2 copies

Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

Distribution of Planktonic Rotifers and Crustaceans in One Hundred and Eight Lakes from Insular Newfoundland

D. A. Scruton, R. Chengalath,
J. C. H. Carter, and W. D. Taylor

Issuing Establishment:
Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

October 1991

Canadian Technical Report of Fisheries and Aquatic Sciences No. 1825

Fisheries and Oceans   Pêches et Océans

Canada

Canadian Technical Report of Fisheries and Aquatic Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457-714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. Numbers 715-924 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport technique canadien des sciences halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annual des publications scientifiques et techniques du Ministère.

Les numéros 1 à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Les rapports techniques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Technical Report of
Fisheries and Aquatic Sciences 1825

October 1991

DISTRIBUTION OF PLANKTONIC ROTIFERS AND CRUSTACEANS IN ONE HUNDRED AND EIGHT LAKES FROM INSULAR NEWFOUNDLAND

by

D. A. Scruton[1], R. Chengalath[2], J.C.H. Carter[3], and W. D. Taylor[3]

[1]Science Branch
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland
A1C 5X1

[2]Invertebrate Zoology Division
National Museum of Natural Sciences
Ottawa, Ontario
K1A OM8

[3]Department of Biology
University of Waterloo
Waterloo, Ontario
N2L 3G1

Cat. No. Fs 97-6/1825E ISSN 0706-6457

Scruton, D. A., R. Chengalath, J.C.H. Carter, and W. D. Taylor. 1991. Distribution of planktonic rotifers and crustaceans in one hundred and eight lakes from insular Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. 1825: iv + 83 p.

CONTENTS

ABSTRACT

Scruton, D. A., R. Chengalath, J.C.H. Carter, and W. D. Taylor. 1991. Distribution of planktonic rotifers and crustaceans in one hundred and eight lakes from insular Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. 1825: iv + 83 p.

One hundred and eight lakes throughout insular Newfoundland were sampled in the summer and fall of 1991 for morphometry, chemistry and zooplankton populations as part of DFO's (Department of Fisheries and Oceans) National Inventory Survey (NIS) conducted under the Departmental acid rain program. Data collected in this study are used to investigate relationships between lake characteristics (morphometric and chemical properties) and zooplankton distributions and associations on the island of Newfoundland. A particular focus of the evaluation was to attempt to identify variables related to the long range transport of air pollutants (LRTAP) and the possible influence of these parameters on zooplankton. Attention is also paid to the zoogeography of zooplankters in the region in this and other studies to provide a comprehensive baseline for future limnological research.

RÉSUMÉ

Scruton, D. A., R. Chengalath, J.C.H. Carter, and W. D. Taylor. 1991. Distribution of planktonic rotifers and crustaceans in one hundred and eight lakes from insular Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. 1825: iv + 83 p.

Dans le cadre du Levé du répertoire national mené durant l'été et l'automne 1991 par Pêches et Océans Canada conformément à son programme dur les pluies acides, on a étudié la morphométrie, la chimie et les populations de zooplancton de cent huit lacs d'un bout à l'autre de l'île de Terre-Neuve. Les données recueillies par cette enquête servent à évaleur les rapports entre les caractéristiques des lacs de l'île de Terre-Neuve (propriétés morphométriques et chimiques) et celles du zooplancton qu'on y trouve (distribution et associations). L'évaluation visait en particulier à discerner des variables associées au transport à grande distance de la pollution atmosphérique (TGDPA) et l'influence éventuelle de ces paramètres sur le zooplancton. La zoogéographie des zooplanctontes dans la région, tant dans la présente étude que dans des études antérieures, est également abordée afin de servir de base globale aux futures recherches limnologiques.

INTRODUCTION

Insular Newfoundland is a geologically diverse region of Canada (Douglas 1970) for which data on the composition and distribution of rotifer and crustacean plankton communities are lacking. There are large gaps in our knowledge of the geographic distribution, environmental tolerance and basic ecology of planktonic organisms in Canadian lakes. Regional studies of crustacean plankton communities do exist for other parts of Canada (Anderson 1971, 1974; Brandlova et al. 1972; Carter et al. 1980; Moore 1978; Patalas 1971, 1975; Patalas and Salki 1973; Pinel-Alloul et al. 1979; Rawson 1960; Reed 1963 for e.g.). Information about the Rotifera from Canada is particularly scarce except for a few sporadic studies (Anderson 1977; Chengalath and Fernando 1973; Nauwerck 1978; Nogrady 1976; Pinel-Alloul et al. 1979).

In insular Newfoundland, a number of localized studies of zooplankton communities have been carried out (e.g. Bateman and Davis 1980; Campbell and Knoechel 1987; Chengalath and Koste 1983; Cushman 1908; Daggett and Davis 1974, 1975; Davis 1972a, 1972b, 1973, 1975, 1976; Knoechel and Campbell 1987; Megyeri 1969; O'Connell and Andrews 1977, 1987; Ryan 1982, 1984). Additionally, a number of baseline studies have been carried out for national parks (e.g. Deichmann and Bradshaw 1984; Kerekes 1878) and as part of environmental impact assessments of major resource developments (e.g. Airphoto/Beak 1976; deGraaf 1981; Newfoundland and Labrador Hydro 1980a, 1980b). These studies have contributed species lists for discrete areas within the insular portion of province. Recently, the Water Quality Branch of Environment Canada documented the species composition, diversity, and community analysis of zooplankton assemblages from 34 insular Newfoundland lakes (Parsons 1987). Most of these studies tended to be site-specific and are inadequate to characterize the zooplankton fauna from the diversity of lake types characterizing insular Newfoundland (Scruton 1985).

In 1981, a comprehensive limnological and fisheries survey was conducted on 109 lakes located throughout the island of Newfoundland, as part of DFO's (Department of Fisheries and Oceans) national lake survey program, entitled the 'National Inventory Survey' (NIS). The primary intent of this program was to determine the status of freshwater fisheries and their lacustrine habitat in relation to anthropogenically derived pollution. These data are also to serve as baseline information against which future change in response to acidic deposition could be evaluated. Detail on the scope and approach of this survey program, from both a national and a regional perspective, is available in Kelso et al. (1986) and Scruton (1983), respectively. Components of this survey program included both lake characterization (morphometry and physical/chemical analysis of water) and zooplankton collections which made it possible to investigate relationships between zooplankton distributions and associations in relation to aquatic physical and chemical environments throughout insular Newfoundland.

Species composition and abundance of limnetic zooplankton generally reflect the influence of one or more environmental and biotic variables. One of the most frequently cited biotic variables is predation. Planktivorous fish and predacious invertebrates radically altering zooplankton assemblages by reducing or eliminating large and small prey species, respectively (Zaret 1980). Lake morphometry may also be an important regulating variable (Patalas 1971). It is often unclear whether community structure is affected by morphometric variables per se, or rather by associated trophic factors, particularly flushing rate.

As the negative effects of acidification have become increasingly manifest, attention has focused on water chemistry, especially pH and its correlates (trace metals in particular), as a major regulator of aquatic ecosystems and biological communities. Studies in Europe e.g. Almer et al. 1974; Fryer 1980; Hobaek and Raddum 1980) and North America (e.g. Brezonik et al. 1984; Keller and Pitblado 1983; Yan and Strus 1980) have demonstrated clear differences in zooplankton communities between acidic and non-acidic lakes. However, few, if any, investigations have included zooplankton data from earlier, pre-acidification periods. Consequently, community changes over time have largely been inferred by contrast to non-acidified lakes within the same geographical area (Dupont and Jeffries 1990). Experimental acidification studies have indicated that zooplankton community composition is altered by acidification and in the early stages species replacements may occur (Malley and Chang 1986) with a net loss in species numbers apparent in the pH range 5.5-6.0 (Shindler et al. 1985). There is much disagreement regarding the chemical pathways and ecological processes involved in these changes which may differ between lakes and between regions (e.g. Bangay and Riordan 1983; Harvey et al. 1981).

In this report we examine the abiotic environment of representative lakes across insular Newfoundland and attempt to determine the environmental and morphometric variables that may affect species associations and distribution of the limnetic zooplankton assemblages. Particular attention is paid to identifying variables that may be related to the long range transport of air pollutants (LRTAP) and the possible influence of these variates on the zooplankton populations. Attention was also paid to the zoogeography of zooplankters in insular Newfoundland to provide detailed baseline information for future limnological research in the region.

MATERIALS AND METHODS

FIELD SAMPLING

One hundred and eight small headwater lakes on the island of Newfoundland (between 46^0 and 52^0N latitude) were surveyed by float plane or helicopter during daylight hours from August 16 to October 18, 1981 (Fig. 1). Lakes were sampled for morphometry, water chemistry, zoo- and phyto-plankton, sediments, benthos, and fish. Details with respect to lake selection criteria and sampling methodologies are contained in Scruton (1983). Lake morphometric data was either collected on site or subsequently were calculated from maps and/or air photos. Bathymetric surveys were conducted on 12 lakes while 'apparent' maximum depth (maximum depth as established from limited sounding) was determined for all lakes.

Water samples were collected from a station established near the lake midpoint. In shallow lakes (≤ 3 m), a water sample was collected by dipping the sample bottle 0.5 m below the surface. In all other lakes, water was collected with a 3 m composite tube sampler (tygon tubing) in accordance with procedures outlined by the Ontario Ministry of National Resources (1980). A surface dip, with subsequent fixation by nitric acid, was used to obtain a sample for trace metals analyses.

Zooplankton samples were collected by vertical haul from just above the bottom (0.5 m) to the surface at the 'visually estimated' deepest point in each lake using a conical, Wisconsin type, plankton net (20.5 cm diameter opening, mesh size of 64 μm, and overall net length of 1.2 m). In lakes of 2 m or less maximum depth, a short horizontal tow was made. A filtration efficiency for the net of 100% was assumed. Samples were subsequently preserved in buffered formalin. Zooplankton samples were successfully collected from 108 of the 109 lakes sampled (one sample bottle was broken prior to analysis).

WATER ANALYSIS

Water samples were analyzed for four parameters (pH, gran alkalinity, dissolved oxygen, and carbon dioxide) at a mobile laboratory within 24 h of collection. Gran alkalinities were determined by acidimetric titration of the sample to pH 3.5 (after Ontario Ministry of Natural Resources 1980) and calculation of the inflection point by computer routine (after Kramer 1978). Dissolved oxygen was determined by Winkler titration (Strickland and Parsons 1972). Twenty-two parameters (including Ph, alkalinity, conductivity, hardness, turbidity, major cations and anions, nutrients, metals, colour, and dissolved organic carbon) were subsequently analyzed at a contracted analytical laboratory, within one month of collection. An additional 10 parameters, including non-marine ('excess') ion concentrations (after Watt et al. 1979) were calculated. All analytical methods followed those outlined in Environment Canada (1979) and the American Public Health Association et al. (1975). Analytical procedures and detection limits are detailed in Scruton (1983).

IDENTIFICATION AND ENUMERATION OF ZOOPLANKTON

Prior to quantitative enumeration of specimens, concentrated samples were scanned under a Wild stereo zoom microscope. Specific identifications were made by making semi-permanent slides of specimens in glycerine for examination under a Wild compound microscope equipped with 100X oil immersion lens. Rotifers and nauplii were counted using a 10X objective with 10X oculars by using of a Hensen-Stempel pipette to introduce a 1 ml subsample into a Sedgwick-rafter cell. Crustacean plankton were enumerated in a counting chamber (with square grids) under a stereo microscope. At least 100 individuals of all the species were counted or in most instances, as the samples contained sparse animal populations, a total count was made. Nauplii of all copepods were counted together. Copepodids were divided into Cyclopoida and Calanoida. Cladoceran juveniles were included with adults. Identifications were based mainly on Edmondson (1959), Pennak (1978), and Ruttner-Kolisko (1974). The monograph of Brooks (1957) was the basis for identifying members of the genus Daphnia, as was the monograph of Deevey and Deevey (1971) for the genus Bosmina. Chengalath et al. (1971) and Smith and Fernando (1978) were also consulted for identifications of rotifers and copepods.

The detailed quantitative data for zooplankton collected from each lake (species lists, enumerations as nos.m^{-3}) are contained in Appendix 1. Data are housed on computer tape at the Northwest Atlantic Fisheries Centre, St. John's, Newfoundland, and can be made available to interested researchers upon request. Zooplankton samples are currently archived with the National Museum of Natural Sciences in Ottawa.

DATA ANALYSIS AND STATISTICAL TREATMENT

The statistical approach used to describe and interpret the biological and chemical data involved a series of correlation, cluster, and factor analyses. Statistical analyses were performed using packages available at the Northwest Atlantic Fisheries Centre (SAS), the University of Guelph (SAS), and University of Waterloo (SPSS, NTSYS). Before beginning statistical treatment, all biological data were edited and transformed. Among the zooplankton, species usually found in littoral or benthic habitats were deleted, leaving only true planktonic species. Copepod nauplii were excluded from the analysis, and copepodites were allocated proportionately to species found in each lake as adults. Zooplankton numbers (nos. m^{-3}) were multiplied by the depth of the vertical haul and expressed as numbers per m^{2-} of surface area. All variables were displayed as stem and leaf and cumulative plots, before and after transformation. Except for the usual problem of many zero-values in the data matrix, all species distributions were reasonably normal after log (n+1) transformation, and consequently this transformation was accepted.

Relationships among the 47 morphometric, physical, and chemical variables were initially explored by simple correlation analyses of the log transformed data (SAS Institute 1979) (see Scruton et al. 1987, Appendix 1). The original matrix was subsequently reduced to 20 selected parameters for multivariate analysis. Redundant variables (such as laboratory measured alkalinity when field alkalinity was measured), summed variables and minor or trace elements were deleted. Other variables were rejected at the outset as irrelevant to the study (e.g. surface temperature and sediment/water interface pH). Bicarbonate was eliminated because the alkalinity in these lakes is completely HCO_3^- . Non-marine or 'excess' concentrations of the major cations and sulphate were also deleted from the analyses. A constant was added to variables with minimum values (< 0) before log transformation. Among the available morphometric variables, only lake surface area and drainage area were measured routinely. Lakes, therefore, could not be classified on the basis of complete morphometric characterization, limiting the investigation of morphometry as a regulator of zooplankton distributions. The morphometric, physical and chemical data were then transformed ($X'=\ln(X+1)$) (all data except pH) to normalize the data and then standardized to give each variable an equal weighting in the analyses. The final list of variables used in the analysis is contained in Table 6.

As a first step in relating the distribution of species to the chemical and morphometric characteristics of the lakes, a factor analysis was performed to simplify the variance structure of the highly correlated and interdependent chemical and morphometric data. This technique is useful when many variables are highly correlated. Rather than facing the impossible task of deciding which of several correlated variables a species is related to, the variables are combined as 'factors.' This analysis was performed on a correlation matrix among the variables, and the principal components solution was then rotated (using the VARIMAX rotation method) to simplify the factor structure.

Zooplankton data were examined to discover if some species were correlated in their abundance among lakes. Species occurring in less than ten lakes were omitted. A correlation matrix was generated and displayed as a single-linkage cluster analysis based on the correlations among species. A number of clustering techniques were explored but UPGMA (unweighted pair groups with arithmetical averaging) produced the highest cophenetic correlations and was consequently adopted. Principal components analysis, based on the variance-covariance matrix, produced similar results but seriously distorted some of the apparent distances among species.

Canonical correlation analysis indicated a correlation between the zooplankton data and the chemical and morphometric data. These lake physical/chemical factors, plus some chemical variables that were not unambiguously related to the factors, were correlated with the abundance of the various species. These factors were also compared to the total number of species and individuals, and among the Cladocera, Copepoda and Rotifera, separately. Spearman rank correlations between the species and each of the derived variables were generated.

RESULTS AND DISCUSSION

LAKE CHARACTERIZATION

One hundred and nine lakes were sampled on one occasion only for lake morphometry, chemistry, and biological parameters over a two-month period (August 16 to October 18) in 1981. Lakes were generally distributed across the island with the exception of the Burin and Avalon peninsulas. The Avalon Peninsula was not intensively surveyed owing to the comprehensive limnological and fisheries data base which exists for that region while lakes designated for survey on the Burin Peninsula were not sampled due to prolonged periods of poor weather preventing aircraft access. The resulting study lake distribution, by geographical region, is as follows (Fig. 1):

Northern (Peninsula) - 23
Central - 20
Eastern - 22
Southern - 24
Western - 7
Avalon (Peninsula) - 3

Nine major widespread geological types were delineated for the island and lakes were sampled from seven of these geotypes (Scruton 1983). The lake distribution by geotype is as follows:

Conglomerate, sandstone, etc. - 1
Limestone, dolomite, sandstone - 8
Gneiss, schist, etc. - 17
Siltstone, quartzite, etc. - 7
Granites - 45
Gabbro, diorite, etc. - 1
Acid to mafic volcanics, etc. - 17
Unclassified - 13

Sixty-two lakes (57%) were located in geotypes designated highly sensitive (after Schilts 1981) to acidic deposition (siliceous bedrock types, not readily weathered and low in available carbonates), while 26 lakes (24%) were located in high to moderately sensitive bedrock types (largely metamorphic or sedimentary rocks, more readily weathered but low in available carbonates), and eight lakes (7%) were in low to non-sensitive geological areas (rocks of sedimentary origin, weathered, and high in calcium/magnesium carbonates). Thirteen lakes (12%) were not classified due to the occurrence of two or more geological types of different sensitivities within their watershed.

Study lakes ranged in size from 21 to 2519 hectares (mean = 153 ha). No lakes were smaller than 10 ha, while 65 lakes (60%) were in the 10 to 100 ha size class, 41 lakes (38%) in the 100 to 1000 ha size class, and 2 lakes (2%) were greater than 1000 ha (Fig. 2). The lake area distribution from this survey has been compared to natural distributions (as obtained by counts and measures of lakes > 1 hectare in geographical subregions) in Fig. 3. It is apparent that the distribution of lake areas from the survey is not representative of the natural distribution, and the sample of study lakes was particularly under-represented in the 0 to 10 ha size class (representing 89% of the natural lake distribution but not sampled in this survey).

inaccessibility by fixed wing aircraft was the primary reason for not surveying 0 to 10 ha size lakes.

Preselected study lakes were predominantly headwater (first order, 1^0) systems (98 lakes, 90%) while 8 lakes (7%) were second order (2^0) and 2 lakes were of higher order (3^0 and 5^0). Study lake distribution by drainage order is also compared to natural distributions in Fig. 3. Again, the lake sample from the survey poorly represents natural lake drainage orders. Drainage order was a criteria used in study lake selection and the survey was directed (biased) to smaller, headwater lakes owing to the acknowledged high sensitivity of these water bodies to acidic deposition (Harvey et al. 1981).

The ratio of watershed area to lake area for the lakes were relatively low, ranging from 2.5 to 36.2 (mean = 8.4) (Fig. 2). Eighty-one lakes (75%) had ratios of less than 10:1. Lake elevations ranged from 24 to 709 m above sea level (mean = 248 m) with 16 lakes (15%) less than 100 m, 84 lakes (78%) in the 100-500 m range, and the remaining 8 lakes (7%) greater than 500 m (Fig. 2). The watershed to lake area ratio and elevation are important features governing relative exposure to acid deposition as well as the availability and interaction of potential buffering elements. Study lakes were located varying distances from salt water (from 3.0 to 87.5 km, mean = 24.5), however, all study lakes were well within 100 km . Previous evaluations have demonstrated the profound influence of marine aerosol deposition on regional water chemistry (e.g. Scruton 1983; Scruton and Taylor 1989).

Maximum depth, mean depth, and lake volume were determined for 10 preselected lakes only. Maximum depth determined for the other 99 lakes was, in effect, the depth measured over the sampling station (established over the expected deepest portion of each lake) and must be considered an estimate only. 'Apparent' maximum depth ranged from 1 to 29 m and forty-one lakes (38%) had maximum depths of less than 3 m. Surface water temperatures (at the time of sampling) varied from 5.6^{0}C to 21.8^{0}C and temperature/depth profiles (at 1 m intervals) were obtained from all lakes. Most lakes demonstrated little evidence of thermal stratification as only 4 of 108 lakes had a clear thermal gradient and true thermocline. These lakes were classified as second class with respect to thermal stratification (stratified but with bottom temperatures greater than 4^{0}C) (Hutchinson 1967). The shallow nature of many lakes, the low amount of solar radiation, and frequent and constant high winds likely contribute to water recirculation and the apparent lack of stratification. Secchi disc depth ranged from 0.3 to l9.5 m (mean = 2.7) (Fig. 2). The Secchi-disc was still visible on the bottom in 34 lakes (31%), therefore the entire water body is considered to be in the euphotic zone (Hutchinson 1957). In the remaining 75 lakes, Secchi disc depth varied from 0.3 to 7.5 m (mean = 2.95) and was strongly correlated to water colour ($r = -0.66$, $P < 0.001$) and turbidity ($r = -0.62$, $P < 0.001$).

A characteristic feature of insular Newfoundland lakes is the high colour content of the water reflecting a natural organic contribution to chemistry and acidity (Scruton 1985). Colour values ranged from 5 to 225 T.C.U. (mean = 48.5). Seventeen lakes (16%) were classified as having clear water (0-15 T.C.U.), 57 lakes (52%) as brown water systems (15-50 T.C.U.), and 35 lakes (32%) as highly coloured systems (greater than 50 T.C.U.) (Fig. 2). Lake turbidities ranged from 0.22 to 3.10 J.T.U. (mean = 0.65) and values in excess of 1.0 were common. Kerekes (1980) has suggested that high turbidities in Newfoundland lakes is a consequence of wind driven recirculation of particulate matter from littoral areas and lake sediments. The high colour content and relatively high turbidities likely restricts the trophogenic zone in some lakes and consequently limits lake primary productivity.

The sum of constituents (or salinity) of the lake water varied from 4.4 to 96.7 mg L^{-1} (mean = 12.8). The mean value is extremely low by global standards (world average is 112 mg L^{-2}, Livingstone 1963). Considering the contribution of highly mineralized lakes in the sample (mean salinity of 53.8 mg L^{-2} for 8 lakes underlain by limestones). and the considerable input of marine aerosols (Scruton 1983), this mean value is indicative of the extremely dilute nature of most of insular Newfoundland's freshwaters. Lake conductivity values ranged 11.4 to 199.0 μScm^{-2} (mean = 28.9), also highlighting the low mineralization of regional lakes. The dominant cation in the lakes was either calcium or sodium, while magnesium was also important and potassium, hydrogen ion (H^+), iron, and aluminum were generally of lesser importance (contributing less than

5% of the cation sum). Lakes underlain by limestones, gabbros, diorites, and volcanics were typically calcium dominated (Ca > Na > Mg > K/H^+/Fe/Al) while lakes underlain by granites, gneisses, siltstones, and the conglomerate/sandstone geotype were more frequently sodium dominated (Na > Ca > Mg > K/H^+/Fe/Al). Chloride was the dominant anion in lakes underlain by poorly weathered bedrock (granites, gneisses, siltstones, and conglomerate/sandstones) in order of Cl > HCO_3 > SO_4 (predominantly Cl > SO_4 > HCO_3 in the gneitic geotype), while bicarbonate ion (HCO_3 > Cl > SO_4) was dominant in the more dissoluable geotypes (limestone, gabbro, and volcanics). The distribution of calcium values (dominant cation of geochemical origin) and chloride (dominant anion) among the study lakes is provided in Fig. 2.

Sulphate, in this study, was determined by the methyl-thymol blue (MTB) method which is prone to colourimetric interference in humic waters (Kerekes 1983). Colourimetric interference is suspected in some samples due to the preponderance of highly coloured waters, which may have lead to overestimation of sulphate in some lakes. In addition, no quantitative consideration of organic constituents was investigated in this study (Scruton 1983). Recently, considerable attention has been paid to characterizing and quantifying the organic content in surface waters in Atlantic Canada (Clair and Freedman 1986, for e.g.). Oliver et al. (1983) developed a method to estimate organic anion concentration ($COOH^-$) from organic carbon measurements (D.O.C., T.O.C.) and pH, which has allowed quantitative consideration of organics as an important anion, and as a weak acid contributing to natural water acidification. Organic anions are now routinely quantified in regional aquatic studies and are recognized as a dominant ionic constituent in dilute, highly coloured Newfoundland freshwaters (Scruton 1985; Howell 1986; Scruton and Taylor 1989a).

Lake pH (field measured values) ranged from 4.90 to 8.39 (mean = 6.40) with 2 lakes (2%) demonstrating a pH of less than 5.00, 8 lakes (7%) in the 5.00 to 5.50 range, 24 lakes (22%) in the 5.50 to 6.00 range, while the remaining 74 lakes (69%) exceeded pH 6.00 (Fig. 2). The pH distribution was unimodal (about the pH interval 6.00 to 6.50) and correlated spatially with the distribution of surficial bedrock types (Scruton 1983). Hydrogen ion contribution from weak organic acids and strong acids in precipitation has likely contributed to the observed acidity. Alkalinity (Fig. 2), determined by the Gran method, varied from -6.4 to 1740 μeq L^{-2} (mean = 95.3). Three lakes (3%) had negative alkalinities (defined as acidified), 56 lakes (52%) had alkalinities from 0 to 40 μeq L^{-2} (considered extremely sensitive to acidification), while 37 lakes (34%) had values from 40 to 200 μeq L^{-2} (classified as moderately sensitive to acidification) (Ontario Ministry of the Environment 1981). Four lakes (4%) had alkalinities from 200 to 500 μeq L^{-2} (considered low in sensitivity to acidification) while 4 lakes (4%) had values in excess of 500 μeq L^{-2} (considered non-sensitive). Spatial correlation of bicarbonate alkalinity and bedrock geology (reflecting the availability of weatherable carbonates) was also good (Scruton 1983). Most lakes demonstrated a deficit in alkalinity (determined from calcium and magnesium minus bicarbonate) in order of 25 to 50 μeq L^{-2}, which was considered to demonstrate a response to acid loading (from both natural and anthropogenic sources).

The foregoing is a brief synopsis of the morphometric, physical and chemical characteristics of the study lakes as they pertain to an evaluation of zooplankton distributions. A more detailed evaluation of lake properties, with particular attention paid to sensitivity to, and effects from, acid rain is available in Kendaris (1982) and Scruton (1983, 1985), while these data have also contributed to other broadscale regional assessments (e.g. Kelso et al. 1986; Jeffries et al. 1986). A similar evaluation of lake characteristics, as they were determined to influence phytoplankton associations, is available in Earle et al. (1987) and Scruton et al. (1987). The detailed physical, chemical and morphometric data for the study lakes are listed in Tables 1 and 2, and a statistical summary is provided in Table 3 (as reproduced from Scruton et al. 1987).

SPECIES COMPOSITION

A total of 66 species were identified from 108 study lakes for a total of 1,023 species occurrences or populations. Thirty-five of the identified species were crustaceans while 31 were rotifers. A larger than usual number of littoral forms were encountered in this study as many of the lakes sampled were small, shallow and wind exposed. Of the 35 species of crustaceans identified, only 20 could be considered truly pelagic while among the 31 rotifer species, 24 taxa could be considered open water forms. The total number of species found in any one lake ranged from 5 to 20 with a mean of 9.0.

Crustacea

The crustacean species encountered in this study, including the percentage of lakes in which each was found and percentage in which each species is considered dominant (i.e. represents more than 10% of all crustaceans in that lake, Patalas 1971), are listed in Table 4. The calanoid copepod, Diaptomus minutus, was by far the most common species and outnumbered all other crustaceans, being found in 94% of the lakes and being dominant in 82%. Patalas (1971), Pinel-Alloul et al. (1979), and Carter et al. (1980) all recorded D. minutus as the most common diaptomid in their respective study areas. This species seems to be tolerant of all extremes relating to morphometry, temperature and water chemistry. Daphnia catawba was the only other significant Daphnia species found in insular Newfoundland, being present in all study regions and in 72% of the lakes (dominant in 45%). Daphnia dubia, present in 6% of all lakes and in the western half of the island only (Fig. 5), was found in very small numbers. Eubosmina longispina and Holopedium gibberum were quite common being recorded in 72% and 60% of lakes, respectively. Deevey and Deevey (1971) have stated that E. longispina has a predominantly northern distribution in North America. E. Longispina was also found to be a common cladoceran in the Yukon Territory of Canada (Lindsey et al. 1981). H. gibberum is considered a soft water form (Hutchinson 1967) most often found in shallow, highly coloured waters with low transparency (Patalas 1971).

The most common cyclopoid copepod found during this study was Cyclops scutifer being found in 49% of the lakes (dominant in 14%). C. scutifer is considered typical of cold, often dilute, waters and is very common in the Canadian arctic (McLaren 1964; Lindsey et al. 1981). Cyclops bicuspidatus thomasi and Cyclops vernalis, two of the most widely distributed cyclopoid copepods in North America (Pinel-Alloul et al. 1979; Moore 1980), were not found at all in the present study. Carter et al. (1980) have also noted C. bicuspidatus thomasi to be completely absent from the maritime provinces of Canada. Cyclops vernalis, on the other hand, has been widely reported from other studies in insular Newfoundland (e.g. Airphoto/Beak 1976; Daggett and Davis 1975; Kerekes 1978; O'Connell and Andrews 1977; Ryan 1984). Epischura lacustris, a common calanoid, was present in 49% of the lakes (dominant in 9%). Another common cyclopoid crustacean with wide distribution in North America, Bosmina longirostris, was found in 37% of the lakes (dominant in 26%). The Diaphanosoma species identified from this study were highly variable in morphology and were very similar to Korinek's (1981) description of D. birgei. This species was common throughout the study area (being found in 22% of the lakes). The only other member of the genus Diaptomus found in this study, D. spatulocrenatus, occurred in 17% of the lakes representing all geographical regions. This species is common in eastern Canada (Pinel-Alloul et al. 1979; Carter et al. 1980) and apparently has never been reported west of Quebec. Mesocyclops edax, found in 12% of the lakes (dominant in only 5%), is also considered to be widely distributed in all regions of northeastern North America (Carter et al. 1980). Tropocyclops prasinus mexicanus, found in most lakes in northeastern North America, is equally common in hard and soft waters (Carter et al. 1980). It was reported absent from the James Bay region of Quebec (Pinel-Alloul et al. 1979) and was present in only one insular Newfoundland study lake in low numbers. The species was recently reported from 6 lakes surveyed by Environment Canada as part of their LRTAP monitoring network (Parsons 1987). Patalas (1971) found this species to be frequently abundant in smaller lakes of shallow to medium depth, low to medium transparency, and highly coloured waters; however, it was not reported in similar lake types in this study. Ceriodaphnia lacustris was present in 6% of the lakes, all with a pH value of over 6.00. This species was found in large numbers only in hardwater lakes with a pH value of over 7.00. This supports the suggestion that C. lacustris is not very successful in soft water lakes (Carter et al. 1980). Eurytemora affinis, considered primarily an estuarine species (Carter et al. 1980), occurred in two lakes on the northern peninsula of Newfoundland (Fig. 5). One of the lakes was small (42 ha) and the other well above average in size (232 ha), located respectively 7.5 km and 13.0 km from the coast. Both were hard water lakes with pH values of 7.27 and 7.77. E. affinis had previously been reported from Newfoundland in only one lake on the west coast of the island by Parsons (1987) in the Environment Canada LRTAP survey of 34 lakes.

Rotifera

The rotifer species reported in this study have been listed and arranged according to frequency of occurrence in Table 5. Also listed is the number of lakes in which a single species contributed more than 10% of the total number of rotifers in that lake and was therefore considered as dominant (Patalas 1971). The number of rotiferan species found in any one sample ranged from 2 to 15 with a mean of 6.7.

The most common species were Kellicottia longispina and Keratella taurocephala, occurring in 90% and 88% of the lakes and being dominant in 58% and 67%, respectively. Five species, Kellicottia longispina, Keratella taurocephala, Conochilus unicornis, Keratella cochlearis and Gastropus stylifer were present in more than 50% of the lakes and were dominant in 20% or more of the lakes. None of the remaining species occurred in more than 41% of the lakes. Trichocerca cylindrica and Ploesoma lenticulare were present in 41% and 34% of the lakes but were dominant in only 8% and 7%, respectively. Three species, Kellicottia bostoniensis, Keratella taurocephala and Trichocerca platessa are endemic to North America and the latter two species are found almost exclusively in acidic water. Keratella crassa and Keratella earlinae demonstrated restricted distributions. K. earlinae was found in only five Northern Peninsula lakes, all above average in size and with clear water. K. crassa was found only on the eastern half of the island. Keratella quadrata, a very common planktonic rotifer found in all regions of Canada (Chengalath 1984) and indeed the world (Ruttner-Kolisko 1974), was not an important member of the rotiferan zooplankton of Newfoundland. Only a single specimen was found in one lake in central Newfoundland.

The total absence of the genera Brachionus and Notholca was also notable. Myers (1937) and Ahlstrom (1940) stated that Brachionus species are entirely absent from acid waters and this may explain why they were not found in the present study as many of the lakes were acidic. Species of the genus Notholca, considered to be cold stenothermal (Ruttner-Kolisko 1974; Koste 1978) and common in arctic and southern Canada (Harring 1921; Chengalath 1978), were absent in Newfoundland lakes sampled in this survey. The absence of this genus from Newfoundland may be related to low pH values and not necessarily temperature. These two genera, however, have recently been reported from ponds on the Avalon Peninsula of Newfoundland (O'Connell and Andrews 1987). Only 10% of the lakes yielded Synchaeta species and usually in small numbers. Species of the genus Synchaeta are common in the limnetic region of cold water lakes and found in large numbers. Polyarthra vulgaris occurred in 14% of the lakes, all with above average surface water temperatures. Although four species of Polyarthra were present in the lakes, they were seldom dominant and almost invariably occurred in low numbers.

SPECIES DISTRIBUTIONS

In this section, short distributional notes are provided for all species encountered in this survey, while maps of individual species distributions are provided in Fig. 4-11. Occurrence of total number of species and selected zooplankters in relation to lake pH, water colour, lake area and lake elevation is provided in Fig. 12-15. A comprehensive list of zooplankton species reported from this survey and other collections from insular Newfoundland is provided in Appendix 222.

Rotifera

Asplanchna priodonta, often a major predator of other rotifers, was found in 24 lakes throughout Newfoundland, excepting the Avalon Peninsula (Fig. 4). There appeared to be no distinct preferences with the four variables evaluated (Fig. 13). A. priodonta is often more abundant in oligotrophic waters (Ruttner-Kolisko 1974). It was found by Kerekes (1978) in some water bodies in Gros Morne National Park, in the Victoria Reservoir of the Baie D'Espoir hydroelectric development (Airphoto/Beak 1976) by Ryan (1982) in ponds of the Experimental Ponds Area in Central Newfoundland, by O'Connell and Andrews (1987) in 3 Avalon Peninsula ponds, and by Parsons (1987) in 13 of 34 Environment Canada's LRTAP monitoring lakes.

Bipalpus hudsoni, a relatively uncommon form, was found in 7 lakes only in the southern and western parts of the island (Fig. 4). It has also been recorded by Ryan (1982) from the Experimental Ponds Area.

Collotheca mutabilis is a moderately common form found in 32 lakes in all regions of Newfoundland (Fig. 4). C. mutabilis showed no notable preferences relative to any of the four key lake variables (Fig. 13). It is characteristic of the summer plankton of northern lakes (Ruttner-Kolisko 1974). Parsons (1987) reported the species to be widespread in the Environment Canada LRTAP monitoring lakes being reported in 26 of 34 lakes.

Conochilus unicornis is a colonial rotifer which occurred in 82 lakes throughout Newfoundland (Fig. 4). One of the most common rotifers in dystrophic acidic lakes in North America (Chengalath et al. 1984; Siegfried et al. 1984), C. unicornis was equally abundant throughout the ranges of each of the four lake variables (Fig. 13). The species has been reported from Clark's Pond at Argentia (Davis 1972b), the Experimental Ponds Area (Ryan 1982), in 4 Avalon Peninsula ponds (O'Connell and Andrews 1987), in Hogans and Bauline Long Pond near St. John's (Davis 1972, 1973), as well as from lakes and reservoirs in the Baie D'Espoir Upper Salmon Hydroelectric Development (Airphoto/Beak 1976). Interestingly, the species was reported absent from all 34 Environment Canada LRTAP monitoring lakes, while C. hippocrepis was reported in 94% of the lakes sampled in that program.

Euchlanis dilitata can be considered being rare, found only in a single lake in south central Newfoundland (Fig. 4). E. dilitata tends to prefer eutrophic waters (Ruttner-Kolisko 1974). The species was recorded by Ryan (1982) from the Experimental Ponds Area.

Euchlanis triquetra was reported from 2 lakes, both in the north-central part of the island (Fig. 11). The species has been reported by Parsons (1987) in 2 of 34 of Environment Canada's LRTAP monitoring lakes and by (Chengalath and Koste 1983) from ponds and bogs on the Northern peninsula.

Gastropus stylifer is a common form occurring in 63 lakes throughout the island (Fig. 4). Its appearances were somewhat more common in slightly acid lakes but showed no distinct preferences with regard to colour, lake area or elevation (Fig. 13). G. stylifer is most noted in the summer plankton of cool waters (Ruttner-Kolisko 1974). The genus was present but uncommon in Gros Morne National Park (Kerekes 1978). The species was also common in the Environment Canada LRTAP lake survey, being reported from 21 of 34 lakes (Parsons 1987).

Kellicottia bostoniensis was found in 14 lakes in widely separated regions of Newfoundland (Fig. 5). It is known as an important component of zooplankton communities in acidic lakes in Ontario (Roff and Kwiatowski 1977). It was a common species from May to mid-June in Clark's Pond (Davis 1972). The species has also been recorded by Ryan (1982) from the Experimental Ponds Area, by O'Connell and Andrews (1987) in 4 Avalon Peninsula lakes, and in 15 lakes by Parsons (1987).

Kellicottia longispina was widespread throughout the island occurring in 98 lakes (Fig. 5). It was equally common at all values of pH, colour, lake area and elevation (Fig. 13). K. longispina is also a typical acid water rotifer in Ontario (Roff and Kwiatowski 1977). The species is common in Clark's Pond (Davis 1972), the Experimental Ponds Area (Ryan 1982), in five ponds on the Avalon Peninsula (O'Connell and Andrews 1977, 1987) and in lakes and reservoirs of the Baie D'Espoir - Upper Salmon Hydroelectric Development (Airphoto/Beak 1976; Newfoundland Hydro 1980). The species also occurred in 29 of 34 lakes in the Environment Canada's LRTAP monitoring network (Parsons 1987).

Keratella cochlearis was found in 76 lakes throughout Newfoundland (Fig. 5) at all ranges of the four key variables (Fig. 13). K. cochlearis is another common acid lake species in Ontario (Roff and Kwiatkowski 1977). The species has been reported from the Experimental Ponds Area (Ryan 1982), in 8 Avalon Peninsula lakes (O'Connell and Andrews 1977, 1987; Davis 1972, 1973), in lakes and reservoirs of the Baie D'Espoir - Upper Salmon Hydroelectric Development (Airphoto/Beak 1976; Newfoundland Hydro 1980), and from the Environment Canada acid rain lake monitoring network (32 of 34 lakes; Parsons 1987).

Keratella crassa was reported from only 14 lakes in Newfoundland, all located in the eastern corner of the island (Fig. 5). These waters were all of relatively high conductivity and clarity (Chengalath et al. 1984). K. crassa is found only in North America. Ryan (1982) also recorded the species from the Experimental Ponds Area and Parsons (1987) reports the species in 20 of 34 lakes surveyed by Environment Canada in 1984.

Keratella earlinae was restricted to 7 lakes on the Northern Peninsula (Fig. 5). These lakes were all large and relatively low in colour (Chengalath et al. 1984). This species is also known only from North America. Its distribution in Newfoundland is curious since it has not been reported from Labrador. Therefore, its' occurrence on the Northern Peninsula is unlikely due to a recent invasion.

Keratella serulata was reported from 5 lakes (Fig. 11) from various regions on the Island. The species has been widely reported previously for the Avalon peninsula (Davis 1972a, O'Connell and Andrews 1977, 1987), reservoirs of the Baie D'Espoir region (Airphoto/Beak 1976), and the Northern peninsula (Chengalath and Koste 1983). Parsons (1987) reports the species from 1 of 34 Environment Canada LRTAP monitoring lakes.

Keratella quadrata was found in only one lake only in the northeast corner of Newfoundland (Fig. 5). K. quadrata is very common through most parts of Canada, although in related studies it was unreported from either Labrador, Nova Scotia, or New Brunswick (Carter et al. 1986). The species has been reported as a minor component of the rotiferan community of 4 Avalon Peninsula ponds (O'Connell and Andrews 1987).

Keratella taurocephala was extremely common, occurring in 96 of the 107 lakes (Fig. 6). K. taurocephala is restricted to North America and, although most typical of acid waters (Chengalath and Fernando 1973), in Newfoundland it was found at all values of pH as well as colour, lake area and elevation (Fig. 13). Ryan (1982) recorded K. taurocephala from the Experimental Ponds Area but makes no comment regarding abundance. The species has also been reported from Bauline Long Pond on the Avalon Peninsula (Davis 1973) and from 5 lakes and reservoir of the Baie D'Espoir in Upper Salmon Hydroelectric Development (Airphoro/Beak 1976; Newfoundland Hydro 1980). The species was also very common in Environment Canada's LRTAP network, being reported from 32 of 34 lakes and being ranked first, in order of relative abundance, of all zooplankters in that study (Parsons 1987).

Lecane bulla was reported from 2 lakes (Fig. 11), one on the Northern peninsula and one in east-central Newfoundland. The species has been previously reported from ponds and bogs on the Northern peninsula (Chengalath and Koste 1983).

Lecane luna was found in only one lake in central Newfoundland (Fig. 11). The species has been previously reported from ponds and bogs on the Northern peninsula (Chengalath and Koste 1983)and lakes in the Hinds Lake hydroelectric development as rare (Newfoundland and Labrador Hydro 1978).

Lecane lunaris was found in 15 lakes (Fig. 11) across the island and was not a dominant species in any of them. The species has been previously reported from ponds and bogs on the Northern peninsula (Chengalath and Koste 1983).

Ploesoma lenticulare was found in 37 lakes distributed widely throughout the island (Fig. 6). Ruttner-Kolisko (1974) describes its habitat as mainly in the pelagial of summer warmed ponds and lakes. In Newfoundland it was found at all pH ranges below 7.2 (Fig. 14). It was also not found at the highest ranges of colour, lake area and elevation (Fig. 14). The species was previously reported from the Victoria reservoir in central Newfoundland (Airphoto/Beak 1976) and by Parsons (1987) in 7 of 34 lakes surveyed in 1984.

Ploesoma truncatum occurred in one lake only on the Northern Peninsula (Fig. 6). It is semipelagic and typical of pools, ponds and small lakes (Ruttner-Kolisko 1974). It is present in the Experimental Ponds Area (Ryan 1982) and from 4 Avalon Peninsula lakes (O'Connell and Andrews 1987). Parsons (1987) also reported the species in 11 lakes surveyed by Environment Canada.

Polyarthra dolichoptera was moderately common, occurring in 31 lakes (Fig. 6). Although tolerant of all pH ranges, the species tended to appear more often in alkaline waters, showing no distinct preferences with respect to colour, lake area and elevation (Fig. 14). P. dolichoptera is considered a cold stenotherm and is most characteristic of oligotrophic lakes of the temperate zone (Ruttner-Kollsko 1974). Ryan (1982) reported the species from the Experimental Ponds Area, while O'Connell and Andrews (1987) reported it from ponds in the Placentia Bay region of the Avalon Peninsula. The species was also reported in 7 insular Newfoundland lakes by Parsons (1987) in a 1984 survey of 34 lakes.

Polyarthra euryptera was found in 15 lakes, mainly in the eastern part of the province, excluding the Avalon Peninsula (Fig. 6). P. euryptera is known as a warm stenotherm typical of eutrophic lakes and ponds. Nineteen of 34 Environment Canada acid rain monitoring lakes also recorded the species (Parsons 1987).

Polyarthra major occurred in 18 lakes in the western half of the island and was never sympatric with P. euryptera (Fig. 7). Unlike the latter, it is more characteristic of oligotrophic waters. Parsons (1987) reported the species from 1 lake in the LRTAP monitoring network of Environment Canada.

Polyarthra minor was found in 2 lakes, one on the Northern peninsula and the other on the south coast (Fig. 11). The species was previously reported from ponds and bogs on the Northern peninsula (Chengalath and Koste 1983).

Polyarthra vulgaris was found in 15 lakes widely dispersed throughout Newfoundland except in the northeast (Fig. 7). Like the other 3 species of this genus, P. vulgaris almost always occurred in low numbers (Chengalath et al. 1984). It has been previously reported from Bauline Long Pond on the Avalon Peninsula (Davis 1973). Parsons (1987) reported this species to be widespread, found in 31 of 34 lakes sampled as part of Environment Canada's LRTAP monitoring network.

Synchaeta pectinata was relatively uncommon, occurring in only 9 lakes, mainly on the Northern Peninsula (Fig. 7). Both S. pectinata and S. stylata are typical of the limnetic regions of cold lakes and their sparse occurrences in Newfoundland are surprising (Chengalath et al. 1984). It was recorded from the Experimental Ponds Area (Ryan 1982). The genus Synchaeta only was reported from the Avalon Peninsula by O'Connell and Andrews (1987), while Parsons (1987) reported the genus occurring in 10 lakes of the Environment Canada LRTAP monitoring network.

Synchaeta stylata was found in 4 lakes only, in 2 of which it was sympatric with S. pectinata (Fig. 7).

Trichocerca capucina was reported from one lake only on the south coast (Fig. 11) and had not previously been reported.

Trichocerca cylindrica occurred in 45 lakes throughout most of the province although it was absent from most of the lakes on the Northern Peninsula (Fig. 7). Pejler (1957) and Maemets (1983) regard T. cylindrica as most typical of dystrophic-eutrophic situations in Europe. In Newfoundland, the species was distributed almost equally throughout the range of pH and colour values, while it was distinctly more common in lakes at lower elevations (Fig. 14). Trichocerca sp. were reported from ponds in the Placentia Bay region of the Avalon Peninsula (O'Connell and Andrews 1987). T. cylindrica was reported by Parsons (1987) in 21 of 34 lakes surveyed.

Tricocerca multicrinis was a rare species occurring in only 8 lakes, four of which also contained T. cylindrica (Fig. 7).

Tricocerca platessa was found in 2 lakes in west-central region and the south coast (Fig. 11). The species has been previously reported from the lakes and reservoirs of the Baie D'Espoir development (Airphoto/Beak 1976), the Hinds lake development (Newfoundland and Labrador Hydro 1978), and from the Northern peninsula (Chengalath and Koste 1983).

Trichotria tetractis was found in only one lake in the north central region (Fig. 11). The species has been reported from the Northern peninsula (Chengalath and Koste 1983) and the Avalon peninsula (O'Connell and Andrews 1987) and by Parsons (1987) in 3 of 34 of Environment Canada's LRTAP monitoring lakes.

Cladocera

Acantholeberis curvirostris was reported from 2 lakes, one near Grand Lake and the other on the Northern peninsula (Fig. 10). The species was previously reported by Daggett and Davis (1975).

Acroperus harpae was found in 6 lakes primarily in the western half of the island (Fig. 10). The species was previously reported by Daggett and Davis (1975).

Alona affinis was found in 2 lakes in the north-central region of the island (Fig. 11). The species was previously reported on the Avalon peninsula by Daggett and Davis (1974).

Alona costata was found in 3 lakes, 2 in central Newfoundland and 1 on the Northern peninsula. The species was previously reported by Daggett and Davis (1975).

Alona guttata was reported from 3 lakes, in a defined area on the west coast of the island (Fig. 11). The species was previously reported from the Avalon peninsula by O'Connell and Andrews (1977) and at the Hinds Lake hydroelectric development (Newfoundland and Labrador Hydro 1978).

Alona intermedia was reported from 4 lakes in the central portion of the island (Fig. 11). The species was previously reported on the Avalon peninsula by Daggett and Davis (1974).

Alonella excisa was found in 1 lake only on the tip of the Northern peninsula (Fig. 10). The species was previously reported by Daggett and Davis (1974, 1975).

Alonella nana was reported from 3 lakes, 2 on the Northern peninsula and also in the central portion of the island (Fig. 10).

Bosmina longirostris was found in 37 lakes throughout the island, excepting the Avalon Peninsula (Fig. 8). It is also known from Terra Nova National Park (Deichmann and Bradshaw 1984) and the Experimental Ponds Area (Ryan 1982), while Parsons (1987) reported the species from 27 of 34 Environment Canada LRTAP monitoring lakes. B. longirostris is common in much of the world and tolerates extremes relating to morphometry and water chemistry (Carter et al. 1980). This is also the case in Newfoundland although the species was absent in lakes above 600 m (Fig. 14).

Chydorus bicornutus was found in 4 lakes, all in the south-central portion of the island (Fig. 11) and has not previously been reported.

Chydorus brevilabris, a newly defined species, was recorded from 5 lakes only, all on the western side of the island (Fig. 8). It is found in the Experimental Ponds Area (Ryan 1982).

Chydorus piger was reported from 2 lakes in the north-central part of the island (Fig. 11). The species was previously reported by Daggett and Davis (1974, 1975).

Chydorus sphaericus was found in 6 lakes (Fig. 8). C. sphaericus is often benthic in its habits and may have been more common in Newfoundland than the record indicates. Daggett and Davis (1975) found it to be one of the most common species in lakes they studied in insular Newfoundland. Parsons (1987) also reported the species from 4 of 34 lakes surveyed in 1984.

Ceriodaphnia lacustris occurred in 5 lakes (Fig. 8). It tends to favour hardwater lakes (Carter et al. 1980), which might explain its scarcity in Newfoundland although, in a similar survey, it was fairly common in New Brunswick and Nova Scotia (Carter et al. 1986). C. lacustris likely has well defined northern limits determined by temperature, as in most Cladocerans. It was found in the Experimental Ponds Area, Central Newfoundland (Ryan 1984), while Parsons (1987) reported the species from only 1 of 34 lakes in the Environment Canada LRTAP monitoring network.

Daphnia catawba was the only common daphnid found in this study, and is apparently very successful, occurring in 79 lakes (Fig. 8). It is also fairly common in New Brunswick and Nova Scotia (Carter et al. 1986). In Newfoundland, it tolerated all values relating to pH, colour, lake area and elevation (Fig. 14). The species has been recorded by many other investigators, including Davis (1972, 1976), Daggett and Davis (1975), deGraaf (1981), Ryan (1982), and others. D. catawba was extremely important in the dystrophic waters of the Cat Arm watershed (Airphoto/Beak 1976).

Daphnia dubia was found in 6 lakes, in 4 of which it was sympatric with D. catawba (Fig. 8). D. dubia has been recorded as far north as the James Bay region of central Canada (Pinel-Alloul et al. 1979). D. dubia has been reported from Spruce Pond in the Experimental Ponds Area of Central Newfoundland (Ryan 1984).

Diaphanosoma birgei. Chengalath et al. (1984) reported that, while variable, individuals of the genus conformed generally to the description of D. birgei given by Korinek (1981). It occurred in 24 lakes, mainly in the central and eastern parts of the island (Fig. 8). It was absent from lakes of pH less than 5.6 (Fig. 14). Carter (1971) also found it to be absent from ponds of lowest pH in the Georgian Bay region of Ontario. In Newfoundland, it was not found in very clear or very coloured lakes (Fig. 14). It has previously been reported from the Experimental Ponds Area (Ryan 1984) and by Parsons (1987) in 3 of 34 lakes surveyed.

Disparalona acutirostris was found in 4 lakes in the western half of the island (Fig. 11). The species was previously reported by Daggett and Davis (1974, 1975).

Eubosmina longispina occurred in 78 lakes throughout the island and was the most common bosminid (Fig. 8). In New Brunswick and Nova Scotia it was considered an acid water indicator, but in other regions it is found in alkaline waters as well (Carter et al. 1986). In Newfoundland, it was found at all values relative to 4 key variables (Fig. 15). Dagget and Davis (1975) recorded the species in their study as did deGraaf (1981). Kerekes (1978) lists the genus only for Gros Morne National Park. Parsons (1987) found the species to be widely distributed, being recorded from 23 of 34 lakes surveyed.

Holopedium gibberum occurred in 65 lakes and was widely distributed throughout the island (Fig. 9). It is usually considered a soft water form (Hutchinson 1967) but in Newfoundland it was not restricted relative to any of the four variables examined (Fig. 15). The species has been widely reported throughout insular Newfoundland by Davis (1972, 1976), Kerekes (1978), deGraaf (1981), Ryan (1982), Deichmann and Bradshaw (1984), O'Connell and Andrews (1987) and Parsons (1987).

Latona setifera was reported from 12 lakes through out the island excepting the western region (Fig. 10). The species was previously reported from Gros Morne National Park (Kerekes 1978).

Leptodora kindtii was collected from only 7 lakes (Fig. 8). Because of its large size, L. kindtii was never common and may in fact occur in lakes where it is not represented in single samples (i.e. more intensive sampling may be required to confirm its presence/absence). It is also a prime target for planktivorous fish and its absence from a particular lake may be due to predation rather than intolerance to the lake's chemistry (Pope and Carter 1975). It has been reported from Terra Nova National Park (Deichmann and Bradshaw 1984), Gros Morne National Park (Kerekes 1978) and the Experimental Ponds Area (Ryan 1982). Parsons (1987) also reported the species in 1 of 34 lakes studied as did O'Connell and Andrews (1987) in 4 Avalon Peninsula ponds.

Ophryoxus gracilis was reported from 2 lakes, one near Grand Lake and the other on the Bonavista peninsula (Fig. 11). The species was previously reported by Daggett and Davis (1974, 1975).

Polyphemus pediculus occurred in 2 lakes only (Fig. 8). It is usually confined to soft water (Carter et al. 1980) and is seldom found in great abundance. It has been previously recorded for insular Newfoundland by Deichmann and Bradshaw (1984), Kerekes (1978), Ryan (1982), Parsons (1987), and O'Connell and Andrews (1987).

Rhynchotalona falcata was found in 2 lakes, both in the eastern half of the island (Fig. 10). The species was previously reported from Gros Morne National Park (Kerekes 1978).

Sida crystallina was found in 2 lakes only (Fig. 8). Like P. pediculus, it is rarely abundant and may occur in the littoral zone where it is not collected with plankton nets. Ryan (1982) reported the species from the Experimental Ponds Area.

Streblocerus serricaudatus was found in only 1 lake on the south coast of the island (Fig. 10). The species was previously reported by Daggett and Davis (1975).

Copepoda

Cyclops scutifer is known as a cold stenotherm and is usually found only in deep water in southern Canada (Elgmork 1967). In Newfoundland, it was found in 81 of the 107 lakes (Fig. 9) including some of the smallest in area although maximum depths were not determined by bathymetric survey. It occurred at all ranges of pH, colour and elevation (Fig. 15). Because of its cold-water requirements it is missing from many species lists. It has, however, been previously reported by Davis (1972, 1976), Kerekes (1978), Deichmann and Bradshaw (1984), Parsons (1987), and O'Connell and Andrews (1987).

Diaptomus minutus was the most common zooplankter in Newfoundland, occurring in 104 of 107 lakes (Fig. 9). It shows a broad tolerance to all morphometric and chemical conditions both here (Fig. 15) and in the rest of eastern Canada where it is the single dominant limnetic crustacean (Carter et al. 1980). It has been widely recorded throughout the island by Davis (1972, 1976), Daggett and Davis (1975), Kerekes (1978), deGraaf (1981), Ryan (1982), Deichmann and Bradshaw (1984), O'Connell and Andrews (1977), Parsons (1987) and others (see Appendix 2).

Diaptomus spatulocrenatus is an exclusively eastern species occurring only as far west as the Ontario-Quebec border. It was observed in 20 lakes on the island (Fig. 10). Although it occurred at most values of pH, it was excluded from lakes of low colour and was not found in either larger lakes or those at higher elevations (Fig. 15). Deichmann and Bradshaw (1984) found it in most ponds of Terra Nova National Park and Ryan (1982) reported it from the Experimental Ponds Area. O'Connell and Andrews (1987) reported the species from 2 Avalon Peninsula ponds and Parsons (1987) reported the species from 18 of 34 lakes surveyed in the Environment Canada LRTAP network.

Epischura lacustris is extremely common through eastern Canada (Carter et al. 1980), including Newfoundland where it occurred in 49 lakes (Fig. 10). It was unrestricted over the pH range encountered in this study but was not found in lakes of highest colour (Fig. 15). It has also been reported by Kerekes (1978), deGraaf (1981), Ryan (1982), Deichmann and Bradshaw (1984), Parsons (1987), and O'Connell and Andrews (1987).

Epischura nordenskioldi is almost entirely restricted to Nova Scotia and New Brunswick (Carter et al. 1980) where it seems to be an acid indicator (Carter et al. 1986). It was found only one lake on the Northern Peninsula (Fig. 10). It is also recorded in the studies of Davis (1972, 1976), Daggett and Davis (1975), deGraaf (1981), Ryan (1984), O'Connell and Andrews (1977, 1987), and Parsons (1987).

Eurytemora affinis is an estuarine species that has recently entered freshwaters (Carter et al. 1980). It occurred only in 2 coastal lakes in the Northern Peninsula (Fig. 10). It had been previously reported in the Newfoundland literature only by Parsons (1987) in one Environment Canada monitoring lake.

Macrocyclops albidus was found in 1 lake only in the north-central region (Fig. 11). The species was previously reported by Daggett and Davis (1974, 1975) and from the Hinds Lake hydroelectric development (Newfoundland and Labrador Hydro 1978).

Mesocyclops edax occurred in 12 lakes, in a relatively small area in southeastern Newfoundland (Fig. 9). While it is normally a summer form through most of its range, it is found quite far north in central Canada (Carter et al. 1980) and its scarcity in Newfoundland is surprising. This might have resulted from the fact that the sampling was completed in autumn (August 16 to October 18). M. edax has been reported from quite acidic waters (Carter 1971). Ryan (1982) reported the species from the Experimental Ponds Area and Parsons (1987) has also reported the species from 6 of 34 lakes in the Environment Canada LRTAP Monitoring network.

Tropocyclops prasinus mexicanus was found in a single lake only (Fig. 9). Pinel-Alloul et al. (1979) reported it absent from the James Bay region and therefore Newfoundland may be outside the northern limits of its range. It was also reported from a single lake by Daggett and Davis (1975). Parsons (1987) reported the species from 6 lakes surveyed in the acid rain monitoring lakes of Environment Canada.

SPECIES ABUNDANCE IN RELATION TO LAKE PHYSICAL/CHEMICAL VARIABLES

Species abundances as well as occurrences of individual species were determined relative to four key lake variables: pH, colour, surface area and lake elevation. While a great many other variables were measured at the time of sampling, these four are considered to represent key lake properties that could potentially influence zooplankton distributions and each showed a moderately wide range over the data set. Additionally, these variables have been used in the representation of other regional zooplankton collections (e.g. Anderson 1971, Patalas 1971) and similar presentation in this report allows for regional comparisons.

The pH of the study lakes varied from 4.90 to 8.39. There was a wide pH gradient across the study lakes and it was found that there was a distinct tendency for species diversity to decrease with increasing acidity (Fig. 12). The values refer to single visits and the full spectrum of species occurring in any lake was most certainly not found. Lake pH values are also subject to wide annual fluctuations (Scruton 1984) and the nature of seasonal variation in the study lakes is largely unknown. In addition, there was not a high proportion of extremely acidic lakes in the survey (only 3 lakes had pH of > 5.0) and previous evaluation of data suggests most lake acidity is of natural origin (Scruton 1983; Earle et al. 1987). Consequently, zooplankton populations in the more acidic lakes likely represents naturally occurring assemblages of acid-adapted fauna rather than a fauna that have responded to recent, anthropogenically derived, pH changes. Consequently, the mean numbers of species (10.5) in the most acid range (pH = 4.8-5.2) is the lowest of all pH ranges but is not evident of greatly impoverished zooplankton communities. Zooplankton assemblages (mean = 15.5) at the most alkaline range (pH > 8.0) are characterized by only 33% more diversity (Fig. 12). Hobaek and Raddum (1980) have found humic, acidic lakes in Norway to have a greater species diversity than clearwater acid lakes and have suggested this observation is evidence of long-term natural adaptation of fauna to organic dominated naturally acidic freshwaters.

Generally, acidic lakes demonstrate an impoverished community structure (numbers of species) relative to less acidic, more circumneutral lakes (Almer et al. 1974, 1978; EPA 1983; Harvey et al. 1981; Hobaek and Raddum 1980; Roff and Kwiatkowski 1977; Sprules 1978). Overrein et al. (1980) reported that Norwegian lakes below pH 5.0 had a mean species number of 7.1 while less acidic lakes (pH > 5.5) had a higher mean number of species (16.1). Similarly, Sprules (1975) reported from 9 to 16 species in lakes greater than pH 5.0 while acid lakes (pH < 5.0) had from 1 to 7 species. Confer et al. (1983) have reported similar observations from lakes in the Northeastern United States (Adirondack Mountains in New York and White Mountains in New Hampshire) where acidic lakes (pH < 5.0) typically had from 3 to 4 crustacean zooplankton species while less acid lakes (pH > 5.5) had 6 or more species. The authors report a loss of 2.4 species and 22.6 mg (dry wt)m^{-2} of biomass per unit decrease in pH. Sprules (1975) and Roff and Kwiatoski (1977) have found the greatest change in species diversity to occur over the pH range of 5.0 to 5.3. All authors suggest that species assemblages in acid lakes are simply reductions of faunal communities in less acidic waterbodies within the same geographic region, i.e. some species may become extinct upon acidification, but there is no invasion of new species to inhabit an extremely acidic niche.

All the major components of rotifer and crustacean plankton communities in insular Newfoundland were either acidobionts or plankters usually found abundantly in lakes with low pH. For the Rotifera, members of the genera Keratella, Kellicottia, and Polyarthra have been reported to be acid tolerant (EPA 1983) and all are key genera in the Newfoundland planktonic assemblages. Kellicottia longispina, the most important rotifer in this study has been reported as an important zooplankter of acidic lakes in Scandinavia (Almer et al. 1974, 1978; Hobaek and Raddum 1980) and Ontario (Roff and Kwiatowski 1977; Sprules 1975; Yan and Strus 1978). The same in true of Keratella cochlearis and K. taurocephala which are important components of zooplankton communities of acidic lakes (EPA 1983). In contrast, the third most abundant rotiferan zooplankter in Newfoundland lakes, Conochilus unicornis (n = 82, dominant in 29), has been reported to be reduced in acidic lakes in Scandinavia

(Raddum 1978). Other rotifer species that have been reported to be positively (e.g. Polyarthra vulgaris, Keratella serulata, Kellicottia bostoniensis) and negatively (e.g. Asplanchna priodonta) influenced by lake acidity were less important components of regional zooplankton assemblages. It is particularly noteworthy that Asplanchna priodonta was absent in acidic waters in this study. The species was seldom found in lakes with a pH value of less than 6.00, and occurred in increasing numbers in neutral or alkaline waters. It is generally believed that rotifers are more tolerant of acidity than crustaceans (Carter 1971), however, in the present study increasing acidity seemed to decrease the number of species of rotifers and crustaceans alike.

For the Cladocerans, Daphnia sp. have been reported to be sensitive to low pH, particularly D. magna and D. pulex, which are most often absent in waters of less than pH 5.5 (Hobaek and Raddum 1975; Sprules 1975; EPA 1983). The most important species of Daphnia in Newfoundland lakes (D. catawba) has been reported to be found primarily in low pH lakes in Ontario (Sprules 1977). Of the Bosminids, Eubosmina longispina and Bosmina longirostris were important components of acidic Scandinavian (Hobaek and Raddum 1980) and Ontario (Hobaek and Raddum 1980; Sprules 1975; Roff and Kwiatowski 1977) lakes. Roff and Kwiatowski (1977) and Confer et al. (1978) have reported Holopedium gibberum to be acid sensitive while Sprules (1977) reported the species to be distributed across all pH ranges. H. gibberum was widely distributed in insular Newfoundland and its distribution appeared to be unrelated to pH. Some other cladocerans that have been reported to be acid sensitive (e.g. Leptodora kindtii and Polyphemus pediculus, EPA 1983), were not widely distributed in this study.

Of the Copepoda, Diaptomus minutus has been reported to be the most important species in acidic lakes (EPA 1983). D. minutus was the most widely distributed and dominant crustacean zooplankter in this study and its distribution appeared unrelated to any one factor. Mesocyclops edax has also been reported to be acid tolerant. By contrast, Epischura lacustris has been reported as acid sensitive (EPA 1983) and became extinct in experimental acidification of lake 203 in the Experimental Lakes Area (Sprules 1975). This species was widely distributed across Newfoundland and appeared unaffected by all ranges of lake acidity.

The number of rotifer species per lake showed a relatively consistent increase from 5.2 at pH 4.8-5.2 to 7.6 at pH 6.8-7.2 (Fig. 4). At pH 7.2-7.60 (n = 9) the number fell to 4.8. At pH 7.6-8.0 and 8.0-8.4 the numbers rose dramatically (8.3 and 11.7, respectively), but sample sizes were small (n = 3). The moderate decline in mean rotifer species abundance with reduced pH is unlikely of major significance. As Hutchinson (1967) points out, the actual limiting factor at pH extremes may be some other variable such as calcium or bicarbonate. Normally a pH of 4.8 is not considered sufficiently low to cause any large scale reduction in diversity. In general, more alkaline waters are usually somewhat more productive than acid waters (Wetzel 1983) and this might ultimately lead to slightly higher species diversity. Similar moderate increases in mean species abundances from the lowest to the higher pH ranges is seen in the cladocerans and copepods, with both rising from 2.7 (pH 4.8-5.2) to 3.9 (pH 7.2-7.6) over the same range.

Rotifers showed a general, if moderate, decrease in mean species abundance with rising colour (7.1 at 10-50 T.C.U, 5.3 at 75-110 T.C.U, Fig. 4). The reasons for this decline are uncertain but may be associated with the reduced bacterial and phytoplankton biomass normally found in dystrophic waters (Wetzel 1983). The cladocerans and copepods demonstrated slightly higher mean species abundances in lakes of intermediate colour (15-75 T.C.U.). As in the rotifers, reduced bacterial and nanoplankton content might be involved with the decrease at higher colour values. In clear waters, it is possible that visibility to planktivorous fish is detrimental to all but the smallest crustacean species (Kitchell and Kitchell 1980).

No consistent relationship appeared between mean rotifer species abundance and lake area (Fig. 4). This was true also of the cladocerans and copepods although, in these two groups, there was some tendency toward slightly lower mean species abundances in smaller lakes (≤ 20 ha). Sprules (1978) has reported lake area (and depth) to be a major determinant of zooplankton community structure in Ontario lakes, although species diversity was unrelated to either variable.

An interesting negative relationship appears between mean number of rotifer species and lake elevation (Fig. 4). Why lakes at lower altitudes should show greater diversity of rotifers is unclear, particularly as a similar trend is absent in both crustacean groups. If post-glacial colonization originally came from the mainland it is understandable that low coastal lakes would be occupied first. Rotifers, however, are small and relatively mobile forms and it might be expected that they would reach lakes of higher elevation before either cladocerans or copepods. On the other hand, greater diversity of rotifers at lower altitudes may be unrelated to elevation per se, but rather to some other factor such as temperature or salinity.

CLUSTER ANALYSIS

The dendrogram of Newfoundland zooplankton demonstrated a very simple pattern (Fig. 16). A number of species were significantly correlated ($r = \geq 0.3$, $p. < 0.01$) while the whole assemblage was split into two clusters of approximately equal numbers. The upper cluster, from Asplanchna priodonta to Polyarthra euryptera, consisted almost exclusively of small species. The upper group is dominated primarily by small rotifers including Trichocerca cylindrica, Keratella cochlearis, K. crassa, Ploesoma lenticulare, and Polyarthra dolichoptera, the small cladoceran, Bosmina longirostris and the large predatory rotifer, Asplanchna priodonta. The lower cluster, from Conochilus unicornis to Mesocyclops edax, contained almost all of the larger forms, including eight crustaceans and one colonial rotifer (C. unicornis). The lower group was dominated primarily by medium to large crustaceans including Eubosmina longispina, Daphnia catawba and Epischura lacustris.

Selection of zooplankton as food by planktivorous fish has been positively related to size of the prey (Hrbacek 1962; Brooks and Dodson 1965; Gardner 1981) and consequently it might be speculated that species in the lower cluster (the larger zooplankters) were concentrated in lakes with reduced predation pressure. Unfortunately the relevant information on fish populations in the lakes necessary to examine this hypothesis is unavailable. While fish sampling was a component of the survey program, the minimum mesh size of gill nets used in sampling was 3.8 cm, thus excluding all smaller fish species and younger (larval) fish. In particular, the study was unable to demonstrate the presence/absence of threespine stickleback (Gasterosteus aculeatus) and ninespine stickleback (Pungitius pungitius) in the survey lakes, two widely distributed planktivorous fish species common to many Newfoundland freshwaters (Scott and Crossman 1964).

An alternative hypothesis, as the lower group included Epischura lacustris, a major predator on B. longirostris (Kerfoot 1977; 1978), and Mesocyclops edax, whose diet includes both Bosmina and rotifers (Williamson and Magnien 1982), it might be argued that the small zooplankters of the upper cluster dominated in lakes where predators from the lower cluster were absent or scarce (see Zaret 1980). Supporting this latter suggestion is the fact that certain piscine planktivores (e.g. lake chub, Couesius plumbeus, lake whitefish, Coregonus clupeaformis, round whitefish, Prosopium cylindraceum) are absent from Newfoundland (Scott and Crossman 1973) and this may reduce predation pressure on invertebrate predators in many lakes. Species isolated in the centre show no significant correlations with other species. Species occurring in less than ten lakes were omitted.

The rate of water renewal or flushing rate of lakes has been demonstrated to have a dramatic effect on lake limnology and zooplankton species composition and associations (Brook and Woodward 1956, O'Connell and Andrews 1977, 1987). Lakes with high flushing rates have been demonstrated to select for taxa with smaller bodies and faster generation times (O'Connell and Andrews 1987) and this could, in part, explain the separation evident in the dendrogram (Fig. 16) based on body size. Unfortunately, owing to the limited morphometric data available for the study lakes, the possible influence of lake volume and flushing rate on the zooplankton collections cannot be evaluated as part of this study. O'Connell (Fisheries and Oceans, pers. comm.) has suggested that lake flushing rate likely has a more dramatic effect in determining species composition in Newfoundland lakes than would predator-prey relationships, particularly when considering the sparse fish fauna in the region's lakes as confirmed in the NIS survey (Scruton 1983).

FACTOR ANALYSIS

The derived environmental factors from the factor analysis and their relationship to the original variables (correlation coefficients) are shown in Table 6. Factors explaining a very small component of the variations, and primarily comprised of single variables to which no species were significantly correlated, were omitted from Table 6. Factor 1, explaining 24% of the variance, was highly correlated with alkalinity, bicarbonate, pH, calcium and, to a lesser extent, magnesium, TDS and potassium, and could be considered a pH-hardness factor. Factor 2, explaining 18% of the variance and highly correlated (positively) with sodium and chloride, was clearly a salinity factor. Factor 3 was related to the drainage area to lake surface area ratio, colour, aluminum and iron and could be considered a dystrophy factor. It explained 11% of the total variance. Factor 4 was positively related to depth and nitrate, and negatively to turbidity, iron and colour and was likely representative of an oligotrophy factor. Factor 5 is related to drainage area and lake surface area and was a simple lake morphometry (size) factor. These last two factors accounted for 10% and 5% of the total variance, respectively.

RELATIONSHIPS BETWEEN SPECIES ASSOCIATIONS AND DERIVED FACTORS

These five factors, plus some chemical variables that were not unambiguously related to the factors, were correlated with the abundance of the various species in Table 7. Species near the top of Figure 16 (E. longispina, E. lacustris, D. catawba, D. minutus) are strongly correlated with factor 4 (oligotrophy). B. longirostris and Polyarthra dolichoptera, near the bottom of Fig. 16, are negatively correlated with factor 4, the former very strongly so. K. taurocephala was negatively correlated with factor 1 (pH-hardness) while P. lenticulare and T. cylindrica were positively correlated with this factor. One species, P. dolichoptera, was positively correlated with factor 2 (salinity) while three species, P. major, D. catawba and D. spatulocrenatus demonstrated negative correlation with this factor. Four species, K. crassa, P. lenticulare, M. edax and E. lacustris, were all strongly associated with factor 5 (lake morphometry). Other strong relationships included C. unicornis with sulphate (negative) and P. dolichoptera with potassium (positive).

Correlations between zooplankton species and the first three derived factors were all weak, suggesting that water chemistry may be unimportant, relative perhaps to other biotic factors, in determining distributions. Four crustaceans were significantly correlated to factor 4 (oligotrophy), one negatively and three positively. As the strongest components of this factor were maximum depth and turbidity (negative), it is probable that these correlations are chiefly related to lake morphometry and water transparency. Factor 5 included two more significant correlations but these are difficult to interpret. A large drainage area and high drainage area/lake area ratio may possibly be evidence of higher than average phosphorus loadings.

Three species, Polyarthra major, Daphnia catawba and Diaptomus spatulocrenatus showed significant negative correlations to factor 2 (salinity). This suggests a below average tolerance to the higher levels of sodium and chloride occurring in lakes situated near the coast of the island. These two parameters demonstrated concentration gradients in relation to distance from salt water. Supporting the contention that salinity, rather than acidity (pH) is implicated in the distribution of these three species is the fact that none were significantly correlated to factor 1. A single species, Polyarthra dolichoptera was positively correlated to factor 2.

Kellicottia bostoniensis and K. longispina were, respectively, positively and negatively correlated with factor 3 (dystrophy). This differing affinity of two congeners to colour and associated metals and humic materials is probably quite real but defies any simple explanation.

Factor 4 is related to oligotrophy as indicated by the negative correlation with turbidity and positive correlations with depth and nitrate (which is less susceptible to denitrification under conditions of low productivity) (Table 6). Several species demonstrated strong correlations with this factor. Possibly the most interesting was the strong difference between Bosmina longirostris (negative) and Eubosmina longispina (positive). The former has long been considered an indicator of eutrophy and the latter (previously referred to incorrectly as B. coregoni) of oligotrophy. However, the mechanism responsible for this displacement has always been disputed. Daphnia catawba, Cyclops scutifer, Diaptomus minutus and Epischura lacustris are other crustaceans with strong positive correlations with factor 4.

Factor 5 is almost entirely associated with lake area and its correlate drainage area. Most of the species correlated with this factor are rotifers. A possible explanation for this relationship is that wind induced turbulence and epilimnetic thickness are important variables in determining distribution of these small animals.

There are numerous species correlations with the three chemical variables that are not clearly linked to any of the five factors. Most noted is the affinity of the rotifer Polyarthra dolichoptera for both potassium and sulphate. This species was indicated earlier as strongly correlated with the salinity factor. Both potassium and sulphate have significant contributions from the marine environment to freshwater chemistry through aerosol deposition (Scruton 1983).

The 5 factors emerging from the analysis were also compared to the total number of species and individuals, in total and among the Cladocera, Copepoda and Rotifera, separately (Table 8). The strongest correlation was between the number of individual copepods and factor 4, the oligotrophic factor. Other strong correlations with this factor include copepod species and cladocerans, both individuals and species. The number of individual rotifers is negatively related to factor 3, the dystrophy factor, as are individual zooplankters in total. The only strong positive correlations with factor 1 (pH-hardness) are total copepod species and total zooplankton species. The contrasting relationships to water transparency of the two taxa indicated by these correlations might bear on the separation in the dendrogram discussed above. Correlations between total species in the three groups and the factors were all weak.

As a whole, none of the three major taxonomic groups were significantly correlated with factor 1 (Table 8) indicating that, from the standpoint of total numbers, neither rotifers, nor cladocerans, nor copepods are affected by pH or its associated variables. The strong positive correlations with factor 1, that occur in total copepod species and total zooplankton species, suggest that on average, there are fewer zooplankton species, and in particular fewer copepod species, in the more acid lakes of the island. This accords closely with the findings from other regions and studies in North America (e.g. Carter 1971; Roff and Kwiatowski 1977; Confer et al. 1983).

Almost all categories, both as individuals and as species, are negatively correlated with factor 3 (dystrophy). This is particularly strong in individual rotifers, and might be related to low abundance of microbial food in humic waters. The strong positive correlation of the two crustacean groups to factor 4, both as individuals and as species (and as numbers within individual species) is probably due, at least in part, to the depth element in this factor: deeper lakes should not only be able to support more individuals but also provide niches for additional species. Rotifers, on the other hand, are predominantly epilimnetic and might not be expected to be significantly more abundant (in either numbers or species) in deeper lakes.

The crustaceans also show certain negative correlations with individual ions. These are particularly strong with manganese for both cladoceran and copepod species. Little is understood about the biological effects of this metal; however, it is known to enter solution at low pH values and can have similar toxicological properties as aluminium, although it is almost always found in much smaller concentrations (Somers and Harvey 1984). It is possible there are crustacean species with a low tolerance to manganese; however, total manganese values provides no indication of the component of biologically labile species of this metal.

CONCLUSIONS

The species composition of rotifer and crustacean plankters in insular Newfoundland is unique relative to other Canadian localities (Patalas 1971; Schindler and Noven 1971; Duthie and Ostrofsky 1974; Roff and Kwiatkowski 1977; Carter et al. 1980 as e.g.). The association of rotifer species clearly indicates the acidic, dilute, oligotrophic and dystrophic nature of many of the lakes covered in this study. The apparent absence of the genera Brachionus, Notholca, Filinia, and Pompholyx was in keeping with neutral or low pH, low calcium concentration, and low trophic conditions of most of the study lakes (Berzins 1949; Pejler 1957). On the other hand, the major components of the rotiferan community in Newfoundland, Keratella taurocephala, Keratella serulata, Polyarthra minor, and Trichocerca platessa are typical of the soft, acidic water plankton. The crustacean plankton, at least, is quite depauperate. Many forms which might show preferences with regard to water chemistry, such as the cladocerans Daphnia retrocurva and D. galeata mendotae, and the copepod Diacyclops thomasi, have never reached the island (Carter et al. 1980). Four large glacial relict copepods are also absent, as they are from the rest of Atlantic Canada (Dadswell 1974; Carter et al. 1980). The crustacean species Diaptomus minutus, Daphnia catawba, and Eubosmina longispina are all considered to be abundant in acid lakes and were dominant, accounting for 42% of the total populations. The presence of only two species of Daphnia was particularly noteworthy. The distribution of some species in the present study was found to be circumscribed (see Fig. 5-12) and the definitive ranges of all species are difficult to delimit without intensive seasonal collections at each of the many localities. Other studies have expanded upon the species list resulting from this survey, and all zooplankters reported in the regional literature have been tabled separately (see Appendix 2) in an effort to provide a comprehensive list of zooplankton species reported for insular Newfoundland.

The multivariate analyses in this study revealed evidence of two zooplankton communities based on body size. This occurrence was hypothesized to be related to the presence or absence of potential fish planktivores or, alternatively, to the possible influence of lake flushing rate. These possibilities would bear further investigation, however the fisheries and lake morphometric data collected during this survey constrain detailed evaluation (Scruton 1983). Acid precipitation, whose pronounced impact on limnetic flora and fauna is well documented, has likely had limited impact on insular Newfoundland freshwaters (Scruton 1983; Scruton and Taylor 1989) despite the overall high sensitivity of the region. No evidence emerged in the multivariate analysis to suggest a factor indicative of anthropogenic acidic deposition. Water acidity (pH) was found to be related (positively) to a lake hardness factor and negatively to a dystrophy factor, factors considered to represent largely natural conditions. Zooplankton assemblages were found to be poorly associated with the lake physical/chemical factors suggesting that other considerations (predation, competition) may be more important in regulating the zooplankton assemblages.

ACKNOWLEDGMENTS

Dobrocky Seatech (Nfld.) Ltd. completed the lake survey program under contract to Fisheries and Oceans (DFO) and the zooplankton identifications/ enumerations were contracted to Beak Consultants Ltd. We are indebted to W. Koste, Quakenbruck, W. Germany for verification of some rotifer identifications. K. Lynch and J. Lannon typed the manuscript. J. Hynes, University of Guelph, completed many of the multivariate analyses. Figures were completed by H. Mullett (DFO) and S. Crowley (under contract). M. O'Connell and K. Houston reviewed the manuscript.

REFERENCES

Ahlstrom, E. H. 1940. A revision of the Rotatorian genera Brachionus and Platyias with descriptions of one new species and two new varieties. Bull. Amer. Mus. Nat. Hist. 77, 3: 148-184.

Airphoto Analysis Consultants Ltd. and Beak Consultants Ltd. 1976. Upper Salmon/Cat Arm: Preliminary Impact Assessment. Prepared for the Newfoundland Department of Consumer Affairs and Environment. xx + 220 p.

Almer, B., W. Dickson, C. Ekstrom, E. Hornstrom, and U. Miller. 1974. Effects of acidification on Swedish lakes. Ambio 3: 30-36.

Almer, B., W. Dickson, C. Ekstrom, and E. Hornstrom. 1978. Ecological Impacts, p. 271-311. In: J. O. Nriagu [ed.] Sulphur in the Environment. J. Wiley and Sons, New York, N. Y.

American Public Health Association. 1975. Standard methods for the examination of water and wastewater. 12th ed. American Public Health Association, New York, N. Y. 769 p.

Anderson, R. S. 1971. Crustacean plankton communities in 146 alpine and subalpine lakes and ponds in western Canada. J. Fish. Res. Board Can. 28: 311-321.

Anderson, R. S. 1974. Crustacean plankton communities of 340 lakes and ponds in and near the national parks of the Canadian rocky mountains. J. Fish. Res. Board Can. 31: 855-569.

Anderson, R. S. 1977. Rotifer populations in mountain lakes relative to fish and species of copepods present. Ergeb. Limnol. (Arch. Hydrobiol. suppl.) 8: 130-134.

Bangay, G. E., and C. Riordan. [ed.] 1983. Memorandum of Intent on Transboundary Air Pollution, Working Group, Final Report, Impact Assessment. Section 3, Aquatic Impacts. 259 p.

Bateman, L. E. and C. C. Davis. 1980. The Rotifera of hummock-hollow formations in a poor (mesotrophic) fen in Newfoundland. Int. Rev. Gesamten. Hydrobiol. 65: 127-153.

Berzins, B. 1949. Zur Limnologie der Seen Südostlettlands. Schweiz. Z. Hydrol. 11: 583-607.

Brandlova, J., Brandl, Z., Fernando, C.H., and S. Fernando. 1972. The Cladocera of Ontario with remarks on some species and distribution. Can. J. Zool. 50: 1373-1403.

Brezonik, P. L., T.C. Crisman, and R. L. Schulze. 1984. Planktonic communities in Florida softwater lakes of varying pH. Can. J. Fish. Aquat. Sci. 41: 46-56.

Brooks, J. L. 1957. The systematics of the North American Daphnia. Memoirs of the Connecticut Academy of Arts and Sciences, Vol. VIII, New Haven, Connecticut, Yale University Press.

Brooks, J. L., and S. I. Dodson. 1965. Predation, body size and composition of the plankton. Science 150: 28-35.

Carter, J.C.H. 1971. Distribution and abundance of planktonic Crustacea in ponds near Georgian Bay (Ontario, Canada) in relation to hydrography and water chemistry. Arch. für Hydrobiol. 68: 204-231.

Carter, J.C.H., W. D. Taylor, R. Chengalath, and D. A. Scruton. 1986. Limnetic zooplankton assemblages in Atlantic Canada with special reference to acidification. Can. J. Fish. Aquat. Sci. 43: 444-456.

Carter, J.C.H., M. J. Dadswell, J. C. Roff, and W. G. Sprules. 1980. Distribution and zoogeography of planktonic crustaceans and dipterans in glaciated eastern North America. Can. J. Zool. 58: 1355-1387.

Chengalath, R. 1984. Bibliographia Invertebratorum Aquaticorum Canadensium Vol. 3. Synopsis Speciorum: Rotifera. National Museum of Natural Sciences, National Museums of Canada, Ottawa. v + 102 p.

Chengalath, R. 1978. A new species of the genus Notholca Gosse, 1886 (Brachionidae: Rotifera), from Great Slave Lake, N.W.T. Can. J. Zool. 56: 363-364.

Chengalath, R., and C. H. Fernando. 1973. The planktonic Rotifera of Ontario with records of distribution and notes on some morphological variation. Nat. Can. 87: 267-277.

Chengalath, R., W. J. Bruce and D. A. Scruton. 1984. Rotifer and crustacean plankton communities of lakes in insular Newfoundland. Verh. Internat. Verein. Limnol. 22: 419-430.

Chengalath, R., and W. Koste. 1983. Rotifera from northeastern Quebec, Newfoundland and Labrador, Canada. Hydrobiologia 104: 49-56.

Clair, T. A., and B. Freeman. 1986. Patterns of dissolved organic carbon in four acidic brownwater streams in Nova Scotia, Canada. Water Air Soil Pollut. 31: 139-147.

Confer, J. L., T. Kaaret, and G. E. Likens. 1983. Zooplankton diversity and biomass in recently acidified lakes. Can. J. Fish. Aquat. Sci. 40: 36-42.

Cushman, J. A. 1908. Freshwater Crustacea from Labrador and Newfoundland. Proc. U.S. Natl. Mus. 33(1589): 705-713.

Dadswell, M. J. 1974. Distribution, ecology and postglacial dispersion of certain crustaceans and fishes in eastern North America. Natl. Mus. Can. Publ. Zool. 11: 1-110.

Daggett, R. F., and Davis, C. C. 1974. A seasonal quantitative study of the littoral Cladocera and copepods in a bog pond and an acid marsh in Newfoundland. Int. Rev. Gesamten Hydrobiol. 59: 667-683.

Daggett, R. F., and C. C. Davis 1975. Distribution and occurrence of some littoral freshwater microcrustaceans in Newfoundland. Nat. Can. 102: 45-55.

Davis, C. C. 1972a. Plankton dynamics in a Newfoundland lake. Verh. Internat. Verein. Limnol. 18: 278-283.

1972b. Plankton succession in a Newfoundland lake. Int. Rev. Ges. Hydrobiol. 57: 367-395.

1973. A seasonal quantitative study of the plankton of Bauline Long Pond, a Newfoundland lake. Nat. Can. 100: 85-105.

1975. Seasonal changes of planktonic Crustacea in two Newfoundland lakes. Int. Ver. Theor. Angew. Limnol. Verh. 19: 739-744.

1976. Simultaneous quantitative comparison of planktonic Crustacea in two Newfoundland boreal lakes. Int. Revue Gesamten. Hydrobiol. 61: 807-823.

Deichmann, K. H., and D. B. Bradshaw. 1984. Terra Nova National Park: Resource description and evaluation. Parks Canada, Environment Canada.

Deevey, E. S., and G. B. Deevey. 1971. The American species of <u>Eubosmina</u> Seligo (Crustacea, Cladocera). Limnol. Oceanogr. 16: 201-218.

De Ridder, M. 1972. Rotatoria. In: The Zoology of Iceland, Copenhagen/Reykjavik. 11, 13: 1-106

Dobrocky Seatech (Nfld.) Ltd. 1983. Digitization of selected riversheds along the south coast of Newfoundland. Contractors report submitted to Fisheries and Oceans, St. John's, Nfld. 14 p. + 3 Appendices.

Douglas, R.W.J. 1970. Geology and economic minerals of Canada. Geol. Surv. Can., Econ. Geol. Rep. 1: 838 p.

Dupont, J., and D.S. Jeffries. 1990. The 1990 Canadian Long-Range Transport of Air Pollutants and Acid Deposition Report. Part 4: Aquatic Effects. Federal-Provincial Research and Monitoring Committee, iv + 151 pp.

Duthie, H. C., and M. L. Ostrofsky. 1974. Plankton, chemistry, and physics of lakes in the Churchill Falls region of Labrador. J. Fish. Res. Board Can. 31: 1105-1117.

Earle, J. C., H. C. Duthie, and D. A. Scruton. 1987. Factors influencing the distribution of phytoplankton in 97 headwater lakes in insular Newfoundland. Can. J. Fish. Aquat. Sci. 44: 639-649.

Edmondson, W. T. [ed.]. 1959. Freshwater Biology, 2nd Eds., John Wiley and Sons Inc., New York, N. Y. xx + 1248 p.

Environment Canada. 1979. Analytical methods manual. Inland Waters Directorate, Water Quality Branch, Water Survey of Canada, Ottawa, Canada. xv + 7 parts.

Environmental Protection Agency. 1983. The acid deposition phenomenon and its effects. Critical assessment review papers. Vol. II. Effects sciences. U.S. EPA, Office of Research and Development, Washington, D. C. EPA-600/8-83-016B, xxvi + 655 p.

Elgmork, K. 1967. On the distribution and ecology of Cyclops scutifer Sars in New England (Copepoda: Crustacea). Ecology 48: 967-971.

Fryer, G. 1980. Acidity and species diversity in freshwater crustacean faunas. Freshwater Biol. 10: 41-45.

Gardner, M. B. 1981. Mechanisms of size selectivity by planktivorous fish: a test of hypothesis. Ecology 62: 571-578.

de Graaf, D. A. 1981. Fisheries investigations in the vicinity of the proposed Dry Pond Brook hydroelectric development. Contractors Report, LGL Ltd., St. John's, Nfld., prepared for Newfoundland and Labrador Hydro.

Harring, H. K. 1921. The rotifera of the Canadian Arctic Expedition 1913-1918. Rep. Can. Arct. Exped., Part E, 8: 3-16.

Harvey, H. H., R. C. Pierce, P. J. Dillon, J. P. Kramer, and D. M. Whelpdale. 1981. Acidification in the Canadian Environment. NRCC Report No. 18475. 369 p.

Hobaek, A., and G. G. Raddum. 1980. Zooplankton communities in acidified lakes in South Norway. SNSF Project, Report IR 75/80. 132 p.

Howell, G. D. 1986. Water quality characterization of 78 acid precipitation monitoring lakes in Atlantic Canada. Environment Canada, Inland Water Directorate, Water Quality Branch, Moncton, N. B., Report IWD-AB-WQB-86-109. iii + 119 p.

Hrbacek, J. 1962. Species composition and the amount of the zooplankton in relation to the fish stock. Rozpravy Ceskosl. Adad. Ved. Rada Matem. Prir. Ved. 72: 1-114.

Hutchinson, G. E. 1967. A treatise on limnology. II. Introduction to lake biology and the limnoplankton. John Wiley and Sons, Inc., New York, 1115 p.

Jeffries, D. S., D. L. Wales, J.R.M. Kelso, and R. A. Linkhurst. 1986. Regional chemical characteristics of lakes in North America: Part I - Eastern Canada. Water Air Soil Pollut. 31: 551-569.

Keller, W., and J. R. Pitblado. 1984. Water quality-crustacean plankton relationships in northeastern Ontario lakes. Water Air and Soil Pollut. 23: 271-291.

Kelso, J.R.M., C. K. Minns, J. E. Gray, and M. L. Jones. 1986. Acidification of surface waters in eastern Canada and its relationship to aquatic biota. Can. Spec. Publ. Fish. Aquat. Sci. 87: 42 p.

Kendaris, T. A. 1982. Acid rain: A survey of selected headwater lakes in Newfoundland. Prepared for Fisheries and Oceans, St. John's, Newfoundland. iv + 67 p., 2 Appendices.

Kerekes, J. 1978. Aquatic Resources Inventory, Gros Morne National Park. Part 5. Limnological conditions. Can. Wildlife Serv., Environment Canada, 153 p.

Kerfoot, W. C. 1977. Implications of copepod predation. Limnol. Oceanogr. 22: 316-325.

1978. Combat between predatory copepods and their prey: Cyclops, Epischura and Bosmina. Limnol. Oceanogr. 23: 1089-1102.

Kitchell, J. A., and J. F. Kitchell. 1980. Size-selective predation, light transmission, and oxygen stratification: evidence from the recent sediments of manipulated lakes. Limnol. Oceanogr. 25: 389-402.

Korinek, V. 1981. Diaphanosoma birgei n.s. (Crustacea, Cladocera). A new species from America and its widely distributed subspecies Diaphanosoma birgei sp. lacustris n. sp. Can. J. Zool. 59: 1115-1121.

Koste, W. 1978. Rotatoria. Borntraeger, Stuttgart-Berlin, 2 vols., 673 p, 234 plates.

Kramer, J. R. 1978. Precise determination of low alkalinities using the modified gran analysis, an inexpensive field procedure. Dept. of Geology, McMaster University, Hamilton, Ontario. 11 p.

Lindsey, C. C., Patalas, K. Bodaly, R. A., and C. P. Archibald. 1981. Glaciation and the physical, chemical and biological limnology of Yukon lakes. Can. Tech. Rep. Fish. Aquat. Sci. 966: 1-43.

Livingstone, D.A. 1963. Chemical composition of rivers and lakes. data of Geochemistry, 6th ed., Chapter G. Geological Survey Professional Paper 400-G, 61 p.

Maemets, A. 1983. Rotifers as indicators of lake type in Estonia. Hydrobiologia 104: 357-361.

Malley, D.F., and P.S.S. Chang. 1986. Increase in the abundance of Cladocera at pH 5.1 in experimentally acidified Lake 223, Experimental Lakes Area, Canada. Wat. Air Soil Pollut. 30:629-637.

McLaren, I. A. 1964. Zooplankton of Lake Hazen, Ellesmere Island, and a nearby pond, with special reference to the copepod Cyclops scutifer Sars. Can. J. Zool. 42: 613-629.

Meijering, M.P.D. 1983. On the occurrence of 'arctic' cladocera with special references to those along the Strait of Belle Isle (Quebec, Labrador, Newfoundland). Int. Revue. Ges. Hydrobiol. 68: 885-893.

Megyeri, J. 1969. Zooplankton in some Canadian lakes. Szegedi Tanarkepzo Foiskola Tudomanyos Koslemenyeibol (1969). 105-119.

Moore, J. W. 1978. Composition and structure of zooplankton communities in eighteen arctic and subarctic lakes. Int. Rev. Gesamten Hydrobiol. 63: 545-565.

1980. Seasonal cycles of zooplankton and related phytoplankton development in three shallow, mesotrophic lakes in northern Canada. Int. Rev. Gesamten Hydrobiol. 65: 357-378.

Myers, F. J. 1937. Rotifera from the Adirondack region of New York. Am. Mus. Novit. 903: 1-17.

Nauwerck, A. 1978. Notes on the planktonic rotifers of Lake Ontario. Arch. Hydrobiol. 84: 269-301.

Newfoundland and Labrador Hydro. 1978. Hinds Lake Hydroelectric Project. Environmental Impact Statement. Environment Policy Department, Newfoundland and Labrador Hydro., May 1978. vii + 97 p.

Newfoundland and Labrador Hydro. 1980a. Upper Salmon Hydroelectric Development: Environmental Impact Statement. xiv + 187 p.

Newfoundland and Labrador Hydro. 1980b. Cat Arm Hydroelectric Development: Environmental Impact Statement. xxiv + 263 p.

Nogrady, T. 1976. Canadian Rotifers 1. Lac Echo, Quebec. Nat. Can. 103: 425-436.

O'Connell, M. F., and C. W. Andrews. 1977. Plankton ecology in Long Pond, St. John's, Newfoundland: A polluted pond characterized by a high flushing rate. Int. Revue. Ges. Hydrobiol. 62: 133-1562.

1987. Plankton ecology in relation to flushing rate in four Newfoundland ponds. Int. Revue. Ges. Hydrobiol. 72: 487-516.

Oliver, B. G., E. M. Thurman, and R. L. Malcolm. 1983. The contribution of humic substances to the acidity of coloured natural waters. Geochim. Cosmochim. Acta 47: 2031-2035.

Ontario Ministry of Natural Resources. 1980. Determination of total inflection point alkalinity. Instruction manual for sampling and field titration. Ontario Ministry of Natural Resources, Fisheries Branch, Environmental Dynamics Division. 35 p.

Ontario Ministry of the Environment. 1981. Acid sensitivity survey of lakes in Ontario. APIOS Report No. 002/81, iv + Appendix.

Overrein, L. N, H. M. Seip, and A. Tollan. 1980. Acid rain: Effects on forests and fish. Final Report of the SNSF Project 1972-1980. SNSF Project FR 19/80. 175 p.

Palmer, C. M. 1965. Phytoplankton periodicity in a Newfoundland Pond. J. Phycol. 1: 39-40.

Parsons, G. J. 1987. Zooplankton communities of 78 acid precipitation monitoring lakes in Nova Scotia and Newfoundland. Water Quality Branch, Environment Canada, Atlantic Region, i + 40 p.

Patalas, K. 1971. Crustacean plankton communities in forty-five lakes in the Experimental Lakes Area, northwestern Ontario. J. Fish. Res. Board Can. 28: 231-244.

1975. The crustacean plankton communities of fourteen North American great lakes. Int. Ver. Theor. Angew. Limnol. Verh. 19: 504-511.

Patalas, K., and A. Salki. 1973. Crustacean plankton and the eutrophication of lakes in the Okanagan Valley, British Columbia. J. Fish. Res. Board Can. 30: 519-542.

Pejler, B. 1957. Taxonomical and ecological studies on planktonic Rotatoria from central Sweden. Kungl. Svensk. Vetenskapaka. Handl. 6: 1-52.

Pennak, R. W. 1978. Freshwater Invertebrates of the United Stated, 2nd Ed., John Wiley and Sons, Toronto. ix + 769 p.

Pepper, V. A., N. P. Oliver, and R. Blundon. 1984. Lake surveys and biological potential of natural lacustrine rearing of juvenile Atlantic salmon (Salmo salar) in Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. No. 1295: iv + 72 p.

Pinel-Alloul, B., P. Legendre, and E. Mangin. 1979. Zooplankton limnetique de 456 lacs et 1 rivières du terretoire de la Baie de James. Can. J. Zool. 5: 1693-1709.

Pope, G. F., and J.C.H. Carter. 1975. Crustacean plankton communities of the Matamek River system and their variation with predation. J. Fish. Res. Board Can. 32: 2530-2535.

Rawson, D. S. 1960. A limnological comparison of twelve large lakes in northern Saskatchewan. Limnol. Oceanogr. 5: 195-211.

Reed, E. B. 1963. Records of freshwater Crustacea from arctic and subarctic Canada. Natl. Mus. Can. Bull. 199: 29-62.

Roff, J. C. and R. E. Kwiatkowski. 1977. Zooplankton and zoobenthos communities of selected Northern Ontario lakes of different acidities. Can. J. Zool. 55: 899-911.

Ruttner-Kolisko, A. 1974. Plankton rotifers - biology and taxonomy, Die Binnengewasser, Vol. XXVIII, supplement, E. Schwerzbartsche, Verlogsbuchhandlung. (Nagele M. Obermiller), Stuttgart.

Ryan, P. M. 1982. Species composition and seasonal abundance of zooplankton in the Experimental Ponds Area, central Newfoundland, 1977-80. Can. Data Rep. Fish. Aquat. Sci. 318: iv + 85 p.

1984. Variation in abundance and diversity of crustacean zooplankton in two small, shallow lakes in central Newfoundland, Canada. Verh. Internat. Verein. Limnol. 22: 412-418.

SAS Institute. 1979. SAS Users guide, 1979 Edition. SAS Institute Inc., North Carolina, USA. 494 p.

Schindler, D.W., K.H. Mills, D.F. Malley, D.L. Findlay, J.A. Shearer, I.J. Davies, M.A. Turner, G.A. Lindsey, and D.R. Cruikshank. 1985. Long-term ecosystem stress: the effects of experimental acidification on a small lake. Science 228: 1395-1398.

Schindler, D. W., and Noven, B. 1971. Vertical distribution and seasonal abundance of zooplankton in two shallow lakes of the Experimental Lakes Area, northwestern Ontario. J. Fish. Res. Board Can. 28: 245-256.

Scott, W. B., and E. J. Crossman. 1964. Fishes occurring in the freshwaters of insular Newfoundland. Dep. Fish. Ottawa. 124 p.

1973. Freshwater fishes of Canada. Fish. Board. Can. Bul. 194. 966 p.

Scruton, D. A. 1983. A survey of headwater lakes in insular Newfoundland, with special reference to acid precipitation. Can. Tech. Rep. Fish. Aquat. Sci. 1195: v + 110 p.

1985. Acid rain studies and limnological characterization of lakes in Newfoundland. Can. Soc. Environ. Biol. Newsletter 42(3): 21-38.

Scruton, D. A., J. C. Earle, and H. C. Duthie. 1987. Phytoplankton assemblages from 95 lakes in Labrador: an assessment of environmental and morphometrical influences on species distributions and associations. Can. Tech. Rep. Fish. Aquat. Sci. 1586: v + 71 p.

Scruton, D. A., and D. H. Taylor. 1989. A survey of dilute lakes on the south coast of insular Newfoundland in relation to natural and anthropogenic acidification. Can. Tech. Rep. Fish. Aquat. Sci. 1711: iv + 58 p.

Siegfried, C. A., J. W. Sutherland, S. O. Quinn, and J. A. Bloomfield. 1984. Lake acidification and biology of Adirondack lakes: I. Rotifer communities. Verh. Internat. Verein. Limnol. 22: 549-558.

Smith, K., and C. H. Fernando. 1978. A guide to the freshwater Calanoid and Cyclopoid Copepod Crustacea of Ontario. University of Waterloo Biology, Series No. 27.

Somers, K. M., and H. H. Harvey. 1984. Alteration of fish communities in lakes stressed by acid deposition and heavy metals near Wawa, Ontario. Can. J. Fish. Aquat. Sci. 41: 20-29.

Sprules, W. G. 1975. Factors affecting the structure of limnetic crustacean zooplankton communities in central Ontario lakes. Int. Ver. Theor. Angew. Limnol. Verh. 19: 635-643.

Strickland, J. D., and T. R. Parsons. 1972. A practical handbook of seawater analysis. Fish. Res. Board Can. Bull. No. 167. 311 p.

Watt, W. D., D. Scott, and S. Ray. 1979. Acidification and other chemical changes in Halifax country lakes after 21 years. Limnol. Oceanogr. 24: 1154-1161.

Wetzel, R. G. 1984. Limnology. W. B. Saunders Co., Toronto. 769 p.

Williamson, C. E., and R. E. Magnien. 1982. Diel vertical migration in Mesocyclops edax: implication for predation rate estimates. J. Plankton Res. 4: 329-339.

Yan,N. D., and P. M. Strus. 1980. Crustacean zooplankton communities of acidic metal-contaminated lakes near Sudbury, Ontario. Can. J. Fish. Aquat. Sci. 37: 2282-2293.

Zaret, T. M. 1980. Predation and freshwater communities. Yale University Press, New Haven, CT. 187 p.

Table 1. Selected physical and chemical characteristics for the 108 Newfoundland lakes.

Lake	LSA	Drainage area (ha)	DA:LSA (ratio)	Water Temp. (^{0}C)	Secchi depth (m)	TDS (mgL^{-2})	Turbidity (JTU)	Colour (TCU)
1	147.0	706.0	4.8	12.4	2.5	150.3	0.44	5
2	23.0	205.0	8.9	13.9	4.2	110.7	0.52	5
3	47.0	597.0	12.7	13.7	1.5	64.2	0.74	50
4	99.0	591.0	6.0	14.0	6.5	22.1	0.48	5
5	29.0	574.0	19.8	14.5	1.5	23.5	0.80	125
6	361.0	1634.0	4.5	13.2	6.0	17.6	0.35	10
7	77.0	572.0	7.4	12.9	4.5	19.2	0.62	25
8	104.0	617.0	5.9	12.7	3.0	17.2	0.76	30
9	130.0	438.0	3.4	9.0	2.5	17.6	0.55	30
10	117.0	342.0	2.9	9.0	4.3	18.1	0.25	10
11	232.0	660.0	2.8	11.7	5.0	106.3	0.54	10
12	25.0	167.0	6.7	8.6	1.0	21.4	0.93	90
13	941.0	3964.0	4.2	8.1	2.2	19.2	1.00	35
14	50.0	643.0	12.9	9.3	1.5	20.7	1.20	125
15	60.0	719.0	12.0	11.5	0.8	21.4	1.20	125
16	64.0	396.0	12.9	10.6	3.5	19.9	0.68	5
17	34.0	98.0	2.9	11.8	0.8	414.4	3.10	30
18	35.0	311.0	8.9	10.5	3.0	18.3	0.56	45
19	32.0	199.0	6.2	10.1	7.5	19.2	0.76	10
20	83.0	529.0	6.4	11.8	2.5	17.6	0.95	45
21	33.0	404.0	12.2	13.5	1.7	86.9	0.58	65
22	33.0	150.0	4.5	11.6	1.0	23.9	0.48	35
23	78.0	368.0	4.7	10.6	5.0	17.0	0.45	15
52	82.0	889.0	10.8	9.9	2.0	22.8	0.96	75
53	406.0	3194.0	7.9	16.1	3.8	17.5	0.40	25
54	103.0	495.0	4.8	15.8	2.0	17.6	0.43	60
55	104.0	910.0	8.8	20.4	3.0	30.9	0.37	45
56	42.0	285.0	6.8	11.4	3.2	30.7	0.40	35
57	82.0	542.0	6.6	19.5	3.0	17.7	0.40	40
58	179.0	2007.0	11.2	21.8	1.0	22.7	0.36	80
59	165.0	659.0	14.0	16.7	2.6	23.8	0.37	10
60	37.0	185.0	5.0	9.5	2.0	15.8	0.65	25
61	123.0	1089.0	8.9	17.1	1.0	24.2	0.50	25
62	31.0	516.0	16.6	6.4	1.5	15.2	0.30	5
63	96.0	714.0	7.4	6.7	1.3	24.5	1.70	45
64	98.0	957.0	9.8	19.7	2.2	18.0	0.55	45
66	72.0	355.0	4.9	15.0	6.0	15.8	0.30	15
67	324.0	1304.0	4.0	16.2	4.5	18.9	0.53	15

Table 1. (Con't.)

Lake	LSA	Drainage area (ha)	DA:LSA (ratio)	Water Temp. (^{0}C)	Secchi depth (m)	TDS (mgL^{-2})	Turbidity (JTU)	Colour (TCU)
68	65.0	358.0	5.5	16.5	5.5	15.9	0.77	30
69	75.0	450.0	6.0	5.6	1.5	15.4	1.30	60
70	164.0	825.0	5.0	20.4	2.1	22.7	0.53	25
71	32.0	791.0	24.7	10.4	2.0	22.1	0.43	65
72	33.0	731.0	22.2	6.0	0.5	21.4	1.10	200
73	125.0	730.0	5.8	15.9	1.2	21.4	0.41	20
75	65.0	350.0	5.4	6.2	2.0	17.8	1.60	55
76	40.0	151.0	3.8	6.5	1.8	18.1	0.77	55
77	24.0	103.0	4.3	6.9	2.0	17.1	0.64	50
78	100.0	462.0	4.6	19.5	2.5	210.4	0.50	20
79	140.0	584.0	4.2	14.8	3.5	24.2	0.40	40
81	141.0	807.0	5.7	16.5	3.0	38.3	0.31	30
82	132.0	717.0	5.4	19.2	2.8	18.9	0.56	30
83	87.0	3150.0	36.2	20.8	1.7	18.6	0.67	60
102	46.0	368.0	8.0	7.5	0.3	49.7	1.70	225
103	46.0	654.0	14.2	7.7	0.8	36.0	1.90	150
104	48.0	129.0	2.7	11.6	5.5	26.4	0.30	25
105	39.0	308.0	7.9	6.8	0.8	36.7	1.30	125
107	114.0	731.0	6.4	6.7	1.0	26.8	1.60	90
108	257.0	1036.0	4.0	14.9	4.5	26.4	0.35	30
109	341.0	1056.0	3.1	18.0	4.	33.5	0.49	10
110	197.0	1570.0	8.0	18.3	3.0	23.8	0.33	40
111	169.0	2047.0	12.1	16.8	4.0	21.2	0.40	35
112	97.0	773.0	8.0	17.8	0.8	19.7	0.85	45
113	95.0	1197.0	12.6	18.0	2.0	23.1	0.80	70
114	57.0	1272.0	22.3	18.8	2.5	23.1	0.60	35
116	24.0	475.0	19.8	8.5	1.5	21.7	0.73	90
117	251.9	1370.6	5.4	16.4	2.0	19.4	0.30	35
118	100.0	648.0	6.5	17.7	4.0	0	0	0
119	127.0	720.0	5.7	14.7	0.8	17.3	0.54	50
120	37.0	323.0	8.7	8.4	1.2	23.4	0.77	45
121	79.0	422.0	5.4	15.5	2.0	20.8	0.54	70
122	226.0	2354.0	10.4	17.6	2.0	21.9	0.47	60
123	353.0	869.0	2.5	16.6	4.0	19.7	0.42	30
124	250.0	1533.0	6.1	16.3	2.0	19.7	0.58	50
125	359.0	1031.0	2.9	15.7	5.5	17.8	0.36	10
152	250.0	5110.0	20.4	17.9	2.0	28.7	0.46	75
153	96.0	404.0	4.2	16.4	3.0	26.4	0.39	30

Table 1. (Con't.)

Lake	LSA	Drainage area (ha)	DA:LSA (ratio)	Water Temp. (^0C)	Secchi depth (m)	TDS (mgL^{-2})	Turbidity (JTU)	Colour (TCU)
154	48.0	396.0	8.2	16.8	2.5	24.2	0.36	35
201	98.0	700.0	7.1	11.8	8.3	31.8	0.33	55
202	34.0	197.0	5.8	10.3	5.5	150.1	0.29	20
203	24.0	127.0	5.3	9.5	3.5	19.9	0.41	25
204	23.0	257.0	11.2	8.5	2.0	21.4	0.69	65
205	80.0	566.0	7.1	16.2	3.5	21.4	1.10	35
206	120.0	874.0	7.3	15.5	2.8	17.3	0.35	35
207	195.0	1057.0	5.4	16.2	4.0	20.4	0.43	25
208	173.0	1030.0	6.0	14.9	2.0	18.2	0.60	55
209	88.0	591.0	6.7	15.5	2.2	23.8	0.48	25
211	95.0	1209.0	12.7	14.4	2.5	19.4	0.66	40
213	209.0	1726.0	8.3	15.4	2.0	18.2	0.60	60
215	87.0	508.0	5.8	15.7	3.8	24.5	0.40	35
217	244.0	1010.0	4.1	16.6	4.2	19.4	0.42	25
219	1177.0	1027.0	5.8	16.7	2.5	21.9	0.63	40
222	36.0	193.0	5.4	8.5	2.8	19.2	0.52	15
224	28.0	148.0	5.3	8.9	0.5	19.2	0.84	55
225	166.0	577.0	3.5	16.3	9.5	20.1	0.22	5
226	176.0	1163.0	6.6	15.4	0.8	20.1	0.58	15
228	71.0	475.0	6.7	9.7	2.2	22.1	0.55	35
229	93.0	813.0	8.7	8.5	1.0	21.1	1.20	80
230	65.0	617.0	9.5	9.7	1.5	22.1	0.64	80
232	82.0	903.0	11.0	16.7	4.0	20.4	0.35	35
251	33.0	415.0	12.6	10.6	0.8	38.3	0.59	40
252	101.0	595.0	5.8	18.8	4.0	19.7	0.42	35
253	37.0	231.0	6.2	11.5	3.5	103.5	0.25	25
254	45.0	254.0	5.6	16.4	2.8	21.4	0.45	40
255	141.0	169.3	12.0	16.2	2.9	25.7	0.45	60
256	21.0	465.0	22.1	9.6	1.0	45.9	1.10	175
257	21.0	321.0	15.3	11.7	1.8	455.4	0.36	70

LSA = lake surface area
DA = drainage area
DA:SLA = drainage area:lake surface area

Table 2. Physical and chemical data for the 108 insular Newfoundland study lakes. All data are in μeqL^{-2} unless otherwise specified (see end of table).

Lake	DO	CD	SD	PH	ALK	CA	MG	NA	K	CL	SO4	PO4	NO3	AL	MN	FE
1	11.6	0.0	2.5	8.39	-	1400	410	139	3	163	50	0.064	0.714	4.6	0.4	2.2
2	10.9	0.4	4.2	8.17	1160.6	1100	224	117	5	141	52	0.064	0.714	2.8	0.8	3.1
3	11.2	1.0	1.5	7.68	478.2	335	287	165	4	205	64	0.064	0.714	8.1	0.8	4.9
4	9.8	1.9	6.5	6.13	19.5	29	32	73	6	84	52	0.258	0.714	4.1	0.2	1.9
5	8.9	2.5	1.5	6.54	49.0	65	39	73	3	81	62	0.064	0.714	28.9	0.4	8.7
6	9.7	2.1	6.0	6.65	10.5	17	16	56	1	61	29	0.258	2.857	5.3	0.3	1.8
7	9.8	1.9	4.5	6.37	23.0	24	29	60	3	67	33	0.064	1.428	6.9	0.1	2.2
8	9.9	2.6	3.0	5.37	2.9	17	17	47	1	59	14	0.129	0.714	10.0	0.4	-
9	11.1	1.8	2.5	5.97	1.4	21	19	56	1	61	27	0.129	0.714	3.9	0.5	6.0
10	10.7	1.3	4.3	6.48	10.0	19	23	60	1	64	29	0.129	5.000	5.2	0.1	0.9
11	11.3	0.3	5.0	8.05	1044.9	800	368	178	6	208	72	0.064	0.714	3.7	0.2	1.5
12	10.5	4.9	1.0	4.90	0.0	27	25	56	3	68	54	0.064	1.428	23.3	1.4	11.6
13	11.7	2.9	2.2	5.50	10.6	16	19	56	2	70	22	0.064	1.428	5.2	0.6	6.9
14	9.9	4.9	1.5	5.10	4.6	24	30	56	2	64	47	0.064	0.714	30.0	0.6	17.8
15	10.1	4.0	0.8	5.00	3.4	21	30	65	3	74	56	0.064	0.714	27.8	0.8	18.8
16	10.0	1.2	3.5	6.16	8.9	19	23	78	1	95	29	0.064	5.000	4.1	0.2	2.2
17	10.3	0.4	0.8	7.37	343.8	380	133	226	8	214	77	0.258	0.714	16.4	0.8	1.8
18	10.5	1.4	3.0	6.79	37.8	44	26	47	2	56	31	0.129	1.428	9.4	0.7	3.4
19	10.3	1.7	7.5	5.51	4.1	15	20	69	1	90	63	0.258	3.571	4.9	0.4	1.2
20	10.0	2.2	2.5	6.22	39.7	52	16	43	2	53	63	0.064	2.857	14.4	0.2	2.8
21	10.2	0.4	1.7	7.46	820.3	550	345	191	8	200	89	0.064	2.143	21.0	0.4	6.3
22	9.1	1.6	1.0	6.63	71.6	79	45	60	5	68	45	0.194	0.714	10.0	0.2	5.7
23	10.6	1.4	5.0	5.54	5.5	13	16	52	2	61	27	0.129	0.714	5.6	0.4	5.2
52	10.1	3.5	2.0	6.44	64.2	103	29	60	6	61	60	0.064	0.714	7.7	0.6	0.1
53	9.2	1.7	3.8	6.03	32.1	30	23	47	3	47	37	0.064	0.714	0.0	0.2	2.7
54	8.8	2.0	2.0	6.30	46.6	26	48	43	2	39	41	0.064	0.714	0.0	0.2	5.8
55	9.3	1.3	3.0	7.38	209.3	195	46	69	4	53	39	0.129	0.714	9.8	0.1	4.4
56	10.7	1.6	3.2	7.28	188.3	185	45	65	1	61	45	0.194	0.714	7.6	0.2	2.7
57	9.1	1.6	3.0	6.99	61.1	34	23	52	3	39	29	0.129	1.430	10.6	0.8	5.5
58	9.2	2.2	1.0	7.04	101.6	120	35	56	1	42	47	0.064	0.714	13.9	0.1	8.0
59	9.6	1.0	2.6	7.60	115.7	85	40	60	4	50	29	0.064	0.714	3.9	0.1	1.9
60	10.7	1.3	2.0	6.82	33.1	22	19	40	2	25	37	0.194	1.428	10.0	0.1	3.0
61	9.3	1.5	1.0	7.29	96.8	85	44	60	6	47	37	0.064	0.714	8.9	0.4	2.2
62	11.4	1.2	1.5	6.52	28.4	16	12	43	2	28	29	0.194	0.714	3.1	0.0	1.0
63	11.6	1.7	1.3	7.11	116.3	115	45	56	5	56	50	0.064	0.714	14.3	0.8	7.4
64	10.0	1.4	2.2	6.70	65.6	70	21	38	1	28	31	0.129	0.714	10.7	0.2	6.6
66	10.1	1.3	6.0	6.68	27.0	25	15	37	2	30	35	0.064	2.143	8.2	0.2	0.9
67	9.4	1.5	4.5	7.48	71.8	54	19	43	3	39	29	0.064	0.714	2.8	0.2	0.9
68	9.8	3.4	5.5	5.77	12.1	23	16	39	2	36	41	0.064	2.143	14.3	0.2	1.5

Table 2. (Con't.)

Lake	DO	CD	SD	PH	ALK	CA	MG	NA	K	CL	SO4	PO4	NO3	AL	MN	FE
69	11.8	2.3	1.5	6.47	18.6	36	15	33	1	33	39	0.129	0.714	9.0	0.4	12.5
70	8.5	1.3	2.1	6.91	95.6	100	39	47	3	47	39	0.129	0.714	6.6	0.2	3.1
71	10.7	2.6	2.0	6.46	45.0	59	31	65	3	73	56	0.064	2.143	19.2	0.4	8.5
72	10.8	6.4	0.5	5.18	6.4	50	31	47	2	56	97	0.064	0.714	15.5	1.2	29.0
73	10.1	4.5	1.2	7.01	64.2	79	23	47	3	45	50	0.064	0.714	4.4	0.2	3.1
75	11.5	2.9	2.0	5.86	22.2	36	18	47	2	53	45	0.064	3.571	31.1	0.3	9.8
76	11.5	3.3	1.8	5.66	5.8	31	15	52	2	50	45	0.064	0.714	24.4	1.1	5.8
77	11.2	2.6	2.0	6.02	23.3	31	23	42	2	47	45	0.064	0.714	10.6	0.2	7.2
78	9.3	1.3	2.5	6.67	65.6	65	38	47	1	50	31	0.064	0.714	5.4	0.2	2.3
79	9.4	3.7	3.5	5.59	13.4	35	29	91	3	107	52	0.064	2.857	9.1	0.3	0.5
81	9.8	1.1	3.0	7.54	246.8	234	51	91	7	97	58	0.129	0.714	9.1	0.1	2.9
82	9.3	1.7	2.8	6.48	42.1	54	27	52	3	53	35	0.064	0.714	10.3	0.2	5.8
83	8.7	2.4	1.7	6.36	38.2	60	21	56	1	4	39	0.064	0.714	13.1	0.5	9.8
102	10.7	6.2	0.3	5.59	47.5	92	110	278	8	394	114	0.064	0.714	42.2	1.8	44.3
103	10.9	5.2	0.8	5.80	25.9	48	70	182	5	233	77	0.064	0.714	47.8	1.7	44.6
104	10.3	1.6	5.5	7.04	84.8	62	48	78	5	92	47	0.194	1.428	7.1	0.2	2.0
105	11.2	4.7	0.8	5.42	13.3	37	62	195	4	261	66	0.194	0.714	38.9	0.7	46.9
107	11.4	4.6	1.0	5.78	12.2	27	53	113	3	143	62	0.323	0.714	30.0	1.1	20.1
108	9.4	1.4	4.5	6.08	27.2	25	43	134	3	149	41	0.064	6.430	14.2	0.2	1.2
109	9.7	1.0	4.5	6.95	173.6	130	80	104	3	104	31	0.129	2.140	2.6	0.4	1.1
110	9.6	1.5	3.0	6.60	56.6	60	46	91	3	95	25	0.129	0.428	8.0	0.2	2.1
111	9.8	2.3	4.0	6.07	27.7	35	35	73	6	78	33	0.064	5.710	12.2	1.4	5.3
112	9.9	1.4	0.8	6.88	62.3	43	27	69	5	56	27	0.064	0.714	7.8	0.3	14.6
113	9.6	2.1	2.0	6.58	67.3	54	35	86	6	70	37	0.064	0.714	21.8	0.9	19.6
114	9.8	1.5	2.5	6.70	79.5	75	39	69	8	64	33	0.064	0.714	8.7	0.2	4.0
116	10.7	4.3	1.5	5.88	31.8	37	27	82	8	84	45	0.129	0.714	26.7	1.3	30.4
117	9.7	1.5	2.0	6.32	38.6	39	32	56	3	59	35	0.064	5.710	9.0	0.2	4.4
118	9.0	2.5	4.0	5.85	11.8	19	52	169	10	-	-	-	-	22.2	0.4	2.9
119	9.7	1.6	0.8	5.90	13.6	31	30	43	2	47	35	0.129	3.571	8.4	0.2	4.1
120	11.0	2.8	1.2	6.72	83.0	90	31	69	3	90	54	0.258	0.714	8.4	0.4	10.7
121	9.2	1.9	2.0	6.50	39.4	33	50	69	5	73	45	0.194	0.714	13.7	0.6	5.8
122	8.5	2.4	2.0	6.36	51.7	60	30	78	3	73	39	0.064	0.714	12.9	0.6	7.1
123	9.2	1.2	4.0	6.67	42.4	54	22	60	3	78	33	0.129	0.714	8.0	0.2	3.6
124	9.4	1.5	2.0	6.84	36.8	54	30	60	3	67	39	0.064	1.428	4.6	0.1	1.6
125	9.7	0.9	5.5	7.44	34.0	30	17	60	2	56	29	0.129	0.714	9.1	0.4	7.9
152	8.4	2.4	2.0	6.67	65.3	54	48	143	3	135	27	0.323	0.714	18.2	0.9	7.7
153	9.2	1.4	3.0	6.72	58.9	41	39	126	2	141	48	0.129	0.714	8.1	0.2	3.2
154	8.8	1.8	2.5	6.25	19.4	32	30	121	2	113	23	0.258	1.428	14.7	0.3	4.5
201	9.4	2.3	3.3	5.58	43.4	66	50	139	5	165	68	0.064	4.285	10.6	0.4	5.2
202	7.8	1.4	5.5	7.02	65.6	87	28	100	1	118	50	0.064	5.714	17.3	0.5	0.1

Table 2. (Con't.)

Lake	DO	CD	SD	PH	ALK	CA	MG	NA	K	CL	SO4	PO4	NO3	AL	MN	FE
203	10.4	2.2	3.5	5.79	0.0	19	16	69	1	81	47	0.064	3.571	10.3	0.3	1.8
204	10.3	4.1	2.0	5.14	0.0	27	20	65	1	73	70	0.064	1.428	18.9	0.7	6.7
205	9.2	2.2	3.5	5.89	16.5	33	20	73	2	78	54	0.129	7.143	14.4	0.3	2.1
206	9.3	1.7	2.8	6.18	21.0	27	16	52	2	47	41	0.064	1.428	8.6	0.5	4.3
207	9.8	2.4	4.0	5.14	1.1	15	18	65	1	73	47	0.064	3.571	11.1	0.8	2.9
209	9.4	1.1	2.2	6.94	85.8	100	26	73	1	73	35	0.258	2.857	3.2	0.3	3.0
211	10.1	1.8	2.5	5.97	22.6	33	19	69	4	64	33	0.064	5.714	8.2	0.1	4.7
213	8.8	2.2	2.0	6.02	20.7	28	25	69	1	64	39	0.064	18.571	16.1	0.2	4.7
215	10.2	2.1	3.8	5.76	13.9	25	30	113	3	123	52	0.064	6.428	17.3	0.3	0.1
217	9.4	2.0	4.2	6.00	24.7	28	22	73	1	78	35	0.194	0.714	6.2	1.5	2.6
219	10.2	1.9	2.5	6.18	18.7	38	29	91	5	92	41	0.258	0.714	11.4	0.6	4.3
220	9.4	1.6	4.8	5.98	16.7	26	21	82	3	87	33	0.194	1.428	9.0	0.1	1.2
221	10.2	1.5	3.0	6.48	42.3	28	30	91	4	99	35	0.194	0.714	8.3	0.4	6.1
222	11.3	2.3	2.8	5.74	5.3	16	16	73	3	73	35	0.064	0.714	6.9	0.3	3.7
224	11.3	3.7	0.5	5.55	5.6	26	19	65	2	70	35	0.064	0.714	10.6	0.5	11.6
225	10.5	1.4	9.5	6.42	6.0	25	17	78	2	76	33	0.194	4.285	6.1	0.5	1.5
226	10.6	1.1	0.8	6.85	36.4	33	19	78	3	78	46	0.064	0.714	3.2	0.1	5.6
228	10.7	2.9	2.2	5.69	7.6	20	23	95	2	98	52	0.064	0.714	18.9	0.5	2.9
229	11.1	3.4	1.0	6.22	52.5	50	28	73	3	76	50	0.064	0.714	15.6	0.6	17.0
230	10.4	4.3	1.5	5.30	12.9	36	26	82	2	90	62	0.064	2.857	23.3	1.9	9.4
232	9.1	2.1	4.0	6.08	14.4	28	23	78	2	81	39	0.064	1.428	11.3	0.4	3.1
251	10.1	1.6	0.8	7.22	317.7	275	77	69	3	56	50	0.064	0.714	6.2	0.4	0.1
252	9.1	1.	4.0	6.84	40.6	48	25	56	3	53	47	0.064	2.143	18.2	0.5	4.6
253	10.3	1.0	3.5	7.81	1221.4	700	406	91	3	101	62	0.194	0.714	5.3	0.1	1.9
254	10.0	2.0	2.8	6.22	23.4	51	23	65	2	65	87	0.258	0.714	14.4	0.4	4.4
255	10.2	1.7	2.9	6.83	104.7	150	35	65	2	59	58	0.194	1.428	13.3	0.4	8.5
256	9.3	2.3	1.0	7.12	174.3	190	25	221	9	211	116	0.129	1.243	41.1	1.0	35.7
257	9.7	1.6	1.8	7.47	470.7	419	154	234	17	256	127	0.194	5.714	13.3	0.4	6.2

DO = Dissolved oxygen (mgL^{-2})
CD = carbon dioxide (mgL^{-2})
MG = Magnesium
NA = Sodium
SUL = Sulphate
AL = Aluminium (μgL^{-2})
CA = Calcium
CL = Chloride
ALK = Alkalinity
K = Potassium
MN = Manganese (μgL^{-2})
FE = Iron (μgL^{-2})

Table 3. Statistical summary of morphometric characteristics, physical and chemical properties, and trace metal levels (from Scruton et al. 1987).

Parameter	n	Minimum	Maximum	Mean	Standard Error
Morphometric characteristics					
Lake area (ha)	109	21.0	2519.0	153.5	280.0
Watershed area (ha)	109	98.0	13706.0	950.3	1496.0
Watershed area to lake area ratio	109	2.50	36.20	8.35	5.41
Elevation (m)	109	24.4	708.7	248.2	141.7
Distance from the coast (km)	109	3.0	87.5	24.5	19.3
Physical Properties					
Colour (TCU)	108	5.0	225.0	48.5	41.3
Turbidity (JTU)	108	0.22	3.10	0.65	0.42
Secchi disc depth (m)	109	0.30	9.50	2.72	1.63
Hardness (μqL^{-2})	109	44.6	2591.6	231.2	395.5
Conductivity (μScm^{-2})	108	11.4	199.0	28.9	29.6
Total dissolved solids (mgL^{-2})	108	15.2	150.3	27.8	21.2
Water Chemistry					
pH	109	4.90	8.39	6.40	0.73
Alkalinity (μqL^{-2})	109	-6.4	1221.4	95.3	209.5
Calcium (μeqL-2)	109	13.0	1400.0	102.5	202.1
Magnesium (μeqL^{-2})	109	12.0	410.0	50.1	75.1
Sodium (μeqL^{-2})	109	33.0	278.0	82.3	46.2
Potassium (μeqL^{-2})	109	1.0	17.0	3.3	2.4
Bicarbonate (μeqL^{-2})	108	0.0	1740.0	99.5	230.7
Chloride (μeqL^{-2})	108	25.0	394.0	87.8	58.4
Sulphate (μeqL^{-2})	108	14.0	127.0	46.8	19.6
Orthophosphate (μeqL^{-2})	108	0.06	0.32	0.11	0.07
Nitrate (μeqL^{-2})	108	0.42	18.57	1.84	2.29
Anion sum (μeqL^{-2})	108	85.3	1953.4	244.4	289.6
Cation sum (μeqL^{-2})	108	75.3	1952.7	241.8	294.0
Excess calcium (μeqL^{-2})	108	11.7	1396.5	101.4	202.4
Excess magnesium (μeqL^{-2})	108	10.1	399.2	44.2	73.6
Excess sodium (μeqL^{-2})	108	13.5	103.5	32.7	15.7
Excess potassium (μeqL^{-2})	108	0.0	11.8	1.5	1.8
Excess sulphate (μeqL^{-2})	108	5.7	91.4	34.5	15.4

Table 3. (Con't.)

Parameter	n	Minimum	Maximum	Mean	Standard Error
Trace Metals					
Lead (μeqL^{-2})	109	0.00	0.20	0.00	0.10
Aluminium (μeqL^{-2})	109	0.00	47.80	12.4	9.00
Manganese (μeqL^{-2})	109	0.00	1.90	0.46	0.39
Cadmium (μeqL^{-2})	109	0.01	0.04	0.01	0.00
Iron (μeqL^{-2})	108	0.10	53.60	7.37	9.97
Copper (μeqL^{-2})	18	0.06	0.10	0.06	0.01
Nickel (μeqL^{-2})	18	0.03	0.03	0.03	0.00
Zinc (μeqL^{-2})	18	0.06	0.07	0.06	0.00

Table 4. Frequency of occurrence of crustacean zooplankton in 108 Newfoundland lakes.

Species	No. of Lakes in which the species occurs	%	No. of Lakes in which the species is dominant (*)	%
Diaptomus minutus	102	94	89	82
Cyclops scutifer	81	75	15	14
Daphnia catawba	79	72	49	45
Eubosmina longispina	78	72	52	48
Holopedium gibberum	65	60	22	20
Epischura lacustris	49	45	10	9
Bosmina longirostris	37	34	28	26
Diaphanosoma birgei	24	22	1	1
Diaptomus spatulocrenatus	19	17	13	12
Mesocyclops edax	12	12	5	5
Latona setifera	12	11	0	0
Leptodora kindtii	7	6	0	0
Chydorus spaericus	6	6	0	0
Acroperus harpae	6	6	0	0
Daphnia dubia	6	6	0	0
Chydorus brevilabris	5	5	2	2
Ceriodaphnia lacustris	5	5	1	1
Alona intermedia	4	4	0	0
Chydorus bicornutus	4	4	0	0
Disparalona acutirostris	4	4	0	0
Alona costata	3	3	0	0
Alona guttata	3	3	0	0
Alonella nana	3	3	0	0
Acantholeberis curvirostris	2	2	0	0
Alona affinis	2	2	0	0
Eurytemora affinis	2	2	0	0
Chydorus piger	2	2	0	0
Ophryoxus gracilis	2	2	0	0
Rhynchotalona falcata	2	2	0	0
Polyphemus pediculus	2	2	0	0
Sida crystallina	2	2	0	0
Tropocycips prasinus mexicanus	1	1	0	0
Macrocyclops albidus	1	1	0	0
Alonella exisa	1	1	0	0
Epischura nordenskioldi	1	1	0	0
Streblocerus serricaudatus	1	1	0	0

* - dominant defined as more than 10% of all crustaceans.

Table 5. Frequency of occurrence of rotifer zooplankton in 108 Newfoundland lakes.

Species	No. of Lakes in which the species occurs	%	No. of Lakes in which the species is dominant	%
Kellicottia longispina	98	90	63	58
Keratella taurocephala	96	88	73	67
Conochilus unicornis	82	75	29	27
Keratella cochlearis	76	70	33	30
Gastropus stylifer	63	58	22	20
Trichocerca cylindrica	45	41	9	8
Ploesoma lenticulare	37	34	8	7
Collotheca mutabilis	32	29	3	3
Polyarthra dolichoptera	31	28	13	12
Asplanchna priodonta	24	22	9	8
Polyarthra major	18	17	6	6
Lecane lunaris	15	14	0	0
Polyarthra euryptera	15	14	7	6
Polyarthra vulgaris	15	14	5	5
Keratella crassa	14	13	6	6
Kellicottia bostoniensis	14	13	2	2
Synchaeta pectinata	9	8	3	3
Trichocerca multicrinis	8	7	1	1
Keratella earlinae	7	6	5	5
Pleosoma hudsoni	7	6	1	1
Keratella serrulata	5	5	0	0
Synchaeta stylata	4	4	2	2
Lecane bulla	2	2	0	0
Polyarthra minor	2	2	0	0
Euchlanis triquetra	2	2	0	0
Trichocerca platessa	2	2	0	0
Lecane luna	1	1	0	0
Ploesoma truncatum	1	1	0	0
Trichocerca capucina	1	1	0	0
Keratella quadrata	1	1	0	0
Trichotria tetractis	1	1	0	0

* - dominant defined as more than 10% of all rotifers.

Table 6. Factor analysis of lake variables including correlation coefficients between five derived factors and the original 20 variables. Coefficients ≤ 0.250 have been replaced by 0. TDS = total dissolved solids; DA = drainage basin area; LSA = lake surface area.

Variable	1	2	3	4	5
Alkalinity	0.947	0	0	0	0
Bicarbonate	0.940	0	0	0	0
pH	0.904	0	0	0	0
Calcium	0.900	0.277	0	0	0
Magnesium	0.721	0.570	0	0	0
TDS	0.686	0.625	0	0	0
Chloride	0	0.938	0	0	0
Sodium	0.266	0.889	0	0	0
Sulphate	0	0.599	0.310	0	-0.450
Manganese	0	0.504	0.358	-0.407	0
Ratio (DA:LSA)	0	0	0.875	0	0
Colour	0	0.275	0.683	-0.390	0
Aluminium	-0.263	0.416	0.610	0	0
Depth	0	0	0	0.751	0
Turbidity	0	0.298	0	-0.715	0
Nitrate	-0.289	0	0	0.709	0
Iron	0	0	0.507	-0.589	0
DA	0	0	0	0	0.939
LSA	0	0	-0.298	0	0.906
Potassium	0.451	0.497	0	0	0
% variance explained by factors	24.16	18.17	11.28	9.85	5.39

Table 7. Spearman rank correlation coefficients between five derived factors plus three chemical variables and abundances of 25 species found in 108 lakes. Critical values are 0.257 (1% - double underlined) and 0.197 (5% - single underlined).

	Factor					Chemical Variable		
Species	**1**	**2**	**3**	**4**	**5**	**K**	**SO4**	**Mn**
Rotifera								
Asplanchna priodonta	0.273	0.093	-0.091	-0.075	-0.064	0.224	0.148	-0.039
Collotheca mutabilis	0.117	-0.079	-0.136	0.158	-0.040	-0.017	-0.131	-0.195
Conochilus unicornis	-0.090	-0.060	-0.101	0.196	0.118	-0.155	-0.305	-0.164
Gastropus stylifer	-0.167	-0.131	-0.152	0.058	-0.245	-0.216	-0.049	-0.151
Kellicottia bostoniensis	-0.023	0.158	0.251	-0.006	0.074	0.188	0.159	0.215
K. longispina	-0.040	0.005	-0.221	0.009	-0.243	-0.037	0.058	0.009
Keratella cochlearis	-0.069	0.173	-0.153	-0.081	-0.206	0.077	0.181	0.125
K. crassa	0.140	0.153	-0.060	-0.109	0.342	0.240	-0.131	0.017
K. taurocephala	-0.308	-0.077	-0.136	-0.026	0.120	-0.234	-0.182	0.054
Ploesoma lenticulare	0.252	0.161	0.019	-0.076	0.306	0.195	-0.086	0.016
Polyarthra dolichoptera	0.163	0.258	-0.003	-0.239	-0.124	0.305	0.271	0.178
P. euryptera	-0.122	0.132	-0.016	-0.140	0.105	0.135	-0.035	0.084
P. major	-0.007	-0.261	-0.106	-0.172	0.025	-0.136	-0.049	-0.059
P. vulgaris	0.020	0.178	0.073	0.254	-0.075	0.069	0.128	0.009
Trichocerca cylindrica	0.258	-0.011	-0.105	-0.113	0.193	0.143	-0.071	0.052
Cladocera								
Bosmina longirostris	0.173	0.114	-0.134	-0.394	-0.051	0.230	0.143	0.166
Daphnia catawba	0.032	-0.263	0.001	0.272	0.074	-0.138	-0.217	-0.238
Diaphanosoma birgei	0.168	-0.068	0.074	0.165	0.191	-0.055	-0.164	-0.175
Eubosmina longispina	-0.070	0.005	-0.081	0.425	-0.014	-0.125	-0.128	-0.292
Holopedium gibberum	-0.024	-0.182	-0.022	0.158	0.098	-0.101	-0.187	-0.014
Copepoda								
Cyclops scutifer	0.154	-0.019	-0.097	0.262	-0.160	0.077	0.078	-0.053
Diaptomus minutus	-0.249	0.123	-0.059	0.487	-0.104	-0.252	-0.045	-0.089
D. spatulocrenatus	0.108	-0.233	0.145	-0.172	-0.151	0.030	0.110	-0.042
Epischura lacustris	0.099	-0.060	0.106	0.349	0.216	-0.107	0.171	-0.222
Mesocyclops edax	-0.082	-0.008	-0.067	0.018	0.324	-0.097	-0.163	-0.105

Table 8. Spearman rank correlation coefficients between five derived factors plus three chemical variables and number of individuals and species within each of the three major taxonomical groups and in total. Critical values are 0.257 (1% - double underlined) and 0.197 (5% - single underlined).

	Factor					Chemical Variable		
	1	2	3	4	5	K	SO4	Mn
Individuals								
Rotifers	-0.021	0.167	-0.328	-0.011	-0.074	-0.034	-0.026	0.039
Cladocera	0.164	0.121	-0.175	0.226	0.001	0.082	-0.012	-0.064
Copepoda	-0.189	0.120	-0.066	0.498	-0.111	-0.210	-0.041	-0.097
Total	-0.056	0.203	-0.250	0.176	-0.093	-0.046	0.019	-0.001
Species								
Rotifera	0.108	0.109	-0.140	-0.005	0.121	0.131	-0.035	-0.036
Cladocera	0.114	-0.252	-0.064	0.286	0.097	-0.166	-0.197	-0.264
Copepoda	0.266	-0.264	0.088	0.231	0.159	0.009	-0.079	-0.311
Total	0.237	-0.100	-0.087	0.147	0.188	0.057	-0.126	-0.216

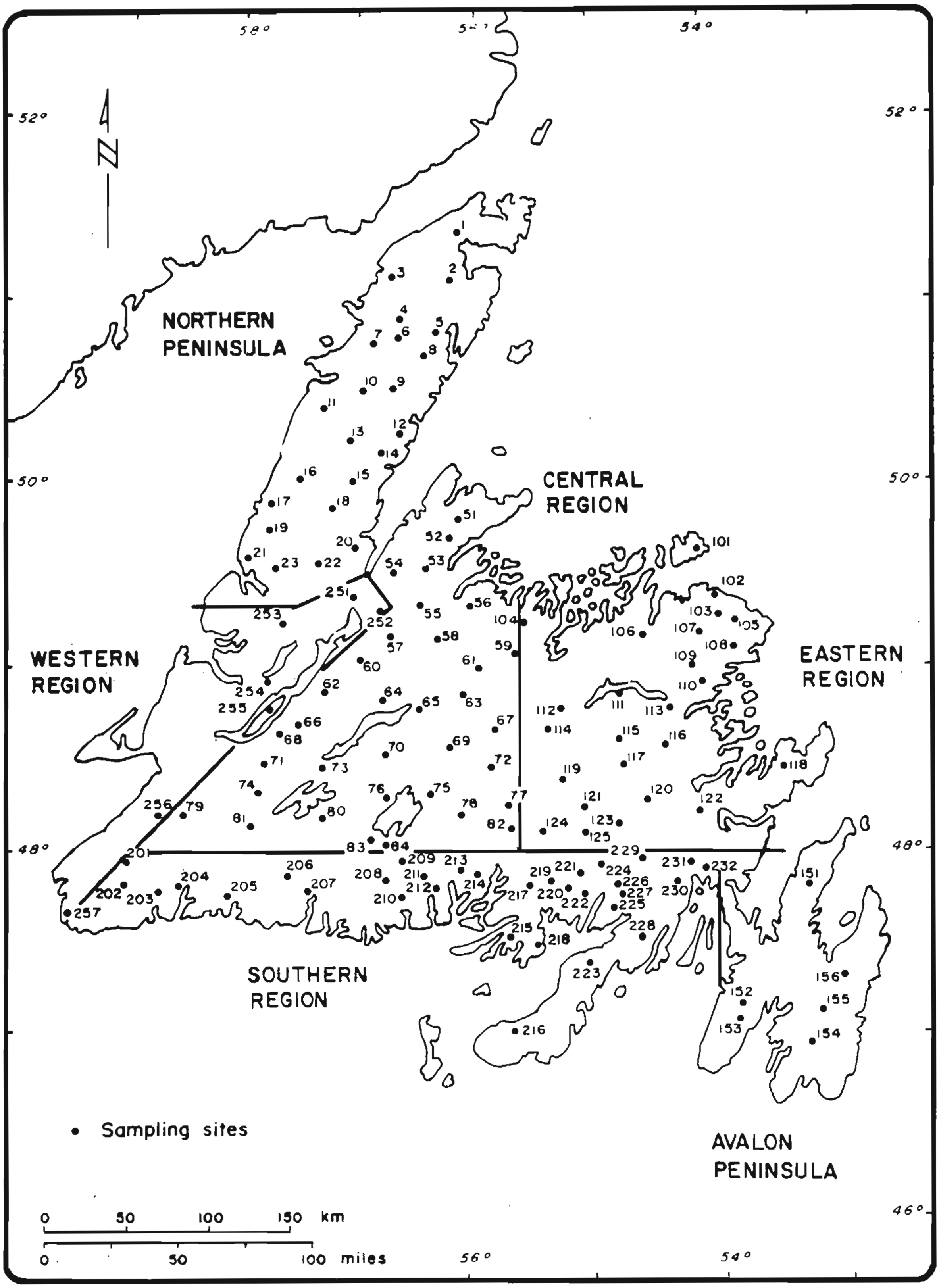


Fig. 1. Map of insular Newfoundland showing the study lakes and geographical regions (after Scruton 1983).

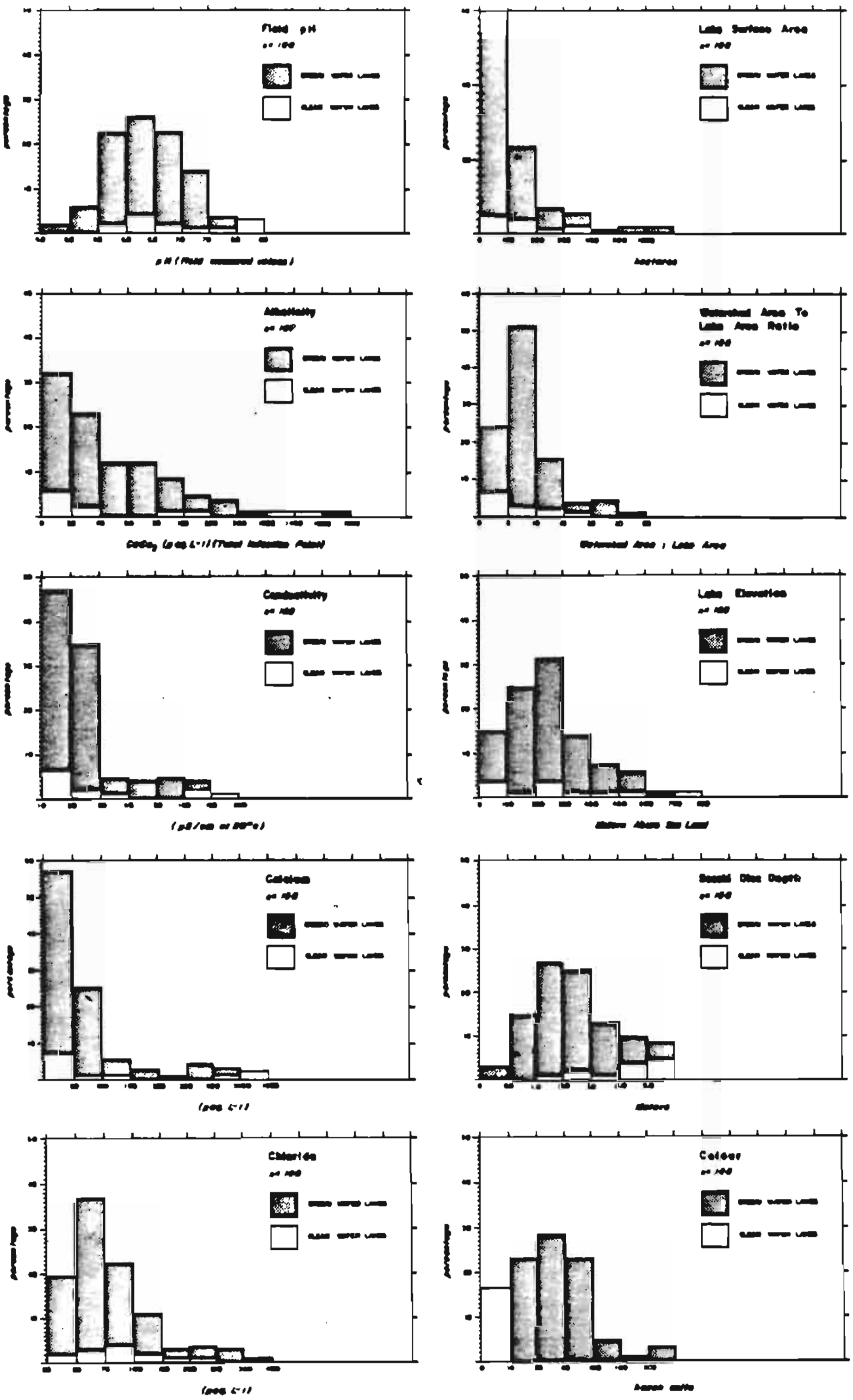


Fig. 2. Histograms for ten key morphometric, physical and chemical variables for the study lakes.

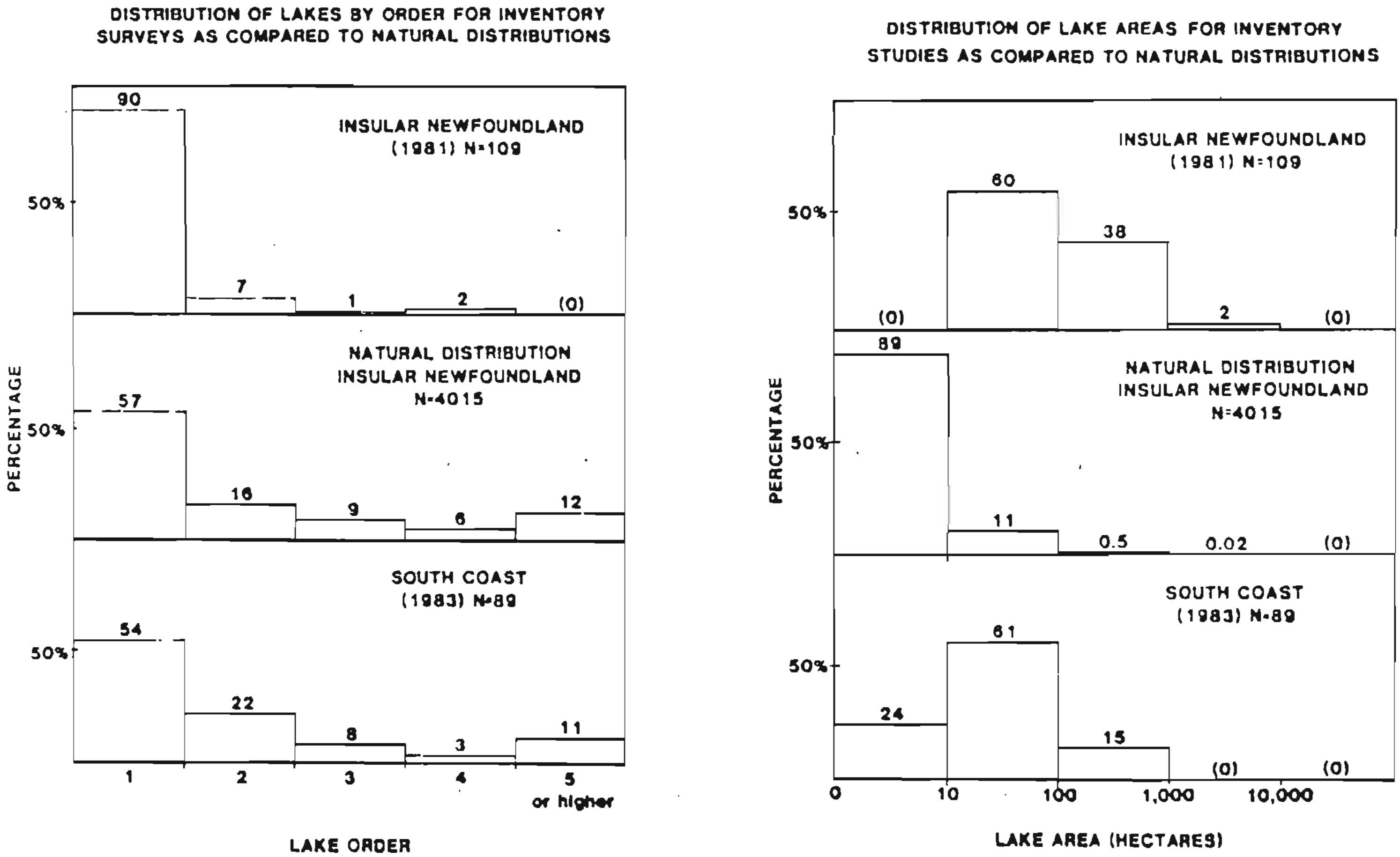


Fig. 3. Distribution of lake area classes and drainage orders for lakes included in this survey versus natural distributions.

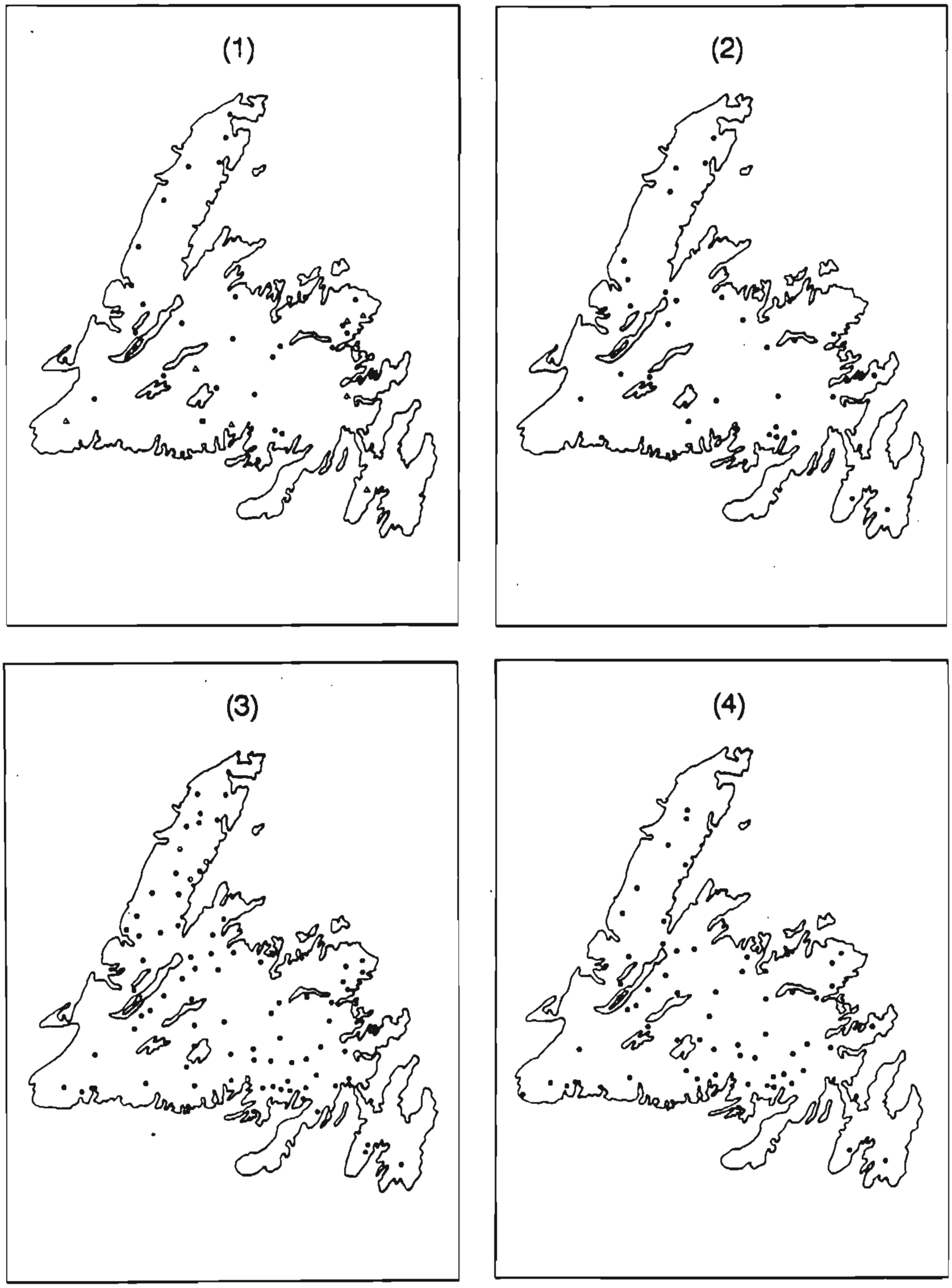


Fig. 4. Distributions of (1) Asplanchna priodonta (●), Bipalpus hudsoni (▵) and Euchlanis dilitata (□); (2) Collotheca mutabilis (●); (3) Conochilus unicornis (●); and (4) Gastropus stylifer (●).

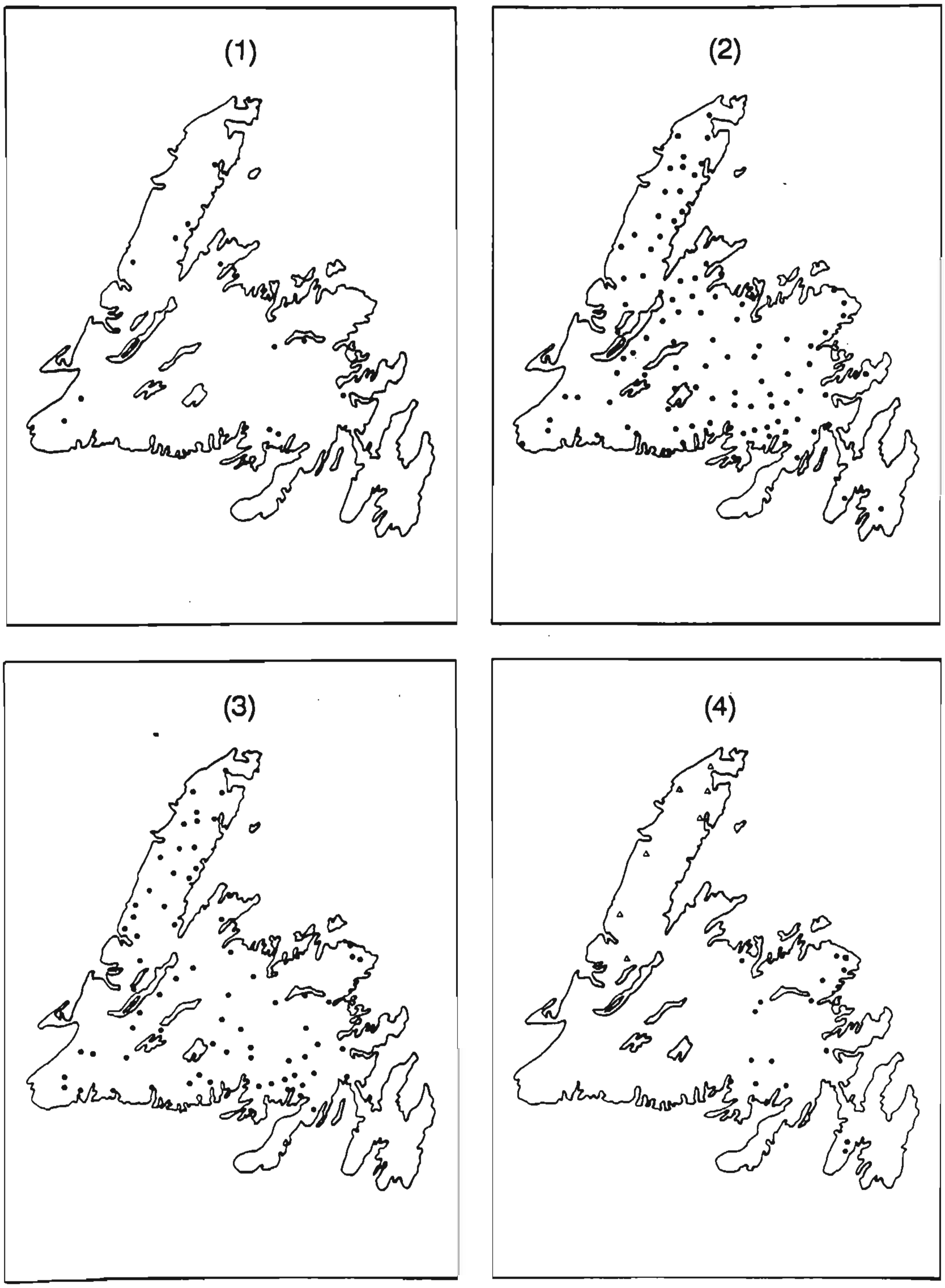


Fig. 5. Distributions of (1) *Kellicottia bostoniensis*; (2) *Kellicottia longispina*; (3) *Keratella cochlearis*; and (4) *Keratella crassa* (●); *Keratella earlinae* (▵) and *Keratella quadrata* (□).

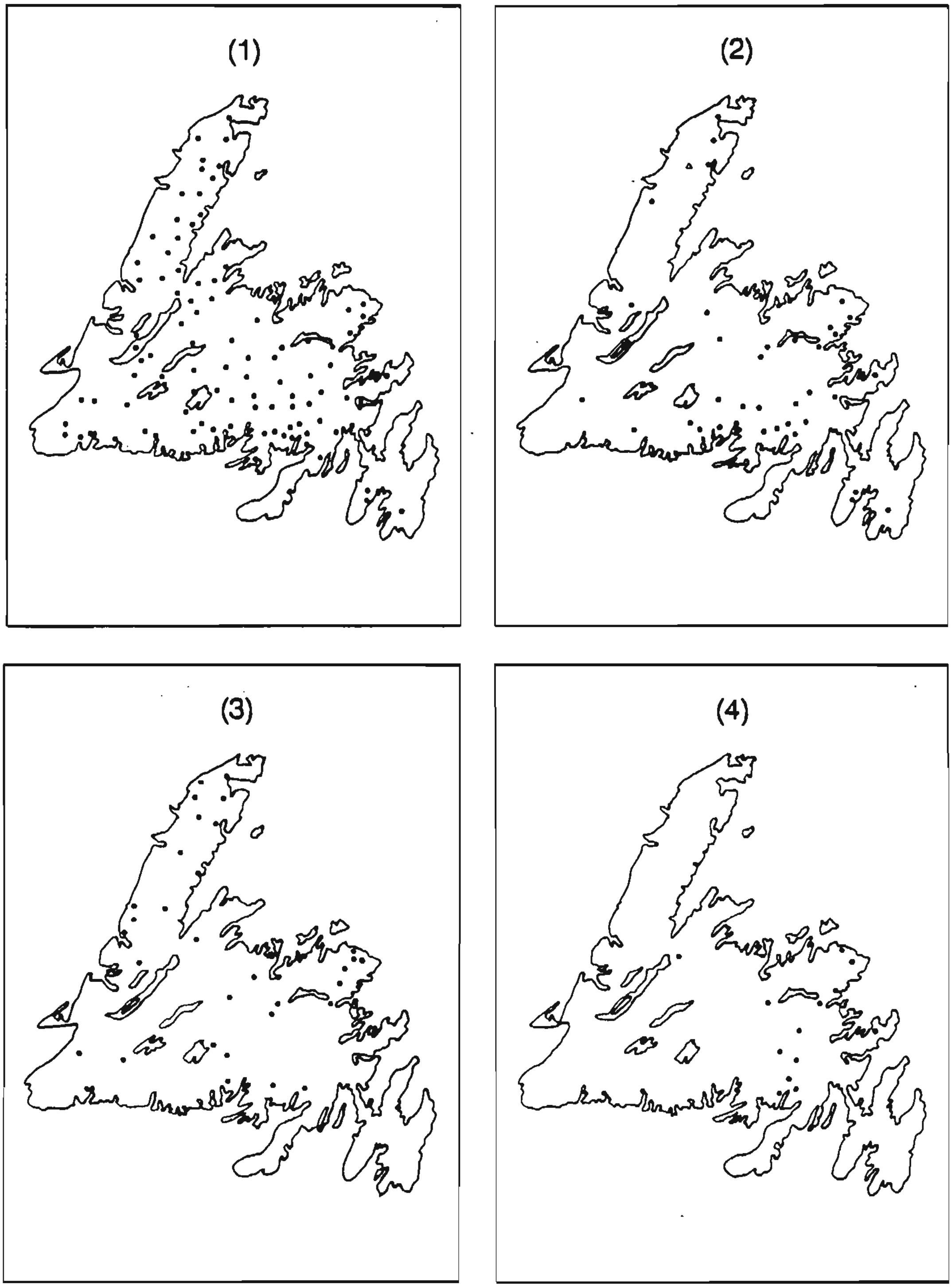


Fig. 6. Distributions of (1) Keratella taurocephala (●; (2) Ploesoma lenticulare (●) and Ploesoma truncatum (▲); (3) Polyarthra dolichoptera (●); and (4) Polyarthra euryptera (●).

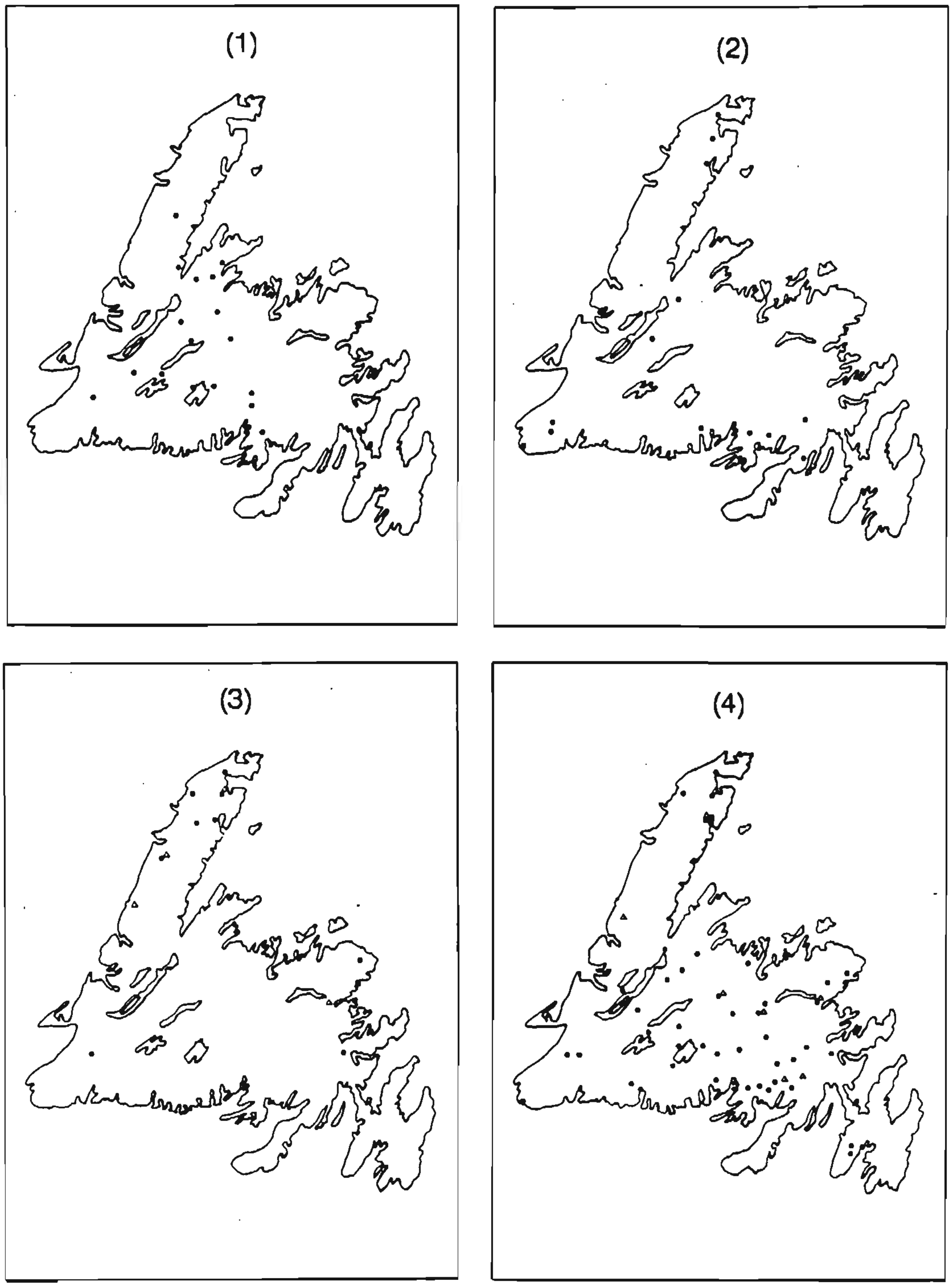


Fig. 7. Distributions of (1) Polyarthra major (•); (2) Polyarthra vulgaris (•); (3) Synchaeta pectinata (•) and Synchaeta stylata (▵); (4) Trichocerca cylindrica (•) and T. multicrinis (▵).

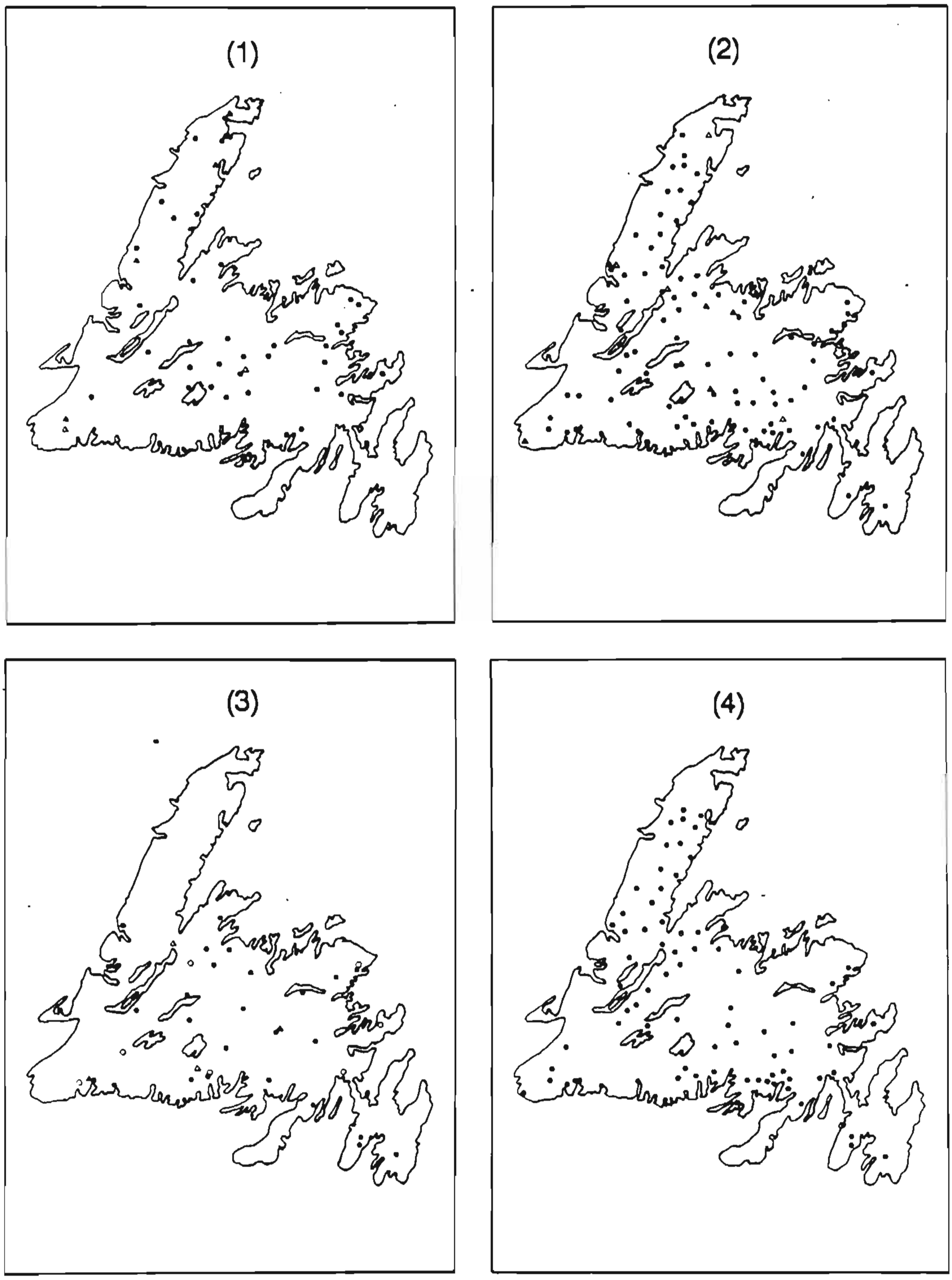


Fig. 8. Distributions of (1) Bosmina longirostris (●), Chydorus brevilabris (▲) and Chydorus sphaericus (△); (2) Daphnia catawba (●), Daphnia dubia (▲) and Ceriodaphnia lacustris (△); (3) Diaphanosoma birgei (●), Leptodora kindtii (○), Polyphemus pediculus (▲) and Sida crystallina (△); and (4) Eubosmina longispina (●).

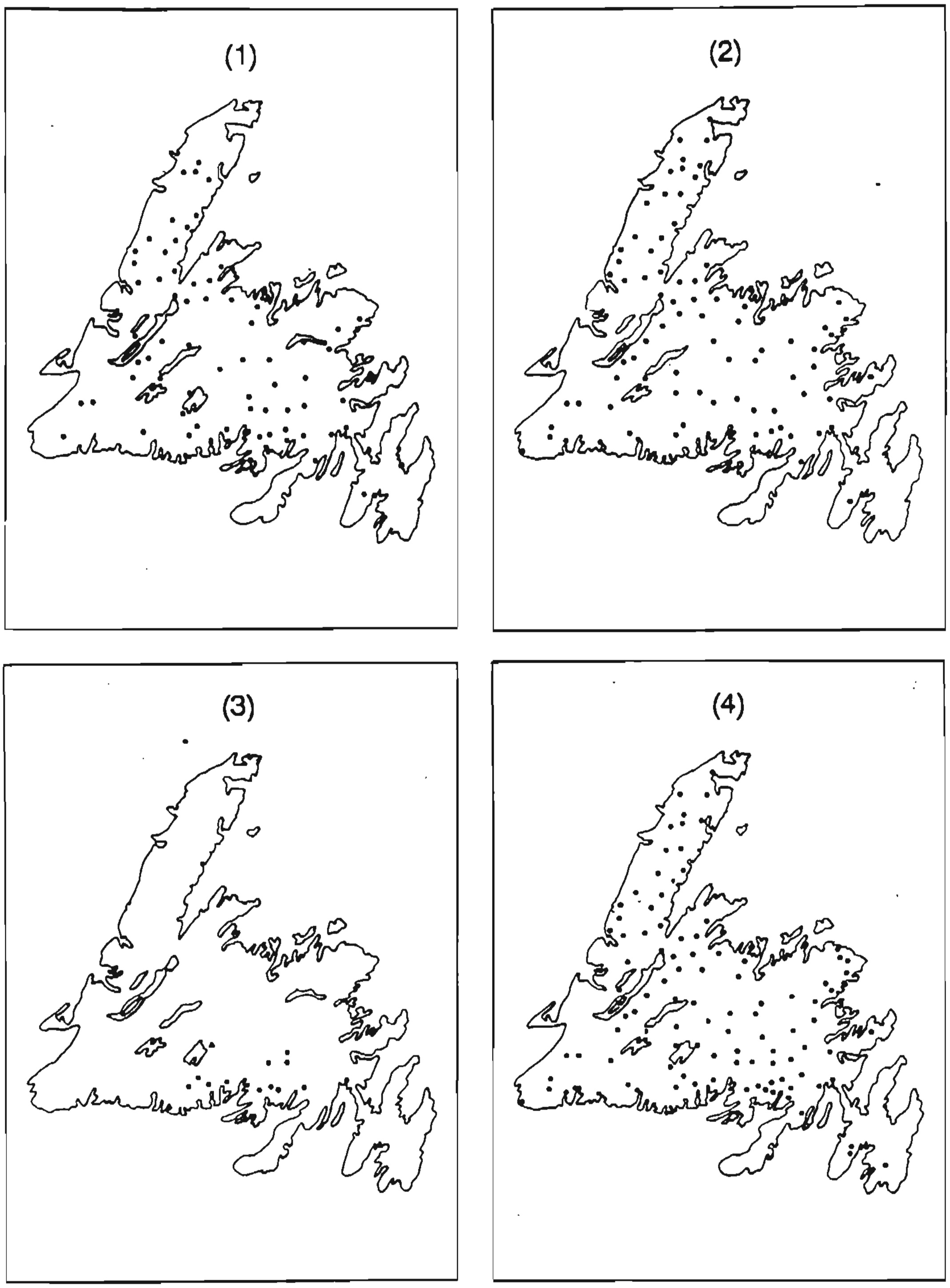


Fig. 9. Distributions of (1) Holopedium gibberum (●); (2) Cyclops scutifer (●); (3) Mesocyclops edax (●) and Tropocyclops prasinus mexicanus (▲); and (4) Diaptomus minutus (●).

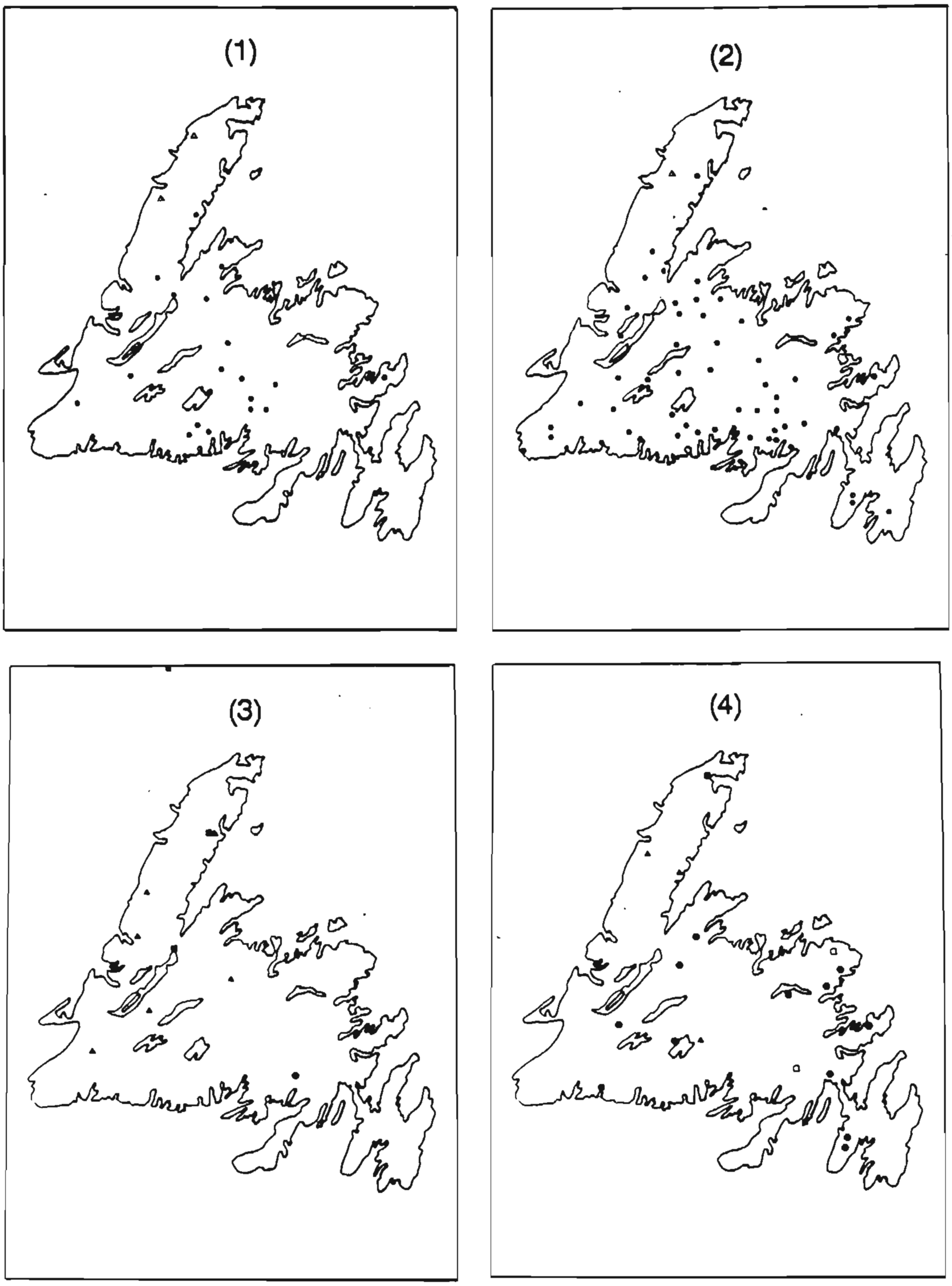


Fig. 10. Distributions of (1) Diaptomus spatulocrenatus (●) and Eurytemora affinis (▵); (2) Epischura lacustris (●) and Epischura nordenskioldi (▵) and (3) Acantholeberis curvirostris (■), Acroperus harpae (▴), and Streblocerus serricaudatus (●); (4) Alonella excisa (■), Alonella nana (▴), Latona setifera (●) and Rhynchotalona falcata (□).

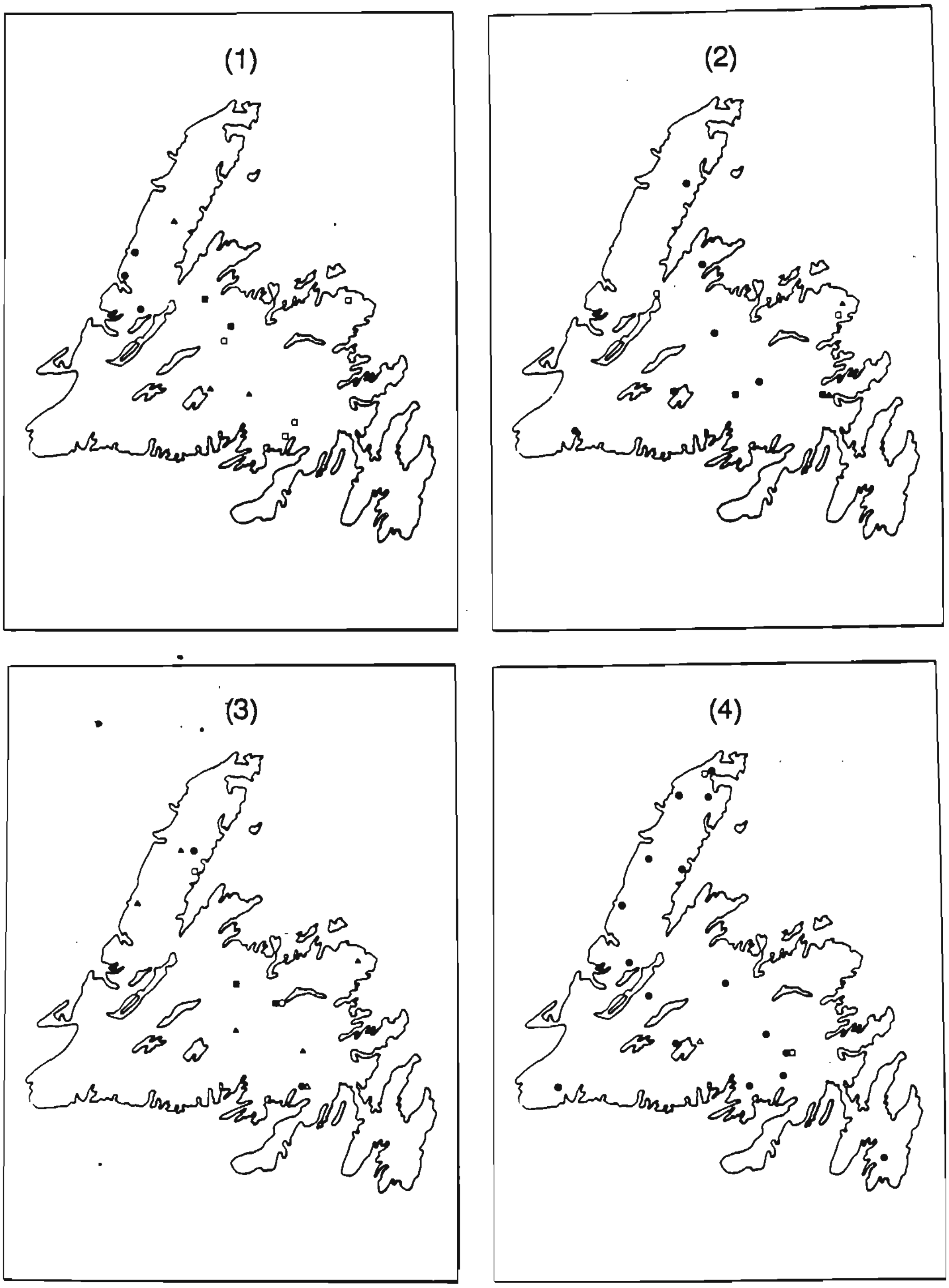


Fig. 11. Distributions of (1) Alona affinis (■), Alona guttata (●), Alona costata (▲) and Alona intermedia (□); (2) Chydorus bicornutus (■), Chydorus piger (▲), Disparalona acutirostris (●), Ophryoxus gracilis (□); (3) Euchlanis triquetra (■), Keratella serrulata (▲), and Polyarthra minor (●), Trichocerca capucina (▲), and Trichocerca tetractis (○); and (4) Lecane bulla (□), Lecane luna (▲), and Lecane lunaris (●).

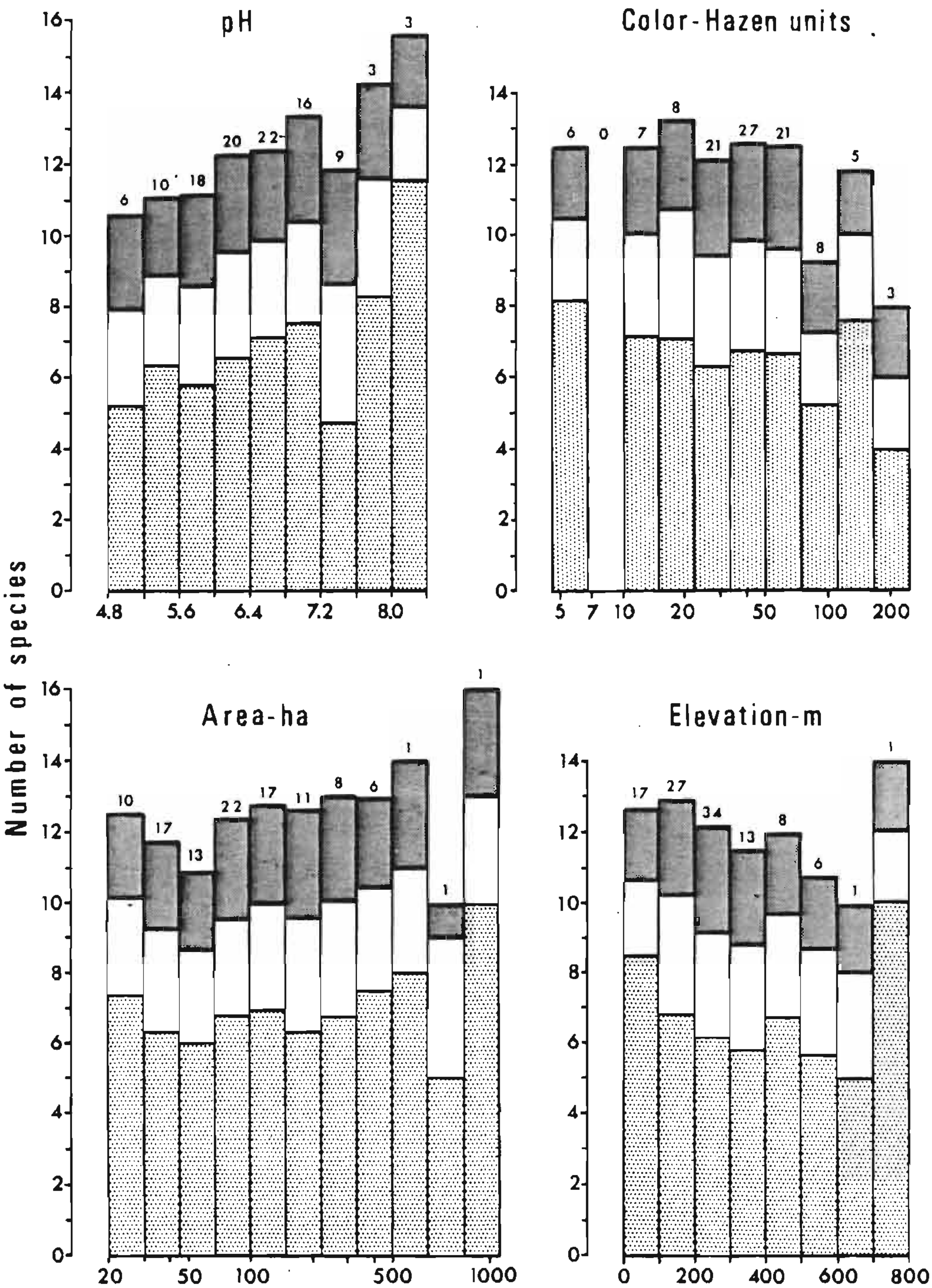


Fig. 12. The relationships between numbers of species and pH, colour (TCU), lake area (ha) and lake elevation (m above sea level). **Rotifera** = lower, dark stippling; **Cladocera** = middle, white; **Copepoda** = upper, light stippling.

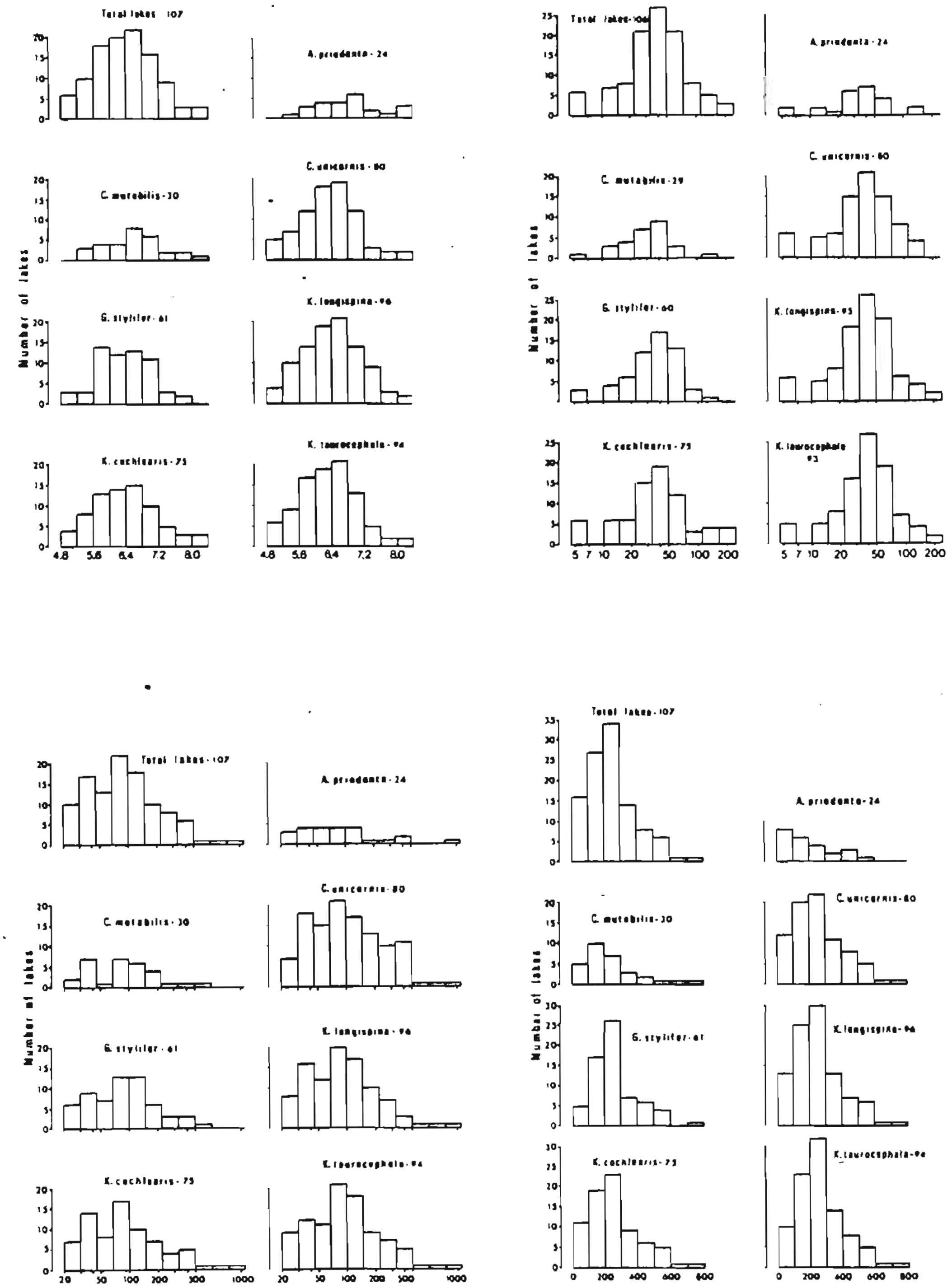


Fig. 13. Occurrences of seven rotifer species in relation to (1) lake pH, (2) water colour (TCU), and (3) lake area (ha) and (4) lake elevation (m above sea level). Total lakes refers to all rotifer species.

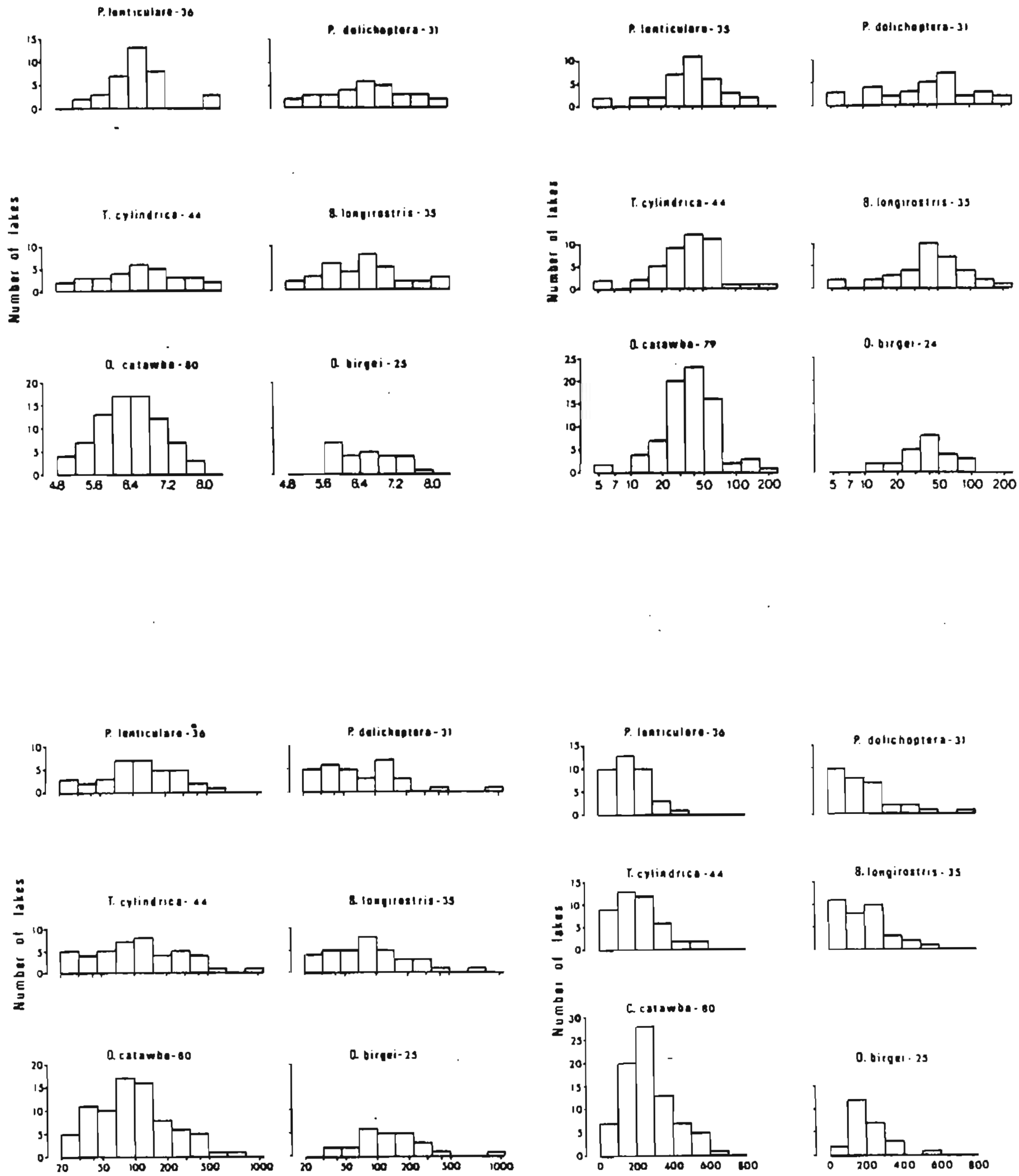


Fig. 14. Occurrences of three rotifer and three cladoceran species in relation to (1) lake pH, (2) water colour (TCU), and (3) lake area (ha) and (4) lake elevation (m above sea level).

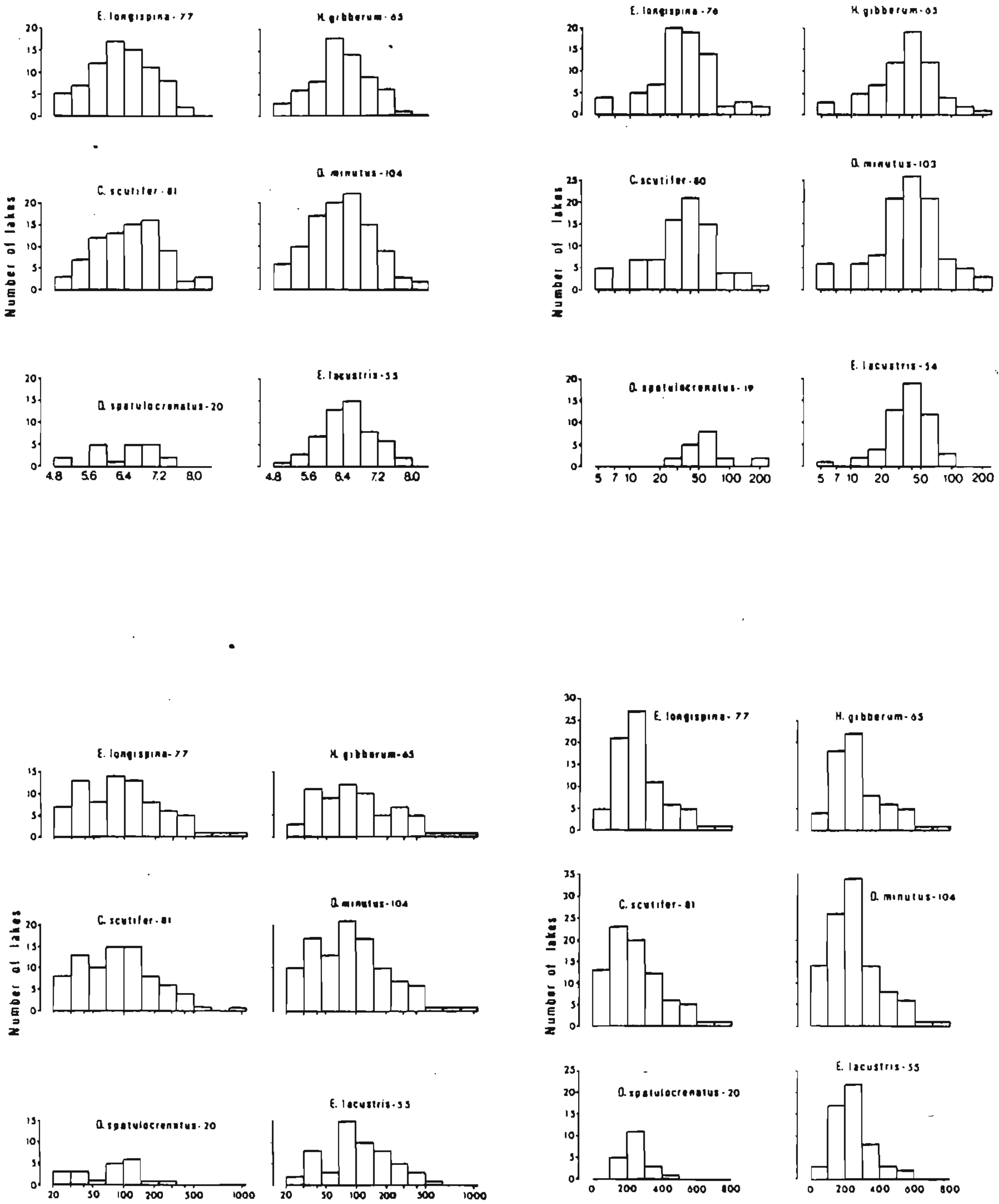
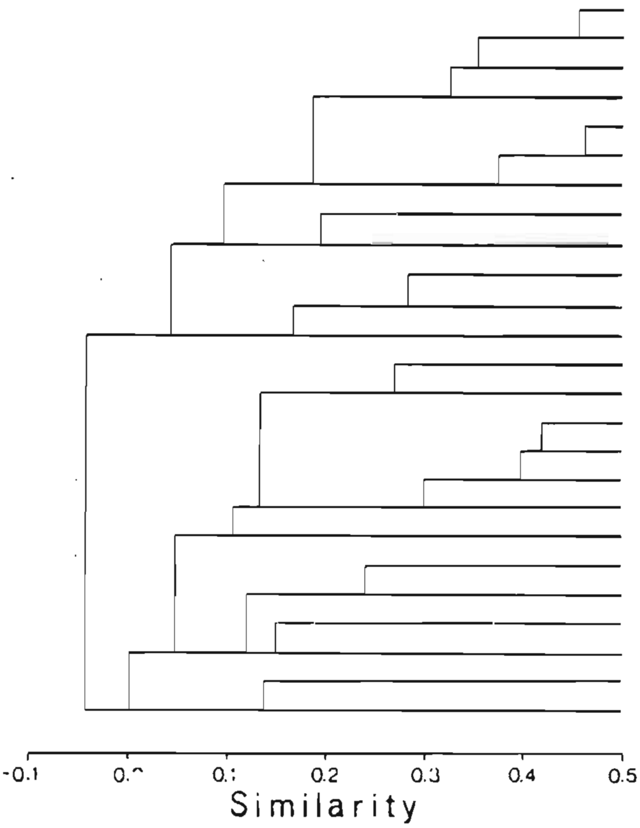


Fig. 15. Occurrences of two cladoceran and four copepod species in relation to (1) lake pH, (2) water colour (TCU), and (3) lake area (ha) and (4) lake elevation (m above sea level).



	r_s with factor				
	1	2	3	4	5
A. priodonta	0.27	0.09	-0.09	-0.08	-0.06
B. longirostris	0.17	0.11	-0.13	-0.39*	-0.05
P. dolichoptera	0.16	0.26	-0.01	-0.12	-0.12
K. cochlearis	-0.07	0.17	-0.15	-0.08	-0.21
K. crassa	0.14	0.15	-0.06	-0.11	0.34*
P. lenticulare	0.25	0.16	0.02	-0.08	0.31
T. cylindrica	0.26	-0.01	-0.11	-0.11	0.19
K. bostoniensis	-0.02	0.16	0.25	-0.01	0.07
C. scutifer	0.15	-0.02	-0.10	0.26	-0.16
C. mutabilis	0.12	-0.08	-0.14	0.16	-0.04
G. stylifer	-0.17	-0.13	-0.15	0.06	-0.25
P. euryptera	-0.12	0.13	-0.02	-0.14	0.11
C. unicornis	-0.09	-0.06	-0.10	0.20	0.12
H. gibberum	-0.02	-0.18	-0.02	0.16	0.10
O. catawba	0.03	-0.26	0.01	0.27	0.07
E. longispina	-0.07	0.01	-0.08	0.43*	-0.01
D. minutus	-0.25	0.12	-0.06	0.49*	-0.10
E. lacustris	0.10	0.06	0.11	0.35*	0.22
D. birgei	0.17	-0.07	0.07	0.17	0.19
K. longispina	-0.04	0.01	0.22	0.01	-0.24
K. taurocephala	-0.31	-0.08	-0.14	-0.03	0.12
P. major	-0.01	-0.27	-0.11	-0.17	0.03
D. spatulocrenatus	0.11	-0.23	0.15	-0.17	-0.15
P. vulgaris	0.02	0.18	0.07	0.25	-0.08
M. edax	-0.08	0.01	-0.07	0.02	0.32*

Fig. 16. Dendrogram of zooplankton species in Newfoundland based on UPGMA, and Spearman rank correlation coefficients between each species and each of the five derived factors. Cophenetic correlation coefficient of dendrogram was 0.66. Asterisk indicates $P \leq 0.01$.

APPENDIX 1

Species lists and enumerations (nos. m^{-2}) of zooplankton collected from the 108 study lakes

Appendix 1. Species lists and enumerations (nos. m^{-2}) of zooplankton collected from the 108 study lakes.

Lake No.	1	2	3	4	5	6	7	8
ROTIFERA								
Asplanchna priodonta	72	282	-	-	39	-	62	-
Collotheca mutabilis	-	4	-	-	12	-	4	-
Conochilis unicornis	111	98	6	98	82	60	110	-
Gastropus stylifer	-	-	-	90	-	28	-	-
Kellicottia bostoniensis	-	-	-	-	70	-	-	-
Kellicottia longispina	234	188	36	52	40	68	12	21
Keratella cochlearis	51	110	16	18	74	20	24	-
Keratella earlinae	173	348	26	-	32	-	-	-
Keratella serrulata	-	-	-	-	-	-	-	-
Keratella taurocephala	110	44	4	16	8	18	-	6
Lecane bulla	2	-	-	-	-	-	-	-
Lecane lunaris	2	8	1	-	-	-	-	-
Ploesoma lenticulare	-	-	-	-	-	4	-	-
Ploesoma truncatum	98	110	-	-	62	-	-	-
Polyarthra dolichoptera	50	72	28	22	10	-	-	-
Polyarthra major	-	-	-	-	-	-	-	-
Polyarthra minor	-	-	-	-	-	-	-	-
Polyarthra vulgaris	62	60	-	-	26	-	-	-
Synchaeta pectinata	391	160	52	-	110	4	-	-
Synchaeta stylata	-	222	-	-	-	-	-	-
Trichocerca capucina	-	-	-	-	-	-	-	-
Trichocerca cylindrica	51	182	49	-	28	-	-	-
Trichocerca multicrinis	-	48	-	-	1	-	-	-
CLADOCERA								
Acanthleberis curvirostris	-	-	-	-	-	-	-	1
Acroperus harpae	-	-	-	-	-	-	-	1
Alona affinis	-	-	-	-	-	-	-	-
Alona costata	-	-	-	-	-	-	-	-
Alona guttata	-	-	-	-	-	-	-	-
Alonella excisa	1	-	-	-	-	-	-	-
Alonella nana	-	-	-	-	-	-	-	-
Bosmina longirostris	101	126	6	-	-	-	-	-
Ceriodaphnia lacustris	-	24	-	-	-	-	-	-
Chydorus brevilabris	4	72	-	-	14	-	-	-
Daphnia catawba	-	-	1	42	-	18	36	22
Daphnia dubia	-	-	-	-	-	-	-	-
Diaphanosoma birgei	-	-	-	-	-	-	-	-
Disparalona acutirostris	-	-	-	-	-	-	-	1
Eubosmina longispina	-	-	-	21	22	38	12	3
Holopedium gibberum	-	-	-	3	-	26	59	1
Latona setifera	-	-	-	-	-	-	-	-
COPEPODA								
Cyclops scutifer F	-	30	-	10	2	22	18	-
Cyclops scutifer M	-	2	-	-	-	-	6	-
Cyclopoid copepodid I-V	42	160	13	-	28	32	36	21
Diaptomus minutus F	17	18	-	886	2	612	3	10
Diaptomus minutus M	8	12	-	20	-	88	-	4
Diaptomus spatulocrenatus F	-	-	-	-	-	-	-	-
Diaptomus spatulocrenatus M	-	-	-	-	-	-	-	-
Diaptomus copepodid I-V	34	68	4	-	20	92	26	26
Epischura lacustris F	-	-	-	-	-	-	-	2
Epischura lacustris M	-	-	-	-	-	-	-	1
Epischura nordenskioldi F	-	-	-	-	-	-	1	-
Eurytemora affinis F	-	-	-	-	-	-	-	-
Eurytemora affinis M	-	-	1	-	-	-	-	-
Eurytemora copepodid I-V	-	-	-	-	-	-	-	-
Nauplius	185	226	22	72	122	12	18	26
MISCELLANEOUS								
Chaoborus sp.	-	-	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-	-	-
Acari	2	-	-	-	-	-	-	1

Appendix 1 (Cont'd.)

Lake No.	9	10	11	12	13	14	15	16
ROTIFERA								
Asplanchna priodonta	-	-	417	-	-	-	-	-
Collotheca mutabilis	-	6	-	-	-	-	-	-
Conochilus unicornis	-	72	-	22	548	52	92	310
Gastropus stylifer	-	40	-	22	-	-	-	42
Kellicottia bostoniensis	-	-	-	-	-	6	8	-
Kellicottia longispina	30	36	-	16	62	20	18	34
Keratella cochlearis	118	18	320	81	82	46	-	12
Keratella earlinae	-	-	688	-	-	-	-	-
Keratella serrulata	-	1	-	-	-	-	-	-
Keratella taurocephala	92	40	-	112	90	32	22	20
Lecane bulla	-	-	-	-	-	-	-	-
Lecane lunaris	-	-	3	3	-	-	-	-
Ploesoma lenticulare	-	-	-	-	-	-	-	-
Ploesoma truncatum	-	-	22	-	-	-	-	-
Polyarthra dolichoptera	-	16	-	28	-	-	-	-
Polyarthra major	-	-	-	-	28	-	-	-
Polyarthra minor	4	-	-	-	-	-	-	-
Polyarhtra vulgaris	-	-	-	-	-	-	-	-
Synchaeta pectinata	-	-	84	-	-	-	-	-
Synchaeta stylata	-	-	1212	-	-	-	-	-
Trichocerca capucina	-	-	-	4	-	-	-	-
Trichocerca cylindrica	-	-	-	-	-	-	-	-
Trichocerca multicrinis	-	-	-	-	-	-	-	-
CLADOCERA								
Acantholeberis curvirostris	-	-	-	-	-	-	-	-
Acroperus harpae	-	-	-	-	-	-	-	1
Alona affinis	-	-	-	-	-	-	-	-
Alona costata	-	-	-	-	1	-	-	-
Alona guttata	-	-	-	-	-	-	-	-
Alonella excisa	-	-	-	-	-	-	-	-
Alonella nana	-	-	12	4	-	-	-	-
Bosmina longirostris	-	-	110	4	18	-	-	-
Ceriodaphnia lacustris	-	-	-	-	-	-	-	-
Chydorus brevilabris	-	-	-	-	-	-	-	-
Daphnia catawba	2	16	-	-	16	118	2	4
Daphnia dubia	-	-	-	-	-	-	-	-
Diaphanosoma birgei	-	-	-	-	-	-	-	-
Disparalona acutirostris	-	-	-	-	-	-	-	-
Eubosmina longispina	6	18	-	-	20	18	56	26
Holopeidum gibberum	-	-	-	8	8	22	4	6
Latona setifera	-	-	-	-	-	-	-	-
COPEPODA								
cyclops scutifer F	9	12	-	-	-	6	-	2
Cyclops sutifer M	-	-	-	-	-	-	-	-
Cyclops copepodid I-V	12	28	28	-	-	28	2	8
Diaptomus minutus F	12	16	-	33	144	48	23	67
Diaptomus minutus M	8	10	-	31	110	42	2	30
Diaptomus spatulocrenatus F	-	-	-	12	-	-	-	-
Diaptomus spatulocrenatus M	-	-	-	18	-	-	-	-
Diaptomus copepodid I-V	16	32	-	38	28	12	11	4
Epischura lacustris F	-	-	-	-	-	-	-	-
Epischura lacustris M	-	-	-	-	-	-	-	-
Epischura nordenskioldi	-	-	-	-	-	-	-	-
Eurytemora affinis F	-	-	2	-	-	-	-	-
Eurytemora affinis M	-	-	2	-	-	-	-	-
Eurytemora copepod.I-V	-	-	20	-	-	-	-	-
Nauplius	20	42	412	8	44	24	16	42
MISCELLANEOUS								
Chaoborus sp.	-	-	-	1	-	-	-	-
Oligochaeta	-	-	1	-	-	-	-	-
Acari	-	-	-	-	-	-	-	-

Appendix 1 (Cont'd.)

Lake No.	17	18	19	20	21	22	23	52
ROTIFERA								
Asplanchna priodonta	92	-	-	-	-	-	-	-
Collotheca mutabilis	-	-	20	-	-	-	16	-
Conochilus unicornis	-	-	33	32	53	110	92	62
Gastropus stylifer	-	-	68	24	-	-	-	-
Kellicottia bostoniensis	-	-	2	-	-	-	-	6
Kellicottia longispina	78	28	40	-	62	68	42	20
Keratella cochlearis	36	80	22	18	40	-	18	60
Keratella earlinae	-	-	2	-	-	-	-	-
Keratella serrulata	3	-	-	-	-	-	-	-
Keratella taurocephala	-	18	16	3	-	12	1	13
Lecane bulla	-	-	-	-	-	-	-	-
Lecane lunaris	10	-	-	-	-	-	-	-
Ploesoma lenticulare	-	-	-	-	-	-	-	-
Ploesoma truncatum	-	-	-	-	-	-	-	-
Polyarthra dolichoptera	82	92	12	-	30	-	-	-
Polyarthra major	-	-	-	30	-	-	-	18
Polyarthra minor	-	-	-	-	-	-	-	-
Polyarthra vulgaris	-	-	-	-	-	-	-	-
Synchaeta pectinata	-	-	-	-	.	-	.	.
Synchaeta stylata	144	-	-	-	-	-	-	-
Trichocerca capucina	-	-	-	-	-	-	-	-
Trichocerca cylindrica	-	-	-	-	-	-	-	-
Trichocerca multicrinis	-	-	1	-	-	-	-	-
CLADOCERA								
Acantholeberis curvirostris	-	-	-	-	-	-	-	-
Acroperus harpae	-	-	-	-	-	-	1	-
Alona affinis	-	-	-	-	-	-	-	-
Alona costata	-	-	-	-	-	-	-	-
Alona guttata	1	-	-	-	1	-	-	-
Alonella excisa	-	-	-	-	-	-	-	-
Alonella nana	-	-	-	-	-	-	-	-
Bosmina longirostris	142	-	-	-	-	-	-	8
Ceridaphnia lacustris	-	-	-	-	6	-	-	-
Chydorus brevilabris	-	-	3	-	-	-	-	-
Daphnia catawba	-	30	-	16	8	14	77	-
Daphnia dubia	-	-	-	-	18	-	-	-
Diaphanosoma birgei	-	-	-	-	1	-	-	1
Disparalona acutirostris	-	-	-	-	-	-	-	3
Eubosmina longispina	-	16	14	8	24	22	20	-
Holopedium gibberum	4	18	6	8	-	10	3	52
Latona setifera	-	-	-	-	-	-	-	-
COPEPODA								
Cyclops scutifer F	-	52	8	-	-	2	6	-
Cyclops scutifer M	-	3	-	-	-	-	2	2
Cyclopoid copepodid I-V	9	-	10	46	36	66	11	24
Diaptomus minutus F	12	24	12	52	118	31	21	10
Diaptomus minutus M	4	22	9	30	52	16	12	8
Diaptomus spatulocrenatus F	-	-	-	-	-	28	-	2
Diaptomus spatulocrenatus M	-	-	-	-	-	17	-	2
Diaptomus copepodid I-V	13	32	16	68	48	62	18	18
Epischura lacustris F	-	-	-	2	6	2	-	-
Epischura lacustris M	-	2	-	1	-	22	-	-
Epischura nordenskioldi	-	-	-	-	-	-	-	-
Eurytemora affinis F	-	-	-	-	-	-	-	-
Eurytemora affinis M	-	-	-	-	-	-	-	-
Eurytemora copepodid I-V	-	-	-	-	-	-	-	-
Nauplius	18	80	18	4	48	42	34	68
MISCELLANEOUS								
Chaoborus sp.	-	-	-	-	-	-	-	7
Oligochaeta	-	-	-	-	-	-	-	-
Acari	-	-	-	-	-	-	-	-

Appendix 1 (Cont'd.)

Lake No.	53	54	55	56	57	58	59	60
ROTIFERA								
Asplanchna priodonta	-	-	-	88	-	-	-	6
Collotheca mutabilis	-	-	-	1	-	-	10	6
Conochilus unicornis	26	-	16	12	26	16	-	12
Euchlanis triquetra	-	-	-	-	-	-	-	-
Gastropus stylifer	-	-	12	-	-	-	6	18
Kellicottia bostoniensis	-	-	-	-	-	-	-	-
Kellicottia longispina	16	10	25	42	14	9	12	31
Keratella cochlearis	24	-	-	3	16	-	14	17
Keratella serrulata	-	-	-	-	-	-	-	-
Keratella taurocephala	44	28	61	-	48	-	14	20
Lecane luna	-	-	-	-	-	-	-	-
Lecane lunaris	-	-	-	-	-	-	-	-
Ploesoma hudsoni	-	-	-	-	-	-	-	-
Ploesoma truncatum	-	-	-	-	-	2	-	-
Polyarthra dolichoptera	-	6	-	-	-	-	7	-
Polyarthra major	8	22	-	-	-	6	-	32
Polyarthra vulgaris	-	-	-	-	-	-	-	-
Trichocerca cylindrica	-	-	2	-	3	-	-	3
Trichocerca multicrinis	-	-	-	-	-	-	-	-
Trichocerca platessa	-	-	-	-	-	-	-	-
CLADOCERA								
Acroperus harpae	-	-	-	-	-	-	-	-
Alona affinis	-	-	1	-	-	-	-	-
Alona costata	-	-	-	-	-	-	-	-
Alona intermedia	-	-	-	-	-	-	-	-
Alonella nana	-	-	-	-	-	-	-	-
Bosmina longirostris	-	3	-	-	-	-	-	-
Chydorus bicornutus	-	-	-	-	-	-	-	-
Chydorus brevilabris	-	-	-	-	-	-	-	-
Chydorus sphaericus	-	-	-	-	-	-	-	-
Daphnia catawba	8	15	10	24	15	-	11	6
Daphnia dubia	-	-	-	-	-	2	1	-
Diaphanosoma birgei	-	-	7	2	-	1	2	-
Disparalona acutirostris	-	-	-	-	-	-	-	-
Eubosmina longispina	16	7	27	12	12	-	10	28
Holopedium gibberum	3	7	11	7	-	-	2	-
Latona setifera	7	-	-	-	1	-	-	-
Leptodora kindti	-	-	-	-	1	-	-	-
COPEPODA								
Cyclops scutifer F	-	2	-	12	3	-	-	-
Cyclops scutifer M	-	-	-	1	-	1	-	-
Cyclopoid copepodid I-V	61	6	30	21	42	-	6	1
Diaptomus minutus F	-	16	26	31	92	8	48	19
Diaptomus minutus M	2	2	12	20	12	7	22	1
Diaptomus spatulocrenatus F	-	-	2	-	-	-	-	-
Diaptomus spatulocrenatus M	-	-	4	-	-	-	-	-
Diaptomus copepodid I-V	-	18	22	12	110	6	16	8
Epischura lacustris F	6	-	8	2	3	2	1	-
Epischura lacustris M	3	-	1	2	6	-	2	-
Epischura copepodid I-V	-	-	-	-	4	-	-	-
Nauplius	34	3	58	51	68	13	51	3
Tropocyclops prasinus mexicanus F	-	-	-	-	-	-	-	-
Tropocyclops prasinus mexicanus M	-	-	-	-	-	-	-	-
MISCELLANEOUS								
Oligocheata	-	-	-	-	-	-	-	-
Acari	-	-	-	1	-	-	-	-

Appendix 1 (Cont'd.)

Lake No.	61a	61b	62	63	64	66	67	68
ROTIFERA								
Asplanchna priodonta	-	-	-	127	-	-	-	-
Collotheca mutabilis	12	12	-	-	-	-	-	-
Conochilus unicornis	21	27	29	-	182	98	-	22
Euchlanis triquetra	-	2	-	-	-	-	-	-
Gastropus stylifer	16	31	62	490	27	16	-	10
Kellicottia bostoniensis	-	110	-	-	-	-	-	-
Kellicottia longispina	30	28	18	310	42	45	40	44
Keratella cochlearis	8	-	4	110	-	-	-	16
Keratella serrulata	-	-	-	-	-	-	-	-
Keratella taurocephala	11	298	-	282	26	46	2022	52
Lecane luna	-	-	-	-	-	-	-	-
Lecane lunaris	-	3	3	-	-	-	-	-
Ploesoma hudsoni	-	-	-	-	-	-	-	-
Ploesoma truncatum	1	-	-	26	-	-	-	-
Polyarthra dolichoptera	-	-	-	51	-	-	-	-
Polyarthra major	37	-	-	34	42	-	-	-
Polyarthra vulgaris	-	16	11	-	-	-	-	-
Trichocerca cylindrica	6	-	-	122	-	3	91	-
Trichocerca multicrinis	-	-	-	18	-	-	-	-
Trichocerca platessa	-	-	-	-	-	-	-	-
CLADOCERA								
Acroperus harpae	1	-	-	-	-	2	-	-
Alona affinis	-	2	-	-	-	-	-	-
Alona costata	-	-	-	-	-	-	-	-
Alona intermedia	-	-	-	1	-	-	-	-
Alonella nana	-	-	-	-	-	-	-	-
Bosmina longirostris	23	-	-	37	2	-	19	12
Chydorus bicornutus	-	-	-	-	-	-	-	-
Chydorus brevilabris	-	6	-	-	-	-	-	-
Chydorus sphaericus	-	-	-	-	-	-	-	-
Daphnia catawba	-	221	-	-	27	19	-	16
Daphnia dubia	-	-	-	-	-	-	-	-
Diaphanosoma birgei	-	-	-	-	2	-	-	2
Disparalona acutirostris	-	1	-	-	-	-	-	-
Eubosmina longispina	-	44	25	-	-	11	6	16
Holopedium gibberum	-	8	13	-	9	5	-	31
Latona setifera	-	-	-	-	-	-	-	-
Leptodora kindti	-	-	-	-	-	-	-	-
COPEPODA								
Cyclops scutifer F	6	-	2	-	-	2	8	28
Cyclops scutifer M	-	-	-	-	-	-	4	12
Cyclopoid cipepodid I-V	16	32	16	11	-	12	13	14
Diaptomus minutus F	38	147	42	-	296	66	6	290
Diaptomus minutus M	2	62	28	-	42	43	2	252
Diaptomus spatulocrenatus F	-	40	-	-	-	-	-	-
Diaptomus spatulocrenatus M	-	32	-	3	-	-	-	-
Diaptomus copepodid I-V	4	49	13	-	99	20	14	323
Epischura lacustris F	-	-	-	-	4	2	-	-
Epischura lacustris M	-	3	-	-	5	4	-	-
Epischura copepodid I-V	-	-	-	-	-	2	-	-
Nauplius	27	118	12	28	16	57	27	192
Tropocyclops prasinus mexicanus F	-	-	-	-	-	-	-	-
Tropocyclops prasinus mexicanus M	-	-	-	-	-	-	-	-
MISCELLA NEOUS								
Oligochaeta	-	1	-	-	-	-	-	-
Acari	-	-	-	-	-	1	-	-

Appendix 1 (Cont'd.)

Lake No.	69	70	71	72	73	75	76	77
ROTIFERA								
Asplanchna priodonta	-	-	-	-	25	60	-	12
Collotheca mutabilis	-	-	3	-	17	-	-	-
Conochilus unicornis	40	121	32	-	-	-	15	32
Euchlanis triqetra	-	-	-	-	-	-	-	-
Gastropus stylifer	28	-	-	-	28	512	30	48
Kellicottia bostoniensis	-	-	-	-	-	-	-	-
Kellicottia longispina	27	81	18	-	16	996	41	87
Keratella cochlearis	32	-	12	13	15	610	-	57
Keratella serrulata	-	-	-	3	-	-	-	-
Keratella taurocephala	80	78	28	18	52	1218	1080	110
Lecane luna	-	-	-	-	-	2	-	-
Lecane lunaris	-	-	-	-	-	-	2	-
Ploesoma hudsoni	-	1	-	-	-	-	-	-
Ploesoma truncatum	-	-	-	-	-	-	-	-
Polyarthra dolichoptera	-	-	-	-	-	40	-	-
Polyarthra major	-	-	9	-	13	32	16	20
Polyarthra vulgaris	-	-	-	-	-	-	-	-
Trichocerca cylindrica	-	5	-	-	20	210	18	8
Trichocerca multicrinis	-	-	-	-	-	-	-	-
Trichocerca platessa	-	-	-	-	2	-	-	-
CLADOCERA								
Acroperus harpae	-	-	-	-	-	-	-	-
Alona affinis	-	-	-	-	-	-	-	-
Alona costata	-	-	-	-	-	2	-	6
Alona intermedia	-	-	-	-	-	-	-	-
Alonella nana	-	-	-	-	-	1	-	-
Bosmina longirostris	4	21	-	5	-	12	21	22
Chydorus bicornutus	-	-	-	-	-	-	2	2
Chydorus brevilabris	-	-	-	-	-	-	-	-
Chydorus sphaericus	-	-	-	1	-	-	-	-
Daphnia catawba	71	41	29	-	17	-	-	3
Daphnia dubia	-	8	-	-	-	-	-	-
Diaphanosoma birgei	-	2	-	-	-	-	-	-
Disparalona acutirostris	-	-	-	-	-	-	-	-
Eubosmina longispina	-	38	31	2	9	-	-	8
Holopedium gibberum	14	-	18	-	4	-	6	6
Latona setifera	-	-	1	-	-	-	1	-
Leptodora kindti	-	-	-	-	-	-	-	-
COPEPODA								
Cyclops scutifer F	-	2	-	-	4	-	12	4
Cyclops scutifer M	-	-	-	-	-	1	7	-
Cyclopoid copepodid I-V	-	4	16	-	12	21	17	17
Diaptomus minutus F	27	18	54	21	32	8	68	72
Diaptomus minutus M	21	12	34	18	18	4	59	87
Diaptomus spatulocrenatus F	12	-	3	9	-	-	-	10
Diaptomus spatulocrenatus M	7	-	-	7	-	2	-	18
Diaptomus copepodid I-V	32	13	110	-	20	4	19	20
Epischura lacustris F	4	4	6	-	2	-	-	-
Epischura lacustris M	2	3	2	-	-	-	-	-
Epischura copepodid I-V	4	-	-	-	-	-	-	-
Nauplius	3	32	180	19	70	47	18	29
Tropocyclops prasinus mexicanus F	-	-	-	-	-	13	-	-
Tropocyclops prasinus mexicanus M	-	-	-	-	-	9	-	-
MISCELLANEOUS								
Oligocheeta	-	-	-	-	-	-	-	-
Acari	-	-	-	-	-	-	-	-

Appendix 1 (Cont'd.)

Lake No.	78	79	81	82	83	102	103	104
ROTIFERA								
Asplanchna priodonta	-	2732	-	-	-	-	3929	-
Collotheca mutabilis	1242	5	-	-	-	-	-	-
Conochilus unicornis	1666	67	-	685	1925	-	-	226
Euchlanis triquetra	-	-	-	-	-	-	-	-
Gastropus stylifer	575	123	-	301	-	-	1589	135
Kellicottia bostoniensis	-	-	-	-	-	-	-	-
Kellicottia longispina	3181	107	223	562	425	280	-	569
Keratella cochlearis	621	655	140	274	-	160	31607	-
Keratella crassa	-	-	-	-	-	-	37643	141
Keratella quadrata	-	-	-	-	-	-	-	-
Keratella serrulata	-	-	-	-	-	-	-	-
Keratella taurocephala	6242	794	591	1479	800	-	-	-
Lecane lunaris	-	-	-	-	-	-	-	-
Ploesoma hudsoni	-	-	-	-	-	-	-	-
Ploesoma truncatum	90	65	-	68	-	-	1464	-
Polyarthra dolichoptera	242	-	102	-	-	240	3750	-
Polyarthra euryptera	-	-	-	-	-	360	-	-
Polyarthra major	-	14	-	425	-	-	-	-
Synchaeta pectinata	-	16	-	-	-	-	-	-
Synchaeta stylata	-	-	-	-	-	-	-	-
Trichocerca cylindrica	333	18	-	-	50	-	-	104
Trichocerca multicrinis	-	-	-	-	-	-	-	-
Trichotria tetractis	-	-	-	-	-	-	-	-
CLADOCERA								
Acroperus harpae	-	3	-	-	-	-	-	-
Alona intermedia	-	-	-	-	-	-	71	-
Bosmina longirostris	439	34	-	-	-	-	33786	-
Ceriodahnia lacustris	-	-	-	-	-	-	-	-
Chydorus bicornutus	-	-	-	-	-	-	-	-
Chydorus piger	-	-	-	-	-	-	-	-
Daphnia catawba	90	4	651	96	550	-	-	54
Daphnia dubia	45	-	-	-	-	-	-	-
Diaphanosoma birgei	15	-	-	-	-	-	-	-
Eubosmina longispina	-	-	237	41	475	-	-	377
Holopedium gibberum	-	114	-	82	225	-	-	10
Latona setifera	-	-	-	-	-	-	-	-
Leptodora kindtil	-	-	9	-	-	-	-	-
Ophryoxus gracilis	-	-	-	-	-	-	-	-
Rhynchotalona falcata	-	-	-	-	-	-	36	-
COPEPODA								
Cyclops scutifer F	-	4	19	-	-	-	-	13
Cyclops scutifer M	30	-	-	-	-	-	-	-
Cyclopoid copepodid I-V	90	16	84	-	-	-	1018	91
Diaptomus minutus F	287	70	3209	247	450	-	321	162
Diaptomus minutus M	181	27	195	219	400	-	286	40
Diaptomus spatulocrenatus F	-	-	-	288	-	-	-	-
Diaptomus spatulocrenatus M	-	-	-	219	-	-	-	-
Diaptomus copepodid I-V	590	65	1405	164	300	40	3786	189
Epischura lacustris F	-	3	37	55	-	-	-	-
Epischura lacustris M	-	-	19	-	75	-	-	-
Epischura copepodid I-V	-	-	74	-	175	-	-	-
Mesocyclops edax F	-	-	-	-	-	-	-	-
Nauplius	3060	140	1000	274	500	-	8607	387
MISCELLANEOUS								
Chaoborus sp.	-	15	-	-	-	-	-	-
Oligochaeta	-	3	-	-	-	-	-	-
Acari	-	-	14	-	-	-	-	-

Appendix 1 (Cont'd.)

Lake No.	105	107	108	109	110	111	112	113
ROTIFERA								
Asplanchna priodonta	-	-	-	106	76	-	467	470
Collotheca mutabilis	-	-	-	-	11	27	600	-
Conochilus unicornis	525	320	11067	258	152	201	1933	591
Euchlanis triquetra	-	-	-	-	-	-	133	-
Gastropus stylifer	-	200	-	-	53	107	2133	621
Kellicottia bostoniensis	-	-	-	-	-	74	133	-
Kellicottia longispina	23125	-	1891	-	49	121	2067	455
Keratella cochlearis	20250	-	-	-	34	101	1067	273
Keratella crassa	-	-	133	384	-	-	133	864
Keratella quadrata	25	-	-	-	-	-	-	-
Keratella serrulata	100	-	-	-	-	-	-	-
Keratella taurocephala	7575	360	667	-	121	228	1067	621
Lecane lunaris	-	-	-	-	-	-	-	-
Ploesoma hudsoni	-	-	12	15	-	-	-	-
Ploesoma truncatum	-	-	73	515	8	148	933	182
Polyarthra dolichoptera	800	280	-	81	-	-	600	106
Polyarthra euryptera	2250	-	-	-	57	-	267	91
Polyarthra major	-	-	-	-	-	-	-	-
Synchaeta pectinata	450	-	-	-	-	-	-	-
Synchaeta stylata	-	-	-	-	-	-	-	61
Trichocerca cylindrica	-	-	182	1076	-	-	3800	576
Trichocerca multicrinis	-	-	-	-	-	-	-	30
Trichotria tetractis	-	-	-	-	-	-	67	-
CLADOCERA								
Acroperus harpae	-	-	-	-	-	-	-	-
Alona intermedia	-	-	-	-	-	-	-	-
Bosmina longirostris	225	-	-	439	38	-	600	152
Ceriodaphnia lacustris	-	-	-	-	-	-	-	30
Chydorus bicornutus	-	-	-	-	-	-	-	-
Chydorus piger	25	-	-	-	-	-	-	-
Daphnia catawba	25	-	91	-	110	94	-	61
Daphnia dubia	-	-	-	-	-	-	-	-
Diaphanosoma birgei	-	-	36	15	-	27	-	-
Eubosmina longispina	-	-	194	-	34	-	-	-
Holopedium gibberum	-	-	97	40	-	34	-	742
Latona setifera	-	-	6	-	4	60	-	-
Leptodora kindti	-	-	12	-	-	-	-	-
Ophryoxus gracilis	-	-	12	-	-	-	-	-
Rhynchotalona falcata	-	-	-	-	-	-	-	-
COPEPODA								
Cyclops scutifer F	-	-	55	-	8	-	-	-
Cyclops scutifer M	-	-	12	-	8	-	-	-
Cyclopoid copepodid I-V	-	-	491	61	27	67	200	121
Diaptomus minutus F	50	-	945	227	68	282	-	182
Diaptomus minutus M	75	-	291	131	61	40	267	121
Diaptomus spatulocrenatus F	-	-	-	-	-	-	-	-
Diaptomus spatulocrenatus M	-	-	-	-	-	-	-	-
Diaptomus copepodid I-V	325	-	539	540	53	262	1067	318
Epischura lacustris F	-	-	18	-	15	-	-	-
Epischura lacustris M	-	-	36	-	15	-	-	-
Epischura copepodid I-V	-	-	12	-	-	-	-	-
Mesocyclops edax F	-	-	-	-	-	-	-	-
Nauplius	400	-	1285	2535	689	1819	1467	561
MISCELLANEOUS								
Chaoborus sp.	-	-	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-	-	-
Acari	-	-	-	-	-	-	-	-

Appendix 1 (Cont'd.)

Lake No.	114	116	117	118	119	120	121	122
ROTIFERA								
Asplanchna priodonta	91	-	-	-	-	-	-	-
Collotheca mutabilis	-	-	-	107	-	-	242	72
Conochilus unicornis	697	464	-	-	4467	522	-	386
Euchlanis triquetra	-	-	-	-	-	-	-	-
Gastropus stylifer	-	-	-	1148	1467	696	-	193
Kellicottia bostoniensis	-	-	-	-	-	-	-	96
Kellicottia longispina	273	214	63	477	1333	435	182	169
Keratella cochlearis	-	-	28	-	-	261	-	253
Keratella crassa	333	-	-	-	-	-	-	627
Keratella quadrata	-	-	-	-	-	-	-	-
Keratella serrulata	-	-	-	-	-	-	-	-
Keratella taurocephala	424	518	97	678	6733	1391	1015	1072
Lecane lunaris	-	-	-	-	200	-	-	-
Ploesoma hudsoni	-	-	-	-	-	-	-	24
Ploesoma truncatum	106	-	-	81	-	130	-	952
Polyarhtra dolichoptera	91	-	-	-	-	-	-	-
Polyarthra euryptera	-	-	40	1208	-	-	652	-
Polyarthra major	-	-	-	-	-	-	-	-
Synchaeta pectinata	-	-	-	-	-	-	-	217
Synchaeta stylata	-	-	-	-	-	-	-	-
Trichocerca cylindrica	136	-	-	-	1867	261	-	434
Trichocerca multicrinis	61	-	-	-	-	-	-	-
Trichotria tetractis	-	-	-	-	-	-	-	-
CLADOCERA								
Acroperus harpae	-	-	-	-	-	-	-	-
Alona intermedia	-	-	-	-	-	-	-	-
Bosmina longirostris	182	107	-	54	-	565	-	265
Ceriodaphnia lacustris	-	-	-	-	-	-	-	-
Chydorus bicornutus	-	-	-	-	133	-	-	24
Chydorus piger	-	-	-	-	-	-	-	24
Daphnia catawba	30	54	99	148	2200	478	394	-
Daphnia dubia	-	-	-	-	-	-	-	-
Diaphanosoma birgei	-	-	-	13	200	-	-	-
Eubosmina longispina	-	-	42	81	1400	-	-	145
Holopeium gibberum	121	-	34	-	800	-	-	217
Latona setifera	-	-	-	7	-	-	-	-
Leptodora kindti	-	-	-	20	-	-	-	-
Ophryoxus gracilis	-	-	-	-	-	-	-	-
Polyphemus pediculus	-	-	-	-	133	-	-	-
Rhynchotalona falcata	-	-	-	-	-	-	-	-
COPEPODA								
Cyclops scutifer F	30	-	53	181	-	130	-	-
Cyclops scutifer M	15	-	44	27	-	-	-	-
Cyclopoid copepodid I-V	121	71	158	242	-	261	-	277
Diaptomus minutus F	136	250	539	792	4800	609	409	566
Diaptomus minutus M	182	321	465	107	1867	391	242	265
Diaptomus spatulocrenatus F	-	-	-	-	1733	-	-	-
Diaptomus spatulocrenatus M	-	-	-	20	1400	-	-	-
Diaptomus copepodid I-V	318	214	372	416	4000	522	485	482
Epischura lacustris F	-	-	22	13	133	-	91	-
Epischura lacustris M	30	-	18	27	267	-	91	-
Epischura copepodid I-V	15	-	16	13	400	-	242	-
Mesocyclops edax F	-	-	-	-	-	-	61	-
Nauplius	636	339	135	1919	2133	913	545	2181
MISCELLANEOUS								
Chaoborus sp.	-	-	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-	-	-
Acari	-	-	-	-	67	-	-	24

Appendix 1 (Cont'd.)

Lake No.	123	124	125	152	153	154	201	202
ROTIFERA								
Asplanchna priodonta	-	-	-	-	-	-	-	-
Collotheca mutabilis	-	-	-	-	319	121	-	-
Conochilus unicornis	34	162	132	863	241	220	-	94
Euchlanis dilatata	-	-	-	-	-	-	-	-
Gastropus stylifer	61	111	-	-	155	68	-	39
Kellicottia bostoniensis	-	-	-	-	-	-	6	-
Kellicottia longispina	86	40	186	-	138	159	43	44
Keratella cochlearis	82	-	24	-	-	-	33	48
Keratella crassa	-	40	12	99	34	-	-	-
Keratella serrulata	9	-	-	-	-	-	-	-
Keratella taurocephala	262	283	588	489	353	254	41	193
Lecane bulla	9	-	-	-	-	-	-	-
Lecane lunaris	12	-	-	-	-	23	-	17
Ploesoma hudsoni	-	-	-	27	-	-	4	-
Ploesoma truncatum	52	121	-	291	328	114	-	-
Polyarthra dolichoptera	-	-	-	-	-	-	-	-
Polyarthra eurvptera	116	-	-	-	-	-	-	-
Polyarthra major	-	-	-	-	-	-	-	-
Polyarthra vulgaris	-	-	-	-	-	-	31	24
Trichocerca cylindrica	52	-	145	176	52	-	-	-
Trichocerca multicrinis	-	-	-	-	-	-	-	-
Trichocerca platessa	-	-	-	-	-	-	-	-
CLADOCERA								
Alona intermedia	-	-	-	-	-	-	-	-
Bosmina longirostris	-	-	-	-	-	-	-	-
Ceriodaphnia lacustris	-	-	-	-	-	-	-	-
Chydorus brevilabris	-	-	-	-	-	-	4	-
Chydorus sphaericus	-	-	-	-	-	-	-	3
Daphnia catawba	56	414	67	-	181	216	33	41
Diaphanosoma birgei	-	-	-	88	17	53	-	-
Disparalona acutirostris	-	-	-	-	-	-	-	-
Eubosmina longispina	78	-	61	225	78	121	54	71
Holopedium gibberum	30	20	61	148	-	-	-	27
Latona setifera	-	-	-	38	17	-	-	-
Leptodora kindti	-	-	-	-	-	-	-	-
Polyphemus pediculus	-	-	-	-	-	-	-	-
Sida crystallina	-	-	-	-	-	-	-	-
Strblocerus serricaudatus	-	-	-	-	-	-	-	-
COPEPODA								
Cyclops scutifer F	-	-	-	-	17	-	76	13
Cyclops scutifer M	-	-	-	-	-	-	4	-
Cyclopoid copepodid I-V	-	71	55	-	103	-	65	32
Diaptomus minutus F	129	111	176	-	664	557	136	442
Diaptomus minutus M	52	91	73	-	69	83	21	42
Diaptomus spatulocrenatus F	-	91	-	-	-	-	-	-
Diaptomus spatulocrenatus M	-	901	-	-	-	-	-	-
Diaptomus copepodid I-V	164	273	255	66	672	981	80	138
Epischura lacustris F	-	40	-	-	-	8	6	9
Epischura lacustris M	-	-	12	-	-	11	4	-
Epischura copepodid I-V	-	61	79	269	181	117	6	30
Mesocyclops edax F	-	111	18	-	-	-	-	-
Mesocyclops edax M	-	-	12	-	-	-	-	-
Nauplius	377	717	558	698	293	424	118	148
MISCELLANEOUS								
Acari	-	10	-	-	-	11	-	-
Oligochaeta	-	-	-	-	-	-	-	-

Appendix 1 (Cont'd.)

Lake No.	203	204	205	206	207	208	209	211
ROTIFERA								
Asplanchna priodonta	-	-	-	-	-	-	-	-
Collotheca mutabilis	-	-	89	-	-	-	304	-
Conochilus unicornis	158	420	-	343	-	233	-	-
Euchlanis dilatata	-	-	-	-	-	-	54	-
Gastropus stylifer	666	720	355	444	80	-	5786	561
Kellicottia bostoniensis	-	-	-	-	-	-	-	-
Kellicottia longispina	-	-	443	525	545	440	-	303
Keratella cohlearis	751	-	48	-	20	69	250	91
Keratella crassa	-	-	-	-	-	-	-	-
Keratella serrulata	-	-	-	-	-	-	-	-
Keratella taurpcephala	5939	960	854	1333	495	276	1964	1636
Leca ne bulla	-	-	-	-	-	-	-	-
Lecane lunaris	-	-	-	-	-	-	-	-
Ploesoma budsoni	-	-	-	-	-	-	-	-
Ploesoma truncatum	-	-	-	182	-	-	54	61
Polyarthra dolichoptera	-	240	-	-	-	-	-	-
Polyarhtra euryptera	-	-	104	-	414	-	-	-
Polyarthra major	-	-	-	-	-	-	-	-
Polyarthra vulgaris	-	-	-	-	-	-	-	439
Trichocerca cylindrica	-	-	-	253	10	-	-	-
Trichocerca multicrinis	-	-	-	-	-	-	-	-
Trichocerca platessa	-	-	-	-	-	-	-	-
CLADOCERA								
Alona intermedia	-	-	-	-	-	-	-	-
Bosmina longirostris	-	-	-	-	-	-	-	-
Ceriodaphnia lacustris	-	-	-	-	-	-	-	-
Chydorus brevilabris	-	-	-	-	-	-	-	-
Chydorus sphaericus	-	-	-	-	-	-	-	-
Daphnia catawba	60	360	56	444	136	9	661	121
Diaphanosoma birgei	-	-	16	-	-	17	-	30
Disparalona acutirostris	-	40	-	-	-	-	-	-
Eubosmina longispina	96	340	64	-	51	155	375	136
Holopedium gibberum	-	-	-	394	-	26	428	-
Latona setifera	-	-	4	-	-	-	-	-
Leptodora kindti	6	-	-	-	-	-	-	15
Polyphemus pediculus	-	40	-	-	-	-	-	-
Sida crystallina	-	-	-	-	-	-	36	-
Streblocerus serricaudatus	-	-	-	-	-	-	-	-
COPEPODA								
Cyclops scutifer F	66	-	20	121	-	-	-	-
Cyclops scutifer M	-	-	16	-	-	-	-	-
Cyclopoid copepodid I-V	60	-	48	162	157	103	286	-
Diaptomus minutus F	472	1320	274	687	146	534	571	242
Diaptomus minutus M	127	400	64	262	20	440	446	179
Diaptomus spatulocrenatus F	-	-	-	-	-	26	161	196
Diaptomus spatulocrenatus M	-	-	-	-	-	-	107	136
Diaptomus copepodid I-V	400	640	190	444	2040	190	857	318
Epischura lacustris F	-	-	24	-	10	-	71	30
Epischura lacustris M	-	-	-	-	5	-	54	60
Epischura copepodid I-V	-	-	48	61	106	17	71	-
Mesocyclops edax F	-	-	-	-	-	34	214	90
Mesocyclops edax M	-	-	-	-	-	26	54	15
Nauplius	284	40	206	313	212	172	1286	393
MISCELLANEOUS								
Acari	-	-	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-	-	-

Appendix 1 (Cont'd.)

Lake No.	213	215	217	219	220	221	222	224
ROTIFERA								
Asplanchna priodonta	-	-	-	269	77	-	-	-
Collotheca mutabilis	-	-	-	-	71	241	53	-
Conochilus unicornis	313	43	80	225	723	482	250	-
Euchlanis dilatata	-	-	-	-	-	-	-	-
Gastropus stylifer	111	21	80	-	142	386	1211	6000
Kellicottia bostoniensis	-	-	-	34	13	-	-	-
Kellicottia longispina	121	15	47	67	-	337	395	2000
Keratella cochlearis	-	50	60	67	39	144	158	1000
Keratella crassa	-	-	-	45	-	-	-	-
Keratella serrulata	-	-	-	-	-	-	-	-
Keratella taurocephala	2121	127	206	606	110	578	868	4500
Lecane bulla	-	-	-	-	-	-	-	-
Lecane lunaris	-	-	10	-	-	-	-	250
Ploesoma hudsoni	20	-	-	-	-	-	-	-
Ploesoma truncatum	161	-	-	157	-	493	-	2625
Polyarthra dolichoptera	222	-	-	337	-	-	-	-
Polyarthra euryptera	-	-	-	-	-	-	211	2250
Polyarthra major	-	-	73	-	-	-	-	-
Polyarthra vulgaris	-	30	106	-	84	-	-	-
Trichocerca cylindrica	40	-	33	135	213	1373	-	-
Trichocerca multicrinis	-	-	-	-	-	-	-	125
Trichocerca platessa	-	-	-	-	-	-	-	125
CLADOCERA								
Alona intermedia	-	-	-	-	-	-	13	125
Bosmina longirostris	-	16	-	-	-	-	-	-
Ceriodaphnia lacustris	-	-	-	-	-	-	-	125
Chydorus brevilabris	-	-	-	-	-	-	-	-
Chydorus sphaericus	-	-	-	-	-	-	-	-
Daphnia catawba	10	-	23	-	25	928	66	-
Diaphanosoma birgei	-	-	-	11	-	-	-	-
Disparalona acutirostris	-	-	-	-	-	-	-	-
Eubosmina longispina	60	21	167	169	232	470	263	1625
Holopedium gibberum	30	25	13	45	-	72	52	-
Latona setifera	-	-	-	-	-	-	-	-
Leptodora kindti	-	-	-	-	-	-	-	-
Polyphemus pediculus	-	-	-	-	-	-	-	-
Sida crystallina	-	-	-	-	-	-	-	-
Streblocerus serricaudatus	-	-	-	-	-	-	-	125
COPEPODA								
Cyclops scutifer F	-	-	-	-	-	-	-	-
Cyclops scutifer M	-	-	-	-	-	-	-	-
Cyclopoid copepodid I-V	-	-	-	90	-	265	-	500
Diaptomus minutus F	404	72	187	224	51	96	473	1125
Diaptomus minutus M	303	8	40	202	39	24	289	750
Diaptomus spatulocrenatus F	-	-	-	-	-	-	-	-
Diaptomus spatulocrenatus M	-	-	-	-	-	-	-	-
Diaptomus copepodid I-V	364	41	160	179	206	590	237	750
Epischura lacustris F	60	3	20	-	-	-	-	125
Epischura lacustris M	40	-	27	-	-	-	-	-
Epischura copepodid I-V	30	21	27	-	19	72	79	500
Mesocyclops edax F	91	-	43	146	32	-	-	-
Mesocyclops edax M	20	-	7	101	-	-	-	-
Nauplius	424	85	203	303	619	747	539	2250
MISCELLANEOUS								
Acari	-	-	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	-	-	125

Appendix 1 (Cont'd.)

Lake No.	225	226	228	229	230	232	251
ROTIFERA							
ASPLANCHNA PRIODONTA	-	-	-	-	-	-	-
Collotheca mutabilis	-	1000	-	-	-	-	200
Conochilus unicornis	153	6800	141	837	197	472	-
Gastropus stylifer	-	2133	-	744	-	-	6533
Kellicottia bostoniensis	-	-	-	-	-	-	-
Kellicottia longispina	57	667	207	1535	266	139	4133
Keratella cochlearis	7	1066	40	419	-	52	-
Keratella crassa	-	933	-	-	-	-	-
Keratella earlinae	-	-	-	-	-	-	-
Keratella taurocephala	78	2133	263	2047	170	417	2667
Lecane lunaris	-	-	-	-	-	-	-
Ploesoma truncatum	-	733	-	186	-	-	-
Polyarthra dolichopter-	-	2000	-	-	-	-	-
Polyarthra euryptera	-	1000	-	-	-	-	-
Polyarthra minor	-	133	-	-	-	-	-
Polyarthra vulgaris	-	-	51	279	-	-	-
Trichocerca cylindrica	-	1333	-	-	-	-	133
Trichocerca multicrinis	-	-	-	46	-	-	-
CLADOCERA							
Acantholeberis curvirostris	-	-	-	-	-	-	67
Alona guttata	-	-	-	-	-	-	-
Bosmina longirostris	-	533	-	46	-	-	-
Ceriodaphnia lacustris	-	-	-	-	-	-	600
Daphnia catawba	-	67	10	-	48	30	133
Daphnia dubia	-	-	-	-	-	-	-
Diaphanosoma birgei	-	-	10	-	-	-	-
Eubosmina longispina	100	1066	66	-	64	35	533
Holopedium gibberum	-	200	20	-	16	17	267
Latona setifera	-	-	-	-	-	9	-
Leptodora kindti	-	-	-	-	-	4	-
Ophryoxus gracilis	-	-	-	-	-	-	67
Rhynchotalona falcata	-	-	-	23	-	-	-
Sida crystallina	-	-	-	-	-	-	67
COPEPODA							
Cyclops scutifer F	-	-	15	-	21	-	267
Cyclops scutifer M	-	-	-	-	-	-	-
Cyclopoid copepodid I-V	-	290	15	-	92	9	400
Diaptomus minutus F	498	266	232	372	309	476	400
Diaptomus minutus M	14	266	91	232	496	117	133
Diatpomus spatulocrenatus F	-	-	-	-	-	-	267
Diaptomus spatulocrenatus M	-	-	-	-	-	-	200
Diaptomus copepodid I-V	291	2066	101	279	261	182	667
Epischura lacustris F	4	-	-	23	-	13	-
Epischura lacustris M	-	-	-	23	-	9	-
Epischura copepodid I-V	21	-	-	93	-	39	-
Macrocyclops albidus F	-	-	-	-	-	-	-
Mesocyclops edax F	-	67	-	-	-	26	-
Mesocyclops edax M	-	-	-	-	-	-	-
Nauplius	399	8066	202	512	122	398	1600
MISCELLANEOUS							
Acari	-	-	-	-	-	-	67
Chaoborus	-	-	-	-	-	-	-
Oligochaeta	-	-	-	46	-	-	67

Appendix 1 (Cont'd.)

Lake No.	252	253	254	255	256	257
ROTIFERA						
Asplanchna priodonta	-	818	223	3936	-	-
Collotheca mutabilis	44	91	-	-	-	-
Conochilus unicornis	133	227	71	190	-	-
Gastropus stylifer	148	409	71	203	-	63
Kellicottia bostoniensis	-	-	-	114	160	-
Kellicottia longispina	363	167	112	158	960	136
Keratella cochlearis	-	962	54	1962	1040	-
Keratella crassa	-	-	-	-	-	-
Keratella earlinae	-	833	-	-	-	-
Keratella taurocephala	259	-	89	127	840	-
Lecane lunaris	-	15	-	-	-	-
Ploesoma truncatum	-	242	-	152	-	-
Polyarthra dolichoptera	-	121	-	-	440	-
Polyarthra euryptera	207	-	-	-	-	-
Polyarthra minor	-	-	-	-	-	-
Polyarthra vulgaris	74	-	-	-	-	79
Trichocerca cylindfica	-	-	107	133	160	16
Trichocerca multicrinis	-	-	-	-	-	-
CLADOCERA						
Acantholeberis curvirostris	-	-	-	-	-	-
Alona guttata	-	8	-	-	-	-
Bosmina longirostris	-	136	-	-	-	-
Ceriodaphnia lacustris	-	-	-	-	-	16
Daphnia catawba	89	8	156	108	1680	-
Daphnia dubia	-	-	-	-	-	126
Diaphanosoma birgei	-	-	-	82	-	-
Eubosmina longispina	148	166	58	108	440	168
Holopedium gibberum	133	-	98	-	480	-
Latona setifera	-	-	-	-	-	-
Leptodora kindti	-	-	-	-	-	-
Ophryoxus gracilis	-	-	-	-	-	-
Rhynchotalona falcata	-	-	-	-	-	-
Sida crystallina	-	-	-	-	-	-
COPEPODA						
Cyclops scutifer F	-	-	-	76	840	-
Cyclops scutifer M	-	-	-	13	160	-
Cyclopoid copepodid I-V	30	-	-	133	2000	58
Diaptomus minutus F	148	152	183	253	480	215
Diaptomus minutus M	89	121	98	190	320	37
Diaptomus spatulocrenatus F	-	-	-	38	240	-
Diaptomus spatulocrenatus M	-	-	-	-	120	-
Diaptomus copepodid I-V	311	295	223	367	960	288
Epischura lacustris F	22	-	9	-	-	42
Epischura lacustris M	22	-	-	-	-	21
Epischura copepodid I-V	44	28	-	-	-	-
Macrocyclops albidus F	15	-	-	-	-	-
Mesocyclops edax F	-	-	-	-	-	-
Mesocyclops edax M	-	-	-	-	-	-
Nauplius	444	371	147	658	1080	162
MISCELLANEOUS						
Acari	-	-	-	-	-	-
Chaoborus	-	-	-	13	-	-
Oligochaeta	-	-	-	-	-	-

APPENDIX 2

Comprehensive list of zooplankton reported from insular Newfoundland's freshwaters

Appendix 2. Comprehensive list of zooplankton reported from insular Newfoundland's freshwaters. (Note: See end of Appendix for reference list and location of water bodies included in each collection.)

Species	This Study	Other Studies (see reference list)
ROTIFERA		
Adineta gracilis (Janson)		15
Adineta steineri (Bartos)		15
Adineta vaga minor (Bryce)		15
Ascomorpha ecaudis (Perty)		15
Ascomorpha saltans (Bartsch)		15
Ascomorpha osalis		20
Aspelta asper (Harring)		15
Aspelta circinator (Gosse)		15
Asplanchna priodonta (Gosse)	X	8,15,19,20
Asplanchnops dahlgreni (Myers)		15
Brachionas bidentata (Anderson)		15,19
Brachionus quadritentatus (Herman)		15
Cephalodella apocolea (Muller)		15
Cephalodella eva (Gosse)		15
Cephalodella gibba (Ehrenberg)		15
Cephalodella hyalina (Myers)		15
Cephalodella inquila (Myers)		15
Cephalodella physalis (Myers)		15
Collotheca campanulata (Dobie)		15
Collotheca edentata (Collins)		15
Collotheca libera (Zacharias)		11,15
Collotheca mutabilis (Hudson)	X	15,20
Colourella obtusa obtusa (Gosse)		15
Colourella siuisha (Carlin)		15
Colourella tesselata (Glasscott)		15
Colurella hindenburgi (Steinecke)		15
Colurella obtusa (Gosse)		15
Colurella uncinata (Muller)		15
Conochilus coenobasis (Skorikov)		15
Conochilus hippocrepis (Schrank)		11,15,20
Conochilus unicornis (Rousselet)	X	4,5,8,11,15,19,20
Dicranophorus capucinus (Harring and Myers)		15
Dicranophorus corystis (Harring and Myers)		15
Dicranophorus forcipatus (Muller)		15
Dicranophorus grandis (Ehrenberg)		15
Dicranophorus lutkeni (Bergendal)		15

Appendix 2. (Cont'd.)

Species	This Study	Other Studies (see reference list)
Dicranophorus thysanus (Harring and Myers)		15
Dissotrocha aculeata (Ehrenberg)		15
Dissotrocha macrostyle tuberculata (Gosse)		15
Elosa worallii (Lord)		15
Euchlanis alata (Voronkov)		15
Euchlanis dilitata (Ehrenberg)		15
Euchlanis incisa (Carlin)		15
Euchlanis lyra (Hudson)		15
Euchlanis meneta (Myers)		15
Euchlanis triquetra (Ehrenberg)	X	15,20
Filinia longiseta (Ehrenberg)		15
Floscularia janus (Hudson)		15
Floscularia ringens (Linnaeus)		20
Gastropus minor		15
Gastropus stylifer (Imhof)	X	15,20
Habrotrocha angusticollis (Murray)		15
Habrotrocha augusticollis augusticollis (Murray)		15
Habrotrocha collaris (Ehrenberg)		15
Habrotrocha constricta (Dujardin)		15
Habrotrocha lata lata (Bryce)		15
Habrotrocha pusilla tectrix brevilabris (Donner)		15
Habrotrocha roeperi (Milne)		15
Habrotrocha tridens (Milne)		15
Kellicotia bostoniensis (Rousselet)	X	5,8,11,19,20,15
Kellicottia longispina (Kellicott)	X	4,5,8,9,11,15,19,20
Keratella cochlearis (Gosse)	X	4,5,8,9,11,15,19,20
Keratella crassa (Ahlstrom)	X	15,20
Keratella earlinae (Ahlstrom)		11,15
Keratella paludosa (Lucks)		15
Keratella quadrata (Muller)	X	5,11,15,19
Keratella serrulata (Ehrenberg)	X	5,8,9,19,20,15
Keratella taurocephala (Myers)	X	5,8,11,20,15
Keratella testudo testudo (Ehrenberg)		15
Lecane acus (Harring)		15
Lecane agilis (Bryce)		15
Lecane aucleata (Jakubski)		15
Lecane brachydactyla (Stenroos)		15
Lecane bulla	X	

Appendix 2. (Con't.)

Species	This Study	Other Studies (see reference list)
Lecane carvicornis (Murray)		15
Lecane closterocerca closterocerca (Schmanda)		15
Lecane closterocerca (Schmarda)		15
Lecane constricta (Murray)		15
Lecane crenata (Harring)		15
Lecane elsma (Harding and Myers)		15
Lecane flexilis (Gosse)		15
Lecane galeata (Bruce)		15
Lecane hemata hemata (Stokes)		15
Lecane intrasinuata (Olofsson)		15
Lecane lauterborni (Hauer)		15
Lecane ligona (Dunlop)		15
Lecane luna (Muller)	X	11,15
Lecane lunaris lunaris (Ehrenberg)		15
Lecane lunaris (Ehrenberg)	X	15
Lecane mira (Murray)		15,20
Lecane michiganensis		20
Lecane pyriformis (Daday)		15
Lecane quadridentata		11
Lecane scutata (Harring and Myers)		15
Lecane stichaea stichaea (Harring)		15
Lecane stichaea (Harring)		15
Lecane tenuiseta (Harring)		15
Lepadella acuminata acuminata (Ehrenberg)		15
Lepadella acuminata (Ehrenberg)		15
Lepadella amphitropis (Harring)		15
Lepadella borealis (Harring)		15
Lepadella cristata (Rousselet)		15
Lepadella ovalis (Muller)		15
Lepadella patella (Muller)		15
Lepadella triptera triptera (Ehrenberg)		15
Lindia caerulta (Harring and Myers)		15
Lindia torulosa (Dujardin)		15
Macrotrachela ehrenbergii (Janson)		15
Macrotrachela gunningi (Murray)		15
Macrotrachela multispinosa (Thompson)		15
Macrotrachela multispinsoa multispinosa (Thompson)		15
Macrotrachela musculosa (Milne)		15

Appendix 2. (Cont'd.)

Macrotrachela natans (Murray)		15
Macrotrachela papillosa (Thompson)		15
Macrotrachela plicata hirundinella (Murray)		15
Macrotrachela plicata plicata (Bryce)		15
Macrotrachela quadricornifera quadricornifera (Milne)		15
Macrotrachela quadricornifera quadricorniferoides (DeKoning)		15
Miniobia bredensis (DeKoning)		15
Monommata aequalis (Ehrenberg)		15
Monommata aeschyna (Myers)		15
Monommata dentata (Wulfert)		15
Monommata longiseta (Muller)		15
Monommata viridis (Myers)		15
Mytilina ventralis (Ehrenberg)		15
Notholca acuminata (Ehrenberg)		9,19,15
Notholca limnetica		19,15
Notholca foliacea (Ehrenberg)		15
Notholca labis (Gosse)		15
Notommata cerberus (Gosse)		15
Notommata copeus (Ehrenberg)		15
Notommata cyrtopus (Gosse)		15
Notommata glyphura (Wulfert)		15
Notommata pachyura traingulata (Kirkman)		15
Notommata peridia (Harring and Myers)		15
Notommata pseudocerberus (Beauchamp)		15
Notommata saccigera (Ehreberg)		15
Notommata tripus (Ehrenberg)		15
Philodina proterva (Milne)		15
Platyias quadricornis (Enrenberg)		9,19,15
Pleuretra sulcata (Bartos)		15
Ploesoma hudsoni (Imhof)	X	20,15
Ploesoma lenticulare (Herrick)	X	8,11,20,15
Ploesoma triacanthum (Bergendal)		15
Ploesoma truncatum (Levander)	X	11,19,20,15
Polyarthra euryptra	X	20,15
Polyarthra nemata (Skorikov)		20,15
Polyarthra vulgaris (Carlin)	X	5,11,20,15
Polyarthra dolichoptera (Idelson)	X	15
Polyarthra major	X	19,20

Appendix 2. (Cont'd.)

Species	This Study	Other Studies (see reference list)
Polyarthra minor (Voigt)	X	15
Proales brevipes (Harring and Myers)		15
Proales decipiens (Ehrenberg)		15
Proales doliaris (Rousselet)		15
Proales fallaciosa (Wulfert)		15
Ptygra pilula (Cubitt)		15
Ptygura brachiata (Hudson)		15
Ptygura crystallina (Ehrenberg)		15
Resticula nyssa (Harring and Myers)		15
Rotaria tridens (Montet)		15
Scaridium longicaudum (Muller)		15
Sinantherina socialis (Linnaeus)		15
Squatinella microdaetyla microdaetyla (Murray)		15
Squatinella mutica minor (Wulfert)		15
Squatinella mutica mutica (Ehrenberg)		15
Squatinella rostrum aurita (Wulfert)		15
Streptognatha lepta (Harring and Myers)		15
Synchaeta grandis (Zacharias)		15
Synchaeta longipes (Wierzejski)		15
Synchaeta pectinata (Ehrenberg)	X	15
Synchaeta stylata	X	15
Testudinella incisa (Ternetz)		15
Testudinella naumanni (Carlin)		15
Testudinella parva (Carlin)		15
Testudinella patina (Hermann)		15
Trichocerca bicristata (Gosse)		15
Trichocerca brachyura (Gosse)		15
Trichocerca capucina	X	
Trichocerca cavia (Gosse)		15
Trichocerca collaris (Rousselet)		15
Trichocerca cylindrica (Imhof)	X	8,11,20,15
Trichocerca insignis (Herrick)		15
Trichocerca lata (Jennings)		15
Trichocerca multicrinis	X	15
Trichocerca myersi (Hauer)		15
Trichocerca platessa (Myers)	X	8,11,15
Trichocerca pocillum (Muller)		15

Appendix 2. (Cont'd.)

Species	This Study	Other Studies (see reference list)
Trichocerca porcellus (Gosse)		15
Trichocerca rattus (Muller)		15
Trichocerca rattus carinata (Ehrenberg)		15
Trichocerca rosea (Stenroos)		15
Trichocerca similus (Wierzejski)		15
Trichocerca tenuoir (Gosse)		15
Trichocerca tetractis similus (Stenross)		15
Trichocerca tetractis tetractis (Ehrenberg)		19,20,15
Trichocerca tigris (Muller)		15
Trichocerca truncata (Whitelegge)		15
Trichotria tetractis	X	15
Tylotrocha monopus (Jennings)		15
Wierzeskiella velox (Wiszniewski)		15
CRUSTACEA		20
Cladocera		20
Acantholeberis curvirostris (O. F. Muller)	X	7
Acroperus alonoides (Hudendorff)		6,7
Acroperus elongatus (Sars)		7
Acroperus harpae (Baird)	X	7
Alona affinis (Leydig)	X	6
Alona costata (Sars)	X	7
Alona guttata (Sars)	X	9,11
Alona intermedia (Sars)	X	6
Alona nana		6,7
Alona quatrangularis (O. F. Muller)	X	6,7
Alona rustica (Scott)	X	6,7
Alonella excisa (Fischer)	X	6,7
Alonella exigua (Lilljeborg)		7
Alonella nana (Baird)	X	6,7
Anchistropus minor (Birge)		6,7
Bosmina coregoni (Baird)		8,9
Camptocercus rectirostris (Schoedler)		7
Ceriodaphnia lascustris (Brige)	X	
Ceriodaphnia quadrangula (O. F. Muller)		6,7
Ceriodaphnia reticulata (Jurine)		7
Chydorus bicornutus (Doolittle)	X	

Appendix 2. (Cont'd.)

Species	This Study	Other Studies (see reference list)
Chydorus brevilabris (Frey)	X	
Chydorus faviformis (Birge)		7
Chydorus ovalis (Kurz)		7
Chydorus piger (Sars)	X	6,7
Chydorus spaericus (O. F. Muller)	X	6,7,8,9,11
Daphina catawba (Coker)	X	7,8,9,11
Daphina dubia (Herrick)	X	
Daphina galeata		20
Daphina longiremis (Sars)		7
Daphina pulex (de Geer)		20
Daphina schodleri		20
Disparalona acutirostris (Birge)	X	6,7
Diaphanosoma birgei (Korinek)	X	
Diaphanosoma brachyuran (Lieven)		7
Diaphanosoma leachtenberghianum (Fischer)		7,8
Eubosmina longispina (Leydig)	X	6,7,11
Eubosmina tubicen		20
Eurycercus gracilis (Lilleborg)		20
Eurycercus lamellatus (O. F. Muller)		11
Graptoleberis testudinaria (Fischer)		20
Holopedium gibberum (Zaddach)	X	6,7,8,10,11
Ilyocryptus spinifer (Herrick)		6,7
Kurzia latissima (Kurz)		20
Lathonura rectirostris (O. F. Muller)		20
Latona parviremis (Birge)		20
Latona setifera (O. F. Muller)	X	10
Leptodora kindtii (Focke)	X	9,11
Ophryoxus gracilis (Sars)	X	6,7
Parophyoxus tubularus (Doolittle)		6,7
Pleuroxus denticulatus (Birge)		7
Pleuroxus larevis (Sars)		7
Pleuroxus procurvus (Birge)		6,7
Polyphemus pediculus (Linn)	X	7,8,10
Rhynchotalona faclata (Sars)	X	10
Scapholeberis aurita (Fischer)		6,7
Sida crystallina (O. F. Muller)	X	6,7
Simocephalus vetulus (O. F. Muller)		6,7
Streblocercus serricaudatus (Fischer)	X	7

Appendix 2. (Cont'd.)

Species	This Study	Other Studies (see reference list)
Copepoda		
Bryocamptus arcticus (Lilljeborg)		7
Canthocanytus vagus (Coker and Morgan)	X	10
Cyclops scutifer (Sars)		7
Cyclops varicans rubellus (Lilljeborg)		7
Cyclops venustoides (Sars)		20
Cyclops vernalis (Fischer)		7,9,10,11
Cyclops nanus (Sars)		20
Diaptomus marshianus		20
Diaptomus minutus (Lilljeborg)	X	6,7,10,9,11
Diaptomus reighardi (Marsh)		20
Diaptomus spatulocrenatus (Pearse)	X	
Epischura lacustris (Forbes)	X	8,11
Epischura nordenskioldi (Lilljeborg)	X	6,7,9
Eurytemora affinis (Poppe)	X	
Eucyclops agilis (Koch)		6,7
Macrocyclops albidis (Jurine)	X	6,7,11
Macrocyclops ater (Herrick)		6,7
Macrocyclops fuscus (Jurine)		6,7,11
Mesocyclops edax (Forbes)	X	7,11
Orthocyclops modestus (Herrick)		7
Tropocyclops prasinus mexicanus (Fischer)	X	7

Appendix 2. (Cont'd.)

1. Cushman (1908) -
2. Palmer (1965) -
3. Meggerl (1969) -
4. Davis (1972a) - 1 lake - Avalon Peninsula
5. Davis (1973) - 1 lake - Avalon Peninsula
6. Daggett and Davis (1974) - 1 lake and 1 marsh - Avalon Peninsula
7. Daggett and Davis (1975) - 82 lakes, ponds, pools, streams, marshes-along the TCH and other highways from the Avalon Peninsula to Corner Brook-Gros Morne Area.
8. Airphoto/Beak (1976) - 5 lakes/reservoirs - Baie D'Espoir - Upper Salmon Hydro Development-Central Nfld.
9. O'Connell and Andrews (1977) - 1 lake - Avalon Peninsula (St. John's)
10. Kerekes (1978) - 7 lakes - Gros Morne National Park - Western Nfld.
11. Newfoundland and Labrador Hydro (1978) - 2 lakes - Hinds Lake Hydro Development - Western Nfld.
12. Bateman and Davis (1980) - 1 fen - Avalon Peninsula
13. deGraaf (1981) - 2 lakes - proposed Dry Pond Brook Hydro Development - South Coast
14. Ryan (1982) - 2 lakes - Central Nfld.
15. Chengaleth and Koste (1983) - 15 bogs and pools - Northern Peninsula
16. Meijering (1983) - 3 lakes - Northern Peninsula
17. Deichman and Bradshaw (1984) - 19 lakes - Terra Nova National Park - Eastern Nfld.
18. Pepper et al. (1982) - 2 lakes - Indian River - N. Central Nfld.
19. O'Connell and Andrews (1987) - 4 lakes - Placentia Bay area, Avalon Peninsula
20. Parsons (1987) - 34 lakes across the island - mostly in Gros Morne and Terra Nova National Parks.