological aspects (Sampaio et al., 2002).

The use of biological approaches to undertake water quality assessment is quite popular now (Uttah et al. 2008; Uttah and Uttah, 2009; Uttah et al. 2012a,b). It is possible to use any group of organisms to examine the biological condition of an aquatic ecosystem, and many attempts have been made using both flora and fauna (Armitage et al., 198; Uttah and Uttah, 2009), including benthos (Uttah et al., 2013). Fish communities are often used as an indicator of high water quality areas (Uttah et al. 2012a, b), as some species have specific water quality requirements (Bauer and Ralph, 2001).

Zooplanktons are sometimes regarded as seldom important in rivers and streams because they cannot maintain positive net growth rates in the face of downstream losses. However, they are highly sensitive to environmental variation, which results in changes in their abundance, species diversity, or community composition and hence provides important indications of environmental change or disturbance (Uttah et al., 2013). Zooplankton communities often respond quickly to environmental change because most species have short generation times. Zooplankton communities responsive to a wide spectrum of disturbances including discharge of chemical substances (Uttah et al., 2013), nutrient loading (Dodson, 1992), acidification (Brett, 1989; Keller and Yan 1991; Marmorek and Kormann 1993), contaminants (Yan et al. 1996), fish densities (Carpenter and Kitchell 1993), and sediment inputs (Cuker 1997).

The Bonny estuary is replete with anthropogenic activities as it hosts oil exploratory activities, including a global-scale refining of natural gas, with all their attendant perturbations. There was palpable need to undertake an environmental audit to determine whether in actuality, there is any empirical evidence of significant stress in the estuary. This study was aimed at ascertaining the zooplankton taxa structure and composition as a way of assessing the environmental quality of the Bonny estuary.

MATERIALS AND METHODS

Description of the Study Area

The Bonny estuary is a busy area as it plays host to large-scale oil exploratory activities. The area also hosts the world-class liquefied natural gas refinery that attracts heavy traffic of international gas tankers. This is in addition to the area being the gateway into the Onne Port near Port Harcourt.

The estuary is also a fishing ground for several near-shore fishing settlements as well as the indigenous Bonny and Finima communities. There are adjoining creeks, one of which is the Finima Creek. These creeks are replete with mangroves. The importance of these mangrove swamps lo the local dependent communities cannot be over-emphasized as these swamps incorporate the whole food chain that leads to socio-economic benefits derivable from resource exploitation (Ogba et al., 2007). The local communities exploit these creek forests for non-timber forest products, agricultural land and fisheries (Utang and Ania, 2012).

Sampling Method

The sampling methods for zooplankton have been described in an earlier paper (Uttah et al., 2008), except that in this case, the sampling was carried out aboard a sea-worthy vessel. Plankton net of 55 µm mesh-size was used to collect samples. A sinker was attached to the plankton net and lowered to 50 meters into the water depending on the depth of the sampling station. The plankton net was towed vertically from the appropriate depth to the water surface, and retrieved onto the deck for processing. The zooplankton samples were preserved in well-labeled 250 ml polyethylene bottles and fixed with 10% formalin. The samples were then transported to the laboratory for further analysis.

Laboratory Analysis

Sorting and counting of the benthic macro-invertebrates were carried out on the standard white panel in the laboratory, using a hand lens. A dissecting microscope was handy for verification of some cases. As much as possible, identification of specimens was made up to species level or genus levels using the keys of WRC (2001).

RESULTS AND DISCUSSION

Abundance

A total of 2,928 zooplankton specimens were collected during the study (see Table 1). The Calanoid copepods were the most abundant constituting 55.3% of all zooplankton specimens collected. This was followed by other copepod groups: Cyclopoida (10.2%) and Harpacticoida (5.8%). Other Zooplankton groups represented in the collections during the study include Copepod larvae (17.0%); Annelida/ Polychaeta larvae (1.9%); Chaetognatha (2.3%); Appendicularia (2.2%); Pisces larvae (2.6%); Tunicate larvae (0.6%); Cnidaria (0.1%); Ctenophora (0.1%); Echinodermata larvae (0.9%); Mollusca larvae (1.2%); Copepoda /Cladocera (0.03%); and Malacostraca (0.1%).

Table 1: Relative Abundance of Zooplankton Classes Collected During the Study.

Taxa	No. counts	% count
Annelida/Polychaeta	55	1.9
Copepoda larvae	499	17.0
Copepoda/Calanoida	1612	55.1
Copepoda/Cyclopoida	299	10.2
Copepoda/Harpacticoida	171	5.8
Malacostraca	2	0.1
Chaetognatha	67	2.3
Copepoda/Cladocera	1	0.03
Chordata/Appendicularia	64	2.2
Pisces larvae	75	2.6
Ascidacea/Tunicate larvae	17	0.6
Cnidaria	4	0.1
Ctenophora	2	0.1
Echinoderm larvae	26	0.9
Mollusca larvae	34	1.2
Total	**2,928**	**100**

This result is congruent with the observation that the crustaceans, which include the copepods, are the most abundant zooplankton (Hutchinson, 1993). Copepods dominate most aquatic ecosystems because of their resilience and adaptability to changing environmental conditions and ability to withstand varying environmental stresses (Uttah et al., 2013). The success of the crustaceans could be attributable to their possession of chitinous exoskeleton, which enhances their survivability in different environmental conditions. Specifically, the copepods are the dominant members of the zooplankton (Uttah et al., 2013). Of all three copepod groups (Calanoida, Harpacticoida and Cyclopoida), the calanoids were the most abundant. The cyclopoids are abundant in the estuaries and are mainly inhabitants of the littoral region, while few are limnetic. The harpacticoids showed close affinity with the sample stations that were replete with vegetation debris. The larval forms of Mollusca were observed among the planktons. Their adult stage is benthic. In this study only the members of Sagittidae family were chaetognath species observed among the zooplanktons. This is understandable as only few chaetognath species are known to be planktonic, majority are benthic. The planktonic larvae were more abundant in the offshore stations (PLBs and PLQs) than in the near-shore estuarine stations. This could be because many estuarine species spawn within the estuary, but larvae and juveniles may spend some period of time in the coastal waters, perhaps to avoid predation within the estuaries (Okun et al., 2008).

The most dominant zooplankton species observed during the study were Paracalanus parvus, Centropages, and Calanus finmarchicus, among others. Expectedly, these are all copepod crustaceans. Paracalanus parvus is known to exist in all tropical and temperate waters but absent in arctic and Antarctic waters (Davis and Otene, 2009). Similarly, Calanus finmarchicus is one of the most abundant and greatest sources of food in estuaries.

Presentation of the zooplankton counts with the five offshore sampling stations and the twenty-three near-shore sampling stations is done in Table 2. The highest counts (227 representing 7.8% of all zooplankton counts) were recorded in the offshore station PLQ-W2, while the near-shore station NRSH-W17 recorded the least zooplankton counts (7 representing 0.2% of all zooplankton collected). The overall mean of zooplankton collected was 105. The mean of collections in the offshore sampling stations was 151, which was well above the overall mean. The mean of counts in the near-shore sampling stations was 85, which was lower than the overall mean, and also significantly lower than mean of offshore collection (t-test; $p < 0.05$).

Diversity

A total of 119 species of zooplankton was collected in the study. The Margalef's diversity index ranged from 1.54 to 7.58. A diversity index increases as the number of species increases and as the numerical distribution of species becomes more even. The Margalef's diversity index did not exhibit any definite pattern when the near-shore estuarine stations and the offshore stations were compared. The highest and lowest Margalef's diversity indices were recorded in the near-shore sampling stations.

Table 2: Relative Abundance and Margalef's Diversity Index of Zooplankton in Relation to Sampling Stations.

Station ID	Total Count	Count (%)	No. Spp	Marg. Index
PLB-W9	114	3.9	22	4.23
PLQ-W2	227	7.8	23	4.06
PLB-W12	162	5.5	25	4.71
PLB-W15	138	4.7	20	3.85
PLB-W16	114	3.9	26	5.27
NRSH-W1	127	4.3	30	5.99
NRSH-W2	69	2.4	13	2.83
NRSH-W3	78	2.7	13	2.75
NRSH-W4	202	6.7	23	4.14
NRSH-W5	129	4.4	16	3.08
NRSH-W6	68	2.3	12	2.61
NRSH-W7	11	0.4	6	2.09
NRSH-W8	126	4.3	14	2.69
NRSH-W9	206	7.0	21	3.75
NRSH-W10	134	4.6	31	6.12
NRSH-W11	140	4.8	31	6.07
NRSH-W12	90	3.1	14	2.89
NRSH-W13	165	5.6	33	6.27
NRSH-W14	68	2.3	33	7.58
NRSH-W15	80	2.7	20	4.34
NRSH-W16	129	4.4	26	5.14
NRSH-W17	7	0.2	4	1.54
NRSH-W18	105	3.6	22	4.51
NRSH-W19	71	2.4	21	4.69
NRSH-W20	11	0.4	6	2.09
NRSH-W21	51	1.7	15	3.56
NRSH-W22	14	0.5	7	2.27
NRSH-W23	87	3.0	33	7.16
Total	**2,928**	**100.0**	**119**	

The highest Margalef's diversity indices were 7.58, 7.16, 6.27 recorded at NRSH-14, NRSH-23, NRSH-13; whereas the least Margalef's diversity indices were 1.54, 2.09, and 209 recorded at NRSH-17, NRSH-7 and NRSH-20 respectively.

In general terms, systems under the influence of strong perturbations typically show reductions in the number of species that are numerically dominant (Uttah et al., 2008). The diversity of zooplankton communities is essentially related to the number and longevity of simultaneously coexistent exploitable niches. In the ecosystem, there are always temporary niches in which growth conditions differ from what exists elsewhere. Such niches are frequently obliterated and reconstituted at random, permitting high between-niche diversity, directly favoring the maintenance of several species. Sometimes faunistic changes indicate arrival of a different water mass of a particular type. Zooplanktons are known to indicate the effect of low levels of oil and chemical pollution in the water body, which might not be as lethal to higher organisms. This is because during their feeding, they accumulate smaller phytoplankton, other zooplankton and debris, and may consequently ingest oil particles in areas where there is oil pollution. (Uttah et al., 2012b). This makes them quite vulnerable to anthropogenic activities which are more rampant in near-shore areas than in the offshore areas, and may explain the relatively lower zooplankton counts recorded in the near-shore sampling stations when compared to the counts obtained from the offshore sampling stations in this study.

The incessant and sustained vehicular traffic involving local and international sea-going that pass through that route to a major port (Onne Port) in Port Harcourt, Rivers State, is a significant perturbation that impact on zooplankton. Runoff from residential and industrial areas, agricultural lands could be beneficial or detrimental to zooplankton abundance and diversity at any point in time and space. Since zooplankton move with water mass, the prevailing abundance and diversity quotients for the mass of water is a product of the balance between the beneficial and detrimental runoffs, the self-recoverability as well as the carrying capacity of the water mass among other factors (Ikpeme et al., 2013).

Relationship between depth of sampling station and Margalef's diversity index of zooplankton is shown in Figure 1 and Figure 2 for near-shore and offshore stations respectively. Depth of sampling station is not regarded as of any significant influence on zooplankton abundance and diversity unlike the benthic organisms where it is important (Wlodarska-Kowalczuk et al., 2004). This observation is expected as plankton communities have no noticeable relationship with depth of sampling stations.

CONCLUSION

There was relatively higher abundance and diversity of zooplankton in the offshore sampling stations than in the near-shore sampling stations. The extent and types of impacts of natural, ecological, and anthropogenic factors in these two groups of sampling stations may be responsible.

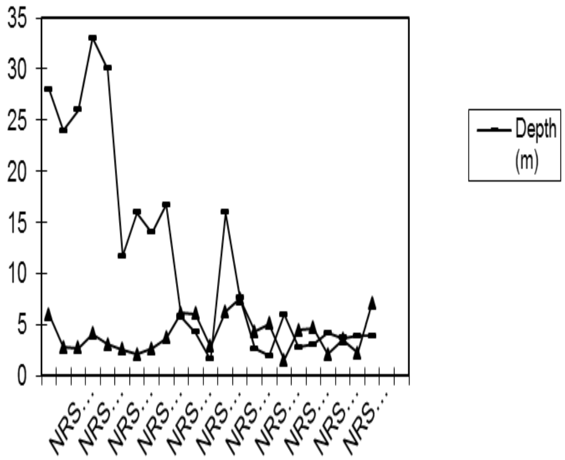

Figure 1: Depth of Near-Shore Sampling Stations in Relation to their Margalef's Diversity Indexes.

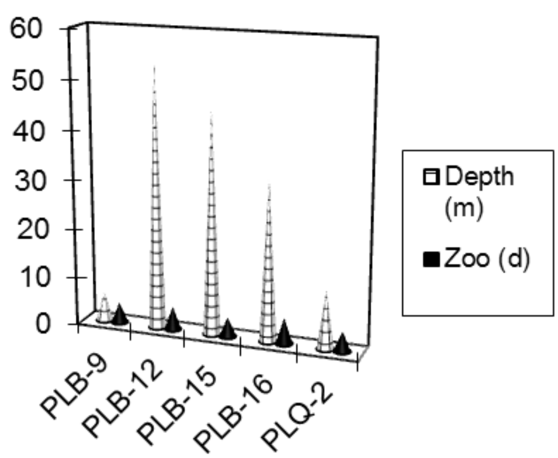

Figure 2: Depth of Offshore Sampling Stations in Relation to their Margalef's Diversity Indexes.

Mitigation measures to significantly check these anthropogenic activities among inhabitants of near-shore areas are recommended. As a matter of urgency, regulatory bodies to enforce compliance with environmental statutes, rules and regulations, international bilateral agreements and protocols should be established and empowered to succeed. This will go a long way to preventing further loss of vulnerable species, stem further deterioration of the aquatic environment, and prevent more biodiversity losses.

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