Infaunal Monitoring

Winter Report

2009

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[This document contains the report for the winter season of the Adelaide Desalination Plant Infaunal Monitoring Program undertaken by Flinders University.]

Contents

Infaunal Monitoring for the Adelaide Desalination Plant

Winter Report October 2009

Introduction

A desalination plant has been approved for construction at Port Stanvac, with a capacity of 100 GL of drinking water per annum (SA Water 2008). The desalination plant will be based on reverse osmosis technology, using seawater sourced from Gulf St. Vincent and will also discharge approved brine back to the local marine environment via intake and outfall pipes.

A variety of impacts on the marine environment may result from the construction and operational phases of desalination facilities. These effects may include habitat modification during initial construction via physical damage, invasive species introduction, increased noise and vibration, sedimentation and chemical spills, as well as operational effects from entrapment, entrainment or effluent discharge (Miri and Chouikhi 2005; Kildea 2008; SA Water 2008). Focusing solely on the effluent, there are numerous properties of the wastewater which can impact on marine organisms. These include hypersalinity, concentrated trace metals and nutrients, pre-treatment chemicals such as H_2SO_4 or HCl, $FeCl_3$ and chlorine, as well as other chemical additives to prevent fouling, scaling, corrosion and foaming (Hoepner 1999; Miri and Chouikhi 2005; SA Water 2008).

Salinity stress from brine discharge is possibly the greatest concern for the benthic infauna communities offshore. To provide technical information for input into the EIS, a macroinfauna/meiofauna characteristic study was carried out by the South Australian Research and Development Institute (SARDI) (Loo *et al.* 2008). This study demonstrated that polychaetes and crustaceans dominate the vicinity of the intended outfall diffuser, off the coast of Port Stanvac, contributing ~96% of the total abundance and ~85% of the taxa collected (Loo *et al.* 2008). These findings were typical of macroinfauna/meiofauna assemblages of benthic marine sediments found elsewhere in the world. The macroinfauna surveys of the Port Stanvac area also indicate a diverse and abundant ecosystem, with over 60 taxonomic groups identified (Loo *et al*. 2008). Such studies provide useful baseline information about the Port Stanvac region. However, further studies are required to encompass the larger invertebrate epifauna communities living on the surface of the sediments and to assess the natural spatial and temporal variability in these communities. Subsequent environmental monitoring during construction and after the desalination plant is in operation.

Monitoring a major development, like the Port Stanvac desalination plant, requires well planned ecological studies that can provide an assessment of the variability in natural communities at two spatial scales; 1) within the construction site and 2) between different sites inside and outside the construction zone to provide a reference for benchmarking any temporal changes detected in subsequent monitoring surveys. The marine environment off Port Stanvac contains numerous habitat types including rocky reefs, soft sediment, shell grit habitat, macroalgae and seagrass (Benkendorff *et al*. 2008; Bryars *et al.* 2008; Edyvane 2008; Fotheringham and Coleman 2008;

Harbison 2008; Loo and Drabsch 2008; Loo *et al.* 2008; Turner and Collings 2008). Suitable control locations are therefore situated at sites with a similar range of habitat, to the north and south of the Port Stanvac desalination plant construction zone.

Three sampling methods will be applied across all zones: suction, dredge and box coring. Brown *et al*. (1987) designed a suction sampler for the sampling of diverse types of substrata. An advantage of this sampling method lies in its successful recovery of undamaged organisms and neighbouring sediment during pumping. The dredge method is designed to skim over the surface of the bottom and because of the large area covered during sampling, is useful for collecting more scarce members of the epifauna, such as cephalopods and crustaceans associated with the sea floor (Eleftheriou and Moore 2005). In comparison to the other two methods, box coring has the advantage of providing a consistent core size, which represents the sediment column as it was *in situ*, which allows for quantative assessment of meiofauna and macrofauna. From a functional aspect, coring devices have a higher digging performance, depending on the weight applied, and are therefore suitable for most sediment types (Eleftheriou and Moore 2005).

Underwood (1991; 1992) recommends replicated before-after-control-impact (beyond BACI) studies, in order to detect anthropogenic effects exceeding the natural variability in local communities. Therefore infauna surveys will be undertaken in two seasons prior to the operation of the desalination plant. This report provides the data from the first season of baseline sampling.

Aims and Approach

The aim of this research was to establish baseline data, relating to the subtidal infauna communities of the Gulf St. Vincent, for future monitoring of potential impacts associated with the Port Stanvac desalination plant. Specific objectives are to apply two standardised infauna survey methodologies to assess the spatial and temporal variability in benthic communities; 1) suction sampling; and 2) a small dredge. Replicate samples were taken from a total of 20 transects, comprised of 10 in the Port Stanvac construction zone and 5 at each of the North and South control zones. Sampling will be repeated in summer January 2010 using the same methods. In addition, a box corer will be used to obtain samples for meiofaunal sampling in spring and summer.

Methodology

Sampling sites

Macrofaunal sampling efforts were conducted at three locations off the Adelaide metropolitan coastline. These sites consisted of the construction zone, Port Stanvac (35°06’ S, 138°28’ E), and a northern and southern control site, Glenelg (34°59’ S, 138°27’ E) and Port Noarlunga (35°09’ S, 138°27’ E) respectively.

Site description

The Port Stanvac area, south-west of Adelaide, covers the area from O’Sullivan’s Beach boat ramp to the Hallett Cove area. The water depth in the Port Stanvac construction zone ranged from 12- 18 m (Figure 1a) and the area was characterised by highly variable sediment structure including fine and coarse sand, shell grit and seagrass beds (*Posidonia* sp.). This variability in habitat has been reflected in the diverse infauna composition collected.

A northern control site, 5 km offshore from Holdfast Shores marina, and a Southern control site, 5 km offshore from Noarlunga, were chosen arbitrarily in terms of the position; however parameters such as depth and sediment structure corresponded to that of Port Stanvac construction zone (Figures 1b and 1c).

The experimental sites were divided into 800 m transects, with 10 transects radiating from the proposed site of the effluent discharge pipe at Port Stanvac and 5 transects radiating from an arbitrarily selected point at each of the control sites (Table 1). Two methods of sediment collection, dredge and suction sampling, were conducted along each transect from late May to June, 2009 (Table 1).

Figure 1. Maps of a) North control zone, 5 km offshore from Glenelg area, b) Port Stanvac construction zone, c) South control zone, 5 km offshore from Noarlunga, including transect positions.

Table 1. Sampling sites across three zones including GPS coordinates (outer extremities of transects), depth, substrate description and date of collection.

Site	Transect	Latitude (S)	Longitude (E)	Depth (m)	Substrate	Date
Port Stanvac	A	35°06.373′	138°27.861′	13	shell grit/seagrass	31/05/2009
	B	35°06.135′	138°27.902′	15	shell grit/seagrass	31/05/2009
	C	35°06.111′	138°27.770′	18	seagrass	31/05/2009
	D	35°06.054′	138°27.489′	18	shell grit/seagrass	31/05/2009
	E	35°05.583′	138°28.022′	20	soft sediment	1/06/2009
	F	35°05.014′	138°28.009′	20	soft sediment	1/06/2009
	G	35°04.982′	138°28.328′	18	soft sediment/shell grit	1/06/2009
	H	35°05.070′	138°28.474′	18	seagrass	2/06/2009
	I	35°05.096′	138°28.597′	15	seagrass	2/06/2009
	J	35°05.448′	138°28.483′	13	shell grit	2/06/2009
North control - Glenelg	A	34°59.603′	138°27.411′	16	seagrass	3/06/2009
	B	35°00.317′	138°26.663′	18	seagrass	3/06/2009
	C	34°59.866′	138°26.384′	16	soft sediment/shell grit	3/06/2009
	D	35°00.386′	138°27.688′	18	seagrass	4/06/2009
	E	35°00.657′	138°27.342′	18	shell grit/seagrass	4/06/2009
South control - Noarlunga	A	35°09.124′	138°27.002′	16	seagrass	4/06/2009
	B	35°09.170′	138°25.685′	18	shell grit/seagrass	5/06/2009
	C	35°09.680′	138°26.370′	16	shell grit/seagrass	5/06/2009
	D	35°08.623′	138°26.359′	18	seagrass	10/06/2009
	E	35°09.513′	138°25.956′	18	soft sediment	10/06/2009

Suction Sampling

Samples were obtained using a suction sampler developed at Flinders University, South Australia. The suction sampler functions via insertion of compressed air into the base of a vertical tube, creating a vacuum and drawing a sediment sample upwards to be deposited in the catchment bag. Samples were taken using controlled air pressure for a duration of 1 minute, which equated to an average sample size of approximately 250 ml, or 0.28 m^2 of sediment. Along each transect, 15 replicate samples were taken, three at each 200 m interval along the length of 800 m transect. GPS co-ordinates were recorded for each position along the transect and CTD scan was used to record the water depth.

Dredge Sampling

Dredge sampling was conducted using a hand held dredge (50 x 30 x 80 cm, 1 cm^2 mesh size), deployed from the rear of the research vessel and towed for 100 m at a speed of 1 knot. A sample was taken from each end of the transect (0 to 100 m, 700 to 800 m) resulting in a total of 40 samples. Macrofauna obtained was extracted from the catchment cage and transported to the Flinders University laboratory for species identification and organism counts.

Sorting and Identification

The samples were preserved in 10% formalin solution in seawater. Prior to sorting, samples were rinsed to remove formalin and macrofauna was isolated using a 0.5 mm sieve. A stereomicroscope was used for identification purposes during sorting and isolating of macrofauna from sediment. The macrofauna was identified to the lowest possible taxonomic levels, often species but predominantly family rank was attributed (Appendix I & II). Individuals were enumerated and transferred to 70% ethanol for storage.

Data Analyses

Species richness (*S*), abundance (A), (expressed as number of individuals per square m^2), and species diversity were determined for each site using data obtained from both the suction and dredge sampling methods.

To determine the diversity and evenness of species composition at all sites, three different diversity indices (Shannon-Wiener index, Pielou's evenness and Simpson's index) were calculated based on the total number of individuals (*N*) from the number of each taxa (*S*) using PRIMER v.6. The Shannon-Wiener index identifies greater species diversity with indices closer to one. Pielou's index is a measure of how evenly the individuals are distributed among the different taxonomic groups, where a larger number indicates less evenness. The Simpson's index is a measure of ecological diversity with infinite diversity decreasing from zero to one, indicating dominance of single species (Clarke and Warwick 2001).

Analyses of invertebrate community composition of the two sampling methods, were undertaken to determine similarities between sites. The data were square root transformed prior to analysis to decrease the influence of dominant species on the analysis, and Bray-Curtis similarities were used to eliminate the effects of joint absence of taxa. Abundance data was used to produce Multi-Dimensional Scaling (MDS) ordination plots in order to provide a visual pattern of invertebrate community structure. MDS plots were produced based on both species and family data. Difference in infauna composition between sites and zones, were examined using Analysis of Similarities (ANOSIM) test. The invertebrate community data was further examined using Similarity of Percentages (SIMPER) to determine the contribution of discriminating species when dissimilar sites and zones were identified (Clarke and Gorley 2006). All multivariate analyses were performed using PRIMER v.6 (Plymouth Routines in Multivariate Ecological Research).

Results

Species Richness

Suction Sampling

The total number of taxa detected using suction sampling across the three zones was 143 (Table 2, Appendix I). Species richness across all sites was highest at the North control zone (transect A, sites 200 and 600) due to the greater number of arthropod species compared to all other sites (Figure 2). Three phyla, Mollusca, Arthropoda and Echinodermata dominated species richness across all sites. The North control zone was dominated by Gastropoda, Bivalvia (Figure 3), Malacostraca (Figure 4) and Ophiuroidea (Figure 5). No cephalopods were recorded from North control zone. All molluscan classes were recorded within the Port Stanvac construction zone, where transects G, H, I had the greatest number of molluscan species (Figure 3). The phylum Arthropoda was mainly represented by Malacostraca, in particular an amphipod species of the family Gammaridae, across all zones (Figure 4). The lowest diversity across all species was recorded at the South control transect A, site 0 where only one Echinodermata species was recorded, closely followed by B0 where two species from Mollusca and Annelida phyla were recorded (Figure 2). All other sites across the three zones had a species number greater than 5 (Figure 2).

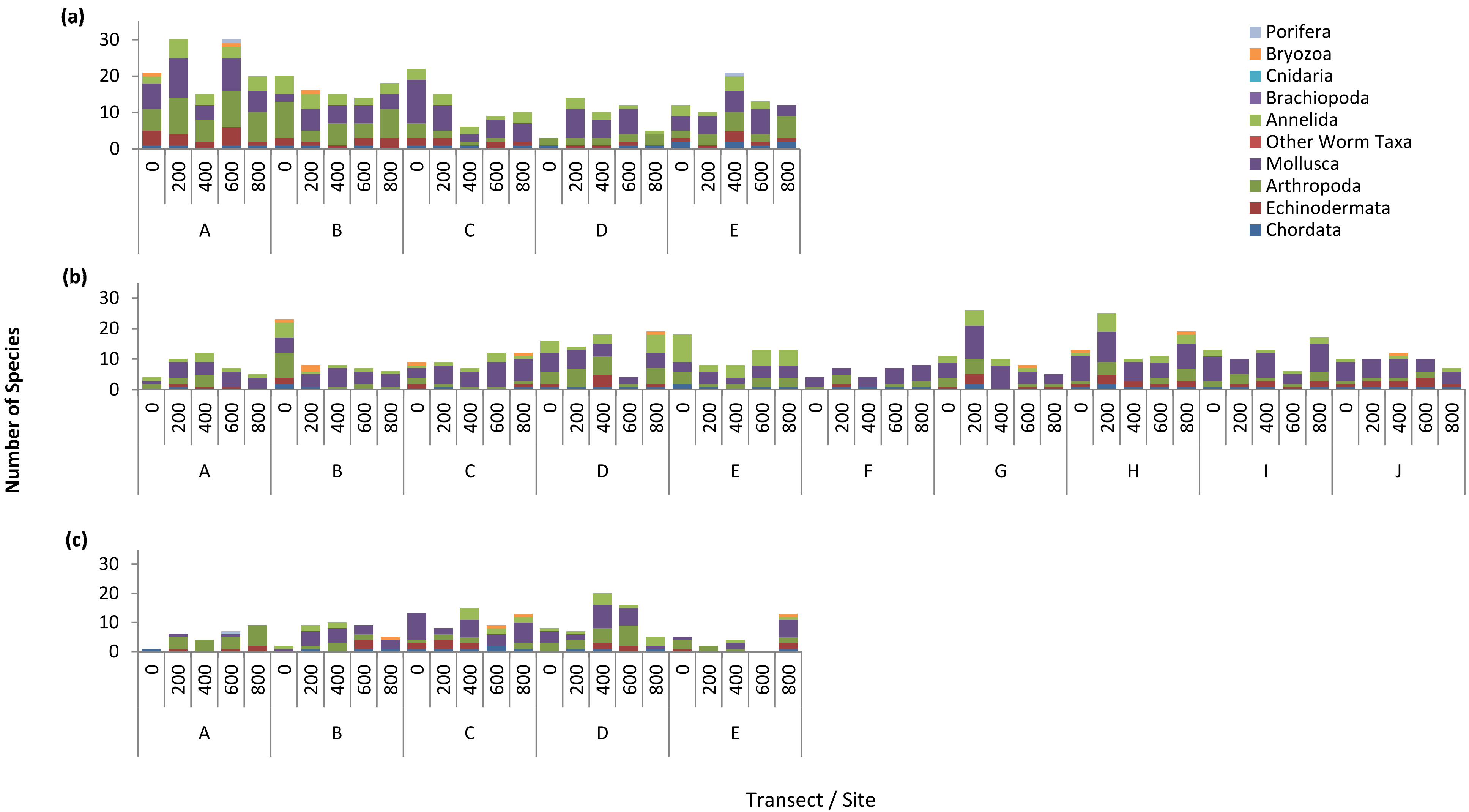


Figure 2: Total species richness of organisms collected using the suction sampler, per phyla identified across the three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

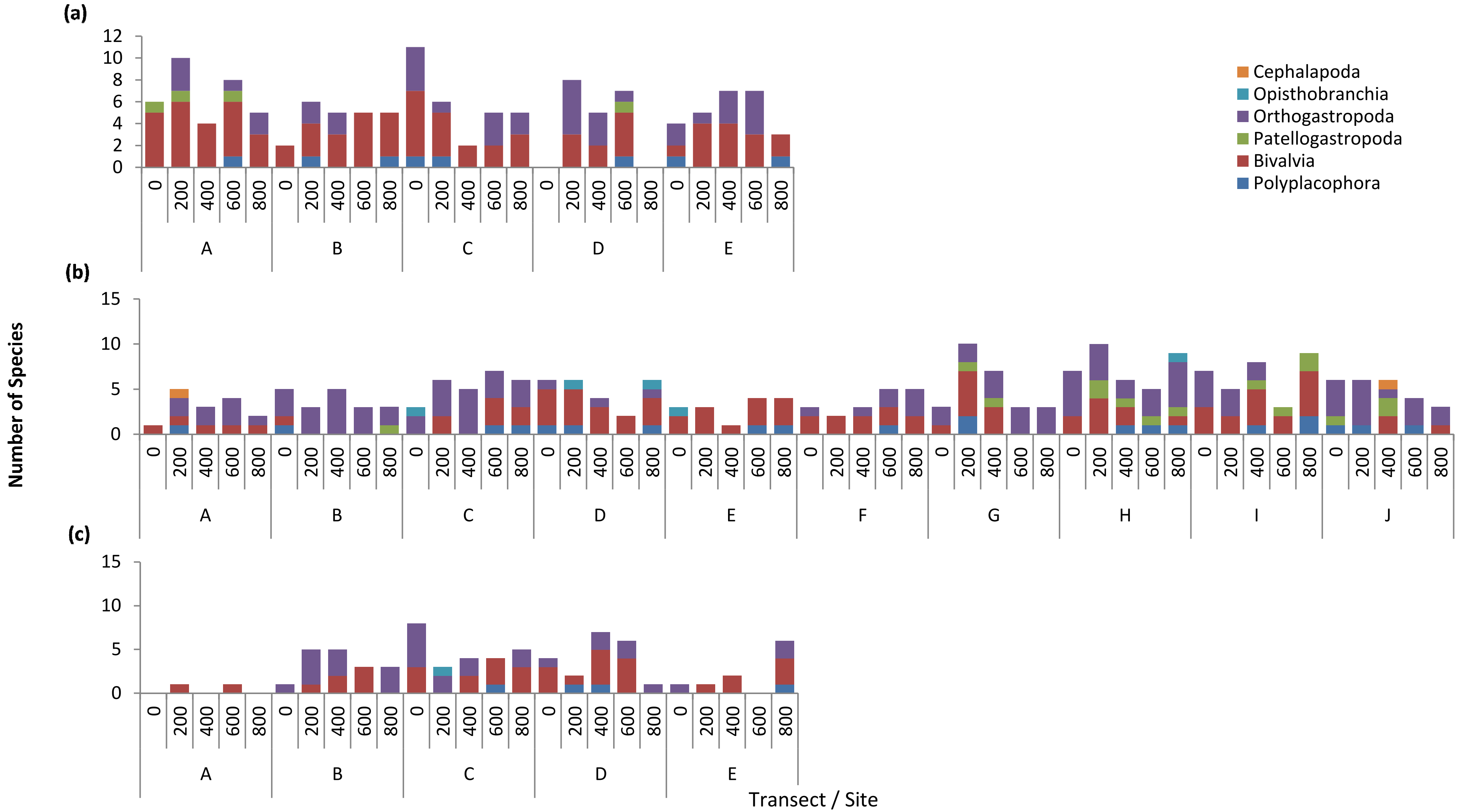


Figure 3. Species richness of organisms collected using the suction sampler across Mollusca, identified across the three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

Figure 4. Species richness of organisms collected using the suction sampler across Arthropoda, identified across the three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

Figure 5. Species richness of organisms collected using the suction sampler across Echinodermata, identified across the three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

Dredge Sampling

The total number of macro invertebrate species was 170 recorded using the dredge (Table 3, Appendix II). Species richness values obtained from dredge data displayed a greater average number of species in the North control zone (n = 36). The Port Stanvac construction zone contained a greater total number of species (n = 270), however this was attributable to the number of transects in this zone being double that of the other zones. Per site, the highest species richness was observed in both the near and the far sites of the North control transects D and E, and the Port Stanvac construction transects D (far site), F (far site) and I (near site), which all had species counts greater than 25 species (Figure 6). These trends did not appear to be solely dictated by a specific group, however Mollusca appeared to be the most dominant phyla in the majority of sites (Figure 6).

No clear trends between the three zones were observed for any phyla other than Mollusca, as all exhibited high variability between sites (Figures 6 & 7). Mollusca displayed a greater mean number of species in the North control zone and the Port Stanvac construction zone, than that observed in the South control zone (Figure 7). Within the Mollusca phyla, Bivalvia was the most dominant class at the majority of sites, (Figure 8a) with the highest number of species recorded. Species from the class Malacostraca dominated the Arthropoda phylum at the majority of sites (Figure 8b). No individual class dominated in the Echinodermata, with both Ophiuroidea and Echinoidea representing a large portion of species (Figure 8c).

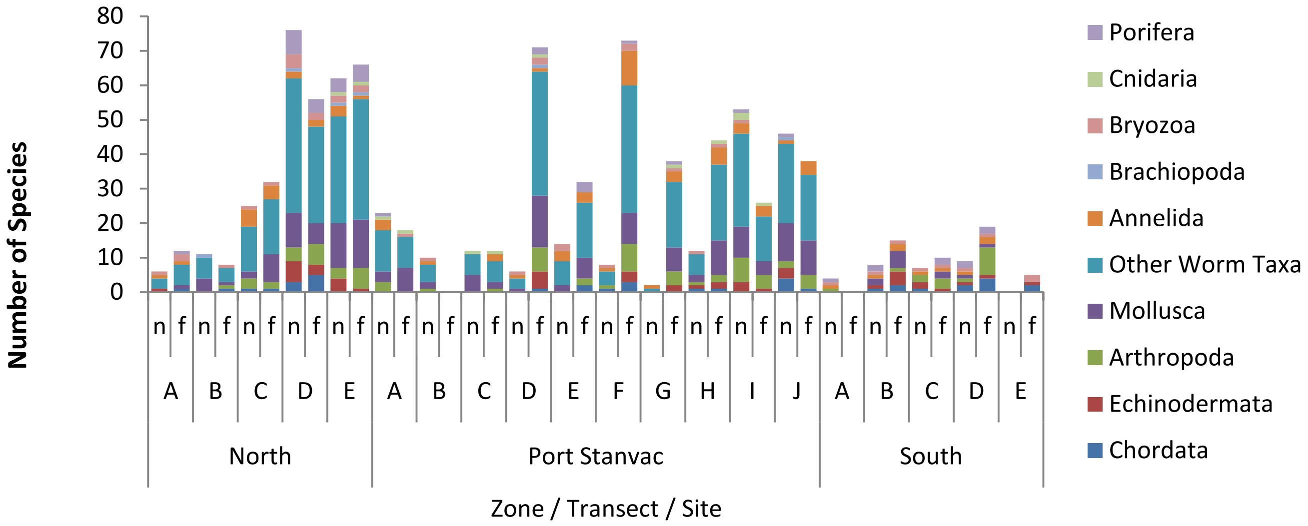


Figure 6. Total species richness of organisms collected using the dredge per phyla identified across the three zones; North control zone, Port Stanvac construction zone and South control zone. Samples were collected along two 100 m lengths at the near (n = 0 to 100 m) and far (f = 700 to 800 m) extremities of 10 (A-J) transects at Port Stanvac (b) and 5 transects (A-E) at the northern (a) and southern (c) control zones.

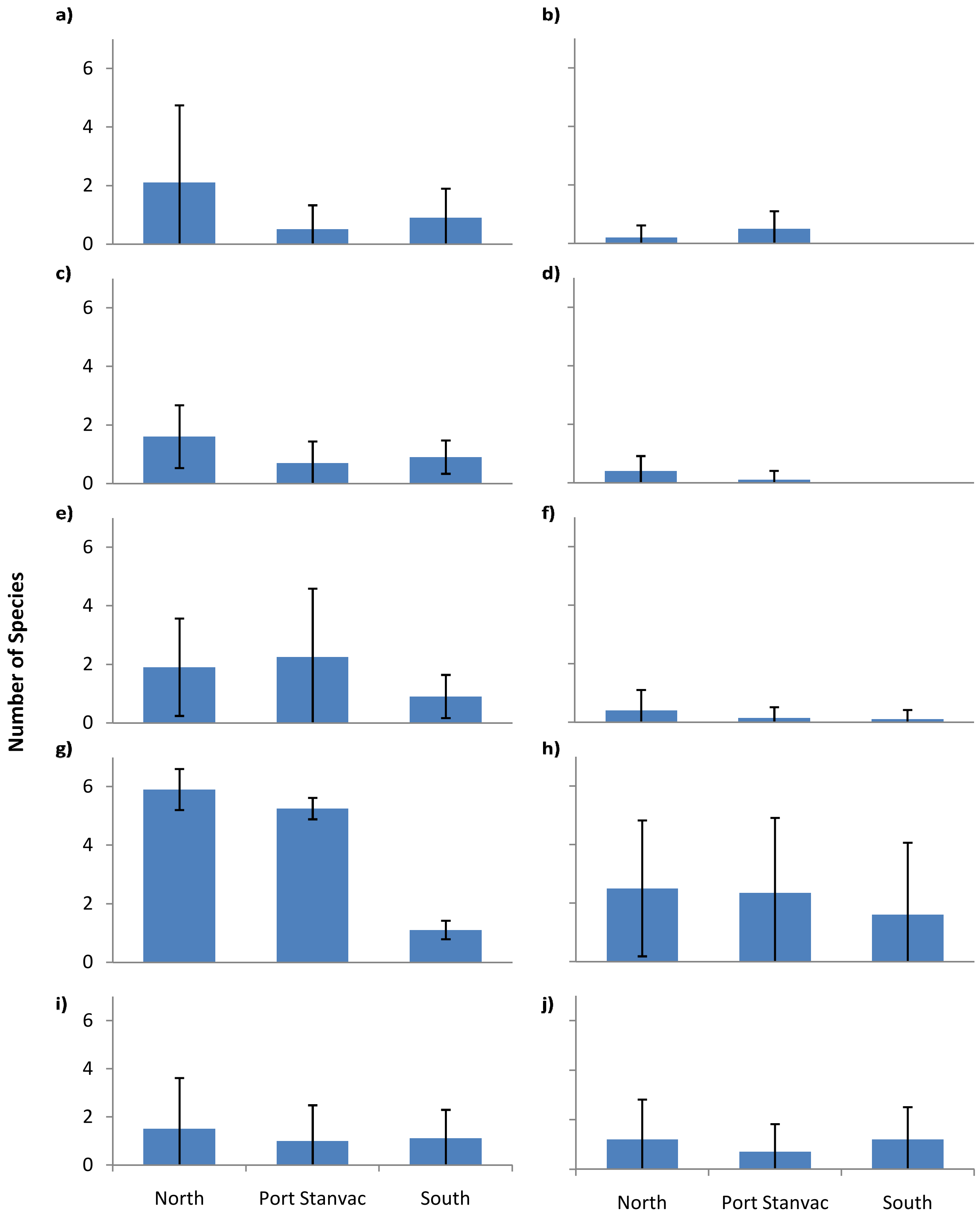


Figure 7. Species richness of organisms collected using the dredge across three zones; North control zone, Port Stanvac construction zone and South control zone per phyla: a) Porifera, b) Cnidaria, c) Bryozoa, d) Brachiopoda, e) Annelida, f) other worm taxa, g) Mollusca, h) Arthropoda, i) Echinodermata and j) Urochordata. Error bars = ± 1 standard deviation.

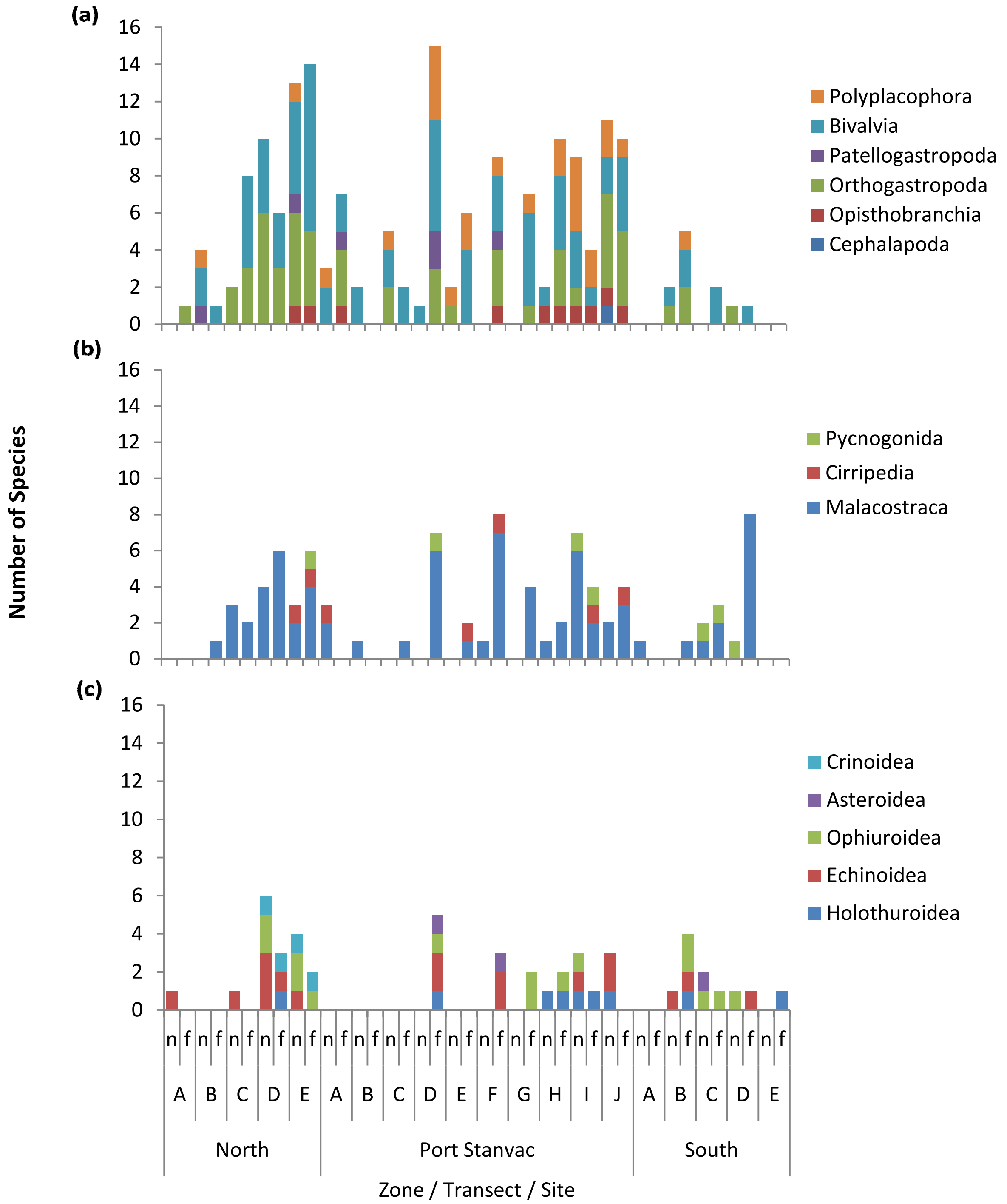


Figure 8. Species richness of organisms collected using the dredge across: (a) Mollusca, (b) Arthropoda and (c) Echinodermata, identified across the three zones; North control zone, Port Stanvac construction zone and South control zone. Samples were collected along two 100 m lengths at the near (n = 0 to 100 m) and far (f = 700 to 800 m) extremities of 10 (A-J) transects at Port Stanvac (b) and 5 transects (A-E) at the northern (a) and southern (c) control zones.

Abundance

Suction Sampling

Mean abundances for the worm phyla, Annelida, Echiura, Platyhelminthes, Sipuncula and Nematoda, identified at all sites were greatest at the Port Stanvac construction transects E, G and F (Figure 9), due to large abundance of Annelida (Figure 10). Across sites mean abundances ranged from 20 to 300 individuals per square metre. The Port Stanvac construction transect F and south control transect A did not contain any representatives from any of these phyla (Figure 9).

In the Port Stanvac construction zone, transects H, I and J, contained greatest total mean abundances for total Mollusca across all sites and all zones (Figure 11). The abundance of bivalves, followed by gastropods and polyplacophorans, contributed most to the greater total abundance observed at the Port Stanvac construction transects: D and I (Figures 12, 13 & 14). Greatest Polyplacophora abundance was found in the Port Stanvac construction site B0 (Figure 12) and the greatest gastropod abundance was recorded at South control transect C (Figure 13).

In general the North control zone had the greatest abundance of Arthropoda (Figure 15). Mean abundance for the phylum identified across all sites was greatest in the North control transect A, site 600 (Figure 15). This was predominantly due to high individual abundance of Malacostraca at North control zone, however the greatest number of Malacostraca individuals per square metre was recorded from transect I, site 800 in the Port Stanvac construction zone (Figure 16).

Mean abundances for Echinodermata across all sites were highest at North control transects A (site 0) and E (site 400) and Port Stanvac construction transect H (site 400), all equalling 400 individuals per square metre (Figure 17). These high overall abundances are attributed to the abundance of Ophiuroidea at the Port Stanvac construction transect H, site 400 (Figure 18) and Echinoidea at North control transect A (site 0) and E (site 400) (Figure 19).

The North control zone contained the greatest number of chordates, 70 per square metre at transect A, site 200, followed by 55 individuals per square metre at Port Stanvac construction transect B, site 0. Less than 40 individuals per square metre were observed in the majority of the sites in the South control zone (Figure 20).

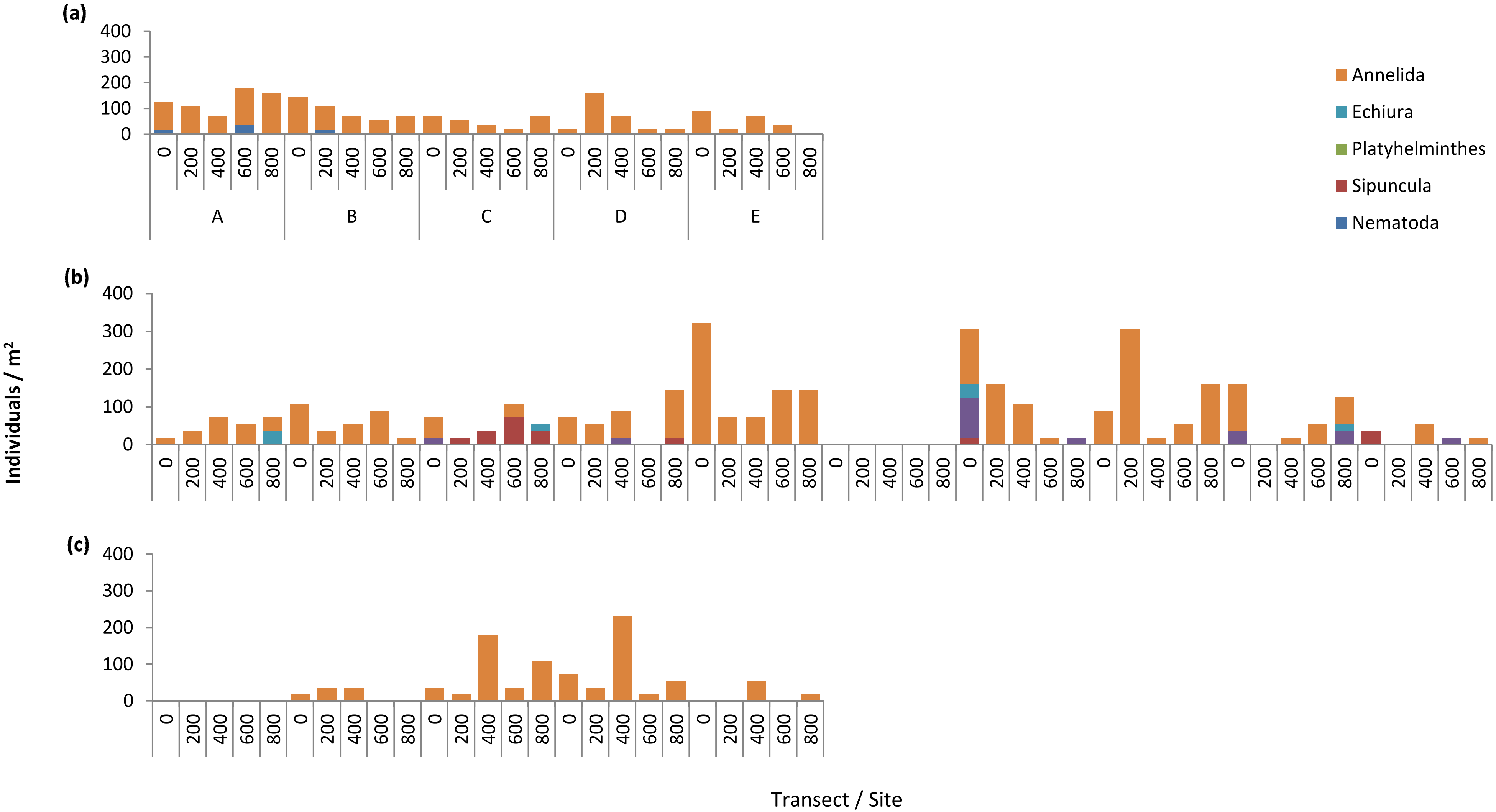


Figure 9. Mean abundance of organisms collected using the suction sampler across Annelida, Echiura, Platyhelminthes, Sipuncula and Nematoda, identified across the three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

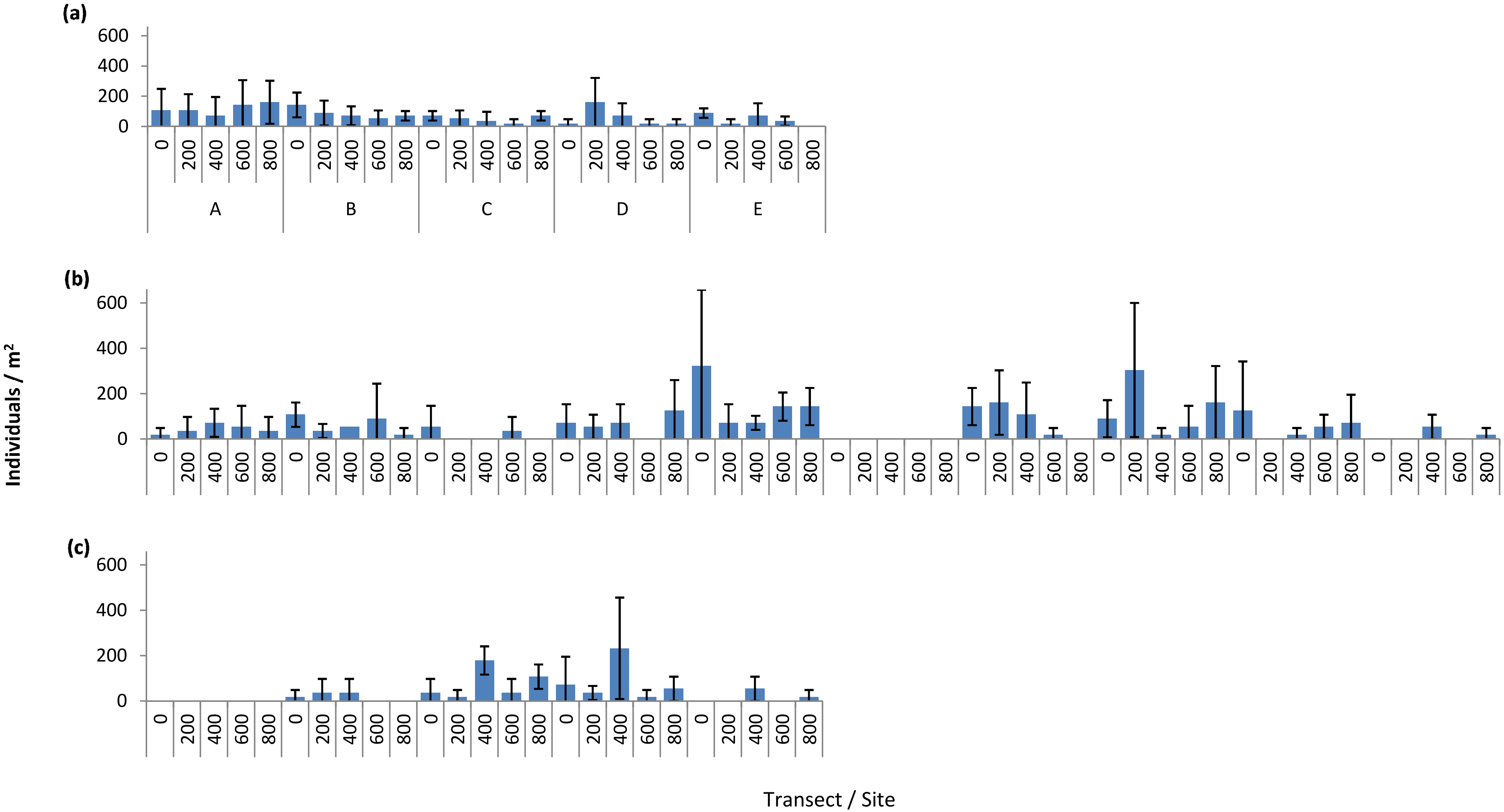


Figure 10. Mean abundance of organisms collected using the suction sampler across Annelida, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Error bars = ± 1 standard deviation. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

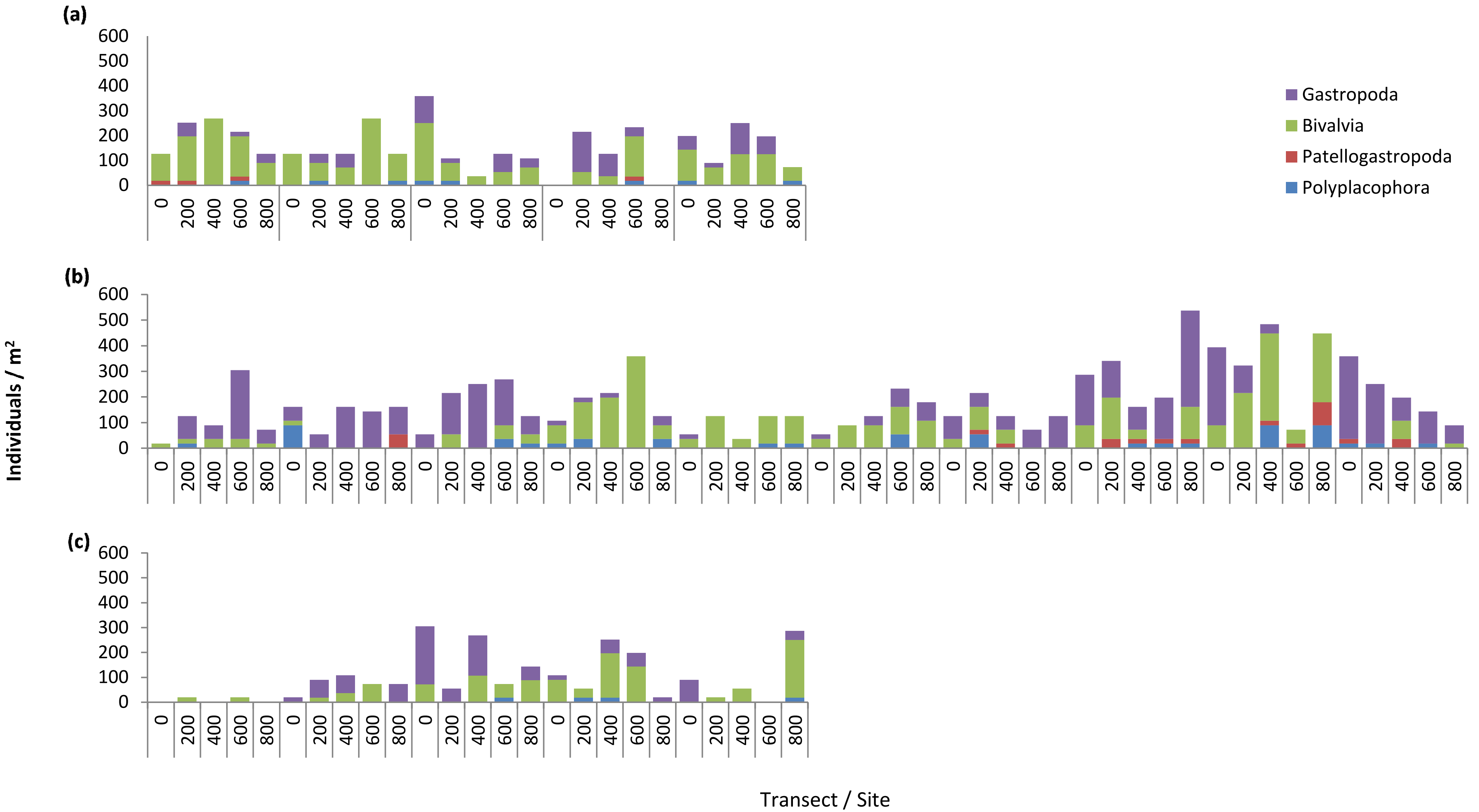


Figure 11. Mean abundance of organisms collected using the suction sampler across Mollusca, identified across the three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

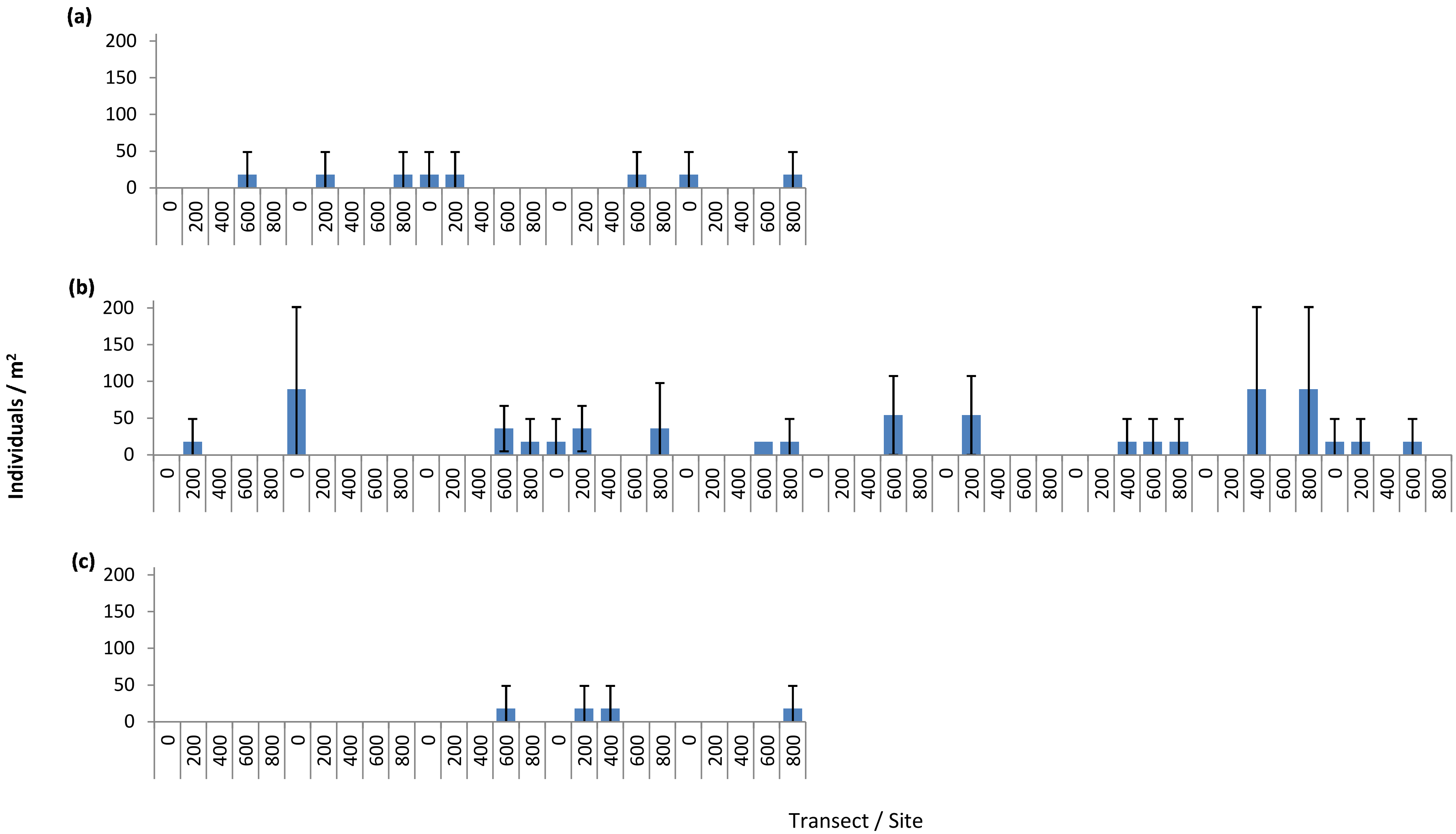


Figure 12. Mean abundance of organisms collected using the suction sampler across Polyplacophora, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Error bars = ± 1 standard deviation. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

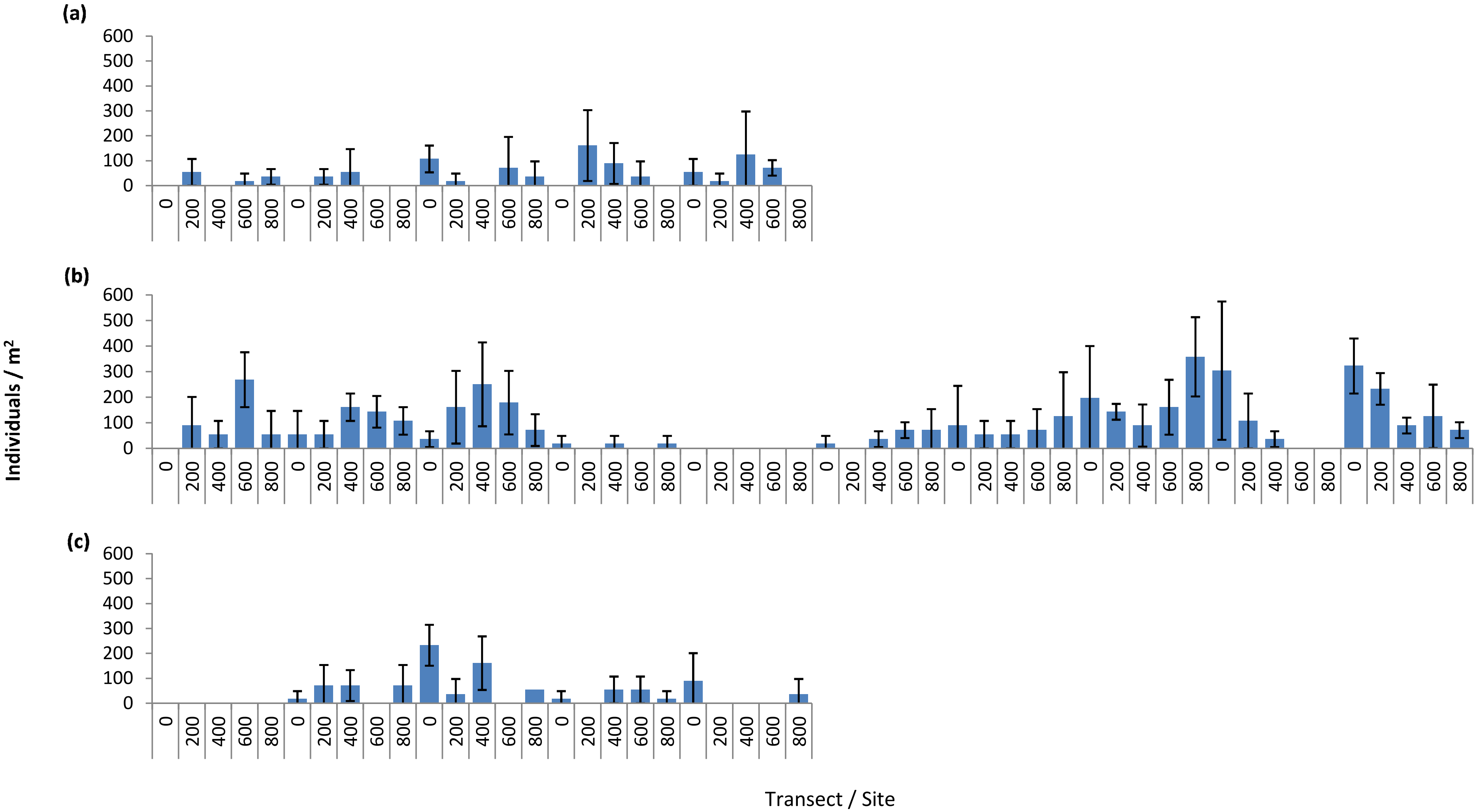


Figure 13. Mean abundance of organisms collected using the suction sampler across Gastropoda, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Error bars = ± 1 standard deviation. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

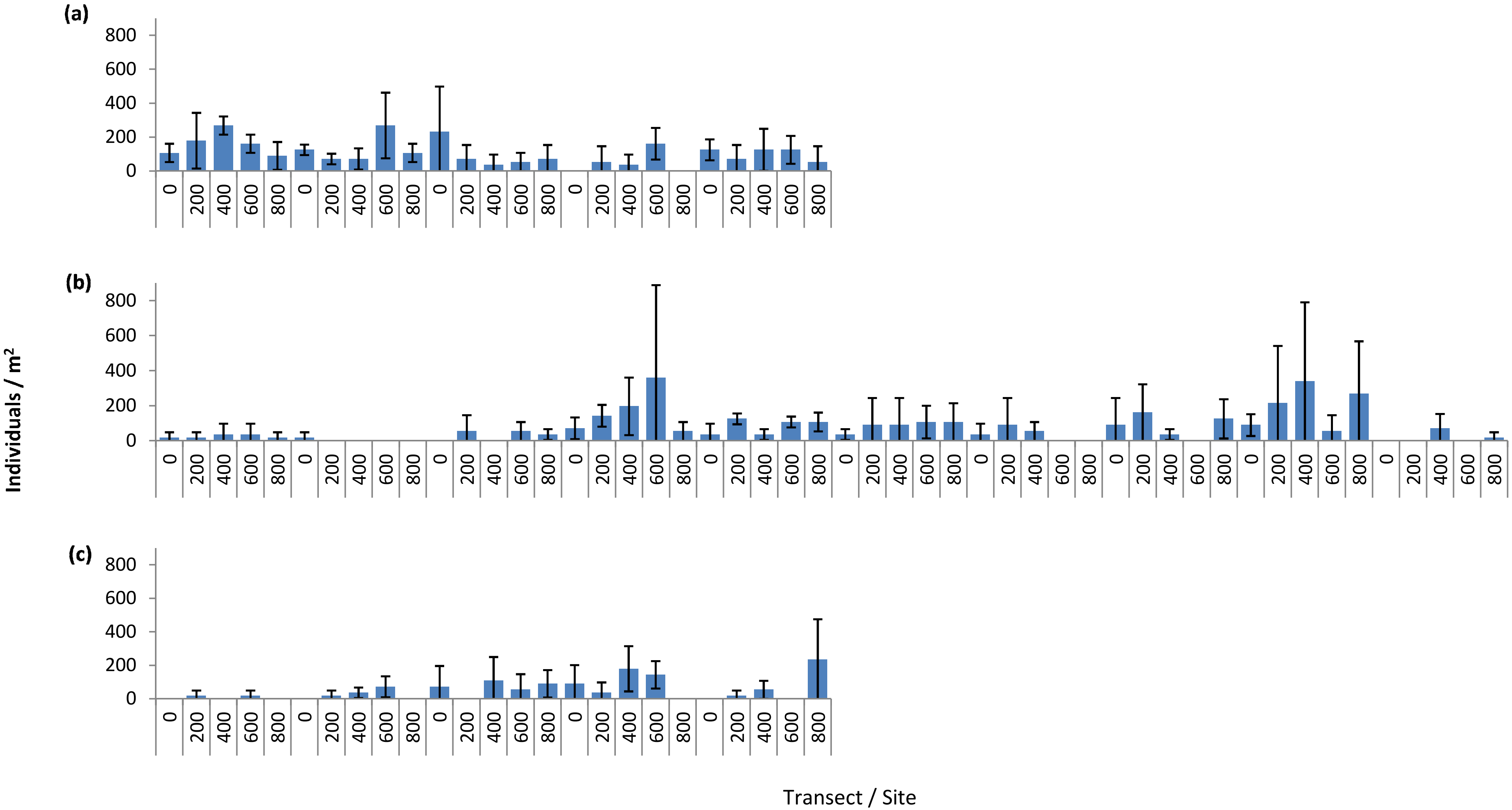


Figure 14. Mean abundance of organisms collected using the suction sampler across Bivalvia, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Error bars = ± 1 standard deviation. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

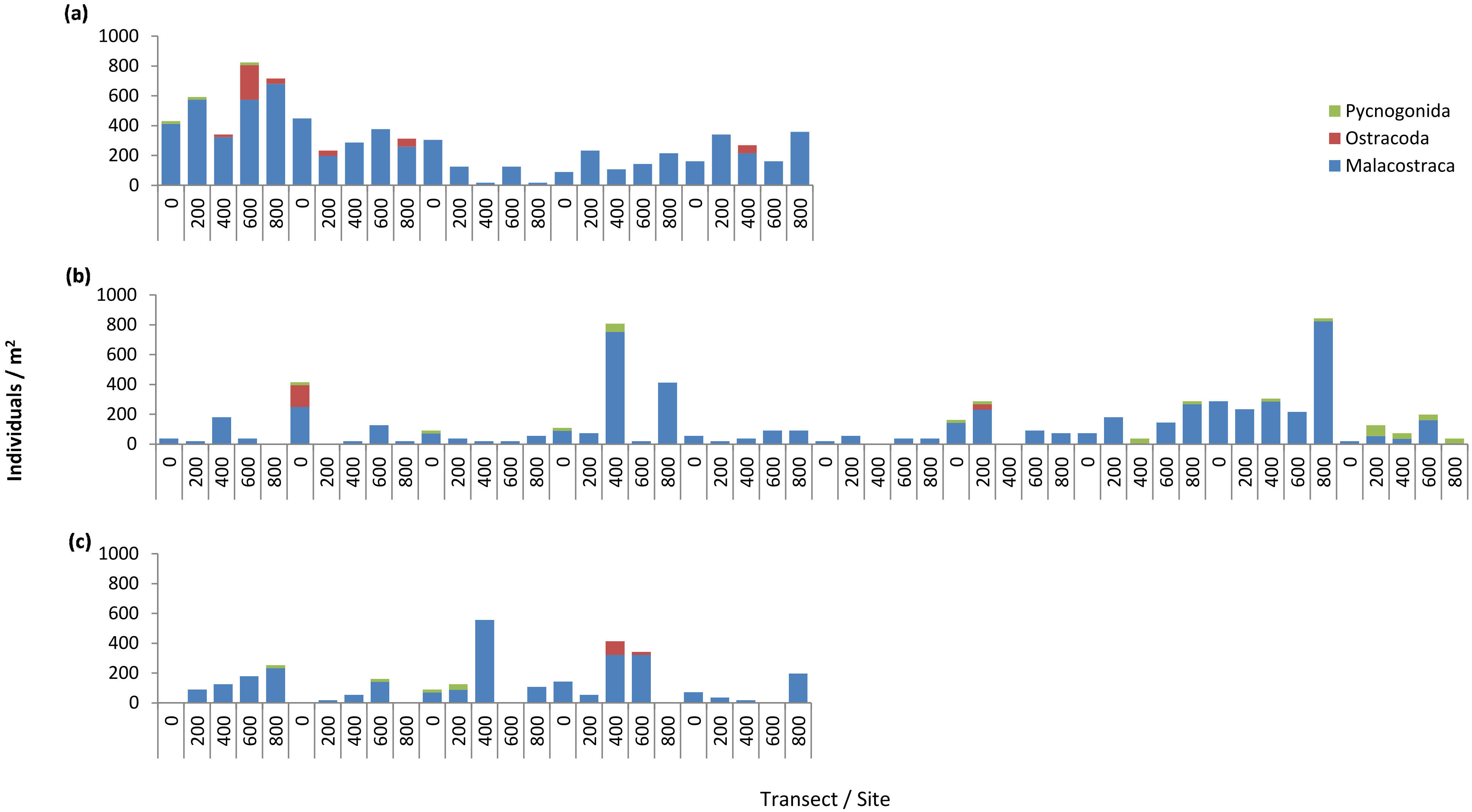


Figure 15. Mean abundance of organisms collected using the suction sampler across Arthropoda, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Error bars = ± 1 standard deviation. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

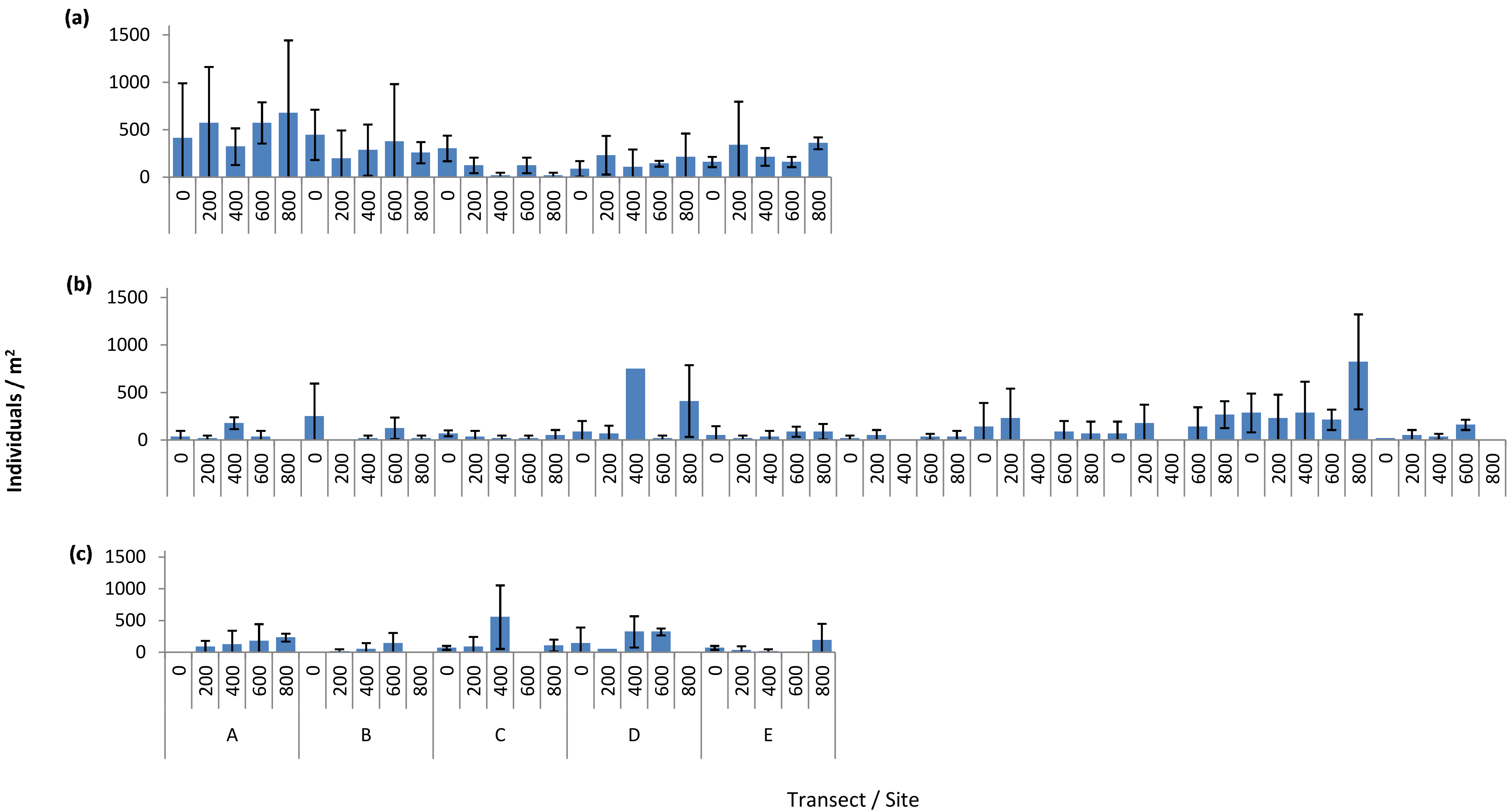


Figure 16. Mean abundance of organisms collected using the suction sampler across Malacostraca, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Error bars = ± 1 standard deviation. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

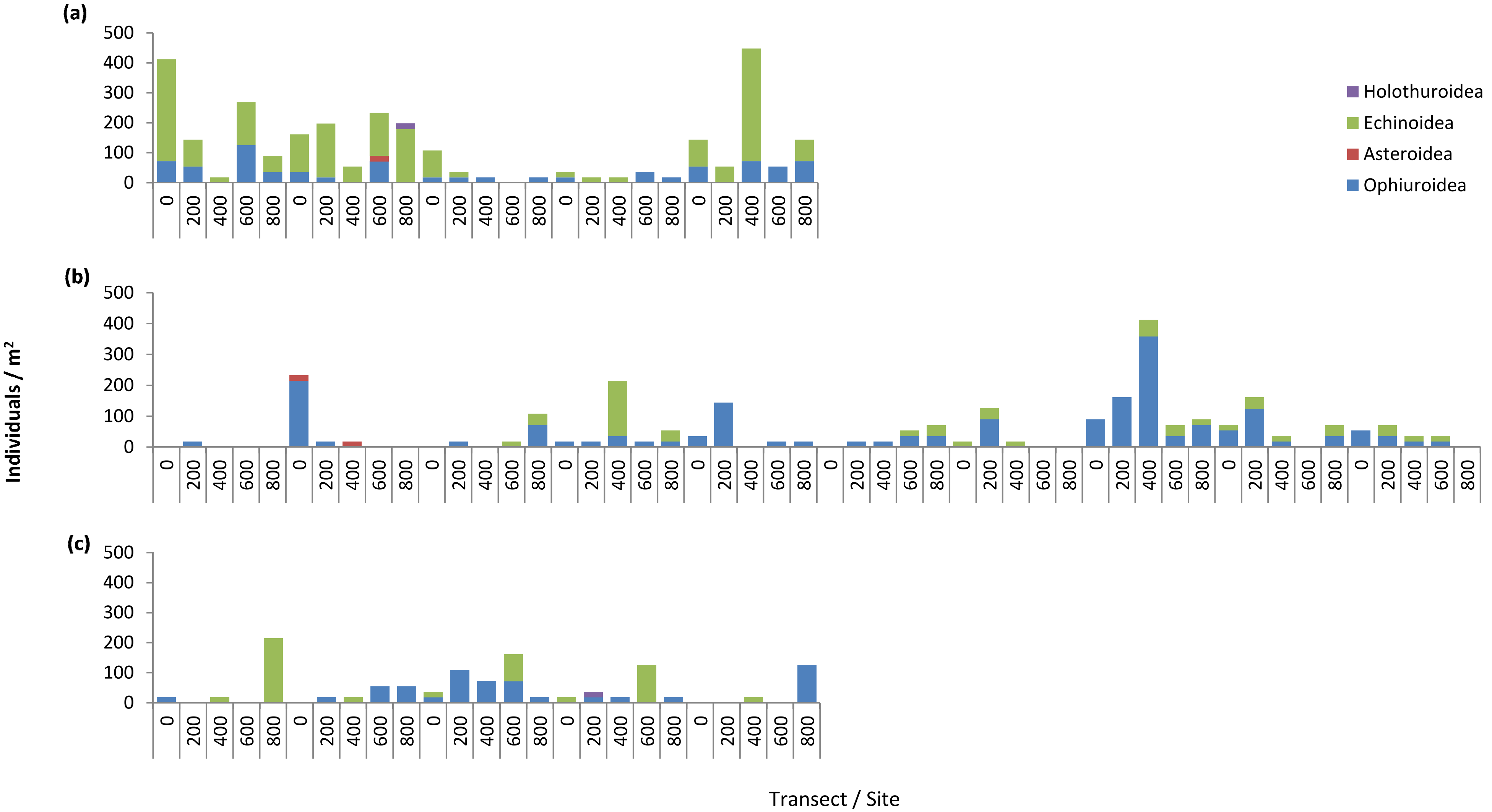


Figure 17. Mean abundance of organisms collected using the suction sampler across Echinodermata, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

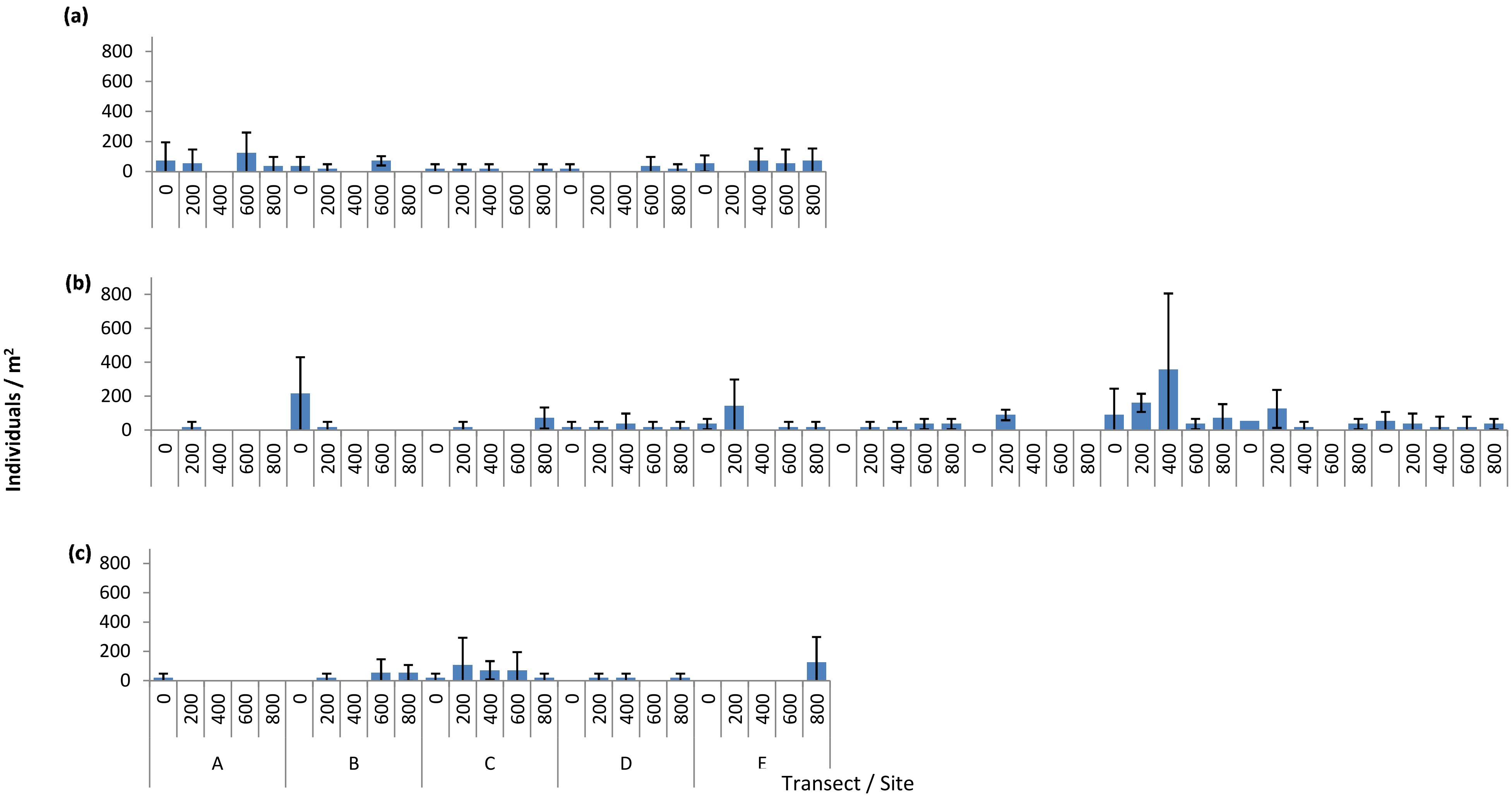


Figure 18. Mean abundance of organisms collected using the suction sampler across Ophiuroidea, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Error bars = ± 1 standard deviation. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

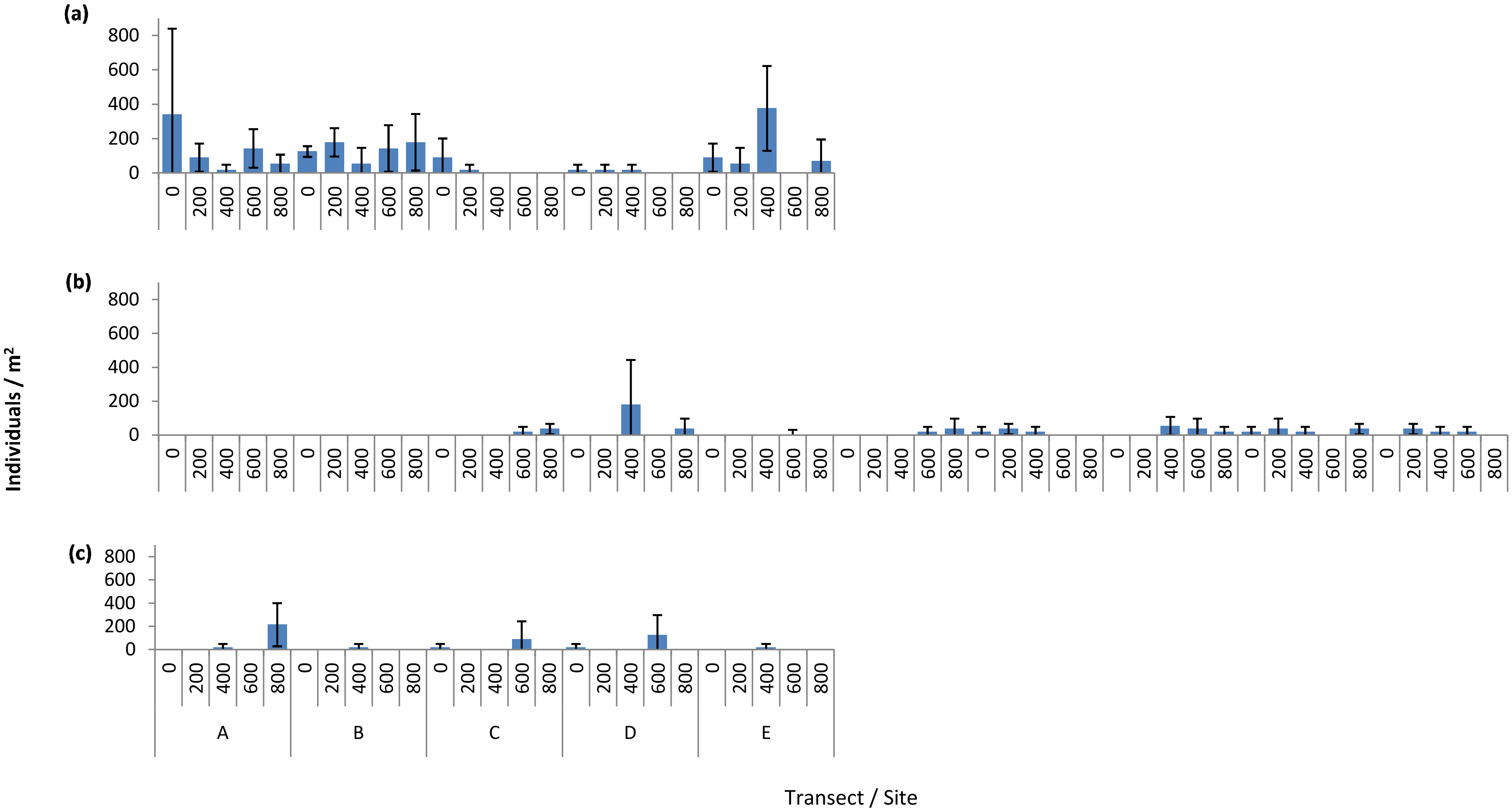


Figure 19. Mean abundance of organisms collected using the suction sampler across Echinoidea, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Error bars = ± 1 standard deviation. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

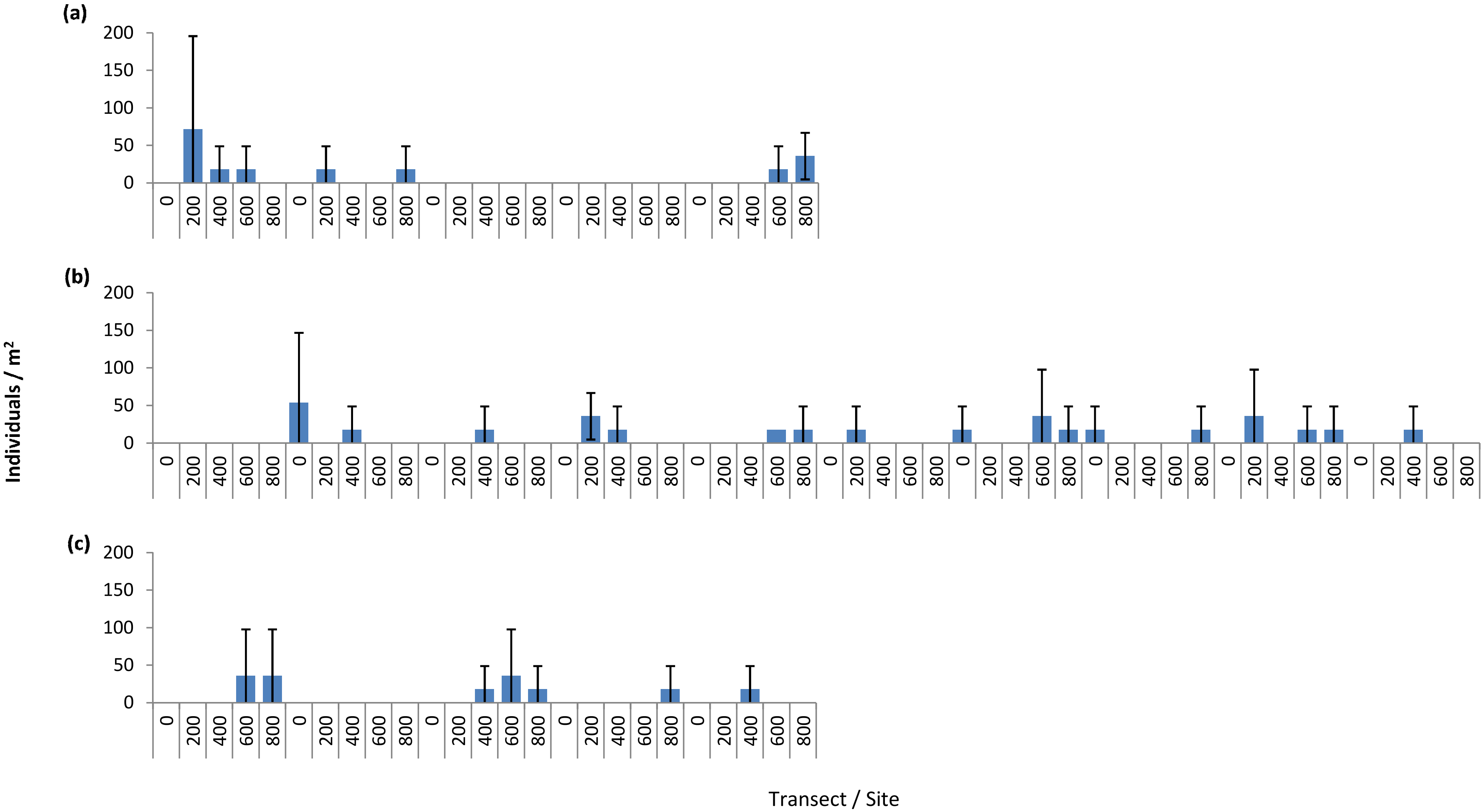


Figure 20. Mean abundance of organisms collected using the suction sampler across Chordata, identified across three zones; (a) North control zone, (b) Port Stanvac construction zone and (c) South control zone. Error bars = ± 1 standard deviation. Samples were collected at five 200 m intervals along 10 (A-J) transects at Port Stanvac (b) and along 5 transects (A-E) at the northern (a) and southern (c) control zones.

Dredge Sampling

Mean organism abundances were observed to be greater in the Port Stanvac construction zone and the North control zone than in the South control zone. A greater total abundance of organisms was observed at Port Stanvac construction zone, however this was attributable to a greater number of transects. Mollusca and Arthropoda were both highly prevalent, particularly in the North control zone and the Port Stanvac construction zone, however these phyla did not appear to be driving abundances (Figure 21).

No distinct definition was observed between the mean abundance of organisms between zones when phyla were isolated. This was attributable to the high levels of variation within zones compared to that observed between zones (Figure 22).

Within Mollusca, Bivalvia was the most dominant taxa, however did not maintain a consistently high abundance and showed high variation between sites (Figure 23a). Malacostraca was the most abundant class within Arthropoda, representing over 95% of organisms found (Figure 23b), with the majority belonging to Gammaridae. No clear dominance of abundance was observed in Echinodermata (Figure 23c).

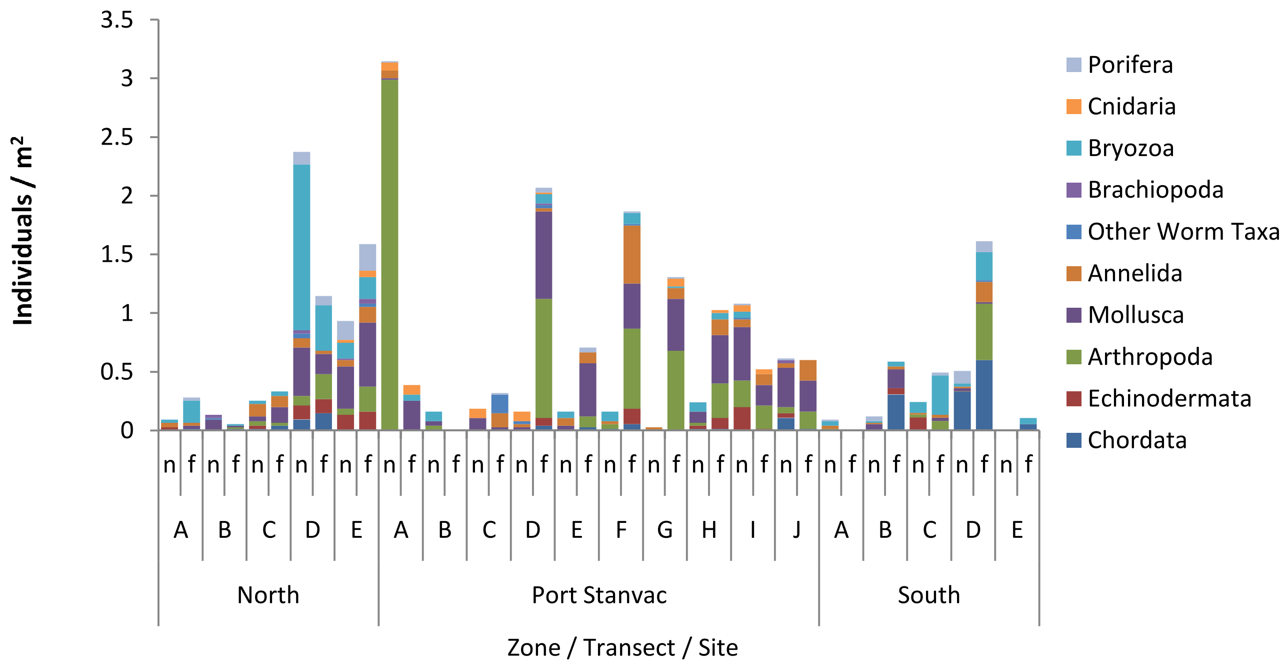


Figure 21. Total abundance of organisms collected using the dredge per phyla identified across the three zones; North control zone, Port Stanvac construction zone and South control zone. Samples were collected along two 100 m lengths at the near (n = 0 to 100 m) and far (f = 700 to 800 m) extremities of 10 (A-J) transects at Port Stanvac (b) and 5 transects (A-E) at the northern (a) and southern (c) control zones.

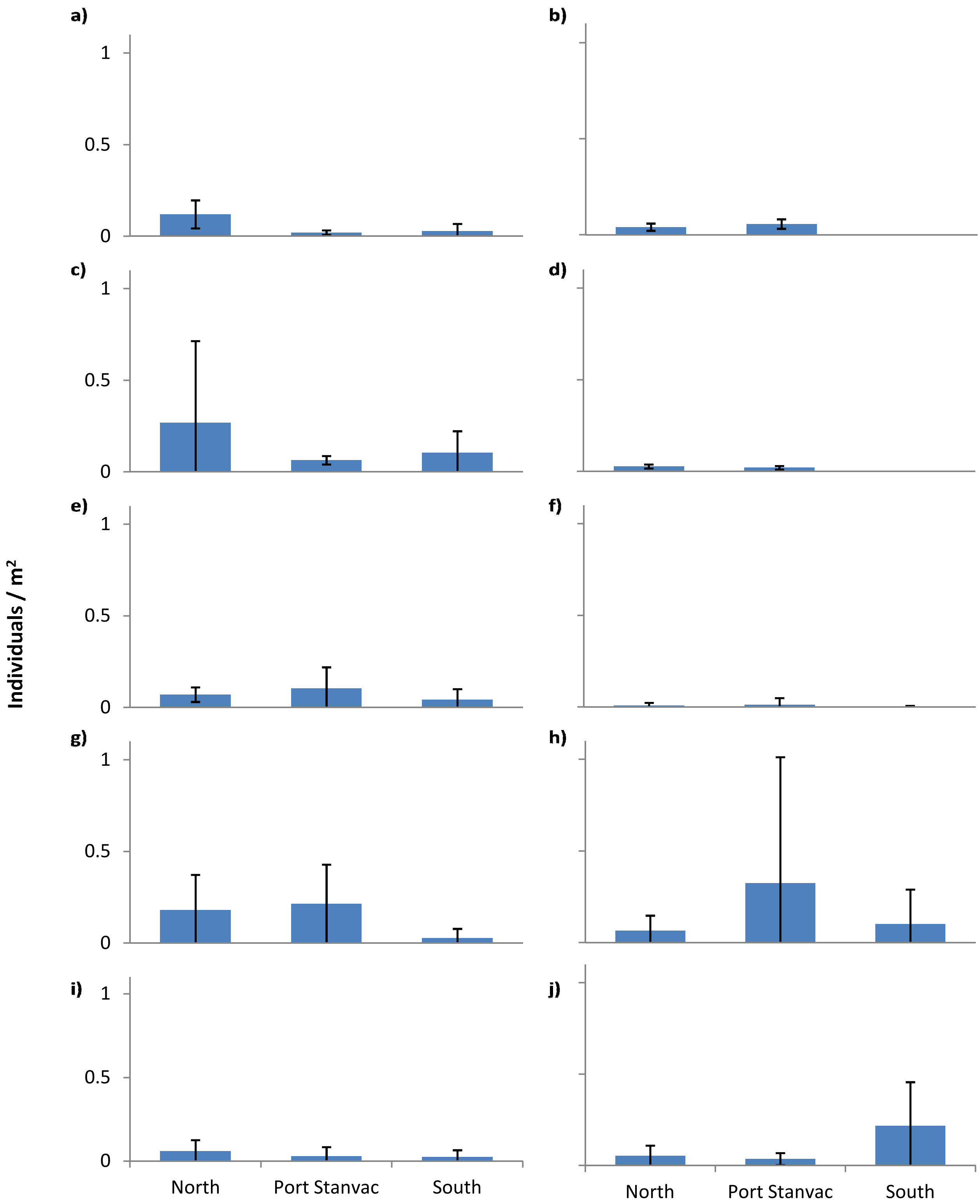


Figure 22. Mean abundance of organisms collected using the dredge across three zones; North control zone, Port Stanvac construction zone and South control zone per phyla: a) Porifera, b) Cnidaria, c) Bryozoa, d) Brachiopoda, e) Annelida, f) other worm taxa, g) Mollusca, h) Arthropoda, i) Echinodermata and j) Urochordata. Error bars = ± 1 standard deviation.

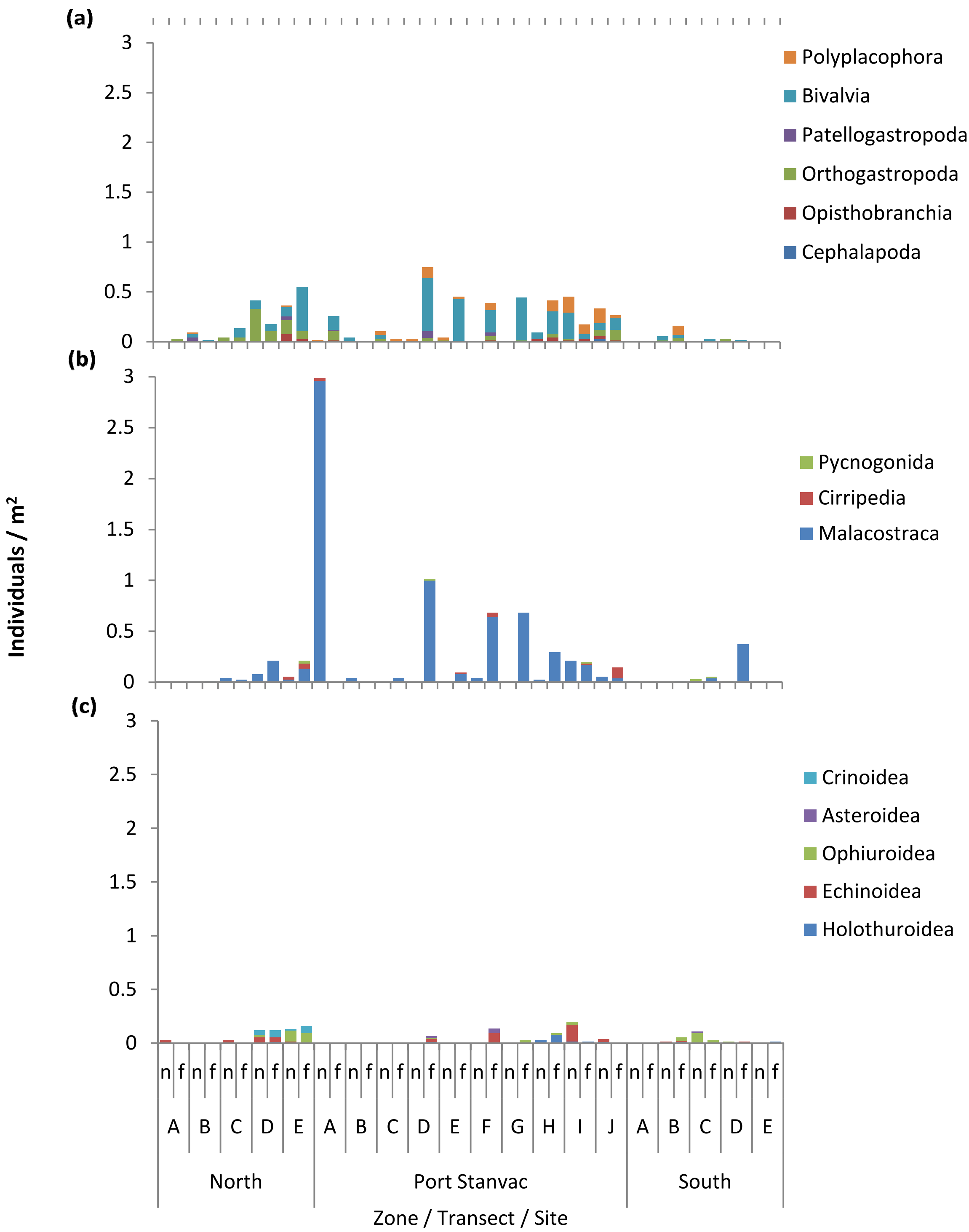


Figure 23. Total abundance of organisms collected using the dredge across: (a) Mollusca, (b) Arthropoda and (c) Echinodermata, identified across the three zones; North control zone, Port Stanvac construction zone and South control zone. Samples were collected along two 100 m lengths at the near (n = 0 to 100 m) and far (f = 700 to 800 m) extremities of 10 (A-J) transects at Port Stanvac (b) and 5 transects (A-E) at the northern (a) and southern (c) control zones.

Species Diversity

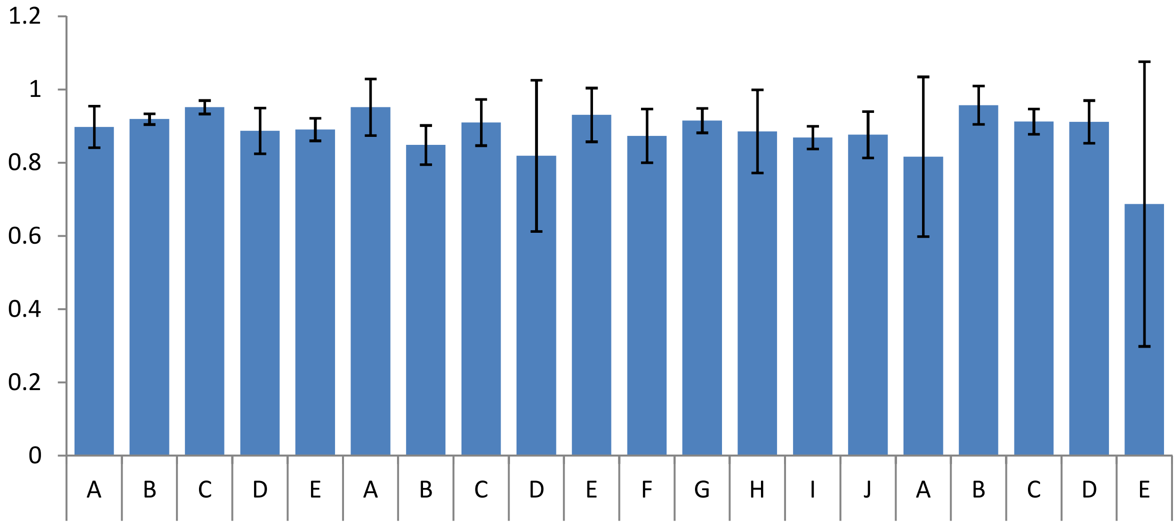
Suction Sampling

The diversity indices calculated from suction sampling data indicated that all transects at the Port Stanvac construction zone and the North and South control zones had high diversity, where Shannon-Wiener index exceeded a value of one (Table 2; Figure 24b). An uneven abundance distribution between species was recorded in all transects according to Pielou's index (>0.8; Table 2). In addition, Simpson's index values for all of the transects in the Port Stanvac construction zone and the North and South control zones were high (Table 1; Figure 24a), indicating dominance of single species. The dominant species across all sites were from the family Gammaridae followed by *Neotogibbula lehmanni* (Port Stanvac), *Amblypneustes ovum* (North) and *Reptorella* sp. (South) (Appendix III).

Table 2. Diversity indices derived from suction sampling data. *S* = number of taxa; *N* = total number of individuals. All values include standard deviation (SD).

Site	Transect	S		N		Shannon-Wiener		Pielou's J		Simpson's	
North	A	25.4	(6.88)	65.6	(17.73)	2.71	(0.35)	0.85	(0.05)	0.90	(0.06)
	B	19.2	(2.17)	43.2	(9.55)	2.62	(0.12)	0.89	(0.02)	0.92	(0.01)
	C	12.8	(5.89)	20.6	(15.42)	2.34	(0.35)	0.95	(0.03)	0.95	(0.02)
	D	10.0	(3.94)	20.6	(9.66)	2.04	(0.41)	0.91	(0.04)	0.89	(0.06)
	E	15.4	(3.97)	37.2	(13.26)	2.35	(0.16)	0.87	(0.05)	0.89	(0.03)
Port Stanvac	A	12.8	(2.77)	20.6	(7.19)	2.34	(0.35)	0.95	(0.03)	0.95	(0.08)
	B	10.8	(8.17)	25.8	(20.24)	1.93	(0.56)	0.88	(0.03)	0.85	(0.05)
	C	11.2	(1.79)	19.6	(3.65)	2.22	(0.25)	0.92	(0.06)	0.91	(0.06)
	D	16.4	(7.02)	42.4	(27.37)	2.24	(0.76)	0.81	(0.14)	0.82	(0.21)
	E	12.0	(4.30)	19.8	(6.42)	2.31	(0.44)	0.95	(0.05)	0.93	(0.07)
	F	6.8	(2.28)	11.8	(5.50)	1.73	(0.36)	0.92	(0.04)	0.87	(0.07)
	G	13.8	(8.17)	27.8	(18.27)	2.30	(0.51)	0.92	(0.02)	0.92	(0.03)
	H	17.2	(6.76)	43.6	(16.56)	2.44	(0.50)	0.87	(0.12)	0.89	(0.11)
	I	15.0	(5.00)	56.2	(26.81)	2.24	(0.26)	0.85	(0.03)	0.87	(0.03)
	J	10.4	(3.13)	22.4	(8.14)	2.05	(0.37)	0.90	(0.07)	0.88	(0.06)
South	A	8.75	(2.75)	20.5	(11.70)	1.78	(0.47)	0.84	(0.19)	0.82	(0.22)
	B	8.0	(3.94)	11.6	(8.38)	1.85	(0.70)	0.97	(0.04)	0.96	(0.05)
	C	13.8	(3.03)	30.8	(18.05)	2.37	(0.24)	0.91	(0.04)	0.91	(0.03)
	D	12.4	(6.19)	27.6	(19.76)	2.17	(0.40)	0.90	(0.05)	0.91	(0.06)
	E	6.4	(5.68)	12.8	(15.32)	1.37	(0.91)	0.72	(0.40)	0.69	(0.39)

a)



b)

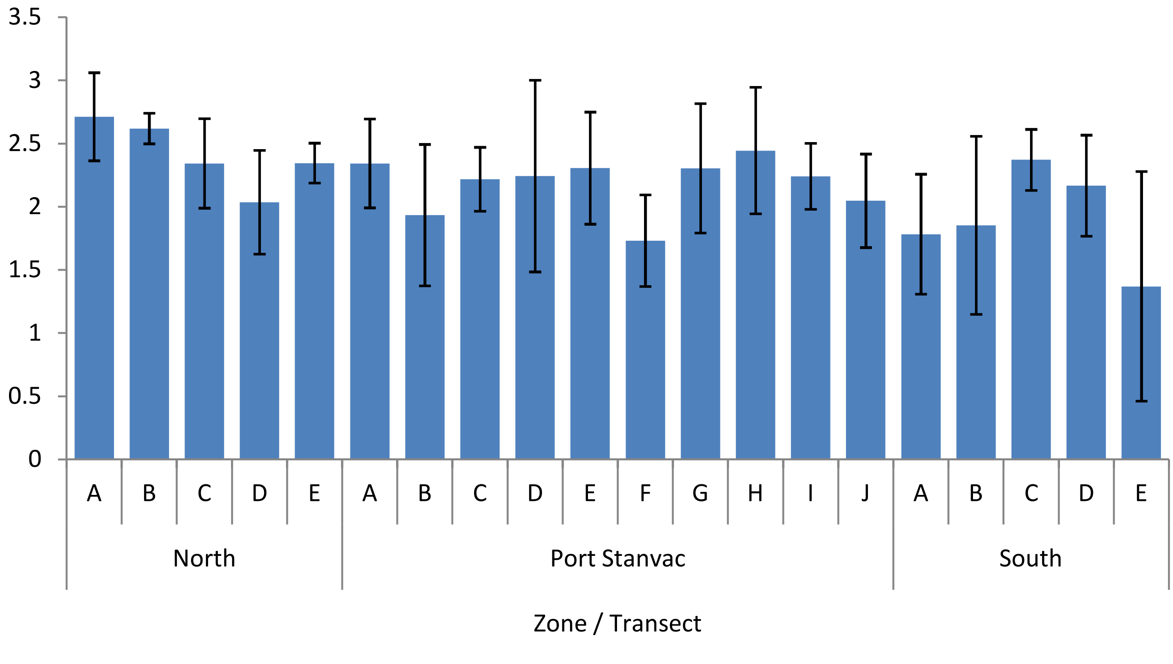


Figure 24. Mean diversity per transect based on (a) Simpson's index and (b) Shannon-Wiener's index across three zones (North control zone, Port Stanvac Construction zone and South control zone), based on suction sampling data. Error bars = ± 1 standard deviation.

Dredge Sampling

The diversity indices calculated from dredge data indicated that all transects at the Port Stanvac construction zone and the North and South control zones had high diversity (Figure 25), where Shannon-Wiener index exceeded value of one, and an uneven distribution according to Pielou's index (Table 3). In addition, Simpson's index values in all zones were high, indicating dominance of single species (Figure 25a), consistent with findings from the suction sampling data.

Table 3. Diversity indices derived from dredge sampling data. *S* = number of taxa; *N* = total number of individuals. All values include standard deviation (SD). 'n/a' is indicative of one site in a transect not containing any species.

Site	Transect	S		N		D		Shannon-Wiener		Pielou's J		Simpson's	
North	A	9	(2.12)	28	(9.90)	2.67	(0.43)	2.34	(0.13)	1.68	(0.20)	1.38	(0.10)
	B	10	(1.41)	14	(4.24)	4.34	(0.00)	3.08	(0.22)	1.95	(0.04)	1.89	(0.08)
	C	29	(2.12)	44	(4.24)	8.74	(0.41)	5.14	(0.09)	1.93	(0.02)	1.92	(0.01)
	D	67	(7.78)	264	(65.1)	13.39	(0.90)	5.18	(0.35)	1.49	(0.15)	1.68	(0.12)
	E	65	(2.12)	189	(34.7)	13.97	(0.11)	6.41	(0.03)	1.84	(0.01)	1.92	(0.00)
Port	A	20	(1.41)	267	(147.8)	4.20	(0.39)	2.31	(1.03)	1.04	(0.48)	0.99	(0.49)
Stanvac	B	5	(3.54)	14	(9.90)	1.52	n/a	1.44	(1.02)	0.89	n/a	0.78	n/a
	C	12	(0.00)	29	(0.71)	3.74	(0.03)	3.09	(0.01)	1.72	(0.01)	1.59	(0.01)
	D	39	(23.3)	165	(102.5)	7.81	(4.29)	3.49	(1.12)	1.57	(0.11)	1.44	(0.14)
	E	23	(6.36)	65	(29.0)	6.19	(0.96)	4.03	(0.22)	1.74	(0.12)	1.76	(0.04)
	F	41	(23.3)	152	(90.5)	8.49	(4.30)	4.28	(1.33)	1.72	(0.01)	1.63	(0.15)
	G	20	(12.7)	103	(70.0)	3.90	(2.76)	2.14	(1.52)	0.73	n/a	0.82	(0.58)
	H	28	(11.3)	95	(41.7)	6.56	(2.19)	4.16	(0.66)	1.72	(0.06)	1.71	(0.05)
	I	40	(9.90)	120	(29.7)	9.19	(1.87)	5.09	(0.43)	1.74	(0.00)	1.81	(0.03)
	J	42	(2.83)	91	(0.71)	10.48	(0.72)	5.50	(0.10)	1.81	(0.01)	1.87	(0.00)
South	A	4	(2.83)	7	(4.95)	1.54	n/a	1.28	(0.90)	0.92	n/a	0.81	n/a
	B	23	(4.95)	74	(11.3)	5.76	(1.13)	3.27	(0.51)	1.35	(0.09)	1.35	(0.15)
	C	17	(2.12)	72	(4.24)	4.17	(0.52)	2.85	(0.02)	1.35	(0.09)	1.31	(0.10)
	D	29	(7.78)	162	(58.0)	6.12	(1.26)	3.84	(0.70)	1.46	(0.11)	1.51	(0.18)
	E	5	(3.54)	9	(6.36)	1.82	n/a	1.47	(1.04)	0.91	n/a	0.83	n/a

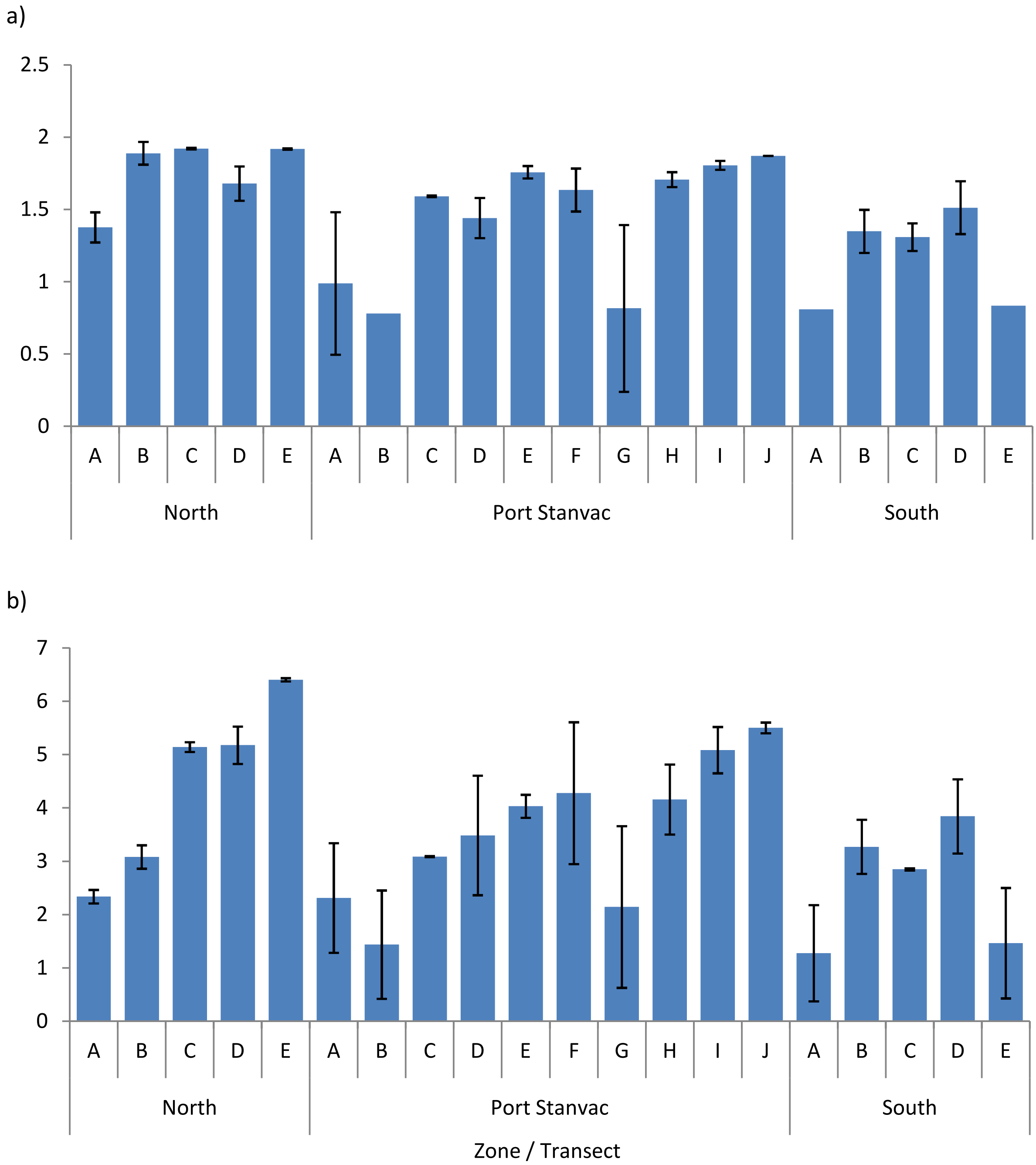


Figure 25. Figure 24. Mean diversity per transect based on (a) Simpson's index and (b) Shannon-Wiener's index across three zones (North control zone, Port Stanvac construction zone and South control zone), based on dredge data. Error bars = ± 1 standard deviation.

Community structure

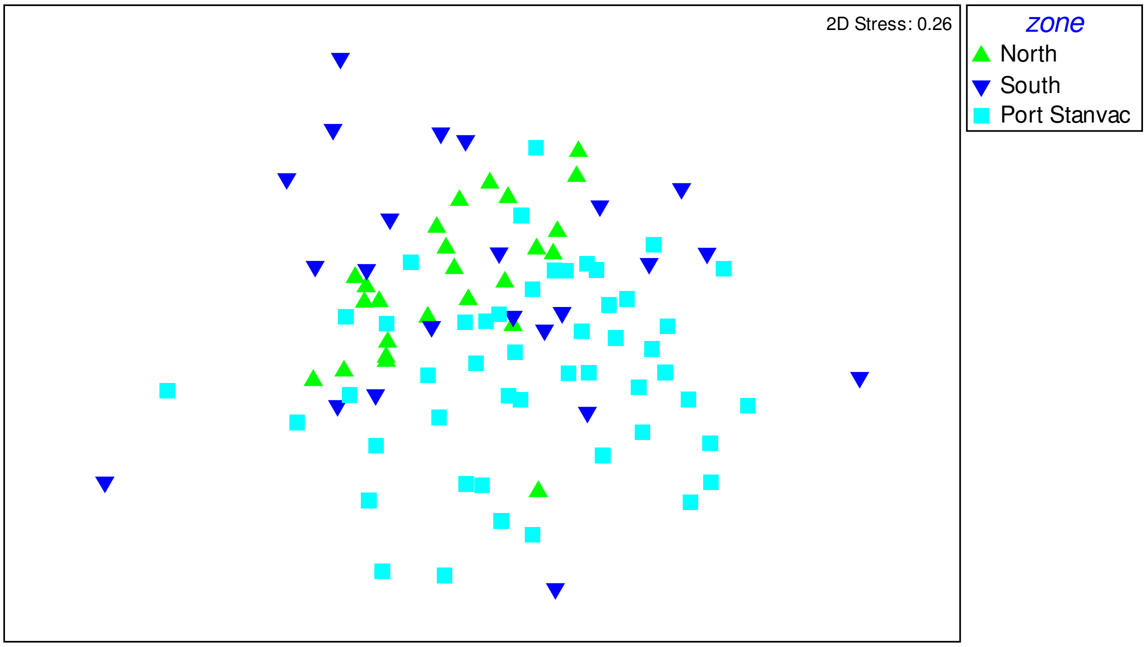
Suction Sampling

Multivariate analyses of the community structure from the infauna suction samples indicated high variability between sites from all three zones. Similarities between sites were generally below 60%, except for two sites from Port Stanvac: F600 and F800 sites with similarity of 70%. The Multi-Dimensional Scaling (MDS) ordination plots based on the species composition show a wide spread of sampling sites for both Port Stanvac and the South control zones, but a tighter clustering of sites from the North control zone (Figure 26a). When undertaken at the taxonomic level of family (Figure 26b), tighter clustering was observed between Port Stanvac samples, but larger variability remained between the South control sites. In the samples from the South and North control zones there were no defined communities and overlap at Port Stanvac was observed. In addition to this, the MDS ordination plot showed no distinct clusters between sites based on the substrate characteristics (Figure 27). Graphical overlap or lack of grouping according to zones and substrates indicates greater variability within sites than between sites (Figures 26 & 27). Further analysis using ANOSIM shows that invertebrate communities at the species level were significantly different between zones (p = 0.003), but the Global R value was low (R = 0.11), supporting the high variability within zones.

The pairwise test showed communities within the North control zone and Port Stanvac construction zone to be significantly different (p = 0.012, R = 0.094), South control zone and Port Stanvac construction zone to be significantly different (p = 0.014, R = 0.115) and the North and South control zones to be significantly different (p = 0.001, R = 0.172) at the species level. At the family level, communities within the North control zone and Port Stanvac construction zone were significantly different (p = 0.041, R = 0.083), in the South control zone and Port Stanvac construction zone to be significantly different (p = 0.008, R = 0.128) and in the North and South control zones were also found to be significantly different at the family level (p = 0.001, R = 0.16).

The differences between zones were further confirmed by SIMPER analysis, where dissimilarity percentage between the Port Stanvac construction zone and South control zone was 85%, between the Port Stanvac construction zone and North control zone is 82% and between North and South control zones was 82%. The high dissimilarity percentages revealed by SIMPER analysis are predominantly attributable to high number of species and although there was a dominance of amphipods (Gammaridae) all zones, the secondarily dominant species differed at the Port Stanvac construction zone, with the gastropod *Neotogibbula lehmanni*, at the North control zone, with the echinoderm *Amblypheustes ovum* and at the South control zone, the bryozoan *Reptorella* sp. (Appendix III).

a)



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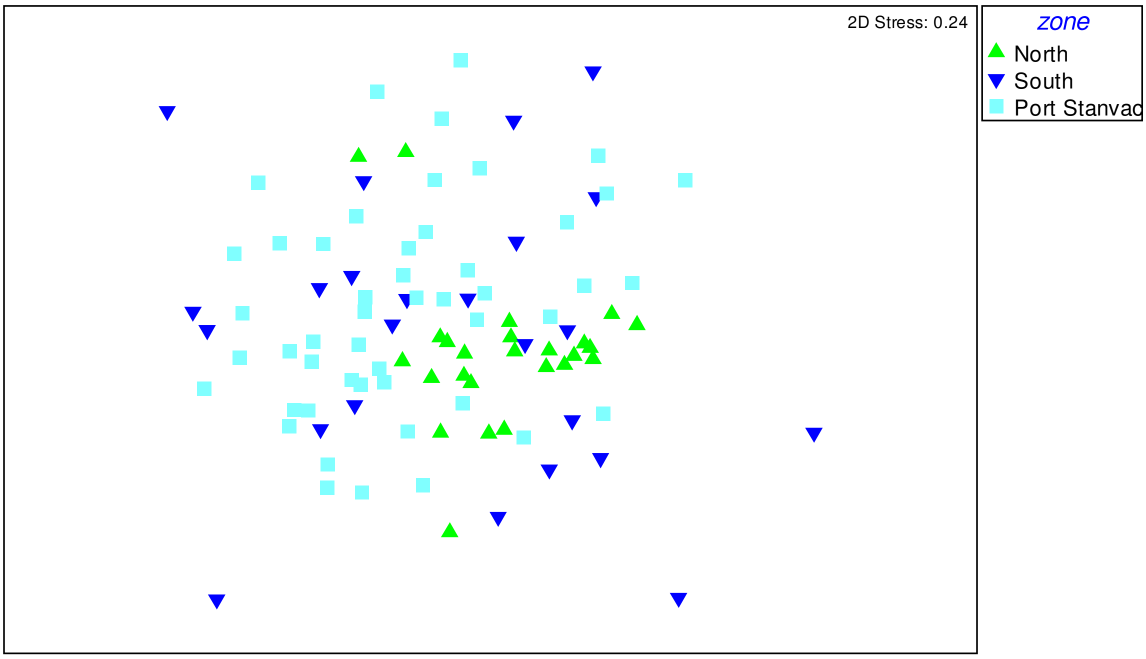

Figure 26. Two dimensional MDS ordination plots of square root transformed abundances (mean values per site) of (a) species based data and (b) family based data of the infauna communities from the North control zone (▲), South control zone (▼) and Port Stanvac construction zone (■).

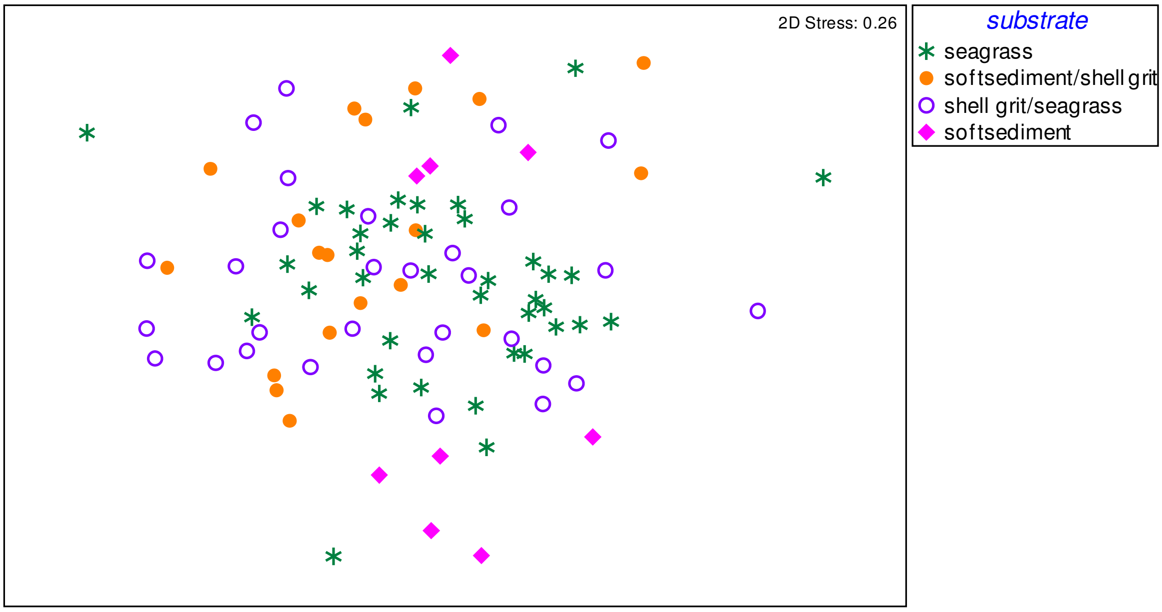

Figure 27. Two dimensional MDS ordination plots of square root transformed abundances (mean values per site) of species based data separated by substrate characteristics.

Dredge Sampling

Multivariate analyses of the community structure from the dredge samples indicated high overlap of community structure between zones (Figure 28). Unlike the suction samples, the sites from the dredge samples at the South control zone were observed to cluster more tightly than the other zones. High variability was observed between samples within Port Stanvac construction zone and the North control zone (Figure 28). The ANOSIM analysis indicated that the communities were significantly different between zones ($p = 0.021$) despite high variability within zones (Global $R = 0.135$), which was supported by high levels of dissimilarity, equal to 92% between the Port Stanvac construction zone and both the North and South control zones; and 87% between North control zone and South control zone.

A pairwise test indicated that communities within the North control zone and Port Stanvac construction zone were not significantly different ($p = 0.059$, $R = 0.1$), however the South control zone and Port Stanvac construction zone were significantly different ($p = 0.019$, $R = 0.184$) and North and South control zone were significantly different ($p = 0.027$, $R = 0.197$) at the species level. This significant difference in communities between zones, in contrast to the high overlap between zones observed in the MDS ordination plot is attributable to the high within zone variation and the shift in dominant species between zones. While the bryozoan *Costaticella solida* was the primary dominant species in all zones, the secondarily dominant species differed with the gastropod *Thalotia conica* in the North control zone, the bivalve *Musculus nanus* in the Port Stanvac construction zone and the ascidian *Botrylloides schlosseri* in the South control zone (Appendix III).

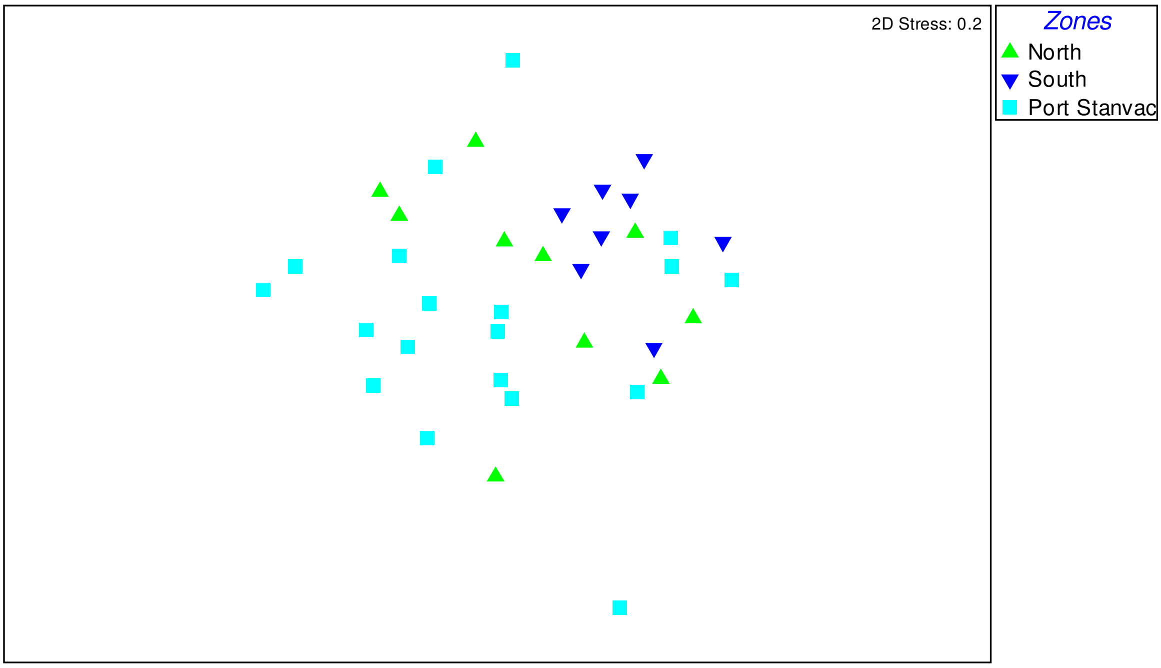

Figure 28. Two dimensional MDS ordination plots of square root transformed abundances all dredge derived infauna communities from the North control zone (▲), South control zone (▼) and Port Stanvac construction zone (■).

Discussion and Conclusion

Infauna monitoring of the Port Stanvac construction zone and the North and South control zones revealed high species diversity and abundances across all sites. Species richness for the Port Stanvac construction zone ranged between the North control zone, which had the highest number of species, and the South control zone which had the lowest. Overall abundance of benthic communities showed similar trends, in addition the Port Stanvac construction zone and North control zone had equal abundances in the dredge sampling. This result indicates that the North and South control zones are suitable as controls for the Port Stanvac construction zone, especially considering that both zones have similar site and substrate characteristics as Port Stanvac.

The diversity indices show that the Port Stanvac construction zone and the North and South control zones had high diversity, with dominance of a single species. The dominant species across all sites were amphipoda (Gammaridae) in the suction sampling and the bryozoan *Costaticella solida* in the dredge sampling. Multivariate analyses of the community structure indicated high variability both within and between sites from all three zones using both sampling methods. This reinforces the importance of within site replication in the sampling design. ANOSIM analysis shows that invertebrate communities were significantly different between zones, accompanied by high dissimilarity percentages revealed by SIMPER analysis, which are attributable to high species richness within sites and differences in secondary dominances within zones. Nevertheless, the control sites encompass the majority of variability observed in the community composition from the Port Stanvac area.

A final report encompassing the winter and summer survey will be submitted at the end of June 2010, which will include analyses of infaunal community structure between sites and seasons. This will establish a seasonal baseline dataset for the Port Stanvac construction zone as well as the North and South control zones to fulfil a complete annual ‘before construction’ dataset.

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Appendix I. Species present in suction samples. North = North control zone, Port Stanvac = Port Stanvac construction zone, South = South control zone. Values indicate the number of sites with species present.

Phylum	Class	Subclass	Family	Species	North	Port Stanvac	South
Porifera	Demospongiae		Callyspongiidae	*Callyspongia* sp.	1	1	1
			Dysideidae	*Euryspongia* sp.	1	0	1
Cnidaria	Anthozoa	Hexacorallina	Zoanthidae	Zoanthidae sp.	0	1	0
Bryozoa	Gymnolaemata		Bugulidae	*Bugula robusta*	0	0	1
			Candidae	*Caberea helicina*	2	0	1
				Menipea roborata	0	2	1
			Catenicellidae	*Costaticella solida*	5	18	8
			Phidoloporidae	*Reteporella* sp.	7	17	10
	Stenolaemata		Crisiidae	*Mesonea radians*	5	2	1
			Horneridae	*Hornera ramosa*	3	1	0
Brachiopoda	Rhynchonellata		Terebratellidae	*Megellania flavascens*	0	9	4
Nematoda			Nematoda	Nematoda sp.	3	0	0
Sipuncula	Phascolosomatidea		Phascolosomatidae	Phascolosomatidae sp.	0	7	0
Platyhelminthes	Turbellaria		Cestoplanidae	Cestoplanidae sp.	0	1	0
			Leptoplanidae	*Notoplana australis*	0	6	0
Echiura	Echiuroidea		Ikedidae	*Ikeda* sp.	0	4	0
Annelida	Polychaeta		Amphinomidae	Amphinomidae sp.	0	2	0
			Arenicolidae	Arenicolidae sp.	4	2	0
			Capitellidae	Capitellidae sp.	4	6	1
			Cirratulidae	Cirratulidae sp.	1	2	3
			Eunicidae	Eunicidae sp.	2	3	0
			Flabelligeridae	Flabelligeridae *sp*	6	1	0
			Glyceridae	Glyceridae sp.	1	3	2

Annelida (cont'd)	Polychaeta (cont'd)		Hesionidae	Hesionidae sp.	2	8	2
			Lumbrineridae	Lumbrineridae sp.	4	4	0
			Lysaretidae	Lysaretidae sp.	0	2	1
			Maldaridae	Maldaridae sp.	3	2	0
			Nereididae	Nereididae sp.	6	3	1
			Oenonidae	*Notopsilus* sp.	5	2	1
			Opheliidae	Opheliidae sp.	0	2	0
			Orbiniidae	Orbiniidae sp.	0	1	0
			Phyllodocidae	*Eulalia* sp.	5	22	1
				Phyllodocidae sp.	7	7	4
			Polynoidae	Polynoidae sp.	0	0	3
			Sabellidae	Sabellidae sp.	3	8	3
			Sigalionidae	Sigalionidae sp.	3	4	2
			Syllidae	Syllidae sp.	8	3	6
			Terebellidae	Terebellidae sp.	0	1	0
Mollusca	Polyplacophora	Neoloricata	Ischnochitonidae	*Ischinochiton elongatus*	3	2	0
				Ischinochiton variegatus	4	11	4
				Ischinochiton wilsoni	1	8	0
	Bivalvia	Heterodonta	Cardiidae	*Fulvia teniuicostata*	2	0	0
			Lucinidae	*Callucina lacteola*	0	2	0
			Mactridae	*Mactra* sp.	8	2	1
			Pholadidae	*Barnea obturamentum*	3	3	3
			Tellinidae	*Tellina albinella*	3	3	2
				Tellina deltoidalis	4	4	3
			Veneridae	*Bassina disjecta*	0	0	2
				Calista kingli	17	11	5

Mollusca (cont'd)	Bivalvia (cont'd)	Heterodonta (cont'd)	Veneridae (cont'd)	*Dosinia* sp.	1	0	2
				Periglypta puerpera	1	0	0
				Tapes literatus	3	1	0
				Venerupis galactites	8	19	4
		Protobranchia	Nuculanidae	*Nuculana crassa*	2	5	4
		Pteriomorphia	Glycymerididae	*Glycymeris radians*	4	1	1
			Limidae	*Limaria orientalis*	8	12	1
				Limatula strangei	6	3	0
			Mytilidae	*Musculus nanus*	8	20	7
			Pectinidae	*Equichlamys bifrons*	2	2	1
			Pteriidae	*Electroma georgiana*	0	0	1
	Gastropoda	Caenogastropoda	Buccinidae	*Cominella eburnea*	1	9	2
				Fusinus australis	0	1	1
				Nassarius pyrehus	5	14	5
			Calyptraeidae	*Calyptraea calyptraeaformis*	3	8	1
			Columbellidae	Columbellidae sp.	1	4	0
				Mitrella australis	4	8	0
			Epitoniidae	Epitoniidae sp.	1	7	2
			Hipponicidae	*Hipponix australis*	0	3	0
			Muricidae	*Pterinotus transformis*	0	1	0
			Naticidae	*Natica* sp.	2	1	2
				Polinices conicus	4	8	1
		Heterobranchia	Aglajidae	Aglajidae sp.	0	1	0
			Burlidae	*Bulla guoyii*	0	1	0
			Haminoeidae	Hamineidae sp.	0	3	1
			Oxynoidae	*Oxynoe viridis*	0	1	0

Mollusca (cont'd)	Gastropoda (cont'd)	Heterobranchia (cont'd)	Philiniade	*Philine angasi*	0	2	1
		Patellogastropoda	Lottidae	*Diodora lincolnensis*	0	4	0
				Notoacmea flammea	3	4	0
				Patelloida alticostata	1	7	0
		Vestigastropoda	Phasianellidae	*Phasianella ventricosa*	4	9	3
			Trochidae	*Clanculus maugeri*	0	2	0
				Ethalia sp.	2	0	2
				Notogibbula lehmanni	7	24	10
				Stomatella impertusa	0	2	0
				Thalotia conica	5	2	1
				Trochidae sp.	0	1	0
	Cephalopoda	Coleoidea	Sepiidae	*Sepia apama*	0	2	0
Arthropoda	Pycnogonida		Ammothidae	*Pycnothea flynii*	0	1	0
			Callipallinidae	*Pseudopallene chevron*	3	1	2
			Callipallinidae	*Parapallene famelica*	0	2	1
			Nymphonidae	*Nymphon aequidigitatum*	0	9	1
	Ostracoda		Ostracoda	Ostracoda sp.	7	2	2
	Malacostraca	Eumalacostraca	Alpheidae	Alpheidae sp.	1	2	0
			Anaspidacea	Anaspidacea sp.	5	1	1
			Aristeidae	Aristeidae sp.	1	0	1
			Armadillidae	*Buddelundia inaequalis*	0	4	1
			Caprellidae	Caprellidae sp.	2	1	3
			Corophiidae	Corophiidae sp.	0	2	0
			Cumacea	Cumacea sp.1	1	3	3
				Cumacea sp.2	4	2	2
			Diogenidae	*Strigopagurus elongatus*	0	4	6

Arthropoda (cont'd)	Malacostraca (cont'd)	Eumalacostraca (cont'd)	Dromiidae	Dromiidae sp.	1	0	0
			Galatheidae	Galatheidae sp.	4	1	1
			Gammaridae	Gammaridae sp.1	22	35	14
				Gammaridae sp.2	15	7	3
				Gammaridae sp.3	1	0	1
			Hippolytidae	*Saron* sp.	3	0	0
			Hymenosomatidae	Hymenosomatidae sp.	17	18	8
			Idoteidae	*Peridotea ungulata*	0	2	0
			Ischyroceridae	*Cerapus* sp.	4	1	4
			Leucosiidae	*Crytocnemus vincentianus*	1	1	1
				Ebalia intermedia	3	3	2
			Lysianassidae	*Waldeckia* sp.	0	3	2
			Majidae	Majidae sp.	1	1	0
			Melitidae	*Ceradocus* sp.	13	8	8
			Paguridae	Paguridae sp.	3	4	0
			Palaemonidae	Palaemonidae sp.	7	1	0
			Serolidae	*Serolina bakeri*	3	2	1
			Sphaeromatidae	*Cymodopsis crassa*	1	0	3
			Tanaidacea	Tanaidacea sp.	13	8	3
		Phyllocardia	Nebaliidae	*Nebalia* sp.	3	0	0
				Nebaliidae sp.	1	1	2
Echinodermata	Ophiuroidea		Amphiuridae	*Amphiura constricta*	0	1	0
			Ophiacanthidae	*Ophiacantha brachygnatha*	6	12	3
			Ophiactidae	*Ophiactis tricolor*	1	0	0
			Ophiodermatidae	*Ophioconis opacum*	10	17	9
			Ophiolepididae	*Ophioceres bispinosus*	0	0	0

Echinodermata (cont'd)	Ophiuroidea (cont'd)		Ophionereididae	*Ophionereis schayeri*	3	7	0
			Ophiuridae	*Ophiocrossota multispina*	1	1	2
	Asteroidea		Asteriidae	*Costinacerias muricata*	1	2	0
	Echinoidea	Euechinoidea	Temnopleuridae	*Amblypneustes elevatus*	1	0	0
				Amblypneustes ovum	19	19	8
	Holothuroidea		Holothuriidae	Holothuriidae sp.	1	0	1
Chordata	Ascidiacea		Holozoidae	*Sycozoa pulchra*	4	3	2
			Pyuridae	*Herdmania fimbriae*	0	1	0
				Pyura gibbosa	0	3	0
				Pyura praeputialis	3	8	4
			Styelidae	*Styela plicata*	1	2	2

Appendix II. Species present in dredge samples. North = North control zone, Port Stanvac = Port Stanvac construction zone, South = South control zone. Values indicate the number of sites with species present.

Phylum	Class	Subclass	Family	Species	North	Port Stanvac	South
Porifera	Calcarea	Calcaronea	Sycettidae	*Sycon* sp.	1	0	2
	Demospongiae		Ancorinidae	*Ecionemia* sp.	2	2	0
			Callyspongiidae	*Callyspongia* sp.	3	4	1
			Chalinidae	*Chalinula* sp.	1	0	0
			Chondrillidae	*Chondrilla* sp.	1	0	1
			Darwinellidae	*Darwinella* sp.	1	0	1
				Dendrilla rosea	0	0	1
			Desmacellidae	*Desmacella* sp.	1	0	0
			Dysideidae	*Dysidea* sp.	0	0	1
				Euryspongia sp.	2	2	0
			Irciniidae	*Ircinia* sp.	1	0	0
			Microcionidae	*Clathria* sp.	2	0	0
			Mycalidae	*Mycale* sp.	0	0	2
			Phloeodictyidae	*Oceanapia* sp.	1	0	0
			Spongiidae	*Coscinoderma pesleonis*	1	0	0
			Stellettidae	*Stelletta* sp.	2	1	0
			Thorectidae	Thorecta sp.	2	0	1
Cnidaria	Anthozoa	Hexacorallina	Actiniidae	Actiniidae sp.	2	0	7
			Isophelliidae	Isophellidae sp.	0	0	1
			Mussidae	Mussidae sp.	0	0	0
				Scolymia australis	0	0	1
			Rhizangiidae	Rhizangiidae sp.	0	0	1
Bryozoa	Gymnolaemata		Candidae	*Canda filifera*	1	0	4

Bryozoa (cont'd)	Gymnolaemata (cont'd)		Candidae (cont'd)	*Menipea roborata*	0	0	1
			Catenicellidae	*Costaticella solida*	6	8	6
			Phidoloporidae	*Iodictyum phoeniceum*	3	0	0
				Reteporellina sp.	0	0	2
				Retoporella granulata	4	1	0
	Stenolaemata		Crisiidae	*Mesonea radians*	2	0	1
Brachiopoda	Rhynchonellata		Terebratellidae	*Megellania flavascens*	4	0	2
Nematoda			Nematoda	Nematoda sp.	1	0	0
Sipuncula	Phascolosomatidea		Phascolosomatidae	*Phascolosoma annulatum*	2	1	1
				Phascolosoma nodoliferum	0	0	0
Platyhelminthes	Turbellaria		Leptoplanidae	*Notoplana australis*	0	0	2
Echiura	Echiuroidea		Ikedidae	*Ikeda* sp.	1	0	0
Annelida	Clitellata	Hirudinea	Piscicolidae	*Pontobdella* sp.	0	0	1
	Polychaeta		Capitellidae	Capitellidae sp.	0	1	1
			Cirratulidae	Cirratulidae sp.	1	0	1
			Eunicidae	*Eunice laticeps*	0	0	4
				Eunicidae sp.	0	0	4
			Flabelligeridae	Flabelligeridae sp.	1	0	3
			Hesionidae	Hesionidae sp.	1	0	3
			Lumbrineridae	Lumbrineridae sp.	0	1	3
			Nereidae	Nereidae sp.	1	1	5
			Oenonidae	*Notopsilus* sp.	3	4	3
				Oenone sp.	3	0	1
			Phyllodocidae	*Eulalia* sp.	1	0	5
				Phyllodocidae sp.	0	2	0
			Pilargidae	Pilargidae sp.	1	0	2

Annelida (cont'd)	Polychaeta (cont'd)		Polynoidae	Polynoidae sp.	2	0	2
			Serpulidae	*Galeolaria caespitosa*	0	0	0
			Sigalionidae	Sigalionidae sp.	1	0	2
			Syllidae	Syllidae sp.	1	0	4
			Terebellidae	Terebellidae sp.	4	0	1
Mollusca	Polyplacophora	Neoloricata	Acanthochitonidae	*Acauthochitona bednalli*	0	0	6
			Chitonidae	*Rhyssoplax exoptanda*	0	0	1
			Ischnochitonidae	*Ischinochiton carious*	0	0	2
				Ischinochiton elongatus	0	0	3
				Ischinochiton torri	1	0	0
				Ischinochiton variegatus	1	1	5
				Ischinochiton wilsoni	0	0	3
				Stenochiton pilsbryanus	0	0	1
			Leptochitonidae	*Leptochiton liratus*	0	0	1
	Bivalvia	Heterodonta	Cardiidae	*Acrosterigma cygnorum*	0	0	1
				Cardita crassicosta	0	0	1
			Chamidae	*Chama ruderalis*	2	0	0
			Corbulidae	*Corbula stolata*	2	0	2
			Lucinidae	*Callucina lacteola*			
			Mactridae	*Lutraria rhynchaena*	0	0	1
			Pholadidae	*Barnea obturamentum*	0	0	4
			Tellinidae	*Tellina victoriae*	1	1	1
			Veneridae	*Placamen placidum*	2	1	1
				Tawera logopus	1	0	2
		Palaeoheterodonta	Trigoniidae	*Neotrigonia margaritacea*	0	1	0
		Pteriomorphia	Anomiidae	*Pododesmus zelandiaus*	1	0	1

Mollusca (cont'd)	Bivalvia (cont'd)	Pteriomorphia (cont'd)	Arcidae	*Barbatia pistachia*	2	0	3
			Glycymerididae	*Glycymeris radians*	1	1	2
			Limidae	*Lima vulgaris*	1	0	0
				Limaria orientalis	1	0	3
				Limatula strangei	0	0	2
			Malleidae	*Malleus meridianis*	0	0	0
			Mytilidae	*Musculista senhousia*	0	0	1
				Musculus nanus	4	2	8
			Ostreidae	*Ostrea angasi*	1	0	3
				Saccostrea glomerata	1	0	0
			Pectinidae	*Equichlamys bifrons*	4	0	3
				Pecten fumatus	0	0	4
				Semipallium aktinos	1	0	0
			Pteriidae	*Electroma georgiana*	1	0	1
	Gastropoda	Caenogastropoda	Batillariidae	*Zeacumantus diemenensis*	0	0	1
			Calyptraeidae	*Calyptraea calyptraeaformis*	3	0	2
			Columbellidae	*Mitrella lincolnensis*	0	2	1
			Fasciolariinae	*Fusinus australis*	2	0	2
			Hipponicidae	*Hipponix australis*	3	0	2
			Turritellidae	*Gazameda iredalei*	3	0	0
		Heterobranchia	Aplysiidae	*Aplysia parvula*	0	0	1
			Philiniade	*Philine angasi*	2	0	7
		Patellogastropoda	Lottidae	*Notoacmea flammea*	1	0	2
				Patelloida alticostata	1	0	1
				Patelloida mimula	0	0	1
		Vestigastropoda	Fissurellidae	*Emarginula* sp.	0	0	1

Mollusca (cont'd)	Gastropoda (cont'd)	Vestigastropoda (cont'd)	Haliotidae	*Haliotis scalaris*	1	0	2
			Phasianellidae	*Phasianella australis*	1	0	4
				Phasianella ventricosa	1	0	2
			Trochidae	*Clanculus limbatus*	0	0	2
				Notogibbula lehmanni	2	1	1
				Thalotia clorostoma	0	0	1
				Thalotia conica	6	1	3
				Trochidae sp.	0	0	1
			Turbinidae	*Astralium squamiferum*	3	0	0
				Turbo torquatus	2	0	1
	Cephalopoda	Coleoidea	Octopodidae	*Octopus berrima*	0	0	1
Arthropoda	Pycnogonida		Ammothidae	*Ammothea* sp.	0	2	1
			Callipallinidae	*Pseudopallene chevron*	1	1	2
	Maxillopoda	Thecostraca	Calanticidae	Calanticidae sp.	2	0	2
				Smilium peronii	0	0	3
	Malacostraca	Eumalacostraca	Aegidae	*Aega serripes*	0	0	1
			Alpheidae	*Alpheus astrinx*	0	0	0
				Alpheus richardsoni	0	0	1
			Ampithoidae	*Amphitoe flindersi*	2	0	0
				Ochlesis eridunda	1	0	1
			Caprellidae	Caprella sp.1	0	2	1
				Caprella sp.2	0	1	1
			Chirostylidae	*Galathea australiensis*	4	0	0
			Diogenidae	*Strigopagurus elongatus*	1	0	0
			Gammaridae	Gammaridae sp.1	0	2	7
				Gammaridae sp.2	0	0	3

Arthropoda (cont'd)	Malacostraca (cont'd)	Eumalacostraca (cont'd)	Goneplacidae	*Litocheira bispinosa*	1	0	1
			Hymenosomatidae	Hymenosomatidae sp.	0	1	2
			Idoteidae	*Euidotea* sp.	1	0	1
			Leucosiidae	*Ebalia intermedia*	2	0	0
			Lysianassidae	*Waldeckia* sp.	0	0	2
			Majidae	*Naxia aurita*	0	1	0
			Melitidae	*Ceradocus rubromaculatus*	1	0	1
				Ceradocus sp.	0	2	0
			Penaeidae	*Metapenaeopsis lindae*	0	1	2
				Penaeus latisulcatus	0	0	1
			Podoceridae	*Podocerus* sp.	1	0	0
			Porcellanidae	*Petrocheles australiensis*	0	0	0
			Portunidae	*Liocarcinus corrugatus*	1	0	0
				Nectocarcinus integrifrons	1	0	3
			Sphaeromatidae	*Cerceis trispinosa*	1	1	2
				Cymodoce sp.	2	1	1
				Cymodopsis crassa	0	0	4
				Neosphaeroma sp.	1	0	0
				Paracilicaea sp.	0	1	0
				Sphaeroma quoyana	1	0	3
			Strahlaxiidae	*Strahlaxius waroona*	0	0	0
			Tanaidacea	Tanaidacea sp.	1	0	0
			Xanthidae	*Actaea calculosa*	0	0	1
Echinodermata	Crinoidea	Articulata	Comasteridae	*Comatulella brachiolata*	4	0	0
	Ophiuroidea		Ophiacanthidae	*Ophiacantha brachygnatha*	0	0	0
			Ophiocomidae	*Ophiocomina australis*	0	0	1

Echinodermata (cont'd)	Ophiuroidea (cont'd)		Ophiodermatidae	*Ophioconis opacum*	0	1	0
				Ophiopeza cylindrica	0	0	0
			Ophionereididae	*Ophionereis schayeri*	0	0	0
			Ophiotrichidae	*Ophiothrix caespitosa*	3	4	2
			Ophiuridae	*Ophiocrossota multispina*	2	0	1
				Ophiura kinbergi	0	0	1
	Asteroidea		Asteriidae	*Allostichaster polyplax*	0	0	0
				Astropecten sp.	0	1	0
				Costinacerias muricata	0	0	1
				Uniophora granifera	0	0	1
	Echinoidea		Cidaridae	*Goniocidaris tubaria*	2	1	3
		Euechinoidea	Temnopleuridae	*Amblypneustes ovum*	1	2	3
				Amblypneustes pallidus	4	0	1
	Holothuroidea		Stichopodidae	*Stichopus ludwigi*	1	2	6
Chordata	Ascidiacea		Didemnidae	*Didemnum lissoclinum*	0	0	0
			Holozoidae	*Sycozoa pulchra*	0	0	1
			Pyuridae	*Herdmania fimbriae*	0	0	1
				Pyura abradata	1	0	2
				Pyura gibbosa	1	4	3
				Pyura praeputialis	1	1	5
			Styelidae	*Botrylloides perspicuus*	2	0	0
				Botrylloides schlosseri	3	5	0
				Polycarpa viridis	4	1	2
				Symplegma brackenhielmi	0	1	0

Appendix III. Output of SIMPER analyses for suction and dredge data across three zones. Only top five contributing species displayed.

Sampling Method	Zone	Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Suction	North	Gammaridae sp.1	1.03	6.13	1.4	22.49	22.49
		Amblypneustes ovum	0.96	3.48	1.03	12.76	35.25
		Calista kingli	0.6	2.36	0.87	8.66	43.91
		Gammaridae sp.2	0.52	2.08	0.63	7.63	51.54
		Hymenosomatidae sp.	0.5	2.01	0.84	7.37	58.91
	Port Stanvac	Gammaridae sp.1	0.74	3.51	0.86	19.18	19.18
		Notogibbula lehmanni	0.52	2.06	0.48	11.26	30.44
		Eulalia sp.	0.38	1.67	0.44	9.14	39.58
		Venerupis galactites	0.33	1.25	0.34	6.83	46.41
		Costaticella solida	0.45	1.05	0.34	5.72	52.12
	South	Gammaridae sp.1	0.55	2.73	0.71	18.77	18.77
		Reteporella sp.	0.36	1.76	0.44	12.14	30.9
		Notogibbula lehmanni	0.35	1.35	0.41	9.26	40.16
		Ophionereis opacum	0.38	1.22	0.37	8.36	48.53
		Ceradocus sp.	0.34	1	0.33	6.9	55.43
Dredge	North	*Costaticella solida*	2.03	3.31	0.56	26.82	26.82
		Thalotia conica	0.71	1.25	0.61	10.09	36.92
		Musculus nanus	0.59	0.83	0.29	6.72	43.64
		Retoporella granulata	1.11	0.68	0.37	5.52	49.16
		Eupolymnia koorangia	0.59	0.54	0.35	4.4	53.56
	Port Stanvac	*Costaticella solida*	0.67	1.24	0.23	12.46	12.46
		Musculus nanus	1.2	1.01	0.42	10.09	22.55
		Gammaridae sp.1	1.84	0.95	0.3	9.54	32.09
		Actinaridae sp.	0.73	0.91	0.32	9.16	41.25
		Philine angasi	0.45	0.5	0.33	4.99	46.25
	South	*Costaticella solida*	2.35	9.88	2.37	38.59	38.59
		Botrylloides schlosseri	2.86	7.85	0.69	30.67	69.26
		Pyura gibbosa	0.93	1.52	0.47	5.93	75.19
		Ophiothrix caespitosa	0.76	1.4	0.5	5.47	80.66
		Callyspongia sp.	0.55	1.4	0.45	5.46	86.12