8-18-1988

The Distribution of Zooplankton in Selected Oregon Lakes

Mary Elizabeth Claska
Portland State University

Follow this and additional works at: https://pdxscholar.library.pdx.edu/open_access_etds

Part of the [Biology Commons](#), [Population Biology Commons](#), and the [Terrestrial and Aquatic Ecology Commons](#)

Let us know how access to this document benefits you.

Recommended Citation

Claska, Mary Elizabeth, "The Distribution of Zooplankton in Selected Oregon Lakes" (1988). *Dissertations and Theses*. Paper 3752.

<https://doi.org/10.15760/etd.5636>

This Thesis is brought to you for free and open access. It has been accepted for inclusion in Dissertations and Theses by an authorized administrator of PDXScholar. Please contact us if we can make this document more accessible: pdxscholar@pdx.edu.

AN ABSTRACT OF THE THESIS OF Mary Elizabeth Claska for the
Master of Science in Biology presented August 18, 1988.

Title: The Distribution of Zooplankton in Selected Oregon
Lakes.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

Richard Petersen, Chair

Leonard Simpson

Lester Newman

Richard Thoms

Zooplankton samples were collected from 166 Oregon lakes. The lakes included a wide range in size, trophic status, and water quality. Lakes were located throughout the state. Zooplankton were identified using standard taxonomic keys and counted. Seventy-four species were identified from the 200 total samples, including 32 species of cladocera, 22 copepods, and 11 rotifers. Two species of

copepod were recorded for the first time in Oregon:

Diaptomus mississippiensis and Diaptomus pallidus. Seven species had widespread distributions throughout most of the watersheds in the state. Seventeen other species had distributions restricted to eastern, central, or western Oregon. The remaining species were either rare or had random distributions.

Zooplankton community structure was related lake to lake by both coefficient of community and percentage similarity. Coefficient of community was found to better describe community structure in this study. Diversity was measured by the Shannon Weaver index and also as the total number of species per lake. Polynomial regression revealed a quadratic relationship between the two. Species number was regressed as the dependent variable using morphometric and chemical parameters as the independent variables. Species associations were found using recurrent group analysis and Cole's coefficient of interspecific association. This study will serve as a basis for further examination of zooplankton distribution and community structure in Oregon.

THE DISTRIBUTION OF ZOOPLANKTON
IN SELECTED OREGON LAKES

by

MARY ELIZABETH CLASKA

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE
in
BIOLOGY

Portland State University

1988

TO THE OFFICE OF GRADUATE STUDIES:

The members of the Committee approve the thesis of
Mary Elizabeth Claska presented August 18, 1988.

Richard Petersen, Chair

Leonard Simpson

Lester Newman

Richard Thoms

APPROVED:

W. Herman Taylor, Chair, Department of Biology

Bernard Ross, Vice Provost for Graduate Studies

ACKNOWLEDGEMENTS

I would like to thank my advisor, Richard Petersen, for his help and encouragement. Also thanks to the members of my committee, Leonard Simpson, Lester Newman and Richard Thoms for their input on such short notice. Special thanks to Dr. Simpson who took care of the final details.

I also want to acknowledge and thank Arni Litt of the Zoology Dept. at the University of Washington who helped me make a start identifying zooplankton. She also confirmed my identification of Diaptomus mississippiensis when I thought I was going crazy.

Special thanks to Allan Vogel who helped me out on some tough identifications. Many thanks for collecting the extra sample from Cleawox.

To Casson Stallings who was always there with a smile and a diet coke. I appreciate all the help he gave with the computer.

Thanks to Dr. Phil Withers for the help in the beginning with the SPSS computer package.

To the people involved in the lake study. It was always enjoyable working in the field with them. Thanks for collecting the zooplankton when I was not there.

To all my sisters and my Mother who kept asking if and when I was ever going to finish.

To the people at Connecticut Valley Biological, especially Sue. She was always so encouraging.

To Jessie, who was always there with an encouraging noise.

Most of all to Pete. Without his help in the analysis of the data, especially the help on the computer and the statistics, it never would have been finished. He was always there when I needed him, whether he wanted to be or not.

TABLE OF CONTENTS

	PAGE
ACKNOWLEDGEMENTS	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
INTRODUCTION	1
MATERIALS AND METHODS	4
RESULTS	13
DISCUSSION	42
REFERENCES	51
APPENDIX A	56
APPENDIX B	81
APPENDIX C	87

LIST OF TABLES

TABLE		PAGE
I	Drainage Basins and Associated Lakes	6
II	Lake Morphometry and Water Quality Measurements	11
III	Frequency of Occurrence of Crustacean Species in 168 Oregon Lakes	14
IV	Frequency of Occurrence of Rotifer Species in 168 Oregon Lakes	16
V	Species Association Using Recurrent Group Analysis	21
VI	Interspecific Species Association Using Coles' C7 Index	24

LIST OF FIGURES

FIGURE		PAGE
1.	Sampling Site Locations Within the 15 Watersheds in the State of Oregon	5
2.	Relationship Between Total Number of Species and Diversity Index (Shannon Weaver) . .	19
3.	Recurrent Group Analysis Showing Association Between Species	22
4.	Diagram Showing Relationships of Major Species Groups Using Cole's C ₇ Interspecific Association Index	27

INTRODUCTION

This study represents the initial statewide examination of lacustrine zooplankton distribution in Oregon. A species list of crustacean and rotifer plankton found in these lakes is included. This list will serve as a data base for further lake zooplankton studies. The results from statistical tests such as diversity and similiarity indices, and multivariate analysis will serve as a starting point for further studies and experiments.

The distribution of zooplankton in North American freshwater lakes has been of interest to aquatic biologists for many years. Western Canadian lakes have been examined by Carl (1940), Anderson (1971, 1974), and Patalas and Salki (1973). Eastern Canadian lakes were intensively investigated by Carter et al. (1980) for crustacean and dipteran species and Carter et al. (1986) for crustacean and rotifer assemblages. Chengalath et al. (1984) investigated lakes in insular Newfoundland for crustacean and rotifer distributions. Other crustacean studies in Canada were done by Patalas (1971, 1975). Many areas in the United States have also been researched. Colorado, in particular, has been extensively studied due to the wide geographical variation within the state (Pennak, 1957; Patalas, 1964;

Sprules, 1972). Cole (1960) surveyed 35 lakes in Arizona for Diaptomus distribution. Planktonic communities in Florida have been studied by Bays and Crisman (1983) and Brezonik et al. (1984). The Pacific Northwest of the United States has received little attention in research on the distribution of zooplankton species. Whittaker and Fairbanks (1958) conducted a survey in S.E. Washington of 40 water bodies. They were among the first to use standard terrestrial ecological methods of analysis on lake communities. Tash (1971) studied 10 lakes in the Upper Klamath River Basin. However this project was limited in scope. Harris (1979) examined 18 lakes and ponds in the Lower Snake River drainage. The sites sampled included many diverse lake types found within the area.

Large-scale studies that include zooplankton are relatively rare, especially in the United States. Most projects involve lakes in a limited geographical area containing lakes similar in nature. The results are then extrapolated to form general concepts which may not be true for other locales. On the other hand, patterns that are revealed in large scale studies can be significant and meaningful for widespread areas (Collins et al., 1983). Carter et al. (1980) and Bays and Crisman (1982) were the among the first to conduct studies that cover a wide geographic region. These studies took into consideration lake morphology and chemical and biological parameters to

help explain the diversity and distribution of the zooplankton populations.

The present study covers the entire state of Oregon, a diverse geographic area. A total of 166 lakes were surveyed. The sites included coastal lakes, volcanic lakes in the Cascades, glaciated lakes in the Wallowas, and lakes in the desert of Eastern Oregon. These lakes exhibited extreme ranges in trophic status (ultraoligotrophic to hypereutrophic), altitude, size, and depth.

Most of the past studies merely identified the zooplankton and listed their abundances and dominance. In the 1970's, more complete analyses of community composition were initiated. Analyses included indices of similarity, indices of diversity, coefficients of community, and species associations. In the late 1970's analyses were done using computer packages such as the Statistical Package for the Social Science (Nei et al., 1975) and BMDP Statistical Software (Dixon, 1985). Using such programs, the zooplankton data are related to measured chemical and biological parameters. Zooplankton distribution then can be explained and related to conditions found in the lakes.

MATERIALS AND METHODS

Zooplankton samples were collected from 166 Oregon lakes (Figure 1, Table I). Most of these samples were collected during a Portland State University study to classify the lakes of Oregon. The majority of the samples were collected during the summer months (June through Sept.) of 1981 through 1984. The sampled lakes were selected based primarily on size and most ranged between 40 acres and 60,000 acres. Some smaller lakes were included in the study due to their location or local significance (Johnson et al., 1985). Forty-two of these lakes were termed "significant" due to size, public familiarity, and recreational usage. These lakes were sampled up to three times. The other 124 lakes were sampled only once. A single sample is sufficient to give a good representation of the species found in each lake. It has been found from comparing a series of samples collected over a period of years, that while relative abundances of the species will vary, the species composition will remain fairly constant (Carl, 1940). Due to logistic problems in a widespread geographical study only one sample was collected from the majority of the lakes. Most zooplankton distribution studies that cover large areas contain lakes sampled only once or twice (Anderson, 1971;

Figure 1. Sampling site locations within the 15 watersheds.
 1= Midcoast, 2= South Coast, 3= Willamette/Sandy, 4= Umpqua,
 5= Rogue, 6= Deschutes, 7= Klamath, 8= Goose/Summer,
 9= Umatilla, 10= John Day, 11= Malheur Lake, 12= Grande
 Ronde, 13= Powder, 14= Malheur River, 15= Owyhee

TABLE I

DRAINAGE BASINS AND ASSOCIATED LAKES

Drainage Basin	No. of lakes	List of Lakes
1 Mid Coast	12	Cleawox, Clear, Collard, Devils, Eckman, Mercer, Munsel, Siltcoos, Sutton, Tahkenitch, Triangle, Woahink
2 South Coast	11	Beale, Croft, Eel, Floras, Garrison, Lower Pony Creek, No. Tenmile, Tenmile, Upper Pony Creek
3 Willamette/Sandy	34	Averill, Big, Blue River, Breitenbush, Clear, Cottage Grove, Cougar, Detroit, Dexter, Dorena, Elk, Fall Creek, Fish, Gold, Henry Hagg, Hills Creek, Lava Camp, Leaburg, Lost, Lower, Lower Eddeeleo, Lower Erma Bell, Marion, Mink, Oswego, Pamelaia, River Mill, Scott, Smith, Timothy, Torrey, Trailbridge, Upper Eddeeleo, Waldo
4 Umpqua	3	Diamond, Lemolo, Loon
5 Rogue	9	Applegate, Agate, Emigrant, Fish, Island, Lost Creek, Selmac, Squaw, Willow
6 Deschutes	39	Antelope Flat, Billy Chinook, Blue, Clear, Charlton, Crane Prairie, Crescent, Davis, Deer, Doris, East, Haystack, Horseshoe, Irish, Island, Lava, Little Cultus, Little Lava, Middle Green, Monon, North Twin, Ochoco, Odell, Ollalie, Paulina, Pine Hollow, Prineville, Rabbit Valley, Rock Creek, Simtustus, Sparks, South Twin, Summit, Suttle,

TABLE I
DRAINAGE BASINS AND ASSOCIATED LAKES
(continued)

6	Deschutes (Cont.)		Three Creeks, Todd, Upper Tumalo, Walton, Wickiup
7	Klamath	17	Agency, Boyle, Bumphead, Devil, Euwana, Fourmile, Gerber, Howard Prairie, Hyatt, Lake of the Woods, Miller, Obenchain, Round Valley, Spring, Strawberry Upper Klamath, Willow Valley
8	Summer/Goose	9	Abert, Crump, Dog, Drews, Goose, Hart, Pelican, Summer, Thompson Valley
9	Umatilla	2	Cold Springs, McKay
10	John Day	3	Magone, Olive, Penland
11	Malheur Lake	5	Chickahominy, Delintment, Fish, Mann, Rock Creek
12	Grande Ronde	7	Glacier, Jubilee, Langdon, Minam, Mirror, Morgan, Wallowa
13	Powder	7	Anthony, Balm Creek, Fish, Phillips, Thief Valley, Unity, Wolf Creek
14	Malheur River	5	Beulah, Bully Creek, Cottonwood, Malheur Res., Warm Springs
15	Owyhee	3	Antelope Res., Owyhee, Upper Cow Creek

Carter et al., 1980; Chengalath et al., 1984; Carter et al., 1986; Stoddard, 1987). A total of 200 samples were taken for this study.

The zooplankton samples were collected at

approximately the deepest part of the lake during daylight hours with a conical plankton net of No. 20 mesh and with a 20 cm mouth diameter. The net was drawn from two times the Secchi disc depth to the surface in a vertical tow. If the lake bottom was shallower than this, vertical tows were taken from the bottom. This procedure should result in samples consisting only of limnetic species. The samples were first preserved in ethanol and later transferred to 4% buffered formalin.

The crustacean and rotifer plankton were identified to species, except for the early larval stages. Other rare plankton collected were identified to the nearest taxon possible. Taxonomic keys used were: Brooks (1957), Edmondson (1959), Deevey and Deevey (1971), Brandlova *et al.* (1972), and Pennak (1978). The entire sample was counted.

Various standard chemical and morphological parameters were measured for each lake. The complete raw data for all these parameters can be found in the Atlas of Oregon Lakes, (Johnson *et al.*, 1985). The chemical data were collected on the same day and at the same site as the zooplankton.

The coefficient of community (Jaccard's Index) was calculated from the formula

$$CC = c/(a+b-c) \times 100$$

where *a* is the number of species in the first sample, *b* is the number of species in the second sample, and *c* is the

number of common species (see Pielou, 1984). This test measures the species common to both community samples. This type of test uses only presence-absence data. It is preferred for use when gross differences in species composition are of interest (Westman, 1985).

The percentage similarity of community was calculated from the formula

$$PSc = 100 - .5 \sum |a - b| = \sum \min (a, b)$$

where *a* and *b* are, for a given species, the percentages of samples A and B which that species represents (Whittaker and Fairbanks, 1958). This test gives weight to the abundance of each species in the community. One problem with this measure is that it tends to be biased towards the more abundant, common species (Omori and Ikeda, 1984).

The diversity index was obtained using the following formula of Shannon-Weaver:

$$DI = - \sum (p_i \ln p_i)$$

where *p_i* is the proportion of a given species in the sample (Poole, 1974). This index was selected over other diversity indices since this is sensitive to rare and intermediate species abundances. This index is sensitive to the evenness of abundances (meaning communities with equal species abundances are considered more diverse) as well as the total number of species present (communities with a greater number

of species are considered more diverse).

Diversity was also determined by counting the number of species per lake. According to Poole (1974) "the number of species is the only objective measure of diversity." The two measures of diversity (Shannon-Weaver and species number) were compared using polynomial regression (SPSS). The number of species per lake was then compared with the physical and the chemical parameters (as the independent variables) using stepwise multiple regression (BMDP2R). In stepwise multiple regression the independent variables are added one at a time. They are selected on the basis of the amount of variance accounted for in the dependent variable. The physical and chemical data used are listed in Table II. Most of these data were transformed using $X' = \ln(X + 1)$ to normalize the distribution. The transformed variables are normally distributed, as is required by the polynomial and multiple regression models. The transformation also allows zero values to be used. The only parameters that were not transformed were elevation, surface temperature, and pH.

Species associations were determined using Recurrent Group Analysis (RGA) (Fager and McGowan, 1963):

$$I = \frac{J}{\sqrt{N_a N_b}} - \frac{1}{2 \sqrt{N_b}}$$

where J is the number of joint occurrences, N_a is the total number of occurrences of species A, N_b is the total number

TABLE II
LAKE MORPHOMETRY AND WATER QUALITY MEASUREMENTS
(From Johnson *et al.*, 1985)

	<u>Ranges</u>	
	<u>minimum</u>	<u>maximum</u>
Area (hectares)	2	- 39414
Elevation (meters)	3	- 2499
Maximum depth (meters)	.6	- 134.1
Volume (cubic hectometers)	.1	- 1383.4
Surface Temp. (°C)	5.9	- 26.2
pH	6.2	- 10.1
Secchi Disk (meters)	.1	- 22
PO ₄ (ug/l)	.1	- 194
Chlorophyll a (ug/l)	.1	- 95.6
Alkalinity (mg/l)	0	- 11515
Conductivity (umhos/cm)	3	- 42000
Major Ions (mg/l)		
Na	.2	- 12176
K	0	- 471
Ca	.1	- 49.9
Mg	.1	- 36.4
Cl	.2	- 49826
SO ₄	0	- 244.5

of occurrences of species B, and species are assigned letters such that $N_b \geq N_a$. Values of greater than 0.50 are considered significant by most other workers. Species that occurred in less than four samples were not considered using this method.

Another test of association is Coles' C₇ (1949):

$$C_7 = \frac{ad - bc}{(a + b)(b + d)}$$

where *a* is the number of joint occurrences, *b* is the number of occurrences of species A, *c* is the number of occurrences

of species B, d is the number of samples with neither species. Species are assigned letters such that species A is less frequent than species B. The equation is valid as long as $ad \geq bc$. Standard error (SE) for this test is

$$SE = \sqrt{\frac{(a + c)(c + d)}{n(a + b)(b + d)}}$$

where the n is the number of total samples. The C₇ value is significant when twice the standard error is less than the value ($C_7 - 2 SE \geq 0$). Species which occurred in less than four samples were not used in this measure.

RESULTS

Seventy-four zooplankton species were identified from the 166 lakes sampled for this study. Thirty-two of these species were cladocerans, 22 were copepods (16 calanoid, 6 cyclopoid), 11 were rotifers and the remainder were water mites, insect larvae, a species of amphipod, and Artemia salina. The average number of species per lake was 5.95, with lakes containing from 1 to 13 species. Nine of the species found are considered littoral species. They were collected from shallow lakes, from lakes with macrophytes on the bottom near the sampling area, or lakes where the zooplankton tow was from the bottom. Each was found in only two or three lakes and they were rarely dominant. Appendix A lists, by lake, all the zooplankton species found.

Table III lists the crustacean species found, the number of samples where each species was present, and the number of samples where it was dominant. Dominance is defined as being greater than 10% of the total population (Patalas, 1971). Bosmina longirostris was the most common crustacean. It was found in 91 samples, and was dominant in 51 samples. The most common copepod was Cyclops bicuspidatus thomasi, a cyclopoid copepod. It was found in 88 samples and was dominant in 40 of these samples. The most common calanoid copepod was Diaptomus novamexicanus (50

TABLE III
 FREQUENCY OF OCCURRENCE OF CRUSTACEAN
 SPECIES IN 166* OREGON LAKES

Species	No. of Lakes			
	in which sp. occurs	%	in which sp. dom.	%
<u>Bosmina longirostris</u>	91	45	51	26.5
<u>Daphnia galeata mendotae</u>	86	43	38	19
<u>Cyclops bicuspidatus thomasi</u>	86	43	40	20
<u>Daphnia schoedleri</u>	78	39	51	25.5
<u>Daphnia rosea</u>	52	26	27	13.5
<u>Diaptomus novamexicanus</u>	50	25	28	14
<u>Diaphanosoma leuchtenbergianum</u>	50	25	15	7.5
<u>Epischura nevadensis</u>	49	24.5	17	8.5
<u>Chydorus sphaericus</u>	46	23	7	3.5
<u>Daphnia pulicaria</u>	46	23	26	13
<u>Holopedium gibberum</u>	32	15.5	21	10.5
<u>Diaptomus forbesi</u>	30	15	11	5.5
<u>Mesocyclops edax</u>	22	11	9	4.5
<u>Diaptomus tyrrelli</u>	20	10.0	15	7.5
<u>Leptodora kindtii</u>	20	10	0	0
<u>Cyclops vernalis</u>	19	9.5	5	2.5
<u>Diaphanosoma brachyurum</u>	19	9.5	10	5
<u>Diaptomus franciscanus</u>	17	8.5	6	3
<u>Macrocyclus albidus</u>	17	8.5	1	0.5
<u>Eubosmina hagmanni</u>	16	8	9	4.5
<u>Ceriodaphnia reticulata</u>	15	7.5	6	3
<u>Ceriodaphnia quadrangula</u>	15	7.5	5	2.5
<u>Daphnia pulex</u>	13	6.5	7	3.5
<u>Diaptomus ashlandi</u>	13	6.5	8	4
<u>Diaptomus hesperus</u>	12	6	5	2.5
<u>Ceriodaphnia affinis</u>	11	5.5	5	2.5
<u>Diaptomus sicilis</u>	11	5.5	9	4.5
<u>Eucyclops agilis</u>	11	5.5	3	1.5
<u>Diaptomus kenai</u>	11	5.5	5	2.5
<u>Daphnia parvula</u>	8	4	2	1
<u>Ceriodaphnia lacustris</u>	7	3.5	5	2.5
<u>Polyphemus pediculus</u>	6	3	1	0.5
<u>Daphnia ambigua</u>	5	2.5	2	1
<u>Ceriodaphnia acanthina</u>	4	2	1	0.5
<u>Daphnia magna</u>	3	1.5	0	0
<u>Daphnia retrocurva</u>	3	1.5	2	1
<u>Diaptomus leptopus</u>	3	1.5	1	0.5
<u>Diaptomus oregonensis</u>	3	1.5	1	0.5

TABLE III
FREQUENCY OF OCCURRENCE OF CRUSTACEAN
SPECIES IN 166* OREGON LAKES
(continued)

<u>Graptoleberis</u>				
<u>testudinaria</u>	3	1.5	1	0.5
<u>Leydigia</u>	3	1.5	0	0
<u>Sida crystallina</u>	3	1.5	1	0.5
<u>Tropocyclops prasinus</u>	3	1.5	1	0.5
<u>Alona rectangula</u>	3	1.5	1	0.5
<u>Alona sp.</u>	2	1	0	0
<u>Alona quadrangularis</u>	2	1	1	0.5
<u>Diaptomus signicauda</u>	2	1	1	0.5
<u>Artemia salina</u>	1	0.5	1	0.5
<u>Chydorus globosus</u>	1	0.5	0	0
<u>Daphnia similis</u>	1	0.5	0	0
<u>Diaptomus eiseni</u>	1	0.5	0	0
<u>Diaptomus</u>				
<u>mississippiensis</u>	1	0.5	1	0.5
<u>Diaptomus nudus</u>	1	0.5	0	0
<u>Diaptomus pallidus</u>	1	0.5	0	0
<u>Eurycercus lamellatus</u>	1	0.5	0	0
<u>Hyaella azteca</u>	1	0.5	0	0
<u>Latona setifera</u>	1	0.5	0	0
<u>Scapholeberis kingi</u>	1	0.5	0	0

*200 samples total

Dominance= more than 10% of all crustacean species

samples). It was dominant in 28 of the samples. There were four Daphnia species that were commonly found: Daphnia galeata mendotae (86 samples), Daphnia schoedleri (78 samples), Daphnia rosea (52 samples) and Daphnia pulicaria (46 samples). Other common crustaceans found were Diaphanosoma leuchtenbergianum (50 samples), Epischura nevadensis (49 samples), and Chydorus sphaericus (46 samples).

Table IV lists the same information for the rotifer species. Kellicottia longispina was by far the most common

TABLE IV
 FREQUENCY OF OCCURRENCE OF ROTIFER
 SPECIES IN 166* OREGON
 LAKES

Species	No. of Lakes			
	in which sp. occur	%	in which sp. dom.	%
<u>Kellicottia longispina</u>	72	36	62	31
<u>Keratella quadrata</u>	25	12.5	18	9
<u>Asplanchna</u> sp.	15	7.5	10	5
<u>Keratella cochlearis</u>	12	6	8	4
<u>Branchionus quadridentata</u>	7	3.5	3	1.5
<u>Trichocerca cylindrica</u>	6	3	5	2.5
<u>Kellicottia bostoniensis</u>	4	2	3	1.5
<u>Conochilus</u> sp.	4	2	4	2
<u>Platylabus patulus</u>	2	1	1	0.5
<u>Polvarthra</u> sp.	2	1	2	1
<u>Trichocerca</u> sp.	2	1	2	1

*200 samples total

Dominance = more than 10 % of all rotifer species

rotifer species; it was found in 72 samples and was dominant in 62 of them. Keratella quadrata was the next most common; it was found in 25 samples and dominant in 18 samples. The other nine rotifer species were found in 15 or fewer samples and dominant in no more than 10 samples. In most of the samples there was only one species of rotifer present. In only 27 of the samples were two species found together, only nine samples had three species, and there was only one lake sample that had four species of rotifer. More than four rotifer species were not found together in any of the 200 samples.

COEFFICIENT OF COMMUNITY

The coefficient of community (CC) was used to relate lake zooplankton communities to each other. The species are related using only presence-absence data, not abundances. In this way the rare species are not ignored and sample size will not affect the index. The results of this calculation are listed in appendix B. Only the highest CC is listed for each lake. The higher the coefficient of community the more similiar are the zooplankton communities of the two lakes. The highest CC found was 100. A CC value of 100 means both lakes had exactly the same species. This occurred only once, between Torrey Lake and Breitenbush Lake. The lowest CC found that was the highest CC for two lakes was 25.0. This was the relationship between Sparks Lake (7/20/82) and Garrison (8/3/81), and between samples from Sparks Lake taken on 7/20/82 and 8/21/81. The average coefficient of community was found for each lake, versus lakes within the same watershed and for lakes outside of the watershed. For 165 lakes the mean CC was greater for lakes within the same watershed. This meant that the lakes within the same watershed had species that were more similar to each other than when compared to lakes outside the watershed.

PERCENTAGE SIMILIARITY

Percentage similiarity (PSc) was also used to compare lakes on the basis of zooplankton assemblages. This index

uses abundance values, not the presence-absence information used in coefficient of community. The highest value for each lake is listed in Appendix C. The highest value between any two lakes was 97.7, found between Fish Lake (Malheur Lake watershed) and Lake of the Woods (5/19/82). Sparks Lake (7/20/82) compared to itself (8/21/81) had the lowest high value of 14.3.

The two indices of similiarity had very different results. Only 21 lake samples were determined to have the highest values with the same sample in both indices. Breitenbush and Torrey, which had a CC of 100, had a PSc of only 40.4. Even though they had the same species composition, the abundances were very different. Fish Lake and Lake of the Woods which had the highest PSc, had a CC value of 11.3. These lakes had a very few species in common, but the species in common were abundant.

DIVERSITY INDEX

Diversity indices for the individual samples had values ranging from 0 to 1.9. This is a measure of both the number of species per lake (richness) and the equality of the abundances of the species (evenness) (Poole, 1974). The values were plotted against the total number of species for each lake (Figure 2) and a polynomial regression was performed to find their relationship. A quadratic

Figure 2. Relationship between total number of species and Shannon Weaver diversity index.

regression line was found to give the best fit to the data ($R^2 = 0.855$, $P < 0.01$).

REGRESSION ANALYSIS

The number of species per sample was used in the stepwise multiple regression with the physical and chemical parameters (Table II) as the independent variables. Using this method, the variables that account for the most variance in the data will be used first. Four of the 17 variables used were found to explain a total of 18 % of the variation in the total number of species per lake. In order of inclusion these were: surface temperature (multiple $R^2 = .05$), chlorophyll a content (multiple $R^2 = .09$), potassium (multiple $R^2 = .14$), and magnesium (multiple $R^2 = .18$).

RECURRENT GROUP ANALYSIS

The results of recurrent group analysis were fairly straightforward since there were few species that showed associations. There were no values greater than 0.5, which most investigators consider indicative of significant species associations (Davies, 1971; Venrick, 1971; Sprules, 1975b; McGowan and Walker, 1979). Fourteen species showed association values between 0.40 and 0.50, and are listed in Table V. Cyclops bicuspidatus thomasi had the most associations at this level. It is also the most common copepod found in this study. Among the rotifers, only

TABLE V
SPECIES ASSOCIATION USING RECURRENT
GROUP ANALYSIS

Species	Association Index	Associated Species
<u>Cyclops bicuspidatus</u>	0.47	<u>Daphnia pulicaria</u>
<u>thomasi</u>	0.40	<u>Daphnia galeata mendotae</u>
	0.44	<u>Daphnia schoedleri</u>
	0.40	<u>Diaphanosoma</u>
		<u>leuchtenbergianum</u>
	0.40	<u>Diaptomus forbesi</u>
	0.40	<u>Diaptomus novamexicanus</u>
<u>Daphnia galeata</u>	0.46	<u>Bosmina longirostris</u>
<u>mendotae</u>	0.47	<u>Daphnia schoedleri</u>
	0.43	<u>Kellicottia longispina</u>
<u>Holopedium gibberum</u>	0.46	<u>Diaptomus tyrrelli</u>
	0.40	<u>Daphnia rosea</u>
	0.43	<u>Epischura nevadensis</u>
<u>Bosmina longirostris</u>	0.49	<u>Kellicottia longispina</u>
	0.40	<u>Daphnia rosea</u>
<u>Daphnia schoedleri</u>	0.41	<u>Daphnia pulicaria</u>
	0.40	<u>Diaptomus novamexicanus</u>
<u>Epischura nevadensis</u>	0.43	<u>Eubosmina nevadensis</u>
<u>Daphnia rosea</u>	0.40	<u>Diaptomus tyrrelli</u>

Kellicottia longispina (the most common rotifer) showed a significant association with any of the other zooplankton species.

There were three association groups formed, of three species each (Figure 3). The first group is Bosmina longirostris, Kellicottia longispina and Daphnia galeata mendotae. The second group is Cyclops bicuspidatus thomasi,

Figure 3. Recurrent group analysis showing associations between species. Fractions are the ratios of the observed number of associations to the number of associations possible. (Fager and McGowan, 1963).

Daphnia schoedleri, and Diaptomus novamexicanus. The third group is Daphnia rosea, Holopedium gibberum and Diaptomus tyrrelli. The first two groups were related because Daphnia galeata mendotae was also associated with Daphnia schoedleri and Cyclops bicuspidatus thomasi. The second group is related to the third group because Bosmina longirostris shows affinity with Daphnia rosea. The remaining five species showing significant relationships were all one way relationships. Thirty-one of the 40 species examined showed

little or no affinity to any of the others.

COEFFICIENT OF INTERSPECIFIC ASSOCIATION

Another coefficient of association used was that developed by Cole (1949). This uses presence-absence, data as recurrent group analysis does. One difference between the two is Cole's C_7 also uses absence of both species from lakes in the equation. A C_7 value is significantly different from random associations when twice the standard error is less than the association value. According to this criterion, a total of 38 species showed an association with at least one other species (Table VI).

Daphnia schoedleri was associated with nine other species. This was the highest number of associations for one species. Figure 4. shows the relationship between the four major association groups. The largest group contained the following four species: Eubosmina hagmanni, Daphnia rosea, Holopedium gibberum, and Diaptomus tyrrelli. There were three groups with three species each. The first group contained Daphnia schoedleri, Diaptomus novamexicanus, and Cyclops bicuspidatus thomasi. The second group was Mesocyclops edax, Diaptomus franciscanus, and Daphnia galeata mendotae. The third group was Brachionus quadridentata, Keratella quadrata, and Ceriodaphnia affinis. All these groups were related to some degree. The group with four species was somewhat removed from the other

TABLE VI
 INTERSPECIFIC ASSOCIATIONS USING
 COLES'S C₇ INDEX

Species	Value $\pm$ 2SE	Associated Species
<u>Cyclops bicuspidatus</u>	.532 $\pm$ .292	<u>Diaptomus forbesi</u>
<u>thomasi</u>	.504 $\pm$ .224	<u>Daphnia pulicaria</u>
	.284 $\pm$ .216	<u>Diaphanosoma</u>
		<u>leuchtenbergianum</u>
	.263 $\pm$ .212	<u>Diaptomus</u>
		<u>novamexicanus</u>
	.157 $\pm$ .156	<u>Daphnia schoedleri</u>
<u>Daphnia galeata</u>	.587 $\pm$ .404	<u>Diaptomus franciscanus</u>
<u>mendotae</u>	.561 $\pm$ .268	<u>Leptodora kindtii</u>
	.362 $\pm$ .350	<u>Mesocyclops edax</u>
	.225 $\pm$ .156	<u>Daphnia schoedleri</u>
	.172 $\pm$ .164	<u>Kellicottia longispina</u>
<u>Holopedium gibberum</u>	.643 $\pm$ .186	<u>Diaptomus tyrrelli</u>
	.569 $\pm$ .246	<u>Diaptomus kenai</u>
	.554 $\pm$ .210	<u>Eubosmina hagdmani</u>
	.503 $\pm$ .184	<u>Epischura nevadensis</u>
	.493 $\pm$ .192	<u>Daphnia rosea</u>
	.230 $\pm$ .202	<u>Macrocyclus albidus</u>
<u>Bosmina longirostris</u>	.541 $\pm$ .512	<u>Diaptomus hesperus</u>
	.416 $\pm$ .368	<u>Mesocyclops edax</u>
	.286 $\pm$ .172	<u>Kellicottia longispina</u>
<u>Daphnia schoedleri</u>	.593 $\pm$ .336	<u>Leptodora kindtii</u>
	.593 $\pm$ .442	<u>Keratella cochlearis</u>
	.532 $\pm$ .294	<u>Diaptomus forbesi</u>
	.364 $\pm$ .204	<u>Daphnia pulicaria</u>
	.350 $\pm$ .296	<u>Keratella quadrata</u>
	.285 $\pm$ .194	<u>Diaptomus</u>
		<u>novamexicanus</u>
	.222 $\pm$ .204	<u>Chydorus sphaericus</u>
<u>Epischura nevadensis</u>	.834 $\pm$ .274	<u>Eubosmina hagdmani</u>
	.338 $\pm$ .242	<u>Diaptomus tyrrelli</u>
<u>Daphnia rosea</u>	.662 $\pm$ .252	<u>Diaptomus tyrelli</u>
	.493 $\pm$ .286	<u>Eubosmina hagdmani</u>
	.398 $\pm$ .234	<u>Diaptomus kenai</u>

TABLE VI
 INTERSPECIFIC ASSOCIATIONS USING
 COLES'S C7 INDEX
 (continued)

<u>Brachionus quadridentata</u>	.443 ± .406	<u>Chydorus sphaericus</u>
	.382 ± .216	<u>Asplanchna</u> sp.
	.244 ± .180	<u>Ceriodaphnia affinis</u>
	.228 ± .216	<u>Ceriodaphnia</u> <u>quadrangula</u>
<u>Ceriodaphnia affinis</u>	.358 ± .246	<u>Diaptomus forbesi</u>
	.222 ± .154	<u>Daphnia pulex</u>
<u>Ceriodaphnia</u> <u>quadrangula</u>	.289 ± .286	<u>Diaptomus</u> <u>novamexicanus</u>
	.250 ± .156	<u>Diaphanosoma</u> <u>brachyurum</u>
<u>Ceriodaphnia reticulata</u>	.394 ± .272	<u>Chydorus sphaericus</u>
	.289 ± .286	<u>Diaptomus</u> <u>novamexicanus</u>
	.279 ± .228	<u>Polyphemus pediculus</u>
	.214 ± .166	<u>Eucyclops agilis</u>
<u>Daphnia ambigua</u>	.348 ± .260	<u>Eubosmina hagmanni</u>
	.344 ± .270	<u>Macrocyclus albidus</u>
	.326 ± .310	<u>Mesocyclops edax</u>
<u>Daphnia parvula</u>	.503 ± .394	<u>Diaphanosoma</u> <u>leuchtenbergianum</u>
	.332 ± .182	<u>Daphnia pulex</u>
<u>Daphnia pulicaria</u>	.410 ± .320	<u>Diaptomus sicilis</u>
	.351 ± .232	<u>Leptodora kindtii</u>
	.312 ± .254	<u>Diaptomus franciscanus</u>
	.264 ± .184	<u>Diaptomus forbesi</u>
<u>Diaphanosoma</u> <u>leuchtenbergianum</u>	.558 ± .458	<u>Trichocerca cylindrica</u>
	.303 ± .248	<u>Cyclops vernalis</u>
	.238 ± .144	<u>Diaptomus</u> <u>novamexicanus</u>
<u>Diaptomus franciscanus</u>	.454 ± .302	<u>Kellicottia</u> <u>bostoniensis</u>
	.339 ± .178	<u>Mesocyclops edax</u>
	.333 ± .194	<u>Diaptomus</u> <u>novamexicanus</u>

TABLE VI
 INTERSPECIFIC ASSOCIATIONS USING
 COLES'S C₇ INDEX
 (continued)

<u>Diaptomus hesperus</u>	.291 ± .204	<u>Trichocerca cylindrica</u>
	.262 ± .182	<u>Diaphanosoma</u> <u>brachyurum</u>
<u>Diaptomus kenai</u>	.295 ± .194	<u>Polyphemus pediculus</u>
	.293 ± .212	<u>Diaptomus tyrrelli</u>
	.209 ± .172	<u>Eubosmina hagmanni</u>
<u>Diaptomus sicilis</u>	.273 ± .222	<u>Keratella quadrata</u>
	.214 ± .186	<u>Asplanchna</u> sp.
	.196 ± .190	<u>Cyclops vernalis</u>
<u>Diaptomus tyrrelli</u>	.444 ± .268	<u>Polyphemus pediculus</u>
	.167 ± .160	<u>Eubosmina hagmanni</u>
<u>Keratella cochlearis</u>	.468 ± .250	<u>Kellicottia</u> <u>bostoniensis</u>
	.271 ± .170	<u>Diaptomus franciscanus</u>
	.185 ± .166	<u>Eubosmina hagmanni</u>
<u>Keratella quadrata</u>	.347 ± .104	<u>Brachionus</u> <u>quadridentata</u>
	.273 ± .222	<u>Ceriodaphnia affinis</u>
	.193 ± .176	<u>Macrocyclus albidus</u>
<u>Mesocyclops edax</u>	.503 ± .302	<u>Kellicottia longispina</u>
	.438 ± .248	<u>Kellicottia</u> <u>bostoniensis</u>
	.172 ± .154	<u>Diaphanosoma</u> <u>brachyurum</u>

groups. This group of four species related most strongly with a group of two species (Daphnia ambigua and Macrocyclus albidus). The first and second groups of three species is directly related due to Daphnia schoedleri (first group) being associated with Daphnia galeata mendotae (second group). The third group of three species is related to the first group because Keratella quadrata (third group)

Figure 4. Diagram showing relationships of major species groups using Cole's C7 interspecific association index.

is associated with Daphnia schoedleri (first group). The second and third groups of three species are not directly related.

Using the Cole C7 method there were only two species that did not positively associate with any other of the species. These species are Ceriodaphnia lacustris and Diaptomus ashlandi.

SPECIES LIST

This species list consists of all the zooplankton found in this study that were identified to species. Common zooplankton identified to genus are also included.

Rare zooplankton that were identified only to phylum or order are not included. This includes the tardigrades, ostracods, and some insect larvae.

Copepoda

Diaptomus ashlandi - Found in 10 lakes. Other studies (Whittaker, 1958; Anderson, 1974; Harris, 1979) consider this species indicative of deep oligotrophic lakes. Wallowa Lake is the only lake that fits this description. The other nine lakes ranged from mesotrophic Lake of the Woods to hypereutrophic Upper Klamath Lake. Tash (1974) has reported it previously in Upper Klamath Lake.

Diaptomus eiseni - Only found in Rabbit Valley Lake. Reported by both Tash (1974) in the Upper Klamath River Basin and Harris (1979) in the Lower Snake River drainage as a rare species. Previously reported in 7 sites in the Sierra Nevada mountains, and showed a significant relationship with absence of fish (Stoddard, 1987). It is a large copepod easily visible to fish. It is probably more widespread than indicated by this study.

Diaptomus franciscanus - Found in 17 lakes located between the coast and the eastern slope of the Cascades. It has been found from British Columbia (Carl, 1940; Anderson, 1971, 1974) to California (Wilson and Yeatman, 1959).

Diaptomus forbesi - Found mainly east of Cascades (23 out of 25 sites). Only found in Emigrant Res. and Hyatt Res. west of the Cascades. Anderson (1974) identified the

species as coming from shallow, warm, and moderately saline lakes. This description matches only one of the lakes in this species' distribution (Mann Lake). The other lakes were warm (except Minam Lake) but not necessarily shallow and only Malheur Res. was slightly saline.

Diaptomus hesperus - Only found in 9 lakes along the coast, a limited distribution. The furthest north was Sutton Lake (near Florence, OR) and the furthest south was Beale Lake (near North Bend, OR), a distance of 50 miles. Carl (1940) found this species only in two locations near the British Columbia coast.

Diaptomus kenai - Located in 11 lakes, all in the Cascades. Wilson and Yeatman (1959) describes it as common in high altitudes from Alaska to California. Found in mountain lakes in Washington (Hairston, 1978).

Diaptomus leptopus - Found in three lakes, Elk Lake (Deschutes watershed), and Morgan Lake and Wallowa Lake (Grande Ronde watershed). Whittaker and Fairbanks (1958), Tash (1974), and Harris (1979) found D. leptopus as a rare species in their study areas (S.E. Washington, Upper Klamath River basin, and S.E. Washington, respectively). Oregon is the southernmost part of its range on the West Coast (Wilson and Yeatman, 1959).

Diaptomus mississippiensis - The present study represents the first recorded observation of this species in the State of Oregon. Only found in Cleawox Lake, an

oligotrophic coastal lake, where it was dominant. A sample taken in July, 1986 showed this species still to be a dominant member of the limnetic zooplankton. It is known from the Southeastern U.S. (Wilson and Yeatman, 1959) where it is a common inhabitant in lakes (Beavers and Stavn, 1975). Found in oligotrophic - mesotrophic lakes in Florida (Bays and Crisman, 1983).

Diaptomus novamexicanus - The most common and widespread diaptomid species in this study. It was found in 41 lakes in 13 of the 15 watersheds (not Rogue and Owyhee watersheds). Whittaker and Fairbanks (1958), Tash (1974), and Harris (1979) found it in their respective study areas in Washington and Oregon. Was found to be indicative of eutrophic conditions (Whittaker and Fairbanks, 1958). Found in 20 eutrophic lakes, 18 mesotrophic lakes and only three oligotrophic lakes.

Diaptomus nudus - Only collected in Unity Res. (Powder watershed). The range (Wilson and Yeatman, 1959) is Alaska, Canada, and the Rocky Mt. states. This is the second record for D. nudus in this area (Harris, 1979, was first). The range seems to have expanded.

Diaptomus oregonensis - Found in three lakes: Lake Oswego and Cottage Grove Res. in Willamette/Sandy watershed, and Squaw Lake in the Rogue watershed. D. oregonensis is one of the more common and widely distributed species in the northern U.S. (Pennak, 1978). Carl (1940) found it only

rarely in British Columbia, mainly on Vancouver Island. Anderson (1974) found it in one lake in the Canadian Rocky Mountains. It is a common copepod in N.E. Canada (Carter, 1971; Carter et al., 1980) where it was found to be tolerant of extremes in lake morphometry, temperature, and water chemistry. Found in more productive lakes in northeastern Ontario lakes (Keller and Pitblado, 1984).

Diaptomus pallidus - Agate Lake (Rogue watershed) was the only collection site. Species range is the Plains states west to Colorado (Wilson and Yeatman, 1959). There is no other recorded occurrence for D. pallidus in Oregon.

Diaptomus sicilis - Found in 10 lakes, all east of the Cascades. Lakes ranged from mesotrophic to hypereutrophic, saline to nonsaline. Whittaker and Fairbanks (1958), Tash (1974), and Harris (1979) found this species in their study areas. Whittaker and Fairbanks (1958) found D. sicilis usually occurs in moderately saline lakes but also occurred in two freshwater lakes. Carl (1940) found it in small stagnant lakes and temporary pools. Patalas (1971) and Carter (1971) found the species in deep, clear lakes and regarded it as a cold water form. Anderson (1974) found it in a wide variety of lake types (permanent mountain lakes to shallow saline prairie lakes). This species tolerates a wide variety of conditions.

Diaptomus signicauda - Found in two Cascade lakes, Averill and Monon, located close together. Distribution is

the mountains of the Pacific coast states (Wilson and Yeatman, 1959). Found in British Columbia (Carl, 1940) in one lake, but not by other Northwest investigators. It is the dominant small-bodied diaptomid in the Sierra Nevada lakes, taking the place of D. tyrrelli (Stoddard, 1987).

Diaptomus tyrrelli - Found in 20 lakes in four watersheds. All lakes except Detroit (478 m) and Suttle (1048 m) were above 1400 m elevation; the highest was Mirror Lake (2332 m) in Grande Ronde watershed. Detroit Lake is downstream from 3 lakes where this species occurs, which may explain its presence at the lower elevation. It has been found at low altitudes but is less common (Wilson and Yeatman, 1959). Anderson (1971, 1974) and Carl (1940) both found it to be a widespread and common species in alpine and subalpine lakes in western Canada.

Epischura nevadensis - Found in 40 lakes located from central to western Oregon. Found in southeastern Washington (Whittaker and Fairbanks, 1959, Harris, 1979) where Whittaker found it associated with D. ashlandi in oligotrophic lakes. Lakes ranged from ultraoligotrophic (7 lakes) to hypereutrophic (2 lakes). From this distribution it seems very tolerant of extreme ranges of trophic state.

Cyclops bicuspidatus thomasi - The most common copepod found in this study. Found in 12 of the 15 watersheds in a total of 72 lakes. It does not seem limited by any extremes in physical or chemical parameters.

Cyclops vernalis - Found in 17 lakes (8 watersheds). Easternmost distribution is Thief Valley Res. (Powder watershed). Other sites were in the Cascades and west to the coast. Whittaker and Fairbanks (1958), Tash (1974) and Harris (1979) also report this species. It is probably more widespread than this study shows but due to sampling methods was not encountered.

Eucyclops agilis - Found in 10 lakes (6 watersheds). Fish Lake and Balm Creek (Powder watershed) were the easternmost lakes in which it occurred. Distribution similiar to C. vernalis but not as common. This is considered a littoral species (Wilson and Yeatman, 1958).

Macrocyclus albidus - Found in 19 lakes (9 watersheds). The second most widespread and common cyclopoid copepod in ths study. One of the more common North American species of copepods (Wilson and Yeatman, 1959). Species was reported in the Northwest by Whittaker and Fairbanks (1958), Tash (1974), and Harris (1979).

Mesocyclops edax - Found in 19 lakes (5 watersheds). As common as M. albidus but the distribution is not as widespread. Most of the lakes were west of the Cascades except for Cold Springs and McKay in Umatilla watershed.

Tropocyclops prasinus - Found in Beale and Eel Lakes (So. Coast watershed), and Squaw Lake (Klamath watershed). Considered a widespread limnetic species (Wilson and Yeatman, 1959) but not common in this study.

Cladocera

Alona rectangularis - Found in three lakes (three watersheds); rare member of the community in all three.

Alona quadrangularis - In two lakes, John C. Boyle (Klamath watershed) and Lava Lake (Deschutes watershed). Considered a limnetic species or a bottom dweller (Brooks, 1959).

Bosmina longirostris - The most common and dominant zooplankton species collected. Found in 77 lakes (11 watersheds). Tash (1974) and Harris (1979) both reported this species. A common species throughout the continent (Brooks, 1957), also considered an indicator of eutrophic conditions (Brooks, 1970).

Eubosmina hagmanni - Found in 12 lakes in 4 watersheds. Lakes ranged from 1184 m (Pamelia) to 2174 m (Anthony); 10 lakes were over 1400 m. Found previously in Elk Lake and Fish Lake (Rogue watershed) (Deevey and Deevey, 1971). Never found to co-occur with B. longirostris in this study.

Ceriodaphnia acanthina - Found in four lakes (3 watersheds). Dominant in mesotrophic North Twin Lake, rare in the 3 eutrophic Lakes. Found in Idaho (Harris, 1979) and British Columbia (Carl, 1940; Anderson, 1974). Not widely distributed.

Ceriodaphnia affinis - Found in 11 lakes mainly east of the Cascades, except Tahkenitch Lake (South Coast

watershed). Dominant in five of the locations. Common in lower elevation lakes in the Sierra Nevada Mountains (Stoddard, 1987).

Ceriodaphnia lacustris - Collected in seven lakes. Found in Oregon previously (Tash, 1979). Reported as more successful in medium to hard water (Carter, et al., 1980) though that was not found to be true for this study.

Ceriodaphnia quadrangula - Found in 15 lakes: three lakes on the coast, the rest east of the Cascades. Primarily considered a littoral species (Brooks, 1959).

Ceriodaphnia reticulata - Found in 15 lakes scattered throughout the state. Described as a common, widespread species (Brooks, 1959). Reported by Tash (1974) and Harris (1979) from the Northwest.

Chydorus globosus - Found only in Haystack Res. (Deschutes watershed) as a rare species.

Chydorus sphaericus - Found in 45 lakes in every watershed except John Day, though dominant in only 7 lakes. Considered and reported to be the most common and widespread cladoceran (Carl, 1940; Tash, 1974; Harris, 1979), though sometimes not truly planktonic (Anderson, 1974). It was not found to be as widespread as other cladocerans in this study.

Daphnia ambigua - Found in five lakes (depth range 5 - 44 m). Reported by Harris (1979) from S.E. Washington and Idaho. Known from small ponds or deep waters of stratified

lakes (Brooks, 1957). Carter et al. (1980) found it in lakes of moderate depth (range 9 - 45 m) similiar to the lakes in this study.

Daphnia galeata mendotae - Found in 69 lakes (13 watersheds). As common as Daphnia schoedleri, but not as widespread in distribution. Found to be very common in British Columbia (Carl, 1940). Found in the Northwest (Brooks, 1957; Tash, 1974; Harris, 1979). More widespread in the present study than Brooks (1957) reported.

Daphnia magna - Found in three lakes; Pelican Lake, Spring Lake and Lake of the Woods. Considered mainly to inhabit marginal waters, small lakes, and ponds (Brooks, 1957). Spring Lake and Pelican Lake are small shallow lakes. Lake of the Woods is larger and deeper.

Daphnia paryula - Found in eight lakes (6 watersheds). In eastern Canada, it is known from small lakes of moderate depth (Carter, et al., 1980). The lakes in this study ranged from 150 hectares to 1387 hectares in size, from 6.7 m to 129 m in depth, showing a great morphometric difference. The distribution of Daphnia paryula does not seem to be limited by this physical parameter.

Daphnia pulex - Found in 11 lakes. A common species, usually in shallow lakes. Sites were disjointed, not found in the northern half of the state. Heavily preyed upon by fish (Carter, et al., 1980).

Daphnia pulicaria - One of the more common species of Daphnia, found in 44 lakes mainly in southern Oregon. Not as common in coastal lakes (Lower Pony Creek) or the North-central part of the state.

Daphnia retrocurva - Found in four large lakes (Drews Res., Odell Lake, Owyhee Lake, and Upper Klamath Lake). In N.E. Ontario, found in productive lakes (Keller and Pitblado, 1984). Known from the Northwest in small lakes by Puget Sound (Brooks, 1957). Found by Tash (1974) in Upper Klamath Lake.

Daphnia rosea - Identified in 45 lakes. Lakes showed a wide range in depth (4 to 134 m), elevation (3 to 2246 m), and trophic status (ultraoligotrophic to eutrophic). Mainly found along the coast or in the Cascades, with a few locales in the Blue Mountains. Brooks (1957) considered this species a shallow water form. Carter et al. (1980) found it in lakes with a maximum depth of at least 18 meters. Anderson (1971, 1974) and Patalas (1964) considered it a montane species. Stoddard (1987) found it common in high elevation lakes in California.

Daphnia schoedleri - The most common Daphnia species, with Daphnia galeata mendotae, in the study (69 lakes). Found in all 15 watersheds, making it the most widespread species in the study. Reported in the Northwest by Brooks (1957), Harris (1979), and Tash (1974).

Daphnia similis - Found only in Summer Lake, an alkali lake. Found in other alkali lakes in Oregon (Tash, 1979).

Diaphanosoma brachyurum - Found in 14 shallow lakes (eight watersheds). Reported by Tash (1974) and Harris (1979) for the Northwest and Anderson (1974) for the Canadian Rocky Mountains. Collected in lower elevation lakes in Colorado (Reed and Olive, 1958).

Diaphanosoma leuchtenbergianum - Found in 47 lakes (11 watersheds). Lake depth ranged more for this species than for the D. brachyurum, though in general most lakes were shallow. Reported by Harris (1979) for S. E. Washington and Anderson (1974) for Western Canada.

Eurycercus lamellatus - Only from Lava Lake (Deschutes). Usually found among weeds. Lava Lake does have macrophyte growth along the edges which may explain the presence of E. lamellatus.

Graptoleberis testudinaria - Found in 3 lakes in 3 watersheds. Lakes all eutrophic, one with extensive macrophytes. Similiar to E. lamellatus in habitat. Found by Harris (1979) in one lake in S.E Washington.

Holopedium gibberum - Found in 29 mountain lakes and two coastal lakes. Found in mountain lakes in Idaho (Harris, (1979). Widely distributed in British Columbia (Carl, 1940; Anderson, 1971, 1974) in high elevation lakes. The distribution of Holopedium is related to water softness (Carter, et al., 1980) though affected by other parameters

(Hamilton, 1958; Anderson, 1974; Stenson, 1973). All the lakes where this was found were soft-water lakes.

Latona setifora - Found only in Fish Lake (Powder). Usually found among weeds, though Fish Lake has little macrophyte growth.

Leptodora kindtii - Found in 18 lakes in nine watersheds. Lakes mainly in central to western Oregon, except Unity Res. (Powder watershed). Harris (1979) reported the species from S. W. Washington. Found in Upper Klamath Lake (Tash, 1974). May be under-represented due to sampling methods.

Leydigia quadrangularis - Found in three shallow, eutrophic lakes. Also known to be found among macrophytes. Tash (1974) and Harris (1979) previously reported this species in the Northwest.

Polyphemus pediculus - Collected in five lakes (3 watersheds). Found in Sierra Nevada lakes (Stoddard, 1987). Occurred from 2500 to 3200 m in the Colorado Rockies (Reed and Olive, 1958). Collected more abundantly in inshore samples by Anderson (1974). Though never found in lakes with a pH greater than 7.3 by Carter, et al. (1980), one lake (Crane Prairie) in which P. pediculus occurred had a pH of 9.8.

Sida crystallina - Found in three shallow lakes in the Cascades. Usually found among macrophytes (Brooks, 1959). These lakes have considerable macrophytes.

Scapholeberis kingi - Found only in Wallowa lake.

Considered primarily a littoral species (Brooks, 1959) but can be found in the limnetic zooplankton.

Rotifera

Asplanchna sp. - Found in 14 lakes, dominant in five. Some species common in the plankton as predators (Edmondson, 1959).

Brachionus quadridentata - Found in seven lakes. Most members of this genus are littoral (Edmondson, 1959).

Conochilus sp. - Found in four lakes, very abundant in two.

Kellicottia bostoniensis - Found in four lakes (three watersheds), dominant in three of the lakes. Co-occurs with K. longispina in Eel Lake (South Coast watershed).

Considered a common genus in the limnoplankton, not common in shallow waters (Edmondson, 1959).

Kellicottia longispina - The most common rotifer found in the study area. Found in 63 lakes, dominant or the only rotifer in 60 of these. Found in all watersheds except Umpqua.

Keratella cochlearis - Found in 12 lakes. Considered the most common planktonic rotifer (Edmondson, 1959) though not in this study.

Keratella quadrata - The second most common rotifer. Found in 26 lakes, two of these lakes were in the western part of the state, the other lakes were all eastern.

Platyias patulus - Boyle Res. (Klamath watershed) and South Twin (Deschutes watershed) were the only collection sites.

Polyarthra sp. - Found in two lakes, Cold Springs (Umatilla watershed) and Monon (Deschutes watershed). Dominant in both. Described as being very common in the plankton of lakes and ponds (Edmondson, 1959).

Trichocerca cylindrica - Found in six lakes. The genus has many members, most are littoral (Edmondson, 1959). Found in non-acid waters in Ontario (MacIsaac, 1987).

Trichocera sp. - Found in two lakes (Suttle and Rock Creek, Deschutes watershed).

Other

Artemia salina - Found only in Lake Abert. The only zooplankter found in this lake due to high salinity.

Hyaella azteca - The only amphipod found in this study. Known to be widely distributed in lakes with submerged vegetation (Chace et al., 1959). Found in Diamond Lake which also contained Graptoleberis. Sampling site may have been in weeds.

Chaoborus sp. - Found in 10 lakes in 8 watersheds. This insect larval species is a large voracious predator. This zooplankter can avoid capture so is probably under represented.

DISCUSSION

Most of the zooplankton species found in this study have been found previously in other lake studies in the Pacific Northwest. These species can be grouped according to their distribution.

The first group contains those zooplankton that were found throughout most of the study area. These include Bosmina longirostris (the most common species found), Cyclops bicuspidatus thomasi, Daphnia galeata mendotae, Daphnia schoedleri, Diaptomus novamexicanus, Chydorus sphaericus and Kellicottia longispina. Daphnia schoedleri was the only species found in all the watersheds. The other four species were found in at least 11 of the 15 watersheds. The distributions of these species did not seem to be limited by any of the morphometric or chemical parameters that were tested. Kellicottia longispina was in all the watersheds except for the Umpqua. Cyclops bicuspidatus thomasi was not found in the South Coast, the Umpqua, and John Day watersheds. Diaptomus novamexicanus was not found in the Rogue and Owyhee watersheds. Chydorus sphaericus and Daphnia galeata mendotae was not found in John Day watershed. In addition, D. galeatae mendotae were not in Goose/Summer watershed. Bosmina longirostris was not found in Umpqua, Malheur Lake, Malheur River and John Day

watersheds. If B. longirostris is indicative of eutrophic conditions, then it should be found in the above watersheds, which all contain eutrophic lakes. These species absences may be due to insufficient sampling and to sampling error. The retention of the net is assumed to be 100 % but in reality is between 40 to 80 % (Rawson, 1956; Patalas, 1971, 1975). Some of the watersheds had very few lakes sampled. The species might have been located if more lakes had been sampled in each watershed or if more samples had been taken from each lake.

Members of the next group were found mainly in the eastern part of the state. Diaptomus ashlandi, Diaptomus forbesi, Diaptomus sicilis, Ceriodaphnia acanthina were never found west of Cascades. Keratella quadrata was found in two western lakes, the rest of this species distribution was eastern. Other species were found in only eastern Oregon but were rarely encountered. Examples are Alona quadrangularis (found in two lakes) and Daphnia retrocurva (found in three lakes)

The third group was found mainly in the western part of the state. These species are Cyclops vernalis, Eucyclops agilis, Diaptomus hesperus (only along the coast), Diaptomus franciscanus, Epischura nevadensis, Daphnia parvula, and Leptodora kindtii (though may be under-sampled).

Some species seem limited in their distribution to lakes located in higher elevations (1450 m) in the Cascades

and in the Wallowas. These are Diaptomus kenai, Diaptomus tyrrelli and Eubosmina hagmanni and perhaps Daphnia rosea and Holopedium gibberum (though believed to be limited by water softness).

There is little to say about the distribution of the 30 uncommon species. The very fact that they were uncommon makes any interpretation of their distributions difficult. They may be under-sampled or limited in distribution due to some physical or chemical parameter. Artemia salina is only found in hypersaline water, and many of the other rare species are littoral species.

In this study there were two species reported for the first time in Oregon. They were Diaptomus mississippiensis and Diaptomus pallidus. Diaptomus mississippiensis occurred in only Cleawox Lake and D. pallidus was found only in Agate Lake. Cleawox Lake is a very popular recreational area on the coast. Agate Lake is mainly used for irrigation but is also used for fishing. These species were the only diaptomid species present in their respective lakes and were the dominant copepods in these lakes. Since each was only found in one lake, it seems likely that they were recently introduced.

SIMILARITY INDICES

Coefficients of Community show similiarity of zooplankton communities using presence-absence data. For

this study, CC seems to be the better index of similarity than PSc, which uses percent abundance. The pair of lakes with the highest PSc had only one species in common out of a total of nine species. This one common species was 97% of the species assemblages in both of the lakes. As Whittaker and Fairbanks (1958) discussed, the dominant species can be overemphasized by using percentage similarity, such that differences in over-all community composition are obscured. They related a small number of species (13) and found PSc worked out well. With the larger number of species found in this study (74), PSc did not accurately indicate relative community composition. Using only presence-absence data, similar community structures are more clearly shown.

DIVERSITY INDEX

The Shannon-Weaver diversity index measures both the number of species per lake (richness) and the abundance of the species (evenness). When the diversity index was plotted against the number of species per lake, a strong positive relationship was obtained (Figure 1). This indicates that the variability in species diversity is due to the richness, not the evenness (Sprules, 1975a). Sprules showed a strong relationship between species number and species diversity. A quadratic equation was found to give the best fit to the data in the present study. This would seem to indicate a plateau in the relationship such that, at

higher numbers of species, the addition of species does not have the same effect on species diversity.

Species diversity (measured by number of species per sample) was regressed against physical and chemical parameters. Four of 17 parameters were found to explain 18 % of the variation in the number of species per lake. The four parameters were surface temperature, chlorophyll a, potassium and magnesium. Warmer temperatures are more favorable for algal growth (Wetzel, 1983) which in turn is favorable for zooplankton growth. It is therefore not surprising that chlorophyll a also is related to species number. Chlorophyll a is a measure of the amount of algae present (standing crop) and an approximate measure of productivity. The total variance explained by these four parameters was not great. There does not seem to be any single overriding cause of species diversity as found in the acidified lakes in eastern North America (Sprules, 1975).

RECURRENT GROUP ANALYSIS

Samples in this study were taken from a more diverse species assemblage than is common when RGA is applied, such as acid stressed lakes in Canada (Sprules, 1975b). Thus, it not surprising that the association values were lower than others have described in the literature. For this study, 0.40 was chosen as an acceptable value for meaningful association. An example will show the reasoning. Daphnia

schoedleri was found in 77 (= N_a) samples. Cyclops bicuspidatus thomasi occurred in 86 (= N_b) samples. They co-occurred in 40 (= J) samples. This is over half the total samples in which D. schoedleri occurred and nearly half the total for Cyclops bicuspidatus thomasi. Their association value is 0.44. Fager and McGowan (1963) defined 0.50 as the minimum value for affinity. They believed the species should be found together in at least half their recorded occurrences if they were to be considered associated. By using the criterion that two species must co-occur in half of the samples of each, the example above is significant. Therefore, declaring association values in excess of 0.40 to be significant is entirely reasonable for the species in the present study.

This index emphasizes the more commonly occurring species. When N_b (the number of occurrences of the more common species) is much greater than N_a (the number of occurrences of the less common species), it is possible that a significant species association might not be revealed. An example of this is Diaptomus franciscanus (found in 17 samples) and Daphnia galeata mendotae (found in 86 samples). The former occurred with the latter in 13 samples. This was three-fourths the number of times that D. franciscanus was found, yet the association value was 0.28, which is not significant.

Many of the associations were one way. For example,

Diaphanosoma leuchtenbergianum is associated with Cyclops bicuspidatus thomasi (0.40), which in turn is associated with Daphnia pulicaria (0.47). But Daphnia pulicaria is not significantly associated with Diaphanosoma leuchtenbergianum (0.20).

Most of the species that showed affinities were the more common species found in the study. Of the 14 species that did show significant associations, nine were the species found in the most samples. They were found in at least 49 samples. The remaining five species occurred in 16 to 46 samples.

The first two recurrent groups of Figure 3 (Diaptomus novamexicanus, Cyclops bicuspidatus thomasi, and Daphnia schoedleri; and Daphnia galeata mendotae, Bosmina longirostris, and Kellicottia longispina) contain the most commonly occurring species in this study. They are found in all lake types and do not seem to be limited by any of the measured parameters. The third group (Daphnia rosea, Holopedium gibberum, and Diaptomus tyrrelli) seems to be found more often in high-elevation oligotrophic lakes. They do seem limited by some physical or chemical parameter.

COEFFICIENT OF INTERSPECIFIC ASSOCIATION

Most of the associations found by RGA were also found using this measure (Coles' C7). Only two species pairs were not significant using C7 which were significant using RGA.

These were Cyclops bicuspidatus thomasi and Daphnia galeata mendotae, and Daphnia galeata mendotae and Bosmina longirostris. The other associations were found to be significant by both RGA and C7. The C7 method found uncommon species associated with other species while RGA did not and therefore grouped more species together than did recurrent group analysis. This is one advantage to using the coefficient of interspecific association. Another advantage of this method is that a perfect association (1.00) is possible. With RGA, a value of 1.00 is highly unlikely because of the correction term for number of occurrences.

SUMMARY

This study covered the entire state of Oregon, sampling lakes of all types. The list of zooplankton species identified in this research is the first of its kind for Oregon.. Two species were recorded for the first time in this state. These were Diaptomus mississippiensis (from Cleawox Lake) and Diaptomus pallidus (from Agate Lake). Lakes were compared on the basis of their similarities in the zooplankton assemblages, using both presence-absence data and abundances. Presence-absence data was more reliable for use in this study because total number of individuals per sample varied greatly from lake to lake. Zooplankton diversity was compared to physical and chemical

parameters. Diversity does not appear to strongly depend on any of the measured parameters, at least over the range encountered in these samples. Zooplankton species associations were found using two methods which group species that commonly occur together. Both methods grouped the common species in about the same manner. RGA associated the most common species with each other, while Cole's C7 also grouped less common species.

This study identifies lakes and areas that have interesting and unusual zooplankton assemblages and relationships. This study will serve as a data base for further research on the distribution of zooplankton in Oregon lakes.

REFERENCES

- Anderson, R. S. 1971. Crustacean plankton of 146 alpine and subalpine lakes and ponds in Western Canada. J. Fish. Res. Bd. Can. 28: 311-321.
- Anderson, R. S. 1974. Crustacean plankton communities of 340 lakes and ponds in and near the National Parks of the Canadian Rocky Mountains. Can. J. Fish. Aquat. Sci. 31: 855-869.
- Bays, J. S., and T. L. Crisman. 1983. Zooplankton trophic state relationships in Florida lakes. Can. J. Fish. Aquat. Sci. 40: 1813-1819.
- Beavers, R. A., and R. H. Stavn. 1975. Seasonal changes in diaptomid copepod populations as a function of vertebrate predation. Verh. Internat. Verein. Limnol. 19: 2966-2975.
- Brandlova, J., Z. Brandl, and C. H. Fernando. 1972. The cladocera of Ontario with remarks on some species and distribution. Can. J. Zool. 50: 1373-1403.
- Brezonik, P. L., T. L. Crisman, and R. L. Schulze. 1984. Planktonic communities in Florida softwater lakes of varying pH. Can. J. Fish. Aquat. Sci. 41: 46-56.
- Brooks, J. L. 1957. The systematics of North American Daphnia. Mem. Conn. Acad. Arts. Sci. 13: 1-180.
- Brooks, J. L. 1959. Cladocera. In Fresh-water Biology. 2nd. ed. (Edmondson, W.T. ed.). John Wiley and Sons, New York. 587-656.
- Brooks, J. L. 1970. Eutrophication and changes in the composition of the zooplankton. In Eutrophication: causes, consequences, correctives. Natl. Acad. Sci., Washington, D. C. 236-255.
- Carl, G. Clifford. 1940. The distribution of some cladocera and free-living copepoda in British Columbia. Ecological Monographs. 10: 55-110.

- Carter, J. C. H. 1971. Distribution and abundance of planktonic Crustacea in ponds near Georgian Bay (Ontario, Canada) in relation to hydrography and water chemistry. Arch. Hydrobiol. 68: 204-231.
- Carter, J. C. H., M. J. Dadswell, J. C. Roff, and W. G. Sprules. 1980. Distribution and zoogeography of planktonic crustaceans and dipterans in glaciated Eastern North America. Can. J. Zool. 58: 1355-1387.
- Carter, J. C. H., W. D. Taylor, R. Chengalath, and D. A. Scruton. 1986. Limnetic zooplankton assemblages in Atlantic Canada with special reference to acidification. Can. J. Fish. Aquat. Sci. 43: 444-456.
- Chace, F. A. Jr., J. G. Mackin, L. Hubricht, A. H. Banner, and H. H. Hobbs, Jr. 1959. Malacostraca. In Fresh-water Biology, 2nd. ed. (Edmondson, W.T. ed.) John Wiley and Sons, New York. 869-901.
- Chengalath, R., W. J. Bruce, and D. A. Scruton. 1984. Rotifer and crustacean plankton communities of lakes in insular Newfoundland. Verh. Internat. Verein. Limnol. 22: 419-430.
- Cole, G. A. 1961. Some calanoid copepods from Arizona with notes on congeneric occurrences of Diaptomus species. Limnol & Oceanogr. 6: 432-442.
- Cole, L. C. 1949. The measurement of interspecific association. Ecology. 30: 411-424.
- Collins, N. C. and W. G. Sprules. 1983. Introduction to large-scale comparative studies of lakes. Can. J. Fish. Aquat. Sci. 40: 1750-1751.
- Davies, W. 1971. The phytosammon of a sandy beach transect. Am. Midl. Nat. 86: 292-308.
- Deevey, E. S. and G. B. Deevey. 1971. The American species of Eubosima Seligo (Crustacea, Cladocera). Limnol & Oceanogr. 16: 201-218.
- Dixon, W. J., (ed.). 1985. BMDP statistical software. Univ. of CA Press, Berkeley. 733 p.
- Edmondson, W. T. (ed.). 1959. Fresh-water Biology. 2nd. ed. John Wiley and Sons, New York. 1249 p.
- Fager, E. W. and J. A. McGowan. 1963. Zooplankton species groups in the North Pacific. Science. 140: 453-460.

- Hairston, N. G. 1979. Carotenoid photoprotection in Diaptomus kenai. Verh. Internat. Verein. Limnol. 20: 2541-2545.
- Hamilton, J.D. 1958. On the biology of Holopedium gibberum Zaddach (Crustacea: Cladocera). Verh. Internat. Verein. Limnol. 13: 785-788.
- Harris M. J. 1979. Planktonic microcrustacea of the Lower snake River drainage. Northwest Science. 53: 63-70.
- Johnson, D. M., R. R. Petersen, D. R. Lycan, J. W. Sweet, M. E. Neuhaus, A. L. Schaedel. 1985. Atlas of Oregon Lakes. Oregon State University Press, Corvallis, OR. 317 p.
- Keller, W. and J. R. Pitblado. 1984. Crustacean plankton in northeastern Ontario lakes subjected to acidic deposition. Water, Air, and Soil Pollution. 23: 271-291.
- McGowan, J. A. and P. W. Walker. 1979. Structure in the copepod community of the North Pacific central gyre. Ecological Monographs. 49: 195-226.
- Nei, H. H., C. H. Hull, J. G. Jendins, K. Steinbrenner, and D. H. Bent. 1975. SPSS: statistical package for the social sciences. 2nd ed. McGraw-Hill, New York. 675 p.
- Omori, M. and T. Ikeda. 1984. Methods in Marine Zooplankton Ecology. John Wiley and Sons, New York. 311 p.
- Patalas, K. 1964. The crustacean plankton communities in 52 lakes of different altitudinal zones of Northern Colorado. Verh. Internat. Verein. Limnol. 15: 719-726.
- Patalas, K. 1971. Crustacean plankton communities in 45 lakes in the Experimental Lakes Area, NW Ontario. J. Fish. Res. Bd. Can. 28: 231-244.
- Patalas, K. 1975. The crustacean plankton communities of 14 North American Great Lakes. Verh. Internat. Verein. Limnol. 19: 504-511.
- Patalas, K., and A. Salki. 1973. Crustacean plankton and the eutrophication of lakes in the Okanagan Valley, B.C. J. Fish. Res. Bd. Can. 30: 519-542.

- Pennak, R.W. 1957. Species composition of limnetic zooplankton communities. Limnol. & Oceanogr. 2: 222-232.
- Pennak, R. W. 1978. Freshwater Invertebrates of the United States. 2nd. ed. John Wiley and Sons, New York. 803 p.
- Pielou, E. C. 1984. The Interpretation of Ecological Data. John Wiley and Sons, New York. 263 p.
- Poole, R. W. 1974. An Introduction to Quantitative Ecology. McGraw-Hill, New York. 532 p.
- Rawson, D. S. 1958. The net plankton of Great Slave Lake. J. Fish. Res. Bd. Canada. 13: 53-127.
- Sprules, W. G. 1972. Effects of size-selective predation and food competition on high altitude zooplankton communities. Ecology. 39: 46-65.
- Sprules, W. G. 1975a. Factors affecting the structure of limnetic crustacean zooplankton communities in central Ontario lakes. Ver. Internat. Verein. Limnol. 19: 635-643.
- Sprules, W. G. 1975b. Midsummer crustacean zooplankton communities in acid-stressed lakes. J. Fish. Res. Board Can. 32: 389-395.
- Stenson, J. A. E. 1973. On predation and Holopedium gibberum (Zadach) distribution. Limnol & Oceanogr. 18: 1005-1010.
- Stoddard, J. L. 1987. Microcrustacean communities of high-elevation lakes in the Sierra Nevada, California. J. of Plank. Res. 9: 631-650.
- Tash, J. C. 1971. Some cladocera and copepoda from the Upper Klamath River Basin. Northwest Science. 45: 239-243.
- Venrick, E. L. 1971. Recurrent groups of diatom species in the North Pacific. Ecology. 52: 614-625.
- Westman, W. E. 1985. Ecology, Impact Assessment, and Environment. John Wiley and Sons, New York. 532 p.
- Wetzel, R. G. 1983. Limnology. 2nd. ed. Saunders College Publishing, Philadelphia. 767 p.

- Whittaker, R. H. and C. W. Fairbanks. 1958. A study of plankton copepod communities in the Columbia Basin, Southeastern Washington. Ecology. 39: 46-65.
- Wilson, M.S. and H. C. Yeatman. 1959. Free-living copepoda. In Fresh-water Biology. (Edmondson, W.T. ed.) John Wiley and Sons, New York. 735-815.

APPENDIX A

The following is a list of species occurrence, grouped according to watershed. Each lake sampled is listed across the top of the page. The species found in this study are listed down the left side of the page. If the species is found in a lake it is marked by an X.

Lakes are identified by abbreviations, which are listed below by watershed.

MIDCOAST

Clw	Cleawox
Clr1	Clear 5/12/82
Clr2	Clear 11/19/82
Col	Collard
Dev	Devils
Eck	Eckman
Mer	Mercer
Mun1	Munsel 7/20/81
Mun2	Munsel 5/1/82Ave
Sit1	Siltcoos 5/12/82
Sit2	Siltcoos 7/28/83
Sut1	Sutton 7/19/81
Sut2	Sutton 5/1/82
Tah1	Tahkenitch 7/29/81
Tah2	Tahkenitch 5/3/82
Tri	Triangle
Woa1	Woahink 5/2/82
Woa2	Woahink 11/20/82
Woa3	Woahink 9/7/83

SOUTHCOAST

Bea	Beale
Cro	Croft

SOUTHCOAST (cont.)

Eel1	Eel 7/27/83
Eel2	Eel 8/5/81
Flo	Floras
Gar1	Garrison 8/3/81
Gar2	Garrison 5/4/82
Gar3	Garrison 11/22/82
LPC	Lower Pony Cr.
Ntn	No. Tenmile
Sau	Saunders
Ten	Tenmile
UPC	Upper Pony Cr.

WILLAMETTE/SANDY

Ave	Averill
Big1	Big 8/29/81
Big2	Big 7/21/83
BlR	Blue River
Bre	Breitenbush
Cle	Clear
Cou	Couger
Det	Detroit
Dex	Dexter
Dor	Dorena
Elk	Elk

WILLAMETTE/SANDY (cont.)

FaC Fall Cr.
 Fis Fish
 Gol Gold
 Hag Henry Hagg
 HiC Hills Cr.
 LaC Lava Camp
 Lea Leaburg
 Los Lost Lake
 LoE Lower Eddeeleo
 LEB Lower Erma Bell
 Mar Marion
 Min Minam
 Osw Oswego
 Pam Pamela
 Riv River Mill
 Sco Scott
 Smi Smith
 Tim Timothy
 Tor Torrey
 Tra Trailbridge
 UpE Upper Eddeeleo
 Wal1 Waldo 8/23/82
 Wal2 Waldo 8/18/81

UMPQUA

Dia Diamond
 Lem Lemolo
 Loo Loon

ROGUE

Aga Agate
 App Applegate
 Emi Emigrant
 Fis Fish
 Isl Island
 Los1 Lost Cr. 9/5/81
 Los2 Lost Cr. 7/14/82
 Sel Selmac
 Squ Squaw
 Wil Willow

GOOSE/SUMMER

Abt Abert
 Cru Crump
 Dog Dog
 Dre Drows

GOOSE/SUMMER (cont.)

Goo Goose
 Har Hart
 Pel Pelican
 Sum Summer
 Tho Thompson Valley

DESCHUTES

AnF Antelope Flat
 Bil1 Billy Chinook
 8/24/82
 Bil2 Billy Chinook
 11/5/82
 Bil3 Billy Chinook
 5/21/82
 Blu1 Blue 7/21/82
 Blu2 Blue 7/21/83
 Cha Charlton
 Cra Crane Prairie
 Cre1 Crescent 8/19/81
 Cre2 Crescent 8/23/82
 Dav1 Davis 7/18/82
 Dav2 Davis 5/20/82
 Dor Doris
 Eas1 East 7/13/81
 Eas2 East 7/23/83
 Hay Haystack
 Hor Horseshoe
 Iri Irish
 Isl Island
 Lav Lava
 LCu Little Cultus
 LLv Little Lava
 MGr Middle Green
 Mon1 Monon 9/19/82
 Mon2 Monon 9/4/81
 NoT No. Twin
 Och Ochoco
 Ode1 Odell 8/19/81
 Ode2 Odell 5/20/82
 Ode3 Odell 8/23/82
 Ode4 Odell 7/24/83
 Oll1 Ollalie 9/4/81
 Oll2 Ollalie 9/19/82
 Pau Paulina
 Pne Pine Hollow
 Pri1 Prineville 5/24/82
 Pri2 Prineville 8/24/82
 Pri3 Prineville 11/5/82

DESCHUTES (cont.)

Rab Rabbit Valley
 Roc Rock Cr.
 Sim Simtustus
 SoT So. Twin
 Spa1 Sparks 8/21/81
 Spa2 Sparks 7/20/82
 Sum Summit
 Sut1 Suttle 5/25/82
 Sut2 Suttle 7/21/82
 Sut3 Suttle 11/7/82
 Sut4 Suttle 7/22/83
 Tod Todd
 Thr Three Cr.
 UpT Upper Tumalo
 Wal Walton
 Wic Wickiup

KLAMATH

Age Agate
 Boy Boyle
 Bum Bumphead
 Dev Devil
 Euw Euwana
 For Fourmile
 Ger Gerber
 How Howard Prairie
 Hya Hyatt
 Lak1 Lake o' Woods 9/11/81
 Lak2 Lake o' Woods 5/19/82
 Lak3 Lake o' Woods 8/12/82
 Mil Miller
 Obe Obenchain
 Rnd Round Valley
 Spr Spring
 Str Strawberry
 UpK1 Upper Klamath 5/18/82
 UpK2 Upper Klamath 8/22/82
 WiV Willow Valley

UMATILLA

Col Cold Springs
 McK McKay

JOHN DAY

Mag Magone
 Oli Olive
 Pen Penland

MALHEUR LAKE

Chi Chickahominy
 Del Delintment
 Fis Fish
 Man Mann
 Roc Rock Creek

GRANDE RONDE

Gla Glacier
 Jub Jubilee
 Lan Langdon
 Min Minam
 Mir Mirror
 Mor Morgan
 Wal1 Wallowa 8/1/82
 Wal2 Wallowa 6/24/82

POWDER

Ant Anthony
 Bal Balm Cr.
 Fis Fish
 Phi Phillips
 Thi Thief Valley
 Uni Unity
 Wol Wolf Cr.

MALHEUR RIVER

Beu Beulah
 BuC Bully Cr.
 Cot Cottonwood
 Mal Malheur Res.
 War Warm Springs

OWYHEE

Ant Antelope
 Owy Owyhee
 UCC Upper Cow Cr.

[illegible]

SOUTHCOAST WATERSHED (continued)

SPECIES	Bea		Cro		Eel		Flo		Gar		Gar		LPC		Ntn		Sau		Ten		UPC	
	1	2	1	2	1	2	1	2	3													
<i>Diatorus siccilis</i>																						
<i>Diatomus signicanda</i>																						
<i>Diatomus tyrelli</i>																						
<i>diatomid copepodid</i>	X	X	X	X	X	X	X	X	X						X	X	X	X	X	X		
<i>Epischura nevadensis</i>																						
<i>epischurid copepodid</i>																						
<i>Eubosmina hasmanni</i>																						
<i>Eucyclops agilis</i>																						
<i>Eurycerus lamellatus</i>										X												
<i>Graptoleberis</i>																						
<i>testudinaria</i>																						
<i>Holopedium gibberum</i>																						
<i>Hyalella azteca</i>																						
<i>Kellicottia bostoniensis</i>	X	X																				
<i>Kellicottia longispina</i>			X																			
<i>Keratella cochlearis</i>																						
<i>Keratella quadrata</i>	X																					
<i>Latona satifera</i>																						
<i>Leptodora kindtii</i>																						
<i>Leydigia</i>																						
<i>quadrangularis</i>																						
<i>Macrocyclus albidus</i>																						
<i>mayfly larvae</i>																						
<i>Mesocyclops edax</i>	X	X	X	X																		
<i>nauplii</i>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
<i>ostracod</i>																						
<i>Pentanaura sp.</i>																						
<i>Platynia patulus</i>																						
<i>Polysphara sp.</i>																						
<i>Polypheuma padiculus</i>																						
<i>Scapholeberis kingi</i>																						
<i>Sida crystallina</i>																						
<i>tardigrade</i>																						
<i>Trichocerca cylindrica</i>																						
<i>Trichocerca sp.</i>	X	X																				
<i>Tropocyclops prasinus</i>	X																					
<i>water mite</i>																						

[illegible]63

WILLAMETTE/SANDY I (continued)

SPECIES	Ave	Big	Big	BIR	Bre	Clr	Cou	Det	Dex	Dor	Eik	FaC	Fis	Gol	Hag	HiC	LaC
	1	2															
Diaptomus sicilis	X																
Diaptomus signicauda		X	X	X													
Diaptomus tyrrelli		X	X	X	X												
diaptomid copepodid		X	X	X	X	X											
Epischura nevadensis		X	X	X	X	X											
epischurid copepodid		X	X	X	X	X											
Eubosmina hagnanni		X	X	X	X	X											
Eucyclops agilis		X	X	X	X	X											
Eurycerus lamellatus																	
Graptoleberis																	
testudinaria																	
Holopedium gibberum		X	X	X	X												
Hyalella azteca																	
Kellicottia bostoniensis																	
Kellicottia longispina		X															
Keratella cochlearia		X															
Keratella quadrata		X	X	X	X												
Latona setifera																	
Leptodora kindtii																	
Leydigia																	
quadrangularis																	
Macrocyclus albidus																	
mayfly larvae																	
Mesocyclops edax																	
nauplii		X	X														
ostracod																	
Pentaneura sp.																	
Platylabus patulus																	
Polvarthra sp.																	
Polypheuma pediculus																	
Scapholeberis kingi																	
Sida crystallina																	
tardigrade																	
Trichocerca cylindrica																	
Trichocerca sp.																	
Tropocyclops prasinus																	
water mite	X																

SPRICES
Lea Los Low LoE LEB Mar Min Oaw Pam Riv Sco Sni Tim Tor Tra UpE Wal Wal
1 2

[illegible]

Lea Los Low LoE LEB Mar Min Osw Pam Riv Sco Smi Tim Tor Tra UpE Wal Wal
1 2

[illegible]

SPECIES	UMPQUA (continued)			ROGUE					GOOSE/SUMMER													
	Dia	Lem	Loo	Aga	App	Emi	Fis	Isl	Los	Los	Sel	Squ	Wil	Abt	Cru	Dog	Dre	Goo	Har	Pel	Sum	Tho
									1	2												
Diapomus sicilis																						
Diapomus signicauda																						
Diapomus tyrrelli																						
diapomid copepodid	X	X		X	X	X		X	X	X		X		X		X	X	X	X	X	X	X
Epischura nevadensis	X							X	X	X												
epischurid copepodid				X	X			X	X	X												
Eubosmina bairdmani																						
Eucyclops agilis			X																			
Eurycercus lamellatus																						
Graptoleberis																						
testudinaria	X							X							X							
Holopedium gibberum																						
Hyalella azteca	X																					
Kellicottia bostoniensis																						
Kellicottia longispina								X						X		X						
Keratella cochlearis																						
Keratella quadrata	X														X							
Latona setifera																						
Leptodora kindtii		X	X			X	X										X					
Levinsia																						
quadrangularis																						
Macrocyclus albidus	X																					
mayfly larvae	X																					
Mesocyclops edax																						
nauplii	X		X		X				X	X	X	X		X								
ostracod																						
Pentaneura sp.																						
Platylabus patulus	X																					
Polvarthra sp.																						
Polyphemus pediculus																						
Scapholeberis kingi																						
Sida crystallina																						
tardigrade																						
Trichocerca cylindrica																						
Trichocerca sp.																						
Tropocyclops prasinus																						
water mite																						

DESCHUTES WATERSHED I

69

DESCHUTES WATERSHED II

[illegible]

KLANATH WATERSHED (continued)

SPECIES	Age Boy Bum Dev Euw For Ger How Hya Lak Lak Lak Lak Mil Obe Rnd Spr Str UpK UpK Wiv											
	1	2	3	1	2	3	1	2	3	1	2	3
<i>Diatomus sicilis</i>												
<i>Diatomus signicauda</i>												
<i>Diatomus tyrrelli</i>												
<i>diatomid copepodid</i>												
<i>Epischura nevadensis</i>												
<i>epischurid copepodid</i>												
<i>Eubosmina bagmanni</i>												
<i>Eucyclops agilis</i>												
<i>Eurycerus lamellatus</i>												
<i>Graptoleberis</i>												
<i>testudinaria</i>												
<i>Holopedium gibberum</i>												
<i>Hyalella azteca</i>												
<i>Kellicottia bostoniensis</i>												
<i>Kellicottia longispina</i>												
<i>Keratella cochlearia</i>												
<i>Keratella quadrata</i>												
<i>Latona setifera</i>												
<i>Leptodora kindtii</i>												
<i>Leydigia</i>												
<i>quadrangularis</i>												
<i>Macrocyclus albidus</i>												
<i>mayfly larvae</i>												
<i>Mesocyclops edax</i>												
<i>nauplii</i>												
<i>ostracod</i>												
<i>Pentaneura sp.</i>												
<i>Platylabus patulus</i>												
<i>Polvarthra sp.</i>												
<i>Polypheusus pediculus</i>												
<i>Scapholeberis kingi</i>												
<i>Sida crystallina</i>												
<i>tardigrade</i>												
<i>Tricheocerca cylindrica</i>												
<i>Trichocerca sp.</i>												
<i>Tropocyclops prasinus</i>												
<i>water mite</i>												

X

SPECIES	POWDER					MALHEUR RIVER					OWYHEE					
	Ant	Bal	Fis	Phi	Thi	Thi	Uni	Wol	Beu	BuC	Cot	Mal	War	Ant	Ovy	UCC
Diaptonus sicilis												X				
Diaptonus signicauda																
Diaptonus tyrelli																
diaptonid copepodid	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Epischura nevadensis																
epischurid copepodid	X															
Eubosmina hagmanni																
Eucyclops agilis		X	X													
Eurycercus lamellatus																
Graptoleberis																
testudinaria									X							
Holopedium gibberum						X										
Hyalella azteca																
Kellicottia bostoniensis																
Kellicottia longispina	X	X	X	X	X	X	X									
Keratella cochlearis																
Keratella quadrata	X									X						
Latona setifera																
Leptodora kindtii								X								
Leydigia																
quadragularis								X								
Macrocyclus albidus																
mayfly larvae																
Mesocyclops edax						X	X	X	X	X	X	X	X	X	X	X
nauplii																
ostracod																
Pentaneura sp.	X															
Platylabus patulus													X			
Polvarthra sp.																
Polyphemus pediculus						X										
Scapholeberis kingi																
Sida crystallina																
tardigrade																
Trichocerca cylindrica																
Trichocerca sp.																
Tropocyclops prasinus																
water mite														X		

APPENDIX B

Coefficient of Communities (Highest value for each sample).

Lake	vs. Lake	CC
Agate	Warm Springs	50.0
Agency	Lake o' Woods (5/19/82)	44.4
	East (7/13/81)	44.4
Antelope Flat	Lake Simtustus	55.6
Antelope Res.	Garrison (11/22/82)	50.0
	River Mill	50.0
Anthony	Crescent (8/23/82)	75.0
Applegate	Lost Creek	33.3
	Lower Lake	33.3
	Woahink (9/7/82)	33.3
Averill	Ollalie (9/19/82)	80.0
Balm Creek Res.	Billy Chinook (11/5/82)	50.0
	Bully Creek	50.0
Beale	Wahink (11/20/82)	37.5
Beulah	Chickahominy	80.0
Big (8/29/81)	Olive	62.5
Big (7/21/83)	Ollalie (9/4/81)	50.0
Billy Chinook (8/24/82)	Billy Chinook (5/21/82)	75.0
Billy Chinook (11/5/82)	Billy Chinook (5/21/82)	72.7
Billy Chinook (5/21/82)	Billy Chinook (8/24/82)	75.0
Blue Lake (7/21/82)	Fourmile	66.7
	Suttle (11/7/82)	66.7
Blue Lake (7/22/83)	Wickiup	55.6
Blue River Res.	Lava Camp	57.1
	Mink	57.1
Breitenbush	Torrey	100.0
Boyle	Lower Pony Creek	40.0
Bully Creek	Wickiup	62.5
Bumphead	Beulah	66.7
	Wolf Creek	66.7
Charlton	Horseshoe	66.7
Chickahominy	Beulah	80.0
Clear (Midcoast, 5/12/82)	Floras	57.1
Clear (Midcoast, 11/19/82)	Munsel (7/20/82)	60.0
Clear (Willamette/Sandy)	Middle Green	33.3
Clear (Deschutes, 11/4/82)	Lake o' Woods (9/11/88)	38.5
Clear (Deschutes, 9/4/81)	Dorena	46.2
Cleawox	Lower Pony Creek	55.6
	Siltcoos (7/28/83)	55.6

Cold Springs	McKay	53.8
Collard	Mercer	50.0
Cottage Grove	Dorena	58.3
Cottonwood	Rock Creek (Malheur Lake)	80.0
Cougar	Detroit	80.0
Crane Prairie	Davis (7/16/82)	61.5
Crescent (8/19/81)	Cougar	50.0
	Detroit	50.0
	Willow	50.0
Crescent (8/23/82)	Anthony	75.0
Croft	Upper Pony Creek	57.1
Crump	Hart	54.5
Davis (7/18/82)	Crane Prairie	61.5
Davis (5/20/82)	Bully Creek	50.0
	South Twin	50.0
Deer	Island (Rouge)	83.3
Delintment	Rabbit Valley	33.3
	Thompson Valley	33.3
Detroit	Cougar	80.0
Devils (Midcoast)	Fall Creek	55.6
Devil (Klamath)	Prineville	62.5
Dexter	Hills Creek	71.4
Diamond	Crane Prairie	42.9
Dog	Odell (5/20/82)	42.9
Dorena	Cottage Grove	58.3
Doris	Lower Eddeeleo	42.9
Drews	Wolf Creek	66.7
East (7/13/81)	East (7/23/83)	50.0
Eckman	Warm Springs	66.7
Eel (7/27/83)	Upper Pony Creek	45.5
Eel (8/5/81))	Cottage Grove	50.0
Elk	Deer	62.5
Emigrant	Odell (8/23/82)	71.4
Euwana	Fish (Rogue)	44.4
	Lemolo	44.4
	Upper Klamath (8/22/82)	44.4
Fall Creek	Billy Chinook (5/21/82)	80.0
Fish (Powder)	Lower Eddeeleo	36.4
	Lower Erma Bell	36.4
Fish (Malheur Lake)	Suttle (7/21/82)	50.0
Fish (Rogue)	Little Lava	60.0
Fish (Willamette/Sandy)	Breitenbush	71.4
	Horseshoe	71.4
	Torrey	71.4
Floras	Clear (Midcoast, 5/12/82)	57.1
Fourmile	Blue Lake	66.7
Garrison (8/3/81)	Todd	50.0
Garrison (5/4/82)	Dorena	50.0
Garrison (11/22/82)	Antelope Res.	50.0
	Fall Creek	50.0
	River Mill	50.0

Gerber	Howard Prairie	40.0
Glacier	Minam	33.3
Gold	Dorena	41.7
Goose	Eckman	33.3
	Summer	33.3
Middle Green	Blue Lake	33.3
	Clear (Will/Sandy)	33.3
Henry Hagg	Big	50.0
Hart	Lower Pony Creek	55.6
Haystack	Billy Chinook (8/24/82)	58.3
Hills Creek	Waldo (8/18/81)	80.0
Horseshoe	Ollalie (9/19/82)	80.0
Howard Prairie	Sutton (5/1/82)	44.4
Hyatt	McKay	41.7
Irish	Island (Rogue)	60.0
	Todd	60.0
Island (Rogue)	Deer	83.3
	Mink	83.3
Island (Deschutes)	Crescent	50.0
	Suttle (5/25/82)	50.0
	Suttle (11/7/82)	50.0
Jubilee	Langdon	66.7
Lake of the Woods (9/11/81)	Lake o' Woods (8/12/82)	63.6
Lake of the Woods (5/19/82)	Suttle (5/25/82)	50.0
Lake of the Woods (8/12/82)	Lake o' Woods (9/12/81)	63.6
Langdon	Jubilee	66.7
Lava Camp	Mink	71.4
Lava Lake	Devil (Klamath)	30.0
	Upper Klamath (5/18/82)	30.0
	Willow Valley	30.0
Leaburg	Trailbridge	50.0
Lemolo	Dexter	55.6
Little Cultus	Deer	66.7
Little Lava	Fish (Rogue)	60.0
Loon (7/27/83)	Dexter	44.4
	Fish (Rogue)	44.4
Lost Lake	Jubilee	62.5
Lost Creek (9/5/81)	Blue Lake	50.0
	Suttle (7/21/82)	50.0
	Timothy	50.0
Lost Creek (7/14/82)	Lost Creek (9/5/81)	40.0
Lower Lake	Island (Rogue)	60.0
Lower Eddeeleo	Mink	62.5
	Upper Eddeeleo	62.5
Lower Erma Bell	Island (Deschutes)	44.4
Lower Pony Creek	Cleawox	55.6
	Hart	55.6
Magone	Leaburg	33.3
	Penland	33.3
Malheur Res.	Devil (Klamath)	40.0
	East (7/13/81)	40.0
	Odell (5/20/82)	40.0

Mann	Emigrant	42.9
Marion	Walton	42.9
McKay	Suttle (5/25/82)	66.7
Mercer	Cold Springs	53.8
Miller	Munsel (7/20/81)	66.7
Minam	Timothy	50.0
Mink	Island (Rogue)	37.5
Mirror	Todd	37.5
Monon (9/19/82)	Island (Rogue)	83.3
Monon (9/4/81)	Deer	57.1
Morgan	Ollalie (9/19/82)	66.7
Munsel (7/20/81)	Averill	37.5
Munsel (5/1/82)	Ollalie (9/4/81)	37.5
North Tenmile	East (7/13/81)	37.5
North Twin	River Mill	75.0
Obenchain	Fall Creek	42.9
Ochoco	Loon	37.5
Odell (8/19/81)	Eel (7/23/83)	37.5
Odell (5/20/82)	Suttle (7/21/82)	55.8
Odell (8/23/82)	Emigrant	66.7
Odell (7/24/83)	Bumphead	44.4
Ollalie (9/4/81)	Devils (Klamath)	44.4
Ollalie (9/19/82)	Dorena	54.4
Olive	Bully Creek	50.0
Oswego	Phillips	50.0
Owyhee	Emigrant	71.4
Pamelia	Anthony	57.1
Paulina	Ollalie (9/19/82)	80.0
Pelican	Averill	80.0
Penland	Horseshoe	80.0
Phillips Res.	Ollalie (9/4/81)	80.0
Pine Hollow	Big (8/29/81)	62.5
Prineville (5/24/82)	Cottage Grove	20.0
Prineville (8/24/82)	Chickahominy	66.7
Prineville (11/5/82)	Olive	30.0
	Mercer	45.5
	Spring Lake	40.0
	Clear (Midcoast)	33.3
	Gold	33.3
	Magone	33.3
	Pine Hollow	33.3
	Billy Chinook (11/5/82)	50.0
	Bumphead	50.0
	Emigrant	50.0
	Odell (5/20/82)	50.0
	Strawberry Res.	50.0
	Rock Creek (Malheur Lake)	50.0
	Billy Chinook (11/5/82)	58.3
	Bumphead	62.5
	Devil (Klamath)	62.5
	Chickahominy	44.4
	Upper Tumalo	44.4

Rabbit Valley	Delintment	33.3
River Mill	Munsel (7/20/81)	75.0
Rock Creek (Deschutes)	Devils (Midcoast)	41.7
	Prineville (11/5/82)	41.7
Rock Creek (Malheur Lake)	Cottonwood	80.0
Round Valley	Cottonwood	50.0
Saunders	Island (Deschutes)	36.4
Scott	Island (Rogue)	71.4
Selmac	Garrison (11/22/82)	40.0
Siltcoos (5/12/82)	Cleawox	44.4
	Siltcoos (7/28/83)	44.4
Siltcoos (7/28/83)	Cleawox	55.6
Simtustus	Antelope Flat	55.6
Smith Res.	Blue River	50.0
	Island (Rogue)	50.0
	Mirror	50.0
	Ollalie (9/4/81)	50.0
	Todd	50.0
	Trailbridge	50.0
South Twin	Bully Creek	50.0
	Davis (5/20/82)	50.0
Sparks (8/21/81)	Fish (Powder)	33.3
	Fish (Malheur Lake)	33.3
	Hyatt	33.3
Sparks (7/20/82)	Garrison (8/3/81)	25.0
	Sparks (8/21/81)	25.0
Spring	Pelican	40.0
Squaw	Antelope Flat	30.8
	Simtustus	30.8
Strawberry	Beulah	75.0
Summer	Goose	33.0
Summit	Waldo (8/18/81)	40.0
Suttle (5/25/82)	Billy Chinook (11/5/82)	66.7
	Marion	66.7
Suttle (7/21/82)	Timothy	66.7
Suttle (11/7/82)	Blue Lake	66.7
Suttle (7/22/83)	Detroit	41.7
	Garrison (5/4/82)	41.7
Sutton (7/19/81)	Dorena	46.2
Sutton (5/1/82)	Clear (Midcoast)	50.0
Tahkenitch (7/29/81)	Siltcoos (7/28/83)	46.2
Tahkenitch (5/3/82)	Odell (8/19/81)	40.0
Tenmile	Woahink (5/2/82)	50.0
Thief Valley	Collard	42.9
Thompson Valley	Beulah	66.7
Three Creeks	Marion	60.0
Timothy	Suttle (7/21/82)	66.7
Todd	Island (Rogue)	66.7
Torrey	Breitenbush	100.0
Trailbridge	Leaburg	50.0
	Smith Res.	50.0

Triangle	Fish (Rogue)	44.4
	Wickiup	44.4
	Blue (7/22/83)	44.4
Upper Tumalo	Jubilee	57.1
Unity	Emigrant	54.5
Upper Eddeeleo	Lower Eddeeleo	62.5
	Scott	62.5
Upper Cow	Prineville (8/29/82)	50.0
Upper Klamath (5/18/82)	Hart	44.4
Upper Klamath (8/22/82)	Owyhee	50.0
Upper Pony Creek	Croft	57.1
Waldo (8/23/82)	Bully Creek	50.0
Waldo (8/18/81)	Hills Creek	80.0
Walton	Emigrant	50.0
Warm Springs	Eckman	66.7
Wickiup	Bully Creek	62.5
Willow	Crescent (8/19/81)	50.0
	Obenchain	50.0
	Waldo (8/18/81)	50.0
Willow Valley	Bumphead	50.0
	Devils (Klamath)	50.0
	Fall Creek	50.0
	Warm Spring	50.0
Woahink (5/2/82)	South Tenmile	50.0
Woahink (11/20/82)	Floras	40.0
Woahink (9/7/83)	Munsel (5/1/82)	40.0
Wolf Creek	Bumphead	66.7
	Drews	66.7
Wallowa (8/1/82)	Wallowa (6/24/82)	40.0
Wallowa (6/24/82)	Wallowa (8/1/82)	40.0

APPENDIX C

Percentage Similiarities (Highest value for each sample).

Lake	vs. Lake	PSc
Agate	Magone	48.6
Agency	Unity	72.1
Antelope Flat	Thompson Valley	71.8
Antelope Res.	Blue River	80.0
Anthony	North Twin	56.7
Applegate	Ollalie (9/19/82)	73.4
Averill	Trailbridge	77.8
Balm Creek Res.	Wickiup	77.6
Beale	Saunders	74.3
Beulah	Billy Chinook (5/21/82)	73.8
Big (8/29/81)	Ollalie (9/19/82)	65.5
Big (7/21/83)	Mirror	73.7
Billy Chinook (8/24/82)	Hills Creek	56.8
Billy Chinook (11/5/82)	Triangle	78.4
Billy Chinook (5/21/82)	Cottonwood	79.5
Blue Lake (7/21/82)	Garrison (8/3/81)	93.7
	Garrison (11/22/82)	93.7
Blue Lake (7/22/83)	Detroit	76.9
Blue River Res.	Fish (Rogue)	80.2
Breitenbush	Big (7/21/83)	68.4
Boyle	Saunders	41.3
Bully Creek	Beulah	42.0
Bumphead	Devil (Klamath)	61.2
Charlton	Lower	80.6
Chickahominy	Phillips	85.1
Clear (Midcoast, 5/12/82)	Croft	83.8
Clear (Midcoast, 11/19/82)	Willow Valley	76.3
Clear (Willamette/Sandy)	Summit	93.8
Clear (Deschutes, 11/4//82)	Little Cultus	87.6
Clear (Deschutes, 9/4/81)	Pine Hollow	84.9
Cleawox	Lower Pony Creek	43.8
Cold Springs	Euwana	51.1
Collard	Fourmile	70.5
Cottage Grove	Dorena	68.4
Cottonwood	Strawberry	86.7
Cougar	Sparks	62.3
Crane Prairie	River Mill	71.0
Crescent (8/19/81)	Ochoco	89.1
Crescent (8/23/82)	Crescent (8/19/81)	70.1
Croft	Clear (Midcoast, 5/12/8)	83.7

Crump	Drews	61.0
Davis (7/16/82)	Prineville (8/24/82)	72.0
Davis (5/20/82)	Odell (5/20/82)	60.9
Deer	Garrison (5/4/82)	74.5
Delintment	Lava	41.2
	Lost Creek	41.2
Detroit	Lake o' Woods (5/19/82)	77.5
Devils (Midcoast)	Sutton (7/19/81)	57.5
Devils (Klamath)	Munsel (5/1/82)	66.7
Dexter	Dorena	75.7
Diamond	Upper Klamath (8/22/82)	58.3
Dog	Hyatt	70.3
Dorena	Lemolo	76.8
Drews	Crump	61.0
East (7/13/81)	East (7/23/83)	71.1
Eckman	Strawberry	71.2
Eel (7/27/83)	Loon (7/27/83)	58.2
Eel (8/5/81))	Loon (7/27/83)	53.8
Elk	Leaburg	85.0
Emigrant	Upper Klamath (5/18/82)	68.1
Euwana	Gerber	68.6
Fall Creek	Croft	81.8
Fish (Powder)	Suttle (5/21/82)	65.6
Fish (Malheur Lake)	Lake o' Woods (5/19/82)	97.7
Fish (Rogue)	Blue River	80.2
Fish (Willamette/Sandy)	Ollalie (9/4/81)	61.1
Floras	Lake o' Woods (9/11/81)	71.3
Fourmile	Collard	70.5
Garrison (8/3/81)	Garrison (11/22/82)	97.2
Garrison (5/4/82)	Timothy	83.5
Garrison (11/22/82)	Garrison (8/3/81)	97.2
Gerber	Round Valley	70.4
Glacier	Pamelia	72.5
Gold	Loon (7/27/83)	64.1
Goose	Upper Cow Creek	65.0
Henry Hagg	Fourmile	58.8
Hart	Summer	84.4
Haystack	Chickahominy	71.3
Hills Creek	Waldo (8/18/81)	77.2
Horseshoe	Fourmile	69.7
Howard Prairie	Lemolo	84.6
Hyatt	Dog	70.2
Irish	Upper Eddeleo	80.5
Island (Rogue)	Monon (9/19/82)	84.0
Island (Willamette/Sandy)	Suttle (11/7/82)	70.0
Jubilee	Langdon	74.0
Lake of the Woods (9/11/81)	Floras	71.3
Lake of the Woods (5/19/82)	Fish (Malheur Lake)	97.7
Lake of the Woods (8/12/82)	Clear (Midcoast, 5/12/82)	80.1
Langdon	Lost	79.0
Lava Lake	Upper Klamath (5/18/82)	61.6

Leaburg	Elk	85.0
Lemolo	Howard Prairie	84.6
Little Cultus	Clear (Deschutes, 11/4/82)	70.6
Little Lava	Prineville (5/24/82)	70.7
Loon	Gold	64.2
Lost Creek (9/5/81)	Blue (7/21/82)	75.0
Lost Creek (7/14/82)	Lava	47.8
Lower Lake	Charlton	80.6
Lower Eddeeleo	Mink	69.1
Lower Erma Bell	Island (M)	65.4
Lower Pony Creek	Big (7/22/83)	65.1
Magone	Mercer	51.7
Malheur Res.	East (7/13/81)	37.5
Mann	Rabbit Valley	76.2
Marion	Chickahominy	66.7
McKay	Upper Pony Creek	73.2
Mercer	Munsel (7/20/81)	71.6
Miller	Balm Creek	70.3
Minam	Scott	65.6
Mink	Mirror	82.2
Mirror	Mink	82.2
Monon (9/19/82)	Island (Rogue)	84.0
Monon (9/4/81)	Big (8/29/81)	51.7
Munsel (7/20/81)	River Mill	73.2
Munsel (5/1/82)	Devil (Klamath)	66.7
North Tenmile	Tenmile	77.0
North Twin	Crescent (8/23/82)	89.1
Obenchain	Willow	70.7
Ochoco	Crescent (8/19/81)	89.1
Odell (8/19/81)	Little Cultus	69.5
Odell (5/20/82)	Detroit	75.4
Odell (8/23/82)	Odell (8/19/81)	61.9
Odell (7/24/83)	Trailbridge	90.3
Lost Lake	Langdon	79.0
Ollalie (9/4/81)	Monon	81.2
Ollalie (9/19/82)	Applegate	73.4
Olive	Henry Hagg	54.8
Oswego	Paulina	43.6
Owyhee	Drews	57.2
Pamelia	Glacier	72.5
Paulina	Oswego	43.6
Pelican	East (7/13/81)	39.4
Penland	Clear (Midcoast, 5/12/82)	42.2
Phillips Res.	Chickahominy	85.2
Pine Hollow	Clear (Deschutes, 9/4/81)	84.9
Prineville (5/24/82)	Billy Chinook (5/21/82)	78.2
Prineville (8/24/82)	Davis (7/6/82)	72.0
Prineville (11/5/82)	Bumphead	50.1
Rabbit Valley	Wallowa (6/24/82)	84.4
River Mill	Willow Valley	82.2
Rock Creek (Deschutes)	Devils (Midcoast)	37.1

Rock Creek (Malheur Lake)	Davis (7/8/82)	88.8
Round Valley	Gerber	70.4
Saunders	Beale	74.3
Scott	Minam	65.6
Selmac	Garrison (11/22/82)	72.9
Siltcoos (5/12/82)	Upper Tumalo	87.3
Siltcoos (7/28/83)	Fish (Rogue)	81.3
Simtustus	Spring	38.8
Smith Res.	Trailbridge	90.3
Tenmile	North Tenmile	77.0
South Twin	Willow	68.3
Sparks (8/21/81)	Cougar	62.3
Sparks (7/20/82)	Sparks (8/21/81)	14.3
Spring	Delintment	40.0
Squaw	Walton	68.7
Strawberry	Cottonwood	86.7
Summer	Hart	84.4
Summit	Clear (Will/Sandy)	93.8
Suttle (5/25/82)	Fish (Baker)	65.6
Suttle (7/21/82)	Suttle (11/7/82)	82.6
Suttle (11/7/82)	Suttle (7/21/82)	82.6
Suttle (7/22/83)	Waldo (8/23/82)	61.5
Sutton (7/19/81)	Devils (Midcoast)	57.5
Sutton (5/1/82)	Suttle (7/21/82)	68.6
Tahkenitch (7/29/81)	Blue River	73.4
Tahkenitch (5/3/82)	Smith Res.	55.8
Thief Valley	Haystack	49.4
Thompson Valley	Antelope Flat	71.8
Three Creeks	Billy Chinook (5/21/82)	56.2
Timothy	Garrison (11/22/82)	85.3
Todd	Irish	79.2
Torrey	Detroit	59.1
Trailbridge	Odell (7/24/83)	90.3
Triangle	Billy Chinook (11/5/82)	78.4
Upper Tumalo	Siltcoos (5/12/82)	87.3
Unity	Agency	72.1
Upper Eddeleo	Irish	80.5
Upper Cow Creek	Goose	65.0
Upper Klamath (5/18/82)	Emigrant	68.1
Upper Klamath (8/22/82)	Diamond	58.3
Upper Pony Creek	McKay	73.2
Waldo (8/23/82)	Waldo (8/18/81)	63.2
Waldo (8/18/81)	Hills Creek	77.1
Walton	Squaw	68.7
Warm Springs	Bumphead	31.4
	Devil (Klamath)	31.4
	Upper Cow Creek	31.4
Wickiup	Balm Creek	77.6
Willow	Obenchain	70.7
Willow Valley	River Mill	82.2
Woahink (5/2/82)	Tenmile	58.8
Woahink (11/20/82)	Woahink (9/7/83)	78.1

Woahink (9/7/83)	Woahink (11/20/82)	78.1
Wallowa (8/1/82)	Wallowa (6/24/82)	78.7
Wallowa (6/24/82)	Rabbit Valley	84.4