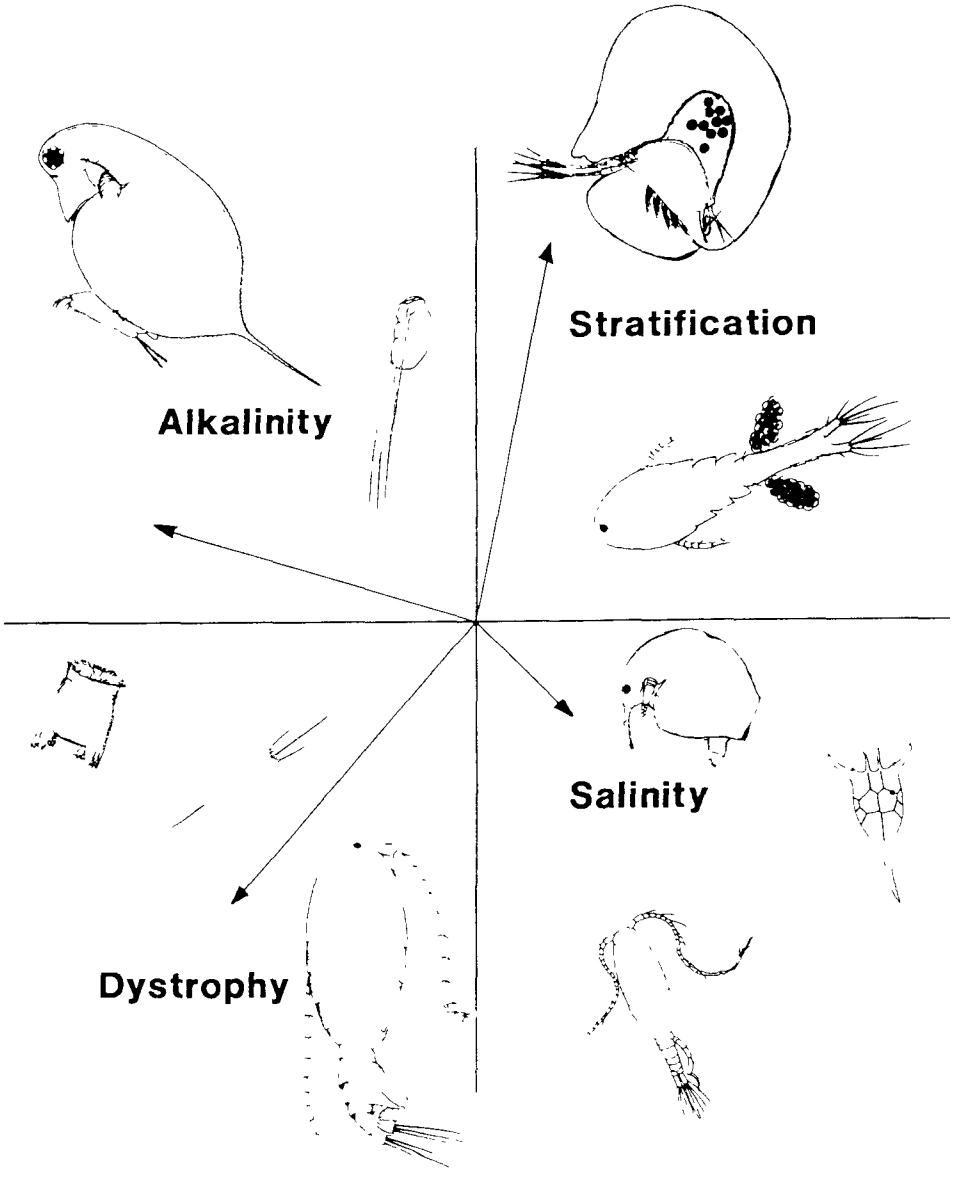
United States
Environmental Protection
Agency

Office of Research and
Development
Washington, DC 20460

EPA/600/R-92/012
September 1991

EPA

Analysis and Interpretation of Zooplankton Samples Collected During Phase II of the Eastern Lake Survey



Aquatic Effects Research Program

EPA/600/R-92/012
September 1991

ANALYSIS AND INTERPRETATION OF ZOOPLANKTON SAMPLES COLLECTED DURING PHASE II OF THE EASTERN LAKE SURVEY

Report No. 88-18

By

Alan J. Tessier and Richard J. Horwitz

The Academy of Natural Sciences of Philadelphia
19th and the Parkway
Philadelphia, PA 19103

The research described in this report has been funded by the U.S. Environmental Protection Agency through cooperative agreement CR813666 with the Academy of Natural Sciences of Philadelphia. This report has been submitted to the Agency's peer and administrative review and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

U.S. Environmental Protection Agency
Region 5, Library (PL-12J)
77 West Jackson Boulevard, 12th Floor
Chicago, IL 60604-3590

A report submitted to the U.S. Environmental Protection Agency Environmental Research Laboratory, 200 SW 35th Street, Corvallis, OR 97333.

Printed on Recycled Paper

TABLE OF CONTENTS

Section		Page
Summary		1
1.	INTRODUCTION	2
1.1	Background	3
1.2	Zooplankton Methodology	4
1.3	Data Files	6
2.	OBJECTIVES OF ZOOPLANKTON ANALYSIS	8
2.1	Primary Objectives	8
2.2	Secondary Objectives	8
2.3	Statistical Techniques	8
2.3.1	Principal Components Analysis (PCA)	8
2.3.2	Other Ordination Procedures	9
2.3.3	Tests for Differences between Zooplankton Communities and between Discrete Classes of Lakes	9
2.3.4	Tests for Relationships among Continuous Variables	10
3.	RESULTS	11
3.1	Quality Assurance	11
3.2	Distribution of Abundance	12
3.3	Zooplankton Patterns	13
3.3.1	Abundance of Major Taxonomic Groups	13
3.3.2	Species Richness	15
3.3.3	Species Diversity	16
3.3.4	Size Structure	19
3.3.5	Abundance of Major Genera	20
3.3.6	Canonical Discriminant Analysis	23
3.4	Physical/Chemical Gradients	25
3.4.1	Description of Chemical Data and Statistical Methods	25
3.4.2	Comparison of Fall and Summer Data Sets	27
3.4.3	Correlation between Physico-Chemical Parameters: Calculation of Chemistry Gradients and Relationships of Gradients to Original Parameters	29
3.5	Relationships between Physico-Chemical Gradients and Zooplankton	32
3.5.1	Relationship between Zooplankton Community Factors and Environmental Gradients	33
3.5.2	Relationships between Genera and Environmental Gradients	35
3.5.3	Relationships between Species Richness and Species Diversity and Environmental Gradients	37
3.6	Individual Species Patterns	37
3.7	Canonical Correspondence Analysis (CCA)	39
4.	INTERPRETATIONS	42
5.	GENERAL RECOMMENDATIONS	44
6.	LITERATURE CITED	45

FIGURES FOR ALL SECTIONS 47

TABLES FOR ALL SECTIONS 179

APPENDICES 253

Appendix A. List of Names, Numbers, Lake Identification Codes, Geographic Locations, Region Associations, and Chemistry Cluster Numbers for All 147 Lakes Sampled in the ELS-II 255

Appendix B. Codes for Genera Used in Generic Analyses 258

Appendix C. Formats of SAS Files 260

Appendix D. List of All Species and Their Summary Statistics for Abundance (Untransformed) Found in All 147 ELS-II Lakes and a Separate Listing for Each Chemistry Cluster 284

Appendix E. List of, and Summary Statistics for, 38 Genera Found in All 147 ELS-II Survey Lakes, Plus a Separate Listing for Each Chemistry Cluster 296

Appendix F. List of Common Species by Genera and Their Code Numbers 300

SUMMARY

Samples from 146 lakes in the northeastern United States, collected during Phase II of the Eastern Lake Survey (ELS-II) were analyzed for abundance of each species and each size class of zooplankton. An estimate of sampling and counting error was provided by replication of lake sampling and sample subsampling. Among-lake variance in zooplankton assemblages was large compared to sampling and counting errors.

The composition of zooplankton assemblages (not abundance) exhibited clear relationships with physical and chemical features of the lakes. Assemblage structure was examined at various levels: diversity, major genera, and individual species. Genera and species level identifications revealed the clearest relationships to water chemistry, although significant relational patterns were discerned using only major taxonomic groups or size structure information.

Significant regional influences (biogeographic patterns) were also observed at various levels of organization (major taxonomic groups, genera, species, and diversity). Only rarely did these biogeographic patterns interact with the general chemistry relationships. In a few cases, however, relationships between chemistry and zooplankton assemblages did depend on geographic region.

These results illustrate the utility of studying zooplankton assemblages as sensitive indicators of water chemistry. This report makes recommendations for improving methods of relating zooplankton species to environmental factors.

1. INTRODUCTION

The primary goal of this study was to provide a broad-scale objective representation of zooplankton assemblages in lakes in the northeastern United States. Secondly, we looked for relationships between zooplankton communities and the physical and chemical components of these lakes.

Ultimately, a mechanistic (causal) understanding of lake plankton communities will require detailed, process-oriented, and generally experimental approaches. By their very nature, however, such studies are limited in scope. This report provides a context within which the generality of results from more selective, process-oriented studies can be evaluated.

From an ecological perspective, lakes are islands, yet they are characterized by strong coupling with the surrounding land and atmosphere. Research directed toward understanding the regulation of biological communities of lakes must acknowledge the interplay of physical, chemical, and biological variables operating both within a lake and in relationships among lake, land, and atmosphere. Five broad classes of influence can be recognized.

1. **Morphometry:** physical structure of the lake basin
2. **Watershed factors:** land use and development, topography, hydrology, geology, and vegetation
3. **Atmospheric factors:** turbulence and chemical loading
4. **Biogeography:** species ranges and immigration rates
5. **Species interactions:** direct and indirect effects of competition, predation, etc.

Since geographic gradients to many of these factors exist, regional patterns might be expected to emerge. However, these factors interact in highly complex ways to create tremendous local variation among lakes in physical, chemical, and especially biological structure.

The National Surface Water Survey (NSWS) conducted by the U.S. Environmental Protection Agency (EPA) has provided an opportunity to evaluate local variation in biological communities against a framework of geographic region and water chemistry. Phase I of the Eastern Lake Survey (ELS-I) of the NSWS sampled 768 lakes in the northeastern United States during fall turnover 1984. These lakes were selected from a map population of 10,758 (identified from 1:250,000-scale maps), according to a stratified design with equal allocation of lakes randomly chosen from each stratum. These strata comprised five geographic regions (Figure 1-1) and three alkalinity classes (acid neutralizing capacity [ANC] < 100 μeq/L; ANC 100-200 μeq/L; ANC > 200 μeq/L), as identified by Omernik and Powers (1982) and Omernik and Kinney (1985). Each alkalinity stratum was nested within each region. Samples were collected at a 1.5-m depth at a central point in each lake and analyzed for a variety of chemical parameters.

A complete discussion of sampling design, chemical and physical parameters measured, and results are presented in Linthurst et al. (1986) and Landers et al. (1988). Field and laboratory analytical methods are detailed in Hillman et al. (1986).

Results from the ELS-I formed the basis of the Eastern Lake Survey - Phase II (ELS-II) sampling, which is the focus of this report. The goals of ELS-II were to examine seasonal variability in water chemistry for a representative subset of ELS-I lakes in the northeastern United States and to assess the status of biological communities in these lakes. The only biological component of ELS-II was a sampling of zooplankton communities during the summer. This report examines the zooplankton data in detail and considers the physical and chemical data only to the extent that it relates to the biology. A complete discussion of the ELS-II design is provided in Thornton et al. (1986); only a brief summary is provided here.

1.1 BACKGROUND

ELS-II lakes were randomly chosen from the 768 ELS-I lakes after exclusion of lakes shown in ELS-I to possess characteristics of low interest (i.e., cultural enrichment, surface area > 2,000 ha, maximum depth < 1.5 m, ANC > 400 μeq/L). Using a diversive cluster algorithm (CLUSB), the ELS-I lakes were classified according to their physical and chemical parameters. Three distinct clusters of lakes were identified along a major gradient of ANC. For lake selection, these three clusters of lakes were further defined as (1) cluster 1 = ANC ≤ 25 μeq/L, (2) cluster 2 = 25 < ANC ≤ 100 μeq/L, and (3) cluster 3 = 100 < ANC ≤ 400 μeq/L.

ELS-II sampled 147 lakes during mid-summer and again during fall turnover 1986. These lakes represented a stratified random sample of the ELS-I lakes. The three chemistry clusters defined by level of ANC constituted the strata. Lakes were chosen as a systemic variable probability sample, with fixed sample sizes (Thornton et al., 1986). Before lake selection, the lakes in each chemistry cluster were sorted by region (major) and site depth (minor). The goal was for each chemistry cluster to contain 50 lakes and for all clusters to have similar yet broad distributions with respect to geography and lake depth.

Table 1-1 presents a summary of the number of lakes in each region and chemistry cluster, and the summary statistics of lake depth for each chemistry cluster. As is apparent from this table, and from Figure 1-2, a broad geographic distribution of lakes was achieved. Furthermore, the mean, range, and distribution of lake depths represented in the chemistry clusters are quite similar (a consequence of the stratified sampling design). A complete listing of lake names, identification numbers, geographic locations, and chemistry clusters is provided in Appendix A for all 147 lakes.

Of the 147 lakes, only 146 were actually sampled for zooplankton. In addition, complete chemistry data were available for only 146 of the lakes. Because of the discrepancy caused by the missing data, analyses of zooplankton patterns were done for 146 lakes, analyses of chemistry patterns were done for

147 lakes, correlations of zooplankton to most chemical parameters were done for 146 lakes, and comparisons of zooplankton to complete suites of chemical parameters (e.g., principal components analysis [PCA]) were done for 145 lakes.

1.2 ZOOPLANKTON METHODOLOGY

The objective of the zooplankton sampling was to achieve comparable estimates of community structure among lakes. The sampling design of this or any study imposes overall limitations on interpretation of results. The major limitations of this study were the use of a single mesh size, a single sampling location, and a single sampling date for each lake. Use of an 80-μm mesh net is a justifiable compromise for sampling both large and small species with moderate efficiency. Small, soft-bodied rotifers are underestimated with this net, but if abundant in a lake, they will still be caught. If a smaller mesh size is used, to improve capture efficiency of small rotifers, capture efficiency of larger species is reduced. Since large species of zooplankton can be important to aquatic food webs, even in low numbers, it was important for this study that a mesh no finer than 80 μm be used to sample the lakes.

The major focus of this study was to derive robust conclusions regarding variance among lakes and the relationship of zooplankton to water chemistry, not to evaluate within-lake (horizontal or seasonal) variability in zooplankton composition. Among-lake variance, however, can be judged significant only when contrasted with some measure of within-lake variance. This is particularly evident for abundance data (whether by species or body size) that involves a sample splitting and counting error in addition to lake sampling error. Therefore, each lake was sampled by three separate, vertical hauls of a net. These three samples were treated individually throughout analysis and therefore provide a measure of within-lake (within-site) variance. We further analyzed replicate subsamples for evaluation of sample splitting and counting error.

Zooplankton were sampled from each of 146 lakes with three vertical hauls of a Wisconsin bucket net (80-μm mesh). The net was lowered to 1 m from the lake bottom and pulled toward the surface at a constant rate of approximately 10 m/min. The three tows were made a few meters apart from each other. Zooplankton from each net tow were rinsed into separate 250-mL glass jars using deionized water (3 jars per lake). The contents of each jar was preserved with a buffered sugar formalin solution (final concentration in the jar was 10% formalin, 4% sucrose, and enough sodium acetate to give a pH of approximately 7.5-8.0. Each jar was labeled with the lake identification number, depth of tow, tow number (1, 2, or 3), date, and time of day.

The three replicate tows from each lake were analyzed separately. Each jar was first examined for taxonomic composition. Individuals were pulled out from the samples and examined using both a Zeiss stereoscope and a Zeiss Universal compound microscope. Examiners attempted to identify all individuals of Copepoda, Cladocera, Rotifera, and Chaoborus to species level. Major keys used included Stemberger (1979), Pennak (1978), Deevy and Deevy (1971), Edmondson (1959), and Cook (1956). In

addition, several minor keys were consulted, including Berner (1982), Megard (1967), and Frey (1980). For consistency, all taxonomic identification was done by the same person (A. Tessier), although C. Goulden was consulted regarding several problem taxa.

In addition to generating a comprehensive species list for each lake, an ocular micrometer was used to measure the sizes (body length) of each species in each sample. Generally, several size classes were designated for each species in each lake. This sizing step was done separately for each lake; we did not assume that the size classes for a given species were constant across lakes. Size classes were designated at 0.1-mm intervals for animals less than 1.0 mm total length, and in 0.2-mm intervals for larger animals. For all species, body length was designated as the maximum length minus caudal seta in Copepoda and minus tail spines in Cladocera.

Using the taxonomic and size class listing as a guide, each jar was then quantified for total abundance of organisms in each species and size class. Generally, if overall densities in the jar were < 300 individuals (excluding nauplii), the entire sample was counted. Otherwise, the jar was split, using a funnel splitter (George et al., 1984). For those jars that were split, approximately 15% were replicated (i.e., replicate splits were counted). This replication allowed estimation of precision for the combined splitting and counting methodology. Furthermore, since there were three jars for each lake, we were able to separate the counting error from the lake sampling error.

Samples (or split samples) were dispensed to a partitioned chamber and counted, using a Zeiss stereoscope equipped for magnification up to 75X. All splitting and counting was performed by one person (N. Roberts). Count data from a given lake were entered onto count sheets that had the species and size class listing for that lake. These sheets were examined for consistency and completeness before computer entry. We used REFLEX (1986) software operating on MS-DOS microcomputers for data entry and as a preliminary database manager system. The following information was entered into REFLEX.

- EPA-NSL lake identification code
- Jar code (3-digit code identifying sample bottle and replicate)
- Species identification code (4-digit code, including order, family, genus, and species information)
- Body size code (2-digit code for body length in mm)
- Subsample size (fraction of sample actually counted)
- Depth of net tow
- Lake number (assigned number 1-147) for tracking convenience
- Count (number of individuals of each species and size class)

A separate file contained header information about each lake: lake identification code, lake name, lake number, latitude, longitude, state in which lake was located, and chemistry cluster (see Appendix A). Raw counts were divided by fraction of sample counted and then divided by depth of tow to give values of abundance comparable among lakes of different depth. Units for abundance are thus the number of individuals per meter of net tow. Data files are currently available on REFLEX for use in rapid searching and for summarizing and exploring the data. Data files were exported to SAS (1985) on a VAX mainframe computer for final data management and statistical analysis. Some statistical analysis was also performed using SYSTAT (Wilkinson, 1986).

1.3 DATA FILES

Because some rare species were found in the initial taxonomic examination of samples, but were not abundant enough to be counted after sample splitting, we created a new data set in which we arbitrarily set the abundance of such rare species at 0.01/m/net tow. The original data set was left untouched. Next, two broadly different data sets were created from this new file. One file was based on taxonomy (species) and the other was manipulated to generate more reduced data sets. In the most reduced form, all species were lumped into major taxa groups (Rotifera, Cladocera, Copepoda, Crustacea, etc.). In a less aggregated form, species were lumped into genera and subgenera categories. This was largely a functional or ecological grouping.

Replicate counts from the same tow and replicate tows from the same lake were kept separate for analyses of counting and sampling precision and for calculation of species diversity and the proportion of each species in each tow. The averages of abundances and proportions of each species over the three replicate tows per lake were used for between-lake comparisons of abundance and community structure. Replicate counts were not used in forming these averages. A new file was formed containing these averages. The average abundance over three replicates of species noted in the original taxonomic scan but not in the quantitative count of the split samples (i.e., those with abundance arbitrarily set to 0.01 for individual samples) was typically not 0.01; however, the average abundances of these species was still less than the abundances of species recorded in the quantitative counts. The averages of diversity indices over the three replicate tows were used in between-lake comparisons of diversity.

These files were used as a basis for further analytical work. Various additional files were created in the course of the analysis, for example, adding factor scores from PCA, or adding selected chemical variables. The basic files used in the study were as follows. Species and genus codes used in coding data and naming variables are documented in Appendix B. Descriptions of the formats of these are contained in Appendix C.

- **ASCII files:** One record for each species occurrence in each sample:

- EPATSPE1.DAT and EPATSPE2.DAT: Finalized raw data files, each containing taxonomic data from half the lakes.

- SIZE.DAT: Finalized raw data file containing size data.

- **SAS files:** One record for each species occurrence in each sample (i.e., record structure is lake number, jar number combining information on replicate tows and replicate counts, species code, and density of that species in the tow, standardized for the volume of the tow, and the fraction of the total sample counted):

  - SIZE.SSD: Size data

  - EPATSPE.SSD: Taxonomic data with species recorded only in initial scan set to 0.01. The data from split samples can be recovered by setting all abundances of 0.01 to 0.

- **SAS files:** Matrix format, with one record for each tow or replicate count (i.e., record structure is lake number, jar number, and abundance of each of the 142 taxa in the tow, with 0 for species not recorded). Abundance of each species formatted as a separate variable:

  - EPASP.SSD: Taxonomic data with species recorded only in initial scan set to 0.01. The data from split sample counts can be recovered by setting all abundances of 0.01 to 0.

- **SAS files:** Matrix format with the abundances of species and proportions of species stored as elements of two arrays:

  - EPASPAR.SSD: Taxonomic data with species recorded only in initial scan set to 0.01. The data from split sample counts can be recovered by setting any array values of 0.01 to 0.

  - EPAMSPAR.SSD: Average of three replicate tows (replicate counts of single tows not included), including species recorded only in initial scan. The data from split sample counts can be recovered by setting any average abundances $\leq$ 0.01 to 0.

- **SAS files:** Special files used for data analysis:

  - EPACGPCA.SSD: Abundance of each of 38 major, nonlittoral genera and species groups (average over tows for each lake; variables R1 through R4 for rotifers, CL1 through CL12 for cladocerans, and COP1 through COP12 for copepods), first 10 factor scores from PCA of generic abundances, first 10 factor scores from PCA of chemical parameters, and selected chemical variables.

2. OBJECTIVES OF ZOOPLANKTON ANALYSIS

2.1 PRIMARY OBJECTIVES

This study had two broad objectives. In addressing both of these objectives, we considered organism abundance, species diversity, taxonomic composition (at various levels), and body size structure.

1. **Zooplankton patterns:** We attempted to characterize summer zooplankton communities for all lakes in the northeastern United States. Since the lakes had already been categorized by geographic region and water chemistry (as determined from samples taken in fall turnover), we examined the ability of these groupings to explain variance in community structure.

2. **Relationships with chemistry and morphometry:** We examined general relationships between summer zooplankton communities and summer water chemistry and morphometry, focusing particular attention on indices of acidification.

2.2 SECONDARY OBJECTIVES

Secondary objectives included the following.

- Assess functional shifts in zooplankton communities that are consistent with the observed structural shifts concordant with acidification.
- Evaluate zooplankton sampling and counting precision.
- Make recommendations concerning lake selection criteria for future, long-term monitoring of lakes.

2.3 STATISTICAL TECHNIQUES

2.3.1 Principal Components Analysis (PCA)

We used principal components analysis (PCA) to define gradients of community structure and environmental factors. The number of taxa and environmental parameters defines a huge number of correlations. Analysis using each of the taxa and parameters would have been unwieldy and would have created problems of separating real patterns from spurious correlations. PCA defines a set of principal components, each a linear combination of the raw variables. The principal components are orthogonal and ordered by their contribution to the total variance among all variables. There are as many principal components as raw variables, but the ordering allows the use of a small subset to encompass much of the variation in the original variables. Unless otherwise noted, PCA was performed on the correlation

matrix of the original variables (i.e., the original variables are standardized to unit mean and variance, so that the analyses do not give disproportionate weight to highly changeable variables.

In the remainder of the report, principal components derived from a specific PCA are referred to as factors. The value of any factor for a given lake is the factor score for that factor and lake. Different sets of factors are defined by different analyses; these are differentiated by context or by the use of consistent names for each set of factors.

PCA was used to describe community patterns in several ways. The original variables in each PCA were:

- Abundances (typically log transformed) of the major taxonomic groups (rotifers, cladocerans, calanoid copepods, cyclopoid copepods), of genera, or of species.
- Proportions (typically arc sine transformed) of major taxonomic groups, genera, or species.
- Indices of species richness and species diversity.

Some analyses were done over all zooplankton in a single PCA; separate analyses were also done over taxa within each of the four major taxonomic groups. The components derived in these analyses have been used descriptively, to summarize patterns of covariance among taxa, and analytically, to serve as dependent variables in analyses of community differences among the three ANC clusters and along environmental gradients.

PCA was also used to define environmental gradients, using the water chemistry and morphometry data collected in conjunction with the study. The resultant factors were used to analyze environmental variation within and between the three ANC clusters, and functioned as independent variables for analysis of zooplankton community/environmental relationships.

2.3.2 *Other Ordination Procedures*

Other algorithms, such as detrended correspondence analysis (DCA) and canonical correspondence analysis (CCA) were used to define community gradients. These procedures are useful for describing gradients involving unimodal patterns of taxonomic abundance along environmental gradients. These techniques are described in the sections of the report relating to their specific applications.

2.3.3 Tests for Differences between Zooplankton Communities and between Discrete Classes of Lakes

Differences in the abundances, proportions, and diversities of zooplankton taxa among the ANC clusters and the geographic subregions were determined using multiple analysis of variance (MANOVA). This statistical test analyzes differences among classes for a number of variables, assuming some

correlation in residual variance among the different variables. Analogous tests were performed using factors defined by various PCAs.

2.3.4 Tests for Relationships among Continuous Variables

The relationships between zooplankton abundance and environmental conditions were tested using multiple regression, with the abundance of zooplankton taxa or factor scores from community analyses as dependent variables, and chemistry factors as independent variables. Individual chemical parameters were not used in multiple regressions because of the extensive covariation among groups of chemical parameters.

3. RESULTS

3.1 QUALITY ASSURANCE

Of the original set of 150 lakes, only 147 were actually sampled in summer 1986. Furthermore, one of these lakes (1A1-015) was sampled for chemistry but not for zooplankton, leading to a final count of 146 lakes for this report. In 2 of the 146 lakes, only 2 net tows were made. Jar 2 is missing for Lake 97 (1C3-032) and jar 3 is missing for Lake 39 (1D1-056). One lake was sampled twice, but on different dates. Samples 128 and 129 are both from Lake 1B3-052. This second sampling has been treated as a different lake in the analyses of zooplankton community structure. The 147 different lakes are used in analyses of environmental gradients. The second sampling of Lake 1B3-052 (Lake 129) is deleted from most analyses of zooplankton/environmental relationships.

All available jars ([147 × 3] - 2 = 439) were completely analyzed without loss. Further, 52 jars were counted twice, using different split subsamples, for an estimate of splitting and counting precision. This process involved an overall counting replication of 35% of all lakes and 12% of all jars.

Precision was calculated separately for each species in each of the 52 replicates, according to the following formula:

$$P_{ij} = (A_{ij} - B_{ij} / X_{ij}$$

where: P_{ij} is the precision estimate for species i in jar j,
A_{ij} and B_{ij} are the counts of species i in jar j for the two replicate splits, and
X_{ij} is the mean count for species i in jar j of the two replicates.

This precision statistic was averaged across all species in a jar to obtain a single estimate of precision for each of the 52 replicated jars. Summary statistics on the 52 estimates of precision are provided in Figure 3-1 and Table 3-1. In both presentations, precision was calculated <u>including</u> all species and also <u>excluding</u> species below some variable abundance. In this way, we could explore how the precision estimate was affected by the rarity of a species. When all species were included, the grand mean precision was 0.569, whereas if only the more common species were considered (abundance > 8 individuals per meter net tow), a mean precision of 0.336 was achieved. This range of precision was somewhat high, but not alarmingly so, considering that both splitting and counting errors were combined in this estimate.

To better quantify the variance in abundance attributable to splitting and counting and compare that to the within-lake (sampling) and among-lake variance, we performed nested analyses of variance using Proc Nested in SAS. Tables 3-2 through 3-6 present the results of this analysis for total abundance and for abundance of major taxa. In these tables, CHEMGRP indicates the chemistry cluster

(ELS-I designation). In general, the splitting and counting error (subsample) was about 1% of the total variance in the samples, and the within-lake variance (samples) was about 5% on average. It is interesting to observe the low variance attributable to chemistry cluster (zero for Cladocera) compared to the high among-lake variance. Generally, these estimates suggest that sampling and subsampling errors were of negligible consequence in comparisons of zooplankton abundance among lakes. They further suggest that the major groups of zooplankton were sampled and subsampled with comparable precision.

To examine sampling error in more detail, we performed nested analysis of variance on the species richness data. We calculated species richness in two ways for this analysis. First, we considered the number of species with abundance > 1 individual per meter net tow (Table 3-7). Table 3-8 presents results for only the common species (abundance > 10). These results suggest that subsampling and sample errors are nearly comparable. Even when combined, they are not much more than 10% of the total variance. As with abundance, most variance in species richness was due to among-lake contrasts; however, large variation was attributable to chemistry cluster when less common species were considered (Table 3-7).

Tables 3-9 and 3-10 explore the partitioning of variance among lakes, samples, and subsamples separately for each water chemistry cluster. Tables 3-11 and 3-12 do the same for species richness. In general, these results suggest that sampling precision was similar across all water chemistry clusters. The only appreciable contrast was that the precision of abundance estimation was apparently less in acidic lakes due to greater variance in the among-samples (within-lake) component. Species that dominate in acidic lakes may exhibit greater horizontal variation.

3.2 DISTRIBUTION OF ABUNDANCE

As was apparent in Section 3.1, abundance data were log(e) transformed before analysis. The justification for this transformation, as opposed to some other or no transformation, is illustrated by power function plots of variance and mean abundance estimates. The slope of the relationship obtained by plotting log(e) mean versus log(e) variance for each species or sample provides information on the underlying distribution. If the slope is 1, then abundance is Poisson distributed (variance increases proportionate with the mean) and a square root transformation is appropriate. If the slope is 2, then a logarithmic transformation is suggested. When the slope is greater than 2, a negative power function is the appropriate transformation. Figure 3-2 presents the power function plot of variance to mean for all species calculated separately for each lake (among-sample, within-lake estimates). Figures 3-3 through 3-5 present the same information but for each water chemistry cluster separately. There is consistency in that a slope somewhat less than 2 but greater than 1.5 is evident in all figures. These plots strongly suggest that a log(e) transformation would normalize the data.

We also examined the distribution of species abundance among lakes. Figures 3-6 through 3-9 present the power function plots for among-lake variance versus mean abundance, where each point indicates a different species. Species that are very rare in the entire data set show a slope approaching 4. However, for the most common species (log mean abundance > 1), a slope of 2 is typical.

We concluded from this analysis that a log(e) transformation of the abundance data would be most appropriate in achieving normality. The success of this transformation is illustrated in frequency histograms of total abundance after log(e) transformation (Figure 3-10). An even more sensitive technique was to examine probability plots of the same data. We presented this information separately for each chemistry cluster (Figure 3-11). The distribution of abundance was similar in all chemistry clusters. With the exception of some skew associated with very low abundance, a normal distribution was evident.

3.3 ZOOPLANKTON PATTERNS

3.3.1 Abundance of Major Taxonomic Groups

Tables 3-13 and 3-14 present summary statistics for total abundance of zooplankton and abundance of major taxonomic groups for all lakes sampled. Both transformed and untransformed values are given. On a numeric basis, Rotifera were dominant, followed by Cladocera and Copepoda (excluding nauplii), which were of similar abundance. Tables 3-15 and 3-16 present the summary statistics of the four major groups of zooplankton (rotifers, cladocerans, cyclopoids, and calanoids) calculated separately for each water chemistry cluster. Box plots illustrate these results in Figures 3-12 through 3-15. There was a weak effect of water chemistry cluster on total zooplankton abundance (Table 3-17; $p = 0.055$), which was due to a low total abundance in chemistry Cluster 3 ($100 < ANC \leq 400$ μeq/L). However, there was no evidence of strong declines or increases in zooplankton abundance with increased lake acidity (Figure 3-12).

Univariate and multivariate analyses of variance did suggest evidence of changes in the composition of zooplankton communities attributable to water chemistry cluster (Table 3-18). Examination of this table and the figures reveals that, with the exception of the Cladocera and nauplii, all major groups show shifts in abundance across water chemistry clusters. Large decreases in cyclopoid abundance and large increases in calanoid abundance characterized Cluster 1 lakes.

Since only weak changes in overall abundance were detected across chemistry cluster, we converted the absolute abundance data to relative (proportional) abundances by dividing through by the total abundance in each lake. Proportions were arc sine square root transformed to help stabilize the variance among lakes. Figures 3-16 and 3-17 illustrate the proportional dominance of each major group for each chemistry cluster. Table 3-19 presents the results of univariate and multivariate analyses of variance of these major zooplankton groups partitioned by chemistry cluster. As was observed for the

absolute abundance data, all major groups except cladocerans showed radical shifts in dominance associated with water chemistry.

In order to better summarize variance in composition of zooplankton communities among the 147 lake samples, we performed PCA using the four major zooplankton groups. PCA was performed both on absolute abundance (log transformed) and on the proportional abundance data. For each approach, we standardized the variables (zooplankton groups) to zero mean and unit variance (using a correlation matrix). In this way, each group was treated as being of potentially equal importance in explaining overall variation.

Table 3-20 presents the results of PCA using the log transformed absolute abundance data. As shown in Table 3-21, water chemistry was important in explaining variance among lakes in each of the first three PCA factors. The first factor describes variance in overall abundance of cladocerans, rotifers, and cyclopoids contrasted to abundance of calanoids. The second factor was essentially abundance of calanoids, and the third factor largely describes variance in rotifers contrasted to abundance of cyclopoids. All three factors were apparently influenced by the large shifts in absolute abundance of calanoids and cyclopoids that occurred across clusters.

The PCA of the proportional data allowed us to focus on compositional variance in zooplankton communities, independent of variance in total abundance. Table 3-22 presents the PCA results for the major groups of zooplankton. A somewhat different pattern emerged from this analysis than from the previous PCA. The first PCA factor (explaining 50% of the compositional variance) describes variance in the dominance of rotifers versus crustaceans. The second factor describes the contrast between calanoid dominance and cyclopoid dominance. This second factor is analogous to the first two factors in the previous PCA. Not surprisingly, this second factor is strongly dependent on water chemistry cluster (Table 3-23). Calanoids predominate in the Cluster 1 lakes (Factor 2, Figure 3-18). Of great interest is the observation that the first PCA factor, clearly the largest gradient in composition of these communities, is essentially independent of water chemistry. There is only a slight and nonsignificant tendency for crustaceans to dominate in Cluster 1 lakes (Figure 3-18).

An important question to ask is, "To what extent are the apparent shifts in zooplankton community (as described for major taxa) robust with respect to geographic region?" The ideal would be for conclusions about the dependence of zooplankton communities on water chemistry to be independent of geographic region. This is comparable to a lack of statistical interaction between chemistry and region with regard to overall shifts in community. To answer this question, we performed cross-factored (3 chemistry clusters × 5 geographic regions), multivariate (4 major taxa) analyses of variance. Strong chemistry effects were expected (previous analyses), but with this analysis, we could determine whether the chemistry patterns we described were independent of region.

Tables 3-24 and 3-25 present the results of the cross-factored, multivariate analyses of variance for absolute abundance and proportional abundance, respectively. Regardless of analysis, no significant multivariate or univariate interactions were detected. Hence, regional and chemical effects on zoo-

plankton communities were independent at the level of major taxa. Strong chemical effects were again noted (see detailed analysis given previously), as well as a single strong regional influence. Calanoid copepods were distinctly less abundant in Region 2 (Poconos/Catskills). This contrast between Region 2 and the other geographic regions is illustrated in Figure 3-19. In terms of both absolute abundance and proportional abundance, there is a relative scarcity of calanoids in Region 2. It is interesting that the basic influence of water chemistry on calanoid abundance is not affected by this geographic influence. Table 3-26 shows how in all regions calanoids become more abundant in acidic (Cluster 1) lakes, but the overall mean is lower in each cluster of Region 2.

3.3.2 Species Richness

The number of species in a given lake was not generally predictable from information on abundance. We considered all species definitely observed in a lake, regardless of abundance, in our calculations of species richness (total number of species in sample). Over all 147 lakes, there was a tendency for species richness to decrease with species abundance ($r = -0.157$). However, on further examination, it was found that species richness was negatively correlated with abundance only in the Cluster 1 lakes ($r = -0.225$), and even in Cluster 1 lakes this relationship was nonsignificant. In lakes with ANC > 25 μeq/L (Clusters 2 and 3), there was no relationship between species richness and zooplankton density. In acidic lakes, large variance in abundance was somewhat attributable to a few species.

Summary statistics of species richnesses are presented in Tables 3-27 (all lakes) and 3-28 (separately by chemistry cluster). As is apparent from these tables, and even more clearly from Figure 3-20, species diversity of all major groups decreases dramatically in Cluster 1 lakes. There are, however, secondary patterns. Observe in Figure 3-20 that rotifer richness displays a tendency to increase in Cluster 2 lakes compared to Cluster 3 lakes. In contrast, crustacean richness declines monotonically with chemistry cluster.

To better synthesize the species richness data, we performed PCA on the richness of the four major taxonomic groups (Table 3-29). Factor 1 of this analysis describes variation in richness for all groups and explains 50% of the total variation. Factor 2, which describes variation in richness of calanoids, is the only other factor of major significance. Hence, variation in richness of calanoids appears to be somewhat independent of variation in richness of the other three major groups.

Having reduced most of the variation in species richness down to orthogonal factors, we performed a cross-factored, multivariate analysis of variance to test for the significance of chemistry cluster and geographic region in explaining this variation (Table 3-30). As expected from the univariate plots, there was evidence for strong influences of water chemistry. The univariate analyses suggest that much of the chemistry effect is acting on PCA Factor 1 (richness of all groups). Interpretation of this chemistry effect was confounded, however, by a strong regional effect and a marginal interaction effect. Interest-

ingly, the regional and interaction effects appeared to be driven largely by variation in Factor 2 (calanoid richness).

Figures 3-21 and 3-22 illustrate the relationship between PCA Factor 1 and geographic region and chemistry cluster, respectively. The marginal significance of region in explaining variation in Factor 1 appeared to be due to slightly greater richness in central New England (Region 3) and perhaps Maine (Region 5). The very strong decrease in richness associated with chemistry Cluster 1 (most acidic) lakes was much more apparent. Univariate analysis of variance of Factor 1 revealed no significant interaction between region and chemistry. The pattern of decreased species richness in Cluster 1 lakes was independent of geographic region.

The significant regional effect on PCA Factor 2 is illustrated in Figure 3-23. Region 2 scores lowest on this factor, which was interpreted as richness of calanoids. It was interesting that Region 2 was also significantly lowest in abundance of calanoids (see previous analysis of abundance patterns). Apparently, both richness and abundance of calanoids are reduced in the Poconos/Catskills region.

Factor 2 also showed a weak interaction between region and chemistry cluster. Graphical examination of Factor 2 plotted against chemistry cluster for each region revealed two distinct patterns. Figure 3-24 summarizes these findings. In Maine and the Adirondacks (Regions 1 and 5), Factor 2 (calanoid richness) declined in the less buffered lakes. In Regions 2, 3, and 4, there was no significant change in richness across chemistry cluster.

Summary statistics for species richness of major taxonomic groups calculated separately for each region are provided in Table 3-31. Consistent with the interpretations of the PCA Factor 2 patterns, calanoid richness in the Poconos/Catskills region was half that of the other regions.

To summarize the species richness analysis, Cluster 1 lakes are characterized by a much reduced richness of species compared with Cluster 2 or Cluster 3 lakes. This effect is independent of geographic region. A strong regional influence is observed, but is confined largely to calanoid richness.

3.3.3 Species Diversity

Species richness ignores what can be interpreted as large contrasts in the abundance of various species among samples. Species richness examines the data from a presence-absence view, whereas other measures of diversity take into account the relative abundance of each species. Indices of species diversity measure the evenness of species abundance within samples, as well as the total number of species; they may be more sensitive to changes in dominance and evenness among species and less sensitive to the occurrence of a few individuals of rare species than species richness. The following diversity indices were calculated for the average zooplankton abundances for each lake:

Shannon-Wiener $H = -\sum_{i=1}^{s} p_i * \ln(p_i)$

Simpson's $S = \sum_{i=1}^{s} p_i^2$

Ln(Simpson's) $L = \ln(S)$

where: p_i is the proportion of the ith species in the sample.

Indices were calculated for each tow; the average of the diversities for each of the three tows per lake (excluding replicate counts) were used in subsequent analyses. Indices were calculated for the entire zooplankton community and for each of the four major taxonomic groups (rotifers, cladocera, calanoid copepods, and cyclopoid copepods) using proportion of each species over all taxa or proportion over each group. The rare species with abundances arbitrarily set were included in the calculation of the indices. The contribution of these species to the estimated diversity of a sample is twofold: (1) the inclusion of sums associated with these species increases the estimated diversity, whereas (2) the decrease in proportions of other species by inclusion of the rare species decreases the estimated diversity. Thus for each index, the sum associated with these species is an overestimate of the contribution of these species to the estimated diversity for each sample. These sums were calculated for each sample and index and were found to form a very small part of the total sum. The arbitrary abundances used for these rare species do not affect the comparisons between lakes.

Summary statistics for the diversity indices (and species richness for comparison) for all species and for the four groups (Table 3-32) show that lakes in Cluster 1 (low ANC) tend to have lower diversity than lakes in Cluster 2 or 3. The differences between the clusters were generally significant (MANOVA, $p < 0.0001$). With one exception, ln(Simpson's) for rotifers, every comparison for all species, rotifers, cladocera, and cyclopoid copepods was highly significant (univariate $p < 0.0005$ unadjusted for the number of comparisons). In each of these significant differences, multiple comparison tests (Tukey's honest significant difference, and the Ryan-Einot-Gabriel-Welsch Multiple F test; SAS, 1985) showed Cluster 1 lakes to have significantly lower diversity than lakes in Clusters 2 and 3; diversity in lakes in Clusters 2 and 3 were not significantly different in any of these comparisons. There was a weakly significant difference ($p < 0.013$) in Shannon-Wiener diversity of calanoid copepods. The REGWF comparison indicated significantly higher diversity in Cluster 3 lakes than in Cluster 1 or 2 lakes. There also appear to be some regional differences in species diversity; the extent of variation in Shannon-Wiener diversity among regions and chemistry clusters is compared in Table 3-33.

These results closely parallel the differences in species richness and indicate that the diversity and richness of zooplankton communities of Cluster 1 lakes are significantly lower than those of Cluster 2 and 3 lakes, with the difference occurring through lower diversities of rotifers, cladocera, and cyclopoid copepods.

PCA was performed on the Shannon-Wiener diversity of each of the four taxonomic groups in each of the lakes to determine the extent of correlation in group diversity within each lake. Diversities of groups that are high or low in the same lakes should correlate together and with the same sign on the same principal components. The results indicate that the diversity of the four main taxonomic groups did not tend to be strongly associated, each with the others, although there is a general trend within each group for lower diversity in Cluster 1 lakes. This weak correlation is demonstrated in the plot of Shannon-Wiener diversity of cladocera versus that of rotifers (Figure 3-25), which shows no strong correlation.

To better interpret this variance in diversity, we used principal components to extract simpler trends in diversity of the four major zooplankton groups. Table 3-34 presents the results of the PCA for Shannon-Wiener diversity. In contrast with the results of the species richness data, the first two PCA factors were equally important in explaining variation in diversity. The first factor describes a contrast between diversity of rotifers and diversity of crustaceans. The second factor describes a contrast between the diversity of calanoids and diversity of other zooplankton. Together these two axes account for nearly 80% of the diversity variation. The change in calanoid diversity relative to other zooplankton diversity was noted in the species richness analysis. The equally strong gradient contrasting rotifer and crustacean diversity was not observed in the species richness analysis. This contrast suggests that many rotifer and crustacean species coexist in a large number of lakes, but that there is large variance among these lakes in the relative diversity of the two groups.

As shown in Table 3-35, we employed these first two PCA factors in a multivariate analysis of variance to examine the influences of chemistry cluster and geographic region and their interaction. Chemistry cluster was very significant in explaining variation in overall diversity (multivariate test statistic), whereas region and interaction effects were weaker. Examination of the univariate statistics suggested that PCA Factor 1 was influenced only by chemistry cluster, and even that is weak compared to the influence of chemistry on Factor 2. Hence, a strong gradient exists among lakes from rotifer diversity to crustacean diversity; this gradient is largely unaffected by chemistry or region. The one weak chemistry effect on this gradient is that in Cluster 2 lakes, rotifer diversity is generally higher than crustacean diversity (Figure 3-26).

Diversity Factor 2, contrasting diversity of calanoids to other zooplankton, showed strong chemistry and regional influences. Figure 3-26 illustrates how the chemistry cluster effect is due to large decreases in Factor 2 in Cluster 1 lakes (calanoid diversity remains high despite large decreases in diversity of other zooplankton). Figure 3-27 summarizes the location of all lakes in PCA Factor 1 and 2

space. We have labeled each lake according to cluster type in this figure. Notice that Factor 2 is important in separating out many of the acidic, Cluster 1 lakes.

Regional influence was interpreted according to Figure 3-28. The Adirondacks and Southern New England are distinctly lower in Factor 2 scores than other regions. Part of the explanation for the low mean score in the Adirondacks is due to the over-representation of Cluster 1 lakes in this region. The interaction effect of chemistry and region was examined by plotting scores for each cluster in each region separately. Our conclusion from this examination is that there are differences in the magnitude of cluster effects depending on region, but the general direction of change is consistent among regions.

3.3.4 Size Structure

In addition to taxonomic identifications, abundance data were also categorized by body size. Tables 3-36 through 3-38 summarize zooplankton abundance for all 147 lakes according to 0.2-mm size classes; for example, Size Class 1 includes animals < 0.2 mm and Size Class 2 includes animals between 0.2 and 0.4 mm. Logarithmic transformation of the data helped stabilize the variance among size classes, but apparent in Table 3-37 is the large decrease in variance (and mean) for size classes greater than Size Class 9 (> 1.8 mm). Also, since the proportional abundance of zooplankton in these larger size classes was negligible (Table 3-38), we excluded Size Classes 10 and larger from analysis.

Tables 3-39 through 3-41 present size class abundance as a function of chemistry cluster. On the basis of abundance, we recognized three groups of size classes. Animals < 0.4 mm were uniformly very abundant (rotifers, nauplii, and small cladocerans), followed next by animals between 0.4 and 1.0 mm, which were approximately one-tenth as abundant. Finally, animals > 1.2 mm were approximately one-one-hundredth as abundant as the small animals. A Kolmogorov-Smirnov test of distributional heterogeneity among chemistry clusters was nonsignificant. However, distributional tests are relatively insensitive in detecting heterogeneity in subsections of the overall distribution when these subsections comprise a small number of the overall counts. For example, Table 3-41 suggests increases in the relative abundance of animals > 1.0 mm with chemistry cluster. However, since the numbers of individuals in these size classes were so minor compared to the small organisms, they had little influence on the overall size distribution.

We treated each size class as a separate variable in a multivariate analysis of variance to examine for heterogeneity among chemistry clusters (Table 3-42). A highly significant effect of water chemistry was detected. Univariate tests suggest that this heterogeneity was caused largely by variance in medium- to large-size crustaceans.

We used PCA to reduce this variance into simpler factors (Table 3-43). The first four PCA factors successfully describe > 70% of the overall variance in size class distributions. The first factor is a simple abundance factor; all size classes loaded positively. The second factor (accounting for 20% of the total variance) describes a contrast between dominance of small (< 0.6 mm) and large (> 1.2 mm) size

classes. The third factor is a contrast of very small (< 0.2 mm) and medium size classes; the fourth factor represents a contrast between the two largest size classes.

Summary statistics for the first four size factors were calculated separately for each water chemistry cluster in Table 3-44. Multivariate and univariate analyses of variance of these four factors are given in Table 3-45 to test for both chemistry cluster and geographic region effects. Strong effects of chemistry cluster but only weak regional and interaction effects were evident. PCA Factor 1 was not influenced by either region or chemistry. Variance in Factor 2 was, however, strongly affected by chemistry cluster. As illustrated in Figure 3-29, there is a shift in the size structure between Cluster 3 and Cluster 2 lakes. Cluster 3 lakes are characterized by the presence of large size classes, compared to Cluster 2 or Cluster 1 lakes. Factor 3 was the only component in which both regional and chemical influences were seen. In general, lake scores on Factor 3 increased with chemistry cluster. The more acidic the lake, the greater the likelihood of dominance by medium size classes. The interaction effect of region and chemistry on Factor 3 was caused by lakes in Regions 2 and 4 (the most southern regions) each having a distinctly different score for Factor 3 than lakes in Region 1, 3, and 5. This difference is illustrated in Figure 3-30. In all regions, Factor 3 scores were lowest in Cluster 1 lakes. The contrast between Cluster 2 and 3 lakes depends on region.

To summarize the size structure analyses: There was no evidence of systematic effects of chemistry cluster or region on total abundance of zooplankton. The major component of variance in size structure among all lakes was a contrast between small and large size classes. This contrast was largely independent of geographic region, but was strongly influenced by water chemistry. Cluster 3 lakes were more likely to contain large zooplankton species than were Cluster 1 or Cluster 2 lakes. Finally, there was significant variance among lakes in the relative abundance of medium versus very small sized animals. This gradient was influenced by region, but regardless of region, Cluster 1 lakes were characterized by a relatively greater abundance of animals in the medium size classes.

3.3.5 Abundance of Major Genera

A complete listing of all species found in the samples (147 lakes) along with summary statistics on individual species abundance is provided in Appendix D. Also presented is a separate listing for each chemistry cluster. For several reasons, we decided to lump species into genera or subgenera, depending on ecological similarity, before analysis. First, the taxonomic certainty of several species was unclear (e.g., *Eubosmina hagmanni* and *E. tubicen* were not clearly distinguished). Secondly some taxa were not identified to species due to lack of adequate adult specimens (e.g., some *Ceriodaphnia* and cyclopoid specimens). Lastly, attempts to ordinate on the basis of species met with little success due to the complexity of the species-specific patterns.

We reduced the data set down to 38 genera by lumping species into genera and subgenera and eliminating taxa known to be benthic or littoral in habitat. The elimination of inappropriate taxa removed

only very rare species of Cladocera and rotifers. Taxa such as *Chydorus*, which were occasionally abundant in the plankton samples, were not eliminated. A listing of the 38 genera and summary statistics are provided in Appendix E.

To ordinate the 38 genera, we performed PCA using both absolute abundance (log transformed) and relative (proportional) abundance. We also explored results from using both the variance-covariance matrix and the correlation matrix in PCA. However, failure to standardize for the variance of each species (use of covariance rather than correlation matrix) focused most attention on the rotifers, due to their large variance in abundance. Since absolute and proportional data produced similar interpretations, we presented only the PCA results based on the absolute (log transformed) abundance standardized for mean and variance of each species.

Table 3-46 presents the results of PCA on the 38 major genera. Only 30% of the variance in all 38 genera is accounted for by the first four generic community factors. These first four factors all show a significant influence of chemistry cluster in univariate analyses of variance (results not presented). Factor 1 was correlated strongly with four rotifer genera (*Keratella, Trichocerca, Asplanchna, Polyarthra*), three cladocera genera, all of which have small body size forms (*Bosmina, Diaphanosoma, Daphnia parvula*), and the smallest size copepod (*Tropocyclops*). In addition, one calanoid genus (*Leptodiaptomus*) loads strongly, but negatively. Hence, Factor 1 can be interpreted as a gradient of lakes ranging from a diversity of small zooplankton on one end to a dominance of *Leptodiaptomus* at the other end. The effect of water chemistry on this factor is illustrated in Figure 3-31. Of interest is the observation that this factor shows a tendency to increase from Cluster 3 to Cluster 2 lakes before decreasing dramatically in Cluster 1 lakes.

Factor 2 was defined by the rotifers *Kellicottia* and *Conochilus*, the cladocerans *Leptodora* and *Sida*, two groupings of large-size *Daphnia*, and the cyclopoids *Mesocyclops* and *Eucyclops*. We interpreted this gradient as representing an ecologically different group of rotifers and relatively large-size crustaceans, compared to Factor 1. In general, Factor 2 scores decreased linearly across the chemistry clusters (Figure 3-31).

Factor 3 was defined by four crustacean groups that appear to change dramatically between Cluster 3 and Cluster 2 lakes (Figure 3-32). These groups were composed of the cladocerans *Diaphanosoma*, *Eubosmina*, and small *Daphnia*, and the cyclopoid *Mesocyclops*.

Factor 4 was positively correlated with several groups (mainly *Leptodora* and *Sida*) that also correlated positively with the second and third factors. However, the fourth factor was negatively correlated with several groups (*Gastropus*, *Conochilus*, the *Daphnia galeata* group, and *Skistodiaptomus*) that were positively correlated with the second or third factors. It is likely that the fourth factor represents residual positive or negative correlation among taxa remaining after their primary correlations were removed.

Remaining factors individually account for a relatively small among of variance in the data set and appear to express single genus trends or pairwise contrasts. We made no intensive effort to interpret these factors.

Interpretation of the first three generic factors was aided by examining the occurrence of individual genera across the three chemistry clusters. We offer the following interpretation. Cluster 3 lakes are inhabited by a diversity of rotifers and crustaceans, but are characterized by large-size species of *Daphnia*. In Cluster 2 lakes, there is a notable reduction of these large *Daphnia* and a comparable reduction in some rotifers (e.g., *Kellicottia*). However, other rotifers and several small-size cladocerans actually increased in importance in Cluster 2 lakes. We observe here that previous results illustrate an increase in diversity of rotifers in Cluster 2 lakes and a trend toward greater abundance. One genus of rotifer (*Keratella*) showed a dramatic increase in abundance in Cluster 2 compared to Cluster 3 lakes. Also, the major result of the size structure analysis was a loss of large-size zooplankton in Cluster 2 lakes compared to Cluster 3 lakes.

In Cluster 1 lakes, there was a reduction in all genera except the calanoid *Leptodiaptomus* (almost entirely the species *Leptodiaptomus minutus*). It is interesting to observe that the second major gradient identified in the size structure analysis was an increased dominance of medium-size (0.6-1.0 mm) animals in Cluster 1 lakes. *L. minutus* was apparently responsible for this size pattern.

We examined for interaction effects by region and by chemistry cluster by region on the first three generic community factors. As might be expected from the previous regional analyses, there were strong region influences on the first two PCA factors. However, there was no significant interaction effect of region and chemistry. We explore some of these regional effects in Section 3.3.6.

To better interpret some of the genera patterns in the data, we analyzed each of the three major taxonomic groups separately (rotifers, cladocerans, and copepods). Since genera within each group are more comparable in range of abundance, we used the covariance matrix in PCA. In this way, the results are affected by differences (variance) in abundance characteristic of each genus; rarer species are less important to the results. Tables 3-47 through 3-49 present the PCA results for copepods, rotifers, and cladocerans, respectively.

Approximately 75% of the variance in copepod composition is explained by the first three PCA factors. The first factor describes the contrast between *Leptodiaptomus* (mostly due to *L. minutus*) and the other major copepod genera. This factor was strongly influenced by region and chemistry cluster, but interpretation was clouded by the strong interaction effect (Table 3-50). Examination of each region separately reveals that the effect of chemistry cluster on Factor 1 was similar in all regions except Region 3 (central New England). Figure 3-33 shows this contrast. In all regions except Region 3, *L. minutus* became dominant in the Cluster 1 lakes to the exclusion of most other copepods. In Region 3, other copepods (especially *Skistodiaptomus* and *Mesocyclops*) remain important in Cluster 1 lakes.

Copepod PCA Factor 2 describes a gradient of abundance in *Mesocyclops, Tropocyclops,* and *Leptodiaptomus*. However, this gradient was independent of water chemistry and geographic region (Table 3-50). Factor 3 represents a contrast between *Mesocyclops* and *Tropocyclops* abundance. These two cyclopoid forms differ greatly in size but they also show a weak tendency to sort out along

chemistry cluster. *Tropocyclops* was less likely to be present in the more acidic lakes (results not presented), but this effect was weak and was also clouded by regional effects.

Nearly 50% of the variance in abundance of major rotifer genera were accounted for in the first two PCA factors (Table 3-48). Furthermore, both factors describe gradients in the rotifer data that were strongly affected by chemistry cluster, with only weak regional influences and no significant interaction effects (Table 3-51). Factor 1 describes overall abundance of the major genera of rotifers. Figure 3-34 illustrates how this factor changes with chemistry cluster. Observe that rotifer abundance increases in Cluster 2 lakes before a sharp decline in the more acidic Cluster 1 lakes.

Rotifer PCA Factor 2 contrasts relative dominance of two groups of genera: *Kellicottia* and *Conochilus* versus *Keratella*, *Trichocerca*, and *Asplanchna*. Figure 3-34 illustrates how Cluster 3 and Cluster 2 lakes are similar in relative composition of these genera. However, in Cluster 1 lakes, the latter three genera become relatively more important. Factor 2 was also dependent on geographic region (Table 3-51; Figure 3-35). The most northern regions (central New England and Maine) displayed higher mean scores for Factor 2, indicating a greater predominance of *Kellicottia* and *Conochilus* relative to *Keratella*, *Trichocerca*, and *Asplanchna*.

PCA of the Cladocera accounted for 47% of the variation in the first two factors. Factor 1 is a contrast of large *Daphnia* forms versus small forms (*Bosmina*, *Diaphanosoma*, and *Daphnia parvula*). As Table 3-52 shows, a weak regional influence on Factor 1 was due entirely to southern New England. Despite this influence, a strong chemistry cluster effect was obvious and is illustrated for the remaining regions in Figure 3-36. The loss of large *Daphnia* in Cluster 2 lakes compared to Cluster 3 lakes is seen in this figure.

Factor 2 from the Cladocera PCA describes a contrast of *Bosmina* versus *Eubosmina* and *Diaphanosoma*. It is interesting that chemistry cluster was not important in explaining variation in this factor (Table 3-53). However, geographic region was significant. Figure 3-37 illustrates how the two most western regions (Adirondacks and Poconos/Catskills) displayed lower Factor 2 scores, indicating increased importance of *Bosmina* compared to *Eubosmina* or *Diaphanosoma* in these regions.

3.3.6 Canonical Discriminant Analysis

In view of apparent taxonomic differences attributable to chemistry cluster, we decided to use discriminant analysis as a means of evaluating the uniqueness of each cluster. We performed discriminant analysis on the size structure, major taxonomic groups, species richness, and genera/subgenera data sets. In addition, we examined the use of both absolute abundance and relative (proportional) abundance data sets.

Discriminant analysis of the species richness, major taxa groups, and size structure was only partially successful. Only 52% of the lakes could be successfully assigned to the correct chemistry cluster on the basis of discriminant analysis of the major taxa groups. Analysis of size structure data

increased the percentage of successful classifications to 63%. A similar classification success was achieved using only the species richness data (61%). However, species richness data allowed correct assignment of Cluster 1 lakes in 88% of the cases. The dramatic declines in noncalanoid species richness in the Cluster 1 lakes clearly identify these lakes.

Although Cluster 1 lakes were easily recognized using only species richness data, Cluster 2 and 3 lakes were not readily distinguished without including more taxonomically explicit data. By using the 38 genera/subgenera data set, we were much more capable of defining all three chemistry clusters. Best results were obtained using the proportional abundance data, although qualitatively similar patterns and classification success were achieved with the absolute abundance. Table 3-54 presents the overall canonical correlations and taxonomic loadings for the two canonical factors. Table 3-55 summarizes the separation among the three clusters, achieved from this analysis, by presenting average Mahalanobis distances from each cluster to other clusters. Observe that Cluster 1 lakes are a little better defined (average distance of 1.077 compared to 1.304 and 1.33 for Cluster 2 and 3 lakes, respectively. However, the degree of separation of all three clusters from each other suggests a linear ordering to the clusters, with the distance between Clusters 1 and 2 similar to that between Clusters 2 and 3.

The degree of separation of the clusters on the basis of these two canonical factors is illustrated in Figure 3-38. Observe that canonical Factor 1 was mainly responsible for separating lakes in Cluster 1 from those in Cluster 3. Cluster 2 lakes, however, overlap with both Clusters 1 and 3 along this first factor. Factors 1 and 2 together help define Cluster 2 lakes.

An 82% successful classification of all lakes was achieved from this analysis. Table 3-56 summarizes the classification of lakes based on the two canonical factors. Notice that 90% of the Cluster 1 lakes can be correctly identified as Cluster 1 on the basis of this analysis. Only 77% of the Cluster 2 lakes and 78% of the Cluster 3 lakes were successfully classified.

We attempted to use discriminant analysis to distinguish among the five geographic regions. However, as shown in previous analyses, regional influences were relatively weak. Table 3-57 presents the canonical correlations and loadings on each of the canonical factors. Consistent with our previous findings is the importance of contrasts between *Eubosmina* and *Bosmina* and between *Leptodiaptomus* and other copepods in defining the first three canonical factors. Classification success is summarized in Table 3-58. Overall, 77% of the lakes are correctly classified as to region in this analysis. The Adirondacks (Region 1), with its higher percentage of Cluster 1 lakes, has the highest classification success (83%).

3.4 PHYSICAL/CHEMICAL GRADIENTS

3.4.1 Description of Chemical Data and Statistical Methods

The chemistry cluster groups provide a discrete classification of continuous variation in ANC. Additional information on the relationship between zooplankton and water chemistry was gained through use of the measurements of chemical parameters. These allow analysis of gradients in ANC, as well as investigation of contributions of other chemical factors.

The validated data set on summer water chemistry analyses was used to develop measures of water chemistry for correlation with zooplankton community structure. The chemistry data set, named SUSFIM01, was provided in SAS format by statisticians at ManTech Environmental Technology, Inc. (formerly Northrop). We performed PCA to derive six statistically independent components that encompass the major sources of variation in water chemistry across the lakes. Most of the analysis focuses on the first four of these factors, which encompass most of the total variance and which are interpretable in terms of the original variables.

The chemistry data consisted of measurements taken at a single site, near the deepest part of each lake. Measurements were taken at one or more depths at each site as follows.

- The full set of chemistry measurements was taken at one or two depths at a single site within each lake. In shallow water (< 3 m), only one depth, 1.5 m below the surface, was used. Measurements were taken at 0.5 m below the surface in one lake of 1.1 m maximum depth. In stratified lakes, the full set was measured at 1.5 m below the surface and at the middle of the hypolimnion. In unstratified lakes, measurements were taken at 1.5 m below the surface and at 1.5 m above the bottom.

- Profiles of temperature and conductivity were taken at a series of depths 1 m apart, from 0.5 m below the surface to 1.1-1.7 m from the bottom.

- Dissolved oxygen (DO) was measured at 0.5 m below the surface, 1.5 m below the surface (where this depth occurred), and at 1.5 m above the bottom (in lakes > 3 m in depth). In stratified lakes, additional measurements of DO were taken at the top of the hypolimnion and, where present, at the middle of the metalimnion.

- For PCA, variables from the epilimnion sample (1.5 or 0.5 m below the surface) were used. In addition, several variables were calculated as measures of vertical heterogeneity; these used the conductivity, temperature, and DO profiles. Lake size and site depth (near maximum lake depth) were also used as variables.

- The following variables were used in PCA, with the code name in the SAS data set given in parentheses. PCA was done on the correlation matrix (i.e., variables were standardized in mean and variance), using the SAS algorithm. Unless indicated otherwise, the logarithmic transform (Y = natural logarithm [X+1]) of the raw data was used in the analysis because of the nonlinear relationships among many of the variables.

- Labile monomeric aluminum (ALDI98). This was calculated by subtraction from other measurements. A few negative values were present; these were set to 0. The log transform was used.

- Alkalinity (ALKA11) in units of μeq/L. The log transform ln(ALKA11+50) was used.

- Calcium (CA98), chloride (CL98), fluoride (FTL98), carbonate (HCO398), potassium (K98), magnesium (MG98), sodium (NA98), ammonium (NH498), nitrate (NO398), and sulfate (SO498), all in units of μeq/L, log transformed.

- Ratio of cations to anions (ANCAT98), log transformed.

- Dissolved organic carbon (DOC02), dissolved inorganic carbon (DIC02), dissolved oxygen at 1.5 m (DO_0151d), iron (FE11), manganese (MN11), total phosphorus (PTL11), and silica (SIO211), all in units of mg/L, log transformed.

- Conductivity at 1.5 m (C0151D), Secchi depth (mean of depth at disappearance and depth at reappearance (SECME98), temperature at 1.5 m (T0151D), hydrogen deposition in $g/m^2/yr$ (HDEP99), and turbidity (TUR02), all log transformed.

- Lake size (surface area in ha; LKSIZ99) and depth at measurement site (DPSIT1D), both log transformed. The value for depth (4.2 m) for Grass Lake was inconsistent with the depths listed for the sample depths (e.g., 4.5 m listed for depth at 1.5 m above bottom); the depth was considered to be 6.0 m.

- Field pH (PH02) and pH at 1.5 m (PH0151D), not log transformed.

- Depth of the aerobic layer (named DPAER) and proportion of the anaerobic layer (named RANAER). A DO concentration of 1.0 mg/L was considered to mark low oxygen conditions limiting most zooplanktors. The depth of the water column with DO > 1.0 mg/L was estimated from the oxygen profiles. Where no DO values were recorded $\leq$ 1.0, DPAER was set equal to the site depth. In shallow lakes with only one oxygen measurement, DPAER was also set equal to the site depth. In lakes with some DO measurement of 1.0 or less, the depth at which 1.0 was reached was estimated by linear interpolation between the two sample points with DO nearest (above and below) 1.0. The proportion of the depth of the anaerobic layer to the site depth was defined as RANAER; it is 0 for lakes with no anaerobic layer.

- Difference in DO between top and bottom of aerobic layer. The difference between surface DO (i.e., DO 0.5 m below the surface) and bottom DO was defined as DIFDO. The bottom DO was set at 1.0 for lakes with low bottom DO. In lakes with no DO < 1.0, the DO at the sample nearest the bottom (usually the DO 1.5 m above the bottom) was used. For shallow lakes in which only one DO measurement was taken, DIFDO was set to 0.

- Difference in temperature between the top and bottom of the aerobic layer (DIFTMP). This is calculated analogously to DIFDO, with two differences. In some lakes, the deepest point in the temperature profile was deeper than the 1.5 m above-bottom sample, and the temperature from the deepest profile was used as bottom temperature. In lakes with low DO, the temperature at the bottom of the aerobic layer was estimated from the nearest temperature profile point within the aerobic layer.

- Difference in conductivity between the top and bottom of the aerobic layer (DIFCON). This was calculated identically to the difference in temperature, using the conductivity profile in place of the temperature profile.

3.4.2 Comparison of Fall and Summer Data Sets

Correlations of zooplankton abundance with environmental parameters were based on the summer data set, that is, from one sampling time per lake. Since the responses of biological communities integrate conditions over periods of time, it is important to determine the robustness of the analysis of relationships between zooplankton and water chemistry. We analyzed the robustness by comparing the summer and fall data sets. We studied two related questions: (1) How similar are the patterns of covariation between chemical parameters within each of the two data sets? and (2) How similar are parameter values or gradient positions from the two periods for each of the study lakes? We performed analogous PCA on each data set, using the same variables, and compared the similarity of the results (correlations of raw variables with principal components and relative importance of the principal components) for the two data sets. Secondly, we calculated the correlations between factor scores for each lake for the two analyses; we also measured correlations between original parameters. These analyses indicated very strong correspondences between the two periods in the pattern of covariation of parameters and scores for the various lakes. The few differences between water chemistry measurements from the two periods could be accounted for by natural seasonal changes or by measurement variance.

The sampling design for the fall study differed somewhat from the summer design. Since fall sampling was done after lake turnover, less information was gathered on vertical variation. Temperature, dissolved oxygen, and conductivity were measured at points 1.5 m below the surface and at 1.5 m above the bottom, but detailed vertical profiles were not measured as in the summer. Other chemical parameters were measured at 1.5 m below the surface. Forty-nine lakes were chosen to be sampled three times during the fall; the second sampling corresponded to the survey time of the other lakes. Three of these could be sampled only once. For the comparison of summer and fall data, only one sampling period was used for each lake: the single, routine sampling for most lakes, the second sampling for the multiple-sampled lakes, and the early sampling for the three remaining lakes.

Two separate PCAs were performed on the summer and fall data sets, using the same variables described in Section 3.4.1, except that variables relating to vertical stratification (DIFTMP, DIFDO, DIFCON, RANAER, DPAER) could not be calculated for the fall data because of the different sampling procedure. The fall data set contains information on the difference between surface and bottom temperature, on DO, and on conductivity, but these are not identical to the summer variables that estimate differences between the surface and the bottom of the aerobic region. The stratification variables were not used in the comparison PCAs for either data set. Thus, the comparison PCA for the summer data set differs from that described in Section 3.4.1 in the exclusion of these variables. Because of missing values for some parameters for a few lakes, the two PCAs were done over slightly different sets of lakes.

The correlation structure of the two chemical parameters was similar for the two periods (Table 3-59). The first four principal components are correlated with the same parameters; in most cases, the

magnitude and direction of the correlations are very similar. In both periods, the first component is a hardness gradient, correlating positively with alkalinity, conductivity, calcium, DIC, carbonate, potassium, magnesium, pH, and total phosphorus, and negatively with aluminum. The directions of the gradients defined by the second component are different (i.e., parameters negatively correlated with the second component in summer are positively correlated in fall, and vice versa), but the basic correlation structure of the original variables is the same. For both periods, the second component reflects positive correlations between lake size, Secchi depth, and site depth, and between color, DOC, iron, turbidity, and total phosphorus, and negative correlations between parameters in these two groups. The third component in both periods is positively correlated with conductivity, chloride, sodium, sulfate, temperature, manganese, and potassium. In both periods, the fourth component is positively correlated with calcium, lake surface area, nitrate, sulfate, and depth. When stratification variables are included in PCA of summer data, they tend to correlate with the fourth component; see Section 3.4.1).

Some differences in the correlation structure for the two periods are noted (Table 3-59). Several parameters (e.g., magnesium, manganese, sodium, nitrate, turbidity, DOC, iron) correlate moderately with two of the first four components in one of the data sets, but with only one component in the other. A few parameters (i.e., ammonia, total iron) load strongly on one of the first four components only in one period. Dissolved oxygen is correlated differently between the two periods. It was strongly negatively correlated with the fourth component in summer, whereas in fall, it was moderately positively correlated with the second component and weakly negatively correlated with the fourth component. Silicate is also correlated differently in the two periods.

The relative importance of the principal components is also similar between the two periods (Table 3-60), with the first component accounting for 28% of the total variation in the summer and 31% in the fall, and the first four components accounting for 65% of the variation in the summer and 67% in the fall.

The factor scores for each lake are also similar between the two periods (Table 3-60) for the first five components. The correlation coefficient (R) for the first component is .96. The magnitude of the correlation for the second through fourth varies from .53 to .81. The correlation is negative for the second, reflecting the switch in polarity of the gradient in the two periods. These correlations were calculated over the 144 lakes for which all values were present in both data sets. Correlations between original parameters were done over all lakes for which that parameter was measured for both periods (usually 144 to 147 lakes). The correlations are also high between the values of the original parameters for each of the lakes (Table 3-60). The median correlation for the 26 variables used in the PCA is .82. The correlations are particularly high (> .95) for many of the parameters correlating with the first and third components (hardness and salinity parameters). A correlation was also calculated between DIFTMP (estimated difference in temperature between the surface and bottom of the aerobic layer) in summer and the surface-bottom temperature difference in fall; this was moderate (R=.59), even though the fall measurements were taken after turnover, which would disrupt temperature stratification.

A few parameters were poorly correlated between the two periods. Differences between the two periods could arise from a number of sources of variation. These differences may indicate seasonal changes in parameter values and patterns of covariation. However, since there is only one value per season, other sources of variation (horizontal spatial heterogeneity, short-term temporal variability, measurement error) would also contribute to the observed variation. The multiple sampling of some lakes in the fall study could be used to determine the relative importance of these sources. However, we did not conduct such an analysis, since it would have been peripheral to the major issue of robustness of the environmental gradients used in zooplankton analysis.

Dissolved oxygen was not highly correlated between the two periods. This finding probably represents true seasonal change, since summer values should be strongly affected by biological processes (production, etc.) and summer temperatures, whereas fall values would be affected by fall temperatures. Ammonia is poorly correlated and nitrate is only moderately correlated; these results may reflect low measurement precision or changes in nutrient relationships between summer and fall. As might be expected, most of the variables that were not highly correlated between the two seasons also showed different correlations with other parameters within each season.

The correlations between summer and fall scores for the first four principal components were high, as were correlations for individual parameters. For each of the first four components, correlations were higher for some of the parameters loading on the component than for the component itself. For example, correlations for alkalinity (.97) and calcium (.99) were higher than correlations for the first principal component (.96), which is correlated with these parameters within each of the seasons. The absolute value of the correlation for the second component is .71, lower than that for color (.81), DOC (.89), or site depth (.97). The correlation for the third component (.77) is lower than that for sodium (.95), chloride (.98), or sulfate (.97). Thus, some of the variation in principal component scores probably reflects temporal or other sources of variation in some of the constituent parameters. Because of their consistency, some of the original parameters may be more useful in defining gradients between lakes than the principal components.

The correlation analysis indicates that for most parameters, the position of each lake on environmental gradients defined by principal components or by single parameters is consistent over seasons. In particular, the main hardness gradient is well defined and stable, as defined either by the first principal component or by some of the original parameters.

3.4.3 Correlation between Physico-Chemical Parameters: Calculation of Chemistry Gradients and Relationships of Gradients to Original Parameters

The lakes were chosen and placed in the three clusters on the basis of measurements of ANC taken in ELS-I studies. The measurements of alkalinity, calcium, and pH taken during the ELS-II studies (Figures 3-39 and 3-40) indicate that the clusters generally separate lakes well on the basis of these

parameters, although there was some overlap between Cluster 1 and Cluster 2 lakes at alkalinities around 0 to 30 μeq/L. Within clusters, lakes were chosen randomly; for example, there was no relationship (Figure 3-41) between chemistry cluster (and therefore alkalinity) and site depth (which is close to the maximum depth of each lake). As expected, there was significant variation in parameters within clusters. Gradients were defined by PCA to identify correlated groups of parameters (e.g., alkalinity and pH) that are independent from each other (e.g., alkalinity and lake depth), in order to relate zooplankton community structure and abundance to the continuous variation in chemical parameters.

PCA was performed on the 35 variables described in Section 3.4.1. The first four principal components contained 60% of the total variation, and the first eight components contained 77%. The first four components are interpretable in terms of the original variables and were used as the primary measures of water chemistry (Tables 3-61 and 3-62). In the following discussion, only relatively large correlations (absolute value > 0.2, unless otherwise noted) between the original variables (or their log transforms) and the principal components are mentioned.

The first component (containing 24% of total variance) represents a water hardness gradient, with positive correlations with alkalinity, conductivity, DIC, carbonate, potassium, magnesium, and the two pH measures. Aluminum is negatively correlated (-.19) with this component, reflecting the decrease in aluminum with increasing pH (Figure 3-42). The plots of the factor scores versus measured alkalinity and pH (Figures 3-43 and 3-44) show the relationship between these parameters and the first factor. The dominance of this component reflects the selection of lakes to span a gradient in alkalinity. As expected, this component correlates strongly with the initial clustering (groups 1, 2, and 3) based on ANC. Cluster 1 lakes generally had PRIN1 values < 0; Cluster 2 lakes generally had PRIN1 values between -2 and 2; Cluster 3 lakes had PRIN1 values > 0.

The second component (containing 16% of total variance) can be considered a measure of dystrophy. It is positively correlated with lake size (Figure 3-45), Secchi depth, top-bottom temperature difference, site depth (Figure 3-46), and depth of the aerobic layer. It is negatively correlated with color (Figure 3-47), DOC, iron, phosphorus, and turbidity. Thus, high values represent deep, clear lakes with low iron and phosphorus concentrations and a deep aerobic layer.

The third component (containing 12.5% of total variance) can be considered a salinity gradient. It is positively correlated with chloride (Figure 3-48), sodium, and sulfate, as well as conductivity, temperature, and hydrogen deposition. It is negatively correlated with the anion/cation ratio. Most of the lakes with high values for this component are near the coast (coastal Maine, Massachusetts, Connecticut, and Rhode Island), whereas most of the interior lakes (e.g., Adirondack lakes) have low values, indicating that the salinity represents oceanic deposition. Figure 3-49 shows the relationship between chloride and distance from the coast (DISM99 from the chemistry data set); since most of the missing values represent interior lakes for which no distance was calculated, the figure underestimates the strength of the relationship. Road salting could contribute to the gradient (e.g., in interior lakes).

The fourth component (containing 7.7% of total variance) can be considered a measure of stratification and vertical heterogeneity. It was positively correlated with the difference in temperature and DO (see Figure 3-50) and negatively correlated with the difference in conductivity (reflecting greater conductivity in deeper water). It was positively correlated with site depth and proportion of the anaerobic layer to total depth. This component reflects the greater opportunity for heterogeneity in deeper lakes. This pattern is reinforced by the way DIFTMP, DIFDO, DIFCON, and RANAER are calculated: in shallow lakes with only one sample point, DIFTMP, DIFDO, DIFCON, and RANAER are automatically set to 0.

PCA was also performed using different sets of chemical parameters (e.g., without the four parameters defining vertical heterogeneity and the aerobic/anaerobic layer) and with different transformations of some variables. These had some effect on the results, but the basic patterns were similar: the parameter loadings on the first three factors were similar; the first component was always a hardness gradient. In some analyses, the relative importance of the dystrophy and salinity gradients varied; that is, in some versions, the salinity gradient was the second factor. The higher factors of the final PCA (e.g., the fourth) were strongly correlated with the vertical heterogeneity parameters; obviously, higher factors in models without these parameters differ. In general, these various analyses indicate that the gradients defined by the environmental parameters are robust with respect to the precise details of the PCA.

For ease in graphical display, indices were defined based on the values of the first four principal components for each lake:

Index	Value of Principal Component
0	≤ -4.0
1	-4.0 to -2.0
2	-2.0 to -1.0
3	-1.0 to 1.0
4	1.0 to 2.0
5	2.0 to 4.0
6	≥ 4.0

The values of these indices are plotted on schematic maps of the study lakes to indicate possible regional differences in water chemistry (Figures 3-51 through 3-54). For comparison, the same maps are shown labelled by cluster (Figure 3-55) and subregion (Figure 3-56). The first component (hardness) shows some regional differentiation, although a range of values is found within each region (Figure 3-51). Most of the Adirondacks lakes (Subregion A) have low PRIN1 values, whereas the Subregion B lakes (southern New York, Pennsylvania, and New Jersey) have mainly high values. The other regions have a range of PRIN1 values.

There is only weak regional differentiation (Figure 3-54) in the second component (dystrophy). Low values (more dystrophic) are more prevalent in Subregion B (Figures 3-52 and 3-56), whereas high values are more prevalent in Subregion E (Maine lakes).

As expected, the third component (identified as a salinity gradient) shows strong regional differences (Figures 3-53 and 3-56). High values are noted for Subregion D (mainly coastal lakes in Massachusetts, Connecticut, and Rhode Island). High and moderately high values are seen in Subregions B (Southern New York, Pennsylvania, and New Jersey) and C (southern New Hampshire and southern Maine), and in coastal parts of Subregion E (Maine). Values are mostly low or moderate in the Adirondacks and very low in the interior lakes in Maine.

There is only weak regional differentiation (Figure 3-54) in PRIN4 (depth and vertical heterogeneity). Values tend to be low in the interior parts of Subregion E and the eastern part of Subregion D (mainly coastal Massachusetts lakes), with a range of values in the remainder of the area.

3.5 RELATIONSHIPS BETWEEN PHYSICO-CHEMICAL GRADIENTS AND ZOOPLANKTON

The large number of taxa recorded, the number of chemical parameters measured, and the variety of types of relationships (linear, unimodal, threshold, etc.) allows a variety of measures of interrelationship. The number of possible correlations can promote spurious correlations. Six basic approaches to analyzing zooplankton and water chemistry were used to examine a variety of plausible relationships:

1. We examined the relationship between the major, independently defined gradients of community structure and water chemistry (representing covarying taxa and parameters). The principal components (called the community factors) of the generic analysis and the water chemistry analysis were used as the major gradients. These have the advantage of independence, providing robust multiple regressions between components. Detrended correspondence analysis of the zooplankton communities was also used to define community gradients; this may be more effective where species patterns are not monotonic over the environmental gradient.

2. We examined the relationships between major gradients of community structure and selected water chemistry parameters. This may be advantageous if some of the chemical parameters are irrelevant to community structure or if the one-time measurements do not provide reliable estimates. The variation in these parameters affects the overall gradients in chemistry, but weakens any relationships between the community and chemistry gradients. Only a few selected parameters (pH, alkalinity, calcium) were used, to avoid the spurious correlations likely with large numbers of comparisons.

3. We examined the relationships between individual taxa and major water chemistry gradients. These are more easily interpreted in terms of the biology of individual taxa and do not depend on the validity of the algorithm for calculating community gradients.

4. We examined the relationships between individual taxa and selected water quality parameters. These are the most direct type of analyses and the most easily interpreted, but they also

provide the greatest opportunity for spurious correlation. They are used mainly to demonstrate the importance of unimodal responses to environmental gradients and to aid in the interpretation of the gradient-based approaches.

5. We defined gradients of zooplankton community structure and water chemistry relative to each other to maximize correlation between the two types of data. Although potentially the most concise and powerful approach to relating the two data sets, this approach is the most procedure sensitive. We used two statistical approaches. One, canonical correlation, appeared to be ineffective because of prominent unimodal relationships between taxa abundance and water chemistry gradients. Preliminary analysis has been conducted using canonical correspondence analysis, which is designed to detect unimodal responses.

6. We analyzed relationships of species richness and diversity to chemistry gradients and parameters.

3.5.1 Relationship between Zooplankton Community Factors and Environmental Gradients

The first 4 zooplankton community factors (based on PCA of the 38 genera and species groups) were regressed against the first 6 chemical factors, using the maximum r^2 improvement procedure (SAS, 1985), which picks the best set of independent variables for models with any given number of variables. For all four community factors, there was a significant ($p < .0001$) regression with the first chemistry factor (hardness). This chemistry factor was the best variable in all one-variable models and appeared in all models with more than one independent variable. The second chemistry factor was significant in regressions with the first ($p < .0001$) and third ($p < .01$) community factors. The third, fifth, and sixth chemistry factors were significant only in regressions with the third chemistry factor. These regression results are summarized in Table 3-63. These results support the earlier finding that zooplankton community structure is correlated with hardness parameters, and suggest the influence of other chemical factors as well. However, despite the significant relationships, model fit was generally poor (< .13 for single variable models and only .27 for the one significant five-variable model). The plots of the generic factors versus the chemistry factors also demonstrate the relatively weak relationship between these factors (Figures 3-57 through 3-63).

Analysis of the relationships of community factors and individual genera with individual chemical parameters suggests that the poor model fit results from at least three causes. First, the chemistry factors include variation of some parameters of little apparent relevance to community structure, so the relationship of community data with chemistry factors is weaker than the relationship of the community data with individual parameters. Second, the relationships between the abundance of most genera and water chemistry are non-monotonic, so the community factor-chemistry factor regressions ineffectively model the complexity of the relationships. Third, in many cases, genera may be abundant only in lakes with a restricted range of water chemistry conditions; however, these genera are often absent from lakes within the suitable range of chemical conditions. The first two complications relate to statistical methodology; the third may be caused by sampling error, but it probably reflects the importance of

other factors in determining the occurrence and abundance of the genera. These complications can be illustrated by comparing the relationships between community factors, generic abundance, chemical parameters, and chemical factors.

The relationships between the community factors and the hardness gradient are shown by the significant regressions with the first chemistry factor (Figures 3-57 through 3-60). On the other hand, the community factors may be related directly to individual parameters, such as alkalinity (Figures 3-64 through 3-67). For these plots, positive slopes signify higher abundances at higher parameter levels for genera positively loading on the community factors (Table 3-46) and lower abundances at higher parameter values for genera negatively loading on the community factors. These relationships are tighter than those with the first chemistry factor. The first community factor is seen to consist of genera with a modal response (Figure 3-64); the first factor scores are highest in some of the mid-alkalinity lakes, lowest in the low alkalinity lakes, and low in many of the higher alkalinity lakes as well.

In contrast, the second community factor shows a more monotonic relationship with alkalinity (Figure 3-65), with factor scores increasing from low alkalinity to high alkalinity lakes. The third community factor (Figure 3-66) also shows a pattern of increasing factor scores in higher alkalinity lakes, but there is little trend in factor scores over a broad range of alkalinity. Most of the low alkalinity lakes have low third factor scores, whereas most of the high alkalinity lakes have high scores. Lakes of moderate alkalinity are highly variable in the abundance of these genera. Scores on the fourth community factor (Figure 3-67) are low in some of the lakes with highest alkalinity, whereas there is little difference over the range from low to moderate alkalinity.

For three of the four factors, community factor scores are low in low alkalinity lakes. All four community factors differ in relative abundance at various regions of higher alkalinity. Given the correlations between alkalinity and other parameters, similar relationships may be expected between community factors and these parameters. For example, the relationship between the first community factor and pH (Figure 3-68) shows the occurrence of high factor scores at lakes with intermediate pH; considering the range of pH among low alkalinity lakes and the range of alkalinity among high pH lakes, the pattern is similar to that between the first community factor and alkalinity. As noted above, the covariation of many of the individual parameters prevents inference about the relative importance of each parameter in producing the community factor-parameter correlation, unless there are strong differences in the strength of the correlations.

The points in Figure 3-57 through 3-68 are labelled by chemistry cluster for each of the lakes. These figures demonstrate the clear differences in community structure among the clusters (see Section 3.3). They also show extensive heterogeneity within the clusters. Lakes in Cluster 1 are especially heterogeneous in the second and third community factor scores. The heterogeneity in the second factor scores appears to be correlated with alkalinity differences within these lakes. Cluster 3 lakes are especially heterogeneous in first, second, and fourth factor scores. The heterogeneity in fourth factor scores is clearly correlated with alkalinity differences within these lakes. Cluster 2 lakes are very

heterogeneous in community factor scores for all four factors. Third factor scores appear weakly correlated with alkalinity differences within Cluster 2 lakes, but the heterogeneity is otherwise unrelated to alkalinity.

We observed significant correlations between the first and third community factors and the second chemical factor. However, these relationships are not more easily interpreted in terms of the parameters that form the second chemical factor (e.g., color, site depth). Whereas factors other than the alkalinity gradient appear to affect zooplankton community structure, these factors are not identifiable as single chemical parameters.

3.5.2 Relationships between Genera and Environmental Gradients

Since the first four community factors were significantly correlated with the first chemical gradient (interpreted as a hardness gradient), correlations were also expected between species loading strongly on these community factors and alkalinity. The relationships between zooplankton abundance and alkalinity for most common genera show (1) a unimodal response, with each group occurring mainly in a specific range of alkalinity, and (2) a variability of occurrence within these suitable ranges. The rotifer genera *Trichocerca*, *Keratella*, *Asplanchna*, and *Polyarthra* are moderately correlated with the first community factor. The abundances of these genera along the alkalinity gradient (Figures 3-69 through 3-72) show most occurrences and peak abundances occurring in lakes with low to moderate alkalinity (e.g., 0-100 μeq/L). For comparison, the relationships between the abundance of *Trichocerca*, the first chemical factor, and the first community factor are shown in Figures 3-73 and 3-74. The occurrence of these species in lakes with low to moderate alkalinity is consistent with the relationship between the first factor scores and alkalinity (Figure 3-64), with high scores found mainly in Cluster 2 lakes.

The rotifer *Kellicottia* shows a similar pattern along the alkalinity and first chemical gradients (Figures 3-75 and 3-76). However, it is correlated primarily with the second community factor (Figure 3-77), indicating that, although found in similar alkalinities as the other rotifer genera, it was usually found in different lakes within that alkalinity range.

The cladocera *Eubosmina*, *Diaphanosoma*, and *Daphnia parvula* and the cyclopoid copepod *Mesocyclops* are correlated (negatively) with the third community factor (Figures 3-78 and 3-79); *Mesocyclops* is also correlated with the second community factor. These are also most common in low to moderate alkalinities (Figures 4-80 through 4-87), but within a somewhat different range than the other genera.

The *Daphnia galeata* group correlates negatively on the fourth community factor. Unlike most of the other groups discussed, it showed highest abundances at high alkalinities (Figure 3-88).

The most frequent and abundant calanoid copepod was *Leptodiaptomus*. It tended to show a monotonic relationship with alkalinity and the first chemical factor (Figures 3-89 and 3-90), being most

common at very low alkalinities (i.e., mainly in Cluster 1 lakes). It was not strongly correlated with any single community factor, but was weakly correlated with the first and fourth factors.

The abundances of several genera were also correlated with site depth, which is not highly correlated with alkalinity (Figure 3-41). *Keratella*, *Diaphanosoma*, the *Daphnia parvula* group, and *Leptodiaptomus* were rare or absent in deep lakes (Figures 3-91 through 3-94). A similar pattern is seen for all rotifers (Figure 3-95). This relationship explains some of the variability of occurrence of these groups within ranges of suitable alkalinity.

Plots of both the community factors and many of the individual taxa versus alkalinity formed clearer patterns than the corresponding plots based on the first chemical factor. This suggests that some of the variation on parameters forming the hardness gradient are not as relevant to zooplankton community structure as alkalinity. This may result from lack of causal relationship between some parameters and zooplankton, from measurement errors in these parameters, or from the inadequacy of the one-time measurement of these parameters for correlation with zooplankton abundance. This does not imply that alkalinity is the best parameter for correlation or that it is the causal basis of the observed relationships. For example, the concentration of calcium is strongly correlated with alkalinity. Relationships between abundance of genera and calcium are similar to those described for alkalinity; however, the correlation between alkalinity and calcium is weakest for high values of both. Many genera are rare or absent in lakes with high values, so that the differences between the two parameters do not greatly affect correlations with genera.

The unimodal nature of the abundance-alkalinity relationships for many species affects the calculation and interpretation of the community gradients. For example, the correlation of abundance between two taxa with overlapping but distinct modes would be complex: they would be positively correlated over the regions in which both occur and in which neither occurs, but would be negatively correlated over the regions in which only one occurs. As a result, each taxon may load on several principal components. Thus, the major community gradients show the general partitioning of taxa across the environmental gradients and do not indicate the taxon-specific responses, which are shown by the single-taxon analyses.

We also performed multiple regressions using the ordinations of each of the three major zooplankton groups separately. Principal component Factors 1 through 5 from the analyses of genera of rotifers, cladocerans, and copepods, each performed separately, were the dependent variables. The first four physical/chemical PCA factors were the predictor variables. We also included ANC, lake depth, lake size, and depth of aerobic zone as predictor variables. These latter variables were included in an effort to maximize the chances of achieving a significant relationship between the genera PCA factors and the environment.

All significant regressions from these analyses are summarized in Table 3-64. A significant amount of variance in the first two rotifer PCA factors and the first copepod PCA factor was explained by the predictor variables. Although also significant, less overall variance in cladoceran assemblages was

explained by this approach. The first four environmental factors, along with ANC, appeared to be important predictor variables. The relative significance of each varied greatly with the dependent variable being examined. For rotifer Factor 1, environmental Factors 1 and 3 were of major importance (Figure 3-96). For rotifer Factor 2, all four of the environmental factors were important. For the copepods and cladoceran Factor 1, environmental Factors 1 and 2 were of major significance. Figure 3-97 shows the relationship between copepod Factor 1 and environmental Factor 1. For cladoceran Factor 2, environmental Factor 3 was the most important, and for cladoceran Factor 3, environmental Factor 4 explained the most variance. Lake depth and aerobic zone size and depth did not make a negligible contribution to any of the regressions.

3.5.3 Relationship between Species Richness and Species Diversity and Environmental Gradients

Species richness and diversity change over the chemistry gradients, paralleling the absence or rarity of many species at the low and high ends of the hardness gradients. Overall species richness (Figure 3-98) increases steeply from low to moderate alkalinities, and then declines slightly from moderate to high alkalinities. A similar trend can be seen from the relationship with the first chemical factor (Figure 3-99). In addition, there is a weak negative relationship with the third chemistry factor (Figure 3-100). Similar patterns were observed for Shannon-Wiener diversity (Figures 3-101 through 3-103). Many of these trends are caused by changes in rotifer richness and diversity (Figures 3-104 through 3-109). Similar, though weaker, trends are also seen for the diversity of calanoid copepods (Figures 3-110 and 3-111) and cyclopoid copepods (Figures 3-112 and 3-113). No pattern was seen for cladoceran richness or diversity.

We compared the Shannon-Wiener diversity of each of the four major zooplankton groups to the physical/chemical PCA factors using Spearman rank order correlation. PCA Factor 1 was significantly positively correlated with cyclopoid (0.365) and rotifer (0.406) diversity. Calanoid diversity was negatively correlated with PCA Factor 1 (-0.40). The only other significant trend was a negative correlation between rotifer diversity and PCA Factor 3 (salinity, -0.225). PCA Factors 2 and 4 had no significant effect on the diversity of any group. There was no significant relationship between cladoceran diversity and PCA Factor 1.

3.6 INDIVIDUAL SPECIES PATTERNS

Although most of the patterns of zooplankton community structure were apparent at the genera/subgenera level (presented in Section 3.5), some species distributions enhanced or modified these conclusions. We examined most of the major species on an individual basis, but for brevity, we present only some of the most robust patterns here. First, however, it is important to recognize that there is a fundamental difference between common and rare species. We can define the commonness of species

either in terms of abundance among habitats, abundance within habitats, or number of occupied habitats. Figure 3-114 depicts a plot of various definitions of commonness against each other. Each species (rotifers, cladocerans, and copepods) is represented as a single point in each plot. There is a significant correlation between the number of habitats (lakes) occupied by a species and its mean abundance among all lakes ($r = 0.885$), or its mean abundance within those lakes it inhabits ($r = 0.652$). In short, common species not only are found in many lakes, but also are generally abundant in those lakes. It is useful to observe that despite these general correlations, there is still tremendous variation in the abundance of species inhabiting a certain number of lakes.

It is easy to identify the common species by scanning the first column of Appendix F. We examined patterns of distribution of each of these common species as a function of region, chemistry cluster, and physical/chemical gradients (PCA analysis). Many of the patterns resembled those observed for the genera/subgenera groupings. A few species, however, exhibited divergence from their mean, genus pattern. We present some of those exceptions here.

Figure 3-115 contrasts the abundance of the two most common species of *Keratella*, *K. crassa* and *K. taurocephala*, as a function of the first PCA factor from the physical/chemical ordination (ANC/pH/calcium gradient). *Keratella crassa*, typical of most rotifers, becomes most abundant in the Cluster 2 lakes characterized by intermediate scores on physical/chemical PCA Factor 1. In contrast, *K. taurocephala* reaches peak abundance in the most acidic Cluster 1 lakes, represented by negative scores for PCA Factor 1.

Figures 3-116 and 3-117 contrast the abundance of *Kellicottia longispina* and *K. bostonensis* along physical/chemical Factors 2 and 4. There is little difference in distribution of these two species along PCA Factor 1 (ANC); both prefer the Cluster 2 lakes. However, as shown in these figures, *K. bostonensis* achieves greater abundance in the more dystrophic and/or the more strongly stratified lakes compared to *K. longispina*.

A final contrast occurs between *Trichocerca multicrenis* and *T. cylindrica* (Figure 3-118). *Trichocerca multicrenis* appears capable of inhabiting more saline lakes (generally coastal) than *T. cylindrica*.

As with the rotifers, few Cladocera species displayed simple monotonic distributions along the PCA gradients. However, simple plots of abundance versus PCA factors show evidence of species having distinctly different ranges of peak abundance, especially with respect to physical/chemical PCA Factors 1 and 4. Figure 3-119 contrasts two species of *Daphnia*: *D. galeata mendotae* and *D. parvula*. *Daphnia parvula* is clearly more tolerant of less buffered, softer waters than is the larger species, *D. galeata mendotae*. *Daphnia catawba* broadly overlaps both these species, but in general it is more intermediate in distribution along PCA Factor 1. This replacement of large *Daphnia* by smaller *Daphnia* and other species contributes to the observed size structure shift. Another example, shown in Figure 3-120, is the replacement of large *D. galeata mendotae* by *Bosmina longirostris* along the ANC gradient.

For the cladocerans, distributions observed at the species level were not compromised greatly by being lumped into the higher taxonomic groups that we created for the previous analyses. We did need

to divide the genus *Daphnia* into three subgroups in order to maintain the integrity of the responses displayed by the different species. Distribution patterns of the cladoceran genera along physical/chemical PCA factors have already been presented.

In contrast to the rotifers and cladocerans, several species of copepods exhibited monotonic distributions across the major environmental ANC gradient. Figure 3-121 illustrates the distribution of the most common copepod, *Leptodiaptomus minutus*, along chemistry PCA Factor 1. Observe that this species, like *L. leptopus*, also shown in this figure, prefers acidic lakes. In contrast to these species are two cyclopoids, *Tropocyclops prasinus-mexicanus* and *Cyclops scutifer*, that display a clear preference for lakes of higher ANC (Figure 3-122). In general, cyclopoids were rare in acidic waters.

There was little indication that physical/chemical PCA Factors 2 and 4 (depth, color, stratification, etc.) explained much of the distribution of copepod species. This is in contrast to the rotifers and cladocerans, where Factors 2 and/or 4 were important influences on species and genus distributions. However, Factor 3 (salinity) was important for several copepod species, with perhaps the greatest segregation observed between the two species of *Epischura* (Figure 3-123). *Epischura lacustris* was restricted to the less saline lakes, whereas *E. nordenskioldi* appeared to prefer the more saline lakes. Similarly, other species showed salinity preferences, though these were weaker than those specifically noted.

3.7 CANONICAL CORRESPONDENCE ANALYSIS (CCA)

PCA proved quite useful in distilling variation within each of the major groups of zooplankton into simpler factors. In several places in this report, however, we indicate that the patterns of abundance of many species and genera were better described as bell-shaped (unimodal) rather than linear or monotonic with respect to the major physical/chemical gradients. PCA is most successful with linear gradients. Other ordination techniques are available that assume unimodal patterns and attempt to maximize the spread of species optima in ordination space. We used CANOCO, a FORTRAN program for correspondence and detrended correspondence analysis, to ordinate the major species and genera of rotifers, cladocerans, and copepods separately (ter Braak, 1987). Since our major goal was to describe variation in zooplankton communities in terms of the major physical/chemical factors, we employed canonical correspondence analysis (CCA) as a direct means of relating species abundance patterns to environmental factors.

We compared CCA, detrended CCA, and redundancy analysis results for each of the major groups of zooplankton. The first four PCA factors of the physical/chemical data were treated as the environmental factors of interest. Species level data were used, but occasionally, congeners were lumped into higher groupings, especially for the Cladocera. In all, 30 rotifer, 16 copepod, and 12 cladoceran groupings were used. Table 3-65 compares the eigenvalues and species-environment correlation coefficients for each analysis for each major zooplankton group. In all cases, CCA and detrended CCA

provided a better fit of species to the environmental factors (larger eigenvalues and larger correlations between species axes and environmental axes) than did redundancy analysis (constrained PCA). Hence, a unimodal model is better than a linear model in relating the zooplankton species abundance patterns to environmental gradients.

Figure 3-124 presents a plot of the major rotifer species and the four major physical/chemical PCA factors (environment factors). The major axes of this plot correspond to the first two species axes of the CCA. Table 3-66 presents the correlation coefficients of these first two species axes to the four environment factors. These four environmental factors are displayed on the plot as four arrows. The direction and length of each arrow represents the direction of change across the plot, and the strength of gradient of each of the four environmental factors. Hence, the plot summarizes the distribution of species with respect to each other and the major environmental gradients.

Figure 3-124 illustrates some of the major conclusions previously mentioned for the rotifers. Observe that the first species axis is strongly correlated with the first environmental factor (PCA factor for ANC, pH, calcium, etc.) The second species axis is strongly correlated with Factors 2 and 4 (color, depth, stratification intensity, etc.). Most species occur at intermediate levels on the ANC gradient, but acid loving species like *Keratella taurocephala* occur toward the 4:00 position. In summary, the major species axis is correlated most strongly with the first environmental factor (PCA Factor 1 = ANC). The second major species axis explains only half as much variation and is correlated most strongly with environmental Factors 2 and 4.

Figure 3-125 presents a plot of the major copepod species and the four environmental factors. The major species axis is correlated most strongly with the first environmental factor (Table 3-66). Observe that species such as *Leptodiaptomus minutus*, whose optima are in acidic waters, occur to the extreme left side of the plot. In contrast to the rotifers, environmental Factors 2 and 4 are not as important in explaining variance in copepod assemblages. Rather, the second major copepod axis is correlated strongly to environmental Factor 3 (salinity). Observe the extreme separation of the two *Epischura* species along this secondary axis.

Figure 3-126 presents a plot of the major cladoceran genera and subgrouping of *Daphnia* species. Species axis 1 of this plot is strongly correlated to the first three environmental factors (Table 3-66), whereas axis 2 is correlated with environmental Factor 4. In general, attempts to relate cladocerans to the environmental factors met with greater success than did the other zooplankton groups (Table 3-65). Unfortunately, this success depended largely on two genera, *Ceriodaphnia* and *Eubosmina*, the former of which was not very common in the samples. *Ceriodaphnia* occurred in lakes having a unique combination of environmental Factor 1 and Factor 3 scores. Similarly, *Eubosmina* occurred in a unique combination of the ordination space. The analyses presented in Figures 3-127 and 3-128 ignore *Ceriodaphnia* and both *Ceriodaphnia* and *Eubosmina*, respectively. Tables 3-67 and 3-68 present the eigenvalues and environmental correlations for these analyses. Observe that all four environmental factors are still important in explaining variation in these remaining cladoceran groupings (species axis 1).

Although the significant correlations presented in Table 3-66 argue for the statistical significance of the relationships between environmental factors and zooplankton assemblages, we further tested the robustness of these relationships by performing Monte Carlo permutation tests for the first species axis (first eigenvalue) of each analysis (ter Braak, 1987). In all cases, the first eigenvalue was significant at the $p < 0.02$ level.

In summary, CCA has revealed significant relationships among all four environmental factors and the pattern of zooplankton species abundance. It clearly demonstrates that optima for zooplankton species exist at different positions along the various environmental gradients; gradient of acidity (ANC, pH, calcium, etc.) is of major importance.

4. INTERPRETATIONS

In the analyses described in Section 3, we employed various approaches to examine patterns of zooplankton assemblages among lakes in the northeastern United States. We used two fundamentally different approaches: (1) analysis of variance, by chemistry cluster and geographic region, and (2) ordination, by principal components analysis (PCA) and canonical correspondence analysis (CCA).

Because lakes were preclassified as to chemistry and region, and because sampling was random (stratified random) within these groupings, results and interpretations from analyses of variance are valid in a general sense. The single most general conclusion of these analyses is that water chemistry (chemistry cluster) has a large and predictable influence on the composition of zooplankton assemblages. We use the word "predictable" because although some dramatic regional effects were observed, interactions of chemistry and region were generally minor, or at worst, were easily categorized. We emphasize the word "composition," since no significant effects of chemistry on abundance were observed.

Cluster 1 lakes (the least buffered) are essentially unique in zooplankton composition even when very crude measures of composition are used. They are characterized by increased calanoid abundance and diversity, decreased diversity of rotifers and cyclopoids, and dominance of a few acid-loving species. Discriminant analyses on the basis of size classes or major genera are equally successful in distinguishing Cluster 1 lakes as unique.

In composition, Cluster 2 and 3 lakes overlap much more than either group does with Cluster 1 lakes. On the basis of general taxonomic groups, it is difficult to separate these lakes. However, large shifts in the composition of major genera are apparent, and even significant separation in size structure is seen. Cluster 3 lakes are more frequently inhabited by large *Daphnia* species than are Cluster 2 lakes. Associated with the decreased importance of large *Daphnia* in Cluster 2 lakes is an increased diversity and abundance of rotifer species. Several crustaceans also have their peak abundances in the Cluster 2 lakes, rather than in the most buffered Cluster 3 lakes. However, many of these species are smaller in size than the *Daphnia* forms, which are much scarcer in Cluster 2 lakes. As a consequence, the size structure of Cluster 2 assemblages shifts to smaller forms in comparison with Cluster 3 assemblages.

Although discriminant analysis was able to achieve rather good separation of Cluster 2 and 3 lakes, it is apparent that information on the relative abundance of major genera (or species) is needed. Consideration of size structure or species presence/absence data alone would not be enough to resolve chemistry influences in this range of lakes. We emphasize that there is little change in overall diversity or species richness among Cluster 2 and 3 lakes; however, the compositional shifts are quite significant. Further, the size structure shifts are easily understood (causal understanding) as shifts in the abundance of particularly common species or groups of species. Size structure of assemblages did prove sensitive to chemistry, but its resolving power appears more limited than species data.

Although regional influences rarely confounded interpretation of chemistry effects, we note that some of these regional patterns were large and worthy of consideration in the design of future studies. Of particular interest are differences in central New England copepod assemblages, and the difference of the Poconos/Catskills calanoid assemblages from those of all other regions. The east-west segregation of *Bosmina* and *Eubosmina* also is of interest, since these species are taxonomically similar, yet have very different responses to environmental variables. There is some suggestion in the data that this segregation may be related to salinity.

The second approach of this study was one of exploratory pattern searching, or more precisely, attempts to relate zooplankton assemblage patterns to the measured physical/chemical (environmental parameters. We used linear models of PCA, multiple regression analysis, and redundancy analysis, and unimodal models of correspondence analysis and CCA and their detrended versions. A general conclusion is that regardless of analytical approach, substantial variation in the zooplankton assemblages can be significantly explained in terms of simple physical and chemical parameters. Furthermore, because the optima for many species are within the range of measured environments, unimodal models are more successful than linear models in describing assemblage variation. This is particularly true for the Cladocera, which, in contrast to the copepods, were successfully related to environmental variables only with a unimodal model.

Results of both linear and unimodal approaches emphasized the importance of chemistry gradients other than simply ANC (general pH, calcium, ANC gradient). For copepods, salinity was of considerable significance in understanding species distributions. For rotifers, lake depth, dystrophy, stratification intensity, and turbidity (summarized by environmental PCA Factors 2 and 4) were also important. All four of the major physical/chemical gradients were significant in describing variance in cladoceran assemblages.

A final conclusion from this study concerns the use of zooplankton in future monitoring of lakes with regard to chemical impacts. Sampling and subsampling precision were such that counting error appeared to have little influence on among-lake comparisons. In addition, within-lake variation (among samples) was small relative to among-lake variation. In short, zooplankton assemblages are relatively easy to sample and quantify with precision. Furthermore, the results of this and previous studies illustrate that zooplankton assemblages are very sensitive to water chemistry, and this sensitivity can be described with enough resolution to allow calibration of the zooplankton gradients to the chemical parameters. We have not explored such calibration in this report, but emphasize that it is a logical next step for use of these data.

5. GENERAL RECOMMENDATIONS

The most limiting aspect of this report is that fisheries data are not available for these lakes. Zooplankton assemblages are notoriously sensitive to the impacts of planktivorous fish. We strongly recommend that future sampling include an effort to quantify fish populations from the standpoint of intensity of planktivory. Even rank ordering data would be enormously useful. Along the same lines, it was apparent that additional biological variables, especially measures of phytoplankton abundance and type, would have aided in separating dystrophy from eutrophy gradients. Since the dystrophy gradient proved important in explaining variation in both rotifer and cladoceran assemblages, we recommend that future efforts attempt to refine this gradient.

Many of the chemistry influences on zooplankton assemblages were shown to be independent of region. We suggest that these gradients be employed to choose a smaller subset of lakes for longer term monitoring. Shifts in assemblage structure at the high end of the ANC gradient (Cluster 2 and 3 lakes) are particularly noteworthy. The loss of large *Daphnia* in Cluster 2 lakes needs more examination. This appears to be related more to calcium changes than to pH, according to summary statistics of Cluster 2 and Cluster 3 lakes.

We strongly recommend calibration as a statistical tool, using unimodal models. Even without fisheries data, CCA was able to find strong associations between the zooplankton assemblages and the environmental factors. If fisheries data were available, they could be treated as a covariate in these analyses, which should allow substantial predictability of water chemistry from zooplankton samples (or vice versa).

6. LITERATURE CITED

Berner, D.B. 1982. *Key to the Cladocera of Par Pond on the Savannah River*. Savannah River Plant, National Environmental Research Park Program, U.S. Department of Energy, Aiken, SC.

Cook, E.F. 1956. *The Nearctic Chaoborinae (Diptera: Culicidae)*. Technical Bulletin 218. University of Minnesota, Agricultural Experiment Station, Minneapolis St. Paul, MN.

Deevy, E.S., and G.B. Deevy. 1971. The American species of *Eubosmina* Seligo (Crustacea, Cladocera). *Limnol. Oceanogr.* 16:201-218.

Edmondson, W.T., ed. 1959. Ward and Whipple, *Freshwater Biology*, 2nd ed. John Wiley & Sons, New York.

Frey, D.G. 1980. On the plurality of *Chydorus sphaericus* (O.F. Muller) (Cladocera, Chydoridae), and designation of a neotype from Sjaelso, Denmark. *Hydrobiologia* 69:83-123.

George, D.M., M.A. Hurley, and B. Winstanley. 1984. A simple plankton splitter with a note on its reduced subsampling variance. *Limnol. Oceanogr.* 29:429-432.

Hillman, D.C., J.F. Potter, and S.J. Simon. 1986. *National Surface Water Survey, Eastern Lake Survey (Phase I - Synoptic Chemistry), Analytical Methods Manual*. EPA/600/4-86//009. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV. 158 pp.

Landers, D.H., J.M. Eilers, D.F. Brakke, and P.E. Kellar. 1988. Characteristics of acidic lakes in the eastern United States. *Verh. Int. Verein. Limnol.* 23:152-162.

Linthurst, R.A., D.H. Landers, J.M. Eilers, D.F. Brakke, W.S. Overton, E.P. Meier, and R.E. Crowe. 1986. *Characteristics of Lakes in the Eastern United States. Volume I. Population Descriptions and Physico-Chemical Relationships*. EPA/600/4-86/007a. U.S. Environmental Protection Agency, Washington, D.C. 136 pp.

Megard, R.O. 1967. Three new species of *Alona* (Cladocera, Chydoridae) from the United States. *Int. Rev. Gesamten Hydrobiol. Syst. Beih.* 52:37-50.

Omernik, J.M., and C.F. Powers. 1982. Total alkalinity of surface waters - a national map. *Ann. Assoc. Am. Geog.* 73:133-136.

Omernik, J.M., and A.J. Kinney. 1985. Regional alkalinity maps. U.S. EPA Environmental Research Laboratory, Corvallis, OR.

Pennak, R.W. 1978. *Freshwater Invertebrates of the United States*, 2nd ed. John Wiley & Sons, New York. 803 pp.

REFLEX. 1986. Borland/Analytica, Inc. San Rafael, CA.

SAS. 1985. Version 5 ed. SAS Institute, Inc., Cary, NC.

Stemberger, R.S. 1979. *A Guide to Rotifers of the Laurentian Great Lakes*. EPA/600/4-79/021. U.S. Environmental Protection Agency, Washington, D.C.

ter Braak, D.J.F. 1987. *Unimodal Models to Relate Species to Environment*. Agricultural Mathematics Group, Wageningen, The Netherlands.

Thornton, K.W., J.P. Baker, K.H. Reckhow, D.H. Landers, and P.J. Wigington, Jr. 1986. *National Surface Water Survey, Eastern Lake Survey - Phase II Research Plan*. U.S. EPA Environmental Research Laboratory, Corvallis, OR.

Wilkinson, L. 1986. *SYSTAT: The System for Statistics*. SYSTAT, Inc., Evanston, IL.

FIGURES FOR ALL SECTIONS

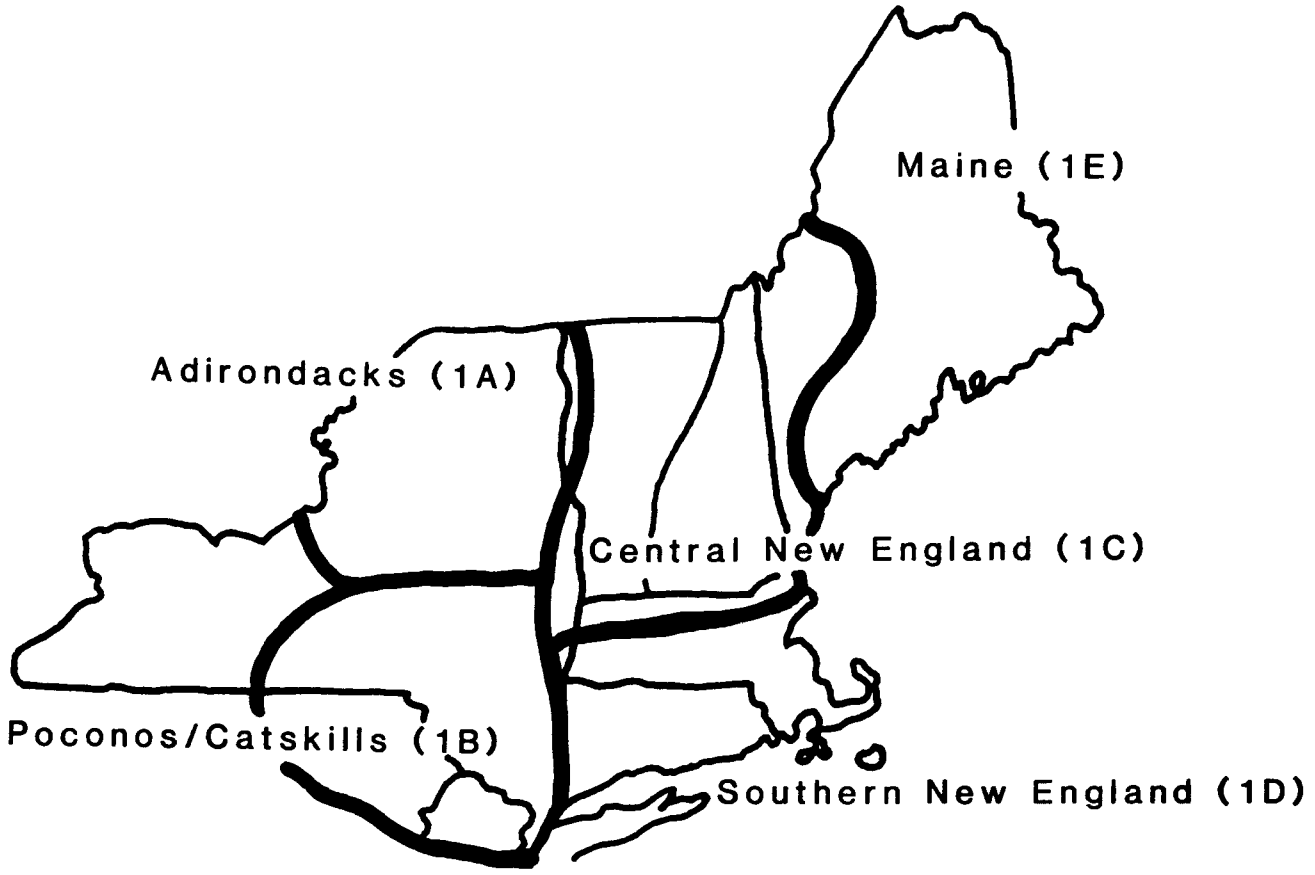


Figure 1-1. **Identification of five geographic regions used in the design of the sampling program for ELS-I and ELS-II of the National Lake Survey. Code in () identifies region association as part of each lake identification code (see Appendix A).**

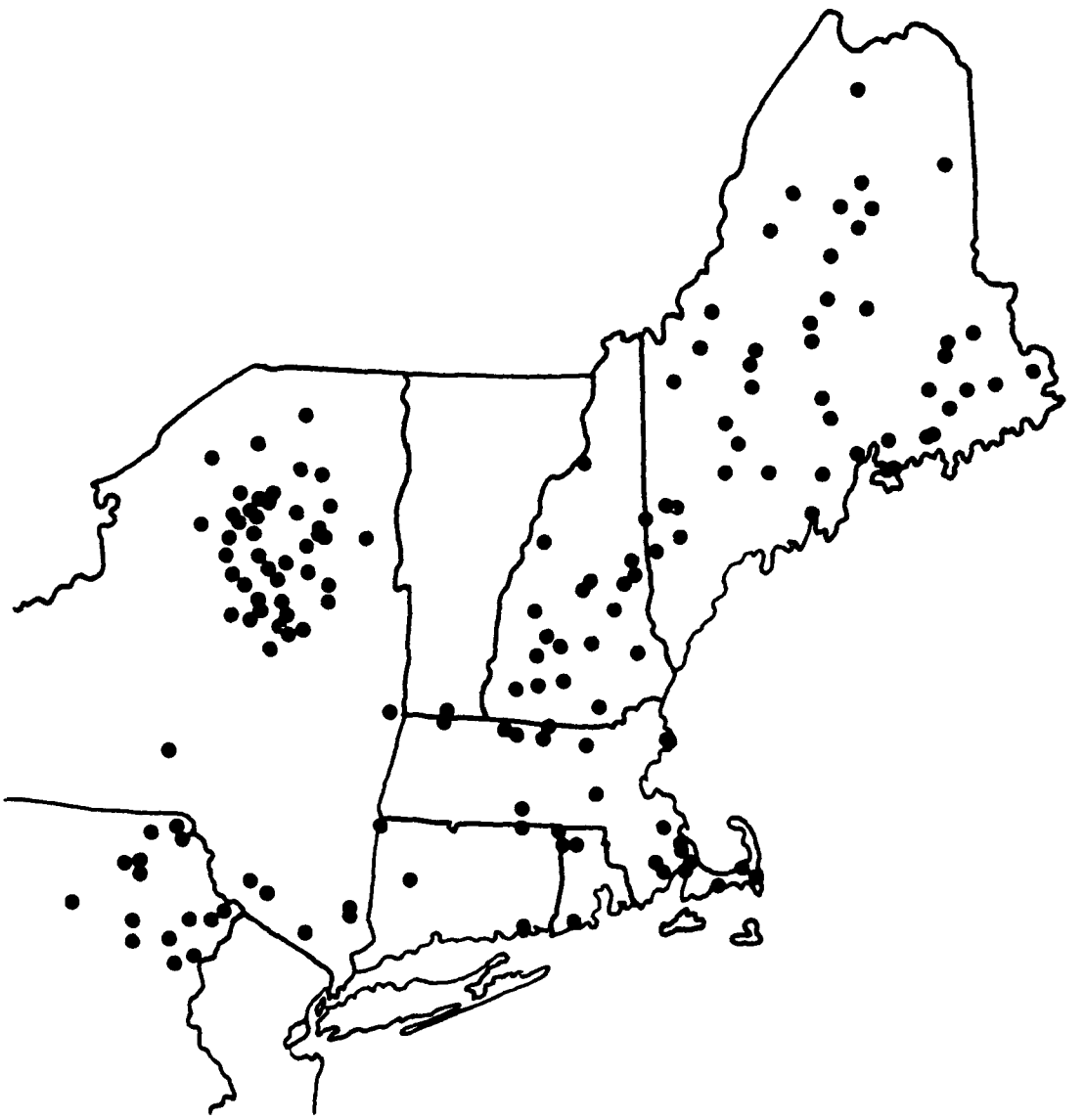


Figure 1-2. Location of initial 150 lakes picked for sampling in ELS-II. Final sampling of 147 lakes differs in some cases from this map due to substitution of alternate lakes.

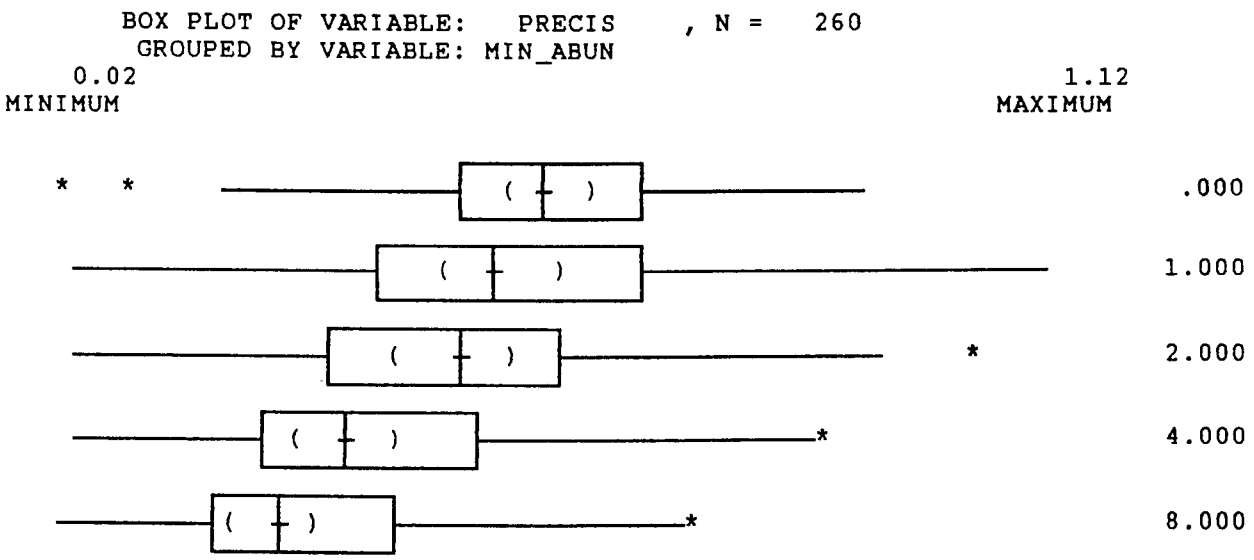
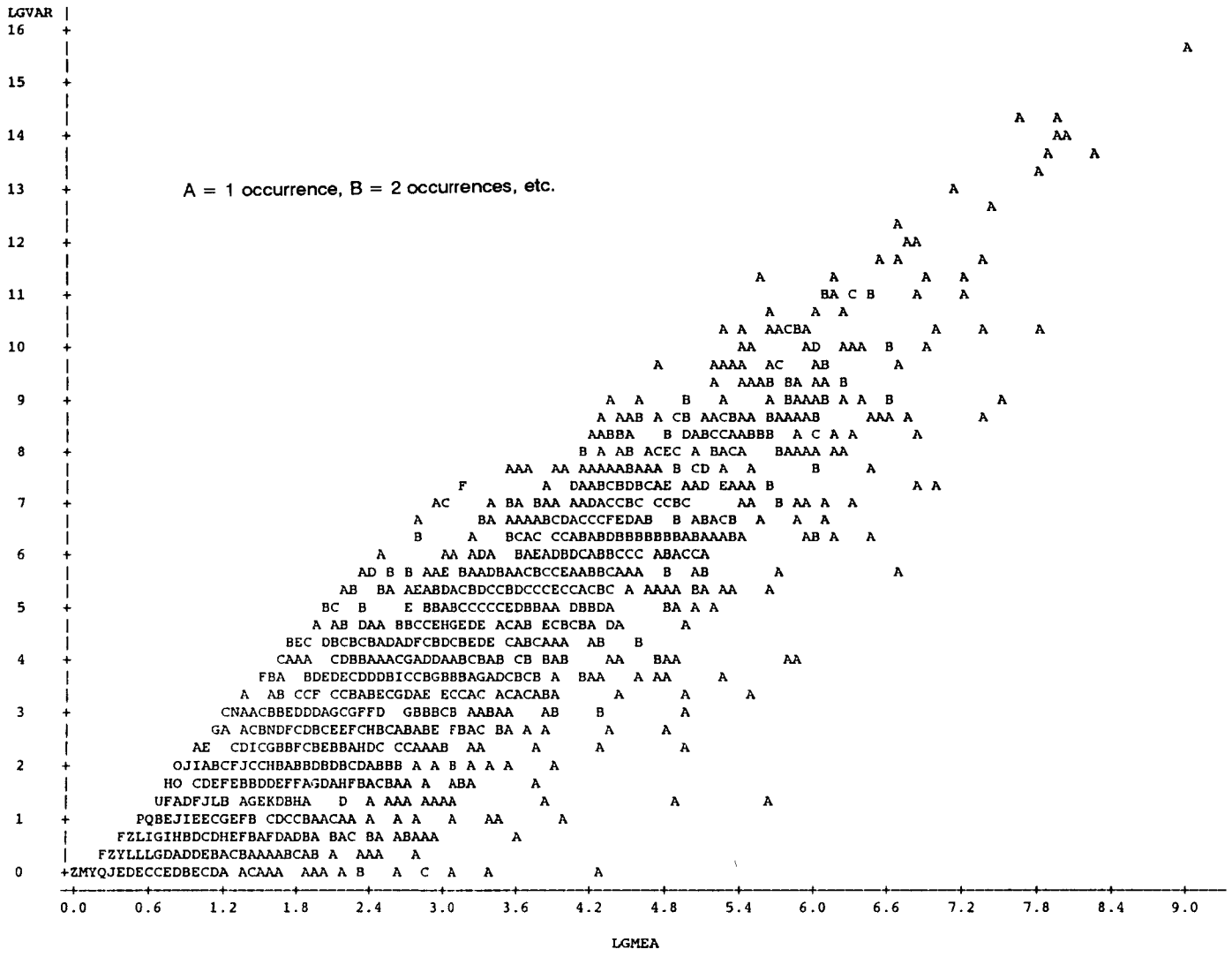


Figure 3-1. **Box plot of precision estimate calculated for all species (0) and excluding species with minimum abundance < 1, 2, 4, or 8 individuals per meter.**



NOTE: 188 OBS HIDDEN

Figure 3-2. **Plot of log variance versus log mean abundance for each species in each lake separately. Variance calculated as within-lake (among-sample) variance.**

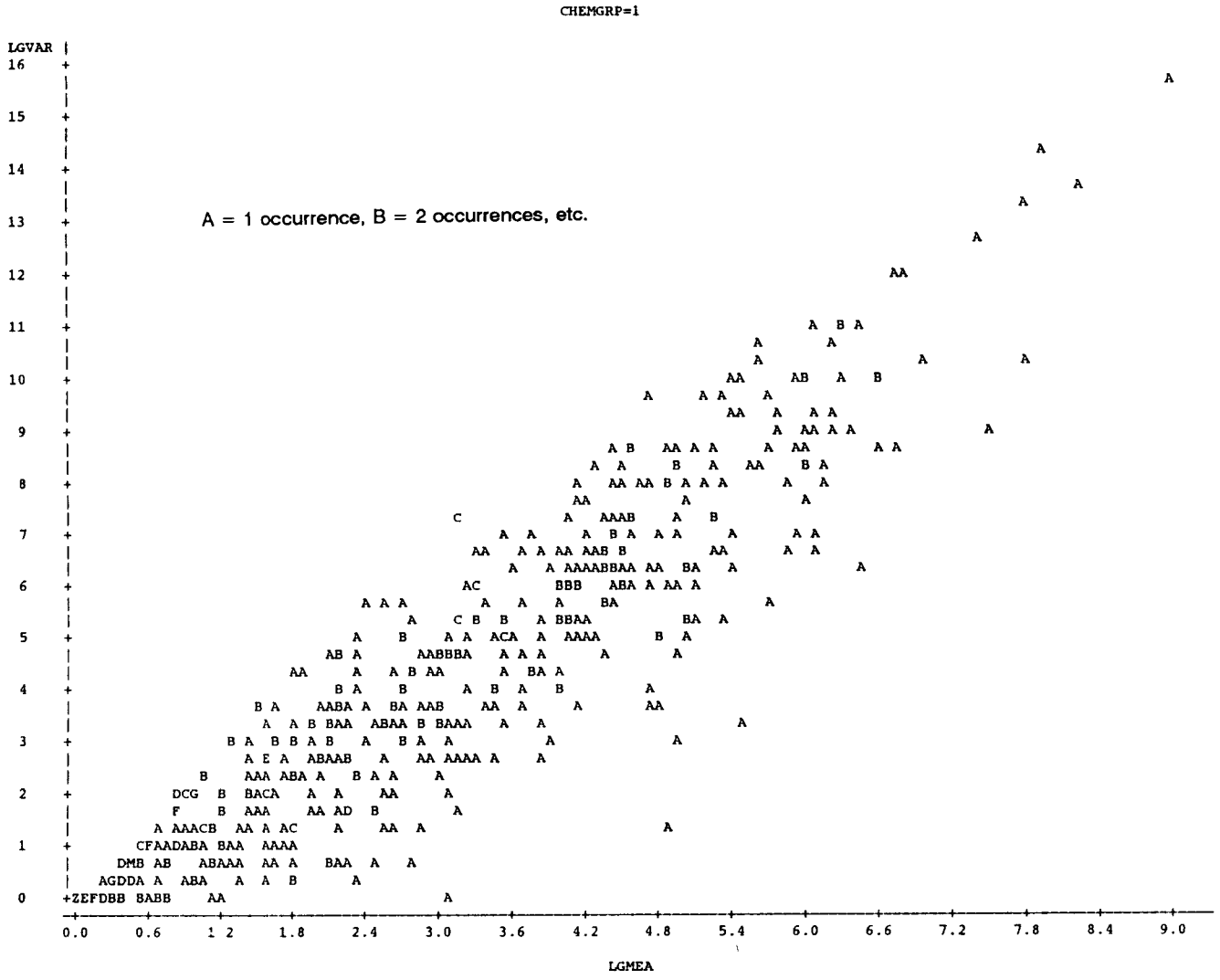
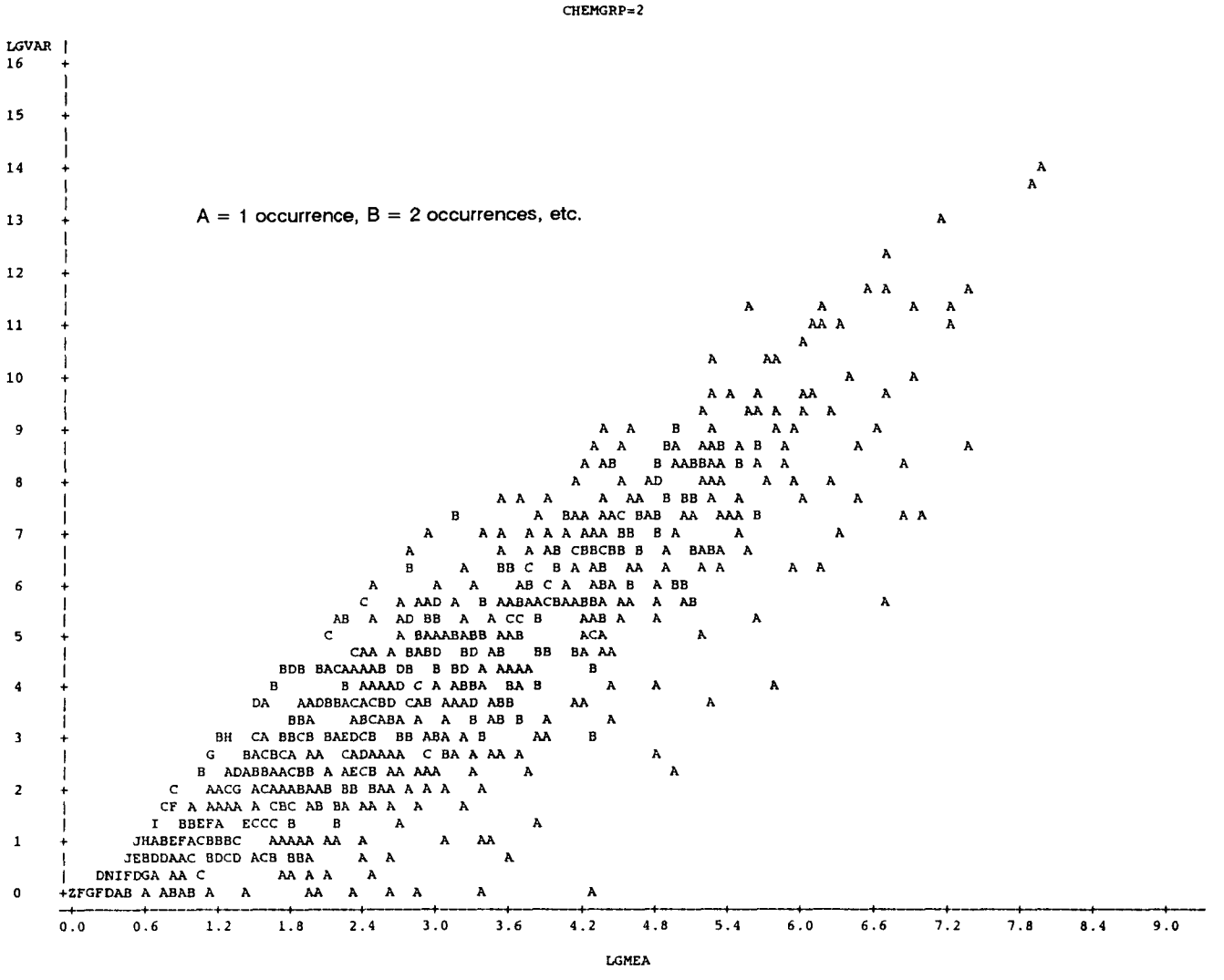


Figure 3-3. **Plot of log variance versus log mean abundance for each species in each Cluster 1 lake. Mean and variance are within lake.**



NOTE: 62 OBS HIDDEN

Figure 3-4. **Plot of log variance versus log mean abundance for each species in each Cluster 2 lake. Mean and variance are within lake.**

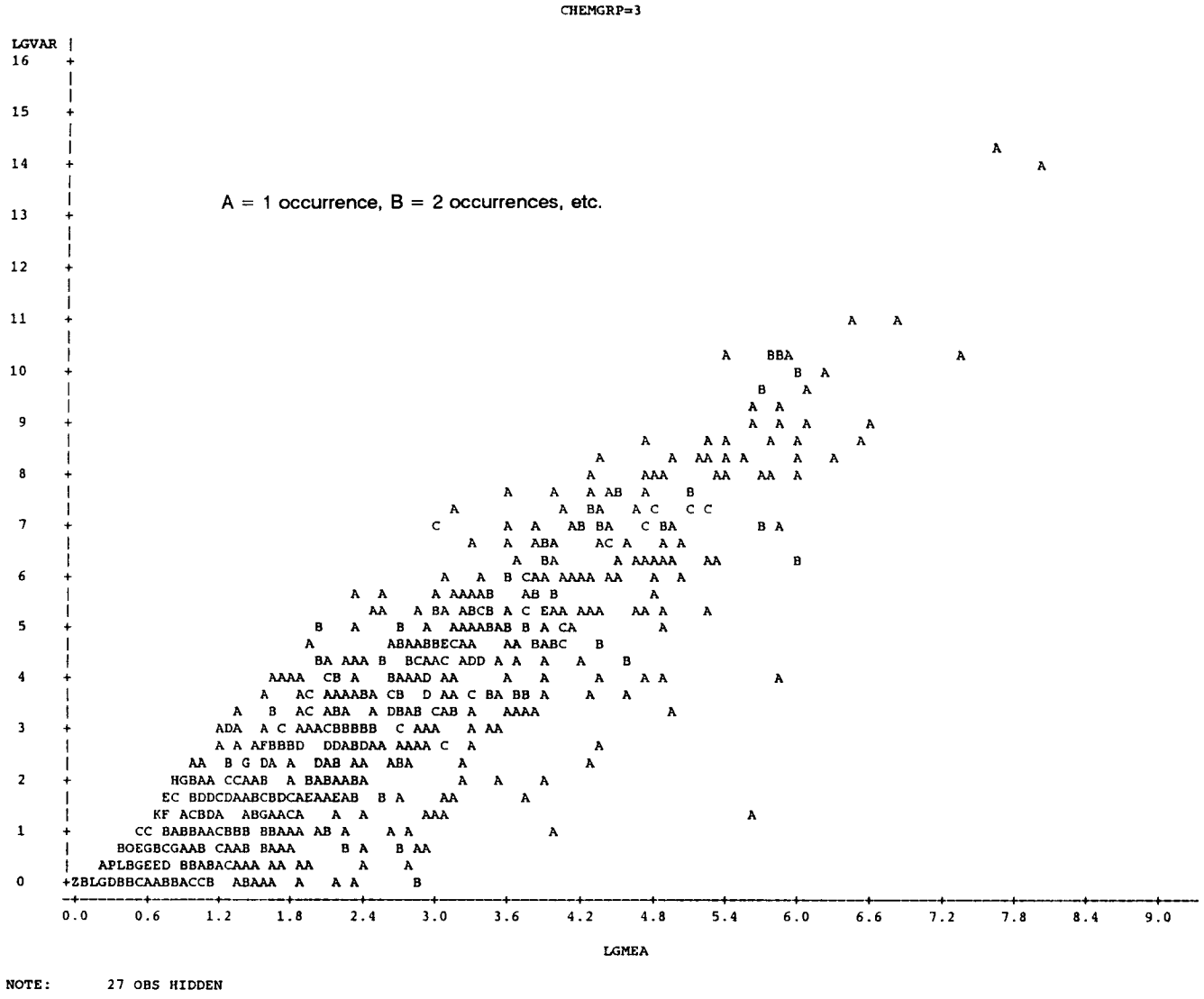


Figure 3-5. **Plot of log variance versus log mean abundance for each species in each Cluster 3 lake. Mean and variance are within lake.**

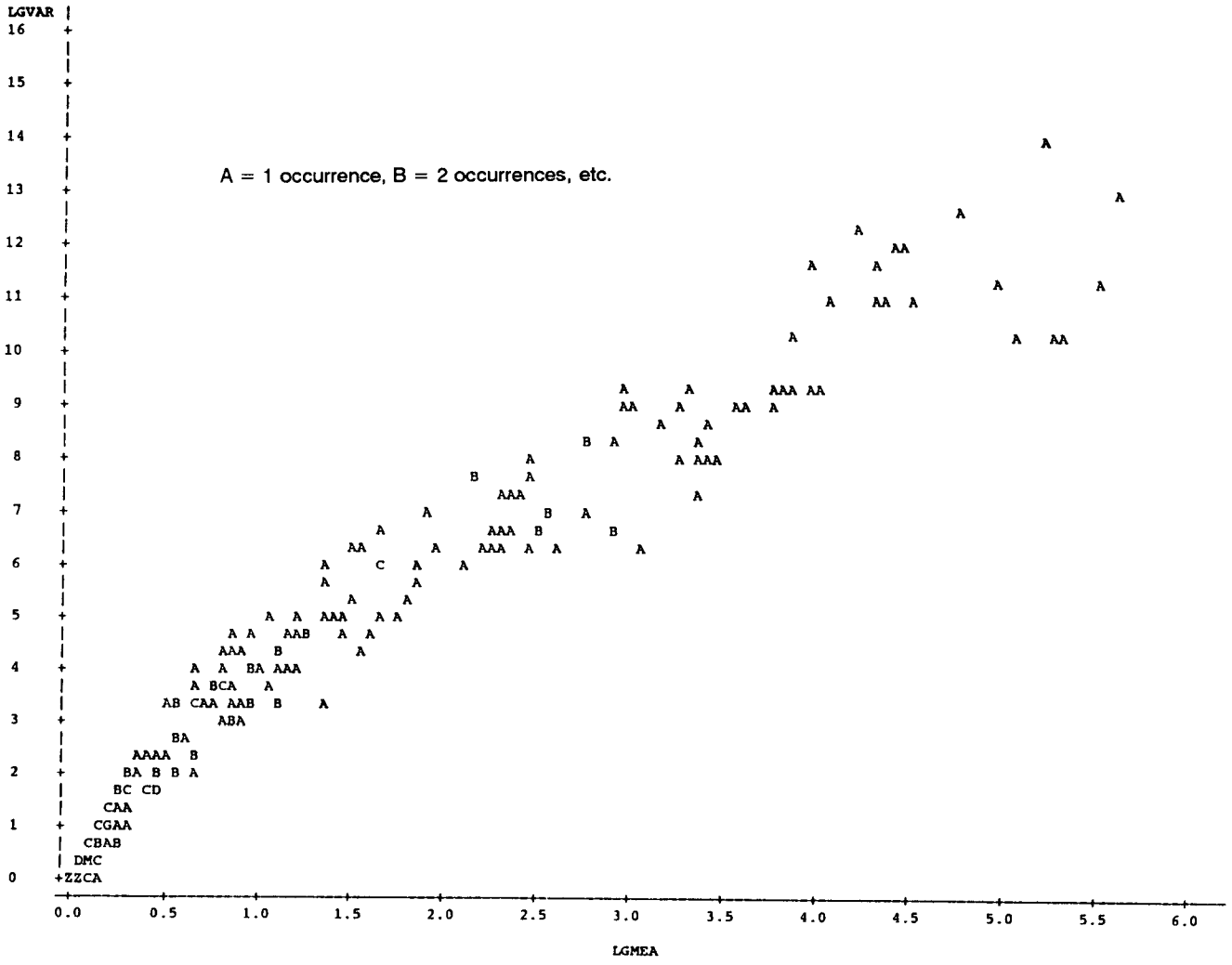


Figure 3-6. **Plot of log variance versus log mean abundance for each species. Mean and variance calculated among all lakes.**

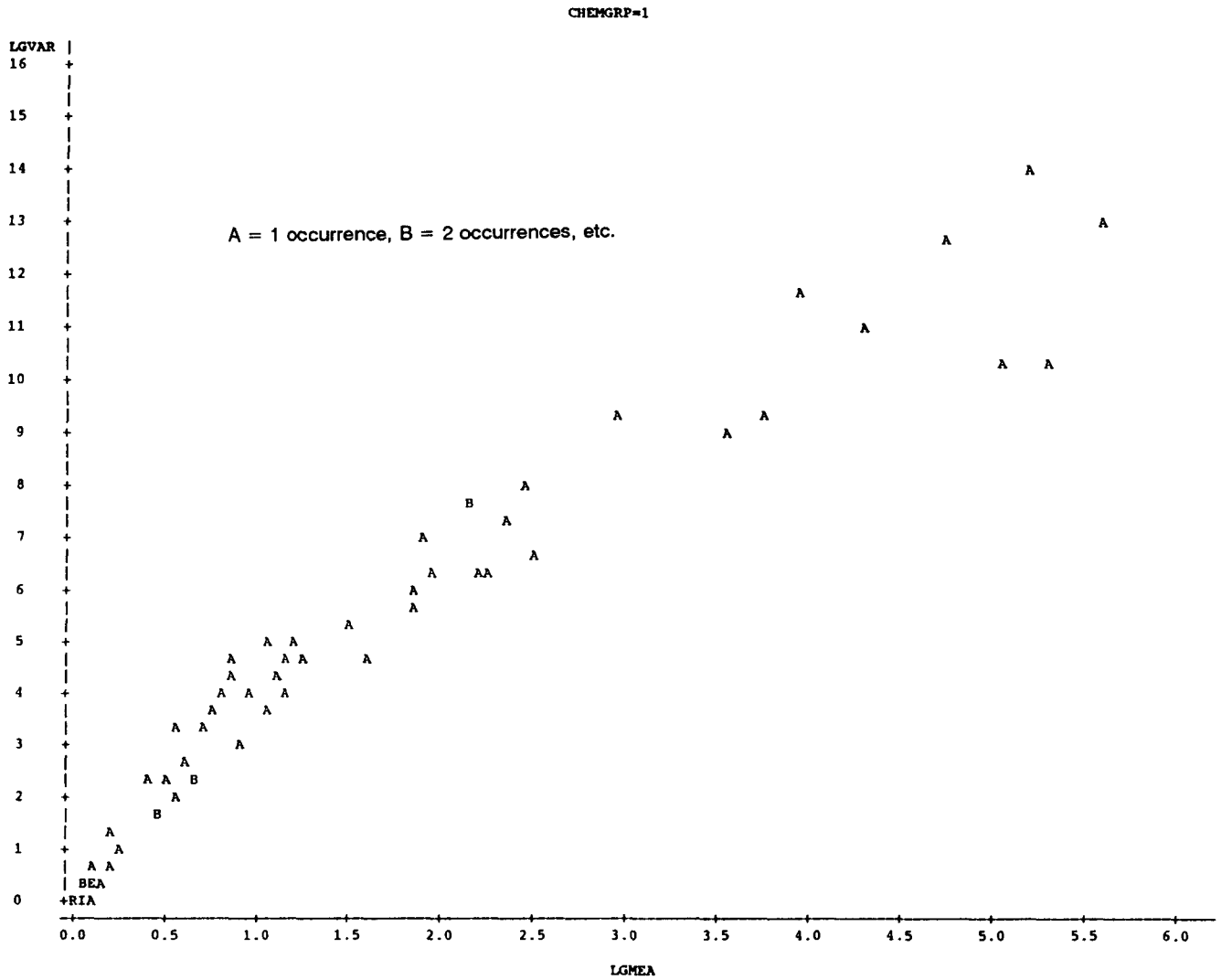


Figure 3-7. **Plot of log variance versus log mean abundance for each species. Mean and variance calculated among Cluster 1 lakes.**

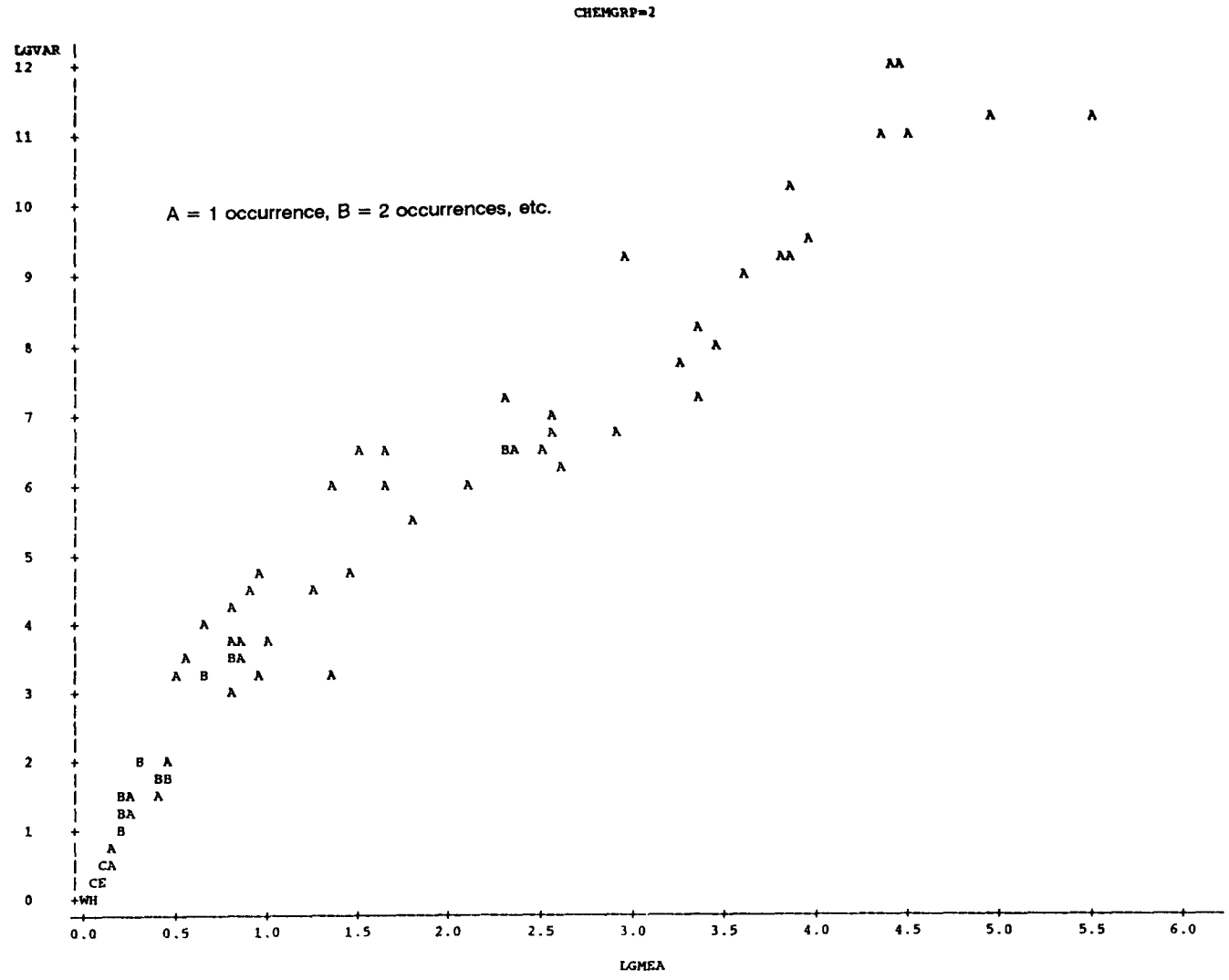


Figure 3-8. **Plot of log variance versus log mean abundance for each species. Mean and variance calculated among Cluster 2 lakes.**

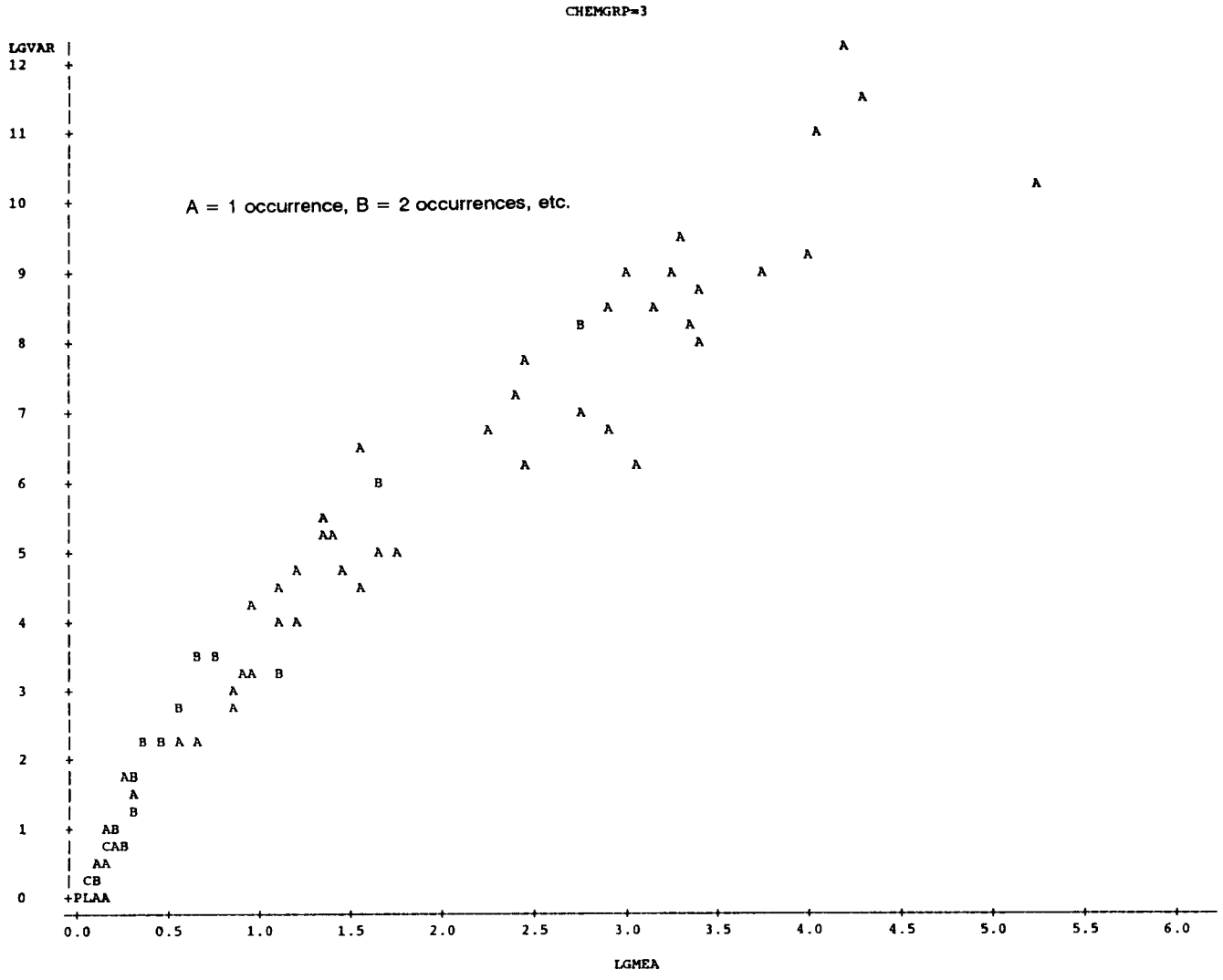


Figure 3-9. **Plot of log variance versus log mean abundance for each species. Mean and variance calculated among Cluster 3 lakes.**

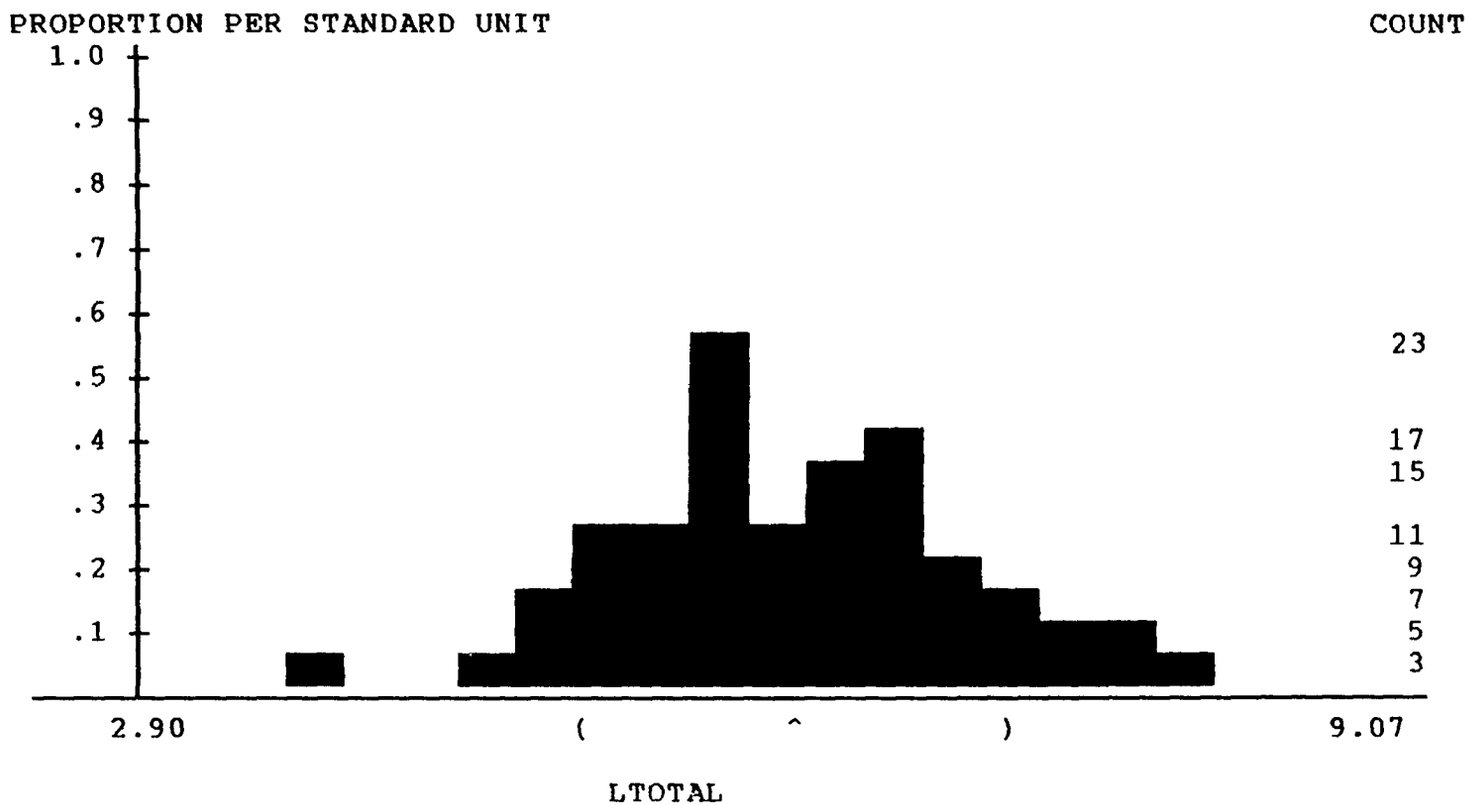


Figure 3-10. Frequency histogram of log(e) transformed total abundance among all 147 lakes.

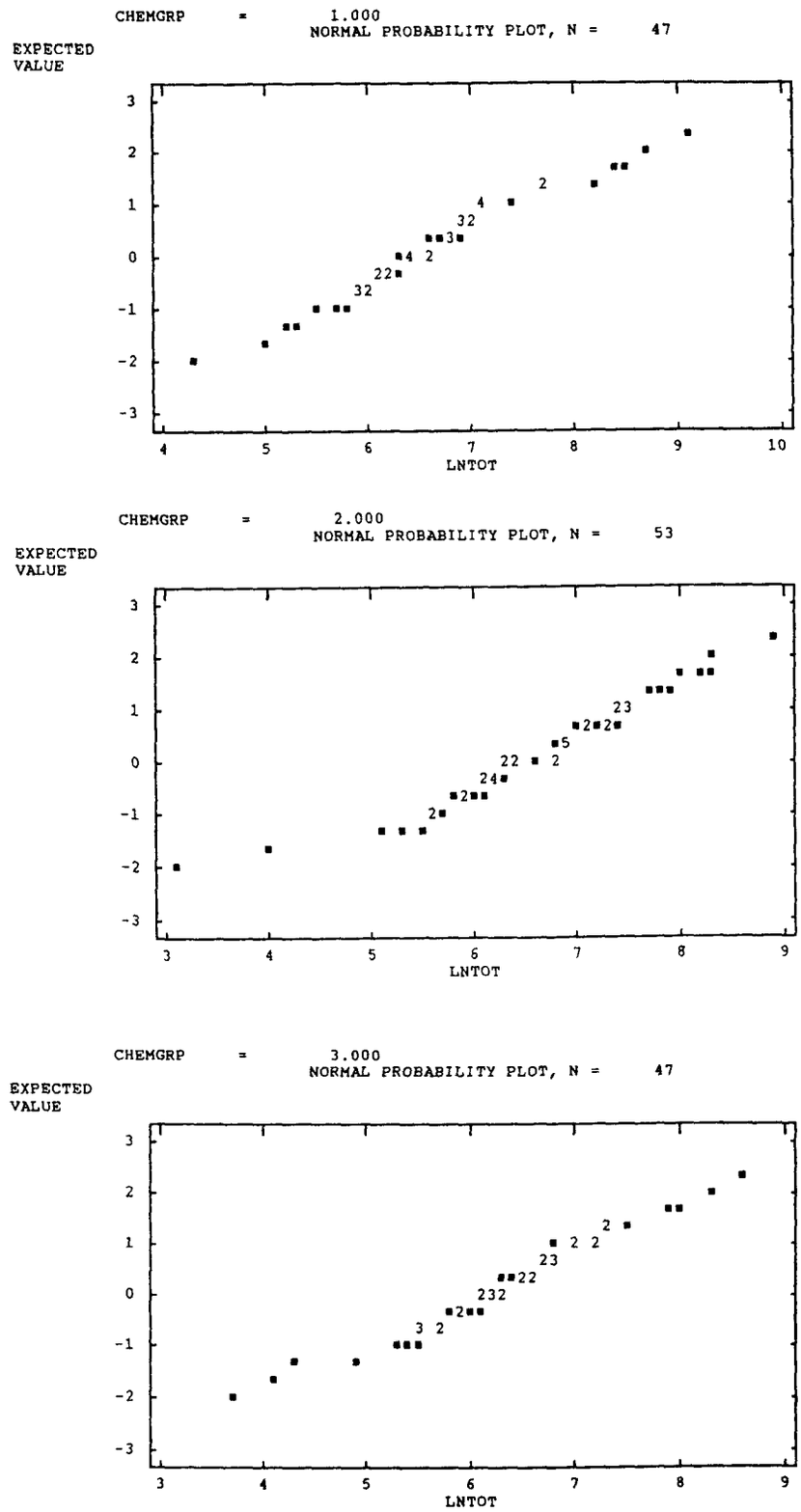


Figure 3-11. **Probability plot of total abundance among lakes plotted separately for Cluster 1, 2, and 3 lakes (solid square = 1 data point; number = total of overlapping data points).**

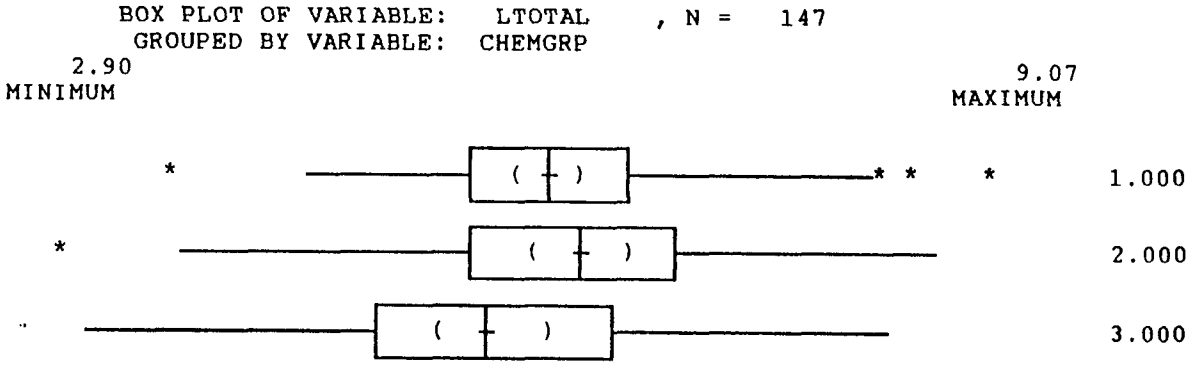
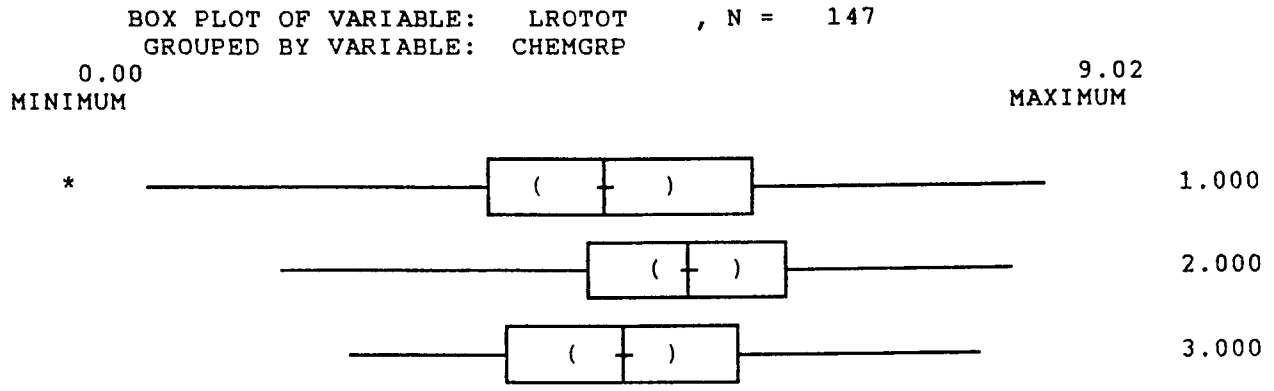


Figure 3-12. **Box plot of total log(e) transformed abundance of zooplankton for each water chemistry cluster plotted separately.**



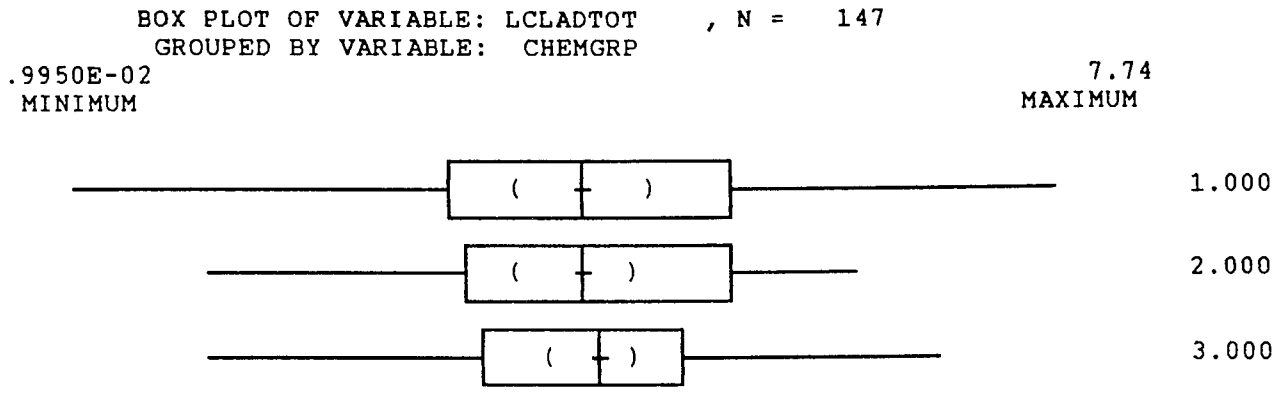
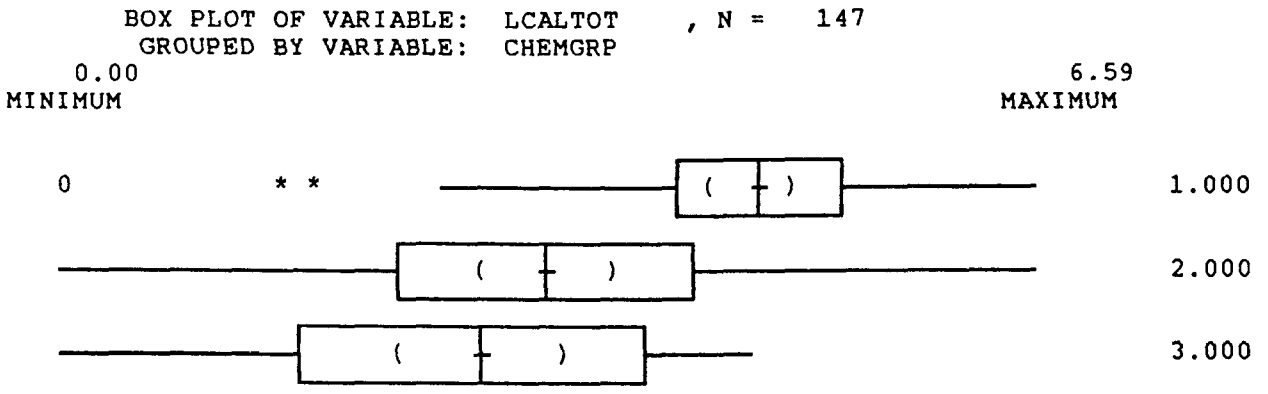


Figure 3-13. **Box plots of total rotifer (LROTOT) and total cladoceran (LCLADTOT) log(e) transformed abundance for each water chemistry cluster plotted separately.**



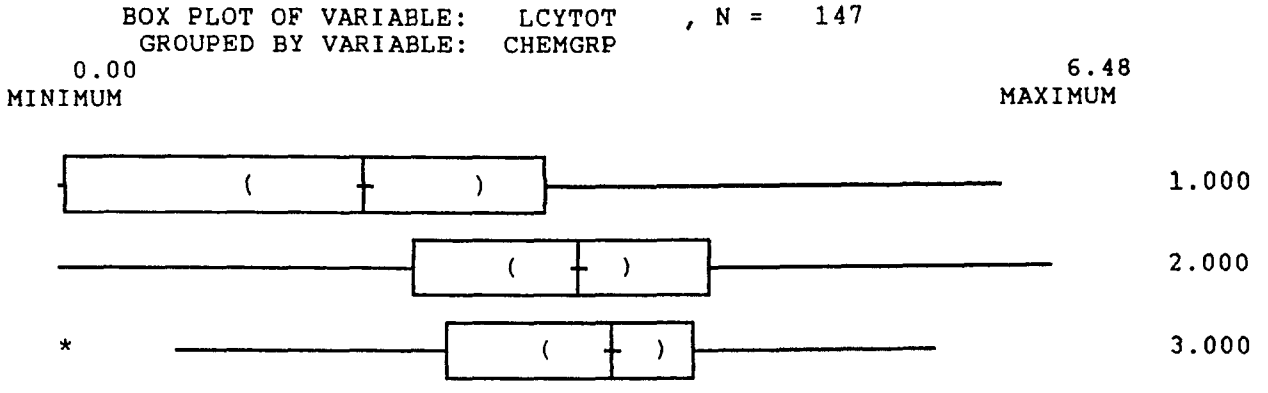
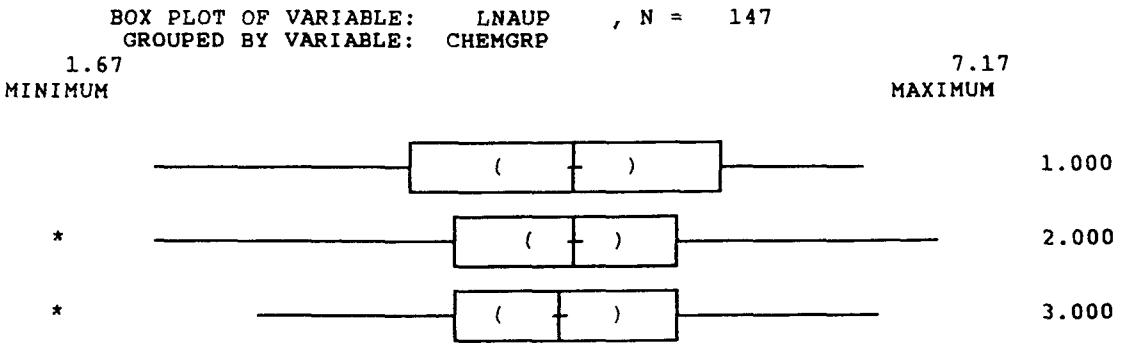
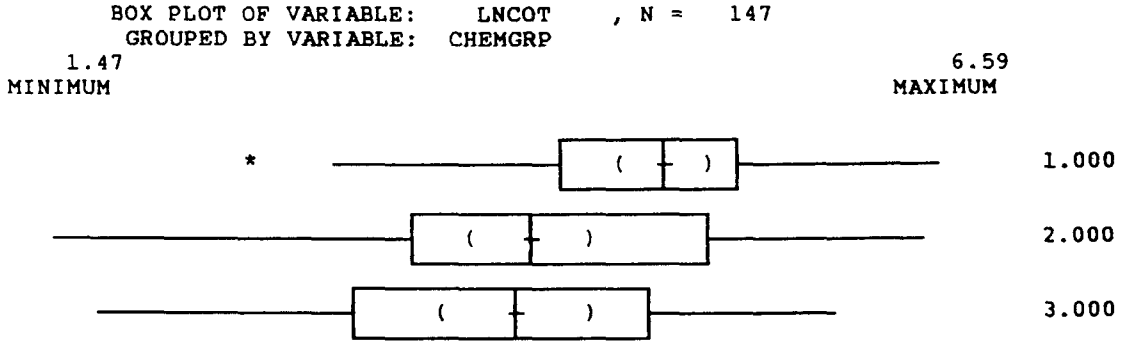


Figure 3-14. Box plots of total calanoid (LCALTOT) and total cyclopoid (LCYTOT) log(e) transformed abundance for each water chemistry cluster plotted separately.





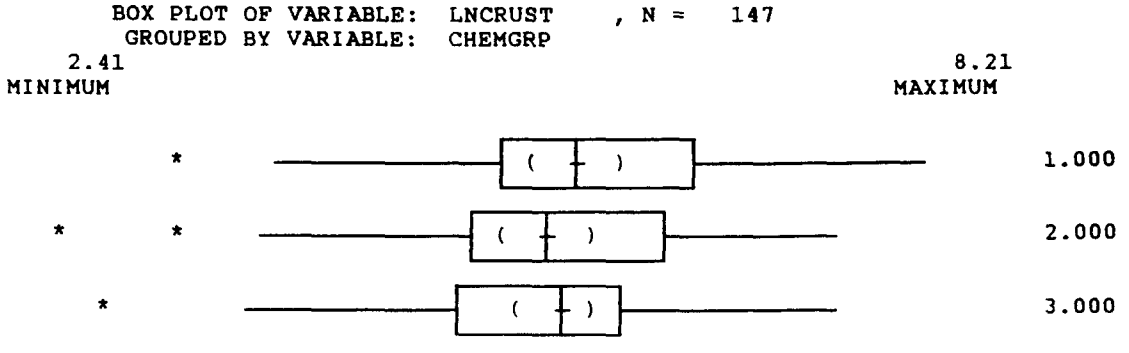
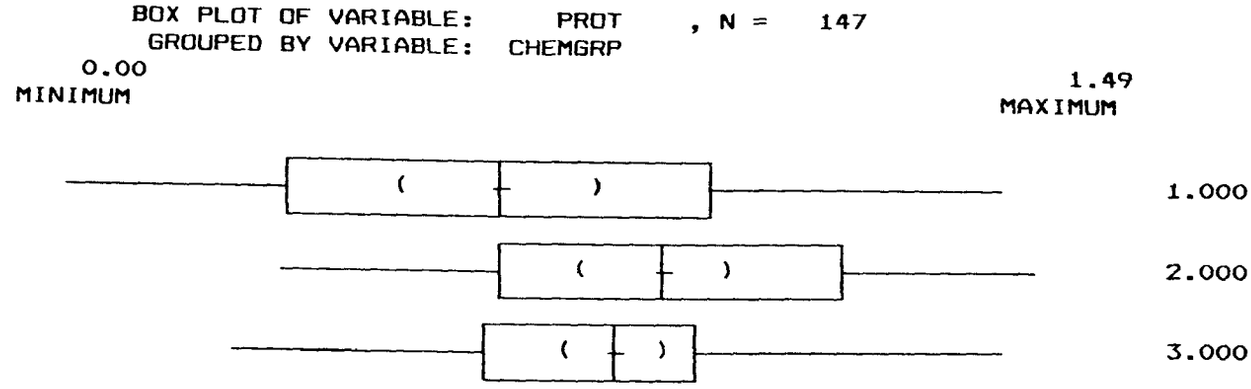


Figure 3-15. **Box plots of total nauplii (LNAUP), copepods (LNCOT), and crustaceans (LNCRUST) log(e) transformed abundance for each water chemistry cluster plotted separately.**



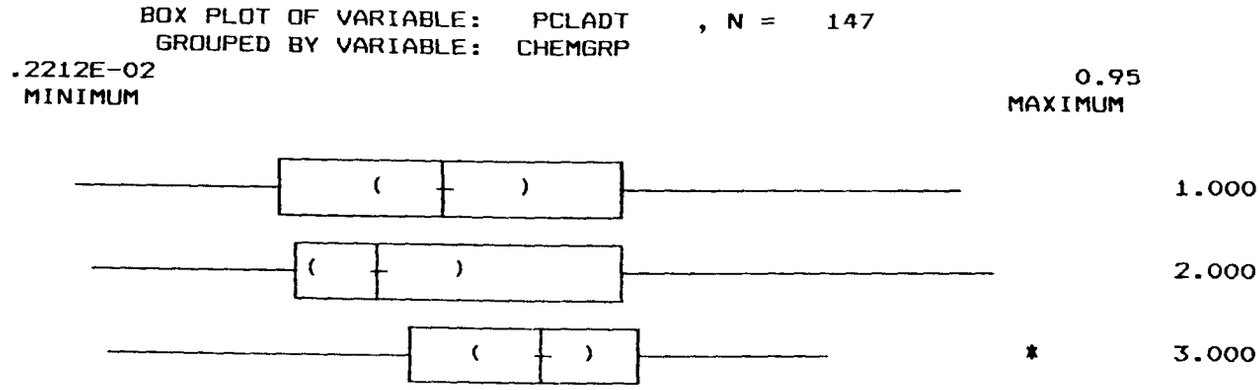
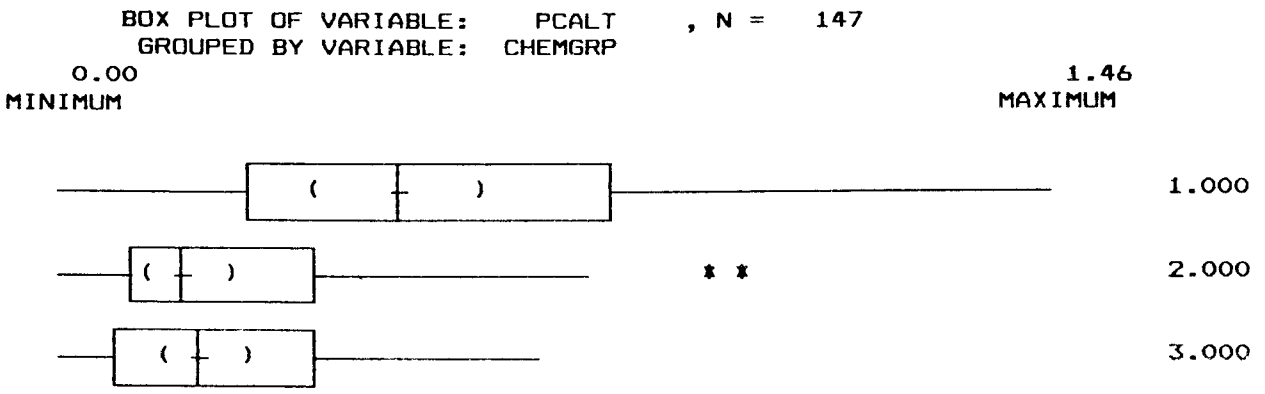


Figure 3-16. Box plots of proportional abundance of rotifers (PROT) and cladocerans (PCLADT) for each water chemistry cluster plotted separately.



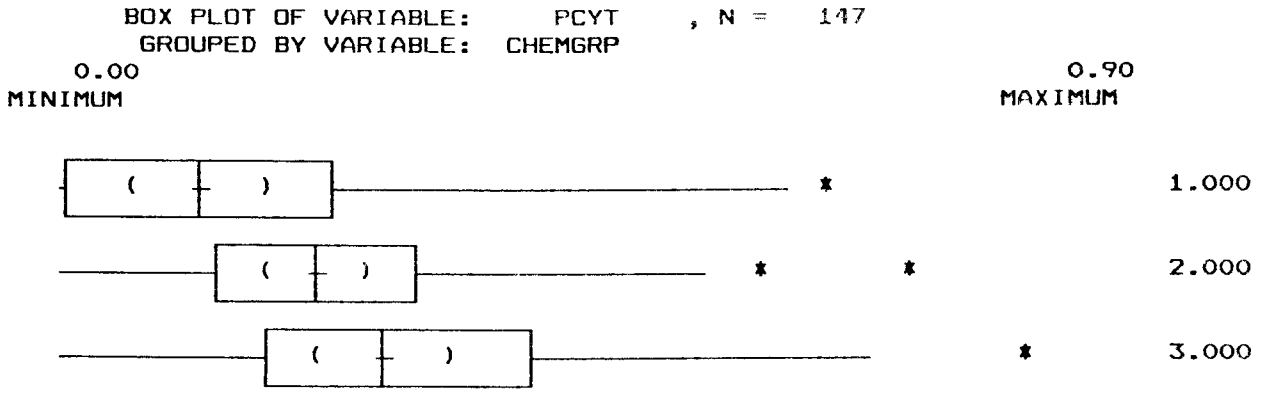


Figure 3-17. Box plots of proportional abundance of calanoids (PCALT) and cyclopoids (PCYT) for each water chemistry cluster plotted separately.

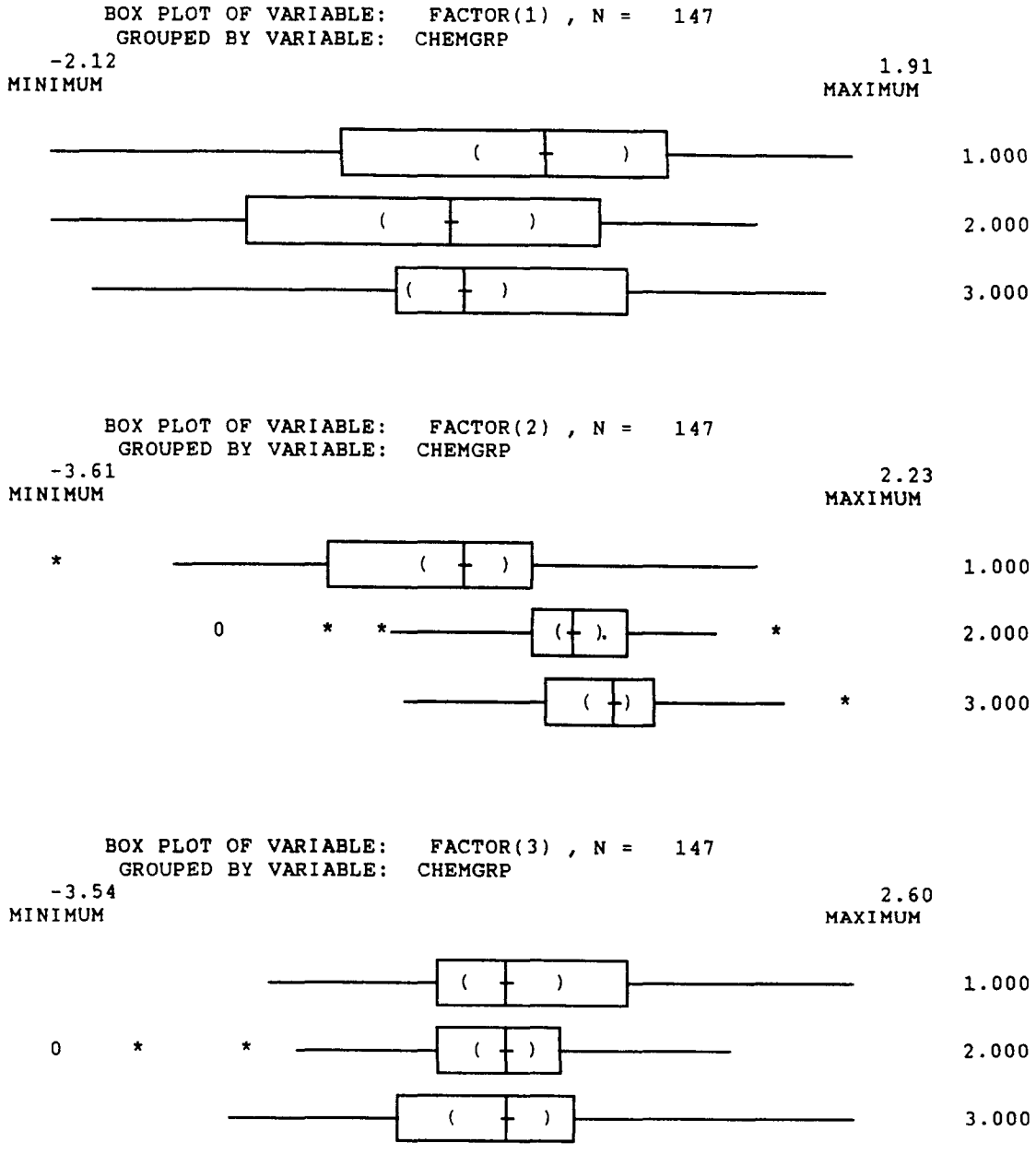
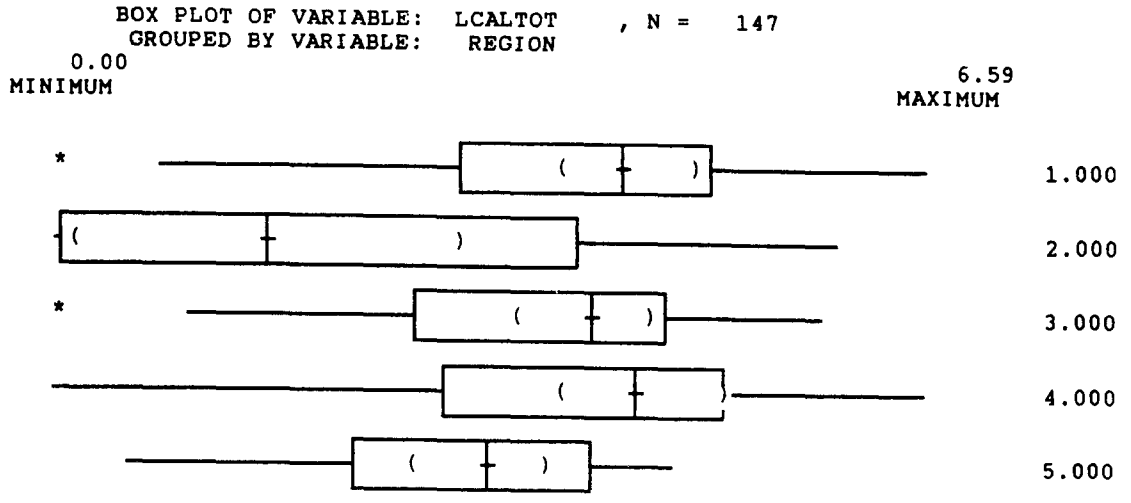


Figure 3-18. **Box plots of first three factors from principal components analysis (PCA) of major zooplankton taxa. Factors plotted separately for each chemistry cluster.**



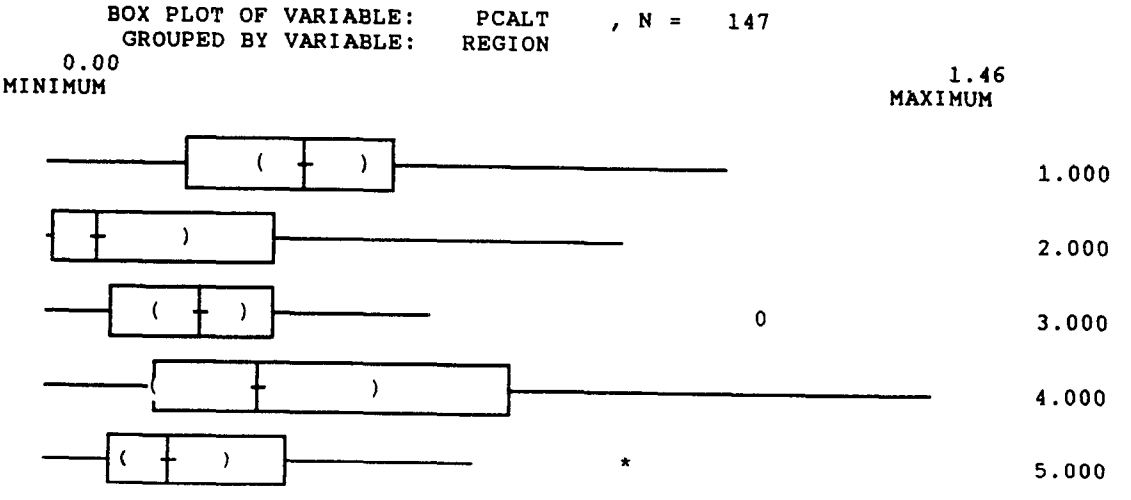


Figure 3-19. **Box plots of log(e) transformed (LCALTOT) and proportional (PCALT) abundance of calanoid copepods, plotted separately for each geographic region.**

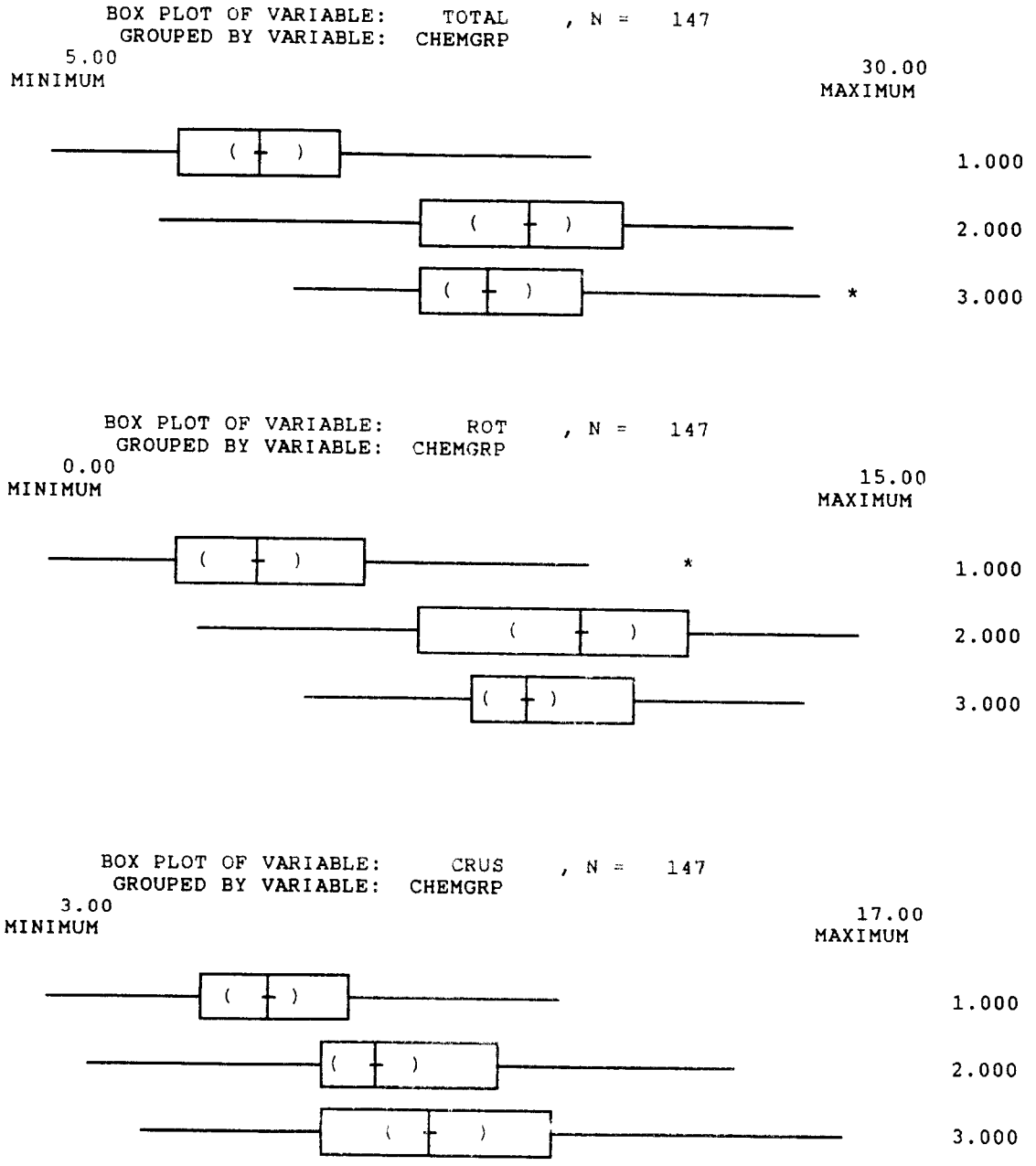


Figure 3-20. **Box plots of species richness for total zooplankton (TOTAL), rotifers (ROT), and total crustaceans (CRUS), plotted separately for each chemistry cluster.**

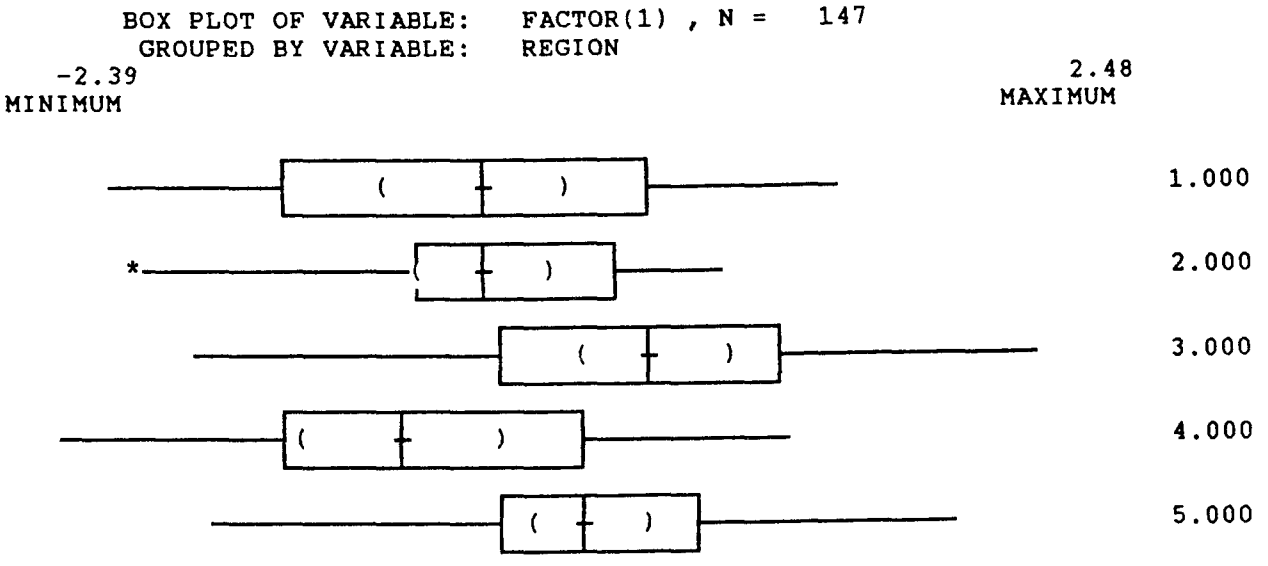


Figure 3-21. Box plot of Factor 1 from principal components analysis (PCA) of species richness plotted separately for each geographic region.

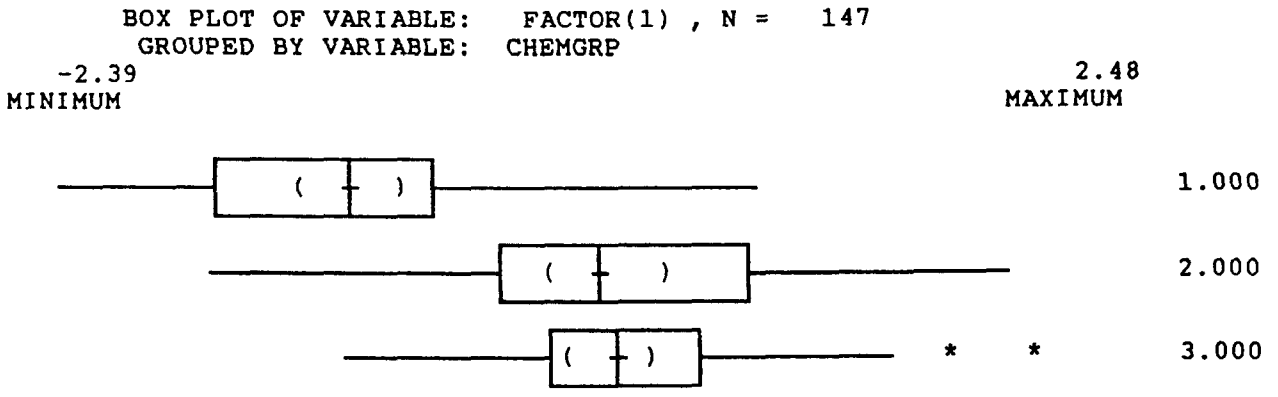


Figure 3-22. **Box plot of Factor 1 from principal components analysis (PCA) of species richness, plotted separately for each water chemistry cluster.**

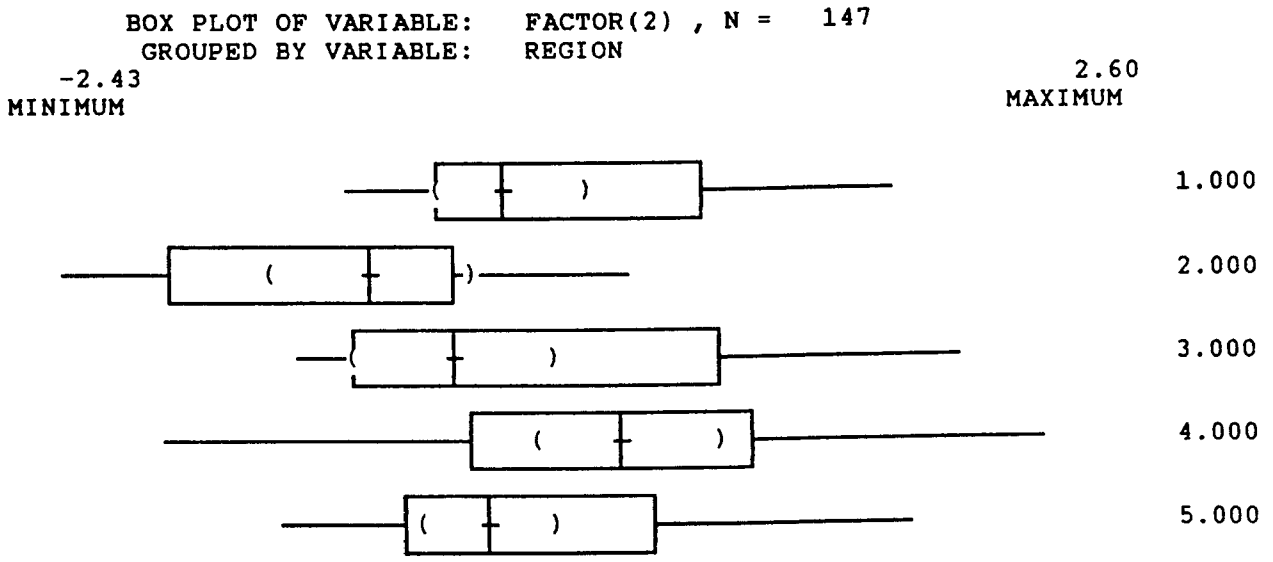
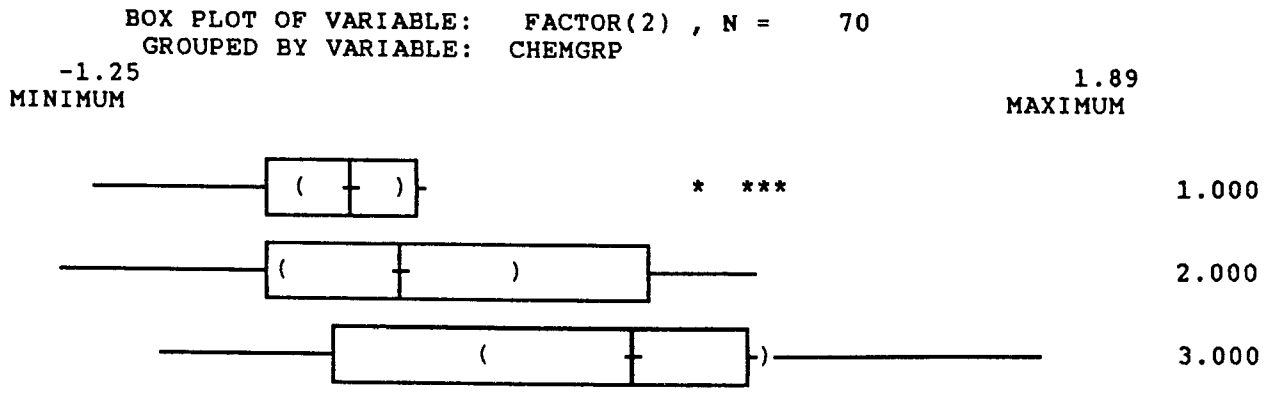


Figure 3-23. **Box plot of Factor 2 from principal components analysis (PCA) of species richness, plotted separately for each geographic region.**



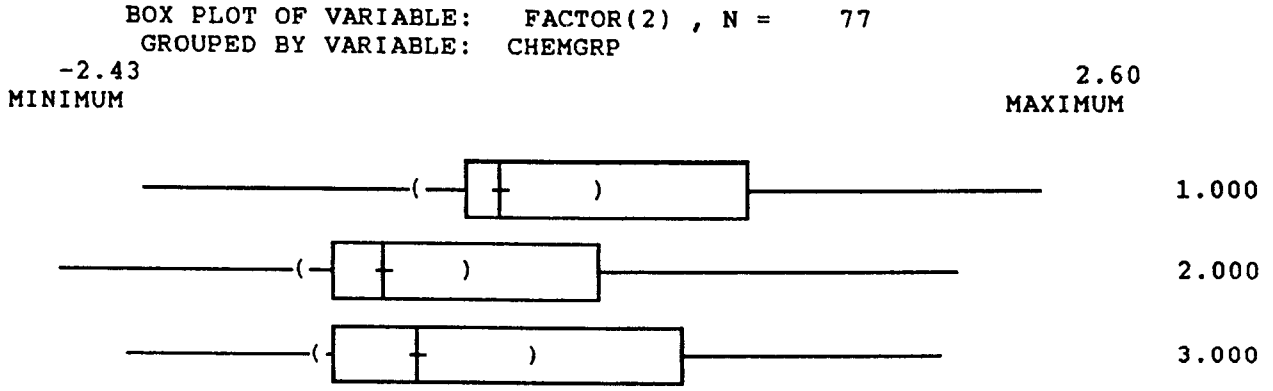


Figure 3-24. **Box plots of Factor 2 from principal components analysis (PCA) of species richness, plotted separately for each water chemistry cluster and calculated separately for Regions 1 and 5 (top) and for Regions 2, 3, and 4 (bottom).**

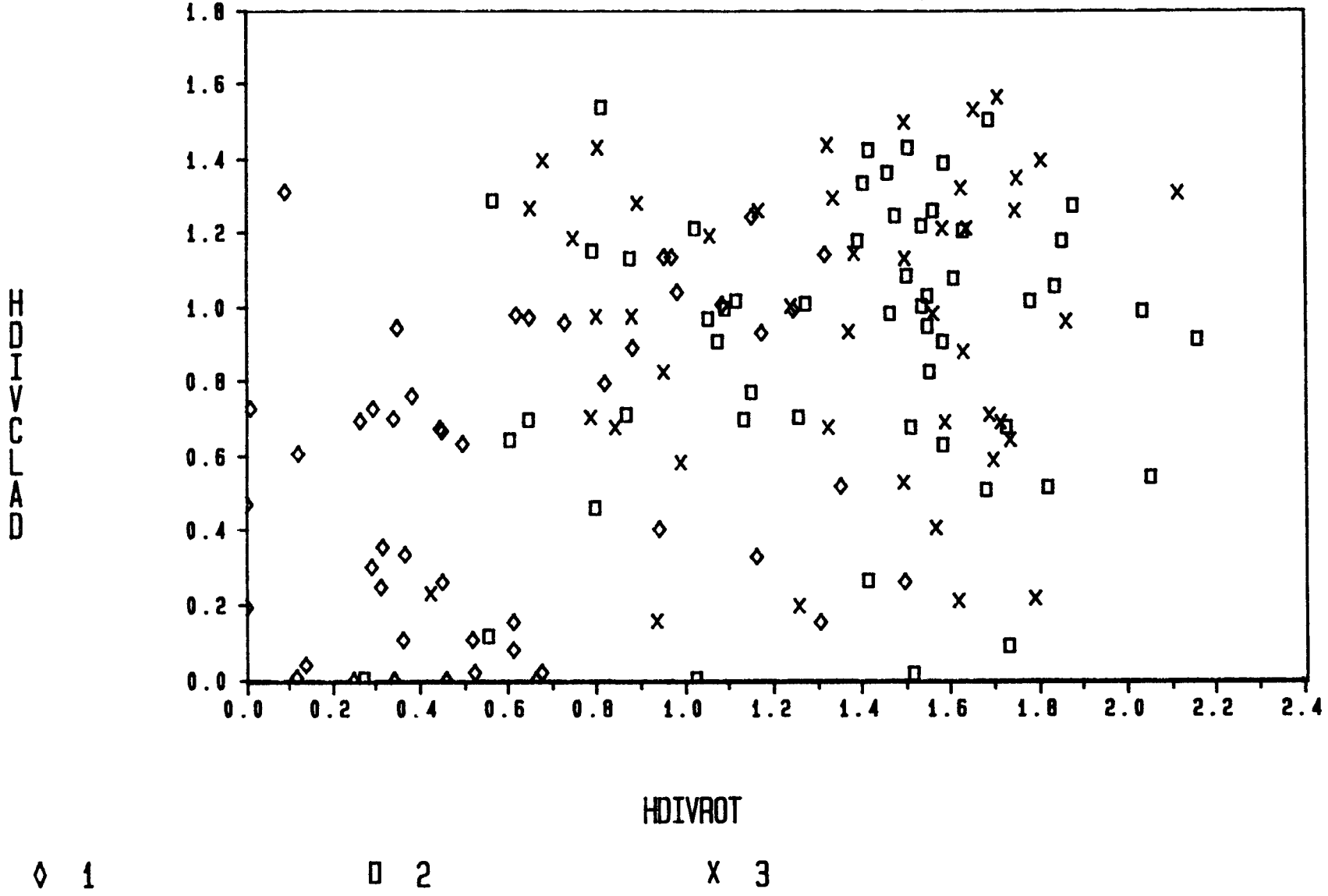
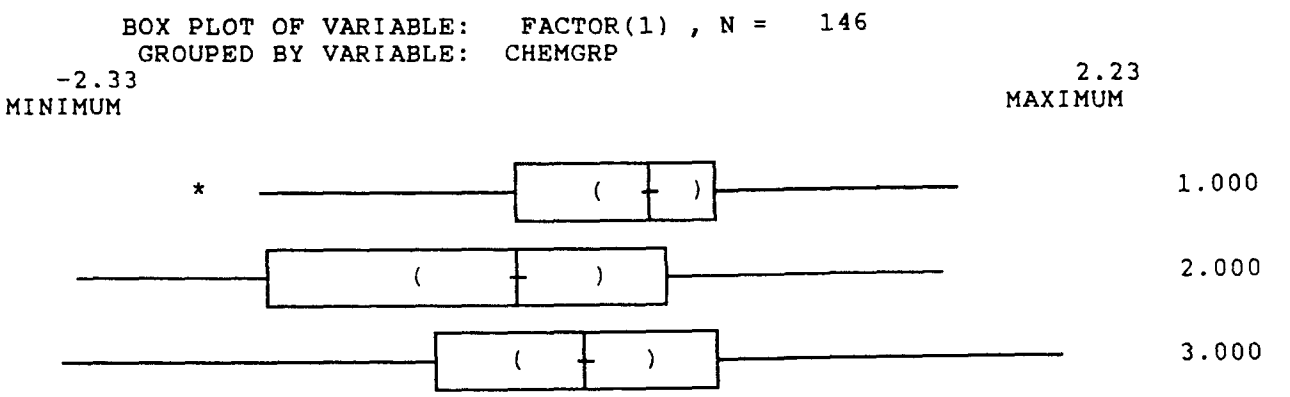


Figure 3-25. Plot of Shannon-Wiener diversity of cladocerans and rotifers for 146 lakes from the summer sampling of the ELS-II.



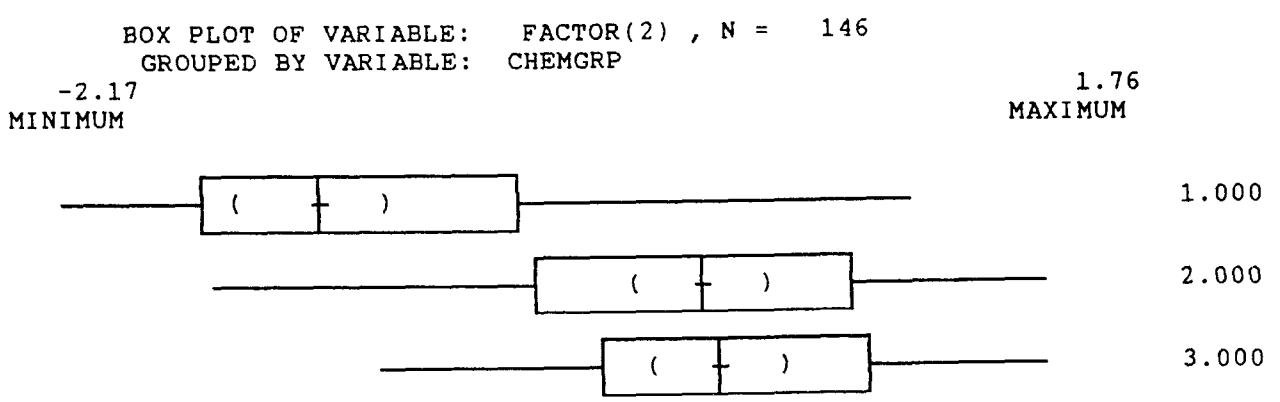


Figure 3-26. Box plots of Shannon-Wiener Diversity for PCA Factors 1 and 2, determined separately for each water chemistry cluster.

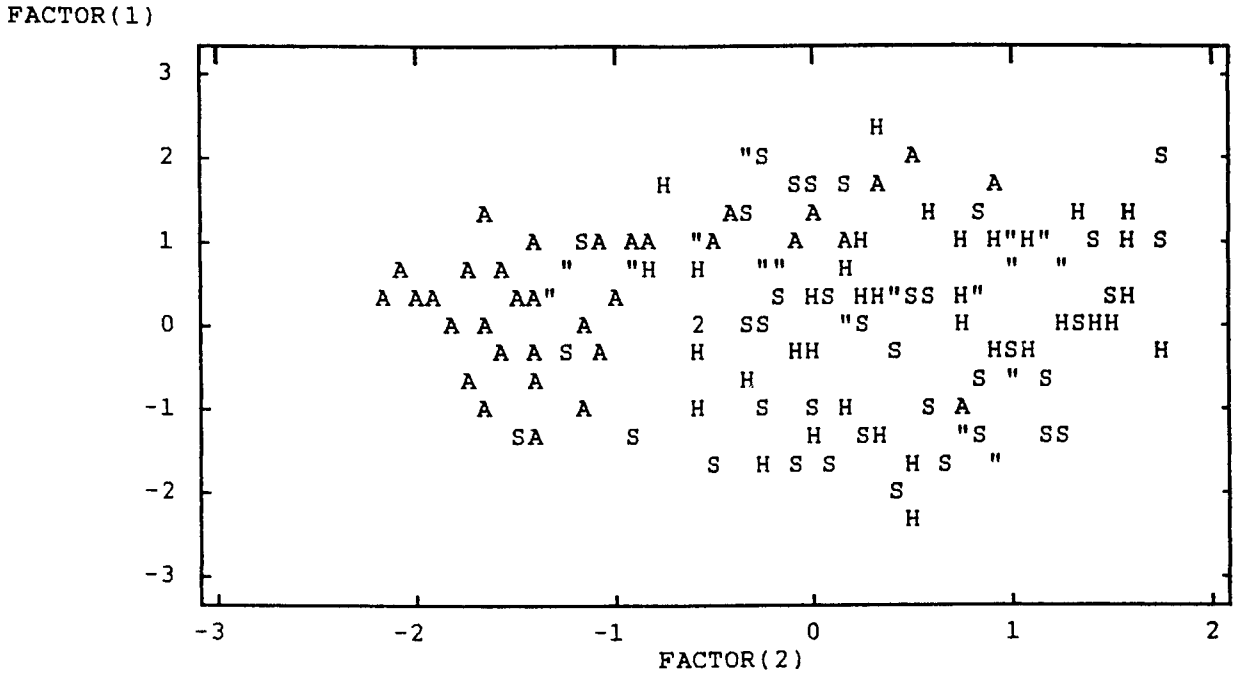


Figure 3-27. **Plot of all lakes as a function of Shannon-Wiener Diversity for PCA Factors 1 and 2. A = Cluster 1 lakes; S = Cluster 2 lakes; H = Cluster 3 lakes; 2 = two lakes with same score; " = two or more lakes with same score.**

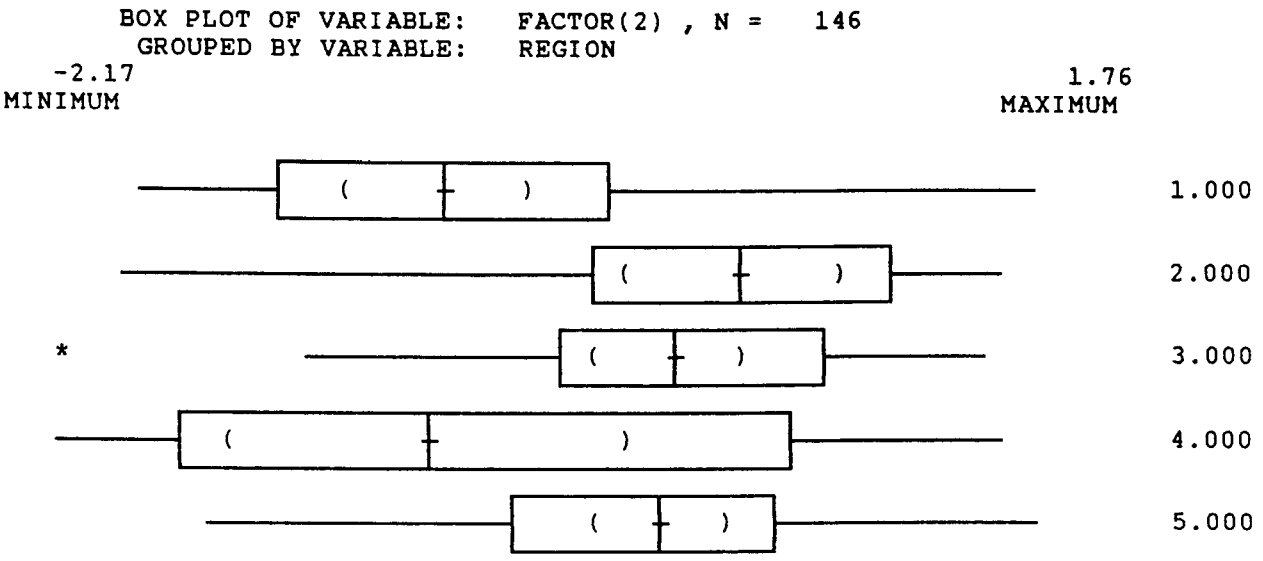
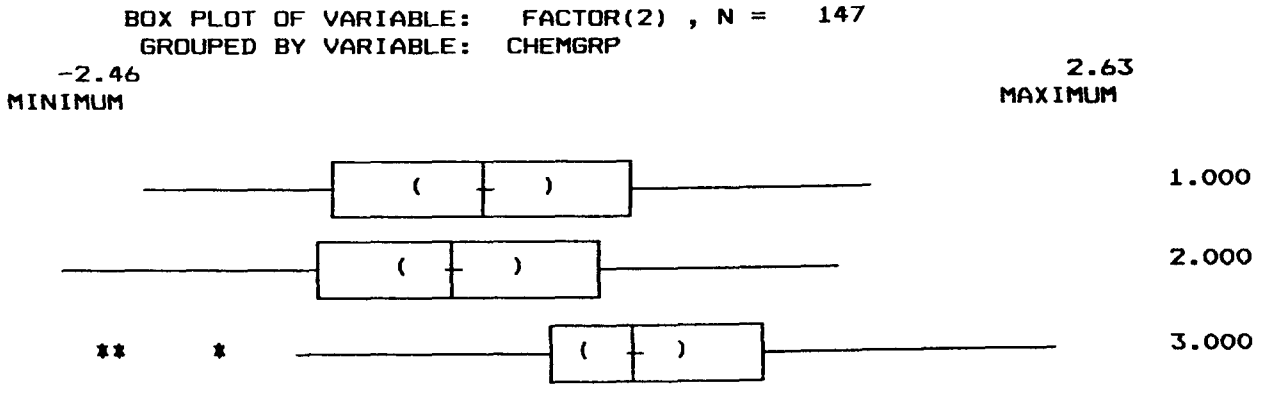


Figure 3-28. Box plots of Shannon-Wiener Diversity for PCA Factor 2, determined separately for each geographic region.



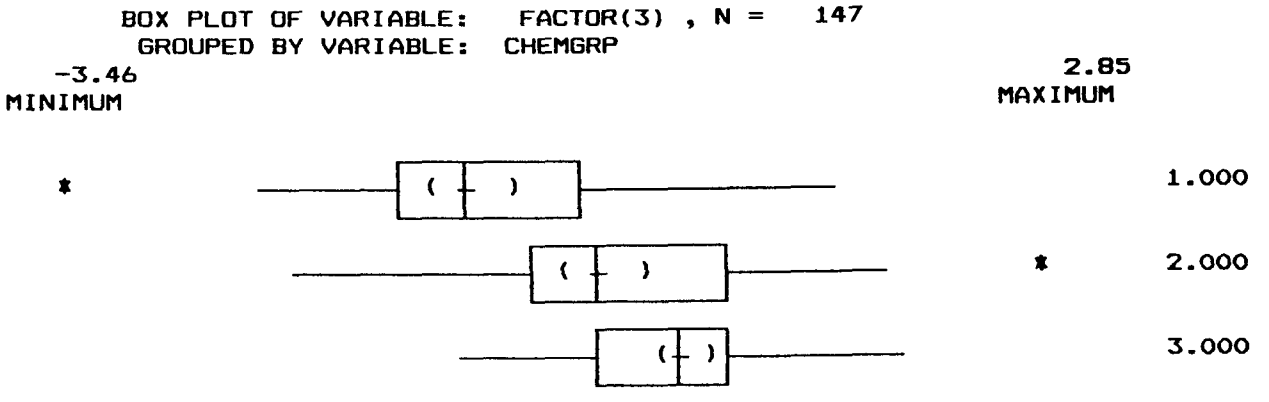
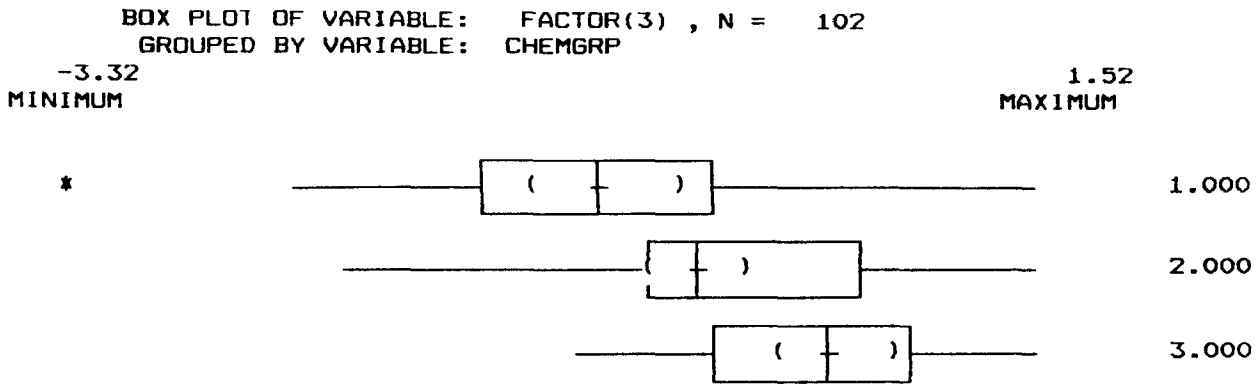


Figure 3-29. Box plots of Factors 2 (top) and 3 (bottom) of principal components analysis (PCA) of size structure, plotted separately for each water chemistry cluster.



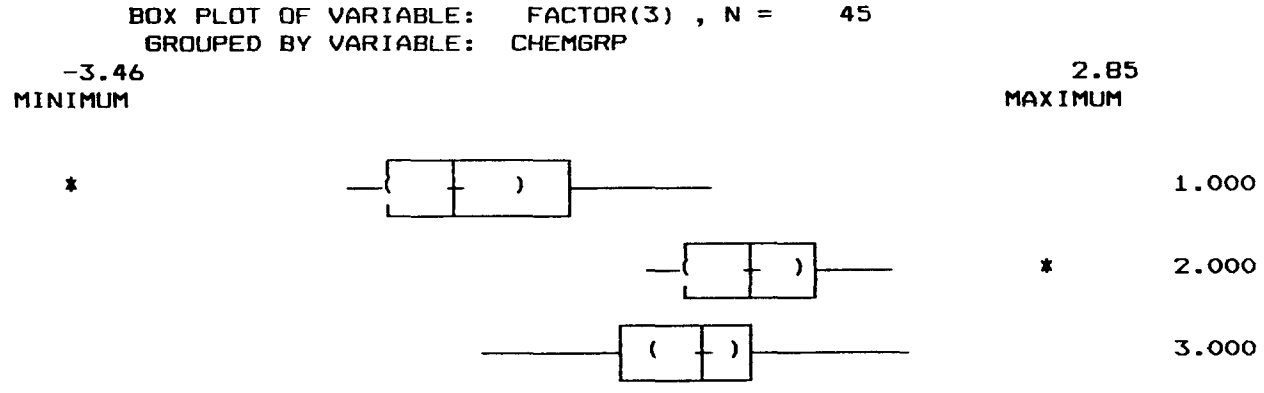
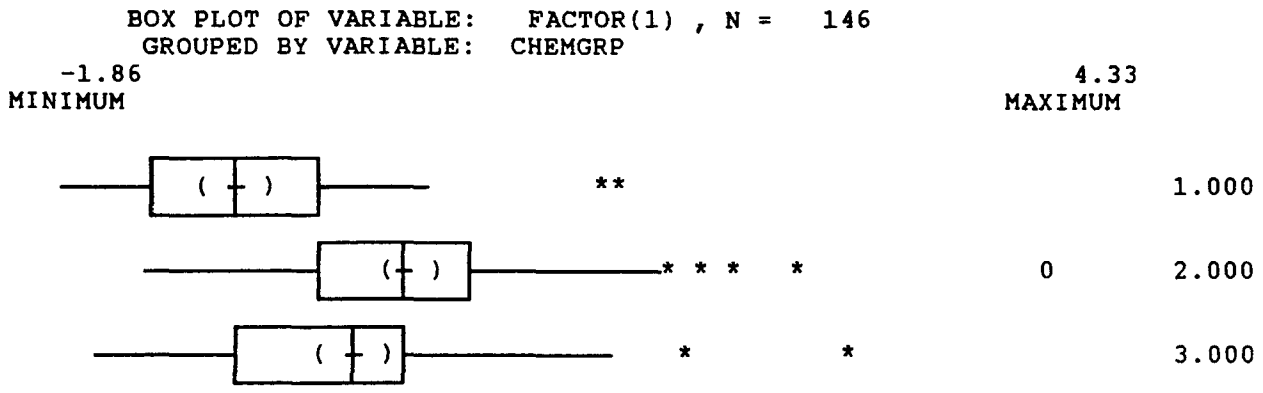


Figure 3-30. **Box plots of Factor 3 of principal components analysis (PCA) of size structure plotted separately for each water chemistry cluster and calculated separately for Regions 1, 3, and 5 (top) and Regions 2 and 4 (bottom).**



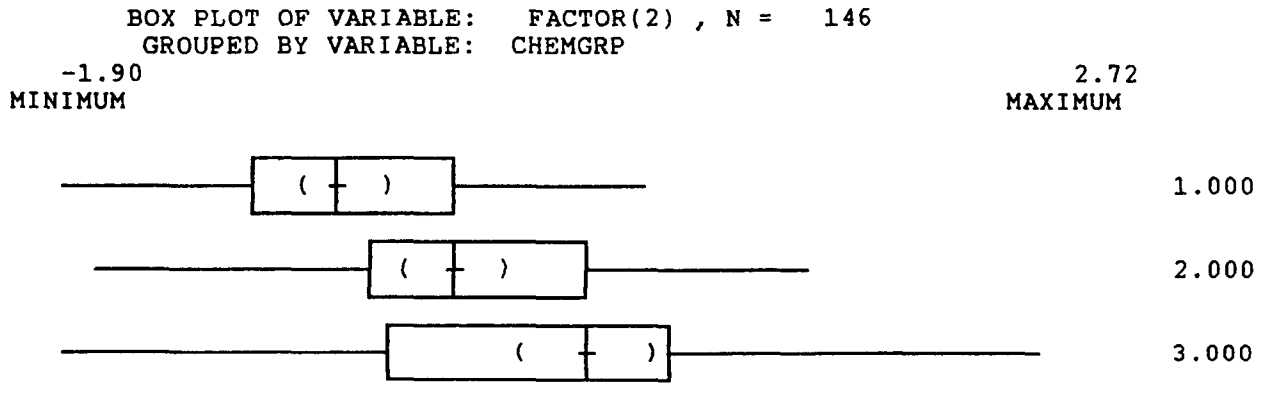
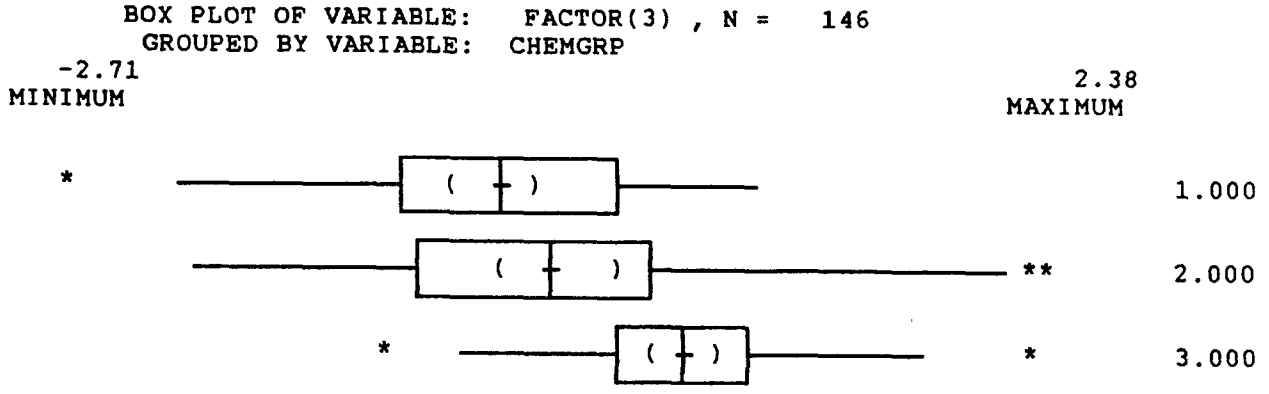


Figure 3-31. Box plots of Factors 1 and 2 of principal components analysis (PCA) of 38 taxa groups, plotted separately for each water chemistry cluster.



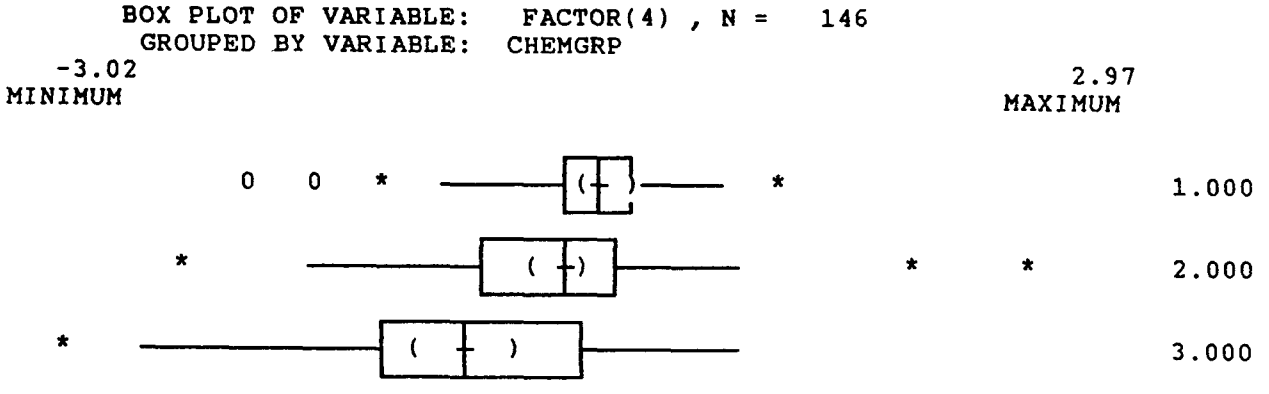


Figure 3-32. Box plots of Factors 3 and 4 of principal components analysis (PCA) of 38 taxa groups, plotted separately for each water chemistry cluster.

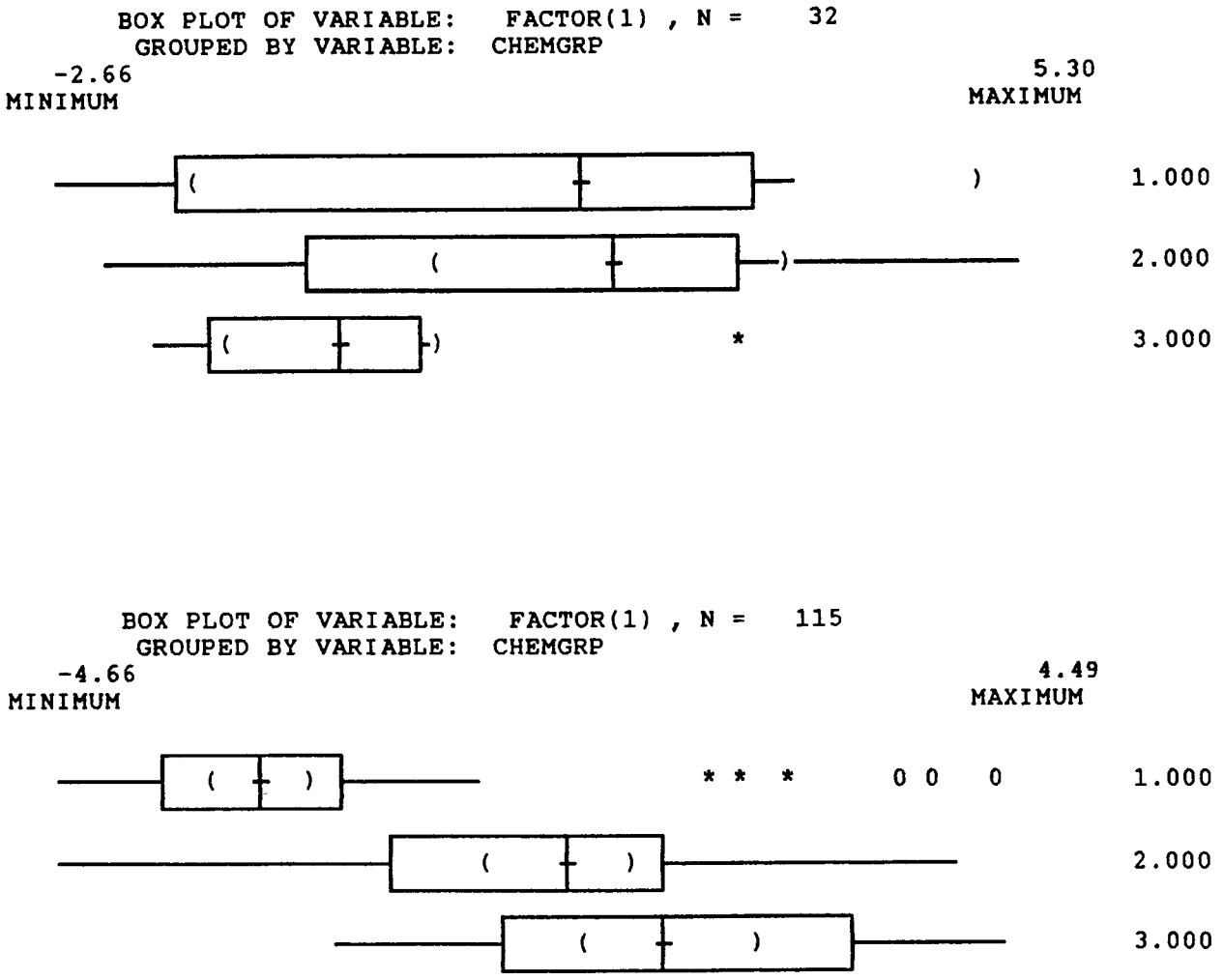
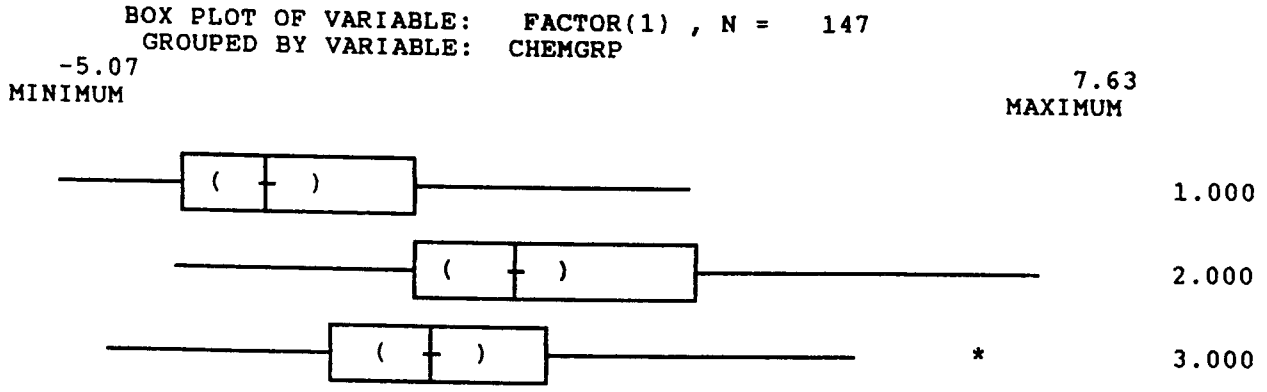


Figure 3-33. **Box plots of Factor 1 of principal components analysis of copepod groups, plotted separately for each chemistry cluster and calculated separately for Region 3 (top) and all other regions (bottom).**



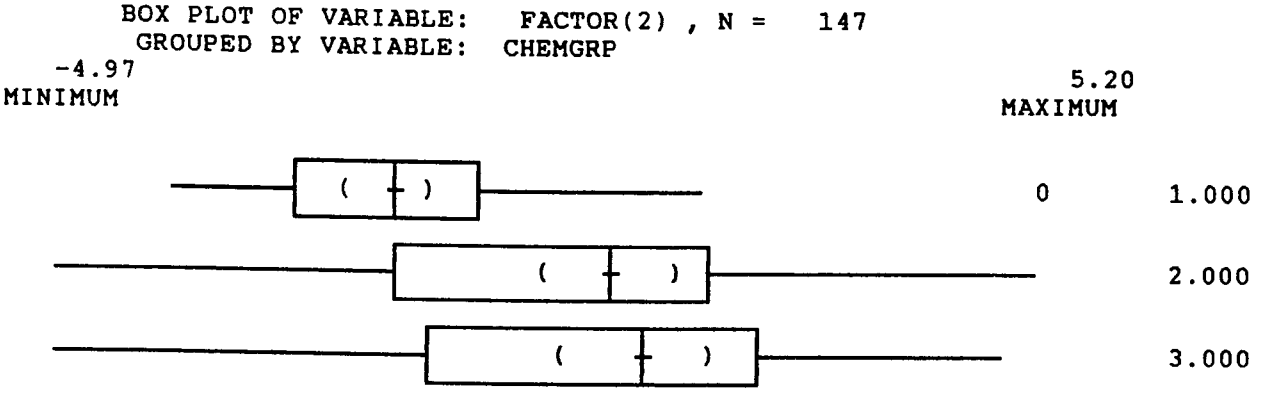


Figure 3-34. Box plots of Factors 1 and 2 of principal components analysis (PCA) of rotifer groups, plotted separately for each chemistry cluster.

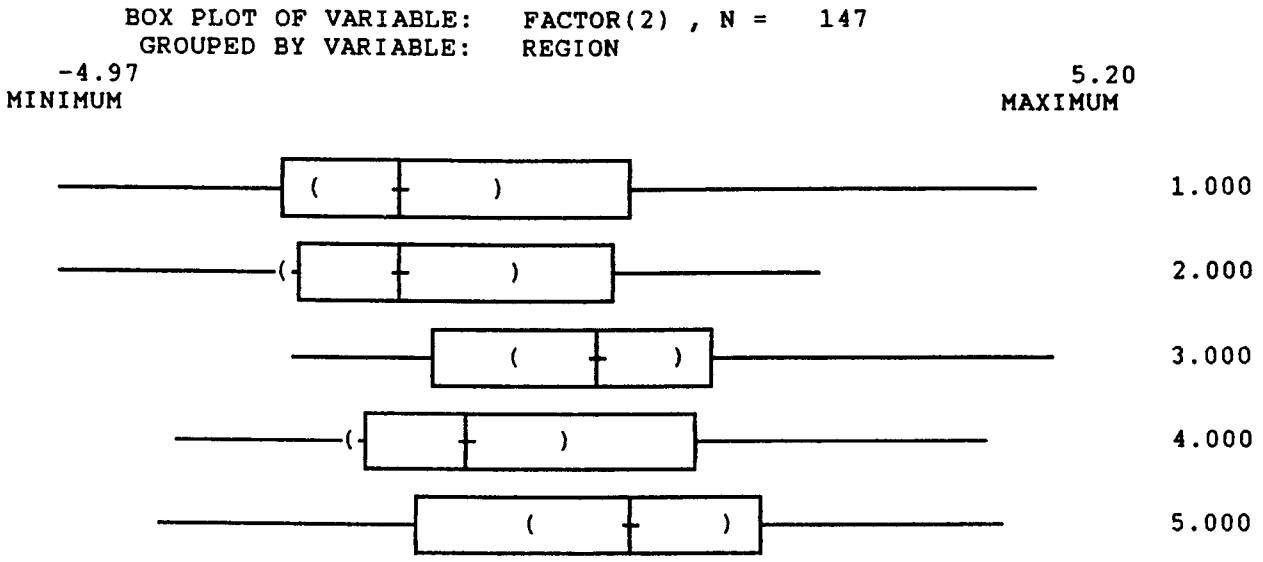


Figure 3-35. **Box plot of Factor 2 of principal components analysis (PCA) of rotifer groups, plotted separately for each geographic region.**

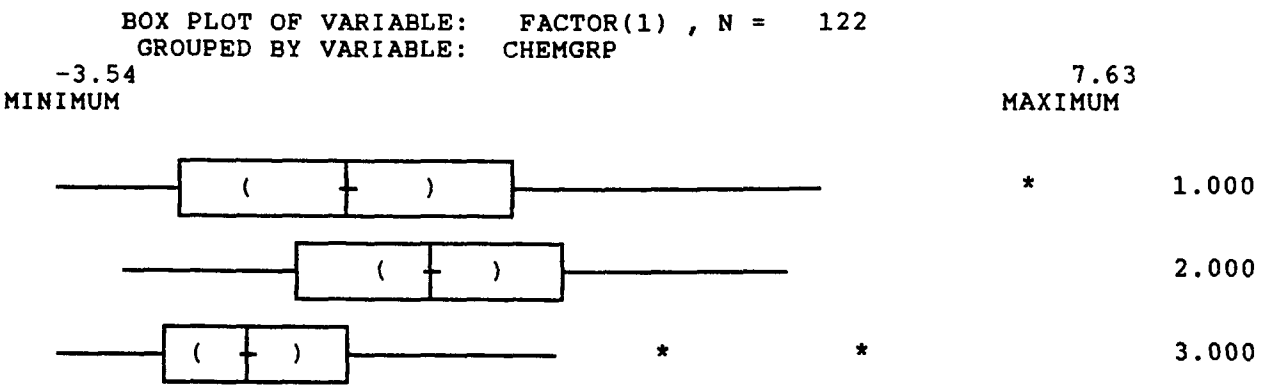


Figure 3-36. Box plot of Factor 1 of principal components analysis (PCA) of cladoceran groups, plotted separately for each chemistry cluster, excluding Region 4.

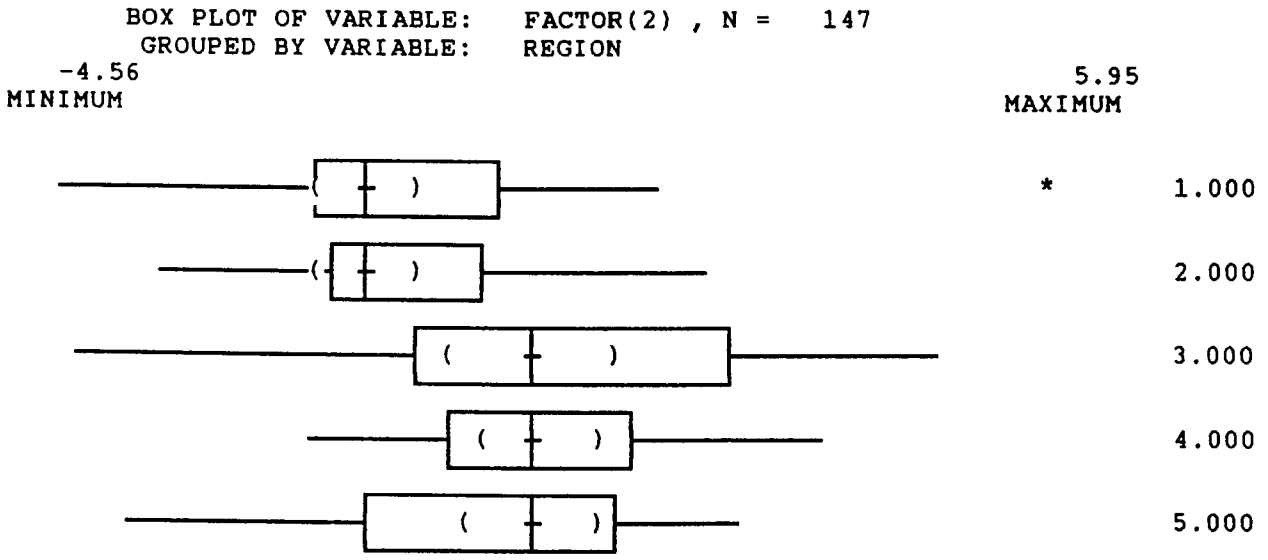


Figure 3-37. **Box plot of Factor 2 of principal components analysis (PCA) of cladoceran groups, plotted separately for each geographic region.**

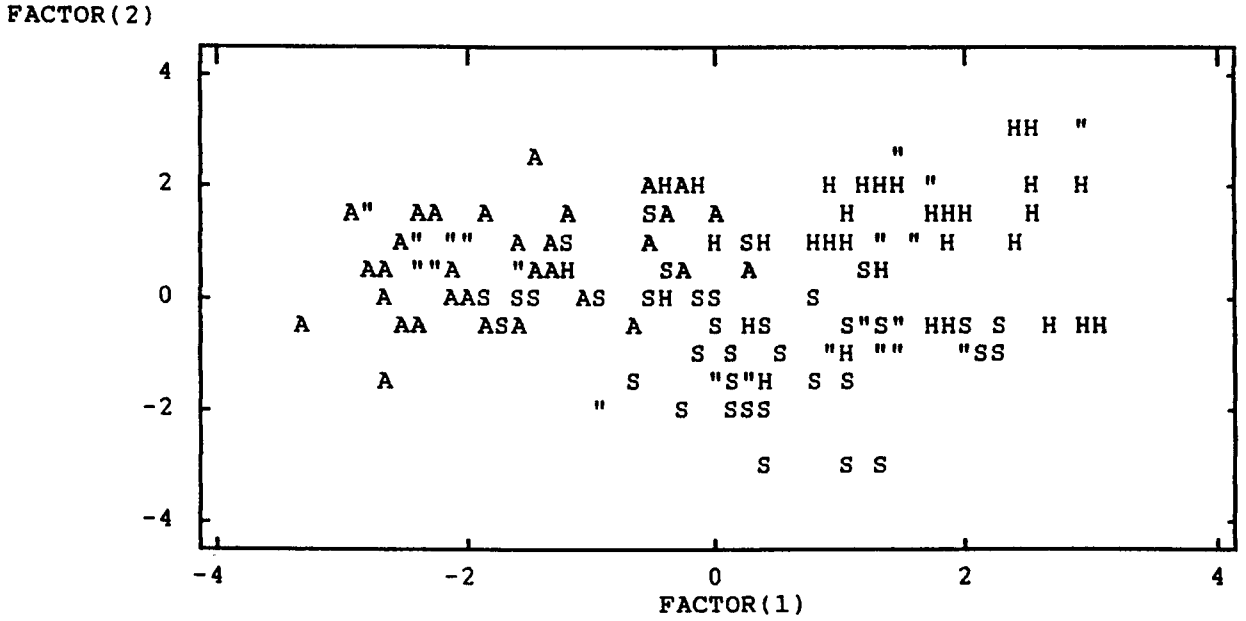


Figure 3-38. **Plot of first two canonical axes of discriminant analysis of proportional abundance of 38 major taxa. A = Cluster 1 lakes; H = Cluster 3 lakes; S = Cluster 2 lakes; " = two or more lakes with same scores.**

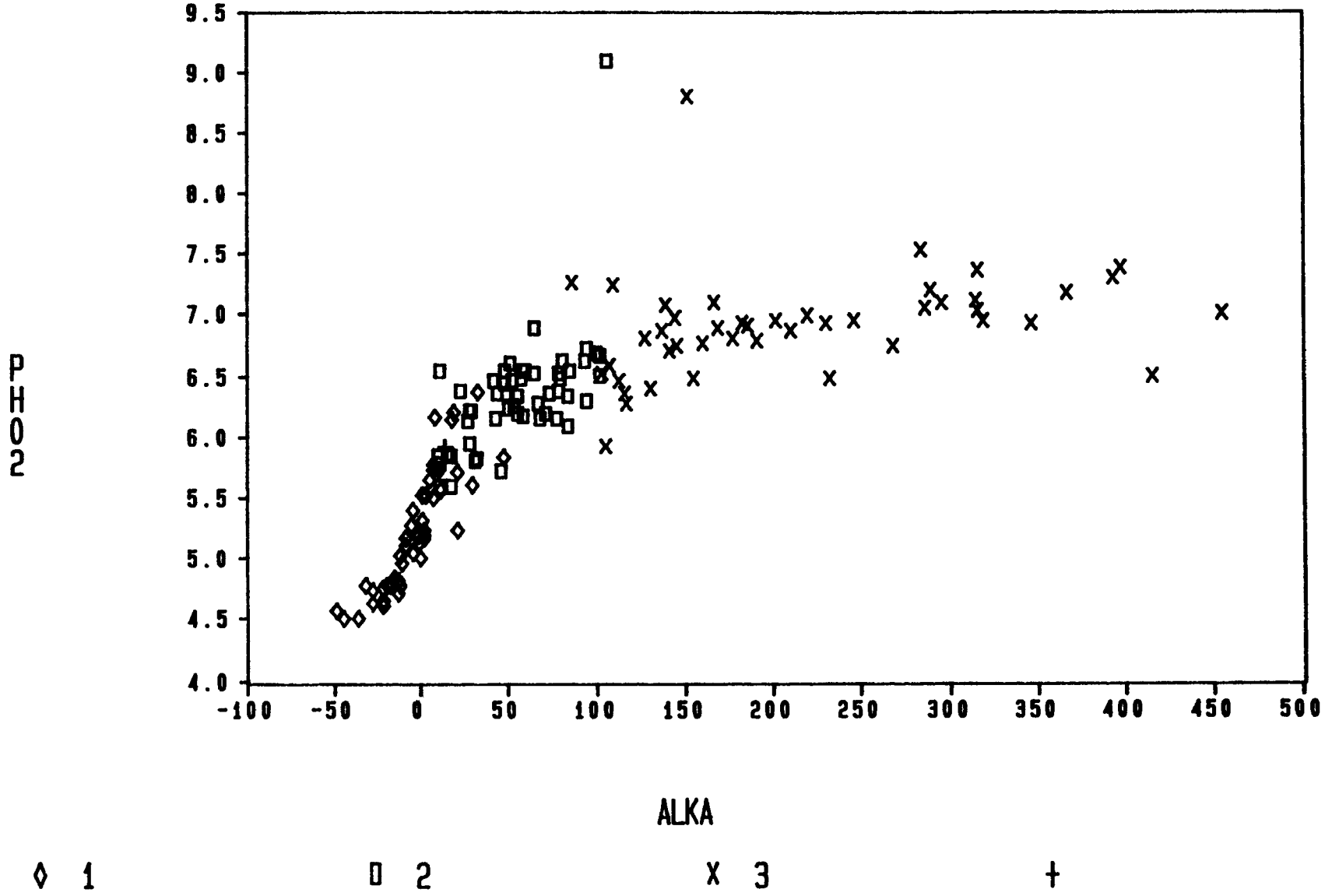


Figure 3-39. Plot of pH and alkalinity for 147 lakes from the summer sampling of the ELS-II.

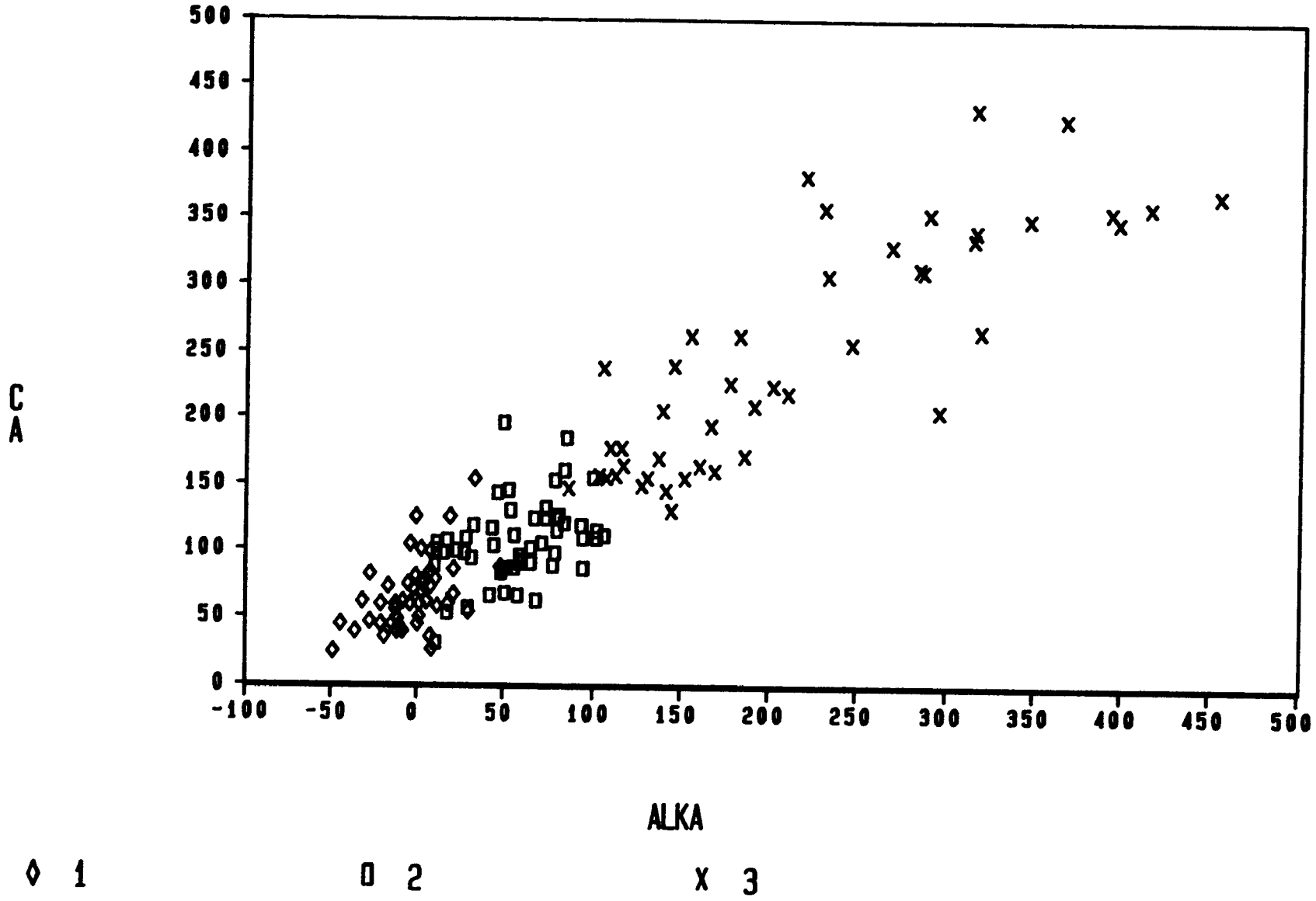


Figure 3-40. Plot of concentration of calcium and alkalinity for 147 lakes from the summer sampling of the ELS-II.

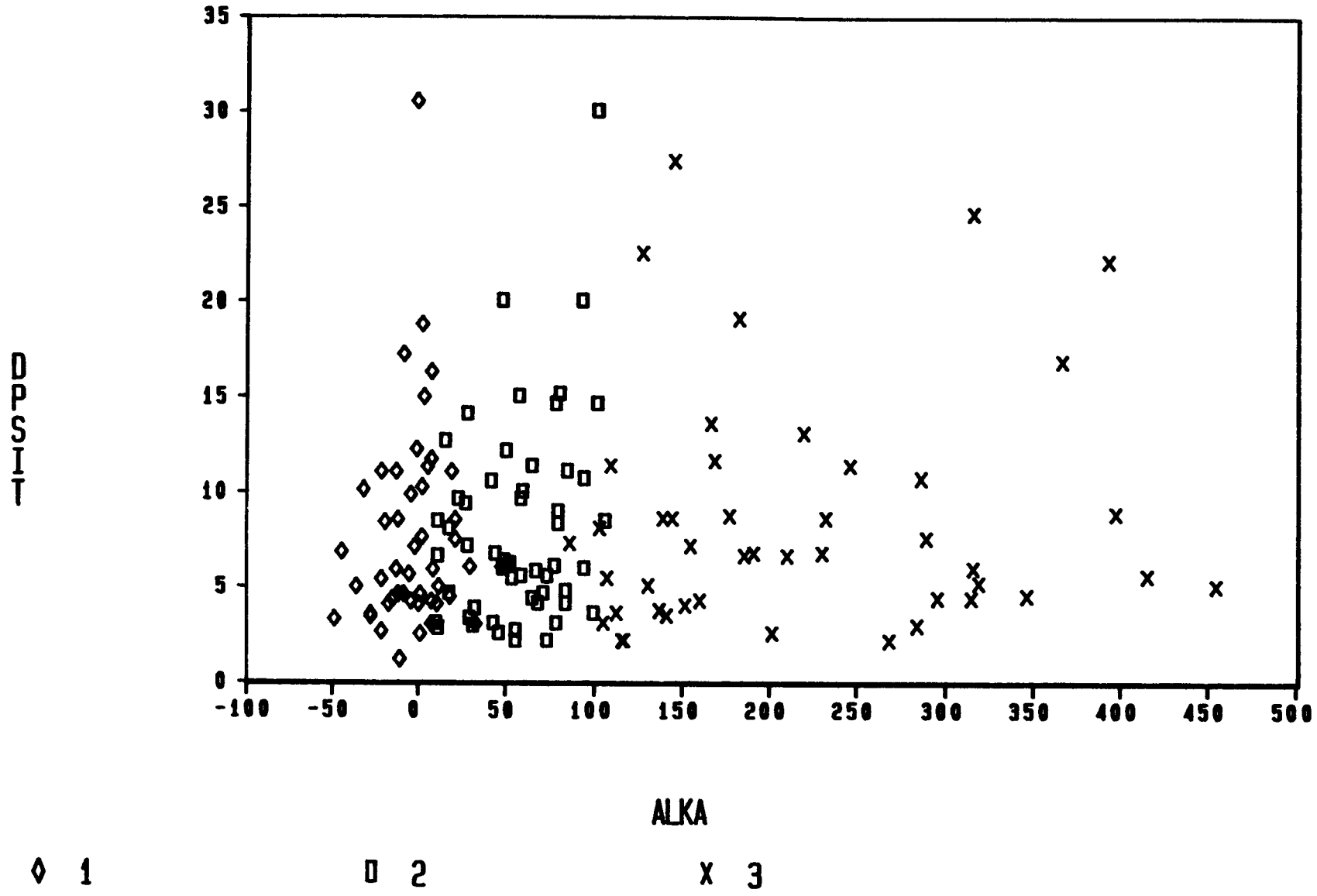


Figure 3-41. Plot of depth of sampling site, which is close to the maximum depth of the lake, and alkalinity for 146 lakes from the summer sampling of the ELS-II.

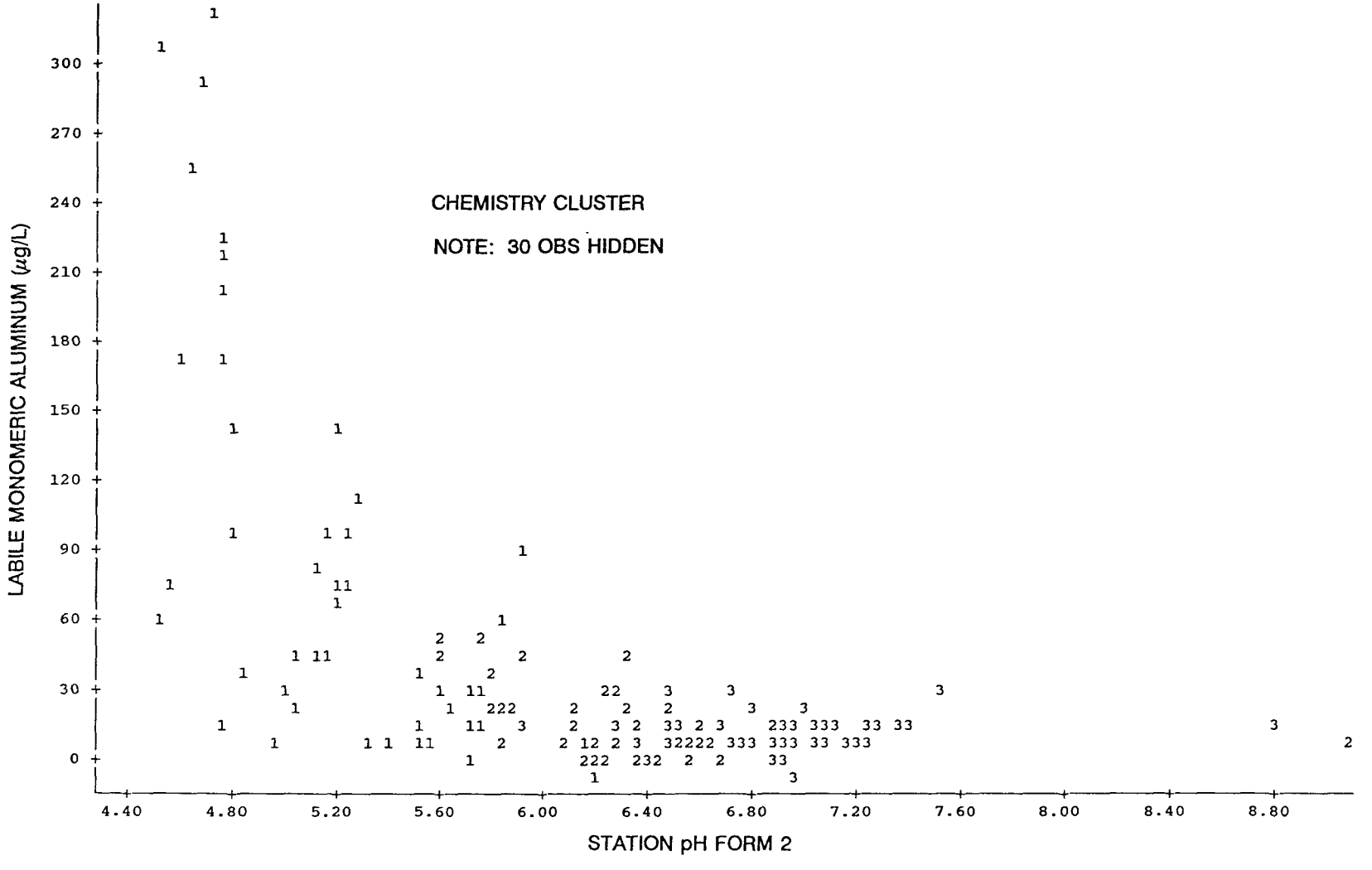


Figure 3-42. Plot of labile monomeric aluminum and pH for 147 lakes from the summer sampling of the ELS-II.

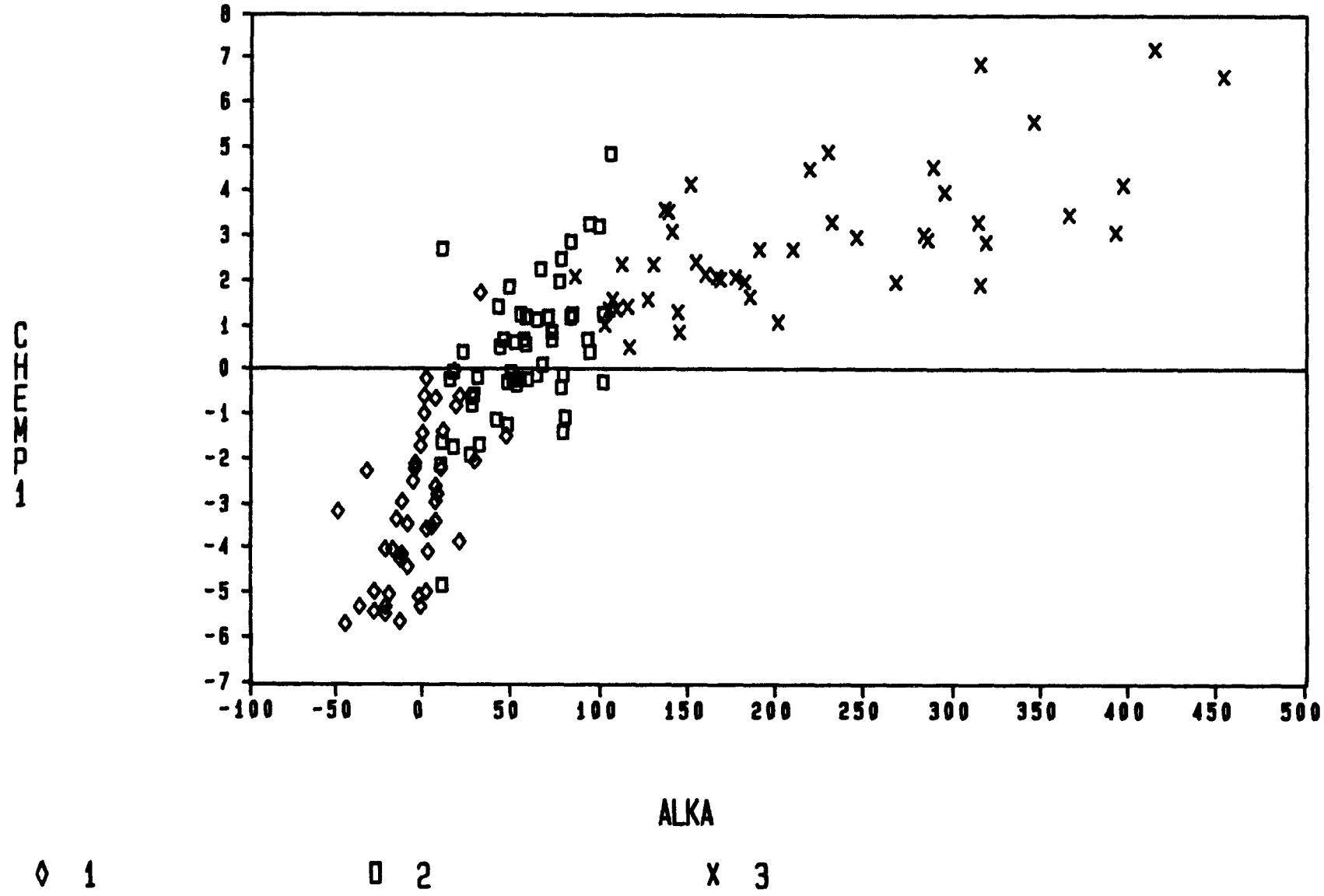


Figure 3-43. Plot of CHEMP1 and alkalinity for 146 lakes from the summer sampling of the ELS-II. CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

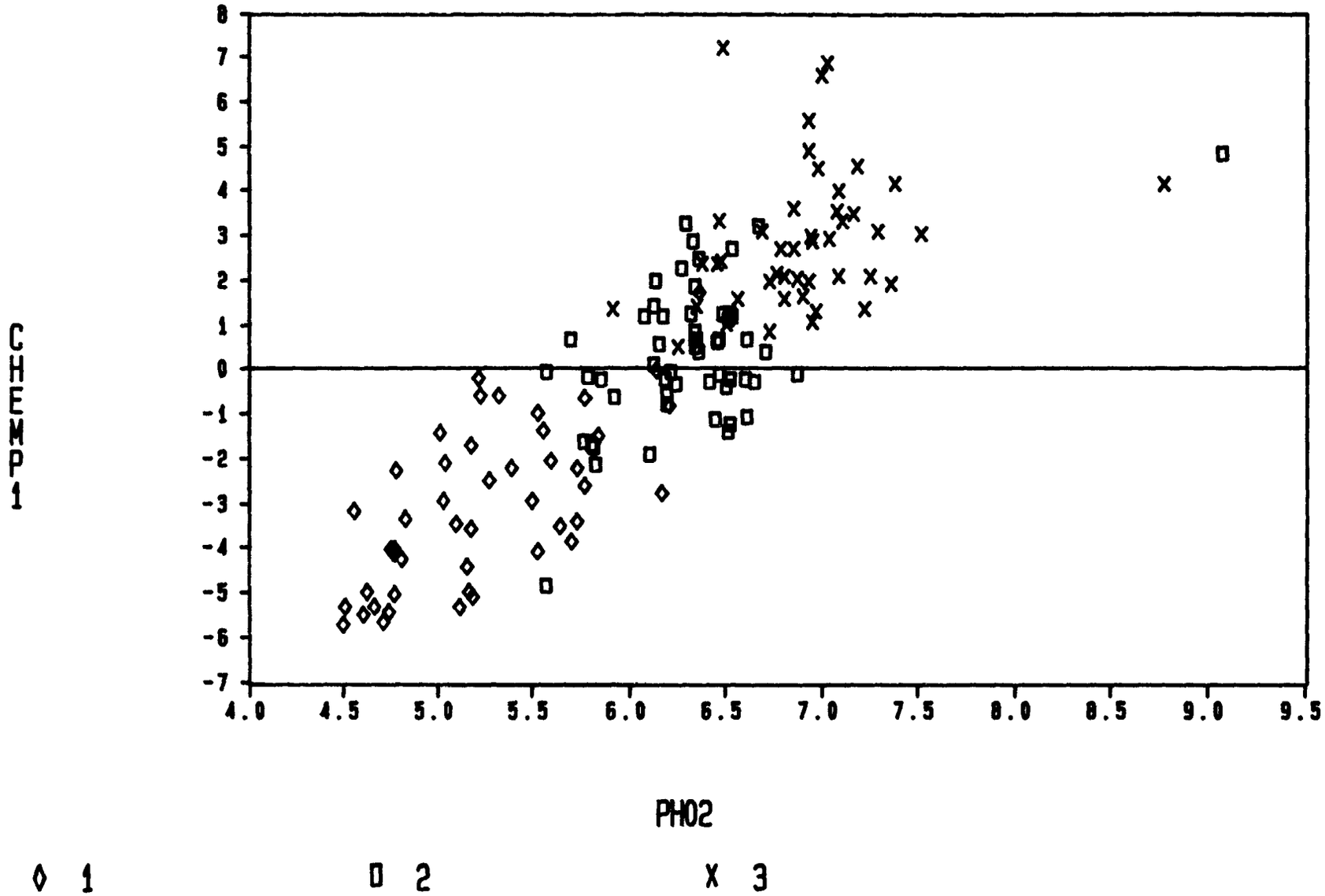


Figure 3-44. Plot of CHEMP1 and field pH for 146 lakes from the summer sampling of the ELS-II. CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

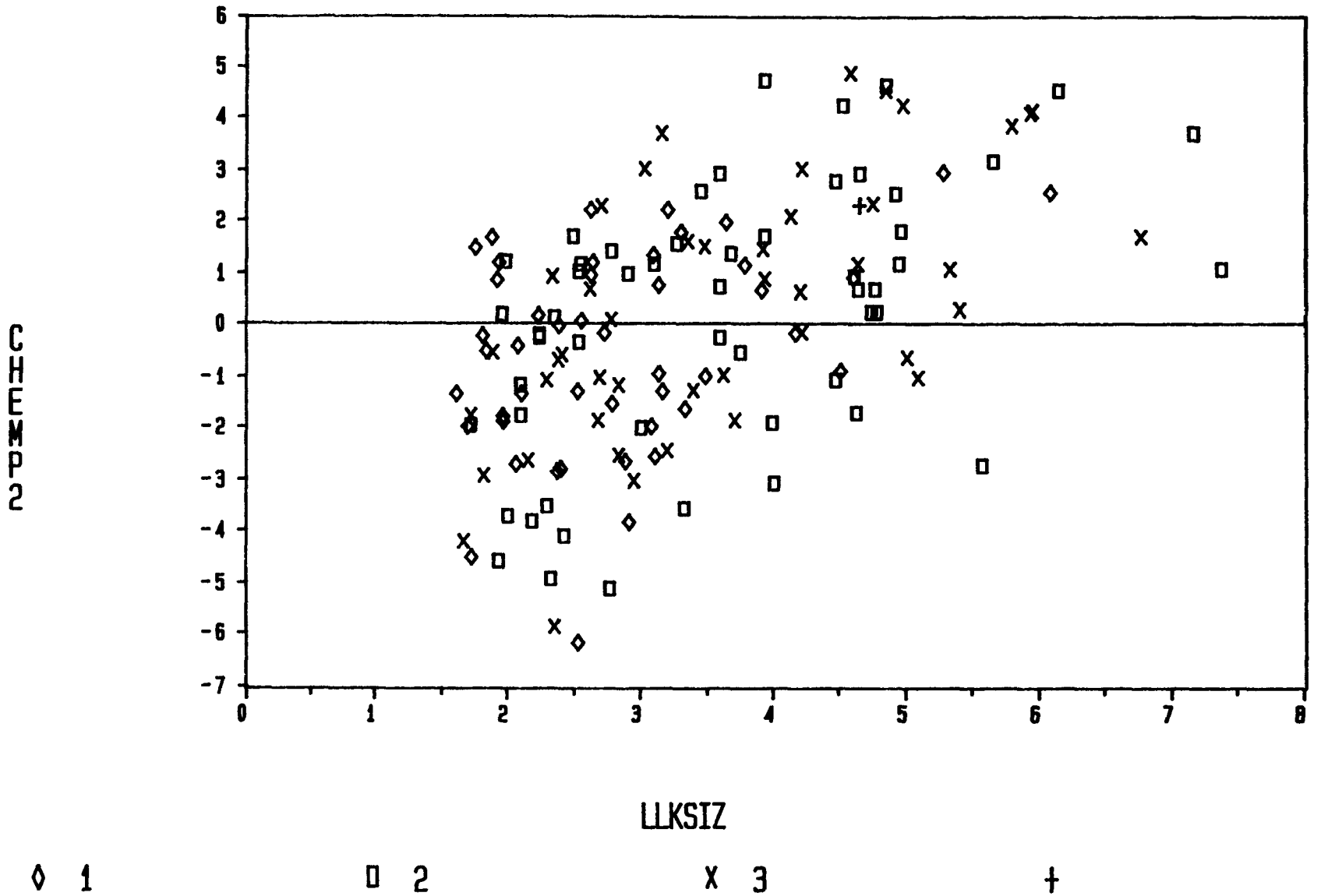


Figure 3-45. Plot of CHEMP2 and log of lake surface area (ha) for 145 lakes from the summer sampling of the ELS-II. CHEMP2 is the second chemical factor calculated by PCA of the chemistry data.

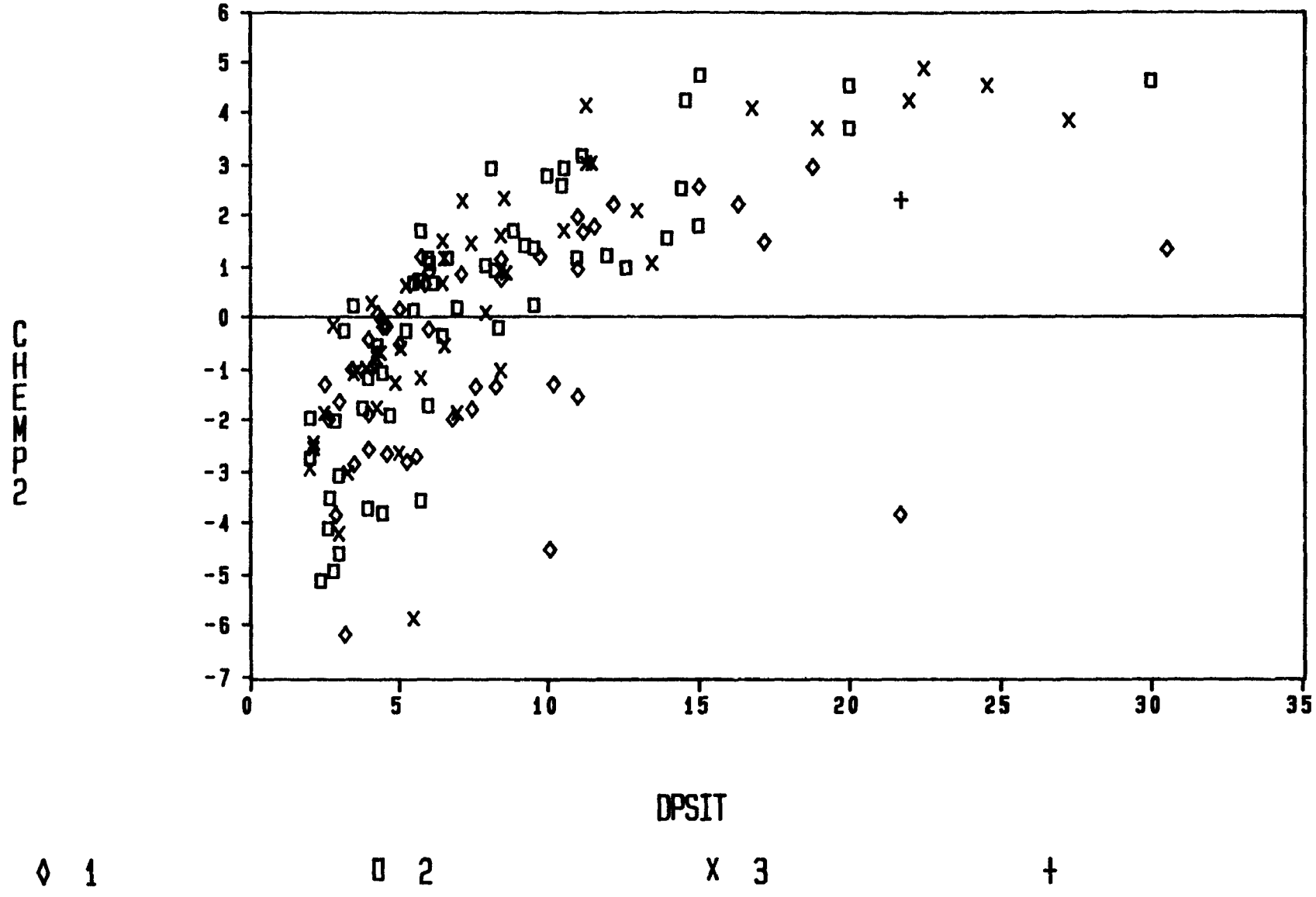


Figure 3-46. Plot of CHEMP2 and the depth of the sampling site, which is close to the maximum depth of the lake, for 145 lakes from the summer sampling of the ELS-II. CHEMP2 is the second chemical factor calculated by PCA of the chemistry data.

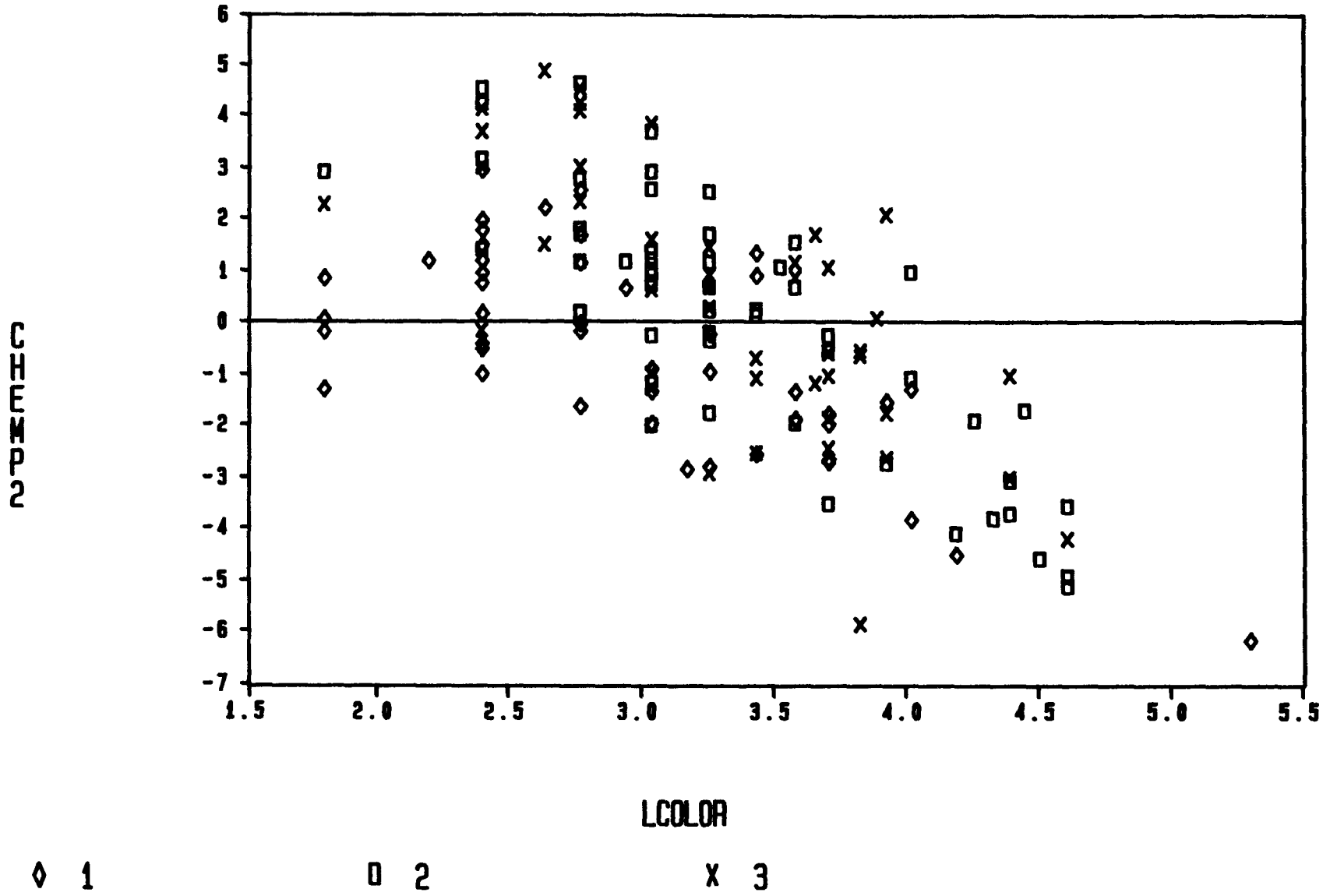


Figure 3-47. Plot of CHEMP2 and log of color for 146 lakes from the summer sampling of the ELS-II. CHEMP2 is the second chemical factor calculated by PCA of the chemistry data.

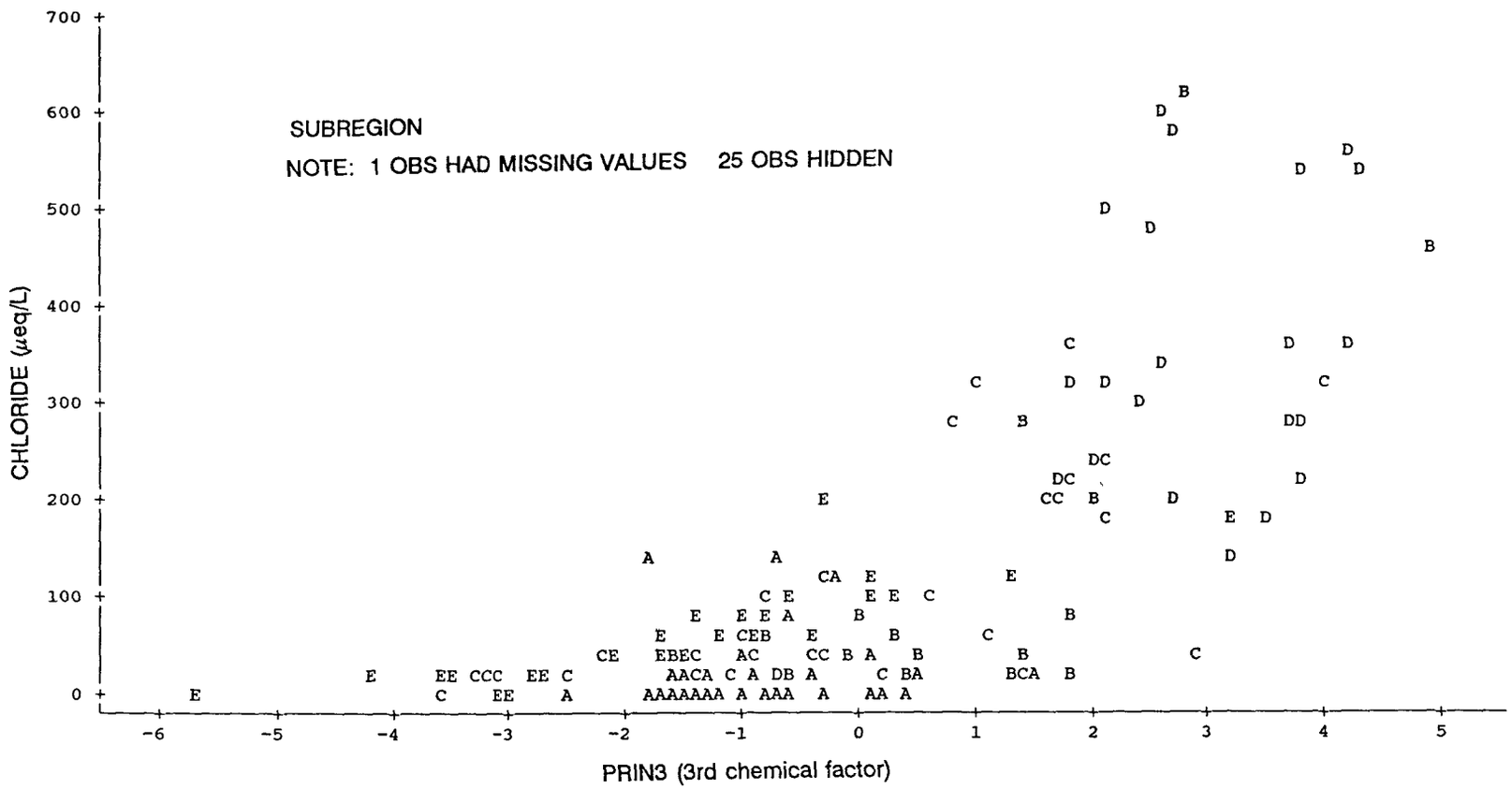


Figure 3-48. Plot of chloride and PRIN3 for 146 lakes from the summer sampling of the ELS-II. PRIN3 is the third chemical factor calculated by PCA of the chemistry data.

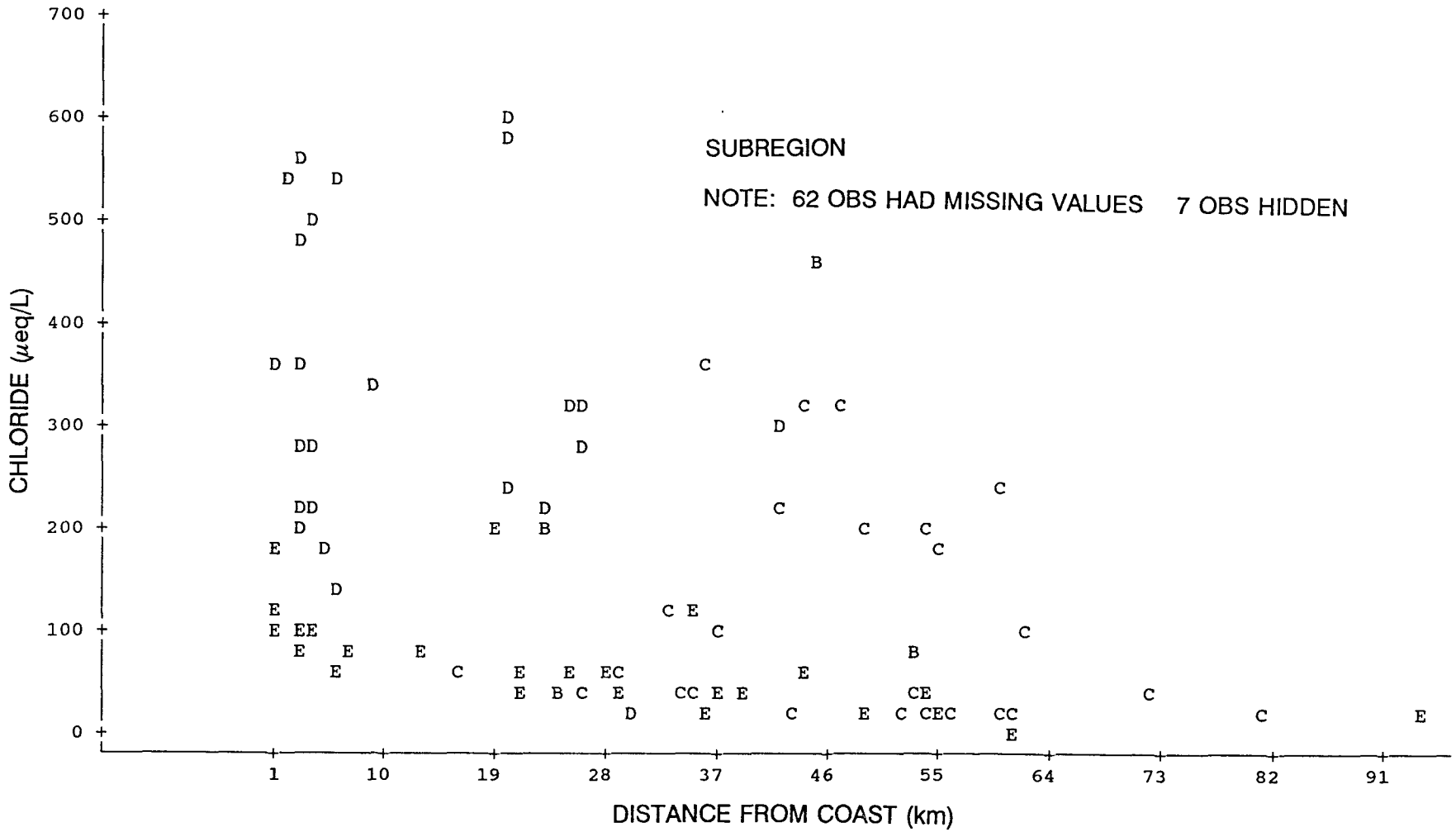


Figure 3-49. Plot of chloride and distance from coast for 146 lakes from the summer sampling of the ELS-II. Most missing values are for interior lakes for which distance from coast was not calculated.

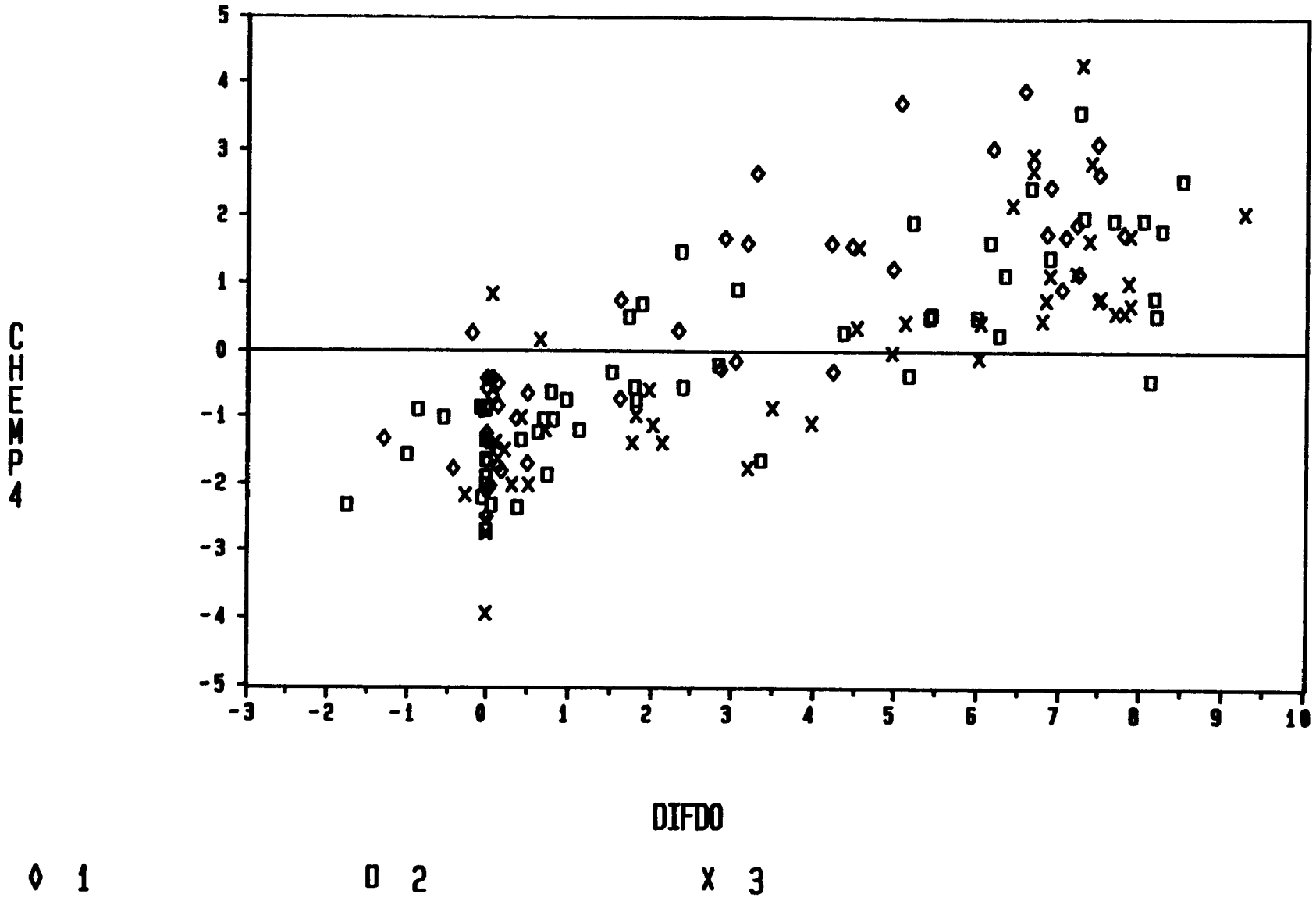


Figure 3-50. Plot of CHEMP4 and the difference between surface and bottom dissolved oxygen for 145 lakes from the summer sampling of the ELS-II. CHEMP4 is the fourth chemical factor calculated by PCA of the chemistry data.

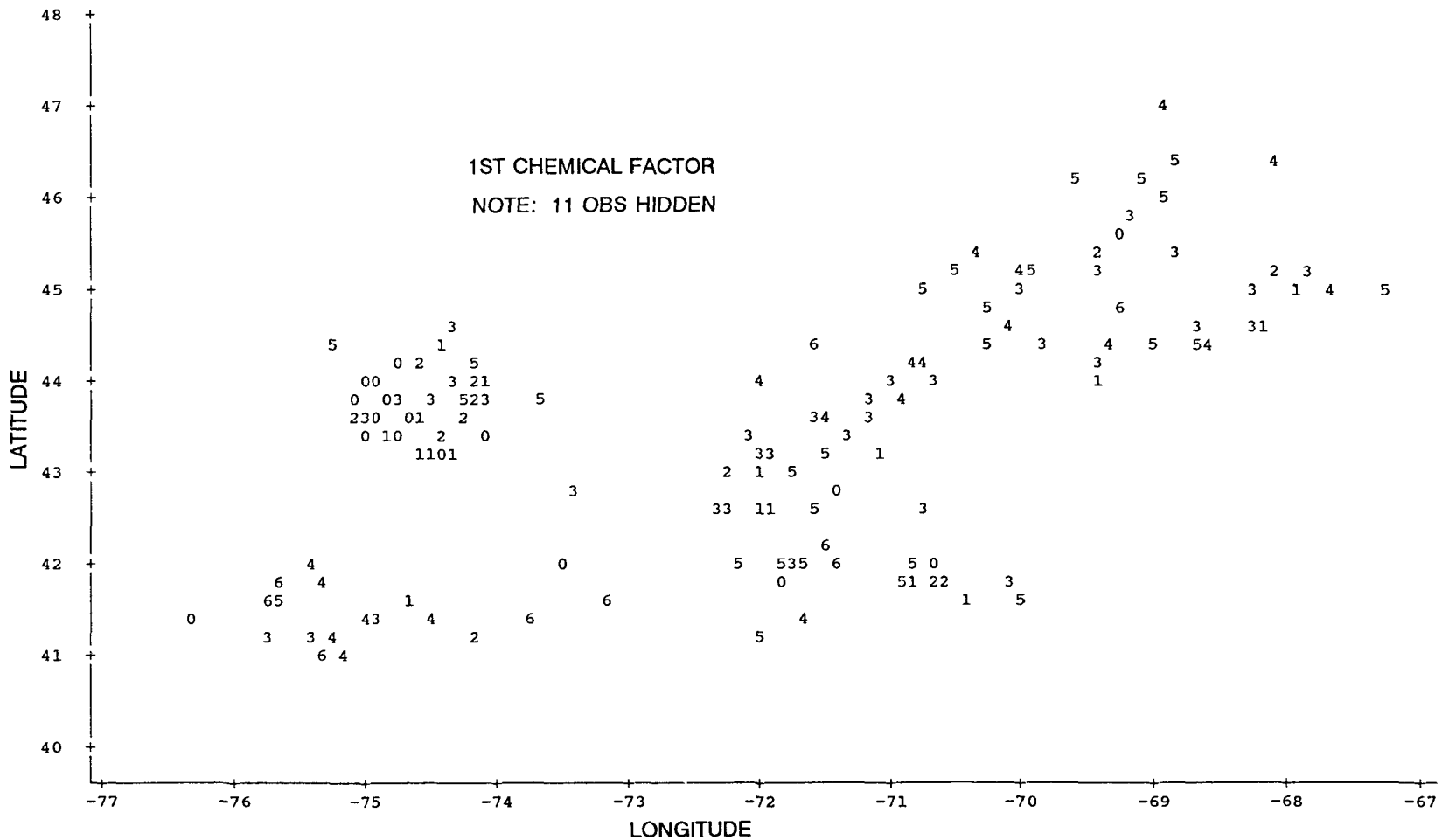


Figure 3-51. **Schematic map of 146 lakes from the summer sampling of the ELS-II. Axes are in decimal degrees of west longitude and north latitude. The scales of the two axes are not equivalent to true geographic distances. Labels are indices of size of factor score of first chemistry factor, with 0 representingthe most negative factor scores and 6 the most positive. See text for explanation.**

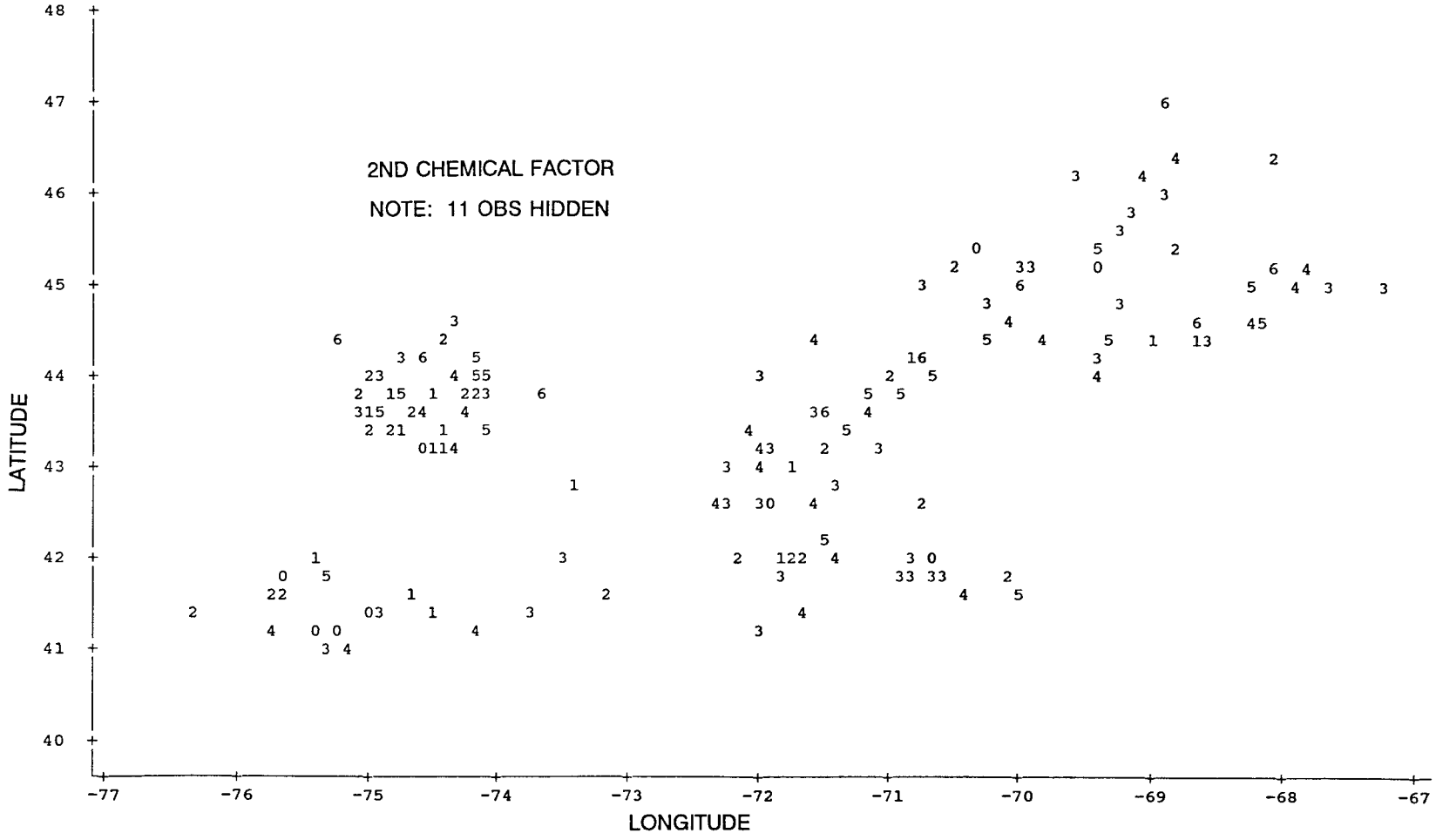


Figure 3-52. **Schematic map of 146 lakes from the summer sampling of the ELS-II. Axes are in decimal degrees of west longitude and north latitude. The scales of the two axes are not equivalent to true geographic distances. Labels are indices of size of factor score of second chemistry factor, with 0 representing the most negative factor scores and 6 the most positive. See text for explanation.**

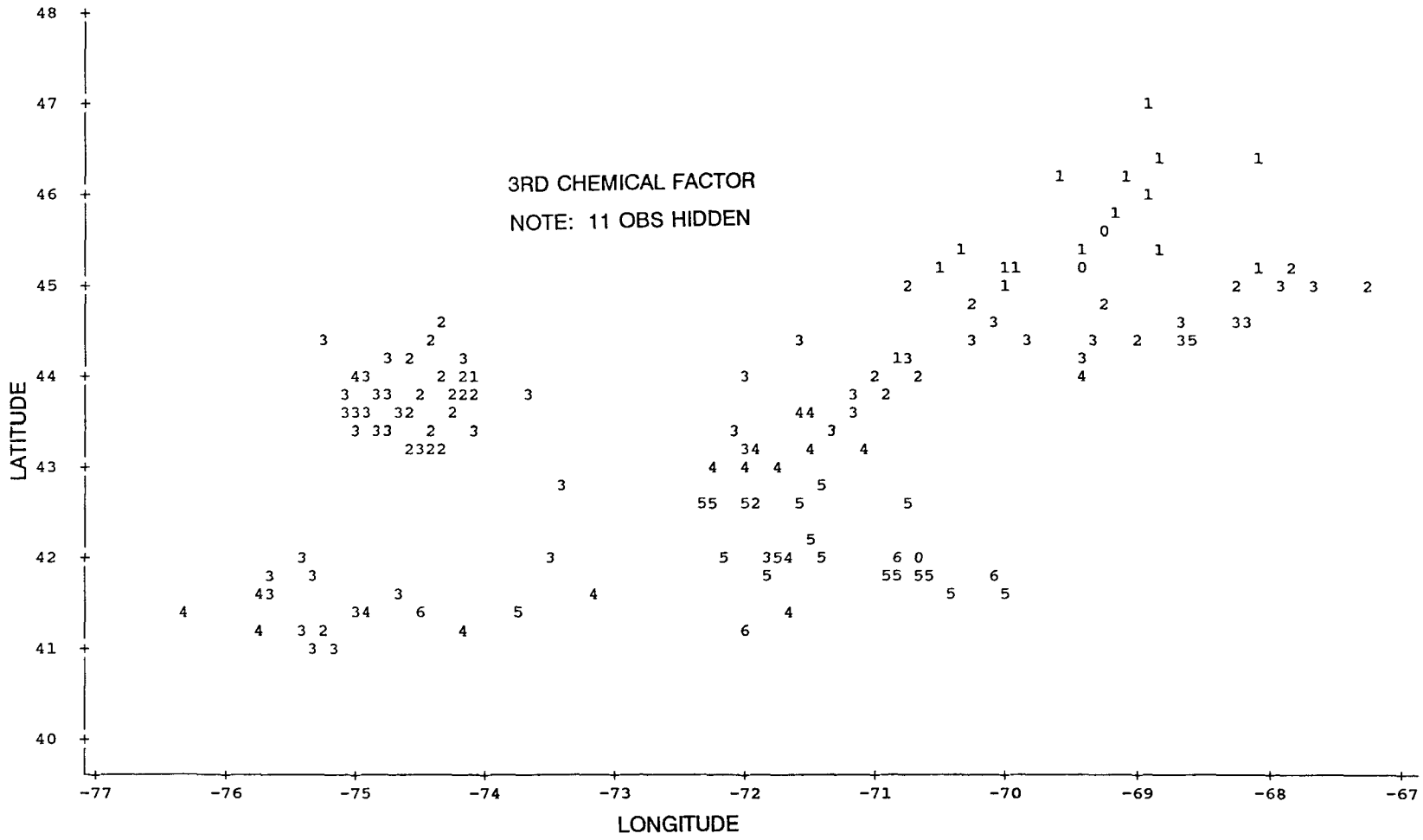


Figure 3-53. **Schematic map of 146 lakes from the summer sampling of the ELS-II. Axes are in decimal degrees of west longitude and north latitude. The scales of the two axes are not equivalent to true geographic distances. Labels are indices of size of factor score of third chemistry factor, with 0 representing the most negative factor scores and 6 the most positive. See text for explanation.**

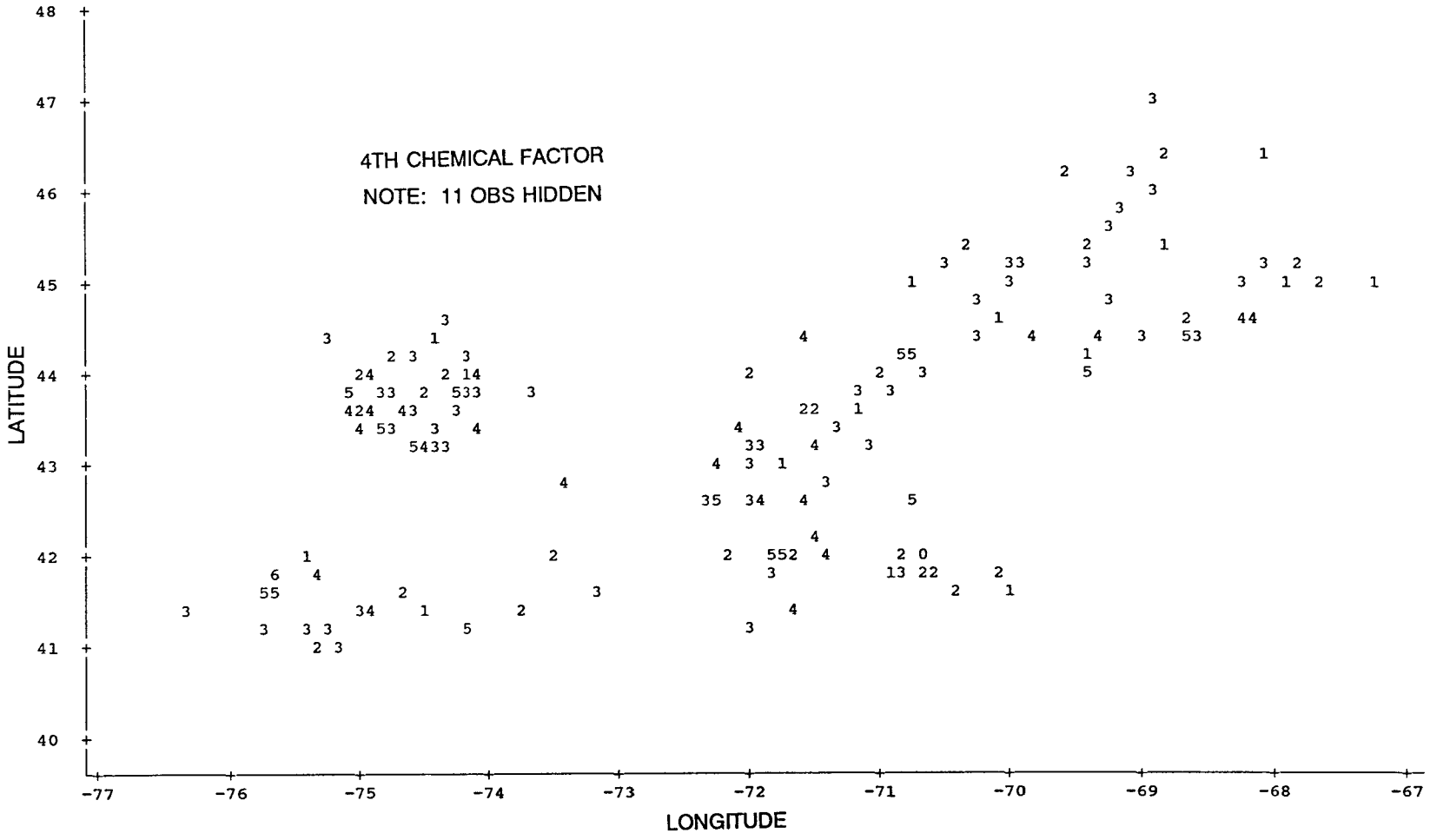


Figure 3-54. **Schematic map of 146 lakes from the summer sampling of the ELS-II. Axes are in decimal degrees of west longitude and north latitude. The scales of the two axes are not equivalent to true geographic distances. Labels are indices of size of factor score of fourth chemistry factor, with 0 representing the most negative factor scores and 6 the most positive. See text for explanation.**

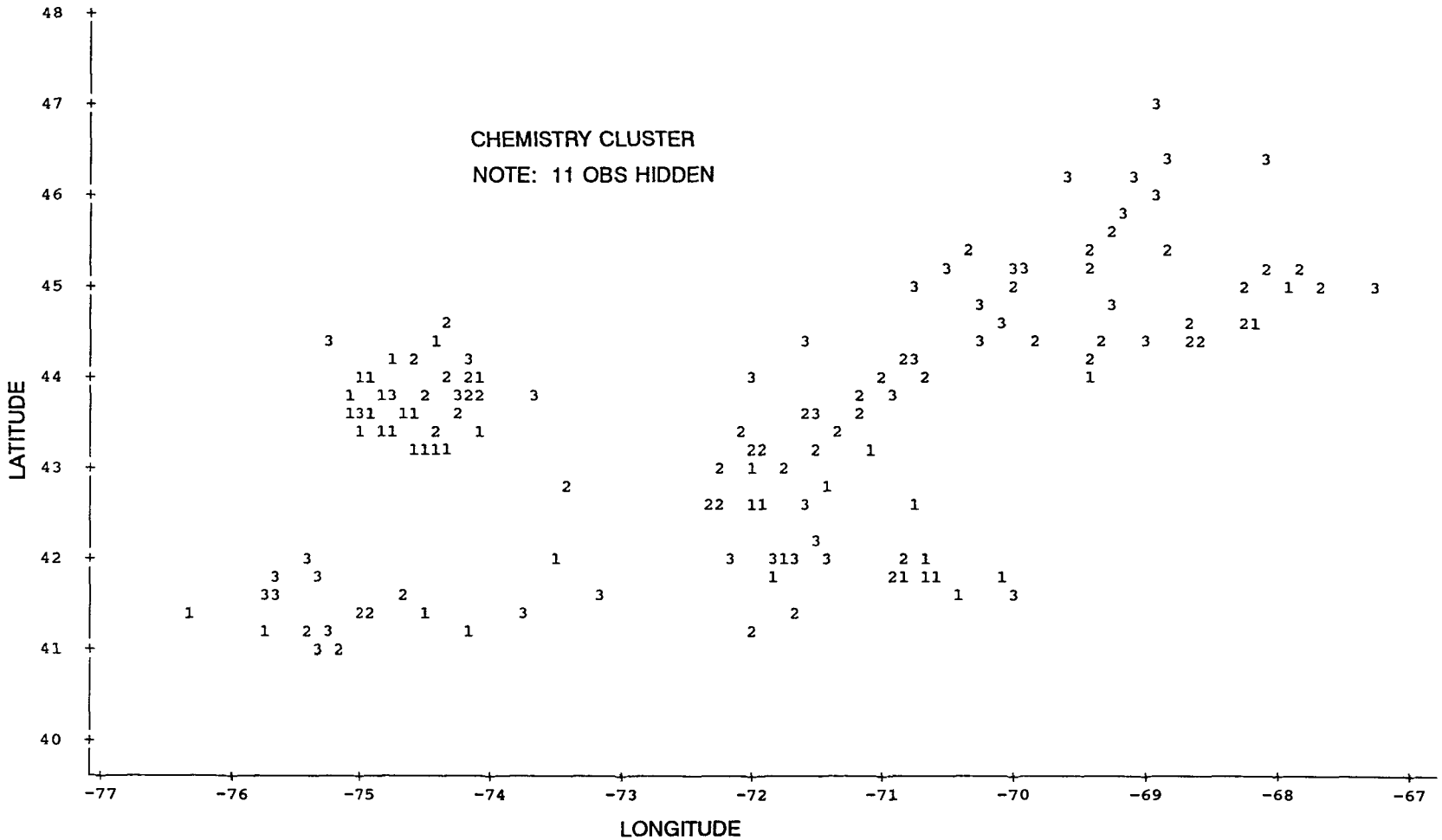


Figure 3-55. **Schematic map of 146 lakes from the summer sampling of the ELS-II. Axes are in decimal degrees of west longitude and north latitude, labelled by chemistry cluster. The scales of the two axes are not equivalent to true geographic distances. See text for explanation.**

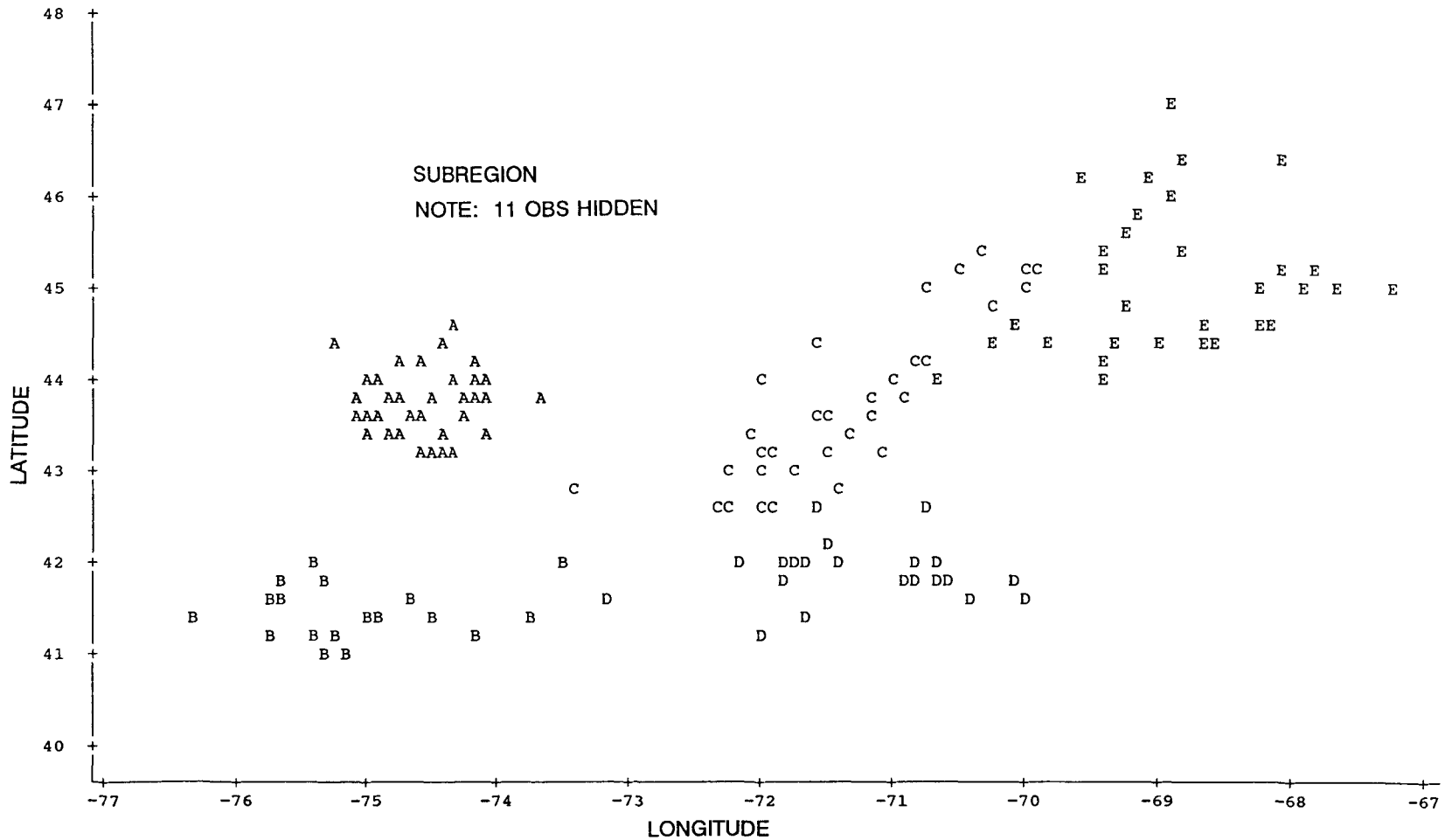


Figure 3-56. **Schematic map of 146 lakes from the summer sampling of the ELS-II. Axes are in decimal degrees of west longitude and north latitude, labelled by subregion. The scales of the two axes are not equivalent to true geographic distances. See text for explanation.**

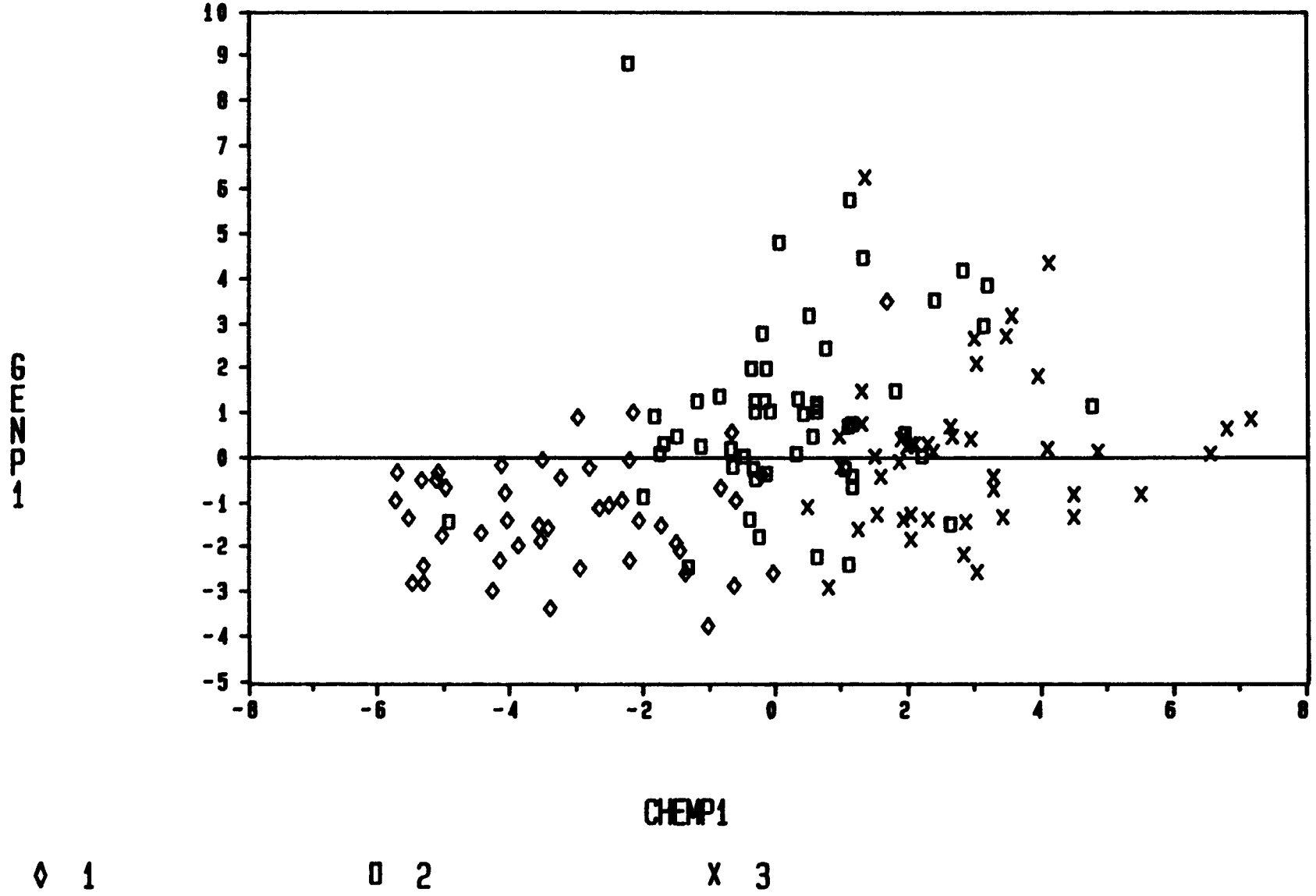


Figure 3-57. Plot of GENP1 and CHEMP1 for 145 lakes from the summer sampling of the ELS-II. GENP1 is the first community factor calculated by PCA of the generic abundance data and CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

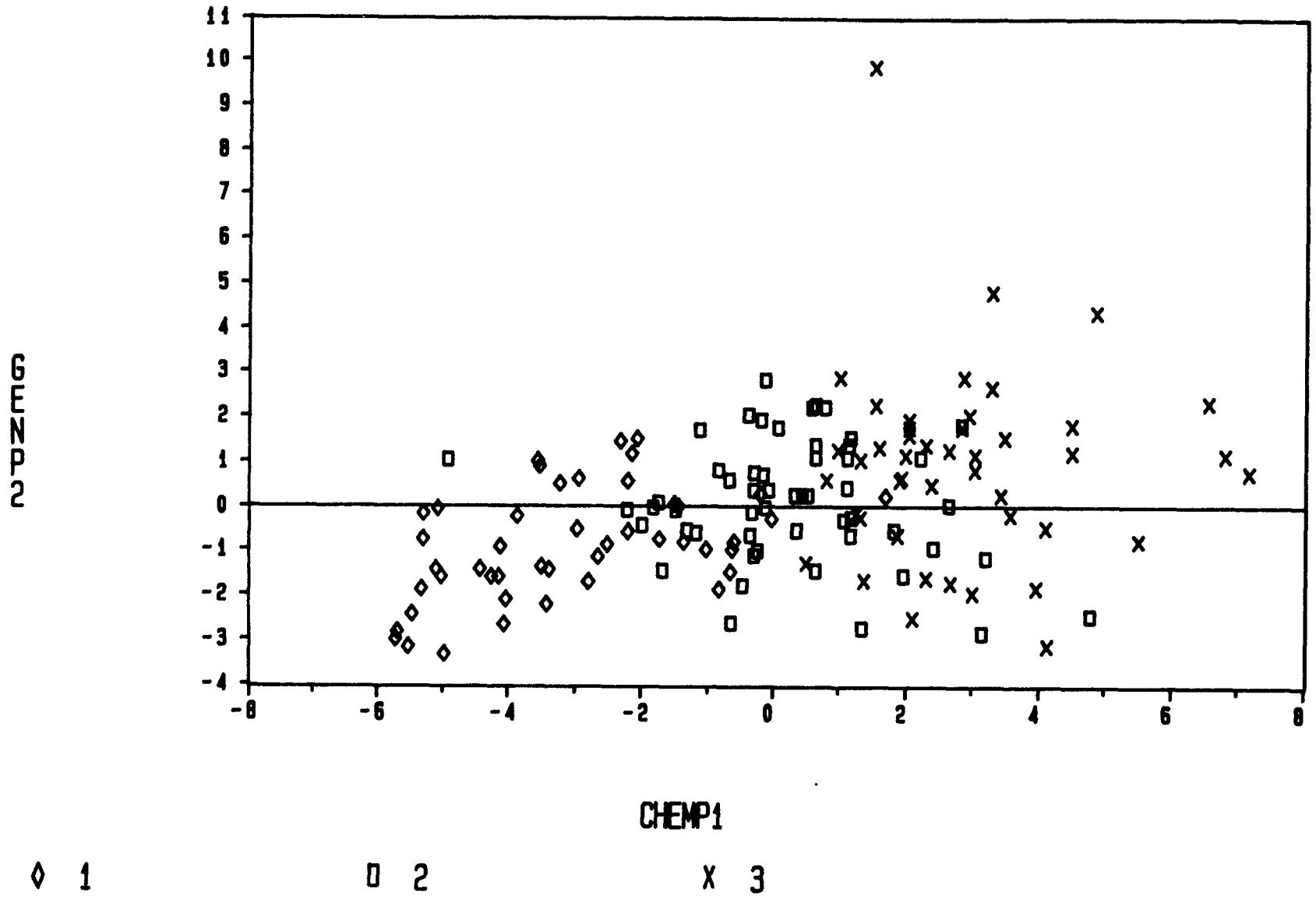


Figure 3-58. Plot of GENP2 and CHEMP1 for 145 lakes from the summer sampling of the ELS-II. GENP2 is the second community factor calculated by PCA of the generic abundance data and CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

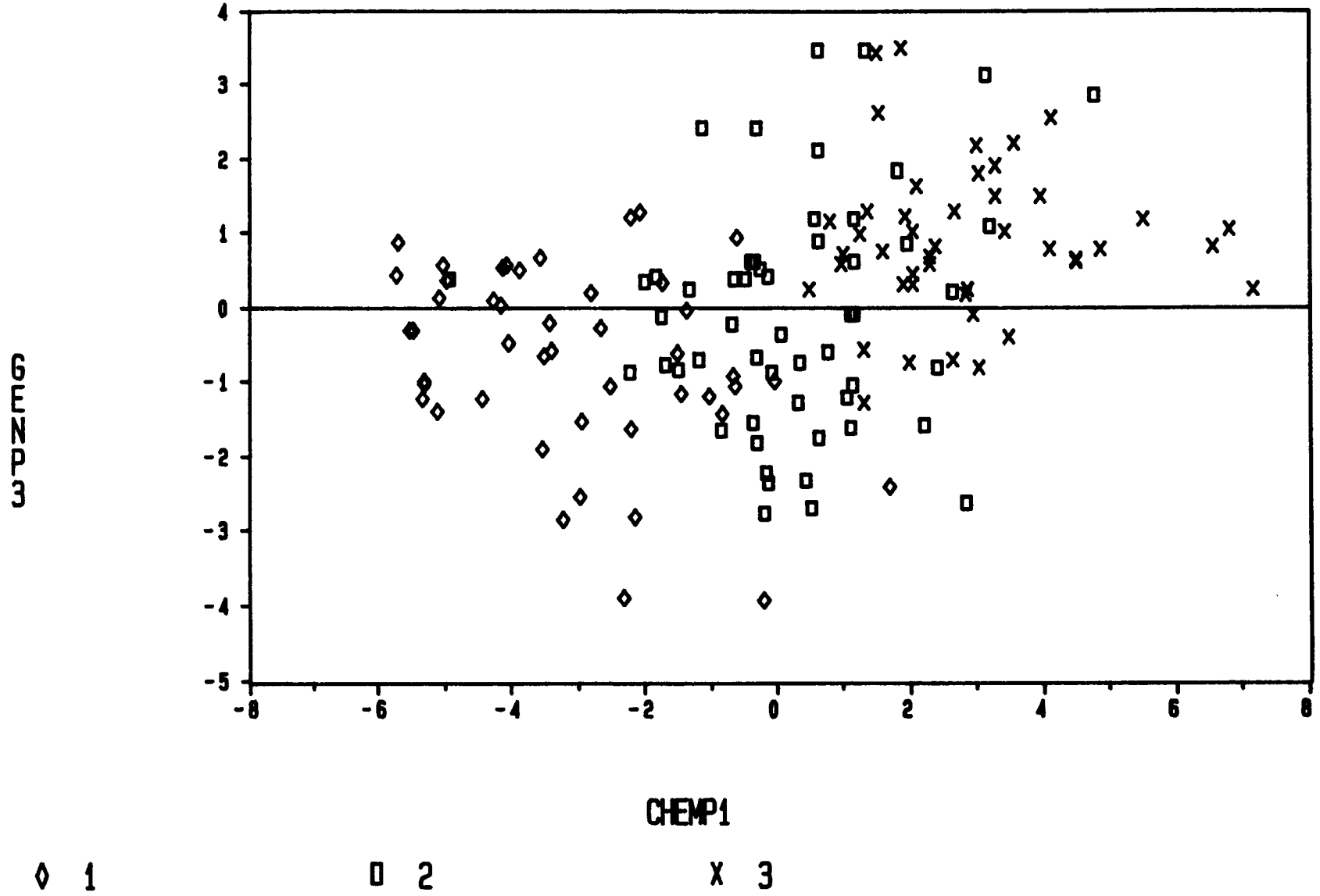


Figure 3-59. Plot of GENP3 and CHEMP1 for 145 lakes from the summer sampling of the ELS-II. GENP3 is the third community factor calculated by PCA of the generic abundance data and CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

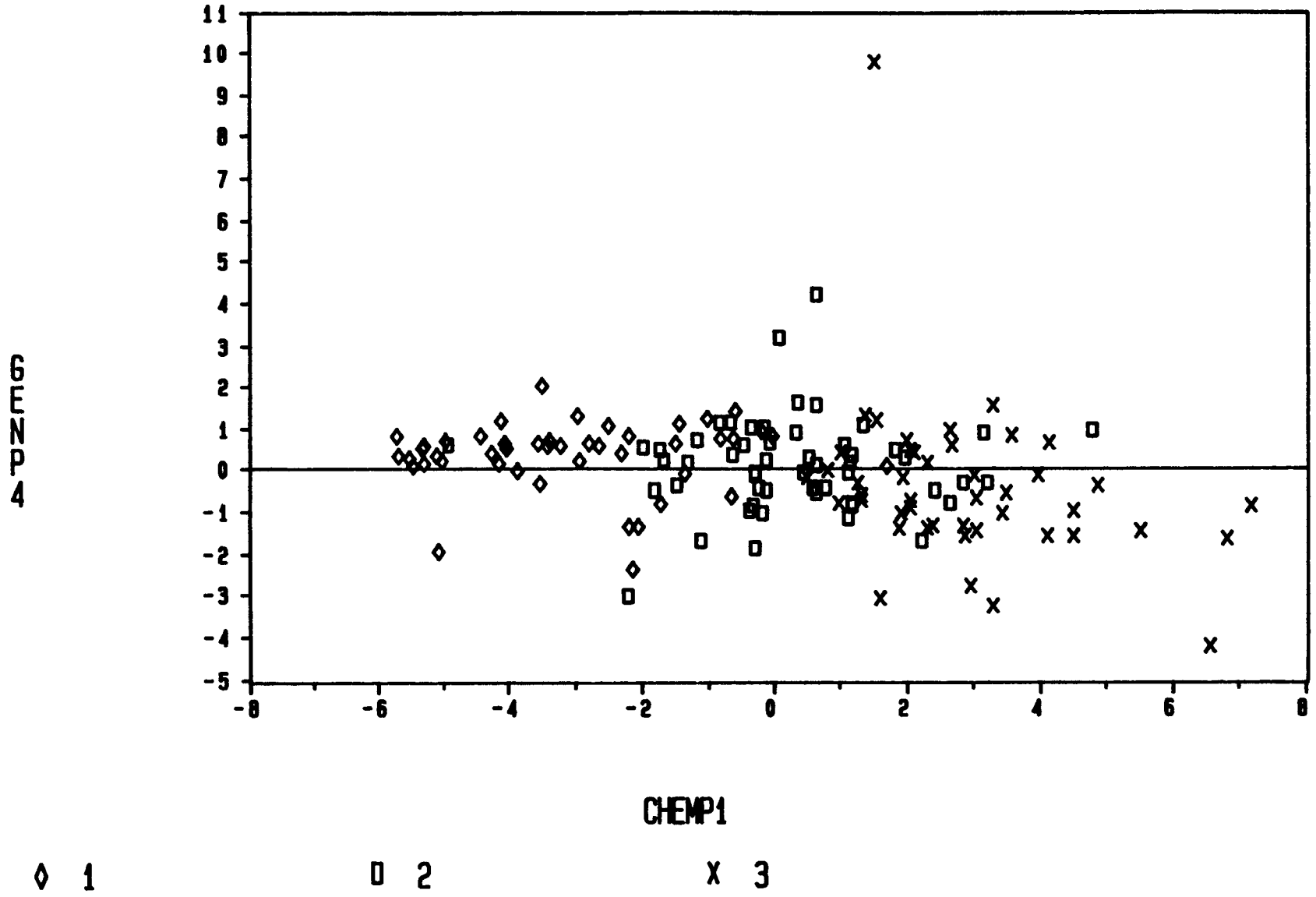


Figure 3-60. Plot of GENP4 and CHEMP1 for 145 lakes from the summer sampling of the ELS-II. GENP4 is the fourth community factor calculated by PCA of the generic abundance data and CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

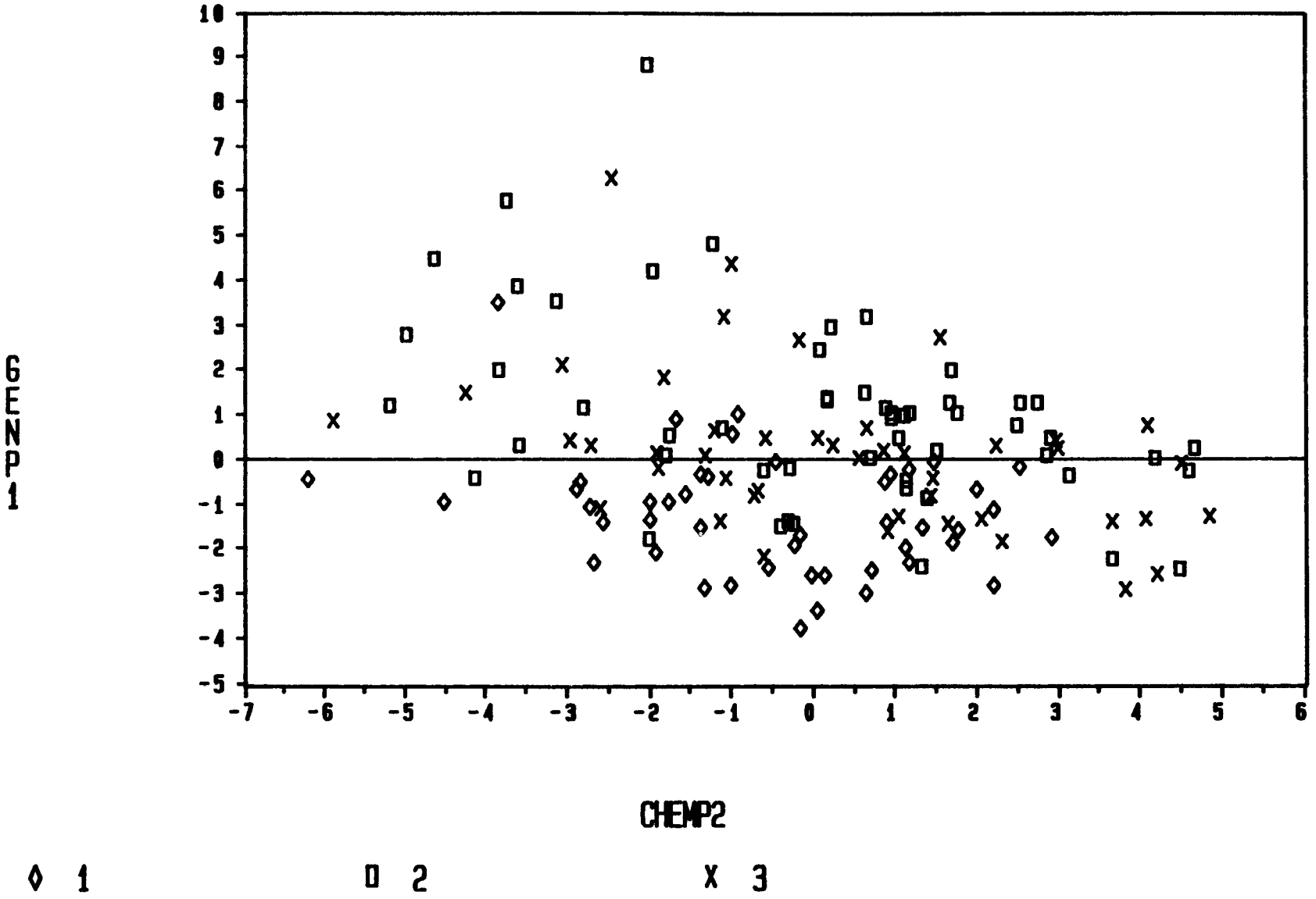


Figure 3-61. Plot of GENP1 and CHEMP2 for 145 lakes from the summer sampling of the ELS-II. GENP1 is the first community factor calculated by PCA of the generic abundance data and CHEMP2 is the second chemical factor calculated by PCA of the chemistry data.

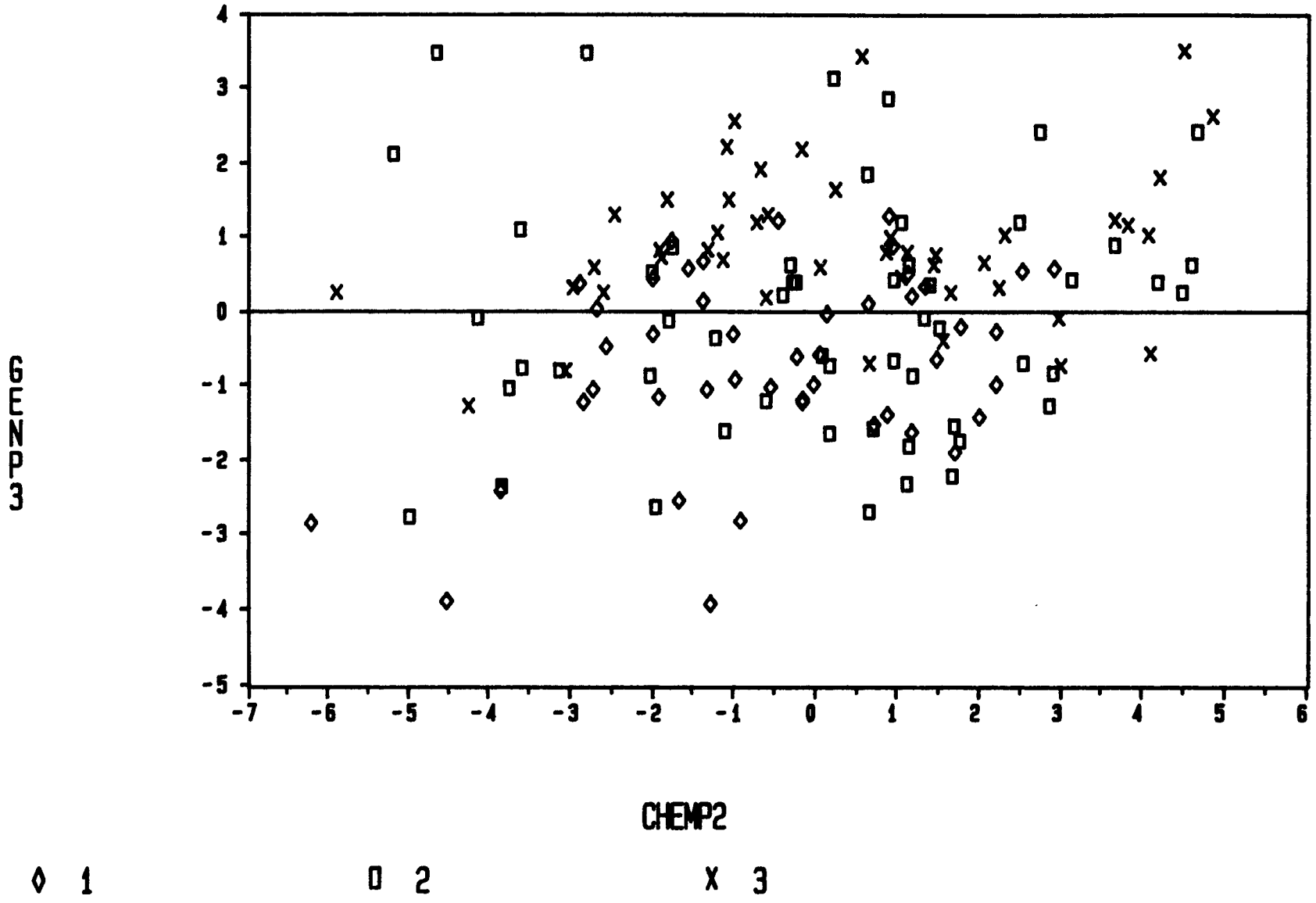


Figure 3-62. Plot of GENP3 and CHEMP2 for 145 lakes from the summer sampling of the ELS-II. GENP3 is the third community factor calculated by PCA of the generic abundance data and CHEMP2 is the second chemical factor calculated by PCA of the chemistry data.

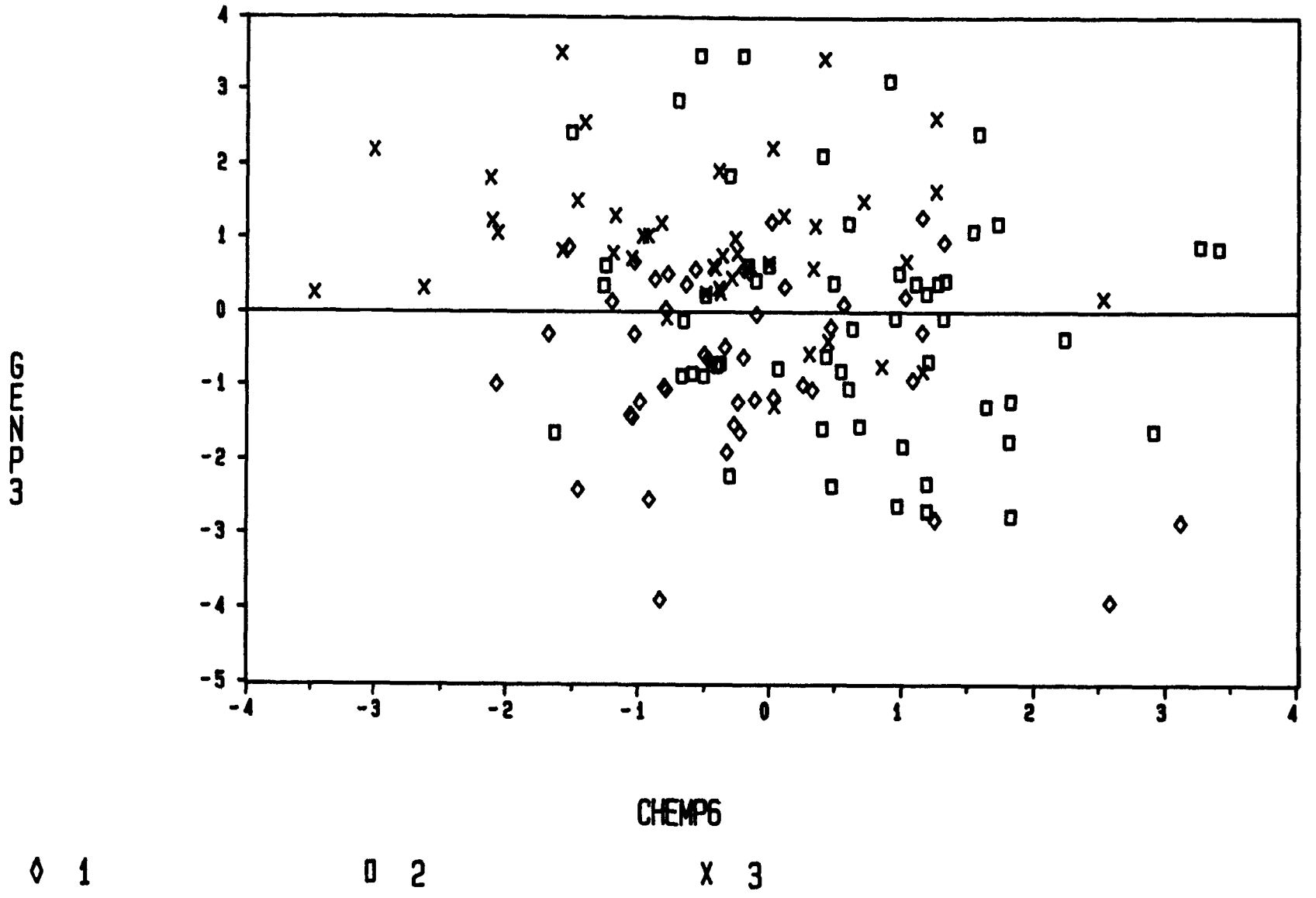


Figure 3-63. Plot of GENP3 and CHEMP6 for 145 lakes from the summer sampling of the ELS-II. GENP3 is the third community factor calculated by PCA of the generic abundance data and CHEMP6 is the sixth chemical factor calculated by PCA of the chemistry data.

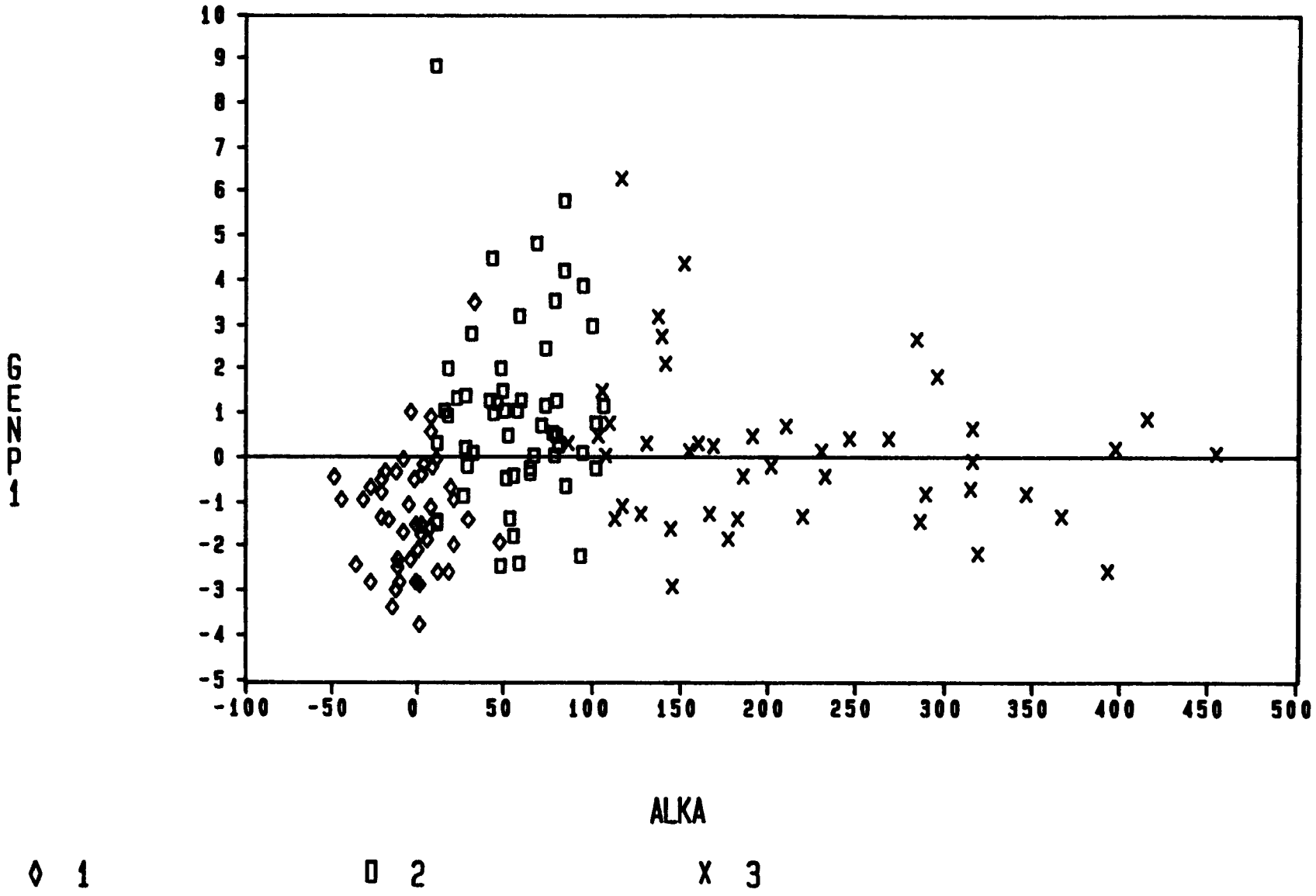


Figure 3-64. Plot of GENP1 and alkalinity for 146 lakes from the summer sampling of the ELS-II. GENP1 is the first community factor calculated by PCA of the generic abundance data.

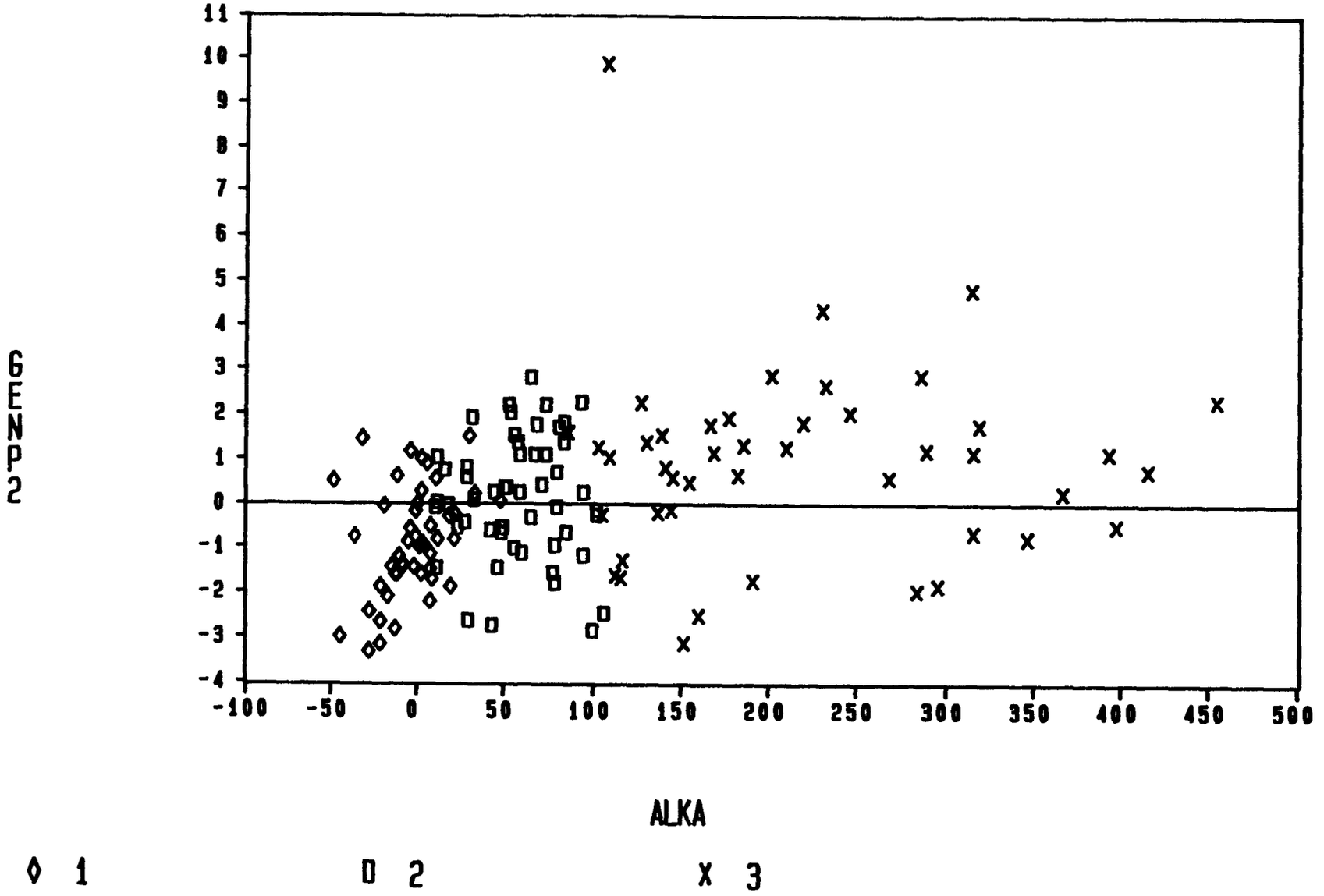


Figure 3-65. Plot of GENP2 and alkalinity for 146 lakes from the summer sampling of the ELS-II. GENP2 is the second community factor calculated by PCA of the generic abundance data.

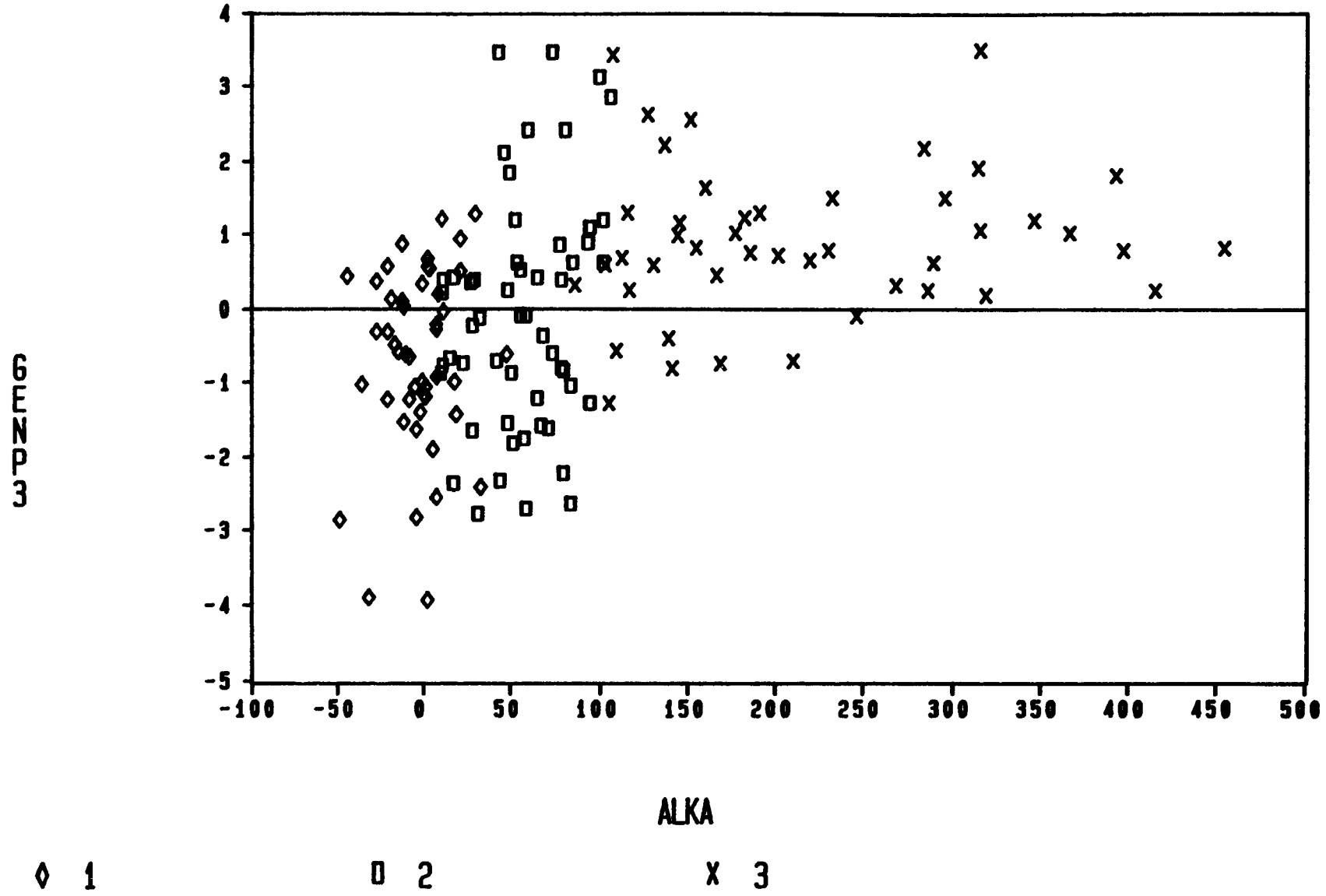


Figure 3-66. Plot of GENP3 and alkalinity for 146 lakes from the summer sampling of ELS-II. GENP3 is the third community factor calculated by PCA of the generic abundance data.

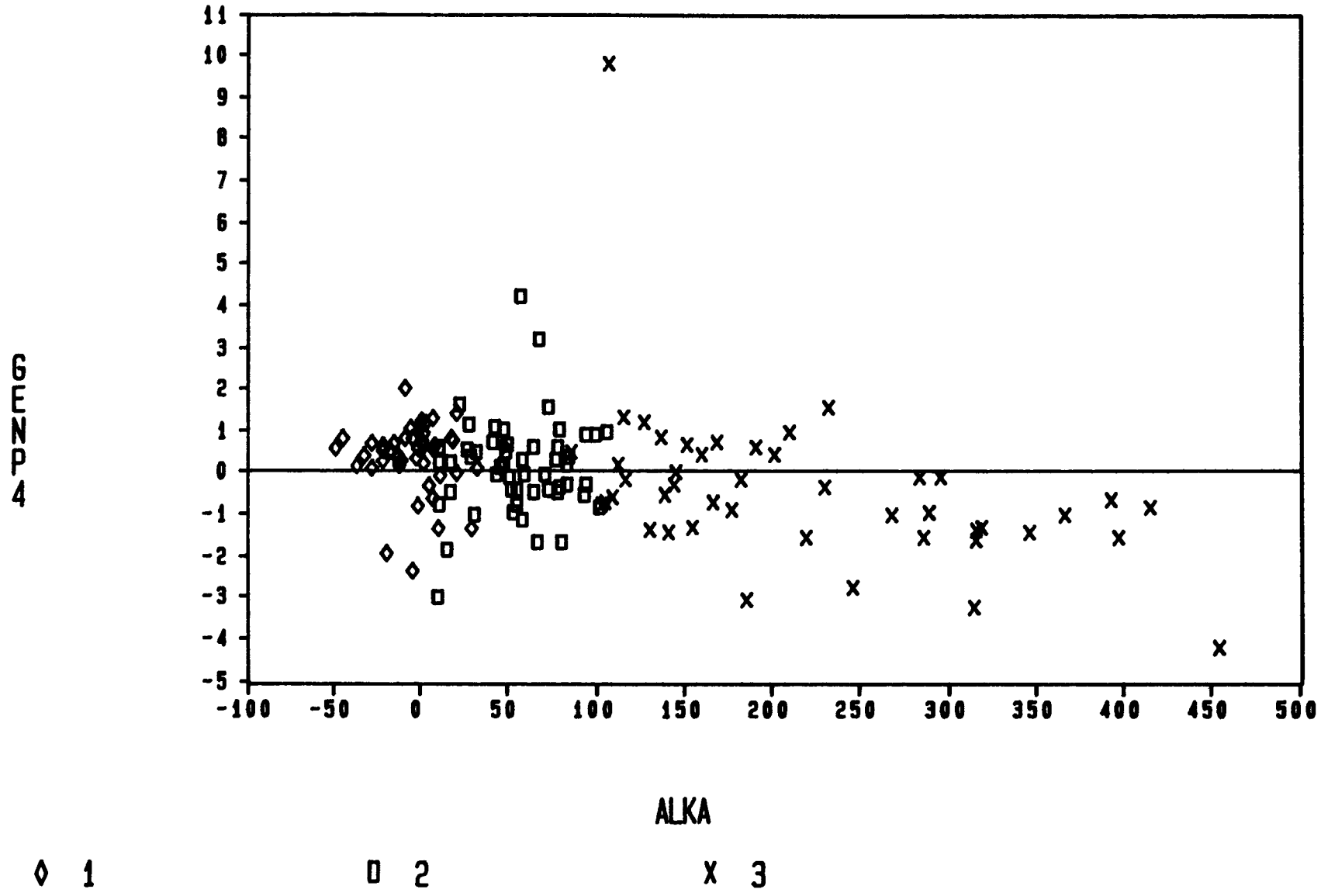


Figure 3-67. Plot of GENP4 and alkalinity for 146 lakes from the summer sampling of the ELS-II. GENP4 is the fourth community factor calculated by PCA of the generic abundance data.

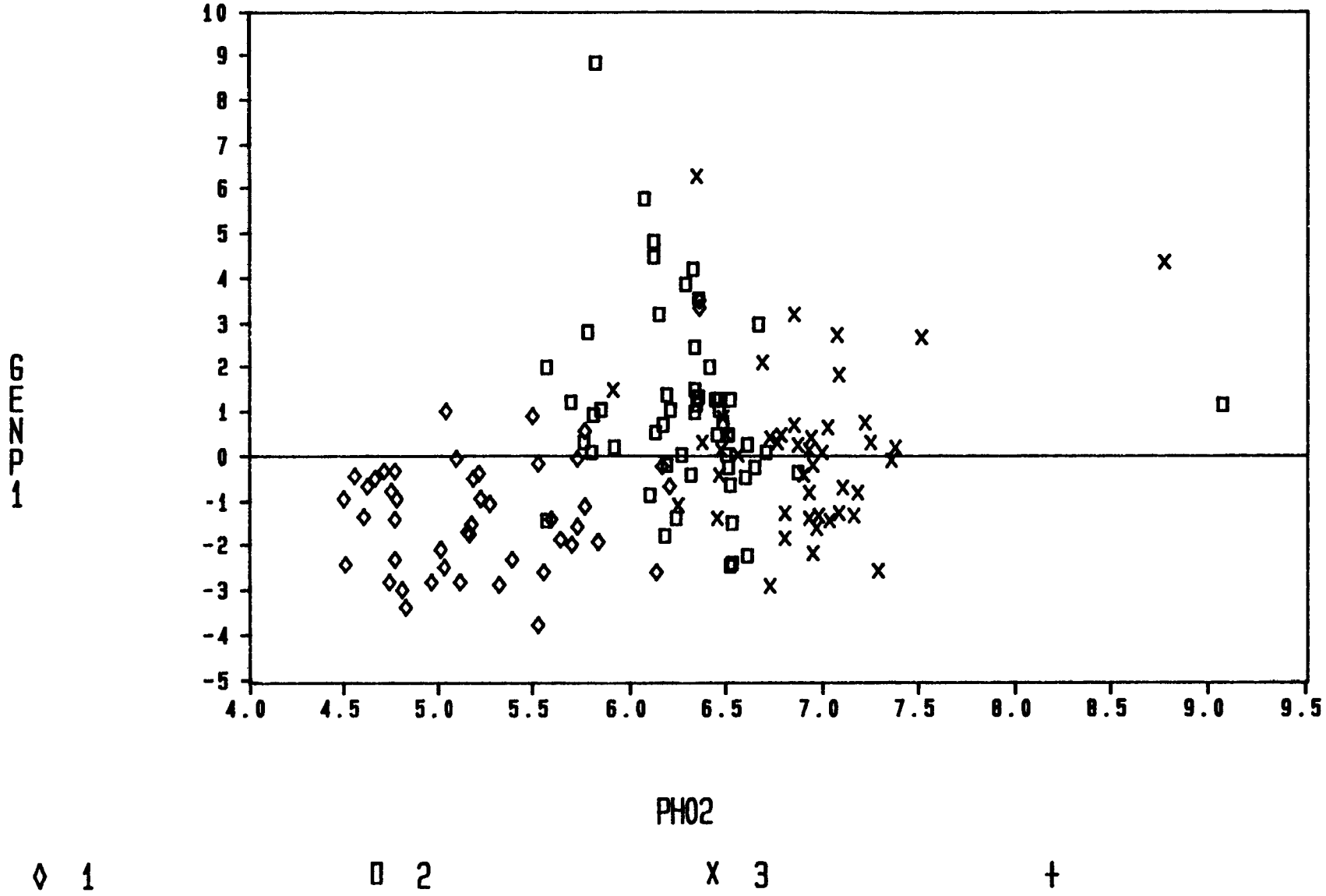


Figure 3-68. Plot of GENP1 and pH for 146 lakes from the summer sampling of the ELS-II. GENP1 is the first community factor calculated by PCA of the generic abundance data.

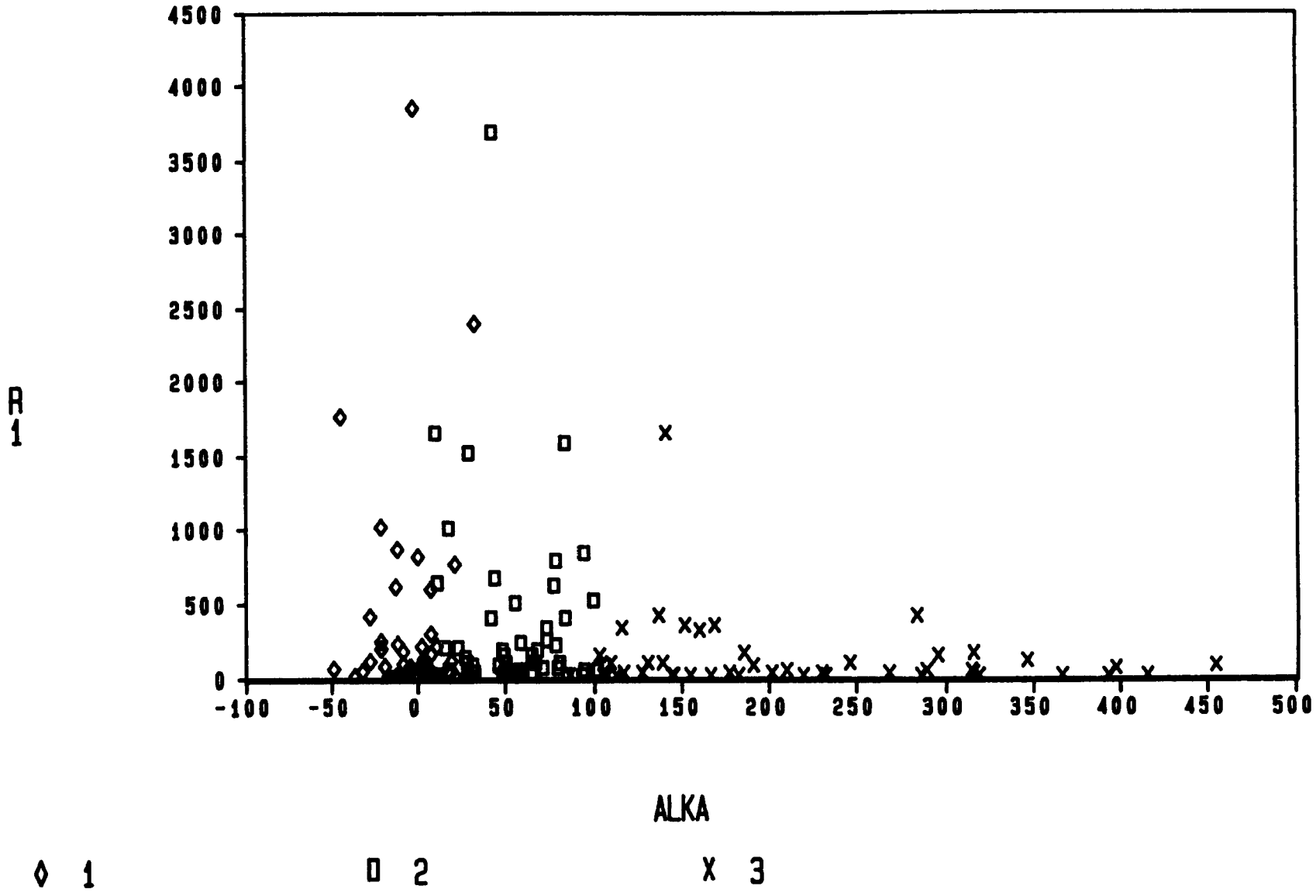


Figure 3-69. Relationship between abundance of the rotifer genus Keratella and alkalinity for the 146 lakes in the ELS-II.

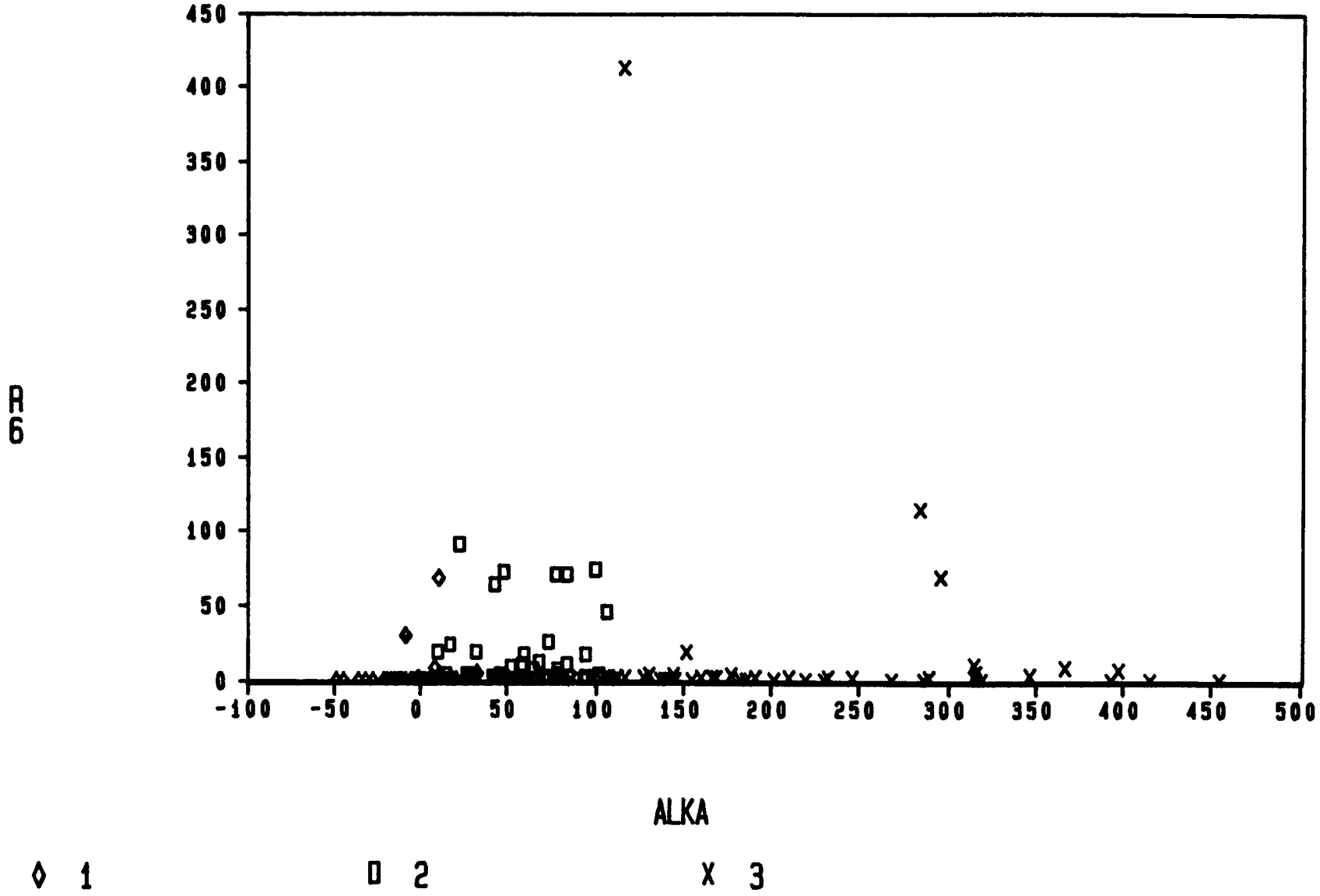


Figure 3-70. Relationship between abundance of the rotifer genus Asplanchna and alkalinity for the 146 lakes in the ELS-II.

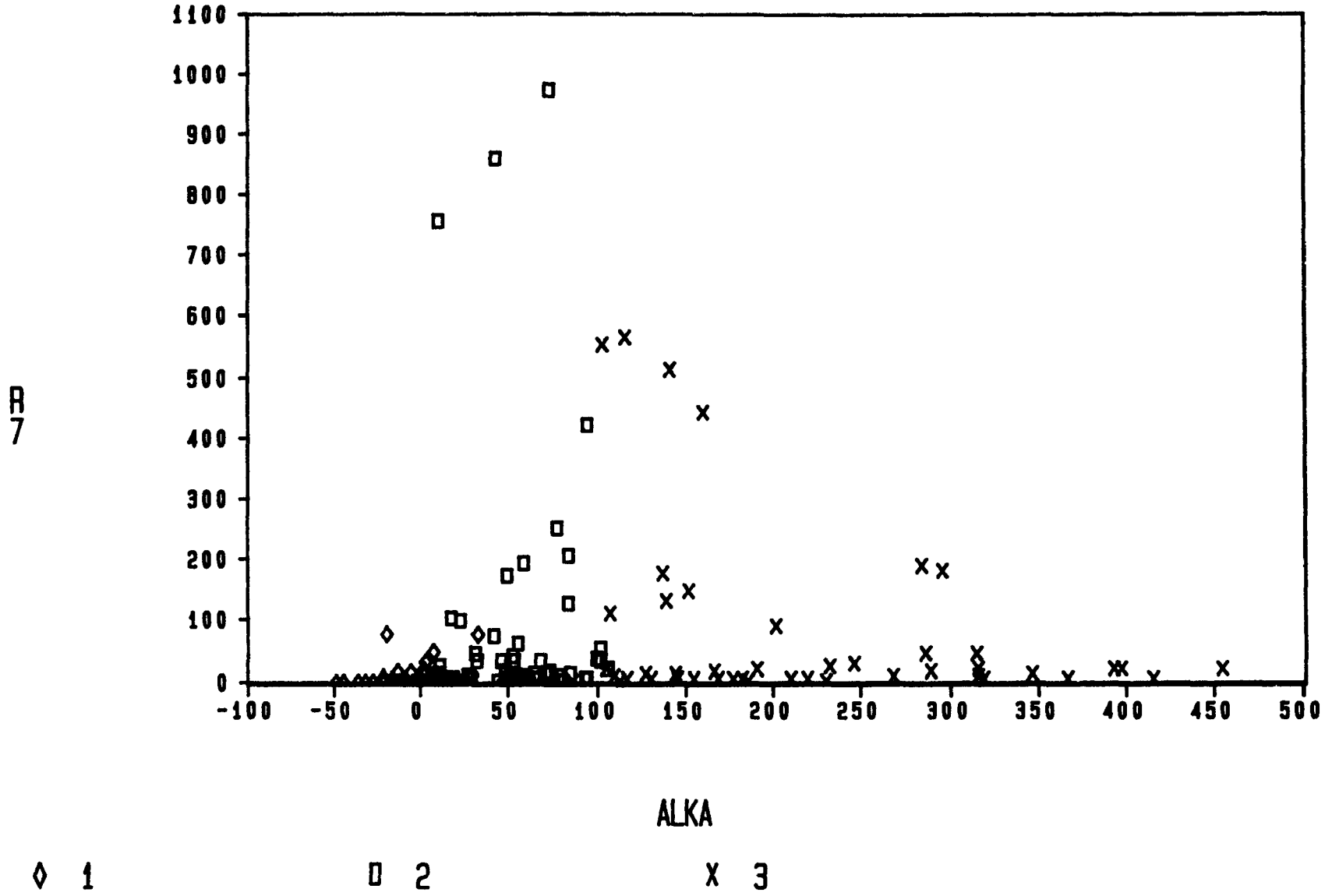


Figure 3-71. Relationship between abundance of the rotifer genus Polyarthra and alkalinity for the 146 lakes in the ELS-II.

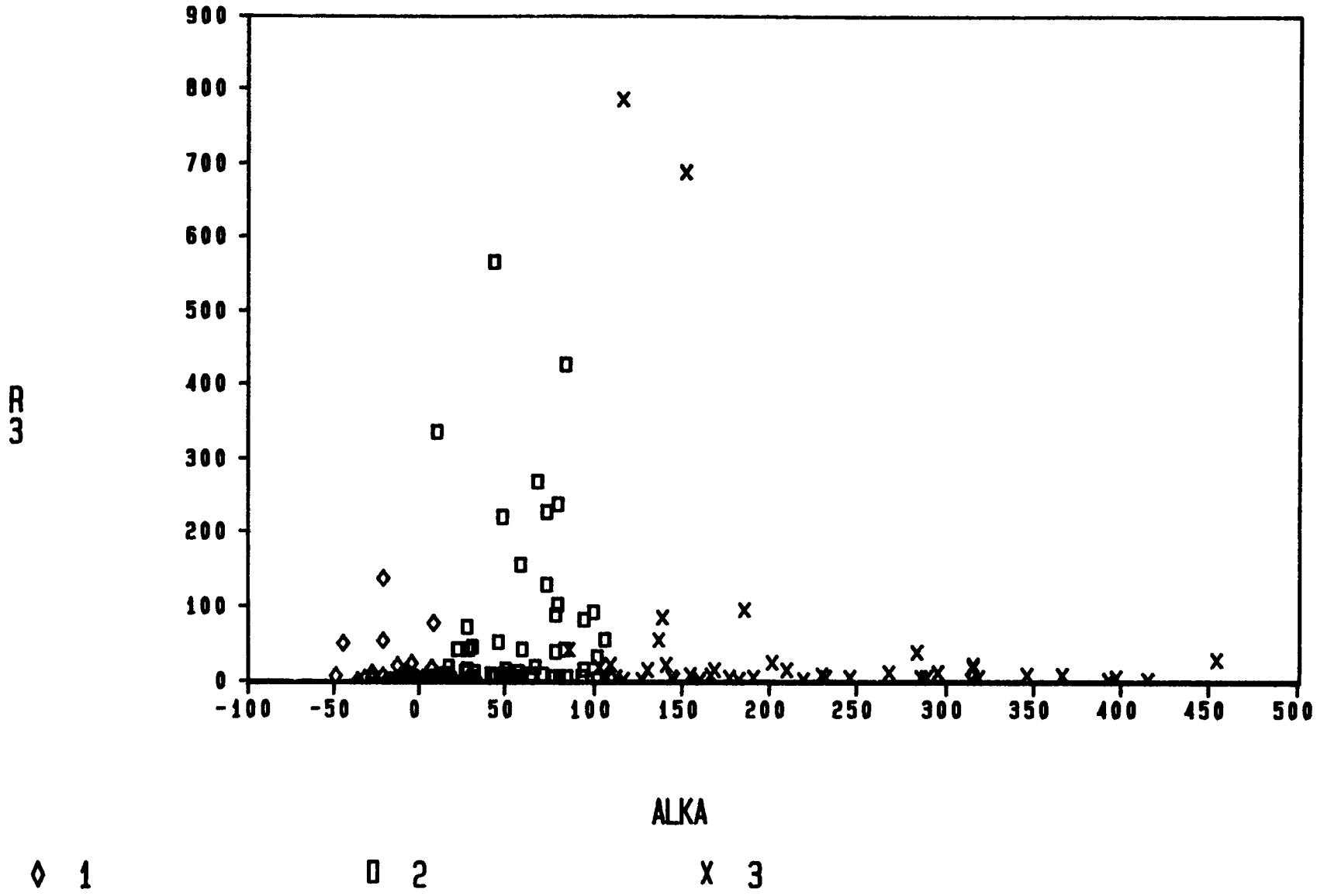


Figure 3-72. Relationship between abundance of the rotifer genus Trichocerca and alkalinity for the 146 lakes in the ELS-II.

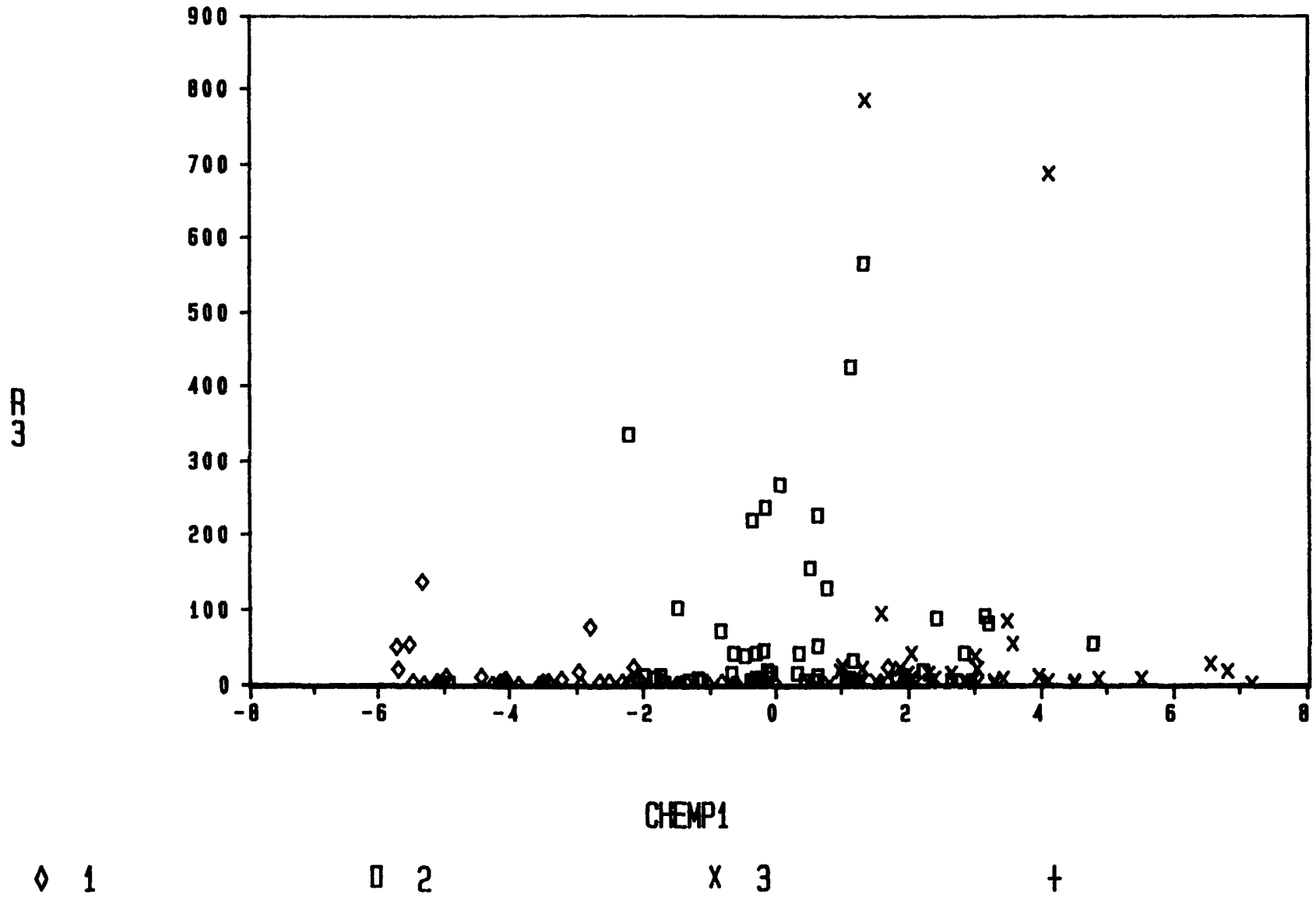


Figure 3-73. Relationship between abundance of the rotifer genus Trichocerca and the first chemical factor (CHEMP1) calculated by PCA of the chemistry data for 145 lakes in the ELS-II.

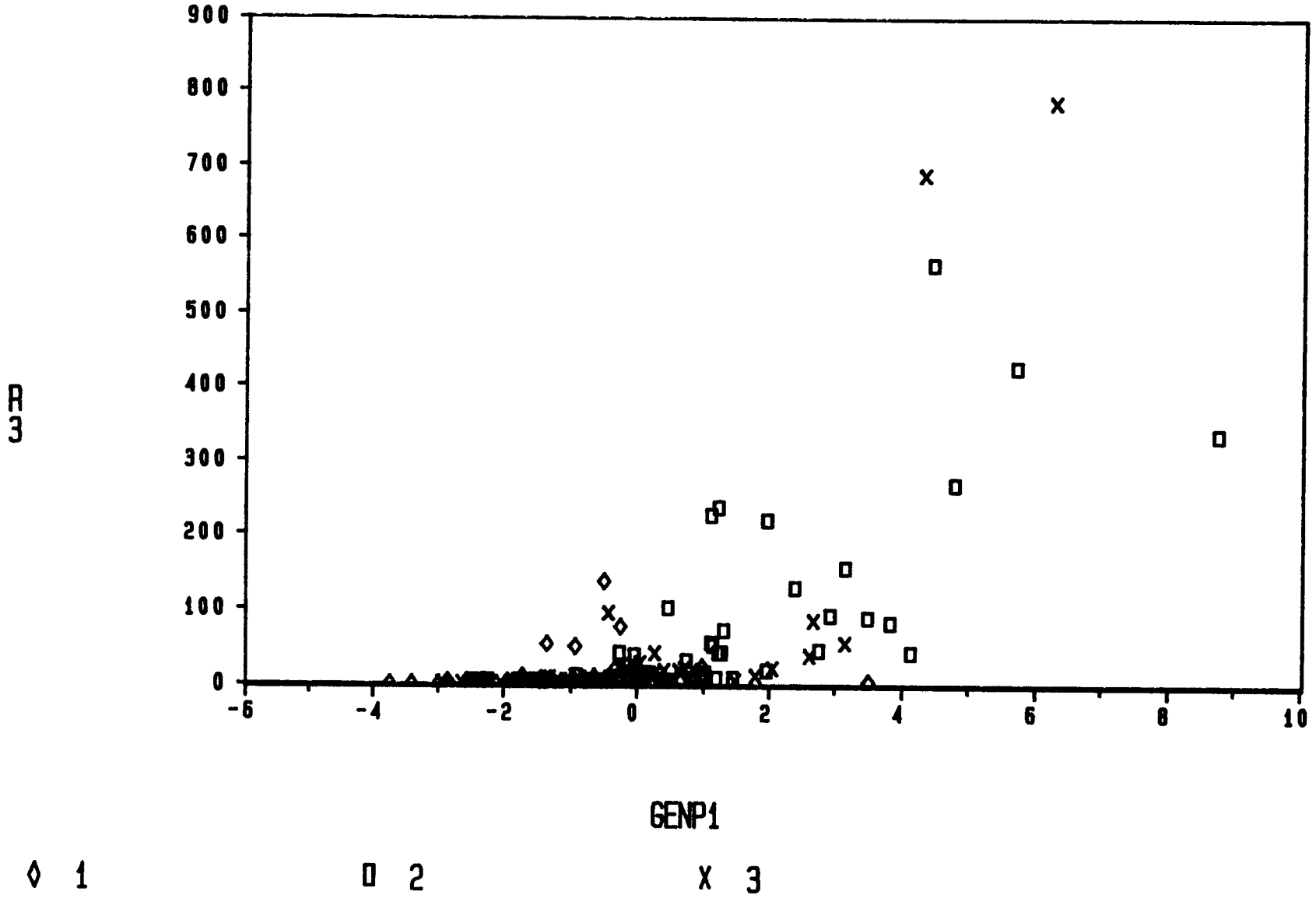


Figure 3-74. Relationship between abundance of the rotifer genus Trichocerca and the first community factor (GENP1) calculated by PCA of the generic abundance data for 146 lakes in the ELS-II.

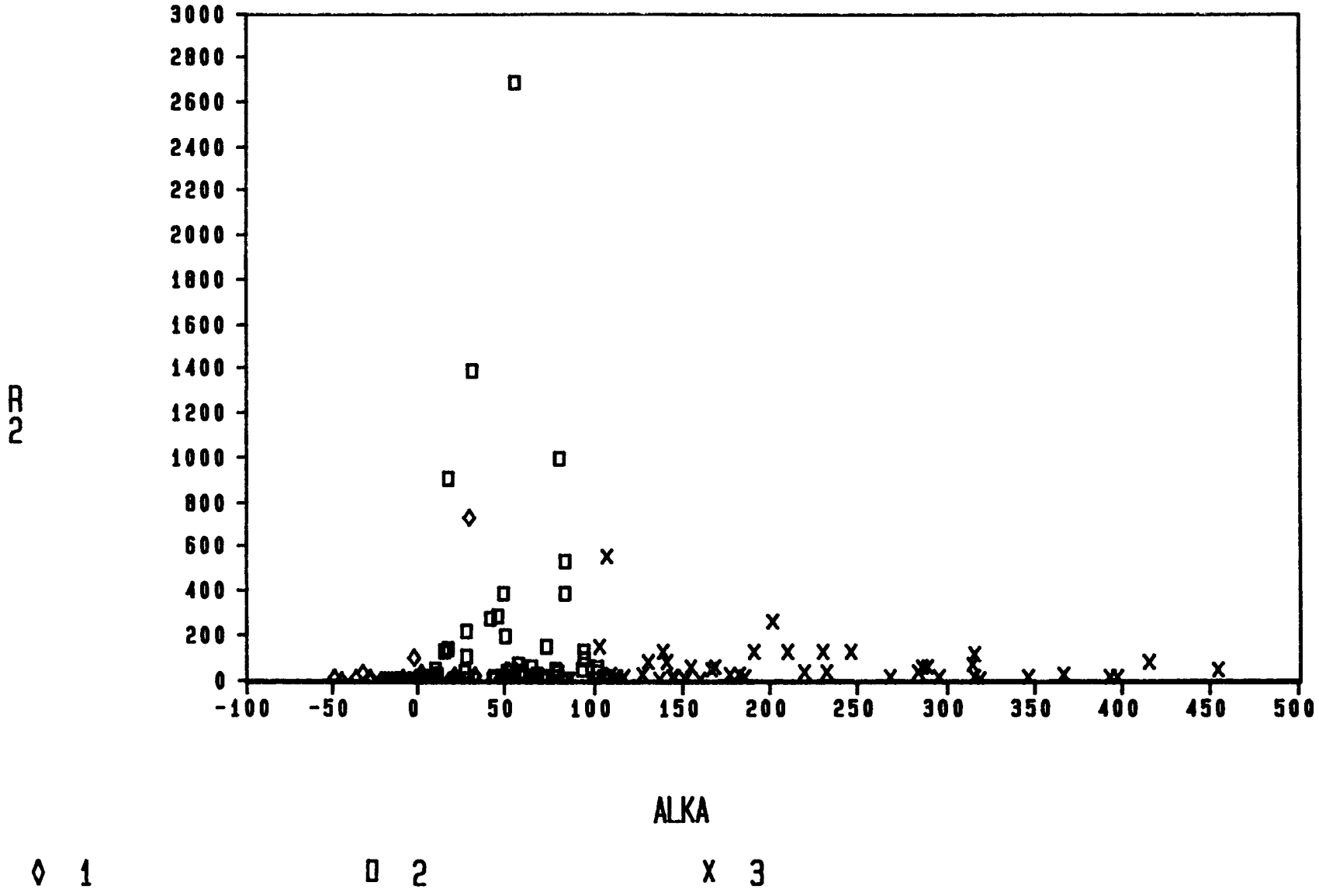


Figure 3-75. Relationship between abundance of the rotifer genus Kellicottia and alkalinity for 146 lakes in the ELS-II.

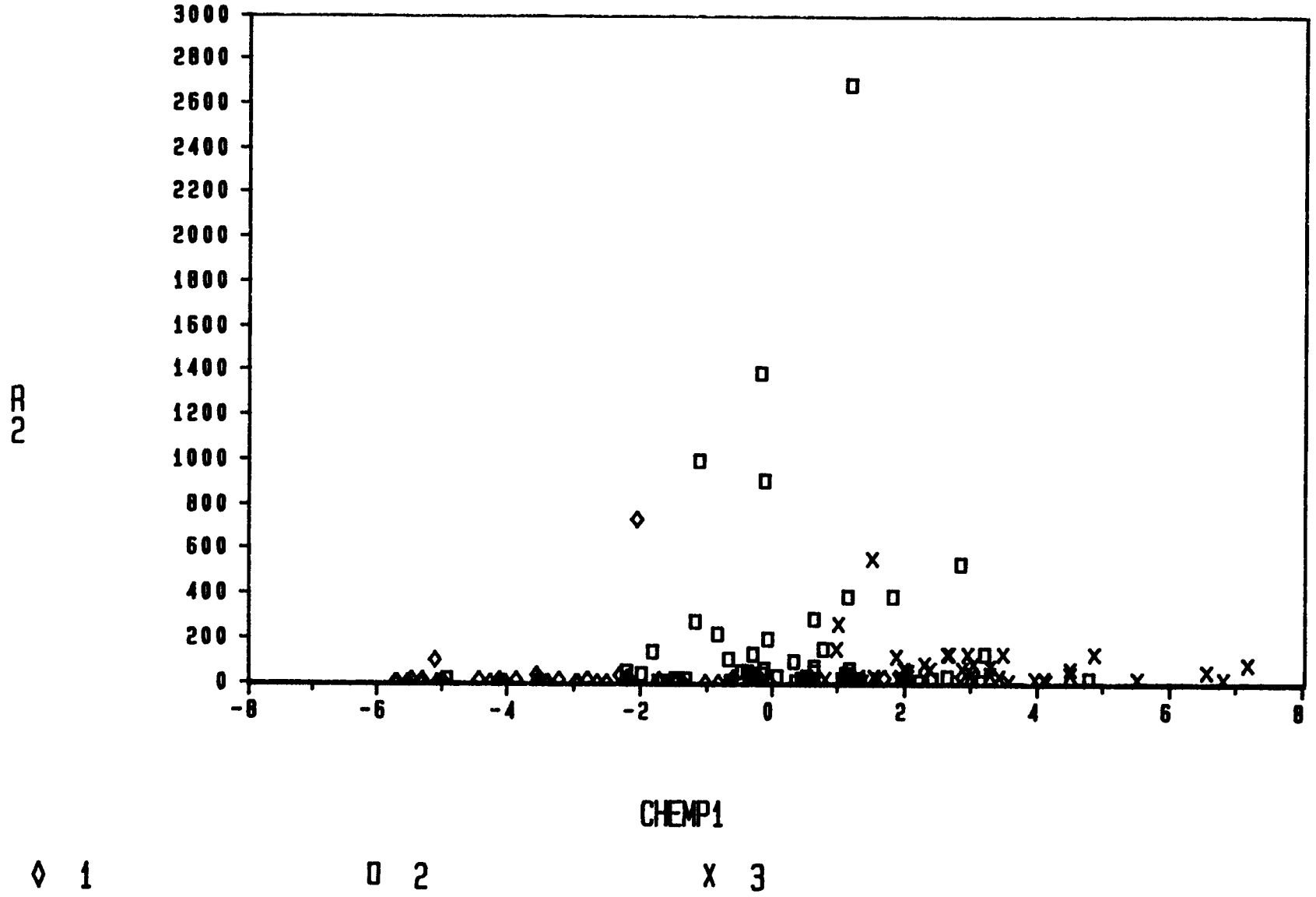


Figure 3-76. Relationship between abundance of the rotifer genus Kellicottia and the first chemical factor (CHEMP1) calculated by PCA of the chemistry data for 145 lakes in the ELS-II.

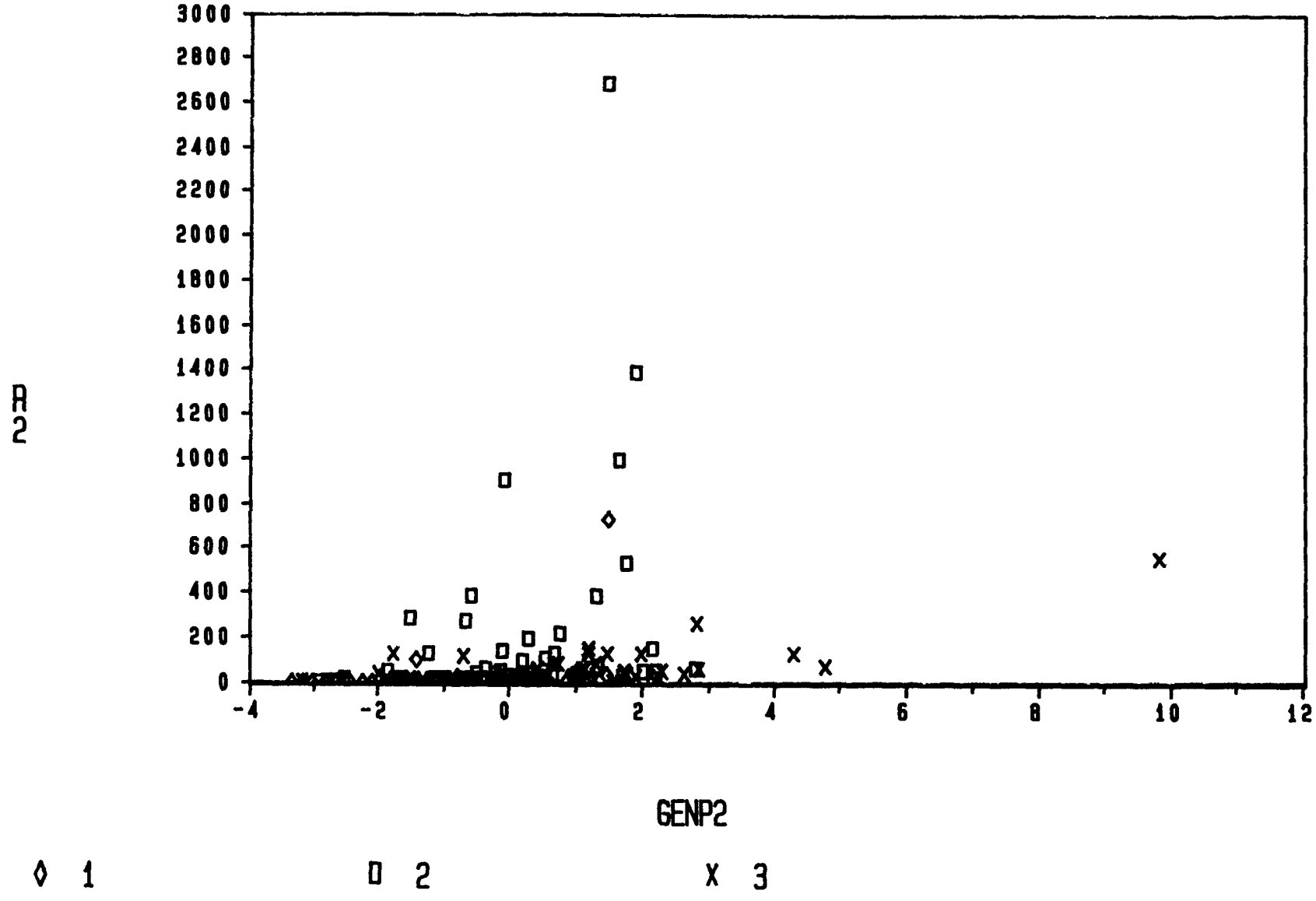


Figure 3-77. **Relationship between abundance of the rotifer genus Kellicottia and the second community factor (GENP2) calculated by PCA of the generic abundance data for 146 lakes in the ELS-II.**

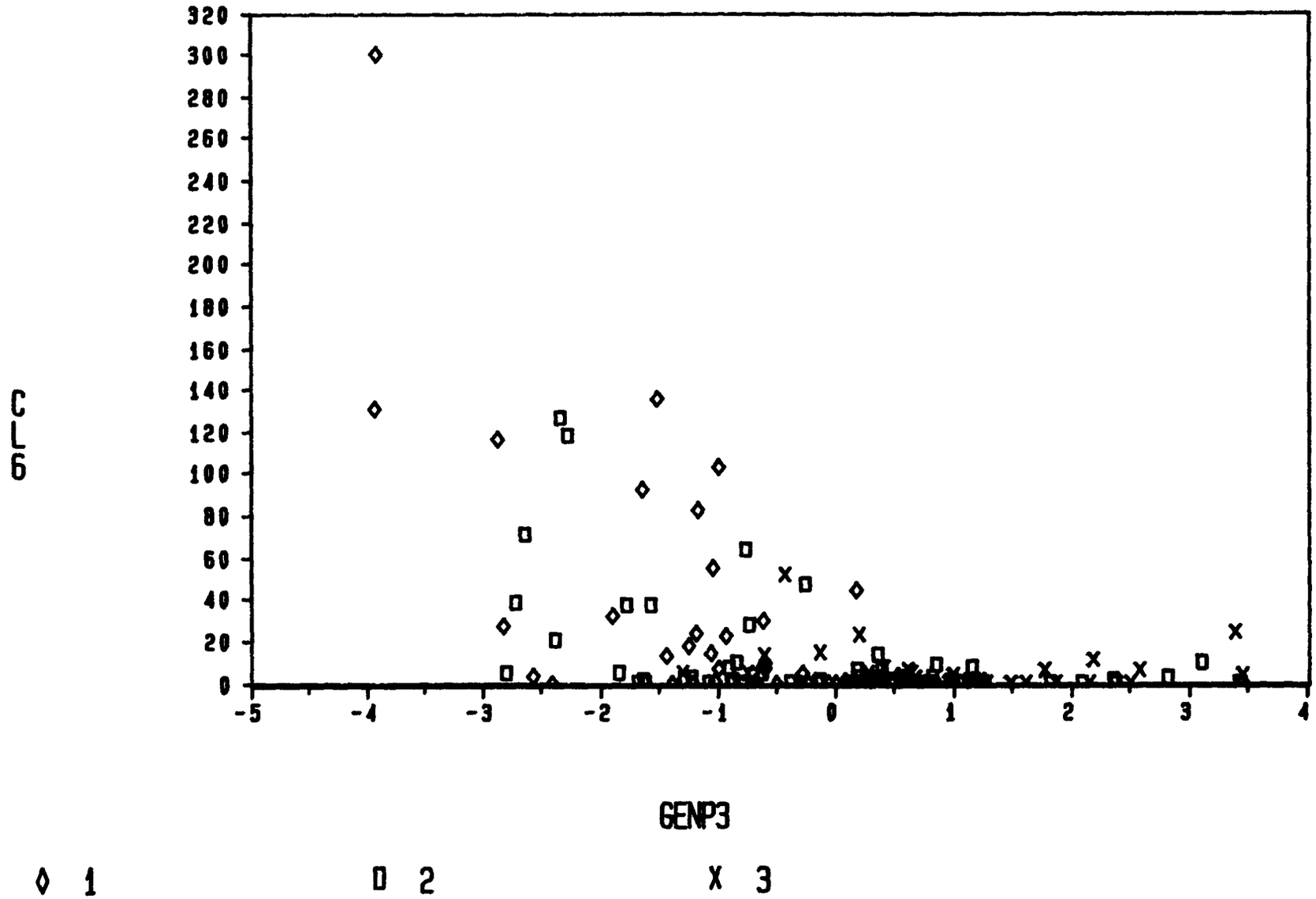


Figure 3-78. Relationship between abundance of the cladocera Eubosmina and the third community factor (GENP3) calculated by PCA of the generic abundance data for 146 lakes in the ELS-II.

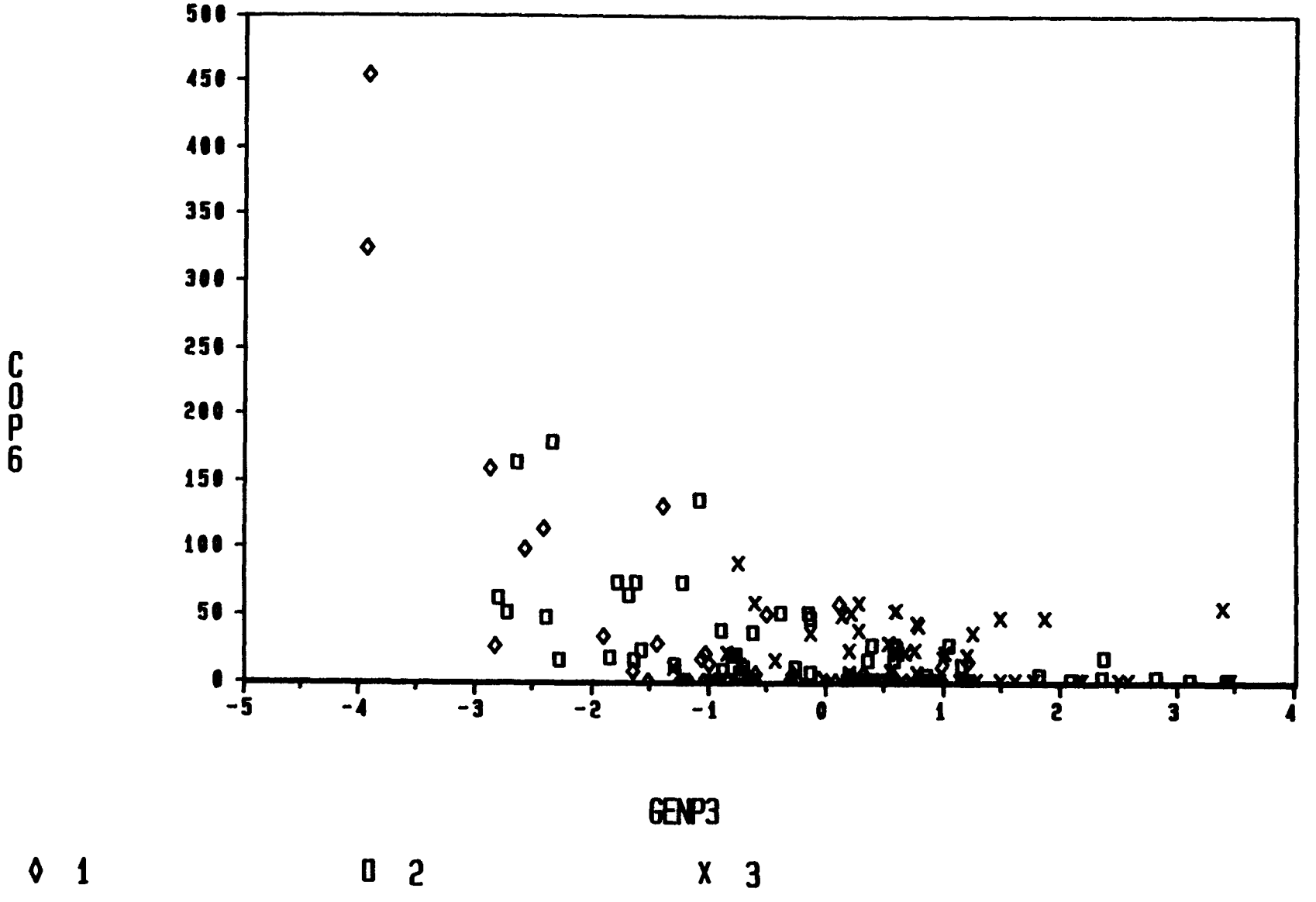


Figure 3-79. Relationship between abundance of the cyclopoid copepod Mesocyclops and the third community factor (GENP3) calculated by PCA of the generic abundance data for 146 lakes in the ELS-II.

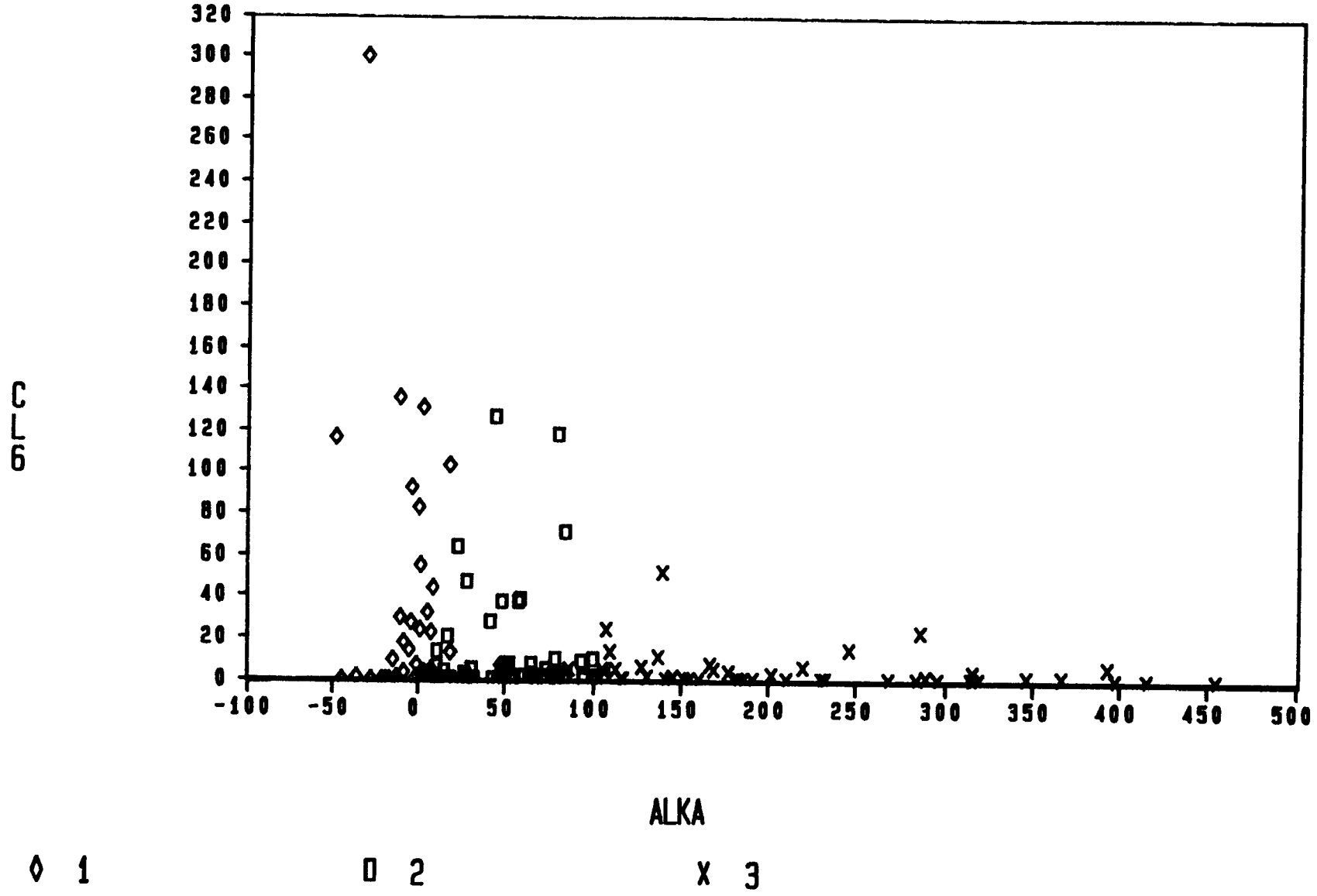


Figure 3-80. Relationship between abundance of the cladocera Eubosmina and alkalinity for 146 lakes in the ELS-II.

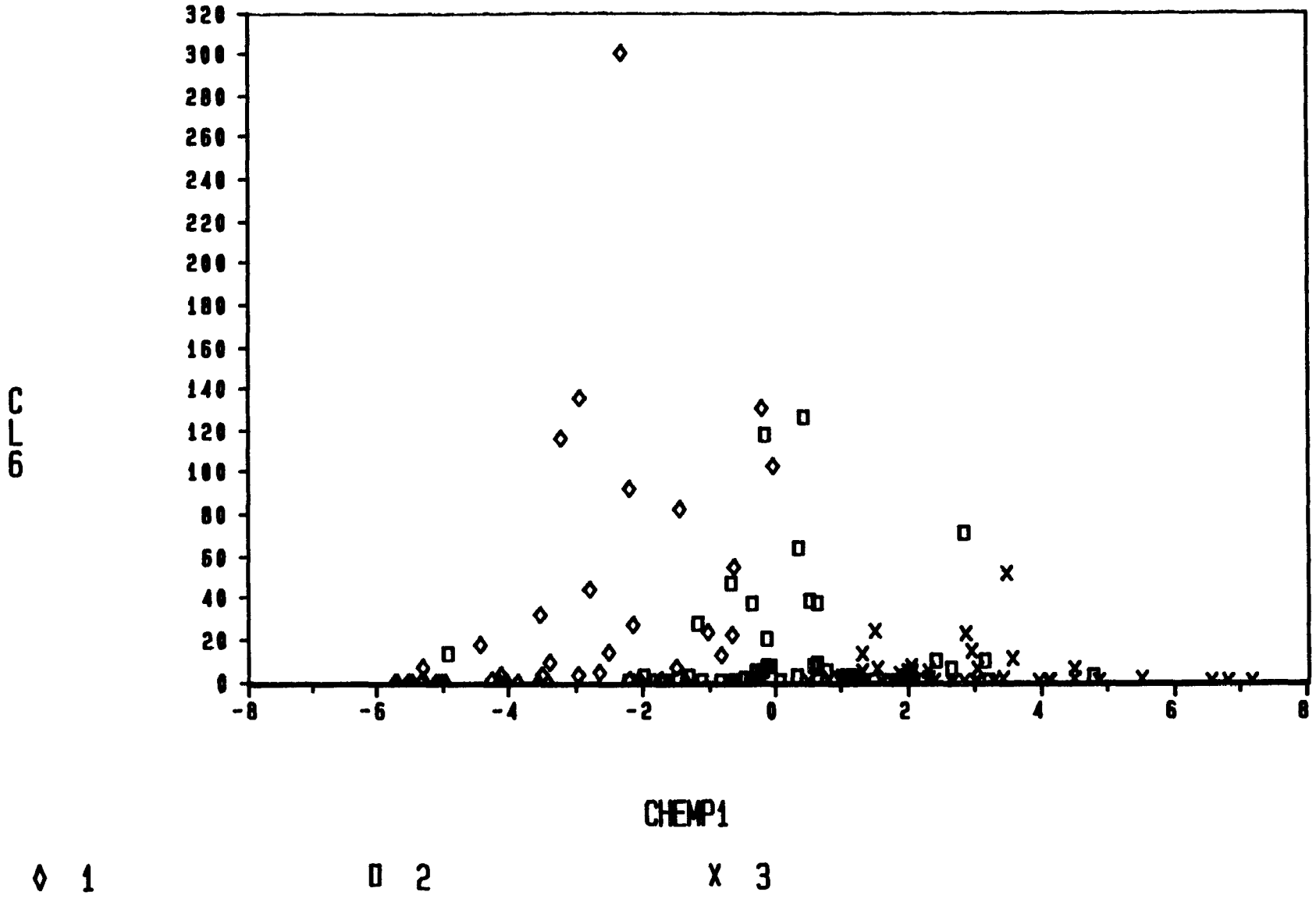


Figure 3-81. Relationship between abundance of the cladocera Eubosmina and the first chemical factor (CHEMP1) calculated by PCA of the chemistry data for 145 lakes in the ELS-II.

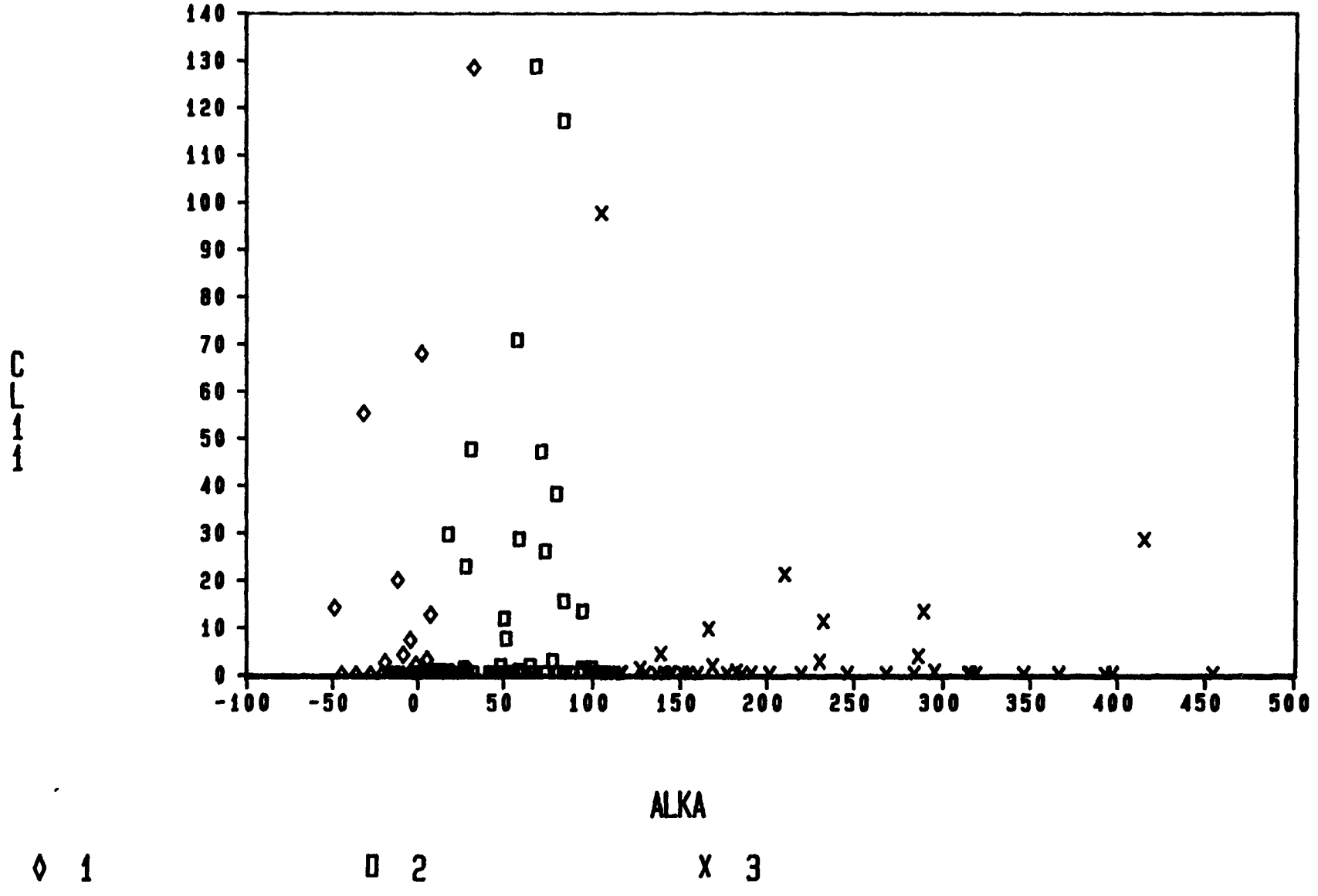


Figure 3-82. Relationship between abundance of the cladocera Daphnia parvula group and alkalinity for 146 lakes in the ELS-II.

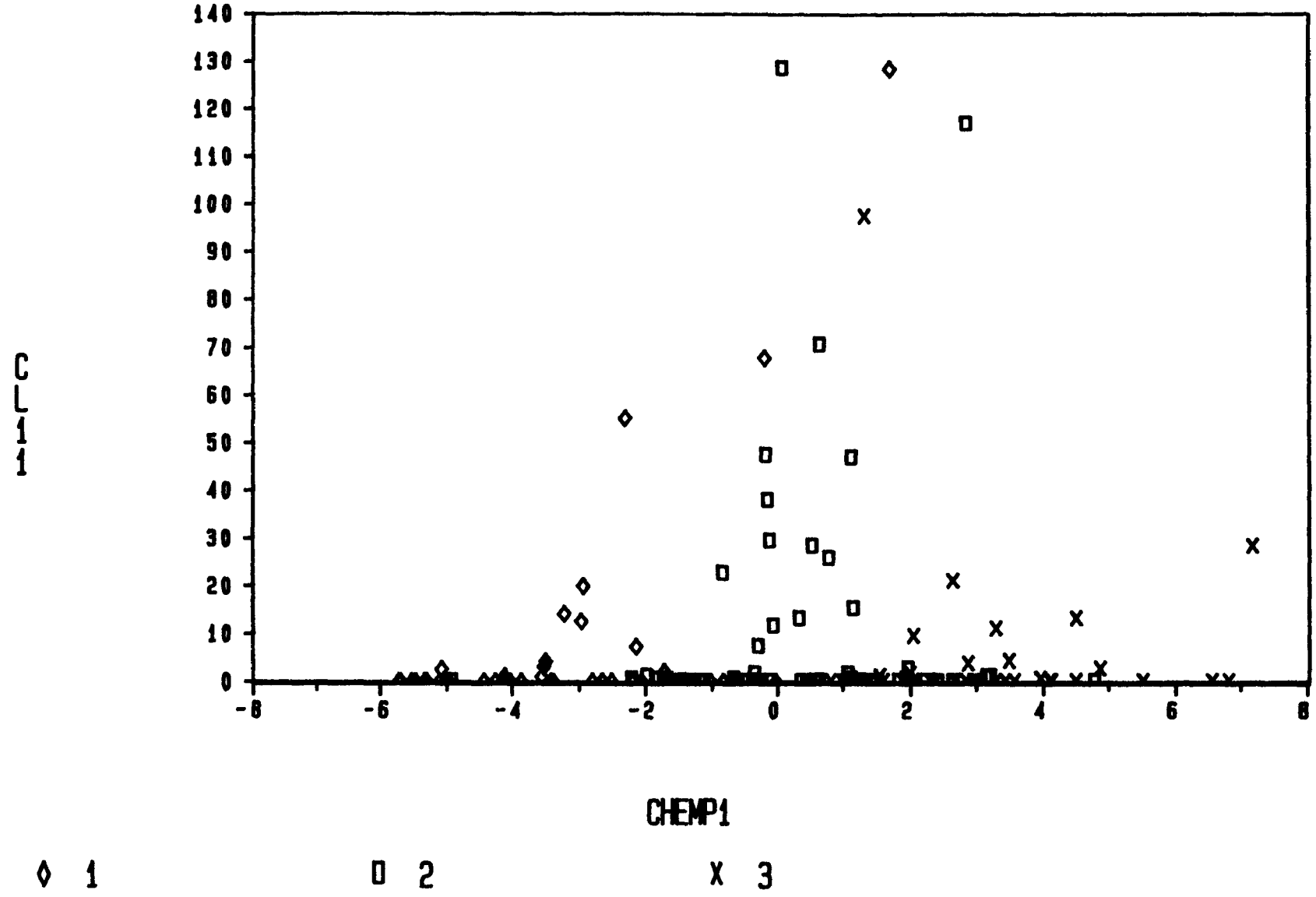


Figure 3-83. Relationship between abundance of the cladocera Daphnia parvula group and the first chemical factor (CHEMP1) calculated by PCA of the chemistry data for 145 lakes in the ELS-II.

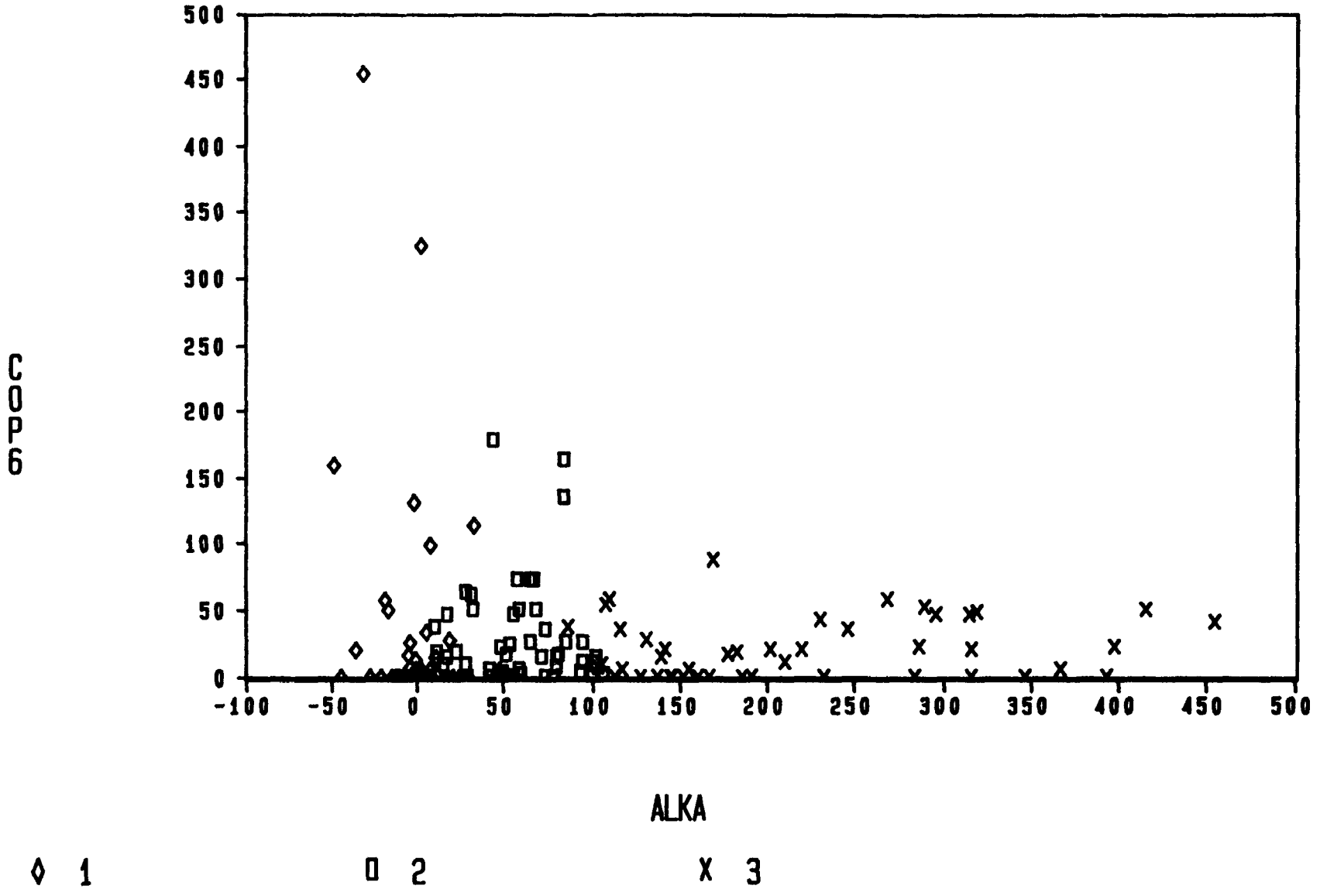


Figure 3-84. Relationship between abundance of the cyclopoid copepod Mesocyclops and alkalinity for 146 lakes in the ELS-II.

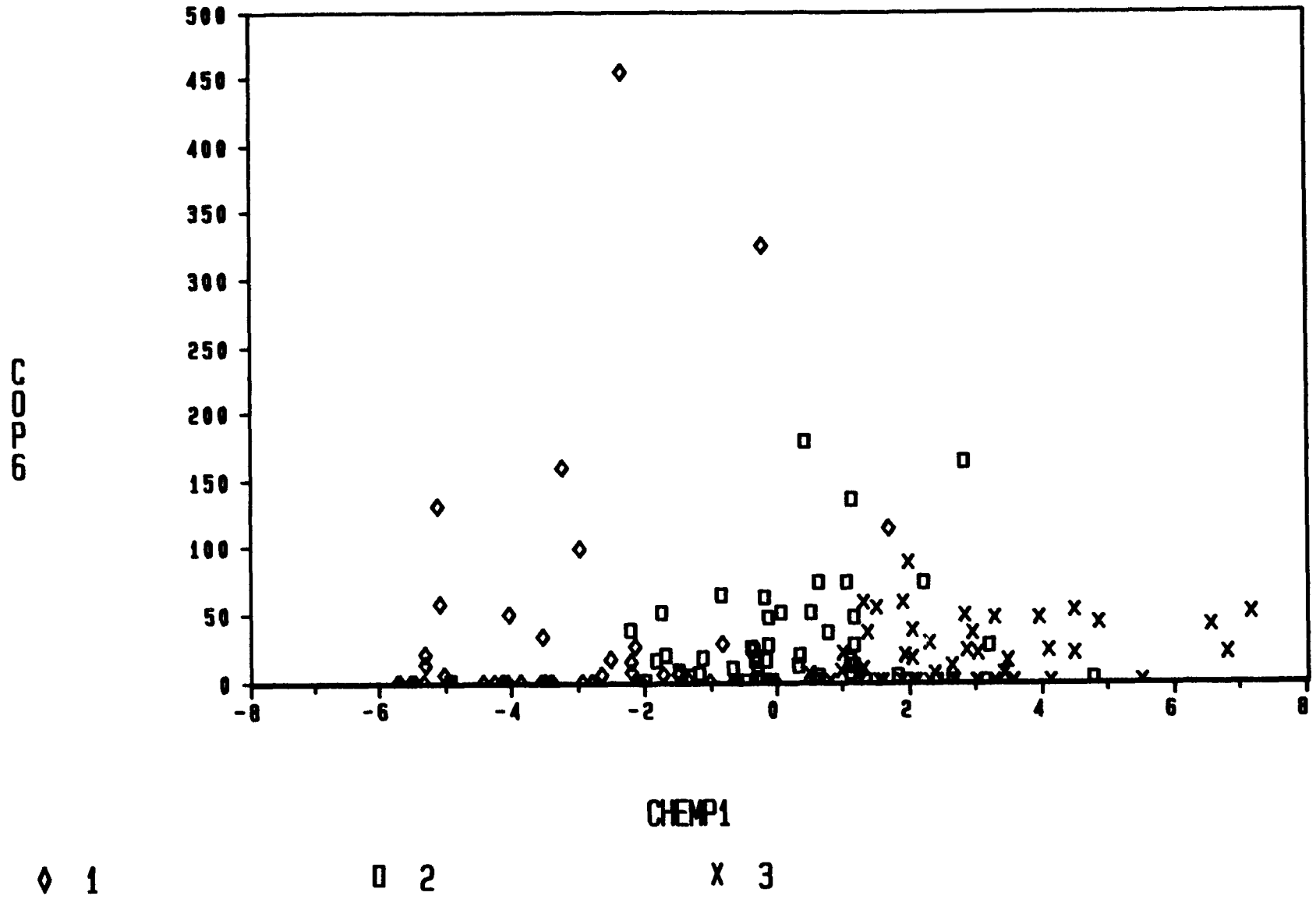


Figure 3-85. Relationship between abundance of the cyclopoid copepod Mesocyclops and the first chemical factor (CHEMP1) calculated by PCA of the chemistry data for 145 lakes in the ELS-II.

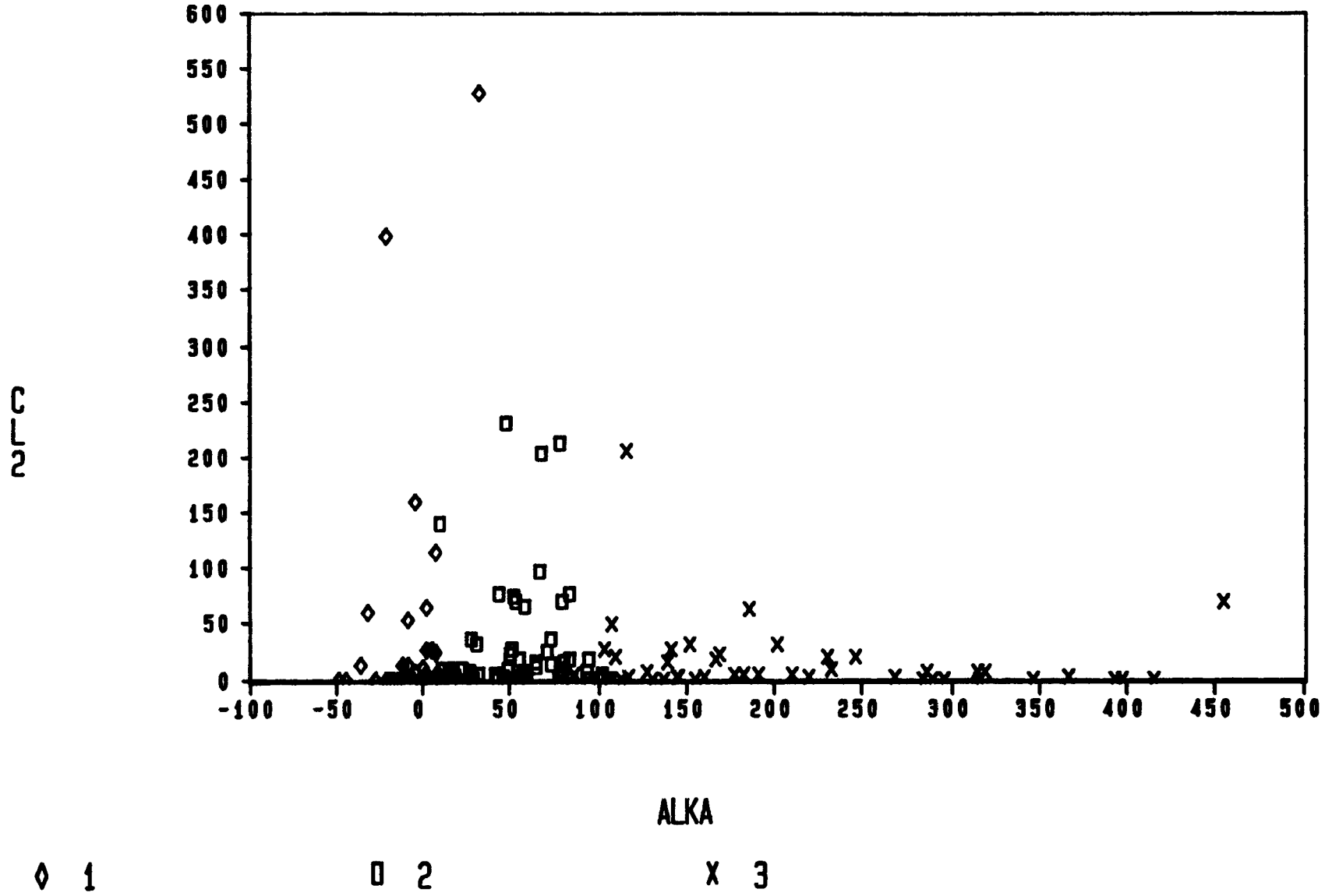


Figure 3-86. Relationship between abundance of the cladocera Diaphanosoma and alkalinity for 146 lakes in the ELS-II.

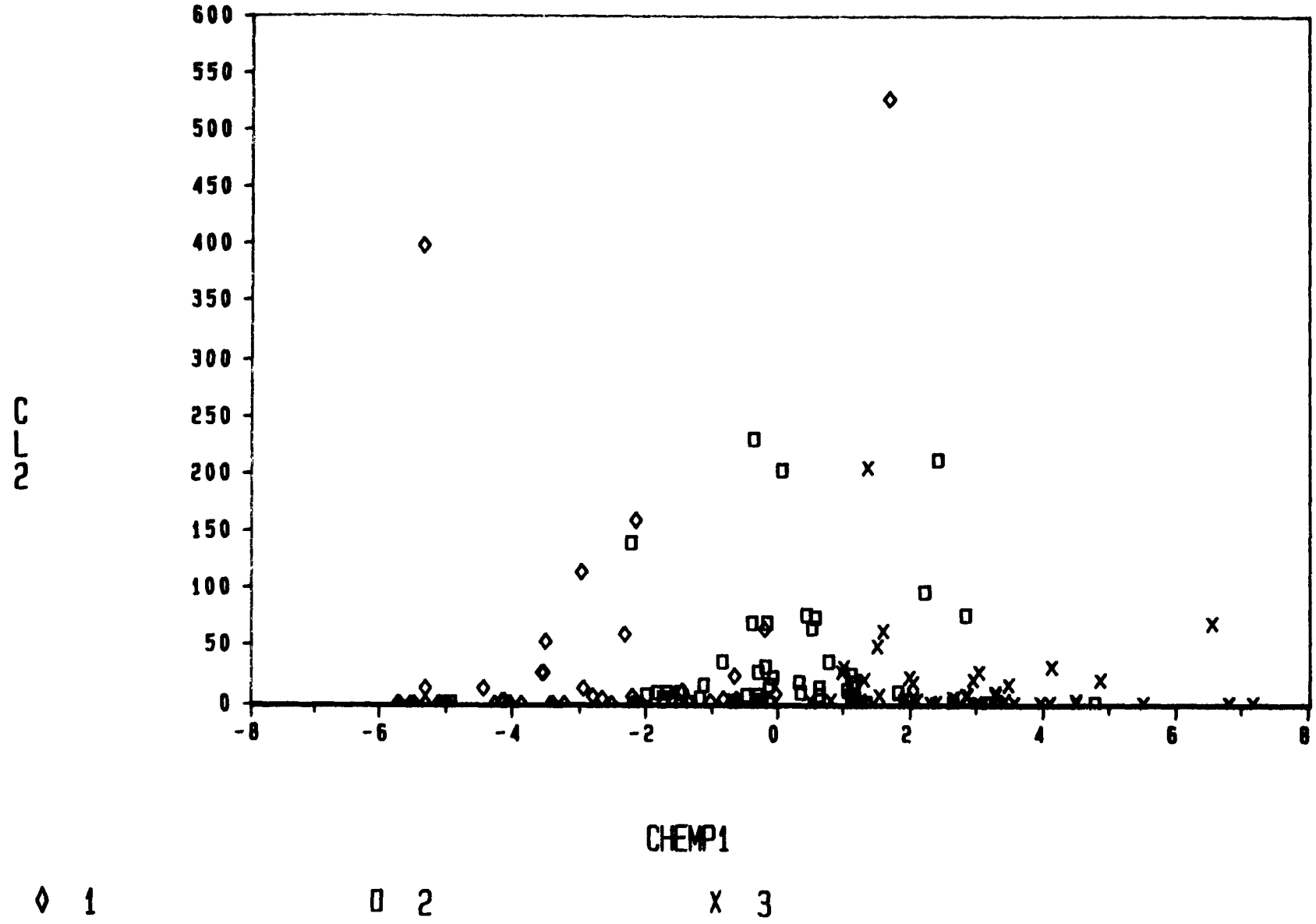


Figure 3-87. **Relationship between abundance of the cladocera Diaphanosoma and the first chemical factor (CHEMP1) calculated by PCA of the chemistry data for 145 lakes in the ELS-II.**

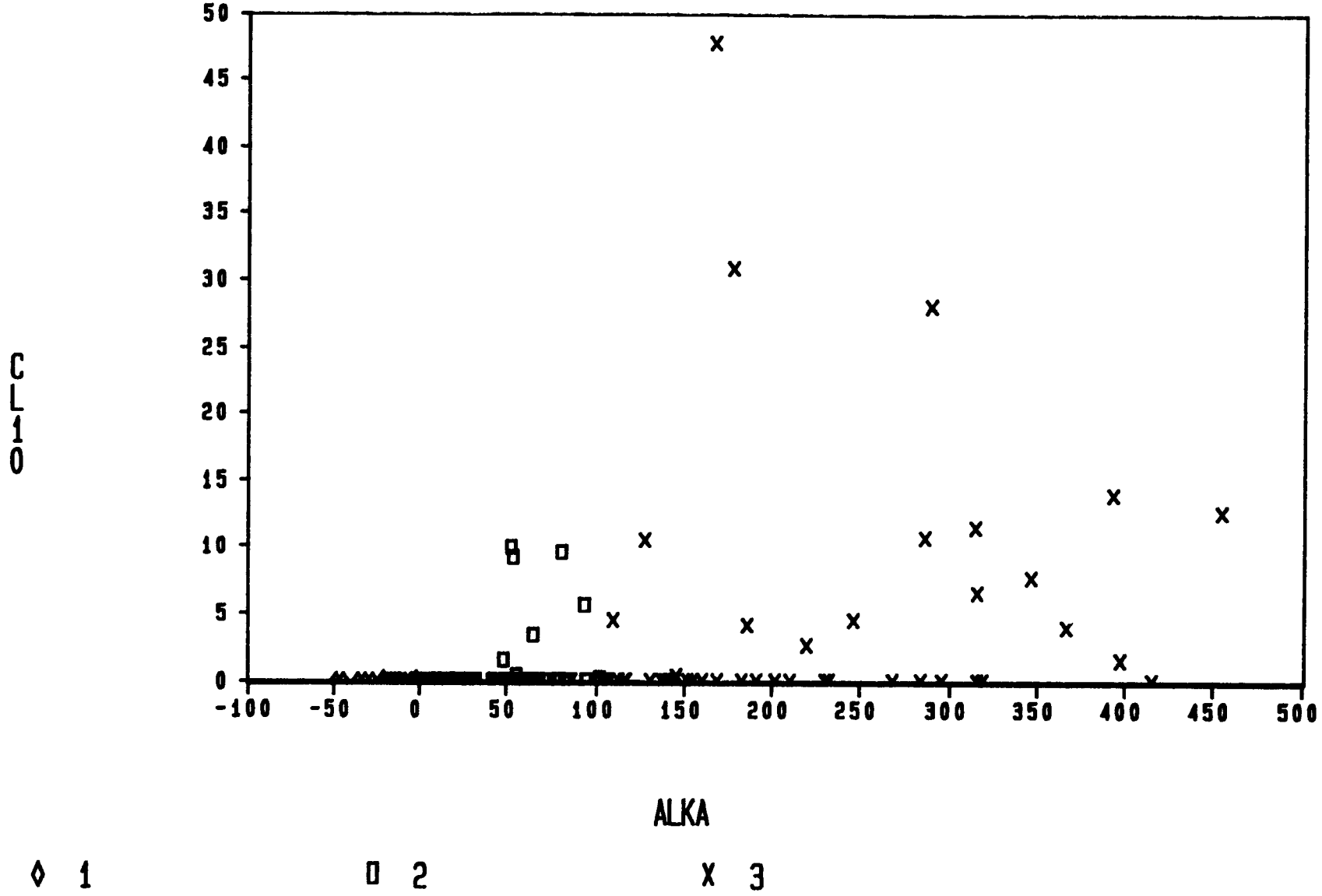


Figure 3-88. Relationship between abundance of the cladoceran Daphnia galeata group and alkalinity for 146 lakes in the ELS-II.

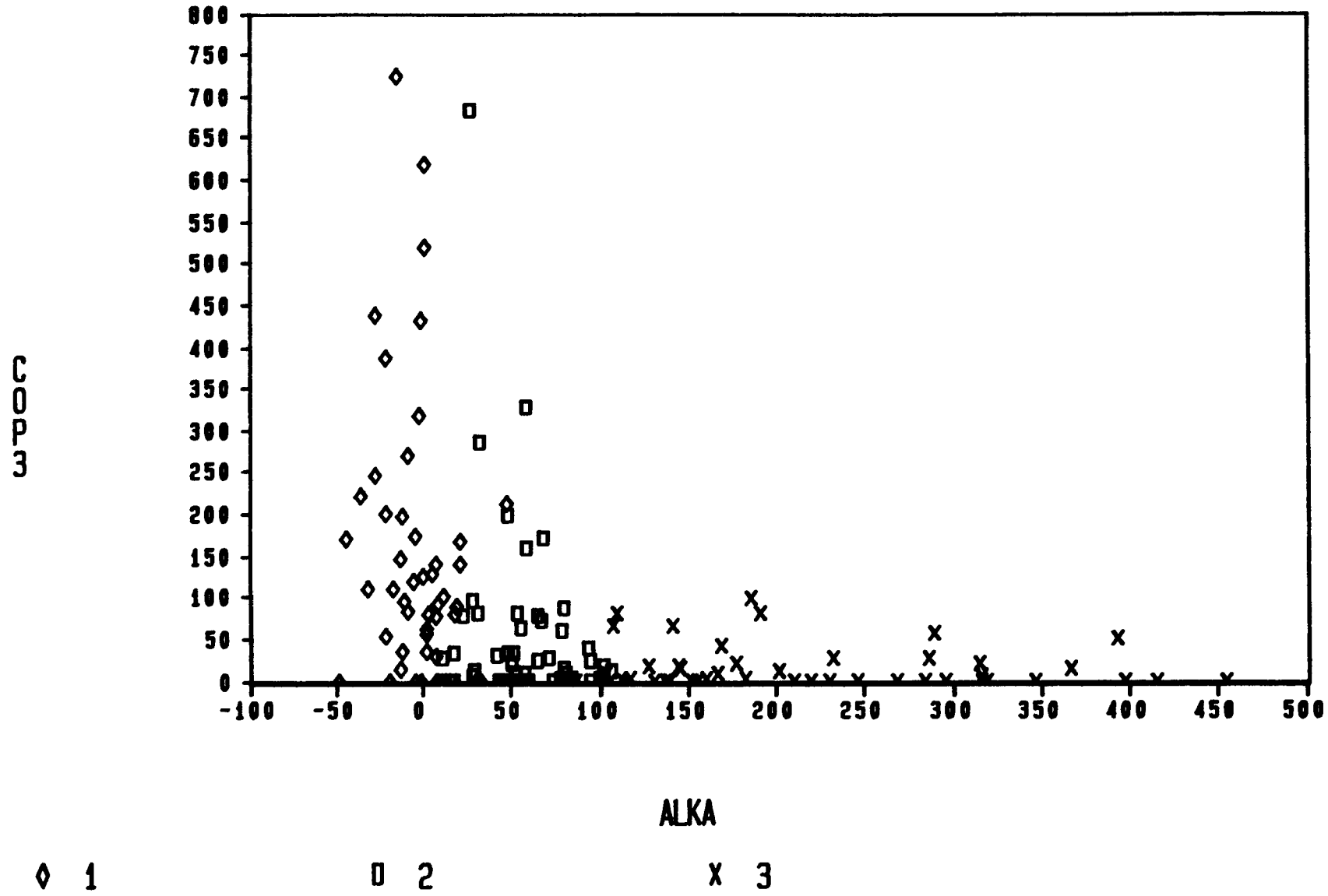


Figure 3-89. Relationship between abundance of the calanoid copepod Leptodiaptomus and alkalinity for 146 lakes in the ELS-II.

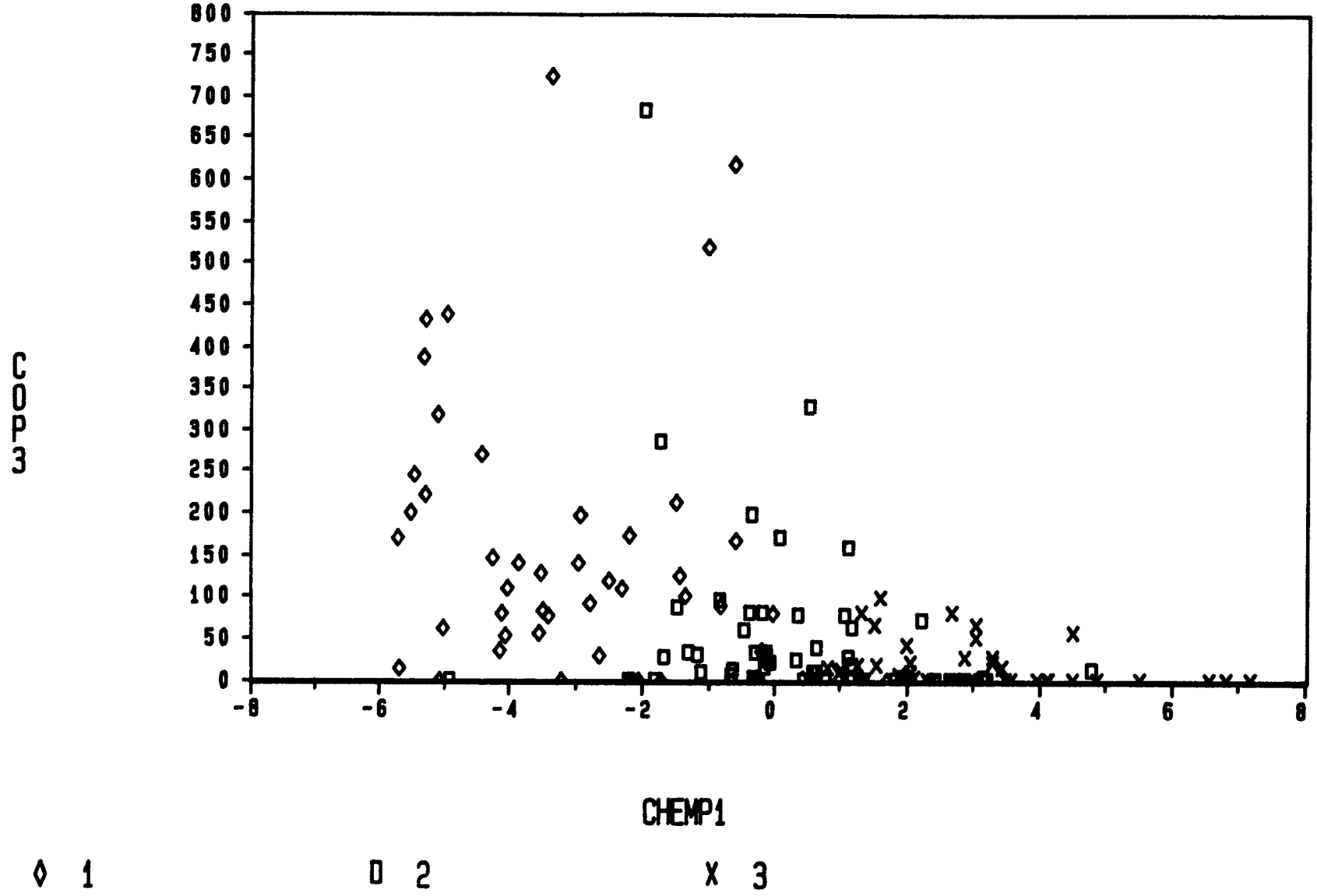


Figure 3-90. **Relationship between abundance of the calanoid copepod Leptodiaptomus and the first chemical factor (CHEMP1) calculated by PCA of the chemistry data for 145 lakes in the ELS-II.**

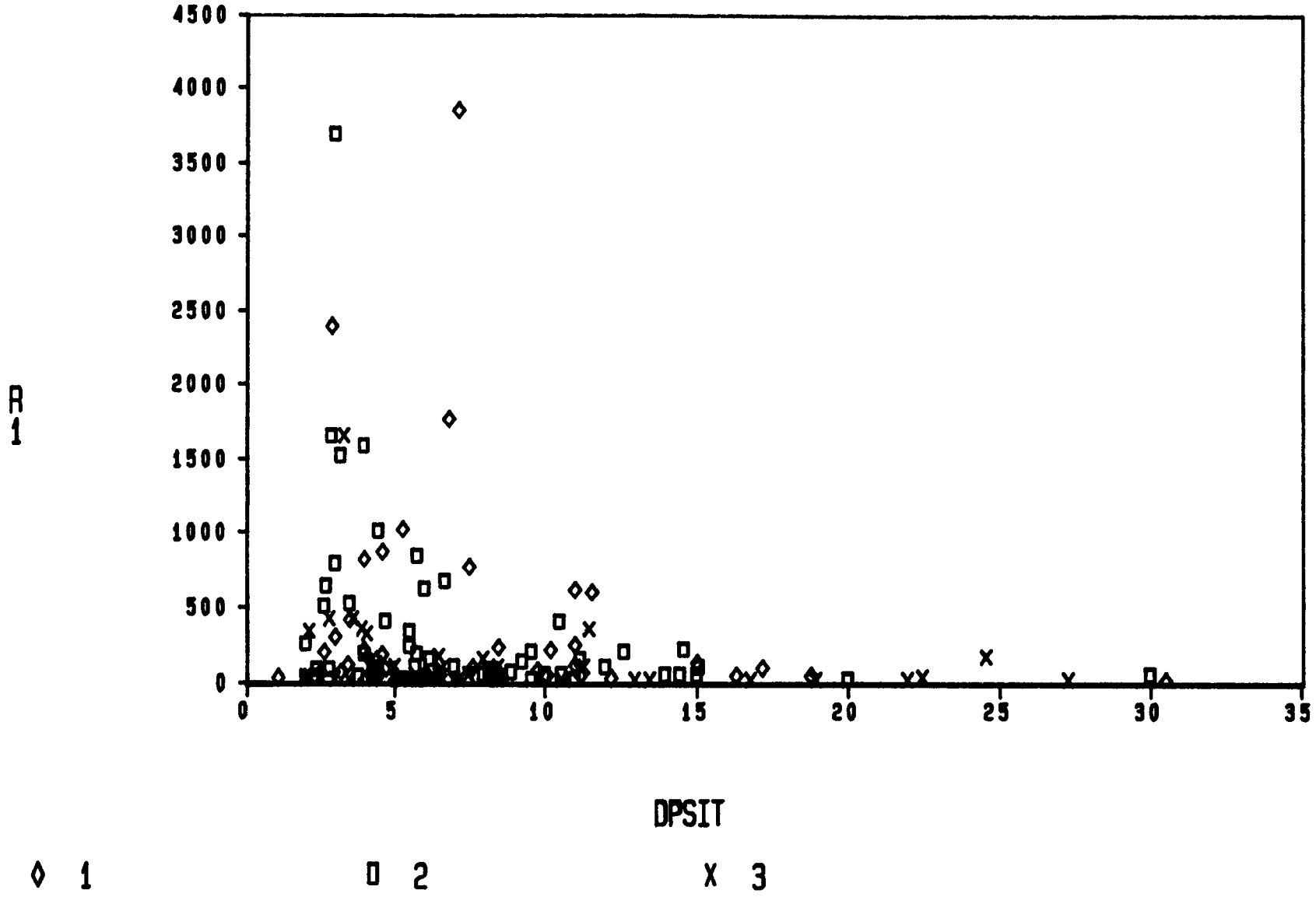


Figure 3-91. **Relationship between abundance of the rotifer genus Keratella and depth of sampling site, which is close to the maximum depth of the lake, for 146 lakes in the ELS-II.**

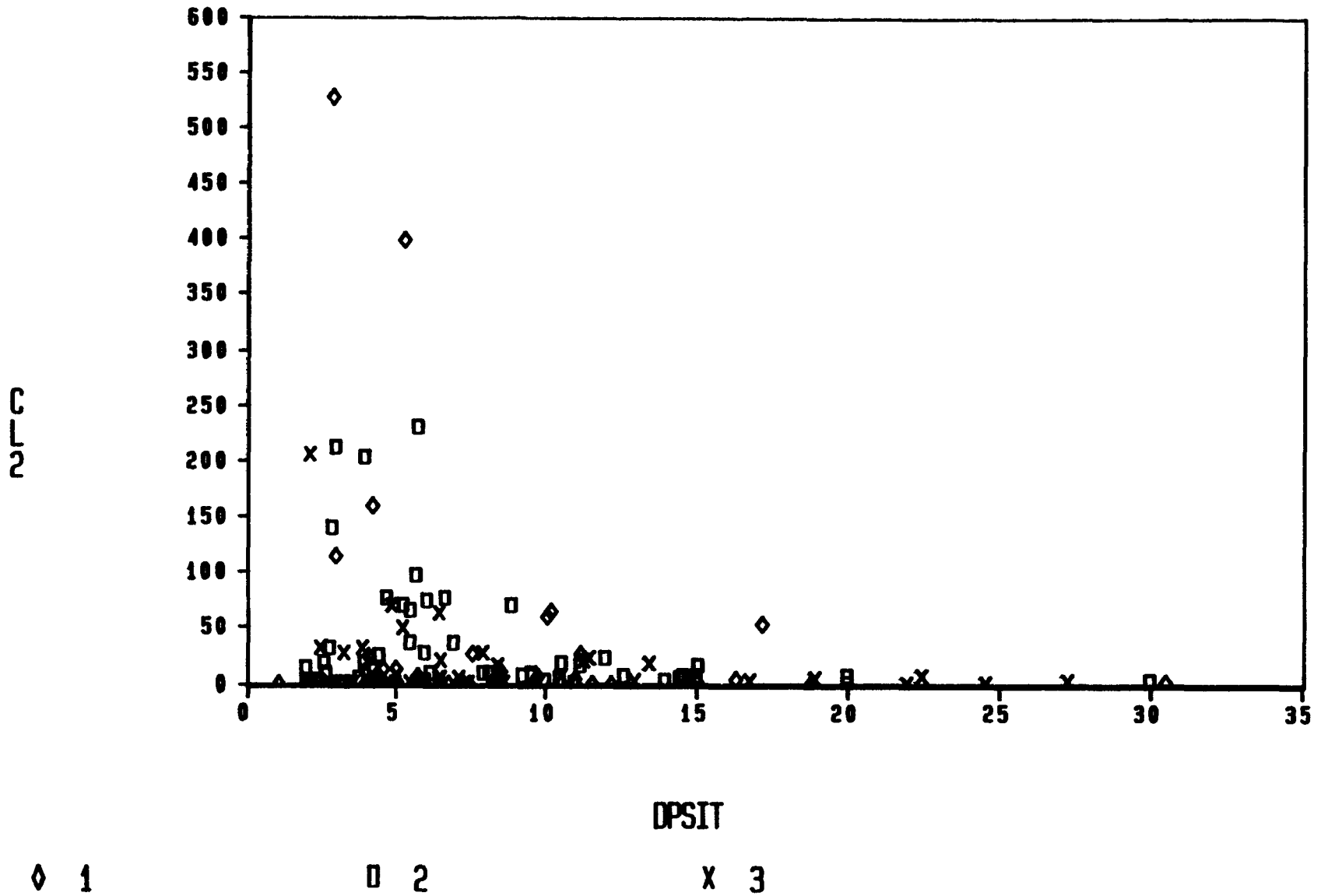


Figure 3-92. Relationship between abundance of the cladocera Diaphanosoma and depth of sampling site, which is close to the maximum depth of the lake, for 146 lakes in the ELS-II.

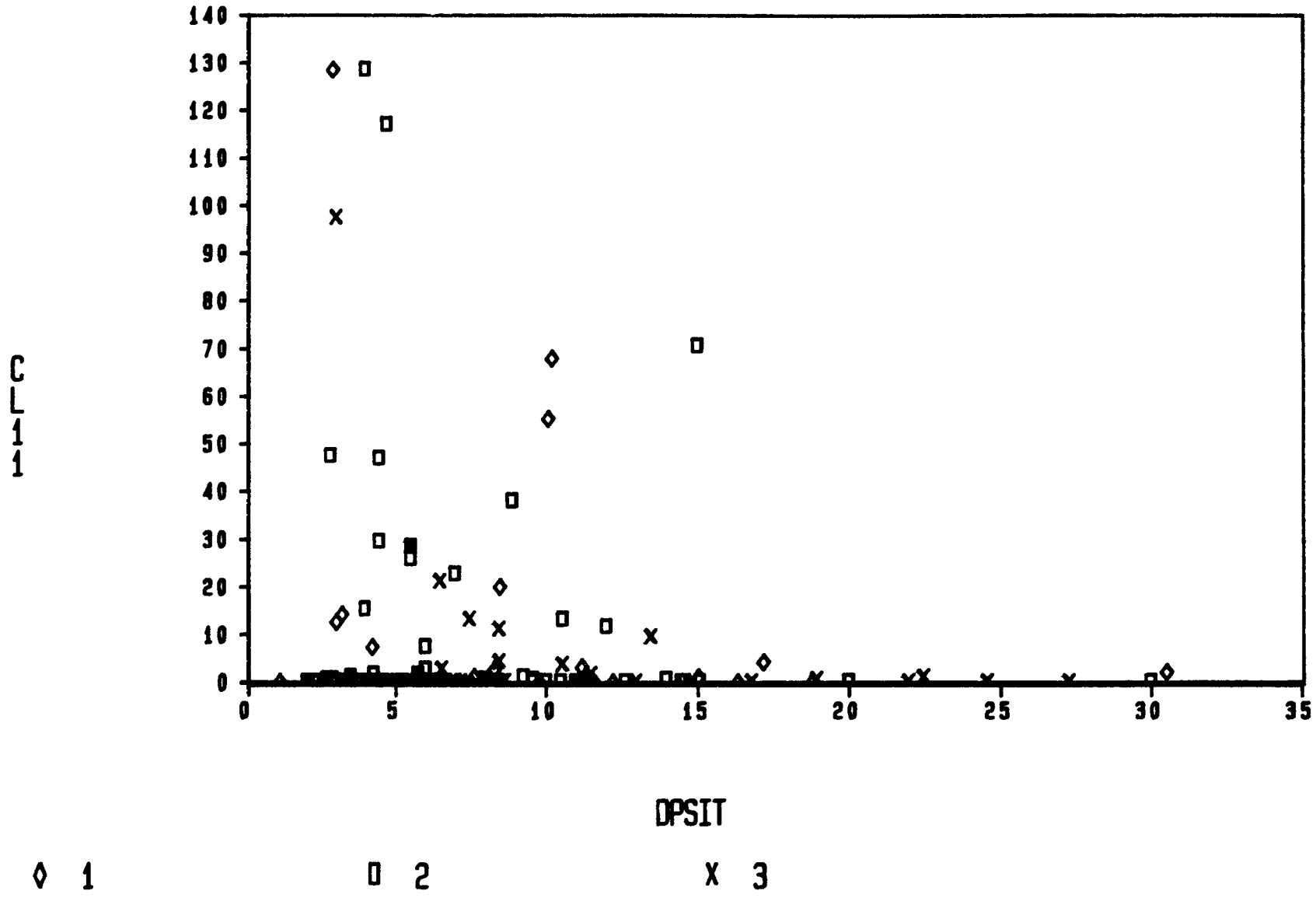


Figure 3-93. Relationship between abundance of the cladoceran Daphnia parvula group and depth of sampling site, which is close to the maximum depth of the lake, for 146 lakes in the ELS-II.

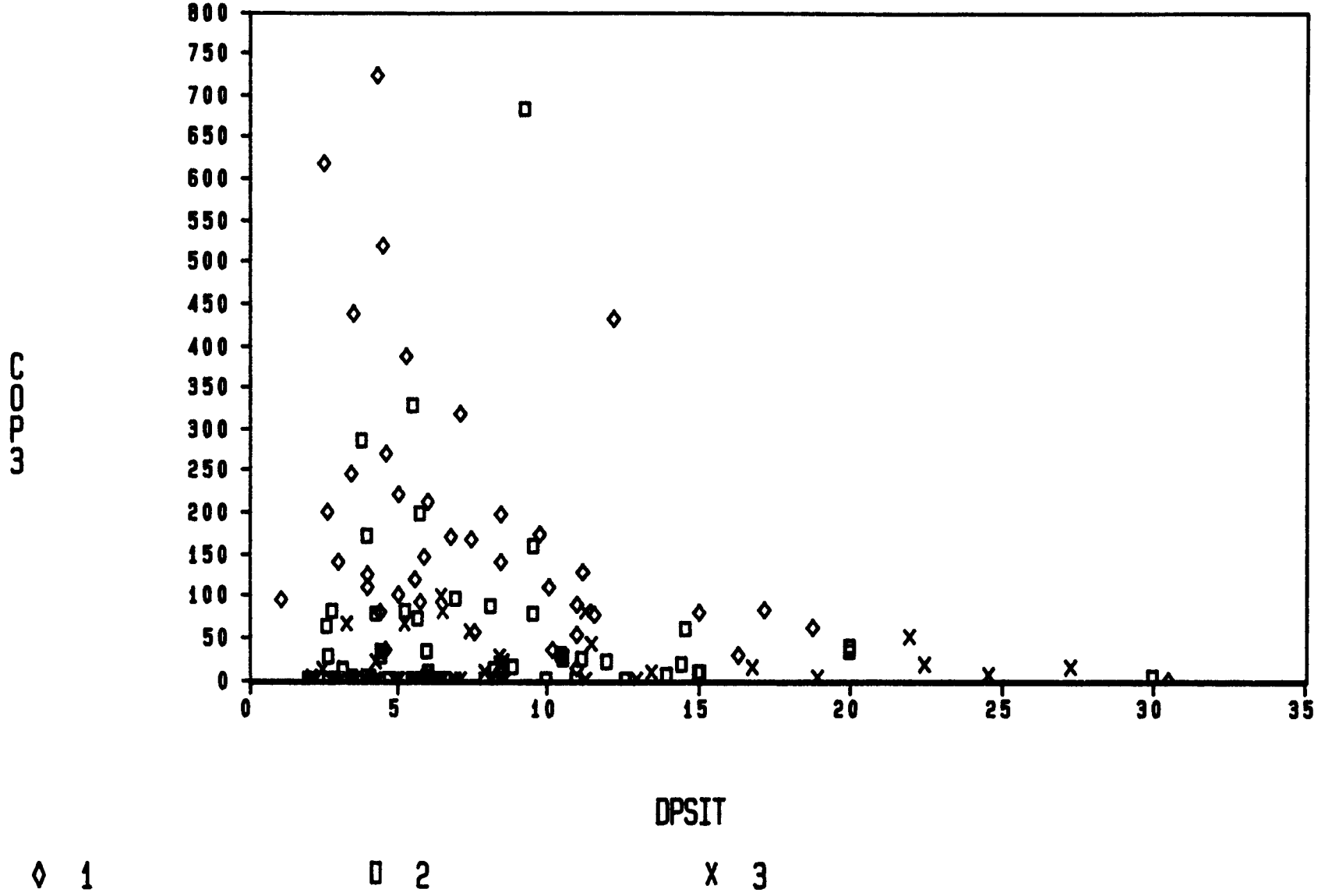


Figure 3-94. Relationship between abundance of the calanoid copepod Leptodiaptomus and depth of sampling site, which is close to the maximum depth of the lake, for 146 lakes in the ELS-II.

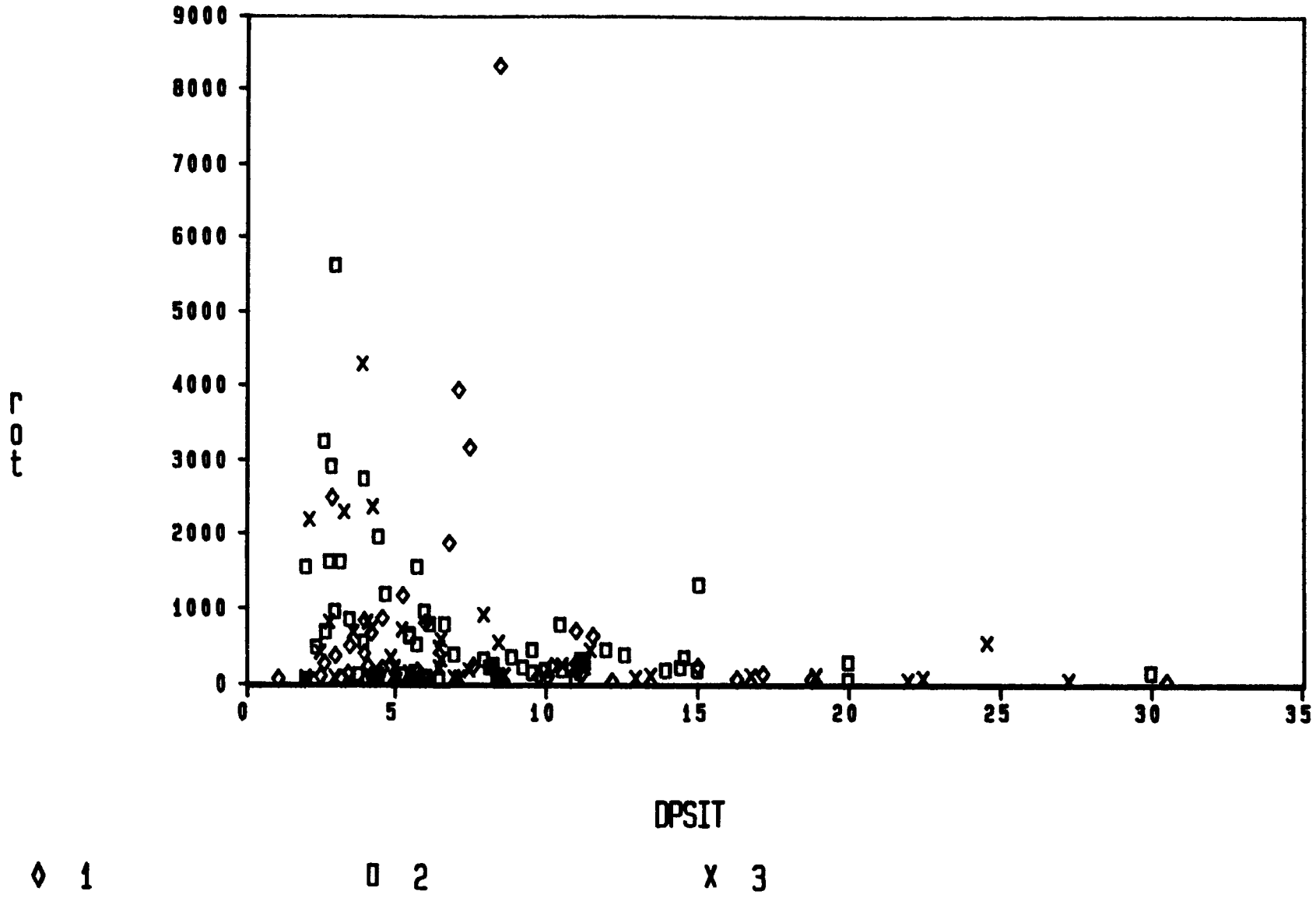


Figure 3-95. Relationship between abundance of rotifers and depth of sampling site, which is close to the maximum depth of the lake, for 146 lakes in the ELS-II.

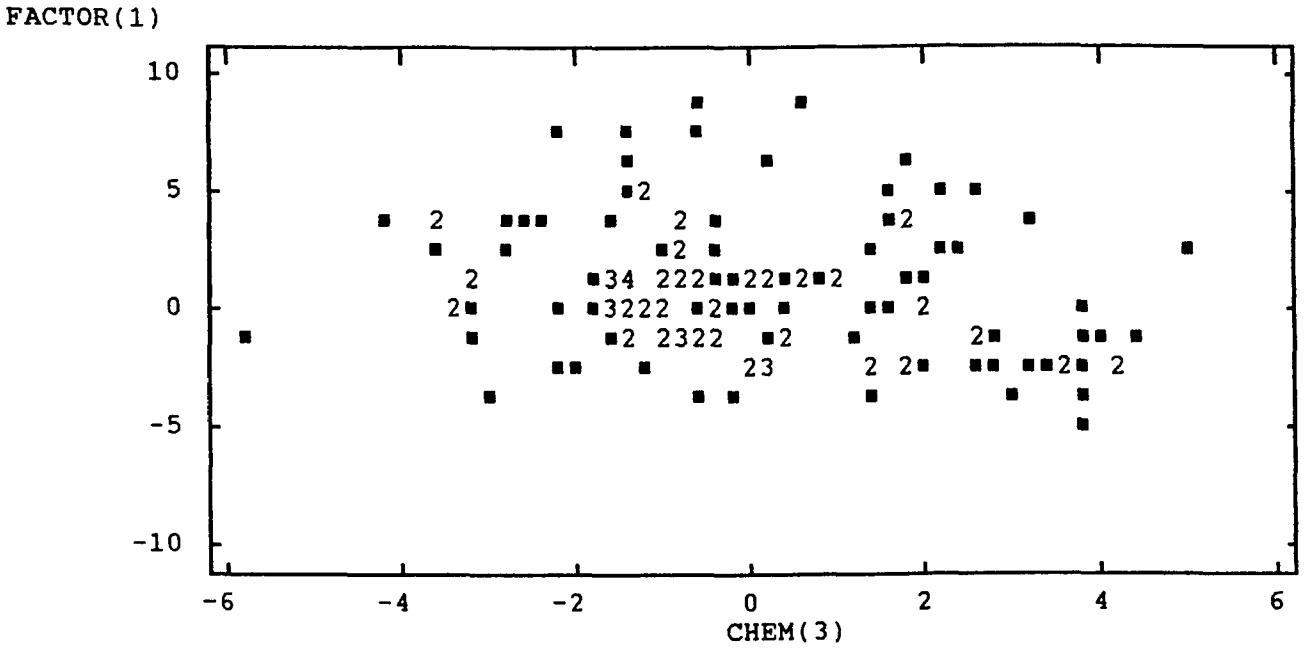


Figure 3-96. **Plot of rotifer genera PCA Factor 1 as a function of environmental PCA Factor 3. Solid square = 1 data point; number = total of overlapping points.**

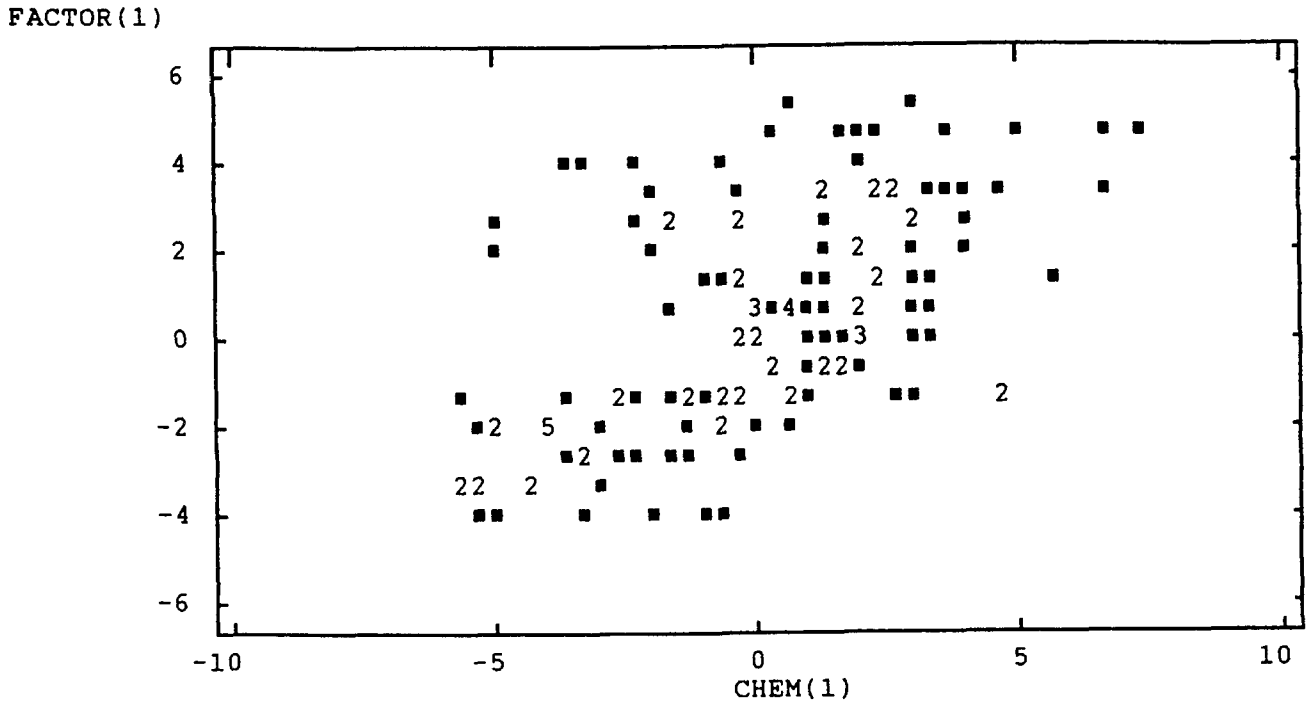


Figure 3-97. **Plot of copepod genera PCA Factor 1 as a function of environmental PCA Factor 1. Solid square = 1 data point; number = total of overlapping points.**

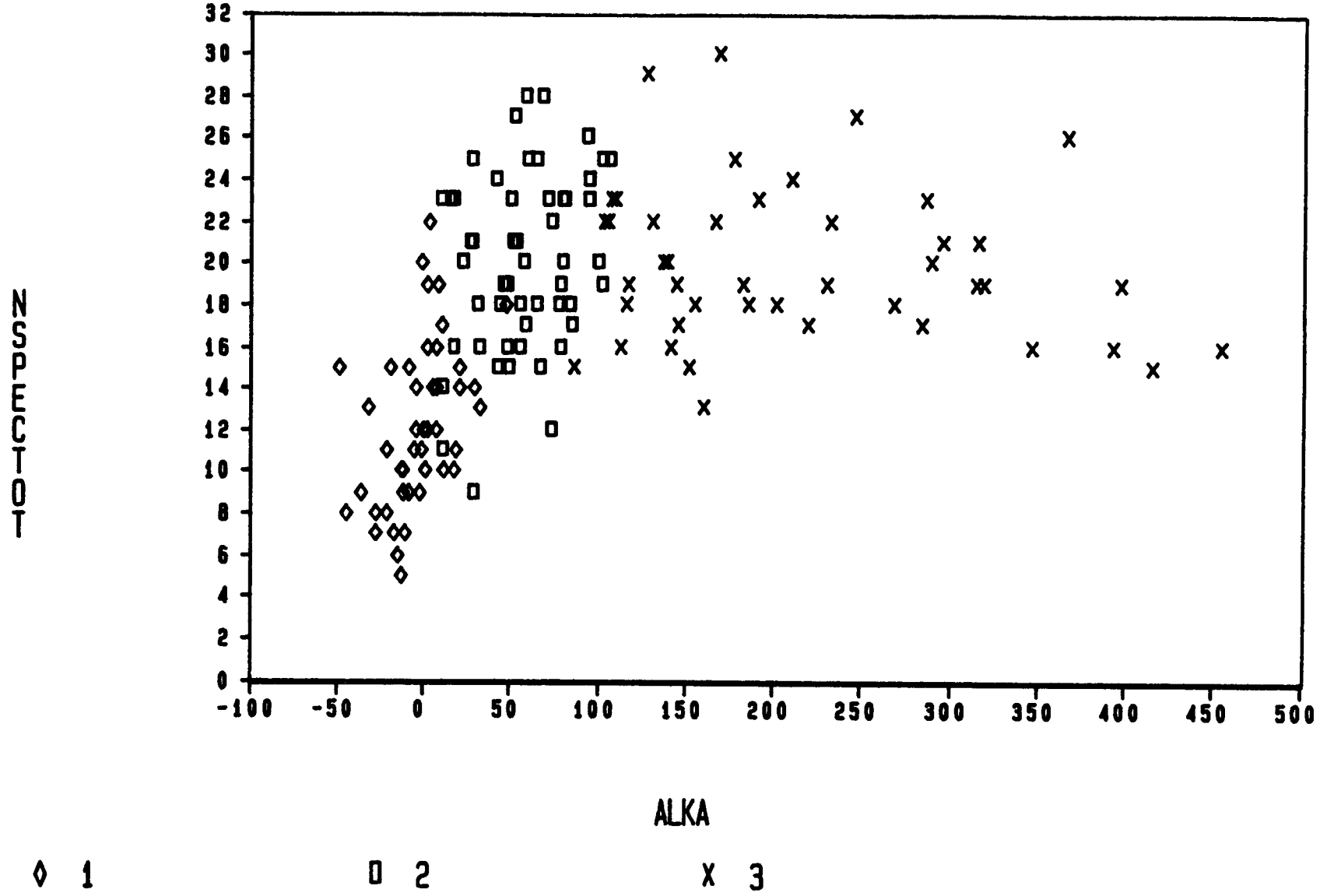


Figure 3-98. Plot of total species richness and alkalinity for 146 lakes from the summer sampling of the ELS-II.

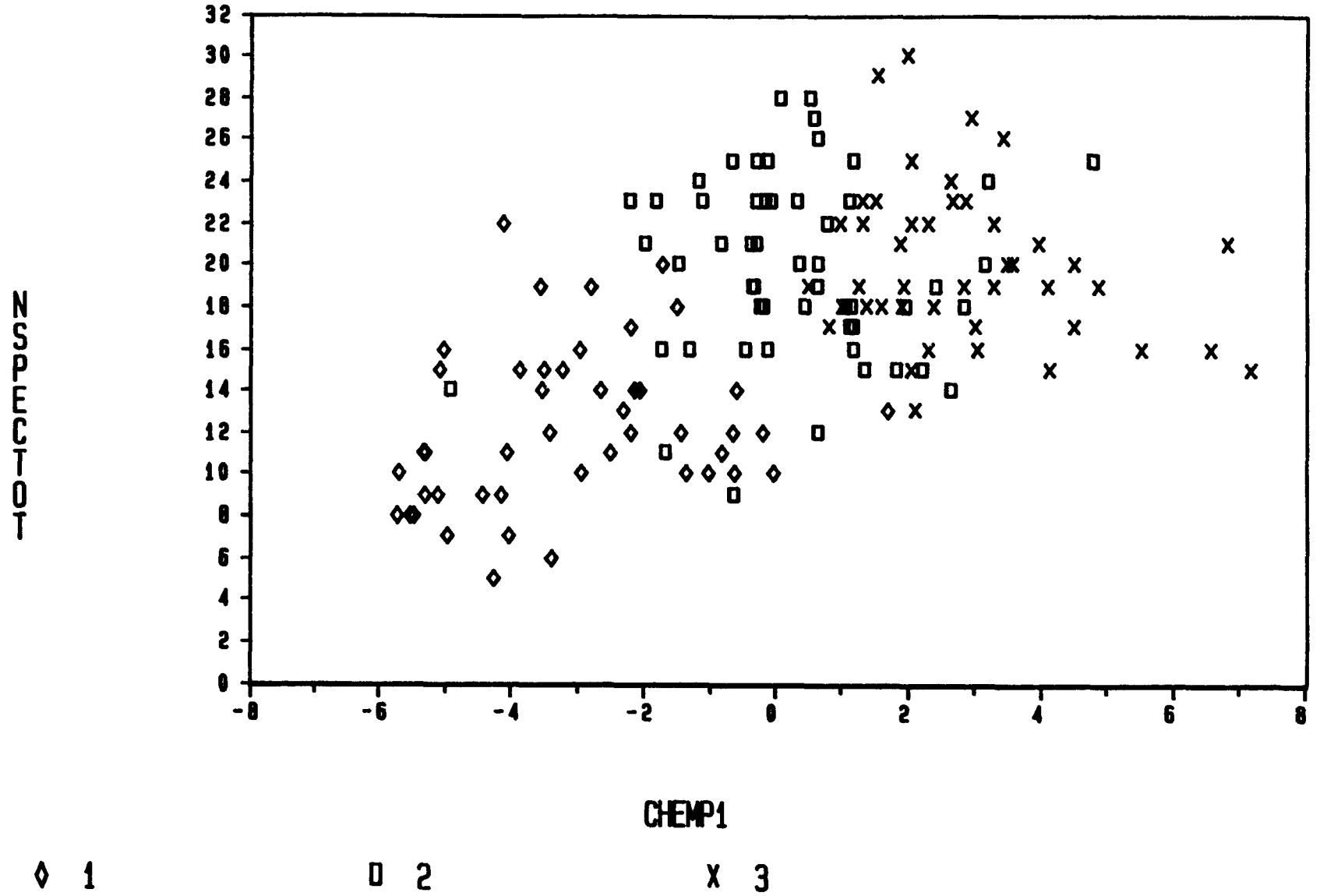


Figure 3-99. Plot of total species richness and CHEMP1 for 146 lakes from the summer sampling of the ELS-II. CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

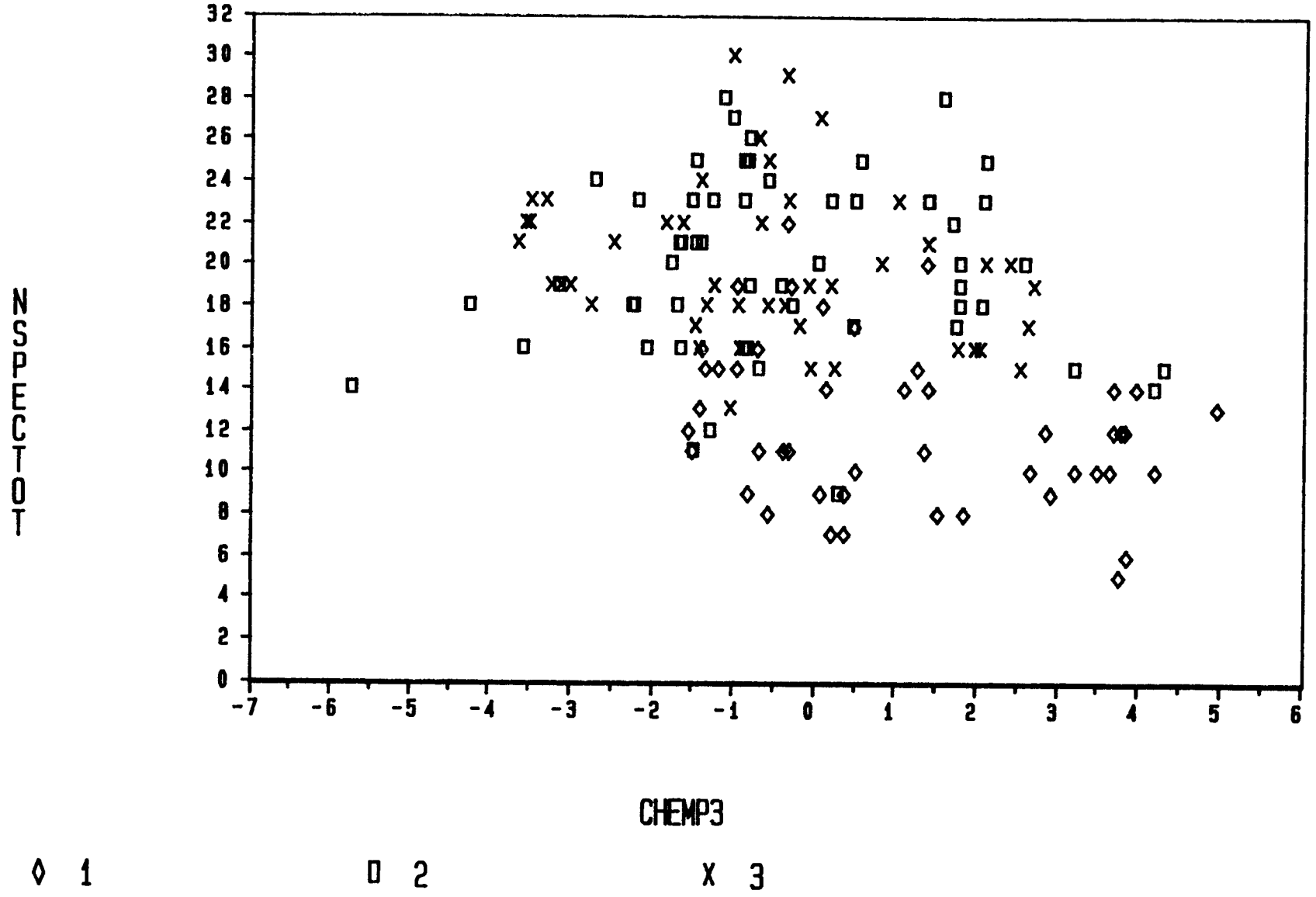


Figure 3-100. Plot of total species richness and CHEMP3 for 145 lakes from the summer sampling of the ELS-II. CHEMP3 is the third chemical factor calculated by PCA of the chemistry data.

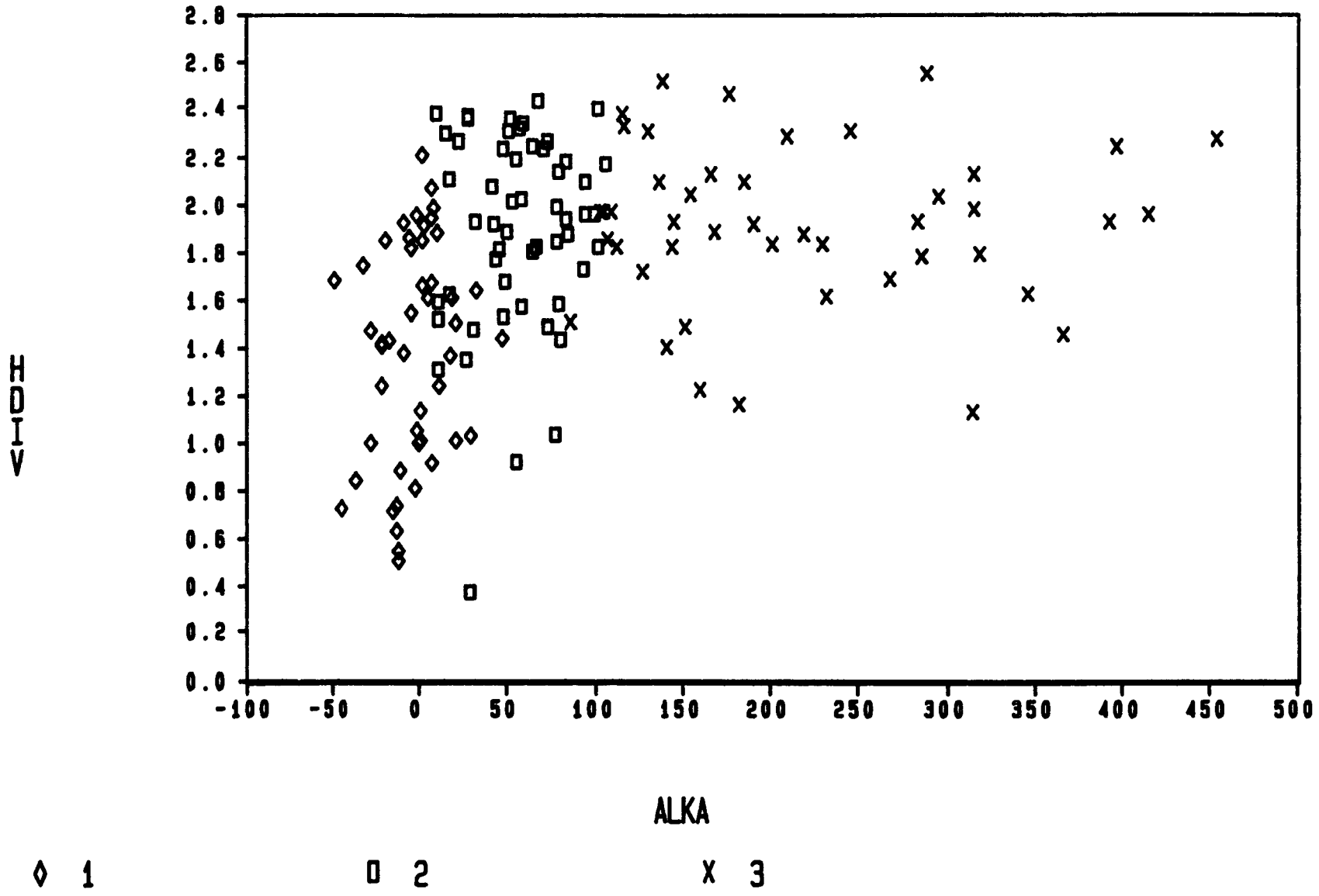


Figure 3-101. Plot of Shannon-Wiener diversity and alkalinity for 146 lakes from the summer sampling of the ELS-II.

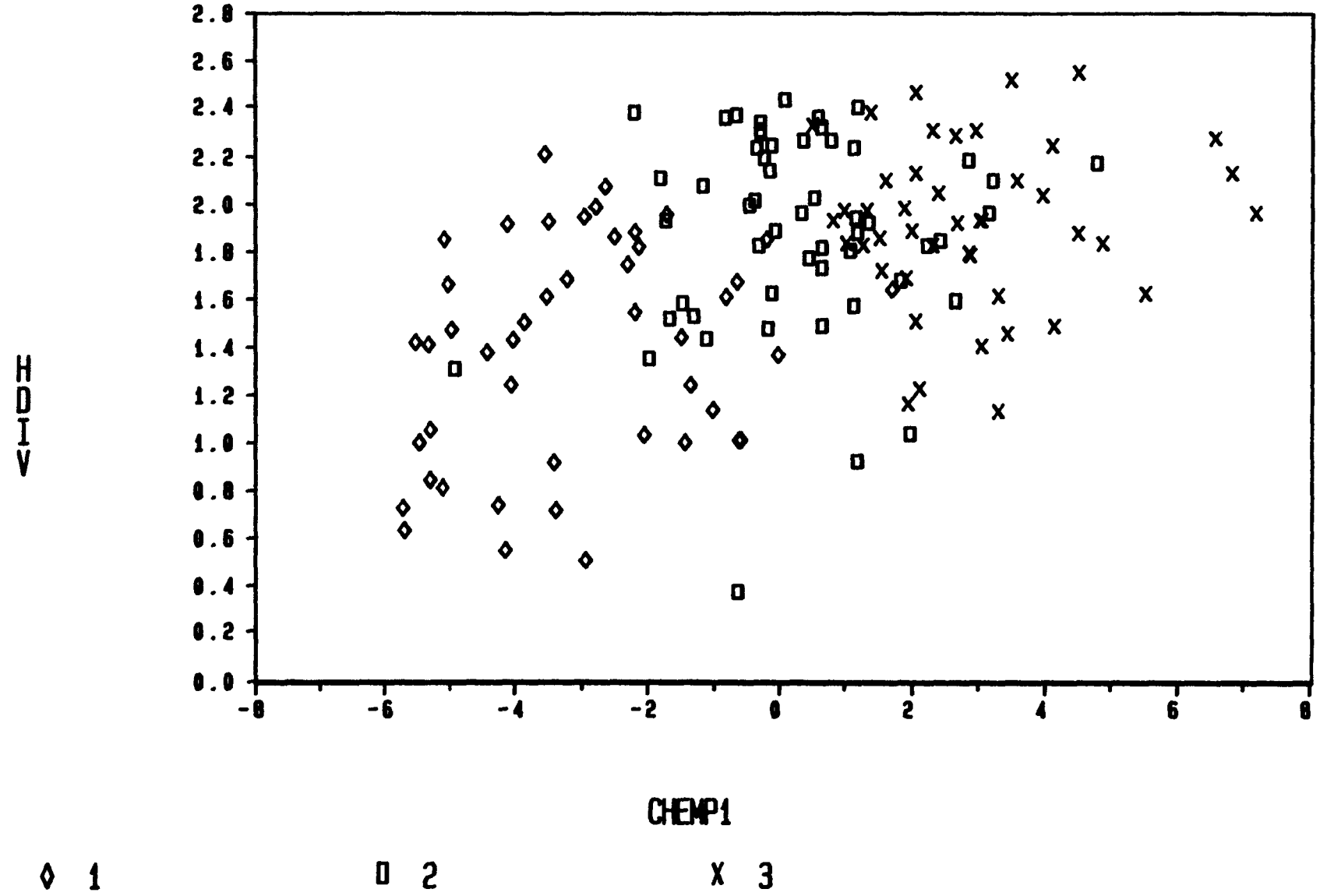


Figure 3-102. Plot of Shannon-Wiener diversity and CHEMP1 for 146 lakes from the summer sampling of the ELS-II. CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

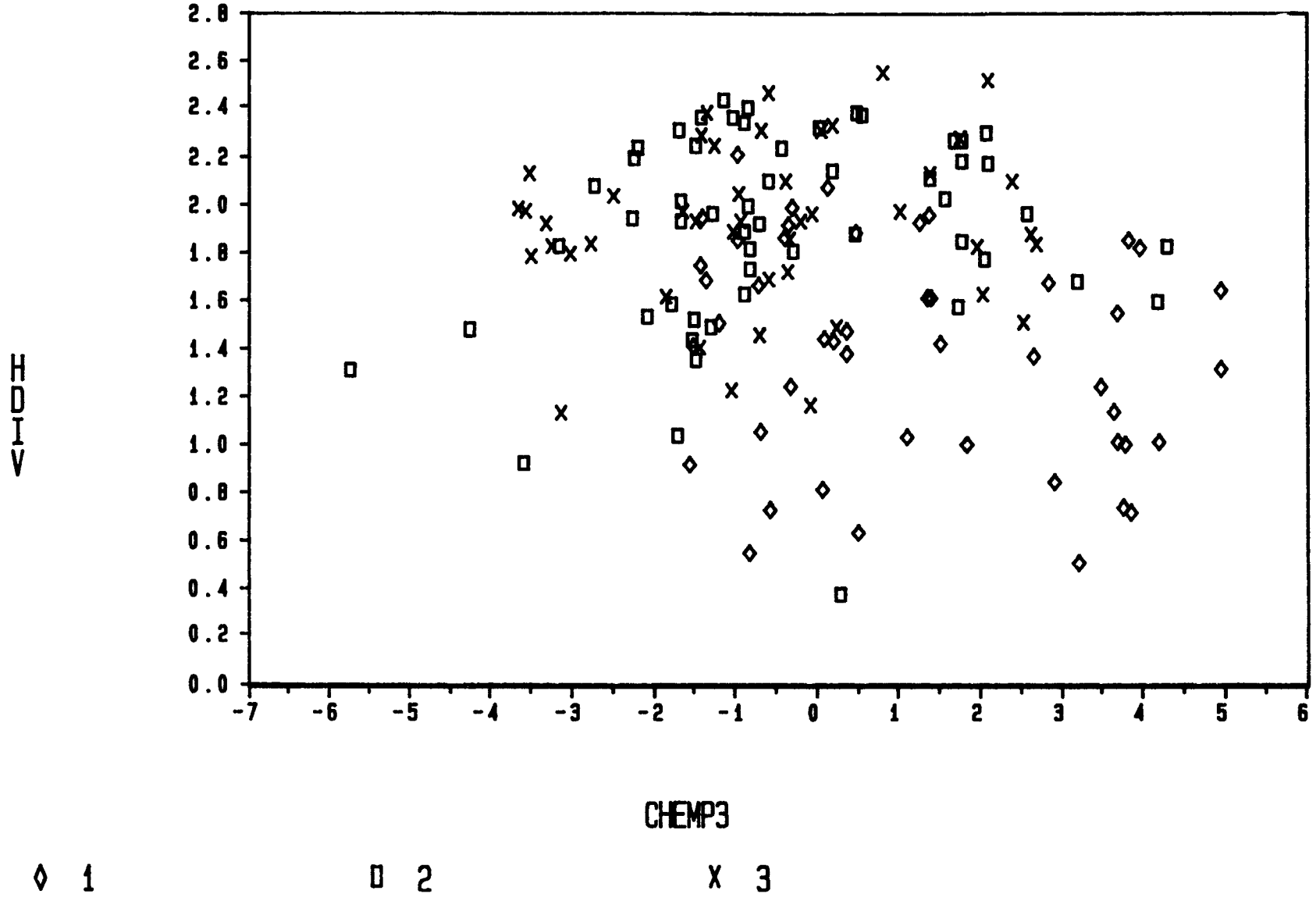


Figure 3-103. Plot of Shannon-Wiener diversity and CHEMP3 for 145 lakes from the summer sampling of the ELS-II. CHEMP3 is the third chemical factor calculated by PCA of the chemistry data.

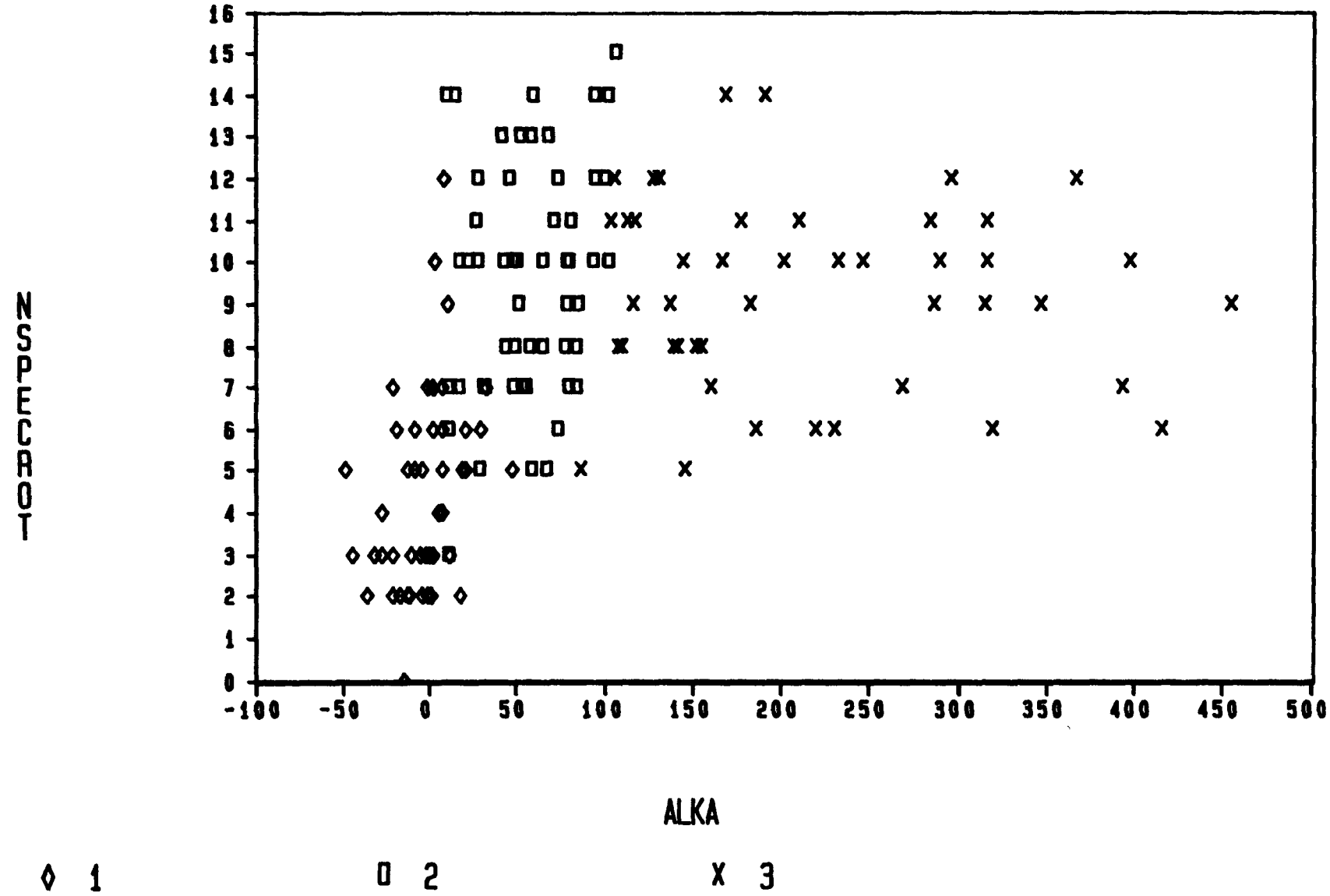


Figure 3-104. Plot of rotifer species richness and alkalinity for 146 lakes from the summer sampling of the ELS-II.

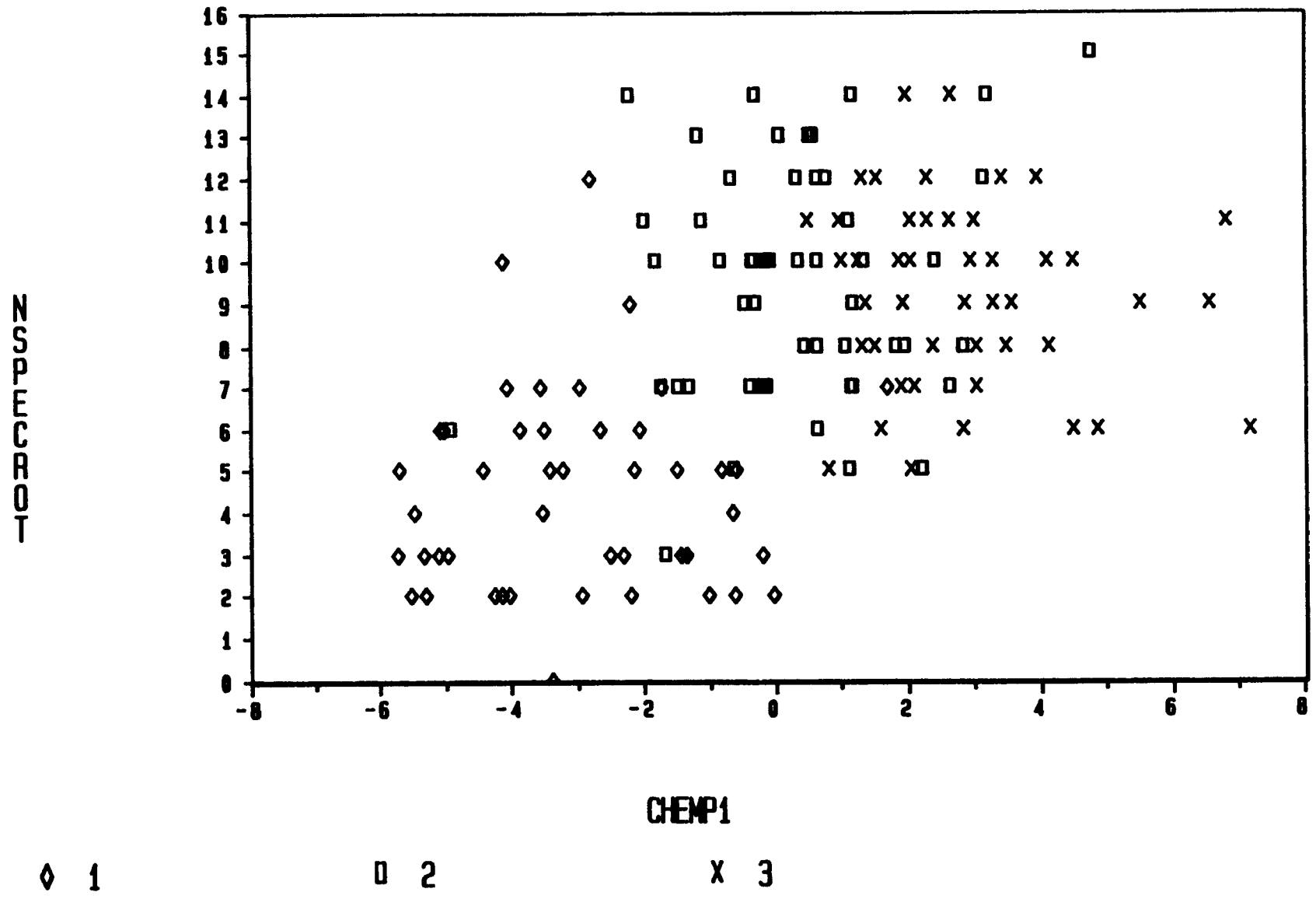


Figure 3-105. Plot of rotifer species richness and CHEMP1 for 146 lakes from the summer sampling of the ELS-II. CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

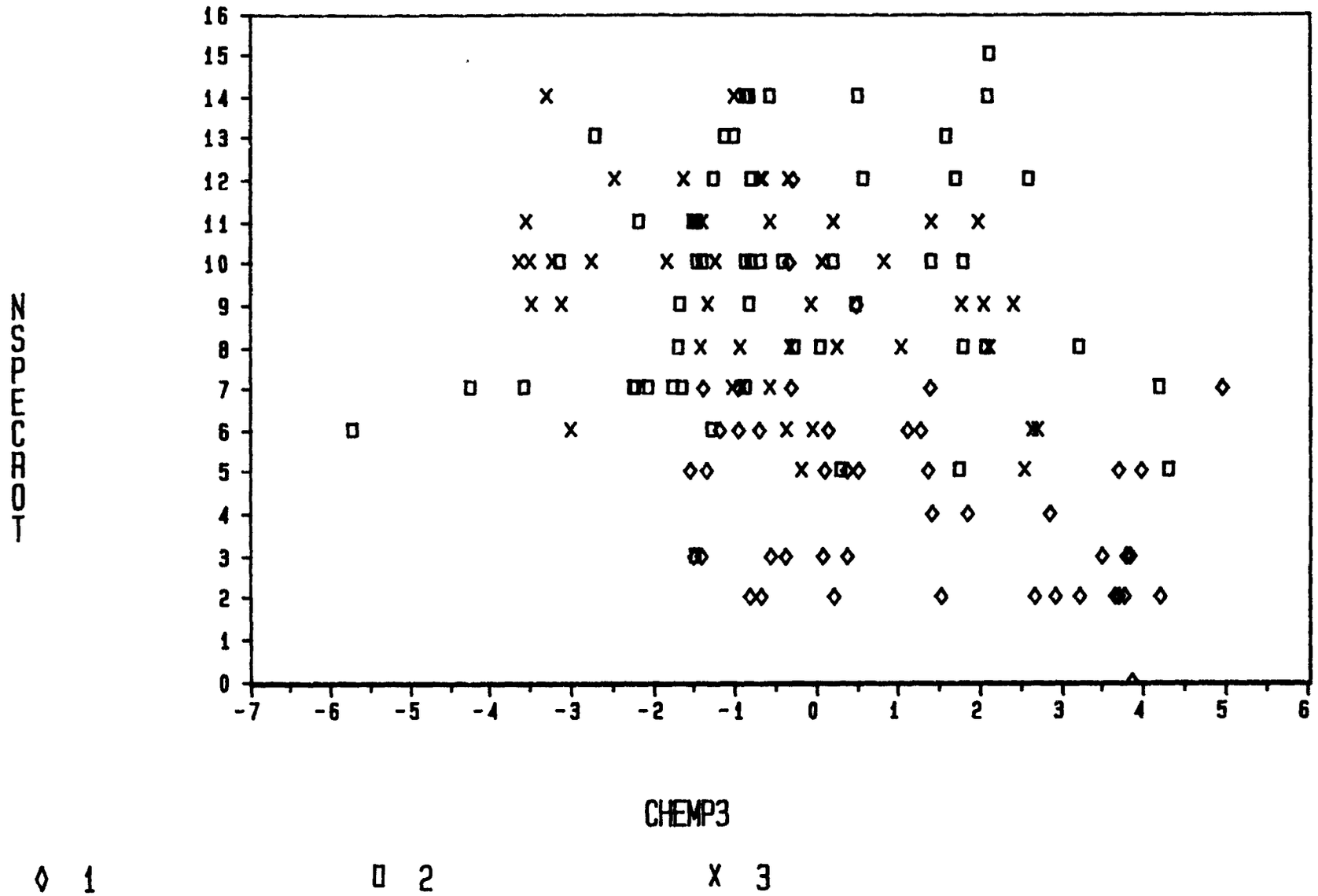


Figure 3-106. Plot of rotifer species richness and CHEMP3 for 145 lakes from the summer sampling of the ELS-II. CHEMP3 is the third chemical factor calculated by PCA of the chemistry data.

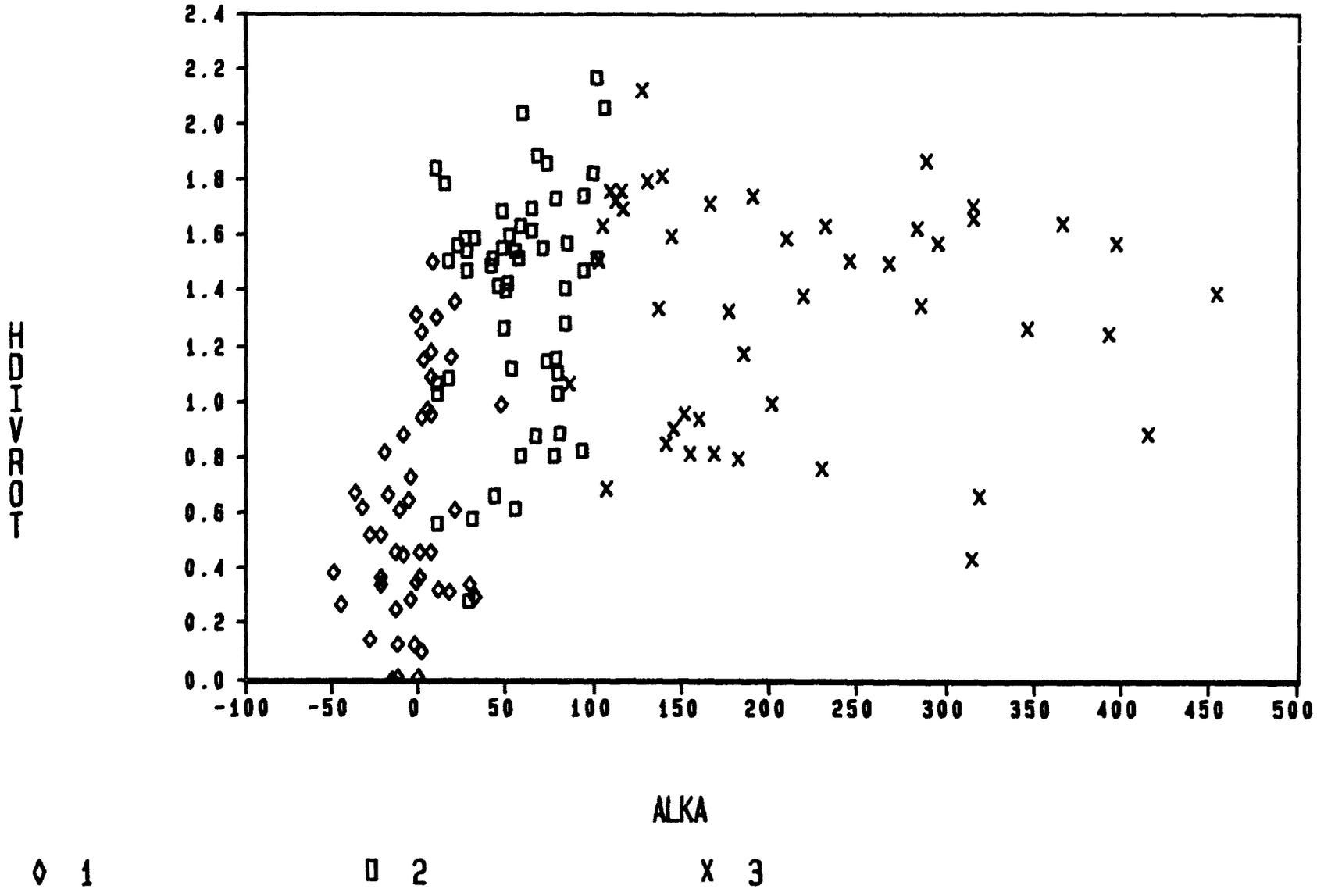


Figure 3-107. Plot of Shannon-Wiener diversity of rotifers and alkalinity for 146 lakes from the summer sampling of the ELS-II.

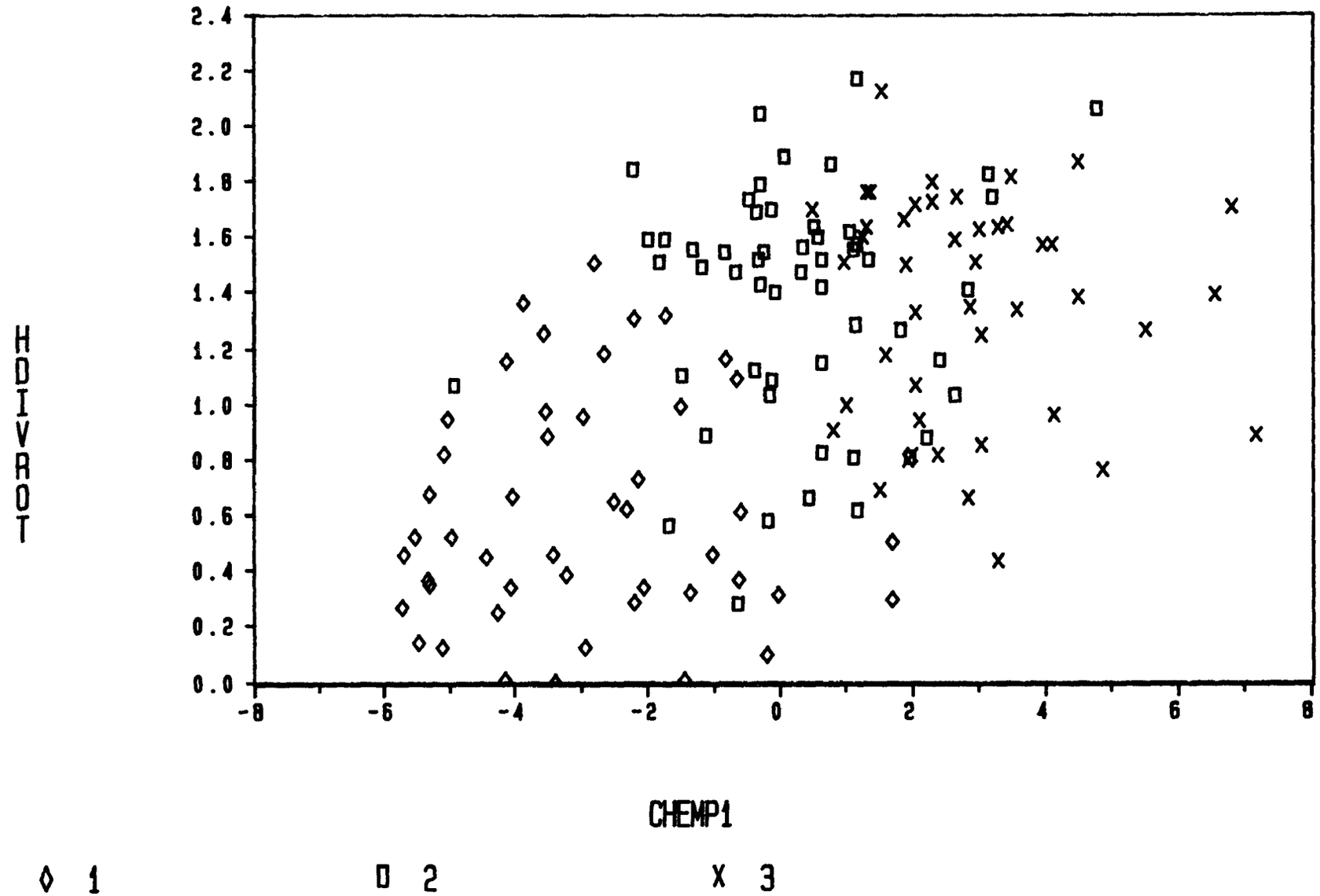


Figure 3-108. Plot of Shannon-Wiener diversity of rotifers and CHEMP1 for 145 lakes from the summer sampling of the ELS-II. CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

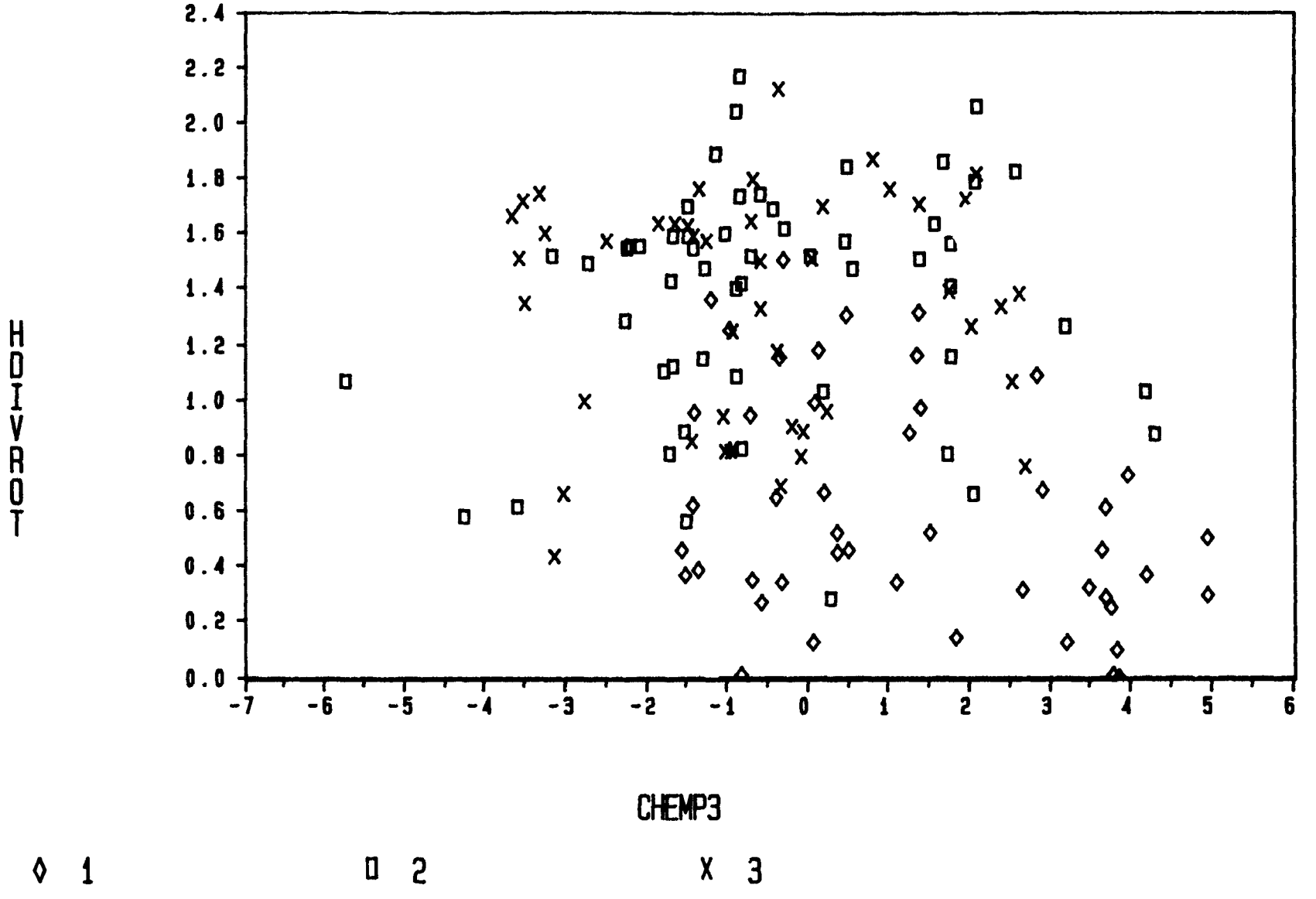


Figure 3-109. Plot of Shannon-Wiener diversity of rotifers and CHEMP3 for 145 lakes from the summer sampling of the ELS-II. CHEMP3 is the third chemical factor calculated by PCA of the chemistry data.

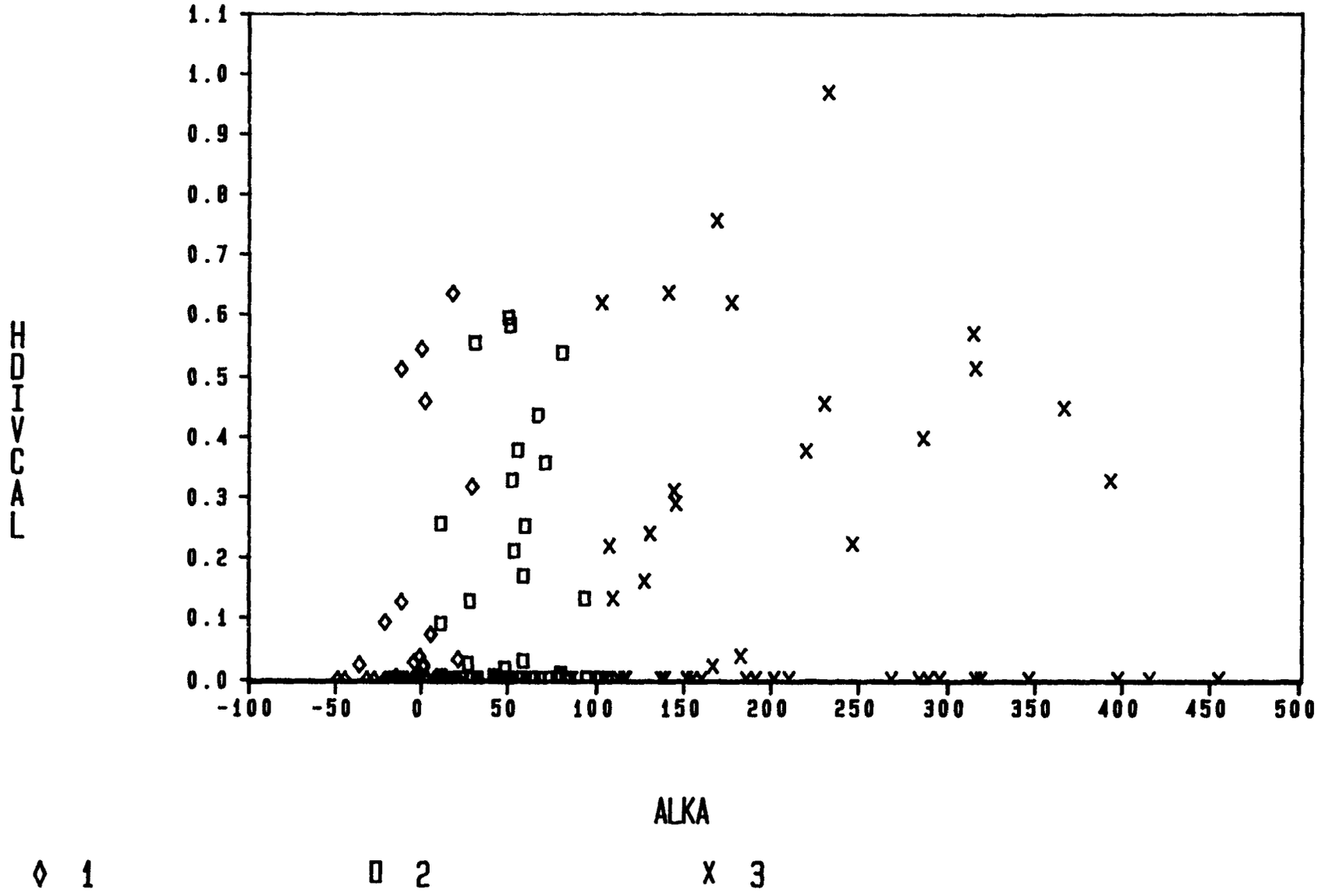


Figure 3-110. Plot of Shannon-Wiener diversity of calanoid copepods and alkalinity for 146 lakes from the summer sampling of the ELS-II.

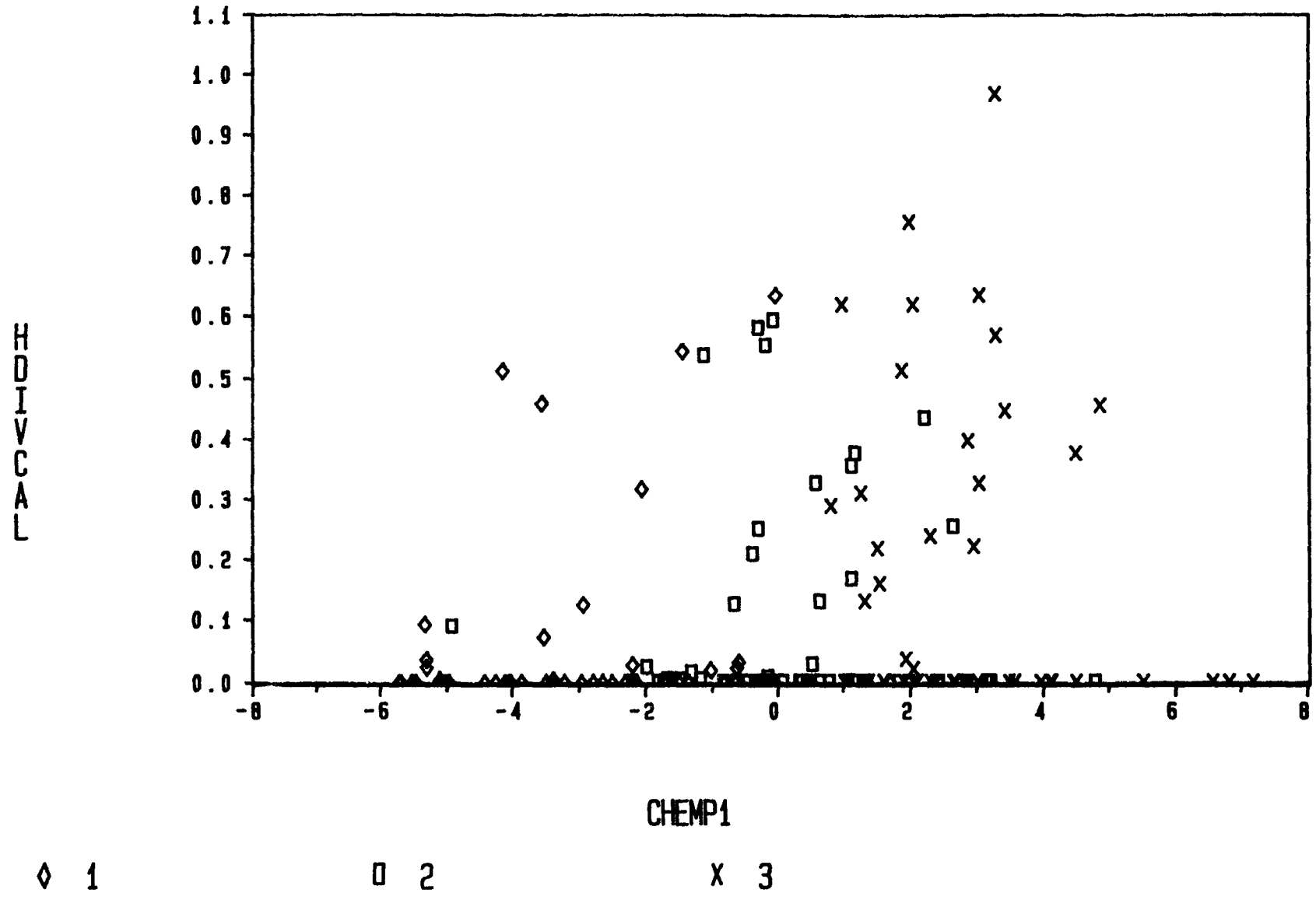


Figure 3-111. Plot of Shannon-Wiener diversity of calanoid copepods and CHEMP1 for 145 lakes from the summer sampling of the ELS-II. CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.

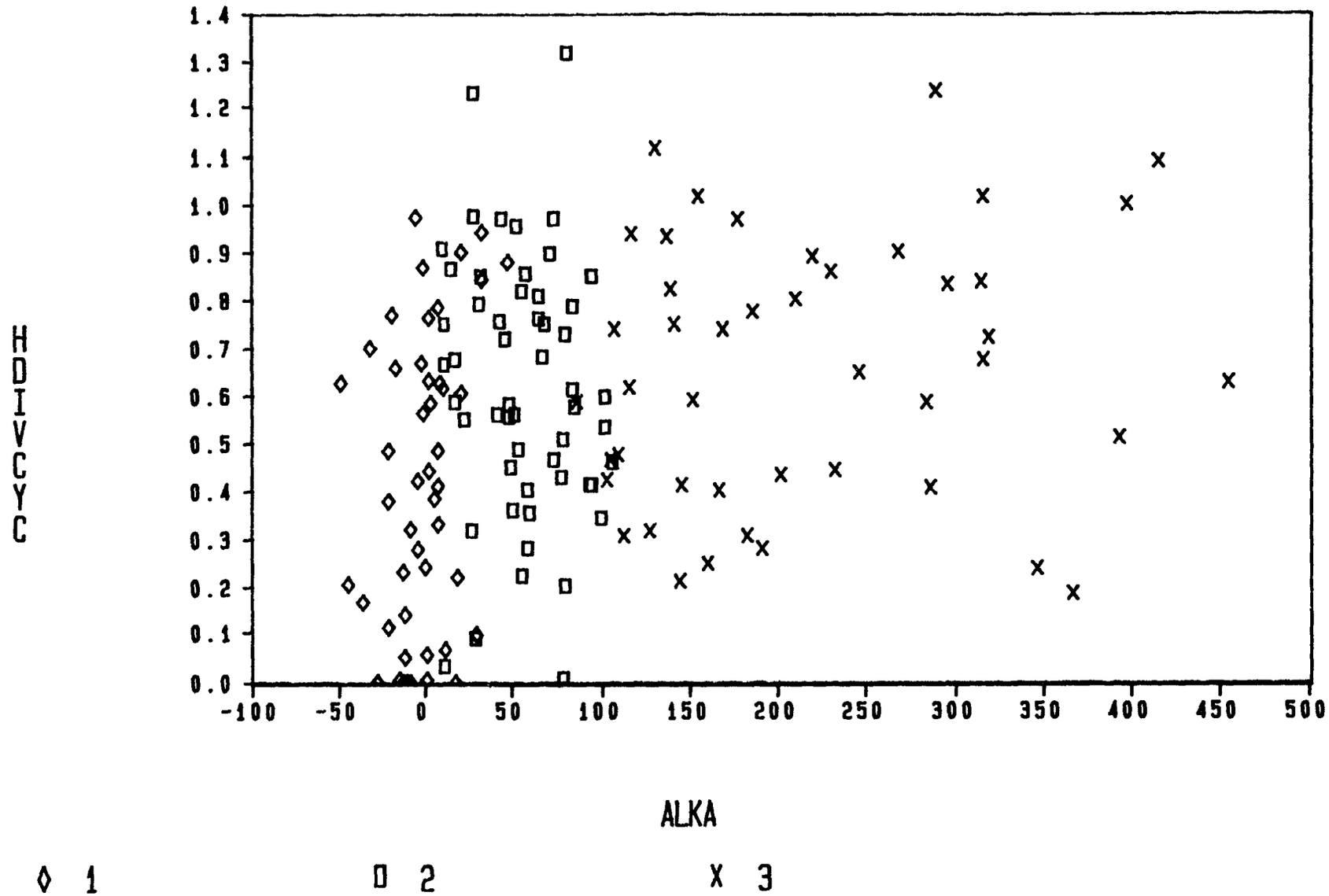


Figure 3-112. Plot of Shannon-Wiener diversity of cyclopoid copepods and alkalinity for 146 lakes from the summer sampling of the ELS-II.

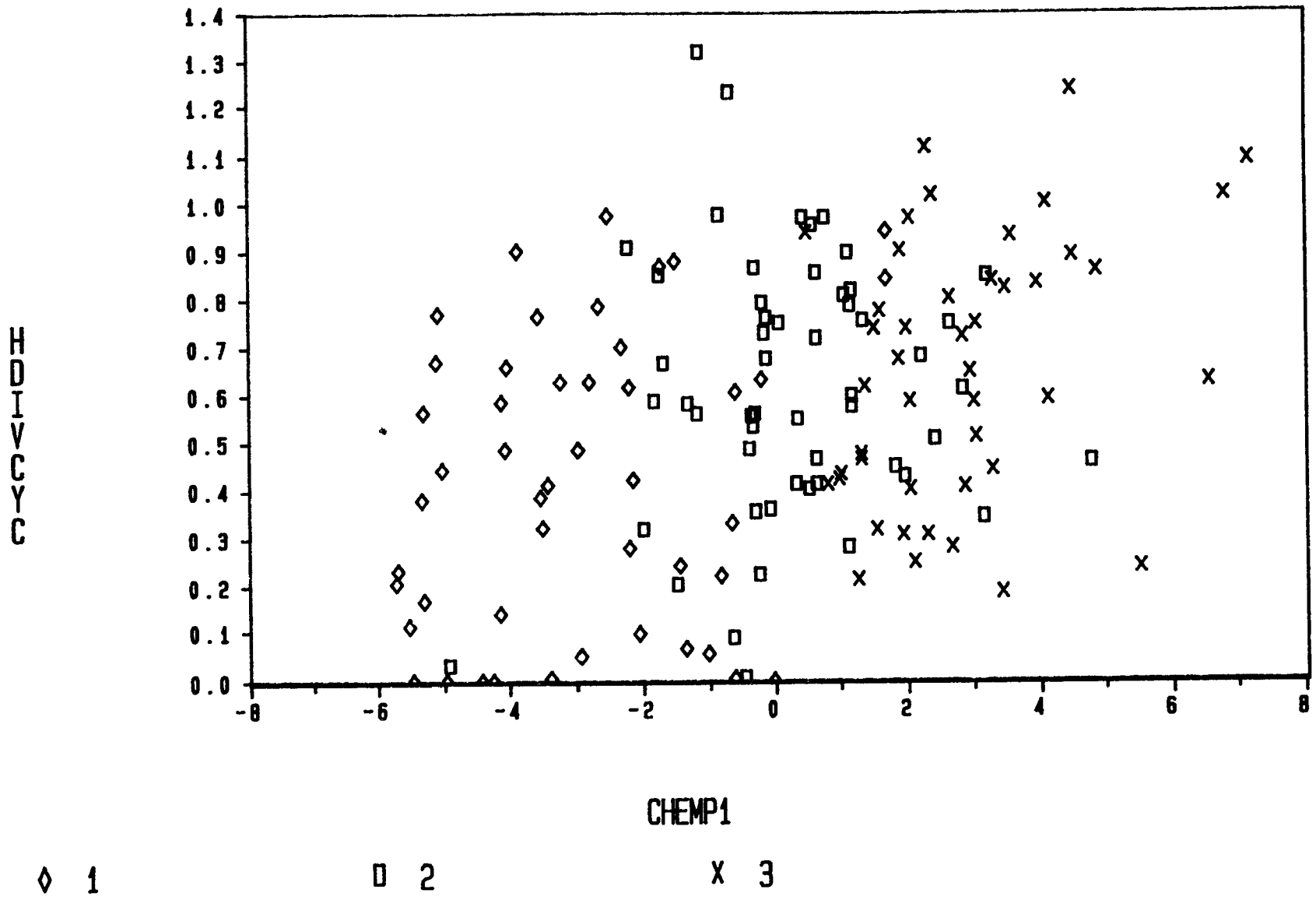
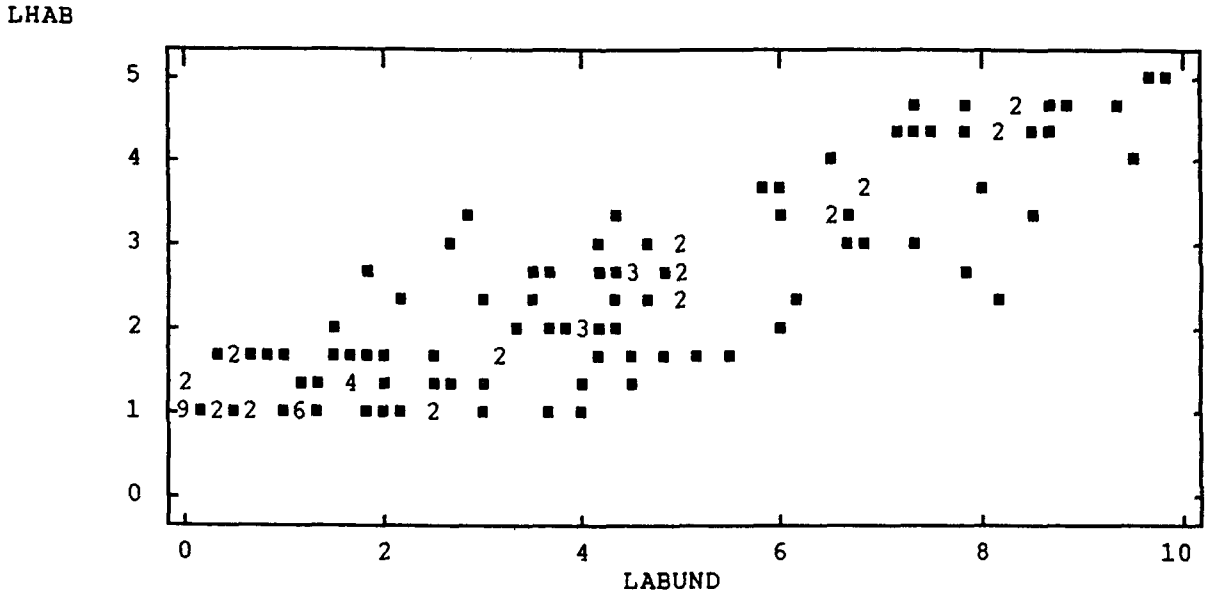


Figure 3-113. Plot of Shannon-Wiener diversity of cyclopoid copepods and CHEMP1 for 145 lakes from the summer sampling of the ELS-II. CHEMP1 is the first chemical factor calculated by PCA of the chemistry data.



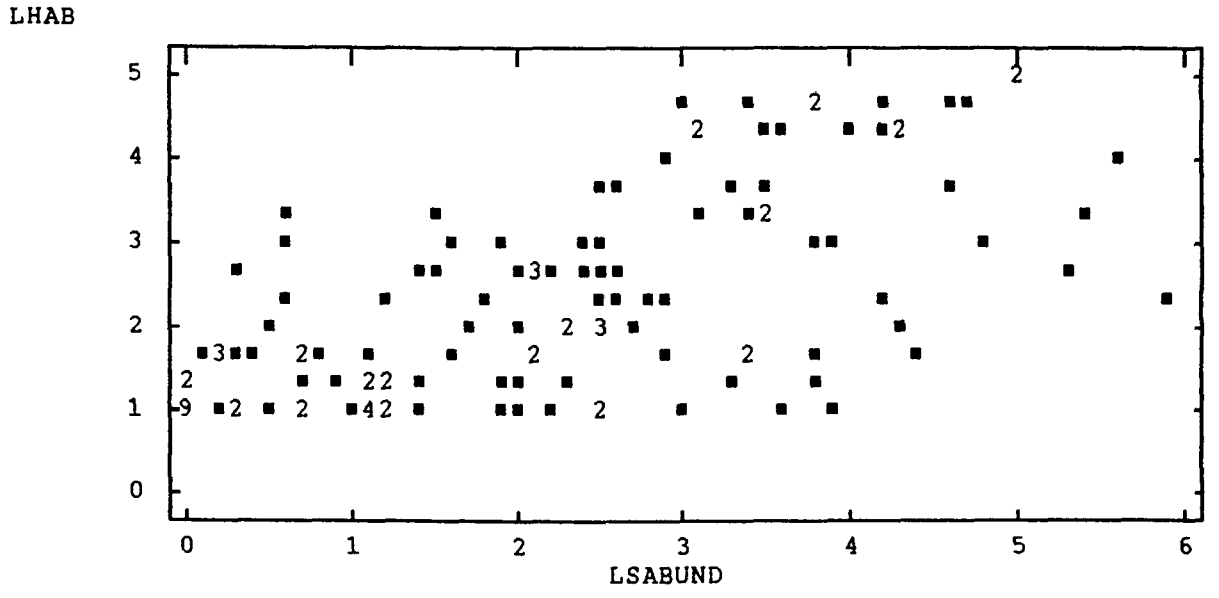
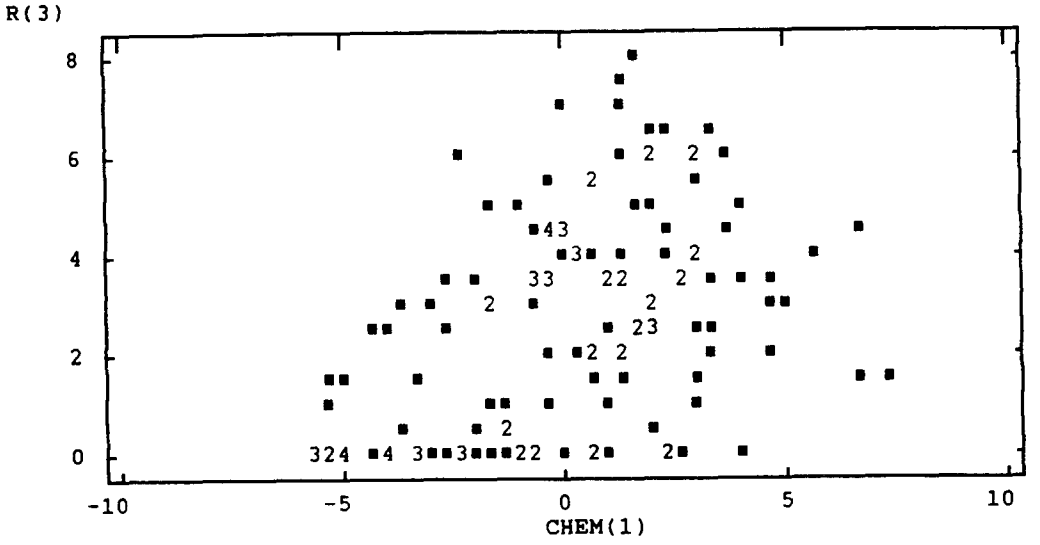


Figure 3-114. Plot of the number of lakes occupied by a species (LHAB = log transformed number) versus the abundance of that species in all lakes combined (LABUND = log transformed abundance, top), or the average abundance of that species in those lakes it does occupy (LSABUND = log transformed abundance, bottom). Solid square = 1 data point; number = total of overlapping points.



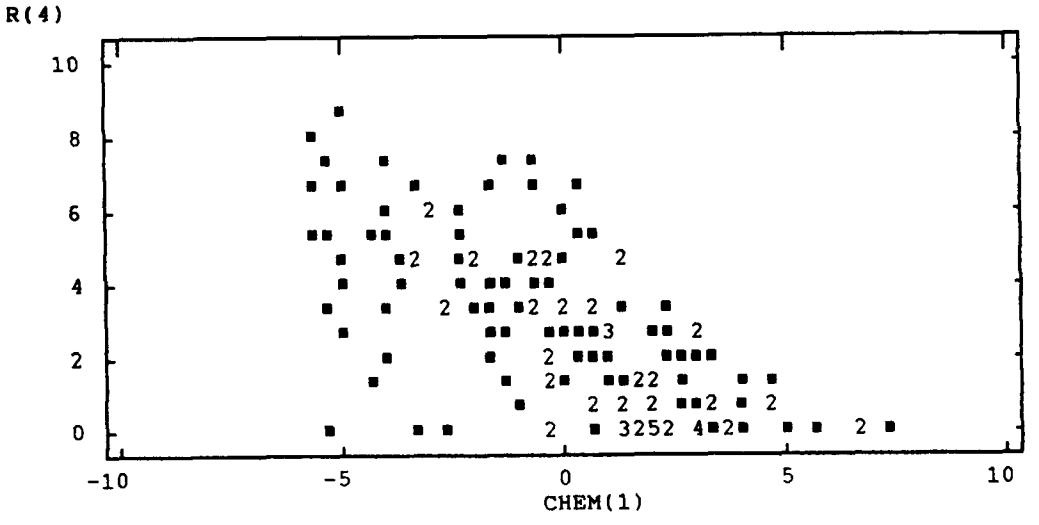


Figure 3-115. Abundance of Keratella crassa [R(3)] and K. taurocephala [R(4)], log(e) transformed, as a function of environmental PCA Factor 1. Solid square = 1 data point; number = total of overlapping points.

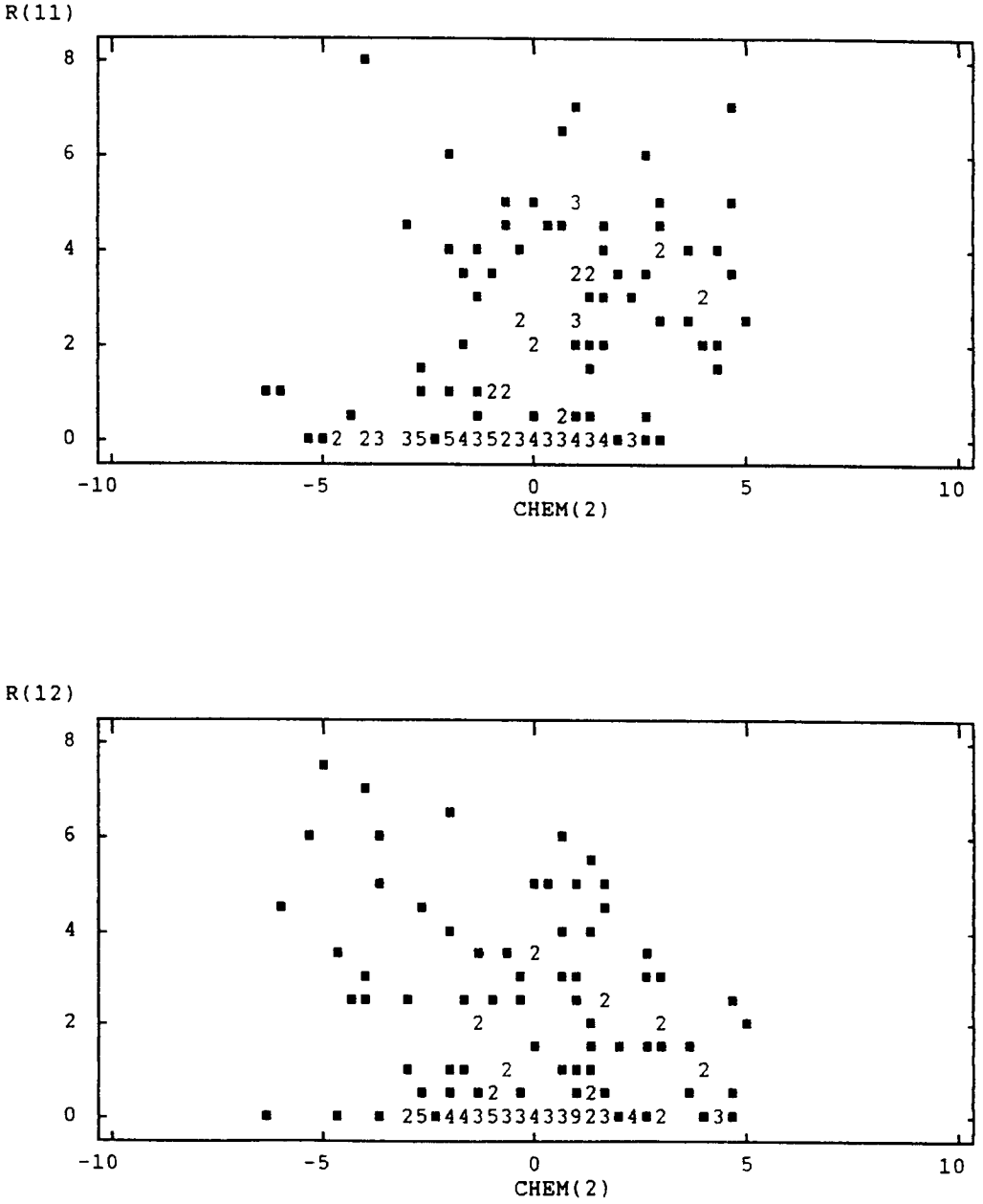


Figure 3-116. Abundance of Kellicottia longispina [R(11)] and K. bostonensis [R(12)], log(e) transformed, as a function of environmental PCA Factor 2. Solid square = 1 data point; number = total of overlapping points.

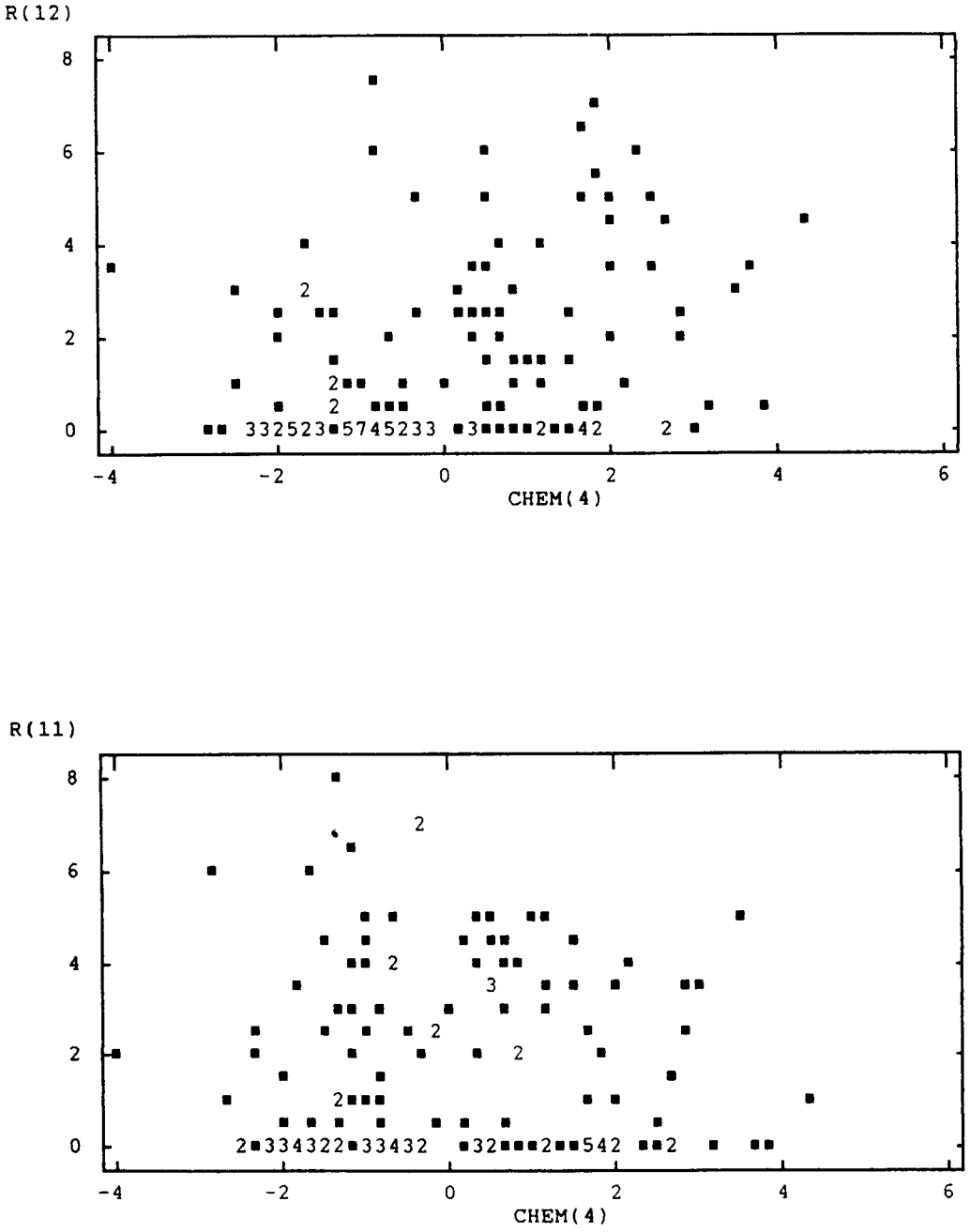


Figure 3-117. **Abundance of Kellicottia longispina [R(11)] and K. bostonensis [R(12)], log(e) transformed, as a function of environmental PCA Factor 4. Solid square = 1 data point; number = total of overlapping points.**

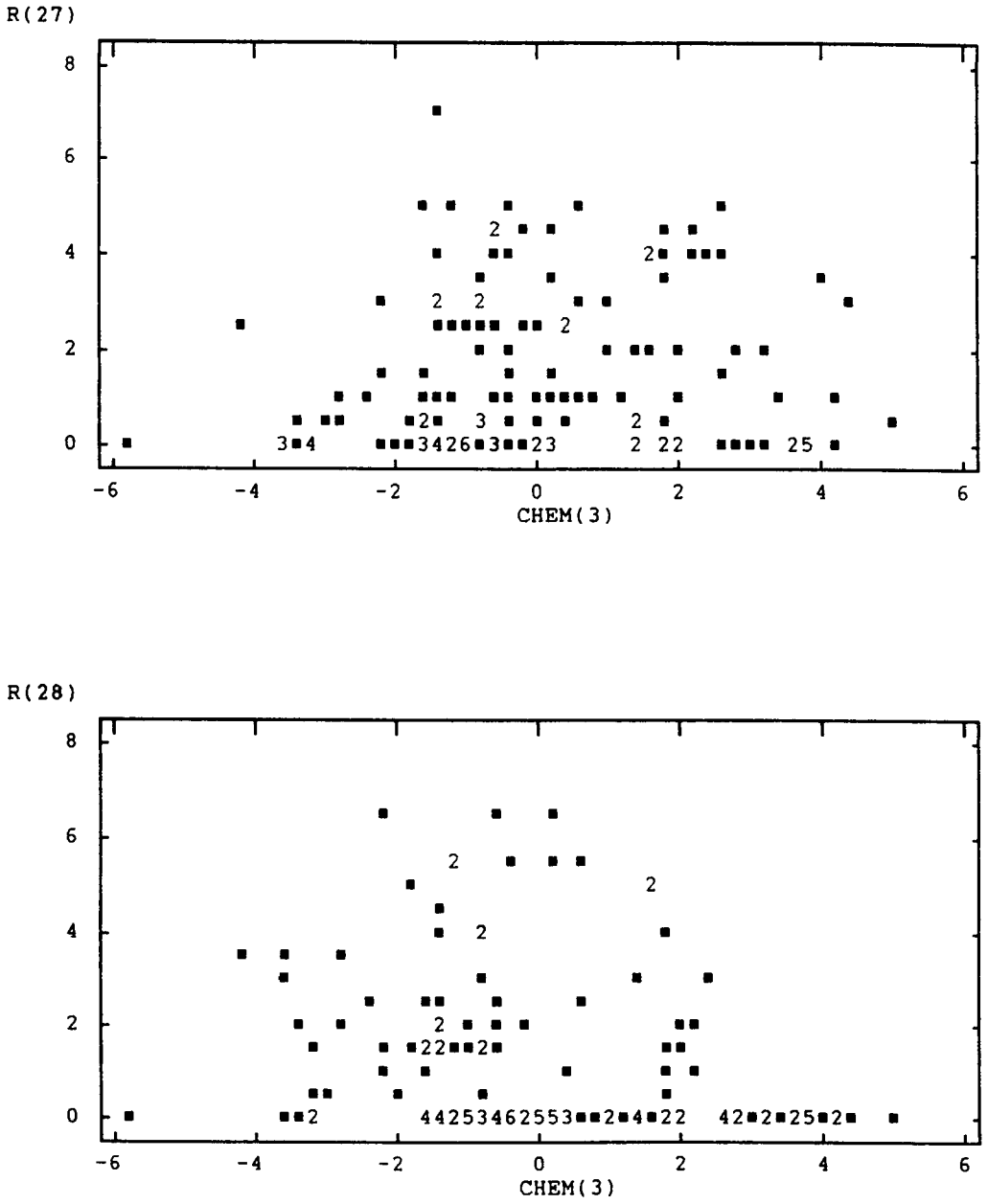


Figure 3-118. Abundance of Trichocerca multicrenis [R(27)] and T. cylindrica [R(28)], log(e) transformed, as a function of environmental PCA Factor 3. Solid square = 1 data point; number = total of overlapping points.

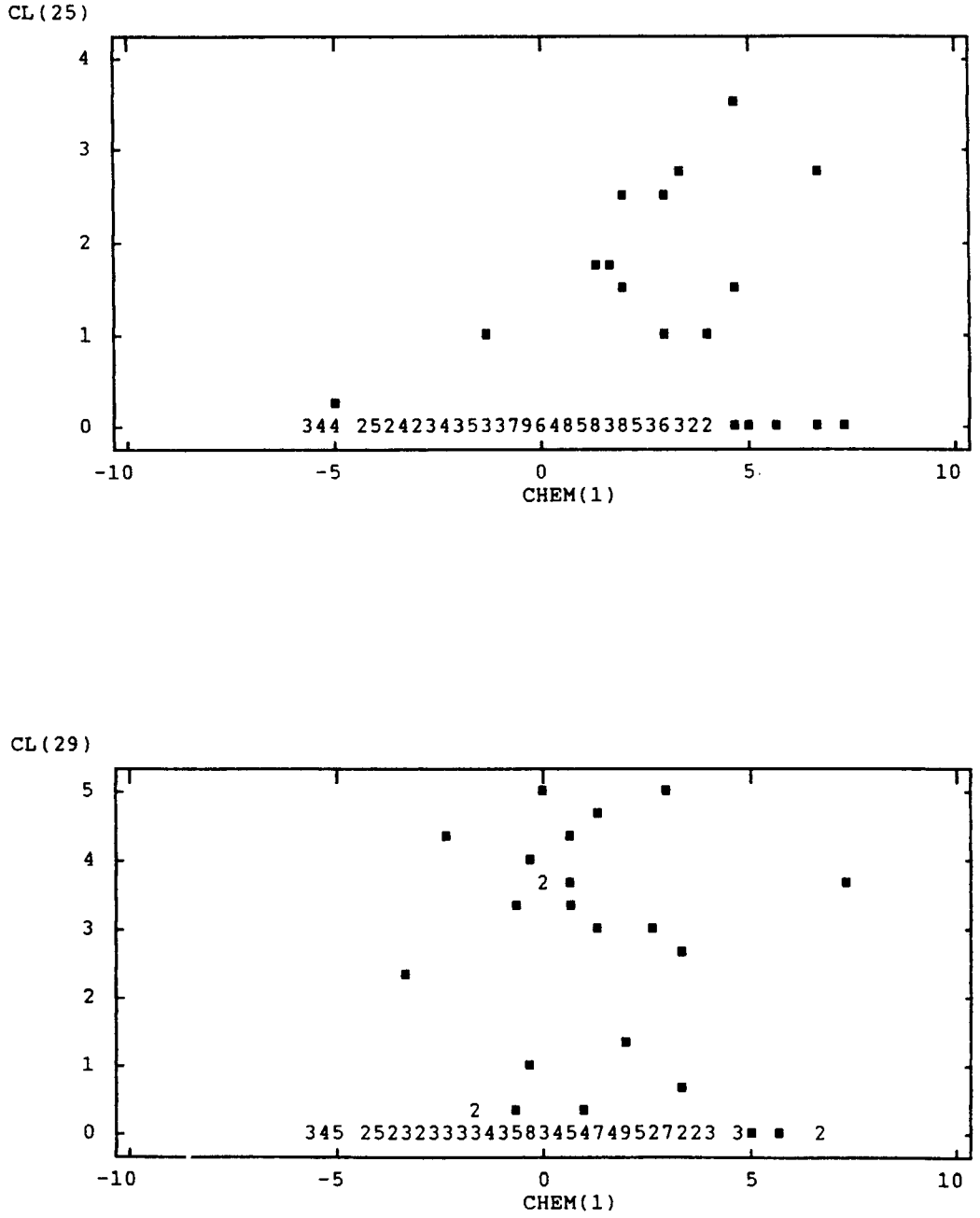


Figure 3-119. Abundance of Daphnia galeata grouping [CL(25)] and D. parvula grouping [CL(29)], log(e) transformed, as a function of environmental PCA Factor 1. Solid square = 1 data point; number = total of overlapping points.

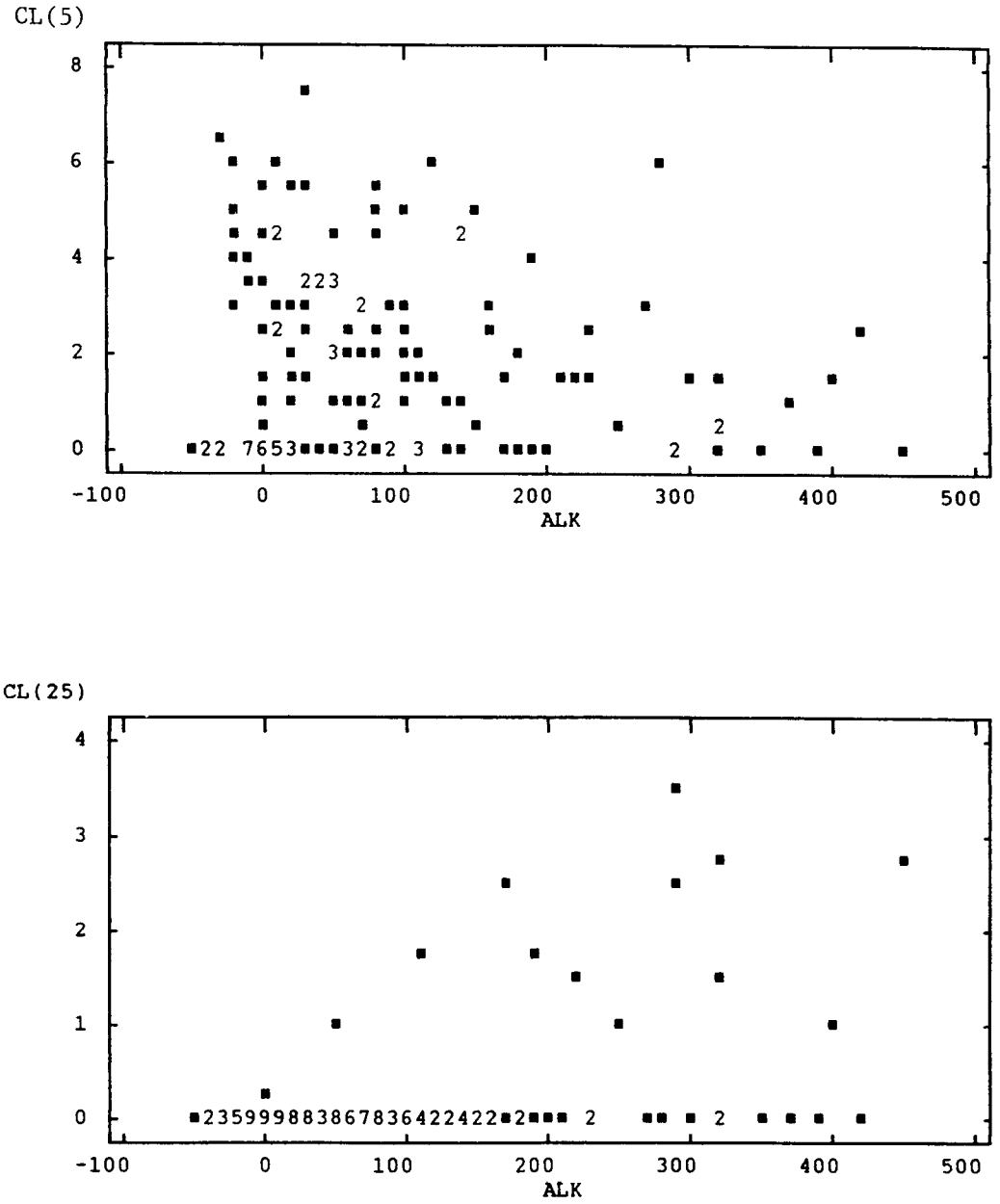
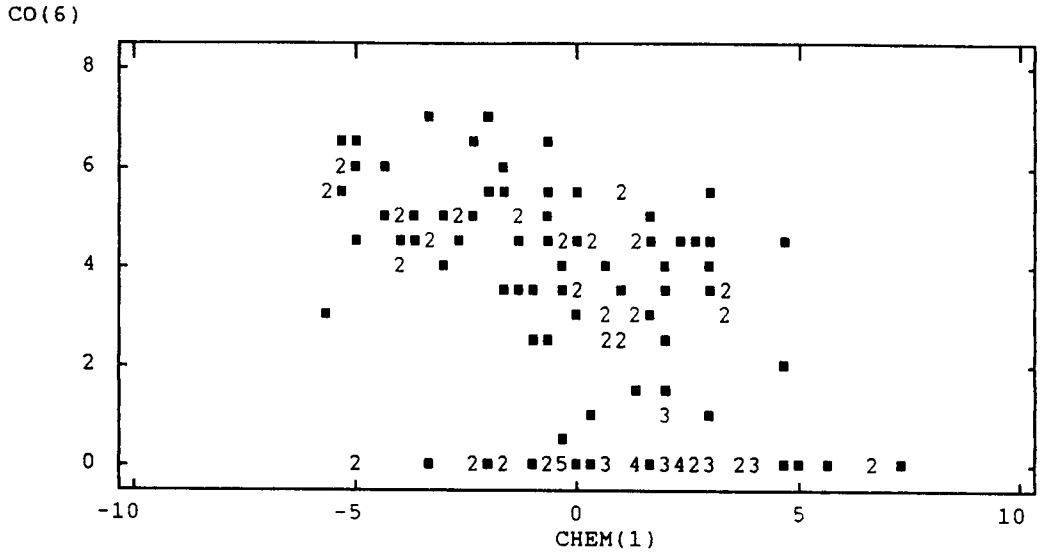


Figure 3-120. Abundance of Bosmina longirostris [CL(5)] and Daphnia galeata grouping [CL(25)], log(e) transformed, as a function of ANC. Solid square = 1 data point; number = total of overlapping points.



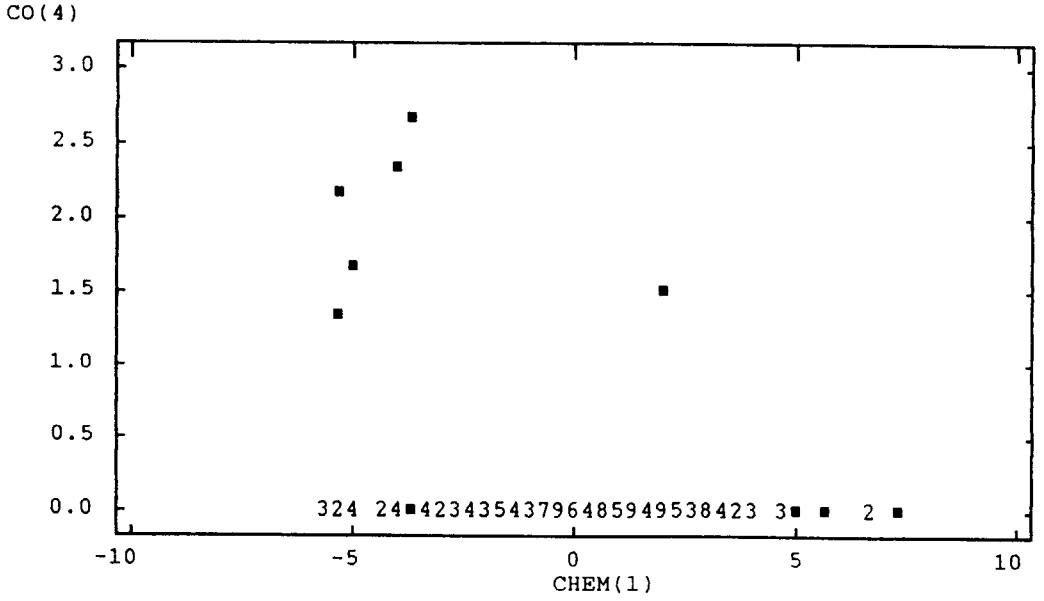
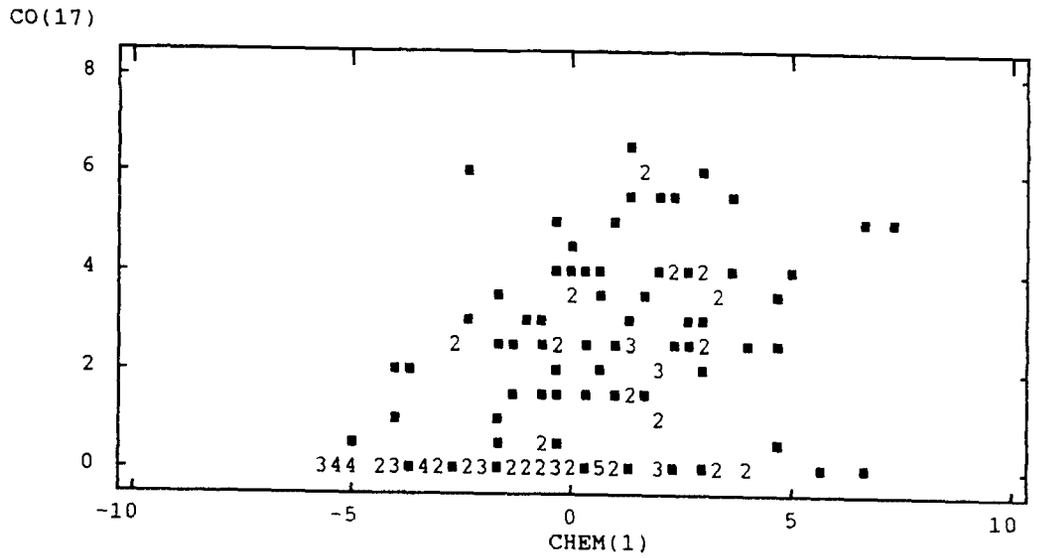


Figure 3-121. Abundance of Diaptomus minutus [CO(6)] and D. leptopus [CO(4)], log(e) transformed, as a function of environmental PCA Factor 1. Solid square = 1 data point; number = total of overlapping points.



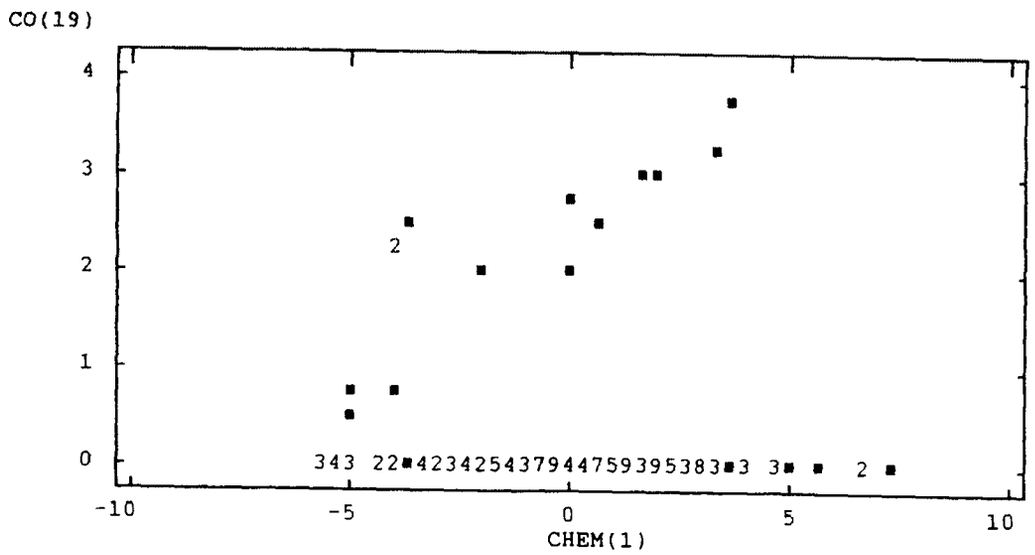


Figure 3-122. Abundance of Tropocyclops prasinus-mexicanus [CO(17)] and Cyclops scutifer [CO(19)], log(e) transformed, as a function of environmental PCA Factor 1. Solid square = 1 data point; number = total of overlapping points.

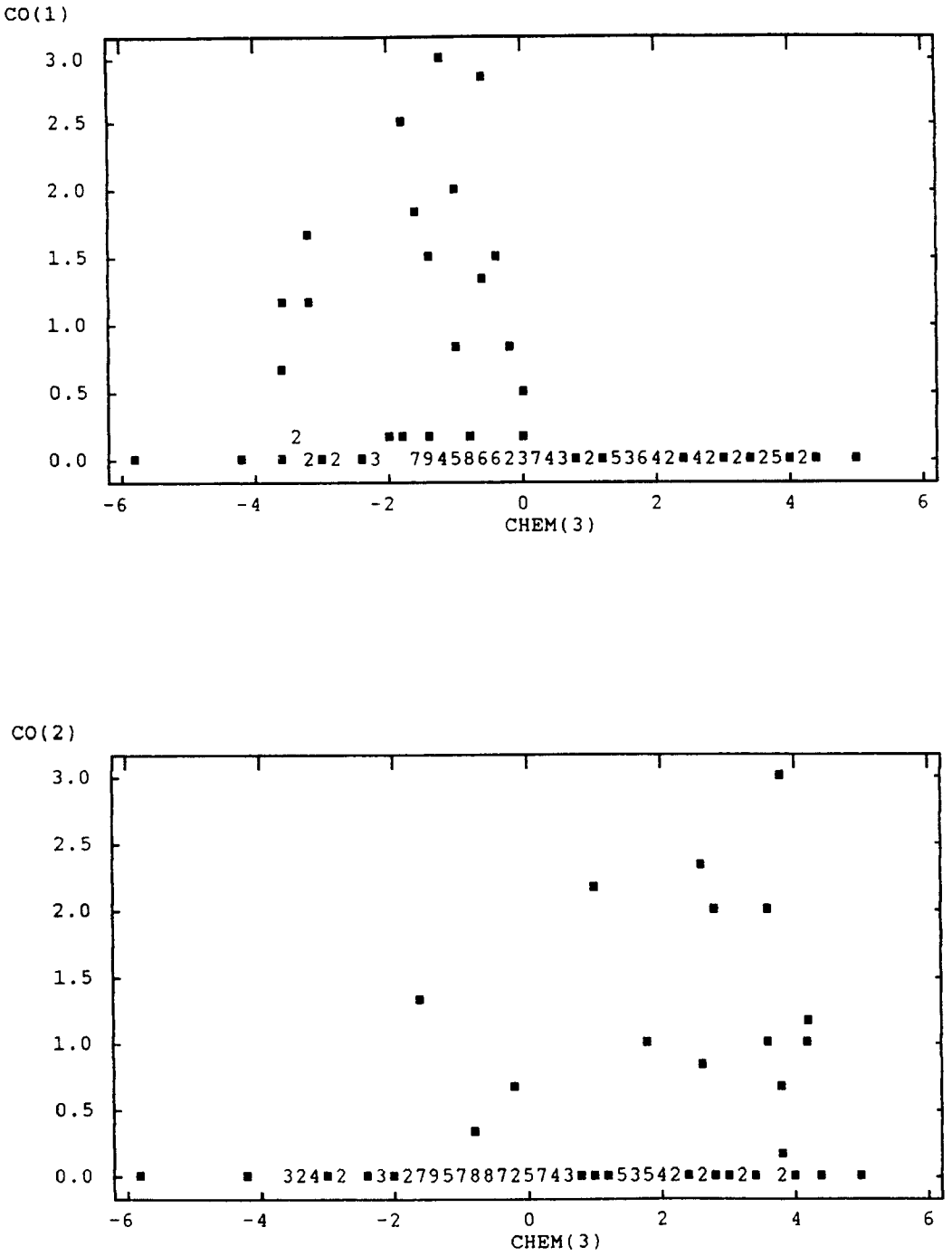


Figure 3-123. Abundance of Epischura lacustris [CO(1)] and E. nordenskioldi [CO(2)], log(e) transformed, as a function of environmental PCA Factor 3. Solid square = 1 data point; number = total of overlapping points.

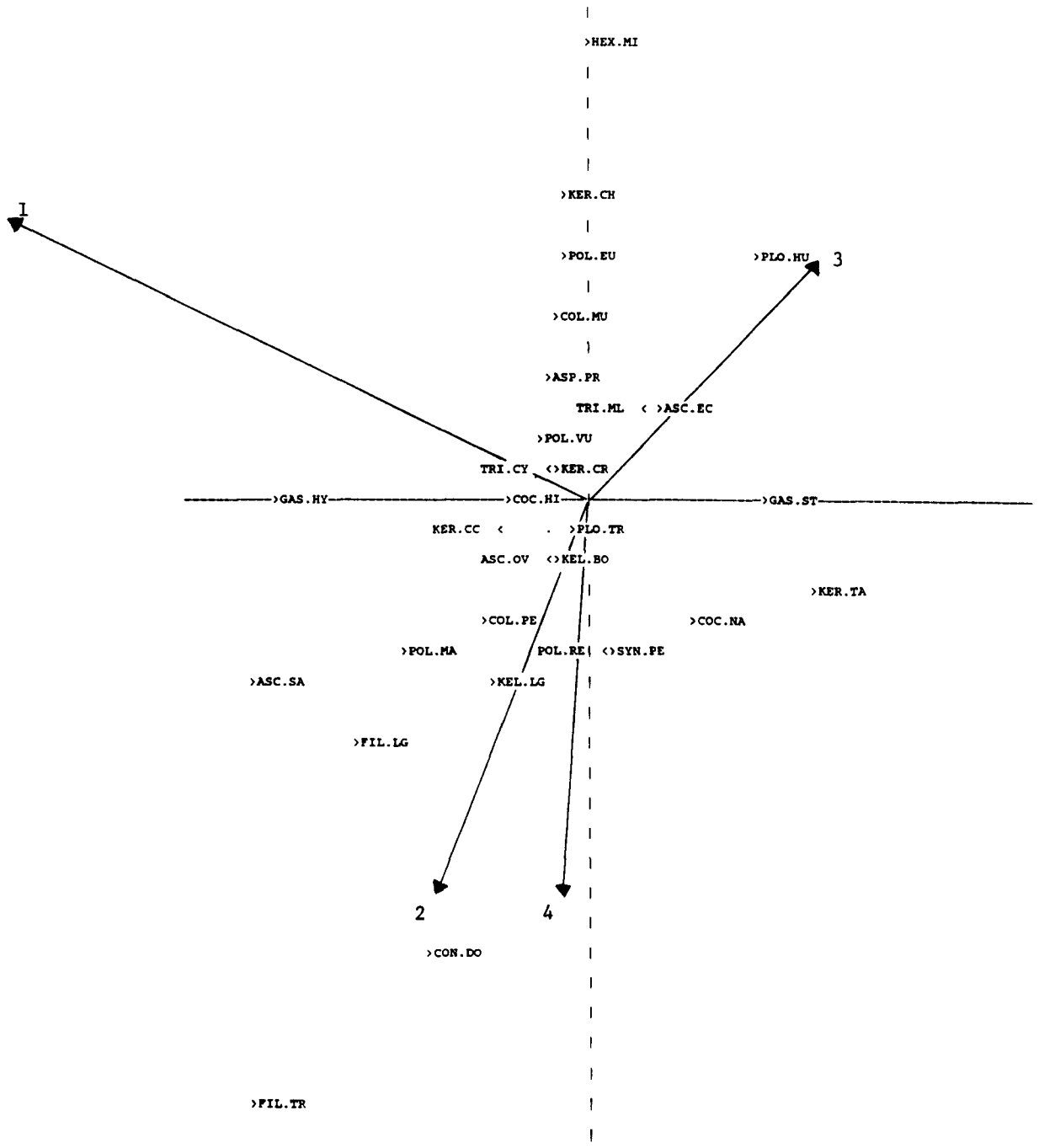


Figure 3-124. Plot of CCA for 30 major rotifer species and first 4 environmental PCA factors. See text for explanation of arrows.

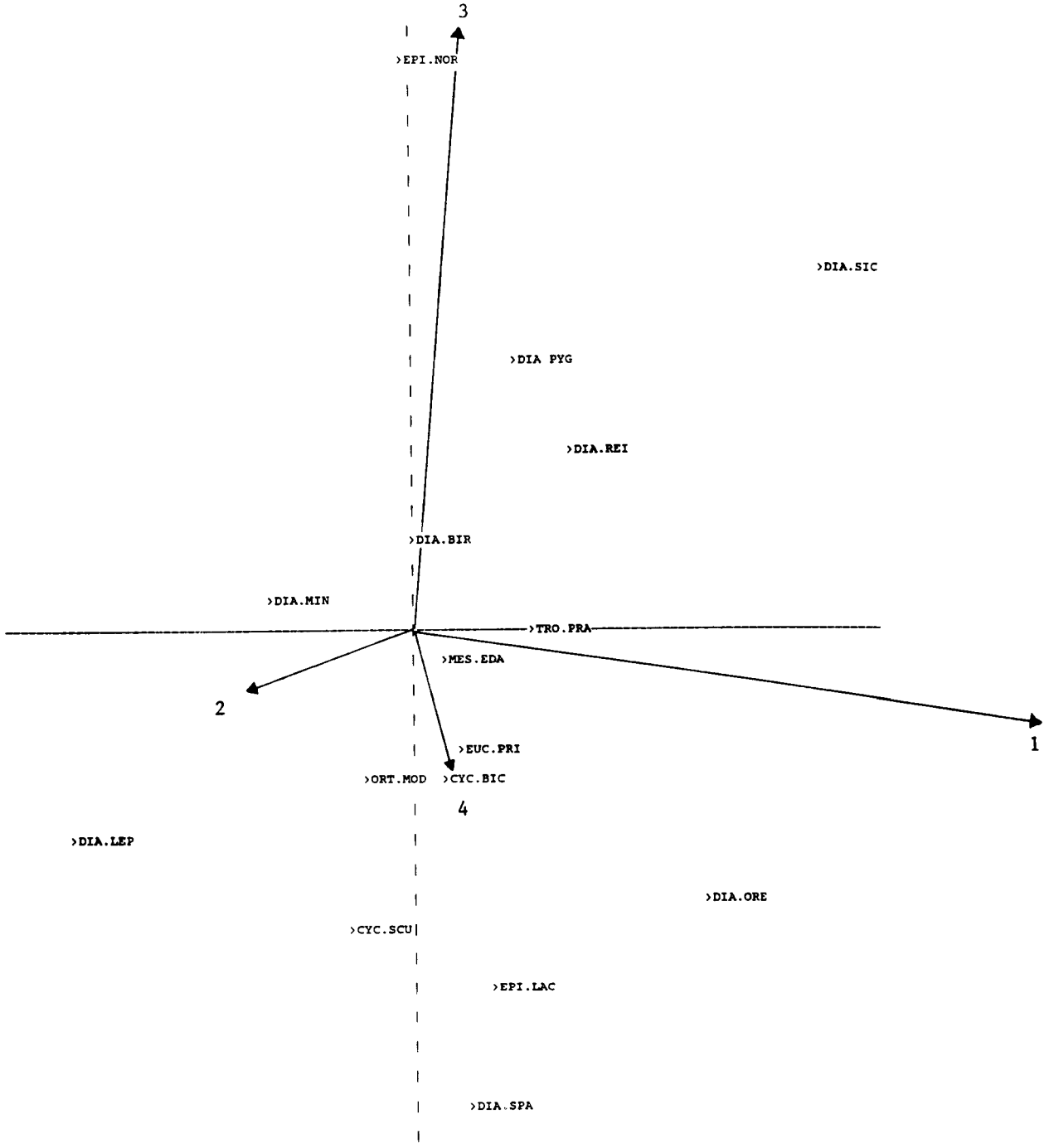


Figure 3-125. Plot of CCA for 16 major copepod species and first 4 environmental PCA factors. See text for explanation of arrows.

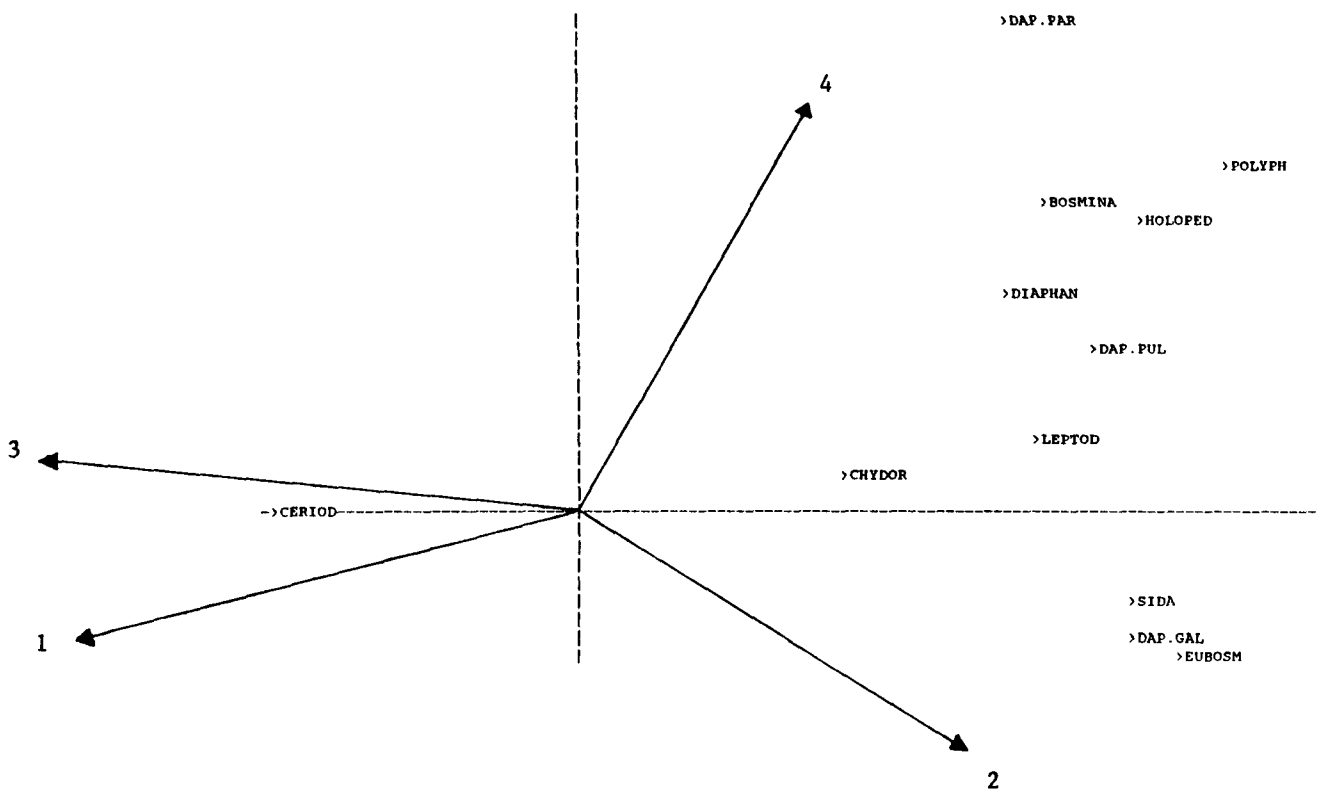


Figure 3-126. Plot of CCA for 12 major cladoceran species, and groupings of species, and first 4 environmental PCA factors. See text for explanation of arrows.

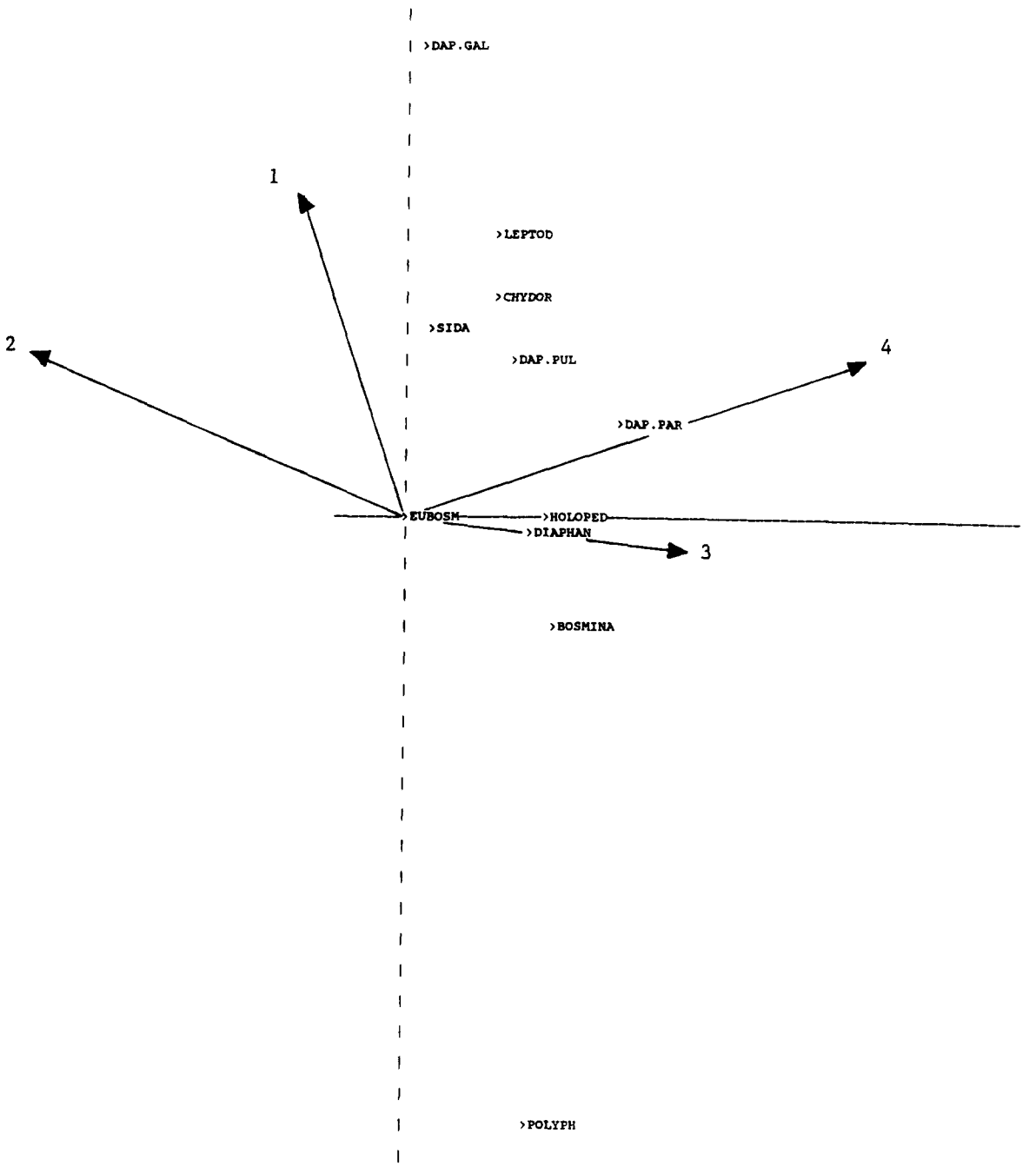


Figure 3-127. Plot of CCA for 11 major groupings of cladocera (excludes Ceriodaphnia) and first 4 environmental PCA factors. See text for explanation of arrows.

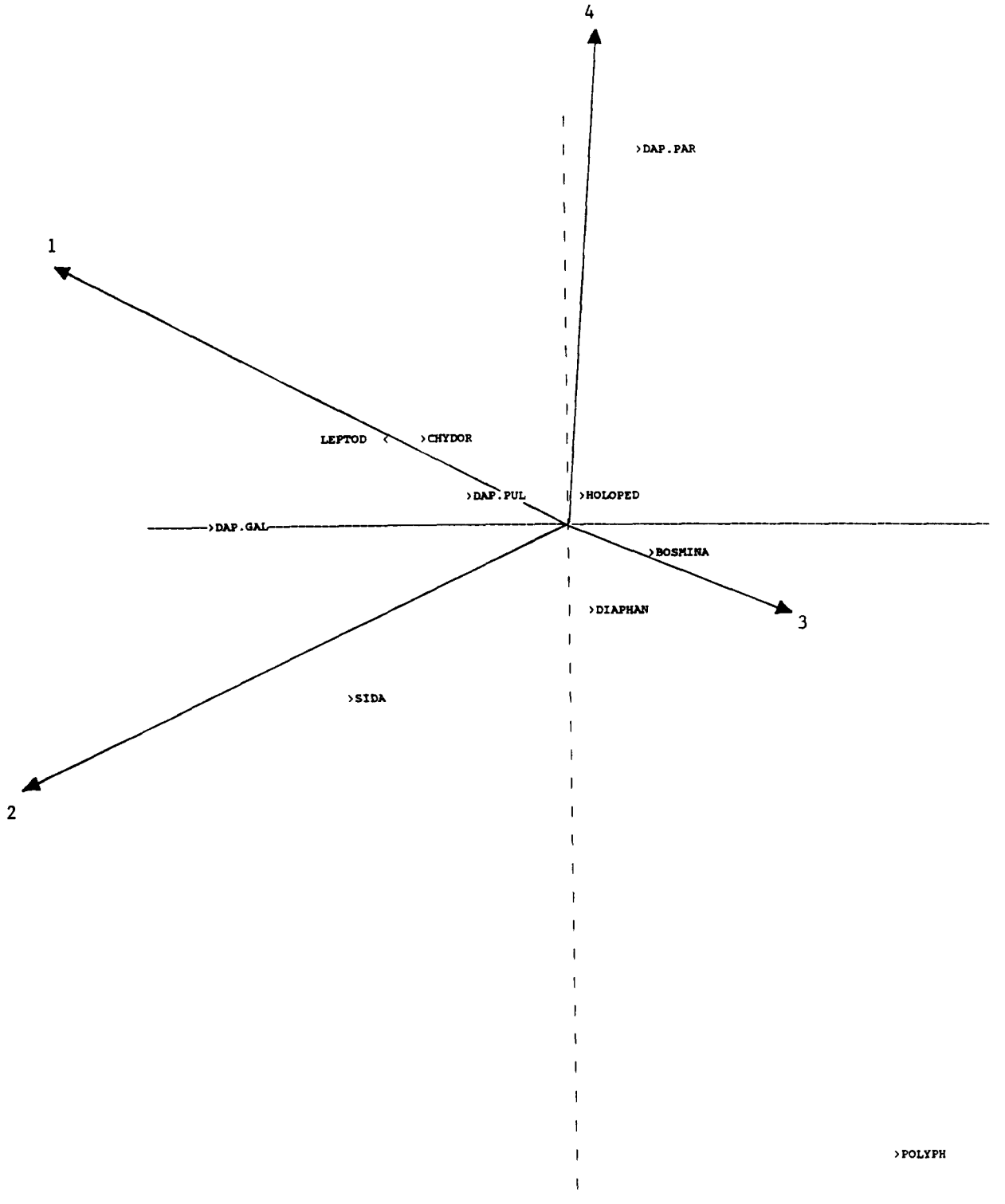


Figure 3-128. Plot of CCA for 10 major groupings of cladocera (excludes both Ceriodaphnia and Eubosmina) and first 4 environmental PCA factors. See text for explanation of arrows.

TABLES FOR ALL SECTIONS

Table 1-1. Number of Lakes Sampled in Phase II of the Eastern Lake Survey Organized by Geographic Region and Water Chemistry Cluster and Summary Statistics of Maximum Lake Depth (m) for Each Water Chemistry Cluster

Region	Chemistry Cluster 1	2	3	All
1 Adirondacks	20	9	7	36
2 Poconos/Catskills	6	5	8	19
3 Central New England	5	17	10	32
4 Southern New England	12	5	8	25
5 Maine	4	18	12	34
All	47	54	45	146
Mean of depths	7.65	7.95	8.44	
Range of depths	1.1-30.5	2-30	2-27.3	
Variance in depths	27.95	28.42	38.21	

Table 3-1. Summary Statistics for Precision Estimates among Subsamples[a]

	Precision Statistic		
	Minimum Abundance Threshold		
	> 0	> 2	> 8
Mean	0.569	0.491	0.336
Minimum	0.054	0.075	0.023
Maximum	0.926	1.055	0.747
Standard error	0.025	0.029	0.024

[a] N = 52 independent split samples. See text for definition of precision and minimum abundance.

Table 3-2. Nested Analysis of Variance of Total Zooplankton Abundance (Log[e] Transformed)

Variance Source	D.F.	Sum of Squares	Percent
Total	479	507.36251	100
Chemgrp.	2	9.1108703	0.662191
Lake	143	475.82659	92.5886
Sample	285	22.087124	6.10254
Subsample	49	0.33793343	0.64666

Table 3-3. Nested Analysis of Variance of Total Copepoda Abundance (Log[e] Transformed)

Variance Source	D.F.	Sum of Squares	Percent
Total	479	596.01891	100
Chemgrp.	2	56.656737	11.8984
Lake	143	499.4831	78.3478
Sample	285	38.598155	7.74428
Subsample	49	1.2809258	2.00943

Table 3-4. Nested Analysis of Variance of Nauplii Abundance (Log[e] Transformed)

Variance Source	D.F.	Sum of Squares	Percent
Total	479	545.64655	100
Chemgrp.	2	1.8075923	0
Lake	143	511.38949	91.0192
Sample	285	31.754623	7.75414
Subsample	49	0.69484469	1.22668

Table 3-5. Nested Analysis of Variance of Total Rotifera Abundance (Log[e] Transformed)

Variance Source	D.F.	Sum of Squares	Percent
Total	479	1247.1051	100
Chemgrp.	2	42.950498	3.10055
Lake	143	1163.953	92.0922
Sample	285	38.384511	3.4041
Subsample	49	1.8171371	1.40314

Table 3-6. Nested Analysis of Variance of Total Cladocera Abundance (Log[e] Transformed)

Variance Source	D.F.	Sum of Squares	Percent
Total	479	905.83574	100
Chemgrp.	2	0.443936	0
Lake	143	869.06462	93.9831
Sample	285	35.31706	4.94614
Subsample	49	1.0101297	1.07072

Table 3-7. Nested Analysis of Variance of Total Species Richness Excluding Species Rarer than a Mean Abundance of 1 (see text)

Variance Source	D.F.	Sum of Squares	Percent
Total	490	93.893063	100
Chemgrp.	2	17.189175	23.7328
Lake	144	69.487651	65.9282
Sample	292	6.5067985	3.80425
Subsample	52	0.70943823	6.53475

Table 3-8. Nested Analysis of Variance of Total Species Richness Excluding Species Rarer than a Mean Abundance of 10 (see text)

Variance Source	D.F.	Sum of Squares	Percent
Total	490	132.17289	100
Chemgrp.	2	7.9422076	6.99987
Lake	144	112.44387	80.0307
Sample	292	11.071268	8.00705
Subsample	52	0.71554215	4.96236

Table 3-9. Nested Analysis of Variance of Total Zooplankton Abundance (Log[e] Transformed) Analyzed by Water Chemistry Cluster

Variance Source	Percent Variance		
	Chemgrp. 1	Chemgrp. 2	Chemgrp.3
Total	100	100	100
Lake	88.41	96.11	93.95
Sample	10.73	3.22	5.65
Subsample	0.86	0.67	0.40

Table 3-10. Nested Analysis of Variance of Abundance for Rotifera and Crustacea (Log[e] Transformed) Analyzed by Water Chemistry Cluster

Variance Source	Percent Variance in Rotifera Abundance		
	Chemgrp. 1	Chemgrp. 2	Chemgrp.3
Total	100	100	100
Lake	93.2	96.75	95.9
Sample	5.45	1.57	2.96
Subsample	1.35	1.68	1.13

Variance Source	Percent Variance in Crustacea Abundance		
	Chemgrp. 1	Chemgrp. 2	Chemgrp.3
Total	100	100	100
Lake	86.88	94.29	92.95
Sample	12.45	5.13	6.77
Subsample	0.67	0.58	0.28

Table 3-11. Nested Analysis of Variance of Total Species Richness Analyzed Separately by Water Chemistry Cluster and Excluding Species Rarer than a Mean Abundance of 1 (see text)

Variance Source	Percent Variance		
	Chemgrp. 1	Chemgrp. 2	Chemgrp.3
Total	100	100	100
Lake	85.2	89.2	83.2
Sample	2.8	5.5	6.6
Subsample	12.0	5.3	10.2

Table 3-12. Nested Analysis of Variance of Total Species Richness Analyzed Separately by Water Chemistry Cluster and Excluding Species Rarer than a Mean Abundance of 10 (see text)

Variance Source	Percent Variance		
	Chemgrp. 1	Chemgrp. 2	Chemgrp.3
Total	100	100	100
Lake	81.9	89.6	84.7
Sample	4.7	9.2	11.1
Subsample	13.4	1.2	4.2

Table 3-13. Summary Statistics for Major Zooplankton Groups among All Phase II Survey Lakes[a]

Total Observations: 147

	Log(e) Transformed Values				
	LTOTAL	LROTOT	LCLADTOT	LCALTOT	LCYTOT
Number of cases	147	147	147	147	147
Minimum	2.898	0.000	0.010	0.000	0.000
Maximum	9.069	9.025	7.744	6.586	6.480
Mean	6.209	5.353	3.990	3.479	2.896
Variance	1.243	2.619	2.065	2.731	3.176
Standard deviation	1.115	1.618	1.437	1.652	1.782
Standard error	0.092	0.133	0.119	0.136	0.147
Skewness	-0.075	-0.288	-0.411	-0.494	-0.256
Kurtosis	0.299	0.156	0.089	-0.410	-0.891

Total Observations: 147

	Untransformed Values				
	TOTAL	ROTOT	CLADTOT	CALTOT	CYTOT
Number of cases	147	147	147	147	147
Minimum	17.140	0.000	0.010	0.000	0.000
Maximum	8676.626	8304.773	2307.567	723.563	650.667
Mean	909.420	634.733	127.599	87.357	59.731
Variance	1542641.317	1246026.919	52319.834	16471.239	10080.560
Standard deviation	1242.031	1116.256	228.735	128.340	100.402
Standard error	102.441	92.067	18.866	10.585	8.281
Skewness	3.233	3.674	6.379	2.783	3.063
Kurtosis	12.951	17.392	55.007	8.761	11.003

[a] Total = all zooplankton; ROTOT = Rotifera; CLADTOT = Cladocera; CALTOT = Calanoid Copepoda; and CYTOT = Cyclopoid Copepoda. L indicates transformed values. Note: one duplicate sample, thus actual lake total = 146.

Table 3-14. Summary Statistics for Various Zooplankton Groups among All Phase II Survey Lakes[a]

Total Observations: 147

Untransformed Abundance

	RDCO	NAUP	RDCRUS	RDCH	RDMISC
Number of cases	147	147	147	147	147
Minimum	3.357	4.317	10.087	0.000	0.000
Maximum	723.573	1301.333	3676.473	65.377	14.093
Mean	151.997	211.856	491.551	2.644	0.242
Variance	23084.085	49959.449	232567.324	46.370	1.518
Standard deviation	151.934	223.516	482.252	6.810	1.232
Standard error	12.531	18.435	39.776	0.562	0.102
Skewness	1.718	2.401	2.877	6.107	9.907
Kurtosis	2.919	7.198	13.012	48.987	107.457

Total Observations: 147

Log(e) Transformed Abundance

	LNCOT	LNAUP	LNCRUST	LNCHT	LNMISC
Number of cases	147	147	147	147	147
Minimum	1.472	1.671	2.406	0.000	0.000
Maximum	6.586	7.172	8.210	4.195	2.714
Mean	4.532	4.889	5.798	0.661	0.112
Variance	1.176	1.071	0.937	0.915	0.113
Standard deviation	1.085	1.035	0.968	0.957	0.335
Standard error	0.089	0.085	0.080	0.079	0.028
Skewness	-0.372	-0.376	-0.605	1.281	4.448
Kurtosis	-0.294	0.241	0.929	0.690	25.554

[a] Total = all zooplankton; RDCO = total Copepoda; NAUP = nauplii; RDCRUS = total Crustacea; RDCH = total Chaoborus; and RDMISC = total miscellaneous (see text). L indicates transformed values. Note: one duplicate sample, thus actual lake total = 146.

Table 3-15. Summary Statistics for Untransformed Zooplankton Abundance Determined Separately for Each Water Chemistry Cluster[a]

			Chemgrp. = 1.000		
	TOTAL	ROTOT	CLADTOT	CALTOT	CYTOT
Number of cases	48	48	48	48	48
Minimum	42.143	0.000	0.010	0.000	0.000
Maximum	8676.626	8304.773	2307.567	723.563	476.460
Mean	1064.094	686.018	163.834	166.830	47.411
Variance	2562509.102	2074628.390	122060.429	26263.062	11587.759
Standard deviation	1600.784	1440.357	349.371	162.059	107.646
Standard error	231.053	207.898	50.427	23.391	15.537
Skewness	3.074	3.658	5.024	1.660	2.970
Kurtosis	10.047	15.052	27.918	2.482	8.125

			Chemgrp. = 2.000		
	TOTAL	ROTOT	CLADTOT	CALTOT	CYTOT
Number of cases	53	53	53	53	53
Minimum	17.140	7.440	2.393	0.000	0.000
Maximum	6284.487	5601.790	465.127	685.820	650.667
Mean	980.501	730.032	110.893	65.479	74.098
Variance	1251307.652	1031296.171	14629.949	12349.779	13094.529
Standard deviation	1118.619	1015.528	120.954	111.130	114.431
Standard error	153.654	139.493	16.614	15.265	15.718
Skewness	2.615	2.743	1.290	3.780	3.057
Kurtosis	8.450	8.954	0.672	17.027	11.055

			Chemgrp. = 3.000		
	TOTAL	ROTOT	CLADTOT	CALTOT	CYTOT
Number of cases	46	46	46	46	46
Minimum	26.363	15.190	2.637	0.000	0.000
Maximum	4482.237	4285.570	848.890	111.110	310.667
Mean	666.123	471.419	109.036	29.635	56.034
Variance	790681.708	643344.817	23276.235	1032.186	5052.623
Standard deviation	889.203	802.088	152.566	32.128	71.082
Standard error	131.106	118.261	22.495	4.737	10.480
Skewness	2.651	3.104	3.144	1.107	2.257
Kurtosis	7.146	10.362	11.148	0.054	4.783

[a] Total = all zooplankton; ROTOT = Rotifera; CLADTOT = Cladocera; CALTOT = Calanoid Copepoda; CYTOT = Cyclopoid Copepoda.

Table 3-16. Summary Statistics for Log(e) Transformed Zooplankton Abundance Determined Separately for Each Water Chemistry Cluster[a]

			Chemgrp. = 1.000		
	LTOTAL	LROTOT	LCLADTOT	LCALTOT	LCYTOT
Number of cases	48	48	48	48	48
Minimum	3.765	0.000	0.010	0.000	0.000
Maximum	9.069	9.025	7.744	6.586	6.168
Mean	6.348	5.047	3.906	4.527	2.041
Variance	1.121	3.657	3.024	2.023	3.837
Standard deviation	1.059	1.912	1.739	1.422	1.959
Standard error	0.153	0.276	0.251	0.205	0.283
Skewness	0.425	-0.276	-0.410	-1.526	0.508
Kurtosis	0.413	0.132	-0.077	2.618	-0.865

			Chemgrp. = 2.000		
	LTOTAL	LROTOT	LCLADTOT	LCALTOT	LCYTOT
Number of cases	53	53	53	53	53
Minimum	2.898	2.133	1.222	0.000	0.000
Maximum	8.746	8.631	6.144	6.532	6.480
Mean	6.358	5.762	4.018	3.223	3.345
Variance	1.248	2.079	1.792	2.429	2.558
Standard deviation	1.117	1.442	1.339	1.558	1.599
Standard error	0.153	0.198	0.184	0.214	0.220
Skewness	-0.477	-0.386	-0.358	-0.376	-0.424
Kurtosis	0.634	-0.180	-0.681	-0.256	-0.440

			Chemgrp. = 3.000		
	LTOTAL	LROTOT	LCLADTOT	LCALTOT	LCYTOT
Number of cases	46	46	46	46	46
Minimum	3.309	2.784	1.291	0.000	0.000
Maximum	8.408	8.363	6.745	4.719	5.742
Mean	5.892	5.200	4.045	2.680	3.271
Variance	1.270	1.955	1.459	2.040	2.180
Standard deviation	1.127	1.398	1.208	1.428	1.477
Standard error	0.166	0.206	0.178	0.211	0.218
Skewness	0.002	0.287	-0.199	-0.460	-0.724
Kurtosis	-0.034	-0.744	-0.152	-0.798	0.075

[a] Total = all zooplankton; ROTOT = Rotifera; CLADTOT = Cladocera; CALTOT = Calanoid Copepoda; CYTOT = Cyclopoid Copepoda. L indicates transformed values.

Table 3-17. Analysis of Variance of Log(e) Transformed Total Zooplankton Abundance Partitioned among Three Water Chemistry Clusters and Five Geographic Regions

Dependent Variable: LTOTAL
Number: 147
Multiple R: .385
Squared Multiple R: .148

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F-ratio	P
Chemgrp.	6.965	2	3.482	2.973	0.055
Region	3.718	4	0.930	0.794	0.531
Chemgrp.* Region	16.918	8	2.115	1.806	0.081
Error	154.604	132	1.171		

Table 3-18. Multivariate Analysis of Variance of Four Major Zooplankton Taxa as Determined by Water Chemistry Cluster

Number of lakes: 147

Dependent variable means:	LROTOT	LCLADTOT	LCALTOT	LCYTOT
	5.353	3.990	3.479	2.896

Squared multiple correlations:	LROTOT	LCLADTOT	LCALTOT	LCYTOT
	0.038	0.002	0.214	0.113

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
LROTOT	14.436	2	7.218	2.824	0.063
Error	367.989	144	2.555		
LCLADTOT	0.519	2	0.260	0.124	0.883
Error	301.000	144	2.090		
LCALTOT	85.517	2	42.758	19.661	0.000
Error	313.173	144	2.175		
LCYTOT	52.191	2	26.096	9.133	0.000
Error	411.466	144	2.857		

Multivariate Test Statistics

Wilks' Lambda =	0.679		
F-statistic =	7.516	DF = 8, 282	PROB = 0.000
Pillai trace =	0.334		
F-statistic =	7.125	DF = 8, 284	PROB = 0.000
Hotelling-Lawley trace =	0.452		
F-statistic =	7.906	DF = 8, 280	PROB = 0.000
Theta = 0.286 S = 2, M = .5, N = 69.5			PROB = 0.000

Table 3-19. Multivariate Analysis of Variance of Four Major Zooplankton Taxa as Determined by Water Chemistry Cluster[a]

Number of lakes: 147

Dependent variable means:	PROT	PCLADT	PCALT	PCYT
	0.836	0.402	0.379	0.253

Squared multiple correlations:	PROT	PCLADT	PCALT	PCYT
	0.082	0.026	0.213	0.112

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
PROT	1.356	2	0.678	6.412	0.002
Error	15.228	144	0.106		
PCLADT	0.162	2	0.081	1.948	0.146
Error	5.997	144	0.042		
PCALT	2.973	2	1.487	19.505	0.000
Error	10.975	144	0.076		
PCYT	0.643	2	0.322	9.068	0.000
Error	5.106	144	0.035		

Multivariate Test Statistics

Wilks' Lambda =	0.681		
F-statistic =	7.468	DF = 8, 282	PROB = 0.000
Pillai trace =	0.327		
F-statistic =	6.934	DF = 8, 284	PROB = 0.000
Hotelling-Lawley trace =	0.457		
F-statistic =	8.001	DF = 8, 280	PROB = 0.000
Theta = 0.301 S = 2, M = .5, N = 69.5			PROB = 0.000

[a] Analysis performed on arc sine square root transformed relative abundance. PROT = Rotifera; PCLADT = Cladocera; PCALT = Calanoid Copepoda; PCYT = Cyclopoid Copepoda. P indicates proportional abundance.

Table 3-20. Principal Components Analysis (PCA) of Four Major Zooplankton Groups in All Phase II Survey Lakes Using Log(e) Transformed Abundance[a]

Correlation Matrix

	LROTOT	LCLADTOT	LCALTOT	LCYTOT
LROTOT	1.000			
LCLADTOT	0.324	1.000		
LCALTOT	-0.152	0.034	1.000	
LCYTOT	0.232	0.564	-0.173	1.000

Component Loadings

	1	2	3	4
LROTOT	0.621	-0.186	0.752	0.118
LCLADTOT	0.821	0.365	-0.089	-0.431
LCALTOT	-0.261	0.926	0.218	0.163
LCYTOT	0.818	0.072	-0.412	0.395

Percent of Total Variance Explained

1	2	3	4
44.927	25.760	19.762	9.551

[a] ROTOT = Rotifera; CLADTOT = Cladocera; CALTOT = Calanoid Copepoda; CYTOT = Cyclopoid Copepoda. L indicates transformed values.

Table 3-21. Multivariate Analysis of Variance of First Three Principal Component Analysis (PCA) Factors of the Four Major Zooplankton Groups, Partitioned among the Water Chemistry Clusters

Number of lakes: 147

Dependent variable means:	Factor 1	Factor 2	Factor 3
	-0.000	-0.000	-0.000

Squared multiple correlations:	Factor 1	Factor 2	Factor 3
	0.080	0.157	0.058

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	11.716	2	5.858	6.282	0.002
Error	134.284	144	0.933		
Factor 2	22.857	2	11.428	13.364	0.000
Error	123.143	144	0.855		
Factor 3	8.488	2	4.244	4.444	0.013
Error	137.512	144	0.955		

Multivariate Test Statistics

Wilks' Lambda =	0.712		
F-statistic =	8.780	DF = 6, 284	PROB = 0.000
Pillai trace =	0.295		
F-statistic =	8.245	DF = 6, 286	PROB = 0.000
Hotelling-Lawley trace =	0.396		
F-statistic =	9.312	DF = 6, 282	PROB = 0.000
Theta = 0.271 S = 2, M = .0, N = 70.0			PROB = 0.000

Table 3-22. Principal Components Analysis (PCA) of Four Major Zooplankton Groups in All Phase II Survey Lakes Using Arc Sine Square Root Transformed Relative Abundance[a]

Correlation Matrix

	PROT	PCLADT	PCALT	PCYT
PROT	1.000			
PCLADT	-0.571	1.000		
PCALT	-0.694	-0.041	1.000	
PCYT	-0.382	0.429	-0.222	1.000

Component Loadings

	1	2	3	4
PROT	-0.957	0.263	0.051	0.115
PCLADT	0.745	0.413	0.522	0.052
PCALT	0.496	-0.855	-0.119	0.095
PCYT	0.559	0.659	-0.502	0.044

Percent of Total Variance Explained

1	2	3	4
50.695	35.116	13.516	0.673

[a] PROT = Rotifera; PCLADT = Cladocera; PCALT = Calanoid Copepoda; PCYT = Cyclopoid Copepoda. P indicates proportional abundance.

Table 3-23. Multivariate Analysis of Variance of First Three Principal Component Analysis (PCA) Factors of the Four Major Zooplankton Groups, Partitioned among the Water Chemistry Clusters[a]

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	4.873	2	2.436	2.486	0.087
Error	141.127	144	0.980		
Factor 2	37.648	2	18.824	25.017	0.000
Error	108.352	144	0.752		
Factor 3	1.793	2	0.896	0.895	0.411
Error	144.207	144	1.001		

Multivariate Test Statistics

Wilks' Lambda =	0.703		
F-statistic =	9.102	DF = 6, 284	PROB = 0.00
Pillai trace =	0.304		
F-statistic =	8.528	DF = 6, 286	PROB = 0.00
Hotelling-Lawley trace =	0.412		
F-statistic =	9.675	DF = 6, 282	PROB = 0.00
Theta = 0.279 S = 2, M = .0, N = 70.0			PROB = 0.00

[a] PCA used relative abundance data.

Table 3-24. Multivariate Analysis of Variance of the Four Major Zooplankton Groups (Log(e) Transformed), Partitioned among Three Water Chemistry Clusters and Five Geographic Regions[a]

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
LROTOT	12.039	2	6.020	2.393	0.095
Error	332.096	132	2.516		
LCLADTOT	0.054	2	0.027	0.013	0.987
Error	271.283	132	2.055		
LCALTOT	58.298	2	29.149	14.933	0.000
Error	257.664	132	1.952		
LCYTOT	31.038	2	15.519	5.624	0.005
Error	364.216	132	2.759		

Multivariate Test Statistics

Wilks' Lambda =	0.721		
F-statistic =	5.742	DF = 8, 258	PROB = 0.000
Pillai trace =	0.291		
F-statistic =	5.535	DF = 8, 260	PROB = 0.000
Hotelling-Lawley trace =	0.372		
F-statistic =	5.947	DF = 8, 256	PROB = 0.000
Theta = 0.243 S = 2, M = .5, N = 63.5			PROB = 0.000

[a] ROTOT = Rotifera; CLADTOT = Cladocera; CALTOT = Calanoid Copepoda; CYTOT = Cyclopoid Copepoda. L indicates transformed values.

(Page 1 of 3)

Table 3-24. Multivariate Analysis of Variance of the Four Major Zooplankton Groups (Log(e) Transformed), Partitioned among Three Water Chemistry Clusters and Five Geographic Regions (Continued)[a]

Test for effect called: REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
LROTOT	8.689	4	2.172	0.863	0.488
Error	332.096	132	2.516		
LCLADTOT	6.468	4	1.617	0.787	0.536
Error	271.283	132	2.055		
LCALTOT	41.889	4	10.472	5.365	0.000
Error	257.664	132	1.952		
LCYTOT	13.780	4	3.445	1.249	0.294
Error	364.216	132	2.759		

Multivariate Test Statistics

Wilks' Lambda =	0.811		
F-statistic =	1.755	DF = 16, 394	PROB = 0.035
Pillai trace =	0.197		
F-statistic =	1.712	DF = 16, 528	PROB = 0.041
Hotelling-Lawley trace =	0.224		
F-statistic =	1.785	DF = 16, 510	PROB = 0.030
Theta = 0.146 S = 4, M = -.5, N = 63.5			PROB = 0.016

[a] ROTOT = Rotifera; CLADTOT = Cladocera; CALTOT = Calanoid Copepoda; CYTOT = Cyclopoid Copepoda. L indicates transformed values.

(Page 2 of 3)

Table 3-24. Multivariate Analysis of Variance of the Four Major Zooplankton Groups (Log(e) Transformed), Partitioned among Three Water Chemistry Clusters and Five Geographic Regions (Continued)[a]

Test for effect called: CHEMGRP BY REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
LROTOT	25.305	8	3.163	1.257	0.271
Error	332.096	132	2.516		
LCLADTOT	21.133	8	2.642	1.285	0.256
Error	271.283	132	2.055		
LCALTOT	14.120	8	1.765	0.904	0.515
Error	257.664	132	1.952		
LCYTOT	27.072	8	3.384	1.226	0.288
Error	364.216	132	2.759		

Multivariate Test Statistics

Wilks' Lambda =	0.792		
F-statistic =	0.975	DF = 32, 477	PROB = 0.509
Pillai trace =	0.225		
F-statistic =	0.982	DF = 32, 528	PROB = 0.498
Hotelling-Lawley trace =	0.243		
F-statistic =	0.967	DF = 32, 510	PROB = 0.521
Theta = 0.099 S = 4, M = 1.5, N = 63.5			PROB = 0.620

[a] ROTOT = Rotifera; CLADTOT = Cladocera; CALTOT = Calanoid Copepoda; CYTOT = Cyclopoid Copepoda. L indicates transformed values.

(Page 3 of 3)

Table 3-25. Multivariate Analysis of Variance of the Four Major Zooplankton Groups (Arc Sine Square Root Transformed Relative Abundance), Partitioned among Three Water Chemistry Clusters and Five Geographic Regions[a]

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
PROT	0.793	2	0.396	3.734	0.026
Error	14.015	132	0.106		
PCLADT	0.136	2	0.068	1.588	0.208
Error	5.653	132	0.043		
PCALT	2.069	2	1.035	14.585	0.000
Error	9.363	132	0.071		
PCYT	0.472	2	0.236	6.604	0.002
Error	4.720	132	0.036		

Multivariate Test Statistics

Wilks' Lambda =	0.738		
F-statistic =	5.296	DF = 8, 258	PROB = 0.000
Pillai trace =	0.267		
F-statistic =	5.013	DF = 8, 260	PROB = 0.000
Hotelling-Lawley trace =	0.349		
F-statistic =	5.576	DF = 8, 256	PROB = 0.000
Theta = 0.247 S = 2, M = .5, N = 63.5			PROB = 0.000

[a] PROT = Rotifera; PCLADT = Cladocera; PCALT = Calanoid Copepoda; PCYT = Cyclopoid Copepoda. P indicates proportional abundance.

(Page 1 of 3)

Table 3-25. Multivariate Analysis of Variance of the Four Major Zooplankton Groups (Arc Sine Square Root Transformed Relative Abundance), Partitioned among Three Water Chemistry Clusters and Five Geographic Regions (Continued)[a]

Test for effect called: REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
PROT	0.540	4	0.135	1.271	0.285
Error	14.015	132	0.106		
PCLADT	0.069	4	0.017	0.403	0.807
Error	5.653	132	0.043		
PCALT	0.682	4	0.171	2.404	0.053
Error	9.363	132	0.071		
PCYT	0.084	4	0.021	0.590	0.670
Error	4.720	132	0.036		

Multivariate Test Statistics

Wilks' Lambda =	0.763		
F-statistic =	2.289	DF = 16, 394	PROB = 0.003
Pillai trace =	0.252		
F-statistic =	2.222	DF = 16, 528	PROB = 0.004
Hotelling-Lawley trace =	0.292		
F-statistic =	2.329	DF = 16, 510	PROB = 0.003
Theta = 0.172 S = 4, M = -.5, N = 63.5			PROB = 0.003

[a] PROT = Rotifera; PCLADT = Cladocera; PCALT = Calanoid Copepoda; PCYT = Cyclopoid Copepoda. P indicates proportional abundance.

(Page 2 of 3)

Table 3-25. Multivariate Analysis of Variance of the Four Major Zooplankton Groups (Arc Sine Square Root Transformed Relative Abundance), Partitioned among Three Water Chemistry Clusters and Five Geographic Regions (Continued)[a]

Test for effect called: CHEMGRP BY REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
PROT	0.617	8	0.077	0.726	0.668
Error	14.015	132	0.106		
PCLADT	0.233	8	0.029	0.679	0.709
Error	5.653	132	0.043		
PCALT	0.991	8	0.124	1.747	0.093
Error	9.363	132	0.071		
PCYT	0.271	8	0.034	0.948	0.480
Error	4.720	132	0.036		

Multivariate Test Statistics

Wilks' Lambda =	0.746		
F-statistic =	1.235	DF = 32, 477	PROB = 0.179
Pillai trace =	0.280		
F-statistic =	1.242	DF = 32, 528	PROB = 0.172
Hotelling-Lawley trace =	0.308		
F-statistic =	1.227	DF = 32, 510	PROB = 0.187
Theta = 0.117 S = 4, M = 1.5, N = 63.5			PROB = 0.430

[a] PROT = Rotifera; PCLADT = Cladocera; PCALT = Calanoid Copepoda; PCYT = Cyclopoid Copepoda. P indicates proportional abundance.

(Page 3 of 3)

Table 3-26. Mean Abundance (Log(e) Transformed) of Calanoid Copepods as a Function of Water Chemistry Cluster[a]

Region	Water Chemistry Cluster 1	2	3
2	3.458 (0.974)	1.61 (0.991)	1.41 (0.401)
1, 3, 4, and 5	4.709 0.167)	3.391 (0.202)	2.948 (0.219)

[a] Region 2 compared with mean of all other regions; value in () = standard error.

Table 3-27. Summary Statistics for Zooplankton Species Richness of All Phase II Survey Lakes[a]

Total Lakes: 147

	TOTAL	ROT	CLAD	COP	CAL
Number of cases	147	147	147	147	147
Minimum	5.000	0.000	1.000	1.000	0.000
Maximum	30.000	15.000	11.000	6.000	3.000
Mean	17.374	7.789	4.456	3.374	1.435
Variance	29.112	11.798	3.907	1.359	0.508
Standard error	0.445	0.283	0.163	0.096	0.059

	CYC	CRUS
Number of cases	147	147
Minimum	0.000	3.000
Maximum	4.000	17.000
Mean	1.939	8.830
Variance	0.811	7.498
Standard error	0.074	0.226

[a] TOTAL = all species; ROT = rotifera; CLAD = cladocera; COP = copepoda; CAL = calanoida; CYC = cyclopoida; CRUS = all crustacea.

Table 3-28. Summary Statistics for Zooplankton Species Richness Calculated Separately for Each Water Chemistry Cluster[a]

CHEMGRP = 1.000

	TOTAL	ROT	CLAD	COP	CAL
Number of cases	48	48	48	48	48
Mean	12.146	4.438	3.250	2.750	1.354
Variance	14.595	5.783	2.149	1.043	0.446

	CYC	CRUS
Number of cases	48	48
Mean	1.396	7.000
Variance	0.840	4.723

CHEMGRP = 2.000

	TOTAL	ROT	CLAD	COP	CAL
Number of cases	53	53	53	53	53
Mean	19.868	9.585	4.943	3.566	1.396
Variance	19.078	8.055	3.362	1.289	0.475

	CYC	CRUS
Number of cases	53	53
Mean	2.170	9.509
Variance	0.682	5.909

CHEMGRP = 3.000

	TOTAL	ROT	CLAD	COP	CAL
Number of cases	46	46	46	46	46
Mean	19.957	9.217	5.152	3.804	1.565
Variance	13.865	5.063	4.221	1.183	0.607

	CYC	CRUS
Number of cases	46	46
Mean	2.239	9.957
Variance	0.497	7.154

[a] TOTAL = all species; ROT = rotifera; CLAD = cladocera; COP = copepoda; CAL = calanoida; CYC = cyclopoida; CRUS = all crustacea.

Table 3-29. Principal Components Analysis (PCA) of Species Richness for Four Major Zooplankton Groups among All Phase II Survey Lakes[a]

Correlation Matrix

	ROT	CLAD	CAL	CYC
ROT	1.000			
CLAD	0.412	1.000		
CAL	-0.083	0.208	1.000	
CYC	0.425	0.462	0.031	1.000

Component Loadings

	1	2	3	4
ROT	0.752	-0.333	0.504	0.264
CLAD	0.809	0.227	0.043	-0.541
CAL	0.150	0.951	0.112	0.247
CYC	0.797	-0.095	-0.541	0.254

Percent of Total Variance Explained

1	2	3	4
46.914	26.890	14.010	12.186

[a] ROT = rotifera; CLAD = cladocerans; CAL = calanoid copepods; CYC = cyclopoid copepods.

Table 3-30. Multivariate Analysis of Variance of Principal Components Analysis (PCA) Factors of Species Richness for the Four Major Zooplankton Groups, Partitioned among Three Water Chemistry Clusters and Five Geographic Regions

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	36.166	2	18.083	31.470	0.000
Error	75.848	132	0.575		
Factor 2	2.660	2	1.330	1.710	0.185
Error	102.634	132	0.778		
Factor 3	4.494	2	2.247	2.365	0.098
Error	125.416	132	0.950		
Factor 4	4.133	2	2.066	2.183	0.117
Error	124.935	132	0.946		

Multivariate Test Statistics

Wilks' Lambda =	0.556		
F-statistic =	11.007	DF = 8, 258	PROB = 0.000
Pillai trace =	0.458		
F-statistic =	9.640	DF = 8, 260	PROB = 0.000
Hotelling-Lawley trace =	0.775		
F-statistic =	12.400	DF = 8, 256	PROB = 0.000
Theta = 0.426 S = 2, M = .5, N = 63.5			PROB = 0.000

(Page 1 of 3)

Table 3-30. Multivariate Analysis of Variance of Principal Components Analysis (PCA) Factors of Species Richness for the Four Major Zooplankton Groups, Partitioned among Three Water Chemistry Clusters and Five Geographic Regions (Continued)

Test for effect called: REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	5.807	4	1.452	2.526	0.044
Error	75.848	132	0.575		
Factor 2	26.450	4	6.613	8.505	0.000
Error	102.634	132	0.778		
Factor 3	2.869	4	0.717	0.755	0.556
Error	125.416	132	0.950		
Factor 4	2.388	4	0.597	0.631	0.641
Error	124.935	132	0.946		

Multivariate Test Statistics

Wilks' Lambda =	0.695		
F-statistic =	3.116	DF = 16, 394	PROB = 0.000
Pillai trace =	0.332		
F-statistic =	2.984	DF = 16, 528	PROB = 0.000
Hotelling-Lawley trace =	0.400		
F-statistic =	3.187	DF = 16, 510	PROB = 0.000
Theta = 0.208 S = 4, M = -.5, N = 63.5			PROB = 0.000

(Page 2 of 3)

Table 3-30. Multivariate Analysis of Variance of Principal Components Analysis (PCA) Factors of Species Richness for the Four Major Zooplankton Groups, Partitioned among Three Water Chemistry Clusters and Five Geographic Regions (Continued)

Test for effect called: CHEMGRP BY REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	2.403	8	0.300	0.523	0.838
Error	75.848	132	0.575		
Factor 2	15.543	8	1.943	2.499	0.015
Error	102.634	132	0.778		
Factor 3	8.085	8	1.011	1.064	0.392
Error	125.416	132	0.950		
Factor 4	13.884	8	1.735	1.834	0.076
Error	124.935	132	0.946		

Multivariate Test Statistics

Wilks' Lambda =	0.693		
F-statistic =	1.562	DF = 32, 477	PROB = 0.028
Pillai trace =	0.344		
F-statistic =	1.555	DF = 32, 528	PROB = 0.028
Hotelling-Lawley trace =	0.392		
F-statistic =	1.563	DF = 32, 510	PROB = 0.027
Theta = 0.161 S = 4, M = 1.5, N = 63.5			PROB = 0.089

(Page 3 of 3)

Table 3-31. Summary Statistics of Species Richness Calculated Separately for Each Geographic Region[a]

Total Lakes: 36 — Region = 1.000

	ROT	CLAD	CAL	CYC	TOTAL
Number of cases	36	36	36	36	36
Mean	6.389	4.194	1.472	1.778	15.639
Variance	10.702	4.161	0.313	0.921	32.237
Standard error	0.545	0.340	0.093	0.160	0.946

Total Lakes: 20 — Region = 2.000

	ROT	CLAD	CAL	CYC	TOTAL
Number of cases	20	20	20	20	20
Mean	8.200	3.650	0.750	1.900	16.200
Variance	7.642	1.608	0.303	0.726	18.063
Standard error	0.618	0.284	0.123	0.191	0.950

Total Lakes: 32 — Region = 3.000

	ROT	CLAD	CAL	CYC	TOTAL
Number of cases	32	32	32	32	32
Mean	9.594	5.156	1.594	2.313	20.656
Variance	9.797	3.814	0.572	0.802	24.749
Standard error	0.553	0.345	0.134	0.158	0.879

Total Lakes: 25 — Region = 4.000

	ROT	CLAD	CAL	CYC	TOTAL
Number of cases	25	25	25	25	25
Mean	5.560	3.640	1.680	1.680	14.160
Variance	15.340	2.573	0.643	1.143	26.307
Standard error	0.783	0.321	0.160	0.214	1.026

Total Lakes: 34 — Region = 5.000

	ROT	CLAD	CAL	CYC	TOTAL
Number of cases	34	34	34	34	34
Mean	8.971	5.147	1.471	1.971	19.176
Variance	5.484	4.553	0.378	0.393	16.089
Standard error	0.402	0.366	0.105	0.108	0.688

[a] Region 1 = Adirondacks; 2 = Pocono Mountains and New Jersey; 3 = Central New England; 4 = Southern New England; 5 = Maine. ROT = rotifers; CLAD = cladocerans; CAL = calanoid copepods; CYC = cyclopoid copepods.

Table 3-32. Species Richness and Diversity Indices for Zooplankton in Three ANC Clusters for 146 Lakes from ELS-II[a]

Cluster	Rotifers	Cladocera	Calanoid Copepods	Cyclopoid Copepods	All Species
Species Richness					
1	4.44 (2.38)	3.25 (1.45)	1.35 (0.66)	3.10 (1.21)	12.15 (3.78)
2	9.54 (2.81)	4.96 (1.81)	1.41 (0.68)	3.96 (1.17)	19.87 (4.29)
3	9.27 (2.23)	5.13 (2.05)	1.56 (0.78)	4.00 (1.07)	19.96 (3.72)
All	7.79 (3.42)	4.46 (1.97)	1.44 (0.71)	3.69 (1.23)	17.37 (5.38)
Species Richness Mode (Median)					
1	2 (4)	2 (3)	1 (1)	3 (3)	10 (12)
2	10 (10)	5 (5)	1 (1)	4=5 (4)	23 (20)
3	10 (9)	4 (4)	1 (1)	5 (4)	19 (19)
All	10 (8)	3=4 (4)	1 (1)	5 (4)	18=19 (18)
Shannon-Wiener Diversity					
1	0.61 (0.40)	0.54 (0.40)	0.06 (0.15)	0.40 (0.31)	1.37 (0.45)
2	1.37 (0.42)	0.90 (0.39)	0.09 (0.17)	0.61 (0.27)	1.87 (0.14)
3	1.35 (0.40)	0.95 (0.40)	0.18 (0.25)	0.65 (0.27)	1.91 (0.11)
All	1.11 (0.54)	0.80 (0.44)	0.11 (0.20)	0.56 (0.30)	1.73 (0.47)
Simpson's Diversity					
1	0.65 (0.23)	0.69 (0.23)	0.92 (0.21)	0.77 (0.18)	0.37 (0.17)
2	0.36 (0.17)	0.50 (0.20)	0.89 (0.24)	0.66 (0.16)	0.25 (0.14)
3	0.37 (0.17)	0.50 (0.20)	0.84 (0.24)	0.64 (0.16)	0.24 (0.11)
All	0.46 (0.23)	0.56 (0.22)	0.89 (0.24)	0.69 (0.18)	0.29 (0.15)
Ln(Simpson's) Diversity					
1	0.47 (0.36)	0.44 (0.36)	0.52 (2.29)	0.29 (0.25)	1.10 (0.46)
2	1.13 (0.43)	0.78 (0.37)	0.71 (2.67)	0.45 (0.26)	1.52 (0.44)
3	1.10 (0.43)	0.78 (0.38)	0.66 (2.35)	0.49 (0.27)	1.52 (0.43)
All	0.91 (0.51)	0.67 (0.40)	0.63 (2.43)	0.41 (0.28)	1.38 (0.48)

[a] Unless otherwise noted, the value in each entry is the mean value over lakes in the cluster, with 1 standard deviation given in parentheses.

Table 3-33. Means for Shannon-Wiener Diversity for the Three Chemistry Clusters and the Five Geographic Regions, Calculated Separately for Each of the Four Major Zooplankton Groups[a]

	Chemistry Cluster		
	1	2	3
Rotifers	0.43056	0.92280	0.82198
Cladocerans	0.28975	0.32233	0.37615
Cyclopoids	0.39392	0.49824	0.55425
Calanoids	0.26032	0.15035	0.14967

	Region				
	1	2	3	4	5
Rotifers	0.580	0.728	0.881	0.547	0.889
Cladocerans	0.353	0.352	0.338	0.284	0.328
Cyclopoids	0.427	0.557	0.513	0.479	0.471
Calanoids	0.236	0.123	0.167	0.219	0.162

[a] Region 1 = Adirondacks; 2 = Poconos/Catskills; 3 = Central New England; 4 = Southern New England; 5 = Maine.

Table 3-34. Principal Components Analysis (PCA) of Diversity of Major Groups of Zooplankton[a]

Correlation Matrix

	CALDIV	CYDIV	CLADIV	ROTDIV
CALDIV	1.000			
CYDIV	-0.042	1.000		
CLADIV	0.034	0.507	1.000	
ROTDIV	-0.496	0.034	-0.082	1.000

Component Loadings

	1	2	3	4
CALDIV	0.574	-0.644	0.457	0.218
CYDIV	0.584	0.647	0.278	-0.403
CLADIV	0.695	0.526	-0.255	0.418
ROTDIV	-0.611	0.613	0.405	0.295

Percent of Total Abundance Explained

1	2	3	4
38.165	37.148	12.897	11.790

[a] CALDIV = calanoid copepods; CYDIV = cyclopoid copepods; CLADIV = cladocerans; ROTDIV = rotifers.

Table 3-35. Multivariate Analysis of Variance of First Two Factors from Principal Components Analysis (PCA) of Species Diversity of Major Taxa

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	7.402	2	3.701	3.803	0.025
Error	127.474	131	0.973		
Factor 2	31.591	2	15.796	27.666	0.000
Error	74.794	131	0.571		

Multivariate Test Statistics

Wilks' Lambda =	0.642		
F-statistic =	16.130	DF = 4, 260	PROB = 0.000
Pillai trace =	0.367		
F-statistic =	14.728	DF = 4, 262	PROB = 0.000
Hotelling-Lawley trace =	0.544		
F-statistic =	17.538	DF = 4, 258	PROB = 0.000
Theta = 0.341 S = 2, M = -.5, N = 64.0			PROB = 0.000

(Page 1 of 3)

Table 3-35. Multivariate Analysis of Variance of First Two Factors from Principal Components Analysis (PCA) of Species Diversity of Major Taxa (Continued)

Test for effect called: REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	3.632	4	0.908	0.933	0.447
Error	127.474	131	0.973		
Factor 2	6.184	4	1.546	2.708	0.033
Error	74.794	131	0.571		

Multivariate Test Statistics

Wilks' Lambda =	0.882		
F-statistic =	2.101	DF = 8, 260	PROB = 0.036
Pillai trace =	0.118		
F-statistic =	2.060	DF = 8, 262	PROB = 0.040
Hotelling-Lawley trace =	0.133		
F-statistic =	2.141	DF = 8, 258	PROB = 0.033
Theta = 0.113 S = 2, M = .5, N = 64.0			PROB = 0.015

(Page 2 of 3)

Table 3-35. Multivariate Analysis of Variance of First Two Factors from Principal Components Analysis (PCA) of Species Diversity of Major Taxa (Continued)

Test for effect called: CHEMGRP BY REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	5.861	8	0.733	0.753	0.645
Error	127.474	131	0.973		
Factor 2	11.842	8	1.480	2.593	0.012
Error	74.794	131	0.571		

Multivariate Test Statistics

Wilks' Lambda =	0.815		
F-statistic =	1.747	DF = 16, 260	PROB = 0.039
Pillai trace =	0.191		
F-statistic =	1.726	DF = 16, 262	PROB = 0.042
Hotelling-Lawley trace =	0.219		
F-statistic =	1.768	DF = 16, 258	PROB = 0.036
Theta = 0.151 S = 2, M = 2.5, N = 64.0			PROB = 0.023

(Page 3 of 3)

Table 3-36. Summary Statistics of Zooplankton Abundance for All Phase II Survey Lakes Determined Separately for Each 0.2-mm Size Class[a]

Total lakes: 147

	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
Number of cases	147	147	147	147	147
Mean	512.454	360.521	71.878	53.647	64.438
Variance	1060036.852	209758.667	13998.461	4737.793	6116.811

	SIZ(6)	SIZ(7)	SIZ(8)	SIZ(9)	SIZ(10)
Number of cases	147	147	147	147	147
Mean	11.048	8.196	2.970	1.189	0.208
Variance	408.769	260.452	48.308	48.832	2.644

	SIZ(11)	SIZ(12)	SIZ(13)
Number of cases	147	147	147
Mean	0.208	0.144	0.042
Variance	1.179	1.183	0.260

[a] Values are untransformed abundances and exclude organisms > 2.6 mm.

Table 3-37. Summary Statistics of Zooplankton Abundance for All Phase II Survey Lakes Determined Separately for Each 0.2-mm Size Class[a]

Total lakes: 147

	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
Number of cases	147	147	147	147	147
Mean	5.131	5.209	3.295	3.275	3.399
Variance	2.689	1.601	2.277	1.795	2.159
	SIZ(6)	SIZ(7)	SIZ(8)	SIZ(9)	SIZ(10)
Number of cases	147	147	147	147	147
Mean	1.516	1.293	0.627	0.275	0.065
Variance	1.918	1.675	1.053	0.444	0.099
	SIZ(11)	SIZ(12)	SIZ(13)	SIZ(14)	SIZ(15)
Number of cases	147	147	147	147	147
Mean	0.077	0.042	0.013	0.190	0.000
Variance	0.121	0.083	0.026	0.270	0.000
	SIZ(16)	SIZ(17)	SIZ(18)	SIZ(19)	SIZ(20)
Number of cases	147	147	147	147	147
Mean	0.013	0.236	0.016	0.068	0.002
Variance	0.026	0.363	0.038	0.179	0.000
	SIZ(21)	SIZ(22)	SIZ(23)		
Number of cases	147	147	147		
Mean	0.029	0.038	0.029		
Variance	0.076	0.065	0.062		

[a] Values are log(e) transformed abundances and include all organisms.

Table 3-38. Summary Statistics of Zooplankton Abundance for All Phase II Survey Lakes Determined Separately for Each 0.2-mm Size Class[a]

Total lakes: 147

	PSIZ1	PSIZ2	PSIZ3	PSIZ4	PSIZ5
Number of cases	147	147	147	147	147
Mean	0.374	0.348	0.070	0.070	0.095
Variance	0.058	0.046	0.007	0.007	0.014
	PSIZ6	PSIZ7	PSIZ8	PSIZ9	PSIZ10
Number of cases	147	147	147	147	147
Mean	0.018	0.014	0.007	0.002	0.000
Variance	0.001	0.001	0.000	0.000	0.000
	PSIZ11	PSIZ12	PSIZ13		
Number of cases	147	147	147		
Mean	0.001	0.000	0.000		
Variance	0.000	0.000	0.000		

[a] Values are expressed as relative abundance in each size class and exclude organisms > 2.6 mm.

Table 3-39. Summary Statistics of Zooplankton Size Classes Determined Separately for Each Water Chemistry Cluster[a]

CHEMGRP = 1.000

	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
Number of cases	48	48	48	48	48
Mean	632.189	296.018	91.330	81.865	98.106
Variance	1945832.647	130669.640	24922.531	9272.229	6131.714

	SIZ(6)	SIZ(7)	SIZ(8)	SIZ(9)
Number of cases	48	48	48	48
Mean	6.340	7.147	3.115	0.224
Variance	203.896	312.053	69.369	0.839

CHEMGRP = 2.000

	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
Number of cases	53	53	53	53	53
Mean	530.274	465.385	67.028	46.377	57.917
Variance	802138.457	293778.217	6846.934	2665.460	8751.113

	SIZ(6)	SIZ(7)	SIZ(8)	SIZ(9)
Number of cases	53	53	53	53
Mean	10.596	7.530	0.560	1.876
Variance	380.607	216.127	3.008	129.474

CHEMGRP = 3.000

	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
Number of cases	46	46	46	46	46
Mean	366.982	307.007	57.168	32.579	36.818
Variance	442702.233	184279.382	10822.536	1241.783	1290.007

	SIZ(6)	SIZ(7)	SIZ(8)	SIZ(9)
Number of cases	46	46	46	46
Mean	16.480	10.057	5.596	1.406
Variance	619.413	264.114	66.894	6.344

[a] Values are untransformed abundances and exclude organisms > 1.8 mm.

Table 3-40. Summary Statistics of Zooplankton Size Classes Determined Separately for Each Water Chemistry Cluster[a]

	CHEMGRP = 1.000				
	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
Number of cases	48	48	48	48	48
Mean	4.864	5.046	3.333	3.788	4.107
Variance	4.551	1.449	3.062	1.423	1.545
	SIZ(6)	SIZ(7)	SIZ(8)	SIZ(9)	
Number of cases	48	48	48	48	
Mean	1.015	1.030	0.496	0.097	
Variance	1.577	1.636	1.119	0.131	
	CHEMGRP = 2.000				
	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
Number of cases	53	53	53	53	53
Mean	5.470	5.463	3.436	3.073	3.112
Variance	1.710	1.783	1.967	2.267	2.333
	SIZ(6)	SIZ(7)	SIZ(8)	SIZ(9)	
Number of cases	53	53	53	53	
Mean	1.521	1.249	0.220	0.227	
Variance	1.758	1.561	0.284	0.524	
	CHEMGRP = 3.000				
	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
Number of cases	46	46	46	46	46
Mean	5.018	5.086	3.091	2.973	2.992
Variance	1.772	1.501	1.850	1.297	1.893
	SIZ(6)	SIZ(7)	SIZ(8)	SIZ(9)	
Number of cases	46	46	46	46	
Mean	2.032	1.617	1.231	0.515	
Variance	2.006	1.740	1.332	0.602	

[a] Values are log(e) transformed abundances and exclude organisms > 1.8 mm.

Table 3-41. Summary Statistics of Zooplankton Size Classes Determined Separately for Each Water Chemistry Cluster[a]

	CHEMGRP = 1.000				
	PSIZ1	PSIZ2	PSIZ3	PSIZ4	PSIZ5
Number of cases	48	48	48	48	48
Mean	0.360	0.292	0.074	0.099	0.147
Variance	0.264	0.227	0.091	0.120	0.148
	PSIZ6	PSIZ7	PSIZ8	PSIZ9	
Number of cases	48	48	48	48	
Mean	0.011	0.009	0.006	0.001	
Variance	0.022	0.019	0.020	0.003	
	CHEMGRP = 2.000				
	PSIZ1	PSIZ2	PSIZ3	PSIZ4	PSIZ5
Number of cases	53	53	53	53	53
Mean	0.390	0.381	0.066	0.061	0.070
Variance	0.230	0.210	0.070	0.072	0.104
	PSIZ6	PSIZ7	PSIZ8	PSIZ9	
Number of cases	53	53	53	53	
Mean	0.017	0.011	0.001	0.002	
Variance	0.029	0.025	0.004	0.013	
	CHEMGRP = 3.000				
	PSIZ1	PSIZ2	PSIZ3	PSIZ4	PSIZ5
Number of cases	46	46	46	46	46
Mean	0.371	0.369	0.071	0.052	0.069
Variance	0.230	0.197	0.083	0.036	0.070
	PSIZ6	PSIZ7	PSIZ8	PSIZ9	
Number of cases	46	46	46	46	
Mean	0.027	0.022	0.013	0.004	
Variance	0.032	0.040	0.020	0.007	

[a] Values are expressed as relative abundances of each size class and exclude organisms > 1.8 mm.

Table 3-42. Multivariate Analysis of Variance of Zooplankton Size Classes Partitioned among Water Chemistry Clusters[a]

Number of lakes: 147

Dependent variable means:	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
	5.131	5.209	3.295	3.275	3.399
	SIZ(6)	SIZ(7)	SIZ(8)	SIZ(9)	
	1.516	1.293	0.627	0.275	

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
SIZ(1)	10.103	2	5.052	1.902	0.153
Error	382.515	144	2.656		
SIZ(2)	5.392	2	2.696	1.700	0.186
Error	228.379	144	1.586		
SIZ(3)	3.033	2	1.517	0.663	0.517
Error	329.461	144	2.288		
SIZ(4)	19.010	2	9.505	5.630	0.004
Error	243.111	144	1.688		
SIZ(5)	36.041	2	18.021	9.297	0.000
Error	279.109	144	1.938		
SIZ(6)	24.274	2	12.137	6.833	0.001
Error	255.771	144	1.776		
SIZ(7)	8.241	2	4.121	2.511	0.085
Error	236.333	144	1.641		
SIZ(8)	26.395	2	13.198	14.927	0.000
Error	127.320	144	0.884		
SIZ(9)	4.279	2	2.139	5.091	0.007
Error	60.505	144	0.420		

Multivariate Test Statistics

Wilks' Lambda =	0.542		
F-statistic =	5.423	DF = 18, 272	PROB = 0.000
Pillai trace =	0.515		
F-statistic =	5.279	DF = 18, 274	PROB = 0.000
Hotelling-Lawley trace =	0.742		
F-statistic =	5.567	DF = 18, 270	PROB = 0.000
Theta = 0.356 S = 2, M = 3.0, N = 67.0			PROB = 0.000

[a] Analysis used log(e) transformed abundances and excluded sizes > 1.8 mm.

Table 3-43. Principal Components Analysis (PCA) of Zooplankton Size Classes Using Log(e) Transformed Abundance[a]

Correlation Matrix

	SIZ(1)	SIZ(2)	SIZ(3)	SIZ(4)	SIZ(5)
SIZ(1)	1.000				
SIZ(2)	0.310	1.000			
SIZ(3)	0.354	0.487	1.000		
SIZ(4)	0.050	0.384	0.393	1.000	
SIZ(5)	-0.024	0.198	0.221	0.588	1.000
SIZ(6)	0.024	0.133	0.123	0.216	0.179
SIZ(7)	0.014	0.110	0.035	0.201	0.332
SIZ(8)	-0.140	-0.107	-0.025	0.089	0.057
SIZ(9)	-0.079	0.039	-0.145	0.024	0.073

	SIZ(6)	SIZ(7)	SIZ(8)
SIZ(6)	1.000		
SIZ(7)	0.396	1.000	
SIZ(8)	0.294	0.314	1.000
SIZ(9)	0.125	0.270	0.047

Component Loadings

	1	2	3	4	5
SIZ(1)	0.282	-0.536	0.560	0.076	-0.436
SIZ(2)	0.626	-0.430	0.152	0.197	0.351
SIZ(3)	0.618	-0.508	0.115	-0.179	0.193
SIZ(4)	0.765	-0.054	-0.431	-0.050	0.086
SIZ(5)	0.671	0.142	-0.540	0.058	-0.320
SIZ(6)	0.499	0.423	0.369	-0.183	0.079
SIZ(7)	0.523	0.557	0.225	0.115	-0.343
SIZ(8)	0.205	0.587	0.225	-0.519	0.207
SIZ(9)	0.131	0.436	0.148	0.787	0.232

Percent of Total Variance Explained

1	2	3	4	5
27.470	19.755	12.072	11.313	7.570

[a] Excludes organisms larger than 1.8 mm; includes all Phase II survey lakes.

Table 3-44. Summary Statistics for First Four Principal Components of Zooplankton Size Classes, Determined Separately for Each Water Chemistry Cluster[a]

CHEMGRP = 1.000

	Factor 1	Factor 2	Factor 3	Factor 4
Number of cases	48	48	48	48
Mean	0.064	-0.157	-0.718	-0.132
Variance	0.812	0.817	1.009	0.661
Standard deviation	0.901	0.904	1.005	0.813
Standard error	0.130	0.130	0.145	0.117

CHEMGRP = 2.000

	Factor 1	Factor 2	Factor 3	Factor 4
Number of cases	53	53	53	53
Mean	-0.045	-0.307	0.204	0.177
Variance	1.138	0.750	0.798	0.941
Standard deviation	1.067	0.866	0.893	0.970
Standard error	0.147	0.119	0.123	0.133

CHEMGRP = 3.000

	Factor 1	Factor 2	Factor 3	Factor 4
Number of cases	46	46	46	46
Mean	-0.015	0.517	0.513	-0.066
Variance	1.075	1.114	0.400	1.407
Standard deviation	1.037	1.055	0.632	1.186
Standard error	0.153	0.156	0.093	0.175

[a] Principal components analysis (PCA) used log(e) transformed abundances.

Table 3-45. Multivariate Analysis of Variance of Zooplankton Size Class Principal Components (1-4) Partitioned among Three Water Chemistry Clusters and Five Geographic Regions[a]

Test for effect called: CHEMGRP

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	0.539	2	0.270	0.277	0.759
Error	128.615	132	0.974		
Factor 2	16.198	2	8.099	9.034	0.000
Error	118.336	132	0.896		
Factor 3	27.973	2	13.986	21.028	0.000
Error	87.798	132	0.665		
Factor 4	4.830	2	2.415	2.580	0.080
Error	123.570	132	0.936		

Multivariate Test Statistics

Wilks' Lambda =	0.628		
F-statistic =	8.449	DF = 8, 258	PROB = 0.000
Pillai trace =	0.403		
F-statistic =	8.190	DF = 8, 260	PROB = 0.000
Hotelling-Lawley trace =	0.544		
F-statistic =	8.706	DF = 8, 256	PROB = 0.000
Theta = 0.302 S = 2, M = .5, N = 63.5			PROB = 0.000

[a] Principal components are based on log(e) transformed abundances.

(Page 1 of 3)

Table 3-45. Multivariate Analysis of Variance of Zooplankton Size Class Principal Components (1-4) Partitioned among Three Water Chemistry Clusters and Five Geographic Regions (Continued)[a]

Test for effect called: REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	6.541	4	1.635	1.678	0.159
Error	128.615	132	0.974		
Factor 2	5.268	4	1.317	1.469	0.215
Error	118.336	132	0.896		
Factor 3	8.357	4	2.089	3.141	0.017
Error	87.798	132	0.665		
Factor 4	7.843	4	1.961	2.095	0.085
Error	123.570	132	0.936		

Multivariate Test Statistics

Wilks' Lambda =	0.799		
F-statistic =	1.885	DF = 16, 394	PROB = 0.020
Pillai trace =	0.214		
F-statistic =	1.868	DF = 16, 528	PROB = 0.021
Hotelling-Lawley trace =	0.236		
F-statistic =	1.885	DF = 16, 510	PROB = 0.020
Theta = 0.126 S = 4, M = -.5, N = 63.5			PROB = 0.048

[a] Principal components are based on log(e) transformed abundances.

(Page 2 of 3)

Table 3-45. Multivariate Analysis of Variance of Zooplankton Size Class Principal Components (1-4) Partitioned among Three Water Chemistry Clusters and Five Geographic Regions (Continued)[a]

Test for effect called: CHEMGRP BY REGION

Univariate F-tests

Variable	SS	DF	MS	F	P
Factor 1	9.519	8	1.190	1.221	0.292
Error	128.615	132	0.974		
Factor 2	2.387	8	0.298	0.333	0.952
Error	118.336	132	0.896		
Factor 3	15.049	8	1.881	2.828	0.006
Error	87.798	132	0.665		
Factor 4	13.589	8	1.699	1.815	0.080
Error	123.570	132	0.936		

Multivariate Test Statistics

Wilks' Lambda =	0.694		
F-statistic =	1.553	DF = 32, 477	PROB = 0.029
Pillai trace =	0.341		
F-statistic =	1.540	DF = 32, 528	PROB = 0.031
Hotelling-Lawley trace =	0.392		
F-statistic =	1.561	DF = 32, 510	PROB = 0.027
Theta = 0.173 S = 4, M = 1.5, N = 63.5			PROB = 0.052

[a] Principal components are based on log(e) transformed abundances.

(Page 3 of 3)

Table 3-46. Principal Components Analysis (PCA) of 38 Major Genera of Zooplankton[a]

Component Loadings

	1	2	3	4	5
Keratella	0.551	-0.302	-0.142	0.057	0.279
Kellicottia	0.284	0.551	0.049	-0.124	-0.095
Trichocerca	0.738	-0.096	0.093	0.034	0.273
Gastropus	0.221	0.226	-0.125	-0.359	0.013
Ascomorpha	0.360	-0.010	-0.157	-0.144	-0.249
Asplanchna	0.606	-0.164	0.252	0.080	0.171
Polyarthra	0.641	0.103	0.348	0.012	-0.010
Synchaeta	0.173	-0.318	0.253	0.113	-0.076
Ploesoma	0.325	-0.177	0.112	0.034	0.186
Filinia	0.006	-0.024	0.281	-0.129	-0.040
Hexarthra	0.257	-0.274	0.266	0.071	0.002
Conochilus	-0.103	0.380	0.173	-0.331	0.419
Conochiloides	0.180	0.081	0.241	0.238	-0.363
Collotheca	0.187	-0.081	0.317	0.149	0.028
Leptodora	-0.008	0.466	0.302	0.529	-0.032
Diaphanosoma	0.428	0.375	-0.408	0.030	0.341
Sida	-0.056	0.592	0.223	0.370	0.029
Holopedium	0.116	0.221	-0.077	0.254	0.152
Bosmina	0.515	-0.270	-0.049	0.090	0.183
Eubosmina	-0.092	0.175	-0.496	0.253	0.056
Chydorus	0.058	0.102	0.089	-0.315	0.213
Polyphemus	-0.125	-0.147	-0.016	-0.071	0.360
Daphnia (pulex)	-0.206	0.591	0.171	-0.314	-0.106
Daphnia (galeata)	-0.182	0.368	0.290	-0.374	0.303
Daphnia (parvula)	0.337	0.244	-0.552	0.145	-0.012
Ceriodaphnia	0.530	0.084	0.057	-0.010	-0.199
Epischura	-0.264	0.360	0.232	0.046	0.186
Aglaodiaptomus	-0.176	0.198	0.049	-0.056	0.076
Leptodiaptomus	-0.446	-0.114	-0.315	0.326	0.396
Skistodiaptomus	0.185	0.198	-0.152	-0.272	-0.434
Onychodiaptomus	0.321	-0.017	-0.089	-0.167	-0.142
Mesocyclops	0.332	0.445	-0.476	-0.098	-0.147
Tropocyclops	0.563	0.311	0.038	-0.127	0.009
Cyclops	0.040	0.325	0.176	0.079	0.252
Orthocyclops	-0.013	-0.050	0.041	-0.067	-0.337
Eucyclops	0.075	0.392	0.053	0.637	-0.158
Ectocyclops	0.236	0.063	-0.060	0.006	0.290
Macrocyclops	-0.157	-0.008	-0.056	0.033	0.125

Percent of Total Variance Explained

1	2	3	4	5
10.731	8.118	5.575	5.200	4.808

[a] PCA used log(e) transformed abundance standardized for mean and variance (correlation matrix).

Table 3-47. Principal Components Analysis (PCA) of Log(e) Transformed Abundance of Major Copepod Genera

Component Loadings

	1	2	3	4	5
Epischura	-0.054	-0.089	-0.091	-0.129	0.152
Aglaodiaptomus	-0.032	0.043	0.034	0.148	0.025
Leptodiaptomus	-1.950	0.821	-0.103	-0.518	0.032
Skistodiaptomus	0.882	-0.330	0.421	-1.057	0.078
Onychodiaptomus	0.050	0.015	-0.018	0.069	-0.037
Mesocyclops	0.737	1.355	0.871	0.177	0.119
Tropocyclops	1.050	0.849	-1.152	-0.208	-0.111
Cyclops	0.037	-0.057	-0.248	0.076	0.990
Orthocyclops	0.021	-0.026	0.057	0.034	-0.057
Eucyclops	-0.000	0.035	0.012	0.003	0.001
Ectocyclops	0.010	0.014	-0.005	0.008	-0.005
Macrocyclops	-0.020	-0.006	0.001	-0.005	0.003

Percent of Total Variance Explained

1	2	3	4	5
39.645	21.336	14.927	9.603	6.621

Table 3-48. Principal Components Analysis (PCA) of Log(e) Transformed Abundance of Major Rotifer Genera

Component Loadings

	1	2	3	4	5
Keratella	1.102	-0.587	0.114	-0.948	-0.793
Kellicottia	0.917	1.780	-0.584	-0.372	0.081
Trichocerca	1.360	-0.384	0.458	-0.335	0.879
Gastropus	0.093	0.078	0.097	0.022	-0.020
Ascomorpha	0.213	0.024	-0.120	-0.097	0.022
Asplanchna	0.883	-0.377	0.244	0.305	0.193
Polyarthra	1.578	0.018	-0.155	1.043	-0.446
Synchaeta	0.262	-0.156	-0.061	0.002	-0.093
Ploesoma	0.254	-0.262	0.057	-0.241	0.058
Filinia	0.017	0.112	-0.003	0.010	0.072
Hexarthra	0.232	-0.263	0.120	0.100	0.231
Conochilus	-0.038	0.933	1.576	0.053	-0.180
Conochiloides	0.285	0.125	-0.476	-0.073	0.275
Collotheca	0.089	-0.068	0.025	0.037	0.049

Percent of Total Variance Explained

1	2	3	4	5
28.040	18.211	12.715	9.032	6.820

Table 3-49. Principal Components Analysis (PCA) of Log(e) Transformed Abundance of Major Cladocera Genera

Component Loadings

	1	2	3	4	5
Leptodora	-0.005	0.016	0.013	0.001	0.004
Diaphanosoma	1.102	0.979	0.708	-0.340	0.244
Sida	-0.026	0.050	0.053	0.013	0.030
Holopedium	0.179	0.235	0.061	1.270	-0.009
Bosmina	1.451	-0.927	0.341	0.196	0.269
Eubosmina	0.212	1.067	-0.824	0.191	0.425
Chydorus	-0.002	0.019	0.142	-0.016	-0.016
Polyphemus	-0.003	-0.022	0.020	-0.024	0.012
Daphnia (pulex)	-0.819	0.482	1.175	0.182	0.019
Daphnia (galeata)	-0.196	0.144	0.233	-0.045	0.084
Daphnia (parvula)	0.678	0.594	-0.213	-0.137	-0.694
Ceriodaphnia	0.313	0.065	0.134	0.174	-0.779

Percent of Total Variance Explained

1	2	3	4	5
26.503	20.584	16.029	10.728	8.010

Table 3-50. Analysis of Variance of Principal Components 1 and 2 for Copepoda Major Genera Partitioned among Three Water Chemistry Clusters and Five Geographic Regions

Dependent variable: Factor 1
N: 147
Multiple R: .710
Squared Multiple R: .504

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P
Region	113.060	4	28.265	8.271	0.000
Chemgrp	108.400	2	54.200	15.859	0.000
Region* Chemgrp	119.457	8	14.932	4.369	0.000
Error	451.113	132	3.418		

Dependent variable: Factor 2
N: 147
Multiple R: .258
Squared Multiple R: .066

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P
Region	7.761	4	1.940	0.560	0.692
Chemgrp	5.576	2	2.788	0.805	0.449
Region* Chemgrp	11.783	8	1.473	0.425	0.904
Error	457.284	132	3.464		

Table 3-51. Analysis of Variance of Principal Components 1 and 2 for Rotifera Major Genera Partitioned among Three Water Chemistry Clusters and Five Geographic Regions

Dependent variable: Factor 1
N: 147
Multiple R: .601
Squared Multiple R: .362

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P
Region	180.496	2	90.248	17.034	0.000
Chemgrp	53.366	4	13.341	2.518	0.044
Region* Chemgrp	82.202	8	10.275	1.939	0.059
Error	699.346	132	5.298		

Dependent variable: Factor 2
N: 147
Multiple R: .494
Squared Multiple R: .244

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P
Region	52.464	2	26.232	6.438	0.002
Chemgrp	46.219	4	11.555	2.836	0.027
Region* Chemgrp	33.293	8	4.162	1.021	0.423
Error	537.820	132	4.074		

Table 3-52. Analysis of Variance of Principal Component 1 for Cladocera Major Genera, Partitioned among Three Water Chemistry Clusters and Five Geographic Regions[a]

Dependent variable: Factor 1
N: 147
Multiple R: .439
Squared Multiple R: .193

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P
Region	43.315	4	10.829	2.600	0.039
Chemgrp	32.432	2	16.216	3.893	0.023
Region* Chemgrp	39.669	8	4.959	1.191	0.309
Error	549.801	132	4.165		

Dependent variable: Factor 1
N: 122
Multiple R: .416
Squared Multiple R: .173

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P
Region	16.183	3	5.394	1.220	0.306
Chemgrp	57.168	2	28.584	6.465	0.002
Region* Chemgrp	18.350	6	3.058	0.692	0.657
Error	486.334	110	4.421		

[a] First analysis (N = 147) includes all Phase II survey lakes; second analysis excludes lakes from Region 4 (southern New England).

Table 3-53. Analysis of Variance of Principal Component 2 for Cladocera Major Genera, Partitioned among Three Water Chemistry Clusters and Five Geographic Regions

Dependent variable: Factor 2
N: 147
Multiple R: .460
Squared Multiple R: .211

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	P
Region	60.733	4	15.183	4.803	0.001
Chemgrp	1.948	2	0.974	0.308	0.735
Region* Chemgrp	27.168	8	3.396	1.074	0.385
Error	417.255	132	3.161		

Table 3-54. Discriminant Analysis of Major Genera of Rotifera and Crustacea Zooplankton in All Phase II Survey Lakes[a]

Canonical Correlations		
	1	2
	0.804	0.644
Canonical Loadings (Correlations between conditional dependent variables and dependent canonical factors)		
Keratella	-0.167	-0.155
Kellicottia	0.301	-0.273
Trichocerca	0.223	-0.343
Gastropus	0.008	-0.155
Ascomorpha	0.119	-0.132
Asplanchna	0.154	-0.180
Polyarthra	0.304	-0.135
Synchaeta	0.066	0.039
Ploesoma	0.060	-0.140
Filinia	0.061	0.038
Hexarthra	0.030	0.053
Conochilus	0.079	0.151
Conochiloides	0.014	0.053
Collotheca	0.071	-0.127
Leptodora	0.142	0.104
Diaphanosoma	0.014	-0.206
Sida	0.154	-0.010
Holopedium	0.033	-0.144
Bosmina	-0.088	-0.036
Eubosmina	-0.159	-0.062
Chydorus	0.106	0.200
Polyphemus	-0.069	0.093
Daphnia (pulex)	0.240	0.313
Daphnia (galeata)	0.260	0.205
Daphnia (parvula)	0.051	-0.099
Ceriodaphnia	0.245	0.164
Epischura	0.137	0.023
Aglaodiaptomus	0.069	-0.223
Leptodiaptomus	0.183	-0.036
Skistodiaptomus	0.082	-0.143
Onychodiaptomus	-0.019	-0.088
Mesocyclops	-0.125	-0.103
Tropocyclops	0.088	0.199
Cyclops	-0.037	0.102
Orthocyclops	0.249	0.274
Eucyclops	0.290	0.198
Ectocyclops	0.031	-0.144
Macrocyclops	0.281	0.138

[a] Arc sine square root transformed relative abundance; canonical correlations and loadings on discriminant axes are shown.

Table 3-55. Summary Statistics of Mahalanobis Distances for Each Water Chemistry Cluster[a]

Total lakes: 48	CHEMGRP = 1.000		
	Distance 1	Distance 2	Distance 3
Number of cases	48	48	48
Mean	1.077	2.809	3.426
Standard error	0.085	0.109	0.124

Total lakes: 53	CHEMGRP = 2.000		
	Distance 1	Distance 2	Distance 3
Number of cases	53	53	53
Mean	2.806	1.304	2.512
Standard error	0.149	0.087	0.114

Total lakes: 46	CHEMGRP = 3.000		
	Distance 1	Distance 2	Distance 3
Number of cases	46	46	46
Mean	3.504	2.481	1.330
Standard error	0.147	0.151	0.107

[a] Distances based on discriminant analysis of arc sine square root transformed relative abundance of major genera of Rotifera and Crustacea.

Table 3-56. Table of Classification of Lakes on the Basis of Discriminant Analysis of Chemistry Clusters[a]

Table of Frequencies	Group	(Rows) by Predict		(Columns)
	1	2	3	Total
1	43	4	1	48
2	9	41	3	53
3	2	8	36	46
Total	54	53	40	147

[a] Group = actual chemistry cluster; predict = classification results.

Table 3-57. Discriminant Analysis of Geographic Regions Using Major Genera (Log[e] Transformed Abundance) of Rotifera and Crustacea Zooplankton in All Phase II Survey Lakes[a]

Canonical Correlations	1	2	3	4
	0.729	0.693	0.648	0.457
Canonical Loadings (Correlations between conditional dependent variables and dependent canonical factors)				
Keratella	0.039	0.076	-0.109	0.148
Kellicottia	0.435	0.060	-0.183	0.096
Trichocerca	0.124	-0.017	-0.142	0.180
Gastropus	0.115	0.013	-0.092	0.020
Ascomorpha	0.090	-0.008	-0.147	-0.136
Asplanchna	0.119	-0.033	-0.198	0.168
Polyarthra	0.138	0.098	-0.355	-0.076
Synchaeta	0.018	0.168	-0.037	0.055
Ploesoma	0.097	0.026	-0.001	0.379
Filinia	-0.035	-0.031	-0.144	-0.180
Hexarthra	-0.172	-0.237	-0.267	0.022
Conochilus	0.110	-0.106	0.210	-0.287
Conochiloides	-0.027	-0.198	-0.055	0.036
Collotheca	0.125	-0.123	0.169	0.045
Leptodora	0.062	0.047	0.070	0.262
Diaphanosoma	0.160	0.000	-0.098	0.185
Sida	0.164	0.033	-0.009	0.018
Holopedium	0.048	0.133	0.103	0.068
Bosmina	-0.217	0.207	-0.226	0.368
Eubosmina	0.214	-0.255	0.266	0.018
Chydorus	0.066	-0.005	0.021	-0.139
Polyphemus	-0.095	0.092	-0.097	-0.069
Daphnia (pulex)	0.029	0.048	0.063	-0.080
Daphnia (galeata)	0.055	0.160	-0.025	-0.155
Daphnia (parvula)	0.179	-0.048	-0.133	0.204
Ceriodaphnia	-0.068	-0.241	-0.142	0.185
Epischura	-0.116	0.012	0.388	-0.014
Aglaodiaptomus	0.082	0.197	-0.045	-0.103
Leptodiaptomus	-0.110	0.324	0.371	-0.048
Skistodiaptomus	0.253	-0.251	0.044	0.111
Onychodiaptomus	-0.143	-0.163	-0.244	0.104
Mesocyclops	0.167	-0.009	-0.142	0.337
Tropocyclops	0.057	-0.259	-0.173	0.240
Cyclops	0.025	0.202	0.100	0.008
Orthocyclops	0.033	0.024	0.003	-0.075
Eucyclops	0.187	0.032	-0.048	0.089
Ectocyclops	0.107	-0.010	0.001	0.215
Macrocyclops	-0.028	-0.071	0.148	-0.132

[a] Canonical correlations and loadings on axes are shown.

Table 3-58. Table of Classification of Lakes on the Basis of Discriminant Analysis of Geographic Regions[a]

Table of Frequencies	Group	(Rows) by Predict				(Columns)
	1	2	3	4	5	Total
1	30	1	1	1	3	36
2	1	15	0	2	2	20
3	2	1	23	2	4	32
4	2	1	1	20	1	25
5	2	0	5	2	25	34
Total	37	18	30	27	35	147

[a] Group = actual region; predict = classification results.

Table 3-59. Loadings of Original Parameters with Summer and Fall Principal Components[a]

Parameter	Summer PCA				Fall PCA			
	PRIN1	PRIN2	PRIN3	PRIN4	PRIN1	PRIN2	PRIN3	PRIN4
Aluminum	-.21			.22	-.25	.21		
Alkalinity	.30				.30			
Anions/Cations			-.23	-.19			-.24	-.26
Conductivity	.23		.30		.20		.31	
Calcium	.29			.21	.28			.22
Chloride			.33				.40	
Color		-.35					.28	
DIC	.26					.28		.24
DOC		-.31				.21	-.25	
DO		.23		-.17				-.45
Fluoride				.32				
Carbonate	.31				.30			
Potassium	.21		.25		.19		.31	
Lake size		.21		.24		-.20		.22
Magnesium	.28				.25		.22	
Manganese	-.22		.22				.30	.23
Sodium	.19		.30		.16		.34	-.19
Ammonia							.30	.22
Nitrate				.50		.23		.23
pH (laboratory)	.29				.29			
pH (field)	.30				.29			
Phosphorus		-.30			.21	.26		
Secchi		.37				-.28		.22
Silicate				.44			-.30	
Sulfate			.26	.22			.24	.19
Temperature			.35				.28	
Turbidity		-.25			.21	.23		
Site depth		.27		.22		-.21		.41

[a] PRIN = principal component; loadings > .20 in absolute value are shown; some loadings < .20 are indicated to facilitate comparison between seasons. All parameters except pH were log transformed.

Table 3-60. Correlations of Principal Components and Chemical Parameters between Summer and Fall Chemistry Data Sets[a]

Principal Component	Proportion of Variance Summer	Proportion of Variance Fall	Correlation (R) between Summer and Fall Scores
PRIN1	.28	.31	.96
PRIN2	.16	.16	-.71
PRIN3	.14	.13	.77
PRIN4	.062	.069	.53
PRIN5	.049	.056	.81
PRIN6	.037	.045	-.08

Parameter	Correlation (R) between Summer and Fall Values
Aluminum (log)	.76
Alkalinity (log)	.97
Calcium (log)	.99
Anion/Cation ratio (log)	.80
Chloride (log)	.98
Color (log)	.81
DIC (log)	.91
DOC (log)	.89
Dissolved oxygen (log)	.30
Iron (log)	.72
Fluoride (log)	.83
Carbonate (log)	.96
Potassium (log)	.94
Magnesium (log)	.99
Manganese (log)	.54
Sodium (log)	.95
Ammonia (log)	.15
Nitrate (log)	.61
pH (laboratory measured)	.88
pH (field measured)	.91
Total phosphorus (log)	.76
Secchi depth (log of mean of disappear, reappear)	.76
Silicate (log)	.80
Sulfate (log)	.97
Temperature (log)	.30
Turbidity (log)	.71
Site depth (log)	.97
DIFTMP (temperature at 1.5 m – temperature at bottom of aerobic layer, summer data only) and TMPD (temperature 1.5 m above bottom, fall data only); not used in PCA	.59

[a] Principal components were calculated for the same 26 parameters from the two data sets; the proportion of variation accounted for by the first six principal components from each analysis are also given.

Table 3-61. Eigenvalues and Proportions of Variance Contained by Principal Components of 35 Chemistry Parameters in the Summer Chemistry Data Set from the EPA's Eastern Lake Survey - Phase II (ELS-II) of 147 Lakes[a]

Component	Eigenvalue	Difference	Proportion	Cumulative
PRIN1	8.37061	2.68251	0.239160	0.23916
PRIN2	5.68810	1.31190	0.162517	0.40168
PRIN3	4.37620	1.69153	0.125034	0.52671
PRIN4	2.68467	0.72540	0.076705	0.60342
PRIN5	1.95926	0.48532	0.055979	0.65940
PRIN6	1.47395	0.26801	0.042113	0.70151
PRIN7	1.20593	0.06359	0.034455	0.73596
PRIN8	1.14234	0.30445	0.032638	0.76860
PRIN9	0.83790	0.01942	0.023940	0.79254
PRIN10	0.81847	0.12281	0.023385	0.81593
PRIN11	0.69566	0.04797	0.019876	0.83580
PRIN12	0.64769	0.02963	0.018505	0.85431
PRIN13	0.61806	0.03692	0.017659	0.87197
PRIN14	0.58113	0.04814	0.016604	0.88857
PRIN15	0.53299	0.05514	0.015228	0.90380
PRIN16	0.47785	0.06136	0.013653	0.91745
PRIN17	0.41649	0.02590	0.011900	0.92935
PRIN18	0.39059	0.08156	0.011160	0.94051
PRIN19	0.30903	0.03843	0.008829	0.94934
PRIN20	0.27059	0.04201	0.007731	0.95707
PRIN21	0.22859	0.03960	0.006531	0.96360
PRIN22	0.18899	0.00720	0.005400	0.96900
PRIN23	0.18178	0.02490	0.005194	0.97420
PRIN24	0.15688	0.01113	0.004482	0.97868
PRIN25	0.14576	0.01582	0.004164	0.98284
PRIN26	0.12994	0.01184	0.003712	0.98656
PRIN27	0.11809	0.01548	0.003374	0.98993
PRIN28	0.10261	0.03228	0.002932	0.99286
PRIN29	0.07033	0.00283	0.002009	0.99487
PRIN30	0.06750	0.03417	0.001929	0.99680
PRIN31	0.03333	0.00170	0.000952	0.99775
PRIN32	0.03163	0.00496	0.000904	0.99866
PRIN33	0.02667	0.00723	0.000762	0.99942
PRIN34	0.01943	0.01848	0.000555	0.99997
PRIN35	0.00095		0.000027	1.00000

[a] See text for explanation of parameters and transformations of variables used in the analysis.

Table 3-62. Eigenvectors of First Six Principal Components from PCA of 35 Chemical Parameters from the Summer Chemistry Data Set of the EPA's Eastern Lake Survey - Phase II (ELS-II) of 147 Lakes[a]

	Eigenvectors					
	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5	PRIN6
LALDI98	-.194935	-.111644	-.016180	0.163654	0.186183	-.129032
LALKA11	0.289521	0.109665	-.107705	-.056983	0.059472	-.115747
LANCAT98	0.122706	-.095970	-.268066	-.029896	-.123537	0.304933
LC0151D	0.220683	0.033832	0.304508	0.029191	0.028368	0.066030
LCA98	0.283595	0.051607	-.070066	0.001492	0.217190	-.229966
LCL98	0.162311	0.059757	0.351153	-.006962	-.041026	0.220749
LCOLOR02	0.118771	-.276256	-.080890	0.143313	0.143361	0.251671
LDIC02	0.256824	-.044508	-.162322	0.076722	0.100311	-.154638
LDOC11	0.181011	-.209357	-.178735	0.117890	0.058948	0.125926
LDO_151D	-.046392	0.199744	0.017791	-.196955	-.070530	0.093377
LFE11	0.021581	-.286977	0.151586	0.139892	0.205694	0.155655
LFTL98	0.048709	0.009693	0.072991	0.134945	0.201205	0.411676
LHCO398	0.304947	0.073750	-.145667	-.065301	0.044648	-.019087
LHDEP99	-.018775	-.022548	0.238902	0.132054	0.123857	0.022866
LK98	0.212897	0.045516	0.258584	0.041786	-.062253	0.060365
LLKSIZ99	0.080624	0.223668	-.042445	-.097408	0.245388	0.186322
LMG98	0.273215	0.026337	0.146573	-.039166	0.055778	-.144832
LMN11	-.214861	-.136372	0.168330	0.096160	0.153277	-.073642
LNA98	0.188329	0.057231	0.314762	-.018933	-.021095	0.297056
LNH498	-.036060	-.109148	-.115955	0.006601	0.055529	0.039195
LNO398	-.106499	-.007168	0.014690	0.072835	0.420781	0.005639
PH0151D	0.283680	0.160066	-.065482	-.116178	-.030935	-.067507
PH02	0.288758	0.142837	-.097530	-.119062	-.010178	-.046778
LPTL11	0.170141	-.280802	0.044169	0.089284	-.068720	-.068957
LSECME98	-.135303	0.336704	0.035968	-.001465	-.029378	0.059700
LSIO211	0.091955	0.017745	-.193464	0.101032	0.413753	0.149325
LSO498	0.021686	0.040794	0.275338	0.006894	0.269234	-.415552
LT0151D	0.021672	0.052886	0.382629	-.010449	-.019618	-.039271
LTUR02	0.174112	-.231913	0.047436	0.066618	-.023931	-.171017
DIFDO	0.095971	0.077441	-.039200	0.481721	-.177812	-.110325
DIFCON	-.028748	-.129300	0.001240	-.308559	0.292590	-.185209
DIFTMP	-.039046	0.248858	-.072831	0.362321	0.129379	-.026600
LDPSIT1D	-.024670	0.328558	-.054857	0.313279	0.045759	-.017514
LDPAER	-.059827	0.354916	-.058383	0.139655	0.151349	0.039121
RANAER	0.095742	-.080631	0.012661	0.418591	-.275969	-.141953

[a] Each principal component is a linear combination of the original variables; the eigenvector for each parameter and component is the coefficient associated with that parameter to the principal component.

Table 3-63. **Results of Regressions of First Four Community Factors (Principal Components of Abundances of Zooplankton Genera and Species Groups) and First Six Water Chemistry Factors (Principal Components of Major Water Quality Parameters)[a]**

	Best 1 Variable Model		Best 2 Variable Model		Best 3 Variable Model		Best 4 Variable Model		Best 5 Variable Model	
	Ind. Var.	p	Ind. Var.	p	Ind. Var.	p	Ind. Var.	p	Ind. Var.	p
GENP1										
Model	CHEMP1	.0001	CHEMP1	.0001						
			CHEMP2	.0002						
R^2	.098		.19							
GENP2										
Model	CHEMP1	.0001								
R^2	.13									
GENP3										
Model	CHEMP1	.0001	CHEMP1	.0001	CHEMP1	.0001	CHEMP1	.0001	CHEMP1	.0001
			CHEMP6	.0086	CHEMP6	.0074	CHEMP6	.0063	CHEMP6	.0054
					CHEMP2	.0098	CHEMP2	.0084	CHEMP2	.0074
							CHEMP3	.0093	CHEMP3	.0082
									CHEMP5	.015
R^2	.12		.16		.20		.23		.27	
GENP4										
Model	CHEMP1	.0035								
R^2	.06									

[a] Each regression is the best model for each number of independent variables. Only models with significant effects for all independent variables are shown.

Table 3-64. Summary of Multiple Regressions[a]

Dependent Factor	Adjusted Squared Multiple R Value	P Value
Rotifer PCA 1	0.214	< 0.001
Rotifer PCA 2	0.223	< 0.001
Cladoceran PCA 1	0.111	0.002
Cladoceran PCA 3	0.114	0.002
Cladoceran PCA 5	0.176	< 0.001
Copepod PCA 1	0.348	< 0.001

[a] Dependent variables are principal component factors calculated separately for each major group of zooplankton. Predictor variables are the first four physical/chemical PCA factors: ANC, lake depth, depth of aerobic zone, and lake size.

Table 3-65. Comparison of Three Direct Analyses of Species-Environment Correspondence[a]

Analysis	Eigenvalue			Correlation Coefficient	
	Axis 1	Axis 2	Trace	Axis 1	Axis 2
RDA	0.1041	0.0323	0.1716	0.7885	0.4692
DCCA	0.1850	0.0730	0.3928	0.8135	0.6037
CCA	0.1850	0.0916	0.3928	0.8135	0.5808
		Copepoda			
RDA	0.1573	0.0157	0.1881	0.6502	0.4333
DCCA	0.2108	0.0937	0.3920	0.6990	0.5289
CCA	0.2108	0.0955	0.3920	0.6990	0.5330
		Cladocera			
RDA	0.0241	0.0007	0.0248	0.1634	0.0842
DCCA	0.9817	0.2183	1.4250	0.9924	0.5966
CCA	0.9817	0.3488	1.4250	0.9924	0.6803

[a] RDA = redundancy analysis; DCCA = detrended canonical correspondence analysis; CCA = canonical correspondence analysis. Eigenvalues for first two species axes and trace and species-environment correlation coefficients presented for each analysis.

Table 3-66. Results of CCA for Each of the Three Major Zooplankton Groups[a]

	PCA Factor 1	PCA Factor 2	PCA Factor 3	PCA Factor 4
Rotifera				
Axis 1	-0.7037	------	0.2873	------
Axis 2	------	-0.3648	------	-0.3400
Copepoda				
Axis 1	0.6694	------	------	------
Axis 2	------	0.5021	------	------
Cladocera				
Axis 1	-0.9701	0.9465	-0.9843	0.3952
Axis 2	------	------	------	0.5425

[a] Significant correlation coefficients between first two species axes and physical/chemical PCA factors.

Table 3-67. Results of CCA for Cladocera Genera, Excluding Ceriodaphnia[a]

	Species Axis 1	Species Axis 2	Trace
Eigenvalue	0.39768	0.09003	0.51560
Correlation			
Environment axis 1	0.7024	------	
Environment axis 2	------	0.5082	
PCA Factor 1	------	0.3809	
PCA Factor 2	-0.4797	------	
PCA Factor 3	0.3512	-----	
PCA Factor 4	0.5800	------	

[a] Eigenvalues for first two species axes and correlation coefficients of species axes with environmental axes and with original PCA factors are shown.

Table 3-68. Results of CCA for Cladocera Genera, Excluding Ceriodaphnia and Eubosmina[a]

	Species Axis 1	Species Axis 2	Trace
Eigenvalue	0.13719	0.04747	0.20723
Correlation			
Environment axis 1	0.5875	------	
Environment axis 2	------	0.4304	
PCA Factor 1	0.3885	------	
PCA Factor 2	0.4179	------	
PCA Factor 3	------	------	
PCA Factor 4	------	0.3318	

[a] Eigenvalues for first two species axes and correlation coefficients of species axes with environmental axes and with original PCA factors are shown.

APPENDICES

APPENDIX A

List of Names, Numbers, Lake Identification Codes, Geographic Locations, Region Associations, and Chemistry Cluster Numbers for All 147 Lakes Sampled in the ELS-II

Lake Code	Chemistry Cluster	Region	Lake Name	Latitude	Longitude	State	Lake Number
1A1-003	1	1	Hawk Pond	43-57'25"N	74-57'30"W	NY	28
1A1-008	2	1	Cedar River Flow	43-42'30"N	74-28'30"N	NY	16
1A1-012	1	1	Whitney Lake	43-35'15"N	74-33'45"W	NY	14
1A1-017	1	1	Constable Pond	43-50'00"N	74-47'45"W	NY	119
1A1-028	1	1	Dry Channel Pond	44-21'10"N	74-26'15"W	NY	112
1A1-029	3	1	Middle Pond	44-20'20"N	74-22'45"W	NY	17
1A1-033	3	1	Kiwassa Lake	44-17'45"N	74-09'30"W	NY	1
1A1-039	1	1	John Pond	44-06'45"N	74-45'50"W	NY	18
1A1-044	2	1	Long Lake	44-02'30"N	74-22'00"W	NY	3
1A1-049	1	1	Middle South Pond	43-59'22"N	75-01'06"W	NY	5
1A1-057	1	1	Hitchcock Lake	43-51'00"N	75-02'30"W	NY	4
1A1-060	3	1	Seventh Lake	43-44'45"N	74-45'00"W	NY	106
1A1-061	1	1	Wolf Lake	43-37'45"N	74-39'15"W	NY	81
1A1-064	2	1	Mt. Arab Lake	44-11'18"N	74-36'03"W	NY	85
1A1-066	1	1	Woodhull Lake	43-35'30"N	74-59'13"W	NY	105
1A1-070	3	1	Paradox Lake	43-53'00"N	73-42'30"W	NY	86
1A1-073	1	1	Gull Lakes	43-51'22"N	74-49'15"W	NY	84
1A2-002	1	1	St. John Lake	43-26'30"N	74-03'40"W	NY	44
1A2-004	1	1	Duck Lake	43-14'08"N	74-27'09"W	NY	43
1A2-006	2	1	Lake Frances	44-41'45"N	74-19'30"W	NY	20
1A2-041	2	1	Mud Lake	43-20'26"N	74-27'14"W	NY	54
1A2-042	1	1	North Branch Lake	43-18'45"N	74-47'40"W	NY	56
1A2-045	1	1	Woods Lake	43-15'10"N	74-19'00"W	NY	55
1A2-048	1	1	(No Name) Lily Lake	43-07'39"N	74-35'20"W	NY	51
1A2-052	1	1	Chub Lake	43-15'30"N	74-31'50"W	NY	53
1A2-054	1	1	Trout Lake	43-20'48"N	74-42'50"W	NY	61
1A2-058	3	1	Trout Lake	44-21'47"N	75-16'08"W	NY	82
1A3-001	2	1	Nate Pond	43-51'30"N	74-05'30"W	NY	2
1A3-028	1	1	Curtis Lake	43-20'10"N	74-57'40"W	NY	111
1A3-040	2	1	Zack Pond	43-56'00"N	74-11'00"W	NY	19
1A3-042	2	1	Cheney Pond	43-52'40"N	74-09'45"W	NY	21
1A3-043	3	1	Unknown	43-49'10"N	74-17'00"W	NY	13
1A3-046	2	1	Long Pond	43-38'15"N	74-17'20"W	NY	15
1A3-048	1	1	Grass Pond	43-41'35"N	75-03'40"W	NY	9
1A3-063	3	1	No Name Windfall	43-41'44"N	75-00'18"W	NY	113
1A3-065	1	1	South Lake	43-30'54"N	74-53'32"W	NY	109
1B1-010	1	2	Ganoga Lake	41-21'30"N	76-19'15"W	PA	125
1B1-023	2	2	Twin Ponds (Lower)	41-23'00"N	74-54'15"W	PA	27
1B1-029	3	2	Skyview Lake	41-17'30"N	75-14'20"W	PA	34
1B1-043	1	2	Penn Lake	41-06'45"N	75-46'10"W	PA	7
1B1-055	2	2	Rock Hill Pond	41-18'49"N	75-00'58"W	PA	126
1B1-064	2	2	Millpond No. 1	41-10'47"N	75-24'39"W	PA	12
1B2-028	1	2	Mill Creek Reservoir	41-15'45"N	75-45'00"W	PA	30
1B3-012	3	2	Little Butler Pond	41-51'45"N	75-37'40"W	PA	11
1B3-019	3	2	Hartley Pond	41-39'30"N	75-42'30"W	PA	10
1B3-025	2	2	Trout Lake	41-35'10"N	74-40'50"W	NY	117
1B3-032	3	2	Wixon Pond	41-23'45"N	73-44'05"W	NY	6
1B3-041	2	2	East Stroudsberg	41-04'00"N	75-10'00"W	PA	29
1B3-043	3	2	Trout Lake	41-00'15"N	75-20'30"W	PA	120
1B3-052	1	2	No Name	41-29'23"N	74-32'20"W	NY	128
1B3-053	3	2	No Name Lake	41-54'18"N	75-24'37"W	PA	26
1B3-056	1	2	Riga Lake	42-01'18"N	73-29'00"W	CT	22
1B3-059	1	2	Island Pond	41-15'26"N	74-08'25"W	NY	24

Lake Code	Chemistry Cluster	Region	Lake Name	Latitude	Longitude	State	Lake Number
1B3-060	3	2	Sly Lake	41-49'25"N	75-20'14"W	PA	108
1B3-062	3	2	Bassett Pond	41-35'33"N	75-42'40"W	PA	8
1C1-009	3	3	Upper Baker Pond	43-54'30"N	71-59'30"W	NH	49
1C1-017	3	3	Welhern Lake	45-12'45"N	70-29'40"W	ME	25
1C1-018	3	3	Decker Pond	45-11'45"N	69-56'15"W	ME	47
1C1-031	2	3	Hunt's Pond	44-05'00"N	71-00'00"W	ME	48
1C1-039	2	3	Ossippee Lake	43-47'30"N	71-08'00"W	NH	77
1C1-050	2	3	Billings Pond	43-17'00"N	71-56'30"W	NH	144
1C1-066	2	3	Haunted Lake	42-59'00"N	71-46'00"W	NH	89
1C1-068	1	3	Lincoln	42-40'10"N	71-54'45"W	MA	118
1C1-070	2	3	Packard Pond	42-38'00"N	72-14'00"W	MA	94
1C1-084	2	3	Upper Beach Pond	43-38'54"N	71-12'15"W	NH	142
1C1-086	2	3	Star Lake	43-27'43"N	72-03'20"W	NH	140
1C2-002	2	3	Iron Pond	45-27'30"N	70-22'30"W	ME	90
1C2-012	2	3	Black Pond	44-08'45"N	70-48'00"W	ME	57
1C2-016	3	3	Trafton Pond	43-50'45"N	70-53'30"W	ME	100
1C2-024	3	3	Lake Waukewan	43-39'30"N	71-31'30"W	NH	95
1C2-028	2	3	Sunset Lake	43-28'15"N	71-18'00"W	NH	76
1C2-035	2	3	Smith Pond	43-09'15"N	72-01'45"W	NH	146
1C2-037	1	3	Mendums Pond	43-10'30"N	71-04'00"W	NH	132
1C2-041	1	3	Juggernaut Pond	42-57'35"N	72-00'45"W	NH	67
1C2-048	2	3	Cranberry Pond	42-44'40"N	73-26'00"W	NY	93
1C2-050	2	3	Moores Pond	42-39'20"N	72-20'50"W	MA	91
1C2-054	1	3	Lake Wampanoag	42-37'02"N	71-57'45"W	MA	88
1C2-056	3	3	Drury Pond	44-42'15"N	70-14'30"W	ME	104
1C2-057	2	3	Babbidge Reservoir	42-56'05"N	72-13'00"W	NH	114
1C2-062	2	3	Lake Pemigewasset	43-36'55"N	71-35'45"W	NH	147
1C2-064	2	3	Hancock Pond	44-57'20"N	69-59'10"W	ME	110
1C2-066	2	3	Turtle Pond	43-15'15"N	71-31'00"W	NH	143
1C2-068	3	3	Quimby Pond	44-59'27"N	70-44'31"W	ME	121
1C3-032	3	3	Bear Pond	44-09'15"N	70-43'00"W	ME	97
1C3-055	1	3	Darrah Pond	42-49'52"N	71-26'40"W	NH	107
1C3-063	3	3	Martin Meadow Pond	44-26'30"N	71-36'30"W	NH	79
1D1-014	3	4	Hamilton Reservoir	42-02'19"N	72-09'16"W	MA	37
1D1-027	2	4	School House Pond	41-24'00"N	71-40'00"W	RI	33
1D1-031	1	4	Kings Pond	41-54'40"N	70-42'15"W	MA	40
1D1-034	1	4	Rocky Pond	41-53'10"N	70-41'45"W	MA	31
1D1-037	1	4	Ezekiel Pond	41-48'15"N	70-36'45"W	MA	133
1D1-046	1	4	Robbins Pond	41-42'20"N	70-06'40"W	MA	122
1D1-054	2	4	Upper Mill Pond	41-43'51"N	70-07'00"W	MA	141
1D1-056	1	4	Little West Pond	41-55'17"N	70-42'24"W	MA	39
1D1-067	1	4	Round Pond	41-58'17"N	71-46'20"W	RI	92
1D1-068	1	4	Little Sandy Pond	41-47'47"N	70-36'13"W	MA	42
1D2-025	2	4	Little Quittacas	41-47'30"N	70-55'00"W	MA	41
1D2-027	1	4	Sandy Pond	41-46'20"N	70-39'15"W	MA	32
1D2-036	1	4	Micah Pond	41-38'20"N	70-22'45"W	MA	134
1D2-049	3	4	Spring Grove Pond	41-54'35"N	71-39'00"W	RI	52
1D2-074	2	4	Stetson Pond	42-01'40"N	70-49'39"W	MA	38
1D2-084	3	4	Goose Pond	41-41'38"N	70-00'28"W	MA	36
1D2-093	3	4	Ashland Reservoir	42-14'22"N	71-27'52"W	MA	46
1D2-094	1	4	Snows Pond	41-45'30"N	70-51'10"W	MA	131
1D3-002	1	4	Dykes Pond	42-36'15"N	70-43'46"W	MA	69
1D3-003	3	4	Sandy Pond	42-33'45"N	71-33'15"W	MA	103
1D3-025	3	4	Long Pond	42-01'15"N	71-49'00"W	CT	127
1D3-026	3	4	Arnold Mill Reservoir	41-59'00"N	71-23'45"W	RI	35
1D3-029	1	4	Killingly Pond	41-51'45"N	71-47'45"W	CT	83
1D3-033	3	4	No Name	41-39'30"N	73-11'30"W	CT	87
1D3-044	2	4	Middle Farm Pond	41-16'30"N	71-58'40"W	NY	45
1E1-009	1	5	Peep Lake	44-54'30"W	67-53'30"W	ME	123
1E1-010	3	5	Six Ponds	46-00'30"N	68-55'30"W	ME	70

Lake Code	Chemistry Cluster	Region	Lake Name	Latitude	Longitude	State	Lake Number
1E1-011	2	5	Fourth Davis	45-15'30"N	69-23'40"W	ME	96
1E1-025	3	5	Bean Pond (Middle)	45-48'45"N	69-11'30"W	ME	116
1E1-040	2	5	Little Greenwood	45-22'00"N	69-24'30"W	ME	99
1E1-050	2	5	Lower Oxbrook Lake	45-17'00"N	67-50'30"W	ME	130
1E1-054	2	5	Duck Lake	45-09'00"N	68-06'00"W	ME	72
1E1-061	2	5	Little Seavey Lake	44-56'15"N	67-38'00"W	ME	135
1E1-062	2	5	Long Pond	44-55'00"N	68-16'11"W	ME	138
1E1-073	2	5	Georges Lake	44-37'00"N	68-14'30"W	ME	101
1E1-074	2	5	Craig Pond	44-35'00"N	68-40'00"W	ME	137
1E1-077	2	5	Parker Pond	44-22'20"N	68-42'30"W	ME	139
1E1-082	2	5	Stephens Pond	44-22'00"N	69-18'00"W	ME	78
1E1-092	2	5	Great Pond	44-36'03"N	68-17'00"W	ME	64
1E1-096	2	5	Middle Chain Lake	45-13'11"N	68-04'45"W	ME	63
1E1-106	2	5	Greenwood Pond	45-32'07"N	69-13'58"W	ME	62
1E1-111	1	5	Long Pond	44-32'02"N	68-10'13"W	ME	136
1E1-120	2	5	No Name	45-27'26"N	68-50'46"W	ME	71
1E1-123	2	5	First Pond	44-22'10"N	68-36'00"W	ME	65
1E2-007	2	5	Fairbanks Pond	44-23'21"N	69-49'52"W	ME	23
1E2-016	3	5	Round Pond	46-14'30"N	69-33'45"W	ME	74
1E2-018	3	5	Webster Lake	46-09'30"N	69-05'00"W	ME	98
1E2-030	3	5	Round Pond	45-01'00"N	67-16'00"W	ME	60
1E2-038	1	5	Nelson Pond	44-24'55"N	70-15'45"W	ME	75
1E2-049	1	5	Gross Pond	44-03'30"N	69-23'35"W	ME	58
1E2-054	3	5	Brettuns Pond	44-23'30"N	70-15'00"W	ME	145
1E2-056	2	5	Peabody Pond	43-56'32"N	70-41'13"W	ME	102
1E2-063	2	5	Kalers Pond	44-06'29"N	69-25'22"W	ME	68
1E3-022	3	5	Number Nine Lake	46-25'00"N	68-03'00"W	ME	124
1E3-041	3	5	Round Pond	44-44'20"N	69-13'30"W	ME	59
1E3-042	3	5	Sand Pond	44-34'10"N	70-07'10"W	ME	66
1E3-045	3	5	McClure Pond	44-29'00"N	68-57'50"W	ME	73
1E3-055	3	5	Togue Pond	46-56'02"N	68-53'31"W	ME	50
1E3-060	3	5	Millinocket Lake	46-18'10"N	68-52'30"W	ME	115

APPENDIX B

Codes for Genera Used in Generic Analyses

Rotifers:

R1	Keratella
R2	Kellicottia
R3	Trichocerca
R4	Gastropus
R5	Ascomorpha
R6	Asplanchna
R7	Polyarthra
R8	Synchaeta
R9	Ploesoma
R10	Filinia
R11	Hexarthra
R12	Conochilus
R13	Conochiloides
R14	Collothea

Cladocera:

CL1	Leptodora
CL2	Diaphanosoma
CL3	Sida
CL4	Holopedium
CL5	Bosmina
CL6	Eubosmina
CL7	Chydorus
CL8	Polyphemus
CL9	Daphnia pulex, Daphnia catawba, and related species
CL10	Daphnia galeata and related species
CL11	Daphnia parvula, Daphnia retrocurva, and related species
CL12	Ceriodaphnia

Calanoid Copepods:

COP1	Epischura
COP2	Aglaodiaptomus
COP3	Leptodiaptomus
COP4	Skistodiaptomus
COP5	Onychodiaptomus

Cyclopoid Copepods:

COP6	Mesocyclops
COP7	Tropocyclops
COP8	Cyclops
COP9	Orthocyclops
COP10	Eucyclops
COP11	Ectocyclops
COP12	Macrocyclops

Size Codes

Code		Size (mm)	
01	----------	< 0.1	
02	----------	0.1 - 0.2	
03	----------	0.2 - 0.3	
04	----------	0.3 - 0.4	
05	----------	0.4 - 0.5	
06	----------	0.5 - 0.6	0.1 mm intervals
07	----------	0.6 - 0.7	
08	----------	0.7 - 0.8	
09	----------	0.8 - 0.9	
10	----------	0.9 - 1.0	

11	----------	1.0 - 1.2	
12	----------	1.2 - 1.4	
13	----------	1.4 - 1.6	
14	----------	1.6 - 1.8	
15	----------	1.8 - 2.0	
16	----------	2.0 - 2.2	
17	----------	2.2 - 2.4	
18	----------	2.4 - 2.6	
19	----------	2.6 - 2.8	
20	----------	2.8 - 3.0	0.2 mm intervals
25	----------	3.8 - 4.0	
30	----------	4.8 - 5.0	
35	----------	5.8 - 6.0	
40	----------	6.8 - 7.0	
45	----------	7.8 - 8.0	
50	----------	8.8 - 9.0	

51	----------	9.0 - 10.0	
52	----------	10.0 - 11.0	
53	----------	11.0 - 12.0	
54	----------	12.0 - 13.0	
55	----------	13.0 - 14.0	
60	----------	18.0 - 19.0	1.0 mm intervals
70	----------	28 - 29	
80	----------	38 - 39	
90	----------	48 - 49	
99	----------	57 - 58	----------

APPENDIX C

Formats of SAS Files

Contents of SAS Member EPAZOOP.EPATSPE

Number of Observations: 13,652 Number of Variables: 4
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
2	JARID	NUM	8	8
1	LAKEID	NUM	8	0
4	RDENSITY	NUM	8	24
3	SPECCD	NUM	8	16

Contents of SAS Member EPAZOOP.EPASP

Number of Observations: 491 Number of Variables: 145
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
2	CHEMGRP	NUM	8	8
3	JARID	NUM	8	16
1	LAKEID	NUM	8	0
4	RD1000	NUM	8	24
5	RD1001	NUM	8	32
6	RD1002	NUM	8	40
7	RD1003	NUM	8	48
8	RD1004	NUM	8	56
9	RD1005	NUM	8	64
10	RD1006	NUM	8	72
11	RD1007	NUM	8	80
12	RD1008	NUM	8	88
13	RD1009	NUM	8	96
14	RD1010	NUM	8	104
15	RD1011	NUM	8	112
16	RD1030	NUM	8	120
17	RD1031	NUM	8	128
18	RD1040	NUM	8	136
19	RD1041	NUM	8	144
20	RD1050	NUM	8	152
21	RD1051	NUM	8	160
22	RD1060	NUM	8	168
23	RD1070	NUM	8	176
24	RD1101	NUM	8	184
25	RD1102	NUM	8	192
26	RD1103	NUM	8	200
27	RD1104	NUM	8	208
28	RD1105	NUM	8	216
29	RD1110	NUM	8	224
30	RD1400	NUM	8	232
31	RD1401	NUM	8	240
32	RD1402	NUM	8	248
33	RD1403	NUM	8	256
34	RD1404	NUM	8	264
35	RD1405	NUM	8	272
36	RD1406	NUM	8	280
37	RD1407	NUM	8	288
38	RD1500	NUM	8	296
39	RD1501	NUM	8	304
40	RD1510	NUM	8	312
41	RD1511	NUM	8	320
42	RD1512	NUM	8	328
43	RD1800	NUM	8	336

Number of Observations: 491
MEMTYPE: Data

Number of Variables: 145

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
44	RD1809	NUM	8	344
45	RD1900	NUM	8	352
46	RD1901	NUM	8	360
47	RD1902	NUM	8	368
48	RD1903	NUM	8	376
49	RD1904	NUM	8	384
50	RD1910	NUM	8	392
51	RD1911	NUM	8	400
52	RD1912	NUM	8	408
53	RD1921	NUM	8	416
54	RD1922	NUM	8	424
55	RD1923	NUM	8	432
56	RD1924	NUM	8	440
57	RD2100	NUM	8	448
58	RD2101	NUM	8	456
59	RD2102	NUM	8	464
60	RD2200	NUM	8	472
61	RD2300	NUM	8	480
62	RD2301	NUM	8	488
63	RD2310	NUM	8	496
64	RD2311	NUM	8	504
65	RD3100	NUM	8	512
66	RD3101	NUM	8	520
67	RD3300	NUM	8	528
68	RD4100	NUM	8	536
69	RD5101	NUM	8	544
70	RD5102	NUM	8	552
71	RD5110	NUM	8	560
72	RD5201	NUM	8	568
73	RD5301	NUM	8	576
74	RD5310	NUM	8	584
75	RD5311	NUM	8	592
76	RD5312	NUM	8	600
77	RD5501	NUM	8	608
78	RD5502	NUM	8	616
79	RD5509	NUM	8	624
80	RD5510	NUM	8	632
81	RD5511	NUM	8	640
82	RD5512	NUM	8	648
83	RD5513	NUM	8	656
84	RD5519	NUM	8	664
85	RD5520	NUM	8	672
86	RD5530	NUM	8	680

Contents of SAS Member EPAZOOP.EPASP (continued)

Number of Observations: 491 Number of Variables: 145
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
87	RD5540	NUM	8	688
88	RD5550	NUM	8	696
89	RD5560	NUM	8	704
90	RD5600	NUM	8	712
91	RD5701	NUM	8	720
92	RD5702	NUM	8	728
93	RD5703	NUM	8	736
94	RD5704	NUM	8	744
95	RD5705	NUM	8	752
96	RD5706	NUM	8	760
97	RD5707	NUM	8	768
98	RD5708	NUM	8	776
99	RD5709	NUM	8	784
100	RD5710	NUM	8	792
101	RD5801	NUM	8	800
102	RD5802	NUM	8	808
103	RD5803	NUM	8	816
104	RD5804	NUM	8	824
105	RD5805	NUM	8	832
106	RD5809	NUM	8	840
107	RD6300	NUM	8	848
108	RD6301	NUM	8	856
109	RD6309	NUM	8	864
110	RD6401	NUM	8	872
111	RD6402	NUM	8	880
112	RD6411	NUM	8	888
113	RD6412	NUM	8	896
114	RD6421	NUM	8	904
115	RD6422	NUM	8	912
116	RD6423	NUM	8	920
117	RD6429	NUM	8	928
118	RD6431	NUM	8	936
119	RD6500	NUM	8	944
120	RD7100	NUM	8	952
121	RD7101	NUM	8	960
122	RD7110	NUM	8	968
123	RD7111	NUM	8	976
124	RD7112	NUM	8	984
125	RD7121	NUM	8	992
126	RD7122	NUM	8	1000
127	RD7123	NUM	8	1008
128	RD7124	NUM	8	1016
129	RD7129	NUM	8	1024

Contents of SAS Member EPAZOOP.EPASP (continued)

Number of Observations: 491 Number of Variables: 145
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
130	RD7131	NUM	8	1032
131	RD7141	NUM	8	1040
132	RD7142	NUM	8	1048
133	RD7143	NUM	8	1056
134	RD7144	NUM	8	1064
135	RD7160	NUM	8	1072
136	RD7200	NUM	8	1080
137	RD7500	NUM	8	1088
138	RD8000	NUM	8	1096
139	RD9100	NUM	8	1104
140	RD9101	NUM	8	1112
141	RD9102	NUM	8	1120
142	RD9199	NUM	8	1128
143	RD9200	NUM	8	1136
144	RD9201	NUM	8	1144
145	RD9300	NUM	8	1152

Contents of SAS Member EPAZOOP.EPASPAR

Number of Observations: 491 Number of Variables: 289
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
2	CHEMGRP	NUM	8	8
289	I	NUM	8	2304
3	JARID	NUM	8	16
1	LAKEID	NUM	8	0
146	PRAR1	NUM	8	1160
147	PRAR2	NUM	8	1168
148	PRAR3	NUM	8	1176
149	PRAR4	NUM	8	1184
150	PRAR5	NUM	8	1192
151	PRAR6	NUM	8	1200
152	PRAR7	NUM	8	1208
153	PRAR8	NUM	8	1216
154	PRAR9	NUM	8	1224
155	PRAR10	NUM	8	1232
156	PRAR11	NUM	8	1240
157	PRAR12	NUM	8	1248
158	PRAR13	NUM	8	1256
159	PRAR14	NUM	8	1264
160	PRAR15	NUM	8	1272
161	PRAR16	NUM	8	1280
162	PRAR17	NUM	8	1288
163	PRAR18	NUM	8	1296
164	PRAR19	NUM	8	1304
165	PRAR20	NUM	8	1312
166	PRAR21	NUM	8	1320
167	PRAR22	NUM	8	1328
168	PRAR23	NUM	8	1336
169	PRAR24	NUM	8	1344
170	PRAR25	NUM	8	1352
171	PRAR26	NUM	8	1360
172	PRAR27	NUM	8	1368
173	PRAR28	NUM	8	1376
174	PRAR29	NUM	8	1384
175	PRAR30	NUM	8	1392
176	PRAR31	NUM	8	1400
177	PRAR32	NUM	8	1408
178	PRARR33	NUM	8	1416
179	PRAR34	NUM	8	1424
180	PRAR35	NUM	8	1432
181	PRAR36	NUM	8	1440
182	PRAR37	NUM	8	1448
183	PRAR38	NUM	8	1456
184	PRAR39	NUM	8	1464

Number of Observations: 491
MEMTYPE: Data

Number of Variables: 289

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
185	PRAR40	NUM	8	1472
186	PRAR41	NUM	8	1480
187	PRAR42	NUM	8	1488
188	PRAR43	NUM	8	1496
189	PRAR44	NUM	8	1504
190	PRAR45	NUM	8	1512
191	PRAR46	NUM	8	1520
192	PRAR47	NUM	8	1528
193	PRAR48	NUM	8	1536
194	PRAR49	NUM	8	1544
195	PRAR50	NUM	8	1552
196	PRAR51	NUM	8	1560
197	PRAR52	NUM	8	1568
198	PRAR53	NUM	8	1576
199	PRAR54	NUM	8	1584
200	PRAR55	NUM	8	1592
201	PRAR56	NUM	8	1600
202	PRAR57	NUM	8	1608
203	PRAR58	NUM	8	1616
204	PRAR59	NUM	8	1624
205	PRAR60	NUM	8	1632
206	PRAR61	NUM	8	1640
207	PRAR62	NUM	8	1648
208	PRAR63	NUM	8	1656
209	PRAR64	NUM	8	1664
210	PRAR65	NUM	8	1672
211	PRAR66	NUM	8	1680
212	PRAR67	NUM	8	1688
213	PRAR68	NUM	8	1696
214	PRAR69	NUM	8	1704
215	PRAR70	NUM	8	1712
216	PRAR71	NUM	8	1720
217	PRAR72	NUM	8	1728
218	PRAR73	NUM	8	1736
219	PRAR74	NUM	8	1744
220	PRAR75	NUM	8	1752
221	PRAR76	NUM	8	1760
222	PRAR77	NUM	8	1768
223	PRAR78	NUM	8	1776
224	PRAR79	NUM	8	1784
225	PRAR80	NUM	8	1792
226	PRAR81	NUM	8	1800
227	PRAR82	NUM	8	1808

Number of Observations: 491 Number of Variables: 289
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
228	PRAR83	NUM	8	1816
229	PRAR84	NUM	8	1824
230	PRAR85	NUM	8	1832
231	PRAR86	NUM	8	1840
232	PRAR87	NUM	8	1848
233	PRAR88	NUM	8	1856
234	PRAR89	NUM	8	1864
235	PRAR90	NUM	8	1872
236	PRAR91	NUM	8	1880
237	PRAR92	NUM	8	1888
238	PRAR93	NUM	8	1896
239	PRAR94	NUM	8	1904
240	PRAR95	NUM	8	1912
241	PRAR96	NUM	8	1920
242	PRAR97	NUM	8	1928
243	PRAR98	NUM	8	1936
244	PRAR99	NUM	8	1944
245	PRAR100	NUM	8	1952
246	PRAR101	NUM	8	1960
247	PRAR102	NUM	8	1968
248	PRAR103	NUM	8	1976
249	PRAR104	NUM	8	1984
250	PRAR105	NUM	8	1992
251	PRAR106	NUM	8	2000
252	PRAR107	NUM	8	2008
253	PRAR108	NUM	8	2016
254	PRAR109	NUM	8	2024
255	PRAR110	NUM	8	2032
256	PRAR111	NUM	8	2040
257	PRAR112	NUM	8	2048
258	PRAR113	NUM	8	2056
259	PRRAR114	NUM	8	2064
260	PRAR115	NUM	8	2072
261	PRAR116	NUM	8	2080
262	PRAR117	NUM	8	2088
263	PRAR118	NUM	8	2096
264	PRAR119	NUM	8	2104
265	PRAR120	NUM	8	2112
266	PRAR121	NUM	8	2120
267	PRAR122	NUM	8	2128
268	PRAR123	NUM	8	2136
269	PRAR124	NUM	8	2144
270	PRAR125	NUM	8	2152

Number of Observations: 491 Number of Variables: 289
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
271	PRAR126	NUM	8	2160
272	PRAR127	NUM	8	2168
273	PRAR128	NUM	8	2176
274	PRAR129	NUM	8	2184
275	PRAR130	NUM	8	2192
276	PRAR131	NUM	8	2200
277	PRAR132	NUM	8	2208
278	PRAR133	NUM	8	2216
279	PRAR134	NUM	8	2224
280	PRAR135	NUM	8	2232
281	PRAR136	NUM	8	2240
282	PRAR137	NUM	8	2248
283	PRAR138	NUM	8	2256
284	PRAR139	NUM	8	2264
285	PRAR140	NUM	8	2272
286	PRAR141	NUM	8	2280
287	PRAR142	NUM	8	2288
4	RDAR1	NUM	8	24
5	RDAR2	NUM	8	32
6	RDAR3	NUM	8	40
7	RDAR4	NUM	8	48
8	RDAR5	NUM	8	56
9	RDAR6	NUM	8	64
10	RDAR7	NUM	8	72
11	RDAR8	NUM	8	80
12	RDAR9	NUM	8	88
13	RDAR10	NUM	8	96
14	RDAR11	NUM	8	104
15	RDAR12	NUM	8	112
16	RDAR13	NUM	8	120
17	RDAR14	NUM	8	128
18	RDAR15	NUM	8	136
19	RDAR16	NUM	8	144
20	RDAR17	NUM	8	152
21	RDAR18	NUM	8	160
22	RDAR19	NUM	8	168
23	RDAR20	NUM	8	176
24	RDAR21	NUM	8	184
25	RDAR22	NUM	8	192
26	RDAR23	NUM	8	200
27	RDAR24	NUM	8	208
28	RDAR25	NUM	8	216
29	RDAR26	NUM	8	224

Contents of SAS Member EPAZOOP.EPASPAR (continued)

Number of Observations: 491 Number of Variables: 289
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
30	RDAR27	NUM	8	232
31	RDAR28	NUM	8	240
32	RDAR29	NUM	8	248
33	RDAR30	NUM	8	256
34	RDAR31	NUM	8	264
35	RDAR32	NUM	8	272
36	RDAR33	NUM	8	280
37	RDAR34	NUM	8	288
38	RDAR35	NUM	8	296
39	RDAR36	NUM	8	304
40	RDAR37	NUM	8	312
41	RDAR38	NUM	8	320
42	RDAR39	NUM	8	328
43	RDAR40	NUM	8	336
44	RDAR41	NUM	8	344
45	RDAR42	NUM	8	352
46	RDAR43	NUM	8	360
47	RDAR44	NUM	8	368
48	RDAR45	NUM	8	376
49	RDAR46	NUM	8	384
50	RDAR47	NUM	8	392
51	RDAR48	NUM	8	400
52	RDAR49	NUM	8	408
53	RDAR50	NUM	8	416
54	RDAR51	NUM	8	424
55	RDAR52	NUM	8	432
56	RDAR53	NUM	8	440
57	RDAR54	NUM	8	448
58	RDAR55	NUM	8	456
59	RDAR56	NUM	8	464
60	RDAR57	NUM	8	472
61	RDAR58	NUM	8	480
62	RDAR59	NUM	8	488
63	RDAR60	NUM	8	496
64	RDAR61	NUM	8	504
65	RDAR62	NUM	8	512
66	RDAR63	NUM	8	520
67	RDAR64	NUM	8	528
68	RDAR65	NUM	8	536
69	RDAR66	NUM	8	544
70	RDAR67	NUM	8	552
71	RDAR68	NUM	8	560
72	RDAR69	NUM	8	568

Contents of SAS Member EPAZOOP.EPASPAR (continued)

Number of Observations: 491 Number of Variables: 289
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
73	RDAR70	NUM	8	576
74	RDAR71	NUM	8	584
75	RDAR72	NUM	8	592
76	RDAR73	NUM	8	600
77	RDAR74	NUM	8	608
78	RDAR75	NUM	8	616
79	RDAR76	NUM	8	624
80	RDAR77	NUM	8	632
81	RDAR78	NUM	8	640
82	RDAR79	NUM	8	648
83	RDAR80	NUM	8	656
84	RDAR81	NUM	8	664
85	RDAR82	NUM	8	672
86	RDAR83	NUM	8	680
87	RDAR84	NUM	8	688
88	RDAR85	NUM	8	696
89	RDAR86	NUM	8	704
90	RDAR87	NUM	8	712
91	RDAR88	NUM	8	720
92	RDAR89	NUM	8	728
93	RDAR90	NUM	8	736
94	RDAR91	NUM	8	744
95	RDAR92	NUM	8	752
96	RDAR93	NUM	8	760
97	RDAR94	NUM	8	768
98	RDAR95	NUM	8	776
99	RDAR96	NUM	8	784
100	RDAR97	NUM	8	792
101	RDAR98	NUM	8	800
102	RDAR99	NUM	8	808
103	RDAR100	NUM	8	816
104	RDAR101	NUM	8	824
105	RDAR102	NUM	8	832
106	RDAR103	NUM	8	840
107	RDAR104	NUM	8	848
108	RDAR105	NUM	8	856
109	RDAR106	NUM	8	864
110	RDAR107	NUM	8	872
111	RDAR108	NUM	8	880
112	RDAR109	NUM	8	888
113	RDAR110	NUM	8	896
114	RDAR111	NUM	8	904
115	RDAR112	NUM	8	912

Contents of SAS Member EPAZOOP.EPASPAR (continued)

Number of Observations: 491 Number of Variables: 289
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
116	RDAR113	NUM	8	920
117	RDAR114	NUM	8	928
118	RDAR115	NUM	8	936
119	RDAR116	NUM	8	944
120	RDAR117	NUM	8	952
121	RDAR118	NUM	8	960
122	RDAR119	NUM	8	968
123	RDAR120	NUM	8	976
124	RDAR121	NUM	8	984
125	RDAR122	NUM	8	992
126	RDAR123	NUM	8	1000
127	RDAR124	NUM	8	1008
128	RDAR125	NUM	8	1016
129	RDAR126	NUM	8	1024
130	RDAR127	NUM	8	1032
131	RDAR128	NUM	8	1040
132	RDAR129	NUM	8	1048
133	RDAR130	NUM	8	1056
134	RDAR131	NUM	8	1064
135	RDAR132	NUM	8	1072
136	RDAR133	NUM	8	1080
137	RDAR134	NUM	8	1088
138	RDAR135	NUM	8	1096
139	RDAR136	NUM	8	1104
140	RDAR137	NUM	8	1112
141	RDAR138	NUM	8	1120
142	RDAR139	NUM	8	1128
143	RDAR140	NUM	8	1136
144	RDAR141	NUM	8	1144
145	RDAR142	NUM	8	1152
288	RDTOTAL	NUM	8	2296

Contents of SAS Member EPAZOOP.EPAMSPAR

Number of Observations: 147 Number of Variables: 286
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
2	CHEMGRP	NUM	8	8
1	LAKEID	NUM	8	0
145	PRAR1	NUM	8	1152
146	PRAR2	NUM	8	1160
147	PRAR3	NUM	8	1168
148	PRAR4	NUM	8	1176
149	PRAR5	NUM	8	1184
150	PRAR6	NUM	8	1192
151	PRAR7	NUM	8	1200
152	PRAR8	NUM	8	1208
153	PRAR9	NUM	8	1216
154	PRAR10	NUM	8	1224
155	PRAR11	NUM	8	1232
156	PRAR12	NUM	8	1240
157	PRAR13	NUM	8	1248
158	PRAR14	NUM	8	1256
159	PRAR15	NUM	8	1264
160	PRAR16	NUM	8	1272
161	PRAR17	NUM	8	1280
162	PRAR18	NUM	8	1288
163	PRAR19	NUM	8	1296
164	PRAR20	NUM	8	1304
165	PRAR21	NUM	8	1312
166	PRAR22	NUM	8	1320
167	PRAR23	NUM	8	1328
168	PRAR24	NUM	8	1336
169	PRAR25	NUM	8	1344
170	PRAR26	NUM	8	1352
171	PRAR27	NUM	8	1360
172	PRAR28	NUM	8	1368
173	PRAR29	NUM	8	1376
174	PRAR30	NUM	8	1384
175	PRAR31	NUM	8	1392
176	PRAR32	NUM	8	1400
177	PRAR33	NUM	8	1408
178	PRAR34	NUM	8	1416
179	PRAR35	NUM	8	1424
180	PRAR36	NUM	8	1432
181	PRAR37	NUM	8	1440
182	PRAR38	NUM	8	1448
183	PRAR39	NUM	8	1456
184	PRAR40	NUM	8	1464
185	PRAR41	NUM	8	1472

Contents of SAS Member EPAZOOP.EPAMSPAR (continued)

Number of Observations: 147 Number of Variables: 286
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
186	PRAR42	NUM	8	1480
187	PRAR43	NUM	8	1488
188	PRAR44	NUM	8	1496
189	PRAR45	NUM	8	1504
190	PRAR46	NUM	8	1512
191	PRAR47	NUM	8	1520
192	PRAR48	NUM	8	1528
193	PRAR49	NUM	8	1536
194	PRAR50	NUM	8	1544
195	PRAR51	NUM	8	1552
196	PRAR52	NUM	8	1560
197	PRAR53	NUM	8	1568
198	PRAR54	NUM	8	1576
199	PRAR55	NUM	8	1584
200	PRAR56	NUM	8	1592
201	PRAR57	NUM	8	1600
202	PRAR58	NUM	8	1608
203	PRAR59	NUM	8	1616
204	PRAR60	NUM	8	1624
205	PRAR61	NUM	8	1632
206	PRAR62	NUM	8	1640
207	PRAR63	NUM	8	1648
208	PRAR64	NUM	8	1656
209	PRAR65	NUM	8	1664
210	PRAR66	NUM	8	1672
211	PRAR67	NUM	8	1680
212	PRAR68	NUM	8	1688
213	PRAR69	NUM	8	1696
214	PRAR70	NUM	8	1704
215	PRAR71	NUM	8	1712
216	PRAR72	NUM	8	1720
217	PRAR73	NUM	8	1728
218	PRAR74	NUM	8	1736
219	PRAR75	NUM	8	1744
220	PRAR76	NUM	8	1752
221	PRAR77	NUM	8	1760
222	PRAR78	NUM	8	1768
223	PRAR79	NUM	8	1776
224	PRAR80	NUM	8	1784
225	PRAR81	NUM	8	1792
226	PRAR82	NUM	8	1800
227	PRAR83	NUM	8	1808
228	PRAR84	NUM	8	1816

Contents of SAS Member EPAZOOP.EPAMSPAR (continued)

Number of Observations: 147 Number of Variables: 286
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
229	PRAR85	NUM	8	1824
230	PRAR86	NUM	8	1832
231	PRAR87	NUM	8	1840
232	PRAR88	NUM	8	1848
233	PRAR89	NUM	8	1856
234	PRAR90	NUM	8	1864
235	PRAR91	NUM	8	1872
236	PRAR92	NUM	8	1880
237	PRAR93	NUM	8	1888
238	PRAR94	NUM	8	1896
239	PRAR95	NUM	8	1904
240	PRAR96	NUM	8	1912
241	PRAR97	NUM	8	1920
242	PRAR98	NUM	8	1928
243	PRAR99	NUM	8	1936
244	PRAR100	NUM	8	1944
245	PRAR101	NUM	8	1952
246	PRAR102	NUM	8	1960
247	PRAR103	NUM	8	1968
248	PRAR104	NUM	8	1976
249	PRAR105	NUM	8	1984
250	PRAR106	NUM	8	1992
251	PRAR107	NUM	8	2000
252	PRAR108	NUM	8	2008
253	PRAR109	NUM	8	2016
254	PRAR110	NUM	8	2024
255	PRAR111	NUM	8	2032
256	PRAR112	NUM	8	2040
257	PRAR113	NUM	8	2048
258	PRAR114	NUM	8	2056
259	PRAR115	NUM	8	2064
260	PRAR116	NUM	8	2072
261	PRAR117	NUM	8	2080
262	PRAR118	NUM	8	2088
263	PRAR119	NUM	8	2096
264	PRAR120	NUM	8	2104
265	PRAR121	NUM	8	2112
266	PRAR122	NUM	8	2120
267	PRAR123	NUM	8	2128
268	PRAR124	NUM	8	2136
269	PRAR125	NUM	8	2144
270	PRAR126	NUM	8	2152
271	PRAR127	NUM	8	2160

Contents of SAS Member EPAZOOP.EPAMSPAR (continued)

Number of Observations: 147 Number of Variables: 286
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
272	PRAR128	NUM	8	2168
273	PRAR129	NUM	8	2176
274	PRAR130	NUM	8	2184
275	PRAR131	NUM	8	2192
276	PRAR132	NUM	8	2200
277	PRAR133	NUM	8	2208
278	PRAR134	NUM	8	2216
279	PRAR135	NUM	8	2224
280	PRAR136	NUM	8	2232
281	PRAR137	NUM	8	2240
282	PRAR138	NUM	8	2248
283	PRAR139	NUM	8	2256
284	PRAR140	NUM	8	2264
285	PRAR141	NUM	8	2272
286	PRAR142	NUM	8	2280
3	RDAR1	NUM	8	16
4	RDAR2	NUM	8	24
5	RDAR3	NUM	8	32
6	RDAR4	NUM	8	40
7	RDAR5	NUM	8	48
8	RDAR6	NUM	8	56
9	RDAR7	NUM	8	64
10	RDAR8	NUM	8	72
11	RDAR9	NUM	8	80
12	RDAR10	NUM	8	88
13	RDAR11	NUM	8	96
14	RDAR12	NUM	8	104
15	RDAR13	NUM	8	112
16	RDAR14	NUM	8	120
17	RDAR15	NUM	8	128
18	RDAR16	NUM	8	136
19	RDAR17	NUM	8	144
20	RDAR18	NUM	8	152
21	RDAR19	NUM	8	169
22	RDAR20	NUM	8	168
23	RDAR21	NUM	8	176
24	RDAR22	NUM	8	184
25	RDAR23	NUM	8	192
26	RDAR24	NUM	8	200
27	RDAR25	NUM	8	208
28	RDAR26	NUM	8	216
29	RDAR27	NUM	8	224
30	RDAR28	NUM	8	232

Contents of SAS Member EPAZOOP.EPAMSPAR (continued)

Number of Observations: 147 Number of Variables: 286
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
31	RDAR29	NUM	8	240
32	RDAR30	NUM	8	248
33	RDAR31	NUM	8	256
34	RDAR32	NUM	8	264
35	RDAR33	NUM	8	272
36	RDAR34	NUM	8	280
37	RDAR35	NUM	8	288
38	RDAR36	NUM	8	296
39	RDAR37	NUM	8	304
40	RDAR38	NUM	8	312
41	RDAR39	NUM	8	320
42	RDAR40	NUM	8	328
43	RDAR41	NUM	8	336
44	RDAR42	NUM	8	344
45	RDAR43	NUM	8	352
46	RDAR44	NUM	8	360
47	RDAR45	NUM	8	368
48	RDAR46	NUM	8	376
49	RDAR47	NUM	8	384
50	RDAR48	NUM	8	392
51	RDAR49	NUM	8	400
52	RDAR50	NUM	8	408
53	RDAR51	NUM	8	416
54	RDAR52	NUM	8	424
55	RDAR53	NUM	8	432
56	RDAR54	NUM	8	440
57	RDAR55	NUM	8	448
58	RDAR56	NUM	8	456
59	RDAR57	NUM	8	464
60	RDAR58	NUM	8	472
61	RDAR59	NUM	8	480
62	RDAR60	NUM	8	488
63	RDAR61	NUM	8	496
64	RDAR62	NUM	8	504
65	RDAR63	NUM	8	512
66	RDAR64	NUM	8	520
67	RDAR65	NUM	8	528
68	RDAR66	NUM	8	536
69	RDAR67	NUM	8	544
70	RDAR68	NUM	8	552
71	RDAR69	NUM	8	560
72	RDAR70	NUM	8	568
73	RDAR71	NUM	8	576

Number of Observations: 147 Number of Variables: 286
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
74	RDAR72	NUM	8	584
75	RDAR73	NUM	8	592
76	RDAR74	NUM	8	600
77	RDAR75	NUM	8	608
78	RDAR76	NUM	8	616
79	RDAR77	NUM	8	624
80	RDAR78	NUM	8	632
81	RDAR79	NUM	8	640
82	RDAR80	NUM	8	648
83	RDAR81	NUM	8	656
84	RDAR82	NUM	8	664
85	RDAR83	NUM	8	672
86	RDAR84	NUM	8	680
87	RDAR85	NUM	8	688
88	RDAR86	NUM	8	696
89	RDAR87	NUM	8	704
90	RDAR88	NUM	8	712
91	RDAR89	NUM	8	720
92	RDAR90	NUM	8	728
93	RDAR91	NUM	8	736
94	RDAR92	NUM	8	744
95	RDAR93	NUM	8	752
96	RDAR94	NUM	8	760
97	RDAR95	NUM	8	768
98	RDAR96	NUM	8	776
99	RDAR97	NUM	8	784
100	RDAR98	NUM	8	792
101	RDAR99	NUM	8	800
102	RDAR100	NUM	8	808
103	RDAR101	NUM	8	816
104	RDAR102	NUM	8	824
105	RDAR103	NUM	8	832
106	RDAR104	NUM	8	840
107	RDAR105	NUM	8	848
108	RDAR106	NUM	8	856
109	RDAR107	NUM	8	864
110	RDAR108	NUM	8	872
111	RDAR109	NUM	8	880
112	RDAR110	NUM	8	888
113	RDAR111	NUM	8	896
114	RDAR112	NUM	8	904
115	RDAR113	NUM	8	912
116	RDAR114	NUM	8	920

Number of Observations: 147 Number of Variables: 286
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position
117	RDAR115	NUM	8	928
118	RDAR116	NUM	8	936
119	RDAR117	NUM	8	944
120	RDAR118	NUM	8	952
121	RDAR119	NUM	8	960
122	RDAR120	NUM	8	968
123	RDAR121	NUM	8	976
124	RDAR122	NUM	8	984
125	RDAR123	NUM	8	992
126	RDAR124	NUM	8	1000
127	RDAR125	NUM	8	1008
128	RDAR126	NUM	8	1016
129	RDAR127	NUM	8	1024
130	RDAR128	NUM	8	1032
131	RDAR129	NUM	8	1040
132	RDAR130	NUM	8	1048
133	RDAR131	NUM	8	1056
134	RDAR132	NUM	8	1064
135	RDARR133	NUM	8	1072
136	RDAR134	NUM	8	1080
137	RDAR135	NUM	8	1088
138	RDAR136	NUM	8	1096
139	RDAR137	NUM	8	1104
140	RDAR138	NUM	8	1112
141	RDAR139	NUM	8	1120
142	RDAR140	NUM	8	1128
143	RDAR141	NUM	8	1136
144	RDAR142	NUM	8	1144

Contents of SAS Member EPAZOOP.EPACGPCA

Number of Observations: 147 Number of Variables: 194
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position	Format	Label
42	ALDI98	NUM	8	354	F8.4	Labile monomeric Al (μg/L)
29	ALKA11	NUM	8	250	F8.1	Alkalinity (μeq/L) form 11
31	ANCAT98	NUM	8	266	F8.4	Cations/Anions ratio
92	BTMP	NUM	8	738		
16	C0151D	NUM	8	146	F8.	Conductivity at 1.5 m (μS/cm) form 11
33	CA98	NUM	8	282	F8.4	Calcium (μeq/L)
108	CHEMGRP	NUM	8	866		
98	CHEMP1	NUM	8	786		
99	CHEMP2	NUM	8	794		
100	CHEMP3	NUM	8	802		
101	CHEMP4	NUM	8	810		
102	CHEMP5	NUM	8	818		
103	CHEMP6	NUM	8	826		
104	CHEMP7	NUM	8	834		
105	CHEMP8	NUM	8	842		
106	CHEMP9	NUM	8	850		
107	CHEMP10	NUM	8	858		
123	CL1	NUM	8	986		
124	CL2	NUM	8	994		
125	CL3	NUM	8	1002		
126	CL4	NUM	8	1010		
127	CL5	NUM	8	1018		
128	CL6	NUM	8	1026		
129	CL7	NUM	8	1034		
130	CL8	NUM	8	1042		
131	CL9	NUM	8	1050		
132	CL10	NUM	8	1058		
133	CL11	NUM	8	1066		
134	CL12	NUM	8	1074		
34	CL98	NUM	8	290	F8.4	Chloride (μeq/L)
55	CLSTR99	NUM	8	446	F8.	Phase II cluster (1, 2, or 3)
24	COLOR02	NUM	8	210	F8.	Color (PCU) form 2
8	CONMH1D	NUM	8	82	F8.	Conductivity at mid-hyp (μS/cm) form 11
12	CON_B1D	NUM	8	114	F8.	Conductivity at btm 1.5 m (μS/cm) form 11
135	COPT	NUM	8	1082		
136	COP2	NUM	8	1090		
137	COP3	NUM	8	1098		
138	COP4	NUM	8	1106		
139	COP5	NUM	8	1114		
140	COP6	NUM	8	1122		
141	COP7	NUM	8	1130		
142	COP8	NUM	8	1138		
143	COP9	NUM	8	1146		
144	COP10	NUM	8	1154		

Contents of SAS Member EPAZOOP.EPACGPCA (continued)

Number of Observations: 147 Number of Variables: 194
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position	Format	Label
145	COP11	NUM	8	1162		
146	COP12	NUM	8	1170		
21	DIC02	NUM	8	186	F8.3	DIC (mg/L) form 2
88	DIFCON	NUM	8	706		
87	DIFDO	NUM	8	698		
59	DIFTMP	NUM	8	474		
44	DISM99	NUM	8	370	F8.	Distance from coast (km)
28	DOC11	NUM	8	242	F8.2	DOC (mg/L) form 11
9	DOMH1D	NUM	8	90	F8.2	Dis. oxygen (mg/L) at mid-hyp form 1D
17	DO_151D	NUM	8	154	F8.2	Dis. oxygen (mg/L) at 1.5 m form 1D
13	DO_B1D	NUM	8	122	F8.2	Dis. oxygen (mg/L) at btm 1.5 m form 1D
57	DPAER	NUM	8	458		
6	DPSIT1D	NUM	8	66	F8.1	Site depth (m) form 1D
26	FE11	NUM	8	226	F8.3	Iron (μg/L) form 11
40	FTL98	NUM	8	338	F8.4	Fluoride (μeq/L)
185	GENP1	NUM	8	1482		
186	GENP2	NUM	8	1490		
187	GENP3	NUM	8	1498		
188	GENP4	NUM	8	1506		
189	GENP5	NUM	8	1514		
190	GENP6	NUM	8	1522		
191	GENP7	NUM	8	1530		
192	GENP8	NUM	8	1538		
193	GENP9	NUM	8	1546		
194	GENP10	NUM	8	1554		
32	HCO398	NUM	8	274	F8.4	HCO3 (μeq/L)
45	HDEP99	NUM	8	378	F8.3	Hydrogen ion deposition ($g/m^2/yr$)
46	HYTYP99	CHAR	9	386		Hydrologic type
56	INDAER	CHAR	4	454		
37	K98	NUM	8	314	F8.4	Potassium (μeq/L)
5	LAKEID	NUM	8	58		
1	LAKE_ID	CHAR	7	0		Lake identification number
2	LAKNA1D	CHAR	30	7		Lake name form 1D
60	LALDI98	NUM	8	482		
61	LALKA11	NUM	8	490		
62	LANCAT98	NUM	8	498		
3	LAT99	CHAR	10	37		Latitude
48	LATDD99	NUM	8	403	F8.4	Latitude (decimal degrees)
63	LC0151D	NUM	8	506		
64	LCA98	NUM	8	514		
161	LCL1	NUM	8	1290		
162	LCL2	NUM	8	1298		
163	LCL3	NUM	8	1306		
164	LCL4	NUM	8	1314		

Number of Observations: 147 Number of Variables: 194
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position	Format	Label
165	LCL5	NUM	8	1322		
166	LCL6	NUM	8	1330		
167	LCL7	NUM	8	1338		
168	LCL8	NUM	8	1346		
169	LCL9	NUM	8	1354		
170	LCL10	NUM	8	1362		
171	LCL11	NUM	8	1370		
172	LCL12	NUM	8	1378		
65	LCL98	NUM	8	522		
66	LCOLOR02	NUM	8	530		
173	LCOP1	NUM	8	1386		
174	LCOP2	NUM	8	1394		
175	LCOP3	NUM	8	1402		
176	LCOP4	NUM	8	1410		
177	LCOP5	NUM	8	1418		
178	LCOP6	NUM	8	1426		
179	LCOP7	NUM	8	1434		
180	LCOP8	NUM	8	1442		
181	LCOP9	NUM	8	1450		
182	LCOP10	NUM	8	1458		
183	LCOP11	NUM	8	1466		
184	LCOP12	NUM	8	1474		
67	LDIC02	NUM	8	538		
68	LDOC11	NUM	8	546		
69	LDO_151D	NUM	8	554		
90	LDPAER	NUM	8	722		
89	LDPSIT1D	NUM	8	714		
70	LFE11	NUM	8	562		
71	LFTL98	NUM	8	570		
72	LHCO398	NUM	8	578		
73	LHDEP99	NUM	8	586		
74	LK98	NUM	8	594		
47	LKSIZ99	NUM	8	395	F8.2	Lake surface area (ha)
75	LLKSIZ99	NUM	8	602		
76	LMG98	NUM	8	610		
77	LMN11	NUM	8	618		
78	LNA98	NUM	8	626		
49	LNGDD99	NUM	8	411	F8.4	Longitude (decimal degrees)
79	LNH498	NUM	8	634		
80	LN0398	NUM	8	642		
4	LONG99	CHAR	11	47		Longitude
81	LPTL11	NUM	8	650		
147	LR1	NUM	8	1178		

Number of Observations: 147
MEMTYPE: Data

Number of Variables: 194

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position	Format	Label
148	LR2	NUM	8	1186		
149	LR3	NUM	8	1194		
150	LR4	NUM	8	1202		
151	LR5	NUM	8	1210		
152	LR6	NUM	8	1218		
153	LR7	NUM	8	1226		
154	LR8	NUM	8	1234		
155	LR9	NUM	8	1242		
156	LR10	NUM	8	1250		
157	LR11	NUM	8	1258		
158	LR12	NUM	8	1266		
159	LR13	NUM	8	1274		
160	LR14	NUM	8	1282		
82	LSCEME98	NUM	8	658		
83	LSIO211	NUM	8	666		
84	LSO498	NUM	8	674		
85	LT0151D	NUM	8	682		
86	LTUR02	NUM	8	690		
35	MG98	NUM	8	298	F8.4	Magnesium (μeq/L)
25	MN11	NUM	8	218	F8.3	Manganese (μg/L) form 11
38	NA98	NUM	8	322	F8.4	Sodium (μeq/L)
41	NH498	NUM	8	346	F8.4	Ammonium (μeq/L)
36	NO398	NUM	8	306	F8.4	Nitrate (μeq/L)
18	PH0151D	NUM	8	162	F8.2	pH at 1.5 m form 1D
22	PH02	NUM	8	194	F8.2	Station pH form 2
10	PHMH1D	NUM	8	98	F8.2	pH at mid-hyp form 1D
14	PH_B1D	NUM	8	130	F8.2	pH at btm 1.5 m form 1D
93	PRIN31	NUM	8	746		
94	PRIN32	NUM	8	754		
95	PRIN33	NUM	8	762		
96	PRIN34	NUM	8	770		
97	PRIN35	NUM	8	778		
30	PTL11	NUM	8	258	F8.4	Total phosphorus (μg/L) form 11
109	R1	NUM	8	874		
110	R2	NUM	8	882		
111	R3	NUM	8	890		
112	R4	NUM	8	898		
113	R5	NUM	8	906		
114	R6	NUM	8	914		
115	R7	NUM	8	922		
116	R8	NUM	8	930		
117	R9	NUM	8	938		
118	R10	NUM	8	946		
119	R11	NUM	8	954		

Contents of SAS Member EPAZOOP.EPACGPCA (continued)

Number of Observations: 147 Number of Variables: 194
MEMTYPE: Data

Alphabetical List of Variables and Attributes:

#	Variable	Type	Length	Position	Format	Label
120	R12	NUM	8	962		
121	R13	NUM	8	970		
122	R14	NUM	8	978		
58	RANAER	NUM	8	466		
50	RT99	NUM	8	419	F8.3	Residence time (yr)
52	SBRGN99	CHAR	1	429		NSWS subregion
43	SECME98	NUM	8	362	F8.1	Mean: Secchi disk disappear/reappear
27	SIO211	NUM	8	234	F8.3	Silica (mg/L) form 11
20	SITETYP	CHAR	9	177		Sampling site or type code
39	SO498	NUM	8	330	F8.4	Sulfate (μeq/L)
51	ST99	CHAR	2	427		State (2-letter abbreviation)
15	T0151D	NUM	8	138	F8.1	Temperature at 1.5 m (deg C) form 1D
7	TMPMH1D	NUM	8	74	F8.1	Temperature at miid-hyp (deg C) form 1D
11	TMP_B1D	NUM	8	106	F8.1	Temperature at btm 1.5 m (deg C) form 1D
91	TTMP	NUM	8	730		
23	TUR02	NUM	8	202	F8.2	Turbidity (NTU) form 2
53	WALA99	NUM	8	430	F8.2	Watershed area/Lake area
54	WSHED99	NUM	8	438	F8.3	Watershed area (ha)
19	WTRSH_ID	CHAR	7	170		

APPENDIX D

List of All Species and Their Summary Statistics for Abundance (Untransformed) Found in All 147 ELS-II Lakes, and a Separate Listing for Each Chemistry Cluster

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for All ELS-II Lakes			
ROTIFERA						
Keratella earlinae	147	0.07693878	0.66607868	11.3100000	0.443661	865.726
K. cochlearis hispida	147	32.63086168	251.44676749	4796.7366667	63225.476883	770.580
K. crassa	147	104.69653061	344.26949798	15390.3900000	118521.487236	328.826
K. taurocephala	147	119.87917234	400.38988849	17622.2383333	160312.062805	333.995
K. cochlearis-cochlearis	147	34.09519274	147.52463505	5011.9933333	21763.517945	432.685
K. hiemalis	147	0.24732426	1.38745448	36.3566667	1.925030	560.986
K. irregularis	147	0.12619048	1.52997821	18.5500000	2.340833	1212.436
K. ticinensis	147	0.00117914	0.01429629	0.1733333	0.000204	1212.436
Keratella c. robusta	147	0.34467120	4.17891623	50.6666667	17.463341	1212.436
K. serrulata	147	0.00702948	0.08522790	1.0333333	0.007264	1212.436
Kellicottia longispina	147	50.18235828	245.30988902	7376.8066667	60176.941651	488.837
K. bostoniensis	147	36.61841270	150.80251846	5382.9066667	22741.399574	411.822
Notholco labis	147	0.00426304	0.05168660	0.6266667	0.002672	1212.436
N. squamula	147	0.03081633	0.31483962	4.5300000	0.099124	1021.665
Brachionus urceolaris	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
B. quadridentatus	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
Euchlanis dilatata	147	0.61907029	7.47792199	91.0033333	55.919317	1207.928
E. pellucida	147	0.24294785	2.94558609	35.7133333	8.676477	1212.436
Platyias patulus	147	0.02120181	0.23223451	3.1166667	0.053933	1095.352
Mytilina spp.	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
Lecane luna	147	0.18197279	1.64257750	26.7500000	2.698061	902.650
L. flexilis	147	0.02780045	0.24232056	4.0866667	0.058719	871.642
L. mira	147	0.00408163	0.03617309	0.6000000	0.001308	886.241
L. tudicola	147	0.01455782	0.17650423	2.1400000	0.031154	1212.436
L. ungulata	147	0.00759637	0.09210111	1.1166667	0.008483	1212.436
Monostyla lunaris	147	0.12192744	0.96534644	17.9233333	0.931894	791.738
Trichocerca multicrinis	147	17.12256236	65.24811675	2517.0166667	4257.316739	381.065
T. cylindrica	147	22.78113379	80.63220480	3348.8266667	6501.552452	353.943
T. pusilla	147	0.14383220	1.62141417	21.1433333	2.628984	1127.296
T. porcellus	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
T. similis	147	0.00274376	0.03162687	0.4033333	0.001000	1152.682
T. rousseleti	147	0.02929705	0.32491639	4.3066667	0.105571	1109.041
T. lata	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
T. elongata	147	0.04882086	0.36532898	7.1766667	0.133465	748.305
Gastropus hyptopus	147	0.22643991	2.23457478	33.2866667	4.993324	986.829
G. stylifer	147	1.04336735	5.92340972	153.3750000	35.086783	567.720
Ascomorpha ovalis	147	0.23104308	1.73811173	33.9633333	3.021032	752.289
A. saltans	147	0.00573696	0.06161670	0.8433333	0.003797	1074.030
A. ecaudis	147	0.66918367	3.01426291	98.3700000	9.085781	450.439
Asplanchna priodonta	147	9.79875283	38.51315372	1440.4166667	1483.263010	393.041
Asplanchna sp.	147	0.03888889	0.47150272	5.7166667	0.222315	1212.436
Polyarthra vulgaris	147	25.87945578	113.56936812	3804.2800000	12898.001374	438.840
P. euryptera	147	21.27784580	76.79368086	3127.8433333	5897.269420	360.909
P. remata	147	5.82875283	19.15899781	856.8266667	367.067197	328.698
P. major	147	5.70546485	38.59259590	838.7033333	1489.388458	676.415
P. dolichoptera	147	0.01968254	0.23863811	2.8933333	0.056948	1212.436

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for All ELS-II Lakes (continued)			
ROTIFERA (continued)						
Synchaeta pectinata	147	5.03816327	27.08630427	740.6100000	733.667879	537.623
S. kitti	147	0.44950113	3.60722129	66.0766667	13.012045	802.494
S. oblonga	147	0.07605442	0.92211086	11.1800000	0.850288	1212.436
Ploesoma truncatum	147	2.88964853	10.53031322	424.7783333	110.887497	364.415
P. lenticularie	147	0.00260771	0.03161680	0.3833333	0.001000	1212.436
P. hudsoni	147	0.79181406	6.33316663	116.3966667	40.109000	799.830
P. triacanthum	147	0.03077098	0.35896881	4.5233333	0.128859	1166.583
Filinia spp.	147	0.04301587	0.52153974	6.3233333	0.272004	1212.436
F. terminalis	147	1.16809524	13.80585703	171.7100000	190.601688	1181.912
F. longiseta	147	0.43467120	3.07953133	63.8966667	9.483513	708.474
Hexarthra mira	147	22.96557823	254.80250912	3375.9400000	64924.318656	1109.497
Conochilus unicornis	147	86.96866213	689.58796170	12784.3933333	475531.584499	792.915
C. hippocrepis	147	1.60646259	15.59927626	236.1500000	243.337420	971.033
Conochiloides dossarius	147	4.67453515	25.02111786	687.1566667	626.056339	535.264
C. natans	147	17.10789116	196.13713999	2514.8600000	38469.777682	1146.472
Collotheca pelagica	147	0.14986395	1.26842661	22.0300000	1.608906	846.385
C. mutabilis	147	0.57712018	3.54396792	84.8366667	12.559709	614.078
Unidentified rotifera	147	0.02247166	0.17274491	3.3033333	0.029841	768.724
CLADOCERA						
Leptodora kindtii	147	0.03375283	0.20615988	4.9616667	0.042502	610.793
Diaphanosoma birgei	147	29.20301587	74.91000499	4292.8433333	5611.508847	256.515
D. brachyurum	147	0.01514739	0.18365237	2.2266667	0.033728	1212.436
Sida crystallina	147	0.11045351	0.63317814	16.2366667	0.400915	573.253
Holopedium gibberum	147	10.02201814	34.12053368	1473.2366667	1164.210819	340.456
Bosmina longirostris	147	41.31733560	153.65058605	6073.6483333	23608.502592	371.879
Eubosmina hagmann	147	2.88492063	25.48957954	424.0833333	649.718665	883 545
E. tubicen	147	8.73029478	23.90060867	1283.3533333	571.239095	273.766
E. longispina	147	2.90606576	15.04752201	427.1916667	226.427919	517.797
Chydorus brevalibris	147	0.75437642	6.22697502	110.8933333	38.775218	825.447
C. sphaericus	147	0.36419501	3.36616317	53.5366667	11.331055	924.275
Chydorus sp.	147	0.01603175	0.19437459	2.3566667	0.037781	1212.436
Alona setulosa	147	0.00013605	0.00116242	0.0200000	0.000001	854.380
A. guttata	147	0.01034014	0.11106906	1.5200000	0.012336	1074.155
A. circumfimbrata	147	0.00823129	0.09814513	1.2100000	0.009632	1192.342
A. barbula	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
Alona sp.	147	0.02412698	0.17127169	3.5466667	0.029334	709.876
Alonella acutirostris	147	0.04362812	0.52813303	6.4133333	0.278924	1210.534
Kurzia laissima	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
Acroperus harpae	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
Eurycercus lamellatus	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
Graptoleberis testudinaria	147	0.00013605	0.00116242	0.0200000	0.000001	854.380
Polyphemus pediculus	147	0.09213152	0.52438469	13.5433333	0.274979	569.170
Daphnia catawba	147	12.96732426	36.20455688	1906.1966667	1310.769939	279.198
D. galeata mendotae	147	0.61628118	2.96126548	90.5933333	8.769093	480.506
D. rosea	147	0.11981859	1.21808167	17.6133333	1.483723	1016.605
D. ambigua	147	2.21098639	12.16791264	325.0150000	148.058098	550.339
D. pulex	147	0.55009070	3.25837770	80.8633333	10.617025	592.335
D. parvula	147	4.86845805	18.13778087	715.6633333	328.979095	373.557
D. schodleri	147	0.39358277	2.56545153	57.8566667	6.581542	651.820
D. retrocurva	147	0.55569161	4.09927439	81.6866667	16.804051	737.689
D. longiremus	147	0.36111111	3.22096560	53.0833333	10.374619	891.960

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for All ELS-II Lakes (continued)			
CLADOCERA (continued)						
D. dubia	147	0.64962585	3.17405257	95.4950000	10.074610	488.597
Scapholebris mucronata	147	0.01258503	0.15258543	1.8500000	0.023282	1212.436
Ceriodaphnia reticulata	147	0.43185941	2.35642588	63.4833333	5.552743	545.647
C. lacustris	147	0.30224490	3.30437515	44.4300000	10.918895	1093.277
C. affinis/dubia	147	6.05038549	38.12871578	889.4066667	1453.798967	630.187
C. quadrangula	147	1.07138322	12.60907155	157.4933333	158.988685	1176.896
Ceriodaphnia sp.	147	0.00006803	0.00082479	0.0100000	0.000001	1212.436
COPEPODA						
Epischura lacustris	147	0.49113379	2.14340759	72.1966667	4.594196	436.420
E. nordenskioldi	147	0.40180272	1.95729450	59.0650000	3.831002	487.128
Epischura spp.	147	0.01435374	0.13613585	2.1100000	0.018533	948.435
Aglaodiaptomus leptopus	147	0.25773243	1.44454461	37.8866667	2.086709	560.482
A. spatulocrenatus	147	0.95744898	9.20436699	140.7450000	84.720372	961.343
Leptodiaptomus minutus	147	73.73926304	129.40992807	10839.6716667	16746.929482	175.497
L. sicilis	147	0.07256236	0.87977184	10.6666667	0.773998	1212.436
Skistodiaptomus oregonensis	147	0.94816327	4.66587818	139.3800000	21.770419	492.096
S. reighhardi	147	3.09308390	28.50755876	454.6833333	812.680906	921.655
S. pygmaeus	147	6.41460317	22.37350552	942.9466667	500.573749	348.790
Skistodiaptomus spp.	147	0.60072562	6.70326279	88.3066667	44.933732	1115.861
Onychodiaptomus birgei	147	0.36589569	3.43794519	53.7866667	11.819467	939.597
Unknown sp. calanoida	147	0.04036281	0.37774830	5.9333333	0.142694	935.882
Tropocyclops sp. 1	147	0.01365079	0.16550708	2.0066667	0.207393	1212.436
Mesocyclops edax	147	27.21916100	55.05663125	4001.2166667	3031.232645	202.272
Tropocyclops sp. 2	147	0.05414966	0.65652973	7.9600000	0.431031	1212.436
T. prasinus-mexicanus	147	17.58734694	47.98196678	2585.3400000	2302.269136	272.821
T. prasinus	147	11.23541950	66.82051728	1651.6066667	4464.981530	594.731
Cyclops scutifer	147	1.03519274	4.47980091	152.1733333	20.068616	432.750
C. strenus strenuus	147	0.00276644	0.03354130	0.4066667	0.001125	1212.436
C. vernalis	147	0.08086168	0.86849448	11.8666667	0.754283	1074.050
C. bicuspidatus thomasi	147	0.85950113	4.14518039	126.3466667	17.182520	482.277
Cyclops sp.	147	0.92269841	5.95812811	135.6366667	35.499291	645.729
Orthocyclops modestus	147	0.53623583	3.01495151	78.8266667	9.089933	562.244
Eucyclops speratus	147	0.02993197	0.20063426	4.4000000	0.040254	670.301
E. agilus	147	0.01462585	0.17732901	2.1500000	0.031446	1212.436
E. prionophonis	147	0.09068027	0.82672871	13.3300000	0.683480	911.696
Ectocyclops phaleratus	147	0.01455782	0.17650423	2.1400000	0.031154	1212.436
Macrocyclops albidus	147	0.03437642	0.33511051	5.0533333	0.112299	974.827
Unknown sp. cyclopoida	147	4.86442177	23.10427219	715.0700000	533.807394	474.964
Ergasilus chautauquaensis	147	0.00446712	0.05168912	0.6566667	0.002672	1157.102
Nauplii	147	211.85553288	31142.51610418	31142.7633333	49959.448828	105.504
MISCELLANEOUS						
Chaoborus punctipennis	147	2.37863946	6.75392556	349.6600000	45.615510	283.941
C. americanus	147	0.19510204	1.28203524	28.6800000	1.643614	657.110
C. flavicens	147	0.04809524	0.58312377	7.0700000	0.340033	1212.436
Chaoborus spp.	147	0.02176871	0.26393155	3.2000000	0.069660	1212.436
Mites 1	147	0.11637188	0.38799526	17.1066667	0.150540	333.410
Mites 2	147	0.00938776	0.08377510	1.3800000	0.007018	892.387
Ostracoda	147	0.11625850	1.17648542	17.0900000	1.384118	1011.956

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for CHEMGRP 1 Lakes			
ROTIFERA						
Keratella earlinae	48	0.00000000	0.00000000	0.0000000	0.00000	.
K. cochlearis hispida	48	5.83333333	35.54544182	280.0000000	1263.47843	609.350
K. crassa	48	116.29013889	520.97633593	5581.9266667	271416.34260	447.997
K. taurocephala	48	276.16857639	630.35881891	13256.0916667	397352.24057	228.251
K. cochlearis-cochlearis	48	2.37277778	11.23871434	113.8933333	126.30870	473.652
K. hiemalis	48	0.07138889	0.27027858	3.4266667	0.07305	378.600
K. irregularis	48	0.00000000	0.00000000	0.0000000	0.00000	.
K. ticinensis	48	0.00000000	0.00000000	0.0000000	0.00000	.
Keratella c. robusta	48	0.00000000	0.00000000	0.0000000	0.00000	.
K. serrulata	48	0.00000000	0.00000000	0.0000000	0.00000	.
Kellicottia longispina	48	17.92562500	105.11320407	860.4300000	11048.78567	586.385
K. bostoniensis	48	1.80000000	6.19809274	86.4000000	38.41635	344.338
Notholco labis	48	0.01305556	0.09045154	0.6266667	0.00818	692.820
N. squamula	48	0.09437500	0.54935516	4.5300000	0.30179	582.098
Brachionus urceolaris	48	0.00000000	0.00000000	0.0000000	0.00000	.
B. quadridentatus	48	0.00000000	0.00000000	0.0000000	0.00000	.
Euchlanis dilatata	48	1.88888889	13.08660610	90.6666667	171.25926	692.820
E. pellucida	48	0.00000000	0.00000000	0.0000000	0.00000	.
Platyias patulus	48	0.00000000	0.00000000	0.0000000	0.00000	.
Mytilina spp.	48	0.00000000	0.00000000	0.0000000	0.00000	.
Lecane luna	48	0.00000000	0.00000000	0.0000000	0.00000	.
L. flexilis	48	0.00000000	0.00000000	0.0000000	0.00000	.
L. mira	48	0.00000000	0.00000000	0.0000000	0.00000	.
L. tudicola	48	0.00000000	0.00000000	0.0000000	0.00000	.
L. ungulata	48	0.00000000	0.00000000	0.0000000	0.00000	.
Monostyla lunaris	48	0.00041667	0.00201941	0.0200000	0.00000	484.658
Trichocerca multicrinis	48	8.31104167	23.48191660	398.9300000	551.40041	282.539
T. cylindrica	48	0.67118056	3.26569703	32.2166667	10.66478	486.560
T. pusilla	48	0.00000000	0.00000000	0.0000000	0.00000	.
T. porcellus	48	0.00000000	0.00000000	0.0000000	0.00000	.
T. similis	48	0.00000000	0.00000000	0.0000000	0.00000	.
T. rousseleti	48	0.00000000	0.00000000	0.0000000	0.00000	.
T. lata	48	0.00000000	0.00000000	0.0000000	0.00000	.
T. elongata	48	0.09548611	0.60815362	4.5833333	0.36985	636.903
Gastropus hyptopus	48	0.00000000	0.00000000	0.0000000	0.00000	.
G. stylifer	48	1.21368056	7.56052043	58.2566667	57.16147	622.942
Ascomorpha ovalis	48	0.04687500	0.27351352	2.2500000	0.07481	583.496
A. saltans	48	0.00000000	0.00000000	0.0000000	0.00000	.
A. ecaudis	48	0.10687500	0.74045172	5.1300000	0.54827	692.820
Asplanchna priodonta	48	2.45243056	10.76218906	117.7166667	115.82471	438.838
Asplanchna sp.	48	0.00000000	0.00000000	0.0000000	0.00000	.
Polyarthra vulgaris	48	1.43055556	4.04400364	68.6666667	16.44305	283.457
P. euryptera	48	2.08930556	7.74462855	100.2866667	59.97927	370.680
P. remata	48	5.26659722	16.20762101	252.7966667	262.68698	307.744
P. major	48	0.00000000	0.00000000	0.0000000	0.00000	.
P. dolichoptera	48	0.00000000	0.00000000	0.0000000	0.00000	.
Synchaeta pectinata	48	3.40395833	14.27777793	163.3900000	203.85494	419.446
S. kitti	48	0.00000000	0.00000000	0.0000000	0.00000	.
S. oblonga	48	0.23291667	1.61369400	11.1800000	2.60401	692.820
Ploesoma truncatum	48	1.12166667	6.61125479	53.8400000	43.70869	589.414
P. lenticularie	48	0.00798611	0.05532940	0.3833333	0.00306	692.820
P. hudsoni	48	0.77194444	5.34818799	37.0533333	28.60311	692.820
P. triacanthum	48	0.09062500	0.62786842	4.3500000	0.39422	692.820

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for CHEMGRP 1 Lakes (continued)			
ROTIFERA (continued)						
Filinia spp.	48	0.13173611	0.91269455	6.3233333	0.83301	692.820
F. terminalis	48	0.00000000	0.00000000	0.0000000	0.00000	.
F. longiseta	48	0.00000000	0.00000000	0.0000000	0.00000	.
Hexarthra mira	48	1.52604167	7.55511655	73.2500000	57.07979	495.079
Conochilus unicornis	48	184.51687500	1165.85122700	8856.8100000	1359209.08350	631.840
C. hippocrepis	48	0.00000000	0.00000000	0.0000000	0.00000	.
Conochiloides dossarius	48	1.36875000	9.48297817	65.7000000	89.92688	692.820
C. natans	48	50.67555556	343.11969370	2432.4266667	117731.12420	677.091
Collotheca	48	0.01173611	0.08131016	0.5633333	0.00661	692.820
C. mutabilis	48	0.01277778	0.06852704	0.6133333	0.00784	692.820
Unidentified rotifera	48	0.03284722	0.22757223	1.5766667	0.05179	692.820
CLADOCERA						
Leptodora kindtii	48	0.00041667	0.00288675	0.0200000	0.00001	692.820
Diaphanosoma birgei	48	41.02003472	113.11002868	1968.9616667	12793.87859	275.743
D. brachyurum	48	0.00000000	0.00000000	0.0000000	0.00000	.
Sida crystallina	48	0.00000000	0.00000000	0.0000000	0.00000	.
Holopedium gibberum	48	9.66270833	41.01469784	463.8100000	1682.20544	424.464
Bosmina longirostris	48	73.88104167	250.66667466	3546.2900000	62833.78179	339.284
Eubosmina hagmanni	48	7.45048611	43.61752439	357.6233333	1902.48843	585.432
E. tubicen	48	11.00993056	30.01501247	528.4766667	900.90097	272.618
E. longispina	48	8.12677083	25.61287169	390.0850000	656.01920	315.167
Chydorus brevalibris	48	0.04965278	0.26982810	2.3833333	0.07281	543.430
C. sphaericus	48	0.00395833	0.02742414	0.1900000	0.00075	692.820
Chydorus sp.	48	0.04909722	0.34015553	2.3566667	0.11571	692.820
Alona setulosa	48	0.00020833	0.00144338	0.0100000	0.00000	692.820
A. guttata	48	0.02784722	0.19293121	1.3366667	0.03722	692.820
A. circumfimbrata	48	0.02520833	0.17171215	1.2100000	0.02949	681.172
A. barbula	48	0.00000000	0.00000000	0.0000000	0.00000	.
Alona sp.	48	0.03770833	0.22913359	1.8100000	0.05250	607.647
Alonella acutirostris	48	0.00000000	0.00000000	0.0000000	0.00000	.
Kurzia laissima	48	0.00020833	0.00144338	0.0100000	0.00000	692.820
Acroperus harpae	48	0.00020833	0.00144338	0.0100000	0.00000	692.820
Eurycercus lamellatus	48	0.00000000	0.00000000	0.0000000	0.00000	.
Graptoleberis testudinaria	48	0.00020833	0.00144338	0.0100000	0.00000	692.820
Polyphemus pediculus	48	0.20465278	0.82307781	9.8233333	0.67746	402.183
Daphnia catawba	48	3.85916667	9.92319192	185.2400000	98.46974	257.133
D. galeata mendotae	48	0.00020833	0.00144338	0.0100000	0.00000	692.820
D. rosea	48	0.06597222	0.45706896	3.1666667	0.20891	692.820
D. ambigua	48	5.51388889	20.76897700	264.6666667	431.35041	376.667
D. pulex	48	1.05312500	5.20085765	50.5500000	27.04892	493.850
D. parvula	48	1.31416667	8.02630603	63.0800000	64.42159	610.753
D. schodleri	48	0.51902778	2.93782184	24.9133333	8.63080	566.024
D. retrocurva	48	0.00000000	0.00000000	0.0000000	0.00000	.
D. longiremis	48	0.00000000	0.00000000	0.0000000	0.00000	.
D. dubia	48	0.00020833	0.00144338	0.0100000	0.00000	692.820
Scapholebris mucronata	48	0.00000000	0.00000000	0.0000000	0.00000	.
Ceriodaphnia reticulata	48	0.00062500	0.00433013	0.0300000	0.00002	692.820
C. lacustris	48	0.00000000	0.00000000	0.0000000	0.00000	.
C. affinis/dubia	48	0.02291667	0.10882268	1.1000000	0.01184	474.863
C. quadrangula	48	0.02625000	0.18186533	1.2600000	0.03308	692.820
Ceriodaphnia sp.	48	0.00000000	0.00000000	0.0000000	0.00000	.

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for CHEMGRP 1 Lakes (continued)			
COPEPODA						
Epischura lacustris	48	0.00020833	0.00144338	0.0100000	0.00000	692.820
E. nordenskioldi	48	0.95350694	3.21995056	45.7683333	10.36808	337.696
Epischura spp.	48	0.00000000	0.00000000	0.0000000	0.00000	.
Aglaodiaptomus leptopus	48	0.72208333	2.43636182	34.6600000	5.93586	337.407
A. spatulocrenatus	48	0.13902778	0.75739380	6.6733333	0.57365	544.779
Leptodiaptomus minutus	48	151.56736111	165.97886088	7275.2333333	27548.98226	109.508
L. sicilis	48	0.00000000	0.00000000	0.0000000	0.00000	.
Skistodiaptomus oregonensis	48	0.00000000	0.00000000	0.0000000	0.00000	.
S. reighardi	48	7.42805556	49.14902306	356.5466667	2415.62647	661.667
S. pygmaeus	48	6.01986111	23.97653830	288.9533333	574.87439	398.291
Skistodiaptomus spp.	48	0.00000000	0.00000000	0.0000000	0.00000	.
Onychodiaptomus birgei	48	0.00000000	0.00000000	0.0000000	0.00000	.
Unknown sp. calanoida	48	0.00000000	0.00000000	0.0000000	0.00000	.
Tropocyclops sp. 1	48	0.00000000	0.00000000	0.0000000	0.00000	.
Mesocyclops edax	48	34.04208333	84.54789661	1634.0200000	7148.34682	248.363
Tropocyclops sp. 2	48	0.00000000	0.00000000	0.0000000	0.00000	.
T. prasinus-mexicanus	48	0.87736111	2.98893293	42.1133333	8.93372	340.673
T. prasinus	48	10.71000000	55.47078391	514.0800000	3077.00787	517.934
Cyclops scutifer	48	0.57659722	2.19974246	27.6766667	4.83887	381.504
C. strenus strenuus	48	0.00000000	0.00000000	0.0000000	0.00000	.
C. vernalis	48	0.00000000	0.00000000	0.0000000	0.00000	.
C. bicuspidatus thomasi	48	0.27395833	1.30273284	13.1500000	1.69711	475.522
Cyclops sp.	48	0.00000000	0.00000000	0.0000000	0.00000	.
Orthocyclops modestus	48	0.80354167	3.56358947	38.5700000	12.69917	443.485
Eucyclops speratus	48	0.03375000	0.16921125	1.6200000	0.02863	501.367
E. agilus	48	0.00000000	0.00000000	0.0000000	0.00000	.
E. prionophonis	48	0.00000000	0.00000000	0.0000000	0.00000	.
Ectocyclops phaleratus	48	0.00000000	0.00000000	0.0000000	0.00000	.
Macrocyclops albidus	48	0.09381944	0.58061555	4.5033333	0.33711	618.865
Unknown sp. cyclopoida	48	1.95229167	9.18361371	93.7100000	84.33876	470.402
Ergasilus chautauquaensis	48	0.00000000	0.00000000	0.0000000	0.00000	.
Nauplii	48	198.62291667	184.53335254	9533.9000000	34052.55820	92.906
MISCELLANEOUS						
Chaoborus punctipennis	48	2.14638889	9.50292519	103.0266667	90.30559	442.740
C. americanus	48	0.59750000	2.20457417	28.6800000	4.86015	368.966
C. flavicens	48	0.00000000	0.00000000	0.0000000	0.00000	.
Chaoborus spp.	48	0.06666667	0.46188022	3.2000000	0.21333	692.820
Mites 1	48	0.08152778	0.21566649	3.9133333	0.04651	264.531
Mites 2	48	0.00000000	0.00000000	0.0000000	0.00000	.
Ostracoda	48	0.00020833	0.00144338	0.0100000	0.00000	692.820

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for CHEMGRP 2 Lakes			
ROTIFERA						
Keratella earlinae	53	0.00000000	0.00000000	0.0000000	0.000000	.
K. cochlearis hispida	53	81.54779874	415.01723871	4322.0333333	172239.308429	508.925
K. crassa	53	137.66666667	274.79963817	7296.3333333	75514.841138	199.612
K. taurocephala	53	78.31735849	234.08999432	4150.8200000	54798.125442	298.899
K. cochlearis-cochlearis	53	43.49031447	98.33248606	2304.9866667	9669.277815	226.102
K. hiemalis	53	0.53037736	2.18570156	28.1100000	4.777291	412.103
K. irregularis	53	0.35000000	2.54803846	18.5500000	6.492500	728.011
K. ticinensis	53	0.00000000	0.00000000	0.0000000	0.000000	.
Keratella c. robusta	53	0.95597484	6.95960191	50.6666667	48.436059	728.011
K. serrulata	53	0.01949686	0.14193925	1.0333333	0.020147	728.011
Kellicottia longispina	53	86.27484277	386.62627755	4572.5666667	149479.878495	448.133
K. bostoniensis	53	90.97540881	242.05182486	4821.6966667	58589.085920	266.063
Notholco labis	53	0.00000000	0.00000000	0.0000000	0.000000	.
N. squamula	53	0.00000000	0.00000000	0.0000000	0.000000	.
Brachionus urceolaris	53	0.00000000	0.00000000	0.0000000	0.000000	.
B. quadridentatus	53	0.00000000	0.00000000	0.0000000	0.000000	.
Euchlenis dilatata	53	0.00000000	0.00000000	0.0000000	0.000000	.
E. pellucida	53	0.67383648	4.90560361	35.7133333	24.064947	728.011
Platyias petulus	53	0.05880503	0.38622936	3.1166667	0.149173	656.796
Mytilina spp.	53	0.00000000	0.00000000	0.0000000	0.000000	.
Lecane luna	53	0.00528302	0.03846096	0.2800000	0.001479	728.011
L. flexilis	53	0.07710692	0.40123636	4.0866667	0.160991	520.364
L. mira	53	0.00761006	0.05401953	0.4033333	0.002918	709.843
L. tudicola	53	0.04037736	0.29395161	2.1400000	0.086408	728.011
L. ungulata	53	0.00000000	0.00000000	0.0000000	0.000000	.
Monostyla lunaris	53	0.17974843	1.15362729	9.5266667	1.330856	641.801
Trichocerca multicrinis	53	17.38377358	29.66312895	921.3400000	879.901219	170.637
T. cylindrica	53	45.80320755	100.84620416	2427.5700000	10169.956894	220.173
T. pusilla	53	0.37018868	2.69361459	19.6200000	7.255560	727.633
T. porcellus	53	0.00018868	0.00137361	0.0100000	0.000002	728.011
T. similis	53	0.00037736	0.00192380	0.0200000	0.000004	509.808
T. rousseleti	53	0.00000000	0.00000000	0.0000000	0.000000	.
T. lata	53	0.00018868	0.00137361	0.0100000	0.000002	728.011
T. elongata	53	0.01490566	0.08536649	0.7900000	0.007287	572.712
Gastropus hyptopus	53	0.01477987	0.10481671	0.7833333	0.010987	709.185
G. stylifer	53	1.77930818	6.73246997	94.3033333	45.326152	378.376
Ascomorpha ovalis	53	0.24534591	1.37867246	13.0033333	1.900738	561.930
A. saltans	53	0.00169811	0.01104812	0.0900000	0.000122	650.612
A. ecaudis	53	1.27232704	4.22831969	67.4333333	17.878687	332.330
Asplanchna priodonta	53	12.49213836	23.66558163	662.0833333	560.059754	189.444
Asplanchna sp.	53	0.10786164	0.78524456	5.7166667	0.616609	728.011
Polyarthra vulgaris	53	44.85075472	173.09780723	2377.0900000	29962.850868	385.942
P. euryptera	53	35.18113208	94.19898992	1864.6000000	8873.449702	267.754
P. remata	53	8.87012579	25.09696915	470.1166667	629.857861	282.938
P. major	53	1.18031447	5.79216592	62.5566667	33.549186	490.731
P. dolichoptera	53	0.00000000	0.00000000	0.0000000	0.000000	.
Synchaeta pectinata	53	1.59100629	5.14444255	84.3233333	26.465289	323.345
S. kitti	53	1.21314465	5.96188311	64.2966667	35.544050	491.440
S. oblonga	53	0.00000000	0.00000000	0.0000000	0.000000	.
Ploesoma truncatum	53	4.95805031	14.68011785	262.7766667	215.505860	296.087
P. lenticularie	53	0.00000000	0.00000000	0.0000000	0.000000	.
P. hudsoni	53	1.49704403	9.25737594	79.3433333	85.699009	618.377
P. triacanthum	53	0.00000000	0.00000000	0.0000000	0.000000	.

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for CHEMGRP 2 Lakes (continued)			
ROTIFERA (continued)						
Filinia spp.	53	0.00000000	0.00000000	0.0000000	0.000000	.
F. terminalis	53	0.02402516	0.12332356	1.2733333	0.015209	513.310
F. longiseta	53	0.92685535	4.77936257	49.1233333	22.842307	515.654
Hexarthra mira	53	4.09836478	26.47007965	217.2133333	700.665117	645.869
Conochilus unicornis	53	11.89176101	34.14761534	630.2633333	1166.059634	287.154
C. hippocrepis	53	3.50295597	25.50190443	185.6566667	650.347130	728.011
Conochiloides dossarius	53	8.95528302	39.15786453	474.6300000	1533.338354	437.260
C. natans	53	0.15201258	0.68484240	8.0566667	0.469009	450.517
Collotheca pelagica	53	0.23899371	1.73990048	12.6666667	3.027254	728.011
C. mutabilis	53	1.28522013	5.54220210	68.1166667	30.716004	431.226
Unidentified rotifera	53	0.00000000	0.00000000	0.0000000	0.000000	.
CLADOCERA						
Leptodora kindtii	53	0.01459119	0.09239276	0.7733333	0.008536	633.209
Diaphanosoma birgeii	53	31.25025157	54.13593327	1656.2633333	2930.699271	173.234
D. brachyurum	53	0.00000000	0.00000000	0.0000000	0.000000	.
Sida crystallina	53	0.07245283	0.27051561	3.8400000	0.073179	373.368
Holopedium gibberum	53	11.77125786	30.96438252	623.8766667	958.792985	263.051
Bosmina longirostris	53	27.84150943	58.99265685	1475.6000000	3480.133562	211.887
Eubosmina hagmanni	53	1.22867925	8.68147963	65.1200000	75.368089	706.570
E. tubicen	53	11.03000000	26.19134490	584.5900000	685.986547	237.456
E. longispina	53	0.47238994	2.15550383	25.0366667	4.646197	456.298
Chydorus brevalibris	53	0.04075472	0.29390507	2.1600000	0.086380	721.156
C. sphaericus	53	0.01270440	0.09248945	0.6733333	0.008554	728.011
Chydorus sp.	53	0.00000000	0.00000000	0.0000000	0.000000	.
Alona setulosa	53	0.00018868	0.00137361	0.0100000	0.000002	728.011
A. guttata	53	0.00018868	0.00137361	0.0100000	0.000002	728.011
A. circumfimbrata	53	0.00000000	0.00000000	0.0000000	0.000000	.
A. barbula	53	0.00018868	0.00137361	0.0100000	0.000002	728.011
Alona sp.	53	0.00018868	0.00137361	0.0100000	0.000002	728.011
Alonella acutirostris	53	0.12100629	0.87954013	6.4133333	0.773591	726.855
Kurzia laissima	53	0.00000000	0.00000000	0.0000000	0.000000	.
Acroperus harpae	53	0.00000000	0.00000000	0.0000000	0.000000	.
Eurycercus lamellatus	53	0.00018868	0.00137361	0.0100000	0.000002	728.011
Graptoleberis testudinaria	53	0.00018868	0.00137361	0.0100000	0.000002	728.011
Polyphemus pediculus	53	0.01660377	0.08632202	0.8800000	0.007451	519.894
Daphnia catawba	53	7.17855346	21.16923478	380.4633333	448.136501	294.896
D. galeata mendotae	53	0.02584906	0.18818397	1.3700000	0.035413	728.011
D. rosea	53	0.00000000	0.00000000	0.0000000	0.000000	.
D. ambigua	53	0.46446541	2.09164863	24.6166667	4.374994	450.335
D. pulex	53	0.29427673	1.61400553	15.5966667	2.605014	548.465
D. parvula	53	9.67874214	26.01710163	512.9733333	676.889577	268.807
D. schodleri	53	0.24610063	1.78604799	13.0433333	3.189967	725.739
D. retrocurva	53	1.25823899	6.66608926	66.6866667	44.436746	529.795
D. longiremis	53	0.21201258	1.32127760	11.2366667	1.745775	623.207
D. dubia	53	0.49635220	1.92631532	26.3066667	3.710691	388.094
Scapholebris mucronata	53	0.00000000	0.00000000	0.0000000	0.000000	.
Ceriodaphnia reticulata	53	0.02849057	0.20463284	1.5100000	0.041875	718.248
C. lacustris	53	0.08339623	0.37258768	4.4200000	0.138822	446.768

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for CHEMGRP 2 Lakes (continued)			
COPEPODA						
C. affinis/dubia	53	4.24163522	21.13205543	224.8066667	446.563767	498.205
C. quadrangula	53	2.93301887	20.99597378	155.4500000	440.830915	715.849
Ceriodaphnia sp.	53	0.00018868	0.00137361	0.0100000	0.000002	728.011
Epischura lacustris	53	0.53415094	2.41809842	28.3100000	5.847200	452.699
E. nordenskioldi	53	0.11421384	0.45822733	6.0533333	0.209972	401.201
Epischura spp.	53	0.02943396	0.21428248	1.5600000	0.045917	728.011
Aglaodiaptomus leptopus	53	0.00000000	0.00000000	0.0000000	0.000000	.
A. spatulocrenatus	53	0.08830189	0.45441736	4.6800000	0.206495	514.618
Leptodiaptomus minutus	53	52.16786164	112.19885793	2764.8966667	12588.583772	215.073
L. sicilis	53	0.20125786	1.46517935	10.6666667	2.146751	728.011
Skistodiaptomus oregonensis	53	1.28968553	6.17004392	68.3533333	38.069442	478.415
S. reighardi	53	0.05566038	0.40521366	2.9500000	0.164198	728.011
S. pygmaeus	53	8.72930818	27.18964998	462.6533333	739.277066	311.475
Skistodiaptomus spp.	53	1.53138365	11.14864124	81.1633333	124.292201	728.011
Onychodiaptomus birgei	53	0.73805031	5.37308739	39.1166667	28.870068	728.011
Unknown sp. calanoida	53	0.00000000	0.00000000	0.0000000	0.000000	.
Tropocyclops sp. 1	53	0.00000000	0.00000000	0.0000000	0.000000	.
Mesocyclops edax	53	27.10421384	39.35183259	1436.5233333	1548.566728	145.187
Tropocyclops sp. 2	53	0.00000000	0.00000000	0.0000000	0.000000	.
T. prasinus-mexicanus	53	24.61433962	50.41443198	1304.5600000	2541.614952	204.817
T. prasinus	53	17.73327044	96.44704463	939.8633333	9302.032418	543.876
Cyclops scutifer	53	0.60603774	2.27407322	32.1200000	5.171409	375.236
C. strenus strenuus	53	0.00767296	0.05585996	0.4066667	0.003120	728.011
C. vernalis	53	0.22427673	1.44395652	11.8866667	2.085010	643.828
C. bicuspidatus thomasi	53	0.94899371	5.28569945	50.2966667	27.938619	556.979
Cyclops sp.	53	2.55918239	9.76741955	135.6366667	95.402485	381.662
Orthocyclops modestus	53	0.12490566	0.82111260	6.6200000	0.674226	657.386
Eucyclops speratus	53	0.01471698	0.10714124	0.7800000	0.011479	728.011
E. agilus	53	0.04056604	0.29532521	2.1500000	0.087217	728.011
E. prionophonis	53	0.07924528	0.57691437	4.2000000	0.332830	728.011
Ectocyclops phaleratus	53	0.04037736	0.29395161	2.1400000	0.086408	728.011
Macrocyclops albidus	53	0.00000000	0.00000000	0.0000000	0.000000	.
Unknown sp. cyclopoida	53	3.16484277	10.90512233	167.7366667	118.921693	344.571
Ergasilus chautauquaensis	53	0.00037736	0.00192380	0.0200000	0.000004	509.808
Nauplii	53	243.67540881	283.49017339	12914.7966667	80366.678410	116.339
MISCELLANEOUS						
Chaoborus punctipennis	53	2.94025157	4.85733325	155.8333333	23.593686	165.201
C. americanus	53	0.00000000	0.00000000	0.0000000	0.000000	.
C. flavicens	53	0.00000000	0.00000000	0.0000000	0.000000	.
Chaoborus spp.	53	0.00000000	0.00000000	0.0000000	0.000000	.
Mites 1	53	0.13264151	0.51465587	7.0300000	0.264871	388.005
Mites 2	53	0.00000000	0.00000000	0.0000000	0.000000	.
Ostracoda	53	0.27855346	1.93513295	14.7633333	3.744740	694.708

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for CHEMGRP 3 Lakes			
ROTIFERA						
Keratella earlinae	46	0.24586957	1.18193693	11.31000000	1.396975	480.717
K. cochlearis hispida	46	4.23268116	19.26654900	194.70333333	371.199910	455.185
K. crassa	46	54.61152174	99.03328000	2512.13000000	9807.590548	181.341
K. taurocephala	46	4.68101449	11.58304936	215.32666667	134.167033	247.447
K. cochlearis-cochlearis	46	56.37202899	240.04285011	2593.11333333	57620.569888	425.819
K. hiemalis	46	0.10478261	0.70765886	4.82000000	0.500781	675.359
K. irregularis	46	0.00000000	0.00000000	0.00000000	0.000000	.
K. ticinensis	46	0.00376812	0.02555661	0.17333333	0.000653	678.233
Keratella c. robusta	46	0.00000000	0.00000000	0.00000000	0.000000	.
K. serrulata	46	0.00000000	0.00000000	0.00000000	0.000000	.
Kellicottia longispina	46	42.25673913	90.88602632	1943.81000000	8260.269781	215.081
K. bostoniensis	46	10.32195652	23.66783362	474.81000000	560.166348	229.296
Notholco labis	46	0.00000000	0.00000000	0.00000000	0.000000	.
Notholco squamula	46	0.00000000	0.00000000	0.00000000	0.000000	.
Brachionus urceolaris	46	0.00021739	0.00147442	0.01000000	0.000002	678.233
B. quadridentatus	46	0.00021739	0.00147442	0.01000000	0.000002	678.233
Euchlanis dilatata	46	0.00731884	0.04963879	0.33666667	0.002464	678.233
E. pellucida	46	0.00000000	0.00000000	0.00000000	0.000000	.
Platyias patulus	46	0.00000000	0.00000000	0.00000000	0.000000	.
Mytilina spp.	46	0.00021739	0.00147442	0.01000000	0.000002	678.233
Lecane luna	46	0.57543478	2.91918747	26.47000000	8.521655	507.301
L. flexilis	46	0.00000000	0.00000000	0.00000000	0.000000	.
L. mira	46	0.00427536	0.02899692	0.19666667	0.000841	678.233
L. tudicola	46	0.00000000	0.00000000	0.00000000	0.000000	.
L. ungulata	46	0.02427536	0.16464352	1.11666667	0.027107	678.233
Monostyla lunaris	46	0.18210145	1.20921755	8.37666667	1.462207	664.035
Trichocerca multicrinis	46	26.01623188	109.80068889	1196.74666667	12056.191281	422.047
T. cylindrica	46	19.32695652	90.40442099	889.04000000	8172.959334	467.763
T. pusilla	46	0.03311594	0.22460325	1.52333333	0.050447	678.233
T. porcellus	46	0.00000000	0.00000000	0.00000000	0.000000	.
T. similis	46	0.00833333	0.05651942	0.38333333	0.003194	678.233
T. rousseleti	46	0.09362319	0.57996715	4.30666667	0.336362	619.470
T. lata	46	0.00000000	0.00000000	0.00000000	0.000000	.
T. elongata	46	0.03920290	0.18584633	1.80333333	0.034539	474.063
Gastropus hyptopus	46	0.70659420	3.98054506	32.50333333	15.844739	563.342
G. stylifer	46	0.01771739	0.11866717	0.81500000	0.014082	669.778
Ascomorpha ovalis	46	0.40673913	2.73112689	18.71000000	7.459054	671.469
A. saltans	46	0.01637681	0.10957567	0.75333333	0.012007	669.090
A. ecaudis	46	0.56101449	2.73279587	25.80666667	7.468173	487.117
Asplanchna priodonta	46	14.36123188	62.90328024	660.61666667	3956.822664	438.008
Asplanchna sp.	46	0.00000000	0.00000000	0.00000000	0.000000	.
Polyarthra vulgaris	46	29.53311594	78.29940951	1358.52333333	6130.797530	265.124
P. euryptera	46	25.28166667	90.44420528	1162.95666667	8180.154269	357.746
P. remata	46	2.91115942	12.99224521	133.91333333	168.798436	446.291
P. major	46	16.87275362	67.87599504	776.14666667	4607.150703	402.282
P. dolichoptera	46	0.06289855	0.42659873	2.89333333	0.181986	678.233
Synchaeta pectinata	46	10.71514493	45.68434115	492.89666667	2087.059027	426.353
S. kitti	46	0.03869565	0.26244668	1.78000000	0.068878	678.233
S. oblonga	46	0.00000000	0.00000000	0.00000000	0.000000	.
Ploesoma truncatum	46	2.35134058	7.51124498	108.16166667	56.418801	319.445
P. lenticularie	46	0.00000000	0.00000000	0.00000000	0.000000	.
P. hudsoni	46	0.00000000	0.00000000	0.00000000	0.000000	.
P. triacanthum	46	0.00376812	0.02555661	0.17333333	0.000653	678.233

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for CHEMGRP 3 Lakes (continued)			
ROTIFERA (continued)						
Filinia spp.	46	0.00000000	0.00000000	0.00000000	0.000000	.
F. terminalis	46	3.70514493	24.67392061	170.43666667	608.802358	665.937
F. longiseta	46	0.32115942	1.96803458	14.77333333	3.873160	612.791
Hexarthra mira	46	67.07557971	454.83578145	3085.47666667	206875.588084	678.094
Conochilus unicornis	46	71.68086957	323.79383998	3297.32000000	104842.450811	451.716
C. hippocrepis	46	1.09768116	5.54337638	50.49333333	30.729022	505.008
Conochiloides dossarius	46	3.19188406	11.39900519	146.82666667	129.937319	357.125
C. natans	46	1.61688406	7.94174746	74.37666667	63.071353	491.176
Collotheca pelagica	46	0.19130435	1.29748921	8.80000000	1.683478	678.233
C. mutabilis	46	0.35014493	2.06497481	16.10666667	4.264121	589.749
Unidentified rotifera	46	0.03753623	0.20441236	1.72666667	0.041784	544.573
CLADOCERA						
Leptodora kindtii	46	0.09061594	0.35085458	4.16833333	0.123099	387.189
Diaphanosoma birgei	46	14.51344203	32.90411870	667.61833333	1082.681027	226.715
D. brachyurum	46	0.04840580	0.32830409	2.22666667	0.107784	678.233
Sida crystallina	46	0.26949275	1.08425703	12.39666667	1.175613	402.333
Holopedium gibberum	46	8.38152174	30.09677859	385.55000000	905.816081	359.085
Bosmina longirostris	46	22.86431159	72.49511784	1051.75833333	5255.542111	317.067
Eubosmina hagmanni	46	0.02913043	0.19757222	1.34000000	0.039035	678.233
E. tubicen	46	3.70188406	9.06079951	170.28666667	82.098088	244.762
E. longispina	46	0.26239130	0.94625804	12.07000000	0.895404	360.629
Chydorus brevalibris	46	2.31195652	11.04620647	106.35000000	122.018677	477.786
C. sphaericus	46	1.14507246	5.98707401	52.67333333	35.845055	522.855
Chydorus sp.	46	0.00000000	0.00000000	0.00000000	0.000000	.
Alona setulosa	46	0.00000000	0.00000000	0.00000000	0.000000	.
A. guttata	46	0.00376812	0.02555661	0.17333333	0.000653	678.233
A. circumfimbrata	46	0.00000000	0.00000000	0.00000000	0.000000	.
A. barbula	46	0.00000000	0.00000000	0.00000000	0.000000	.
Alona sp.	46	0.03753623	0.19818988	1.72666667	0.039279	527.996
Alonella acutirostris	46	0.00000000	0.00000000	0.00000000	0.000000	.
Kurzia laissima	46	0.00000000	0.00000000	0.00000000	0.000000	.
Acroperus harpae	46	0.00000000	0.00000000	0.00000000	0.000000	.
Eurycercus lamellatus	46	0.00000000	0.00000000	0.00000000	0.000000	.
Graptoleberis testudinaria	46	0.00000000	0.00000000	0.00000000	0.000000	.
Polyphemus pediculus	46	0.06173913	0.39345933	2.84000000	0.154810	637.293
Daphnia catawba	46	29.14115942	56.89169581	1340.49333333	3236.665052	195.228
D. galeata mendotae	46	1.93942029	5.07985002	89.21333333	25.804876	261.926
D. rosea	46	0.31405797	2.13004479	14.44666667	4.537091	678.233
D. ambigua	46	0.77677536	2.73083477	35.73166667	7.457459	351.560
D. pulex	46	0.31992754	1.66849507	14.71666667	2.783876	521.523
D. parvula	46	3.03500000	13.18037386	139.61000000	173.722255	434.279
D. schodleri	46	0.43260870	2.93409493	19.90000000	8.608913	678.233
D. retrocurva	46	0.32608696	1.48529172	15.00000000	2.206092	455.489
D. longiremis	46	0.90971014	5.58297508	41.84666667	31.169611	613.709
D. dubia	46	1.50387681	5.21297517	69.17833333	27.175110	346.636
Scapholebris mucronata	46	0.04021739	0.27276762	1.85000000	0.074402	678.233
Ceriodaphnia reticulata	46	1.34659420	4.08923359	61.94333333	16.721831	303.672
C. lacustris	46	0.86978261	5.89764567	40.01000000	34.782224	678.060
C. affinis/dubia	46	14.42391304	63.92533674	663.50000000	4086.448678	443.190
C. quadrangula	46	0.01702899	0.08659891	0.78333333	0.007499	508.538
Ceriodaphnia sp.	46	0.00000000	0.00000000	0.00000000	0.000000	

Variable	N	Mean	Standard Deviation	Sum	Variance	C.V.
			Summary Statistics for CHEMGRP 3 Lakes (continued)			
COPEPODA						
Epischura lacustris	46	0.95384058	2.76960968	43.87666667	7.670738	290.364
E. nordenskioldi	46	0.15746377	0.93533098	7.22433333	0.874844	593.998
Epischura spp.	46	0.01195652	0.08109308	0.55000000	0.006576	678.233
Aglaodiaptomus leptopus	46	0.07014493	0.47574605	3.22666667	0.226334	678.233
A. spatulocrenatus	46	2.81286232	16.39846155	129.39166667	268.909541	582.981
Leptodiaptomus minutus	46	17.38134058	27.53939174	799.54166667	758.418097	158.442
L. sicilis	46	0.00000000	0.00000000	0.00000000	0.000000	.
Skistodiaptomus oregonensis	46	1.54405797	5.01819273	71.02666667	25.182258	325.000
S. reighardi	46	2.06927536	9.02985626	95.18666667	81.538304	436.378
S. pygmaeus	46	4.15956522	12.55821884	191.34000000	157.708861	301.912
Skistodiaptomus spp.	46	0.15528986	0.74202412	7.14333333	0.550600	477.832
Onychodiaptomus birgei	46	0.31891304	2.16297350	14.67000000	4.678454	678.233
Unknown sp. calanoida	46	0.12898551	0.67177152	5.93333333	0.451277	520.812
Tropocyclops sp. 1	46	0.04362319	0.29586686	2.00666667	0.087537	678.233
Mesocyclops edax	46	20.23202899	21.89939922	930.67333333	479.583686	108.241
Tropocyclops sp. 2	46	0.17304348	1.17363797	7.96000000	1.377426	678.233
T. prasinus-mexicanus	46	26.92753623	63.86002576	1238.66666667	4078.102890	237.155
T. prasinus	46	4.29702899	20.60028538	197.66333333	424.371758	479.408
Cyclops scutifer	46	2.00818841	7.25759786	92.37666667	52.672727	361.400
C. strenus strenuus	46	0.00000000	0.00000000	0.00000000	0.000000	.
C. vernalis	46	0.00000000	0.00000000	0.00000000	0.000000	.
C. bicuspidatus thomasi	46	1.36739130	4.58821663	62.90000000	21.051732	335.545
Cyclops sp.	46	0.00000000	0.00000000	0.00000000	0.000000	.
Orthocyclops modestus	46	0.73123188	3.89033969	33.63666667	15.134743	532.025
Eucyclops speratus	46	0.04347826	0.29488391	2.00000000	0.086957	678.233
E. agilus	46	0.00000000	0.00000000	0.00000000	0.000000	.
E. prionophonis	46	0.19847826	1.34614506	9.13000000	1.812107	678.233
Ectocyclops phaleratus	46	0.00000000	0.00000000	0.00000000	0.000000	.
Macrocyclops albidus	46	0.01195652	0.08109308	0.55000000	0.006576	678.233
Unknown sp. cyclopoida	46	9.86137681	38.32007646	453.62333333	1468.428260	388.587
Ergasilus chautauquaensis	46	0.01384058	0.09237596	0.63666667	0.008533	667.428
Nauplii	46	189.00144928	178.16647364	8694.06666667	31743.292329	94.267
MISCELLANEOUS						
Chaoborus punctipennis	46	1.97391304	5.08109681	90.80000000	25.817545	257.412
C. americanus	46	0.00000000	0.00000000	0.00000000	0.000000	.
C. flavicens	46	0.15369565	1.04241463	7.07000000	1.086628	678.233
Chaoborus spp.	46	0.00000000	0.00000000	0.00000000	0.000000	.
Mites 1	46	0.13398551	0.36310296	6.16333333	0.131844	271.002
Mites 2	46	0.03000000	0.14878935	1.38000000	0.022138	495.965
Ostracoda	46	0.05036232	0.33706154	2.31666667	0.113610	669.273

APPENDIX E

List of, and Summary Statistics for, 38 Genera Found in All 147 ELS-II Survey Lakes, Plus a Separate Listing for Each Chemistry Cluster

Taxa	Mean	Variance	C.V.	Sum
Keratella	293.33640091	403325.823841	216.502	128774.680000
Kellicottia	87.16706150	84927.402250	334.327	38266.340000
Trichocerca	40.30662870	13646.341784	289.822	17694.610000
Gastropus	1.27375854	50.261135	556.582	559.180000
Ascomorpha	0.91009112	30.844127	610.241	399.530000
Asplanchna	9.88243736	1607.320645	405.683	4338.390000
Polyarthra	58.95316629	26248.187301	274.816	25880.440000
Synchaeta	5.58906606	839.519167	518.413	2453.600000
Ploesoma	3.72810934	189.733199	369.473	1636.640000
Filinia	1.65328018	210.988831	878.584	725.790000
Hexarthra	23.07020501	70838.087374	1153.671	10127.820000
Conochilus	88.97865604	510467.696657	802.968	39061.630000
Conochiloides	21.88166287	39131.993994	904.036	9606.050000
Collotheca	0.71025057	14.417133	534.599	311.800000
Leptodora	0.03207289	0.081042	887.599	14.080000
Diaphanosoma	29.32093394	6317.966564	271.088	12871.890000
Sida	0.11091116	0.825234	819.055	48.690000
Holopedium	10.06291572	1237.452531	349.575	4417.620000
Bosmina	41.50371298	25422.894193	384.172	18220.130000
Eubosmina	14.33902050	1386.720605	259.702	6294.830000
Chydorus	1.13977221	54.487609	647.636	500.360000
Polyphemus	0.09250569	0.526361	784.284	40.610000
Daphnia (pulex)	14.03455581	1515.411962	277.375	6161.170000
Daphnia (galeata)	1.61066059	35.146235	368.074	707.080000
Daphnia (parvula)	7.66804100	552.413763	306.512	3366.270000
Ceriodaphnia	7.89173121	1681.723054	519.643	3464.470000
Epischura	0.89100228	9.958191	354.170	391.150000
Aglaodiaptomus	1.21886105	88.224792	770.622	535.080000
Leptodiaptomus	73.92938497	18566.946949	184.312	32455.000000
Skistodiaptomus	11.08965831	1360.146100	332.564	4868.360000
Onychodiaptomus	0.36756264	13.033093	982.183	161.360000
Mesocyclops	27.35687927	3211.292762	207.144	12009.670000
Tropocyclops	29.00300683	6643.688492	281.036	12732.320000
Cyclops	2.87596811	74.665897	300.453	1262.550000
Orthocyclops	0.53867882	9.929020	584.956	236.480000
Eucyclops	0.13585421	0.939693	713.542	59.640000
Ectocyclops	0.01462415	0.093302	2088.696	6.420000
Macrocyclops	0.03453303	0.192321	1269.927	15.160000

Taxa	Mean	Variance	C.V.	Sum
CHEMGRP 3				
Keratella	122.45029851	69238.109713	214.888	16408.3400000
Kellicottia	53.87447761	8955.525814	175.656	7219.1800000
Trichocerca	44.66611940	23815.795221	345.505	5985.2600000
Gastropus	0.73992537	17.293138	562.016	99.1500000
Ascomorpha	0.62149254	24.048962	789.064	83.2800000
Asplanchna	14.78985075	4351.142862	446.003	1981.8400000
Polyarthra	76.68194030	23374.390165	199.378	10275.3800000
Synchaeta	11.07485075	2351.271306	437.838	1484.0300000
Ploesoma	2.41343284	59.923433	320.747	323.4000000
Filinia	4.14649254	648.814354	614.298	555.6300000
Hexarthra	69.07783582	229258.454146	693.145	9256.4300000
Conochilus	74.95104478	133655.551733	487.771	10043.4400000
Conochiloides	4.95231343	195.381219	282.250	663.6100000
Collotheca	0.49194030	5.929745	495.000	65.9200000
Leptodora	0.08731343	0.232478	552.218	11.7000000
Diaphanosoma	14.77014925	1128.376114	227.427	1979.2000000
Sida	0.27738806	2.513095	571.501	37.1700000
Holopedium	8.50664179	976.923238	367.428	1139.8900000
Bosmina	23.50492537	5571.607742	317.564	3149.6600000
Eubosmina	4.05276119	89.058297	232.855	543.0700000
Chydorus	3.56022388	170.171766	366.409	477.0700000
Polyphemus	0.06320896	0.237314	770.695	8.4700000
Daphnia (pulex)	30.46694030	3902.131327	205.032	4082.5700000
Daphnia (galeata)	4.40507463	96.740863	223.281	590.2800000
Daphnia (parvula)	4.25522388	285.406679	397.018	570.2000000
Ceriodaphnia	17.15455224	4276.984025	381.232	2298.7100000
Epischura	1.15656716	10.791367	284.032	154.9800000
Aglaodiaptomus	2.96298507	276.813684	561.519	397.0400000
Leptodiaptomus	15.89164179	721.208851	168.990	2129.4800000
Skistodiaptomus	8.16485075	259.044712	197.124	1094.0900000
Onychodiaptomus	0.32843284	4.752407	663.759	44.0100000
Mesocyclops	20.72029851	607.518603	118.955	2776.5200000
Tropocyclops	32.13873134	4573.700279	210.429	4306.5900000
Cyclops	3.35097015	73.100630	255.147	449.0300000
Orthocyclops	0.75305970	15.990394	531.007	100.9100000
Eucyclops	0.24917910	2.285239	606.672	33.3900000
Ectocyclops	0.00000000	0.000000	.	0.0000000
Macrocyclops	0.01231343	0.019825	1143.490	1.6500000

Taxa	Mean	Variance	C.V.	Sum
CHEMGRP 2				
Keratella	337.54561728	405575.967462	188.670	54682.3900000
Kellicottia	174.11524691	201326.586967	257.700	28206.6700000
Trichocerca	64.22364198	15376.417709	193.078	10404.2300000
Gastropus	1.76086420	68.415307	469.733	285.2600000
Ascomorpha	1.81549383	61.785704	432.961	294.1100000
Asplanchna	12.36666667	598.855928	197.883	2003.4000000
Polyarthra	88.51734568	48301.887285	248.287	14339.8100000
Synchaeta	2.75222222	91.772135	348.074	445.8600000
Ploesoma	6.33555556	384.413221	309.467	1026.3600000
Filinia	0.93327160	29.415190	581.136	151.1900000
Hexarthra	4.02246914	738.155824	675.431	651.6400000
Conochilus	15.10962963	1900.390867	288.515	2447.7600000
Conochiloides	8.93864198	1651.442387	454.632	1448.0600000
Collotheca	1.49598765	33.216142	385.253	242.3500000
Leptodora	0.01432099	0.024673	1096.830	2.3200000
Diaphanosoma	30.81925926	3086.938694	180.278	4992.7200000
Sida	0.07111111	0.133425	513.666	11.5200000
Holopedium	11.65660494	1016.073085	273.458	1888.3700000
Bosmina	27.35555556	3927.309653	229.088	4431.6000000
Eubosmina	12.51018519	775.089061	222.542	2026.6500000
Chydorus	0.05246914	0.276491	1002.158	8.5000000
Polyphemus	0.01648148	0.021565	890.993	2.6700000
Daphnia (pulex)	7.94450617	454.393835	268.318	1287.0100000
Daphnia (galeata)	0.72061728	6.099561	342.724	116.7400000
Daphnia (parvula)	11.19030864	793.434014	251.717	1812.8300000
Ceriodaphnia	7.15179012	915.267184	423.018	1158.5900000
Epischura	0.66543210	7.095359	400.298	107.8000000
Aglaodiaptomus	0.08666667	0.328709	661.537	14.0400000
Leptodiaptomus	52.96191358	13867.506117	222.349	8579.8300000
Skistodiaptomus	11.39111111	856.838959	256.971	1845.3600000
Onychodiaptomus	0.72438272	31.281204	772.100	117.3500000
Mesocyclops	26.73512346	1673.501715	153.014	4331.0900000
Tropocyclops	41.71080247	11038.769722	251.891	6757.1500000
Cyclops	4.26567901	130.971133	268.287	691.0400000
Orthocyclops	0.12259259	0.813029	735.510	19.8600000
Eucyclops	0.13203704	0.610664	591.841	21.3900000
Ectocyclops	0.03962963	0.252831	1268.806	6.4200000
Macrocyclops	0.00000000	0.000000		0.0000000

Taxa	Mean	Variance	C.V.	Sum
CHEMGRP 1				
Keratella	403.38426573	677385.96912	204.032	57683.9500000
Kellicottia	19.86356643	11074.21153	529.784	2840.4900000
Trichocerca	9.12671329	702.51003	290.410	1305.1200000
Gastropus	1.22216783	60.72197	637.591	174.7700000
Ascomorpha	0.15482517	0.97314	637.156	22.1400000
Asplanchna	2.46958042	118.33714	440.491	353.1500000
Polyarthra	8.84790210	483.02375	248.396	1265.2500000
Synchaeta	3.66230769	241.88610	424.669	523.7100000
Ploesoma	2.00615385	80.88576	448.303	286.8800000
Filinia	0.13265734	0.96728	741.388	18.9700000
Hexarthra	1.53671329	57.34238	492.771	219.7500000
Conochilus	185.80720280	1431349.45649	643.888	26570.4300000
Conochiloides	52.40825175	117247.49537	653.359	7494.3800000
Collotheca	0.02468531	0.03265	732.023	3.5300000
Leptodora	0.00041958	0.00001	685.531	0.0600000
Diaphanosoma	41.25853147	14585.10514	292.712	5899.9700000
Sida	0.00000000	0.00000	.	0.0000000
Holopedium	9.71580420	1744.59451	429.901	1389.3600000
Bosmina	74.39769231	67122.12140	348.236	10638.8700000
Eubosmina	26.04972028	3073.36941	212.816	3725.1100000
Chydorus	0.10342657	0.40886	618.234	14.7900000
Polyphemus	0.20608392	1.35645	565.142	29.4700000
Daphnia (pulex)	5.53559441	134.42854	209.451	791.5900000
Daphnia (galeata)	0.00041958	0.00000	479.522	0.0600000
Daphnia (parvula)	6.87580420	511.23196	328.841	983.2400000
Ceriodaphnia	0.05013986	0.13225	725.285	7.1700000
Epischura	0.89769231	12.43932	392.890	128.3700000
Aglaodiaptomus	0.86713287	8.03056	326.804	124.0000000
Leptodiaptomus	152.06776224	31042.59243	115.862	21745.6900000
Skistodiaptomus	13.48888112	2967.29438	403.835	1928.9100000
Onychodiaptomus	0.00000000	0.00000	.	0.0000000
Mesocyclops	34.28013986	7348.54733	250.068	4902.0600000
Tropocyclops	11.66839161	3196.78119	484.558	1668.5800000
Cyclops	0.85650350	6.82137	304.935	122.4800000
Orthocyclops	0.80916084	14.41284	469.180	115.7100000
Eucyclops	0.03398601	0.04313	611.076	4.8600000
Ectocyclops	0.00000000	0.00000	.	0.0000000
Macrocyclops	0.09447552	0.56920	798.572	13.5100000

APPENDIX F

List of Common Species by Genera and Their Code Numbers

ROTIFERA

Keratella earlinae	1000
K. cochlearis hispida	1001
Keratella crassa	1002
Keratella taurocephala	1003
K. cochlearis-cochlearis	1004
Keratella hiemalis	1005
Keratella irregularis	1006
Keratella ticinensis	1007
Keratella c. robusta	1008
Keratella serrulata	1009
Kellicottia longispina	1010
Kellicottia bostoniensis	1011
Notholco labis	1030
Notholco squamula	1031
Brachionus urceolaris	1040
Brachionus quadridentatus	1041
Euchlanis dilatata	1050
Euchlanis pellucida	1051
Platyias patulus	1060
Mytilina spp.	1070
Lecane luna	1101
Lecane flexilis	1102
Lecane mira	1103
Lecane tudicola	1104
Lecane ungulata	1105
Monostyla lunaris	1110
Trichocerca multicrinis	1400
Trichocerca cylindrica	1401
Trichocerca pusilla	1402
Trichocerca porcellus	1403
Trichocerca similis	1404
Trichocerca rousseleti	1405
Trichocerca lata	1406
Trichocerca elongata	1407
Gastropus hyptopus	1500
Gastropus stylifer	1501
Ascomorpha ovalis	1510
Ascomorpha saltans	1511
Ascomorpha ecaudis	1512
Asplanchna priodonta	1800
Asplanchna sp.	1809
Polyarthra vulgaris	1900
Polyarthra euryptera	1901
Polyarthra remata	1902
Polyarthra major	1903
Polyarthra dolichoptera	1904
Synchaeta pectinata	1910
Synchaeta kitti	1911
Synchaeta oblonga	1912
Ploesoma truncatum	1921
Ploesoma lenticularie	1922
Ploesoma hudsoni	1923
Ploesoma triacanthum	1924
Filinia spp.	2100
Filinia terminalis	2101
Filinia longiseta	2102
Hexarthra mira	2200
Conochilus unicornis	2300
Conochilus hippocrepis	2301
Conochiloides dossarius	2310
Conochiloides natans	2311
Collotheca pelagica	3100
Collotheca mutabilis	3101
Unidentified rotifera	3300

CLADOCERA

Leptodora kindtii	4100
Diaphanosoma birgei	5101
Diaphanosoma brachyurum	5102
Sida crystallina	5110
Holopedium gibberum	5201
Bosmina longirostris	5301
Eubosmina hagmanni	5310
Eubosmina tubicen	5311
Eubosmina longispina	5312
Chydorus brevalibris	5501
Chydorus sphaericus	5502
Chydorus sp.	5509
Alona setulosa	5510
Alona guttata	5511
Alona circumfimbrata	5512
Alona barbula	5513
Alona sp.	5519
Alonella acutirostris	5520
Kurzia laissima	5530
Acroperus harpae	5540
Eurycercus lamellatus	5550
Graptoleberis testudinaria	5560
Polyphemus pediculus	5600
Daphnia catawba	5701
Daphnia galeata mendotae	5702
Daphnia rosea	5703
Daphnia ambigua	5704
Daphnia pulex	5705
Daphnia parvula	5706
Daphnia schodleri	5707
Daphnia retrocurva	5708
Daphnia longiremis	5709
Daphnia dubia	5710
Scapholebris mucronata	5801
Ceriodaphnia reticulata	5802
Ceriodaphnia lacustris	5803
C. affinis/dubia	5804
Ceriodaphnia quadrangula	5805
Ceriodaphnia sp.	5809

COPEPODA

Epischura lacustris	6300
Epischura nordenskioldi	6301
Epischura spp.	6309
Aglaodiaptomus leptopus	6401
A. spatulocrenatus	6402
Leptodiaptomus minutus	6411
L. sicilis	6412
Skistodiaptomus oregonensis	6421
S. reighardi	6422
S. pygmaeus	6423
Skistodiaptomus spp.	6429
Onychodiaptomus birgei	6431
Unknown sp. calanoida	6500
Tropocyclops sp. 1	7100
Mesocyclops edax	7101
Tropocyclops sp. 2	7110
T. prasinus-mexicanus	7111
T. prasinus	7112
Cyclops scutifer	7121
C. strenus strenuus	7122
C. vernalis	7123
C. bicuspidatus thomasi	7124
Cyclops sp.	7129
Orthocyclops modestus	7131
Eucyclops speratus	7141
E. agilus	7142
E. prionophonis	7143
Ectocyclops phaleratus	7144
Macrocyclops albidus	7160
Unknown sp. cyclopoida	7200
Ergasilus chautauquaensis	7500
Nauplii	8000

MISCELLANEOUS

Chaoborus punctipennis	9100
C. americanus	9101
C. flavicens	9102
Chaoborus spp.	9199
Mites 1	9200
Mites 2	9201
Ostracoda	9300

★U.S. GOVERNMENT PRINTING OFFICE: 1992-648-003/40720