# INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

**The quality of this reproduction is dependent upon the quality of the copy submitted.** Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

**UMI**

A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600

Université d'Ottawa · University of Ottawa

National Library of Canada
Acquisitions and Bibliographic Services
395 Wellington Street
Ottawa ON K1A 0N4
Canada

Bibliothèque nationale du Canada
Acquisitions et services bibliographiques
395, rue Wellington
Ottawa ON K1A 0N4
Canada

*Your file Votre reference*

*Our file Notre reference*

The author has granted a non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de cette thèse sous la forme de microfiche/film, de reproduction sur papier ou sur format électronique.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

L'auteur conserve la propriété du droit d'auteur qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

0-612-28445-X

Canada

# Relationships between Composition and Size Distribution of Invertebrates Colonizing Navigation Buoys and Physico-chemical Parameters of the St. Lawrence River, Montreal (Quebec).

© Vincent Mercier

## Acknowledgements

First and foremost I would like thank my supervisors Drs. Antoine Morin and Christiane Hudon for their guidance and patience in seeing this work through. I would also particularly like to thank Chantal Vis who was indispensable for preparing the field sampling and providing data and information, Dr. Hans Damman for his beneficial comments, Aline Sylvestre, Sophie Wong, Kim Desrochers and Thierry Danserault for their technical assistance in the field and the lab. I am grateful to the laboratories of the Centre Saint-Laurent (Montreal, Quebec) for providing chemical analyses and field equipment and to Biomedico, Inc., for conducting fecal coliform counts.

Furthermore, I would like to express my gratitude to my family and friends and particularly to the students from the Currie, Pick, Morin, Chapleau and Moon labs for their advice and understanding, but most of all for the friendships that we have developed over the last two years. Special thanks to Mylène, not only for proofreading my thesis with a fine toothed comb, but also for sharing the finer moments of this experience, and seeing me through the occasional frustration.

Funding for this project was provided by an N.S.E.R.C. grant to Dr. Antoine Morin, by the Ontario Government (O.G.S.) and by the St. Lawrence Center of Environment Canada, for providing labour, equipment and analyses.

## Abstract:

Water, algae and invertebrates colonizing navigational buoys at 18 sites in the Montreal area of the St. Lawrence River were sampled during the spring, summer and fall of 1995 to assess which measures of invertebrate assemblages (density, biomass, size distribution, and taxonomic composition) best respond to wastewater discharge and to compare invertebrate responses among sampling dates. Increases of up to five orders of magnitude in fecal coliforms, 2-fold increases in TP and $PO_4$, 20-fold increases in $NH_4$ concentration and 2-3-fold decreases in water clarity (Secchi depth, suspended matter) were found downstream of point sources of urban wastewater discharge. Despite these physico-chemical changes, invertebrate assemblages were only weakly related to wastewater exposure, since DFA on composition and size distribution only correctly classified 44-61% of sites into groups based on fecal coliform concentration for all four sampling dates. Fecal coliforms were best predicted by Chironomidae, other Diptera and Nematoda density in the fall (mult. reg. adj.$r^2$=0.69, $p<0.001$), density of invertebrates in the size class 4-8 μg in the fall (adj.$r^2$=0.65, $p<0.001$), and total invertebrate density (adj.$r^2$=0.75, $p=0.002$) in the spring. Periphyton biomass, suspended matter concentration and current velocity were the main environmental correlates of invertebrate composition and size distribution patterns in the fall. The moderate response of invertebrates suggest that they are not very useful bioindicators of wastewater exposure in the St. Lawrence River at the present range of exposure levels.

In the second chapter, spatio-temporal patterns of buoy invertebrate and algal size distributions were investigated, in relation to trophic gradients in the river. The size

distributions were not significantly related to physico-chemical parameters of the river, although variability in the data may have been too high to detect trophic effects. Size spectra on buoys, despite the fact that protozoans were not accounted for, had striking similarities with other complete size distributions (containing algae, protozoans and invertebrates) from stream, lake and marine littoral zones. The results suggest that size distributions, determined over broad size ranges, are relatively robust to environmental conditions and are impractical for assessing ecological degradation because of the labour required to obtain precise measurements.

## Résumé:

L'eau, ainsi que les algues et les invertébrés colonisant les bouées de navigation du fleuve Saint-Laurent, ont été échantillonnés du printemps à l'automne 1995, à dix-huit sites dans la région de Montréal. Les objectifs du premier chapitre étaient de déterminer quelles mesures des ensembles d'invertébrés (densité, biomasse, composition taxonomique et structure en taille) répondaient le mieux aux décharges d'eaux usées et de comparer ces réponses entre les dates d'échantillonnage. Des augmentations allant jusqu'à 5 ordres de grandeur en coliformes fécaux, 2x en concentration de PT et de $PO_4$ et 20x en $NH_4$, accompagnées par des diminutions de 2-3x de la transparence de l'eau (profondeur Secchi et matière en suspension) ont été trouvées en aval des sources ponctuelles de décharges d'eaux usées municipales. Malgrés ces changements physico-chimiques, les ensembles d'invertebrés n'étaient que faiblement corrélés aux eaux usées, puisque la composition taxonomique et la distribution en taille n'ont classifiées que 44-61% des sites correctement en groupes de coliformes fécaux pour les quatres dates d'échantillonnage. Les paramètres qui prédisaient le mieux les concentrations de coliformes fécaux étaient les densités de chironomides, autres diptères et nematodes de septembre (reg. mult. adj.$r^2$=0.69, $p<0.001$), la densité d'invertébrés dans l'intervalle de taille 4-8 µg de septembre (adj.$r^2$=0.65, $p<0.001$) et la densité totale d'invertébrés de mai (adj.$r^2$=0.75, $p=0.002$). La biomasse de périphyton, les matières en suspension et la vitesse du courant étaient les principaux paramètres environnementaux expliquant les changements en composition et de structure en taille. Ces réponses modérées par les invertébrés suggèrent que leur utilité comme bioindicateurs d'exposition aux eaux usées dans le fleuve Saint-Laurent est limitée à l'étendue actuelle des niveaux d'exposition.

Dans le second chapitre, les patrons spatio-temporels des structures en taille des algues et invertébrés colonisant les bouées, ainsi que leurs changements selon le gradient trophique du fleuve, dans la région de Montréal, ont été examinés. Les distributions en taille n'étaient pas significativement corrélées aux paramètres physico-chimiques du fleuve, par contre les niveaux de variabilité étaient probablement trop élevés pour pouvoir détecter ces effets trophiques, s'ils existaient. Les distributions provenant des bouées, même sans tenir compte des protozoaires, avaient une surprenante similarité avec d'autres distributions complètes (celles ayant des protozoaires, algues et invertebrés) provenant de ruisseaux, lacs et zones littorales marines. Les résultats suggèrent que les distributions, déterminées pour une grande étendue de taille d'organismes, sont relativement robustes aux conditions environnementales. De plus, les efforts requis pour obtenir des mesures précise rendent les spectres inefficaces à l'évaluation d'impacts écologiques.

## Contents

**Acknowledgements** ..... ii

**Abstract:** ..... iii

**Résumé:** ..... v

**List of Figures** ..... ix

**List of Tables** ..... x

**General Introduction** ..... 1

**Chapter 1:** Invertebrate communities on navigation buoys as an indicator of wastewater discharge in the Montreal area of the St. Lawrence River ..... 5

Introduction: ..... 6
Methods: ..... 9
Results: ..... 15
Discussion: ..... 22
Conclusion ..... 27
Tables and Figures ..... 28

**Chapter 2:** Patterns in invertebrate and periphyton size distributions from navigation buoys in the St. Lawrence River ..... 42

Introduction ..... 43
Methods ..... 45
Results and Discussion ..... 48
Tables and Figures ..... 53

**General Conclusions** ..... 60

**References** ..... 63

**Appendix A:** Density of invertebrate taxa (ind.cm$^{-2}$) of each replicate collected on each navigation buoy for May, June, August and September sampling dates ..... 77

**Appendix B:** Physicochemical measurements made at each navigation buoy for May, June, August and September sampling dates ..... 84

**Appendix C:** Allometric relationships for the conversion of invertebrate lengths (mm) to dry mass (µg), conversion factors for weight measurements and biomass/density calculations ..... 89

**Appendix D:** Invertebrate density (ind.$m^{-2}$) per size class ($log_{10}$ upper limit) for each taxa of each replicate from September, 1995 ..... **91**

**Appendix E:** Invertebrate and algal density (ind.$m^{-2}$) per size class ($log_{10}$ upper limit) for each taxa of each replicate from May, June, August and September, 1995..... **110**

**Appendix F:** Classification and jackknifed classification matrices for the buoys sampled in May, June, August and September based on fecal coliform groups using density of 3 taxa ($log_{10}$ transformed) and density from 3 size classes ($log_{10}$ transformed) from September ..... **113**

**Appendix G:** Component loadings of the first two eigenvectors from the principal component analysis of the density of all taxa ($log_{10}$ transformed), collected in September 1995 ..... **117**

## List of Figures

Fig. 1.1. The sampling sites in the Beauharnois Canal (upstream) and the green water mass of the St-Lawrence River in Montreal. ..... 28

Fig. 1.2. Average (±SE) total phosphorous, suspended matter and fecal coliform concentration for three regions of the St. Lawrence River for each sampling date. ..... 33

Fig. 1.3. Relative density (%) of dominant taxa throughout the sampling season..... 35

Fig. 1.4. PCA factors 1 and 2 showing the ordination of buoys (n=18) based on density ($log_{10}$ transformed) of the 9 invertebrate taxa, sampled in September 1995. ..... 37

Fig. 1.5. Average size distributions of invertebrates belonging to 3 water quality groups of buoys, sampled in September 1995. Average relative density per size class (%) of the 3 or 4 most dominant taxa of September assemblages, for the 3 water quality groups (lower panels). ..... 38

Fig. 1.6. Size distributions predicted by polynomial model (table 3) for low and high values of each parameter. ..... 40

Fig. 2.1. Size ranges for dominant groups of organisms found colonizing navigation buoys. The Chlorophyceae group does not include *Cladophora*. ..... 55

Fig. 2.2. Average dry biomass (±SE, $log_{10}$ transformed) of organisms per size class (left panel) and average biomass of invertebrates (empty bars) and algae (filled bars) per size class (right panel). ..... 56

Fig. 2.3. Density of invertebrates and algae per size class colonizing buoys for each sampling date in 1995. ..... 58

Fig. 2.4. Size distributions of invertebrates and algae from St. Lawrence River buoys and protozoans, algae and macroinvertebrates from lakes (Cattaneo 1987), marine littoral zones (Schwinghammer 1981) and temperate streams (Cattaneo 1993)..... 59

## List of Tables

Table 1.1. Mean (±SD) physico-chemical characteristics for five groups of buoys by water quality, measured throughout the sampling season. Groups are based on fecal coliform concentration (UFC/100 mL). ..... 30

Table 1.2. Pearson correlation coefficients, along with their p-values, for the correlations between fecal coliform concentration and the physico-chemical variables, for each of the sampling dates. ..... 32

Table 1.3. Multiple regression models predicting fecal coliform concentration ($log_{10}$ transformed) from invertebrate taxa densities for each sampling date and from size classes for September assemblages. ..... 36

Table 1.4. Polynomial regression model, for September 1995, describing invertebrate density ($log_{10}$ transformed) per size class ($ind.m^{-2}$) as a function of dry mass (M, in µg dry mass), chlorophyll a (Chla, in µg $m^{-2}$), suspended matter (S, in mg/L), current velocity (C, in m $s^{-1}$) and ammonia ($NH_4$, in µg/L) (n=342, $r^2$=0.65, RMS=0.09). * $p < 0.0001$. ..... 41

Table 2.1. Polynomial regression model parameters describing invertebrate and algae $log_{10}$density per size class (ind. $m^{-2}$) as a function of dry Mass (M, µg ) (adj. $R^2$=0.83, RMS=1.23, n=198). Note that TP and the interaction TP*M were not significant parameters in the model. ..... 54

## List of abbreviations

AFDW - Ash Free Dry Weight ($mg/cm^2$)

DFA - Discriminant Function Analysis

DM - Dry Mass ($\mu g$)

ESD - Equivalent Spherical Diameter ($\mu m^3$)

MUC – Montreal Urban Community

NSD - Normalized Size Distribution (biomass/mass interval) ($mg/m^2$)

PCA - Principal Components Analysis

TP - Total Phosphorous ($\mu g/l$)

UFC - Units of Fecal Coliform (cells/100ml)

# General Introduction

**General Introduction:**

Public concerns over the degrading state of ecosystems have sparked a critical need for developing cost-effective tools that enable us to properly assess and predict anthropogenic impacts on our fresh water resources (Schindler 1987, Karr 1993, Hart 1994, Naiman et al. 1995). We are further challenged with the need to use these environmental assessment tools to manage water resources in ways that protect human health and ecological integrity, while integrating long-term economic development (Courtemanch 1994). One of the most important ecological applications to reappear lately which could meet these environmental challenges is ambient biological monitoring (Courtemanch 1994, Hart 1994). This potentially powerful tool makes inferences about environmental quality through the structural and functional responses of individuals, communities or ecosystems to ambient conditions. In fact, national biomonitoring protocols were implemented to guide management decisions in the United-States (EMAP, U.S. EPA 1990; NAWQA, Gurtz 1994; BEST, IFTM 1992) and U.K. (RIVPACS, Armitage et al. 1983), with New-Zealand, Canada and Australia in the planning stages. For these initiatives to work in improving resource management, biological monitoring must rest on sound ecological concepts (Schindler 1987, Hart 1994). Therefore, as academic biologists, it is essential to assume more direct responsibilities in using the theory we develop by bridging the gaps between basic and applied research (Hart 1994) and by dealing directly with decision makers (i.e. government, environmental agencies and the general public) to promote our ideas (Schindler 1987, Naiman et al. 1995).

In Canada, one of our most important natural resources, which provides us with indispensable goods and services, is the St. Lawrence River. The river, along with the Great-Lakes watershed (area 1.61 million $km^2$), contains 25% of the world's fresh water supply (Inland Waters Directorate 1990) from which 46% of Quebecers draw their drinking water (SLC 1996). The watershed has a rich diversity of habitats which include shallow lakes with reed beds, deep channels, freshwater, brackish water and saltwater areas, with well over 1645 species of plants, fish, mammals and birds (SLC 1996). From an economical perspective, the river provides shipping transport (revenue of $1.2 billion in 1990, Ports Canada 1991), electricity (4489 MW annually, SLC 1996), commercial fishing and aquaculture ($200 million in 1992, Fisheries and Oceans 1992), and tourism and recreation (annual revenue of $3 billion, SLC 1996). However, these uses come at the cost of altered basin morphology and hydrologic conditions, overharvesting of aquatic species and the release of municipal and industrial wastewaters (annual cost ?). Most of the socioeconomic activity of the river, along with the potential for ecological impact, is concentrated in the fluvial section which stretches from Cornwall to Trois-Rivières, and more precisely in the Metropolitan Montreal area, which has about 3 million inhabitants (close to 50% of Quebec's population). In an effort to reduce point sources of pollution in the St. Lawrence River, the Montreal Urban Community (MUC) has recently (1994-95) upgraded its wastewater treatment facilities of municipal and industrial effluents (Purenne 1996). To determine whether the ecological integrity of the St. Lawrence River has been affected, and following efforts at reducing pollution caused by MUC wastewater discharges, bioassessment field studies[1] were conducted in collaboration with the St. Lawrence Center, a section of Environment Canada, in Montreal.

[1]See Vis (1997) for complementary biomonitoring study.

The broad objective of the present thesis is to evaluate cost-effective, easily replicable biological indicators of wastewater discharge in the Montreal area that would complement routine physical (e.g. suspended solids), chemical (e.g. TP) and microbial (e.g. fecal coliforms) monitoring of wastewater discharge in the St. Lawrence River. The first chapter specifically deals with the development of indicators using the responses in composition and size distribution of invertebrate assemblages colonizing buoys downstream of storm sewer overflow and treated effluent discharge into the river. In the second chapter, the spatio-temporal variability of size distribution composed of algae and invertebrates colonizing buoys, were examined, along with their relationships to trophic gradients. Size distributions can potentially provide useful community measures for use in environmental assessments that avoid the taxonomic expertise normally required for invertebrate identification (Morin et al. 1995) and that are easily comparable across ecosystems and among ecoregions (Strayer 1991, Cattaneo 1993, Poff et al. 1993).

# Chapter 1:

## Invertebrate communities on navigation buoys as an indicator of wastewater discharge in the Montreal area of the St. Lawrence River

**Introduction:**

Water quality monitoring in large rivers bordering on urban areas has become mandatory in many countries, but remains problematic and costly because water quality is an encompassing term. Monitoring activity has thus far generally been focused on characterizing the physical (e.g. turbidity), chemical (e.g. nutrients and pollutants) and/or bacteriological (e.g. fecal coliforms) aspects of the water to infer potential impact to human health and aquatic life (Reynoldson and Metcalfe-Smith 1992). This approach is limited, however, because monitoring programs can focus only on a small subset of the multitude of possible factors affecting water quality. Moreover, these aspects alone provide little information on the biological impacts of polluted waters. Multiple contamination sources (i.e. industrial, municipal and agricultural (Johnson et al. 1995)) often generate a mixture of pollutants (e.g. trace metals and nutrients) that varies in time and space (Sweeting 1994, Cairns et al. 1993, SLC 1996). It is therefore important to measure biological responses to water quality because organisms integrate these multiple and cumulative effects (Cook 1976, Cairns et al. 1993).

It has become standard practice to use benthic invertebrates for the bioassessment of streams and small rivers. Many characteristics of invertebrate assemblages have been used as indicators of water quality in aquatic habitats (See Armitage et al. 1983, Washington 1984, Cairns et al. 1993, Rosenberg and Resh 1993, Suter 1993, Kerans and Karr 1994). Density and biomass of whole assemblages and/or specific taxa often respond to degraded water quality (e.g. tubificid worms and organic enrichment (Resh 1995)) and are routinely used in the multimetrics developed for the United States Environmental Protection Agency (U.S. EPA)

bioassessment protocols (e.g. Kerans and Karr 1994, Barbour et al. 1996). Metrics based on the size distribution of organisms forming the assemblages have also been proposed to streamline the process by reducing the taxonomic expertise required (Morin et al. 1995). However, it is unclear whether these indicators, generally developed for streams and small rivers, are sensitive enough to be useful in large rivers, where large volumes of water can dilute pollutants and narrow pollution gradients.

Indeed, previous studies on the use of St. Lawrence River invertebrates as water quality indicators have failed to show any clear pollution response patterns (Ferraris 1984, Pinell-Alloul et al. 1996, Willsie and Costan 1996). However, whether this lack of association between invertebrate assemblages and water quality is due to the low signal/noise ratio or simply to a lack of response by invertebrates remains unknown. The large sampling variability, the weak contaminant gradients, and the unaccounted effects of physical factors, such as current, seasonality and turbidity, could all have led to low signal/noise ratios.

In our study we have attempted to maximize the signal/noise ratio to assess the relationship between invertebrate community structure and exposure to wastewater discharges. We used invertebrates colonizing navigation buoys while maximizing the gradient of exposure to stormwater and municipal wastewaters (as reflected by fecal coliform concentration, Geldreich 1978, Purenne 1996). Buoys were selected because they provide a standardized habitat among sites (Rosenberg and Resh 1982), and because the invertebrate assemblages developing on buoys are exposed to very localized physical and chemical water conditions, integrated over the colonization period (approximately six months).

The objectives of this study were 1) to quantify the relationships between characteristics of the invertebrate assemblages (density, biomass, taxonomic composition and size structure) and fecal coliform concentration (used as a proxy for wastewater exposure), 2) to describe how these relationships vary throughout the ice-free season, and 3) to determine which environmental characteristics, other than coliform concentration, are best correlated with taxonomic composition and size distribution.

**Methods:**

*Study site*

The sampling sites were located in two distinct areas of the St. Lawrence River in Quebec: the Montreal area (45°33'N,73°30'O - 45°53'N,73°15'O) and the Beauharnois Canal (45°13'N,74°09'O), an area approximately 20 km upstream of Montreal (fig. 1.1). All sampling sites are in the waters of the St. Lawrence River, which drains the Great Lakes watershed and constitute roughly 80% of the discharge downstream of Montreal (7000 $m^3s^{-1}$) (Environment Canada 1996). The water in this stretch of the river is clear (average Secchi depth 3.2 m), strongly mineralized (average conductivity 266 µS/cm), mesotrophic (average TP 16 µg/L) and generally fast flowing (average current velocity 0.9 m $s^{-1}$).

In the Montreal area, the river receives liquid wastes from the approximately 2.1 million people inhabiting Montreal Island and its surrounding municipalities, and from industries such as pulp and paper mills and metallurgical, petrochemical, organic and inorganic chemical, agri-food and textile plants (St. Lawrence Action Team 1992, CERS 1996, MUC 1996, SLC 1996). In 1995, the Ile Charron wastewater treatment plant serving the community of Longueuil on the south shore released domestic and industrial effluents at a mean rate of 3 $m^3s^{-1}$ (CERS 1996) (fig. 1.1). The Montreal Urban Community (MUC) discharged domestic and industrial effluent at the Ile aux Vaches treatment plant at an average of 23 $m^3s^{-1}$(MUC 1996). Until it was diverted to Ile aux Vaches in August, 1995, one collector released wastewater directly into Montreal Harbour. Raw wastewater is still periodically discharged into the harbour and along the south shore from storm sewer overflows during rainfall events

(Deschamps et al. 1997). Sampling sites located in the Beauharnois Canal (upstream) are not impacted by urban wastewater discharge and therefore served as reference sites.

The Montreal Urban Community has a combined sewer system, whereby, surface runoff and municipal sewage are transported to the Ile aux Vaches wastewater treatment plant under normal flow conditions (Purenne 1996). In high flow periods, where volumes exceed treatment plant capacity (i.e. under heavy precipitation), some wastewaters are dicharged into the Montreal harbour from storm sewer collectors. Wastewater treatment begins with chemical flocculation using ferric chloride and an anionic polymer, followed by sedimentation. This process is designed to reduce suspended solids and total phosphorous discharge. Consequently, automated monitoring of treated effluents, at the outflow, revealed that total phosphorous and suspended solid concentrations were 79% and 85% lower than in the original wastewaters, respectively (Purenne 1996). MUC monitoring also measured important concentrations of BOD, COD, alkalinity, coliforms (including fecal coliforms), iron, aluminum, and oils and greases in the outflow (Purenne 1996). Other chemicals which are expected to be discharged include: nutrients (e.g. ammonia), metals (e.g. copper, zinc) (Chambers et al. 1997) and organic compounds (e.g. PCBs and PAHs), which may be toxic and highly persistent even at low concentrations (Pham and Proulx 1996).

*Sampling design and sample processing*

Invertebrate sampling was conducted on navigation buoys. These red metallic buoys, which range from 0.8 to 1.4 m in diameter, are placed in the river each spring, in April or May, just after ice breakup. They remain in the water until late fall when they are retrieved to be

cleaned and repainted over the winter months. We sampled 9 buoys on May 7$^{th}$, 17 on June 7$^{th}$, 18 on August 1$^{rst}$ and 18 on September 26$^{th}$, 1995. Triplicate samples of invertebrate communities were collected from each buoy 20 cm below the water surface using a specially designed sampling apparatus (Vis 1997). The sampling device allowed a surface of 45.6 cm$^2$ to be brushed clean of invertebrates and periphytic algae and transferred into a glass jar. In the field, the collected material was sonicated for 10 min and aliquots were retained for algal taxonomy and chlorophyll *a* analysis before adding formaldehyde for preservation.

In the laboratory, invertebrates were sorted from the collected material under a dissecting microscope at 12 - 25X. Samples that contained more than 200 individuals were divided into smaller fractions using a Folsom plankton splitter, until there remained at least 100 individuals. The invertebrates were categorized by broad taxonomic group: Nematoda, Chironomidae, Diptera, Ephemeroptera, Trichoptera, Amphipoda, Copepoda, Acarina and Oligochaeta. Organisms from the September sampling date were then measured using an image analysis system (±0.01 mm). Allometric equations were used to estimate individual dry masses of Diptera, Chironomidae, Ephemeroptera, and Trichoptera (Smock 1980, Meyer 1989), Amphipoda (Marchant and Hynes 1981), Copepoda (Culver et al. 1985) and Oligochaeta (Ladle and Bird 1984, Lafont 1987, Lindegaard et al. 1994). Acarina and Nematoda dry mass were estimated by DM (µg) =1 L$^3$ (mm) (Morin and Nadon 1991). Density and biomass of invertebrates were determined by dividing the total number of organisms or their total mass by sampling surface (0.0045 m$^2$). Size distributions of invertebrate communities, from each replicate, were quantified by grouping organisms into 19 logarithmic size classes of individual dry mass ranging from $2^{-6}$ to $2^{12}$ µg.

Periphytic algal biomass on buoys was estimated from chlorophyll *a* concentrations (Bergman and Peters 1980). Ash free dry mass (AFDM) of organic matter on buoys was determined using the methodology of Wetzel and Likens (1981), from periphytic samples, once invertebrates were removed.

*Physical and chemical measurements*

At each sampling site and date, a series of physical and chemical measurements were performed to characterize the water. Water temperature, conductivity, and pH were measured using a portable hydrolab at a constant depth of 20 cm in the water surrounding the buoys. Current velocity was measured using PVM.2A Montedoro Whitney and Price 622A current meters. Water transparency was estimated by measuring both the light extinction coefficient using Li-Cor, Li-1000 light meter and Secchi depth. Triplicate water samples were collected 20 cm below the surface to estimate suspended matter, $NO_2 + NO_3$, $NH_4$, total phosphorus, $PO_4$, and $SiO_2$ concentrations, which were analysed in the St. Lawrence Centre laboratories using standard methods (Environment Canada 1993). Fecal coliform concentration was estimated from underwater agar plate counts at Biomedico labs, within 24 hours of sample collection (APHA 1995).

*Statistical analyses and model fitting*

Replicate biological, chemical and physical measurements taken on each buoy and at each sampling time were averaged for the statistical analyses. When taken within the same site,

these measurements are spatially autocorrelated and would violate the assumption of independence in statistical analyses (Legendre 1993).

Groups of buoys associated with different concentrations of fecal coliforms were characterized using discriminant function analysis (DFA) with respect to the taxonomic composition and size distribution of invertebrates found on them. Buoys were separated into five levels of fecal coliform concentration corresponding to criteria for drinking water (< 3 UFC/100 mL), swimming and water-contact sports (3–200 UFC/100 mL) (MEQ 1990), and 200–2000, 2000–20 000 and > 20 000 UFC/100 mL. DFA allowed for the comparison of two sets of variables (size distribution and taxonomic composition) in discriminating among groups, to explore the similarities among groups and to test multivariate differences among those groups (Wilkinson et al. 1996). We assessed the validity of the classification functions by examining the jackknife classification matrix, a form of cross-validation which reclassifies the sites by leaving out one case at a time (Wilkinson et al. 1996). Three taxa and three size classes only were used to classify water quality groups in each case because of the low number of replicates in most groups (Wilkinson et al. 1996). The three taxa and classes selected for the analyses, following preliminary tests, were the ones which discriminated the most among water quality groups based on the F to remove statistic in the DFA output (Wilkinson et al. 1996).

The spatial variability in the taxonomic composition of invertebrates was described using principal component analysis (PCA) on the densities of the taxa for each of the four sampling dates (Wilkinson et al. 1996, Manly 1986). Densities were transformed prior to PCA analysis to normalize data and to stabilize variance between sites. To assess which variables

affect the spatial distribution of the invertebrates, multiple regression analysis was performed, using PCA factors as dependent variables and the physical/chemical measures of each site as the independent variables.

The effects of environmental characteristics on the amplitude and shape of the size distribution of the invertebrates was assessed by fitting their distributions to polynomial regression models (Bourassa and Morin 1995). The models include the physical (e.g. current velocity in m $s^{-1}$), chemical (e.g. TP, in µg/L) and biological (e.g. chlorophyll *a*, µg/$m^2$) parameters of each site, as well as their first order interactions (e.g. TP x current velocity) and their interactions with individual dry mass (M, µg x TP), as the independent variables predicting density of invertebrates per size class. Since some size classes contained no organisms, density was transformed using $\log_{10}$ (density + 167) (see above), which stabilized residual variance among sites and size classes. Regression analyses were based on 342 observations for September (19 size classes x 18 sites).

All statistical analyses were done using Systat 6.0 for Windows (Wilkinson et al. 1996) on IBM-compatible computers.

**Results:**

*Water quality in the Montreal area*

The discharge of urban wastewater in the Montreal area had a clear effect on water quality, both spatially and seasonally. There was a gradual decrease in fecal coliform concentration within the MUC effluent plume in a downstream direction (groups 4 and 5, table 1.1) and a 5 order of magnitude increase between the reference sites and sites located downstream of Montreal (table 1.1, fig. 1.2). Nutrients (TP) and water clarity (suspended matter) varied throughout the season with a gradual narrowing of environmental gradients from June to September (fig. 1.2). Improvements in water quality were also apparent with the diversion of the last wastewater collector from Montreal Harbour to the Ile aux Vaches treatment facility in August, 1995 (fig. 1.2). In fact, four of the five buoys located in the harbour had at least an order of magnitude decrease in coliforms in September (> 200 UFC/100 mL) (fig. 1.2).

The upstream sites had the lowest fecal coliform concentrations (< 3 UFC/100 mL), lowest nutrient (TP ~10 and ammonia ~6 µg/L) and suspended matter (~1.4 mg/L) concentrations and clearest water (Secchi depth ~7.3 m) (table 1.1). Sites located in the St. Lawrence Seaway and Montreal Harbour (except for September) (group 3) generally exhibited intermediate coliform concentrations (200–2000 UFC/100 mL), mid-range levels of nutrients (TP ~15 and silicates ~831 µg/L) and suspended matter (~3.8 mg/L), and lower water clarity (Secchi depth ~2.1 m). The two buoys in group 5, located just downstream of the MUC outfall (fig. 1.1), had the highest levels of coliforms (> 20 000 UFC/100 mL), highest TP and

ammonium (~25 and 135 µg/L) and suspended matter (4.5 mg/L) concentrations and low water clarity (Secchi depth ~2.3 m) (table 1.1).

Silicates, total phosphorous, Secchi depth, light transmission coefficient, and suspended solids were generally significantly correlated with fecal coliform concentration throughout the season (table 1.2). Ammonium was significantly correlated with fecal coliforms in June and nearly significantly correlated in August and September. By contrast, current velocity, conductivity, nitrate/nitrite, dissolved inorganic phosphorous and measurements of periphyton biomass on buoys (chlorophyll *a* and AFDM) were generally not correlated with coliform concentration (table 1.2).

*Taxonomic composition and seasonal trends*

Approximately 32 000 invertebrates were collected and identified during the four sampling sessions in 1995. The density of invertebrates increased dramatically from May assemblages (300 ± 100 ind./$m^2$) to those sampled in June (42 800 ± 16 600), August (32 200 ± 12 800) and September (63 400 ± 27 200).

Although the overall abundance of invertebrates did not change significantly between the last three sampling dates, important shifts in taxonomic composition did occur. May and June invertebrate assemblages were numerically dominated by chironomids while nematodes dominated the September assemblages (fig. 1.3). August assemblages had similar abundance of oligochaetes, nematodes and chironomids: all three made up the bulk of these communities (fig. 1.3). Except for the early assemblages sampled in May, Amphipoda, Diptera,

Ephemeroptera, Trichoptera and Copepoda had more or less constant low relative abundances throughout the sampling season.

*Fecal coliform group classification using size distribution and taxonomic composition*

Invertebrate composition and size distribution could be roughly related to fecal coliform contamination level by using DFA for each sampling date. Abundance of three taxa could be used to correctly classify 7 out of 9 buoys (78%) for May, 14 out of 17 buoys (82%) for June and 14 out of 18 buoys (78%) for both August and September. Invertebrate density in three size classes (0.062, 0.125 and 250 µg) classified 15 out of 18 buoys (83%) for September (see Appendix F for detailed results of DFA).

The sound performance of the DFA in assigning sites to the proper category of fecal coliform contamination is probably somewhat misleading, since cross-validation of the classification yielded lower accuracy. The jackknife classification matrix indicated that 56% of buoys in May, 59% in June, 61% in August and 56% in September were correctly classified based on three taxa and that 44% of buoys were correctly classified in September based on size classes. Analyses using more taxa or size classes for estimation of classification function yielded inferior cross-validation results.

A reanalysis of the September classification of buoys, with exclusion of the five harbour sites, was conducted using taxonomic composition. This was done to verify that harbour sites did not muddle DFA classification since the important reductions in fecal coliform concentrations in the harbour, in September, created an additional water quality group (group

2, table 1.1). Moreover, invertebrate assemblages observed on harbour buoys in September may certainly have been a reflection of the physico-chemical conditions prior to September. However, the results of the jackknife classification revealed that 62% of buoys were correctly classified, which is only slightly higher than the results of the original DFA for September.

*Invertebrate indicators of wastewater discharge*

In order to develop useful models of invertebrate response to wastewater discharge, direct linear relationships between invertebrate abundance and fecal coliform concentration were tested using multiple regression analysis, for each of the sampling dates (table 1.3). September invertebrates were found to have the best linear relationships since they had relatively high adj. $R^2$ and low residual mean squared error (table 1.3). Fecal coliform concentration in September could best be predicted from nematode, chironomid and other Diptera density ($log_{10}$ transformed) and from the density of all invertebrates in the size class 8–16 µg ($log_{10}$ transformed). Density of all invertebrates in May also had a strong positive relationship with coliforms (table 1.3), but this relationship was strongly influenced by one particularly low density value.

*Environmental correlates of invertebrate community structure for September*

*1) Taxonomic composition*

Invertebrate assemblages found in September were numerically dominated by Nematoda (~45 000 ind.$m^{-2}$), followed by Chironomidae (~8000 ind.$m^{-2}$) and Oligochaeta (~4000 ind.$m^{-2}$). Biomass of these communities was mainly composed of Chironomidae (~450 mg DM·$m^{-2}$), Ephemeroptera (~120 mg DM·$m^{-2}$) and Amphipoda (120 mg DM·$m^{-2}$).

Periphyton biomass, current velocity, and suspended matter concentration were the strongest environmental correlates of taxonomic composition of assemblage change on buoys. The first two orthogonal vectors of a principal component analysis of the taxonomic data (density of individuals per taxa for each site) explained 59% and 19% of the variability, respectively (fig. 1.4; see loading in appendix G). The first vector (factor 1), representing overall invertebrate abundance, was positively correlated to periphyton chlorophyll *a* and suspended matter (n=18, $r^2$= 0.80, RMS=0.2, $p<0.001$). The second vector (factor 2), an index of taxonomic composition, was positively correlated to current velocity and to suspended matter (n=18, $r^2$= 0.85, RMS=0.15, $p<0.001$). Therefore, buoys with higher concentrations of suspended matter and higher current velocity had higher relative abundance of Chironomidae and Ephemeroptera, whereas sites with low suspended matter and low current velocity had higher relative abundance of Acarina, Amphipoda and Copepoda.

Assemblages from upstream sites in the Beauharnois Canal (group 1) were distinct from other groups of buoys and were characterized by a lower invertebrate density and higher relative abundance of Amphipoda (fig. 1.4). Two of the Montreal Harbour assemblages (far right in fig. 1.4) were also distinct from the other sites by the very high abundance of nematodes, giving them a higher score on factor 1. The assemblages from the other Montreal Harbour and Seaway coliform groups did not form distinct groupings based on taxonomic composition and total density. The two buoys located in the MUC outfall effluent plume (group 5) exhibited a very similar abundance and composition, but are like other assemblages

in their intermediate total density and higher relative abundance of Chironomidae and Ephemeroptera.

Patterns in invertebrate density and composition for each of the other sampling dates were all significantly correlated to ash free dry mass of periphyton, according to PCA and multiple regression analyses.

*2) Size distribution*

Approximately 10 800 invertebrates, collected in September, were measured for the purposes of relating size distribution to environmental characteristics. Invertebrates spanned 19 logarithmic size classes ranging from 0.016 µg (approximate body length of 0.25 mm) to 4 mg dry mass (~16 mm).

Density in all size classes tended to be higher at sites with higher coliform concentration (fig. 1.5). Upstream average size distribution had very little or no invertebrates in the small size classes (< 1 µg) and a low peak of invertebrate density (~300 ind.$m^{-2}$). Buoys located in the MUC outfall effluent plume supported an average size distribution with a much higher density peak (~3200 ind.$m^{-2}$) and a higher overall density per size class than upstream and Seaway groups, except in the very small body sizes (< 0.1 µg), where Seaway assemblages had higher densities (fig. 1.5).

When size distributions were separated into average relative abundance (%) of the three or four most dominant taxa in each fecal coliform group, differences among the groups were

further highlighted (fig. 1.5). Trichoptera and Amphipoda, which were numerically important in the medium and large size classes upstream (1–4000 μg), were gradually replaced in Seaway and effluent groups by Nematoda, which became increasingly dominant in the small size classes (< 2 μg). Oligochaeta, which occupied the small to medium size classes (1–8 μg), and Chironomidae, which essentially dominated the medium to large size classes (4–1000 μg).

Size distributions were significantly related to periphyton abundance, suspended matter concentration, current velocity and ammonia concentration (table 1.4). Increases in periphyton biomass were associated with increases in overall invertebrate abundance and a slight shift in the peak toward smaller size classes (fig. 1.6). Similarly, high suspended matter concentration was correlated to higher abundance of invertebrates and a more peaked response in the shape of the size distribution, which flattened under low suspended matter conditions (fig. 1.6). Invertebrate abundance in all size classes decreased with increasing current velocity and decreasing ammonium concentration (fig. 1.6).

**Discussion:**

St. Lawrence River water quality differed spatially and seasonally in 1995 in relation to effluent discharge (Ile aux Vaches and Ile Charron) and to storm sewer overflow (Montreal Harbour and south shore). Although fecal coliform concentration spanned five orders of magnitude (< 3 to >20 000 UFC/100 mL) and generally exceeded the provincial environment ministry guidelines for water consumption and/or swimming (< 3 and < 200 UFC/100 mL, respectively) (MEQ 1990), coliform levels decreased to < 200 UFC/100 mL in Montreal Harbour in September (table 1.1, fig. 1.2). This change in water quality coincided with low rainfall and final diversion of collectors from the harbour to the MUC treatment plant. Nutrient (except for $PO_4$ and $NO_2 + NO_3$) increases and water clarity (e.g. Secchi depth) decreases, which were within narrow ranges (e.g. TP 10–25 µg/L), were strongly correlated to coliform concentration. Thus, fecal coliform levels provided a useful proxy measure of wastewater exposure and a simple criteria for evaluating water quality.

Invertebrate responses to wastewater exposure were similarly weak among sampling dates according to DFA (jackknife classification), which classified buoys correctly 44–61% of the time. Likewise, DFA classification on the more mature invertebrate assemblages collected in September yielded only slightly better classification (62%) once corrected for the shift in coliform groups in the harbour. DFA classification may also have been less reliable for May assemblages because of the low number of sites sampled. In contrast, the regression models predicting coliform concentration based on invertebrate density, suggests stronger responses for September assemblages because of the tighter linear relationships. Coincidentally,

invertebrate measurements made in September probably offer the most information since they integrate the cumulative effects of water pollution events since ice breakup, such as storm sewer overflows and increased effluent discharge following rain storms (Cook, 1976, Cairns et al. 1993, Rosenberg and Resh 1993).

The degree to which invertebrates responded to wastewater exposure was consequent with the results of Vis (1997), who studied the suitability of using periphyton colonizing buoys as indicators of water quality for the same buoys over the same time period used in this study. She concluded that natural seasonal variation was much more important in determining abundance and composition of periphyton than was wastewater discharge in the St. Lawrence River. The weak responses of invertebrates and periphyton colonizing buoys may certainly be a result of low pollution levels in the river, but they may also be due to the selective colonization (Rosenberg and Resh 1982), by more tolerant organisms of these substrates and/or unmeasured contamination in upstream sites reducing the signal created by wastewaters.

Strong seasonal changes in the density and composition of invertebrates were also obvious. The average density of invertebrates collected from buoys placed in the water 10–15 days earlier in May was much lower (by two orders of magnitude) than it was during the other months, when average densities remained at similar levels (32 200–63 400 ind.$m^{-2}$). As well, considerable shifts were noted throughout the season in the dominant taxa of the assemblages, as chironomids gradually yielded to nematodes as the most abundant taxa (fig. 1.3).

Unfortunately, invertebrate colonization dynamics on artificial substrates, and on buoys, for that matter, remain relatively unknown and seem to be very condition specific (i.e. habitat, type of substrate and time of year), (Rosenberg and Resh 1982, Casey and Kendall 1996). Until such time as multi-year data on invertebrate buoy assemblages are available, the existing evidence leads us to believe that the narrow environmental gradients found in the waters of the St. Lawrence may not be so severe as to upset natural patterns of succession. This could also partly explain why no strong responses were detected in previous benthic assessments in the St. Lawrence River (Ferraris 1984, Cattaneo et al. 1995, Pinell-Alloul et al. 1996, Willsie and Costan 1996, Vis 1997). Events which may have influenced colonization patterns were the initial environmental conditions (e.g. the timing of ice breakup, seasonal river discharge: Vis 1997) and water temperatures (Rosenberg and Resh 1982), which likely were important determinants of the development of organic biofilm. This biofilm, which provides invertebrates with habitat (or structure on smooth surfaces) and resources (fungi, algae, bacteria, and detritus: Alan 1995), may ultimately determine invertebrate colonization dynamics on clean buoys (Rounick and Winterbourn 1983, MacKay 1992, Casey and Kendall 1996).

Not surprisingly, spatial distribution patterns in September invertebrate composition and size distributions were strongly correlated to periphyton biomass, suspended matter, and current velocity. Epiphytic algae provide texture (heterogeneous habitat) to the buoys and are an important food source to grazer invertebrates (Allan 1995, Merrit and Cummins 1996). Suspended matter in the river water also serves as an important food source for invertebrates (Anderson and Sedell 1979), since it contains fine particulate organic matter (Palmer and O'Keefe 1990) which is consumed directly by filter feeders, such as cased caddisflies, or which

accumulates in the periphyton and consumed by collector-gatherers such as chironomids (Merrit and Cummins 1996). The significant positive relationship between invertebrate density (factor 1) and suspended matter and periphyton suggests that invertebrate assemblages found on buoys are limited by food resources. At the same time, stronger water currents may be removing periphyton and preventing certain invertebrates, such as amphipods, acarians and copepods, from attaching to buoys (Allan 1995). Swifter currents may also provide filterers with a greater supply of suspended particulate organic matter.

The response in size distribution to organic enrichment (increased density in all size classes), in our study, is different from what Bourassa and Morin (1995) and Morin et al. (1995) found in temperate Canadian streams. They described an increase in the abundance of large invertebrates only (> 1 μg) with increasing trophy in these streams. To explain their observations, Bourassa and Morin (1995) suggest that larger invertebrates may be better competitors and can sequester food and/or space in eutrophic conditions, or that large invertebrates are resource limited. In our case, it seemed apparent by the increase in density in all size classes that invertebrates of all sizes were resource limited. Differences in size distribution responses between studies could also certainly be due to environmental conditions, such as higher current velocities in the river and higher TP range in streams, the texture of substrates (MacKay 1992, Way et al. 1995), or the distance between the buoys and the river bottom and littoral zones where these invertebrates are found. Since studies on benthic size distributions are scarce and in their early developmental stages, unlike pelagic studies (Strayer 1991, Rasmussen 1993), these arguments remain speculative.

Taxonomic measures performed only slightly better than did size-based metrics in their responses to environmental impacts; DFA classified taxonomic composition and size distribution into coliform groups at a rate of 56% and 44%, respectively. To our knowledge, only one study has compared size-based with taxon-based responses to water quality, and this for periphytic algae colonizing macrophytes in the St. Lawrence River (Cattaneo et al. 1995). Their results showed that toxicological and ecological variables better explain the variability in size distributions (61.3% from 5 size classes) than the taxonomic composition of algae (37.3% from broad taxonomy and 37.1% from the species level). On the other hand, Rodriguez and Magnan (1993) and Bourassa and Morin (1995) found that size distributions of invertebrates in lakes and streams were surprisingly invariant across substrate types compared with the great taxonomic changes that occurred. In our study, relating patterns in size distributions to physicochemical parameters appeared to yield no additional information beyond taxonomic composition, as both community measures were related to the same characteristics of the river (except for ammonium). However, comparison of the size distribution of dominant taxa (fig. 1.5) provided us with a better understanding of the community changes taking place along this gradient of wastewater discharge. For monitoring purposes, size distributions using whole communities are probably not very useful unless used as tools to estimate secondary production (Morin and Nadon 1991) or used in models of energy and contaminant trophic transfers (Griesbach et al. 1982, Vézina 1986).

## Conclusion

Important differences in water quality were observed at sites around the Island of Montreal and downstream of effluent outfalls, resulting in a wide concentration range in fecal coliforms (< 3 to > 20 000 UFC/100 mL) and a narrower concentration range in total phosphorus (10–25 µg/L), ammonium (6–135 µg/L), suspended solids (1.4–4.5 mg/L) and water clarity (Secchi depth 7.3–2.0 m). Invertebrate assemblages underwent strong seasonal changes and responded weakly to wastewater exposure, since DFA classified 44–61% of buoys in the correct fecal coliform groups for all sampling dates, based on taxonomic composition and size distribution. The best indicators of urban wastewater exposure were total density of invertebrates in spring, density of invertebrates in the size class 8–16 µg in September and chironomid, nematode and other Diptera density in September. Changes in invertebrate composition and size distribution in September were both primarily related to suspended matter concentration, periphyton biomass and current velocity. The lack of strong, obvious responses from invertebrates colonizing navigation buoys in the St. Lawrence River, throughout the sampling season, limits their importance as sensitive indicators of wastewater to their present levels of exposure.

## Tables and Figures

Fig. 1.1. The sampling sites in the Beauharnois Canal (upstream) and the green water mass of the St. Lawrence River in Montreal.

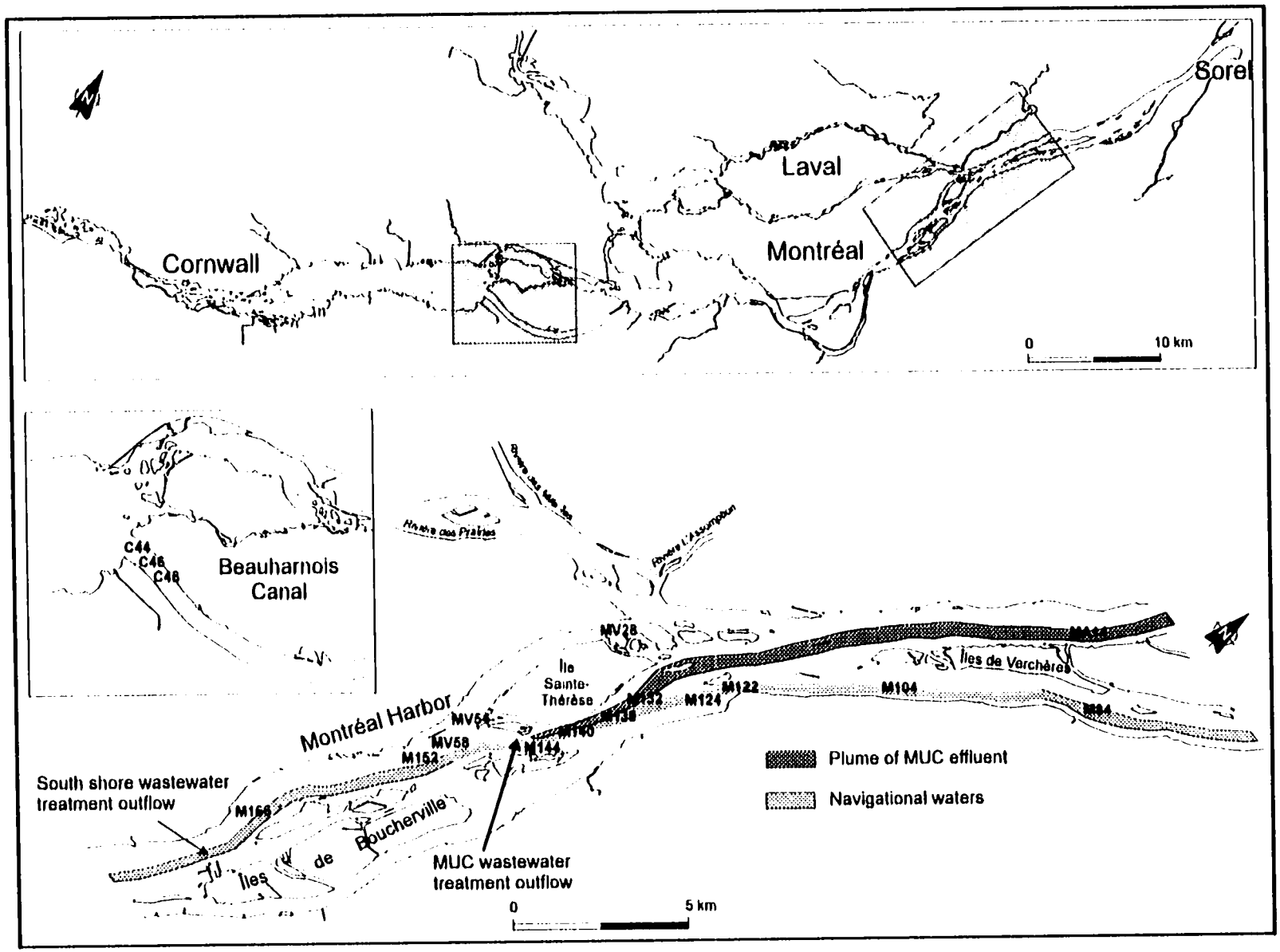

Cornwall
Laval
Montréal
Sorel
0
10 km
Beauharnois
Canal
C44
C46
C48
Rivière des Prairies
Rivière L'Assomption
MV28
M132
M124
M122
M104
M84
Île Sainte-Thérèse
Îles de Verchères
Montréal Harbor
MV56
MV58
M152
M144
M140
M138
South shore wastewater treatment outflow
M156
Boucherville
Îles de
MUC wastewater treatment outflow
0
5 km
Plume of MUC effluent
Navigational waters

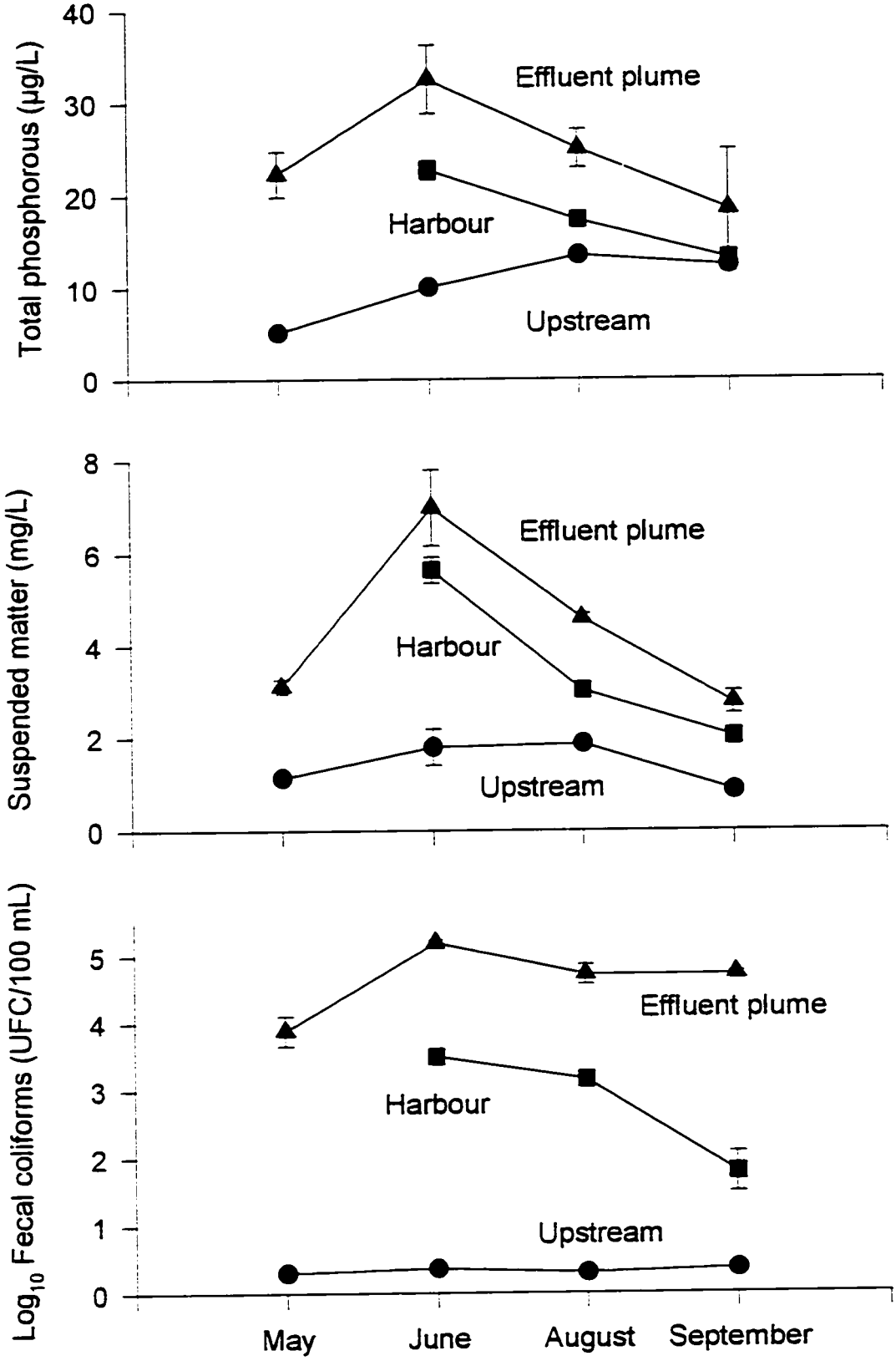
Table 1.1. Mean (±SD) physico-chemical characteristics for five groups of buoys by water quality, measured throughout the sampling season. Groups are based on fecal coliform concentration (UFC/100 mL).

| Water quality group (fecal coliform range, UFC/100ml) | 1 (< 3) | 2 (3-200) | 3 (200-2000) | 4 (2000-20000) | 5 (> 20000) |
|---|---|---|---|---|---|
| Location | Upstream | Harbour Sept. 1995 | Seaway and Harbour | Seaway and downstream of MUC effluent | MUC effluent |
| n | 12 | 6 | 24 | 13 | 7 |
| Conductivity ($\mu S\ cm^{-1}$) | 286 (14) | 272 (3) | 265 (17) | 247 (28) | 275 (10) |
| Current velocity ($m\ s^{-1}$) | 0.77 (0.14) | 0.92 (0.28) | 1.01 (0.32) | 0.79 (0.36) | 1.22 (0.18) |
| Light transmission coefficient | 0.35 (0.06) | 0.46 (0.03) | 0.64 (0.18) | 0.83 (0.26) | 0.75 (0.22) |
| Secchi depth (m) | 7.3 (3.1) | 4.0 (0.4) | 2.1 (1) | 2.0 (0.8) | 2.3 (1.2) |
| Suspended matter (mg/L) | 1.4 (0.6) | 2.0 (0.3) | 3.8 (1.5) | 4.2 (1.5) | 4.5 (1.9) |
| Silicates ($\mu gSiO_2/L$) | 455 (75) | 707 (34) | 831 (384) | 1345 (665) | 1155 (538) |
| NO2 + NO3 ($\mu g/L$) | 223 (80) | 187 (10) | 196 (76) | 231 (81) | 213 (78) |
| Ammonium ($\mu g/L$) | 6 (4) | 10 (2) | 11 (4) | 61 (72) | 135 (52) |
| Dissolved inorganic phosphorous ($\mu g/L$) | 3.1 (2.2) | 4.1 (0.3) | 4.8 (2.2) | 5.7 (2.5) | 3.1 (1.2) |
| Total phosphorous ($\mu g/L$) | 10 (3) | 13 (2) | 15 (4) | 20 (4) | 25 (8) |
| Chlorophyll a ($\mu g\ cm^{-2}$) | 4.9 (5.0) | 7.3 (4.9) | 5.2 (4.1) | 3.8 (3.9) | 3.3 (2.5) |
| Ash free dry weight ($mg\ cm^{-2}$) | 0.45 (0.38) | 0.84 (0.40) | 0.74 (0.50) | 0.49 (0.36) | 0.64 (0.46) |

Table 1.2. Pearson correlation coefficients, along with their p-values, for the correlations between fecal coliform concentration and the physico-chemical variables, for each of the sampling dates.

| Sampling date | May<br>r (p-value) | June<br>r (p-value) | August<br>r (p-value) | September<br>r (p-value) |
|---|---|---|---|---|
| n | 9 | 17 | 18 | 18 |
| Conductivity ($\mu S\ cm^{-1}$) | 0.003<br>(1.00) | -0.66<br>(0.052) | -0.52<br>(0.31) | 0.024<br>(1.00) |
| Current velocity ($m\ s^{-1}$) | 0.65<br>(0.70) | 0.18<br>(1.00) | 0.29<br>(1.00) | 0.21<br>(1.00) |
| Light transmission coefficient | – | 0.88<br>(<0.001) | 0.71<br>(0.01) | 0.79<br>(0.001) |
| Secchi depth (m) | -0.92<br>(0.005) | -0.88<br>(<0.001) | -0.78<br>(0.002) | -0.67<br>(0.03) |
| Suspended matter (mg/L) | 0.96<br>(<0.001) | 0.92<br>(<0.001) | 0.57<br>(0.16) | 0.80<br>(0.001) |
| Silicates ($\mu gSiO_2/L$) | 0.96<br>(<0.001) | 0.84<br>(<0.001) | 0.80<br>(0.001) | 0.69<br>(0.02) |
| NO2 + NO3 ($\mu g/L$) | -0.98<br>(<0.001) | 0.26<br>(1.00) | 0.10<br>(1.00) | -0.07<br>(1.00) |
| Ammonium ($\mu g/L$) | 0.76<br>(0.21) | 0.71<br>(0.02) | 0.60<br>(0.10) | 0.63<br>(0.06) |
| Dissolved inorganic phosphorous ($\mu g/L$) | 0.91<br>(0.01) | 0.38<br>(1.00) | -0.20<br>(1.00) | -0.54<br>(0.25) |
| Total phosphorous ($\mu g/L$) | 0.87<br>(0.03) | 0.86<br>(<0.001) | 0.80<br>(0.001) | 0.58<br>(0.14) |
| Chlorophyll a ($\mu g\ cm^{-2}$) | 0.81<br>(0.10) | -0.13<br>(1.00) | -0.09<br>(1.00) | -0.42<br>(0.94) |
| Ash free dry weight ($mg\ cm^{-2}$) | 0.96<br>(<0.001) | 0.056<br>(1.00) | -0.12<br>(1.00) | 0.24<br>(1.00) |

Fig. 1.2. Average (±SE) total phosphorous, suspended matter and fecal coliform concentrations for three regions of the St. Lawrence River for each sampling date. Effluent refers to buoys immediately downstream of MUC effluent outfall. Harbour (n=5), effluent (n=2) and upstream (n=3).


Total phosphorous (µg/L)
40
30
20
10
0
Effluent plume
Harbour
Upstream
Suspended matter (mg/L)
8
6
4
2
0
Effluent plume
Harbour
Upstream
Log10 Fecal coliforms (UFC/100 mL)
5
4
3
2
1
0
Effluent plume
Harbour
Upstream
May
June
August
September

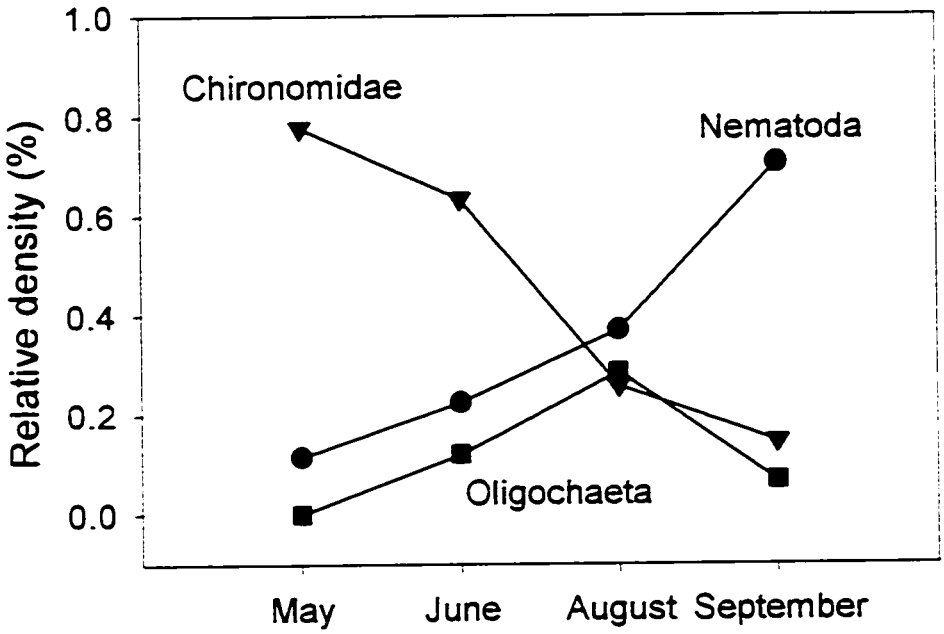



Fig. 1.3. Relative density (%) of dominant taxa throughout the sampling season (n=9 buoys for May, n=17 for June, n=18 for August and n=18 for September). Note the shift in dominance of Chironomidae to Nematoda from May to September.

Table 1.3. Multiple regression models predicting fecal coliform concentration ($log_{10}$ transformed) from invertebrate taxa densities for each sampling date and from size classes for September assemblages.

| Regression model parameters predicting fecal coliform concentration ($log_{10}$) | t (p-value) | n | RMS | P | adj.$R^2$ |
|---|---|---|---|---|---|
| **May** | | | | | |
| 9.38<br>+ 4.72 $log_{10}$(Chironomidae) | 4.59 (0.003)<br>3.47 (0.01) | 9 | 1.28 | 0.01 | 0.58 |
| 9.50<br>+ 5.02 $log_{10}$(total density) | 6.58 (<0.001)<br>5.02 (0.002) | 9 | 0.76 | 0.002 | 0.75 |
| **June** | | | | | |
| -2.23<br>+ 1.30 $log_{10}$(Chironomidae)<br>– 3.17 $log_{10}$(Diptera) | 1.02 (0.32)<br>2.22 (0.04)<br>2.32 (0.04) | 17 | 1.45 | 0.025 | 0.33 |
| **August** | | | | | |
| 5.00<br>+1.65 $log_{10}$(Diptera) | 4.36 (<0.001)<br>1.89 (0.08) | 18 | 1.52 | 0.077 | 0.13 |
| **September** | | | | | |
| 5.86<br>-1.07 $log_{10}$(Nematoda)<br>+ 2.36 $log_{10}$(Chironomidae)<br>+ 2.37 $log_{10}$(Diptera) | 5.74 (<0.001)<br>3.49 (0.004)<br>4.45 (0.001)<br>2.93 (0.01) | 18 | 0.61 | < 0.0001 | 0.69 |
| -5.60<br>+ 2.75 $log_{10}$(density size class (8 - 16µg)) | 4.00 (0.001)<br>5.72 (<0.001) | 18 | 0.67 | < 0.0001 | 0.65 |

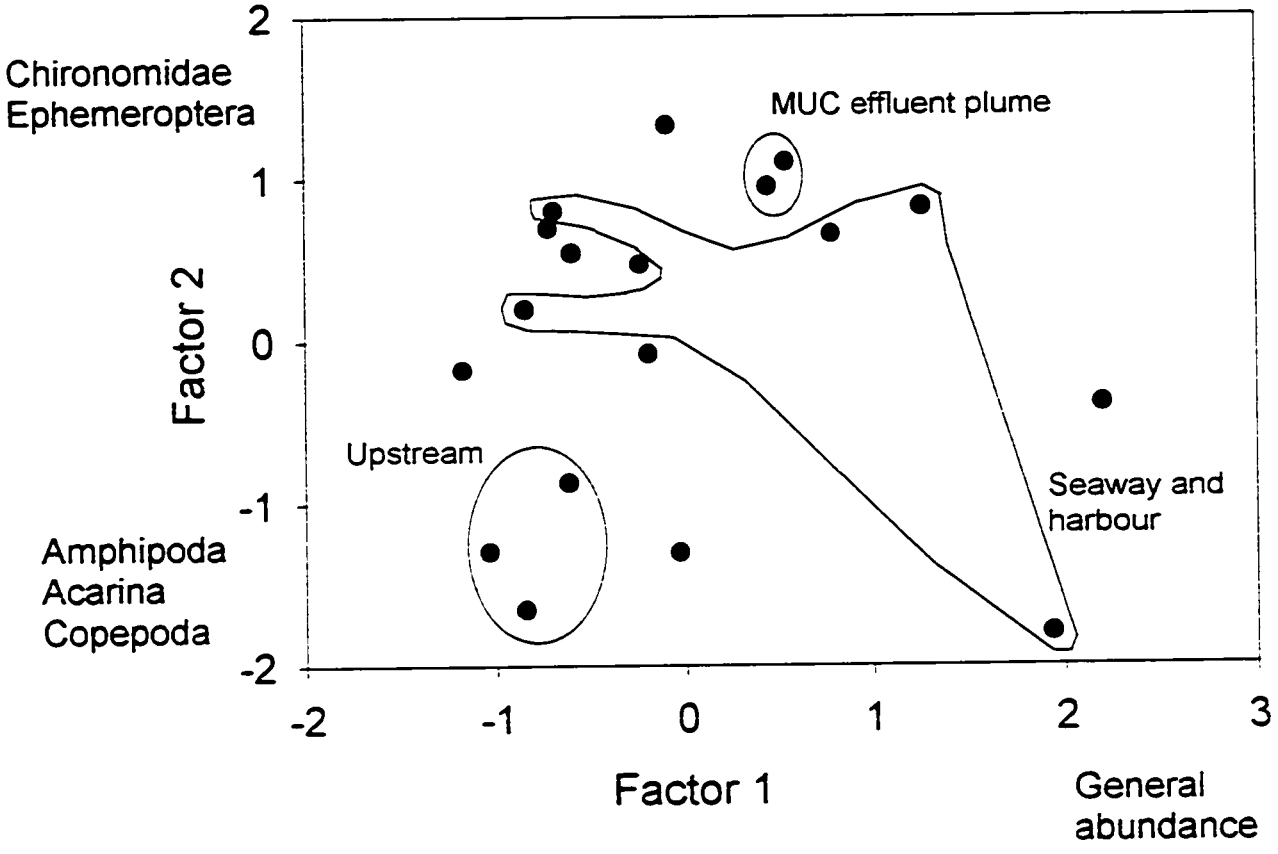
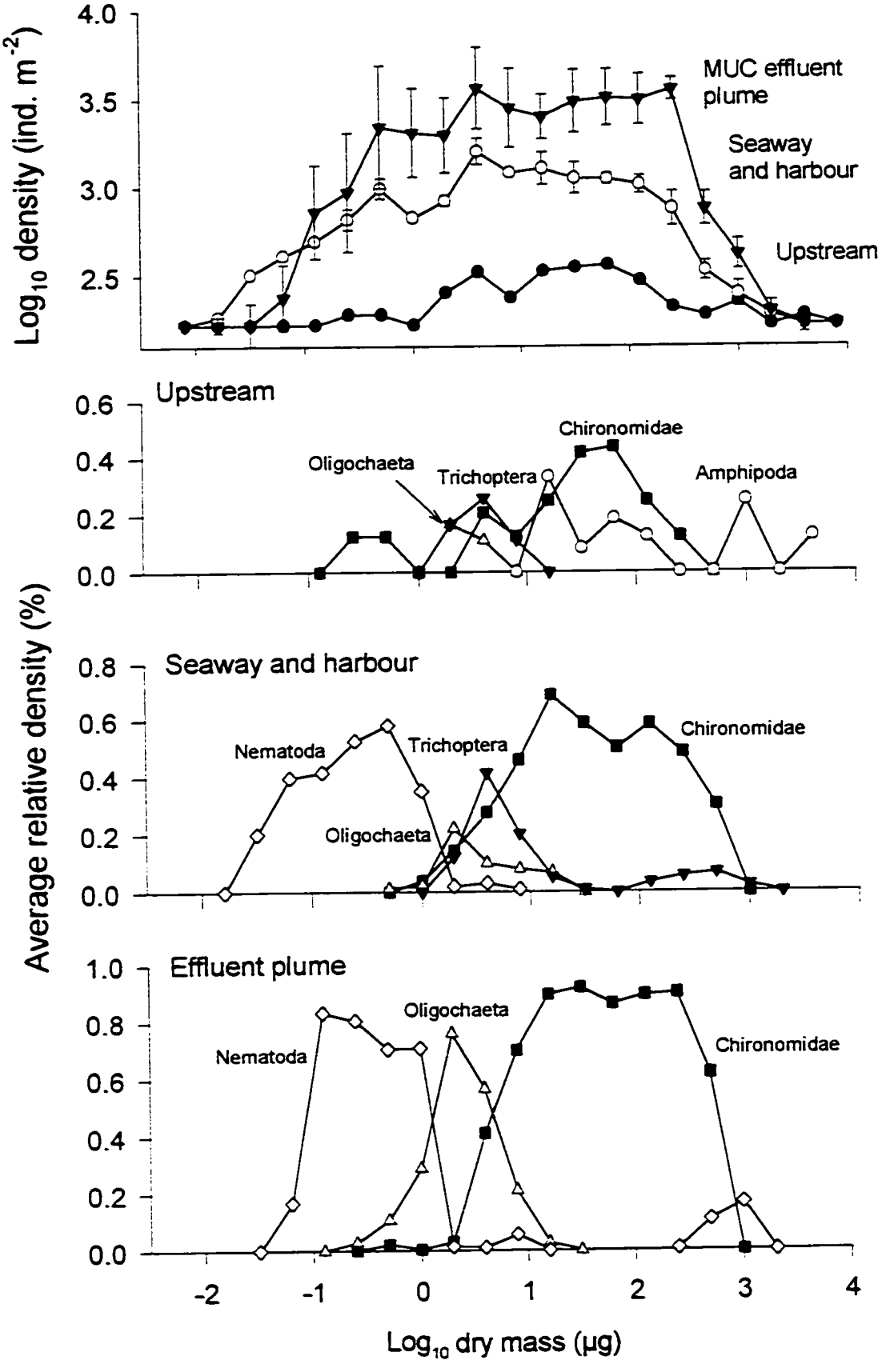



Fig. 1.4. PCA factors 1 and 2 showing the ordination of buoys (n=18) based on density ($log_{10}$ transformed) of the 9 invertebrate taxa, sampled in September 1995. Factor 1 is an index of overall invertebrate abundance and factor 2 is a ratio of Chironomidae + Ephemeroptera / Amphipoda + Acarina + Copepoda (CE/AAC). Circled groups of buoys represent water quality groups upstream, Seaway and harbour and MUC effluent plume. Other points represent 3 sites farther downstream of MUC effluent and 3 upstream harbour sites.

Fig. 1.5. Average size distributions of invertebrates belonging to three groups of buoys by water quality, sampled in September 1995 (n=3 buoys for upstream, n=5 for Seaway and n=2 for effluent plume) (upper panel). Average relative density per size class (%) of the three or four most dominant taxa of September assemblages, for the three water quality groups (lower panels).


Log10 density (ind. m-2)
4.0
3.5
3.0
2.5
MUC effluent plume
Seaway and harbour
Upstream
Average relative density (%)
Upstream
0.6
0.4
0.2
0.0
Oligochaeta
Trichoptera
Chironomidae
Amphipoda
Seaway and harbour
0.8
0.6
0.4
0.2
0.0
Nematoda
Trichoptera
Oligochaeta
Chironomidae
Effluent plume
1.0
0.8
0.6
0.4
0.2
0.0
Nematoda
Oligochaeta
Chironomidae
-2
-1
0
1
2
3
4
Log10 dry mass (µg)

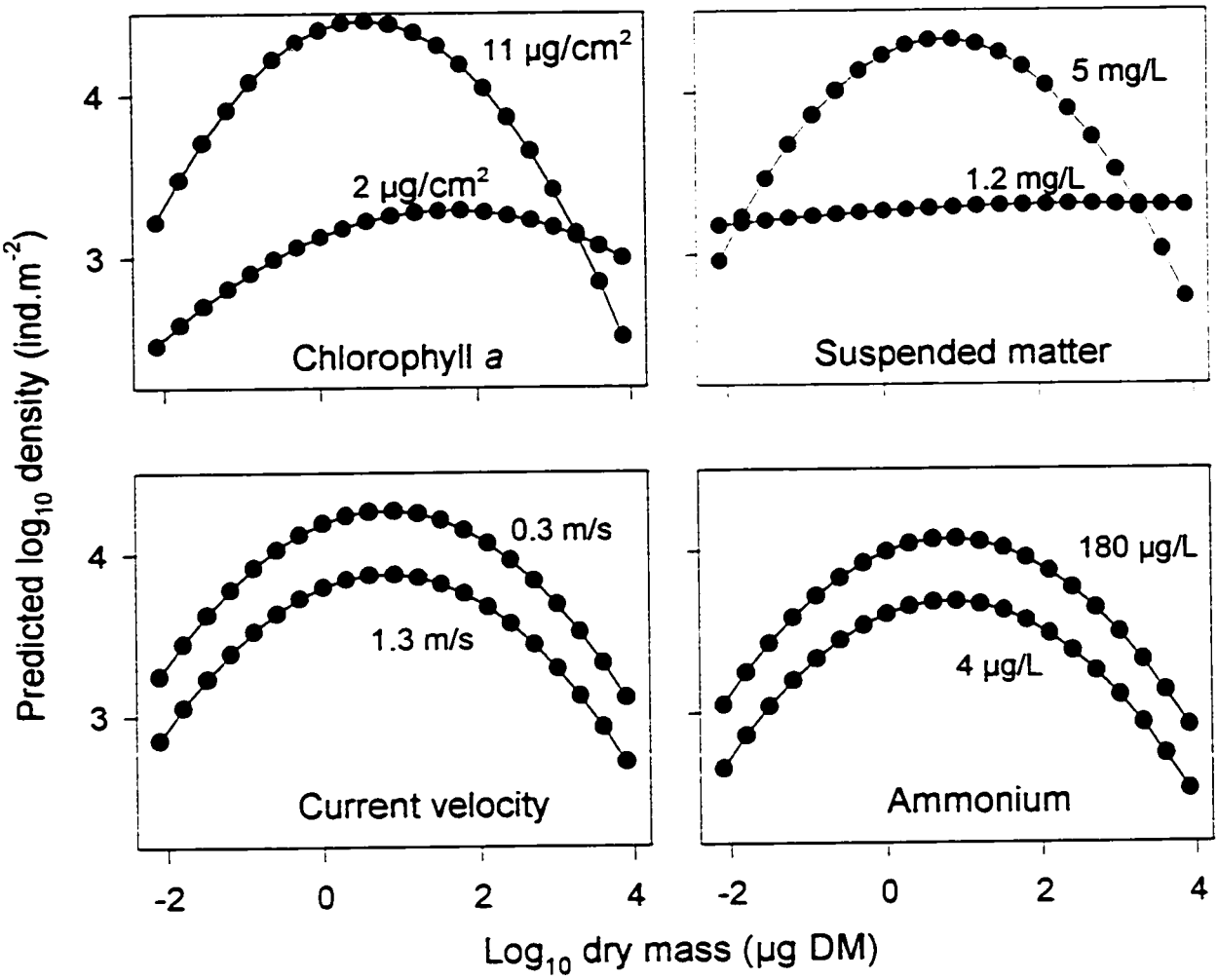



Fig. 1.6. September 1995 size distributions predicted by polynomial model (table 1.4) for low and high values of each parameter, while maintaining other parameters at average levels. Note the weak sensitivity of invertebrate size distribution to ammonium, in spite of considerable (45x) increases in concentration.

Table 1.4. Polynomial regression model, for September 1995, describing invertebrate density ($log_{10}$ transformed) per size class ($ind.m^{-2}$) as a function of dry mass (M, in µg dry mass), chlorophyll a (Chla, in µg $m^{-2}$), suspended matter (S, in mg/L), current velocity (C, in m $s^{-1}$) and ammonia ($NH_4$, in µg/L) (n=342, $r^2$=0.65, RMS=0.09). * $p < 0.0001$.

| Independent variable | Coefficient (standard error) |
|---|---|
| Intercept | 1.700 (0.137)* |
| $(Log_{10} M)^2$ | 0.124 (0.020)* |
| $Log_{10}$ Chla | 1.717 (0.119)* |
| $Log_{10}$ Chla x $(Log_{10} M)^2$ | -0.156 (0.021)* |
| $(Log_{10} S)^2$ | 1.977 (0.186)* |
| $Log_{10} S \times Log_{10} M$ | 0.366 (0.029)* |
| $Log_{10} S \times (Log_{10} M)^2$ | -0.255 (0.027)* |
| $(Log_{10} C)^2$ | -1.383 (0.202)* |
| $Log_{10} NH_4$ | 0.231 (0.047)* |

# Chapter 2:

## Patterns in invertebrate and periphyton size distributions from navigation buoys in the St. Lawrence River

## Introduction

The potential use of benthic size distributions for making community structure comparisons among ecosystems (Strayer 1991, Cattaneo 1993, Poff et al. 1993), predictions about aquatic processes or components (Borgmann 1987, Boudreau and Dickie 1992) and for use in environmental assessments (Cattaneo et al. 1995, Morin et al. 1995) has often been stated. However, the scarcity of benthic size distributions data and predictive models have impeded the routine use of benthic size distributions as an alternative or complementary measure to taxonomic descriptions of aquatic organisms. Quantification of seasonal and spatial variability, in relation to environmental characteristic is, therefore, essential to the understanding and practical use of size distributions (Morin et al. 1995).

There are considerable differences in the amplitudes and shapes of the few existing benthic size distributions among studies and ecosystems. Unimodal (Strayer 1986, Morin and Nadon 1991, Rodriguez and Magnan 1993, Bourassa and Morin 1995), bimodal (Cattaneo 1987, Poff et al. 1993, Rasmussen 1993) and trimodal distributions (Schwinghammer 1981) with different peaks and troughs have been found in lake, stream and marine littoral ecosystems (see Cattaneo 1993). These differences may not only be due to environmental constraints (Schwinghammer 1981, Warwick and Joint 1987) and/or evolutionary history (Strayer 1991) but to methodological differences, such as organism size ranges examined (Poff et al. 1993), trophic groups sampled (i.e. zoobenthos only) and different graphical representations leading to varying conclusions (i.e. non-logarithmic scales, Hanson et al. 1989). Some of these differences were reconciled in temperate North American streams, when size distributions were

constructed from organisms spanning a wide range of body sizes, which included protozoans, algae and macroinvertebrates (Cattaneo 1987, Morin and Nadon 1991 and Cattaneo 1993). These distributions were found to be very similar to pelagic distributions (Sheldon et al. 1972, Sprules and Munawar 1986, Ahrens and Peters 1991) with roughly even biomass in logarithmically increasing size classes and a normalized size distribution (log density per size class) with a slope of approximately -1.

Although size distributions for pelagic assemblages comprising algae, protozoa and invertebrates appear similar among sites and across ecosystems, there is a substantial amount of variability from the smooth linear trend. It is this variability, according to Sprules and Munawar (1986), that may contain information about anthropogenic impacts. It is therefore important to examine the effect of season and environmental factors, not only on the general negative trend between normalized biomass and organism body mass, but also on the systematic deviations from this general trend.

In this paper, the seasonal and temporal patterns in invertebrate and algal size distributions from navigational buoys sampled over a trophic gradient in the Montreal area of the St. Lawrence River are investigated. Size spectra observed on buoys are then compared to previously described size distributions. Lastly, their usefulness as descriptors of aquatic communities for environmental assessments is discussed.

## Methods

*Study area and sampling*

Detailed descriptions of the study area, sampling design and protocol are found in the previous chapter and in Vis (1997). Invertebrate and algal size measurements were taken from 4 buoys on May 7th, 5 buoys on June 7th, 6 buoys on August 1rst and 6 buoys on September 26th, 1995. These buoys were chosen to represent the widest trophic gradient possible in the Montreal area of the St. Lawrence River (a 5 - 28 $\mu gL^{-1}$ range in total phosphorous).

*Invertebrate and algae collection and processing*

Invertebrate processing and measuring, along with physical and chemical water measurements were conducted in the same manner as in the previous chapter. Due to time required for slide preparation and algal identifications, the 3 subsamples of material collected from buoys intended for algal measurements were combined, homogenized and subsampled (Vis 1997). Therefore, algal measurements are based on 1 replicate per buoy per date, whereas invertebrate estimates have 3 replicates.

Algal cells were counted at 640X and 160X in random fields using a Zeiss inverted microscope, with 0.4 - 5 ml subsamples depending on algal density (Vis 1997 and personal communication). Filamentous algae (e.g. *Cladophora*) were counted under a dissecting scope at 6.6X using whole samples (~ 600ml). The length and width of individual cells were measured using an image analysis system connected to the microscopes. Algal volumes were calculated by approximation to known geometric shapes using mean species length and width

(Vis 1997). Each algal filament (e.g. *Cladophora*) was treated as an individual, as it was done by Cattaneo (1987) and Vis (1997). Therefore, estimates of algal volume represent whole colonies and not individual cells within filaments. However, some measurement error in lengths of individuals are undoubtedly due to fragmentation from brushing and sonication during sampling. In order to reduce this error, the length of each individual was considered to be equal to the average filament length of each sample (Cattaneo 1987).

Cell volumes were converted to wet mass by multiplying volume ($\mu m^3$) with 1 $\mu g \mu m^{-3}$ (specific density of aquatic organisms, Schwinghammer 1981 and Cattaneo 1993) and to dry mass by dividing wet mass by 4 (Cummins and Wuycheck 1971). Density and biomass of organisms was determined by dividing the number of organisms and total dry mass of organisms by surface area of sampler ($45 cm^2$).

Invertebrates and algae were grouped into 11 logarithmic size classes which correspond to an 8-fold increase in individual dry mass or a doubling of "equivalent spherical diameter" (ESD) (Cattaneo 1993) and range in size from $10^{-6}$ to $10^{4}$ µg DM (figure 1). Larger size intervals were used to quantify size distributions in this chapter in order to reduce noise due to measurement error (Ahrens and Peters 1991) when calculating algal density per size class based on average species size and not individual size.

*Statistical analyses*

As in chapter 1, the effects of environmental characteristics on the amplitude and shape of the size distributions of the invertebrates and algae were assessed by fitting their

distributions to polynomial regression models (Bourassa and Morin 1995). These models included terms such as TP and suspended matter to test for physico-chemical effects on density, regardless of size class, as well as interaction terms between $\log_{10}$DM and environmental factors which test for size dependent changes in density.

Monte Carlo simulations were run to estimate our ability to detect changes in size distributions in response to TP. To generate simulated data sets, we used the regression model to first predict the $\log_{10}$ density in each size class for each buoy. We then added a normally distributed error term with a mean of 0 and a variance equal to the RMS of the regression model. To this randomized predicted density, we finally added hypothetical trophic effects in various scenario. In one of these scenario, for example, we increased density in all size classes by 50%, over the observed 5 - 28µg TP gradient. For each analysis, we generated 500 simulated data sets and counted the percentage of times TP was significant in the regression models.

**Results and Discussion**

Algae and invertebrates measured to describe size spectra, ranged in size from $10^{-6}$ to $10^{4}$ µg dry mass (fig. 2.1). Diatoms (Bacillariophyceae) and blue green algae (Cyanophyceae) occupied the smallest size classes ($10^{-6}$ to $10^{-3}$ µg), whereas green algae (Chlorophyceae) spanned 6 orders of magnitude in size from $10^{-5}$ to 10 µg. The filamentous algae, *Cladophora*, was found in the largest classes (10 to $10^{4}$ µg). Invertebrates occupied the $10^{-1}$ to $10^{5}$ µg size classes.

Biomass was not evenly distributed among size classes but average values in most intervals were generally within an order of magnitude of the geometric mean biomass for each sampling date (fig 2.2). Biomass in three size classes were consistently lower than the geometric mean biomass, corresponding to organisms < $10^{-6}$ and between 0.004 and 0.260 µg DM for each sampling date. This trough between large non-filamentous algae and small invertebrates may correspond to ciliates, which can be highly abundant in streams (Bott and Kaplan 1989 and Cattaneo 1993) and ranged in size from $10^{-4}$ to 0.26 µg DM in Laurentian Streams (Cattaneo 1993). Flagellates may also have overlapped in size with the smallest algae (< $10^{-6}$ µg DM) (Bott and Kaplan 1989). Unfortunately, ciliates and flagellates were not quantified in this study but their presence on buoys were observed when algae samples were counted (C. Vis personal communication); it is unknown whether inclusion of protozoans would have produced more even biomass distributions.

Seasonal changes in the biomass occurred between spring and fall of 1995. Some of the successional events which can be related to these changes include slower invertebrate colonization relative to unicellular algae (in May), potential grazing of algae by invertebrates (June) and the development of filamentous algae, predominantly *Cladophora*, in August and September (fig. 2.2). In May, overall biomass was high (601±223 mg $m^{-2}$) and mainly composed of non-filamentous algae (585±214 mg $m^{-2}$). In June, algal biomass was much lower (141±104 mg $m^{-2}$), whereas, invertebrate biomass was considerable higher (277±142 mg $m^{-2}$) than in May (see large size classes, fig. 2.2). In August and September, filamentous algae (mainly *Cladophora*) had developed resulting in an increase of biomass in the large size classes (> 16 µg DM). Overall biomass levels in August and September (651±177 and 685±95 mg $m^{-2}$, respectively) were comparable to those found in May.

Density distributions (or normalized biomass spectra) of buoy assemblages, for each of the sampling dates, were best described by fourth and fifth order polynomials (fig. 2.3). These distributions had similar shapes throughout the sampling period, although variability in density per size class increased in the mid to large size classes (> $10^{-3}$ µg) with time. The difficulties in estimating the density of algal filaments and assigning them to their proper size classes undoubtedly contributed significantly to this variability. The fourth and fifth order curves that were fitted to these data are probably not representative of the curves that would normally be observed if all organisms (including protozoans) within the size ranges sampled, had been quantified. Cattaneo (1993) fitted linear regressions to her benthic distributions, as in many pelagic studies (e.g. Sheldon et al. 1972, Sprules and Munawar 1986 and Ahrens and Peters 1991), with slopes ranging from –0.97 to –0.81. However, regression residuals were probably

highly correlated due to the presence of peaks and troughs in her distributions (Rasmussen 1993 and Morin et al. 1995), therefore, higher order polynomial regressions may have provided better fit in some cases.

Environmental conditions apparently were not important in determining size distributions since none of the physico-chemical parameters significantly improved the fit of polynomial models describing size distributions (table 2.1). Monte Carlo simulations revealed that our ability to detect changes in size distribution related to TP was low. Density in all size classes would have to increase by 3-fold over the observed TP range for 50% chance of detection, and by 5-fold increases if only the 5 larger size classes were affected. When applying the model developed by Bourassa and Morin (1995) for Eastern Canadian streams over our observed 5 – 28 $\mu gL^{-1}$ range of total phosphorous, only a 1.1-1.8 fold increase in density, in response to this increase in TP, would be expected. Therefore, given the residual variation of our polynomial models, the chance of detecting trophic effects on size distributions, if they exist, were low.

Size distributions of algae and invertebrates colonizing buoys were visually compared with the most complete published benthic distributions, which contained protozoans, macroinvertebrates and epiphyton found in lakes (Cattaneo 1987), streams (Cattaneo 1993) and marine littoral areas (Schwinghammer 1981) (fig. 2.4). Our size distribution had similar abundance in most size classes, except for the obvious troughs in the smallest class and the middle size classes, which probably correspond to missing flagellates and ciliates, respectively. These strong similarities despite clearly different species assemblages, across ecosystems and

substrates, suggest strong size based constraints on community organization and resource allocation (Peters 1983). Environmental conditions, therefore, seem to be of lesser importance in determining benthic size distribution, especially when quantifying a broad size range of organisms.

The difficulties in detecting systematic deviations related to Montreal area trophic gradients (or wastewater discharge), along with the apparent similarity of size spectra across ecosystems imply that they are not very useful or practical community measures to assess ecological changes in the St. Lawrence River. In order to obtain higher measurement precision to increase the chances of detecting trophic effects, if indeed they exist, more data or more precise data (e.g. reducing measurement error of *Cladophora* filaments) would be required for statistical analysis. The only way to achieve this level of precision would be to conduct more field sampling and organism measurements, even in studies such as this one where standardized habitats were used to reduce sampling noise (Rosenberg and Resh 1982). However, these effort may be much more labour intensive than measuring other potentially more sensitive components of the benthic assemblages, particularly in situations of low levels of pollution which elicit subtle responses. For example, size distributions of particular trophic groups (e.g. epiphyton or invertebrates) may be more responsive to environmental conditions (see chapter 1, Bourassa and Morin 1995, Cattaneo et al. 1995) because these organisms share similar ecological limitations (e.g. particulate organic matter for invertebrates) or are physiologically susceptible to particular stressors (e.g. herbicides). Alternatively, the use of size distributions of particular taxa (e.g. Baetidae family of Ephemeroptera) which are expected to be particularly tolerant or sensitive to changes in water quality, would probably be more sensitive

and less labour intensive (S. McKee personal communication). Future research in integrating size distributions with environmental assessments should probably focus on the last approach to maximize our ability to detect ecosystem perturbations.

## Tables and Figures

Table 2.1. Polynomial regression model parameters describing invertebrate and algae $log_{10}$density per size class (ind. $m^{-2}$) as a function of dry Mass (M, µg ) (adj. $R^2$=0.83, RMS=1.23, n=198). Note that TP and the interaction TP*M were not significant parameters in the model.

| Independent variable | Coefficient (standard error) | P |
|---|---|---|
| Intercept | 3.22 (0.25) | <0.0001 |
| $Log_{10}$ M | -0.52 (0.11) | <0.0001 |
| $(Log_{10} M)^2$ | 0.48 (0.04) | <0.0001 |
| $(Log_{10} M)^3$ | -0.02 (0.01) | <0.0001 |
| $(Log_{10} M)^4$ | -0.02 (0.00) | <0.0001 |
| TP | | 0.91 |
| TP*$log_{10}$M | | 0.67 |

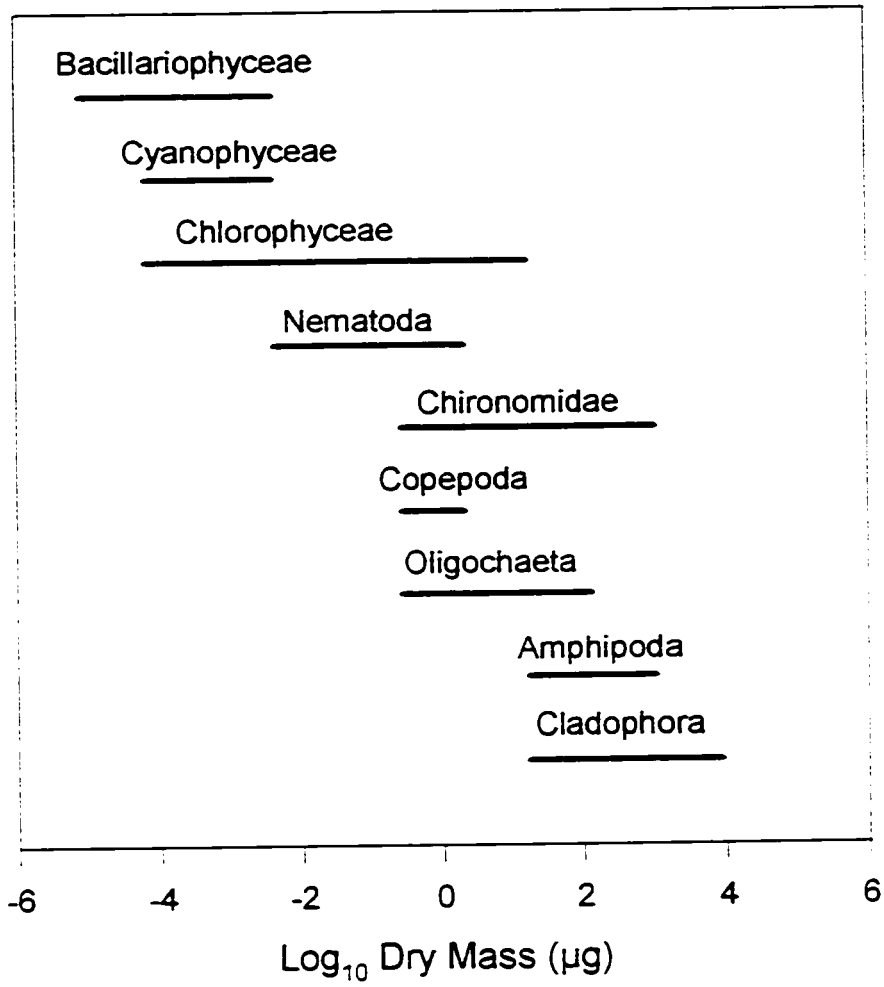
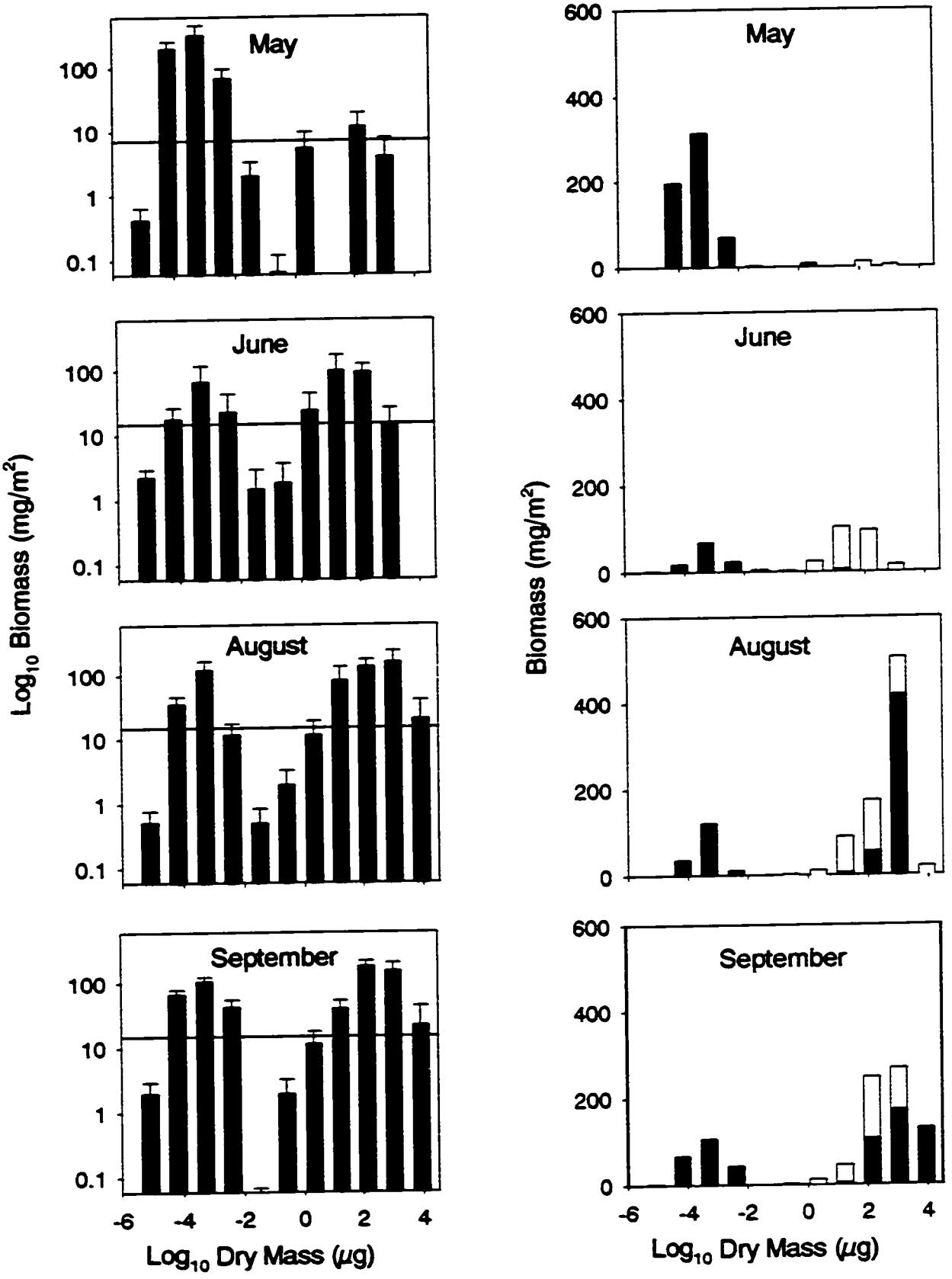



Fig. 2.1. Size ranges for dominant groups of organisms found colonizing navigation buoys. The Chlorophyceae group does not include *Cladophora*.

Fig. 2.2. Average dry biomass (±SE) of organisms per size class (left panel) and average biomass of invertebrates (empty bars) and algae (filled bars) per size class (right panel) (n=4 in May, n=4 in June, n=5 in August and n=5 in September). The reference line represents the geometric mean biomass for each date.


May
June
August
September
100
10
1
0.1
600
400
200
0
-6
-4
-2
0
2
4
Log10 Biomass (mg/m2)
Biomass (mg/m2)
Log10 Dry Mass (μg)

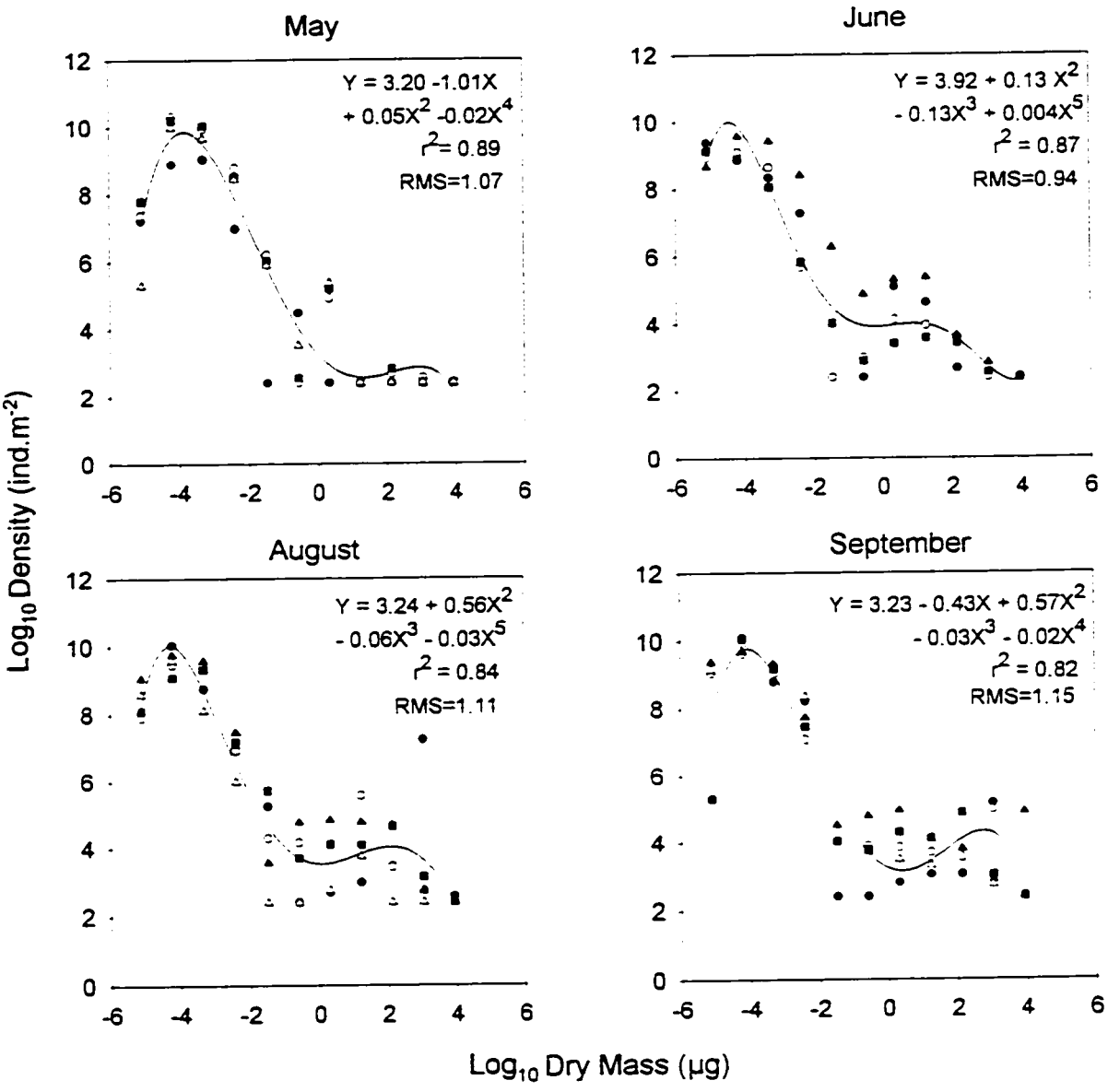



Fig. 2.3. Density of invertebrates and algae per size class colonizing buoys for each sampling date in 1995 (n=4 in May, n=4 in June, n=5 in August and n=5 in September). The line represents fourth and fifth order linear regressions. The symbols ● ○ ▲ △ ■ are in order of increasing trophy.

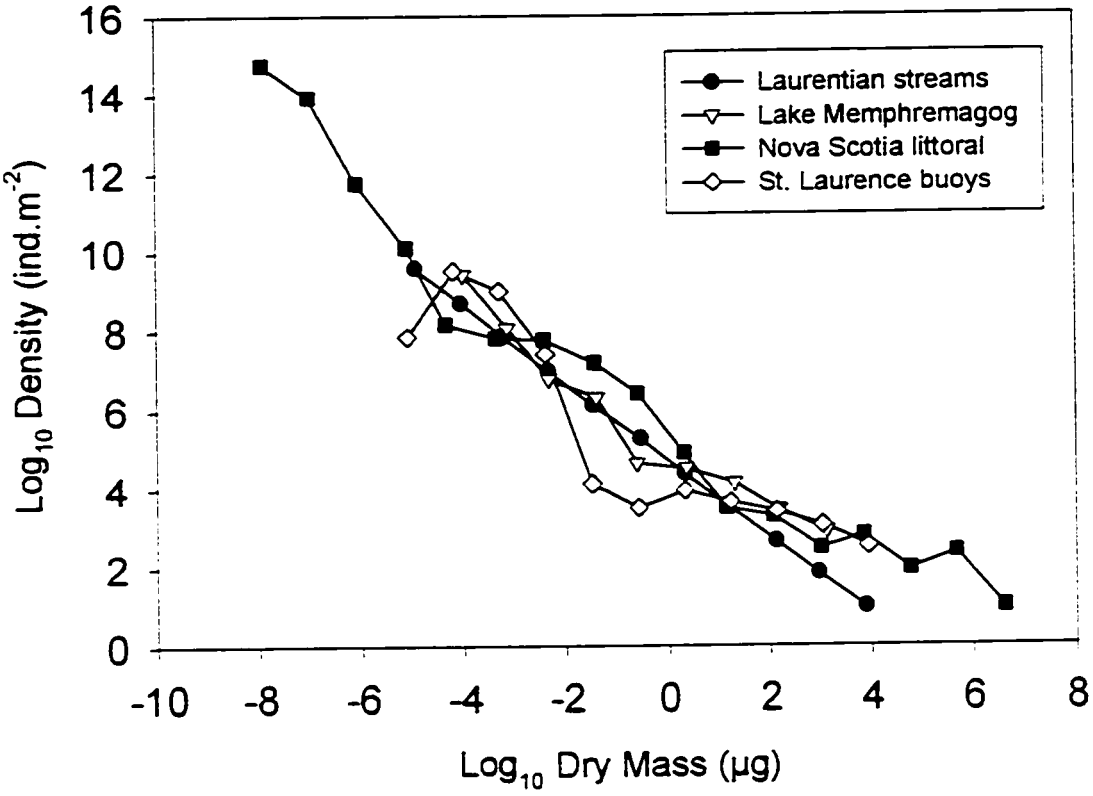



Fig. 2.4. Size distributions of invertebrates and algae from St. Lawrence River buoys and protozoans, algae and macroinvertebrates from lakes (Cattaneo 1987), marine littoral zones (Schwinghammer 1981) and temperate streams (Cattaneo 1993).

# General Conclusions

**General Conclusions:**

In the first chapter, which dealt specifically with developing bioindicators of Montreal area wastewater discharge, it is concluded that invertebrates colonizing navigational buoys are of limited use under the current levels of exposure. Even though fecal coliform concentration associated to wastewater discharge increased by 5 orders of magnitude, environmental parameters such as nutrients (TP, $NH_4$) and water clarity (Secchi depth, suspended matter and light extinction coefficient) varied only 2-20 fold. These narrow environmental gradients coupled with the possible selective colonization of buoys by more tolerant assemblages, could be responsible for the small responses of invertebrates to wastewater discharge.

In the second chapter, the potential use of size spectra of algae and invertebrates colonizing buoys as community measures for assemblage response along a trophic gradient was examined. Size distributions were found to be of limited use for this purpose since physico-chemical parameters of the river water were not significantly related to changes in size distributions. Monte Carlo simulations suggest that density would have had to increase 3-5 fold over the observed TP gradient (surrogate measure for trophy) for the analyses to likely detect significant effects. Interestingly, size spectra from buoys, which unfortunately lacked protozoans, had striking similarities with other complete size distributions (containing algae, protozoans and invertebrates) from streams (Cattaneo 1993), lakes (Cattaneo 1987) and marine littoral zones (Schwinghammer 1981). Size distributions of whole assemblages may be too robust to environmental conditions for diagnosis in cases where low to mid-levels of

pollution persist and do not threaten to impair ecosystems at a functional level (Odum 1985), or when sample size is small.

In conclusion, organisms inhabiting navigational buoys in the St. Lawrence River from May to September of 1995 generally exhibited weak community level effects from exposure to wastewaters originating form storm sewer overflows and wastewater treatment facilities in the Montreal area (see Vis 1997), when these effects could be detected (see Chapter 2). Fecal coliforms, which were harmless to biota (Geldreich 1978), provided useful tracers of exposure to wastewaters both spatially and temporally, by reflecting the physico-chemical changes associated to wastewater discharge. Furthermore, the weak responses observed in the bioindicators, referenced by upstream conditions, suggest that natural riverine communities may not be seriously impaired by Montreal wastewater discharge, at least within short time periods (i.e. from ice break to ice formation) and actual exposure levels. Efforts to improve physico-chemical treatment of wastewaters in Montreal may have been efficient in reducing ecological impact to the St. Lawrence River, however, the data presented in this thesis cannot be used to address this possibility. Future studies should focus on quantifying the long-term influence of urban wastewater pollution on economically and ecologically important organisms and to validate the use of biological indicators in protecting ecological integrity.

## References

Ahrens, M.A. and R.H. Peters. 1991. Patterns and limitations in limnoplankton size spectra. Can. J. Fish. Aquat. Sci. 48:1967-1978.

Allan, D. 1995. Stream Ecology: Structure and function of running waters. Chapman & Hall, London.

Anderson, N.H. and J.R. Sedell. 1979. Detritus processing by macroinvertebrates in stream ecosystems. Annu. Rev. Entomol. 24:351-377.

APHA - American Public Health Association. 1995. Standard methods for the examination of water and wastewater. American Public Health Association, Washington D.C., U.S.A.

Armitage, P.D., D. Moss, J.F. Wright and M.T. Furse. 1983. The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running-water sites. Wat. Res. 17:333-347.

Barbour, M.T., J. Gerritsen, G.E. Griffith, R. Frydenborg, E. McCarron, J.S. White and M.L. Bastian. 1996. A framework for biological criteria for Florida streams using benthic macroinvertebrates. J. N. Am. Benthol. Soc. 15(2):185-211.

Bergman, M. and R.H. Peters. 1980. A simple reflectance method for the measurement of particulate pigment in lake water and its application to phosphorous-chlorophyll-seston relationships. Can. J. of Fish. Aquat. Sci. 37: 111-114.

Borgmann, U. 1987. Models on the slope of, and biomass flow up, the biomass size spectrum. Can. J. Fish. Aquat. Sci. 44:136-140.

Bott, T.L. and L.A. Kaplan. 1989. Densities of benthic protozoa and nematodes in a Piedmont stream. J. N. Am. Benthol. Soc. 8:187-196.

Boudreau, P.R. and L.M. Dickie. 1992. Biomass spectra of aquatic ecosystems in relation to fisheries yield. Can. J. Fish. Aquat. Sci. 49:1528-1538.

Bourassa, N. and A. Morin. 1995. Relationships between size structure of invertebrate assemblages and trophy and substrate composition in streams. J. N. Am. Benthol. Soc. 14(3):393–403.

Cairns, J., Jr., P.V. McCormick and B.R. Niederlehner. 1993. A proposed framework for developing indicators of ecosystem health. Hydrobiol. 263:1–44.

Casey, R.J. and S.A. Kendall. 1996. Comparisons among colonization of artificial substratum types and natural substratum by benthic macroinvertebrates. Hydrobiol. 341:57-64.

Cattaneo, A. 1987. Size distribution in periphyton. Can. J. Fish. Aquat. Sci. 44:2025-2028.

Cattaneo, A. 1993. Size spectra of benthic communities in Laurentian streams. Can. J. Fish. Aquat. Sci. 50:2659-2666.

Cattaneo, A. and B. Mousseau. 1995. Empirical analysis of the removal rate of periphyton by grazers. Oecologia 103(2):249-254.

Cattaneo, A., G. Méthot, B. Pinel-Alloul and T. Niyonsenga. 1995. Epiphyte size and taxonomy as biological indicators of ecological and toxicological factors in Lake Saint-François (Québec). Environ. Pollut. 87:357-372.

CERS. 1996. Monthly summary report for 1994-1995. Aquacers. Société de gestion du CERS (Centre d'Épuration de la Rive Sud) Inc. Longueil, Quebec, Canada.

Chambers, P.A., M. Allard, S.L. Walker, J. Marsalek, J. Lawrence, M. Servos, J. Busnarda, K.S. Munger, K. Adare, C. Jefferson, R.A. Kent and M.P. Wong. 1997. Impacts of municipal wastewater effluents on Canadian waters: A review. Water Qual. Res. J. Canada 32(4):659-713.

Cook, S.E. 1976. Quest for an index of community structure sensitive to water pollution. Environ. pollut. 11:268-287.

Courtemanch, D.L. 1994. Bridging the old and new science of biological monitoring. J. N. Am. Benthol. Soc. 13(1):117-121.

Culver, D.A., M.M. Boucherle, D.J. Bean and J.W. Fletcher. 1985. Biomass of freshwater crustacean zooplankton from length weight regressions. Can. J. Fish. Aquat. Sci. 42:1380-1390.

Cummins, K.W. and J C. Wuycheck. 1971. Caloric equivalents for investigations in ecological energetics. Int. Ver. Theor. Angew. Limnol. Mit. 18:1-158.

DesChamps, G., C. Juteau and P. Cejka. 1997. Bilan Sommaire des activités du réseau de suivi écologique de 1990 à 1995. Communauté Urbaine de Montréal, Montreal, Quebec, Canada.

Environment Canada. 1993. Manuel des méthodes d'analyses (Anexes B). Regional Laboratory-Quebec Region. Ecotoxicology and Environmental Chemistry section, St. Lawrence Centre, Environment Canada, Montreal Quebec, Canada.

Environment Canada. 1996. Daily flow values for the St. Lawrence. Hydrology Section, Atmospheric Environment Service, Quebec Region, Montreal, Quebec, Canada.

Ferraris, J. 1984. Macroinvertébrés V (Benthos et Invertébrés Phytophiles): Synthèse de

la Variabilité Spatio-temporelle des Macroinvertébrés Benthiques et Phytophiles Récoltés du 7 Avril 1982 au 27 Juillet 1983. Élaboration de la Clé de Potentiel et Description des Communautés aux Habitats-Types. Ministère du Loisir, de la Chasse et de la Pèche. Rapport Technique, 368 p.

Fisheries and Oceans. 1992. Marine Fisheries in Quebec – Annual Statistical Review 1992-1991. Economics, Statistics and Informatics Branch, Statistics and Informatics Division, Québec.

Geldreich, E.E. 1978. Bacterial populations and indicator concepts in faeces, sewage, stormwater and solid wastes. In: G. Berg. (Ed.) Indicators of viruses in water and food. Ann Arbor Science Publishers Inc., Ann Arbor. pp.51-97

Griesbach, S., R.H. Peters and S. Youakim. 1982. An allometric model for pesticide accumulation. Can. J. Fish. Aquat. Sci. 39:727-735.

Gurtz, M.E. 1994. Design of biological components of the National Water-Quality Assessment (NAWQA) Program. In: S.L. Loeb and A. Spacie (eds.). Biological monitoring of aquatic systems. Lewis Publishers, Boca Raton, Florida.

Hanson, J.M., E.E. Prepas and W.C. MacKay. 1989. Size distribution of the macroinvertebrate community in a freshwater lake. Can. J. Fish. Aquat. Sci. 46:1510-1519.

Hart, D.D. 1994. Building a stronger partnership between ecological research and biological monitoring. J. N. Am. Benthol. Soc. 13(1):110-116.

ITFM – International Task Force on Monitoring Water Quality. 1992. Ambient water-quality monitoring in the United States: First year review, evaluation, and recommendations. Report to Office of Management and Budget, Washington, D.C.

Inland Waters Directorate. 1990. Water – Here, there and everywhere. Fact sheet No. 2. Environment Canada, Conservation and Protection, Ottawa.

Johnson, B.L., W.B. Richardson and T.J. Naimo. 1995. Past, Present, and Future Concepts in Large River Ecology. Bioscience 45(3):134-141.

Karr, J.R. 1993. Defining and assessing ecological integrity: Beyond water quality. Environ. Toxicol. Chem. 12:1521-1531.

Kerans, B.L. and J.R. Karr. 1994. A benthic index of biotic integrity (B-IBI) for rivers of the Tennessee Valley. Ecological Applications 4:768-785.

Ladle, M. and G.J. Bird. 1984. The biology of *Psamoryctides barbatus* (Grube) in English chalk streams. Hydrobiol. 115:109-112.

Lafont, M. 1987. Production of Tubificidae in the littoral zone of Lake Léman near

Thono-les-Bains: A methodological approach. Hydrobiol. 155:179-187.

Legendre, P. 1993. Spatial autocorrelation: Trouble or new paradigm?. Ecology 74(6):1659-1673

Lindegaard, C., K. Hamburger and P.C. Dall. 1994. Population dynamics and energy budget of *Marionina southerni* (Cernosvitov) (Enchytraeidae, Oligochaeta) in the littoral of Lake Esrom, Denmark. Hydrobiol. 278:291-301.

MacKay, R.J. 1992. Colonization by lotic macroinvertebrates: A review of processes and patterns. Can. J. Fish. Aquat. Sci. 49:617-628.

Manly, B.F.J. 1986. Multivariate Statistical Methods. A Primer. Chapman and Hall, London.

Marchant, R. et H.B.N. Hynes. 1981. Field estimates of feeding rate for *Gammarus pseudolmnaeus* (Crustacea: Amphipoda) in the Credit River, Ontario. Freshwater Biol. 11:27-36.

McKee, S. Ottawa-Carleton Institute of Biology, University of Ottawa, P.O. Box 450, Stn. A, Ottawa, Canada, K1N 6N5.

MEQ - Ministère de l'Environnement du Québec. 1990. Critères de qualité de l'eau.

Service d'évaluation des rejets toxiques et Direction de la qualité des cours d'eau, Ministère de l'Environnement du Québec, Québec, Canada. 423 p.

Merrit, R.W. and K.W. Cummins. 1996. An introduction to the aquatic insects of North America. Kendall/Hunt Publishing Company, Iowa.

Meyer, E. 1989. The relationship between body length parameters and dry mass in running water invertebrates. Arch. Hydrobiol. 117(2):191-293.

Morin, A. and D. Nadon. 1991. Size distribution of epilithic lotic invertebrates and implications for community metabolism. J. N. Am. Benthol. Soc. 10(3):300-308.

Morin, A., M. Rodriguez and D. Nadon. 1995. Temporal and environmental variation in the biomass spectrum of benthic invertebrates in streams: an application of thin-plate splines and relative warp analysis. Can. J. Fish. Aquat. Sci. 52:1881-1892.

MUC. 1996. Monthly summary reports for 1994-1995. Montreal Urban Community, Environment Services, Montreal, Quebec, Canada.

Naiman, R.J., J.J. Magnuson, D.M. McKnight, J.A. Stanford and J.R. Karr. 1995. Freshwater ecosystems and their management: A national initiative. Science 270:584-586.

Odum, E.P. 1985. Trends expected in stressed ecosystems. Bioscience 35:419-422.

Palmer, R. and J. O'Keefe. 1990. Transported material in a small river with multiple impoundments. Freshwater Biol. 24:563-575.

Peters, R.H. 1983. The ecological implications of body size. Cambridge University Press, Cambridge, England. 329p.

Pham, T.-T. and S. Proulx. 1996. Caractérisation des biphényles polychlorés et des hydrocarbures aromatiques polycycliques dans les eaux de la station d'épuration de la Communauté Urbaine de Montréal et dans le panache de son effluent dans le Saint-Laurent. Rapport scientifique et technique ST-43. Environnement Canada – Région du Québec, Conservation de l'environnement, Centre Saint-Laurent, Montréal.

Pinell-Alloul, B., G. Méthot, L. Lapierre and A. Willsie. 1996. Macroinvertebrate community as a biological indicator of ecological and toxicological factors in Lake Saint-François (Québec). Environ. Pollut. 91(1):65-87.

Poff, N.L., M.A. Palmer, P.L. Angermeier, R.L. Vadas Jr., C.C. Hakenkamp, A. Bely, P. Arensburger, and A.P. Martin. 1993. Size structure of the metazoan community in a Piedmont Stream. Oecologia. 95:202-209.

Ports Canada. 1991. Tour d'horizon et répertoire. Canada Ports Corporation Services. Ottawa.

Purenne, P. 1996. Analyse de la qualité des eaux brutes et de l'eau traitée à la station d'épuration et évaluation du rendement des installations. Communauté Urbaine de Montréal, Service de l'Environnement, Montreal, Quebec, Canada.

Rasmussen, J.B. 1993. Patterns in the size structure of littoral zone macroinvertebrate communities. Can. J. Fish. Aquat. Sci. 50:2192-2207.

Resh, V.H. 1995. Freshwater benthic macroinvertebrates and rapid assessment procedures for water quality monitoring in developping and newly industrialized countries. In: *Biological assessment and criteria: Tools for resource planning and decision making* (eds. W.S. Davis and T. Simon) Lewis Publishers, Chelsea, MI, USA.

Reynoldson, T.B. and J.L. Metcalfe-Smith. 1992. An overview of the assessment of aquatic ecosystem health using benthic invertebrates. J. Aquat. Ecosys. Health 1:295-308.

Rodriquez, M.A. and P. Magnan. 1993. Community structure of lacustrine macrobenthos: Do taxon-based and size-based approaches yield similar insights? Can. J. Fish. Aquat. Sci. 50:800-815.

Rosenberg, D.M. and V.H. Resh. 1982. The use of artificial substrates in the study of freshwater benthic macroinvertebrates, p. 175-235. *In:* J. Cairns (ed.) Artificial substrates. Ann Arbor Science Publishers, Ann Arbor, MI.

Rosenberg, D.M. and V.H. Resh (eds.). 1993. Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York, 488 p.

Rounick, J.S. and M.J. Winterbourn. 1983. The formation, structure and utilization of stone surface organic layers in two New Zealand streams. Freshwater Biol. 13:57-72.

Schindler, D.W. 1987. Detecting ecosystem responses to anthropogenic stress. Can. J. Fish. Aquat. Sci. 44(Suppl. 1):6-25.

Schwinghammer, P. 1981. Characteristic size distributions of integral benthic communities. Can. J. Fish. Aquat. Sci. 38:1255-1263.

Sheldon, R.W., A. Prakash and W.H. Sutcliffe Jr. 1972. The size distribution of particles in the ocean. Limnol. Oceanogr. 17:327-340.

SLC – St. Lawrence Centre. 1996. State of the Environment Report on the St. Lawrence River. Volume 1: The St. Lawrence Ecosystem. Environment Canada - Quebec Region, Environmental Conservation and Les Éditions MultiMondes, Montreal. St. Lawrence UPDATE series.

Smock, L.A. 1980. Relationships between body size and biomass of aquatic insects. Freshwater Biol. 10:375-383.

Sprules, W.G. and M. Munawar. 1986. Plankton size spectra in relation to ecosystem productivity, size and perturbation. Can. J. Fish. Aquat. Sci. 43:1789-1794.

St. Lawrence Action Team. 1992. Bilan provisoire de la réduction des rejets des 50 industries du Plan d'action Saint-Laurent. Environment Canada and Ministère de l'Environnement du Québec. 21p.

Strayer, D. 1986. The size structure of a lacustrine zoobenthic community. Oecologia 69:513-516.

Strayer, D. 1991. Perspectives on the size distributions of lacustrine zoobenthos, its causes, and its consequences. J. North Am. Benthol. Soc. 10:210-221.

Suter, G.W., II. 1993. A critique of ecosystem health concepts and indexes. Environ. Toxicol. and Chem. 12:1533-1539.

Sweeting, R.A. 1994. River Pollution. In: P. Calow and G.E. Petts (eds.). The rivers handbook II: Hydrological and ecological principles. Blackwell Scientific Publications, Oxford, U.K.

US EPA – U.S. Environmental Protection Agency. 1990. Environmental monitoring and assessment program overview. EPA /600 /9-90 /001.

Vézina, A. 1986. Body size and mass flow in freshwater plankton: models and tests. J. Plankton Res. 8:939-956.

Vis, C. 1997. L'influence de la qualité physico-chimique des eaux du Saint-Laurent sur le périphyton. Thèse de Maîtrise, Département de Sciences Biologiques, Université de Montréal.

Vis, C. St. Lawrence Centre, Environment Canada, 105 McGill St., 7th floor, Montreal, Quebec, Canada, H2Y 2E7.

Warwick, R.M. and I.R. Joint. 1987. The size distribution of organisms in the Celtic Sea: from bacteria to metazoa. Oecologia 73:185-191.

Washington, H.G. 1984. Diversity, biotic and similarity indices: a review with special relevance to aquatic ecosystems. Wat. Res. 18: 653-694.

Way, C.M., A.J. Burky, C.R. Bingham and A.C. Miller. 1995. Substrate roughness, velocity refuges, and macroinvertebrate abundance on artificial substrates in the lower Mississippi River. J. North Am. Benthol. Soc. 14(4):510-518

Wetzel, R.G. and G.E. Likens. 1981. Limnological analyses. Second Edition. Springer-Verlag, New York. 391 pp.

Wilkinson, L., G. Blank and C. Gruber. 1996. Desktop data analysis with SYSTAT. Prentice-Hall. New-Jersey. 798 p.

Willsie, A. and G. Costan. 1996. Analyse des communautés benthiques comme indicateur de santé des écosystèmes du Saint-Laurent. St. Lawrence Centre, Environmental Conservation, Environment Canada - Quebec Region.

# Appendix A

Density of invertebrate taxa (ind.$cm^{-2}$) of each replicate collected on each navigation buoy for May, June, August and September sampling dates.

| Buoy | Replicate | Nematoda | Chironomidae | Amphipoda | Diptera | Ephemeroptera | Trichoptera | Acarina | Copepoda | Oligochaeta |
|---|---|---|---|---|---|---|---|---|---|---|
| C44 | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | B | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | A | 0.03 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | B | 0 | 0.12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | C | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | A | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | B | 0 | 0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | C | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | A | 0 | 0.12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | B | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | C | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | A | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | C | 0 | 0.06 | 0.03 | 0 | 0 | 0 | 0 | 0.03 | 0 |
| M144 | A | 0 | 0.03 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | B | 0 | 0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Buoy | Replicate | Nematoda | Chironomidae | Amphipoda | Diptera | Ephemeroptera | Trichoptera | Acarina | Copepoda | Oligochaeta |
|---|---|---|---|---|---|---|---|---|---|---|
| C44 | A | 0 | 0.43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | B | 0 | 0.36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | C | 0 | 0.19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | A | 0 | 0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | B | 0 | 0.09 | 0.03 | 0.06 | 0 | 0 | 0 | 0 | 0 |
| C46 | C | 0 | 0.03 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| C48 | A | 0 | 0.33 | 0.03 | 0.02 | 0 | 0 | 0 | 0 | 0 |
| C48 | B | 0.33 | 0.87 | 0.13 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| C48 | C | 0.02 | 0.34 | 0.02 | 0.07 | 0 | 0 | 0 | 0 | 0 |
| M104 | A | 2.01 | 4.30 | 0 | 0 | 0 | 0 | 0 | 0 | 1.66 |
| M104 | B | 0.60 | 2.13 | 0 | 0 | 0 | 0 | 0 | 0 | 1.11 |
| M104 | C | 1.95 | 4.52 | 0 | 0 | 0 | 0 | 0 | 0 | 1.80 |
| M122 | A | 0.55 | 3.92 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0.10 |
| M122 | B | 1.00 | 3.80 | 0 | 0 | 0 | 0 | 0 | 0 | 0.94 |
| M122 | C | 0.89 | 3.91 | 0 | 0.07 | 0 | 0 | 0 | 0 | 0 |
| M124 | A | 0 | 1.34 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| M124 | B | 0.09 | 2.09 | 0 | 0 | 0 | 0 | 0 | 0 | 0.06 |
| M124 | C | 0 | 0.95 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | A | 0.23 | 1.71 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | B | 0.22 | 2.60 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0.09 |
| M130 | C | 0.15 | 1.26 | 0 | 0 | 0 | 0 | 0 | 0 | 0.06 |
| M132 | A | 0 | 1.31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | B | 0 | 0.66 | 0 | 0 | 0 | 0 | 0 | 0 | 0.03 |
| M132 | C | 0 | 0.55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | A | 0.03 | 0.45 | 0 | 0 | 0 | 0 | 0 | 0 | 0.23 |
| M138 | B | 0.03 | 0.84 | 0 | 0 | 0 | 0 | 0 | 0 | 0.10 |
| M138 | C | 0.32 | 0.97 | 0 | 0 | 0 | 0 | 0 | 0 | 0.71 |
| M140 | A | 0.13 | 0.19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | B | 0.04 | 1.20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | C | 0.11 | 1.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0.11 |
| M144 | A | 0 | 0.97 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| M144 | B | 0.03 | 1.56 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| M144 | C | 0.06 | 1.39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | A | 0.25 | 3.35 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| M152 | B | 0.12 | 1.79 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | C | 0 | 0.94 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | A | 0.06 | 3.34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | B | 0.24 | 2.45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | C | 0.15 | 1.14 | 0 | 0 | 0 | 0 | 0 | 0 | 0.06 |
| M84 | A | 6.75 | 19.05 | 0.06 | 0.06 | 0.14 | 0 | 0 | 0.40 | 7.89 |
| M84 | B | 3.30 | 15.38 | 0.06 | 0.06 | 0.12 | 0 | 0 | 0.53 | 6.30 |
| M84 | C | 5.70 | 13.34 | 0 | 0.03 | 0.06 | 0 | 0 | 0.38 | 5.06 |
| MV28 | A | 15.33 | 5.05 | 0.06 | 0 | 0 | 0 | 0 | 0.99 | 0.46 |
| MV28 | B | 4.32 | 2.32 | 0.09 | 0 | 0 | 0.06 | 0 | 0.06 | 0.19 |
| MV28 | C | 2.99 | 2.55 | 0.10 | 0 | 0 | 0 | 0.03 | 0.44 | 0.10 |
| MV54 | A | 1.09 | 3.81 | 0.05 | 0 | 0.05 | 0 | 0 | 0.11 | 0.16 |
| MV54 | B | 0.93 | 3.53 | 0.03 | 0 | 0 | 0 | 0 | 0.09 | 0.12 |
| MV54 | C | 0.96 | 2.99 | 0 | 0 | 0 | 0 | 0 | 0.15 | 0.06 |
| MV58 | A | 0 | 3.68 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| MV58 | B | 0.12 | 2.34 | 0 | 0.03 | 0.03 | 0 | 0 | 0 | 0 |
| MV58 | C | 0.09 | 1.18 | 0 | 0 | 0 | 0 | 0 | 0 | 0.06 |

August 1, 1995

| Buoy | Replicate | Nematoda | Chironomidae | Amphipoda | Diptera | Ephemeroptera | Trichoptera | Acarina | Copepoda | Oligochaeta |
|---|---|---|---|---|---|---|---|---|---|---|
| C44 | A | 0 | 0.69 | 0 | 0 | 0 | 0 | 0 | 0 | 0.03 |
| C44 | B | 0 | 0.25 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| C44 | C | 0 | 0.38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | A | 0 | 0.20 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| C46 | B | 0 | 0.47 | 0 | 0 | 0 | 0.03 | 0 | 0 | 0 |
| C46 | C | 0.03 | 0.45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | A | 0 | 0.24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | B | 0 | 0.31 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | C | 0 | 0.37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | A | 2.40 | 0.86 | 0 | 0 | 0 | 0 | 0 | 0 | 9.50 |
| M104 | B | 10.23 | 2.03 | 0 | 0.06 | 0 | 0.03 | 0 | 0 | 3.29 |
| M104 | C | 2.90 | 3.42 | 0 | 0.12 | 0 | 0.12 | 0 | 0 | 5.00 |
| M122 | A | 0.06 | 0.16 | 0 | 0.03 | 0 | 0.03 | 0 | 0 | 0.03 |
| M122 | B | 0 | 0.23 | 0 | 0.10 | 0.03 | 0.03 | 0 | 0 | 0.03 |
| M122 | C | 0 | 0.10 | 0 | 0.17 | 0 | 0.07 | 0 | 0 | 0 |
| M124 | A | 0 | 0.46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | B | 0.03 | 1.05 | 0 | 0.06 | 0.37 | 0 | 0 | 0 | 0.06 |
| M124 | C | 0 | 0.12 | 0 | 0 | 0.09 | 0 | 0 | 0 | 0 |
| M130 | A | 0 | 0.16 | 0 | 0.03 | 0 | 0.03 | 0 | 0 | 0 |
| M130 | B | 0 | 0.09 | 0 | 0 | 0 | 0.03 | 0 | 0 | 0 |
| M130 | C | 0.06 | 1.00 | 0 | 0.08 | 0.03 | 0.03 | 0 | 0 | 0 |
| M132 | A | 0 | 0.19 | 0 | 0.22 | 0.03 | 0 | 0 | 0 | 0 |
| M132 | B | 0.03 | 0.20 | 0 | 0.26 | 0.12 | 0 | 0 | 0 | 0.06 |
| M132 | C | 0 | 0.17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | A | 0 | 0.06 | 0 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| M138 | B | 0 | 0.25 | 0 | 0 | 0 | 0.04 | 0 | 0 | 0 |
| M138 | C | 0 | 0.16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | A | 1.28 | 0.82 | 0 | 0.10 | 0.16 | 0.03 | 0 | 0 | 2.80 |
| M140 | B | 0.19 | 1.81 | 0 | 0.06 | 0 | 0.03 | 0 | 0 | 1.05 |
| M140 | C | 0.15 | 0.68 | 0 | 0.06 | 0 | 0.21 | 0.41 | 0 | 0.97 |
| M144 | A | 0.06 | 1.40 | 0 | 0.15 | 0.03 | 0.15 | 0 | 0 | 0.09 |
| M144 | B | 0 | 1.76 | 0.03 | 0 | 0.21 | 0.15 | 0 | 0 | 0 |
| M144 | C | 0.21 | 2.72 | 0 | 0.11 | 0.03 | 0 | 0 | 0.11 | 0.11 |
| M152 | A | 1.18 | 0.97 | 0 | 0.09 | 0.03 | 0 | 0 | 0.18 | 0.53 |
| M152 | B | 0.23 | 2.26 | 0 | 0.06 | 0 | 0.06 | 0 | 0 | 0 |
| M152 | C | 0.38 | 1.27 | 0 | 0 | 0 | 0.03 | 0 | 0.32 | 0.83 |
| M166 | A | 0.03 | 0.44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | B | 0.03 | 0.09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | C | 0 | 0.09 | 0 | 0 | 0.09 | 0 | 0 | 0 | 0 |
| M84 | A | 2.30 | 1.47 | 0.12 | 0.03 | 0 | 0.06 | 0 | 0 | 6.66 |
| M84 | B | 0.60 | 1.97 | 0.14 | 0.17 | 0.06 | 0.03 | 0 | 0 | 0.46 |
| M84 | C | 22.58 | 3.95 | 0 | 0.06 | 0 | 0 | 0 | 1.16 | 19.39 |
| MA14 | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | B | 0 | 0.21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | A | 0.92 | 0.39 | 0.09 | 0 | 0.04 | 0 | 0 | 0.57 | 0.13 |
| MV28 | B | 0.53 | 0.61 | 0.14 | 0.03 | 0.08 | 0.06 | 0.06 | 0.89 | 0.03 |
| MV28 | C | 1.52 | 0.85 | 0.03 | 0.06 | 0 | 0.08 | 0 | 0.54 | 0.08 |
| MV54 | A | 0.14 | 0.40 | 0 | 0.03 | 0 | 0 | 0 | 0.03 | 0.03 |
| MV54 | B | 0.25 | 0.56 | 0 | 0.36 | 0 | 0.06 | 0 | 0.42 | 0 |
| MV54 | C | 0.37 | 0.63 | 0 | 0.09 | 0 | 0 | 0 | 0.29 | 0 |

*(continued from previous table)*

| Buoy | Replicate | Nematoda | Chironomidae | Amphipoda | Diptera | Ephemeroptera | Trichoptera | Acarina | Copepoda | Oligochaeta |
|---|---|---|---|---|---|---|---|---|---|---|
| MV58 | A | 9.96 | 0.53 | 0.06 | 0.18 | 0 | 0 | 0 | 0.88 | 0.41 |
| MV58 | B | 5.55 | 0.54 | 0 | 0.03 | 0.03 | 0.11 | 0 | 1.49 | 0.09 |
| MV58 | C | 2.63 | 0.27 | 0 | 0 | 0 | 0.09 | 0 | 0.30 | 0.12 |

| Buoy | Replicate | Nematoda | Chironomidae | Amphipoda | Diptera | Ephemeroptera | Trichoptera | Acarina | Copepoda | Oligochaeta |
|---|---|---|---|---|---|---|---|---|---|---|
| C44 | A | 0 | 0.12 | 0.06 | 0 | 0 | 0.03 | 0 | 0 | 0 |
| C44 | B | 0 | 0 | 0.03 | 0 | 0 | 0.07 | 0 | 0 | 0 |
| C44 | C | 0 | 0.12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | A | 0 | 0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | B | 0 | 0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | C | 0.75 | 0.36 | 0.07 | 0 | 0 | 0.11 | 0 | 0 | 0.29 |
| C48 | A | 0.06 | 0 | 0.17 | 0 | 0 | 0.03 | 0 | 0 | 0.03 |
| C48 | B | 0 | 0.08 | 0.08 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | C | 0 | 0.16 | 0.07 | 0 | 0 | 0.03 | 0 | 0 | 0 |
| M104 | A | 0.03 | 0.56 | 0.06 | 0.09 | 0.06 | 0.19 | 0 | 0.03 | 0 |
| M104 | B | 3.64 | 0.36 | 0.03 | 0.11 | 0.11 | 0.31 | 0 | 0 | 0.25 |
| M104 | C | 10.54 | 1.33 | 0 | 0.14 | 0.08 | 0.11 | 0.03 | 0.08 | 0.60 |
| M122 | A | 0.03 | 0.33 | 0 | 0 | 0.07 | 0.03 | 0 | 0 | 0 |
| M122 | B | 0.10 | 0.73 | 0 | 0 | 0.10 | 0.07 | 0 | 0 | 0 |
| M122 | C | 0 | 0.39 | 0 | 0 | 0.04 | 0.11 | 0 | 0 | 0 |
| M124 | A | 0 | 0.37 | 0 | 0 | 0.10 | 0.24 | 0 | 0 | 0 |
| M124 | B | 0 | 0.18 | 0 | 0 | 0 | 0.07 | 0 | 0 | 0 |
| M124 | C | 0 | 0.12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | A | 0 | 0.42 | 0 | 0 | 0.10 | 0 | 0 | 0 | 0 |
| M130 | B | 0.03 | 0.34 | 0 | 0 | 0.03 | 0 | 0 | 0 | 0 |
| M130 | C | 0 | 0.69 | 0.03 | 0 | 0.13 | 0.13 | 0 | 0 | 0 |
| M132 | A | 0.21 | 2.30 | 0 | 0.03 | 0 | 0.03 | 0 | 0 | 0 |
| M132 | B | 0.09 | 2.02 | 0 | 0.06 | 0 | 0.03 | 0 | 0 | 0.06 |
| M132 | C | 0 | 1.13 | 0.03 | 0.06 | 0.03 | 0.06 | 0 | 0 | 0.12 |
| M138 | A | 0.56 | 2.64 | 0.12 | 0.12 | 0.09 | 0.03 | 0 | 0 | 0.78 |
| M138 | B | 0.78 | 3.30 | 0 | 0 | 0.03 | 0.13 | 0 | 0 | 2.30 |
| M138 | C | 0.21 | 3.32 | 0 | 0.15 | 0.03 | 0.09 | 0 | 0 | 0.48 |
| M140 | A | 0.06 | 1.21 | 0.06 | 0 | 0.21 | 0.06 | 0 | 0 | 0 |
| M140 | B | 1.57 | 0.81 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0.16 |
| M140 | C | 1.40 | 1.85 | 0.03 | 0.12 | 0.03 | 0.06 | 0 | 0.03 | 8.68 |
| M144 | A | 0.25 | 0.69 | 0 | 0 | 0.03 | 0.09 | 0 | 0 | 0 |
| M144 | B | 0.12 | 0.24 | 0 | 0 | 0 | 0.09 | 0 | 0 | 0 |
| M144 | C | 0.28 | 0.78 | 0 | 0 | 0.06 | 0.06 | 0 | 0 | 0 |
| M152 | A | 0.11 | 0.95 | 0 | 0 | 0.03 | 0.03 | 0 | 0 | 0.20 |
| M152 | B | 3.03 | 0.77 | 0 | 0.09 | 0.24 | 0.09 | 0 | 0 | 0.06 |
| M152 | C | 0.99 | 1.39 | 0 | 0 | 0 | 0.03 | 0 | 0 | 0 |
| M166 | A | 0 | 0.09 | 0 | 0 | 0.03 | 0 | 0 | 0 | 0 |
| M166 | B | 0.10 | 0.36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | C | 0 | 0.03 | 0 | 0 | 0.03 | 0 | 0 | 0 | 0 |
| M84 | A | 0.43 | 1.55 | 0.03 | 0 | 0.03 | 0.15 | 0 | 0 | 0.36 |
| M84 | B | 0.83 | 1.63 | 0.13 | 0.08 | 0.08 | 0.21 | 0 | 0.05 | 0.03 |
| M84 | C | 37.04 | 4.13 | 0 | 0.15 | 0.21 | 0.33 | 0.06 | 0.61 | 0.64 |
| MA14 | A | 1.02 | 0.54 | 0.22 | 0.06 | 0 | 0.06 | 0 | 0.10 | 0.10 |
| MA14 | B | 0.09 | 0.29 | 0.03 | 0.03 | 0 | 0 | 0 | 0 | 0 |
| MA14 | C | 0.03 | 0.32 | 0.09 | 0 | 0 | 0.03 | 0.03 | 0.03 | 0 |
| MV28 | A | 26.88 | 0.25 | 0.06 | 0.31 | 0 | 0.44 | 0.13 | 2.88 | 1.63 |
| MV28 | B | 6.71 | 0.53 | 0 | 0.30 | 0 | 0.06 | 0.18 | 0.89 | 0.47 |
| MV28 | C | 21.80 | 0.44 | 0.13 | 0.56 | 0 | 0.50 | 0.63 | 1.25 | 0.94 |
| MV54 | A | 5.89 | 0.46 | 0.03 | 0.03 | 0.03 | 0.06 | 0 | 0.12 | 0 |
| MV54 | B | 1.92 | 0.73 | 0 | 0.11 | 0.03 | 0 | 0 | 0 | 0 |
| MV54 | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.03 |

*(continued from previous table)*

| Buoy | Replicate | Nematoda | Chironomidae | Amphipoda | Diptera | Ephemeroptera | Trichoptera | Acarina | Copepoda | Oligochaeta |
|---|---|---|---|---|---|---|---|---|---|---|
| MV58 | A | 32.15 | 1.95 | 0 | 0.11 | 0.11 | 0.46 | 0 | 1.37 | 1.37 |
| MV58 | B | 80.70 | 1.25 | 0.19 | 0 | 0.19 | 1.32 | 0.75 | 5.45 | 3.88 |
| MV58 | C | 5.09 | 0.41 | 0.19 | 0.03 | 0 | 0.16 | 0 | 0.22 | 0 |

# Appendix B

Physicochemical measurements made at each navigation buoy for May, June, August and September sampling dates.

May 7, 1995

| Buoy | Temperature °C | SpConductivity (µS/cm) | Current velocity (m/s) | Light extinction coefficient | Secchi Depth (m) | Suspended matter (mg/l) | SiO2 (mgSiO2/l) | NH4 (mgN/l) | NO2/NO3 (mgN/l) | PO4 (mgP/l) | TP (mgP/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 8.43 | 263 | 0.89 | 0.28 | 11.30 | 1.28 | 0.33 | 0.005 | 0.30 | 0.0010 | 0.0051 |
| C46 | 8.53 | 263 | 0.84 | 0.29 | 11.00 | 0.90 | 0.33 | 0.005 | 0.30 | 0.0010 | 0.0050 |
| C48 | 8.65 | 265 | 0.55 | 0.29 | 10.00 | 1.20 | 0.33 | 0.005 | 0.30 | 0.0010 | 0.0053 |
| M104 | 8.79 | 248 | 1.01 | | 3.50 | 2.92 | 0.49 | 0.004 | 0.27 | 0.0010 | 0.0083 |
| M130 | 8.73 | 246 | 1.00 | | 3.00 | 2.56 | 0.59 | 0.007 | 0.26 | 0.0020 | 0.0084 |
| M132 | 9.06 | 246 | 0.88 | | 3.00 | 3.24 | 0.90 | 0.139 | 0.26 | 0.0027 | 0.0142 |
| M138 | 9.26 | 264 | 1.04 | | 2.00 | 3.48 | 0.98 | 0.263 | 0.24 | 0.0027 | 0.0247 |
| M140 | 9.53 | 281 | 1.19 | | 3.00 | 3.16 | 1.10 | 0.156 | 0.24 | 0.0034 | 0.0199 |
| M144 | 9.01 | 240 | 1.28 | | 3.00 | 2.60 | 0.78 | 0.003 | 0.26 | 0.0020 | 0.0091 |

| Buoy | Fec. Coliform (UFC/100ml) | AFDW (mg/cm2) | Chlorophyll a (µg/cm2) |
|---|---|---|---|
| C44 | 2 | 0.20 | 0.23 |
| C46 | 2 | 0.04 | 0.21 |
| C48 | 2 | 0.04 | 0.28 |
| M104 | 345 | 0.35 | 2.43 |
| M130 | 500 | 0.58 | 5.21 |
| M132 | 7850 | 0.67 | 4.23 |
| M138 | 18000 | 0.93 | 3.83 |
| M140 | 50500 | 0.95 | 5.50 |
| M144 | 470 | 0.57 | 6.63 |

June 7, 1995

| Buoy | Temperature °C | SpConductivity (µS/cm) | Current velocity (m/s) | Light extinction coefficient | Secchi Depth (m) | Suspended matter (mg/l) | SiO2 (mgSiO2/l) | NH4 (mgN/l) | NO2/NO3 (mgN/l) | PO4 (mgP/l) | TP (mgP/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 15.55 | 304 | 0.87 | 0.44 | 4.50 | 2.24 | 0.55 | 0.004 | 0.29 | 0.0010 | 0.0103 |
| C46 | 15.63 | 304 | 0.89 | 0.42 | 4.50 | 2.12 | 0.55 | 0.001 | 0.28 | 0.0010 | 0.0103 |
| C48 | 15.64 | 306 | 0.60 | 0.44 | 4.50 | 1.00 | 0.54 | 0.002 | 0.31 | 0.0010 | 0.0096 |
| M104 | 15.80 | 262 | 1.16 | 0.82 | 1.50 | 6.04 | 1.26 | 0.014 | 0.31 | 0.0016 | 0.0149 |
| M122 | 15.71 | 265 | 0.90 | 0.81 | 1.50 | 5.20 | 1.22 | 0.011 | 0.30 | 0.0016 | 0.0142 |
| M124 | 15.74 | 271 | 1.32 | 0.80 | 1.50 | 4.52 | 1.11 | 0.014 | 0.31 | 0.0031 | 0.0125 |
| M130 | 15.81 | 252 | 1.37 | 0.89 | 1.50 | 5.52 | 1.41 | 0.017 | 0.32 | 0.0024 | 0.0139 |
| M132 | 16.12 | 242 | 1.08 | 1.09 | 1.50 | 6.08 | 1.74 | 0.047 | 0.30 | 0.0099 | 0.0203 |
| M138 | 16.44 | 266 | 1.08 | 0.92 | 1.25 | 7.80 | 1.97 | 0.17 | 0.31 | 0.0010 | 0.0363 |
| M140 | 16.34 | 257 | 1.15 | 1.12 | 1.25 | 6.16 | 1.88 | 0.129 | 0.31 | 0.0022 | 0.0288 |
| M144 | 16.12 | 234 | 1.27 | 1.00 | 1.50 | 5.72 | 1.76 | 0.018 | 0.30 | 0.0111 | 0.0174 |
| M152 | 16.40 | 212 | 0.95 | 0.95 | 1.50 | 6.16 | 2.16 | 0.023 | 0.30 | 0.0056 | 0.0260 |
| M166 | 16.43 | 214 | 1.18 | 1.20 | 1.25 | 6.12 | 2.10 | 0.027 | 0.30 | 0.0063 | 0.0242 |
| M84 | 15.88 | 260 | 1.31 | 0.89 | 1.50 | 5.04 | 1.26 | 0.014 | 0.30 | 0.0082 | 0.0171 |
| MA14 | 16.26 | 239 | 0.00 | 1.06 | 1.50 | 4.64 | 1.76 | 0.032 | 0.27 | 0.0010 | 0.0189 |
| MV28 | 16.42 | 212 | 0.18 | 1.11 | 1.25 | 6.00 | 2.13 | 0.02 | 0.26 | 0.0065 | 0.0206 |
| MV54 | 16.65 | 212 | 0.34 | 0.97 | 1.50 | 4.88 | 2.18 | 0.022 | 0.31 | 0.0047 | 0.0210 |
| MV58 | 16.52 | 212 | 0.59 | 1.07 | 1.50 | 5.04 | 2.18 | 0.022 | 0.30 | 0.0049 | 0.0217 |

| Buoy | Fec. Coliform (UFC/100ml) | AFDW (mg/cm2) | Chlorophyll a (µg/cm2) |
|---|---|---|---|
| C44 | 2 | 0.16 | 1.54 |
| C46 | 2 | 0.07 | 0.79 |
| C48 | 3 | 0.24 | 2.89 |
| M104 | 680 | 0.25 | 1.60 |
| M122 | 765 | 0.19 | 1.11 |
| M124 | 380 | 0.09 | 0.36 |
| M130 | 715 | 0.10 | 0.29 |
| M132 | 25500 | 0.08 | 0.31 |
| M138 | 170000 | 0.10 | 0.26 |
| M140 | 145000 | 0.15 | 0.33 |
| M144 | 2450 | 0.13 | 0.37 |
| M152 | 3650 | 0.16 | 0.91 |
| M166 | 4825 | 0.16 | 1.38 |
| M84 | 825 | 0.77 | 4.95 |
| MA14 | 17500 | | |
| MV28 | 1800 | 0.95 | 6.39 |
| MV54 | 3450 | 0.59 | 5.12 |
| MV58 | 2900 | 0.44 | 1.93 |

August 1, 1995

| Buoy | Temperature | SpConductivity (µS/cm) | Current velocity (m/s) | Light extinction coefficient | Secchi Depth (m) | Suspended matter (mg/l) | SiO2 (mgSiO2/l) | NH4 (mgN/l) | NO2/NO3 (mgN/l) | PO4 (mgP/l) | TP (mgP/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 23.26 | 291 | 0.89 | 0.44 | 3.00 | 1.80 | 0.46 | 0.007 | 0.12 | 0.0061 | 0.0132 |
| C46 | 23.36 | 290 | 0.95 | 0.40 | 4.00 | 1.88 | 0.46 | 0.001 | 0.12 | 0.0054 | 0.0129 |
| C48 | 23.40 | 290 | 0.62 | 0.34 | 5.00 | 1.88 | 0.46 | 0.011 | 0.12 | 0.0054 | 0.0146 |
| M104 | 23.54 | 281 | 1.07 | 0.63 | 0.75 | 5.14 | 0.55 | 0.009 | 0.13 | 0.0061 | 0.0205 |
| M122 | 23.42 | 280 | 0.70 | 0.57 | 1.00 | 4.84 | 0.58 | 0.01 | 0.14 | 0.0073 | 0.0177 |
| M124 | 23.37 | 281 | 1.41 | 0.53 | 1.25 | 4.52 | 0.56 | 0.013 | 0.14 | 0.0073 | 0.0160 |
| M130 | 23.42 | 278 | 1.32 | 0.56 | 2.00 | 3.38 | 0.60 | 0.012 | 0.14 | 0.0061 | 0.0163 |
| M132 | 23.60 | 275 | 0.99 | 0.58 | 1.50 | 4.08 | 0.72 | 0.081 | 0.13 | 0.0050 | 0.0212 |
| M138 | 23.63 | 276 | 1.53 | 0.60 | 1.50 | 4.68 | 0.77 | 0.157 | 0.12 | 0.0031 | 0.0229 |
| M140 | 23.70 | 283 | 1.39 | 0.65 | 1.25 | 4.50 | 0.79 | 0.13 | 0.13 | 0.0046 | 0.0271 |
| M144 | 23.60 | 269 | 1.46 | 0.55 | 1.50 | 3.08 | 0.68 | 0.007 | 0.13 | 0.0058 | 0.0163 |
| M152 | 23.75 | 263 | 1.03 | 0.52 | 2.00 | 2.96 | 0.77 | 0.011 | 0.12 | 0.0058 | 0.0160 |
| M166 | 23.81 | 262 | 1.23 | 0.58 | 2.00 | 3.12 | 0.79 | 0.009 | 0.12 | 0.0058 | 0.0160 |
| M84 | 23.64 | 282 | 0.93 | 0.79 | 0.75 | 7.24 | 0.56 | 0.001 | 0.13 | 0.0065 | 0.0224 |
| MA14 | 23.94 | 275 | 0.34 | 0.53 | 2.00 | 2.80 | 0.67 | 0.014 | 0.12 | 0.0061 | 0.0212 |
| MV28 | 23.95 | 269 | 0.36 | 0.64 | 2.00 | 3.50 | 0.72 | 0.013 | 0.10 | 0.0069 | 0.0201 |
| MV54 | 24.02 | 263 | 0.75 | 0.51 | 2.00 | 2.76 | 0.74 | 0.012 | 0.12 | 0.0073 | 0.0174 |
| MV58 | 23.94 | 265 | 0.85 | 0.60 | 2.50 | 2.76 | 0.75 | 0.015 | 0.12 | 0.0073 | 0.0174 |

| Buoy | Fec. Coliform (UFC/100ml) | AFDW (mg/cm2) | Chlorophyll a (µg/cm2) |
|---|---|---|---|
| C44 | 2 | 0.48 | 3.35 |
| C46 | 2 | 1.02 | 7.66 |
| C48 | 2 | 0.74 | 4.88 |
| M104 | 1337 | 0.65 | 3.73 |
| M122 | 1005 | 0.26 | 1.69 |
| M124 | 1090 | 0.44 | 3.46 |
| M130 | 1150 | 0.80 | 2.42 |
| M132 | 15500 | 0.33 | 1.86 |
| M138 | 75000 | 0.22 | 1.53 |
| M140 | 38000 | 1.12 | 4.71 |
| M144 | 1150 | 0.75 | 3.03 |
| M152 | 1455 | 1.08 | 4.83 |
| M166 | 850 | 0.12 | 0.80 |
| M84 | 1150 | 1.45 | 6.74 |
| MA14 | 4300 | 0.16 | 1.39 |
| MV28 | 2500 | 1.09 | 13.79 |
| MV54 | 1550 | 0.81 | 12.79 |
| MV58 | 1400 | 0.82 | 14.47 |

September 26, 1995

| Buoy | Temperature | SpConductivity (µS/cm) | Current velocity (m/s) | Light extinction coefficient | Secchi Depth (m) | Suspended matter (mg/l) | SiO2 (mgSiO2/l) | NH4 (mgN/l) | NO2/NO3 (mgN/l) | PO4 (mgP/l) | TP (mgP/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 15.52 | 285 | 0.79 | 0.29 | 10.00 | 0.90 | 0.49 | 0.009 | 0.17 | 0.0047 | 0.0114 |
| C46 | 15.53 | 284 | 0.80 | 0.30 | 9.50 | 0.90 | 0.48 | 0.009 | 0.18 | 0.0047 | 0.0122 |
| C48 | 15.51 | 284 | 0.60 | 0.32 | 10.00 | 0.73 | 0.49 | 0.010 | 0.17 | 0.0047 | 0.0137 |
| M104 | 15.58 | 279 | 0.96 | 0.46 | 3.25 | 2.07 | 0.62 | 0.012 | 0.17 | 0.0041 | 0.0136 |
| M122 | 15.52 | 277 | 0.80 | 0.43 | 3.75 | 2.38 | 0.63 | 0.013 | 0.17 | 0.0044 | 0.0125 |
| M124 | 15.52 | 277 | 1.11 | 0.42 | 4.25 | 2.29 | 0.62 | 0.014 | 0.17 | 0.0044 | 0.0121 |
| M130 | 15.51 | 277 | 1.15 | 0.41 | 4.25 | 2.24 | 0.65 | 0.012 | 0.17 | 0.0044 | 0.0141 |
| M132 | 15.62 | 280 | 1.02 | 0.46 | 4.00 | 2.20 | 0.75 | 0.1 | 0.19 | 0.0044 | 0.0194 |
| M138 | 15.74 | 286 | 1.03 | 0.59 | 3.50 | 3.00 | 0.85 | 0.181 | 0.19 | 0.0034 | 0.0249 |
| M140 | 15.54 | 275 | 1.21 | 0.65 | 4.00 | 2.50 | 0.73 | 0.025 | 0.19 | 0.0037 | 0.0121 |
| M144 | 15.52 | 274 | 1.15 | 0.44 | 4.00 | 2.13 | 0.72 | 0.009 | 0.20 | 0.0037 | 0.0121 |
| M152 | 15.52 | 272 | 0.95 | 0.48 | 4.50 | 2.28 | 0.70 | 0.008 | 0.19 | 0.0044 | 0.0114 |
| M166 | 15.52 | 269 | 1.12 | 0.49 | 4.25 | 1.96 | 0.75 | 0.007 | 0.18 | 0.0041 | 0.0157 |
| M84 | 15.64 | 279 | 0.89 | 0.45 | 3.25 | 2.37 | 0.62 | 0.013 | 0.16 | 0.0044 | 0.0139 |
| MA14 | 15.74 | 277 | 0.24 | 0.62 | 3.00 | 1.84 | 0.69 | 0.024 | 0.15 | 0.0041 | 0.0129 |
| MV28 | 15.54 | 273 | 0.28 | 0.62 | 3.00 | 2.23 | 0.66 | 0.016 | 0.15 | 0.0051 | 0.0143 |
| MV54 | 15.69 | 269 | 0.59 | 0.47 | 3.25 | 1.56 | 0.70 | 0.011 | 0.19 | 0.0041 | 0.0121 |
| MV58 | 15.60 | 270 | 0.53 | 0.44 | 4.00 | 2.03 | 0.72 | 0.01 | 0.19 | 0.0044 | 0.0125 |

| Buoy | Fec. Coliform (UFC/100ml) | AFDW (mg/cm2) | Chlorophyll a (µg/cm2) |
|---|---|---|---|
| C44 | 2 | 0.61 | 11.58 |
| C46 | 2 | 0.83 | 11.70 |
| C48 | 3 | 0.97 | 13.79 |
| M104 | 505 | 0.91 | 10.09 |
| M122 | 440 | 2.17 | 4.95 |
| M124 | 345 | 1.30 | 4.32 |
| M130 | 165 | 1.14 | 4.35 |
| M132 | 16000 | 1.03 | 5.83 |
| M138 | 58000 | 1.05 | 5.95 |
| M140 | 50500 | 0.87 | 4.64 |
| M144 | 45 | 0.71 | 4.61 |
| M152 | 30 | 0.51 | 8.20 |
| M166 | 100 | 1.11 | 3.59 |
| M84 | 700 | 0.93 | 9.48 |
| MA14 | 4800 | 0.56 | 8.73 |
| MV28 | 605 | 1.34 | 12.55 |
| MV54 | 10 | 0.27 | 6.19 |
| MV58 | 50 | 1.29 | 16.66 |

# Appendix C

Allometric relationships for the conversion of invertebrate lengths (mm) to dry mass (μg), conversion factors for weight measurements and biomass/density calculations.

| Taxon | Length-Mass relationship | Reference |
|---|---|---|
| Acarina | $1L^{3}$ | Morin and Nadon 1991 |
| Amphipoda | $4.86L^{3}$ | Marchant and Hynes 1981 |
| Chironomidae | $5.1L^{2.52}$ | Smock 1980 |
| Copepoda | $7.07L^{2.56}$ | Culver et al. 1985 |
| Diptera | $2.48L^{2.57}$ | Meyer 1989 |
| Ephemeroptera | $6.56L^{2.88}$ | Smock 1980 |
| Nematoda | $1L^{3}$ | Morin and Nadon 1991 |
| Oligochaeta | $1L^{2}$ | Ladle and Bird 1984 |
| | | Lafont 1987 |
| | | Lindegaard et al. 1994 |
| Trichoptera | $5.06L^{2.80}$ | Meyer 1989 |

| Measurement | Conversion | Reference |
|---|---|---|
| dry weight wet weight ratio all taxa except Oligochaeta | 0.25 | Cattaneo 1993<br>Schwinghammer 1981 |
| dry weight wet weight ratio Oligochaeta | 0.18 | Lindergaard et al. 1994 |
| dry weight ash free dry weight ratio | 1.18 | Cattaneo and Mouseau 1995 |
| biomass | number of individuals/sampling surface ($45.6cm^2$) | |
| density | total dry mass of individuals(mg)/sampling surface ($45.6cm^2$) | |

# Appendix D

Invertebrate density (ind.$m^{-2}$) per size class ($log_{10}$ upper limit) for each taxa of each replicate from September, 1995.

Acarina

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 272 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*(Acarina continued)*

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 304 | 304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 295 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 3133 | 2506 | 627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 1781 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 3133 | 2506 | 627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 3133 | 3759 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Amphipoda

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 580 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 340 | 0 | 0 | 0 | 0 | |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 718 | 0 | |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 580 | 290 | 0 | 0 | 0 | 290 | 0 | 29 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 387 | 0 | 387 | 0 | 0 | 0 | 0 | 0 | |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 329 | 0 | 0 | 0 | 329 | 0 | 0 | |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 311 | 0 | 311 | 0 | |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 278 | |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 326 | 0 | 0 | 0 | 0 | |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 0 | |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 311 | 0 | 0 | 0 | 622 | 0 | 311 | 0 | |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 304 | 0 | 0 | 0 | |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 313 | 0 | 0 | 0 | |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 0 | 0 | |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 0 | 0 | |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 533 | 0 | 267 | 0 | |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 318 | 318 | 637 | 637 | 318 | 0 | 0 | |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 286 | 0 | |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 295 | 589 | 0 | 0 | |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 286 | 0 | 0 | |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 627 | 0 | 0 | 627 | 0 | 0 | 0 | |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 627 | 0 | 0 | 0 | 627 | 0 | |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 0 | |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1253 | 627 | 0 | 0 | |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 318 | 0 | 318 | 318 | 637 | 0 | 637 | |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 603 | 603 | 0 | 0 | |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

Chironomidae

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 290 | 0 | 290 | 290 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 299 | 299 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 321 | 321 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 359 | 359 | 718 | 359 | 1077 | 1077 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 0 | 290 | 0 | 290 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 387 | 387 | 0 | 0 | 0 | 0 | 0 | 0 | 387 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 658 | 0 | 329 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 817 | 2450 | 5172 | 5717 | 9528 | 7895 | 4900 | 2722 | 3811 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 335 | 0 | 0 | 0 | 1004 | 335 | 335 | 1004 | 669 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 346 | 346 | 1385 | 1039 | 1385 | 1385 | 346 | 346 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 705 | 705 | 1410 | 1057 | 352 | 352 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 681 | 340 | 1361 | 0 | 681 | 340 | 1021 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356 | 711 | 0 | 356 | 356 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 306 | 612 | 0 | 306 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 324 | 647 | 971 | 647 | 971 | 647 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 686 | 686 | 0 | 343 | 1030 | 686 | 343 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 326 | 652 | 1631 | 2284 | 979 | 979 | 326 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 299 | 1495 | 1495 | 3289 | 2691 | 3888 | 3589 | 2093 | 897 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 918 | 2142 | 3366 | 2448 | 2754 | 3060 | 3672 | 612 | 306 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 1161 | 580 | 2032 | 2322 | 2612 | 1451 | 290 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 311 | 0 | 311 | 1865 | 1865 | 2487 | 2797 | 4041 | 4662 | 5595 | 932 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 324 | 1941 | 2912 | 2588 | 2912 | 2588 | 6795 | 7765 | 971 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2093 | 2990 | 4187 | 2990 | 5084 | 6579 | 6280 | 1495 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 607 | 1215 | 2733 | 2733 | 1215 | 1215 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 313 | 1253 | 940 | 1566 | 940 | 627 | 1253 | 313 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 304 | 3036 | 2126 | 2429 | 3340 | 2126 | 1822 | 1822 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 316 | 0 | 0 | 316 | 632 | 1895 | 1263 | 1263 | 1263 | 316 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 306 | 306 | 306 | 0 | 918 | 306 | 306 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1253 | 1566 | 1880 | 940 | 940 | 313 | 313 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 280 | 0 | 0 | 1120 | 560 | 1960 | 1680 | 2520 | 840 | 1120 | 840 | 280 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 295 | 0 | 1473 | 295 | 589 | 2062 | 1767 | 295 | 295 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 603 | 1507 | 1808 | 1205 | 1507 | 1808 | 603 | 1808 | 603 | 0 | 0 | 0 |

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 313 | 0 | 0 | 0 | 0 | 0 | 313 | 313 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 329 | 0 | 0 | 1645 | 987 | 0 | 658 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 297 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1518 | 1822 | 2126 | 2733 | 2429 | 2429 | 1215 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 533 | 533 | 2134 | 2134 | 2134 | 2134 | 3467 | 1867 | 800 | 267 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 3036 | 6984 | 7895 | 9109 | 6073 | 4251 | 2429 | 607 | 304 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 637 | 0 | 318 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 286 | 1430 | 572 | 286 | 0 | 572 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 295 | 884 | 0 | 1767 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 580 | 871 | 290 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 274 | 822 | 548 | 274 | 0 | 548 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 286 | 286 | 572 | 572 | 286 | 2288 | 0 | 286 | 286 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 669 | 1673 | 3011 | 1673 | 2007 | 2007 | 1673 | 1004 | 669 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 304 | 304 | 304 | 911 | 1518 | 304 | 911 | 304 | 607 | 304 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 2002 | 5435 | 8295 | 2288 | 1430 | 1144 | 286 | 572 | 286 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 627 | 1253 | 0 | 0 | 627 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 594 | 1781 | 594 | 594 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 627 | 1253 | 627 | 1880 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 607 | 0 | 911 | 1215 | 607 | 911 | 304 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 282 | 0 | 282 | 1128 | 1692 | 1128 | 1128 | 564 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5721 | 3432 | 1144 | 3432 | 0 | 1144 | 2288 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 1253 | 1253 | 1880 | 3133 | 1880 | 0 | 1253 | 1253 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 955 | 0 | 955 | 0 | 637 | 637 | 637 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 301 | 0 | 0 | 0 | 904 | 603 | 603 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 904 | 0 | 904 | 603 | 904 | 301 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Copepoda

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 311 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 272 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 343 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 324 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 267 | 267 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 607 | 911 | 3340 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 637 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 627 | 2506 | 6892 | 13158 | 1880 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 1781 | 3562 | 4155 | 594 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 1880 | 5013 | 4386 | 1880 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 911 | 304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 1144 | 1144 | 10298 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 6266 | 29449 | 11278 | 1253 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 318 | 955 | 637 | 318 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Diptera

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 311 | 311 | 0 | 0 | 311 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 278 | 0 | 556 | 0 | 278 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 272 | 544 | 272 | 272 | 0 | 817 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 299 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 306 | 0 | 0 | 0 | 306 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 0 | 0 | 290 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 311 | 0 | 311 | 622 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 324 | 324 | 324 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 299 | 299 | 299 | 299 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 607 | 0 | 607 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 295 | 295 | 295 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 301 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 607 | 0 | 0 | 0 | 0 | 0 | |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 267 | 0 | 0 | 533 | 0 | 0 | 0 | 0 | 0 | |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 911 | 0 | 304 | 304 | 0 | 0 | 0 | 0 | 0 | |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 637 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 286 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 274 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 335 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1253 | 1253 | 627 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2374 | 0 | 594 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 627 | 627 | 1253 | 1253 | 627 | 0 | 0 | 0 | 0 | 0 | |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 846 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 318 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

Ephemeroptera

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 311 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 556 | 0 | 0 | 278 | 278 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 272 | 544 | 0 | 0 | 272 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 669 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 693 | 346 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 352 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 681 | 0 | 340 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 324 | 324 | 0 | 0 | 0 | 0 | 324 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 343 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 326 | 326 | 0 | 0 | 652 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 311 | 622 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 324 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 299 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 911 | 304 | 0 | 304 | 304 | 304 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 313 | 0 | 0 | 0 | 313 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1767 | 0 | 589 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 297 | |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 533 | 0 | 267 | 0 | 0 | |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 0 | 1215 | 304 | 304 | 0 | 0 | 0 | |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1144 | 0 | 0 | 0 | 0 | |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1253 | 0 | 0 | 0 | 0 | |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

Oligochaeta

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 359 | 359 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 556 | 834 | 556 | 278 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 544 | 272 | 544 | 4083 | 1089 | 544 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 306 | 0 | 306 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 580 | 580 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 1243 | 2797 | 2797 | 311 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 324 | 2588 | 4530 | 4206 | 5500 | 1941 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 897 | 3289 | 299 | 299 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 627 | 0 | 1253 | 940 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 607 | 7287 | 10931 | 11539 | 3947 | 304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 295 | 295 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 304 | 304 | 607 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 304 | 911 | 2429 | 1215 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 318 | 0 | 0 | 318 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 627 | 4386 | 3759 | 3759 | 627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 1187 | 2374 | 1187 | 594 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 627 | 3133 | 6892 | 627 | 627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 282 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 1144 | 1144 | 2288 | 8009 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 1880 | 9399 | 8772 | 3759 | 627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Trichoptera

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 340 | 340 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 359 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 329 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 932 | 622 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 834 | 1946 | 556 | 0 | 0 | 0 | 278 | 0 | 0 | 0 | 0 | |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1361 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 335 | 0 | |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 693 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 352 | 352 | 352 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1021 | 0 | 0 | 0 | 0 | 0 | 681 | 340 | 0 | 0 | |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356 | 0 | 0 | 0 | 0 | 0 | 356 | 0 | 0 | 0 | |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 326 | 979 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 299 | 0 | |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 306 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 0 | 0 | 0 | 290 | 0 | 0 | 0 | 0 | 0 | |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 311 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 324 | 0 | 0 | 0 | 647 | 647 | 0 | 0 | 0 | 0 | |
| M138 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 299 | 299 | 299 | 0 | 0 | 0 | |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 607 | 0 | |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| M140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 0 | 0 | 304 | 0 | |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 316 | 316 | 316 | 0 | 0 | 0 | |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 612 | 0 | 0 | 0 | 0 | 306 | 0 | 0 | 0 | 0 | |
| M144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 313 | |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 280 | 0 | 0 | 0 | 0 | 0 | |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 295 | 0 | 0 | 0 | 295 | 0 | 295 | 0 | 0 | 0 | 0 | |
| M152 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 301 | 0 | 0 | 0 | 0 | 0 | |

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 313 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1215 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 267 | 1600 | 267 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 607 | 607 | 1822 | 304 | 911 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 318 | 318 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 295 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 548 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 286 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3759 | 1253 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 594 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2506 | 1253 | 1253 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1144 | 3432 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3759 | 6892 | 1253 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 318 | 1273 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 301 | 301 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Nematoda

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 278 | 834 | 1946 | 10285 | 12787 | 3892 | 278 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 3267 | 7623 | 13067 | 29401 | 40290 | 9800 | 1089 | 0 | 1089 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 346 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M122 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 324 | 647 | 324 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 343 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 299 | 0 | 299 | 299 | 0 | 299 | 0 | 0 | 0 | 299 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 612 | 612 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 306 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 622 | 311 | 2176 | 1865 | 311 | 311 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 324 | 1618 | 2912 | 647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 324 | 0 | 0 | 0 | 0 |
| M138 | 0 | 0 | 0 | 598 | 299 | 0 | 299 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 299 | 299 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 304 | 304 | 0 | 0 | 304 | 0 | 0 | 0 | 0 | 0 | 304 | 0 | 0 | 0 |
| M140 | 0 | 0 | 1253 | 1880 | 2506 | 3759 | 940 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M140 | 0 | 0 | 0 | 1215 | 3036 | 19433 | 8502 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 632 | 632 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 316 | 0 | 0 | 0 |
| M144 | 0 | 0 | 0 | 0 | 612 | 306 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M144 | 0 | 0 | 627 | 627 | 940 | 627 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 0 | 560 | 280 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 295 | 295 | 1767 | 5302 | 7070 | 7659 | 884 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 0 | 0 | 301 | 301 | 1205 | 1507 | 603 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| site | -1.8 | -1.5 | -1.2 | -0.9 | -0.6 | -0.3 | 0 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 | 3 | 3.3 | 3.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 329 | 0 | 987 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M166 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 607 | 1518 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 0 | 267 | 800 | 1600 | 2667 | 267 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M84 | 0 | 4858 | 19433 | 43725 | 87449 | 155466 | 58300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 318 | 318 | 2865 | 5093 | 955 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 286 | 572 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MA14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 295 | 295 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 0 | 335 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 0 | 0 | 0 | 0 | 0 | 607 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV18 | 572 | 1716 | 1144 | 286 | 286 | 572 | 0 | 0 | 286 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 6266 | 40727 | 53258 | 140978 | 28196 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 0 | 1781 | 13653 | 29086 | 13059 | 0 | 594 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV28 | 0 | 0 | 5013 | 15038 | 72682 | 102757 | 20050 | 0 | 2506 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 3340 | 1822 | 13968 | 22773 | 28846 | 2733 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 0 | 6865 | 44622 | 92677 | 154462 | 24028 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 9399 | 37594 | 93985 | 225564 | 375940 | 65790 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV58 | 0 | 318 | 1592 | 7640 | 15280 | 16872 | 2228 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MV8 | 0 | 0 | 0 | 0 | 0 | 306 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# Appendix E

Invertebrate and algal density (ind.$m^{-2}$) per size class ($log_{10}$ upper limit) for each taxa of each replicate from May, June, August and September, 1995.

May 7, 1995

| Size | -5.1 | -4.2 | -3.3 | -2.4 | -1.5 | -0.6 | 0.3 | 1.2 | 2.1 | 3.0 | 3.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Algae | | | | | | | | | | | |
| C46 | 1.68E+07 | 7.95E+08 | 1.09E+09 | 9.28E+06 | 0 | 3.00E+04 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 9.60E+09 | 4.71E+09 | 2.79E+08 | 7.73E+05 | 3.00E+03 | 2.30E+05 | 0 | 0 | 0 | 0 |
| M132 | 2.41E+07 | 2.07E+10 | 8.79E+09 | 6.11E+08 | 1.56E+06 | 0 | 8.00E+04 | 0 | 0 | 0 | 0 |
| M140 | 6.44E+07 | 1.63E+10 | 1.13E+10 | 3.32E+08 | 1.03E+06 | 0 | 1.60E+05 | 0 | 0 | 0 | 0 |
| Invertebrates | | | | | | | | | | | |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| M104 | 0 | 0 | 0 | 0 | 0 | 104 | 0 | 0 | 0 | 0 | 0 |
| M132 | 0 | 0 | 0 | 0 | 0 | 0 | 104 | 0 | 208 | 104 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 104 | 0 | 0 | 417 | 0 | 0 |

June 7, 1995

| Size | -5.1 | -4.2 | -3.3 | -2.4 | -1.5 | -0.6 | 0.3 | 1.2 | 2.1 | 3.0 | 3.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Algae | | | | | | | | | | | |
| C46 | 2.40E+09 | 7.00E+08 | 2.11E+08 | 1.86E+07 | 0 | 0 | 1.20E+05 | 4.00E+04 | 0 | 0 | 0 |
| M140 | 1.37E+09 | 8.05E+08 | 1.16E+08 | 4.64E+05 | 1.00E+04 | 0 | 0 | 0 | 0 | 0 | 0 |
| M152 | 8.83E+08 | 1.26E+09 | 4.28E+08 | 2.58E+05 | 0 | 0 | 4.00E+03 | 0 | 0 | 0 | 0 |
| M84 | 4.64E+08 | 3.74E+09 | 2.71E+09 | 2.53E+08 | 1.93E+06 | 2.00E+04 | 4.00E+04 | 1.70E+05 | 0 | 0 | 0 |
| Mv18 | 0 | 7.00E+08 | 4.81E+07 | 5.72E+06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Invertebrates | | | | | | | | | | | |
| C46 | 0 | 0 | 0 | 0 | 0 | 0 | 104 | 417 | 208 | 0 | 0 |
| M140 | 0 | 0 | 0 | 0 | 0 | 521 | 2292 | 3542 | 2396 | 104 | 0 |
| M152 | 0 | 0 | 0 | 0 | 0 | 729 | 8646 | 8542 | 3542 | 0 | 0 |
| M84 | 0 | 0 | 0 | 0 | 625 | 53750 | 154271 | 65208 | 4063 | 417 | 0 |
| Mv18 | 0 | 0 | 0 | 0 | 0 | 0 | 313 | 2188 | 729 | 0 | 0 |

August 1, 1995

| Size | -5.1 | -4.2 | -3.3 | -2.4 | -1.5 | -0.6 | 0.3 | 1.2 | 2.1 | 3.0 | 3.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Algae | | | | | | | | | | | |
| C46 | 1.10E+08 | 1.08E+10 | 5.65E+08 | 8.51E+06 | 1.70E+05 | 0 | 0 | 0 | 0 | 1.67E+07 | 0 |
| m140 | 1.27E+08 | 1.24E+09 | 2.14E+09 | 1.49E+07 | 5.16E+05 | 0 | 0 | 0 | 4.00E+04 | 0 | 0 |
| m152 | 7.80E+07 | 2.96E+09 | 2.76E+09 | 7.73E+06 | 1.90E+04 | 1.00E+04 | 0 | 3.50E+05 | 0 | 0 | 0 |
| m84 | 1.17E+09 | 5.63E+09 | 3.76E+09 | 2.86E+07 | 1.40E+03 | 3.00E+03 | 0 | 0 | 4.00E+04 | 0 | 0 |
| ma14 | 3.83E+08 | 3.90E+09 | 1.27E+08 | 7.73E+05 | 0 | 0 | 0 | 5.00E+03 | 0 | 0 | 0 |
| mv18 | 1.81E+07 | 2.31E+08 | 1.57E+08 | 4.46E+07 | 3.09E+05 | 9.73E+04 | 0 | 0 | 0 | 0 | 0 |
| Invertebrates | | | | | | | | | | | |
| c46 | 0 | 0 | 0 | 0 | 0 | 0 | 227 | 680 | 2524 | 441 | 107 |
| m140 | 0 | 0 | 0 | 0 | 101 | 4685 | 12539 | 11546 | 3183 | 1126 | 0 |
| m152 | 0 | 0 | 0 | 0 | 0 | 4041 | 11171 | 7644 | 2376 | 292 | 0 |
| m84 | 0 | 0 | 0 | 0 | 2024 | 55116 | 68003 | 57975 | 6928 | 267 | 0 |
| ma14 | 0 | 0 | 0 | 0 | 0 | 0 | 308 | 308 | 0 | 0 | 0 |
| mv18 | 0 | 0 | 0 | 0 | 0 | 202 | 425 | 1094 | 1050 | 213 | 0 |

September 26, 1995

| Size | -5.1 | -4.2 | -3.3 | -2.4 | -1.5 | -0.6 | 0.3 | 1.2 | 2.1 | 3.0 | 3.9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Algae | | | | | | | | | | | |
| c46 | 0 | 1.20E+10 | 6.17E+08 | 1.62E+08 | 0 | 0 | 0 | 0 | 0 | 1.40E+05 | 0 |
| m140 | 0 | 1.13E+10 | 1.52E+09 | 2.84E+07 | 1.00E+04 | 1.80E+03 | 0 | 0 | 7.00E+04 | 0 | 0 |
| m152 | 1.13E+09 | 4.15E+09 | 1.84E+09 | 1.14E+07 | 1.00E+04 | 1.00E+03 | 0 | 0 | 0 | 9.00E+04 | 0 |
| m84 | 2.42E+09 | 4.94E+09 | 2.08E+09 | 5.22E+07 | 3.00E+04 | 3.80E+03 | 5.00E+03 | 0 | 0 | 0 | 8.00E+04 |
| ma14 | 1.39E+09 | 8.52E+09 | 1.12E+09 | 2.26E+08 | 1.00E+04 | 3.00E+03 | 0 | 0 | 7.00E+04 | 0 | 0 |
| mv18 | 4.29E+08 | 3.14E+09 | 1.71E+09 | 9.64E+07 | 0.00E+00 | 2.10E+04 | 0 | 4.00E+03 | 0 | 0 | 0 |
| Invertebrates | | | | | | | | | | | |
| c46 | 0 | 0 | 0 | 0 | 0 | 0 | 359 | 812 | 837 | 120 | 0 |
| m140 | 0 | 0 | 0 | 104 | 0 | 3904 | 19210 | 12697 | 4074 | 813 | 0 |
| m152 | 0 | 0 | 0 | 0 | 388 | 6175 | 6470 | 4471 | 3116 | 495 | 0 |
| m84 | 0 | 0 | 0 | 0 | 1810 | 56496 | 82553 | 11495 | 5866 | 469 | 0 |
| ma14 | 0 | 0 | 0 | 0 | 0 | 1891 | 2719 | 1694 | 1692 | 292 | 0 |
| Mv18 | 0 | 0 | 0 | 0 | 858 | 3356 | 7697 | 2713 | 1678 | 0 | 0 |

# Appendix F

Classification and jackknifed classification matrices for the buoys sampled in May, June, August and September based on fecal coliform groups using density of 3 taxa ($log_{10}$ transformed) and density from 3 size classes ($log_{10}$ transformed) from September.

## May - (Nematoda, Chironomidae and Amphipoda)

**Classification matrix**

| Coliform Group | 1 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|
| 1 | 3 | 0 | 0 | 0 | 100 |
| 3 | 0 | 1 | 1 | 1 | 33 |
| 4 | 0 | 0 | 2 | 0 | 100 |
| 5 | 0 | 0 | 0 | 1 | 100 |
| Total | 3 | 1 | 3 | 2 | 78 |

**Jackknifed classification matrix**

| Coliform Group | 1 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|
| 1 | 3 | 0 | 0 | 0 | 100 |
| 3 | 1 | 1 | 0 | 1 | 33 |
| 4 | 1 | 0 | 1 | 0 | 50 |
| 5 | 0 | 1 | 0 | 0 | 0 |
| Total | 5 | 2 | 1 | 1 | 56 |

## June - (Chironomidae, Diptera and Oligochaeta)

**Classification matrix**

| Coliform Group | 1 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|
| 1 | 2 | 0 | 0 | 1 | 67 |
| 3 | 0 | 4 | 2 | 0 | 67 |
| 4 | 0 | 0 | 6 | 0 | 100 |
| 5 | 0 | 0 | 0 | 2 | 100 |
| Total | 2 | 4 | 8 | 3 | 82 |

**Jackknifed classification matrix**

| Coliform Group | 1 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|
| 1 | 2 | 0 | 0 | 1 | 67 |
| 3 | 0 | 3 | 2 | 1 | 50 |
| 4 | 0 | 1 | 4 | 1 | 67 |
| 5 | 0 | 0 | 1 | 1 | 50 |
| Total | 2 | 4 | 7 | 4 | 59 |

## August - (Diptera, Ephemeroptera and Acarina)

**Classification matrix**

| Coliform Group | 1 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|
| 1 | 3 | 0 | 0 | 0 | 100 |
| 3 | 0 | 9 | 1 | 0 | 90 |
| 4 | 1 | 1 | 1 | 0 | 33 |
| 5 | 1 | 0 | 0 | 1 | 50 |
| total | 5 | 10 | 2 | 1 | 78 |

**Jackknifed classification matrix**

| Coliform Group | 1 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|
| 1 | 3 | 0 | 0 | 0 | 100 |
| 3 | 1 | 8 | 1 | 0 | 80 |
| 4 | 1 | 1 | 0 | 1 | 0 |
| 5 | 1 | 0 | 1 | 0 | 0 |
| total | 6 | 9 | 2 | 1 | 61 |

## September - (Chironomidae, Amphipoda and Trichoptera)

**Classification matrix**

| Coliform Group | 1 | 2 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|---|
| 1 | 3 | 0 | 0 | 0 | 0 | 100 |
| 2 | 0 | 4 | 2 | 0 | 0 | 67 |
| 3 | 0 | 0 | 4 | 0 | 1 | 80 |
| 4 | 0 | 0 | 0 | 1 | 1 | 50 |
| 5 | 0 | 0 | 0 | 0 | 2 | 100 |
| Total | 3 | 4 | 6 | 1 | 4 | 78 |

**Jackknifed classification matrix**

| Coliform Group | 1 | 2 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|---|
| 1 | 3 | 0 | 0 | 0 | 0 | 100 |
| 2 | 1 | 3 | 2 | 0 | 0 | 50 |
| 3 | 0 | 1 | 3 | 1 | 0 | 60 |
| 4 | 1 | 0 | 0 | 0 | 1 | 0 |
| 5 | 0 | 0 | 0 | 1 | 1 | 50 |
| Total | 5 | 4 | 5 | 2 | 2 | 56 |

**September - size classes (0.031-0.062, 0.062-0.125 and 125-250 µg).**

**Classification matrix**

| Coliform Group | 1 | 2 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|---|
| 1 | 3 | 0 | 0 | 0 | 0 | 100 |
| 2 | 1 | 4 | 1 | 0 | 0 | 67 |
| 3 | 0 | 1 | 4 | 0 | 0 | 80 |
| 4 | 0 | 0 | 0 | 2 | 0 | 100 |
| 5 | 0 | 0 | 0 | 0 | 2 | 100 |
| Total | 4 | 5 | 5 | 2 | 2 | 83 |

**Jackknifed classification matrix**

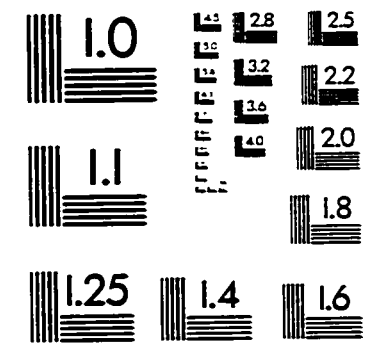
| Coliform Group | 1 | 2 | 3 | 4 | 5 | % correct |
|---|---|---|---|---|---|---|
| 1 | 2 | 1 | 0 | 0 | 0 | 67 |
| 2 | 1 | 1 | 4 | 0 | 0 | 17 |
| 3 | 0 | 1 | 3 | 1 | 0 | 60 |
| 4 | 0 | 0 | 1 | 1 | 0 | 50 |
| 5 | 0 | 1 | 0 | 0 | 1 | 50 |
| Total | 3 | 4 | 8 | 2 | 1 | 44 |

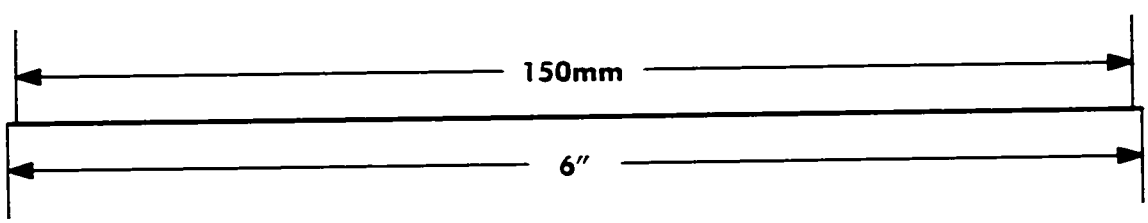
# Appendix G

Component loadings of the first two eigenvectors from the principal component analysis of the density of all taxa ($log_{10}$ transformed), collected in September 1995.

| | Eigenvector | |
|---|---|---|
| Taxa | 1 | 2 |
| Nematoda | 0.92 | 0.06 |
| Chironomidae | 0.62 | 0.69 |
| Amphipoda | 0 60 | -0.55 |
| Diptera | 0.86 | 0.03 |
| Ephemeroptera | 0.30 | 0.85 |
| Trichoptera | 0.82 | 0.08 |
| Acarina | 0.84 | -0.38 |
| Copepoda | 0.89 | -0.31 |
| Oligochaeta | 0.86 | 0.10 |
| Variance explained by components | 5.29 | 1.76 |
| Percent of total variance explained | 58.8 | 19.5 |

TEST TARGET (QA-3)




APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989

© 1993, Applied Image, Inc., All Rights Reserved