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The Effects of Sieve Mesh Sizes on Benthic Macrofuana of Azuabie and Obufe Creeks in the Upper Bonny Estuary, Niger Delta

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Abstract

An investigation of benthic macrofauna was undertaken in the Azuabie and Obufe Creeks of the upper Bonny Estuary. One aim of the study was to determine the effect of sieve mesh sizes on macrobenthic fauna in the two Creeks. Five and four Stations were chosen in Azuabie and Obufe Creeks respectively and Sediment samples were collected monthly with an Eckman grab from February 2021 to January 2022. Four replicate samples were collected and sieved through 1mm, 0.5mm and 0.35mm sieve mesh sizes. Monthly composite data from each creek was used to determine the effects of sieve mesh size on the composition and abundance of benthic organisms. The data was subjected to Analysis of Variance (ANOVA) and Tukey tests where significant difference was inferred by ANOVA. A total of eighteen (18) species were observed but two (2 species (Obinnia johnsoni and unidentified cumacean) were not retained in the 1.0mm mesh sieve and this is suggestive of exclusion based on size. The 0.35mm sieve retained the highest percentage abundance (88% in Azuabie and 63% in Obufe) of benthic macrofauna followed by 0.5mm (10% in Azubie and 28% in Obufe) and the least being 1.0mm (2% in Azuabie and 9% in Obufe). Also, the 0.35mm and had significantly higher values of mean total abundance than the 0.5mm and 1.0 mm mesh in both Azuabie and Obufe Creeks (ANOVA, $p<0.001$), with Tukey Tests showing 0.35mm > 0.5mm > 1.0mm in Azuabie and 0.35mm>0.5mm=1.0mm in Obufe. . It is concluded that the 0.35mm mesh sieve is the preferable option for detailed studies of macrobenthos in the Bonny Estuary.

Keywords: *Upper Bonny Estuary; Sediment; Macrobenthos; Sieve Mesh Size;*

INTRODUCTION

The Bonny Estuary is one of the richest estuaries in the Niger Delta aquatic ecosystem, with a network of creeks/tributaries linking various habitats of highly economic and ecological importance (Ekweozor *et al*., 2004). These ecosystems are often the site where many pollution problems exist (Ekweozor *et al*., 2004) and where pollution loading caused significant changes in abundance and species composition. Benthic macro fauna are those organisms that live on or inside the deposit at the bottom of a water body (Barnes and Hughes, 1988; Idowu and

Ugwumba, 2005). Benthic macro in-fauna are particularly suitable as ecological indicators because their habitat preference and relatively slow movement cause them to be directly affected by substances that enter the environment, (Umesi and Daka, 2004). Because benthic organisms live and feed in sediments, benthic organisms are usually the first organisms affected by pollution or stress (Dean, 2001). Macro benthic invertebrates are useful bio-indicators providing a more accurate understanding of changing aquatic conditions than chemical and microbiological data, which at least give short-term fluctuations (Ravera, 1998, 2000; Ikomi *et al.,* 2005).

Several studies have been carried out on the benthic macrofauna in the upper Bonny Estuary using only one sieve mesh size like that of (Ekweozor, 1985; Ikomah *et al.* 2005; Umei and Daka, 2004); Umesi and Wokoma (2017) who used 1mm sieve mesh size and (Nweke, 2000; Hart and Zabbey 2005; Moslen and Daka 2014; Anyanwu *et al*. 2018; Nkwoji *et al*. 2020) used 0.5mm sieve mesh size. We used three sieve mesh sizes (1mm, 0.5mm and 0.35mm) for the examination of benthic community structure in the Creeks. (Hartwet *et al.,* 2015) stated that under sampling by bigger mesh sizes was most severe for juveniles and small species resulting in biased interpretation of benthic community structure. Sorting benthic macroinvertebrates from sediments and organic matter, as well as counting and identifying them, takes considerable time and effort (Ciborowski, 1991; Vlek *et al*., 2006). While an exhaustive sorting of samples is the only way to assure a thorough description of the structure and composition of a macroinvertebrate community (Courtemanch, 1996; Cao *et al*., 1998). The manner in which samples are collected and processed influences the description of the macroinvertebrate community being examined (Tanaka & Leite, 1998; Morin *et al*., 2004; Boonsoong *et al*., 2009); mesh size is a primary influencing factor (Battle *et al*., 2007; Buss & Borges, (2008). A fine mesh gives a more precise estimate of the community but increases the effort needed for processing (Bartsch *et al*., 1998). In this paper we present an assessment of the effect of three sieve mesh sizes (0.35mm, 0.5mm and 1.0mm) on the composition and abundance of macrabenthos in the upper Bonny Estuary.

Materials and Methods

Study Sites and Sampling Stations

Azuabie and Obufe Creek are tributaries of the Upper Bonny Estuary in the Niger Delta. The Creek receives industrial effluent from the Trans-Amadi Industrial Layout drains, especially, that from the Rivers Vegetable Oil Company (RIVOC). The major vegetation along this Creek is the mangrove forest, mainly of *Rhizophora racemosa*, *Nypa fruticans* and *Avicennia nitida* (Moslen and Daka, 2014), Azuabie Town is found along the Azuabie Creek from where numerous domestic wastes are generated and dumped along the Creek. A major abattoir and some other companies are located upstream of the Azuabie Creek. The Azuabie Creek is open to different kinds of human activities such as dredging, bunkering, fishing, swimming, dumping of waste, etc. which translate into the discharge of various kinds of wastes into the Creek. The frequent discharge of wastes into this Creek can cause a change in the macro-benthic community structure of the Creek (Daka *et al*., 2007, Moslen and Daka, 2014). The Obufe Creek is nearer inland toward, the Elelenwo, Woji and Agpajo axis. The Creek was a narrow estuarine water body that has now widened due to sand mining activities. The Creek receives effluent from oil industries

located downstream, boat construction companys and from small abattoirs along the Creek. The major vegetations along the Creek is *Rhizophora racemosa*, *Nypa fructicans* and *Avicennia nitida*. Okujagu and Aberrepele are towns found along the Creek. The activities carried out on the Creek includes Fishing, dredging, bunkering, swimming, dumping of waste, etc. Five (5) sampling stations were chosen for Azuabie Creek and four (4) stations in Obufe Creek.(Fig.1).

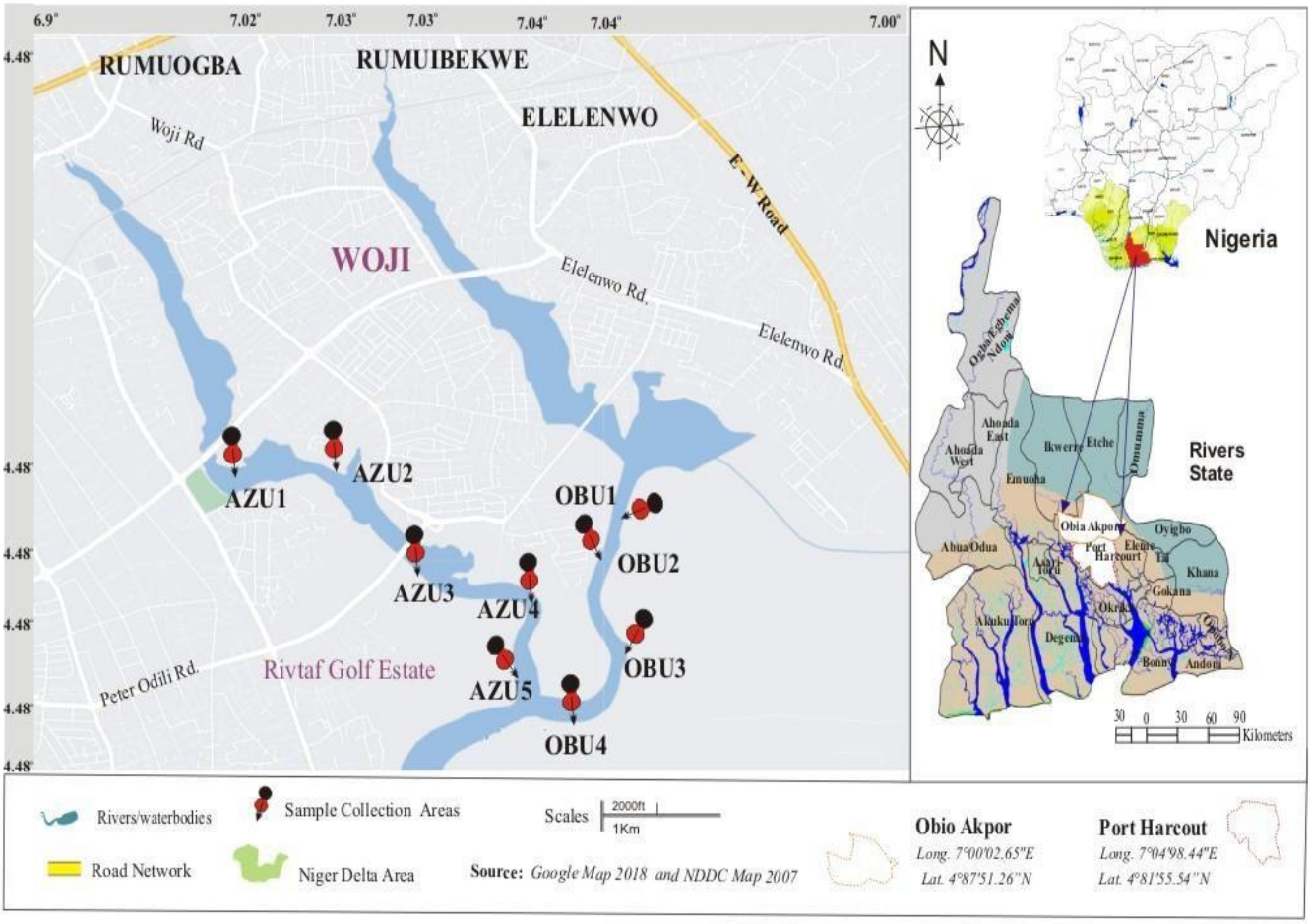

Fig 1: Map Showing the Sampling Sites in the Study Area

Sample Collection and Analysis

Four (4) replicate samples of benthos were collected from each station monthly for twelve months from February 2021 to January 2022. Sediment samples were collected with an Eckman grab (16cm by 16cm) and emptied into a 15liter wide plastic basin. The samples were washed through a series of sieves (1mm, 0.5mm and 0.35mm mesh size sieves) to a clean and clear state to obtain benthic macro fauna. The material retained by the sieves were placed in containers and

preserved with 10% formalin against the volume of brackish-water mixture and stained in Eosin to facilitate sorting before identification to the lowest possible taxonomic level using appropriate Keys (Day 1967; Fauchald, 1977); individuals of each taxonomic group were counted and recorded. Data from monthly collections were composited for the five stations in Azuabie Creek and four stations in Obute Creek for comparison of the effects of mesh size on the composition and abundance of benthos in each Creek.

Data Analysis

One–way Analysis of Variance (ANOVA) was employed to compare differences between mean abundance values of fauna (total abundance and the five most abundant fauna) collected in each sieve size. This was done separately for Azuabie Creek and Obufe Creek. Where ANOVA result showed a significant difference, Turkey test was performed for mean separation.

Results and Discussion

A total of eighteen (18) species (10 polychaetes, five crustaceans, 1 insect and 3 molluscs) were observed (Table 1). Collectively in the two Creeks, 2 species (*Obinnia johnsoni* and unidentified cumacean) were not retained in the 1.0mm mesh sieve.

Table 1: Composition of benthic macrofauna from different sieve sizes in Azuabie and Obufe Creeks

Taxa	Azuabie Creek			Obufe Creek		
	1.0mm	0.5mm	0.35mm	1.0mm	0.5mm	0.35mm
Polychaeta						
Streblospio sp	+	+	+	+	+	+
Polydora capensis	+	+	+	+	+	+
Nereis diversicolor	+	+	+	+	+	+
Nephtys hombergii	+	+	+	+	+	+
Capitella capitata	+	+	+	+	+	+
Notomastus tenuis	+	+	+	+	+	+
Glycera convoluta	+	+	+	+	+	+
Obinnia johnsoni	0	0	0	0	+	+
Fabricia filamentosa	+	+	+	+	+	+
Scoloplos armiger	0	0	0	+	+	+
Crustacea						
Isopod	+	+	+	+	+	+
Peneas spp	+	+	+	+	+	+
Talitri spp	+	+	+	+	+	+
Uca tangeri	+	+	+	0	0	0
Cumaceans	0	0	0	0	+	+

Taxa	Azuabie Creek			Obufe Creek		
	1.0mm	0.5mm	0.35mm	1.0mm	0.5mm	0.35mm
Insecta						
Chironomus ablabiesmia	+	+	+	0	0	0
Mollusca						
Lucinia subfragilis	+	+	+	0	0	0
Cerithidea spp	+	+	+	0	0	0
Tympanotonus fuscatus	0	0	0	+	+	+

+ = Present' 0 = Absent

In Azuabie Creek, the mean total abundance of benthic macrofauna were 71(±61), 417(±248) and 3761(±2351) individuals in the 1.0mm, 0.5mm and 0.35mm mesh sizes respectively (Fig. 2A). This represents 2% in 1.0mm, 10% in 0.5mm and 88% in 0.35mm. There was significant difference in the mean total abundance of mcrofauna retained by the various sieves (p=0.001, Table 1). Turkey pairwise comparisons showed significant difference as follows: 0.35mm > 0.5mm > 1.0mm (Fig. 2A). The mean abundance of *Streblospio* sp in Azuabie Creek ranged from 64 (±67) in 1.0mm to 573 (±419) in 0.35mm (Fig. 2B); ANOVA showed significant differences in the sieves (p=0.001; Table 1). Turkey pairwise comparisons showed significant difference as follows: 0.35mm= 0.5mm > 1.0mm (Fig. 2B). Also, the respective mean abundance values of *Polydora capensis* (6, 2, 1, Fig. 2C), *Nereis diversicolor* (17, 9, 3, Fig. 2D) and *Capitella capitata* (14, 6, 1, Fig. 2E) were in the order 0.35>0.5mm>1.0mm. However, there was no significant difference in the mean values of any of these three species between the mesh sizes (Table 2).

Table 2: Analysis of Variance showing the effects of the Sieves Mesh Sizes on the Macrobenthic Fauna in Azuabie Creek

Fauna	DF	Adj SS	Adj MS	F-Value	P-Value
Total Abundance	2	17140	8569.9	63.11	<0.001
Streblospio spp	2	1628797	814399	10.48	<0.001
Polydora capensis	2	245.4	122.69	2.71	0.081
Nereis diversicolor	2	1116	557.9	1.17	0.186
Capitella capitata	2	1056	528.1	2.45	0.102

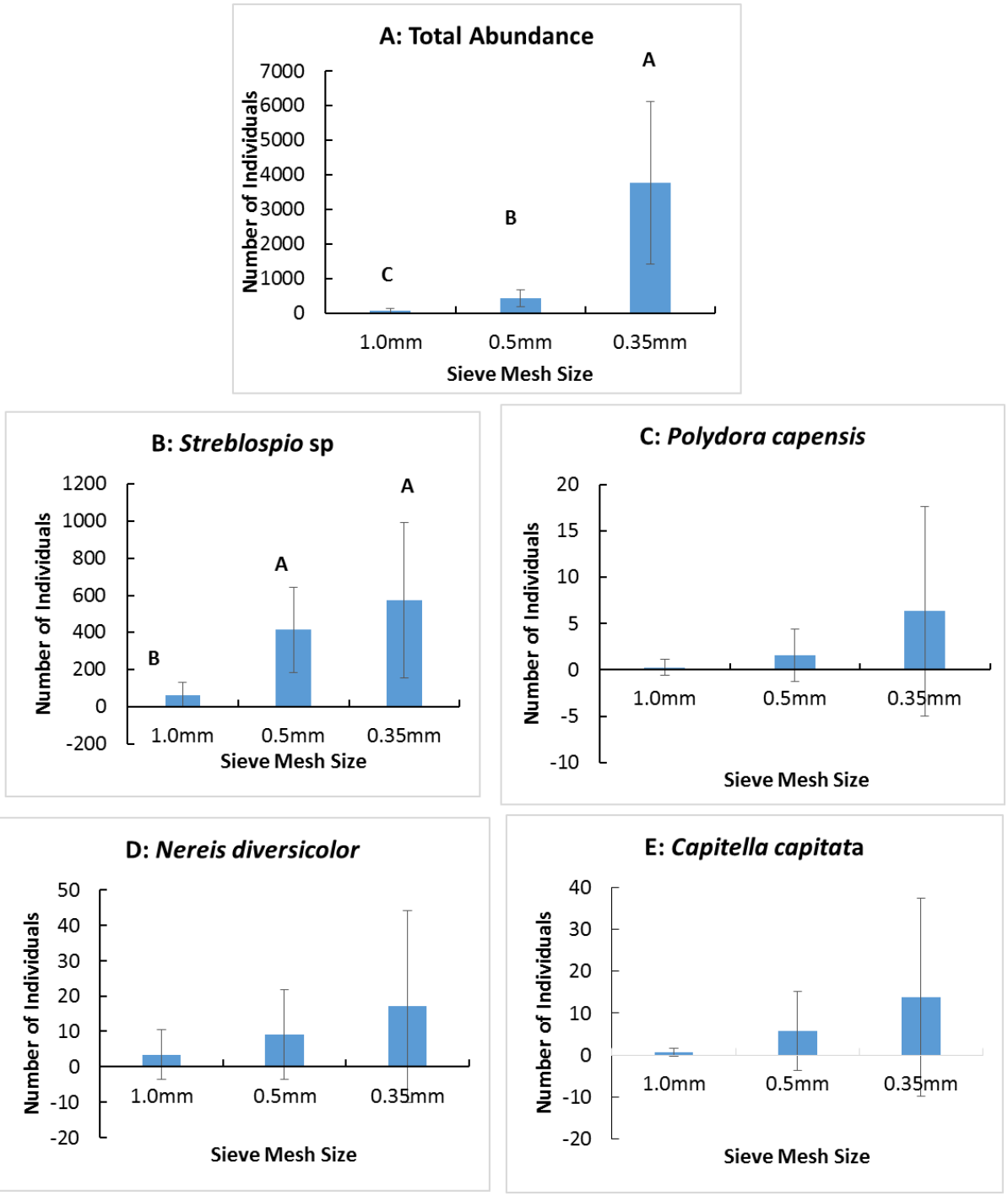

Fig 2. Abundance of Macrobenthic Fauna Mean (Mean ±SD, n= 12) from Three Sieve Mesh Sizes in Azuabie Creek. Means with different alphabets are significantly different (Tukey, $p<0.05$).

Mean total abundance in Obufe Creek ranged from 59 (±32.87) in 1.0mm to 396.25 (±297.63) individuals in the 1.0mm and 0.35mm; the values in 0.5mm is 180 ±105 (Fig. 3A) This represents 9%, 28% and 63% respectively in 1.0mm, 0.5mm and 0.35mm respectively. ANOVA showed thee was significant difference in the mean total abundance ($p<0.001$, Table 2) with Tukey tests indicating 0.35mm>0.5mm=1.0mm (Fig. 3A). Mean abundance values of *Streblospio* sp were 39, 134 and 304 individuals in 1.0mm, 0.5mm and 0.35mm respectively (Fig. 3B). Significant differences were obtained ($p=0.002$, Table 3) with mean separation by Tukey tests showing 0.35mm>0.5mm=1.0mm (Fig. 3B). Abundance of *Polydora capensis* were 2, 6 and 14 individuals in 1.0mm, 0.5mm and 0.35mm respectively, with ANOVA showing significant difference ($p=0.028$) between sieves (Fig. 3C, Table 3). Tukey tests showed that 0.35mm > 1.0mm; 0.35mm=0.5mm and 0.5mm=1.0mm. There was no significant difference ($p=0.419$; Table 2 in the mean number of individuals of *Nereis diversicolor* (9 in 1.0mm, 12in 0.5mm, 15 in 0.35mm; Fig 3D). The mean abundance of *Capitella capitata* were 6, 11 and 23 individuals in 1.0mm, 0.5mm and 0.35mm respectively, with ANOVA showing significant difference ($p=0.040$) between sieves (Fig. 3E, Table 3). Tukey tests showed that 0.35mm > 1.0mm; 0.35mm=0.5mm and 0.5mm=1.0mm.

Table 3: Analysis of Variance showing the effects of the Sieves Mesh Sizes on the Macrobenthic Fauna in Obufe Creek

Fauna	DF	Adj SS	Adj MS	F-Value	P-Value
Total Abundance	2	98115695	49057847	25.53	<0.001
Streblospio sp	2	432401	216200	7.85	0.002
Polydora capensis	2	1081	540.3	3.98	0.028
Nereis diversicolor	2	187.7	93.86	0.89	0.419
Capitella capitata	2	1879	939.4	3.54	0.040

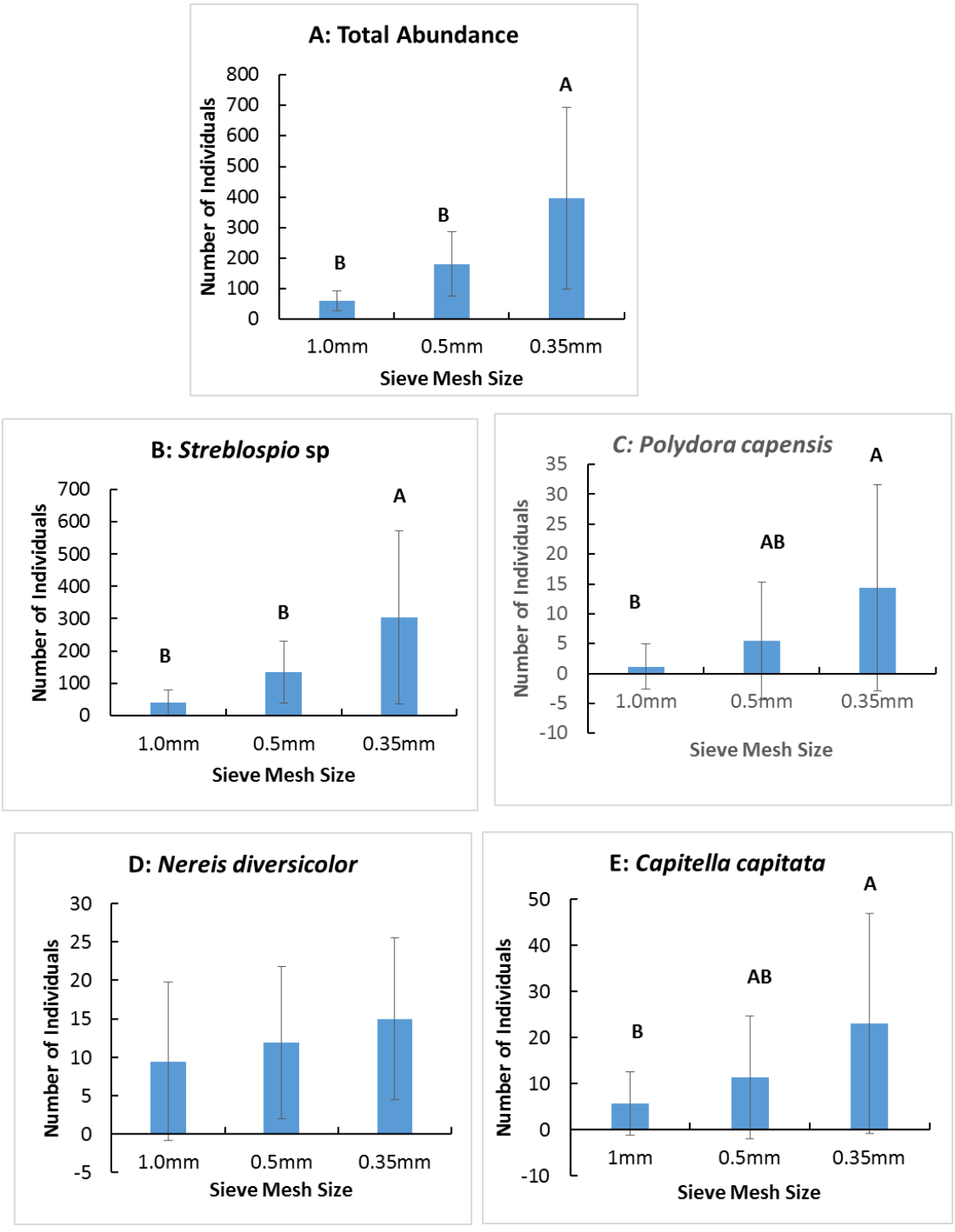

Fig 3. Abundance of Macrobenthic Fauna Mean (Mean ±SD, n= 12) from Three Sieve Mesh Sizes in Obufe Creek. Means with different alphabets are significantly different (Tukey, $p<0.05$).

Several authors have reported on the effects of sieve mesh sizes on macrobenthic fauna. Hart *et al*. (2015) who used 1mm and 0.5mm sieve mesh sizes and reported the 1mm mesh retained fewer organisms and the 0.5mm sampled more than half abundance, while Thomas and Tris (1996) used 1mm, 0.5mm and 0.25mm sieve mesh sizes and recorded that only 8% abundance was retained by the 1mm mesh and 55% abundance was retained by the 0.5mm mesh, whereas the 0.25mm mesh sampled all macrofauna adequately, Hammerstrom *et al.* (2010) reported that a 1.0-mm screen captured 74% of the species and 68% of the individuals collected in the 0.5-mm screen off California, Barba *et al*. (2008) used 1mm and 0.5mm sieve mesh size and discovered that if only the large fraction (1mm) is examined, the community descriptors are affected, Marcel and Fosca (1998) used 2mm, 1mm, 0.5mm and 0.1mm reported that 2mm and 1mm mesh sizes sampled less organisms, the 0.5mm mesh retained 85.5% abundance, while the 0.1mm mesh retained 94.5% abundance, also Mbaka *et al.* (2014) used > 0.5mm and < 0.5mm and reported >0.5mm mesh retained lower invertebrates, while <0.5 mesh retained 85% of inverbrates. Couto et al. (2010) reported that 1.0-mm sieves retained only 67% of the species found on a 0.5-mm sieve in Portuga Patrick and Jean (1998) in their study found out that the 0.5mm mesh size retained less species and the 0.24mm mesh retained most species, while 0.1mm mesh retained 90% of benthic species. Thompson, Riddle, and Stark (2003) determined that the 1.0-mm sieve fraction contained 70% of individuals and 94% of taxa when compared to 0.5-mm sieves in Antarctica. It has been demonstrated in this study that the 0.35mm sieve captured significantly higher abundances of macrobenthos and tends to eliminate bias from exclusion of smaller species or juveniles in the population. Clearly this was the case in both Azuabie and Obufe Creeks with the 0.35mm capturing 88% and 63% of the mean abundance respectively in comparison with 0.5mm (10% and 28%) and 1.0mm (2% and 9%).

Conclusion

The 0.35mm sieve retained the highest proportions of benthic macrofauna and had significantly higher values of mean total abundance than the 1.0mm and 0.5mm mesh in both Azuabie and Obufe Creeks. It is concluded that the 0.35mm mesh sieve is the preferable option for detailed studies of macrobenthos in the Bonny Estuary.

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