Benthic macroinvertebrate communities of Lake Simcoe (Ontario, Canada): Investigating an 85 year time-scale

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Lake Simcoe is the largest inland waterbody in southern Ontario and has been the focus of much scientific study over the past 30 years. Increases in phosphorus loading over the past century have impacted algae and aquatic plant biomass, deepwater anoxia, and the sustainability of the coldwater fishery. Management efforts have been made to restore Lake Simcoe to an ecologically sustainable state, but colonization by invasive species, climate change, and the rapid urbanization of the basin continue to complicate management strategies. Benthic macroinvertebrate communities can be used to investigate both historic and present-day ecological change in Lake Simcoe and the first comprehensive benthic survey was carried out by Rawson in 1926. I replicated this study in 2011 by sampling the same sites in a similar time period in order to quantitatively and qualitatively assess change in the benthos of Lake Simcoe. Total invertebrate abundance was 15 times greater in 2011 across all sites, with all major benthic taxa significantly increasing in abundance since 1926 with the exception of Sphaeriidae. Chironomidae was the dominant taxon in 1926 and 2011, representing 51% and 33% of total invertebrate abundance, respectively. Community structure at sites was driven by depth in 2011, with shallow sites dominated by amphipods, isopods, and *Dreissena* being separate from deep sites. Community structure at sites in 1926 was influenced primarily by site density. Major taxonomic changes include the presence of *Dreissena* and absence of *Chaoborus* in 2011, and the complete absence of Hirudinea in 1926. The increases in phosphorus loading since 1926 along with the influence of *Dreissena* is likely shaping the qualitative and quantitative changes observed in 2011. By routinely investigating benthic communities in Lake Simcoe along these sites, long-term research can continue to track historic changes in the benthos and provide a baseline for future monitoring.

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Introduction

Lake Simcoe is the largest (722 km^2) inland waterbody in southern Ontario and has been the focus of much scientific research over the past 30 years (see Palmer et al. 2011). Increases in phosphorus loading over the past century have impacted algae and aquatic plant biomass, deepwater anoxia, and the sustainability of the coldwater fishery (Palmer et al. 2011). Management efforts have been made to restore Lake Simcoe to an ecologically sustainable state (Winter et al. 2011), but colonization by invasive species, climate change, and the rapid urbanization of the basin continue to complicate management strategies. Long-term monitoring and directed research on Lake Simcoe have been important tools in determining the lake's current ecological state, addressing new environmental issues, and evaluating the effectiveness of lake management strategies such as the Lake Simcoe Protection Plan (Palmer et al. 2011). Efforts to detect changes in the ecological status of aquatic ecosystems have included the use of biota as indicators of a variety of environmental conditions (Lake 2001, Eloranta and Soininen 2002, Schaumburg et al. 2004). Many organisms (e.g. diatoms, zooplankton, benthic invertebrates) have well-documented responses to changes in the environment, and have been used to track both historic (e.g. Rodé 2009, Hawryshyn 2010) and present-day ecological change in Lake Simcoe.

The first comprehensive benthic survey of Lake Simcoe was carried out from 1926-1928 in response to declines in commercially important fish species (Rawson 1928). Currently, recreation and sport fishing have replaced commercial activity and generate $200 million annually for the communities within the Lake Simcoe basin (LSEMS 2008). Population decline in cold-water fish such as lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*) and lake herring (*Coregonus artedi*) remains an issue (Evans et al. 1996) and the Lake Simcoe Environmental Management Strategy (LSEMS) was established in the 1980s to investigate and improve water quality and the recruitment of cold-water fishes. Of primary concern was anthropogenic phosphorus (P) loading into the basin and the subsequent unfavourable hypoxic conditions preventing the recruitment of cold-water species (Evans et al. 2011). While monitored closely due to their economic value, fish are not the only organisms affected by phosphorus loading; benthic invertebrates have been shown to be affected by anthropogenic stressors over time (Schindler 1987; Smith et al. 1999; Chandra et al. 2005). The Rawson survey was both spatially and temporally comprehensive of Lake Simcoe, making it a foundational investigation of lake benthos in North America. By re-sampling Rawson's sites during a similar time period, this study is the first to directly evaluate the changes in benthic macroinvertebrate communities in Lake Simcoe over the intervening 85 years.

In 1926, Rawson sampled seven transects (Fig. 1) in June/July and October/November using the closing dredge introduced by Ekman in 1911. With modifications to the dredge by Birge in 1922, benthic

sampling had become more effective, and several studies were conducted throughout North America during this time (Rawson 1930). Rawson's work on Lake Simcoe was the second benthic survey conducted in Canada and remains as the earliest record of quantitative benthic sampling for the lake. The communities in the basin at this time were dependant on the lake for many ecological services including the commercial fishery, ice harvesting, and drinking water. Lake Simcoe has been called "Ontario's first cottage country" due to the rail line that connected the lake to the urbanized Toronto region and the human population in the basin at that time is estimated at 50,000 (Nicholls 1997). Manufacturing activity was prominent; the construction of carriages, carts, and a tannery created an industrial region along Kempenfelt Bay during the 1920s. The commercial fishery was sustained by the introduction of the common carp (C*yprinus carpio*) in the late 1890s that were routinely harvested (104 tonnes annually) from 1923-1925 (Rawson 1928). The investigation of the benthos was done to better understand the relationship between benthic invertebrates and fish populations throughout the year. Donald Rawson completed the initial survey of the lake as his master's thesis project and later expanded the project for the Fisheries Commission Board and the University of Toronto.

Since Rawson's benthic surveys, the human population within the Lake Simcoe basin has increased significantly. Centrally located in Southern Ontario and less than a one hour drive from Toronto (Canada's largest city, population over 2.5 million) it has been home to seasonal cottages and resorts for more than 100 years. Recreational activities on the lake (e.g. fishing, ice-fishing, and boating) have contributed to the basin becoming one of the fastest growing regions in Canada (Palmer et al. 2011).The city of Barrie, at the western end of Kempenfelt Bay in Lake Simcoe, is the fastest growing city in Ontario, and has increased in population by over 62% since 1996 (CBEDS 2009). Rapid urbanization has led to habitat destruction and the installation of impervious surfaces that effectively divert nutrient-rich run-off to surface water instead of being re-absorbed into the groundwater (Carpenter et al. 1998). These non-point sources of nutrients and other pollutants flow directly to Lake Simcoe during heavy precipitation events, snow melt and irrigation. The major point sources of pollution in Lake Simcoe began in the 1930s when sewage treatment plants were constructed along the waterways to prevent hazardous human waste from directly entering surface waters (Evans et al. 1996). In 1984, sewage from Newmarket and Aurora were rerouted to Lake Ontario, leaving 14 facilities discharging effluents containing phosphorus into the basin (LSEMS 1994; LSEMS 2008; Nicholls et al. 1985). Phosphorus loading collectively contributes to eutrophication, a process whereby nutrient additions promote excess phytoplankton and macrophyte growth. Decaying plant material settles to the lake bottom where bacteria break it down, in the process consuming oxygen and potentially reducing hypolimnetic dissolved oxygen (DO) levels. In Lake Simcoe, as in many eastern Canadian lakes, phosphorus is the limiting nutrient

controlling phytoplankton blooms and subsequent changes in dissolved oxygen in the benthos (Evans et al. 1996).

In addition to nutrient loading, urbanization can influence the physical structure of the littoral zone where many benthic invertebrates are found (Christensen et al. 1996, Brauns et al. 2007). Shoreline development reduces the amount of coarse woody debris deposited into the littoral zone, increases the deposition of fine sediments, and contributes to shoreline hardening (Christensen et al. 1996, De Sousa et al. 2008). This reduces the heterogeneity of sediments in the littoral zone, decreasing interstitial refuge for aquatic invertebrates, and increasing their risk of predation (De Sousa et al. 2008). The hardening of shorelines alters the cycling of sediments and nutrients in the nearshore, disturbing the natural erosion and buildup of sediments (Shear et al. 2003). Lake Simcoe has a heavily developed shoreline, with an additional 50 000 inhabitants within the basin during the summer months (LSEMS 2008). The construction of cottages greatly alters the riparian vegetation important for sediment and nutrient retention, and leaf litter for invertebrate shredders (Fennessy and Cronk 1997, Cummins et al. 1989). The littoral and riparian zones of Lake Simcoe have been altered significantly in most regions that underwent extensive development with the urbanization of the basin.

Agricultural land use within the Lake Simcoe basin has also increased extensively: the conversion of forested habitats to agriculture occurred from 1880 to 1940, with little expansion since (Wilson and Ryan 1988). The Holland Marsh is one of the most important agricultural regions in Ontario; construction of canals, dams and dikes in the 1930s allowed settlers to convert wetland into polder agriculture and farm the land intensively (Merriam 1961). Currently the Marsh is one of the major exporters of market vegetables locally and internationally generating $450 million annually (Bartram et al. 2007). The Marsh is located south of Lake Simcoe along the West Holland River, a major tributary draining into Cook's Bay. A second tributary, the East Holland River, drains the urbanized areas of Aurora, Newmarket, and Holland Landing. The East and West Holland rivers transport phosphorus from both urban and agricultural run-off into Cook's Bay and have made it the most eutrophic part of the lake (Winter et al. 2011). Nicholls and MacCrimmon (1974) reported that 90% of the total P runoff from cultivated plots from Holland Marsh flowing into the Holland River is in the soluble reactive (or biologically available) form.

In the 1990s, LSEMS targeted a reduction in lake-wide TP levels in order to limit increased macrophyte growth and improve DO levels for fish recruitment (Winter et al. 2011). Both agricultural and urban sources were reduced and since the 1980s the TP loading to the lake has been reduced from 100 tons/year to approximately 72 tons/year (Winter et al. 2007). Although late summer hypolimnetic DO

concentrations have not met the historic 7mg/L level, also thought to be ideal for cold water fish recruitment (Davis 1975, Rodé 2009), improvements to water quality have been made and continue to be monitored through LSEMS and the Lake Simcoe Protection Plan.

In addition to nutrient loading, species introductions, largely through human activities (Mills et al. 1993), have played an important role in North American waters, including Lake Simcoe. The Great Lakes have had numerous invaders from the Ponto-Caspian Region arriving in ballast water from trans-oceanic shipping, resulting in serious ecological and economic damage (Ricciardi and MacIssac 2000). Although not one of the Laurentian Great Lakes, more than 15 species of aquatic plants, invertebrates and fish have been introduced to Lake Simcoe over the past 100 years (LSPP 2009). Thought to be introduced intentionally or accidently as bait releases, attached to boats, or aquarium escapes, some of the most well-known introduced species in Lake Simcoe include spiny water flea (*Bythotrephes longimannus)*, rusty crayfish (*Orconectes rusticus)*, common carp (C*yprinus carpio*) and the round goby (*Neogobious melanostomus*). In 1993, zebra mussels (*Dreissena polymorpha*), the most notorious aquatic invader of North American waters, were first reported in Lake Simcoe and by 1995 had expanded their range throughout most of the lake (Evans et al. 2011). Dreissenid mussels have been successful invaders due to high fecundity and a planktonic larval (veliger) stage that facilitates quick dispersal within an ecosystem (Griffiths et al. 1991). Surface waves and currents in lakes are sufficient to transport veligers, resulting in rapid expansion both downstream and within the main basin of a lake (Johnson and Carlton 1996). Zebra mussels are epifaunal, colonizing hard substrates with byssal threads that permit suspension feeding in areas unavailable to native infaunal mussels (Mackie 1991). In addition to outcompeting native bivalves for space and food, dreissenids are thought to influence numerous abiotic components including nutrient cycling, water clarity and habitat structure in aquatic ecosystems (MacIsaac 1996, Hecky et al. 2004).

A model proposed by Hecky et al. (2004), describes dreissenids as the driving force for changes in nutrient and energy cycling in the nearshore. Nutrients from the water column filtered by dreissenid mussels are excreted or deposited in particulate form, i.e. feces and pseudofeces. Colonization of hard or soft sediments by zebra mussels usually leads to increase invertebrate abundance and richness (Beekey et al. 2004, Botts et al. 1996, Ricciardi et al. 1997). The changes in surface area and complexity of substrate made by the zebra mussel shells facilitate the colonization of benthic algae that require hard surfaces for anchorage (Heckey et al. 2004). Macrophyte growth also has the potential to increase in the presence of dreissenids, as high clearance rates improve water clarity and permit light penetration to previously aphotic areas (MacIsaac 1996). Along with reduction in P loading to the lake (Ginn 2011), mussel filtering probably explains the increased Secchi depth throughout the lake from a mean 3.8 m in 1980-1995 before zebra mussel invasion to a mean of 7.2 m since 1995 after widespread establishment. The

long-term effects of zebra mussels on the ecology of Lake Simcoe remain unclear, and will likely continue to change with new aquatic invaders.

Lakes have been described as sentinels for climate change due in part to their sensitivity and responsiveness to climatic variation and the profound response by certain aquatic organisms to these changes (Adrian et al. 2009, Fischer et al. 2011). Trends of increasing air temperature have been predicted to influence the strength and timing of thermal stratification along with the number of ice-free days (Williamson et al. 2009). The length of the stratified period in the main basin of Lake Simcoe has increased 33 days during the period of 1980-2008 and is strongly correlated with the increase in average air temperature (Stainsby et al. 2011). Changes in the thermal regimes of lakes are thought to decouple predator-prey interactions that are dependent on temperature-mediated primary production (Winder and Schindler 2004, Daufrense et al. 2009). Increasing air temperatures have been shown to shift the occurrence of phytoplankton blooms earlier in the year; however zooplankton that are less temperature sensitive lag in reproduction and the exploitation of peak food abundance is missed (Winder and Schindler 2004). The increase in strength of thermal stratification associated with warming air temperatures has implications for dissolved oxygen levels temporally and spatially in lakes (Ficke et al. 2007). In lakes that experience seasonal mixing, such as Kempenfelt Bay on Lake Simcoe, turnover events are vital for the return of nutrients to the epilimnion and oxygen to the hypolimnion. Variability in oxygen concentrations can influence habitat tolerance of coldwater species. Delay in turnover events prolongs hypolimnetic hypoxia (Ficke et al. 2007) an issue that will further complicate the recruitment and survival of coldwater species in Lake Simcoe.

Change in community structure of benthic macroinvertebrates has been well documented for lakes similar to Lake Simcoe and with many of the same anthropogenic stressors. During the first half of the twentieth century, burrowing mayflies, *Hexagenia*, were abundant throughout the western end of Lake Erie, but anoxic conditions associated with eutrophication resulted in declines in their abundance and distribution in the 1950s (Shelford and Boesel 1942; Krieger et al. 1996). In 1993, after nutrient reductions to the lake, populations of burrowing mayflies were discovered colonizing some nearshore areas, and by 1995, large swarms were observed over the lake indicating widespread recolonization (Krieger et al. 1996). A dramatic increase in the number of benthic macroinvertebrate taxa in the Cleveland Harbour area of Lake Erie over an 11 year study suggested reductions in nutrient and sediment loading improved habitat quality (Krieger and Ross 1993). Zebra mussels became widespread in Lake Erie by 1989, resulting in declines in the abundance of native clams (*Pisidium* spp.) and the deepwater amphipod *Diporeia hoyi* in the eastern portion of the lake (Dermott and Kerec 1997). Similar post-*Dreissena* declines in *Diporeia* have been reported from Lake Huron (McNickle et al. 2006). Another

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aquatic invader, the round goby, was found to impose regulatory effect on quagga mussel (*Dreissena rostriformis bugensis*) populations in eastern Lake Erie, selectively feeding on intermediate size class of mussels (Barton et al. 2005). The change in benthic community structure in lakes similar to Lake Simcoe provides insight to the impact of similar anthropogenic stressors presently or in the future.

Recent studies of the benthos of Lake Simcoe include a short term study by Stantec Ltd. carried out in 2005 that reported 138 benthic macroinvertebrate taxa. Interesting findings of the study include the occurrence of an introduced amphipod, *Echinogammarus ischnus*, and the presence of numerous sensitive groups such as beetles, mayflies and caddisflies in the nearshore (Stantec 2006). The Stantec study determined water depth was the primary driver of benthic community composition with total organic carbon content of sediments as the second most important factor. Similarly, Kilgour et al. (2008) found a relationship between community composition and total Kjeldahl nitrogen (TKN) of sediments in some areas of the sublittoral zone. Sediments with high concentrations of TKN had higher relative abundances of worms, amphipods, and snails that are thought to be more tolerant of excessive nutrients (Kilgour et al. 2008). Community structure of benthic organisms in the rocky littoral zone in Lake Simcoe has also been shown to be influenced by the presence of dreissenid mussels. A low β- diversity value, suggesting a homogeneous community, was thought to be due to the increase and even distribution of food and physical changes to habitat throughout the littoral benthos caused by dreissenid colonization (Ozersky et al. 2011a). Jimenez et al. (2011) investigated changes in the community structure of the benthos from 1983-2008 at many depths in Lake Simcoe. Major findings include an increase in the abundance of isopods, amphipods, and gastropods from 1983-2008, but overall a decrease in total abundance of invertebrates following the dreissenid invasion (Jimenez et al. 2011). This is in contrast to many other studies that found increases in overall abundance of benthic invertebrates after dreissenid invasion (e.g. Stewart and Haynes 1994; Dermott and Kerec 1997).

In light of the limited number of studies investigating the long-term changes in benthic macroinvertebrate communities across many sites throughout the year in Lake Simcoe, replication of the Rawson survey in 2011 will be the first study at this time scale conducted in the lake. By qualitatively and quantitatively assessing change in the benthos over 85 years, the results from this study add insight to the impact of anthropogenic stressors and invasive species in Lake Simcoe, strengthening the baseline for future monitoring of the benthos.

Methods

Study Site

Lake Simcoe is a relatively shallow (average depth = 14.2 m), mesotrophic lake located 50 km north of Toronto along the Trent-Severn Waterway that connects Lake Ontario to Georgian Bay on Lake Huron. With a surface area of 722 km^2, Lake Simcoe is the largest inland lake in southern Ontario and has six major tributaries: Holland River, Beaver River, Talbot River, Pefferlaw Brook and Black River (MOE 2010). The lake is typically divided into three main regions: Cook's Bay (Z_{max}= 15 m), Kempenfelt Bay (Z_{max} = 42 m), and the main basin (Z_{max} = 33 m) (Table 1). Lake Simcoe's basin is primarily underlain by sedimentary bedrock and the catchment contains a number of physiographical areas including the Oak Ridges Moraine, a glacial landform unique to southern Ontario (Sharpe et al. 2004), as well as alvars, wetlands, and tall grass prairies. Agriculture makes up 47% of land cover in the basin and forest cover (40% land cover) is predominantly deciduous forest, wetland, and treed swamp (MOE 2010). The largest environmental pressure is likely from rapidly increasing urban development (currently 12% of land cover).

Sampling

Sampling for benthic macroinvertebrates occurred in Lake Simcoe in May/June and October/November 1926 and 2011 at 50 sites located in Kempenfelt Bay, Cook's Bay, and the southern portion of the main basin (Table 2, Fig. 2). Site co-ordinates were determined using descriptions from Rawson's 1928 and 1930 publications (Table 3) unpublished field notes, and hydrographic charts (CHS Chart 2028). Each site was sampled in triplicate with a Petite Ponar grab (0.0231m^2 sampling area) and rinsed with water using a Wildco 500 μm stainless steel mesh bucket. Depth was measured at each site using a Hondex digital depth sounder and substrate type was categorized from inspection of each grab sample. Rinsed samples were stored in jars and preserved with 10% buffered formalin. In the laboratory, formalin was rinsed out of the samples with distilled water using 250 μm mesh and sorting took place under a dissecting microscope at 12x magnification. Subsampling occurred when samples contained large amounts of organic material and would take more than 3 hours to sort. Subsampling was done by randomly selecting ¼ of the original sample and storing the remainder for future reference. All macroinvertebrates were identified to the lowest practical taxonomic level and stored in vials with 70% ethanol (Appendix 1).

In 1926 Rawson sampled with the Ekman dredge and used a series of bolting cloths and netting to sieve benthic grabs. A single grab was taken from each site and all macroinvertebrates were enumerated and identified to the class or family level. A subset of invertebrates sampled were identified to species.

Data Analysis

Raw counts from Rawson (1928) and the current study were converted into areal abundances (#/m^2) for comparison. The level of taxonomy from Rawson (1928) was family, class, or genus level and in order to compare to 2011 data, taxonomy had to be resolved. This was done by grouping taxa to the same level as 1926 data, and did require removing rare taxa from 2011 that did not appear in 1926.

To investigate patterns in community composition, PRIMER 6 statistical software was used for the non-metric multi-dimensional scaling analysis (NMDS) on data from 1926 and 2011. A Bray-Curtis similarity matrix was used for analysis on sites and taxa and all abundance data was square-root transformed to downweight the contributions of abundant taxa. Each NMDS analysis was run with 50 restarts and all stress values were ≤0.20. Ordinations were initially run with all samples to identify outliers. Outliers were removed to facilitate interpretation, but only if it resulted in an improvement in either the stress value, or the visual representation of sites in ordination. Student's paired t-test was used to compare abundances of taxa at sites between years.

Results

2011 Study

Benthic samples collected in 2011 yielded 134 invertebrate taxa (Table 4) including 41 Chironomidae, 13 Hirudinea, and 11 Gastropoda. The number of taxa decreased with depth (R^2=0.4, p<0.05, Fig. 3) but at least 10 taxa were found at every site. Chironomidae were present at all sites and were the most abundant benthic organism (33% of all invertebrates collected) with the most abundant being early instar Chironominae (4.8%), *Chironomus salinarius* (3.7%), *Dicrotendipes* sp. (3.4%), and *Paratanytarsus* sp. (3.1%). Oligochaeta made up 15% of the total invertebrate abundance with the most abundant taxa being immature Tubificidae (7.8%) and *Aulodrilus pluriseta* (2.7%). Isopoda represented 15% of the total invertebrate abundance with *Lirceus lineatus* being the single most abundant taxon identified during sampling (11.8%). The majority of *Dreissena* (13% of all invertebrates collected) were represented by *D. polymorpha* (8.9%) with a small percentage being *D. bugensis* (1.1%) and the remaining being too small (<2mm) to identify to species. *Hyaella azteca* and *Gammarus fasciatus* were the fifth and sixth most abundant taxa identified with 6.91% and 4.8% of the total invertebrate abundance, respectively. Gastropoda contributed only 3.5% of the total invertebrate abundance with *Amnicola limosa* (0.71%) and *Valvata tricarinata* (0.37%) being the most abundant taxa. Other abundant taxa include *Hydra* spp. (0.69%), Sphaeriidae (0.60%) and *Caenis* sp. (0.55%).

Three non-native species, *Echinogammarus ischnus*, *D. bugensis* and *D. polymorpha* were recognized, and data from recent studies (Kilgour et al. 2008, B.Ginn, LSRCA, pers. comm.) were used to evaluate how well established these species were in Lake Simcoe in 2011. The amphipod *Echinogammarus ischnus* was found at two sites in Cook's Bay in 2011 and in 2006, *E. ischnus* was reported at many sites around the lake except for Cook's Bay. In 2005, no *D. bugensis* were identified and 68% of *Dresissena* were *D. bugensis* at the same sites in 2012. *Dreissena* densities declined sharply between 2005 and 2008 at depths <10 m but may be increasing in deeper water (Fig. 4).The apparent recent changes in densities of *Dreissena* may be somewhat site-specific. For example, comparison of counts from the sites sampled in both 2009 and 2011 showed that *Dreissena* density was greater at 4 of 7 transects in 2011, but overall density decreased by 18.6% (Fig. 5).

Benthic community structure was investigated at 50 sites using NMDS. Despite the collection of samples in either spring or fall of 2011 (Table 2), no seasonal effects were observed during any of the analyses. Initial ordination using the lowest taxonomic resolution revealed two clear outliers (Fig. 6): Site I-2 had much lower than average abundances of both *Dreissena* and Chironomidae, and site I-3 had relatively few *Dreisenna* but large numbers of the otherwise rare *Cladotanytarsus*. These sites were deleted and subsequent ordination generally grouped sites by transect, primarily along the vertical axis

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(Fig. 7c). Sites falling to the left of the axis were in deep water, while those on the right (Fig. 7c) had shallow depths. To confirm the depth related patterns, all sites were categorized into depth zones using a frequency distribution graph to isolate appropriate bin sizes (Fig. 8). The deepest sites (>28m) group closely together on the left of the axis while the shallow sites (<5.9m) are somewhat variable but generally plot on the right of the axis in NMDS ordination (Fig. 9c).

Sites at transect V (Fig. 9c) yielded high densities of the amphipod *Hyalella azteca* and formed a tight cluster with the exception of V-1, V-4 which had much lower densities of *Dreissena* compared to other sites along the same transect. Transect III plots into two distinct groups due to shallow sites with large densities of animals being separate from the sites with intermediate depths and moderate animal density. Transect II shows separation from all other transects due to the high abundance of naidid worms and *Micropsectra*, as well as low *Dreissena* densities at some sites.   Transect I is divided along the horizontal axis, all sites had similar density but with different contributions by Oligochaeta, Chironomidae, and *Dreissena*. Site I-1, low on the axis, was dominated by immature Tubificidae while site I-6 high on the axis, was dominated by Chironomidae and *Dreissena*, and had few Oligochaeta.

The majority of sites in this study were characterized by muddy bottoms, but sites with sand and combination sand/shell plot in two separate groups, one representing deep sandy sites and the other are shallow sandy sites (Fig 10).

1926 vs. 2011

Mean Secchi disk depth in 1926-28 was 6.5 m but was less than 5 m during 1985 to 1994. Water clarity is generally greater in recent years, often surpassing the historic values (Fig 11). All sites sampled in 1926 were resampled (within 5 calendar days) during 2011 with the exception of one site that was eliminated from the analysis due to high density macrophytes that prevented boat access (Table 2). Rawson (1928) identified approximately 80 taxa including 20 Gastropoda, 14 Bivalvia, 12 Hydracarina, and 8 Chironomidae but only 13 broader taxa were reported quantitatively: Sphaeriidae, Bivalvia, Gastropoda, Chironomidae, Oligochaeta, Isopoda, *Chaoborus*, Amphipoda, Ostrocoda, Nematoda, Ephemeridae, Trichoptera, and Hydracarina. Hirudinea were absent from dredging records in 1926 but were present at 44% of sites in 2011. *Chaoborus* was collected at 36% of sites in 1926 but was not found during 2011. The species represented by the taxon Bivalvia in 1926 were from the family Unionidae (e.g. *Lampsilis siliquoidea* and *Pyganodon grandis*). No living Unionidae were collected in 2011, but one empty small shell was found. "Bivalvia" are represented exclusively by *Dreissena* spp. in 2011 as Sphaeriidae were categorized by Rawson as its own taxonomic group.

Chironomidae were the most abundant taxon collected in 1926, occurring at all sites and making up 51% of the total fauna. Amphipoda accounted for 15% of individuals, but were present at less than 15% of the sites. Both Gastropoda and Sphaeriidae were moderately abundant and contributed 8% and 7% respectively to total invertebrate abundance. Comparing total invertebrate abundance between years, 2011 was significantly higher, by a factor of 15 (Fig. 12), especially in shallow water. All major taxa (found at >10% of sites) were significantly less abundant in 1926 than in 2011 (Fig. 12), except for Sphaeriidae (p=0.38). Bivalvia, Amphipoda and Isopoda were found only at depths >10 m in 1926 but were collected at all depths in 2011.

One site (I-5) yielded no animals in 1926, so was excluded from subsequent analyses. Using the 13 taxon resolution used in 1926, outliers (I-1, IV-3, IV-4, and V-1) were removed from subsequent analyses for the 2011 sites (Fig. 13). These outliers had either lower than average abundances of chironomids or high abundances of Ostrocoda and Oligochaeta. NMDS ordination of sites from 1926 and 2011 show a distinct separation between years (Fig. 14), but patterns among sites were less obvious in 1926. The horizontal axis in Figure 7a appeared to reflect the density of the fauna, with sites low on the axis having larger numbers of invertebrates, especially Amphipoda, Isopoda and Chironomidae. Sites from transect V that plot below the axis are due to the high densities of Amphipoda, Gastropoda, Bivalvia, Chironomidae, Hydracarina, and Isopoda in the lake in 1926. Several sites from transect 7 also plot low on the axis and this is primarily due to high abundances of Oligochaeta and *Chaoborus* (Table 5). In the plot of the 1926 data, depth generally increased from upper left to lower right, but the shallowest sites were scattered throughout (Fig. 9a). The majority of sites in 1926 were categorized as mud and no distinct substrate related patterns were observed in ordination (Fig. 15). Ordination of taxa in 1926 isolated Nematoda and Ostracoda from all others (Fig. 16a). Using the same 13 taxa grouping with 2011 sites, the vertical axis again reflects depth, with shallow sites on the left (high densities of Amphipoda, Isopoda and *Dreissena*) (Fig. 9b). Three sites from transect 3 plot the furthest to the left due to the highest densities of animals lake wide (Fig. 7b), and deep sites on the right of the axis yielded relatively few organisms. In 2011, Sphaeriidae were separate from all other taxa while *Dreissena* were closely associated with Chironomidae and Oligochaeta in 2011 (Fig. 16b).

Discussion

The most striking change in the benthic community of Lake Simcoe from 1926 to 2011 was the 15x increase in total invertebrate abundance. There were significant increases in all major benthic taxa except Sphaeriidae, and some substantial shifts in the qualitative composition of the fauna. A number of factors may have contributed to these changes, most of which are the direct result of human activity within the basin.

Over the 85 years between these surveys, the Lake Simcoe basin has been subjected to phosphorus (P) loading and a number of other anthropogenic stressors. The human population has increased 8x since 1926 and the estimated pre-settlement (~1796) P loading rate was 32 tonnes/year (Nicholls 1997). Beginning in the 1800s, accelerated erosional P deposition began from the construction of roads, deforestation and agricultural activity (Johnson and Nicholls 1989). By 1926, the estimated total P load was approximately 70 tonnes/year, and a very small portion (approx. 2 tons/year) was from point sources (Johnson and Nicholls 1989). Increases in point source pollution and atmospheric deposition, particularly in 1980-1990s, contributed to total P loads >100 tonnes/year (Winter et al. 2007). Through the work of abatement programs, such as LSEMS and LSPP, the lake has experienced load reductions and currently has a P loading rate of approximately 72 tonnes/year (LSRCA, MOE 2009). Changes in algal and macrophytic production, water transparency as well as coldwater fish recruitment reflect P loading in the basin (Palmer et al. 2011). Although current P loading rates are comparable to 1926, there has functionally been a shift in the P cycling in the lake in recent years driven by *Dreissena*. Redirection of offshore production to the nearshore and benthos through filter feeding and deposition of waste (Hecky et al. 2004) has resulted in improved water transparency that is similar to historic levels (Fig 11). This has resulted in an increase in benthic primary production to substantial depths and an increase in the diversity and abundance of animals found there.

Chironomidae are the dominant macroinvertebrate taxa in many aquatic ecosystems (Pinder 1986), and seven species were identified in 1926 in Lake Simcoe. *Chironomus plumosus*, a species regarded as tolerant to pollution (Saether 1979), made up 54% of the community by weight. Rawson noted that although Kempenfelt Bay was thought be polluted by the organic waste from a tannery, the abundance of *C. plumosus* was not elevated in this region (Rawson 1928). All chironomid species that were described in 1926 except *C. plumosus*, were identified among the 41species in 2011. The dramatic increase in the number of species was partly due to major taxonomic changes including the description of new species and narrower definitions of some genera. In addition, the growing human population within the basin and P loading to the basin likely influenced the increased number of species in the lake. The majority of chironomids from 2011 belong to the subfamily Chironominae and are tolerant of a wide

range of pH, oxygen concentrations, and substrates (Pinder 1986). Many Chironomiinae have been shown to be tolerant of organic pollution and changes in species composition can reflect changes in trophic state (Merilainen et al. 2000). Genera such as *Dicrotendipes* and *Micropsectra* were only identified in 2011 and are associated with eutrophic and oligotrophic conditions, respectively (Saether 1979). Although it is impossible to reconcile all of Rawson's identifications in terms of current taxonomy, the absence of several genera in 1926 that were abundant in 2011 suggests significant changes in the species composition. An increase in human activity in the basin over time has resulted in transient lake trophic states favouring chironomids tolerant of a changing system. Long term P-loading along with substrate modification due to *Dreissena* shells have altered the benthos and the communities found there.

In contrast to the Chironomidae, the number of species of Gastropoda was likely overestimated in 1926. With 19 species reported in 1926 and only 14 in 2011, changes in taxonomy contributed to the lower number of species identified. The snail community in Lake Simcoe was also likely influenced by the *Dreissena* invasion. It has been shown that large-bodied gastropod species decline in response to *Dreissena* invasions possibly due to feeding difficulty on the structurally complex mussel aggregations (Ricciardi et al. 1997). It was noted that the majority of gastropods from 2011 were small (<5mm in width) and all specimens >10mm in width were dead. There was little overlap in the species present in 1926 and 2011, though taxonomic issues make comparisons difficult. Gastropod species and shell size should continue to be monitored in Lake Simcoe to track the potential effects of *Dreissena* on the snail community.

There have also been major changes in the species composition of the bivalve communities in Lake Simcoe. Live unionid mussels have not been reported in Lake Simcoe in recent years and were likely extirpated following the *Dreissena* invasion in the early 1990s. A number of unionid species were reported at the mouth of the Black River in 1926, but only a single dead unionid shell (likely *Elliptio complanata*) from Kempenfelt Bay was recovered during 2011. The extreme decline in populations or extirpation of unionid mussels following *Dreissena* invasion has been reported from many aquatic systems (Ricciardi et al. 1998). Competition for plankton and colonization of unionid shells by *Dreissena* may prevent the recovery of unionid mussels in Lake Simcoe.

The absence of Hirudinea in 1926 is surprising as leeches were collected at 44% of sites in 2011. Rawson noted that a few leeches were scraped from rocks in the nearshore during 1926, but no specimens were recovered during dredging or present in the stomach contents of fish from later surveys (Rawson 1930). The large gastropod community in Lake Simcoe in 1926 would have been ideal food for a number of leech species, but only two were reported (Rawson 1928). In contrast, 13 species, mostly from the

family Glossiphonidae, were collected in 2011. One of the most common, *Glossiphonia complanata*, has been shown to have reduced feeding success on soft substrates due to inhibited locomotion, so tends to be restricted to rocky or macrophytic substrates (Brönmark 1992). The abundance of *Dreissena* shell material and macrophytes in 2011 would enhance the amount of suitable habitat and expand the distribution of leeches offshore. Consistent with the current study, results from western Lake Erie showed an increase in density of leeches after the establishment of *Dreissena* (Stewart et al. 1998). Another taxon completely absent from 1926 was Tricladida, which was found at 28% of sites in 2011. With a diet consisting of gastropods and to a lesser extent, worms, amphipods, and isopods (Boddington and Mettrick 1974), the flat worm's predatory behaviour may be enhanced by the restructuring of soft sediments by *Dreissena* (Ward and Ricciardi 2007).

Phantom midge larvae (*Chaoborus*) made up 3.4% of total invertebrate abundance in 1926, but were not collected during 2011. Recent benthic surveys during similar sampling dates in the Lake Simcoe basin have reported *Chaoborus* at two sites in the west Holland River (B.K. Ginn pers. comm.). In later studies of Lake Simcoe, Rawson noted the lifecycle of *Chaoborus,* and the peak in adult emergence was in late July (Rawson 1930). Shifts in the timing of emergence of other benthic species have been linked to increasing water temperatures in experimental manipulations and observations in stream ecosystems (Harper and Peckarsky 2006, Hogg and Williams 1996). The changing thermal regime in Lake Simcoe could have influenced densities of *Chaoborus* during 2011 sampling. Some species of Chaoboridae feed in the water column during the night and hide in the benthos during the day (Merritt and Cummins 1996), so it is also possible that *Chaoborus* was particularly vulnerable to predation by benthic fish such as the recently (2006) introduced round goby (*Neogobius melanostomus)*.

The role of substrate in structuring species composition is evident between years as seen in Ephemeroptera. In 1926, 55% of mayflies were from the family Ephemeridae, known for their burrowing behaviour and preference for softer substrates (Merritt and Cummins 1996). In 2011, 93% of mayflies were *Caenis*, which are sprawlers or climbers and live on surface sediments, detritus, or macrophytes (Merritt and Cummins 1996). Only a small fraction (0.55%) of total benthic invertebrates were represented by Ephemeroptera in 2011, which is a decrease from the 2.8% in 1926 (Table 4). The alteration of substrates by *Dreissena* may be causing the shift to epifaunal species of mayfly, such as *Caenis*, and the rarity of burrowing species in Lake Simcoe in 2011.

There have been a number of qualitative changes observed in the benthos of Lake Simcoe and many are a result of the anthropogenic stressors structuring the physical and biological conditions in the lake. Urban and agricultural land use has rapidly increased in the basin, and invasive species continue to

complicate biological interactions in the benthos. While the shifts in fauna are important ecologically, so too are the large scale changes in the quantity of animals in the benthos. The observed increases in animal density are likely caused by the same anthropogenic stressors influencing the species composition in Lake Simcoe.

Chironomidae was the most abundant taxon in 1926, but did not reach the densities, especially in the nearshore, that occurred in 2011 (Fig 12). Long-term P loading in the basin is likely to have influenced densities; it has been shown that increases in abundance of chironomids reflect P levels during experimental manipulations (Blumenshine et al. 1997). Chironomidae have also been shown to increase in abundance in the presence of *Dreissena* (Botts et al. 1996, Ricciardi et al. 1997). The response of macroinvertebrates to *Dreissena* invasions has been documented many times, but with mixed results from both lake surveys and experimental manipulations (Ward and Ricciardi 2007). In most cases, macroinvertebrate density increases in the presence of *Dreissena* (Stewart and Haynes 1994, Stewart et al.1996, Botts et al. 1996). It has been shown experimentally that some taxa respond to the deposition of organic material from *Dreissena* colonies in the form of faeces and pseudofaeces (Botts et al. 1996) which are used as food by chironomids and a number of other taxa including Oligochaeta (Stewart et al. 1998).Worms were the second most abundant group of invertebrates in 2011, but ranked fifth in 1926. The highest density of Oligochaeta in 1926 was in Kempenfelt Bay where industrial pollution, particularly organic waste from a tannery, was thought to have created a polluted region in the lake. Some oligochaete species, much like chironomids, are known to be tolerant and thrive in areas high in organic waste, e.g., *Limnodrilus hoffmeisteri* and *Tubifex tubifex* (Chapman et al. 1982). Oligochaeta abundance was significantly higher in the nearshore in 2011, dominated by tubificid worms such as *L. hoffmeisteri*, but oligochaete densities were similar in 1926 and 2011 at the deepest sites. The abundance of *Dreissena* declined with increasing depth, suggesting a strong linkage between oligochaetes and mussels.

The association between Chironomidae, Oligochaeta, and *Dreissena* in taxonomic ordination (Fig 16b) further supported a positive relationship among these taxa in Lake Simcoe, likely driven by the deposition of organic materials by *Dreissena.* In the nearshore, these taxa were higher in abundance in 2011, coinciding with the preferred depth of *Dreissena*. Abundances of chironomids and worms at the deepest sites were more similar between years, suggesting that offshore conditions have changed less over time. In 1926, taxonomic ordination did not reveal any explicit relationships between Oligochaeta and Chironomidae (Fig 16a) and the abundances of these taxa were quite similar at all depths. The species composition, magnitude of change, and distribution in the abundance of Chironomidae and Oligochaeta reflects the long-term P loading in the lake and influence of *Dreissena* in the nearshore.

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Another effect of *Dreissena* mussels is the physical alteration of the benthic environment through accumulation of shell material creating interstitial spaces favoured by isopods and amphipods (Botts et al. 1996). Thus it was somewhat surprising that in 2011, isopod densities were greatest along transects 3 and 4 located in Cook's Bay (Table 5). These areas had only moderate densities of mussels, most likely because mussel colonization is inhibited by the muddy substrate (Mellina and Rasmussen 1994). Cook's Bay is the most eutrophic region in the lake as it is fed by the East and West Holland rivers that cut through the polder agricultural region of the Holland Marsh (West Holland) as well as the urban regions of Newmarket and Aurora (East Holland). Cook's Bay also has the highest macrophyte biomass in Lake Simcoe (Ginn 2011) which even prevented boat access to one site in 2011 that had been sampled in 1926. Dominant macrophytes include *Ceratophyllum demersum*, *Myriophyllum spicatum*, and *Vallisneria americana* (Ginn 2011). This is a substantial change from 1926 when Rawson reported only a fringe of emergent macrophytes in very shallow water. Transect 5, south of Georgina Island, also crossed a shallow area with moderate macrophyte densities (mostly *Chara*), but the substrate is sand/shell, there is no tributary stream input and samples yielded very few isopods. Isopods have been reported to be the most abundant species in a coastal wetland of Lake Michigan, with densities near the mouth of a very eutrophic stream where oxygen and nutrients are replenished (Mackenzie et al. 2004). The end of Cook's Bay is similarly characterized by an aquatic wetland fed by a major tributary which is not present at any other region sampled in 2011. Isopoda are very abundant in the most organically-enriched portions of the Laurel Creek system in the City of Waterloo (D.R. Barton, pers. comm.). The abundance of Isopoda in Cook's Bay therefore seems more likely to reflect the organic loading and unique macrophyte communities rather than the physical influence of mussel shells.

While both Georgina Island and Cook's Bay had higher than average densities, the amphipods along Georgina Island were represented almost exclusively by *Hyalella azteca* in 2011. This transect (average depth 2.4m) is sheltered from wind by the island, Duclos Point to the east, and by sand bars to the west, creating a small wave-protected bay. It has been noted that *H. azteca* has some preference for habitats sheltered from wave action (Barton and Hynes 1978) and this may explain the regional hotspot of this taxon along the transect. In Cook's Bay, *Gammarus fasciatus* was the dominant species, and studies have shown significant increases in *G. fasciatus* following mussel invasions (Ricciardi et al. 1997, Stewart and Haynes 1994). Isotopic analysis from Lake Erie found that *G. fasciatus* and *H. azteca* had similar carbon signatures suggesting they consumed similar food resources (Limén et al. 2005). The spatial difference in these two species is difficult to understand and further studies on habitat preference may be important in predicting their distribution within Lake Simcoe.

In 1926, Isopoda and Amphipoda were limited to a few shallow sites near Georgina Island (transect 5) where amphipod density was the highest lake wide (Table 5). Only two species of amphipod were identified, *G. limnaeus* and *H. azteca*, and this transect had an excess of shell material, mostly gastropod, 1 – 2.5 inches deep, and dense *Chara* growth (Rawson 1928). No other sites in the lake recorded an abundance of *Chara* in 1926 (Rawson 1928)*,* and the protection provided by the bay, shell material and *Chara* growth may be favourable habitat for amphipods. In 1926, isopods and amphipods were limited to <10m, which is in contrast to 2011 data where they were present at all depths.

One of the major transformations in Lake Simcoe occurred in Cook's Bay. In 1926, the bay had not yet been subjected to the high nutrient flux caused by agricultural activity in the basin. The Holland Marsh, which is drained by the West Holland River and flows into Cook's Bay, was dyked and intensive agricultural activity started in the 1930s (Merriam 1961). Dominated by Sphaeriidae and Gastropoda, Rawson (1928) described the bay as having a soft muddy substrate with an indefinite marshy shoreline with beds of reeds and lily pads just along the shore (Rawson 1928). The bay has since become a submerged macrophyte dominated region fuelled by P inputs which, over time, have shifted the dominant taxa and the abundance of life supported in this area. While Cook's Bay is currently regarded as one the most nutrient-rich regions in the lake, in 1926 the focus was on organic pollution from a tannery in Kempenfelt Bay.

Some taxa have not increased in abundance over the 85 years, including native bivalves, which have to compete with the high filtration rates generated by large dreissenid mussel colonies (Mackie 1991). Sphaeriidae have been reported to decline after *Dreissena* invasions (Dermott and Kerec 1997, Lauer and McComish 2001), and was the only major taxon that did not significantly increase in abundance since 1926. It should be noted that Rawson reported it difficult to isolate "minute sphaeriids" while sieving and counting samples, so their abundance may have been underestimated. In 2011 species ordination (Fig. 16b), Sphaeriidae plotted furthest away from *Dreissena* suggesting competitive interactions between these taxa. The invasive round goby has been shown to prefer *Dreissena* mussels over sphaeriid clams (Ghedotti et al. 1995), though some preference for sphaeriids has been observed at deeper parts of Lake Huron (Schaeffer et al. 2005). Although statistically significant, the increase in abundance of gastropods may not continue in the future. Only large differences at the shallowest depths in the abundance of gastropods were observed when comparing to 1926 (Fig. 12). Studies have shown initial increases in the abundance of gastropods post-*Dreissena* invasion (Stewart and Haynes 1994) but over time, some species dropped to below pre-invasion densities (Haynes et al. 1999). Continuing to monitor the benthos will be important in determining the relationship between *Dreissena* densities and the gastropod community.

A recent study by Ozersky et al. (2011b) investigated the littoral zone of Lake Simcoe pre and post *Dreissena*, and found a 45x increase in nondreissenid invertebrate abundance 14 years after invasion. Consistent with the current study, a significant increase in chironomids, oligochaetes, amphipods, and isopods in the nearshore after *Dreissena* was reported (Ozersky et al. 2011b). Total invertebrate abundance was not inflated in the nearshore in 1926 and displayed a more homogenous distribution with increasing depth (Fig 12). The increased production in the nearshore following *Dreissena* invasion is evident on both short and long time scales. Another survey of Lake Simcoe found a decrease in total invertebrate abundance following *Dreissena* invasion, from 1983 to 2008 at depths >10m, mainly due to fewer ostracods, oligochaetes, and nematodes in 2008 (Jiminez et al. 2011). Inconsistencies in sorting of minute taxa such as ostracods and nematodes may contribute to variations in abundance over time, and by not sampling shallower water much of the invertebrate community is overlooked in Lake Simcoe. In addition, the survey did not include any sites from Cook's Bay, where total animal densities were the highest during 2011 (Table 5).

When considering the large scale increase in benthic invertebrate abundance in Lake Simcoe since 1926, a number of methodological differences should be considered. While replication of the initial survey was intended, improvements in sampling in order to accurately depict the current community may have influenced the observed changes. The Ekman dredge used in 1926 is less efficient on hard substrates than the Petite Ponar Grab used in 2011. It should be noted, however, that studies have shown the Ponar and Ekman to have similar sampling proficiency for chironomids and oligochaetes on the same substrate type (Flannagan 1970; Howmiller 1971). Dredged samples were rinsed through a series of cloths and netting in 1926, and it is likely that organisms got stuck on the material and overlooked. By using standardized 500µm rinsing mesh in 2011, consistent sorting to a known size was possible. In addition, the lack of magnification and live sorting of invertebrates in 1926 may have caused underestimations of the more minute species and early instars. While the combined effect of these methodological differences cannot account for the 15x increase in total invertebrate abundance, it should be considered as a source of error when comparing the benthic communities over time.

The fish community of Lake Simcoe can also influence benthic invertebrate structure and abundance over time. While concerns with declining fish populations were prominent in 1926, it was due to overfishing from commercial activity on the lake and the influence of the newly introduced (1896) carp, *Cyprinus carpio* (Rawson 1930). In 1911, it was reported that 209 tonnes of carp was taken from Lake Simcoe and in the nearshore they were likely destroying spawning habitat and feeding success of the smallmouth bass (*Micropterus dolomieu*). The coldwater fish species were considered to have stable populations, but warm and cool water species (*Sander vitreus*, *M. dolomieu*) were being stocked annually

(Rawson 1930). It is plausible that fish were more abundant in 1926, even with the commercial and recreational harvesting activity. In the 1960s – 1980s, coldwater fish species failed to recruit naturally and egg rearing and stocking have been important in maintaining populations (Evans et al.1996). Estimated winter fish catch has decreased while angling effort continues to increase during ice fishing on Lake Simcoe (Robillard et al. 2013).

Conclusions and Recommendations

The changes in abundance of benthic animals in Lake Simcoe since 1926 certainly reflect the anthropogenic stressors in the basin. The nearshore fauna is significantly more abundant than in 1926 due to the increase in benthic production from P loading and influence of invasive species. Aquatic invaders, primarily *Dreissena*, have competitively excluded some species (i.e. unionid bivalves) while facilitating others. While some other aquatic invaders, including *N. melanostromus*, were not considered, their role in structuring the benthos through predation should be integrated during analysis across multiple trophic levels. Rawson's approach of complementing the benthic survey with gut content analysis from major fish species is valuable and should be considered in future research in Lake Simcoe. The fish communities in Lake Simcoe not only impact the benthos, but are subject to the many of the same stressors as benthic invertebrates. Benthic invertebrates play an important role in the diets of most juvenile fish and a number of recreationally important species in the lake. Focus on the loss of coldwater fish habitat should be paired with investigations of warmwater fishes that persist in the littoral zones where the most change has occurred in the benthos over time.

By comparing contemporary benthic data with the Rawson survey completed 85 years ago, major changes have been quantified and long-term research can continue to add to the understanding of the benthos and stressors influencing it. By identifying invertebrates to the lowest practical level in 2011, data were able to be analyzed with more defined patterns and a baseline for future quantitative monitoring of rare species is now accessible.
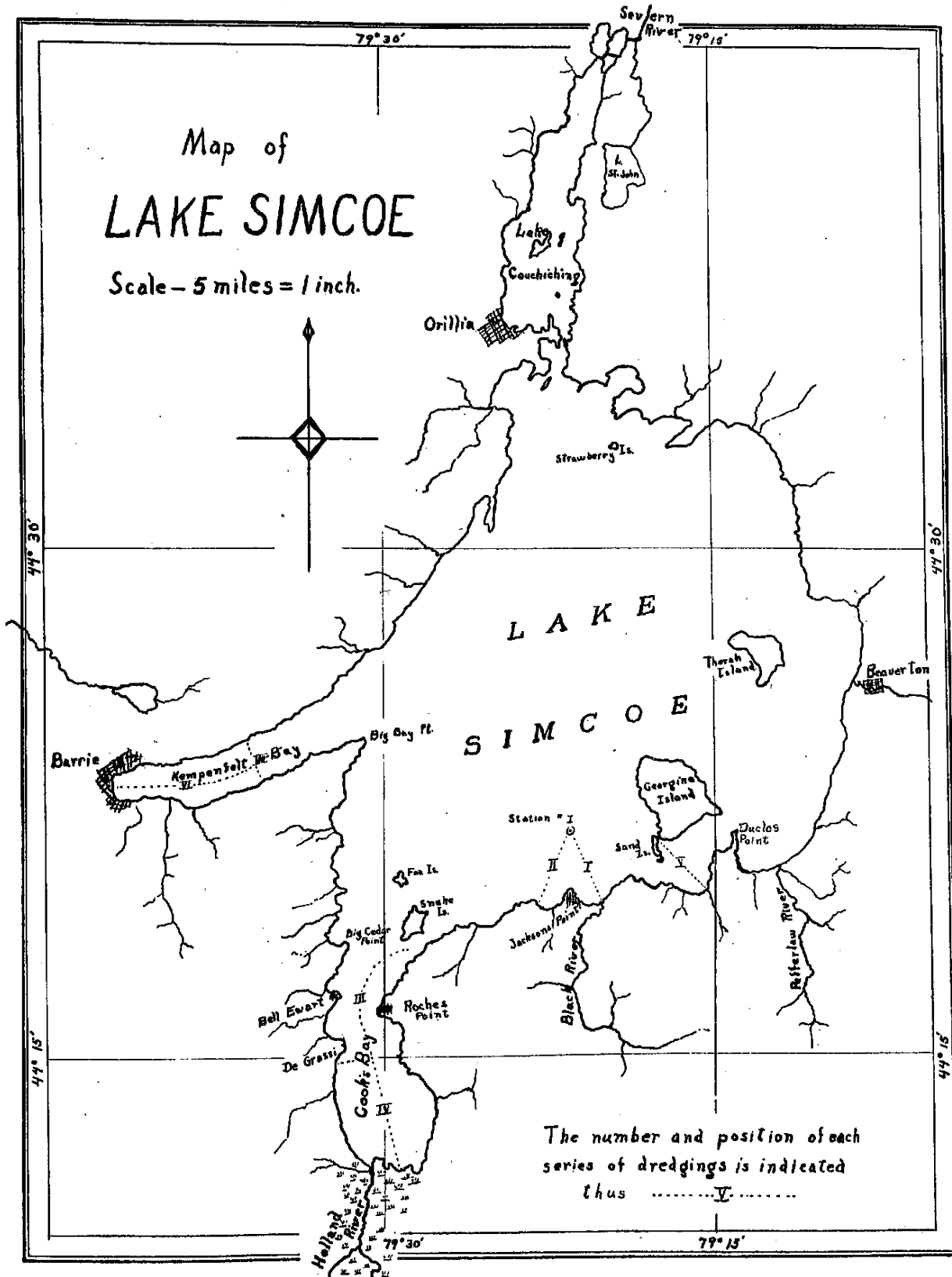
Figure 1. Original map drawn by Rawson of sites sampled in 1926.
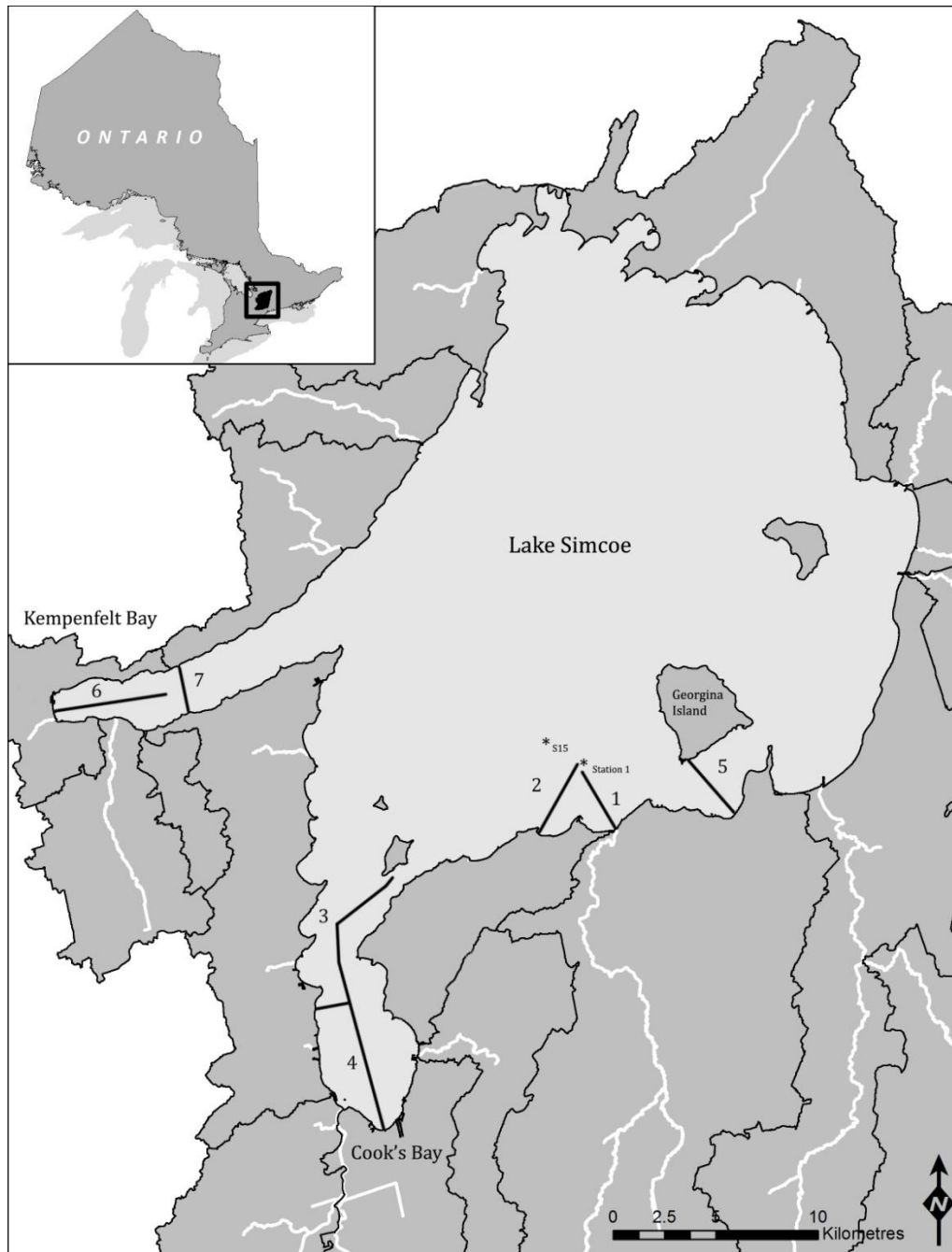
Figure 2. Map of Lake Simcoe with black lines indicating transects sampled in 1926 and 2011. Transects 1-4 were sampled in the month of July and the remaining transects in October/November. Secchi disk depth measurements were taken at Stations 1 (1926-1928) and S15 (1985- onward).
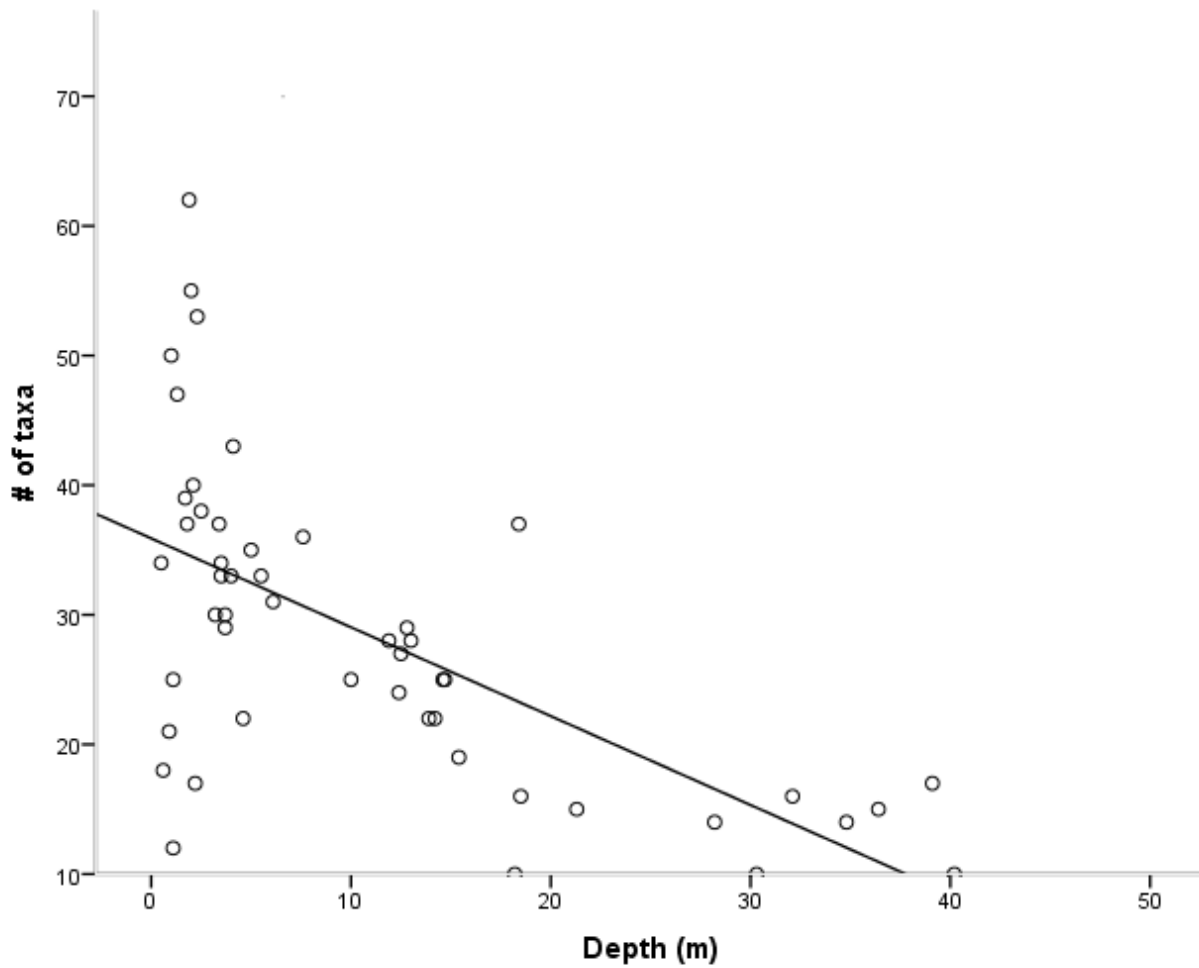
Figure 3.Taxa richness (lowest taxonomic resolution) from 2011 plotted against site depth. Richness was defined as the number of different taxa present at each site. $r^2= 0.4$ and $p<0.05$.
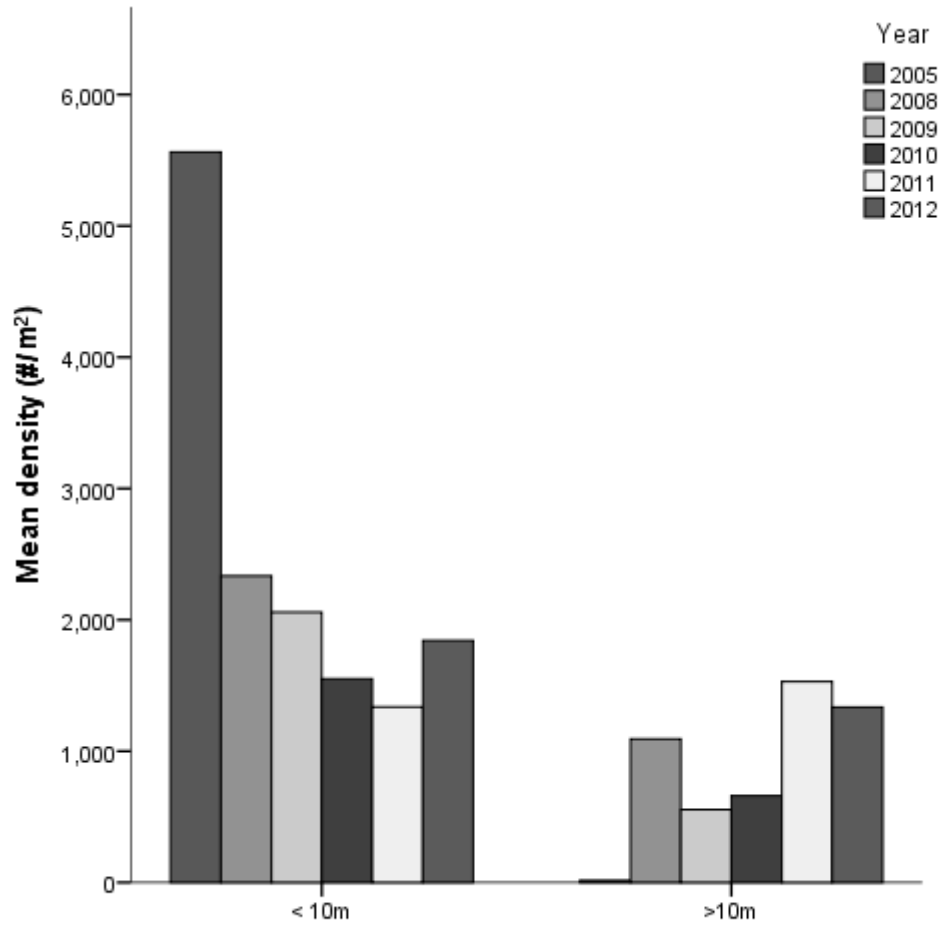
Figure 4. Mean *Dreissena* mussel density at lake zones in years: 2005, 2008-2012. (Data from Kilgour et al. 2008; B. Ginn, LSRCA, pers. comm.)
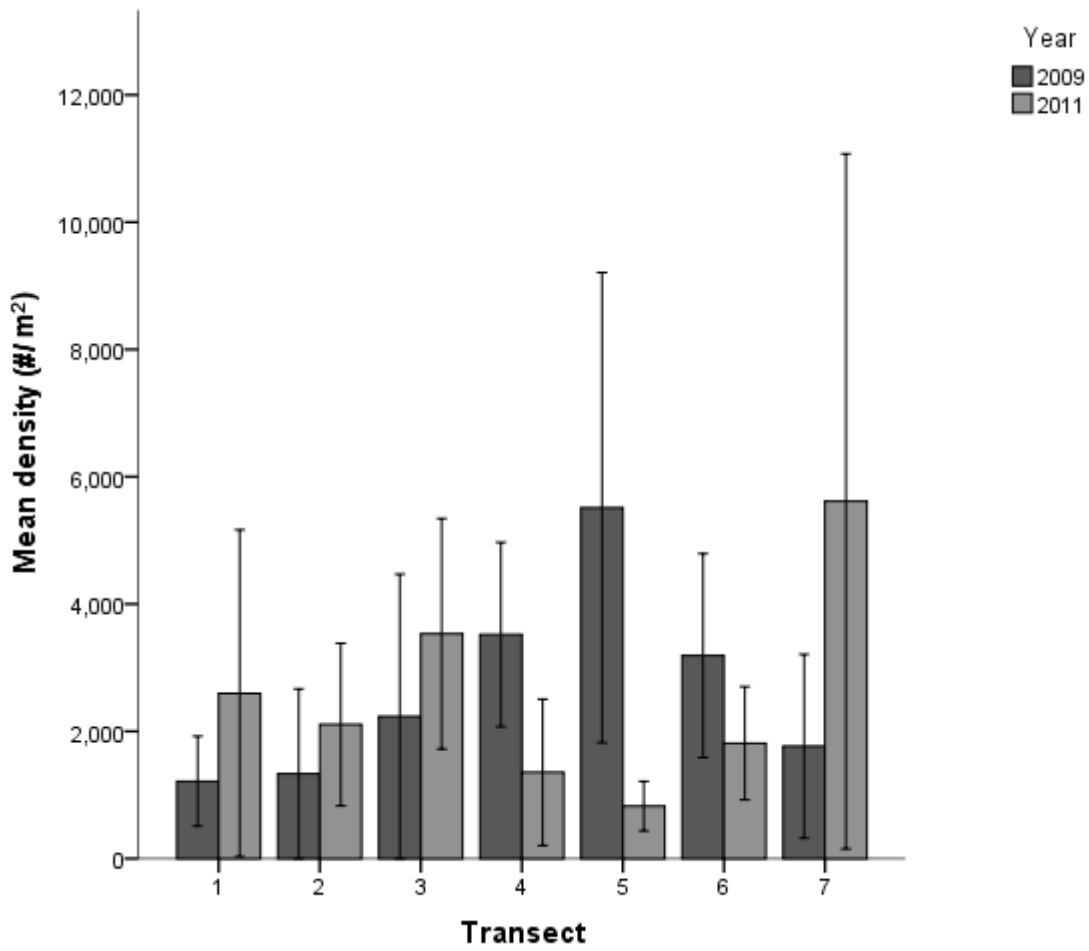
Figure 5.Mean density (#/m^2±1standard error) of *Dreissena* at transects from 2011 and comparable sites with similar depths (±3m) from 2009 (LSRCA).
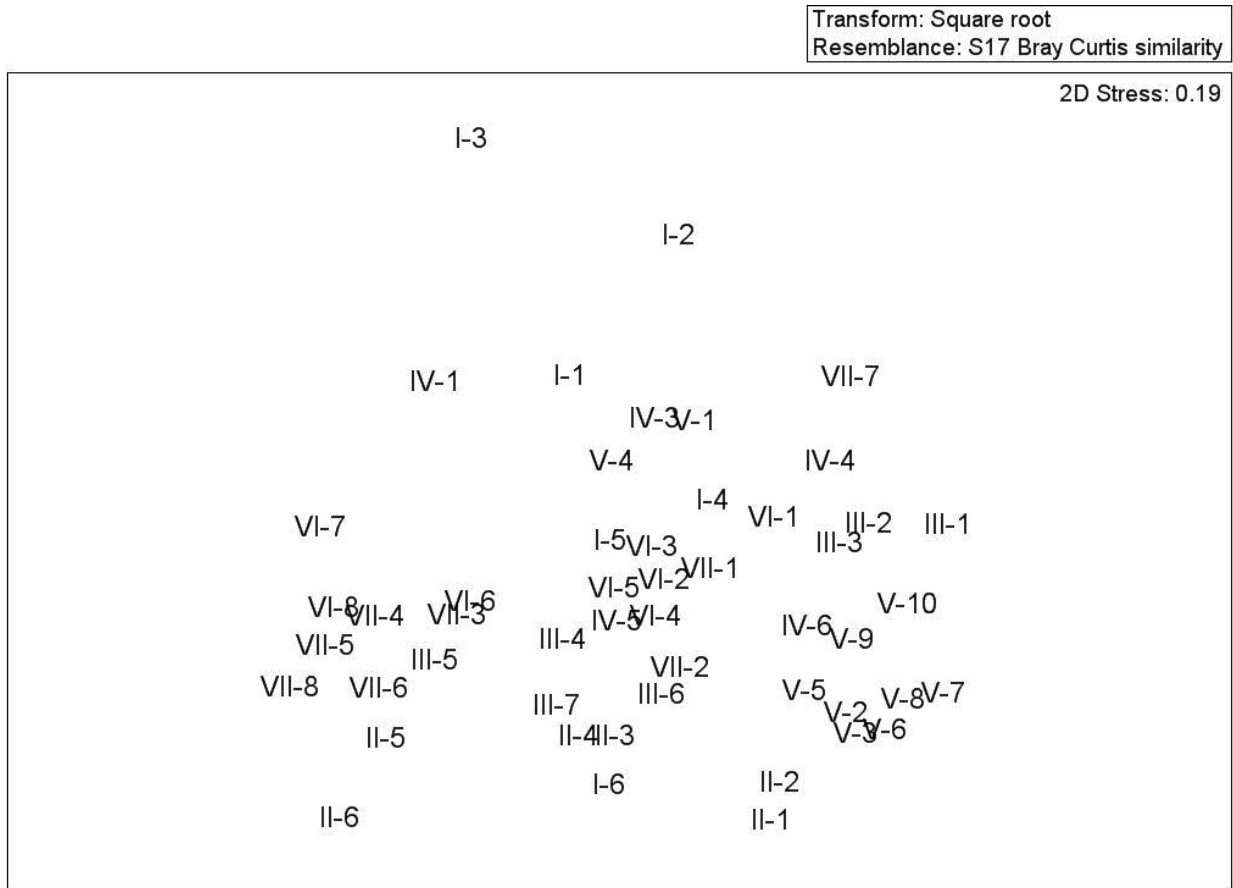
Figure 6. Non-metric multi-dimensional scaling of sites from 2011 using the lowest taxonomic resolution to isolate outliers. Removal of sites I-2, I-3 did not improve the stress value.
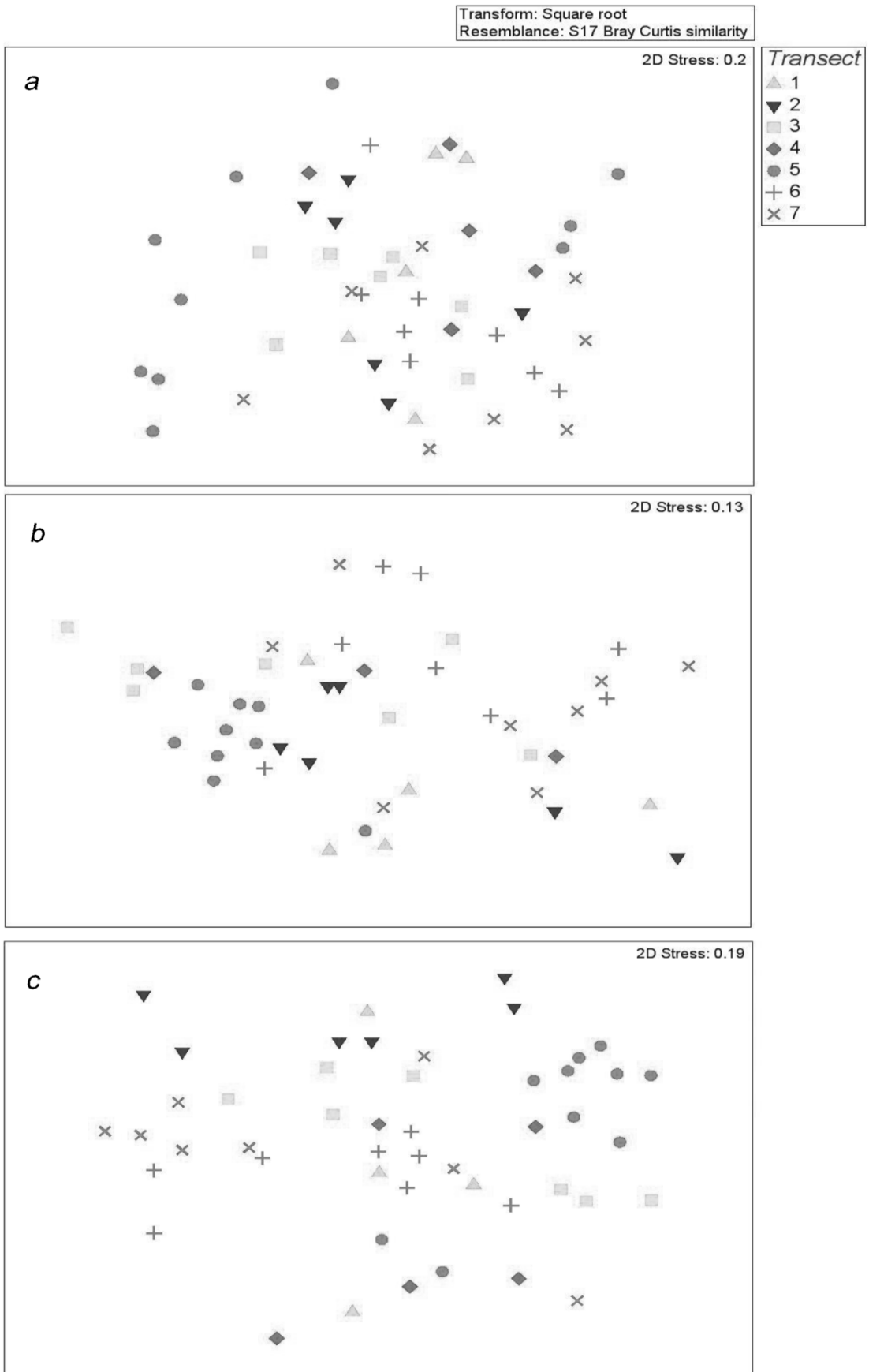
Figure 7. Non-metric multi-dimensional scaling of sites showing transects in a) 1926 b) 2011 (13 taxa grouping) c) 2011 (lowest taxonomic resolution).
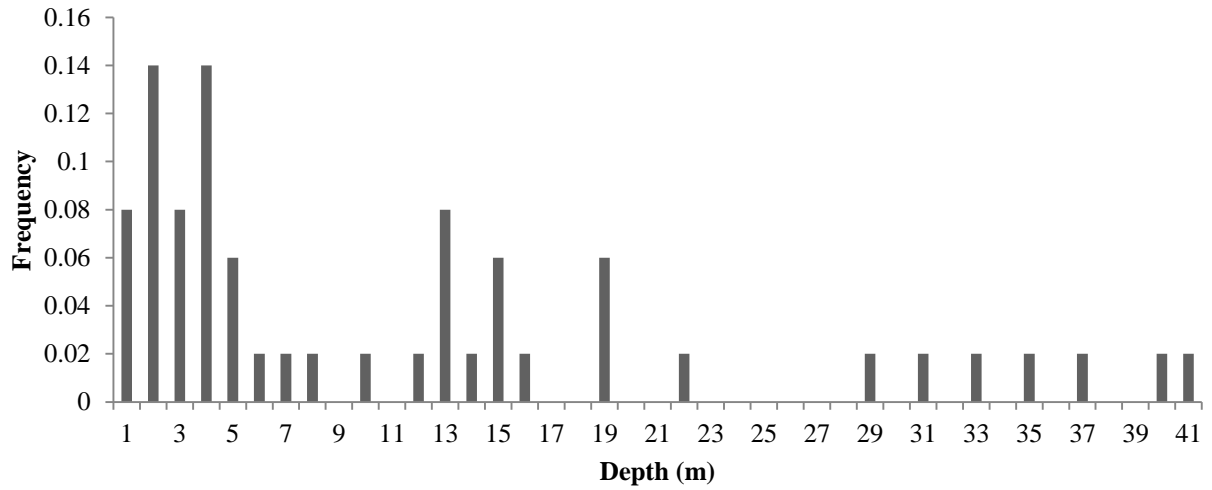
Figure 8.Frequency distribution of 2011 sample sites at each depth. Depth zones were determined to be 0-2.9m, 3- 5.9m, 6-9.9m, 10-16m, 18-22m and >28m.
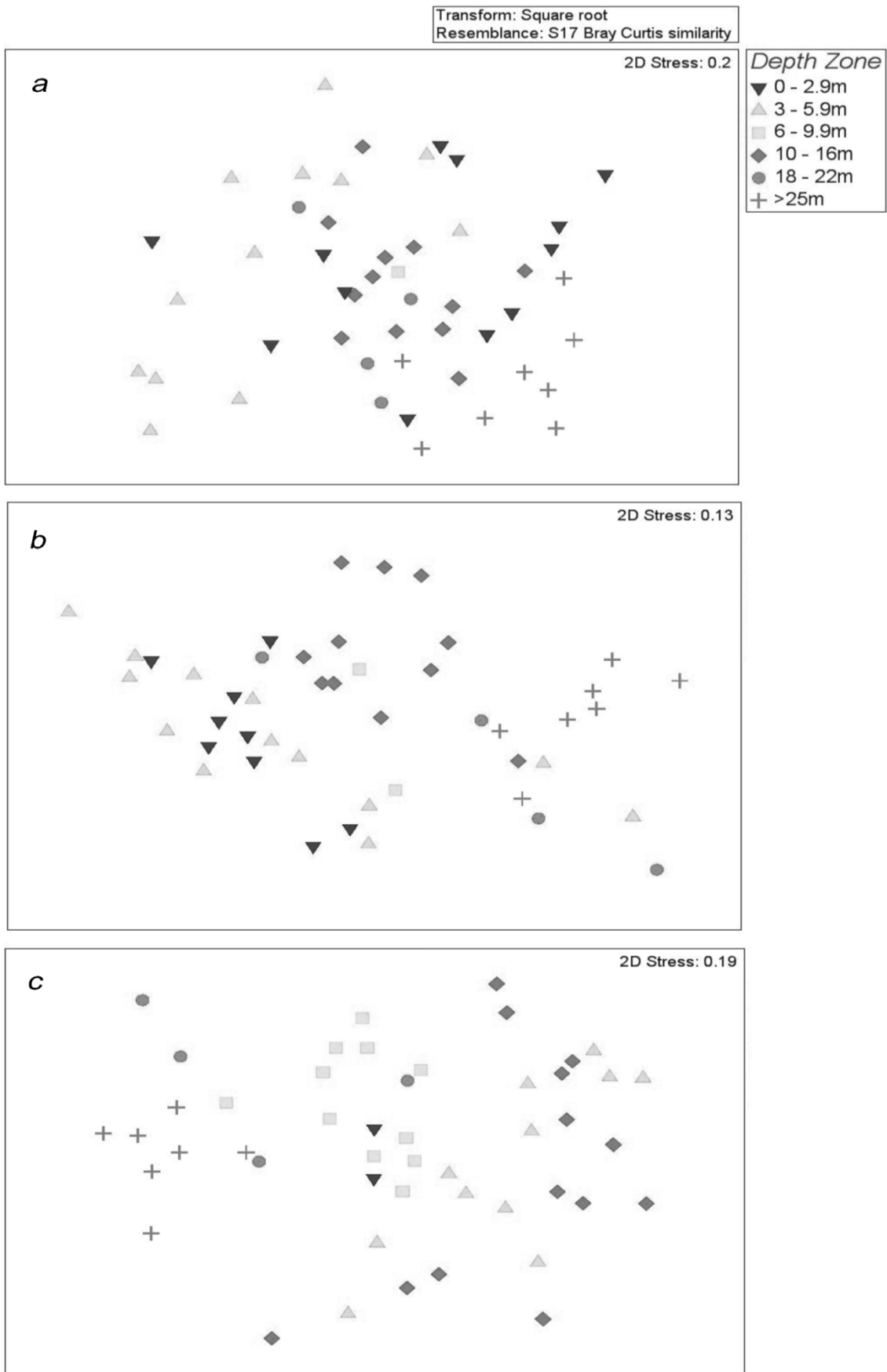
Figure 9. Non-metric multi-dimensional scaling of sites showing depth zones in a) 1926 b) 2011 (13 taxa grouping) c) 2011 (lowest taxonomic resolution).
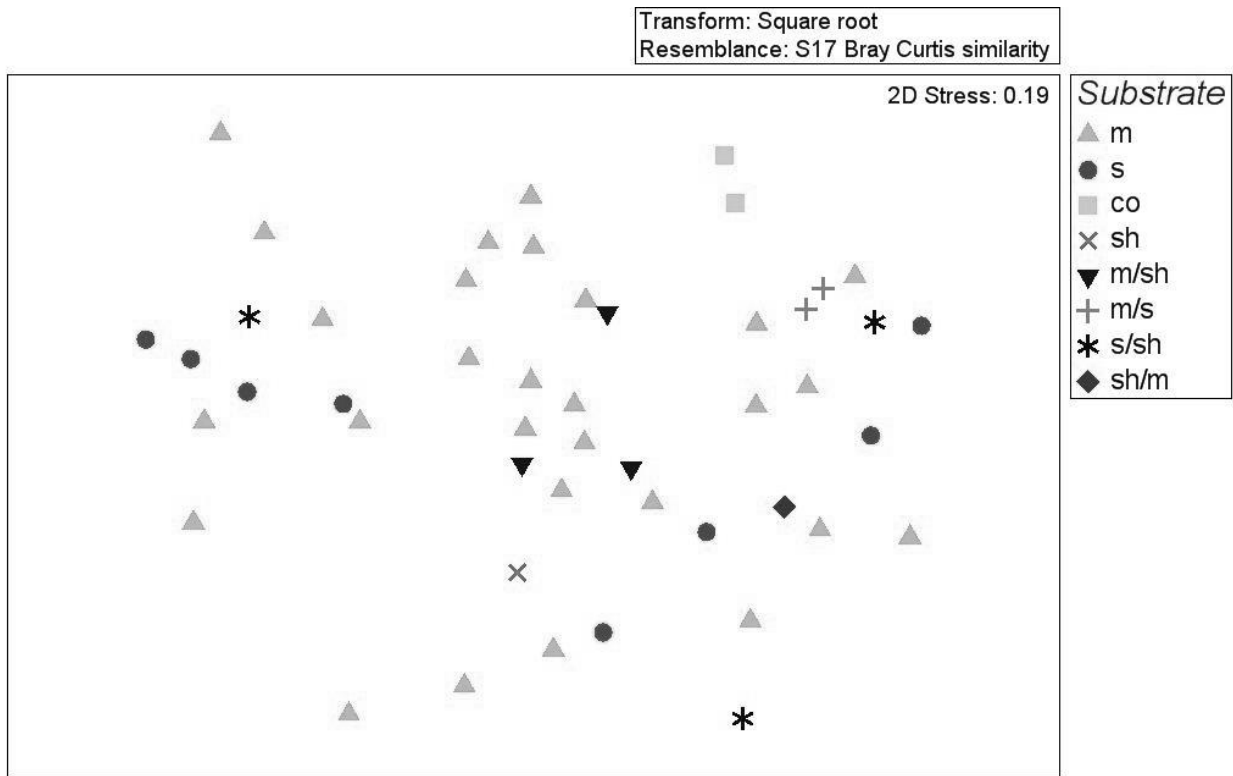
Figure 10. Non-metric multi-dimensional scaling showing sites by substrate type in 2011. Substrate codes: **m**ud, **s**and, **co**bble, **sh**ell.
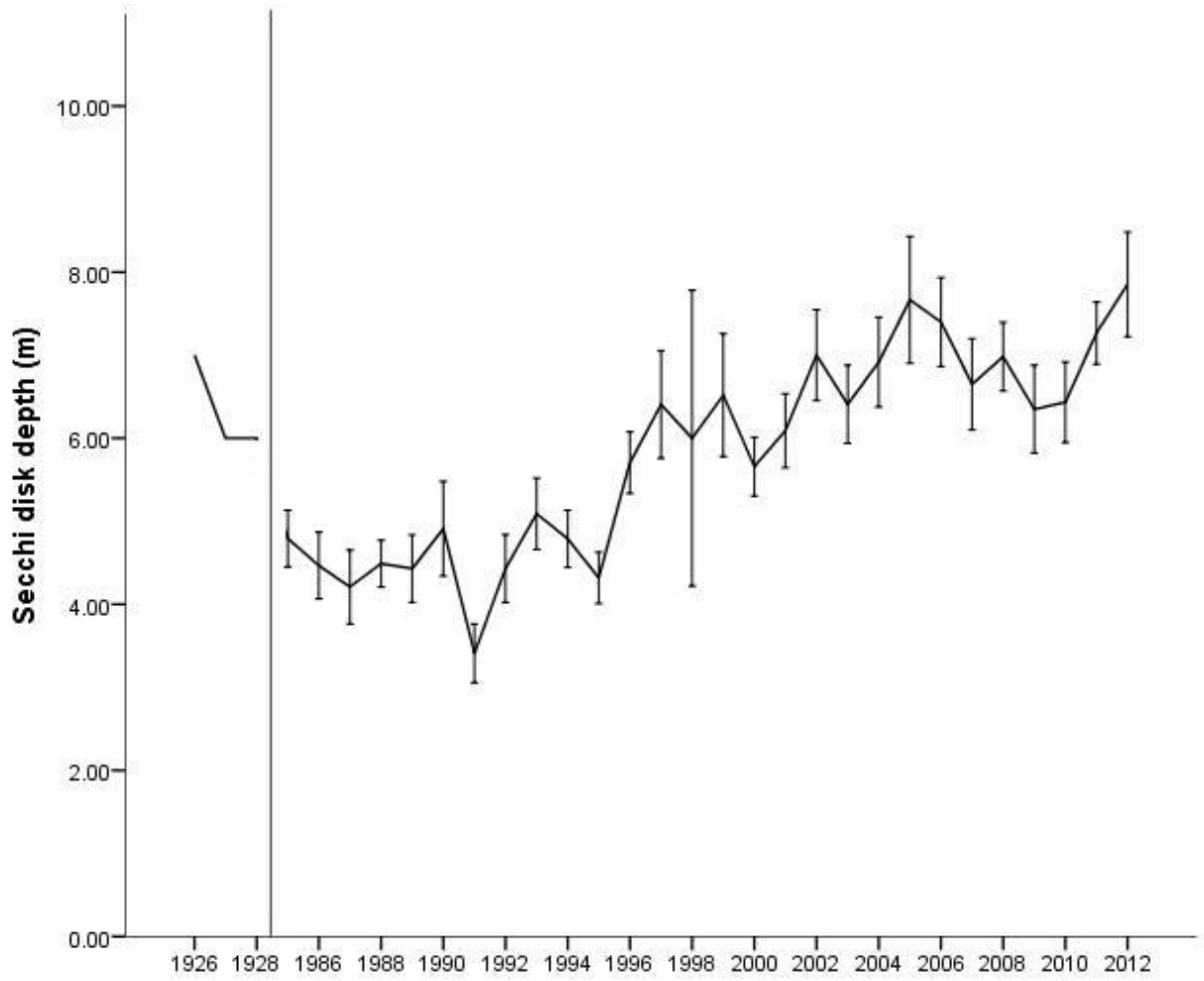
Figure 11. Mean Secchi disk depth from sampling station 1 (1926-1928) and S15 (1985-2012). The vertical line represents a gap in historical data. Error bars are ±1 standard error.

Figure 12. Abundance (#/m^2) of major benthological taxa from 1926 and 2011 sampling over categorical depth zones. Error bars are ±1 standard error. Connecting lines have been added strictly for emphasis (next page).
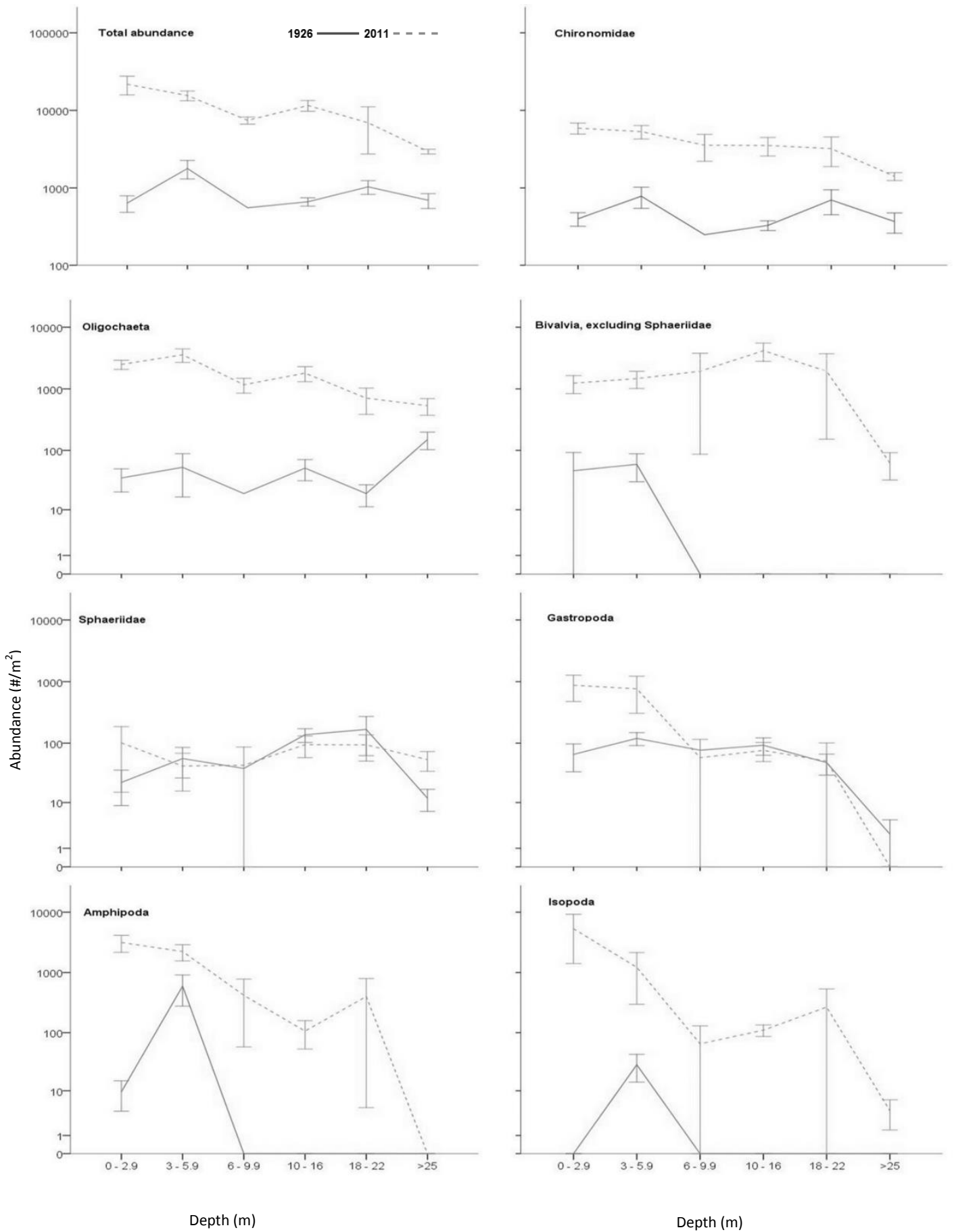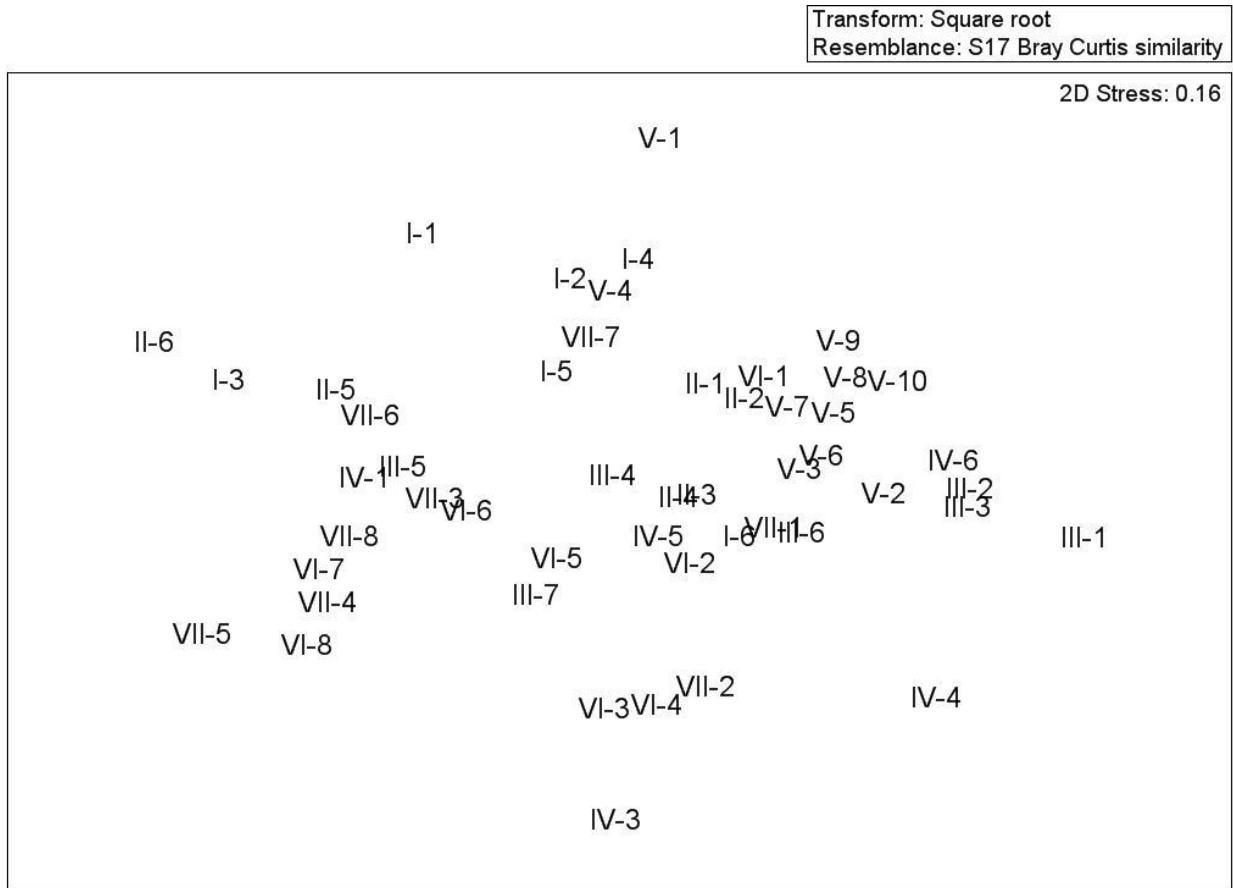
Figure 13. Non-metric multi-dimensional scaling of sites in 2011 using the 13 taxa grouping showing four outliers. Sites I-1, IV-4, and V-1 had below average densities of chironomids and site IV-3 had above average densities of Ostracoda.
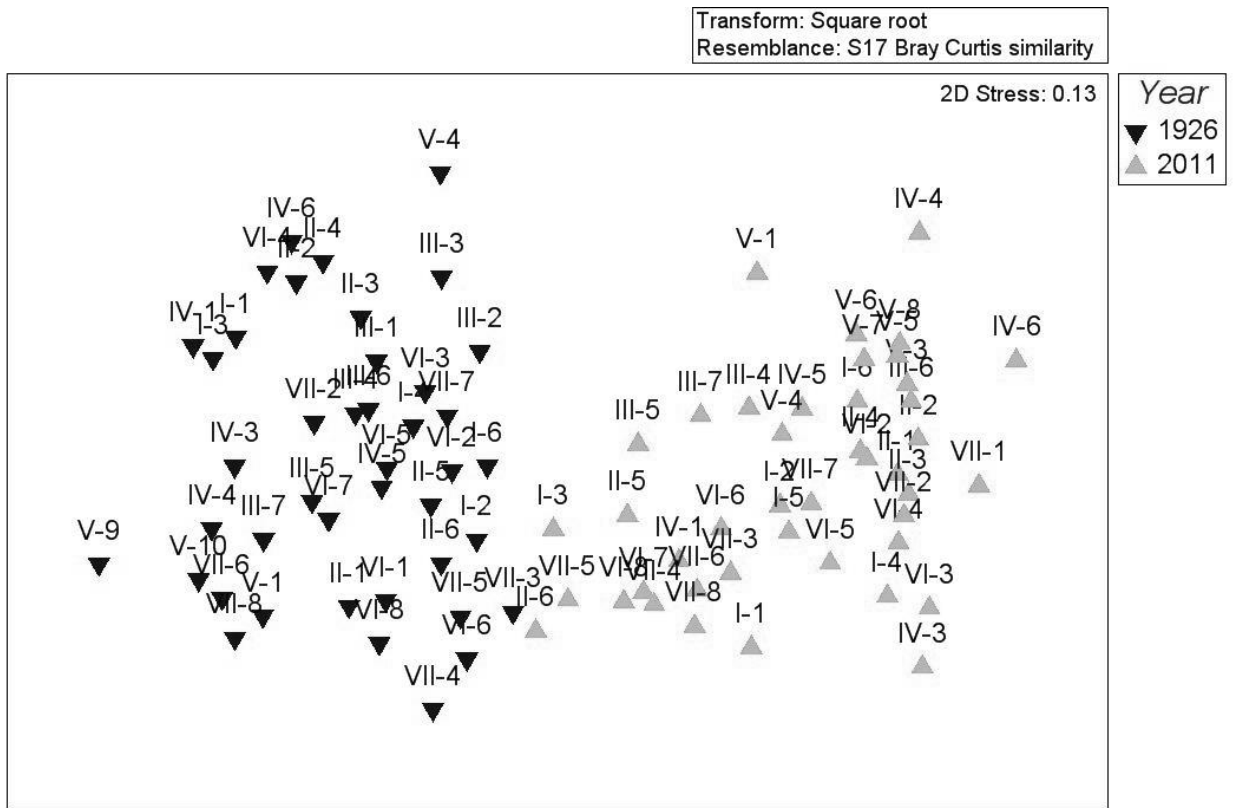
Figure 14. Non-metric multi-dimensional scaling with all 1926 and 2011 sites.
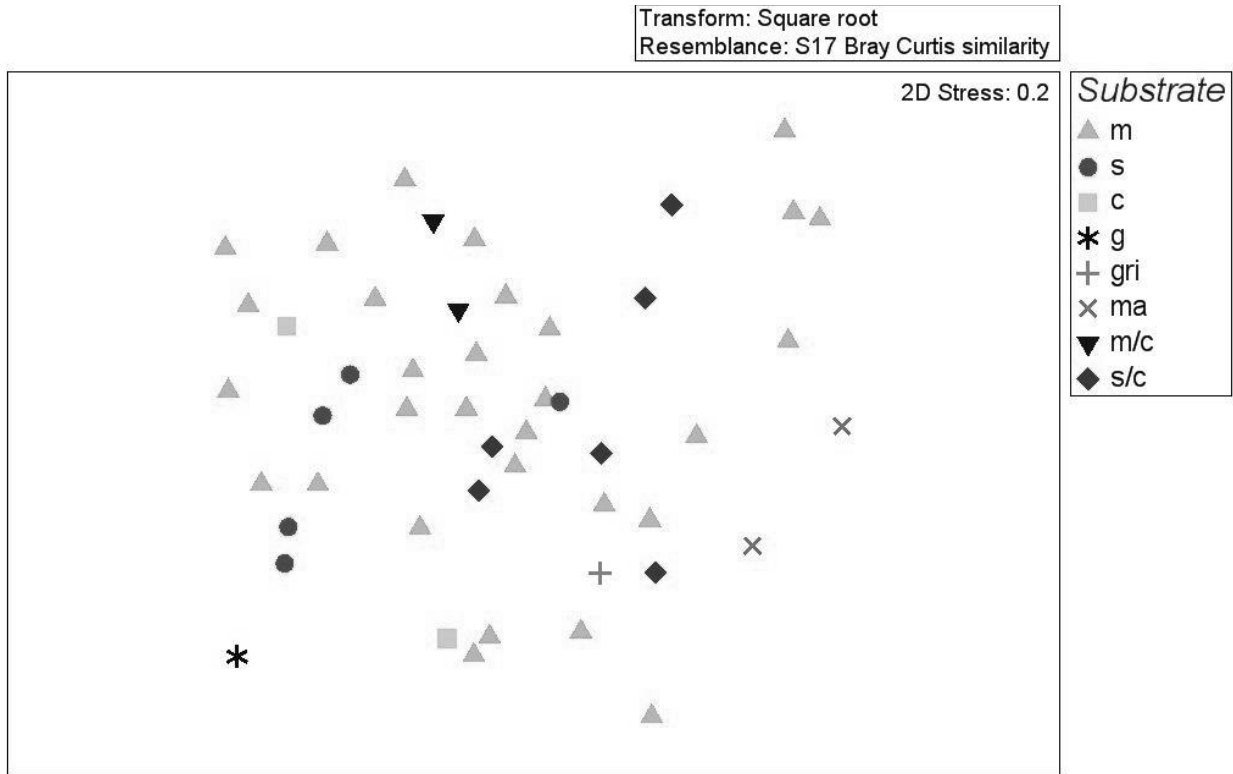
Figure 15. Non-metric multi-dimensional scaling of sites showing substrate type in 1926. Substrate codes: **m**ud, **s**and, **c**lay, **g**ravel, **gri**t, **ma**rl.
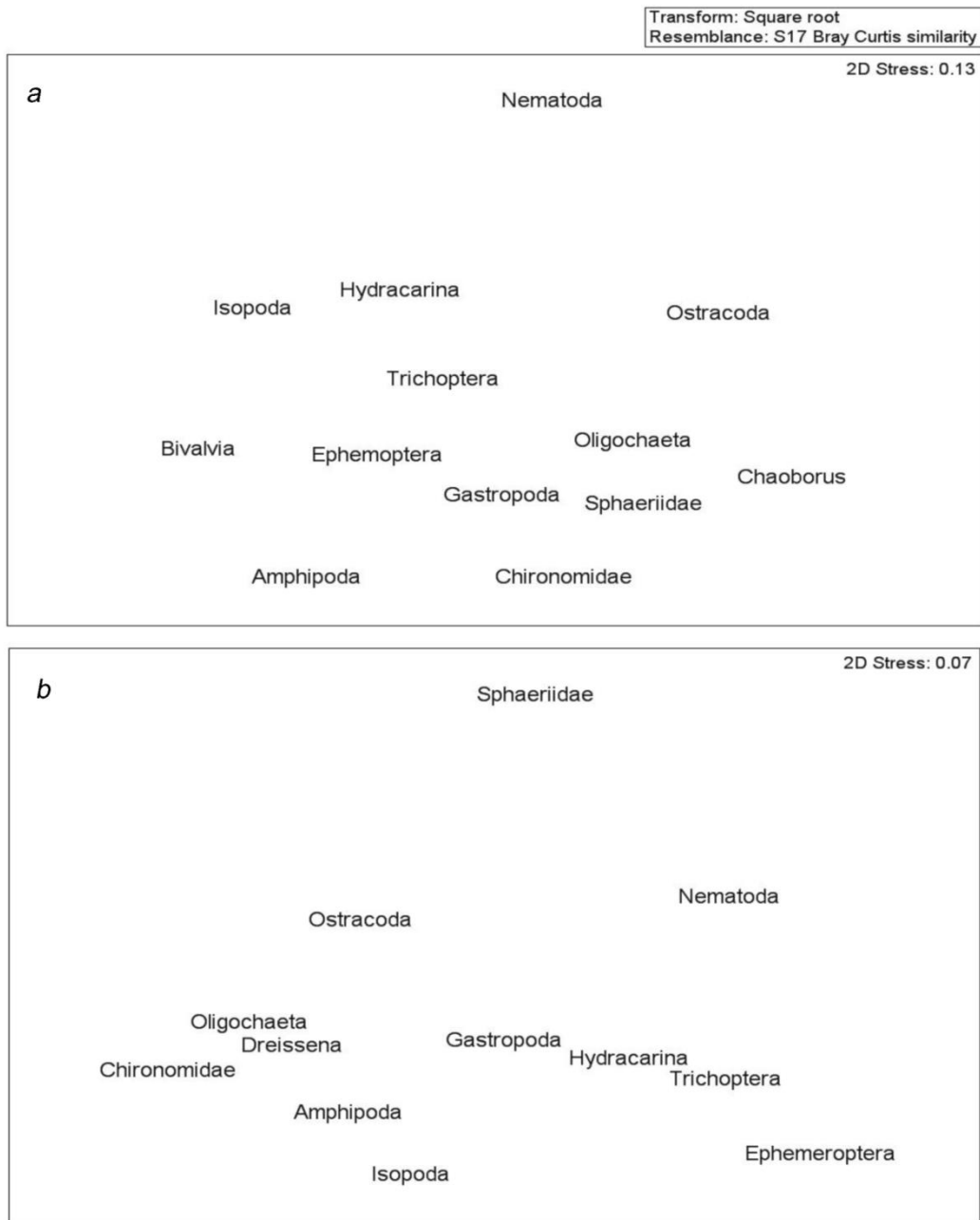
Figure 16. Non-metric multi-dimensional scaling of 13 taxa from a) 1926 b) 2011.

Table 1. Mean (2004-2008) physical and chemical variables for the three main regions in Lake Simcoe (MOE 2010).

	Cook's Bay	Kempenfelt Bay	Main Basin
Surface area (km^2)	44	34	643
Mean depth (m)	13	20	14
Maximum depth (m)	15	42	33
Chlorophyll *a* ($\mu g\ L^{-1}$)	3.2	2.8	2.4
Total P ($\mu g\ L^{-1}$)	18.8	15.1	14.1
P load (tonnes/yr)	20	10	42
Secchi disk depth (m)	4.8	7.1	7.1
Alkalinity ($mg\ L^{-1}$)	114	116	116

Table 2. Summary of transects and number of sites at each, date of sampling in 1926, and date of sampling in 2011. *= one site excluded from analysis.

Transect	Number of sites	Date sampled in 1926	Date sampled in 2011
1	6	July 14	July 19
2	6	July 15	July 19
3	7	July 23	July 20
4	6*	July 24	July 19
5	10	October 27	November 2
6	8	October 30	October 27
7	8	November 1	October 28

Table 3. Site coordinates in degree decimal minutes from 2011 sampling.

Site	Latitude	Longitude	Site	Latitude	Longitude
I-1	44 19.465	79 20.599	V-2	44 21.060	79 17.860
I-2	44 19.502	79 20.672	V-3	44 20.953	79 17.758
I-3	44 19.586	79 20.714	V-4	44 20.895	79 15.577
I-4	44 19.697	79 20.792	V-5	44 20.759	79 17.338
I-5	44 19.761	79 21.094	V-6	44 20.659	79 17.188
I-6	44 20.185	79 21.340	V-7	44 20.473	79 16.786
II-1	44 19.524	79 23.398	V-8	44 20.401	79 16.644
II-2	44 19.617	79 23.378	V-9	44 20.153	79 16.289
II-3	44 19.833	79 23.256	V-10	44 20.043	79 16.116
II-4	44 20.277	79 22.929	VI-1	44 23.063	79 41.153
II-5	44 20.934	79 22.402	VI-2	44 23.066	79 41.047
II-6	44 20.674	79 21.800	VI-3	44 23.018	79 40.839
III-1	44 14.913	79 31.551	VI-4	44 23.052	79 40.725
III-2	44 15.032	79 31.545	VI-5	44 23.031	79 40.601
III-3	44 15.040	79 31.373	VI-6	44 23.127	79 39.843
III-4	44 14.898	79 30.684	VI-7	44 23.160	79 38.687
III-5	44 15.698	79 31.003	VI-8	44 23.227	79 37.728
III-6	44 17.478	79 30.984	VII-1	44 24.153	79 36.059
III-7	44 17.834	79 29.881	VII-2	44 24.103	79 36.019
IV-1	44 11.809	79 29.318	VII-3	44 24.005	79 35.944
IV-3	44 12.141	79 29.496	VII-4	44 23.657	79 35.714
IV-4	44 13.334	79 29.984	VII-5	44 23.373	79 35.524
IV-5	44 14.149	79 30.364	VII-6	44 23.122	79 35.402
IV-6	44 18.204	79 28.900	VII-7	44 22.906	79 35.229
V-1	44 21.148	79 17.990	VII-8	44 24.197	79 33.901

Table 4. Complete taxa list from 1926 and 2011 sampling. Symbols in the 1926 column represent the presence of that species. Values represent the taxon's % of the total invertebrate abundance across all sites. In 1926, X refers to a taxon identified during qualitative sampling. * = Ostracods removed from total abundance calculiation in 2011 due to highly variable counts.

Taxa	1926 % of total abundance	2011 % of total abundance
MOLLUSCA:BIVALVIA		
DREISSENIDAE (total)**:**		14.422
Dreissena polymorpha		8.889
Dreissena rostriformis bugensis		1.138
MOLLUSCA:SPHAERIIDAE (total)**:**	7.172	
PISIDIINAE:		
Pisidium spp.		0.600
Pisidium adamsi	X	
Pisidium compressum	X	
Pisidium lilljeborgi	X	
Pisidium nitidum	X	
Pisidium variabile	X	
Pisidium ventricusum	X	
Pisidium walkeri	X	
SPHAERIINAE:		
Sphaerium emarginatum	**X**	
Sphaerium simile	**X**	
Sphaerium striatinum	**X**	
UNIONIIDAE:	2.674	
Lampsilis siliquoidea	X	
Pyganodon grandis	X	
Elliptio complanata	X	
GASTROPODA (total)	7.658	3.533
ANCYLIDAE:		
Ferrissia fragilis		0.011
HYDROBIIDAE:		0.254

Amnicola emarginata	X	
Amnicola limosa	X	0.710
Amnicola lustrica	X	
Amnicola walkeri	X	
LYMNAEIDAE:		
Lymnaea stagnalis	X	
Lymnaea emarginata	X	
Lymnaea obrussa decampi	X	
PHYSIDAE:		
Physella ancillaria	X	
Physella integra	X	0.005
PLANORBIDAE:		1.749
Armiger crista		0.037
Ferrissia parallela	X	
Helisoma complanatum	X	
Helisoma antrosum	X	
Helisoma promenetus	X	
Gyraulus circumstriatus		0.040
Gyraulus deflectus	X	0.094
Gyraulus parvus		0.106
Promenetus exacuous	X	0.092
VALVATIDAE:		0.013
Valvata perconfusa	X	
Valvata sincera	X	0.045
Valvata tricarinata	X	0.370
VIVIPARIDAE:		
Bithymia tentaculata		0.007
Campeloma decisum	X	
CHELICERATA:ARACHNIDA	0.486	
HYDRACARINA:		1.313

Tiphys torris	X	
Arrhenurus krameri	X	
Arrhenurus serratus	X	
Arrhenurus sp.	X	
Hygrobates ruber	X	
Leberta porosa	X	
Limnesia histrionica	X	
Limnesia wolcotti	X	
Mideopsis orbicularis	X	
Neumania ovata	X	
Neumania teniupalpis	X	
Piona pugilis	X	
Piona sp.	X	
ARTHROPODA:CRUSTACEA:		
DECAPODA(unidentifiable)**:**		0.011
Orconectes propinquus		0.018
OSTRACODA	1.216	*
AMPHIPODA: (total)	15.357	11.731
GAMMARIDAE:		
Echinogammarus ischnus		0.005
Gammarus fasciatus		4.791
Gammarus lacustris		0.002
Gammarus limnaeus	X	
HYALELLIDAE:		
Hyalella azteca	X	6.933
ISOPODA: (total)	0.729	14.901
ASELLIDAE:		
Caecidotea racovitzai		3.132
Lirceus lineatus	X	11.769
INSECTA:DIPTERA		

CERATOPOGONIDAE:	X	0.018
Bezzia		0.011
Probezzia		0.045
Sphaeromias		0.002
CHAOBRIDAE:		
Chaoborus	3.444	
CHIRONOMIDAE: (total)	51.094	33.505
CHIRONOMINAE(unidentifiable)**:**		4.775
Unknown Pupae		0.033
Chironomus (PUPAE)		0.020
Chironomus (Type 1)		2.601
Chironomus (Type 2)		0.942
Chironomus annularius		0.532
Chironomus plumosus	X	
Chironomus salinarius		3.700
Chironomus	X	
Cladopelma (PUPAE)		0.002
Cladopelma		0.057
Cladotanytarsus		0.422
Corynoneura		0.033
Cryptotendipes (PUPAE)		0.053
Cryptotendipes		0.343
Cryptochironomus	X	0.237
Dicrotendipes (PUPAE)		0.059
Dicrotendipes		3.320
Glyptotendipes (Type 1)		0.163
Glyptotendipes (Type 2)		0.002
Micropsectra (PUPAE)		0.029
Micropsectra		2.992
Microtendipes (PUPAE)		0.007

Microtendipes	X	1.591
Nimbocera (PUPAE)		0.002
Parachironomustenuicaudatus		0.029
Paratanytarsus (PUPAE)		0.022
Paratanytarsus		3.127
Paratendipes		0.127
Phaenopsectra		0.092
Polypedilum (PUPAE)		0.053
Polypedilum		1.048
Psectrocladius (PUPAE)		0.029
Psectrocladius flavus		0.517
Psectrocladius vernalis		0.205
Pseudochironomus		0.011
Sergentia coracina		0.009
Stictochironomus		0.357
Tanytarsus (PUPAE)		0.090
Tanytarsus	X	1.681
Tribelos		0.454
Xenochironomus		0.067
DIAMESINAE(unidentifiable)**:**		
ORTHOCLADIINAE(unidentifiable)**:**		0.011
ORTHOCLADIINAE (PUPAE)		0.004
Cricotopus(PUPAE)		0.020
Cricotopus tremulus		0.009
Cricotopus cylindraceus		0.002
Cricotopus trifascia		0.016
Cricotopus		0.261
Heterotrissocladius marcidus		0.002
PROMIAMESINAE(unidentifiable)**:**		0.005
Monodiamesia		0.029

Protanypus		0.027
TANYPODINAE(unidentifiable)**:**		0.097
Ablabesmyia(PUPAE)		0.011
Ablabesmyia	X	0.846
Coelotanypus		0.002
Conchopolopia		0.016
Larsia		0.005
Nartarsia		0.090
Procladius	X	2.219
EMPIDIDAE:		
Hemerodromia		0.020
EPHEMEROPTERA: (total)	2.796	0.589
BAETIDAE:		0.002
CAENIDAE:		
Caenis	X	0.549
EPHEMERIDAE:		
Ephemera	X	
Hexagenia	X	0.007
Ephemerella	X	0.004
Leptophlebia	X	
Stenonema		0.018
LEPIDOPTERA		
PYRALIDAE:		
Acentria		0.002
Crambidae		0.013
MEGALOPTERA		
SIALIDAE:		
Sialis		0.016
Climacia		0.002
ODONATA		

COENAGRIONIDAE:		0.049
TRICHOPTERA: (total)	0.932	0.601
Trichoptera pupae		0.005
HELICOPSYCHIDAE:		
Helicopsyche borealis	X	
HYDROPTILIDAE(unidentifiable)**:**		0.049
Agraylea		0.009
Hydroptila		0.002
Orthotrichia		0.144
Oxyethira		0.092
LEPTOCERIDAE(unidentifiable)**:**		0.009
Ceraclea		0.011
Mystacides		0.005
Nectopsyche albida		0.047
Oecetis		0.067
Ocetis osteni		0.063
Ocetis cincerasins		0.018
Ocetis georgia		0.016
MOLANNIDAE:		
Molanna	X	
PHILOPTAMIDAE(unidentifiable)**:**		0.005
POLYCENTROPODIDAE:		
Neureclipsis		0.054
CNIDARIA:HYDROZOA:		
Hydra		0.688
NEMATODA:	0.162	0.353
NERMATEA:		0.007
PLATYHELMINTHES:TRICLADIDA		0.283
ANNELIDA:HIRUDINEA(unidentifiable)		0.227
ERPOBDELLIDAE:		0.007

Dina	X	0.002
Nephelopsis obscura	X	
GLOSSIPHONIIDAE:		
Alboglossiphonia heteroclita		0.005
Batracobdela phalera		0.002
Glossiphonia		0.063
Glossiphonia complanata		0.018
Glossiphonia heteroclita		0.150
Gloiobdella elongata		0.002
Helobdella		0.029
Helobdella fusca		0.018
Helobdella lineata		0.009
Helobdella stagnalis		0.184
Helobdella papillata		0.002
Placobdella parasitica		0.009
HAEMOPIDAE:		
Haemopis grandis	X	
ANNELIDA:OLIGOCHAETA (total)	6.280	16.408
NAIDIDAE:		
Arcteonais lomondi		0.009
Chaetogaster diaphanus		0.009
Nais bretscheri		0.780
Nais communis		0.056
Nais variabilis		1.173
Nais pardalis		0.195
Ophidonais serpentina		0.004
Paranais frici		0.002
Slavina appendiculata		0.002
Specaria josinae		0.136
Stylaria lacustris		0.937

Uncinais uncinata	0.245
Vejdovskyella intermedia	0.047
SPARGANOPHILIDAE:	0.022
Sparganophilus eiseni	0.056
TUBIFICIDAE:	
Immature(unidentifiable)	8.752
Aulodrilus pigueti	0.025
Aulodrilus pluriseta	3.006
Limnodrilus hoffmeisteri	0.510
Potamothrix vejdovskyella	0.020
Tubifex tubifex	0.422

Table 5. Average abundances (individuals/m^2) of major taxa at transects one through seven in 1926 and 2011. Bivalvia is represented by a single family, Unionidae in 1926, and by *Dreissena* in 2011.

Taxa	1926	2011	1926	2011	1926	2011	1926	2011	1926	2011	1926	2011	1926	2011
	1		2		3		4		5		6		7	
Amphipoda	10	34	0	115	14	3906	0	1483	710	3792	0	25	0	189
Bivalvia	0	890	0	2090	0	2894	0	1841	126	1160	0	1625	0	2578
Chaoborus	0	0	48	0	25	0	15	0	0	0	31	0	105	0
Chironomidae	246	4632	539	5847	470	5537	165	2947	706	5911	380	2054	651	2989
Ephemeroptera	0	5	19	5	57	4	27	6	52	345	0	14	19	5
Gastropoda	67	19	64	12	74	1565	38	1293	119	447	89	72	29	5
Hydracarina	6	60	0	82	0	229	0	107	13	342	2	245	5	7
Isopoda	0	46	0	130	0	11325	0	2499	21	195	0	97	17	11
Nematoda	0	10	6	26	0	130	0	26	2	62	2	9	0	40
Oligochaeta	29	3437	22	2220	14	1672	54	1925	13	1685	84	2244	187	1916
Ostracoda	48	29	0	38	0	517	0	4773	0	302	19	2578	17	759
Sphaeriidae	19	51	153	36	148	350	57	63	0	3	96	36	33	31
Trichoptera	22	0	6	10	8	54	8	38	10	263	0	58	10	14
Total	**34**	**768**	**66**	**884**	**62**	**2349**	**28**	**1417**	**136**	**1209**	**54**	**755**	**82**	**712**

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Appendix 1

Average raw counts of triplicate samples from 2011.

	I-1	I-2	I-3	I-4	I-5	I-6	II-1	II-2	II-3	II-4	II-5	II-6	III-1	III-2	III-3	III-4	III-5	III-6	III-7
Depth (m)	4.6	0.9	1.1	5	6.1	11.9	1.8	2.5	12.8	14.7	18.5	18.2	2	1.9	2.3	12.5	14.2	18.4	14.6
DREISSENIDAE:	0	0	0	0	0	35	3.333	13.33	14.33	53.33	0	1.333	0.667	0.333	0	2	0	33.67	24
Dreissena polymorpha	1.333	0	0	0.667	1.667	60.33	16.67	14.33	57	57.67	0	0	136.7	56.67	36	18.67	0	133	20.333
Dreissena bugensis	0	0	0	0	0.333	24	7.667	4.333	22.33	23.67	0.333	0	0	0	0.667	0	0	1.667	.667
SPHAERIIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pisidium spp.	4.667	0.333	2	0	0	0	0	0	0.333	2	2.667	0	1	30	1.667	6	7	4.667	6.333
MOLLUSCA:GASTROPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANCYLIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ferrissia fragilis	0	0	0	0	0	1	0	0.333	0	0	0	0	0	0	0	0	0	0	0
HYDROBIIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0	0	0	0
Amnicola limosa	0	0	0	0	0	0.333	0	1	0	0	0	0	0	0	1.333	0	0	0.333	0
PHYSIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physa integra	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0.333	0	0	0	0	0
PLANORBIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	89.67	25.67	62	0	0	0.667	0
Armiger crista	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Gyraulus circumstriatus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3.667	0	0	0.333	0
Gyraulus deflectus	0	0	0	0	0	0	0	0	0	0	0	0	8.333	1.333	0	0	0	0	0
Gyraulu sparvus	0	0	0	0	0	0	0	0	0	0	0	0	14.33	0	0	0	0	0	0
Promenetus exacuous	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.333	0
VALVATIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0
Valvata sincera	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	1.333	1.667	0.667	1
Valvata tricarinata	0	0.333	0	0	0	0	0	0	0	0	0	0	0.333	4	27.67	1.333	0.333	0.667	0
VIVIPARIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bithymia tentaculata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CHELICERATA:ARACHNIDA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDRACARINA:	1	1	0.667	4.333	1.333	0	3	8.333	0	0	0	0	18.67	10	7.667	0.333	0	0.333	0
ARTHROPODA:CRUSTACEA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DECAPODA:	0	0	0	0	0	0	0	0	0	1.667	0	0	0	0	0	0	0	0	0
Orconectes propinquus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAMMARIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinogammarus ischnus	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	0
Gammarus fasciatus	0	0.333	0	0	0	2.667	5.667	7.333	0.333	1	0	0	163.7	124.7	236.7	11.33	2.333	36.67	2.667
Gammaru spseudolinaeus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gammarus lacustris	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0
HYALELLIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hyalella azteca	0	0	0	0.333	1.333	0	0.333	1	0	0	0	0	0.667	7	42.33	3	0.333	0	0
CLADOCERA:	0	0.333	0	31.67	4.333	1	7.667	8	2.667	0.333	1	0	1	1.667	1.667	1.333	0	0.333	0.333
ISOPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASELLIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caecidotea racovitzai	0	0	0	0	0	4.333	0	11.33	4.667	2	0	0	179	43.33	61.67	0.667	0	23.67	0.667
Lirceus lineatus	0	0	0	0	0	2	0	0	0	0	0	0	1178	219.3	120.3	3	0.667	1	0.333
OSTRACODA:	0.667	0	0	0.667	1	1.667	0.667	1.333	1.667	1.333	0.333	0	31.67	20	18.33	1.333	2.667	8.667	1
COPEPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CYCLOPOIDA:	42.33	2.333	0.333	16.33	3.667	0	0.333	1.667	0.333	0	0	0	1	2.667	3	3.667	0.667	2	0
HARPACTICOIDA:	2	0	0	31	5.667	0	0	0.333	0.333	0	0	0	0	0.333	2.667	0	0	0	0
INSECTA:DIPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	I-1	I-2	I-3	I-4	I-5	I-6	II-1	II-2	II-3	II-4	II-5	II-6	III-1	III-2	III-3	III-4	III-5	III-6	III-7
CERATOPOGONIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bezzia	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Probezzia	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphaeromias	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMINAE:	0	4	1.667	30	36.33	0	69.67	23	2.333	2.667	0	0	53	23	12	0	0	8	0
Unknown Pupae	0	0	0	0	0	0	1.667	0	0	0	0.333	0.333	0.667	1.333	0.333	0	0.333	0	0
Chironomus (PUPAE)	0	0	0	0.667	0	0	0.333	0	0	0	0	0	0	0.667	0.667	0	0	0	0
Chironomus (2 pair ventral tubules)	14.67	0.333	0	0.333	9	0	1.333	0	0	0	0	0	5	36.67	66.67	3	1.333	0	1.333
Chironomus (1 pair ventral tubules)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. annularius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. salinarius	0	0	0	4.333	10	71.33	0.333	3.333	85.33	29	17.33	7.333	1.667	0.333	1	16.67	15.67	22	7.667
Cladopelma (PUPAE)	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladopelma	0	0	0	0.667	2	0	0	0	0	0	0	0	2.667	0.333	0	0	0	0	0
Cladotanytarsus	0	40.67	4	15	1.667	0	0.333	0.333	0	0	0	0	0	0.333	1	0	0	0	0
Corynoneura	0	0	0	0	0	0	0	0	0	0	0	0	1.333	1	0	0	0	1.667	0
Cryptotendipes (PUPAE)	0	0	0	0	0	0	7.667	0	0	0	0	0	0	0	0	0	0.333	0	0
Cryptotendipes	0	0	0	0	0.333	0	46	0	0	0.333	0	0	0	0.333	0	0	0.667	0	0
Cryptochironomus	1.667	2.333	2	7.333	1	0	0	0.333	0	0	0	0	1.667	5.667	3.333	0.667	0	0	0
Dicrotendipes (PUPAE)	0	0	0	0	0	0	0	0.667	0	0	0	0	1.667	0	0	0	0	0	0
Dicrotendipes	0	0	0	15.33	0.333	5.667	0	37.67	6.667	0	0	0	49	13.33	9	4	0	9.667	1.333
Glyptotendipes (tubules absent)	0.333	0	0	0	0	0	0	0	0	0	0	0	0.333	0.333	0	0	0	0	0
Glyptotendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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	I-1	I-2	I-3	I-4	I-5	I-6	II-1	II-2	II-3	II-4	II-5	II-6	III-1	III-2	III-3	III-4	III-5	III-6	III-7
Lauterborniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropsectra (PUPAE)	0	0	0	3.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0
Micropsectra	0	0	0.667	6.667	5.333	40	17.67	7	128.3	83	24.67	6.333	1.333	0	0	5.667	2.333	95	4.333
Microtendipes (PUPAE)	0	0	0	0	0	0	0.667	0	0	0	0	0	0	0	0	0	0	0	0
Microtendipes	0	0	0	0.667	0.333	0.667	0.667	0.333	1.333	0	0	0	78.33	84	39.67	1	0	1	0.333
Nimbocera (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0
Parachironomus tenuicaudatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paratanytarsus (PUPAE)	0	0	0	0	0	0	1	0	0	0	0	0	0.333	1	0	0	0	0	0.333
Paratanytarsus	0	0.667	0.333	26.33	6.333	3.333	21.33	3.333	0.667	0.333	0	0.333	21.33	16	3.333	0	0	7.667	0
Paratendipes	0	0	0	0	0	0.667	0.667	0.333	1.333	1	0	0	0	0	0	0.333	0.333	1	0
Phaenopsectra	0	0	0	0.333	0.333	0.333	0.333	0	0	0	0	0	3.667	3	0.667	0	0	0	0
Polypedilum (PUPAE)	0	6	0.333	0	0	0	0	0	0	0	0	0	0	1.667	0	0	0	0	0
Polypedilum	0	101.3	7.333	9.667	12.33	0.333	1	0.333	0	0	0	0	0.667	17.67	1	0	0	0	0
Psectrocladius (PUPAE)	0	0	0	0.667	0	0	0.667	3	0	0	0	0	0	0	0	0	0	0	0
Psectrocladiusflavus (type 1)	0	0	0	1.667	1	0	6.667	15	0.333	0	0.333	0	0	0	0	0	0	0.333	0.333
Psectrocladiusvernalis (type 2)	0	0	0	1.333	0	0	1.667	24.33	0	0	0	0	0	0	0	0	0	1.333	0
Pseudochironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rheotanytarsus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sergentiacoracina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stictochironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanytarsus (PUPAE)	0	0	0	1	0	0.667	3	0	2.667	2	0	0.333	0	0	0.333	0.333	0	0.333	0
Tanytarsus	0	0	0	18.33	7.333	7.333	0.333	0.667	1	24.33	9.333	1.667	1.333	0.333	3	15.33	8.333	4	3.667
Tribelos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.667	0	0	0	0

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	I-1	I-2	I-3	I-4	I-5	I-6	II-1	II-2	II-3	II-4	II-5	II-6	III-1	III-2	III-3	III-4	III-5	III-6	III-7
Xenochironomus	0	0	0	0	0	0	0	0	0	0	0	0	6.667	0.333	0.333	0	0	0	0
DIAMESINAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE (PUPAE)	0	0.333	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus(PUPAE)	0	0.333	0	0	0	0	0.333	0.667	0	0	0	0	1.667	0	0	0	0	0	0
Cricotopus temulus (Oliver)	0	0	0	0	0	0	0	0	0	0	0	0	0	1.333	0	0	0	0	0
Cricotopus cylindraceus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0
Cricotopus trifascia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus	0.333	1	0	0	0	0	0	4.667	0	0	0	0	17.33	0	1	0	0	0	0
Heterotrissocladius marcidus	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0
PROMIAMESINAE:	0	0	0	0	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monodiamesia	0	0.333	0	3.667	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protanypus	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	0.333	0	0
TANYPODINAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ablabesmyia(PUPAE)	0	0	0	0.667	0	0	0	0.667	0	0	0	0	0.333	0	0	0	0	0	0
Ablabesmyia	0	0.333	0	9	1.667	0.667	7	4.333	0.333	0.667	0	0	2	3	2.333	0	0.333	0.333	0
Coelotanypus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conchopolopia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larsia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nartarsia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Procladius	3	0	0	23.33	17	22.67	0.667	1.667	12.67	22.67	7	2.333	1.333	4.667	3	6	8	9	2.333
EMPIDIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemerodromia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	I-1	I-2	I-3	I-4	I-5	I-6	II-1	II-2	II-3	II-4	II-5	II-6	III-1	III-2	III-3	III-4	III-5	III-6	III-7
EPHEMEROPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BAETIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0
CAENIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caenis	0	0	0	0	0	0	0.333	0.333	0	0	0	0	0	0.333	0	0	0	0	0
EPHEMERIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexagenia	0	0	0	0	0.333	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemerella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stenonema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEPIDOPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYRALIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acentria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crambidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEGALOPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SIALIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sialis	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0
Climacia	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0
ODONATA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COENAGRIONIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	1.667	0	0	0	0	0
TRICHOPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0	0	0	0	0
Trichoptera pupae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDROPTILIDAE:	0	0	0	0	0	0	0.667	0.333	0	0	0	0	1.667	1.333	0	0	0	0	0
Agraylea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydroptila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	I-1	I-2	I-3	I-4	I-5	I-6	II-1	II-2	II-3	II-4	II-5	II-6	III-1	III-2	III-3	III-4	III-5	III-6	III-7
Orthotrichia	0	0	0	0	0	0	0	0	0	0	0	0	1.333	0	0	0	0	0	0
Oxyethira	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEPIDOSTOMATIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidostoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEPTOCERIDAE:	0	0	0	0	0	0	0.333	0	0	0	0	0	0	0.667	0.333	0	0	0	0
Ceraclea	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0.667	0	0.333	0	0	0
Mystacides	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0	0	0	0	0
Nectopsyche albida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0
Ocetis osteni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocetis cincerasins	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocetis georgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHILOPTAMIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0	0	0	0	0
POLYCENTROPODIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neureclipsis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CNIDARIA:HYDROZOA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDRIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydra spp.	0	1.333	0	0.333	0	0	0.667	0.333	0.333	1.333	0	0	13.33	1	8.667	0	0	3.667	0.333
NEMATODA:	0.667	0	0	0.333	0	0.333	0	0	0.333	0.667	1	1.667	1.333	12.33	5.333	1.333	0.667	0	0
NERMATEA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLATYHELMINTHES:	0	0	0	0	0	0	0	0	0	0	0	0	0	3.333	1	0	0	1.333	0.333
ANNELIDA:HIRUDINEA:	0	0	0	0	0	0	0	0	0	0	0	0	28	3.333	0.333	0	0	0	0
ERPOBDELLIDAE:	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	I-1	I-2	I-3	I-4	I-5	I-6	II-1	II-2	II-3	II-4	II-5	II-6	III-1	III-2	III-3	III-4	III-5	III-6	III-7
Dina	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLOSSIPHONIIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alboglossiphonia heteroclita	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0	0	0	0
Batracobdela phalera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glossiphonia	0	0	0	0	0	0	0	0	0	0	0	0	7.333	0	0	0	0	0	0
Glossiphonia complanata	0	0	0	0	0	0	0	0	0	0	0	0	2	0.667	0	0	0	0	0
Glossiphonia heteroclita	0	0	0	0	0	0	0	0	0	0	0	0	8.667	4	0	0	0	0	0
Gloiobdella elongata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helobdella	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
Helobdella fusca	0	0	0	0	0	0	0	0	0	0	0	0	0.667	1.333	0	0	0	0	0
Helobdella lineata	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0	0	0	0	0
Helobdella stagnalis	0.333	0	0	0	0	0.667	0	0	1	0	0	0	5.333	15	1	0	0.333	0	0.333
Helobdella papillata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Placobdella parasitica	0	0	0	0	0	0	0	0	0	0	0	0	1.333	0	0	0	0	0	0
ANNELIDA:OLIGOCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAIDIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arcteonais lomondi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaetogaster diaphanus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0	0	0	0
Nais bretscheri	0	0	0	0	0	0	56	49.67	0	0	0	0	0	0	0	0	0	0.667	0
Nais communis	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0
Nais variabilis	12.67	1.333	0	0	0	0	15	114.7	0	0	0	0	2	2.333	0.667	0	0	0	0
Nais pardalis	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0
Ophidonais serpentina	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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	I-1	I-2	I-3	I-4	I-5	I-6	II-1	II-2	II-3	II-4	II-5	II-6	III-1	III-2	III-3	III-4	III-5	III-6	III-7
Paranais frici	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slavina appendiculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Specaria josinae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stylaria lacustris	0	0	0	0	0	0	0	0	0	0	0	0	11	10.33	17.33	0	0	0	0
Uncinais uncinata	0	2.333	14	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vejdovskyella intermedia	0	0	0	4	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0
SPARGANOPHILIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sparganophilus eiseni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TUBIFICIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Immature	143	47	3.333	78.67	17	4.333	2.333	1	21	15.33	3.667	2	48.33	36	27.67	15.67	3.333	20.67	6.333
Aulodrilus pigueti	0	0	0	0	0	0	0	1	2.333	0	0	0	0	0	0	0	0	0	0
Aulodrilus pluriseta	32	3	0	53.33	17	0.667	0	0	4.333	12	4	1	6.667	8.667	5.333	1.333	8.333	15.33	6.667
Limnodrilus hoffmeisteri	12.67	0	0	9	0	0	0	1	0	0.333	0.333	0	1.333	3	7	0.333	0	0	0.333
Potamothrix vejdovskyella	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Tubifex tubifex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larval fish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0
Brown mite*	0	0	0	0	0	0	0	0	0	0	0	0	1.333	0	0	0	0	0	0
Bythotrephes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mysis diluviana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**275.3**	**217.3**	**37**	**432**	**167.3**	**293.7**	**312**	**372.7**	**377**	**339.3**	**73**	**24.67**	**2228**	**874.7**	**856.7**	**126**	**66.33**	**454.7**	**96.33**

	IV-1	IV-3	IV-4	IV-5	IV-6	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
Depth (m)	0.6	1.1	3.7	7.6	4.1	0.5	1.3	1.7	3.7	3.4	3.5	3.5	3.2	2.1	1
DREISSENIDAE:	0	0	0	2.667	31.33	0.333	18.33	21.67	0.667	23.33	37.33	21	14.33	12.67	2
Dreissena polymorpha	0.333	0	14.33	84.67	73.33	0	26.67	15	0.333	9.333	3.667	6	13	0.667	33.33
Dreissena bugensis	0	0	0.333	0	5.667	0	2.333	2.667	0	0.667	0.333	0	2	0	0.333
SPHAERIIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pisidium spp.	0	0	5.333	2	0	0	0	0	0.333	0.333	0	0	0	0	0
MOLLUSCA:GASTROPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANCYLIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ferrissia fragilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDROBIIDAE:	0	0	25.33	0.333	10.67	0	0	0	0	0	0	0	0	0	0
Amnicola limosa	0	0.333	1.667	0	1.333	16	7	8.333	0.333	17.67	13	6.333	0.667	1.333	18.33
PHYSIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physa integra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLANORBIDAE:	0	0	64.67	2	13	0	0	0	0	0	0	0	0	0	1.667
Armiger crista	0	0	3	0	0.667	0	0	0	0	0	0	0	0	0	0
Gyraulus circumstriatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gyraulus deflectus	0	0	0	0	0	0	0.667	1.667	0	0	0	1	0.667	0	0.333
Gyraulus parvus	0	0	0	0	0	0	0	0	0	0	0	1.333	0	0	0
Promenetus exacuous	0	0	8.333	0	0	0	0	0	0	0	4	0	0	0	0
VALVATIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valvata sincera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valvata tricarinata	0	0	17.67	0.333	0	2	0	0	0	0	0	0	0	0	0
VIVIPARIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bithymia tentaculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	IV-1	IV-3	IV-4	IV-5	IV-6	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
CHELICERATA:ARACHNIDA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDRACARINA:	0	2	4.333	0.667	5.333	0.667	13.33	4	0.333	9	2.667	9.333	9.333	21	9.333
ARTHROPODA:CRUSTACEA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DECAPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Orconectes propinquus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAMMARIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinogammarus ischnus	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0
Gammarus fasciatus	0	3	20.67	17.33	7	5.333	1	0	2.667	1.333	1.333	0	0.333	0.667	31.67
Gammarus pseudolinaeus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gammarus lacustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYALELLIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hyalella azteca	7	0.667	24.33	0.333	90.67	8	187.7	81.33	10.67	155.3	75.33	59	95.67	42.67	116
CLADOCERA:	1.333	70.67	3.333	1.333	1.667	2.333	38.67	14.33	0.333	38.33	53.67	21	13.33	14.33	2.333
ISOPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASELLIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caecidotea racovitzai	0	0.667	48.33	3	61.33	0	0	0	0	0	0	0	0	0	0
Lirceus lineatus	0	0	0	0	175.3	0	8.667	11.67	0	0	13.33	0.333	1.333	8.333	1.333
OSTRACODA:	5.667	508.7	29.67	5	2.333	0	52	9	0	4.333	0.333	0.667	0.333	0	3
COPEPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CYCLOPOIDA:	5.667	34.67	15.67	13.67	1.333	2	15.67	27.33	3	15.67	5	11	4	1.667	0.333
HARPACTICOIDA:	0.667	21	2.667	5	7.667	0	1	0	0	0	0	0	0	0	3.667
INSECTA:DIPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	IV-1	IV-3	IV-4	IV-5	IV-6	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
CERATOPOGONIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.667
Bezzia	0.333	0	0	0	0	0.333	0	0	0.667	0	0	0	0	0	0
Probezzia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Sphaeromias	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMINAE:	0	5.667	0	6.667	40.67	0	4.667	1	35	8.667	1.333	16.33	12	43.67	110.3
Unknown Pupae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomus (PUPAE)	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomus (2 pair ventral tubules)	4.333	22.67	0	1.667	70.33	4	22	1	0.333	0	4	0.667	12.33	7.333	0
Chironomus (1 pair ventral tubules)	0.333	0	0	0	0	0.667	10	12.67	0.333	34	9.667	24.67	47.33	1.667	0
C. annularius	17	0	0	0	0	0	11	2.667	0	15.33	9	12	3.667	0.333	0
C. salinarius	1	6	0.333	14.67	2.333	2	29.67	5.333	0.333	15	2.667	0	0	2.667	0
Cladopelma (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladopelma	0	2.667	0	0	0	0	0	0	0.333	0	0	0	0	0	0
Cladotanytarsus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corynoneura	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Cryptotendipes (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptotendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptochironomus	0	1.333	0	0.333	0.667	0.667	0	0	0.333	0	0	0	0	0	1
Dicrotendipes (PUPAE)	0	0	0	0	6.667	0	0	0	0	0	0	0	0	0	0
Dicrotendipes	0	0	0	2.333	43	1.667	56	9	0	20.67	2	43.33	55	36	2
Glyptotendipes (tubules absent)	0	0	0	0	0	0	22.33	0	0	0	0	1.333	0	0	0
Glyptotendipes	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	IV-1	IV-3	IV-4	IV-5	IV-6	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
Lauterborniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropsectra (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropsectra	0	0	0	8.333	5	0	0.333	0	0.333	0	0	0	0	0	0
Microtendipes (PUPAE)	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0
Microtendipes	0	0	0	0.667	11	0	0	0	0	0	0	0	0	0	0.333
Nimbocera (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parachironomus tenuicaudatus (Epler)	0	0	1.333	0	0.333	0	0	2.667	0	0	0	0	0	0	0
Paratanytarsus (PUPAE)	0	0	0	0	0.667	0	0	0	0	0	0	0	0	0	0
Paratanytarsus	0	0	0	1.667	8	0.333	39	20	0.667	14	3	16.33	53.33	71.67	45.33
Paratendipes	0	0	0	0	0	0.333	0	0	13.33	0	0	0	0	0	0
Phaenopsectra	0	0	0	0	3	0.667	0	0.333	0	0	0	0	0	0	0
Polypedilum (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polypedilum	0	0	0	0.667	0.333	1.667	0	0	3	0	0	0	0	1.667	0
Psectrocladius (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psectrocladiusflavus (type 1)	0	0	0	0	0.333	0	18	7	0	2.333	3	8.333	8	4	0
Psectrocladiusvernalis (type 2)	0	0	0	0	0	0.333	0	0	0	0	0	1.333	0	0	0
Pseudochironomus	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0	1.333
Rheotanytarsus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sergentiacoracina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stictochironomus	0	0	0	0	0	0.667	0	0	16	0	0	0	0	0	0.333
Tanytarsus (PUPAE)	0	0	0	1.333	0.333	0	0	0	0	0	0	0	0	0	0
Tanytarsus	0	0	0	7.667	8.333	0	5	1.667	8	0	0	0	0	4.333	0
Tribelos	0	0	0	0	0	0.667	0	0	0	0	0	0	0	14.67	8.667

	IV-1	IV-3	IV-4	IV-5	IV-6	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
Xenochironomus	0	0	0	0	0	0	2.333	0.333	0	0	0	0	0	0	0
DIAMESINAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE:	0	0	0	0	0	0	0	0	0	1.333	0	0	0	0	0.333
ORTHOCLADIINAE (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus(PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus temulus (Oliver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus cylindraceus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus trifascia	0	0	0	0	0	0	0	2.333	0	0	0	0	0	0	0
Cricotopus	0	0	0	0	0	0	7	4	0	0.333	0	0	0	0	2.333
Heterotrissocladius marcidus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PROMIAMESINAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monodiamesia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protanypus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TANYPODINAE:	0	0	0	0	0	0	0	0	0	0.333	0	5.333	0	0	3.333
Ablabesmyia(PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ablabesmyia	0	0.333	0.333	0	11	1.333	26.33	15.33	0.333	10	11.33	6	8	0.667	1.333
Coelotanypus	0	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0
Conchopolopia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larsia	0	0	0	0	0	0	0	0	0	0.667	0	0	0	0	0
Nartarsia	0	0	0	0	0	0	0	0	0	0	0	0.333	0.333	5	7.667
Procladius	0.333	1	0	5	11.33	1.333	1.667	0	6.667	11.33	0	0	12	5.333	10.33
EMPIDIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemerodromia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667

	IV-1	IV-3	IV-4	IV-5	IV-6	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
EPHEMEROPTERA:	0	0	0	0	0	0	0	0	0	0	1.333	0	0	0	0
BAETIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAENIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caenis	0	0.667	0	0	0	27.33	1	0	5.333	0.667	1.333	1.667	3.333	11.33	26.67
EPHEMERIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexagenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333
Ephemerella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667
Stenonema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEPIDOPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYRALIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acentria	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0
Crambidae	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
MEGALOPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SIALIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sialis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Climacia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ODONATA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COENAGRIONIDAE:	0	0	0	0	0	0.333	2.667	1.333	0	0	0	0	0	1.333	0
TRICHOPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera pupae	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDROPTILIDAE:	0	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0
Agraylea	0	0	0	0	0	0	1.333	0	0	0	0	0	0	0	0
Hydroptila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	IV-1	IV-3	IV-4	IV-5	IV-6	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
Orthotrichia	0	0	0	0	2.333	0	0	0	0	0	0	0	2	1.667	14
Oxyethira	0	0	0	0	0	0	0.667	0	0	4.667	1.667	1.333	0	5.333	0
LEPIDOSTOMATIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidostoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEPTOCERIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceraclea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mystacides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nectopsychealbida	0	0	0	0	0	0	0.667	0	0	0	0	0	0.667	1.667	2
Oecetis	0	0	0	0.333	0.333	0	0	0	0	0	0	0	0	0.333	8.667
Ocetisosteni	0	0	0	0	0	0	2	0.333	0	0.333	0	0	0.667	0	6
Ocetiscincerasins	0	0	0	0	0	0	2.333	0	0	0	0	0	0	0	0
Ocetisgeorgia	0	0	0	0	0	0	0	1.333	0	0	0	0.333	0	0.667	0
PHILOPTAMIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCENTROPODIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neureclipsis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CNIDARIA:HYDROZOA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDRIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydra spp.	0	0	3	2.667	21	0	6	4.667	0	6.667	4	0.667	0	0.333	18
NEMATODA:	0	1	1.667	0.333	0	1.667	1.333	5.667	0	0.333	0.333	1.333	0.333	3	0.333
NERMATEA:	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
PLATYHELMINTHES:	0	0	11.33	0.333	0.667	0.333	15.67	2	0	1.667	0	0	0	0.667	2
ANNELIDA:HIRUDINEA:	0	0	1.333	0.333	0	0	0.333	0	0	0	0	0	0	0	0
ERPOBDELLIDAE:	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0

	IV-1	IV-3	IV-4	IV-5	IV-6	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
Dina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLOSSIPHONIIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alboglossiphoniaheteroclita	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Batracobdelaphalera	0	0	0	0	0	0	0	0.333	0	0	0	0	0	0	0
Glossiphonia	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Glossiphoniacomplanata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glossiphoniaheteroclita	0	0	2.667	0	0	0	2.333	0.667	0	0.333	3.667	0	0	0	0
Gloiobdellaelongata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333
Helobdella	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0
Helobdellafusca	0	0	0	0	0.333	0	0	0.333	0	0	0	0	0	0	0
Helobdellalineata	0	0	0.333	0	0.333	0	0	0	0	0	0	0	0	0	0
Helobdellastagnalis	0	0.333	0	0.667	0	0	0	0	0	0	0	0	0	0	0
Helobdellapapillata	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0
Placobdellaparasitica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNELIDA:OLIGOCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAIDIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arcteonaislomondi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.333
Chaetogasterdiaphanus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333
Naisbretscheri	0	0	0	0	0	0	0	0	0	0	1.333	0	0	0	0
Naiscommunis	0	4	0	0	1.667	0	2.333	0	0	0	0	0	0	0	0
Naisvariabilis	0	5.333	0	0	0	0	0	0	0	0	5.333	3.333	5.333	4.667	0
Naispardalis	0	0	0	0	0	0	3	12.67	0	0.667	3.667	1.333	1.333	2.333	0
Ophidonaisserpentina	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	IV-1	IV-3	IV-4	IV-5	IV-6	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10
Paranaisfrici	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slavinaappendiculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Specariajosinae	0	0	0	0	0	0	9.667	3.667	0	2.667	1.667	0.667	0	0	2.333
Stylarialacustris	0	4	5.333	0	5	0	17.67	13.67	0	17.67	7.667	18.33	4.333	5.333	1.333
Uncinaisuncinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vejdovskyellaintermedia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPARGANOPHILIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	2.667	0.667
Sparganophiluseiseni	0	0	0	0	0	0	0	0	1.667	0	0	0	0	0	0
TUBIFICIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Immature	0	29	14.67	15	39.33	58.67	0.667	0	28.33	1.333	1.333	0	0	25	32.33
Aulodriluspigueti	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0
Aulodruspluriseta	12.33	46.33	21.33	4.333	4.333	16.67	0	0	38.67	10.67	0.667	0.333	0	0	4
Limnodrilushoffmeisteri	0.333	0	0	0.333	9.333	2.667	0	1.333	1.667	0	0	0	0	4	0
Potamothrixvejdovskyella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubifextubifex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Larval fish	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0
Brown mite*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	11.67
Bythotrephes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mysisdiluviana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**58.67**	**772.7**	**355.3**	**214.3**	**797.7**	**163**	**700.3**	**330.3**	**180**	**457.3**	**290**	**302.3**	**385**	**374.7**	**561.7**

	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8
Depth (m)	4	10	12.4	13.9	15.4	21.3	34.8	30.3	5.5	13	32.1	39.1	36.4	28.2	2.2	40.2
DREISSENIDAE:	0	17.33	2.667	38	20	7	0	3	0	191	3.333	0.333	0.333	1.667	0	0
Dreissena polymorpha	29.33	55.33	23.33	70.33	29.67	1.333	0	0	82.67	131.3	0.667	0	0	0	2.333	0
Dreissena bugensis	0	0.333	0.333	1.667	0	0.667	0	0	2.333	59.67	0.667	0	0	0	0	0
SPHAERIIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pisidium spp.	0	1.333	0	0	0	1.333	2	2	0	1	0	2	2.667	0	0	0
MOLLUSCA:GASTROPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANCYLIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ferrissia fragilis	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	0
HYDROBIIDAE:	0	0	0	0	0	0	0	0	0	0.667	0	0	0	0	0	0
Amnicola limosa	3.333	5.333	0	1.333	0	0	0	0	0	0	0	0	0	0	0	0
PHYSIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physa integra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLANORBIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Armiger crista	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyraulus circumstriatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyraulus deflectus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyraulu sparvus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Promenetus exacuous	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALVATIDAE:	0	1.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valvata sincera	0	0	0	1.667	0	0	0	0	0	0	0	0	0	0	0	0
Valvata tricarinata	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0	0
VIVIPARIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8
Bithymia tentaculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHELICERATA:ARACHNIDA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDRACARINA:	39.67	2.667	1.333	0	0	0	1.667	0	1	0	0	0	0	0	0	0.333
ARTHROPODA:CRUSTACEA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DECAPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Orconectes propinquus	2.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAMMARIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinogammarus ischnus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gammarus fasciatus	0	1.333	0	0.667	0.667	0.333	0	0	19.33	0.333	0	0	0	0	0	0
Gammaru spseudolinaeus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gammarus lacustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYALELLIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hyalella azteca	1.667	0	0	0	0	0	0	0	0.333	0	0	0	0	0	15	0
CLADOCERA:	2.333	0	0	0	0	0	0	0	0	0	0	1.667	1.667	0.333	0	1.333
ISOPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASELLIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caecidotea racovitzai	9.333	2.667	3	2.667	0	0	0	0.333	0	1.333	0.333	0	0	0	0	0
Lirceus lineatus	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	0	0
OSTRACODA:	4	25.33	250.7	116.3	17.33	11.33	25	26.33	57	1	6.333	35	22.67	2.333	0	16
COPEPODA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CYCLOPOIDA:	20	12	25.33	79	73.67	117.7	768.3	105	5.333	1	2.333	12.33	3.333	1	0	0.667
HARPACTICOIDA:	5.667	6.667	3	0	0	0	0	0	2	0	0	0.333	0	0	6.667	0

	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8
INSECTA:DIPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CERATOPOGONIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bezzia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Probezzia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphaeromias	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHIRONOMINAE:	30	18.67	20.67	10	11.67	0	0	0	53.33	2	0	0	0	0	10	0
Unknown Pupae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomus (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomus (2 pair ventral tubules)	1.667	5.333	4.667	1.333	10.33	4.667	0.667	0	33.33	17	10	0	0	3.667	4	0
Chironomus (1 pair ventral tubules)	0	0	0	0	0	1.667	0	0	0	0	0	0	0	0	0	0
C. annularius	4	1.333	2.667	1.667	0	0	0	0	0	0	0	0	0	0	0	0
C. salinarius	0.333	0	0.333	0.333	0	21.67	14.33	14.33	5.333	0.667	24	28.33	13.33	28.33	0.333	21.33
Cladopelma (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladopelma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladotanytarsus	0	0	0	0	0	0	0	0	0.667	0	0	0	0	0	0	0
Corynoneura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptotendipes (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptotendipes	0	0	3	0	0	0	0	0	0	0.333	0	0	0	0	0	0
Cryptochironomus	0.667	2.667	1.333	0	0.333	0.333	0	0	0	0.333	0	0	0	0	0	0
Dicrotendipes (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicrotendipes	16	6.667	1	0.667	1.667	0	0	0	35.33	1.333	0	0	0	0.333	6.333	0
Glyptotendipes (tubules absent)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8
Glyptotendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lauterborniella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropsectra (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropsectra	0	0	0	0	0.333	0	0	0	0	0	0	0.333	0.667	0	0	0
Microtendipes (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microtendipes	1.333	0	0.333	0.667	0	0	0	0	8.667	3	0	0	0	0	1.667	0
Nimbocera (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parachironomus tenuicaudatus (Epler)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paratanytarsus (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paratanytarsus	2.667	0	1.667	6.667	2.667	0	0	0	5.667	1	0	0	0	0	53.33	5.333
Paratendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phaenopsectra	0	0	0	0	0	0	0	0	1.333	0	0	0	0	0	0	0
Polypedilum (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polypedilum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psectrocladius (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psectrocladiusflavus (type 1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psectrocladiusvernalis (type 2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudochironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rheotanytarsus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sergentiacoracina	0	0	0	0	0.333	0	0	0	0	0	0	0.333	0.667	0	0	0
Stictochironomus	30.67	2.667	0	0	0	0	0	0	1.667	1	0	0	0	0	0	0
Tanytarsus (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0
Tanytarsus	0	10.67	3	0	2	24	12	9.333	20.67	0.667	7.667	7.333	1.333	8.667	0	0.667

	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8
Tribelos	0	0	0	0	0	0	0	0	9	1	0.667	0	0	0	31	0
Xenochironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIAMESINAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORTHOCLADIINAE (PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus(PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus temulus (Oliver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus cylindraceus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus trifascia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cricotopus	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heterotrissocladius marcidus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PROMIAMESINAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monodiamesia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protanypus	0	0	0	0	0	0	0.333	0	0	0	0	0.667	1	1.333	0	0
TANYPODINAE:	1.333	0	0	0	0.667	0	0	0	0	0.667	0	0	0	0	2.667	0
Ablabesmyia(PUPAE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ablabesmyia	0	0	1.667	0	0	0	0	0	2	0.333	0	0	0	0	0	0
Coelotanypus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conchopolopia	0	0	0	0	0	0	0	0	2.333	0	0	0	0	0	0	0
Larsia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nartarsia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Procladius	0.333	20	6.333	2.667	12	4.333	1	0.667	44	11.67	3	2	1.333	1	3	2
EMPIDIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8
Hemerodromia	0	0	0	0	0	0	0	0	2.333	0	0	0	0	0	0	0
EPHEMEROPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BAETIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAENIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caenis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
EPHEMERIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hexagenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemerella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stenonema	2.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEPIDOPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYRALIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acentria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crambidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEGALOPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SIALIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sialis	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	1.333	0
Climacia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ODONATA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COENAGRIONIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRICHOPTERA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera pupae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDROPTILIDAE:	1.333	1.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agraylea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8
Hydroptila	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0	0
Orthotrichia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxyethira	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEPIDOSTOMATIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidostoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEPTOCERIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceraclea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mystacides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nectopsychealbida	0	0	0	0	0	0	0	0	0.667	0	0	0	0	0	1.333	0
Oecetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocetisosteni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocetiscincerasins	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0	0
Ocetisgeorgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHILOPTAMIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCENTROPODIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neureclipsis	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CNIDARIA:HYDROZOA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDRIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydra spp.	0	0	0	0	0	0	0	0	0	3.667	0	0	0	0	0	0
NEMATODA:	1.333	0	0.333	0	0	0	0	0	0.667	0	0	0	0.333	6.333	0	0
NERMATEA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLATYHELMINTHES:	1.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNELIDA:HIRUDINEA:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8
ERPOBDELLIDAE:	0	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLOSSIPHONIIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alboglossiphoniaheteroclita	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Batracobdelaphalera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glossiphonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glossiphoniacomplanata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glossiphoniaheteroclita	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gloiobdellaelongata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helobdella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helobdellafusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helobdellalineata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helobdellastagnalis	0	1.333	0.333	0.333	0.333	0	0	0	0	0	0	0	0	0	0	0
Helobdellapapillata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Placobdellaparasitica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNELIDA:OLIGOCHAETA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NAIDIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arcteonaislomondi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaetogasterdiaphanus	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0	0
Naisbretscheri	5.333	0	0	0	0	0	0	1.333	1.333	0	0	0	0	0	0	0
Naiscommunis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naisvariabilis	1.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naispardalis	1.333	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0

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	VI-1	VI-2	VI-3	VI-4	VI-5	VI-6	VI-7	VI-8	VII-1	VII-2	VII-3	VII-4	VII-5	VII-6	VII-7	VII-8
Ophidonaisserpentina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paranaisfrici	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slavinaappendiculata	0	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0	0
Specariajosinae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stylarialacustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uncinaisuncinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vejdovskyellaintermedia	0	0	0	0	0	0	2.667	0	0	0	0	0	0	0	0	0
SPARGANOPHILIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sparganophiluseiseni	0	0	0	0	0	0	0	0	6.667	0	0	0	0	0	0	0
TUBIFICIDAE:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Immature	95.67	117.3	48.67	35	33.67	5.333	4	1.333	111.3	59.67	14.33	2.333	0.333	7.667	18.67	0
Aulodriluspigueti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aulodriluspluriseta	7.333	13.33	0	2.667	5	12.33	0.333	0	35	27	3	0.333	0	0	0	0
Limnodrilushoffmeisteri	4.333	0	5.667	3	3	0	1	0	0	0	2.333	0.333	0.667	0	0	0.333
Potamothrixvejdovskyella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tubifextubifex	0	0	0	0	0	0	3.667	0	11.33	0	1.667	4.667	0.333	4.667	8	28.33
Larval fish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown mite*	0	0	0	0	0	0	0	0	1.333	0	0	0	0	0	0	0
Bythotrephes	0	0	0	0	0	0	0	0.333	0	0	0	0.333	1	0	0	1.333
Mysisdiluviana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333
Total	**337.7**	**333.3**	**411.3**	**377**	**225.3**	**214**	**837**	**164**	**565.7**	**519.3**	**80.67**	**99.33**	**51.67**	**67.67**	**168.7**	**78**

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