

JUVENILE KOKANEE DIET AND GROWTH, AND
ZOOPLANKTON COMMUNITY DYNAMICS
IN LAKE PEND OREILLE, IDAHO

A Thesis

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Lance Clark

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Major Professor: David H. Bennett, Ph. D.

ABSTRACT

The kokanee population in Lake Pend Oreille has been declining since the 1960s. Some research suggests that competition for food with *Mysis* shrimp may limit kokanee survival. This study was initiated to quantify food abundance for kokanee, and to understand predator prey relationships between juvenile kokanee and zooplankton. I studied zooplankton community dynamics in bays and open water sites, diet of newly emerged kokanee, and growth of age-0 kokanee in June and October in Lake Pend Oreille, Idaho from 1997-1998.

Total zooplankton density estimates for May through September, 1998 ($39.1 \cdot L^{-1}$) were higher than any comparable reported estimate since 1974, and similar estimates for 1997 ($23.5 \cdot L^{-1}$) were higher than most years. Zooplankton densities in summer 1998 were higher than normal because (i) the copepod *Cyclops bicuspidatus thomasi* was unusually abundant in June, and (ii) the cladoceran zooplankton *Daphnia* and *Bosmina longirostris* became abundant earlier in the summer and remained abundant later in autumn than in normal years. I did not find evidence that kokanee zooplanktivory was impacting August-September *Daphnia* populations in 1997 and 1998, suggesting that mid-summer food densities were sufficient to support current kokanee densities.

The most important zooplankter in the diet of newly emerged kokanee in May-June 1998, *Cyclops bicuspidatus thomasi*, was also the most abundant prey item. The copepod *Diaptomus ashlandi* and *Daphnia* were also important prey items for kokanee fry, and young-of-the-year *Mysis relicta* appeared in stomachs in late June. I found a higher incidence of empty kokanee stomachs in May and early June, but I speculate that

this was due to scant feeding by recently emerged fry, rather than an indication of food limitation.

Results of *in-situ* growth experiments performed in June and October 1998, in which kokanee fry were fed a range of zooplankton food rations, showed positive kokanee growth at ambient food levels. In both experiments, kokanee fed much higher than ambient food rations did not grow significantly more than fish fed ambient food rations, but in the June experiment fish fed low food rations did grow significantly slower. Significant kokanee mortality did not occur in either experiment. My results indicate that wild kokanee in Lake Pend Oreille would not have grown significantly more in June and October 1998 if zooplankton were more abundant.

Based on the results of this study, I do not believe that zooplankton densities limited juvenile kokanee growth in 1998. Kokanee diet analysis and growth experiments were not performed in 1997, therefore I cannot conclude that zooplankton densities were sufficient to support kokanee growth in June and October 1997. However, juvenile kokanee survival was strong in 1977, a year with similar mean May-September zooplankton densities as 1997.

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CHAPTER 1. Introduction, objectives and study area.

Introduction

Kokanee *Oncorhynchus nerka* are valued by fisheries managers as both a sport-fish and forage species for piscivorous salmonids such as Kamloops rainbow trout *O. mykiss gairdneri*, lake trout *Salvelinus namaycush*, and bull trout *S. confluentas* (Wydoski and Bennett 1981). As a pelagic planktivore, kokanee fill an “empty” niche in many coldwater lakes and reservoirs (Nesler and Bergersen 1991). Successful establishment of kokanee in lakes and man-made impoundments throughout the western United States has often resulted in increased numbers and size of the piscivores.

Kokanee and the freshwater shrimp *Mysis relicta* both utilize zooplankton as a primary food source (Nesler and Bergersen 1991). As a result of widespread *Mysis* introductions in the mid 1960s, the two species now co-occur in many western U.S. lakes and reservoirs. Prior research has reported declines in kokanee fisheries that roughly correspond to the timing of *Mysis* introductions within many of those systems (Beattie and Clancy 1991; Martinez and Bergersen 1991; Northcote 1991). Declines in cladoceran macrozooplankton densities, specifically species of *Daphnia* and *Bosmina*, due to overgrazing by the predaceous *Mysis* may have caused the loss of numerous kokanee fisheries (Martinez and Bergersen 1991; Spencer et al. 1991; Morgan et al. 1978). Lake Pend Oreille, a naturally occurring lake in northern Idaho, experienced a similar decline in the kokanee fishery following the introduction of *Mysis* by the Idaho Department of Fish and Game (IDFG) from 1966 to 1970 (Rieman and Falter 1981). However, declines in the kokanee population of Lake Pend Oreille also parallel operational changes at Albeni Falls Dam, which was built in 1952 on the lake’s outlet.

Operated for hydropower production, Albeni Falls Dam regulates water level fluctuations within the lake. Since 1966, minimum pool levels of 625.14 m (2051.71 ft) occur in late winter at Lake Pend Oreille. Research by IDFG indicates that kokanee year-classes were stronger in the first 13 years of dam operation, when winter lake levels were maintained at 626.67 m (2056.73 ft). At the lower winter lake levels, key shoreline spawning sites are above waterline, forcing kokanee to spawn in less suitable locations. A 5-year study was initiated in October, 1996 to assess effects of maintaining the lake's minimum pool level at 626.36 m (2055.71 ft). By keeping pool levels 1.22 m (4.0 ft) higher in winter, IDFG personnel believe that egg to fry survival of kokanee will increase. My research is one part of the study on lake level manipulations, and will evaluate interactions between the lake's macrozooplankton community and kokanee. My goal was to quantify spatial and temporal distribution of the macrozooplankton community and investigate the growth and survival of age-0 kokanee as a function of zooplankton abundance and community structure. From this study, fishery managers will be able to better predict the growth and survival of young-of-the-year kokanee in Lake Pend Oreille, determine optimum stocking levels of hatchery reared kokanee, and potentially calculate the carrying capacity of Lake Pend Oreille for kokanee.

Objectives

1. To quantify temporal and spatial variations in crustacean zooplankton density and biomass in selected bays and open water sites in Lake Pend Oreille, Idaho.
2. To evaluate the diet of newly emerged kokanee fry in Lake Pend Oreille.
3. To determine the importance of varied crustacean zooplankton composition and abundance on the survival and growth of both newly emerged kokanee fry in June, and age-0 kokanee in October in Lake Pend Oreille.

Study Area

As glacial ice retreated from Idaho into British Columbia near the end of the Pleistocene era, a trough known as the Purcell trench emerged in its wake (Merriam 1975). Lake Pend Oreille, in the northern Panhandle of Idaho, lies within this glacially carved trench, which had been subsequently over-deepened by 70-100 Missoula flood episodes (Figure 1.1). The 383 km² lake has a mean depth of 164 m, a maximum depth of 351 m, and a shoreline length of approximately 310 km (Rieman and Bowler 1980). Mean surface elevation before the lake level manipulations was 629 m above sea level (Rieman and Bowler 1980). The Clark Fork River and numerous smaller streams supply the lake's water, while the Pend Oreille River is the outlet.

Lake Pend Oreille is a temperate lake that cools below 4° C but rarely freezes (Rieman 1976). Warming of the epilimnion begins in April and continues into August, a thermocline is typically established in July at a maximum depth of about 20 m; and the lake remains

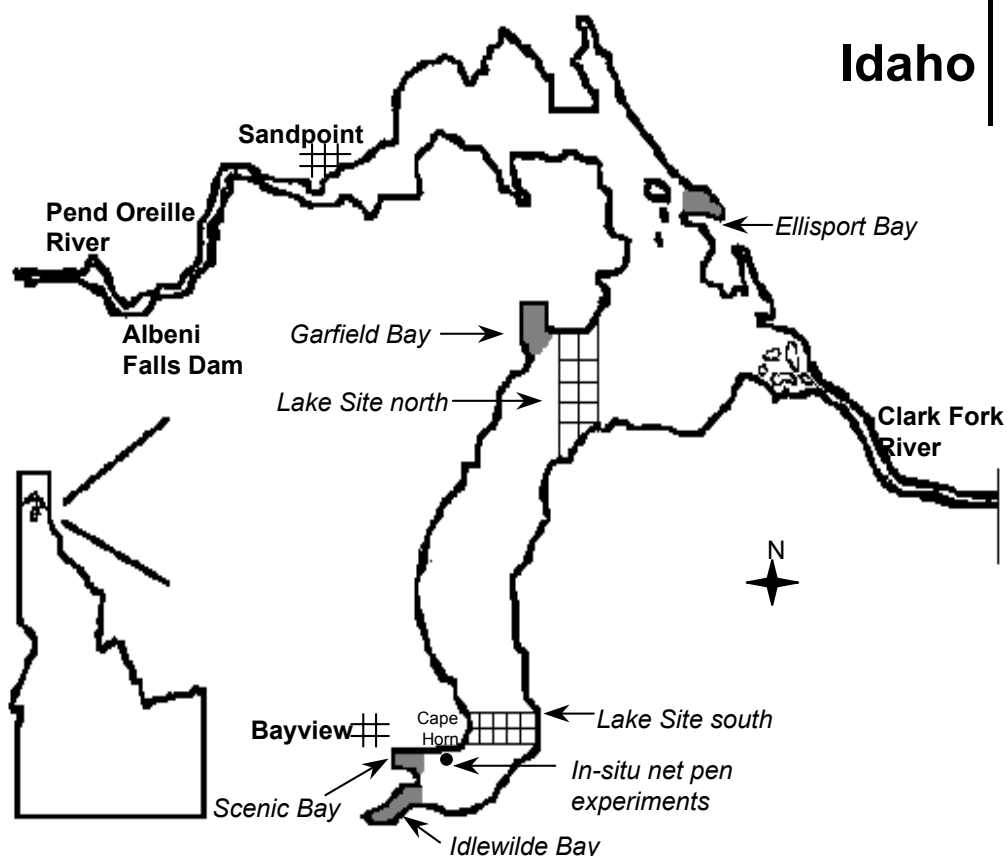


Figure 1.1. Map of Lake Pend Oreille showing zooplankton sampling sites and approximate location of *in situ* net pen experiments in italic.

stratified into September. The northern end of the lake warms more quickly in spring, perhaps due to inflows of turbid, warmer water from the Clark Fork River.

Nutrient inputs from the Clark Fork River settle into the extensive hypolimnion of Lake Pend Oreille, and become unavailable for primary productivity. As a consequence, total nitrogen, total phosphorus, secchi disk readings and chlorophyll-a concentrations verify that the lake is oligotrophic (Woods 1991). No significant water quality changes have occurred in the main channel of Lake Pend Oreille since the first limnological study was conducted at the lake in 1954, although cultural eutrophication is increasing the nutrient levels of some bays (Falter and Olson 1990).

CHAPTER 2. Temporal and spatial variations in crustacean zooplankton density and biomass in selected bays and open water sites of Lake Pend Oreille, Idaho.

Introduction

The kokanee fishery at Lake Pend Oreille, Idaho once produced annual harvests in excess of 1 million kokanee (Rieman and Bowler 1980), but declined in the late 1960s. Researchers postulated that introductions of omnivorous *Mysis relicta* reduced densities of crustacean zooplankton available as food for kokanee (Rieman 1976; Rieman and Falter 1981). Limnological studies at Lake Pend Oreille in the mid 1970s (Rieman and Bowler 1980) documented temporal shifts in the zooplankton community that coincided with increased abundance of *Mysis relicta*, providing evidence to support the theory. Stross (1954) studied the lake before *Mysis* introductions and collected an average of 3.0 *Daphnia*·L⁻¹ from August to October and 7.1 *Bosmina*·L⁻¹ from mid June to August. In contrast, Rieman and Falter (1981) found an average of only 2.1 cladocera·L⁻¹ (including *Daphnia* spp., *Bosmina longirostris*, *Diaphanasoma leuchtenbergianum*, and *Leptodora kindtii*) in comparable seasons while studying the lake from 1974 to 1978. Chipps (1997) linked fluctuations in cladoceran zooplankton densities at Lake Pend Oreille with seasonal consumption rates of *Mysis relicta*.

Spatial distribution of freshwater zooplankton is not uniform. Previous research has reported zooplankton swarms (Colebrook 1960), wind-induced zooplankton patches (McNaught and Hasler 1961), vertical and horizontal heterogeneity (Malone and McQueen 1983), and heterogeneity from mesoscale to microscale patterns (Pinel Alloul et al. 1988). Shifts in the zooplankton community structure of near-shore and offshore regions attributable

to predation from *Mysis* shrimp and planktivorous fishes also have been reported (Evans and Jude 1986).

Since zooplankton distributions are not uniform, and variations in zooplankton density and composition at a sampling site can occur daily (Watson 1975), a complete description of the temporal, horizontal, and vertical changes of the zooplankton community throughout Lake Pend Oreille is not realistic. However, this study explores the zooplankton community dynamics of Lake Pend Oreille on a finer time scale than previous studies (Stross 1954; Rieman 1976; Rieman and Bowler 1980; Paragamian and Bowles 1995) and is the first known project to characterize the horizontal zooplankton distribution within selected bays in Lake Pend Oreille, Idaho.

Methods

Six sampling locations were established in Lake Pend Oreille for quantification of macrocrustacean zooplankton composition and abundance (Figure 1.1). Scenic, Idlewilde, Garfield and Ellisport bays represent current or historical kokanee spawning sites (Jeppson 1959), and thus were chosen for examining differences in horizontal distribution. The remaining two sampling locations, sampled vertically, are open water sites in the northern and southern portion of Lake Pend Oreille. In 1997, all locations were sampled weekly from June 8 to October 27, and bimonthly in November and December, except the northern open water site which was established on July 30. I sampled zooplankton monthly from January through April 1998, weekly from May 21 to July 10, 1998 and monthly from August through November, 1998. Surface water temperatures at each location were measured using a Yellow Springs Instruments Model-54 temperature probe. I collected measurements of water transparency in Lake Pend Oreille using a standard 20 cm secchi disk.

Horizontal Sampling Protocol

Horizontal sampling was conducted during daylight hours using a 10 L Schindler box (Schindler 1969). Extending out from the shoreline, one sample was collected at the following depths: (i) in 1 m deep water, (ii) at 5 m depth at 10 m total depth, and at depths of (iii) 5 m and (iv) 10 m in water deeper than 50 m, except at Ellisport Bay, which is a shallower bay, and had a total depth deeper than 25 m. All crustacean zooplankton were preserved in sugared, 4% formalin (Haney and Hall 1973). Within each bay, samples were collected at three conveniently selected sampling sites from June 1997 to April 1998, and at six randomly selected sites from May through November, 1998. The randomly selected sites were chosen using the following protocol: the shoreline of each bay was divided into 10 units of equal length, with each unit assigned a number. Six units were then randomly selected, and horizontal sampling extending out from the shoreline began at the center-points of these units.

Lake Site Sampling Protocol

I collected crustacean zooplankton by vertical sampling using a 10 L Schindler box at two main lake locations (hereafter referred to as Lake Sites; Figure 1.1) at depths of 5, 10, 15, and 20 m. One sample was collected at each depth. Within each Lake Site location, samples were collected by convenience sampling at three sampling sites from June 1997 to April 1998, and at six randomly selected sites from May through November, 1998. The randomly selected sites were chosen using the following protocol: a grid pattern overlaying a map of each Lake Site location partitioned the location into a number of boxes. Six boxes were then randomly selected, and vertical samples were collected from the center-points of those boxes. A GPS unit (Magellan model Nav 5000DX) was used to locate the box center-points, which represent the sampling sites at each Lake Site location.

Lab Analysis

In the laboratory, I identified, enumerated, and measured crustacean zooplankton. Samples were subsampled when necessary, washed into a counting chamber, and counted by species. Subsampling methods closely followed procedures detailed in Edmundson (1971). Briefly, the whole sample was washed into a beaker with a known amount of water; that varied in volume depending on the abundance of zooplankton. The diluted sample was mixed to assure a random distribution of organisms, and 2-4 5 ml aliquot subsamples were taken with a wide-mouth Henson “Stemple pipette” to achieve a target density of 200 subsampled zooplankton. Subsamples were then placed in the counting chamber, identified, enumerated and measured following identical procedures used for total counts, except that entire samples were also sorted for enumeration of the less abundant *Leptodora*. Using an ocular micrometer, the first 25 individuals of the commonly occurring species (*Daphnia spp.*, *Bosmina longirostris*, *Cyclops bicuspidatus* and *Diaptomus ashlandi*) were measured according to body shape (Figure 2.1). *Cyclops bicuspidatus* is referred to as *Diacyclops bicuspidatus* in some studies (Watson 1976; Martinez and Bergersen 1991). Two ecologically and morphologically similar species of *Daphnia* (*D. thorata* and *D. galeata mendotae*) occur in Lake Pend Oreille (Rieman 1976). However, I did not identify *Daphnia* to the species level.

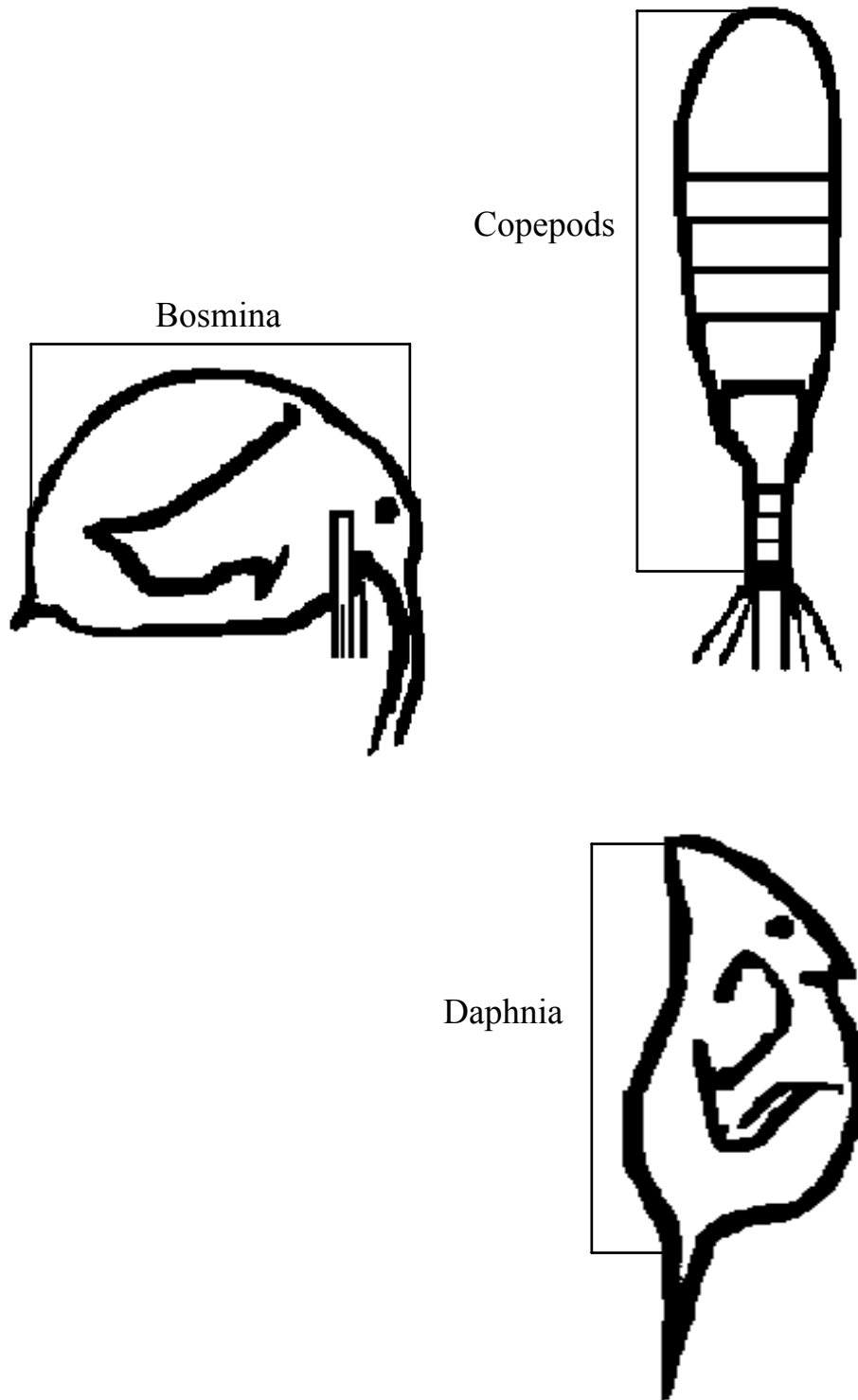


Figure 2.1. Approximate location of body length measurements for three zooplankton body shapes.

Biomass Estimates

I estimated total zooplankton biomass, in milligrams, by converting length to weight for each zooplankton species from established length-weight relationships.

Length(L)- wet-weight(W) relationships for selected zooplankton are as follows

(Culver et al. 1985):

$$\textit{Bosmina longirostris} \quad W=17.7369 \times L^{2.2291} \quad (1)$$

$$\textit{Daphnia spp.} \quad W=7.4997 \times L^{1.5644} \quad (2)$$

$$\textit{Diaphanasoma leuchtenbergianum} \quad W=5.0713 \times L^{1.0456} \quad (3)$$

$$\textit{Leptodora kindtii} \quad W=1.5605 \times L^{1.8730} \quad (4)$$

$$\textit{Chydorus sphaericus} \quad W=14.0793 \times L^{1.9796} \quad (5)$$

$$\textit{Cyclops bicuspidatus thomasi} \quad W=5.6713 \times L^{1.9347} \quad (6)$$

$$\textit{Diaptomus ashlandi} \quad W=7.8273 \times L^{2.6484} \quad (7)$$

where: W = the zooplankter wet weight (μg) and,

L = the zooplankter length (mm) according to body shape (Figure 2.1).

I used estimated mean lengths for *Diaphanasoma* (1.0 mm) and *Leptodora* (4.0 mm) in Lake Pend Oreille as reported by Rieman and Bowler (1980). Mean length for *Chydorus* (0.3 mm) and mean biomass for copepod nauplii (0.25 μg) were from McCauley (1984).

Statistical Analysis

I tested for differences in mean monthly crustacean zooplankton biomass estimates among bays and between lake sites (i.e. Lakes Sites north and south) from May-November 1998 using an aligned ranks test ($\alpha=0.05$). All statistical analyses in this objective were performed using SAS statistical software (SAS institute, version 6.11).

I used an ANOVA with repeated measures by depth stratum to test for mean monthly differences in estimated horizontal zooplankton densities. The model for this analysis is:

$$Y = \mu + \alpha_i + \beta_j + \gamma_k + \alpha_i \beta_j + \alpha_i \gamma_k + \beta_j \gamma_k + \varepsilon_{ijk} \quad (8)$$

where:

- α = the effect of months on zooplankton densities,
- β = the effect of sampling location (e.g. bays) on zooplankton densities,
- γ = the effect of depth strata on zooplankton densities,
- $\alpha\beta$ = the interactive effect of months and sampling locations on zooplankton densities,
- $\alpha\gamma$ = the interactive effect of months and depth strata on zooplankton densities and,
- $\beta\gamma$ = the interactive effect of sampling locations and depth strata on zooplankton densities.

Two zooplankton density estimates in my study, occurring in June 1997 at the 1 m depth strata in Ellisport Bay and in June 1998 at the 10 m at 50 m depth strata in Idlewilde Bay, were unusually high. While these two outlier density estimates were accurate, and probably represented dense microscale zooplankton patches, they were excluded from statistical analysis to maintain homogeneity of variance. An initial statistical analysis using the model described above showed an interaction between months and depth strata (i.e. $\alpha\gamma$ in the above model) which influenced zooplankton densities. Therefore, the effect of individual sampling months on zooplankton densities by depth strata was tested by ANOVA (Slice Procedure; SAS institute, version 6.11).

Results

Zooplankton Density

Zooplankton densities were highest in June, 1998 and lowest in March, 1998 at all sampling locations in Lake Pend Oreille (Figures 2.2-2.4; Appendix Table 2.1). Annual peak zooplankton densities, which occurred in July 1997 and in June 1998, were between 149% (Lake Site south) and 262% (Scenic Bay) higher in 1998 than in 1997. Zooplankton densities were similar in August 1997 and 1998. Cladoceran zooplankton (e.g. *Daphnia spp.*, *Bosmina longirostris*, *Diaphanasoma leuchtenbergianum*, *Chydorus sphaericus*, and *Leptodora kindtii*) densities increased earlier in the summer, and remained higher in autumn 1998, than in 1997. Mean copepod (e.g. *Cyclops bicuspidatus*, *Diaptomus ashlandi* and *Epischura nevadensis*) densities were approximately 8x higher in June 1998 than in June 1997.

Zooplankton species composition varied slightly by sampling location, but the copepod *Cyclops* was generally the most abundant zooplankter in this study. For all sampling locations, the highest observed *Cyclops* densities occurred in June, 1998 with peak *Cyclops* densities ranging from $39.64 \cdot L^{-1}$ at Lake Site north to $103.46 \cdot L^{-1}$ in Idlewilde Bay (Figures 2.2-2.4; Appendix Table 2.1). *Diaptomus* was the second most abundant zooplankter, with trends in density following those of *Cyclops*. The highest observed density of *Epischura* was $0.77 \cdot L^{-1}$, making it the least abundant copepod.

Daphnia became abundant earlier in the summer, and remained abundant later into the fall of 1998 than in 1997. Mean *Daphnia* densities for all sampling locations were $1.87 \cdot L^{-1}$ in the second week of July and $0.20 \cdot L^{-1}$ in the third week of October, 1998 versus $0.028 \cdot L^{-1}$ and $0.07 \cdot L^{-1}$ during the same weeks in 1997. However, for most sampling locations, peak summer

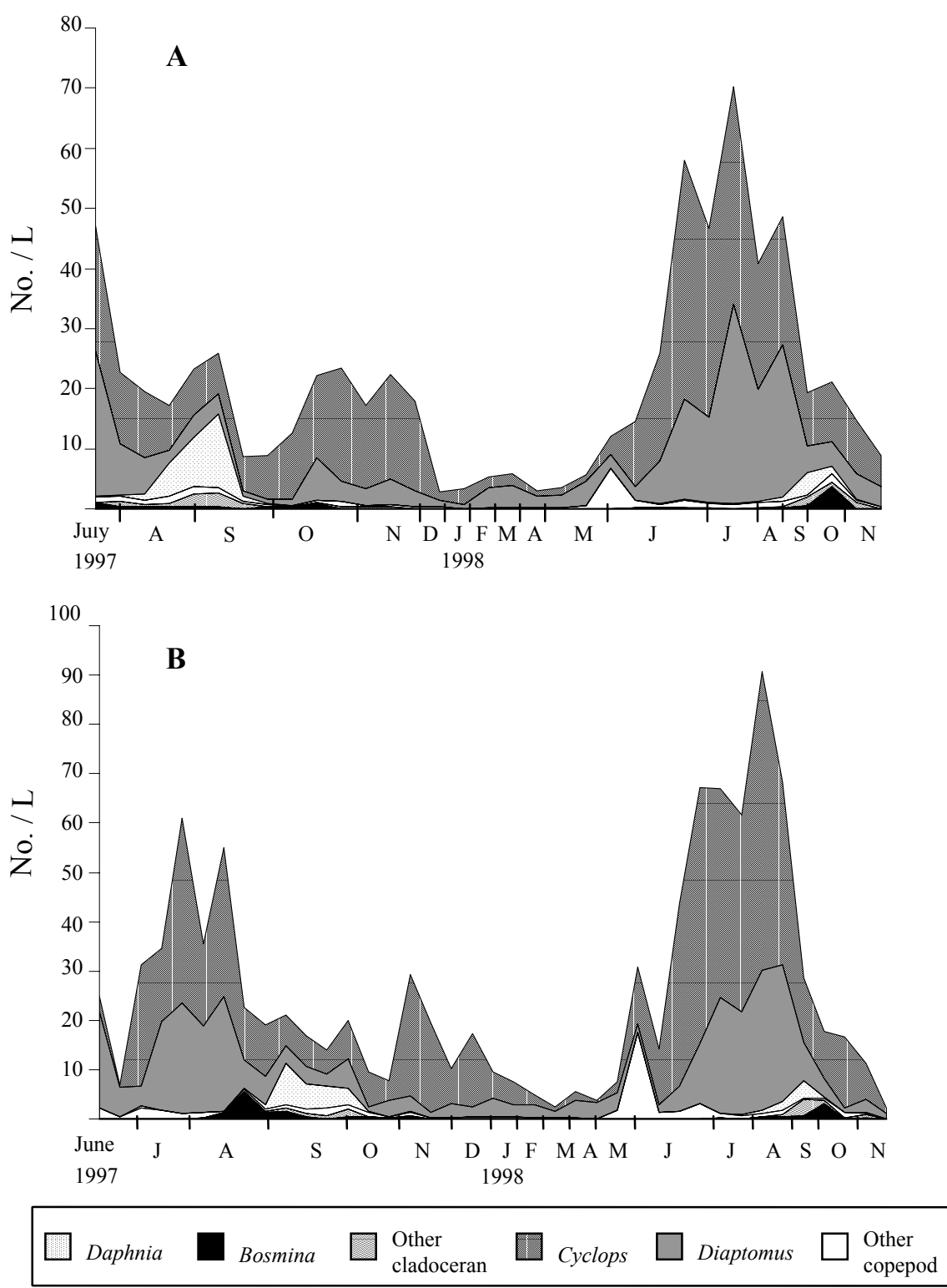


Figure 2.2. Estimated crustacean zooplankton density in Lake Site north (A) and Lake Site south (B) in Lake Pend Oreille, 1997-1998.

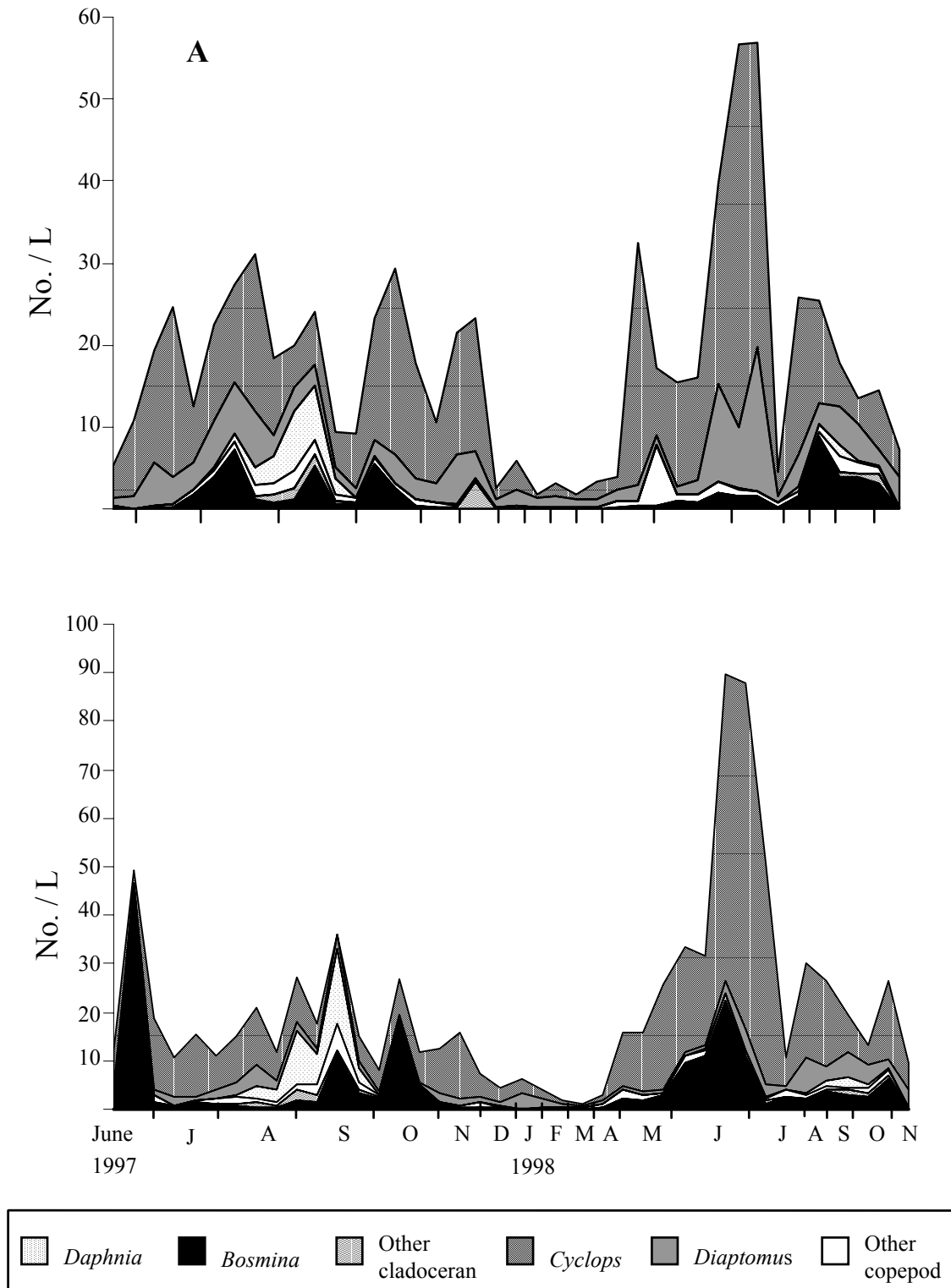


Figure 2.3. Estimated crustacean zooplankton density in Garfield Bay (A) and Ellisport Bay (B) in Lake Pend Oreille 1997-1998.

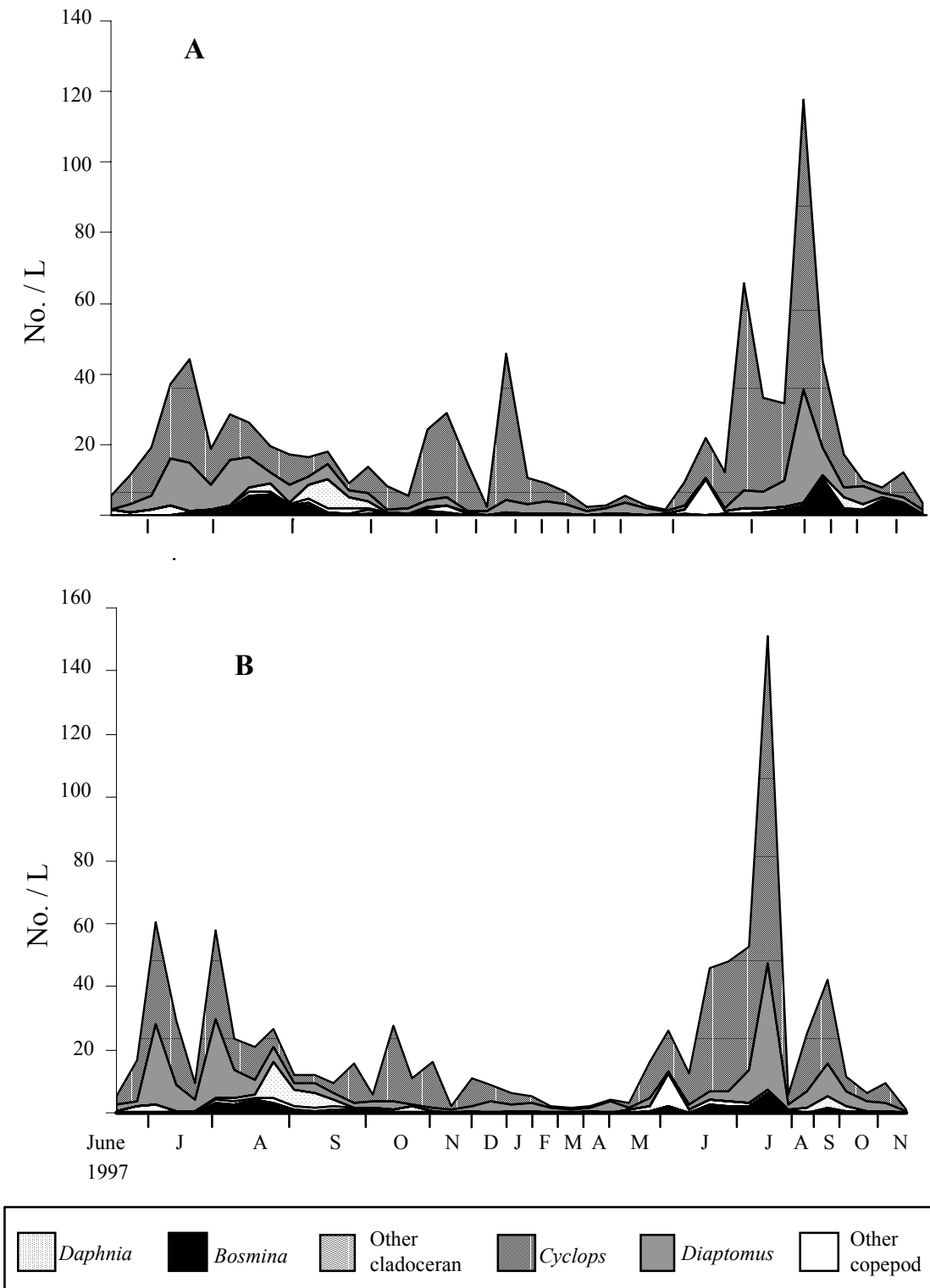


Figure 2.4. Estimated crustacean zooplankton density in Scenic Bay (A) and Idlewild Bay (B) in Lake Pend Oreille 1997-1998.

Daphnia densities were higher in 1997 than 1998. I observed a higher abundance of *Bosmina* in Ellisport Bay than in other sampling locations, and *Bosmina* densities increased earlier in the summer in 1997 and 1998 at Ellisport Bay than at the other locations. At Ellisport Bay, peak *Bosmina* densities occurred in June 1997 and 1998, but did not occur until mid-summer at other sampling locations. Population trends for *Diaphanasoma* were similar to those of *Daphnia*, although *Diaphanasoma* was usually much less numerous. *Chydorus* and *Leptodora* were the least abundant cladocerans in this study.

Zooplankton Biomass

No statistically significant differences in mean zooplankton biomass existed either among bays ($F=0.19_{27}$; $p=0.9020$) or between lake sites ($F=0.19_{13}$; $p=0.6710$) at Lake Pend Oreille, although Garfield Bay consistently had lower standing zooplankton biomass than Scenic and Idlewilde bays on most sampling dates (Figures 2.5-2.7; Appendix Table 2.1). During this study, mean estimated zooplankton biomass was highest in late June 1998 ($1923 \text{ mg}\cdot\text{L}^{-1}$) and lowest in March 1998 ($57.60 \text{ mg}\cdot\text{L}^{-1}$). The most abundant zooplankters, *Cyclops* and *Diaptomus*, represented the highest overall percentages of zooplankton biomass in this study (48.80% and 33.65%, respectively). However, in mid-August to mid-September 1997, *Daphnia* represented 57.48% of the total zooplankton biomass. During the same period in 1998, *Daphnia* biomass was 19.69% of the total standing biomass. Generally, biomass of *Diaphanasoma* exceeding 10% of the total standing biomass was rare in mid-summer, although the overall August-September mean *Diaphanasoma* biomass was 3.95% of the total. Mean *Bosmina* biomass was highest in mid-summer (7.86%), with isolated measurements exceeding 20% of total standing biomass. However, among bay locations in June 1998,

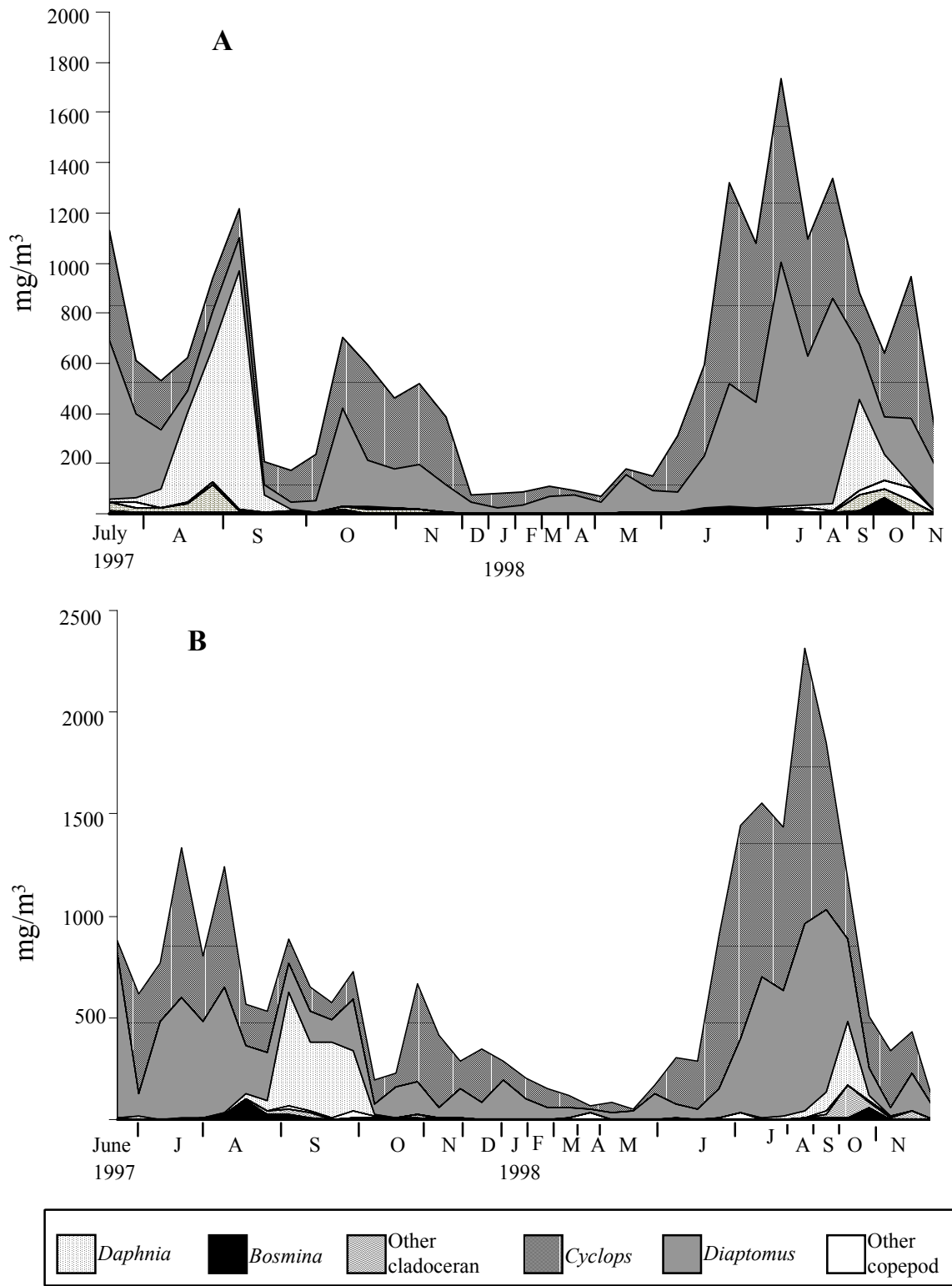


Figure 2.5. Estimated crustacean zooplankton biomass (mg wet weight) in Lake Site north (A) and Lake Site south (B) in Lake Pend Oreille, 1997-1998.

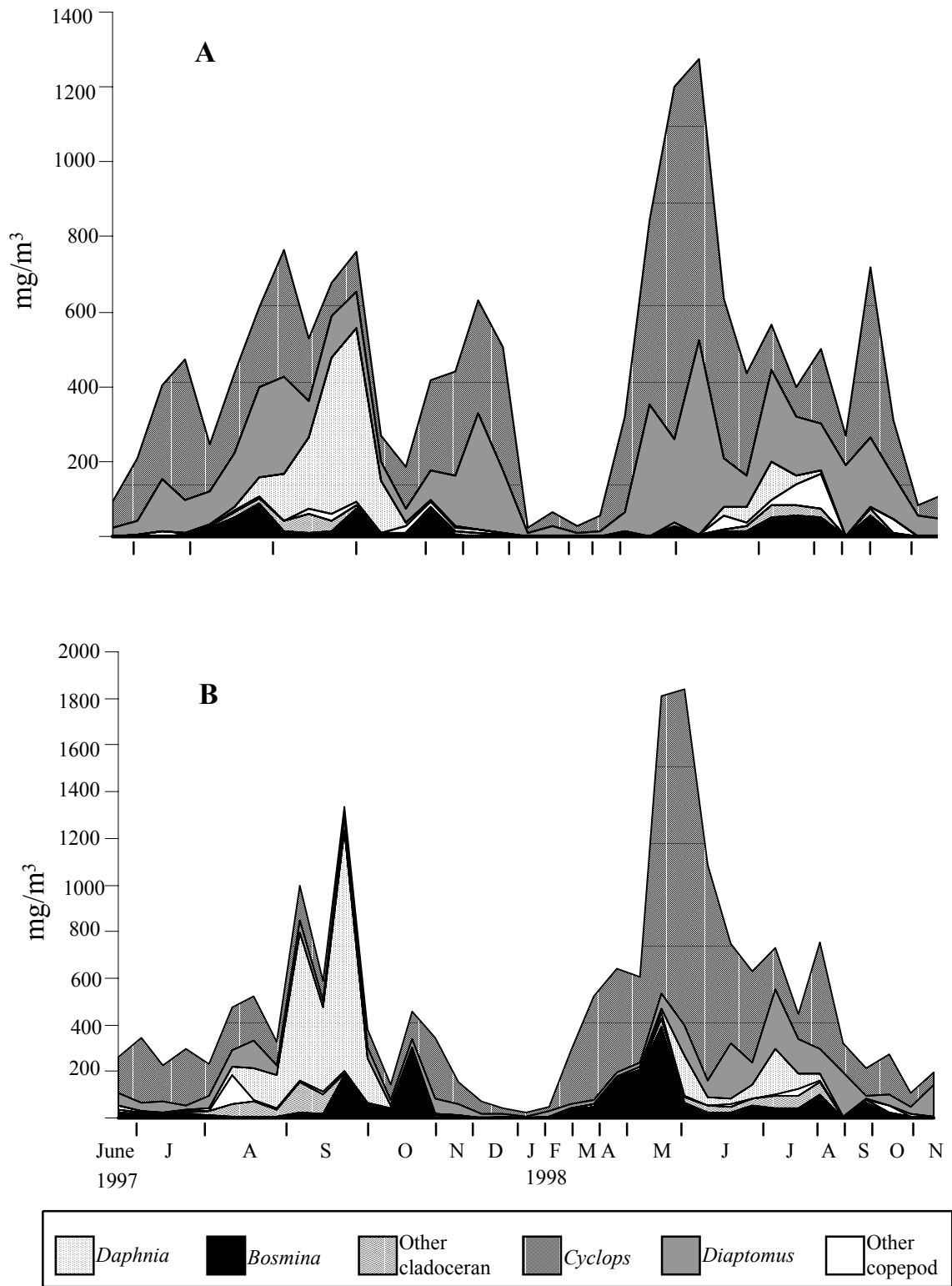


Figure 2.6. Estimated crustacean zooplankton biomass (mg wet weight) in Garfield Bay (A) and Ellisport Bay (B) in Lake Pend Oreille 1997-1998.

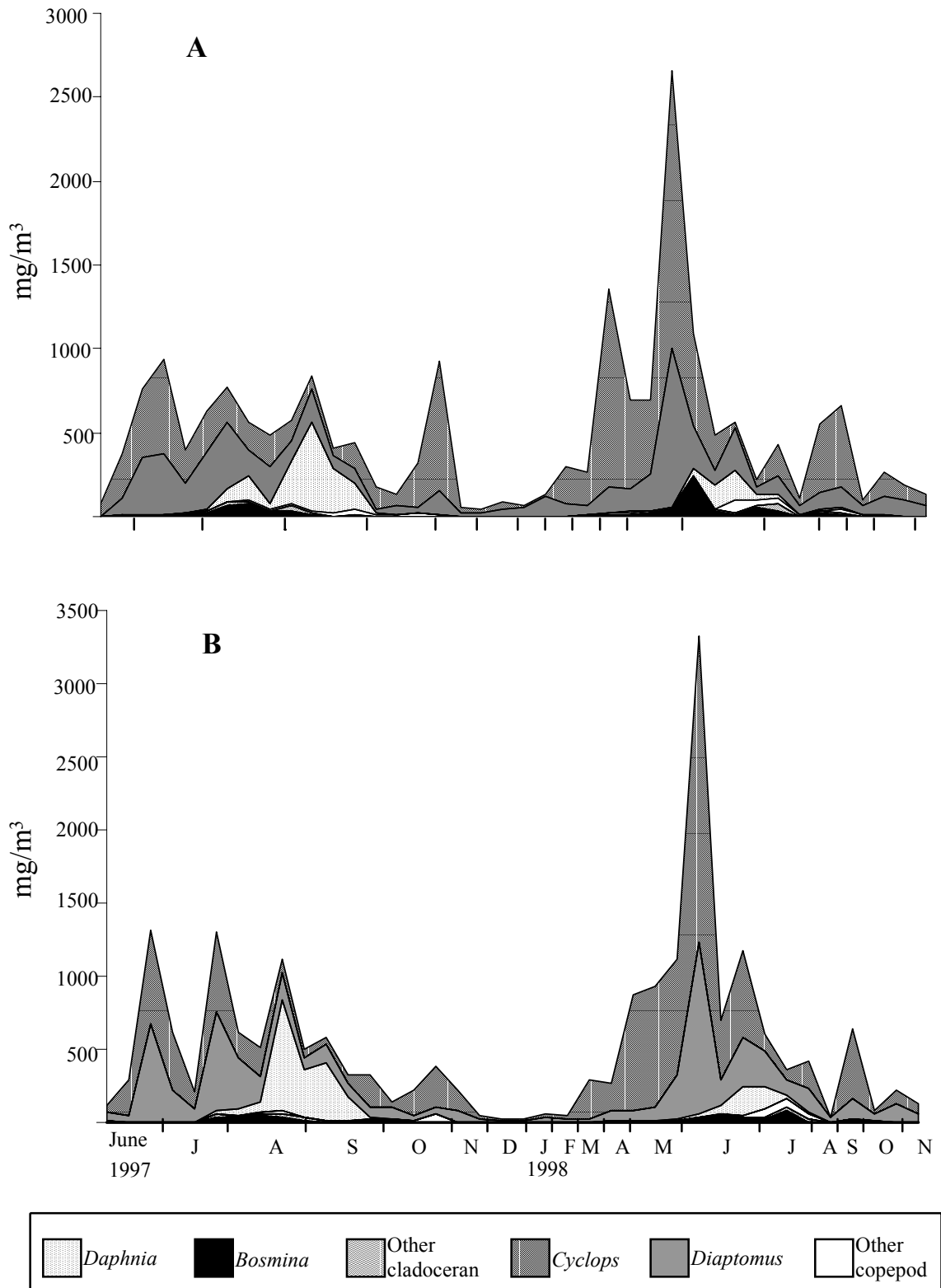


Figure 2.7. Estimated crustacean zooplankton biomass (mg wet weight) in Scenic Bay (A) and Idlewilde Bay (B) in Lake Pend Oreille 1997-1998.

Bosmina biomass represented the highest percentage of standing zooplankton biomass in Ellisport Bay (13.20%) and the lowest percentage in Idlewilde Bay (0.71%). *Epischura* and *Leptodora* represented 1.42% and 0.71% of the mean summer (e.g. June-September) biomass.

Horizontal distribution within bays

Significant differences in total zooplankton densities between depth strata existed for some summer months (e.g. June-September) in 1997 and 1998, but were not detected in the spring, autumn or winter (Appendix Table 2.2). In the summer, the lowest density measurements were consistently nearest to shore (e.g. the 1 m depth stratum), whereas the highest densities were usually at the 10 m at deeper than 50 m depth strata (Figure 2.8). In the winter, zooplankton densities were consistently low across all depth strata. Peak zooplankton densities varied by sampling location and by depth strata within locations in 1997, but in 1998 occurred in June for all depth strata and locations. During this study, mean peak zooplankton densities for each depth strata were lowest for the 1 m stratum ($65.38 \cdot L^{-1}$) and highest for the 10 m at deeper than 50 m depth stratum ($158.64 \cdot L^{-1}$).

Copepod zooplankton was more abundant than cladoceran zooplankton at each depth stratum (Figures 2.9-2.12). Across all sampling locations, cladocerans represented the highest proportion of the total zooplankton density at the 1 m depth stratum (22.06%) and the lowest proportion at the 10 m depth at deeper than 50 m total depth stratum (8.50%). Differences in the relative proportions of cladocerans to copepods between depth strata were more pronounced at Ellisport Bay than other locations, where cladocerans accounted for 40.70% of total zooplankton densities at 1 m versus 11.24% at the 10 m depth at deeper than 50 m total depth stratum.

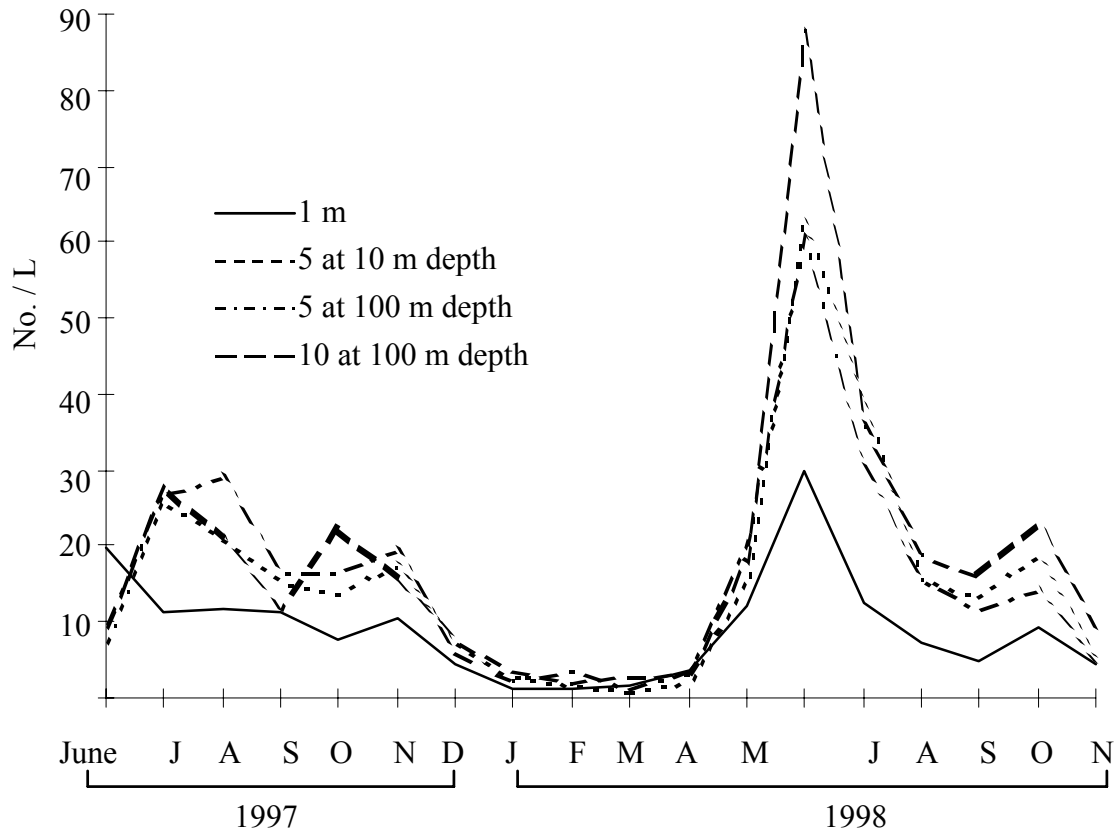


Figure 2.8. Mean zooplankton density (No./ L) by depth strata across all horizontal sampling locations in Lake Pend Oreille, 1997-1998.

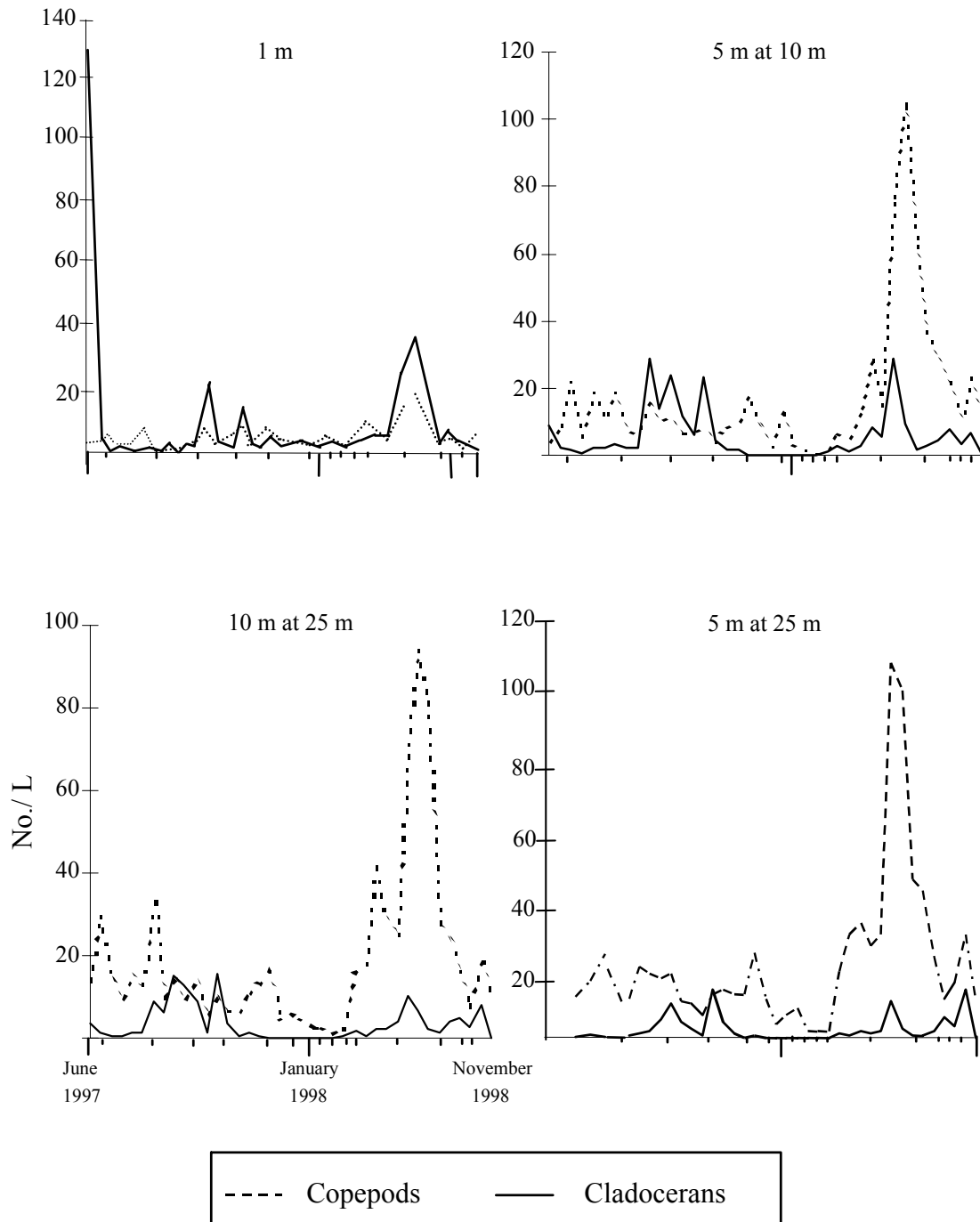


Figure 2.9. Estimated densities of copepods and cladocerans at four depth strata in Ellisport Bay, Lake Pend Oreille 1997-1998.

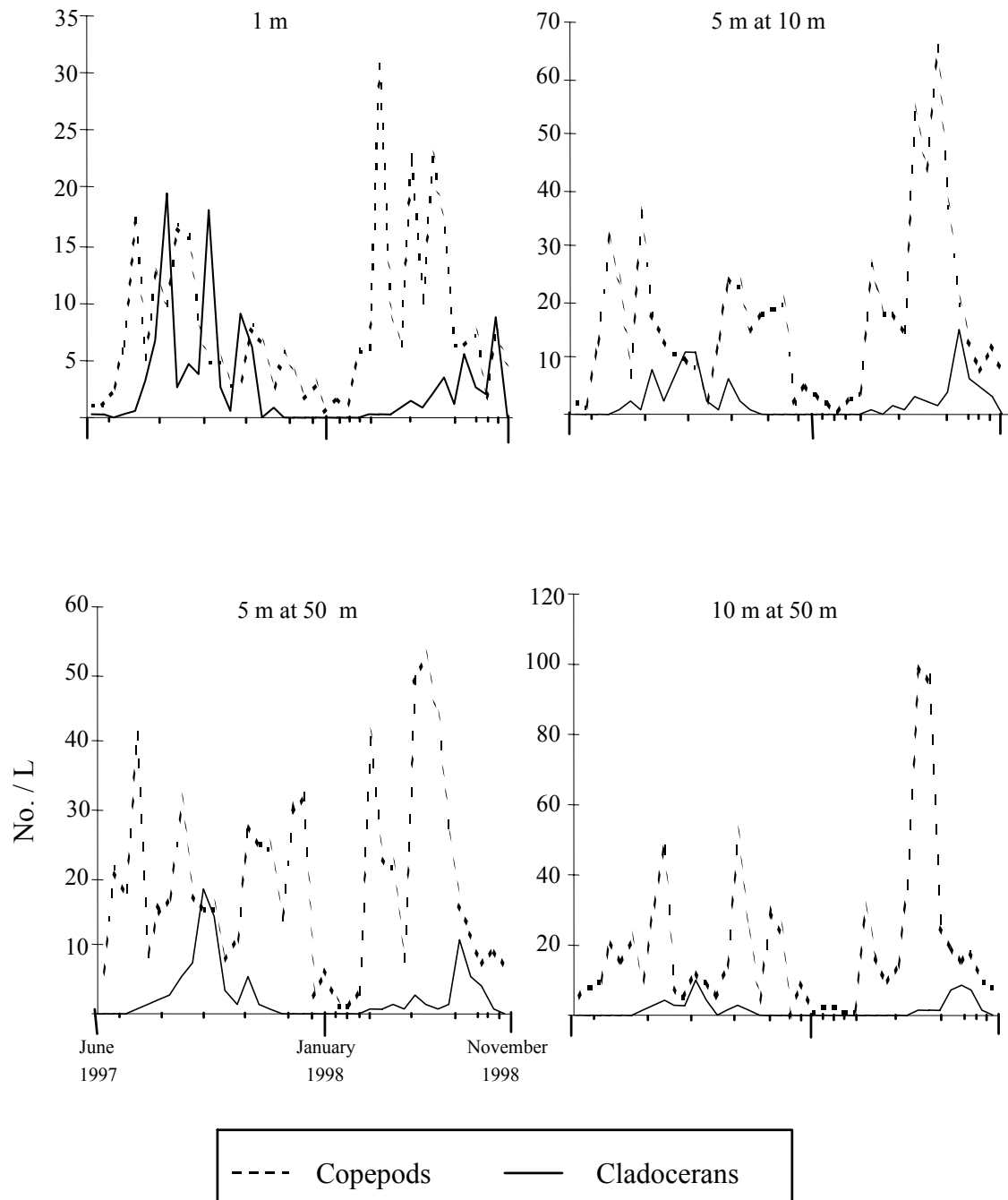


Figure 2.10. Estimated densities of copepods and cladocerans at four depth strata in Garfield Bay, Lake Pend Oreille 1997-1998.

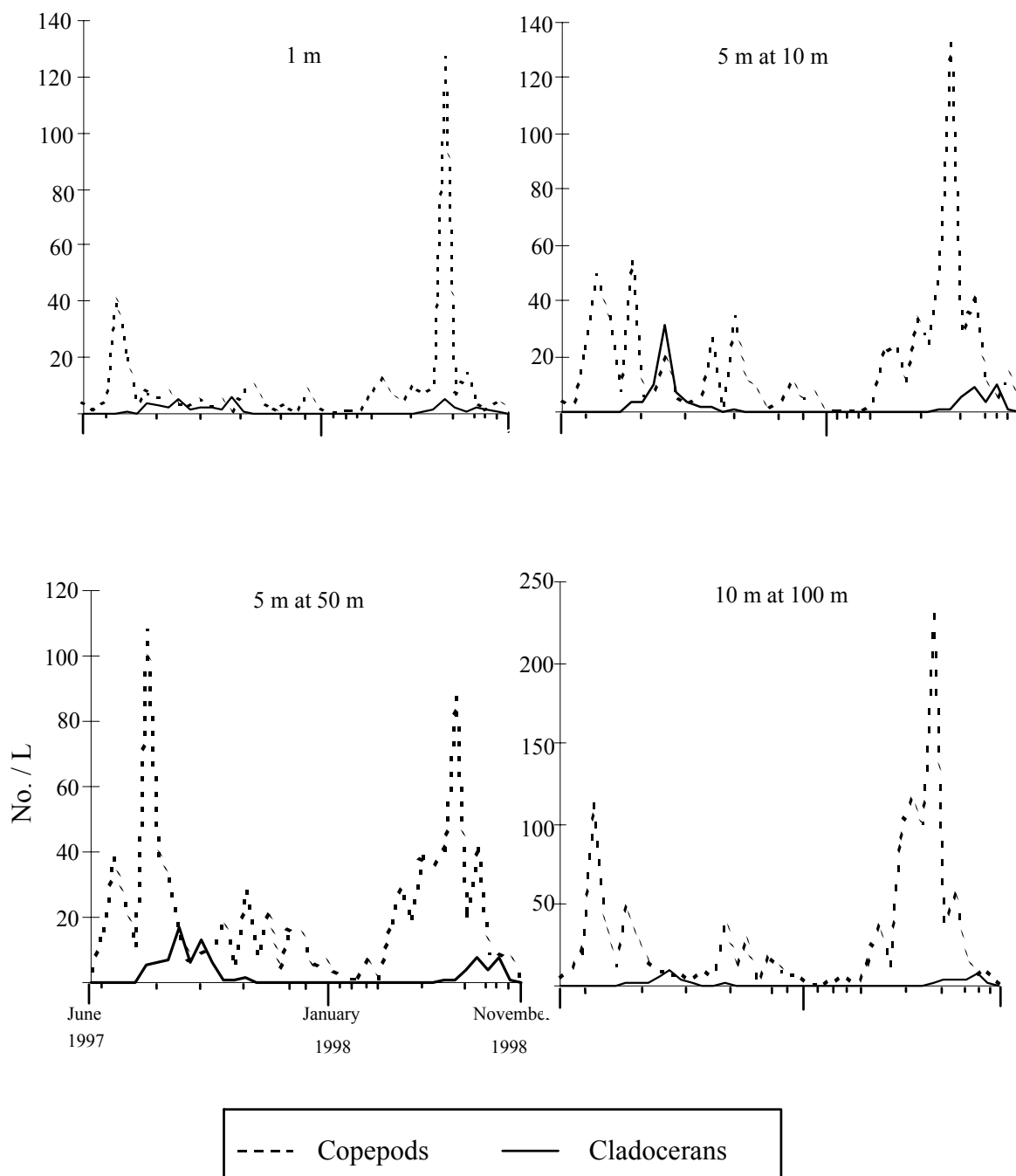


Figure 2.11. Estimated densities of copepods and cladocerans at four depth strata in Idlewilde Bay, Lake Pend Oreille 1997-1998.

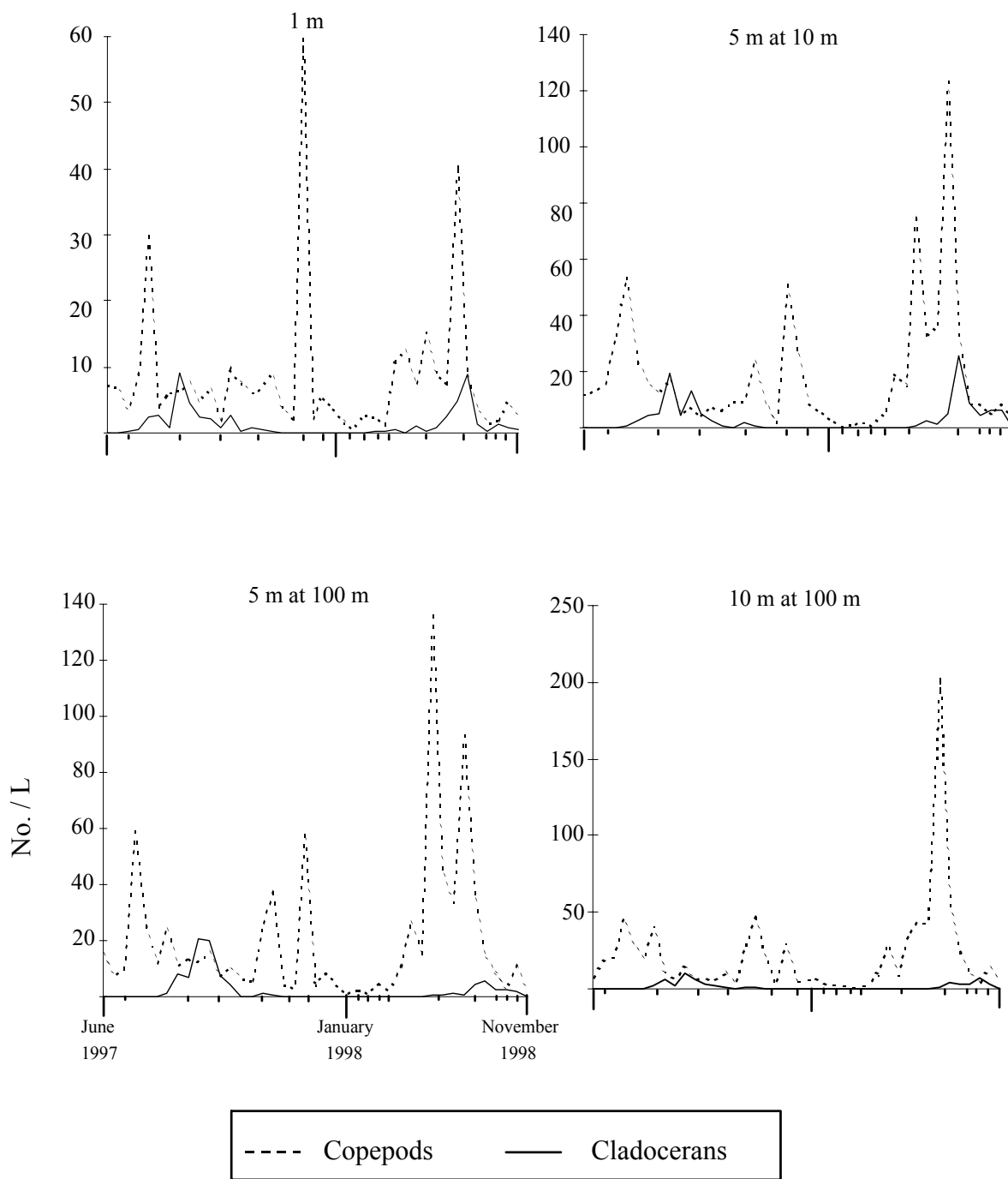


Figure 2.12. Estimated densities of copepods and cladocerans at four depth strata in Scenic Bay, Lake Pend Oreille 1997-1998.

Zooplankton Lengths

Length measurements for *Cyclops*, *Diaptomus* and *Bosmina* varied little seasonally, and among sampling locations, in Lake Pend Oreille from 1997-1998 (Appendix Table 2.2). *Daphnia* lengths fluctuated widely by sampling date and among sampling locations in the summer of 1997 (Figure 2.13), but changes in *Daphnia* length were generally consistent among sampling locations in 1998. *Daphnia* lengths peaked in September at most sampling locations, and declined quickly in October. Mean *Daphnia* lengths were similar between 1 m (0.81 mm) and 5 m at 10 m (0.83 mm) depth strata, and at the 5 m at 100 m (0.91 mm) and 10 m at 100 m (0.89 mm) depth strata.

Water Temperatures

Surface temperatures in 1998 were warmer in June, but slightly cooler in mid-summer at most sampling locations compared to 1997 (Figure 2.14). At Ellisport Bay, water temperatures warmed above 15°C earlier in the spring than at other sampling locations. By late September 1997, water temperatures had cooled below 15°C, except at Ellisport Bay, whereas in 1998 water temperatures at all locations remained above 15°C until October. Mean zooplankton densities were correlated with water temperature ($r=0.46$, $p=0.0027$).

Water Transparency

At most sampling locations, spring and early summer secchi disk measurements were comparable, but measurements were generally lower in late summer and fall 1997 compared to 1998 (Figure 2.15). Secchi depths were often lower in the northern sampling locations (e.g. Lake Site north and Ellisport Bay) than in southern locations. The highest secchi disk measurements occurred in mid winter, and were generally between 9 and 10 m. Mean zooplankton densities were inversely correlated to water transparency ($r=-0.41$, $p=0.0089$).

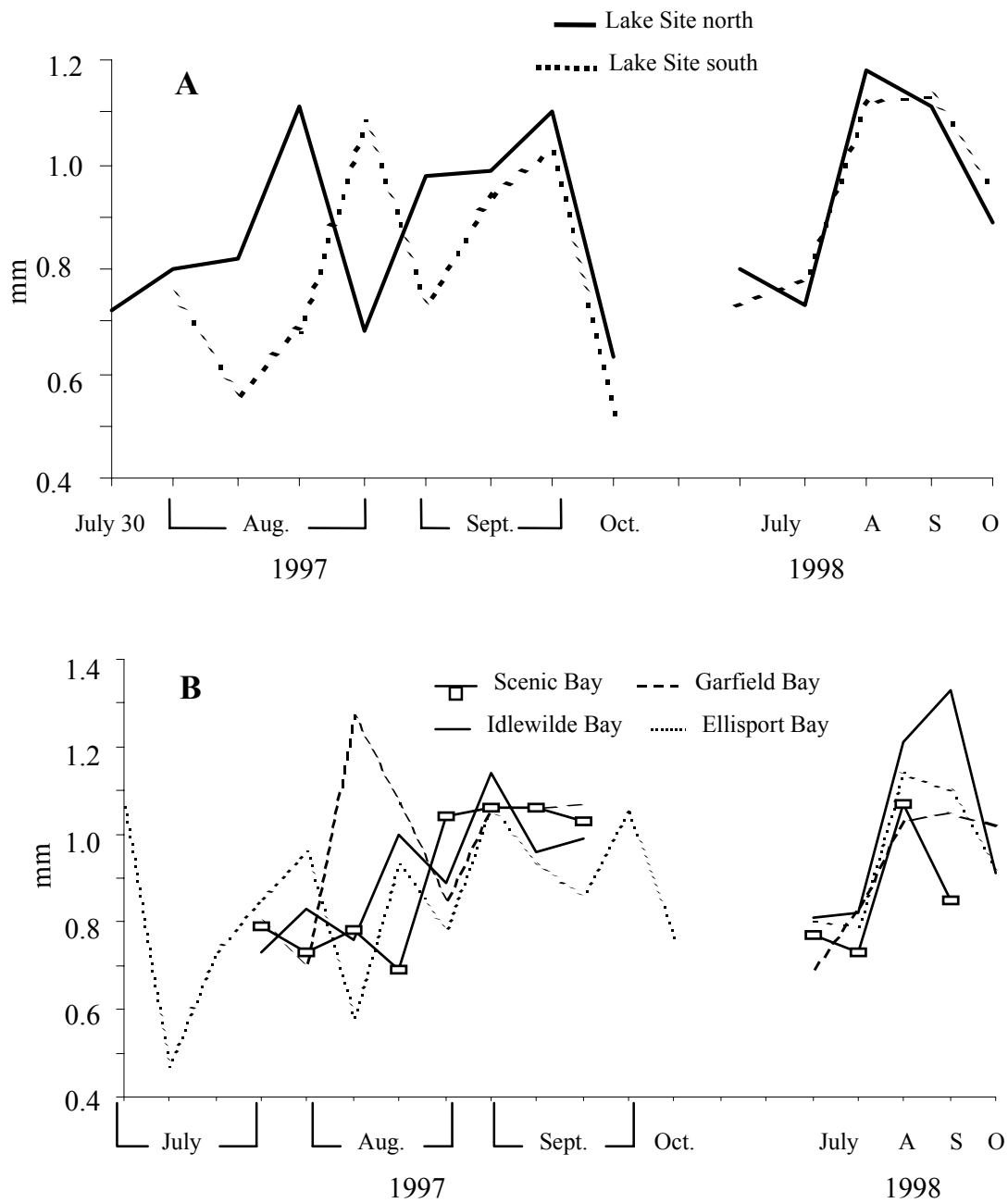


Figure 2.13. Lengths (mm) of *Daphnia spp.* for Lake Sites (A) and bays (B) in Lake Pend Oreille, 1997-1998.

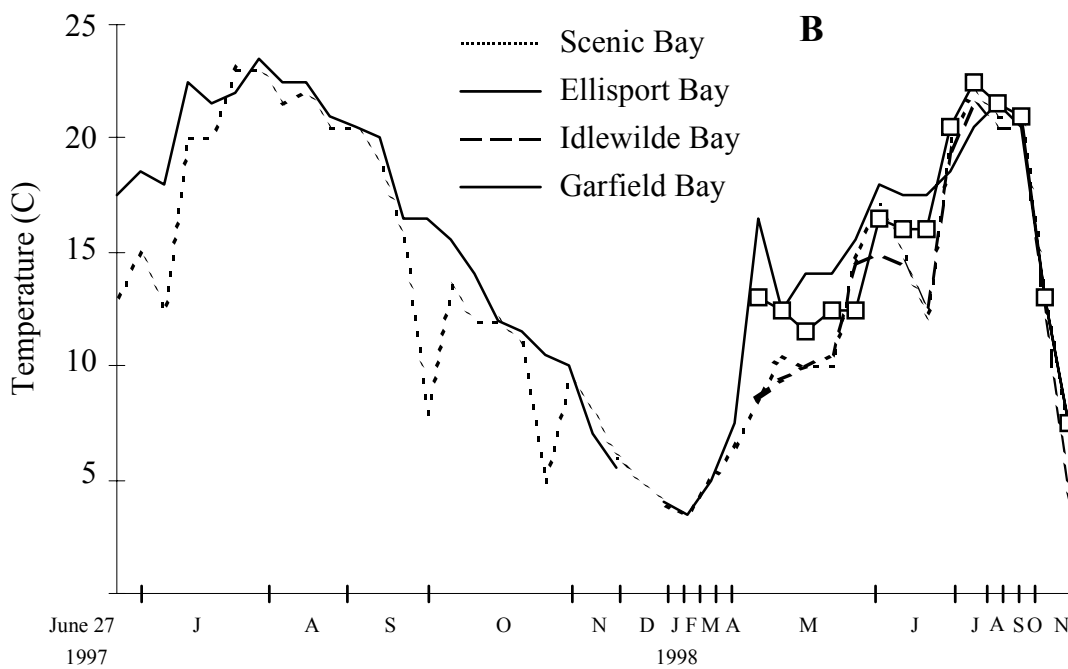
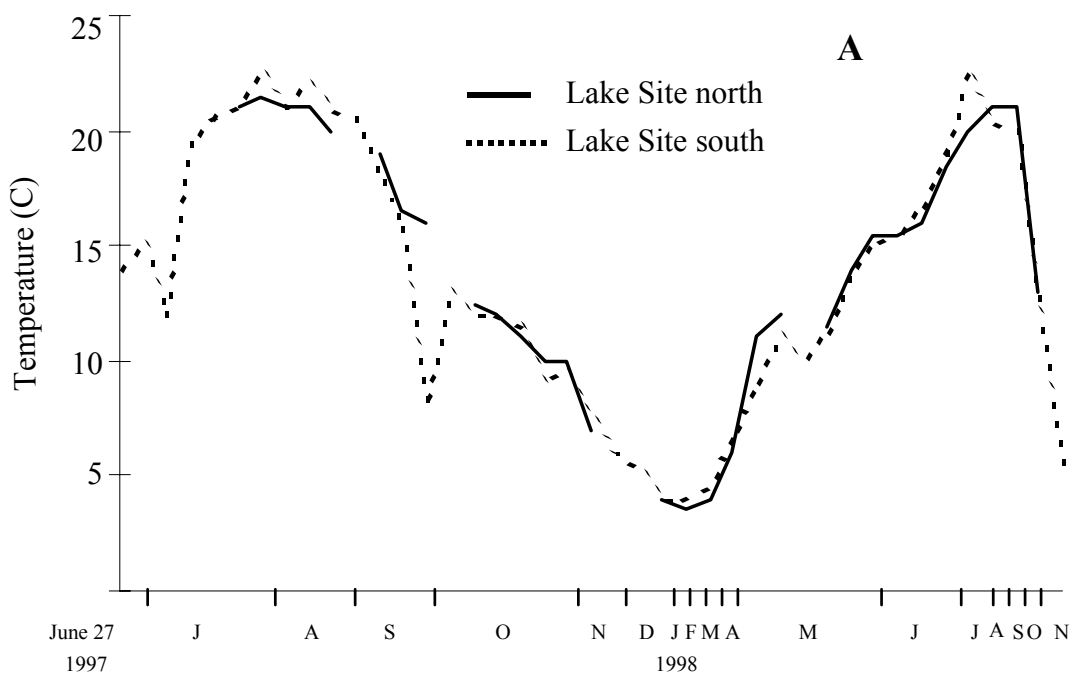


Figure 2.14. Surface temperatures (degrees C) for Lake Sites (A) and bays (B) in Lake Pend Oreille, 1997-1998.

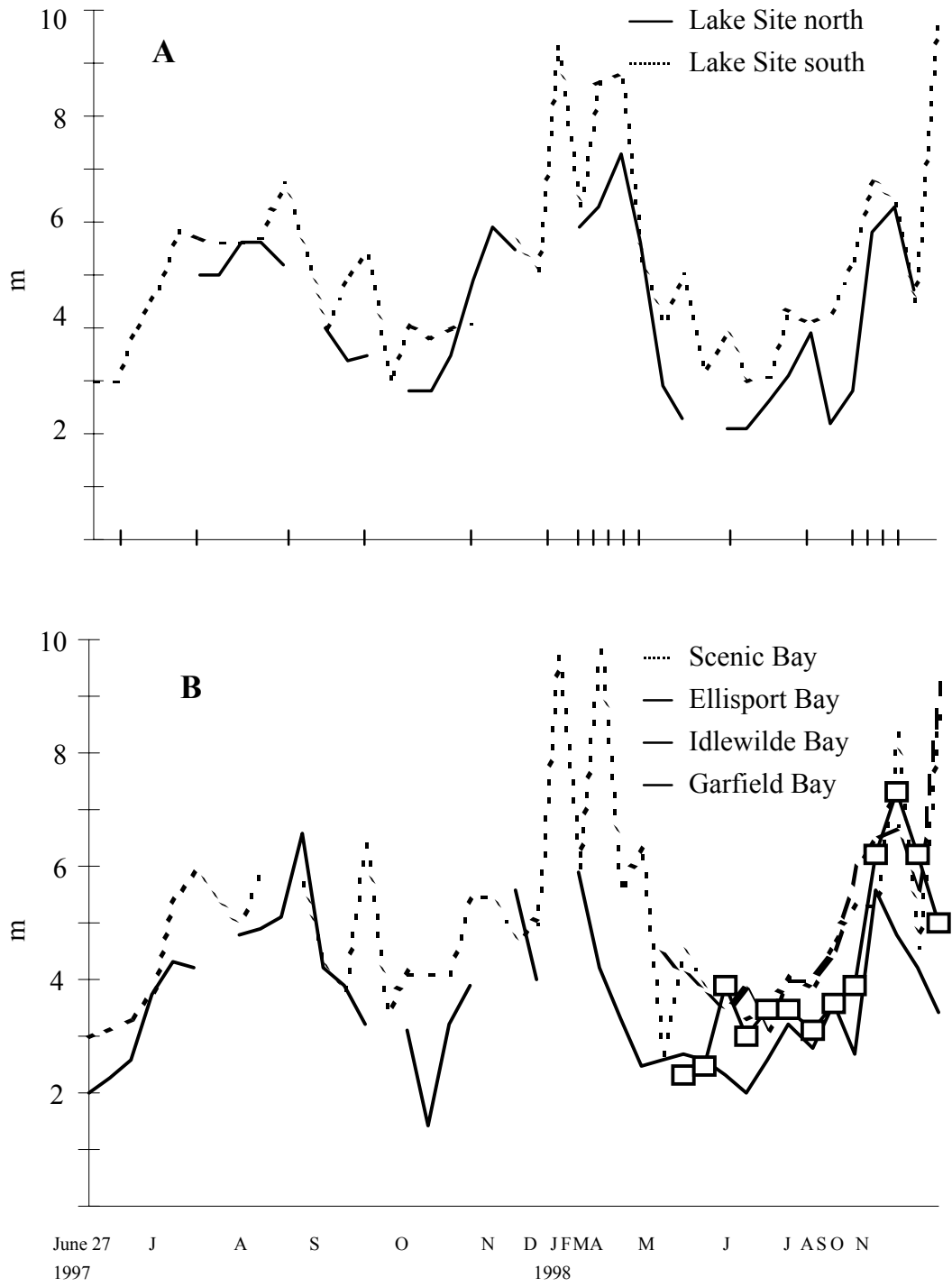


Figure 2.15. Secchi disk measurements (meters) for Lake Sites (A) and bays (B) in Lake Pend Oreille, 1997-1998.

Discussion

I examined temporal and spatial factors influencing crustacean zooplankton community dynamics in Lake Pend Oreille in 1997-1998 by collecting zooplankton samples from bays located on the northern (Ellisport Bay), middle (Garfield Bay), and southern (Scenic and Idlewilde bays) sections of the lake, and the main body of the lake in the northern (Lake Site north) and southern (Lake Site south) sections. Limnological variables such as water column transparency, nutrient dynamics and temperature gradients differ between northern and southern regions of Lake Pend Oreille (Woods 1991). My sampling locations were thus chosen to capture the breadth of limnological conditions which could influence secondary productivity, and therefore zooplanktivorous kokanee in Lake Pend Oreille. I also included a horizontal sampling component in this study because (i) studies have documented patchy zooplankton distributions on horizontal spatial scales (Watson 1976; Malone and McQueen 1983; Verreth 1990; Pinel-Alloul and Pont 1991), (ii) near-shore zooplankton abundance and species composition may be more important to newly emerging kokanee fry than zooplankton community composition in pelagic zones, (iii) shifts in zooplankton community structure as a result of other environmental factors (i.e. eutrophication or pollution) may affect near-shore regions before affecting off-shore regions (Evans and Jude 1986).

I observed variable zooplankton community dynamics on all temporal and spatial scales investigated. However, general trends in the zooplankton community of Lake Pend Oreille following establishment of *Mysis relicta* and described by Rieman and Falter (1981), Paragamian and Ellis (1994) and Chipps (1997) were similar to those observed here. Zooplankton species composition appears to have remained unchanged since the establishment of *Mysis relicta*, and the suite of commonly occurring cladocerans identified in

this study (e.g. *Daphnia* spp., *Bosmina longirostris*, *Diaphanasoma leuchtenbergianum*, *Chydorus sphaericus*, *Leptodora kindtii*) were similar to previous Lake Pend Oreille studies. The copepods *Cyclops* and *Diaptomus* were numerically the dominant zooplankters in previous studies and in 1997-1998. In addition, I observed mid-summer increases in cladoceran zooplankton abundance following establishment of a thermocline at Lake Pend Oreille, and decreased cladoceran densities immediately after the thermocline dissipated; a trend originally described by Rieman and Falter (1981).

Zooplankton Abundance

In 1997 and 1998, peak total zooplankton densities occurred in early summer. In 1998 however, *Cyclops* was unusually abundant in June and July, causing total zooplankton density estimates also to be unusually high. This phenomenon was most evident at Scenic and Idlewilde bays, where peak zooplankton estimates were 117.85 and $146.86 \cdot L^{-1}$. Zooplankton density estimates were much higher in 1998 than in previous studies. Stross (1954) recorded a peak total zooplankton density of nearly $160 \cdot L^{-1}$ east of the mouth of Scenic Bay, and an average peak zooplankton density across all sampling locations of approximately $50 \cdot L^{-1}$ in June 1953. From 1974-1978 the highest reported peak *Cyclops* density at Lake Pend Oreille was approximately $25 \cdot L^{-1}$ in July 1977 (Rieman and Bowler 1980). By comparison, across all sampling locations the mean peak *Cyclops* density in 1998 was $67.30 \cdot L^{-1}$. From 1985-1992 Paragamian and Ellis (1994) reported that the highest mean zooplankton densities (approximately $45 \cdot L^{-1}$) occurred in July 1992. Chipps (1997) reported peak copepod densities estimates in July 1995 (approximately $50 \cdot L^{-1}$) and 1996 (approximately $85 \cdot L^{-1}$) that were lower than those I recorded in 1998 ($91.83 \cdot L^{-1}$). In 13 years of study (spanning 16 years from 1974-1989) conducted after the establishment of *Mysis* at Lake Pend Oreille, the average estimated mid-summer (May-September) total zooplankton density was $17.5 \cdot L^{-1}$, and ranged

from 10.0 to 25.0·L⁻¹ (Table 2.1). A comparable estimate in my study, spanning May-September 1998 at similar sampling locations (samples in previous studies were collected mostly from the main lake, thus I include only Lake Sites north and south in this estimate) is 39.12·L⁻¹. From late June-September 1997 a comparable estimate is 23.54·L⁻¹.

Researchers believe that factors influencing zooplankton abundance include physical variables such as water temperature (Patalas 1972; Johannsson and O’Gorman 1991), top-down variables such as planktivory (Johannsson and O’Gorman 1991), and bottom-up variables that include production of zooplankton food resources including bacteria, phytoplankton, rotifers, and copepod nauplii (Neill and Peacock 1980; Williamson and Gilbert 1980; Johannsson and O’Gorman 1991). Water temperatures were generally higher in the southern sampling locations and lower in the northern sampling locations of Lake Pend Oreille in June 1998 than in June 1997. Thus, the unusually abundant *Cyclops* populations in Scenic and Idlewilde bays in June 1998 may be partially explained by earlier warming of the epilimnion in spring 1998. In addition, planktivory by *Mysis relicta* probably exerts a controlling influence over early season zooplankton communities in Lake Pend Oreille (Chipps 1997). High June 1998 zooplankton abundance in the southern sections of the lake could therefore be related to low *Mysis* densities. Moreover, adult *Mysis* population estimates in the southern sections of Lake Pend Oreille in 1998 were approximately one third of 1997 estimates (M. Maiolie, Idaho Department of Fish and Game, unpublished data). Food for *Cyclops* might also have been more abundant early in the summer of 1998 than in normal years. Inflows into Lake Pend Oreille from the Clark Fork River reached record levels in 1997, resulting in

Table 2.1. Mean summer (May-September) total zooplankton densities (No./L) for most years from 1974-1998 in Lake Pend Oreille. Data in years 1974-1989 were summarized in Hoelscher (1993).

Year	Total Density
1974	13.3
1975	10.0
1976	15.0
1977	25.0
1978	15.7
1979	21.0
1980	15.9
1981	16.6
1985	19.8
1986	13.7
1987	16.6
1988	23.3
1989	22.0
1997	23.5
1998	39.1

localized flooding of low lying areas surrounding the lake. Nutrient levels at Lake Pend Oreille should have been exceptionally high in 1997 as a result of flooding. Water transparency remained low through late summer and fall 1997, providing evidence that higher nutrient loads caused higher phytoplankton growth in 1997. I believe that residual effects from flooding in 1997 may have spurred increased food production for *Cyclops* early in the summer of 1998. Flooding at Lake Pend Oreille in 1974, similar to that in 1997, resulted in increased phytoplankton production in 1975 (Rieman 1976). In addition, median chlorophyll “a” values in Scenic Bay ($\approx 10 \mu\text{g/L}$) suggests that phytoplankton production was higher than normal in September 1998 (Anonymous 1999). Also, *Cyclops bicuspidatus thomasi* is a divoltine species, with one cohort over-wintering (i.e. diapause) in the bottom sediments as stage V copepodids and re-appearing in the spring (Rieman 1976). Perhaps the high flows and nutrient loading to Lake Pend Oreille in 1997 resulted in a stronger over-wintering *Cyclops* cohort.

Daphnia Abundance

Summer trends in *Daphnia* abundance and temporal distribution were noticeably different between 1997 and 1998. I recorded *Daphnia* in zooplankton samples earlier in the summer in 1998 than in 1997, which I attribute to lower planktivory by *Mysis relicta* in 1998. *Mysis* prefer cool water temperatures, and will not migrate into the epilimnion when water temperatures exceed 15°C (Chipps 1997). In 1997 surface water temperatures did not warm above 15°C until mid July, but water temperatures warmed above 15°C in early June 1998, providing an early refuge to *Daphnia* from *Mysis* predation.

The earlier appearance of *Daphnia* in 1998 did not, however, result in a more abundant mid-summer *Daphnia* population. Peak *Daphnia* densities among sampling locations were 2.5-7 times higher in 1997 than in 1998. Density differences between 1997

and 1998 could theoretically be explained by increased planktivory from a more abundant kokanee population, although kokanee population estimates were lower in 1998 than 1997 (M. Maiolie, Idaho Department of Fish and Game, unpublished data). An alternative explanation is that abundant *Cyclops*, an omnivore whose diet includes phytoplankton and small zooplankton (Neill and Peacock 1980), suppressed *Daphnia* populations through either competition for phytoplankton or possibly predation on newly hatched *Daphnia*.

Kokanee are size selective predators and will generally select larger *Daphnia* over smaller bodied individuals (Rieman 1978). If kokanee foraging did suppress *Daphnia* populations in 1998, then shorter *Daphnia* length measurements in my study would indicate cropping of larger individuals. However, mid-summer *Daphnia* lengths at most sampling locations increased or remained stable until cooler water temperatures in October facilitated increased *Mysis* predation in the epilimnion. A possible cropping effect by kokanee was only identified in Scenic Bay, where estimated *Daphnia* lengths declined from 1.07 to 0.85 mm from August to September, 1998.

Horizontal Zooplankton Abundance

Lake Pend Oreille supports a substantial community of reidside shiners *Richardsonius balteatus* and other juvenile cyprinids and centrarchids along its limited littoral zone (D. Vidergar, University of Idaho, unpublished data). Reidside shiners and most juvenile fish are shallow-water planktivores (Wydoski and Whitney 1979), hence zooplanktivory could influence the zooplankton community at the 1 m sampling depth stratum. I believe that smaller mean *Daphnia* lengths at the 1 m depth stratum versus the off-shore depth strata suggests cropping of larger bodied cladocerans, and provides evidence that fishes can structure the near shore zooplankton communities of Lake Pend Oreille. Lower total zooplankton densities and lower proportions of copepods to cladocerans in near-shore areas

versus pelagic zones, as I observed, have been reported by investigators elsewhere (Watson 1976; Pinel-Alloul and Pont 1991).

Temporal and Spatial Variability

On a lake-wide scale, the zooplankton abundance and species compositions described in this study show considerable variability among sampling dates and locations. Variability appears to be higher among bays in Lake Pend Oreille than in the main lake. However, previous studies at Lake Pend Oreille have mostly focused zooplankton sampling efforts on the main body of the lake (Rieman 1976; Rieman and Bowler 1980; Paragamian and Ellis 1994) and have largely ignored conditions within bays. Varying basin morphologies, levels of cultural eutrophication, and proximity to nutrient and thermal inputs from the Clark Fork River are probably factors that best explain the zooplankton variability observed among bays in my study. Scenic and Idlewilde bays are deeper, cooler and farther from the Clark Fork River than Garfield and Ellisport bays. Hence the timing and magnitude of zooplankton production was similar in Scenic and Idlewilde bays. Ellisport Bay is the shallowest bay in this study, is in close proximity to the Clark Fork River, and has the highest shoreline development of the four bays I sampled. Also, Ellisport Bay is the only bay in this study located north of the Clark Fork River. Rieman (1976) believed that most of the Clark Fork River water is channeled into the north arm of the lake, resulting in higher turbidity and dilution in the north. Although Ellisport Bay is off the main lake channel and is likely sheltered from direct river inflows, it may receive higher nutrient loads from the Clark Fork River than Garfield, Idlewilde or Scenic bays. Among the four bays I studied, secchi disk measurements were usually lowest at Ellisport Bay. I believe that turbidity from Clark Fork River inflows caused lower early summer secchi disk measurements at Ellisport Bay, but lower measurements in mid to late summer show higher rates of primary productivity than at

other bay locations. Furthermore, I believe that higher primary productivity and warmer water temperatures resulted in higher cladoceran abundance and earlier increases in cladoceran populations at Ellisport Bay than at other sampling locations. Of the cladocerans, *Bosmina* was especially abundant at Ellisport Bay compared to the other sampled bays.

Peak zooplankton density estimates in my study would likely have been much lower if samples had been collected monthly or twice monthly rather than weekly. Zooplankton populations increased rapidly to peak abundance in June, 1998 and then declined quickly thereafter. For example, total zooplankton density estimates in Idlewilde Bay in the weeks immediately before and after the peak density estimate was recorded, were approximately 33% and 20% of the peak estimate. Such rapid population fluxes suggest the importance of frequent sampling to adequately characterize population level variability, especially in early summer when peak zooplankton densities at Lake Pend Oreille are known to occur.

Trophic Level Interactions

When cladoceran zooplankton are abundant, kokanee will feed preferentially upon them (Foerster 1968). Therefore, diminished spring and autumn *Daphnia* and *Bosmina* abundance from densities observed before establishment of *Mysis relicta* in Lake Pend Oreille should represent a decrease in preferred prey biomass available to kokanee. Reduced cladoceran zooplankton abundance from *Mysis* zooplanktivory has been implicated in kokanee population declines at Lake Pend Oreille (Rieman and Falter 1981) and elsewhere (Morgan et al. 1978; Beattie and Clancey 1991; Martinez and Bergersen 1991), although the mechanisms directly responsible for those declines could not be identified. Some researchers speculate that diminished cladoceran zooplankton biomass in spring and autumn from *Mysis* grazing can slow growth of planktivorous fish (Langeland et al. 1991; Chipps 1997). Rieman and Bowler (1980) report lower juvenile kokanee growth in some years following *Mysis*

establishment, a result they attribute to changes in *Daphnia* and *Bosmina* availability.

Decreased cladoceran zooplankton densities and slower kokanee growth were also reported in Lake Tahoe, Nevada (Morgan et al. 1978) and Lake Granby, Colorado (Martinez and Bergersen 1991) after establishment of *Mysis relicta*. However, investigations examining kokanee population declines occurring concurrent to *Mysis* introductions found no difference in mean kokanee spawner lengths despite reduced cladoceran densities (Lasenby et al. 1986; Beattie and Clancey 1991).

In 1998, however, *Cyclops* biomass was unusually high at Lake Pend Oreille, and likely provided additional forage for kokanee. Results from kokanee diet analysis (Objective 2) and growth experiments (Objective 3) in 1998 indicate that newly emerged kokanee achieved strong growth on a diet composed mostly of *Cyclops*. In addition, *Cyclops* abundance at Lake Pend Oreille was high in the spring of 1977, an occurrence that was attributed to early warming of the lake, and survival of age-0 kokanee was also strong (Rieman and Bowler 1980). Thus, I believe that the loss of early season cladoceran forage for kokanee may be compensated in some years by high *Cyclops* biomass. Conversely, kokanee growth and survival could also be affected in years when spring *Cyclops* biomass is low, and does not replace the lost cladoceran biomass.

A number of proposals have been suggested to recover kokanee in Lake Pend Oreille (Rieman and Bowler 1980; Bowles et al. 1991; Paragamian and Bowles 1995). However, I believe that spring fertilization to increase zooplankton standing biomass in areas of kokanee emergence coupled with on-going efforts to improve egg to fry survival of wild kokanee through lake level manipulations may be the most successful approach to kokanee recovery. If a relationship between growth of newly emerged kokanee and spring zooplankton biomass exists in Lake Pend Oreille, then increasing zooplankton biomass through food web

alterations may prove beneficial, especially in seasons when zooplankton biomass is low. The concept of cascading trophic interactions (Carpenter et al. 1985) predicts that decreasing planktivore abundance (e.g. top-down effects) and/or increasing nutrient levels (e.g. bottom-up effects) should result in higher zooplankton abundance. By applying fertilizer to the epilimnion of nutrient poor lakes, numerous *in-situ* and whole lake experiments have demonstrated the utility of bottom-up manipulations for increasing zooplankton biomass (LeBrasseur et al. 1978; Kyle 1994; Budy et al. 1998). Studies have also demonstrated increased growth of juvenile kokanee and sockeye salmon following fertilization of oligotrophic lakes (LeBrasseur et al. 1978; Stockner and Macisaac 1996; Budy et al. 1998). Furthermore, studies have shown only small declines in water transparency resulting from increased phytoplankton abundance through fertilization (Budy et al. 1998).

Conclusions

In conclusion, the generally abundant zooplankton community among all sampling locations in June and July 1998 suggests that food should not limit kokanee fry growth during that period. Crustacean zooplankton biomass appears lower in June 1997 than in 1998, but I do not know if zooplankton availability in 1997 was sufficient for kokanee fry growth, since kokanee growth experiments (Objective 3) were performed only in 1998. In 1977, kokanee year-class survival was high, and mean May-September zooplankton density estimates were approximately equal to those I recorded from June-September in 1997 (Rieman and Bowler 1980). Total zooplankton densities, and densities of cladocerans, were higher in autumn 1998 than 1997. Based on the results of October growth experiments (Objective 3) and of zooplankton density estimates that showed above normal cladoceran zooplankton densities in October, I believe that autumn 1998 zooplankton densities were sufficient for juvenile kokanee growth. The lower *Daphnia* densities in the summer of 1998 versus 1997 could

suggest food limitations for kokanee, resulting in slower growth. However, except in Scenic Bay, *Daphnia* lengths did not decline throughout the summer of 1998, leading to my conclusion that *Daphnia* abundance was probably sufficient to support mid-summer kokanee growth. In addition, I believe that the location specific variability exhibited by zooplankton populations in my study reinforces the need for location specific zooplankton sampling to describe food resources for kokanee stocks in Lake Pend Oreille. If the goal of a zooplankton sampling program were to describe food availability for newly emerging kokanee, then sampling should occur in Scenic and Idlewilde bays, where most of the kokanee egg deposition occurs (Rieman and Bowler 1980).

Summary

1. I examined zooplankton community dynamics in Lake Pend Oreille in 1997-1998 by collecting zooplankton samples in Ellisport, Garfield, Scenic and Idlewilde bays, and from northern and southern sections of the main lake. Zooplankton densities and biomass were estimated for each location. I also estimated the horizontal distribution of zooplankton in bays by collecting samples along transects extending out from the shoreline.
2. Zooplankton species composition at Lake Pend Oreille has remained unchanged from previous studies conducted after the establishment of *Mysis relicta*. As in previous studies, *Cyclops bicuspidatus thomasi* and *Diaptomus ashlandi* were the most numerous zooplankters, and cladoceran zooplankton (e.g. *Daphnia* spp. *Bosmina longirostris*, *Diaphanosoma leuchtenbergianum*, *Cydorus sphaericus*, *Leptodora kidtii*) became numerous following lake stratification in mid-summer.
3. Zooplankton densities and biomass were much higher at all sampling locations in the summer of 1998 compared to 1997. My mean summer (May-September) zooplankton density estimate was $23.54 \cdot L^{-1}$ in 1997 and $39.12 \cdot L^{-1}$ in 1998. My 1998 estimate is considerably higher than comparable estimates from previous Lake Pend Oreille studies conducted after the establishment of *Mysis relicta*.
4. Summer trends in *Daphnia* abundance and temporal distribution were noticeably different between 1997 and 1998. *Daphnia* appeared earlier in samples in 1998 than in 1997, but peak *Daphnia* densities among sampling locations were 2.5-7 times higher in 1997 than in 1998. A possible cropping effect by kokanee on larger sized *Daphnia* was identified in Scenic Bay in September, 1998.
5. No statistically significant differences in zooplankton biomass among bays or between main lake sampling locations were identified, however zooplankton community dynamics

at Ellisport Bay appeared to be different from other bay locations. Cladoceran zooplankton became abundant earlier in summer, and remained abundant later in autumn, at Ellisport Bay than at other bay locations.

6. In bays, summer zooplankton densities were usually lowest in near-shore areas. Copepods were more abundant than cladocerans at each horizontal depth stratum sampled in this study, but cladocerans represented the highest proportion of total zooplankton densities at the near-shore depth.
7. Crustacean zooplankton were more abundant than normal in the summer of 1998. Based on the results of juvenile kokanee growth experiments in June and October, 1998 (Objective 3), and the zooplankton density estimates recorded in this study, I believe that zooplankton densities were sufficient to support juvenile kokanee survival and growth in June and October, 1998.

CHAPTER 3. *The diet of newly emerged kokanee fry in Lake Pend Oreille, Idaho.*

Introduction

Kokanee eggs deposited in the gravel along shorelines at the southern end of Lake Pend Oreille typically initiate emergence in May, with peak emergence occurring in June (Rieman and Bowler 1980). Emerging fry feed on zooplankton soon thereafter (Burgner 1991). Following the establishment of *Mysis relicta* in the early 1970's, researchers reported changes in the lake's springtime zooplankton community (Rieman and Falter 1981). Rieman and Falter (1981) speculated that reduced kokanee survival was due to the delay in *Daphnia* production later in the summer, and depressed springtime densities of *Bosmina longirostris*. Stross (1954) and Rieman and Bowler (1980) demonstrated that *Daphnia* are an important component in the summer diet of kokanee in Lake Pend Oreille. Similarly, dietary analyses and bioenergetic simulations of kokanee in other western region lakes illustrate the importance of *Daphnia* as a food source (Northcote and Lorz 1966; Narver 1970; Morgan et al. 1978; Martinez and Bergersen 1991; Beauchamp et al 1995). Although *Bosmina* are smaller and numerically less abundant in Lake Pend Oreille than the copepod *Cyclops bicuspidatus*, Stross (1954) found that *Bosmina* comprised 80% of the organisms in kokanee stomachs (n=25) in early June, suggesting that *Bosmina* was a preferred food source for kokanee. Also, limited stomach analysis of age-0 kokanee (n=7) sampled from Lake Pend Oreille in July, 1976, showed that *Bosmina* was numerically the most important prey item, accounting for 42% of the average prey biomass (Rieman 1980). *Bosmina* were selected by sockeye salmon *O. nerka* fry in Cultus Lake, British Columbia (Foerster 1968). Researchers at Cultus Lake hypothesized that smaller fish selected *Bosmina* over *Cyclops* because of the smaller size and higher visibility of *Bosmina*. The presence of pigmented eggs carried under

the carapace may further increase *Bosminas*' visibility (Flinkman and Vuorinen 1991; see also Mellors 1975).

The purpose of this study was to quantify diets of kokanee fry shortly after emergence in Lake Pend Oreille. Specifically, two questions are answered from this project: 1) Which zooplankton species were utilized as prey by recently emerged kokanee fry? and 2) Are kokanee fry feeding selectively?

Methods

I collected larval kokanee by trawling during the 4 h period following dusk in Scenic and Idlewilde bays and in the main lake south of Cape Horn from May 15th through June, 1998 (Figure 1.1). Initially, larval kokanee were captured using a 1 m diameter larval fish net with 1 mm mesh netting. To improve capture efficiency, in early June I changed to a 750 μm mesh net with an opening measuring approximately 181 cm high and 128 cm wide. All larval kokanee were immediately preserved in 10% buffered formalin, and later length (mm total length) and weight (mg blotted wet weight) were recorded. Fulton's condition factor {K} (Anderson and Neumann 1996) was calculated for each fish using the formula:

$$K = (W/L^3) \times 10^5 \quad (1)$$

where: K = condition factor of a kokanee,

W = weight (grams) and,

L = total length (millimeters);).

I used a Kruskal Wallis ranked ANOVA to test for differences in kokanee condition factor by week for the 5-week sampling period (SAS Institute, Version 6.11).

Prey Analysis

Prey items from each captured kokanee were identified to the lowest practical taxon under a dissecting microscope in the laboratory. Number, and when practical, lengths, of crustacean zooplankton were recorded. I estimated the relative contribution of each zooplankton species to total ingested mass by measuring lengths from a sample of each zooplankton species present, and converting length to weight from established length-weight relationships (Culver et al. 1985; Objective 2) Unidentifiable prey items were counted, but were excluded from further dietary analysis.

Diet Analysis

For each prey type I calculated the following parameters : Frequency of occurrence (FO), the percentage of fish in a sample that ate a food item, the percentage of each food type of the total number of food items eaten by all fish in the sample (%N), and the percent mass (mg of wet biomass) of the total mass of all food items eaten (% M; Carpenter and Kitchell 1993). From those parameters an index of absolute importance (IAI) was calculated for each prey type using the formula:

$$IAI = \%N + \%M + FO \quad (2)$$

From the calculated IAI values I generated an Index of Relative Importance (IRI) using the formula:

$$IRI = 100 \times IAI / \Sigma IAI \quad (3)$$

Selectivity Index

I used a selectivity index first proposed by Strauss (1979) to compare zooplankton species ingested by kokanee with potentially available prey. The index is defined as:

$$L_i = r_i - p_i \quad (4)$$

where: L_i = selectivity index value ranging from -1 to +1, indicating strong

avoidance or preferential prey selection,

r_i = the relative abundance by number of prey taxon in kokanee stomachs,

p_i = the relative abundance of the same taxon estimated from weekly sampling in the upper 10 m of Scenic and Idlewilde bays in Lake Pend Oreille in May and June 1998 (Objective 1).

Weekly *Mysis relicta* population estimates, specific to my kokanee capture and zooplankton sampling sites, are not available for June 1998. Therefore I excluded *Mysis* from the selectivity index.

Results

I examined the stomachs of 322 newly emergent kokanee sampled during 5 weeks from May through June, 1998. Approximately 69% (n=225) of the stomachs were from kokanee 23-25 mm in length, while 48 stomachs were from kokanee 25-36 mm in length (Figure 3.1). The condition factor of sampled fish changed significantly over the 5 week period ($F=10.49$, $p<0.0001$; Figure 3.2, Appendix Table 3.1). Eighty-two of the sampled stomachs were empty; the percentage of empty stomachs declined over the sampling period (Figure 3.2) and as kokanee lengths increased (Figure 3.3). Four stomachs from fish ranging in size from 20 to 24 mm contained only egg yolk and were excluded from diet analysis. Length, weight, condition factor, and stomach biomass for each sampled fish is summarized in Appendix Table 3.2.

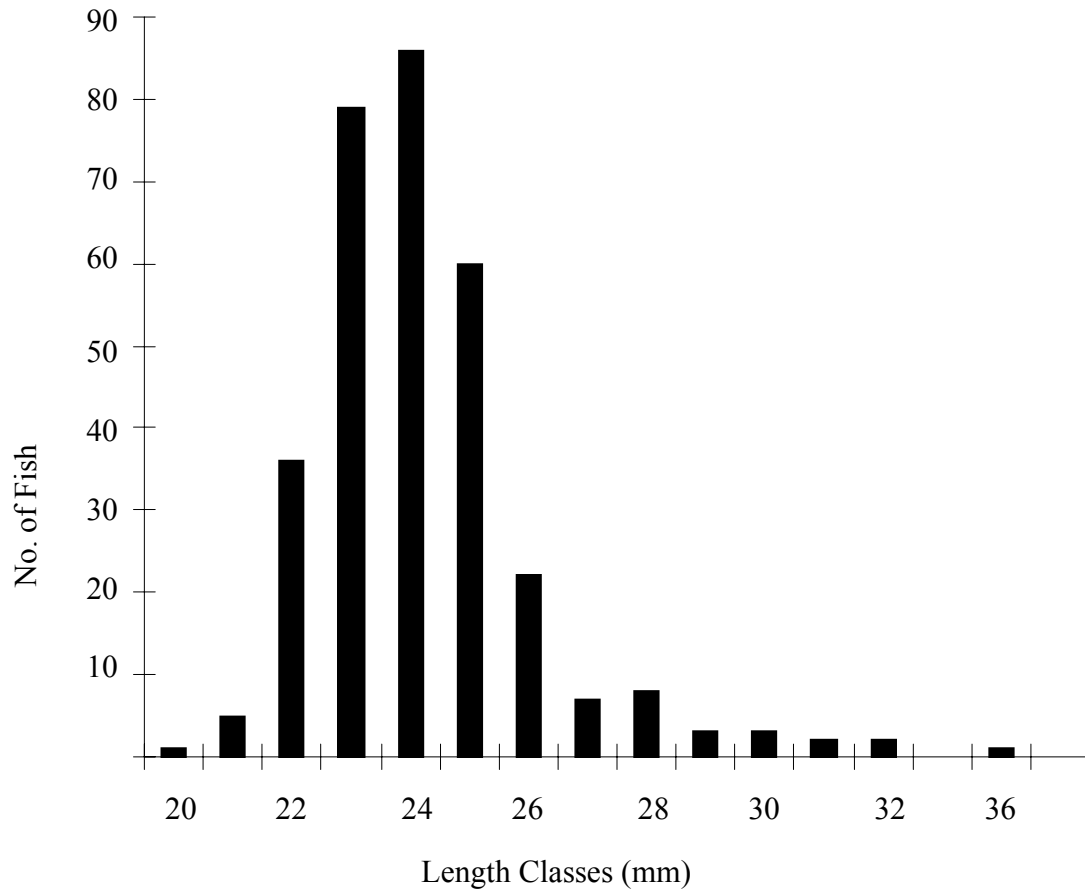


Figure 3.1. Length classes for age-0 kokanee captured for diet analysis in Lake Pend Oreille, May and June 1998.

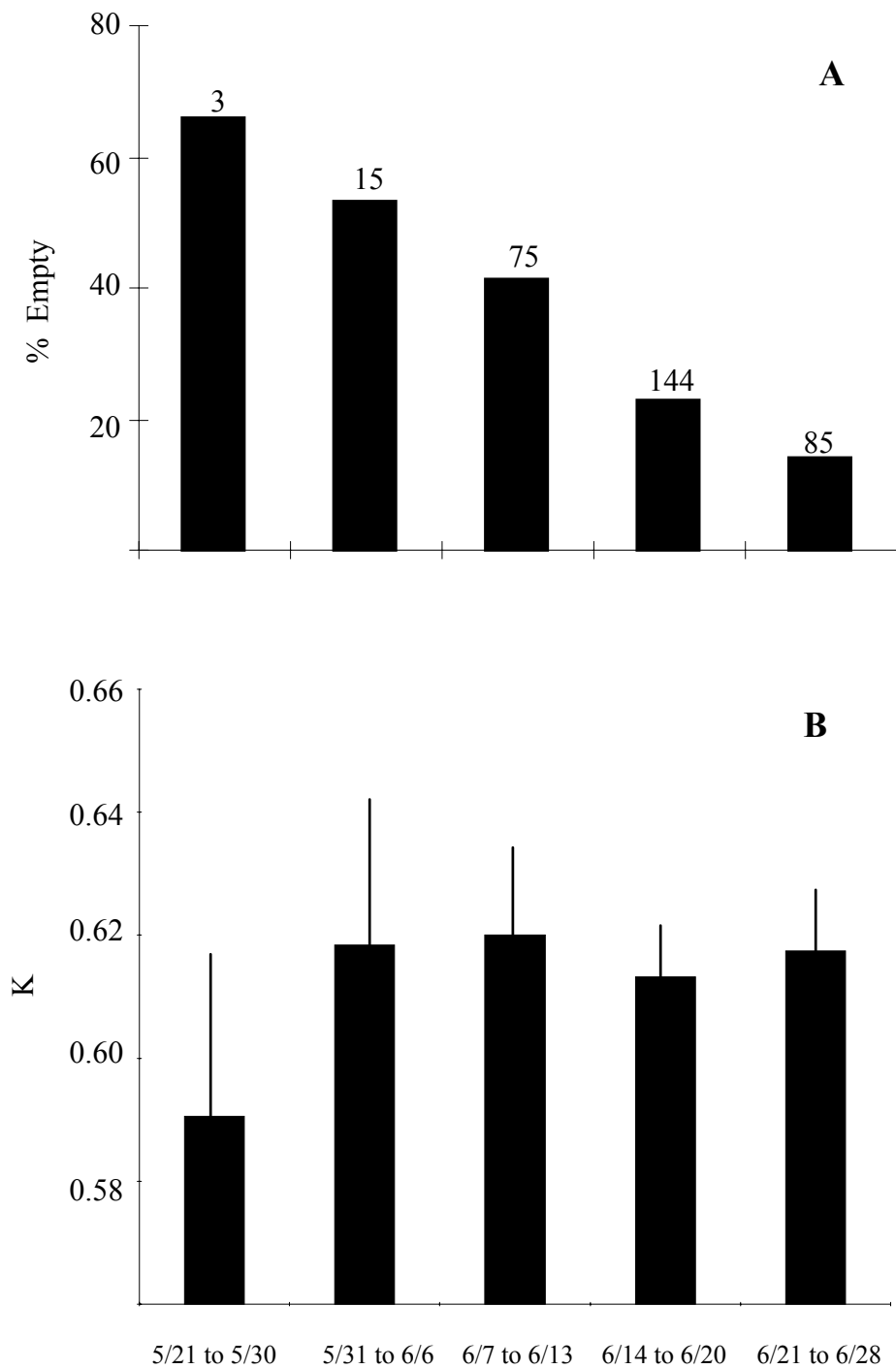


Figure 3.2. Percent empty stomachs (A) and Fulton condition factor (K, B) by week for age-0 kokanee sampled in Lake Pend Oreille in May and June 1998. Vertical bars represent 2 standard errors. Numbers above bars represents number of fish sampled.

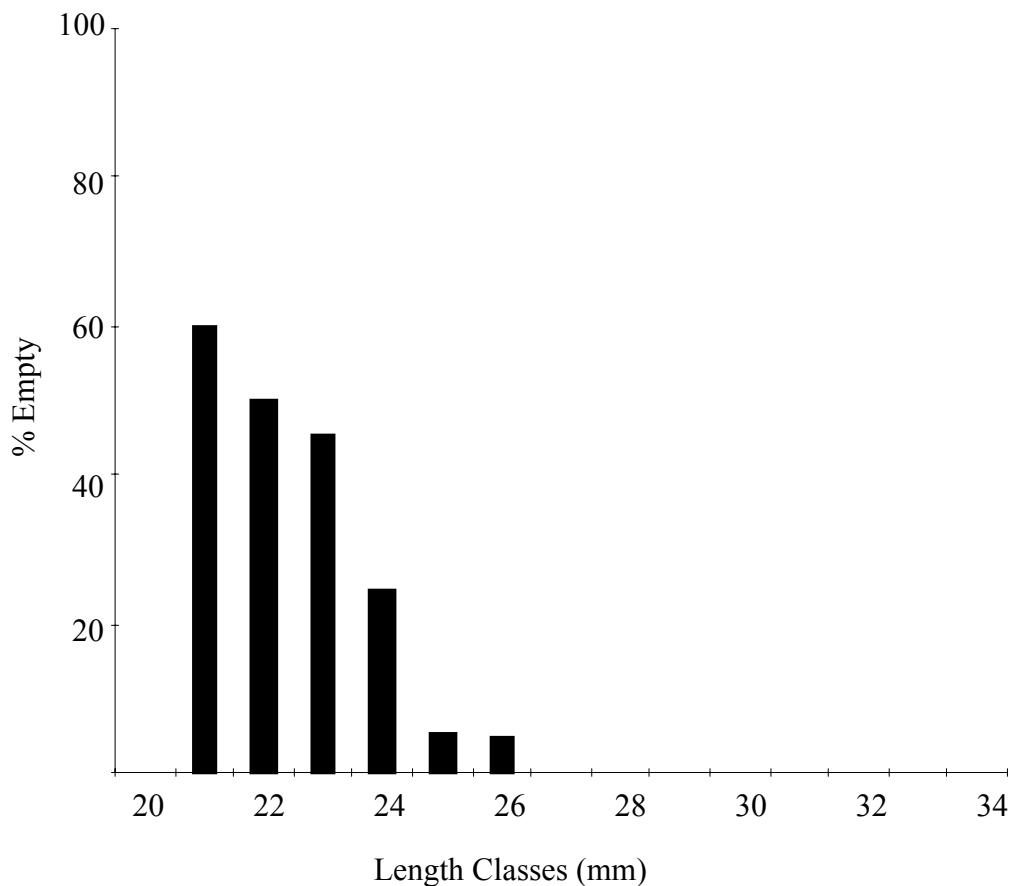


Figure 3.3. Percent empty stomachs by length class for age-0 kokanee captured for diet analysis in Lake Pend Oreille, May and June 1998.

Diet Analysis

The diet of kokanee varied slightly over the 5-week sampling period (Figure 3.4, Appendix Table 3.3). The copepod *Cyclops bicuspidatus thomasi* was the most abundant prey item in stomachs in each sampling week, and represented almost 91% (n=12,469) of the 13,705 prey items identified. The copepod *Diaptomus ashlandi* and the cladoceran *Daphnia* represented 5.65% (n=774) and 2.65% (n=363) of the identified prey items respectively, whereas all other prey types accounted for 0.7% of identifiable items. *Cyclops* also occurred most frequently in stomach samples (70.53%), with *Diaptomus* identified in 49.84% and *Daphnia* seen in 21.94% of all stomachs. *Daphnia* and *Mysis relicta* were first identified in

stomach samples on June 11 (n=1), and all other occurrences of *Daphnia* were from fish collected on or after June 16th. Mean length measurements for the individual prey types are summarized in Table 3.1.

Cyclops accounted for the highest amount of prey biomass identified in kokanee stomachs (79.28%). However, *Cyclops* were generally smaller than *Diaptomus* and *Daphnia*. Consequently, *Cyclops*' contribution to overall prey biomass was lower than their contribution to the number of items consumed (90.98%). *Cyclops* and *Diaptomus* represented over 99% of the total prey biomass during the first 2 sampling weeks (Figure 3.4). Later in the sampling period, stomach biomass from *Daphnia* and *Mysis relicta* increased; together they accounted for nearly 28% of consumed biomass in week 5. *Mysis relicta* were identified from stomachs of kokanee as small as 23 mm in length. Twenty-five individuals of *Bosmina* were counted in stomach samples and *Bosmina* accounted for 0.2% of total ingested biomass.

Results of the index of relative importance (IRI) show that the copepods were most important to the diet of newly emerged kokanee in the spring of 1998. Overall, copepods represented 86.61% of the index, with *Cyclops* being the largest contributor to the index (66.52%, Table 3.2). Although *Diaptomus* was consumed by nearly half the sampled fish, it represented only 18.40% of the index, while *Daphnia* accounted for 8.68%.

Selectivity Index

Cyclops and *Diaptomus* were the only zooplankton species with weekly index values larger than ± 0.10 (Figure 3.5). *Cyclops* was actively selected by kokanee in all but the second sampling week, with index values ranging from -0.056 to 0.695. *Diaptomus* was actively

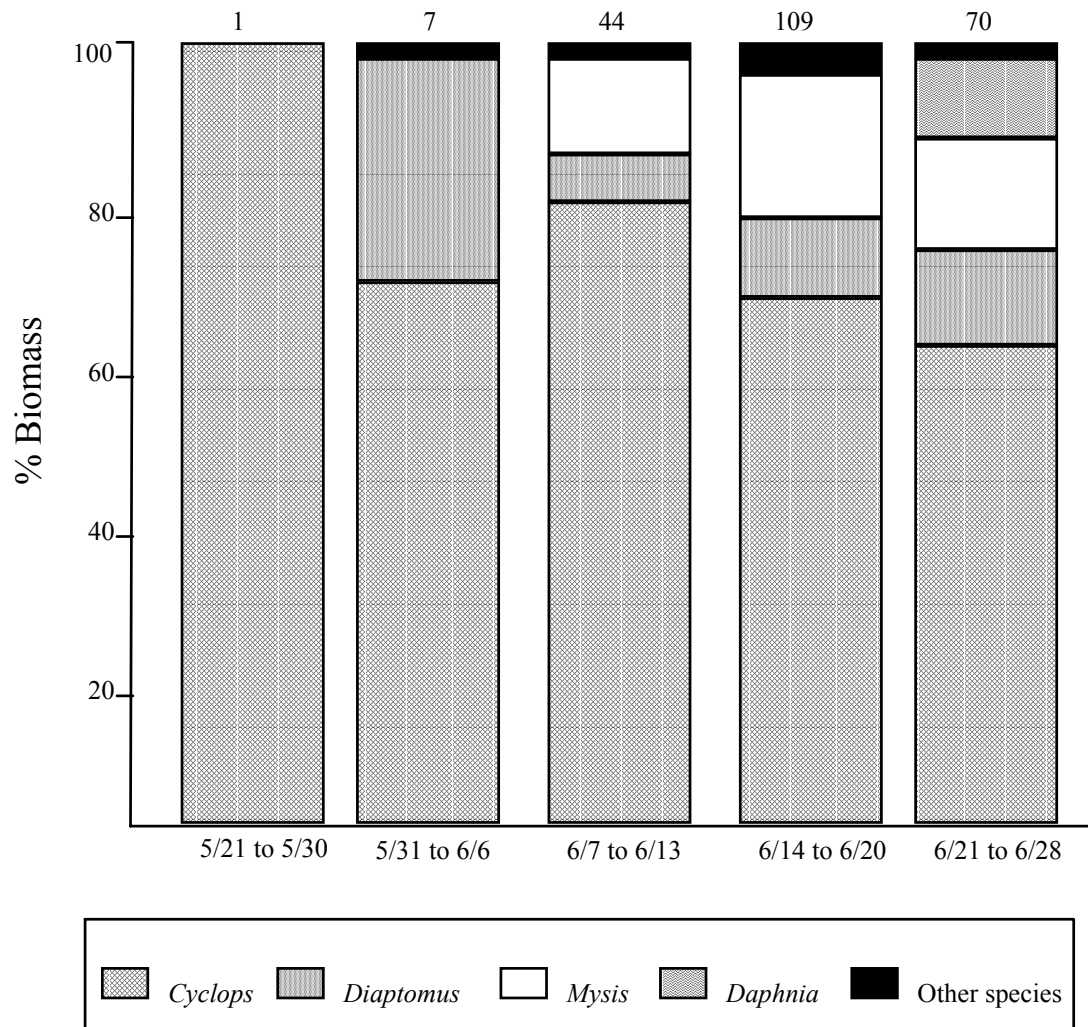


Figure 3.4. Diet composition (percent biomass) by week of newly emergent kokanee collected in Lake Pend Oreille in May and June, 1998. Numbers above bars indicate number of stomachs sampled.

Table 3.1. Mean lengths of individual prey items identified in kokanee stomachs from Lake Pend Oreille, May-June 1998.

Prey Item	Number Sampled	Mean Length (mm) \pm (SE) ^a
<i>Cyclops</i>	385	0.71 \pm (.0060)
<i>Diaptomus</i>	96	0.95 \pm (.0123)
<i>Epischura</i>	2	1.74
<i>Daphnia spp.</i> ^b	74	1.11 \pm (.0260)
<i>Bosmina</i>	13	0.51 \pm (.0511)
<i>Mysis</i>	1	3.10

^a SE represents one standard error.

^b *Daphnia thorata* and *D. galeata mendotae*.

avoided in all but the second sampling week, with index values ranging from -0.23 to 0.08. In each week, the two cladocerans *Daphnia* and *Bosmina* were preyed upon in nearly the same proportion as their availability in the environment, and had index values no larger than \pm 0.028. Age-0 kokanee did not actively select nor avoid other zooplankton species occurring in the diet. Selectivity index values for each zooplankton species are listed in Appendix Table 3.4.

Discussion

The copepod *Cyclops bicuspidatus thomasi* occurred most frequently and represented the largest biomass of prey items identified in age-0 kokanee stomachs in Lake Pend Oreille in May and June, 1998. As judged by those criteria, *Cyclops* represented the most important prey item in this diet analysis. The cladoceran *Bosmina longirostris*, which had been identified in studies as an important early-season kokanee food source before the introduction of *Mysis relicta* to Lake Pend Oreille (Stross 1954), and in some years following the establishment of *Mysis relicta* (Rieman and Bowler 1980), was an unimportant dietary item in my study. The cladoceran *Daphnia*, identified in studies as a preferred prey item of all age classes of kokanee

Table 3.2. Index of relative importance calculated for stomach contents of age-0 kokanee captured in Lake Pend Oreille in May and June, 1998.

Prey Item	%IRI
Cladocera	
<i>Daphnia spp.</i> ^a	8.68
<i>Bosmina longirostris</i>	1.66
<i>Diaphansoma leuchtenbergianum</i>	0.28
<i>Leptodora kindtii</i>	0.00
<i>Chydorus sphaericus</i>	0.20
Copepoda	
<i>Cyclops bicuspidatus thomasi</i>	66.52
<i>Diaptomus ashlandi</i>	18.40
<i>Epischura nevadensis</i>	0.89
nauplii	0.80
Mysis relicta	2.57
TOTAL = 100.00	

^a *Daphnia thorata* and *D. galeata mendotae*.

when abundant (Rieman and Bowler 1980; Beattie and Clancy 1991; Martinez and Bergersen 1991) was only an important prey item in my study in the final sampling week. Age-0 kokanee also preyed upon *Mysis relicta* in sampling weeks three through five. The copepod *Diaptomus ashlandi* was present in the diet in sampling weeks two through five, but were not selected by emerging kokanee

The feeding behavior of *O. nerka* is plastic, their prey selection depends greatly on the availability and relative abundance of prey items (Burgner 1991). In my study, the predominance of *Cyclops* in the stomach contents of kokanee fry reflected *Cyclops*' higher abundance in Lake Pend Oreille in May and June, 1998. Prey selectivity index values showed

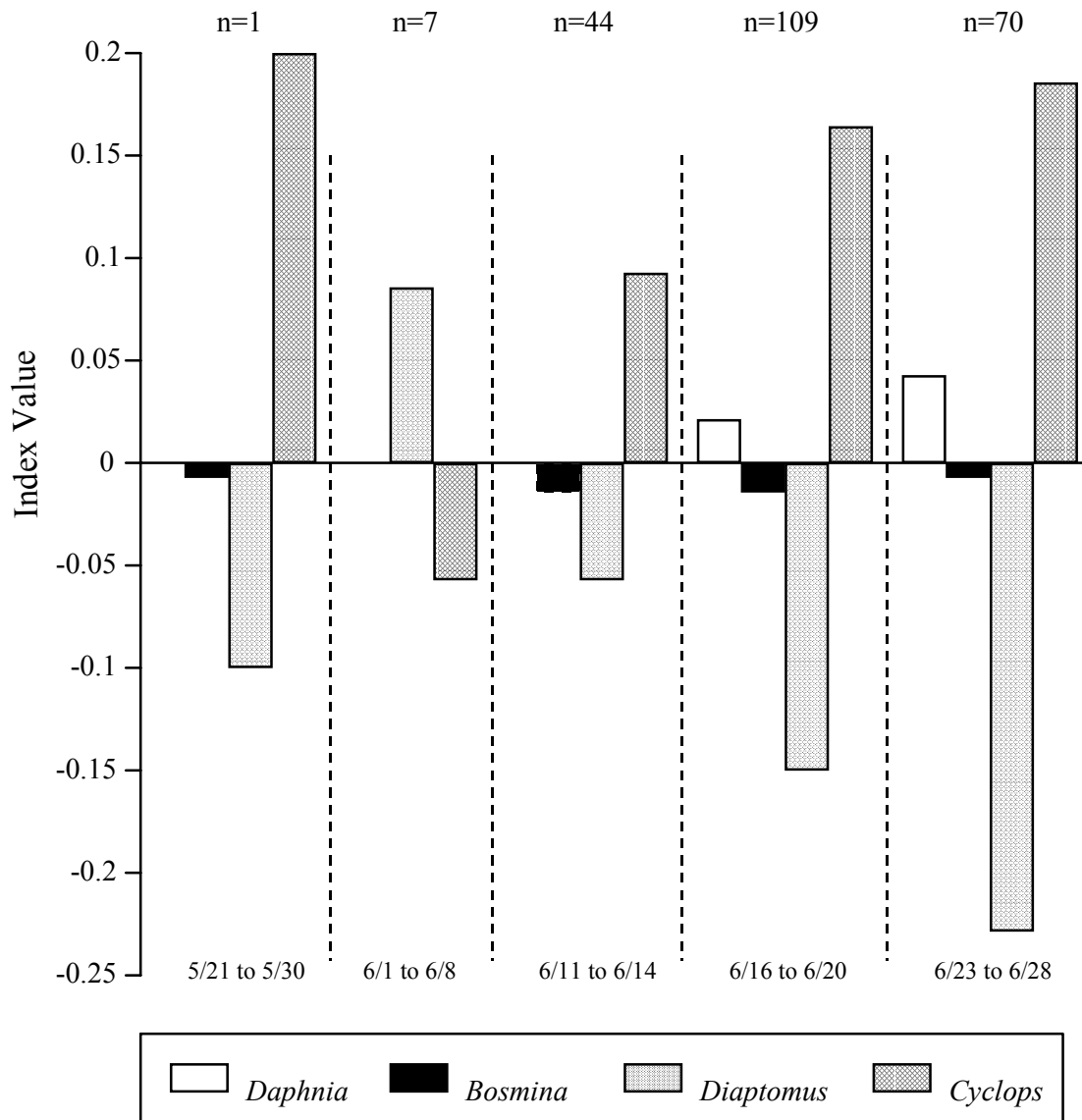


Figure 3.5. Prey selectivity by age-0 kokanee in Lake Pend Oreille, May-June 1998, for the four highest represented zooplankton species in the index of relative importance. Numbers above bars indicate number of stomachs sampled.

only slight positive or negative selection for *Cyclops* in all 5 sampling weeks, further demonstrating that kokanee prey selection generally mirrored prey abundance. However, active predatory avoidance of the copepod *Diaptomus ashlandi* by kokanee fry in four of the five sampling weeks may have reflected a preference by kokanee for the smaller *Cyclops*, or a greater ability by *Diaptomus* to avoid predation through faster movement rates (O'Brien 1979). My study did not detect a strong selection for the larger bodied *Daphnia*, although late June *Daphnia* densities were higher than $0.2 \text{ Daphnia} \cdot \text{L}^{-1}$ (Objective 1). In contrast, Beattie and Clancy (1991) found selective predation on *Daphnia* by newly emerged kokanee in Flathead Lake, Montana, despite *Daphnia* densities that were nearly undetectable by zooplankton sampling.

Prior kokanee diet analyses at Lake Pend Oreille, and at other western region lakes, have shown significant predation on *Cyclops* by newly emerged kokanee fry. In a 1986-1987 study of young of the year kokanee feeding at Flathead Lake, *Cyclops* represented 69% of the diet (Beattie and Clancey 1991). At Lake Granby, Colorado, *Cyclops* was the only crustacean zooplankton identified in the stomachs of age-0 kokanee collected in mid June, 1982 (Martinez and Bergersen 1991). In 1977, *Cyclops* was unusually abundant in the spring at Lake Pend Oreille, and was the dominant diet source for newly emerged kokanee (Rieman and Bowler 1980).

The presence of *Mysis relicta* in the stomach contents of kokanee captured in this study was unexpected. I am not aware of any other study that has identified *Mysis* in the diet of newly emerged kokanee, though larger kokanee have been shown to consume *Mysis* in Lake Pend Oreille (Rieman and Bowler 1980) and elsewhere (Morgan et al. 1978; Martinez and Bergersen 1991; Northcote 1991). Although easily identifiable, the *Mysis* I observed in stomach contents were often partially digested or fractionated, making accurate length

measurements difficult. However, I estimate that *Mysis* prey length was less than 5 mm, consistent with the length range of individuals from a newly released spring brood (Chipps 1997). That kokanee as small as 23 mm total length contained *Mysis* in the gut suggests that gape limitations do not preclude newly emerged kokanee from feeding upon them as suggested by other researchers (Rieman and Bowler 1980). In my study, kokanee stomachs typically contained less than three *Mysis*, though one stomach contained seven *Mysis*, and most stomachs with *Mysis* also contained crustacean zooplankton prey items. *Mysis* did not contribute substantially to the diet of newly emerged kokanee in my study, and were identified in about 7% of fish captured after June 11. By comparison, *Mysis* were identified in 19-23% of the stomachs of larger kokanee at Lake Pend Oreille in 1977-1978 (Rieman and Bowler 1980), and in 16-29% of kokanee stomachs at Lake Granby, Colorado in 1982-1983 (Martinez and Bergersen 1991). I conclude from these observations that young of the year *Mysis* were preyed upon opportunistically by age-0 kokanee in Lake Pend Oreille, but did not provide a principal food source to kokanee fry.

My observation of predation on *Mysis* by kokanee fry may represent an anomaly. Increased predatory interactions between kokanee and *Mysis relicta* resulting from an unusual set of limnological conditions (e.g. water temperatures, turbidity) may have caused changes in the vertical distributions of *Mysis* and kokanee fry. Most kokanee fry, and large quantities of *Mysis*, were captured by trawling the surface 20 m of the pelagic zone after sunset. Perhaps lake conditions unique to 1998 caused juvenile *Mysis* to ascend to the surface earlier in the evening, or descend from the surface later in the morning, reducing spatial segregation and affording greater opportunities for kokanee predation on *Mysis*.

The high incidence of empty kokanee stomachs in my study, especially in the first 2 sampling weeks, could be attributed to several factors. Empirical observations by other

researchers suggest that kokanee fry may feed sparingly immediately following emergence. A diet analysis of kokanee fry at Lake Pend Oreille, before *Mysis* were introduced, showed that stomachs of fry caught in June were “empty of any recognizable material” (Allison 1958). In addition, Lebrasseur et al. (1978) report that sockeye *O nerka* fry in Great Central Lake, British Columbia, typically feed little for the first 2 weeks following their emergence in April. Also, my sample sizes in weeks 1-2 were small, and may not adequately represent the population. However, given the unusually high zooplankton densities in Lake Pend Oreille during kokanee fry sampling in 1998 (Figure 3.5), it appears unlikely that limited food availability was directly related to the high incidence of empty stomachs in this study.

I do not know whether a switch from a diet dominated by *Bosmina* before the introduction of *Mysis* to the *Cyclops*-dominated diet observed in this study has consequences for kokanee fry survival and growth. Some studies suggest that smaller prey items, such as *Bosmina*, are a better diet source for smaller fish (Mills et al. 1984; Confer and Lake 1987). Kokanee can reduce the water content of the cladoceran *Daphnia* during ingestion, thereby allowing kokanee to increase the biomass of prey packed into the stomach (Stockwell et al. 1999). Similar information is not available for *Bosmina* and copepod zooplankton. However, if kokanee fry in Lake Pend Oreille were similarly able to “squeeze” water from the cladoceran *Bosmina*, but not from the copepod *Cyclops*, then kokanee preying on *Bosmina* could benefit from a meal with a higher biomass, and potentially a higher energy content, at each feeding. It is possible that crustacean zooplankton biomass, rather than community

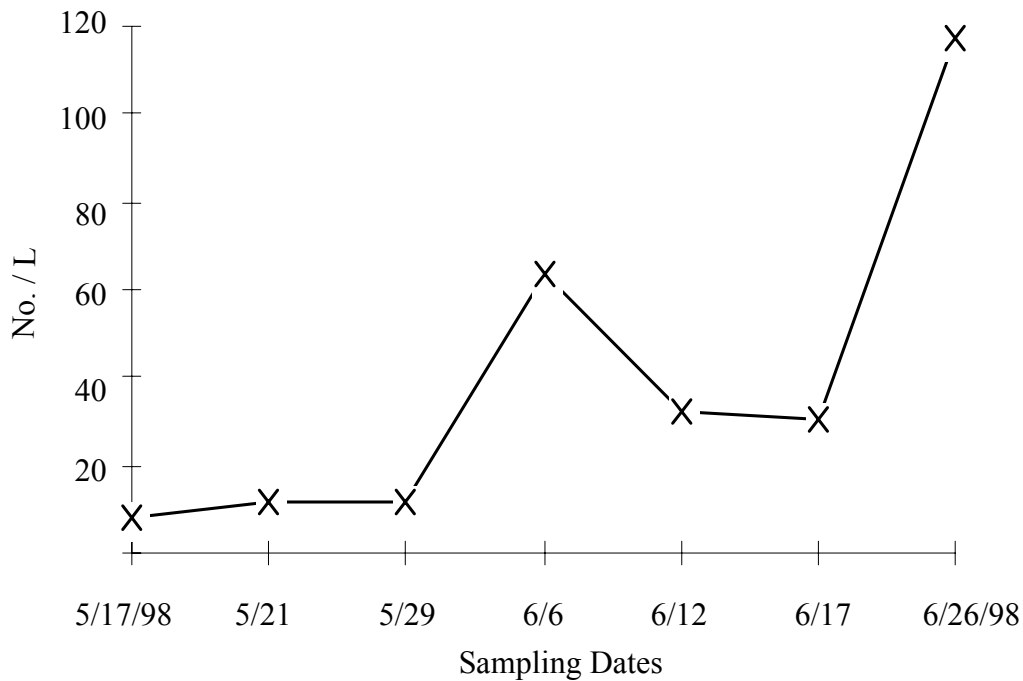


Figure 3.6. Estimate of zooplankton food densities available (No./L) to kokanee fry in Scenic Bay, Lake Pend Oreille, in May and June 1998. Estimate excludes copepod nauplii, which are not considered a food source.

composition, is more important to the growth and survival of newly emerged fry. In May-June 1977 at Lake Pend Oreille, kokanee fry preyed heavily on a dense *Cyclops* population, and age-0 kokanee survival was higher than in 1975, 1976, and 1978; three years characterized by low spring zooplankton densities, but higher incidence of feeding on *Bosmina* (Rieman and Bowler 1980). Because zooplankton densities and *Cyclops* consumption by kokanee in 1998 were similar to 1977, I believe that kokanee fry survival in 1998 should be similar to 1977, assuming other sources of mortality were also similar.

Summary

1. I investigated the diet of newly emerged kokanee in Lake Pend Oreille in May and June, 1998. Larval kokanee were collected by trawling after dusk in Scenic and Idlewilde bays, and in the main lake south of Cape Horn.
2. The copepod *Cyclops bicuspidatus thomasi* was the most important prey item for newly emerged kokanee fry in May and June, 1998, whereas the copepod *Diaptomus ashlandi* was the next most important zooplankter preyed upon. The first occurrence of both the cladoceran *Daphnia* and *Mysis relicta* in stomach samples was on 11 June. *Daphnia* and *Mysis relicta* together accounted for nearly 28% of prey biomass in the 5th sampling week. The cladoceran *Bosmina longirostris* was unimportant in the diet of larval kokanee in this study.
2. *Cyclops* was an actively selected prey item by newly emerged kokanee in this study, whereas *Diaptomus* was actively avoided. The two cladocerans *Daphnia* and *Bosmina* were preyed upon in nearly the same proportion as their availability in the environment.
3. This is the only study I am aware of to document predation on *Mysis relicta* by newly emerged kokanee, although *Mysis* did not contribute substantially to the diet of kokanee in my study.

CHAPTER 4. The importance of varied crustacean zooplankton composition and abundance on the survival and growth of both newly emerged kokanee fry in June and age-0 kokanee in October in Lake Pend Oreille.

Introduction

Water temperature, density-dependent competition for food, and zooplankton abundance and species composition influence juvenile kokanee *Onchorhynchus nerka* growth (Goodlad et al. 1974; Rieman and Myers 1992; LeBrasseur et al. 1978). Results from net pen experiments conducted in Lake Pend Oreille in 1993 to understand effects of sustained underwater sound on the feeding and growth of kokanee suggest that kokanee growth may be sensitive to small fluctuations in zooplankton abundance (Bennett et al. 1994). Bennett et al. (1994) observed lowered growth rates in September that were attributed to “a concomitant decrease in zooplankton abundance in Lake Pend Oreille in mid-September”. Other work has demonstrated the relationship between zooplankton community dynamics and the growth or survival of both kokanee and sockeye *O. nerka*. In Great Central Lake, British Columbia, a nine-fold increase in zooplankton biomass following lake fertilization resulted in increased survival of age-0 and increased growth of age-2 sockeye (LeBrasseur et al. 1978). Paragamian and Bowles (1995) reported a correlation between mean zooplankton densities from May through October, and the survival of hatchery reared age-0 kokanee in Lake Pend Oreille. In Lake Granby, Colorado, kokanee survival and growth to maturation was thought to be controlled by the timing of appearance and peak biomass of *Daphnia* populations (Martinez and Wiltzius 1995). During a 20-year period, the mean length of sockeye salmon smolts in Frazer Lake, Alaska, decreased from 148 mm to 89 mm as seasonal zooplankton densities dropped from an average of 10,620/m³ to 1,450/m³ (Kyle et al. 1988).

Correlations between kokanee growth and zooplankton densities are not always evident. In Flathead Lake, Montana, age-0 kokanee continued to grow in the fall, after zooplankton abundance and water temperatures began to decline (Beattie and Clancey 1991). In a study of four lakes of the Fraser river system, British Columbia, Goodlad et al. (1974) concluded that relationships between growth of sockeye salmon *O. nerka* fry and zooplankton densities existed in two lakes, but found a stronger correlation between kokanee growth and water temperature in the deepest, coldest lake investigated

Temporal shifts in the zooplankton community at Lake Pend Oreille, characterized by reduced spring and autumn densities of cladoceran zooplankton (Rieman and Falter 1981), may cause starvation or slow growth for newly emergent kokanee. Using bio-energetics modeling, Chipps (1997) predicted that *Mysis* predation on cladoceran zooplankton in Lake Pend Oreille would be highest in June and October because (i) two omnivorous *Mysis* cohorts exist in early summer (e.g. June) and autumn (e.g. October), whereas in mid-summer one *Mysis* cohort is omnivorous, and an immature second cohort feeds predominantly on algae or detritus and (ii) A combination of optimum water temperatures (*Mysis* prefer water temperatures between 9-11 °C) and lower light levels (*Mysis* are light sensitive) in spring and autumn allow increased *Mysis* foraging time in the epilimnion. Although research has been conducted to understand how such shifts in the zooplankton community have impacted kokanee (Rieman and Bowler 1980; Rieman 1981; Paragamian and Ellis 1992), questions persist about the growth and survival of Age-0 kokanee (Williams et al. 1997). I conducted *in situ* experiments to test whether ambient food resources in Lake Pend Oreille were sufficient for newly emerged kokanee to survive and grow in June 1998, and for age-0 kokanee to grow in October, 1998. In both experiments I compared the growth of kokanee exposed to higher and lower zooplankton densities against kokanee fed at ambient zooplankton densities.

Methods

I conducted *in-situ* experiments in the southern basin of Lake Pend Oreille (Figure 1.1). For the June experiments, I obtained newly emerged kokanee from Cabinet Gorge Hatchery. On May 30, 1998 three fish were stocked into each of 15 cylindrical net pen enclosures measuring 78 cm in diameter and 2 m long, enclosing approximately 1,000 liters of water each. Net pens were randomly suspended approximately 1 m below the water from either side of a dock located on the north side of Scenic Bay. Eleven zooplankton-impervious treatment pens were constructed of 153 μm mesh net, while four pens were made of 1,590 μm (1/16th inch) mesh, allowing ambient drift of zooplankton from the lake into the pens. I estimated the mean beginning dry weight of individual larval kokanee at 15.48 mg (n=36; SE=0.90 mg) by drying kokanee to a constant weight in an 80° C oven, and weighing them to the nearest 0.0001 g.

I designed four treatment levels for this experiment, corresponding to “HIGH”, “AMBIENT”, “LOW”, and “VERY LOW” zooplankton densities (Figure 4.1). The zooplankton impervious pens used for “HIGH”, “LOW”, and “VERY LOW” treatments were stocked with zooplankton collected with vertical tows using a 20 cm diameter Wisconsin-style plankton net. Four replicate pens of the “HIGH” treatment group contained higher than

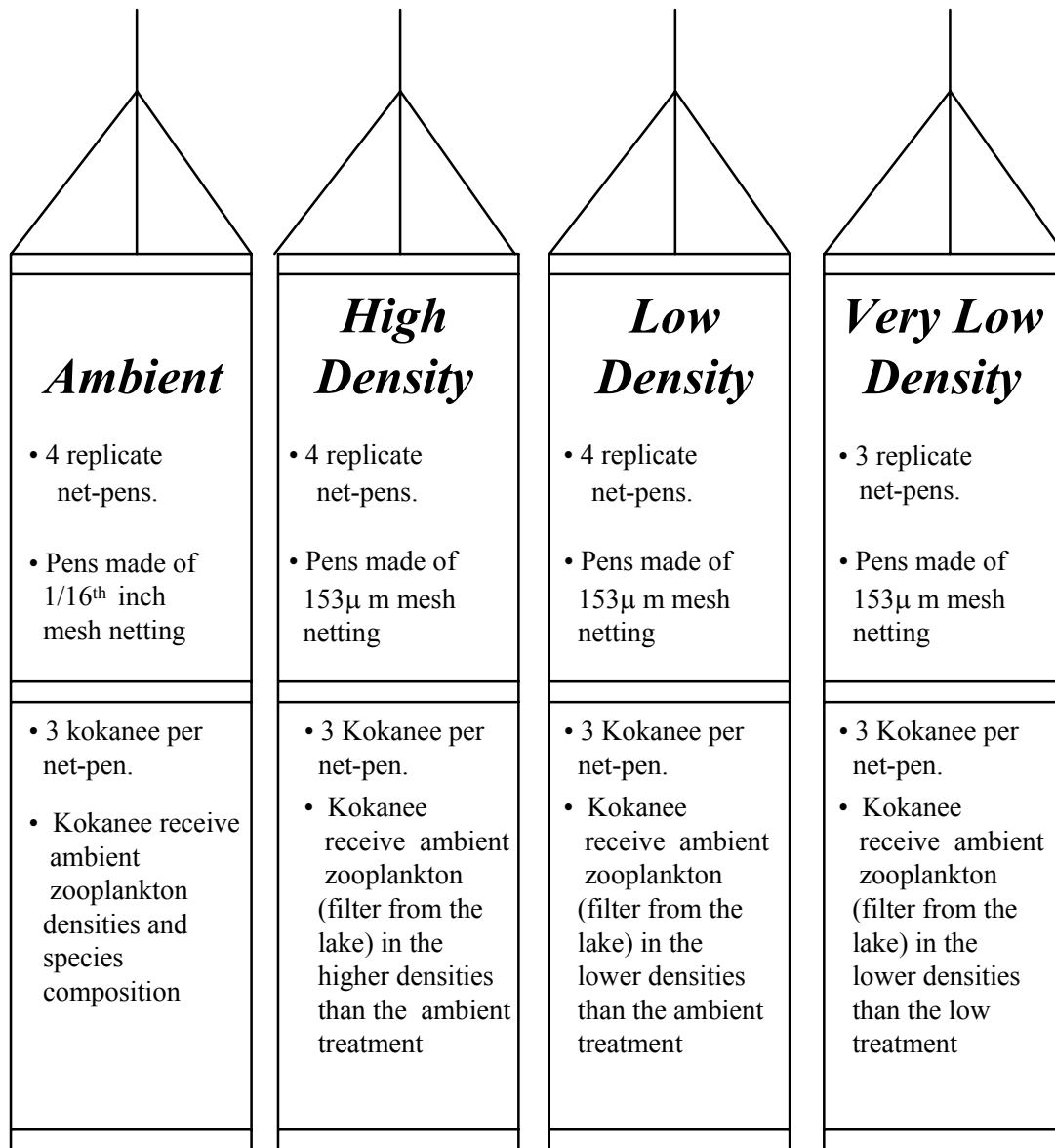


Figure 4.1. Schematic of experimental design showing four treatment groups (i.e. AMBIENT, HIGH, LOW, VERY LOW) used in kokanee growth experiments conducted in June and October, 1998 in Lake Pend Oreille, Idaho.

ambient zooplankton densities, four replicates of the “LOW” treatment group contained lower than ambient zooplankton densities, while three “VERY LOW” replicate pens contained the lowest zooplankton densities.

Target zooplankton densities within each treatment pen were maintained and confirmed approximately twice a week by zooplankton sampling. One 44 L sample was collected in each pen by first raising the top of the net pen slightly above the surface, opening the zippered access, then lowering the Wisconsin-style plankton net 140 cm to the pen bottom, and hauling the net to the surface. Samples were preserved in 70 % ethyl alcohol, and soon thereafter the contents were identified and enumerated under a dissecting microscope. Adjustments to zooplankton densities in individual net pens were made within 24 hours after sampling. To reduce algae growth on the outside of net pens, each pen was cleaned every 3-4 days with a pressure sprayer.

Larval kokanee in the ambient treatment pens could potentially graze down zooplankton densities faster than they could be replenished. I therefore compared zooplankton densities within AMBIENT treatment pens to densities outside the pens on the last three sampling dates of the June experiment and on all sampling dates of the October experiment, by taking one sample from each side of the dock, collected within 2 m of ambient pens, with a 140 cm vertical tow of the plankton net. I tested for differences in mean zooplankton densities between the ambient treatment group and samples taken from outside the net pens using a Kruskal Wallis ranked ANOVA (SAS Institute, Version 6.11).

After 21 days, all kokanee were removed and preserved in 10 % formalin. In the lab, fish were measured for total length, dried, and weighed. Instantaneous growth rate (G) and Fulton condition factor (K) were calculated for each fish using the following equations:

$$G = \ln W_1 - \ln W_0 / (t_1 - t_2) \quad (1)$$

where: W_1 = the ending weight,

W_0 = the beginning weight and,

$(t_1 - t_2)$ = the elapsed time of the experiment (Van Den Avyle 1993).

$$K = (W/L^3) \times 10^5 \quad (2)$$

where: W = weight (grams) and,

L = total length (millimeters; Anderson and Neumann 1996).

The October experiment, initiated on October 10th, was conducted in a similar manner as the June experiment with the following exceptions. Kokanee for the October experiment were age-0 fish originally obtained from the Cabinet Gorge Hatchery in June, but not used in the spring experiment (Mean dry weight=305.02 mg, SE=13.38). Net pens suspended from a Navy barge anchored near the mouth of Scenic Bay were used to hold these fish until the initiation of the October experiment. These fish were assumed to be representative of wild age-0 kokanee in the lake. The four treatment groups employed in June were unchanged, except I used two net pens for the “VERY LOW” treatment group.

For each experiment, I used a Kruskal Wallis ranked ANOVA to test for differences in growth among treatments (SAS institute, version 6.11). When appropriate, I performed post hoc pair-wise comparisons using Fisher’s Least Significant Difference.

Results

During the June experiment, I visually confirmed two dead kokanee on June 10, one each from a HIGH and AMBIENT density treatment pen. Also on June 10, I located only two live kokanee from a high density treatment pen, although one dead fish could not be found. Thereafter, each pen was maintained with two kokanee. One kokanee perished from a HIGH density treatment pen early during the October experiment, and was replaced with a fish from a “holdover” group maintained in a net pen at the dock. Surface water temperatures in Scenic

Bay were 10.5°C when the June experiments began, and 16°C at their conclusion. Water temperatures in Scenic Bay in October were not recorded, however surface temperatures in the main lake were 15°C on October 10th and 11.5°C on October 31st.

June Experiment

The mean kokanee dry weight at the beginning of growth studies in June was 0.0154 g, and the mean ending dry weights for individual treatment pens ranged from 0.0216 g for a VERY LOW treatment to 0.0789 g for a HIGH treatment pen (Table 4.1). Mean total kokanee biomass increased with increasing zooplankton densities, with the highest growth occurring in the HIGH treatment group (Figure 4.2). Final mean kokanee dry weights were significantly different among treatment groups ($F=19.09$, $p>0.0001$), but no significant differences were identified between HIGH and AMBIENT treatments ($F=3.44$, $p>0.1130$) or between LOW and VERY LOW treatments ($F=2.50$, $p>0.1747$).

In the June experiments mean instantaneous growth rates for age-0 kokanee ranged from 1.53 to 7.72%·day⁻¹, and condition factor varied from 0.58 to 0.92 (Table 4.1). Mean instantaneous growth and condition factor both increased with increasing zooplankton densities, although the highest observed mean condition factor was in an AMBIENT zooplankton density net pen (0.92). Instantaneous growth positively corresponded to condition factor ($r=0.84$, $p=0.0002$, Figure 4.3). The densities of food resources available to kokanee in the HIGH treatment were higher than in the AMBIENT treatment, but mean

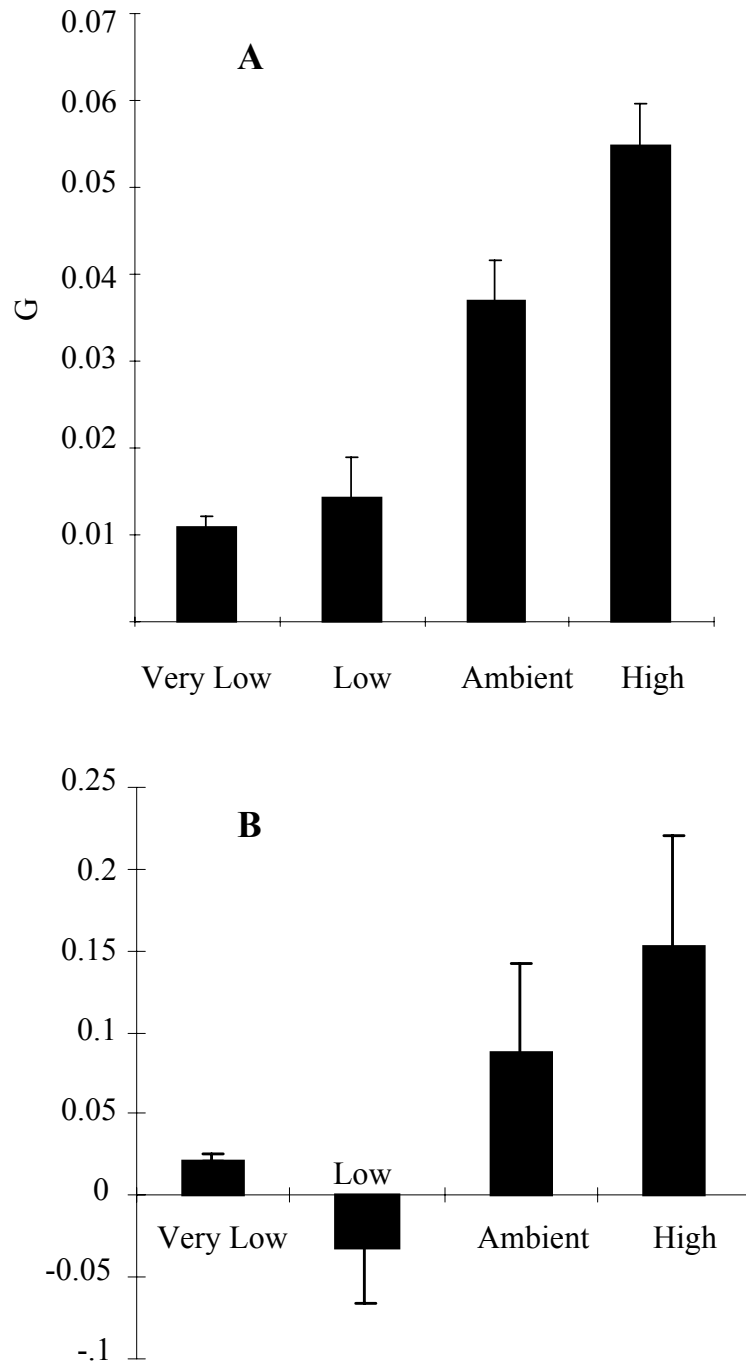


Figure 4.2. Mean increase in kokanee biomass (grams dry weight) by treatment for June (A) and October (B) net pen experiments conducted in Lake Pend Oreille, 1998. Vertical bars represent 2 SE.

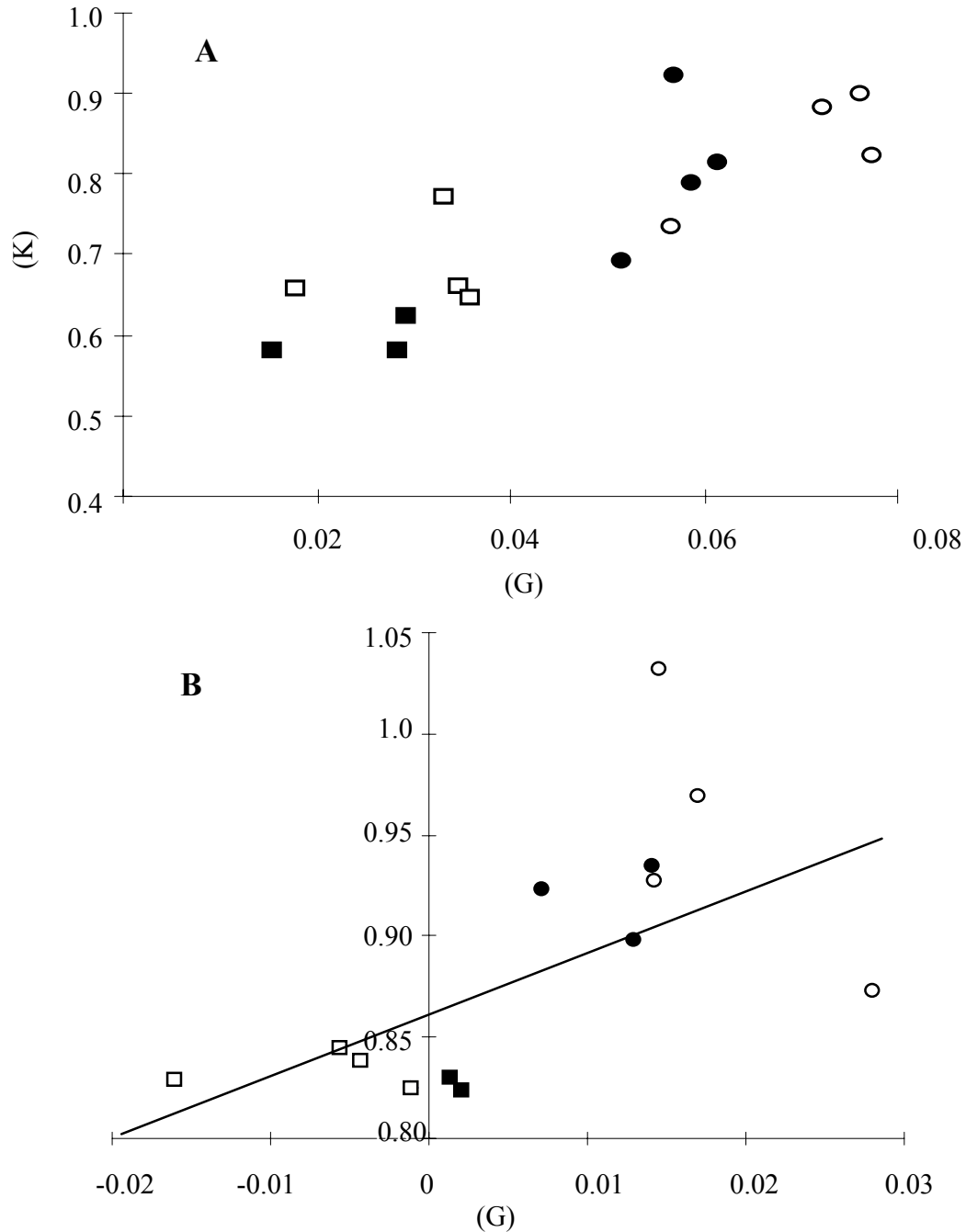


Figure 4.3. Relationship between condition factor (K) and instantaneous growth (G) from June (A) and October (B) experiments in Lake Pend Oreille, 1998. Treatment groups are represented as follows: Solid square is VERY LOW, open square is LOW, solid circle is AMBIENT, open circle is HIGH.

Table 4.1. Mean final biomass (grams dry weight) and standard error (SE), instantaneous growth rate (G), and ending condition factor (K) for age-0 kokanee used in June *in situ* growth experiments. n represents the concluding number of fish in a treatment net pen.

Treatment Pen	n	Mean Final Biomass (g) \pm (SE)	G ^a	K
VERY LOW 13		.0284 \pm (.0102)	2.82	0.58
VERY LOW 23		.0292 \pm (.0042)	2.92	0.62
VERY LOW 33		.0216 \pm (.0025)	1.53	0.58
LOW 1	3	.0321 \pm (.0006)	3.47	0.66
LOW 2	3	.0225 \pm (.0006)	1.78	0.66
LOW 3	3	.0329 \pm (.0014)	3.58	0.65
LOW 4	3	.0313 \pm (.0024)	3.32	0.77
AMBIENT 1	3	.0577 \pm (.0092)	6.13	0.82
AMBIENT 2	3	.0460 \pm (.0040)	5.13	0.69
AMBIENT 3	3	.0531 \pm (.0018)	5.86	0.79
AMBIENT 4	2	.0532 \pm (.0150)	5.68	0.92
HIGH 1	2	.0706 \pm (.0025)	7.22	0.88
HIGH 2	3	.0530 \pm (.0108)	5.65	0.74
HIGH 3	2	.0789 \pm (.0102)	7.72	0.82
HIGH 4	3	.0788 \pm (.0132)	7.62	0.90

^a Expressed as % change in body weight \cdot day⁻¹.

instantaneous growth in the AMBIENT treatment (5.7% \cdot day⁻¹) was nearly that of fish in the HIGH treatment (7.0% \cdot day⁻¹; Figure 4.4). Mean instantaneous growth of kokanee in LOW and VERY LOW treatments was similar (3.0% \cdot day⁻¹ and 2.4% \cdot day⁻¹ respectively).

Mean zooplankton densities in the HIGH treatment pens were generally higher than in the AMBIENT treatment, except for the June 10th sampling date (Figure 4.5). The AMBIENT treatment had higher mean zooplankton densities than the LOW and VERY LOW treatments for each sampling date except the first date (June 4), when densities were approximately equal

among the three treatments. The LOW treatment had higher zooplankton densities than the VERY LOW treatment on June 4th and 14th. No statistically significant difference in mean zooplankton densities existed between the AMBIENT treatment and samples taken from outside the net pens ($F=2.10$, $p>0.1665$), although zooplankton densities were consistently higher outside the net pens than within AMBIENT pens.

October Experiment

The mean beginning kokanee dry weight for the October experiment was 0.3050 g and the mean ending dry weights for individual treatment pens ranged from 0.2192 g for a LOW treatment to 0.5530 g for a HIGH treatment pen (Table 4.2). Mean total kokanee biomass increased with increasing zooplankton densities, except for the LOW treatment, which had a mean decline in overall kokanee biomass (Figure 4.2). Final mean kokanee dry weights were significantly different among all treatment groups ($F=16.4$, $p>0.0009$), but no significant differences were identified between HIGH and AMBIENT treatments ($F=0.83$, $p>0.4144$) or between AMBIENT and VERY LOW treatments ($F=8.0$, $p>0.1056$).

Mean Instantaneous growth rates for age-0 kokanee in October ranged from -1.61 to 2.79%·day⁻¹ and condition factor varied from 0.82 to 1.03 (Table 4.2). The highest observed mean condition factor ($K=1.03$) and instantaneous growth rate (2.79%·day⁻¹) were in HIGH treatment pens. The lowest condition factors were in both the LOW and VERY LOW treatments and the lowest instantaneous growth rates were observed in LOW treatment pens, despite the LOW treatments having higher zooplankton densities than the VERY LOW treatments (Table 4.2, Figure 4.6). Increases in instantaneous growth corresponded to increases in condition factor ($r=0.65$, $p=0.0169$, Figure 4.3). Zooplankton densities within

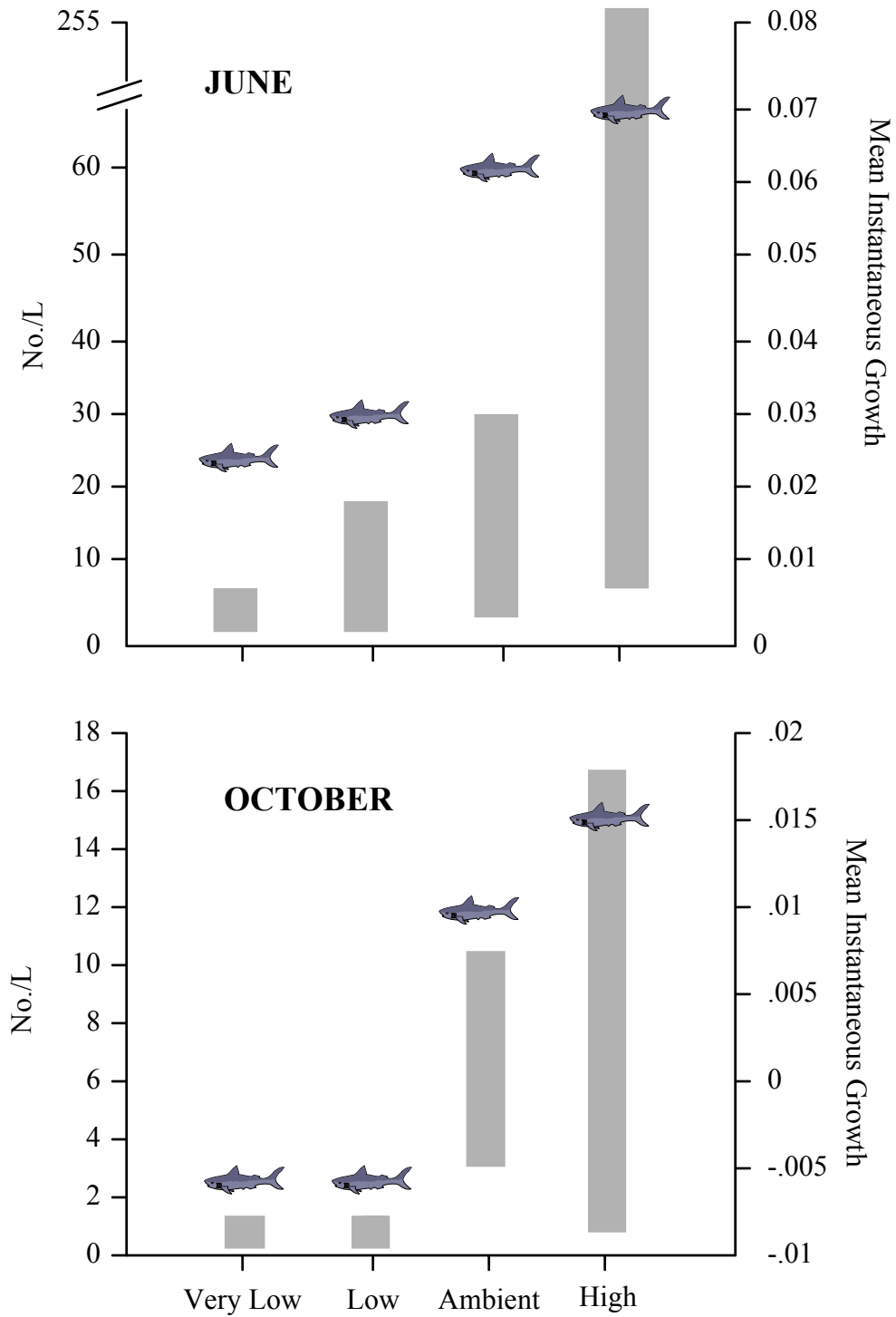



Figure 4.4. Relationship between the range of mean zooplankton densities by treatment group (indicated by solid bars) and mean instantaneous growth by treatment group (indicated by ) for juvenile kokanee experiments conducted in Lake Pend Oreille in June and October, 1998.

HIGH treatment pens were sometimes lower than in AMBIENT pens. Despite a wider range of food resources (e.g. zooplankton densities), mean instantaneous growth for kokanee in the HIGH treatment pens ($1.84\% \cdot \text{day}^{-1}$) were higher than those in the AMBIENT treatment pens ($0.83\% \cdot \text{day}^{-1}$; Figure 4.4)

Age-0 kokanee in the October experiment quickly grazed down zooplankton densities within treatment pens, causing HIGH density treatments to have lower zooplankton levels than AMBIENT treatments on two sampling dates (Figure 4.6). On each sampling date, AMBIENT zooplankton densities were higher than LOW zooplankton densities, and the VERY LOW treatment had the lowest zooplankton densities. No statistically significant difference in mean zooplankton densities existed between the AMBIENT treatment and samples taken from outside the net pens ($F=0.55$, $p>0.4760$), although zooplankton densities were generally higher outside the net pens than within AMBIENT pens (Figure 4.6).

Discussion

This study demonstrated that growth of age-0 kokanee in Lake Pend Oreille can be influenced by food (e.g. zooplankton) densities. In laboratory studies Brett et al. (1969) found growth of fingerling sockeye salmon to be a function of both food rations and temperature. In each treatment group in these studies, except the LOW treatment in the October experiment, kokanee growth fluctuated directly with levels of zooplankton densities. Differences in kokanee growth rates (i.e. $\% \text{ change in body weight} \cdot \text{day}^{-1}$) were smallest between the LOW and VERY LOW treatments and the HIGH and AMBIENT treatments, and were highest between the LOW and AMBIENT treatments for both experiments, suggesting that a

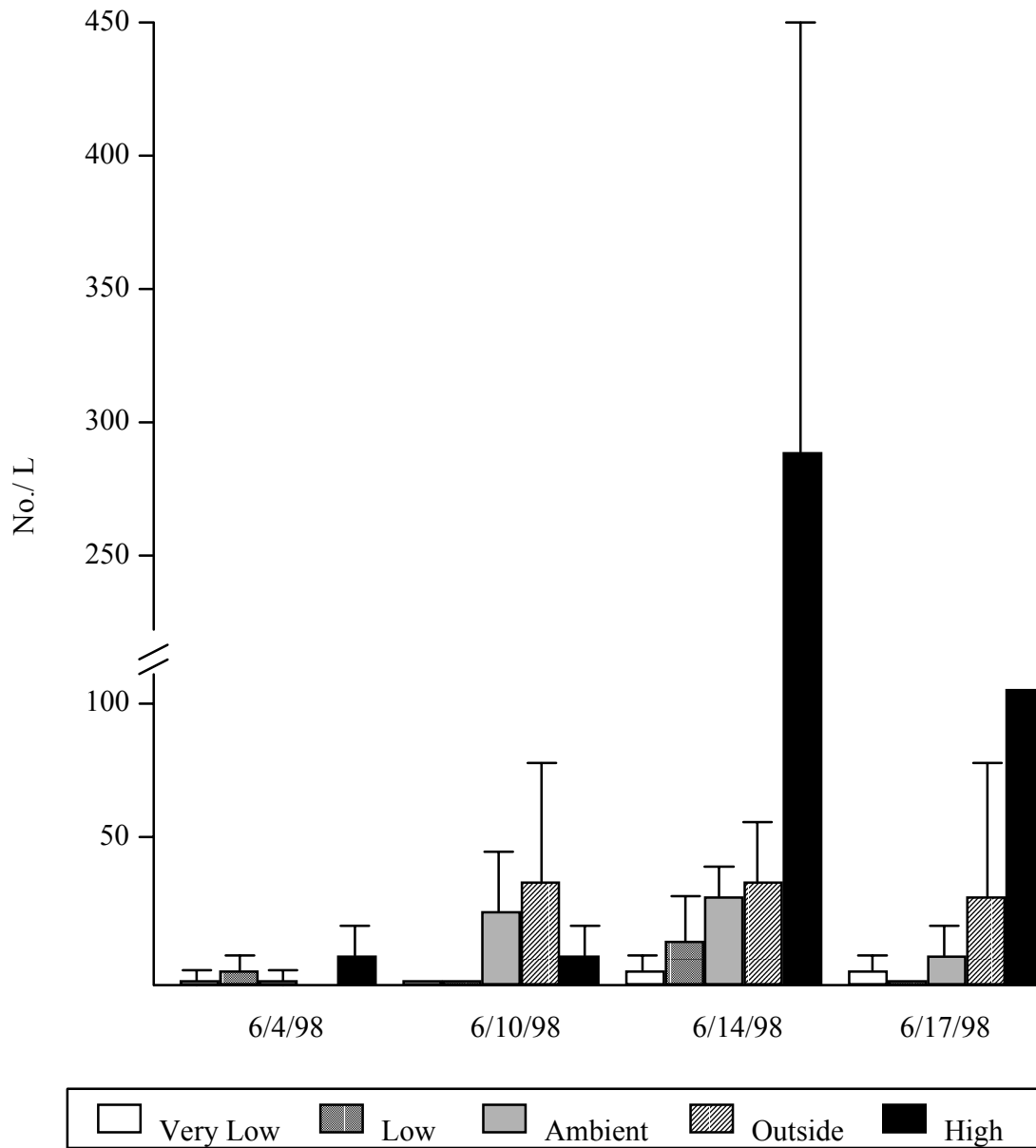


Figure 4.5. Total zooplankton per liter by treatment group for June 1998 net pen experiments conducted on age-0 kokanee in Lake Pend Oreille. Vertical bars represent 2 SE. Standard error for HIGH treatment on 6/17 is 47.4.

Table 4.2. Mean final biomass (grams dry weight) and standard error (SE), instantaneous growth rate (G), and ending condition factor (K) for age-0 kokanee used in October *in situ* growth experiments. n represents the concluding number of fish in a treatment net pen.

Treatment Pen	n	Mean Final Biomass (g) \pm (SE)	G ^a	K
VERY LOW 13		0.3235 \pm (.0368)	0.21	0.82
VERY LOW 23		0.3185 \pm (.0383)	0.13	0.83
LOW 1	3	0.3009 \pm (.0329)	-0.12	0.83
LOW 2	3	0.2784 \pm (.0478)	-0.57	0.84
LOW 3	2	0.2192 \pm (.0284)	-1.61	0.83
LOW 4	3	0.2803 \pm (.0251)	-0.44	0.84
AMBIENT 1	3	0.3091 \pm (.0548)	-0.11	0.83
AMBIENT 2	3	0.4158 \pm (.0452)	1.41	0.93
AMBIENT 3	3	0.4005 \pm (.0177)	1.29	0.90
AMBIENT 4	3	0.3608 \pm (.0517)	0.71	0.92
HIGH 1	3	0.4365 \pm (.0109)	1.70	0.97
HIGH 2	3	0.4116 \pm (.0151)	1.42	0.93
HIGH 3	3	0.4139 \pm (.0030)	1.45	1.03
HIGH 4	3	0.5530 \pm (.0570)	2.79	0.87

^a Expressed as % change in body weight \cdot day⁻¹.

threshold of food densities existed for kokanee in my experiments. At food densities below the threshold, kokanee growth rates quickly declined with decreasing food, whereas increases in growth rates slowed at increasing food densities above the threshold. Although zooplankton density differences between treatment groups were generally maintained in these experiments, zooplankton densities within treatment groups did fluctuate. In addition, water temperatures either increased (June experiment) or decreased (October experiment) throughout the experiments. Betsill and Van Den Ayle (1997) suggest that the effect of temperatures can mask prey effects. Also, bio-energetics modeling on sockeye salmon *O. nerka* demonstrates the sensitivity of sockeye growth to temperature changes (Beauchamp et

al. 1989). Consequently, I cannot estimate the zooplankton density that resulted in growth thresholds observed in these two experiments. However, the growth trends I describe are consistent with relationships exhibited between *Cyclops* biomass and larval kokanee growth in earlier net pen experiments at Lake Pend Oreille (Rieman 1981). In addition, research on other larval fishes suggests the existence of a growth threshold at high zooplankton densities (Betsill and Van Den Avyle 1997).

Three kokanee deaths were confirmed during the June and October experiments combined, and those deaths occurred in HIGH and AMBIENT treatment pens. I therefore conclude that starvation was likely not a cause of mortality in these experiments. If the performance of kokanee fry in these experiment were indicative of wild fry, then starvation from June-October was not a major source of mortality for the 1998 kokanee cohort in Lake Pend Oreille.

Lake levels declined several meters at Lake Pend Oreille throughout October 1998. Consequently, two AMBIENT treatment pens, positioned closest to shoreline on either side of the dock by random selection, and suspended in approximately 3 m deep water at the experiments' initiation, were lying on the lake bottom when the experiment ended. Benthic organisms that are not normally utilized as prey by the pelagic wild kokanee of Lake Pend Oreille were therefore available to kokanee in those pens. For that reason, I excluded the kokanee from these pens from analysis.

Mean instantaneous growth rates of kokanee fry fed ambient zooplankton densities in the June experiment ($5.7\% \cdot \text{day}^{-1}$) were slightly higher than the highest rates observed by

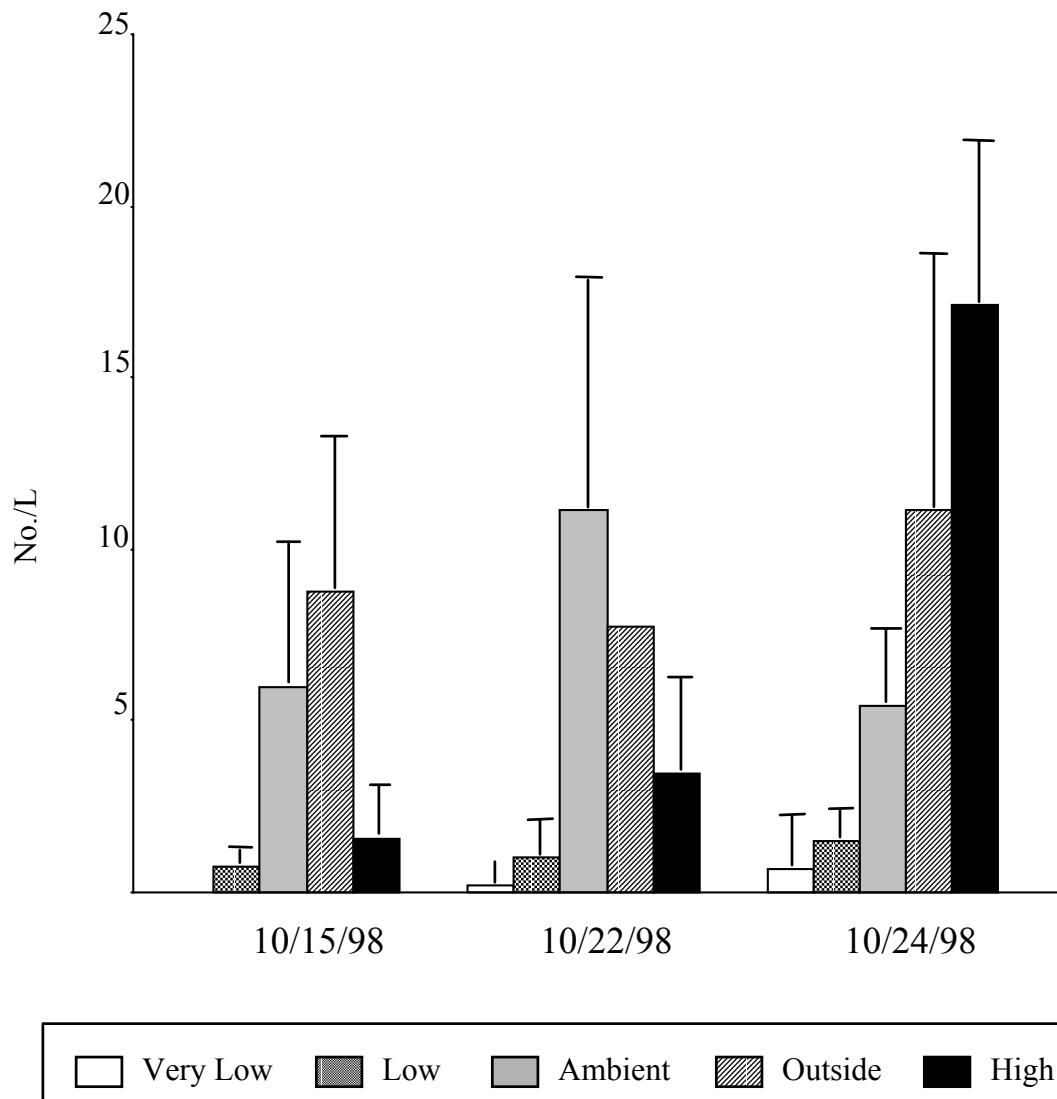


Figure 4.6. Total zooplankton per liter by treatment group for October 1998 net pen experiments conducted on age-0 kokanee in Lake Pend Oreille. Vertical bars represent 2 SE.

Rieman ($5.1\% \cdot \text{day}^{-1}$; 1981) for a similar set of experiments conducted on newly emerged kokanee fry at Lake Pend Oreille from April-July, 1980. Comparisons of temperature profiles and zooplankton density estimates in Lake Pend Oreille for both years suggest that June, 1998 was warmer and had higher zooplankton abundance than June, 1980. Thus, the higher growth rates observed in this study are not surprising. In addition, Rieman (1981) measured positive growth from kokanee fry exposed to zooplankton biomass as low as $2 \text{ mg (dry weight) \cdot m}^{-3}$. Positive kokanee growth was also measured at the lowest zooplankton biomass in the June experiment, which I estimated between about $2\text{-}8 \text{ mg} \cdot \text{m}^{-3}$ over the 21-day experiment for the VERY LOW treatment group.

Growth rates for kokanee receiving ambient food densities in these experiments may not represent growth rates of wild fish. Indeed, the consistently lower zooplankton density measurements inside AMBIENT treatment pens versus outside the pens suggests the possibility that treatment fish received less food than wild fish. Rieman (1981) also measured consistently higher zooplankton densities outside net pens than inside kokanee holding pens. However, Rieman (1981) experimented with densities of 0 kokanee \cdot net pen $^{-1}$ and 50 kokanee \cdot net pen $^{-1}$ and found the same relationship between zooplankton densities outside the pens versus inside the pens, leading him to conclude that zooplankton density differences were due to net pen clogging with algae, rather than grazing by kokanee. If kokanee in AMBIENT treatments pens in my study received the same food rations as wild fish, then growth of treatment fish should also be similar to wild fish. However, other *in situ* growth studies with juvenile salmonids have shown growth rates for confined fish equal to, or greater than, their free-roaming counterparts (Lebrasseur 1969; English 1983; Johnston 1990). In this study, net pens were not long enough to allow vertical migration by kokanee, nor did they force kokanee to expend energy searching for prey.

Restrictions of these two metabolic activities probably resulted in higher growth by kokanee in these experiments than would be observed from kokanee encountering similar prey densities in the wild.

Results from experiments conducted at Kootenay Lake, British Columbia by Johnston (1990) could aid in estimating the growth rates of wild kokanee fry in Lake Pend Oreille, using measured growth rates from AMBIENT treatment fish. At Kootenay Lake, newly emerged kokanee were confined in small net pens in the epilimnion, and instantaneous growth rates of confined fry were compared to those of wild fry. Growth rates for fry confined from May-October were approximately 20% higher than those of wild fish. By applying a 20% correction to the growth rates measured in my experiment, I estimate instantaneous growth rates of wild fry in Lake Pend Oreille in June could be $4.1\text{-}4.9\%\cdot\text{day}^{-1}$ and in October could be $-0.009\text{-}0.01\%\cdot\text{day}^{-1}$.

Observed kokanee growth rates in HIGH treatment pens in the June experiments probably represent the maximum possible growth by kokanee fry given excess food rations consisting mostly of *Cyclops* (the most abundant zooplankter in June zooplankton samples and in the diet of wild kokanee fry, Objectives 1 and 2), and given the specific water temperatures present in June and October. However, growth in the HIGH treatments pens in October might be lower than the maximum. More effective grazing by the larger kokanee in the October experiments made it difficult to maintain targeted zooplankton densities in HIGH treatment pens. Therefore, kokanee growth could have been higher if a consistently higher ratio of food density to kokanee density had been achieved over the 21 day October experiment.

A paradigm exists in fisheries which states that the strength of a cohort is often directly related to survival rates of post-emergent fry (Wootton 1990; Van Den Avyle 1993).

Studies have clearly demonstrated direct relationships between fry survival and year-class strength (Le Cren 1987). Furthermore, relationships between fry survival and the timing of production of suitable prey (i.e. zooplankton) also have been demonstrated (Cushing 1995). In Lake Pend Oreille, kokanee fry emergence initiates in May, peaks in June, and diminishes in July (Rieman and Bowler 1980). Historically, the timing of increases in zooplankton abundance at Lake Pend Oreille corresponded closely with kokanee emergence (Stross 1954). However, since the introduction of omnivorous *Mysis relicta* to the lake, spring zooplankton densities have been reduced, prompting speculation that low zooplankton densities may retard growth of kokanee fry (Hassemer 1984). Based on my zooplankton abundance estimates (Objective 1) and results presented here, I believe that zooplankton densities in Lake Pend Oreille probably did not limit survival or growth of newly emerged kokanee in June 1998. Also, based on the results of my October experiment, I conclude that growth by wild kokanee did occur in October, but growth was slower than in June. If these *in-situ* studies are accurate predictors of kokanee fry survival, then survival should be strong for that portion of the 1998 kokanee cohort to emerge in June-July. Furthermore, continued application of kokanee fry *in-situ* growth studies in future years, similar to those conducted by Rieman (1981) and myself, combined with adequate wild kokanee population estimates, may show relationships between kokanee growth and year class strength that could aid fisheries managers in predicting cohort abundance as adults.

Summary

1. I investigated the growth and survival of newly emerged kokanee in June, and age-0 kokanee in October, by conducting in-situ net-pen experiments in Lake Pend Oreille in 1998. I had four treatment levels for these experiments, corresponding to “HIGH”, “AMBIENT”, “LOW”, and “VERY LOW” zooplankton densities
2. Starvation was not a source of mortality in either experiment, suggesting that the 1998 kokanee cohort in Lake Pend Oreille would not die of starvation from June-October.
3. With the exception of a treatment group in October, kokanee growth increased with increasing food resources in both experiments. Differences in kokanee growth were smallest between kokanee fed low zooplankton densities (e.g. the LOW treatment) and kokanee fed very low zooplankton densities (e.g. the VERY LOW treatment) and also between kokanee fed ambient zooplankton densities (e.g. the AMBIENT treatment) and those fed high zooplankton densities (e.g. the HIGH treatment). Growth differences were highest between the LOW and AMBIENT treatments for both experiments. My results suggest that food availability did not limit the growth of wild kokanee in June or October, 1998.
4. Continued application of *in-situ* kokanee growth studies, similar to those conducted by Rieman (1981) and myself, combined with wild kokanee population estimates, may show relationships between kokanee growth and year-class strength. Such relationships could be useful in predicting cohort strength as adults.

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Appendix Table 2.1. Estimates of zooplankton densities (No./L) and biomass (mg live weight / m3) for sampling locations in Lake Pend Oreille, Idaho, 1997-1998.

Date and Location	N	<i>Cyclops</i>		<i>Diatomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		
		No./L	%Total	No./L	%Total	No./L	%Total	No./L	%Total	No./L	Biomass/m3	
June 20-22, 1997												
Scenic Bay	9	4.11	72.71	0.00	0.00	0.00	0.00	1.53	27.14	5.64	79.99	
Idlewilde Bay	9	2.56	50.71	2.11	42.00	0.06	1.10	0.29	5.73	5.02	115.45	
Garfield Bay	9	3.94	75.42	0.89	17.00	0.00	0.00	0.30	5.74	3.07	94.63	
Ellisport Bay	9	2.74	5.55	0.39	0.80	0.00	0.00	0.18	0.36	3.32	63.49	
Lake Site south	9	2.99	12.08	19.60	79.22	0.03	0.13	2.12	8.58	24.74	882.38	
June 27-28, 1997												
Scenic Bay	12	8.13	72.40	2.42	21.52	0.04	0.37	0.55	4.90	11.14	620.16	
Idlewilde Bay	11	3.05	63.10	1.59	32.95	0.00	0.00	0.13	2.76	4.78	102.64	
Garfield Bay	12	3.06	66.97	0.76	16.59	0.03	0.55	0.53	11.67	4.38	84.87	
Ellisport Bay	12	5.91	54.58	0.82	7.54	0.02	0.15	1.36	12.55	2.73	1 82.61	
Lake Site south	9	0.43	6.24	6.06	87.17	0.09	1.32	0.33	4.68	14.35	278.96	
July 2-3, 1997												
Scenic Bay	12	13.49	70.99	3.92	20.63	0.00	0.00	1.48	7.77	18.89	364.64	
Idlewilde Bay	12	12.81	77.30	1.60	9.66	0.01	0.05	2.10	12.67	16.51	294.89	
Garfield Bay	12	9.19	78.90	1.46	12.52	0.00	0.00	0.92	0.87	11.57	204.77	
Ellisport Bay	11	14.89	78.92	1.14	6.03	0.03	0.15	1.29	6.83	17.34	321.17	
Lake Site south	11	24.76	78.92	3.99	12.72	0.00	0.00	2.27	7.23	31.02	601.98	
July 11-12, 1997												
Scenic Bay	12	21.08	56.98	13.17	35.62	0.00	0.00	2.62	7.08	36.87	754.25	
Idlewilde Bay	12	32.40	53.74	25.36	42.06	0.00	0.00	2.30	3.81	60.06	1308.08	
Garfield Bay	12	13.82	71.26	5.19	26.77	0.08	0.43	0.18	0.95	19.28	400.54	
Ellisport Bay	12	8.26	76.61	1.68	15.62	0.04	0.39	0.13	1.16	10.11	211.47	
Lake Site south	12	14.82	42.87	17.97	51.98	0.02	0.05	1.74	5.04	34.54	770.28	
July 16-17, 1997												
Scenic Bay	12	29.11	66.02	13.90	31.54	0.02	0.05	0.42	0.96	43.46	932.05	

Appendix Table 2.1. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total			
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m ³	No./L	Biomass ^a /m ³
June 20-22, 1997																
Scenic Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.15	0.01	0.11	5.65	80.10		
Idlewilde Bay	0.00	0.00	0.01	0.22	0.00	0.00	0.00	0.00	0.01	0.22	0.02	0.26	5.04	115.45		
Garfield Bay	0.00	0.00	0.08	1.49	0.00	0.00	0.00	0.00	0.02	0.42	0.10	1.22	5.23	94.63		
Ellisport Bay	0.01	0.02	45.61	92.21	0.06	0.11	0.00	0.00	0.47	0.94	46.14	663.27	49.46	726.77		
Lake Site south	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.74	882.38		
June 27-28, 1997																
Scenic Bay	0.00	0.00	0.08	0.74	0.00	0.00	0.00	0.00	0.01	0.07	0.09	1.80	11.23	620.16		
Idlewilde Bay	0.00	0.00	0.05	1.04	0.00	0.00	0.00	0.00	0.01	0.17	0.06	0.66	4.83	102.64		
Garfield Bay	0.02	0.36	0.13	2.92	0.02	0.36	0.02	0.36	0.01	0.18	0.19	6.65	4.57	84.87		
Ellisport Bay	0.05	0.46	2.57	23.71	0.03	0.23	0.01	0.08	0.08	0.69	2.73	43.93	10.83	182.61		
Lake Site south	0.01	0.12	0.02	0.24	0.01	0.12	0.01	0.12	0.00	0.00	0.04	2.82	6.95	278.78		
July 2-3, 1997																
Scenic Bay	0.00	0.00	0.04	0.20	0.00	0.00	0.03	0.18	0.04	0.23	0.07	8.13	19.01	372.78		
Idlewilde Bay	0.00	0.00	0.04	0.25	0.00	0.00	0.00	0.00	0.02	0.10	0.06	0.81	16.57	295.70		
Garfield Bay	0.00	0.00	0.07	0.57	0.00	0.00	0.01	0.07	0.01	0.07	0.08	2.78	11.65	207.55		
Ellisport Bay	0.02	0.11	1.23	6.49	0.02	0.11	0.01	0.07	0.24	1.28	1.52	25.69	18.86	346.85		
Lake Site south	0.33	1.06	0.00	0.00	0.00	0.00	0.01	0.03	0.01	0.03	0.34	16.62	31.37	618.61		
July 11-12, 1997																
Scenic Bay	0.03	0.08	0.04	0.12	0.02	0.06	0.00	0.00	0.03	0.08	0.12	3.56	36.99	757.81		
Idlewilde Bay	0.04	0.07	0.19	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.23	4.87	60.29	312.95		
Garfield Bay	0.02	0.09	0.08	0.43	0.00	0.00	0.00	0.00	0.02	0.09	0.12	1.96	19.39	402.51		
Ellisport Bay	0.04	0.39	0.60	5.57	0.00	0.00	0.03	0.23	0.01	0.08	0.68	16.58	10.78	228.05		
Lake Site south	0.01	0.02	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.61	34.56	770.89		
July 16-17, 1997																
Scenic Bay	0.02	0.04	0.52	1.20	0.04	0.09	0.00	0.00	0.05	0.11	0.63	10.97	44.09	943.02		
Idlewilde Bay	0.00	0.00	0.25	0.86	0.02	0.06	0.00	0.00	0.03	0.09	0.29	4.73	29.05	617.20		

Appendix Table 2.1. Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L	Biomass/m ³	
July 16-17, 1997 Cont.												
Idlewilde Bay	12	20.23	69.62	8.11	27.91	0.01	0.03	0.42	1.43	28.76	612.47	
Garfield Bay	12	20.78	84.11	3.29	13.32	0.03	0.10	0.32	1.28	24.42	466.43	
Ellisport Bay	12	12.66	82.90	0.81	5.29	0.03	0.16	0.28	1.80	13.77	268.47	
Lake Site south	12	37.29	61.25	22.53	37.00	0.01	0.01	0.98	1.60	60.80	1329.49	
July 23, 1997												
Scenic Bay	12	10.04	53.48	6.99	37.21	0.02	0.09	0.70	3.73	17.75	380.61	
Idlewilde Bay	11	5.50	57.51	3.54	36.96	0.00	0.00	0.37	3.83	9.41	201.74	
Garfield Bay	12	6.80	53.86	3.43	27.19	0.00	0.00	0.50	3.96	10.73	214.00	
Ellisport Bay	12	7.11	63.61	1.78	15.96	0.01	0.07	0.92	8.20	9.82	187.15	
Lake Site south	12	16.68	46.87	17.63	49.54	0.01	0.02	0.94	2.65	35.25	796.02	
July 30-31, 1997												
Scenic Bay	12	12.83	44.79	12.99	45.35	0.01	0.04	0.78	2.74	26.61	590.88	
Idlewilde Bay	12	27.94	48.42	25.15	43.58	0.03	0.06	1.08	1.88	54.21	1220.37	
Garfield Bay	12	11.77	52.18	5.79	25.68	0.03	0.15	0.81	3.58	18.40	362.64	
Ellisport Bay	12	9.63	63.25	2.50	16.41	0.77	5.03	0.64	4.21	13.54	376.67	
Lake Site north	12	20.85	44.29	24.03	51.05	0.01	0.02	0.87	1.84	45.76	1076.08	
Lake Site south	12	30.13	54.73	23.27	42.26	0.02	0.03	0.22	0.39	53.63	1210.32	
August 6-7, 1997												
Scenic Bay	12	9.81	37.54	8.52	32.59	0.01	0.04	1.21	4.61	19.54	612.15	
Idlewilde Bay	12	10.10	42.78	9.06	38.37	0.01	0.04	0.87	3.67	20.03	531.06	
Garfield Bay	12	12.02	43.78	6.23	22.71	0.02	0.09	1.03	3.76	19.31	456.23	
Ellisport Bay	12	11.57	55.40	4.66	22.31	0.03	0.16	0.88	4.23	17.14	313.09	
Lake Site north	12	11.80	53.47	8.53	38.63	0.14	0.64	0.78	3.51	21.24	568.65	
Lake Site south	12	10.71	47.17	5.68	25.00	0.03	0.11	0.49	2.17	16.90	444.71	
August 14-15, 1997												
Scenic Bay	12	8.70	50.53	4.82	27.98	0.02	0.10	0.53	3.10	14.07	416.52	
Idlewilde Bay	12	10.79	51.27	4.46	21.18	0.04	0.20	0.48	2.26	15.77	373.09	

Appendix Table 2.1. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total	
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m ³	No./L	Biomass ^a /m ³
July 16-17, 1997 Cont.														
Garfield Bay	0.02	0.07	0.22	0.88	0.04	0.17	0.00	0.00	0.02	0.07	0.29	5.92	24.71	472.34
Ellisport Bay	0.06	0.38	1.39	9.11	0.01	0.05	0.03	0.16	0.02	0.11	1.50	29.51	15.27	297.98
Lake Site south	0.04	0.07	0.01	0.01	0.00	0.00	0.00	0.00	0.03	0.05	0.08	2.70	60.88	1332.19
July 23, 1997														
Scenic Bay	0.02	0.12	0.71	3.76	0.03	0.18	0.00	0.00	0.27	1.42	1.03	16.31	18.78	396.92
Idlewilde Bay	0.00	0.00	0.15	1.57	0.01	0.09	0.00	0.00	0.00	0.00	0.16	2.56	9.57	204.30
Garfield Bay	0.03	0.26	1.66	13.14	0.16	1.25	0.03	0.26	0.01	0.07	1.89	39.20	12.63	253.21
Ellisport Bay	0.19	1.72	0.74	6.64	0.06	0.52	0.06	0.52	0.31	2.76	1.36	41.91	11.18	229.07
Lake Site south	0.03	0.07	0.22	0.61	0.07	0.19	0.01	0.02	0.01	0.02	0.33	9.61	35.58	805.63
July 30-31, 1997														
Scenic Bay	0.14	0.48	1.80	6.28	0.07	0.23	0.01	0.04	0.02	0.06	2.03	38.38	28.64	629.26
Idlewilde Bay	0.44	0.77	2.71	4.69	0.34	0.59	0.00	0.00	0.01	0.01	3.50	78.74	57.71	1299.11
Garfield Bay	0.27	1.18	3.73	16.52	0.09	0.41	0.03	0.15	0.03	0.15	4.15	186.58	22.55	548.92
Ellisport Bay	0.58	3.83	0.59	3.88	0.33	2.13	0.16	1.04	0.03	0.22	1.69	95.40	15.23	472.07
Lake Site north	0.18	0.37	1.02	2.16	0.09	0.19	0.03	0.07	0.00	0.00	1.13	33.02	47.08	1109.11
Lake Site south	0.03	0.06	1.22	2.21	0.16	0.29	0.00	0.00	0.02	0.03	1.43	27.27	55.06	1237.60
August 6-7, 1997														
Scenic Bay	1.23	4.70	4.98	19.05	0.36	1.38	0.00	0.00	0.02	0.09	6.59	162.58	26.13	774.73
Idlewilde Bay	0.77	3.25	2.71	11.47	0.08	0.35	0.00	0.00	0.02	0.07	3.58	88.43	23.61	619.49
Garfield Bay	0.91	3.31	6.99	25.47	0.23	0.82	0.02	0.06	0.00	0.00	8.14	153.51	27.45	609.75
Ellisport Bay	2.37	11.33	0.39	1.88	0.88	4.19	0.10	0.48	0.01	0.04	3.74	207.60	20.88	520.69
Lake Site north	0.26	1.17	0.35	1.59	0.17	0.76	0.04	0.19	0.01	0.04	0.83	39.03	22.07	608.68
Lake Site south	0.32	1.40	5.43	23.90	0.04	0.18	0.01	0.04	0.01	0.04	5.80	118.97	22.70	563.68
August 14-15, 1997														
Scenic Bay	0.53	3.10	2.55	14.81	0.07	0.39	0.00	0.00	0.00	0.00	3.15	79.00	17.22	487.53
Idlewilde Bay	1.13	5.34	3.95	18.76	0.20	0.95	0.00	0.00	0.01	0.04	5.28	133.18	21.05	506.27
Garfield Bay	2.18	7.00	1.10	3.54	0.46	1.48	0.02	0.05	0.03	0.11	3.78	164.80	31.07	766.30
Ellisport Bay	2.50	20.75	0.34	2.84	0.54	4.50	0.03	0.21	0.01	0.07	3.42	182.04	12.06	326.59

Appendix Table 2.1. Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		Biomass/m ³
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	
August 14-15, 1997 Cont.												
Garfield Bay	12	19.25	61.96	6.73	21.67	0.02	0.05	1.28	4.13	27.29	601.49	
Ellisport Bay	12	6.11	50.69	1.71	14.18	0.01	0.07	0.82	6.78	8.64	144.56	
Lake Site north	12	10.94	56.30	6.08	31.26	0.00	0.00	0.67	3.43	17.68	434.85	
Lake Site south	12	10.53	15.15	5.72	29.93	0.02	0.09	0.48	2.49	16.74	441.77	
August 22-23, 1997												
Scenic Bay	12	5.50	33.32	2.58	15.62	0.06	0.34	1.16	7.00	9.29	248.99	
Idlewilde Bay	12	5.29	20.05	4.78	18.09	0.08	0.28	1.34	5.08	11.48	290.87	
Garfield Bay	12	9.54	51.67	2.50	13.54	0.10	0.54	1.13	6.14	13.28	280.62	
Ellisport Bay	12	9.17	33.70	1.98	7.26	0.03	0.12	1.08	3.95	12.25	205.05	
Lake Site north	12	7.48	43.42	2.16	12.52	0.03	0.19	1.15	6.67	10.83	223.98	
Lake Site south	12	6.02	28.68	3.62	17.24	0.08	0.36	0.64	3.06	10.35	277.56	
August 30, 1997												
Scenic Bay	12	3.40	18.95	4.33	24.12	0.09	0.50	1.04	5.79	1.13	289.93	
Idlewilde Bay	12	2.66	22.11	2.18	18.09	0.05	0.42	1.10	9.15	5.98	139.65	
Garfield Bay	12	5.01	26.37	2.93	15.45	0.10	0.53	1.98	10.40	10.02	217.81	
Ellisport Bay	12	5.13	28.92	1.24	7.00	0.09	0.52	2.29	12.91	8.76	130.42	
Lake Site north	12	7.53	32.48	3.72	16.04	0.05	0.22	1.29	5.58	12.58	289.03	
Lake Site south	12	6.23	36.80	3.61	21.33	0.04	0.25	0.89	5.27	10.77	275.91	
September 6, 1997												
Scenic Bay	12	2.14	23.53	1.90	20.90	0.16	1.71	1.28	14.06	5.47	142.38	
Idlewilde Bay	12	2.62	22.00	3.06	25.72	0.04	0.35	0.68	5.75	6.40	181.39	
Garfield Bay	12	6.35	26.47	2.57	10.70	0.05	0.21	1.63	6.77	10.59	209.70	
Ellisport Bay	6	2.86	7.61	1.76	4.67	0.08	13.33	5.53	14.69	10.25	119.94	
Lake Site north	12	6.66	25.78	3.38	13.07	0.04	0.16	0.80	3.10	10.88	255.31	
Lake Site south	12	4.72	34.00	2.49	17.92	0.02	0.16	1.46	10.48	8.68	194.44	
September 13, 1997												
Scenic Bay	12	7.26	53.37	2.33	17.16	0.27	1.96	0.40	2.94	10.26	278.82	

Appendix Table 2.1. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total	
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m ³	No./L	Biomass ^a /m ³
August 14-15, 1997 Cont.														
Lake Site north	1.08	5.57	0.28	1.46	0.36	1.84	0.02	0.09	0.01	0.04	1.75	96.66	19.43	531.50
Lake Site south	0.78	4.06	1.33	6.94	0.25	1.31	0.02	0.09	0.00	0.00	2.37	89.96	19.11	531.74
August 22-23, 1997														
Scenic Bay	3.89	23.56	2.69	16.32	0.61	3.67	0.02	0.10	0.01	0.07	7.22	319.31	16.51	568.30
Idlewilde Bay	11.88	45.03	2.46	9.32	0.39	1.48	0.05	0.19	0.13	0.47	14.91	824.51	26.39	1115.38
Garfield Bay	3.36	18.19	0.87	4.69	0.89	4.78	0.01	0.05	0.08	0.41	5.19	249.70	18.47	530.32
Ellisport Bay	11.03	40.53	1.73	6.37	2.03	7.44	0.13	0.46	0.04	0.15	14.95	790.52	27.20	995.57
Lake Site north	5.48	31.77	0.33	1.93	0.58	3.38	0.02	0.10	0.00	0.00	6.41	396.36	17.23	620.34
Lake Site south	8.52	50.66	1.66	7.91	0.45	2.15	0.00	0.00	0.00	0.00	0.00	609.56	20.975	887.12
August 30, 1997														
Scenic Bay	8.13	45.33	0.69	3.84	0.26	1.42	0.00	0.00	0.01	0.06	9.09	544.36	17.94	834.29
Idlewilde Bay	5.08	42.20	0.58	4.78	0.38	3.12	0.02	0.14	0.00	0.00	6.04	354.86	12.03	494.51
Garfield Bay	7.30	38.44	1.09	5.75	0.58	3.07	0.00	0.00	0.00	0.00	8.98	429.66	18.99	677.05
Ellisport Bay	6.18	34.84	1.41	7.93	1.34	7.56	0.06	0.33	0.00	0.00	8.97	376.62	17.75	587.30
Lake Site north	8.15	35.18	0.43	1.87	1.93	8.35	0.07	0.29	0.00	0.00	10.58	651.92	23.17	940.95
Lake Site south	5.15	30.44	0.54	3.20	0.44	2.61	0.02	0.10	0.00	0.00	6.15	372.68	16.92	648.58
September 6, 1997														
Scenic Bay	3.23	35.57	0.11	1.22	0.27	3.00	0.00	0.00	0.00	0.00	3.62	261.01	9.09	403.39
Idlewilde Bay	4.77	40.08	0.41	3.43	0.32	2.66	0.00	0.00	0.00	0.00	5.49	401.60	11.89	582.99
Garfield Bay	6.73	28.07	5.23	21.78	1.40	5.84	0.04	0.17	0.00	0.00	13.40	548.81	23.99	758.51
Ellisport Bay	15.38	33.35	11.28	24.46	0.68	1.48	0.02	0.04	0.03	0.07	27.40	1216.78	37.65	1336.73
Lake Site north	12.29	47.60	0.33	1.26	2.30	8.91	0.03	0.13	0.00	0.00	14.95	958.76	25.83	1214.07
Lake Site south	4.46	32.08	0.02	0.16	0.72	5.20	0.00	0.00	0.00	0.00	5.20	377.65	13.89	572.10
September 13, 1997														
Scenic Bay	1.88	13.85	0.33	2.41	1.12	8.26	0.01	0.04	0.00	0.00	3.34	157.08	13.59	435.91
Idlewilde Bay	2.00	21.49	0.48	5.19	0.78	8.42	0.00	0.00	0.00	0.00	3.27	172.98	9.31	325.48
Garfield Bay	1.98	20.93	0.49	5.19	0.57	5.98	0.00	0.00	0.00	0.00	3.04	143.93	9.48	270.67
Ellisport Bay	2.89	19.36	3.45	23.16	0.75	5.03	0.01	0.06	0.01	0.06	7.11	251.42	14.92	379.30

Appendix Table 2.1 Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		Biomass/m ³
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L		
September 13, 1997 Cont.												
Idlewilde Bay	12	3.17	34.02	2.23	23.90	0.02	0.18	0.63	6.80	6.04	152.50	
Garfield Bay	12	4.45	46.97	1.32	13.90	0.03	0.26	0.64	6.77	6.43	126.74	
Ellisport Bay	11	4.99	33.44	1.35	9.02	0.03	0.17	1.45	9.72	7.81	127.88	
Lake Site north	12	5.58	64.45	1.01	11.66	0.04	0.48	0.31	3.56	6.93	141.14	
Lake Site south	12	7.72	38.68	5.98	29.99	0.21	1.04	0.60	3.01	14.51	426.19	
September 20, 1997												
Scenic Bay	12	6.50	80.70	0.73	9.10	0.06	0.76	0.42	5.17	7.71	168.09	
Idlewilde Bay	10	12.58	79.36	1.62	10.23	0.06	0.37	0.54	3.42	14.80	302.92	
Garfield Bay	12	6.71	72.85	1.06	11.49	0.09	1.00	0.43	4.62	8.28	164.03	
Ellisport Bay	12	4.24	53.41	0.68	8.50	0.02	0.21	0.43	5.46	5.37	91.63	
Lake Site north	12	7.39	82.59	0.70	7.82	0.17	0.19	0.37	4.10	8.48	155.14	
Lake Site south	12	7.00	73.55	1.06	11.12	0.05	0.53	0.80	8.41	8.91	178.92	
September 27, 1997												
Scenic Bay	12	3.24	61.22	1.65	31.13	0.01	0.10	0.06	1.15	4.98	130.28	
Idlewilde Bay	12	2.08	36.18	1.93	33.58	0.00	0.00	0.01	0.14	4.03	118.06	
Garfield Bay	12	14.81	63.83	2.02	8.69	0.09	0.40	0.71	3.05	17.63	332.07	
Ellisport Bay	12	7.45	27.68	1.15	4.27	0.05	0.19	0.47	1.73	9.12	162.95	
Lake Site north	12	10.98	87.17	1.11	8.80	0.02	0.13	0.12	0.93	12.23	231.89	
Lake Site south	11	3.94	50.35	3.40	43.52	0.05	0.59	0.13	1.60	7.50	222.41	
October 4, 1997												
Scenic Bay	12	20.23	83.09	1.82	7.48	0.03	0.14	0.68	2.81	22.77	512.98	
Idlewilde Bay	12	23.88	84.36	2.68	9.45	0.03	0.09	0.69	2.44	27.27	609.10	
Garfield Bay	12	22.62	76.28	3.48	11.72	0.01	0.03	0.53	1.80	26.63	637.61	
Ellisport Bay	12	6.36	53.93	0.39	3.32	0.00	0.00	0.51	4.31	7.26	129.80	
Lake Site north	12	13.76	61.97	6.95	31.31	0.01	0.04	0.36	1.61	21.08	673.04	
Lake Site south	12	24.57	83.73	3.17	10.79	0.03	0.11	0.71	2.41	28.48	642.21	

Appendix Table 2.1. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total	
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m3	No./L	Biomass ^a /m3
September 13, 1997 Cont.														
Lake Site north	0.84	9.73	0.03	0.39	0.84	9.73	0.00	0.00	0.00	0.00	1.72	65.40	8.65	206.54
Lake Site south	3.46	17.34	0.47	2.34	1.51	7.56	0.01	0.04	0.00	0.00	5.44	302.89	19.95	729.08
September 20, 1997														
Scenic Bay	0.08	1.03	0.21	2.62	0.05	0.62	0.00	0.00	0.00	0.00	0.34	9.75	8.06	177.84
Idlewilde Bay	0.13	0.79	0.90	5.65	0.03	0.18	0.00	0.00	0.00	0.00	1.05	23.11	15.85	326.03
Garfield Bay	0.13	1.45	0.73	7.96	0.04	0.45	0.00	0.00	0.02	0.18	0.93	20.03	9.21	184.07
Ellisport Bay	0.16	1.99	2.35	29.59	0.07	0.84	0.00	0.00	0.00	0.00	2.58	49.03	7.94	140.66
Lake Site north	0.12	1.30	0.28	3.17	0.07	0.74	0.01	0.09	0.00	0.00	0.48	15.33	8.95	170.48
Lake Site south	0.15	1.58	0.35	3.68	0.11	1.14	0.00	0.00	0.00	0.00	0.61	18.90	9.52	197.81
September 27, 1997														
Scenic Bay	0.01	0.21	0.32	6.08	0.00	0.00	0.00	0.00	0.01	0.10	0.34	5.64	5.30	135.92
Idlewilde Bay	0.00	0.00	1.72	29.81	0.02	0.29	0.00	0.00	0.00	0.00	1.73	24.39	5.76	142.45
Garfield Bay	0.07	0.29	5.38	23.20	0.10	0.43	0.00	0.00	0.03	0.11	5.58	82.88	23.20	414.95
Ellisport Bay	0.10	0.37	17.43	64.77	0.27	0.99	0.00	0.00	0.00	0.00	17.8	291.91	26.92	454.87
Lake Site north	0.03	0.26	0.17	1.32	0.18	1.39	0.00	0.00	0.00	0.00	0.38	5.29	12.60	237.18
Lake Site south	0.00	0.00	0.27	3.41	0.03	0.43	0.00	0.00	0.01	0.11	0.31	4.83	7.81	227.23
October 4, 1997														
Scenic Bay	0.22	0.89	1.14	4.68	0.21	0.84	0.00	0.00	0.02	0.07	1.58	43.75	24.35	556.74
Idlewilde Bay	0.00	0.00	0.76	2.68	0.28	0.97	0.00	0.00	0.00	0.00	1.03	24.75	28.30	633.85
Garfield Bay	0.07	0.22	2.58	8.71	0.38	1.26	0.00	0.00	0.00	0.00	3.03	79.09	29.66	716.71
Ellisport Bay	0.14	1.20	4.16	35.27	0.17	1.41	0.00	0.00	0.07	0.57	4.53	83.65	11.79	213.45
Lake Site north	0.03	0.11	0.95	4.28	0.16	0.71	0.00	0.00	0.00	0.00	1.13	27.99	22.21	701.04
Lake Site south	0.11	0.37	0.38	1.31	0.37	1.25	0.00	0.00	0.01	0.03	0.87	21.70	29.34	670.36
October 17, 1997														
Scenic Bay	0.22	0.77	0.46	1.57	0.24	0.81	0.00	0.00	0.02	0.06	0.93	35.21	28.99	666.63
Idlewilde Bay	0.00	0.00	0.12	1.05	0.04	0.38	0.00	0.00	0.00	0.00	0.16	3.77	11.11	215.81
Garfield Bay	0.08	0.47	0.22	1.22	0.17	0.94	0.00	0.00	0.00	0.00	0.47	18.21	17.69	441.29
Ellisport Bay	0.05	0.41	1.34	11.00	0.23	1.91	0.00	0.00	0.01	0.07	1.64	36.12	12.20	259.57

Appendix Table 2.1. Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		Biomass/m ³
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L		
October 17, 1997												
Scenic Bay	12	23.77	81.97	2.42	8.34	0.13	0.44	1.75	6.04	28.06	631.42	
Idlewilde Bay	12	8.35	75.17	0.78	6.98	0.05	0.45	1.78	15.99	10.95	212.04	
Garfield Bay	12	13.91	78.61	2.56	14.46	0.06	0.33	0.70	3.96	17.23	423.08	
Ellisport Bay	12	8.25	67.65	1.67	13.67	0.13	1.02	0.52	4.27	10.56	223.45	
Lake Site north	12	14.41	86.67	0.90	5.41	0.01	0.05	1.11	6.66	16.43	326.86	
Lake Site south	12	18.87	80.37	3.30	14.06	0.06	0.25	0.89	3.80	23.12	578.95	
October 24, 1997												
Scenic Bay	12	13.32	92.06	0.56	3.84	0.09	0.65	0.37	2.57	14.34	316.00	
Idlewilde Bay	12	14.40	90.24	0.87	5.43	0.34	2.14	0.29	1.83	15.90	382.56	
Garfield Bay	12	7.38	70.52	2.25	21.51	0.23	2.23	0.31	2.95	10.17	304.14	
Ellisport Bay	12	9.30	74.10	1.62	12.88	0.17	1.33	0.32	2.52	11.40	248.01	
Lake Site north	12	13.93	80.74	2.73	15.84	0.04	0.24	0.20	1.16	16.91	443.94	
Lake Site south	12	18.30	93.49	1.05	5.36	0.00	0.00	0.13	0.68	19.48	408.45	
October 31 - November 1, 1997												
Scenic Bay	12	1.27	50.13	1.22	48.16	0.04	1.53	0.01	0.22	2.54	95.46	
Idlewilde Bay	12	1.10	50.57	0.97	44.44	0.06	2.68	0.03	1.53	2.16	79.05	
Garfield Bay	12	14.86	69.01	6.18	28.72	0.07	0.31	0.23	1.05	21.25	622.01	
Ellisport Bay	12	13.46	85.59	1.53	9.75	0.03	0.21	0.43	2.70	15.45	333.05	
Lake Site north	12	17.49	78.12	4.20	18.76	0.03	0.11	0.38	1.67	22.09	504.62	
Lake Site south	12	7.11	69.13	2.93	28.45	0.03	0.24	0.13	1.30	10.19	289.36	
November 7-8, 1997												
Scenic Bay	11	41.39	90.90	3.57	7.83	0.01	0.02	0.52	1.14	45.49	922.09	
Idlewilde Bay	12	8.41	78.10	2.03	18.81	0.01	0.08	0.29	2.71	10.73	224.61	
Garfield Bay	12	16.13	69.63	3.32	14.31	0.04	0.18	0.37	1.58	19.86	500.77	
Ellisport Bay	12	4.76	72.53	1.17	17.78	0.01	0.15	0.35	5.28	6.28	143.71	
Lake Site north	12	14.85	83.24	2.59	14.53	0.01	0.05	0.32	1.78	17.77	385.48	
Lake Site south	11	14.76	85.48	2.16	12.50	0.02	0.10	0.28	1.64	17.21	343.48	

Appendix Table 2.1. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total			
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m ³	No./L	Biomass ^a /m ³
October 17, 1997 Cont.																
Lake Site north	0.03	0.14	0.05	0.21	0.28	1.17	0.00	0.00	0.00	0.00	0.36	16.39	23.48	595.35		
Lake Site south	0.01	0.05	0.03	0.15	0.17	1.00	0.00	0.00	0.00	0.00	0.20	9.10	16.63	335.96		
October 25, 1997																
Scenic Bay	0.03	0.23	0.01	0.08	0.08	0.58	0.00	0.00	0.00	0.00	0.13	6.80	14.47	322.80		
Idlewilde Bay	0.00	0.00	0.03	0.21	0.03	0.16	0.00	0.00	0.00	0.00	0.06	1.74	15.96	384.30		
Garfield Bay	0.00	0.00	0.27	2.55	0.03	0.24	0.00	0.00	0.00	0.00	0.29	7.05	10.46	311.19		
Ellisport Bay	0.03	0.27	0.98	7.77	0.13	1.06	0.01	0.07	0.00	0.00	1.15	25.94	12.55	273.95		
Lake Site north	0.00	0.00	0.01	0.05	0.34	1.98	0.00	0.00	0.00	0.00	0.35	17.49	17.26	461.44		
Lake Site south	0.00	0.00	0.03	0.13	0.07	0.34	0.00	0.00	0.00	0.00	0.09	3.80	19.58	412.25		
October 31 – November 1, 1997																
Scenic Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.54	95.46		
Idlewilde Bay	0.00	0.00	0.02	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.24	2.18	79.28		
Garfield Bay	0.02	0.08	0.00	0.00	0.17	0.77	0.00	0.00	0.02	0.08	0.20	9.68	21.53	631.69		
Ellisport Bay	0.00	0.00	0.08	0.53	0.14	0.90	0.01	0.05	0.04	0.26	0.28	11.60	15.73	344.65		
Lake Site north	0.00	0.00	0.03	0.11	0.28	1.23	0.00	0.00	0.00	0.00	0.30	14.51	22.39	519.13		
Lake Site south	0.00	0.00	0.00	0.00	0.09	0.89	0.00	0.00	0.00	0.00	0.09	4.65	10.28	294.01		
November 7-8, 1997																
Scenic Bay	0.00	0.00	0.01	0.02	0.04	0.08	0.01	0.02	0.00	0.00	0.08	4.45	45.55	926.53		
Idlewilde Bay	0.00	0.00	0.00	0.00	0.03	0.31	0.00	0.00	0.00	0.00	0.03	1.69	10.77	226.30		
Garfield Bay	0.00	0.00	0.00	0.00	3.32	14.31	0.00	0.00	0.00	0.00	3.32	168.19	23.18	668.97		
Ellisport Bay	0.00	0.00	0.24	3.66	0.04	0.61	0.00	0.00	0.00	0.00	0.28	8.16	6.56	151.87		
Lake Site north	0.00	0.00	0.01	0.05	0.07	0.37	0.00	0.00	0.00	0.00	0.08	3.57	17.84	389.04		
Lake Site south	0.01	0.05	0.01	0.05	0.03	0.19	0.00	0.00	0.00	0.00	0.05	2.11	17.27	345.58		
November 22, 1997																
Scenic Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.61	266.36		
Idlewilde Bay	0.02	0.19	0.00	0.00	0.01	0.09	0.01	0.09	0.00	0.00	0.03	3.37	8.88	224.84		
Garfield Bay	0.01	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.51	2.61	83.40		
Ellisport Bay	0.20	4.49	0.04	0.94	0.00	0.00	0.00	0.00	0.29	6.55	0.53	13.92	4.45	104.38		

Appendix Table 2.1. Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diatomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		Biomass/m ³
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L		
November 22, 1997												
Scenic Bay	12	7.52	70.90	2.82	26.60	0.06	0.58	0.21	1.94	10.61	266.36	
Idlewilde Bay	12	5.44	61.28	3.22	36.22	0.01	0.09	0.18	2.06	8.85	221.47	
Garfield Bay	12	1.41	54.00	1.06	40.58	0.01	0.32	0.13	4.79	2.60	82.89	
Ellisport Bay	12	3.00	67.42	0.73	16.29	0.01	0.19	0.18	4.12	3.92	90.45	
Lake Site north	12	5.42	52.29	4.74	45.78	0.02	0.16	0.18	1.69	10.35	343.48	
Lake Site south	12	1.49	52.75	1.08	37.85	0.01	0.30	0.25	8.87	2.81	73.77	
December 6, 1997												
Scenic Bay	12	5.11	56.35	3.54	39.12	0.00	0.00	0.41	4.48	9.06	191.26	
Idlewilde Bay	12	3.55	57.19	2.40	38.74	0.00	0.00	0.26	4.20	6.21	128.36	
Garfield Bay	12	3.55	60.37	1.95	33.16	0.00	0.00	0.38	6.52	5.88	109.82	
Ellisport Bay	10	2.78	44.68	3.17	50.98	0.05	0.80	0.22	3.55	6.22	197.17	
Lake Site north	11	2.54	77.49	0.69	21.09	0.00	0.00	0.05	1.52	3.28	79.85	
Lake Site south	12	5.40	56.25	3.83	39.84	0.01	0.09	0.37	3.82	9.60	205.32	
December 19, 1997												
Scenic Bay	12	3.38	51.26	2.67	40.40	0.00	0.00	0.55	8.33	6.60	135.23	
Idlewilde Bay	12	2.18	39.98	2.71	49.79	0.00	0.00	0.55	10.11	5.43	110.55	
Lake Site south	12	4.78	62.94	2.31	30.37	0.00	0.00	0.52	6.80	7.61	152.26	
January 17-18, 1998												
Scenic Bay	12	1.25	50.91	1.11	45.25	0.00	0.00	0.09	3.62	2.45	58.64	
Idlewilde Bay	12	0.78	37.61	1.23	58.81	0.00	0.00	0.05	2.40	2.06	47.35	
Garfield Bay	12	0.50	27.65	1.18	65.98	0.00	0.00	0.13	7.37	1.81	25.44	
Ellisport Bay	12	1.94	46.23	1.75	41.67	0.00	0.00	0.49	11.71	4.18	72.75	
Lake Site north	11	1.71	32.11	3.40	63.75	0.00	0.00	0.20	3.75	5.31	85.85	
Lake Site south	12	1.94	39.90	2.71	55.83	0.00	0.00	0.21	4.28	4.87	110.97	
February 20-22, 1998												
Scenic Bay	12	0.72	26.81	1.67	62.07	0.00	0.00	0.29	10.93	2.69	41.17	
Idlewilde Bay	12	0.61	39.68	0.77	50.01	0.00	0.00	0.15	9.78	1.53	24.29	

Appendix Table 2.1. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total	
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m3	#/L	Biomass ^a /m3
November 22, 1997 Cont.														
Lake Site north	0.00	0.00	0.00	0.00	0.01	0.30	0.00	0.00	0.00	0.00	0.01	0.42	2.82	74.19
Lake Site south	0.00	0.00	0.00	0.00	0.01	0.08	0.00	0.00	0.00	0.00	0.01	0.42	10.35	283.99
December 06, 1997														
Scenic Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.01	0.07	9.06	191.34
Idlewilde Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.21	128.36
Garfield Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.88	109.82
Ellisport Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.22	197.17
Lake Site north	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.28	79.85
Lake Site south	0.00	0.00	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	9.61	205.46
December 19, 1997														
Scenic Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.60	135.23
Idlewilde Bay	0.00	0.00	0.01	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	5.44	110.69
Lake Site south	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.61	152.26
January 17, 1998														
Scenic Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.23	0.01	0.07	2.46	58.71
Idlewilde Bay	0.00	0.00	0.03	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	2.08	47.35
Garfield Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.81	25.44
Ellisport Bay	0.00	0.00	0.02	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.22	4.20	72.97
Lake Site north	0.01	0.23	0.01	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.70	5.33	86.55
Lake Site south	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.87	110.97
February 22, 1998														
Scenic Bay	0.00	0.00	0.01	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.11	2.69	41.28
Idlewilde Bay	0.00	0.00	0.01	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	1.53	24.44
Garfield Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.14	63.91
Ellisport Bay	0.03	1.72	0.07	3.44	0.00	0.00	0.00	0.00	0.10	5.15	0.20	3.95	1.94	39.65
Lake Site north	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	0.01	0.11	5.86	112.34
Lake Site south	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38	38.11

Appendix Table 2.1. Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diatomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		Biomass/m ³
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L		
February 20-22, 1998 Cont.												
Garfield Bay	12	1.58	50.14	1.43	45.37	0.00	0.00	0.14	4.51	3.14	63.91	
Ellisport Bay	12	0.73	37.37	0.82	42.10	0.00	0.00	0.20	10.31	1.74	35.70	
Lake Site north	12	1.89	32.29	3.83	65.30	0.00	0.00	0.13	2.28	5.85	112.24	
Lake Site south	12	0.94	39.52	1.30	54.55	0.00	0.00	0.14	5.94	2.38	38.11	
March 20, 1998												
Scenic Bay	12	1.63	30.52	3.41	64.01	0.00	0.00	0.28	5.16	5.31	87.04	
Idlewilde Bay	12	0.35	20.40	1.21	70.42	0.00	0.00	0.14	8.26	1.70	24.10	
Garfield Bay	12	0.62	36.10	0.96	56.11	0.00	0.00	0.12	6.83	1.69	28.32	
Ellisport Bay	12	0.58	46.67	0.42	33.33	0.00	0.00	0.15	12.00	1.15	20.94	
Lake Site north	12	0.80	26.82	2.08	69.84	0.00	0.00	0.10	3.35	2.98	94.58	
Lake Site south	12	1.76	31.97	3.52	63.94	0.00	0.00	0.23	4.09	5.50	86.55	
April 18, 1998												
Scenic Bay	11	0.47	18.46	1.95	76.34	0.00	0.00	0.07	2.61	2.50	66.29	
Idlewilde Bay	11	0.58	13.82	3.38	81.09	0.00	0.00	0.17	4.00	4.12	51.79	
Garfield Bay	12	2.09	64.70	0.98	30.42	0.00	0.00	0.13	4.12	3.21	57.07	
Ellisport Bay	11	1.02	36.05	0.70	24.67	0.00	0.00	0.65	23.05	2.36	39.92	
Lake Site north	12	1.23	34.12	2.18	60.82	0.00	0.00	0.18	4.87	3.58	71.87	
Lake Site south	12	0.45	12.03	3.21	85.78	0.00	0.00	0.07	1.78	3.73	51.58	
May 9-10, 1998												
Scenic Bay	12	0.40	24.10	0.91	54.77	0.00	0.00	0.27	16.06	1.58	40.98	
Idlewilde Bay	11	1.51	50.28	0.54	18.06	0.00	0.00	0.95	31.67	3.00	50.35	
Garfield Bay	12	1.61	41.13	1.29	33.03	0.00	0.00	0.91	23.23	3.81	79.46	
Ellisport Bay	12	10.96	69.89	0.53	3.40	0.01	0.05	1.98	12.60	13.48	242.99	
Lake Site north	12	1.14	19.68	4.16	72.05	0.00	0.00	0.39	6.74	5.69	173.70	
Lake Site south	12	2.36	30.99	3.38	44.46	0.01	0.11	1.82	23.87	7.57	171.77	
May 16-17, 1998												
Scenic Bay	11	6.33	68.42	1.46	15.79	0.00	0.00	1.19	12.88	8.98	181.22	

Appendix Table 2.1. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total	
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m3	No./L	Biomass ^a /m3
March 20, 1998														
Scenic Bay	0.00	0.00	0.02	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.32	5.31	87.36
Idlewilde Bay	0.00	0.00	0.01	0.49	0.00	0.00	0.00	0.00	0.01	0.49	0.02	0.25	1.72	24.46
Garfield Bay	0.01	0.49	0.00	0.00	0.00	0.00	0.01	0.49	0.00	0.00	0.02	1.67	1.71	29.99
Ellisport Bay	0.01	0.67	0.03	2.67	0.00	0.00	0.00	0.00	0.06	4.67	0.10	1.73	1.25	22.67
Lake Site north	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.98	94.58
Lake Site south	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.50	86.55
April 18, 1998														
Scenic Bay	0.04	1.52	0.02	0.87	0.00	0.00	0.00	0.00	0.01	0.22	0.07	2.36	2.56	68.65
Idlewilde Bay	0.01	0.30	0.03	0.60	0.00	0.00	0.00	0.00	0.01	0.20	0.05	1.13	4.16	52.92
Garfield Bay	0.00	0.00	0.03	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.48	3.23	57.55
Ellisport Bay	0.00	0.00	0.01	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17	3.59	72.04
Lake Site south	0.00	0.00	0.01	0.22	0.01	0.22	0.00	0.00	0.00	0.00	0.02	0.57	3.74	52.15
May 9-10, 1998														
Scenic Bay	0.03	2.01	0.02	1.01	0.00	0.00	0.00	0.00	0.03	2.01	0.08	2.28	1.66	43.27
Idlewilde Bay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	50.35
Garfield Bay	0.00	0.00	0.07	1.71	0.00	0.00	0.00	0.00	0.03	0.85	0.10	1.71	3.91	81.17
Ellisport Bay	0.05	0.32	2.07	13.18	0.01	0.05	0.00	0.00	0.08	0.53	2.21	40.12	15.68	283.11
Lake Site north	0.01	0.22	0.04	0.72	0.00	0.00	0.03	0.43	0.01	0.22	0.07	6.69	5.78	180.29
Lake Site south	0.00	0.00	0.02	0.22	0.00	0.00	0.00	0.00	0.03	0.33	0.04	0.32	7.61	172.10
May 16-17, 1998														
Scenic Bay	0.01	0.09	0.17	1.85	0.00	0.00	0.05	0.54	0.04	0.41	0.27	14.59	9.25	195.83
Idlewilde Bay	0.00	0.00	0.13	0.84	0.00	0.00	0.00	0.00	0.03	0.21	0.17	2.69	15.78	325.31
Garfield Bay	0.00	0.00	0.44	1.36	0.00	0.00	0.00	0.00	0.02	0.05	0.46	8.71	32.40	690.56
Ellisport Bay	0.00	0.00	1.58	10.12	0.00	0.00	0.02	0.11	0.08	0.53	1.68	31.77	15.64	304.91
May 21-22, 1998														
Scenic Bay	0.00	0.00	0.08	0.34	0.00	0.00	0.00	0.00	0.01	0.06	0.09	1.59	21.95	248.83
Idlewilde Bay	0.01	0.04	0.05	0.22	0.00	0.00	0.00	0.00	0.01	0.03	0.07	1.47	24.12	288.20

Appendix Table 2.1. Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		Biomass/m ³
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L		
May 16-17, 1998 Cont.												
Idlewilde Bay	12	11.33	71.77	2.53	16.05	0.01	0.05	1.74	11.04	15.61	322.62	
Garfield Bay	12	29.43	90.84	1.97	6.07	0.09	0.28	0.45	1.39	31.94	681.86	
Ellisport Bay	12	12.12	77.47	0.65	4.16	0.03	0.16	1.17	7.46	13.96	273.13	
May 21-22, 1998												
Scenic Bay	24	11.26	51.31	0.43	1.94	0.01	0.04	10.17	46.34	21.86	247.25	
Idlewilde Bay	23	13.04	54.05	0.54	2.24	0.00	0.02	10.47	43.39	24.05	286.74	
Garfield Bay	24	8.18	47.72	1.18	6.88	0.00	0.00	7.37	42.95	16.73	210.12	
Ellisport Bay	24	21.84	84.65	0.54	2.10	0.05	0.19	0.49	1.92	22.93	469.69	
Lake Site north	22	2.87	23.89	2.44	20.35	0.01	0.08	6.65	55.38	11.96	149.36	
Lake Site south	24	11.52	37.36	1.87	6.07	0.00	0.00	17.41	56.49	30.80	305.07	
May 28-30, 1998												
Scenic Bay	24	10.11	82.91	0.82	6.73	0.00	0.03	0.82	6.75	11.75	235.02	
Idlewilde Bay	24	9.70	78.19	1.63	13.14	0.10	0.77	0.85	6.89	12.28	270.75	
Garfield Bay	24	12.63	82.19	0.95	6.21	0.00	0.00	0.79	5.15	14.37	290.32	
Ellisport Bay	23	21.77	65.15	0.53	1.59	0.05	0.13	1.51	4.51	23.85	467.63	
Lake Site north	24	10.89	74.55	2.27	15.54	0.01	0.06	1.22	8.41	14.40	304.24	
Lake Site south	24	11.35	80.17	1.42	10.00	0.00	0.03	1.32	9.30	14.09	282.10	
June 3-6, 1998												
Scenic Bay	24	58.45	89.05	5.10	7.77	0.09	0.14	1.61	2.46	65.27	1345.21	
Idlewilde Bay	23	39.18	89.90	2.56	5.87	0.03	0.06	1.71	3.93	43.49	871.19	
Garfield Bay	24	12.60	78.34	1.80	11.19	0.01	0.03	0.85	5.28	15.26	308.33	
Ellisport Bay	24	18.42	58.47	0.55	1.76	0.02	0.05	1.19	3.78	20.18	390.96	
Lake Site north	24	17.90	69.07	7.18	27.69	0.00	0.00	0.63	2.44	25.70	572.97	
Lake Site south	24	27.06	84.96	4.93	11.30	0.04	0.09	1.55	3.55	43.58	899.64	
June 11-13, 1998												
Scenic Bay	24	26.59	80.22	4.52	13.64	0.05	0.14	0.97	2.92	32.12	677.40	
Idlewilde Bay	23	40.89	88.64	3.25	7.05	0.03	0.05	1.66	3.59	45.82	925.37	

Appendix Table 2.1. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total	
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m3	No./L	Biomass ^a /m3
May 21-22, 1998 Cont.														
Garfield Bay	0.07	0.41	0.28	1.65	0.06	0.36	0.00	0.00	0.01	0.05	0.43	11.68	17.15	221.80
Ellisport Bay	0.04	0.16	2.76	10.70	0.03	0.12	0.00	0.00	0.04	0.16	2.87	52.03	25.80	521.72
Lake Site north	0.00	0.00	0.02	0.19	0.00	0.00	0.00	0.00	0.01	0.11	0.04	0.66	12.00	150.02
Lake Site south	0.00	0.00	0.03	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.44	30.83	305.51
May 28-30, 1998														
Scenic Bay	0.03	0.27	0.37	3.02	0.00	0.03	0.00	0.00	0.03	0.27	0.44	9.12	12.19	244.14
Idlewilde Bay	0.00	0.00	0.06	0.50	0.00	0.00	0.00	0.00	0.06	0.50	0.13	1.87	12.40	272.61
Garfield Bay	0.01	0.05	0.94	6.13	0.00	0.00	0.00	0.00	0.04	0.24	0.99	18.93	15.36	309.26
Ellisport Bay	0.14	0.43	9.31	27.87	0.00	0.01	0.02	0.05	0.09	0.26	9.56	173.69	33.42	641.32
Lake Site north	0.02	0.11	0.20	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.21	4.62	14.61	308.87
Lake Site south	0.00	0.00	0.03	0.18	0.00	0.00	0.00	0.00	0.05	0.32	0.07	1.04	14.16	282.69
June 3-6, 1998														
Scenic Bay	0.01	0.01	0.28	0.42	0.03	0.04	0.00	0.00	0.07	0.11	0.38	7.62	65.64	1352.83
Idlewilde Bay	0.03	0.06	0.07	0.16	0.01	0.01	0.00	0.00	0.00	0.00	0.11	2.88	43.59	874.07
Garfield Bay	0.01	0.03	0.78	4.87	0.00	0.00	0.00	0.00	0.05	0.31	0.84	11.36	16.10	319.69
Ellisport Bay	0.24	0.75	11.04	35.04	0.01	0.03	0.03	0.08	0.02	0.05	11.32	217.13	31.50	608.08
Lake Site north	0.07	0.27	0.14	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.21	20.03	25.91	593.00
Lake Site south	0.01	0.02	0.04	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.05	1.16	43.62	900.80
June 11-13, 1998														
Scenic Bay	0.14	0.41	0.85	2.55	0.01	0.01	0.00	0.00	0.04	0.12	1.03	22.16	33.14	699.57
Idlewilde Bay	0.06	0.12	0.24	0.52	0.01	0.01	0.00	0.00	0.01	0.02	0.31	7.08	46.13	932.45
Garfield Bay	0.02	0.04	1.96	4.93	0.01	0.01	0.01	0.01	0.02	0.04	2.00	28.10	39.65	871.52
Ellisport Bay	0.27	0.30	22.06	24.61	0.05	0.05	0.16	0.18	0.07	0.07	22.60	445.58	89.64	1812.08
Lake Site north	0.08	0.13	0.16	0.28	0.01	0.01	0.01	0.01	0.01	0.01	0.26	21.74	57.93	1320.95
Lake Site south	0.06	0.09	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.10	4.87	67.26	1444.38
June 17-20, 1998														
Scenic Bay	0.07	0.21	1.30	4.14	0.01	0.03	0.01	0.01	0.06	0.19	1.44	28.85	31.51	690.03
Idlewilde Bay	0.12	0.24	0.50	0.97	0.01	0.02	0.00	0.00	0.05	0.09	0.68	15.50	51.33	1118.80

Appendix Table 2.1. Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		Biomass/m ³
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L		
June 11-13, 1998 Cont.												
Garfield Bay	24	24.45	61.66	11.85	29.88	0.00	0.00	1.36	3.43	37.65	843.22	
Ellisport Bay	24	63.29	70.61	2.34	2.61	0.13	0.14	1.29	1.44	67.04	1366.50	
Lake Site north	25	39.64	68.43	16.71	28.85	0.04	0.06	1.29	2.22	57.68	1299.20	
Lake Site south	24	52.02	77.35	12.13	18.03	0.20	0.29	2.82	4.19	67.16	1439.52	
June 17-20, 1998												
Scenic Bay	22	21.83	69.26	7.43	23.57	0.01	0.03	0.81	2.57	30.07	661.19	
Idlewilde Bay	22	39.13	76.24	10.51	20.47	0.02	0.04	0.99	1.93	50.65	1103.30	
Garfield Bay	23	46.65	82.36	7.49	13.22	0.01	0.02	0.66	1.17	54.82	1164.54	
Ellisport Bay	23	71.45	81.35	4.31	4.91	0.01	0.02	0.82	0.93	76.59	1571.25	
Lake Site north	24	31.51	67.50	14.18	30.36	0.01	0.01	0.77	1.65	46.46	1054.97	
Lake Site south	24	42.47	63.35	23.42	34.93	0.00	0.00	0.96	1.43	66.85	1548.25	
June 24-26, 1998												
Scenic Bay	24	82.10	69.67	32.04	27.19	0.01	0.01	0.88	0.74	115.03	2603.76	
Idlewilde Bay	24	103.46	70.45	40.00	27.24	0.03	0.02	1.02	0.70	144.52	3273.10	
Garfield Bay	24	37.09	65.25	17.60	30.96	0.01	0.02	0.47	0.82	55.18	1270.01	
Ellisport Bay	23	45.71	89.97	2.52	4.95	0.01	0.01	0.39	0.76	48.61	997.29	
Lake Site north	23	36.18	51.49	33.15	47.18	0.01	0.01	0.70	0.99	70.04	1709.73	
Lake Site south	24	39.82	64.64	20.85	33.85	0.01	0.01	0.60	0.98	61.28	1420.22	
July 2-3, 1998												
Scenic Bay	24	24.56	56.18	7.84	17.73	0.03	0.08	0.50	1.13	32.93	804.93	
Idlewilde Bay	23	17.89	65.42	5.57	20.37	0.08	0.28	0.14	0.52	23.68	590.14	
Garfield Bay	23	19.13	74.11	4.03	15.60	0.24	0.93	0.40	1.55	23.80	594.16	
Ellisport Bay	24	19.23	64.15	7.35	24.54	0.07	0.22	0.72	2.41	27.37	676.08	
Lake Site north	24	20.97	51.41	18.49	45.34	0.10	0.26	0.86	2.10	40.42	1081.33	
Lake Site south	23	60.52	66.70	28.51	31.41	0.13	0.15	0.50	0.55	89.66	2288.95	
July 9-10, 1998												
Scenic Bay	24	9.37	54.56	2.75	16.00	0.03	0.15	0.33	1.89	12.46	301.09	

Appendix Table 21. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total	
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m ³	No./L	Biomass ^a /m ³
June 17-20, 1998 Cont.														
Garfield Bay	0.25	0.43	1.45	2.56	0.02	0.04	0.01	0.02	0.10	0.18	1.83	34.79	56.65	1199.33
Ellisport Bay	1.03	1.17	9.89	11.27	0.11	0.12	0.10	0.11	0.12	0.13	11.24	27.76	87.83	1598.99
Lake Site north	0.12	0.25	0.08	0.17	0.02	0.04	0.00	0.00	0.01	0.02	0.23	23.63	46.69	1078.60
Lake Site south	0.05	0.07	0.14	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.19	5.67	67.04	1553.93
June 24-25, 1998														
Scenic Bay	0.21	0.18	2.52	2.14	0.05	0.04	0.00	0.00	0.04	0.03	2.82	58.15	117.85	2661.91
Idlewilde Bay	0.32	0.22	1.91	1.30	0.02	0.01	0.00	0.00	0.09	0.06	2.33	49.63	146.86	3322.73
Garfield Bay	0.07	0.13	1.43	2.51	0.02	0.03	0.01	0.01	0.15	0.27	1.67	25.91	56.85	1295.91
Ellisport Bay	0.52	1.03	1.22	2.39	0.27	0.53	0.08	0.16	0.10	0.20	2.19	86.36	50.80	1083.65
Lake Site north	0.19	0.26	0.04	0.06	0.00	0.00	0.00	0.00	0.01	0.01	0.23	26.14	70.27	1735.87
Lake Site south	0.25	0.40	0.02	0.03	0.01	0.01	0.00	0.00	0.05	0.08	0.33	18.22	61.61	1438.45
July 2-3, 1998														
Scenic Bay	0.93	2.13	9.68	22.14	0.07	0.15	0.01	0.01	0.11	0.26	10.79	285.95	43.72	1090.89
Idlewilde Bay	1.12	4.08	2.39	8.73	0.14	0.51	0.00	0.00	0.02	0.09	3.66	103.48	27.35	693.63
Garfield Bay	0.42	1.64	1.47	5.70	0.06	0.23	0.01	0.02	0.06	0.22	2.02	39.26	25.82	633.41
Ellisport Bay	0.42	1.39	1.93	6.45	0.10	0.33	0.08	0.26	0.08	0.25	2.60	69.96	29.97	746.04
Lake Site north	0.21	0.51	0.08	0.18	0.07	0.17	0.00	0.00	0.01	0.03	0.37	15.62	40.79	1096.95
Lake Site south	0.67	0.73	0.33	0.37	0.07	0.08	0.00	0.00	0.01	0.01	1.08	41.92	90.74	2330.88
July 9-10, 1998														
Scenic Bay	3.06	17.84	1.57	9.15	0.05	0.29	0.01	0.02	0.02	0.10	4.70	186.89	17.17	487.98
Idlewilde Bay	3.62	8.41	1.69	3.92	0.21	0.48	0.00	0.00	0.01	0.01	5.53	230.63	43.11	1172.36
Garfield Bay	0.86	3.36	8.70	34.10	0.26	1.03	0.00	0.00	0.06	0.23	9.88	69.78	25.53	437.18
Ellisport Bay	1.18	4.44	3.81	14.31	0.11	0.41	0.13	0.47	0.02	0.06	5.25	143.59	26.64	631.66
Lake Site north	0.57	1.16	0.20	0.41	0.07	0.14	0.00	0.00	0.01	0.01	0.84	35.61	48.66	1336.34
Lake Site south	1.93	2.82	0.50	0.73	0.32	0.46	0.01	0.02	0.00	0.00	2.75	119.61	68.37	1855.23
August 23-24, 1998														
Scenic Bay	1.74	17.73	0.67	6.85	0.29	2.93	0.00	0.00	0.01	0.05	2.70	206.94	9.80	566.27
Idlewilde Bay	1.50	11.01	1.61	11.80	0.33	2.42	0.01	0.03	0.04	0.31	3.48	192.38	13.63	600.80

Appendix Table 2.1. Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		Biomass ^a /m ³
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	
July 9-10, 1998 Cont.												
Idlewilde Bay	25	26.75	62.07	10.43	24.20	0.06	0.14	0.34	0.79	37.58	941.73	
Garfield Bay	24	12.40	48.59	2.63	10.28	0.04	0.16	0.58	2.25	15.65	367.40	
Ellisport Bay	24	17.70	66.43	2.90	10.90	0.01	0.02	0.79	2.96	21.39	488.07	
Lake Site north	24	21.43	44.04	25.36	52.12	0.02	0.04	1.01	2.07	47.82	1300.72	
Lake Site south	24	37.18	54.38	27.58	40.34	0.10	0.15	0.75	1.10	65.61	1735.62	
August 23-24, 1998												
Scenic Bay	22	1.73	17.66	4.82	49.21	0.45	4.58	0.10	0.99	7.10	359.32	
Idlewilde Bay	24	4.82	35.37	4.86	35.67	0.30	2.20	0.17	1.22	10.15	408.42	
Garfield Bay	22	5.29	29.69	4.75	26.68	0.09	0.51	2.01	11.30	12.15	380.96	
Ellisport Bay	14	7.72	39.99	4.94	25.60	0.03	0.16	0.53	2.76	13.23	436.38	
Lake Site north	24	8.97	46.26	4.32	22.30	0.10	0.53	0.33	1.69	13.72	444.40	
Lake Site south	19	12.98	45.47	7.90	27.69	0.11	0.39	0.20	0.69	21.19	721.48	
September 12-13, 1998												
Scenic Bay	22	1.64	20.72	1.36	17.17	0.19	2.38	0.23	2.90	3.42	123.99	
Idlewilde Bay	24	2.57	20.57	3.03	24.23	0.35	2.80	0.15	1.20	6.10	232.62	
Garfield Bay	24	3.10	22.95	4.48	33.17	0.27	1.98	1.06	7.88	8.90	296.39	
Ellisport Bay	24	4.18	31.30	4.10	30.70	0.13	0.94	0.87	6.50	9.26	285.48	
Lake Site north	24	9.88	46.91	4.07	19.34	0.09	0.44	1.30	6.20	15.34	432.05	
Lake Site south	24	9.71	54.45	3.71	20.82	0.18	0.98	0.25	1.40	13.85	414.58	
October 17-18, 1998												
Scenic Bay	24	6.91	56.97	1.72	14.18	0.26	2.16	0.28	2.27	9.17	345.77	
Idlewilde Bay	24	6.45	63.28	2.60	25.53	0.20	1.96	0.13	1.23	9.38	378.57	
Garfield Bay	24	7.16	52.24	1.96	14.30	0.59	4.29	0.33	2.40	10.04	419.97	
Ellisport Bay	24	16.28	61.37	1.63	6.13	0.06	0.22	1.00	3.77	18.96	571.44	
Lake Site north	24	8.95	60.54	4.24	28.66	0.09	0.62	0.32	2.14	13.60	885.76	
Lake Site south	24	7.15	63.57	2.88	25.55	0.10	0.85	0.17	1.52	10.30	398.76	

Appendix Table 2.1. Cont.

Date and Location	<i>Daphnia</i>		<i>Bosmina</i>		<i>Diaphanasoma</i>		<i>Leptodora</i>		<i>Chydorus</i>		Total Cladoceran		Overall Total	
	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	% total	No./L	Biomass ^a /m ³	No./L	Biomass ^a /m ³
August 23-24, 1998 Cont.														
Garfield Bay	1.27	7.12	3.82	21.46	0.53	2.95	0.04	0.24	0.01	0.06	5.67	186.72	17.82	567.19
Ellisport Bay	2.16	11.19	2.88	14.92	1.00	5.16	0.03	0.13	0.02	0.11	6.16	292.99	19.31	729.25
Lake Site north	3.80	19.58	0.59	3.05	1.28	6.60	0.00	0.00	0.01	0.05	5.60	438.50	19.40	882.90
Lake Site south	3.45	12.08	0.71	2.49	2.84	9.94	0.05	0.19	0.31	1.09	7.36	479.37	28.55	1200.86
September 12-13, 1998														
Scenic Bay	0.42	5.34	4.00	50.53	0.08	1.00	0.00	0.00	0.00	0.00	4.50	97.09	7.91	221.09
Idlewilde Bay	0.24	1.90	5.58	44.63	0.34	2.70	0.00	0.00	0.25	1.97	6.40	130.00	12.50	362.62
Garfield Bay	0.27	1.98	3.85	28.54	0.45	3.30	0.02	0.15	0.01	0.06	4.59	104.35	13.49	400.74
Ellisport Bay	0.75	5.62	2.53	18.96	0.71	5.31	0.08	0.56	0.02	0.12	4.08	158.89	13.34	444.36
Lake Site north	1.21	5.74	3.75	17.81	0.75	3.56	0.01	0.04	0.00	0.00	5.72	207.32	21.06	639.37
Lake Site south	0.27	1.50	3.11	17.43	0.60	3.34	0.00	0.00	0.01	0.07	3.98	114.15	17.83	528.74
October 17-18, 1998														
Scenic Bay	0.25	2.06	1.85	15.21	0.87	7.14	0.00	0.00	0.00	0.00	2.96	87.69	12.13	433.46
Idlewilde Bay	0.10	0.94	0.22	2.17	0.50	4.86	0.00	0.00	0.01	0.04	0.82	35.93	10.20	414.50
Garfield Bay	0.13	0.96	3.11	22.66	0.44	3.18	0.00	0.00	0.00	0.00	3.67	81.60	13.71	501.57
Ellisport Bay	0.50	1.89	6.07	22.88	0.93	3.49	0.01	0.03	0.06	0.24	7.56	181.79	26.52	753.22
Lake Site north	0.16	1.13	0.06	0.39	0.96	6.51	0.00	0.00	0.00	0.00	1.19	61.69	14.78	683.28
Lake Site south	0.05	0.41	0.15	1.41	0.75	6.70	0.00	0.00	0.00	0.00	0.96	43.19	11.25	441.95
November 22, 1998														
Scenic Bay	0.00	0.00	0.15	3.41	0.01	0.42	0.00	0.00	0.00	0.00	0.16	3.83	3.41	113.96
Idlewilde Bay	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	0.85	35.95
Garfield Bay	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.02	1.06	7.25	268.71
Ellisport Bay	0.03	0.00	0.05	0.01	0.01	0.00	0.00	0.00	0.05	0.01	0.13	4.00	9.63	322.48
Lake Site north	0.00	0.00	0.00	0.00	.05	0.01	0.00	0.00	0.00	0.00	0.05	2.34	8.87	302.57
Lake Site south	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.48	2.27	83.64

Appendix Table 2.1. Cont.

Date and Location	N	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Epischura</i>		Nauplii		Total Copepods		Biomass ^a /m ³
		#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	#/L	%Total	
November 22, 1998												
Scenic Bay	24	1.95	57.10	1.14	33.38	0.04	1.10	0.13	3.91	3.25	110.13	
Idlewilde Bay	23	0.26	31.16	0.55	64.79	0.00	0.00	0.02	2.47	0.84	35.56	
Garfield Bay	24	3.44	47.44	3.58	49.34	0.00	0.00	0.21	2.87	7.23	267.66	
Ellisport Bay	24	5.50	57.16	3.67	38.12	0.00	0.00	0.32	3.33	9.50	318.48	
Lake Site north	24	5.11	57.63	3.48	39.22	0.01	0.06	0.23	2.57	8.82	300.24	
Lake Site south	24	1.12	49.27	1.10	48.35	0.00	0.00	0.04	1.84	2.25	83.16	

Appendix Table 2.2. Results (F value and probability>F) from statistical analysis of mean monthly zooplankton density differences among depth strata.

Year	Month	F Value	Pr>F
1997	June	2.94	0.0350
	July	5.76	0.0009
	August	4.61	0.0041
	September	0.62	0.6013
	October	3.46	0.0179
	November	1.44	0.2327
	December	0.18	0.9081
1998	January	0.09	0.9663
	February	0.11	0.9570
	March	0.06	0.9801
	April	0.06	0.9815
	May	1.23	0.3014
	June	53.14	0.0001
	July	13.05	0.0001
	August	2.39	0.0709
	September	2.29	0.0803
	October	3.27	0.0228
	November	0.50	0.6808

Appendix Table 2.3. Estimated lengths of the four most abundant zooplankters in Lake Pend Oreille, 1997-1998.

Month and Location	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Daphnia</i>		<i>Bosmina</i>	
	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)
June, 1997								
Scenic Bay							10	0.35 \pm (0.059)
Idlewilde Bay							8	0.29 \pm (0.061)
Garfield Bay					1	1.30	18	0.35 \pm (0.043)
Ellisport Bay					1	0.90	360	0.28 \pm (0.010)
Lake Site north								
Lake Site south							1	0.35
July, 1997								
Scenic Bay	1333	0.57 \pm (0.012)	1227	0.66 \pm (0.016)	23	0.75 \pm (0.213)	402	0.32 \pm (0.010)
Idlewilde Bay	791	0.58 \pm (0.016)	731	0.66 \pm (0.020)	24	0.78 \pm (0.200)	243	0.32 \pm (0.013)
Garfield Bay	740	0.55 \pm (0.019)	605	0.65 \pm (0.024)	39	0.80 \pm (0.081)	385	0.32 \pm (0.011)
Ellisport Bay	544	0.56 \pm (0.021)	444	0.68 \pm (0.042)	242	0.89 \pm (0.060)	532	0.32 \pm (0.013)
Lake Site north	399	0.60 \pm (0.025)	400	0.72 \pm (0.023)	13	0.72 \pm (0.255)	68	0.31 \pm (0.026)
Lake Site south	994	0.58 \pm (0.007)	965	0.79 \pm (0.103)	5	0.70 \pm (1.058)	101	0.32 \pm (0.021)
August, 1997								
Scenic Bay	1692	0.61 \pm (0.028)	1528	0.82 \pm (0.064)	1068	0.90 \pm (0.027)	1172	0.31 \pm (0.012)
Idlewilde Bay	1040	0.55 \pm (0.013)	900	0.76 \pm (0.021)	640	0.90 \pm (0.034)	610	0.31 \pm (0.009)
Garfield Bay	740	0.55 \pm (0.019)	912	0.76 \pm (0.024)	685	0.84 \pm (0.036)	508	0.30 \pm (0.009)
Ellisport Bay	1127	0.52 \pm (0.013)	615	0.65 \pm (0.029)	857	0.85 \pm (0.030)	308	0.31 \pm (0.019)
Lake Site north	399	0.60 \pm (0.014)	975	0.77 \pm (0.019)	633	0.88 \pm (0.035)	173	0.32 \pm (0.018)
Lake Site south	1128	0.57 \pm (0.014)	965	0.79 \pm (0.017)	584	0.92 \pm (0.039)	132	0.35 \pm (0.020)
September, 1997								
Scenic Bay	1240	0.58 \pm (0.031)	895	0.77 \pm (0.020)	669	1.04 \pm (0.039)	103	0.33 \pm (0.022)
Idlewilde Bay	720	0.55 \pm (0.015)	572	0.79 \pm (0.024)	445	1.06 \pm (0.045)	187	0.32 \pm (0.021)
Garfield Bay	780	0.52 \pm (0.014)	459	0.76 \pm (0.031)	410	0.95 \pm (0.043)	292	0.32 \pm (0.013)
Ellisport Bay	645	0.51 \pm (0.021)	312	0.73 \pm (0.040)	346	0.92 \pm (0.053)	491	0.34 \pm (0.014)

Appendix Table 2.3. Cont.

Month and Location	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Daphnia</i>		<i>Bosmina</i>	
	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)
September, 1997 Cont.								
Lake Site north	993	0.53 \pm (0.013)	500	0.78 \pm (0.024)	409	1.02 \pm (0.049)	47	0.34 \pm (0.036)
Lake Site south	986	0.55 \pm (0.017)	785	0.79 \pm (0.022)	436	1.08 \pm (0.045)	60	0.36 \pm (0.030)
October, 1997								
Scenic Bay	1572	0.59 \pm (0.011)	893	0.85 \pm (0.018)	2	0.98 \pm (4.139)	247	0.33 \pm (0.014)
Idlewilde Bay	948	0.58 \pm (0.015)	450	0.84 \pm (0.023)			65	0.32 \pm (0.026)
Garfield Bay	867	0.58 \pm (0.016)	567	0.86 \pm (0.023)	5	0.87 \pm (0.409)	230	0.39 \pm (0.023)
Ellisport Bay	866	0.56 \pm (0.017)	262	0.91 \pm (0.025)	15	0.72 \pm (0.593)	339	0.34 \pm (0.013)
Lake Site north	900	0.59 \pm (0.016)	756	0.88 \pm (0.017)	6	0.71 \pm (0.940)	128	0.37 \pm (0.027)
Lake Site south	1312	0.57 \pm (0.012)	695	0.84 \pm (0.018)	14	0.52 \pm (0.188)	37	0.35 \pm (0.013)
November, 1997								
Scenic Bay	831	0.56 \pm (0.016)	620	0.78 \pm (0.020)			1	0.48
Idlewilde Bay	532	0.54 \pm (0.017)	428	0.77 \pm (0.027)				
Garfield Bay	665	0.59 \pm (0.019)	500	0.84 \pm (0.025)	1	0.75		
Ellisport Bay	830	0.58 \pm (0.016)	346	0.79 \pm (0.038)			30	0.41 \pm (0.045)
Lake Site north	864	0.56 \pm (0.014)	630	0.79 \pm (0.020)			5	0.39 \pm (0.159)
Lake Site south	522	0.54 \pm (0.017)	385	0.77 \pm (0.025)			1	0.26
December, 1997								
Scenic Bay	724	0.57 \pm (0.012)	724	0.66 \pm (0.023)				
Idlewilde Bay	490	0.56 \pm (0.017)	444	0.66 \pm (0.028)				
Garfield Bay	220	0.55 \pm (0.028)	173	0.63 \pm (0.047)	1	0.75		
Ellisport Bay	204	0.58 \pm (0.028)	190	0.79 \pm (0.039)				
Lake Site north	194	0.61 \pm (0.025)	45	0.75 \pm (0.105)				
Lake Site south	516	0.57 \pm (0.017)	473	0.66 \pm (0.028)			1	0.52

Appendix Table 2.3. Cont.

Month and Location	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Daphnia</i>		<i>Bosmina</i>	
	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)
April, 1998 Cont.								
Lake Site north								
Lake Site south								
May, 1998								
Scenic Bay	1145	0.56 \pm (0.015)	337	0.74 \pm (0.037)	6	0.73 \pm (0.450)	75	0.37 \pm (0.040)
Idlewilde Bay							29	0.35 \pm (0.045)
Garfield Bay					3	0.89 \pm (2.869)	1364	0.37 \pm (0.016)
Ellisport Bay					10	0.74 \pm (0.227)	381	0.36 \pm (0.011)
Lake Site north					3	0.60 \pm (0.187)	92	0.38 \pm (0.049)
Lake Site south							9	0.36 \pm (0.355)
June, 1998								
Scenic Bay	2241	0.58 \pm (0.013)	1376	0.69 \pm (0.020)	27	0.70 \pm (0.136)	427	0.36 \pm (0.013)
Idlewilde Bay					66	0.78 \pm (0.105)	295	0.34 \pm (0.105)
Garfield Bay					76	0.68 \pm (0.073)	887	0.31 \pm (0.012)
Ellisport Bay					324	0.88 \pm (0.068)	1144	0.36 \pm (0.014)
Lake Site north					54	0.80 \pm (0.081)	84	0.34 \pm (0.027)
Lake Site south					30	0.94 \pm (0.200)	81	0.34 \pm (0.028)
July, 1998								
Scenic Bay	573	0.61 \pm (0.017)	348	0.71 \pm (0.034)	204	0.74 \pm (0.045)	271	0.41 \pm (0.032)
Idlewilde Bay					386	0.81 \pm (0.063)	473	0.33 \pm (0.010)
Garfield Bay					123	0.76 \pm (0.065)	485	0.32 \pm (0.015)
Ellisport Bay					111	0.78 \pm (0.107)	1144	0.36 \pm (0.014)
Lake Site north					128	0.76 \pm (0.076)	42	0.40 \pm (0.093)
Lake Site south					304	0.76 \pm (0.043)	134	0.33 \pm (0.019)

Appendix Table 2.3. Cont.

Month and Location	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Daphnia</i>		<i>Bosmina</i>	
	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)
August, 1998								
Scenic Bay	143	0.64 \pm (0.028)	163	0.64 \pm (0.042)	94	1.24 \pm (0.074)	78	0.32 \pm (0.017)
Idlewilde Bay					132	1.21 \pm (0.059)	62	0.32 \pm (0.021)
Garfield Bay					178	1.05 \pm (0.071)	338	0.31 \pm (0.021)
Ellisport Bay					97	1.13 \pm (0.066)	87	0.32 \pm (0.013)
Lake Site north					150	1.17 \pm (0.087)	49	0.33 \pm (0.037)
Lake Site south					108	1.12 \pm (0.067)	36	0.32 \pm (0.022)
September, 1998								
Scenic Bay	157	0.59 \pm (0.044)	145	0.74 \pm (0.133)	5	1.07 \pm (0.439)	333	0.35 \pm (0.011)
Idlewilde Bay					56	1.41 \pm (0.179)	352	0.33 \pm (0.012)
Garfield Bay					39	1.05 \pm (0.157)	280	0.31 \pm (0.010)
Ellisport Bay					171	1.10 \pm (0.050)	367	0.30 \pm (0.013)
Lake Site north					266	1.11 \pm (0.098)	510	0.32 \pm (0.012)
Lake Site south					93	1.26 \pm (0.112)	539	0.33 \pm (0.012)
October, 1998								
Scenic Bay	529	0.70 \pm (0.032)	359	0.92 \pm (0.038)	56	0.87 \pm (0.159)	287	0.34 \pm (0.017)
Idlewilde Bay					29	0.99 \pm (0.210)	65	0.34 \pm (0.021)
Garfield Bay					34	0.91 \pm (0.052)	211	0.34 \pm (0.015)
Ellisport Bay					100	0.86 \pm (0.118)	172	0.35 \pm (0.012)
Lake Site north					36	0.97 \pm (2.426)	3	0.30 \pm (0.152)
Lake Site south					13	0.95 \pm (0.449)	36	0.39 \pm (0.013)
November, 1998								
Scenic Bay	321	0.62 \pm (0.025)	205	0.86 \pm (0.036)			32	0.40 \pm (0.022)
Idlewilde Bay								
Garfield Bay								
Ellisport Bay					5	1.33 \pm (0.212)	9	0.38 \pm (0.048)

Appendix Table 2.3. Cont.

Month and Location	<i>Cyclops</i>		<i>Diaptomus</i>		<i>Daphnia</i>		<i>Bosmina</i>	
	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)	N	Length \pm (CI)

November, 1998 Cont.

Lake Site north

Lake Site south

Appendix Table 3.1. Weekly variation in percent of empty stomachs and condition factor for age-0 kokanee captured in Lake Pend Oreille in May and June, 1998.

Week	Number Sampled	%Empty Stomachs	Condition Factor \pm (SE) ^a
5/21 to 5/30	3	66.70	.590 \pm (.0138)
5/31 to 6/6	15	53.3	.618 \pm (.0157)
6/7 to 6/13	74	40.5	.620 \pm (.0066)
6/14 to 6/20	142	23.2	.613 \pm (.0061)
6/21 to 6/28	82	14.6	.617 \pm (.0890)

^aSE indicates one standard error.

Appendix Table 3.2. Capture date, total length (mm), blotted wet weight (g), Fulton condition factor (K), and prey biomass (μg) in the stomachs of individual age-0 kokanee sampled from Lake Pend Oreille in May and June, 1998.

Capture Date	Total Length	Weight	Condition Factor	Prey Biomass
5/21/98	23	0.0692	0.5688	590.86
5/30/98	24	0.0811	0.5867	0.00
5/30/98	24	0.0852	0.6163	0.00
6/1/98	23	0.0762	0.6263	29.93
6/1/98	26	0.1153	0.6560	38.64
6/1/98	25	0.1197	0.7660	1175.89
6/2/98	24	0.0873	0.6315	0.00
6/2/98	22	0.0599	0.5625	464.37
6/2/98	23	0.0745	0.6123	0.00
6/2/98	24	0.0822	0.5946	0.00
6/2/98	25	0.0937	0.5997	0.00
6/2/98	24	0.0782	0.5657	29.93
6/2/98	24	0.0719	0.5201	486.59
6/4/98	22	0.0660	0.6198	0.00
6/4/98	24	0.0944	0.6829	0.00
6/4/98	22	0.0687	0.6451	0.00
6/4/98	23	0.0815	0.6698	0.00
6/4/98	25	0.0893	0.5715	2764.91
6/8/98	21	0.0598	0.6457	329.23
6/11/98	20	0.0546	0.6825	0.00
6/11/98	21	0.0575	0.6209	0.00
6/11/98	23	0.0644	0.5293	149.65
6/11/98	22	0.0689	0.6471	89.79
6/11/98	23	0.0697	0.5729	0.00
6/11/98	21	0.0701	0.7570	0.00
6/11/98	23	0.0706	0.5803	0.00
6/11/98	23	0.0728	0.5983	589.37
6/11/98	23	0.0738	0.6066	149.65
6/11/98	24	0.0753	0.5447	389.09
6/11/98	24	0.0802	0.5802	0.00
6/11/98	23	0.0809	0.6649	0.00
6/11/98	24	0.0814	0.5888	0.00
6/11/98	23	0.0827	0.6797	0.00
6/11/98	24	0.0827	0.5982	0.00
6/11/98	25	0.1090	0.6976	2148.16
6/11/98	25	0.1127	0.7213	2505.82
6/11/98	23	0.0617	0.5071	666.17
6/11/98	22	0.0796	0.7476	0.00
6/11/98	23	0.0798	0.6559	2149.65
6/11/98	23	0.0817	0.6715	2785.31
6/11/98	23	0.0832	0.6838	0.00
6/11/98	24	0.0852	0.6163	0.00
6/11/98	25	0.0872	0.5581	0.00
6/11/98	23	0.0872	0.7167	0.00
6/11/98	24	0.0954	0.6901	0.00
6/11/98				0.00
6/13/98	23	0.0829	0.6814	0.00

Appendix Table 3.2. Cont.

Capture Date	Total Length	Weight	Condition Factor	Prey Biomass
6/13/98	25	0.0887	0.5677	2641.55
6/13/98	22	0.0494	0.4640	0.00
6/13/98	21	0.0574	0.6198	0.00
6/13/98	22	0.0641	0.6020	478.88
6/13/98	22	0.0675	0.6339	1709.56
6/13/98	24	0.0690	0.4991	1795.8
6/13/98	22	0.0695	0.6527	389.09
6/13/98	22	0.0704	0.6612	0.00
6/13/98	23	0.0717	0.5893	0.00
6/13/98	23	0.0722	0.5934	0.00
6/13/98	23	0.0731	0.6008	0.00
6/13/98	23	0.0752	0.6181	0.00
6/13/98	24	0.0796	0.5758	3479.59
6/13/98	24	0.0831	0.6011	1354.56
6/13/98	24	0.0851	0.6156	2567.18
6/13/98	24	0.0877	0.6344	0.00
6/13/98	25	0.0947	0.6061	1826.64
6/13/98	24	0.0989	0.7154	0.00
6/13/98	25	0.0992	0.6349	2102.81
6/13/98	22	0.0640	0.6011	0.00
6/13/98	23	0.0644	0.5293	1436.64
6/13/98	22	0.0658	0.6180	1286.99
6/13/98	22	0.0669	0.6283	2934.05
6/13/98	25	0.0798	0.6559	3053.77
6/13/98	23	0.0815	0.6698	779.09
6/13/98	24	0.0854	0.6178	29.93
6/13/98	25	0.0864	0.5530	4190.20
6/13/98	25	0.0918	0.5875	3272.72
6/13/98	24	0.0927	0.6706	2828.84
6/13/98	24	0.0934	0.6756	5111.23
6/13/98	25	0.0936	0.5990	2687.81
6/13/98	23	0.0687	0.5646	0.00
6/13/98	23	0.0708	0.5819	239.44
6/13/98	23	0.0710	0.5835	119.72
6/13/98	23	0.0722	0.5934	0.00
6/13/98	23	0.0783	0.6435	2448.95
6/13/98	24	0.0795	0.5751	1773.58
6/13/98	23	0.0809	0.6649	0.00
6/13/98	24	0.0817	0.5910	0.00
6/13/98	24	0.0829	0.5997	0.00
6/13/98	24	0.0872	0.7167	867.97
6/13/98	23	0.0872	0.7167	29.93
6/13/98	25	0.0921	0.5894	3907.23
6/13/98	25	0.0929	0.5946	4029.93
6/13/98	25	0.0963	0.6163	2581.69
6/13/98	25	0.1009	0.6976	0.00
6/13/98	25	0.1095	0.7008	2029.93
6/13/98	30	0.1896	0.7022	2311.82
6/14/98	24	0.0640	0.4630	404.51
6/14/98	22	0.0672	0.6311	755.96
6/14/98	22	0.0695	0.6527	0.00
6/14/98	22	0.0732	0.6875	0.00
6/14/98	23	0.0761	0.6254	1242.55
6/14/98	24	0.0788	0.5700	1969.49

Appendix Table 3.2. Cont.

Capture Datete	Total Length	Weight	Condition Factor	Prey Biomass
6/14/98h	25	0.1000	0.6400	3310.69
6/14/98	26	0.1101	0.6264	2763.09
6/14/98	22	0.0611	0.5738	127.43
6/14/98	23	0.0776	0.6378	2627.95
6/14/98	23	0.0797	0.6551	160.00
6/14/98	24	0.0798	0.5773	935.54
6/14/98	24	0.0813	0.5881	1505.12
6/14/98	25	0.0817	0.5229	748.25
6/14/98	24	0.0851	0.6156	1706.92
6/14/98	24	0.0859	0.6214	187.29
6/14/98	24	0.0950	0.6872	2133.65
6/14/98	25	0.0967	0.6189	2364.47
6/16/98	22	0.0624	0.5860	0.00
6/16/98	22	0.0649	0.6295	0.00
6/16/98	23	0.0674	0.5540	0.00
6/16/98	24	0.0674	0.4876	508.81
6/16/98	22	0.0683	0.6414	97.50
6/16/98	24	0.0733	0.5302	966.38
6/16/98	23	0.0777	0.6386	0.00
6/16/98	24	0.0792	0.5729	1257.06
6/16/98	24	0.0819	0.5924	0.00
6/16/98	24	0.0841	0.6084	1692.50
6/16/98	25	0.0854	0.5466	2821.13
6/16/98	25	0.0856	0.5478	2610.53
6/16/98	25	0.0943	0.6035	1308.62
6/16/98	24	0.0947	0.6850	0.00
6/16/98	26	0.1062	0.6042	3311.27
6/16/98	28	0.1338	0.6095	1183.6
6/16/98	31	0.2363	0.7931	7295.61
6/16/98	23	0.0773	0.6353	0.00
6/16/98	24	0.0774	0.5598	778.18
6/16/98	24	0.0881	0.6372	1974.79
6/16/98	25	0.0987	0.6317	1203.41
6/16/98	26	0.1229	0.6992	3043.06
6/16/98	26	0.1253	0.7129	3451.57
6/16/98	23	0.0523	0.4298	89.79
6/16/98	24	0.0650	0.4702	1061.47
6/16/98	24	0.0697	0.5042	1354.56
6/16/98	23	0.0697	0.5729	1092.9
6/16/98	23	0.0701	0.5761	0.00
6/16/98	26	0.0750	0.4267	420.83
6/16/98	24	0.0795	0.5751	2424.33
6/16/98	25	0.0873	0.5587	1549.56
6/16/98	28	0.1685	0.7676	1765.87
	29	0.1784	0.7315	8171.7
6/16/98				883.39
6/16/98	22	0.0589	0.5532	0.00
6/18/98	23	0.0678	0.5572	973.18
6/18/98	22	0.0704	0.6611	0.00
6/18/98	24	0.0740	0.5353	149.65
6/18/98	27	0.1427	0.7250	6000.00
6/18/98	27	0.1526	0.7753	6742.87
6/18/98	23	0.0720	0.5918	0.00
6/18/98	24	0.0805	0.5823	1489.70
6/18/98	24	0.0914	0.6612	1280.19
6/18/98	23	0.0924	0.7594	1986.64
6/18/98	26	0.0992	0.5644	2858.77
6/18/98	23	0.0717	0.5893	0.00
6/18/98	23	0.0823	0.6764	0.00

Appendix Table 3.2. Cont.

Capture Date	Total Length	Weight	Condition Factor	Prey Biomass
6/18/98a	23	0.0866	0.7118	29.93
6/18/98	23	0.0690	0.5671	0.00
6/18/98	24	0.0727	0.5259	2454.26
6/18/98	23	0.0701	0.5761	0.00
6/19/98	23	0.0716	0.5885	2895.82
6/19/98	23	0.0768	0.6312	0.00
6/19/98	22	0.0617	0.5794	0.00
6/19/98	24	0.0756	0.5469	718.32
6/19/98	23	0.0820	0.6740	0.00
6/19/98	25	0.1030	0.6592	3452.39
6/19/98	24	0.0790	0.5715	0.00
6/19/98	25	0.0886	0.5670	1160.47
6/19/98	25	0.1201	0.7686	2890.52
6/19/98	30	0.1928	0.7141	6067.57
6/19/98	24	0.0874	0.6322	3158.98
6/19/98	24	0.0920	0.6655	1573.78
6/19/98	25	0.0984	0.6298	5558.75
6/19/98	29	0.1732	0.7102	10312.65
6/19/98	31	0.2346	0.7875	9492.61
6/19/98	22	0.0568	0.5334	598.60
6/19/98	22	0.0658	0.6180	29.93
6/19/98	23	0.0695	0.5712	0.00
6/19/98	22	0.0696	0.6536	0.00
6/19/98	23	0.0697	0.5729	0.00
6/19/98	23	0.0728	0.5983	0.00
6/19/98	23	0.0759	0.6238	0.00
6/19/98	25	0.0945	0.6048	1423.04
6/19/98	22	0.0598	0.5616	2003.81
6/19/98	24	0.0676	0.4890	2711.74
6/19/98	23	0.0748	0.6148	4601.17
6/19/98	24	0.0769	0.5563	89.79
6/19/98	25	0.0797	0.5101	4458.60
6/19/98	25	0.0818	0.5235	1893.30
6/19/98	25	0.0867	0.5549	2617.83
6/19/98	25	0.0938	0.6003	4369.23
6/19/98	26	0.0952	0.5416	0.00
6/19/98	26	0.0971	0.5525	3176.32
6/19/98	27	0.1240	0.6300	4683.84
6/19/98	31	0.2318	0.7781	3115.18
6/19/98	23	0.0665	0.5466	269.37
6/19/98	23	0.0718	0.5901	29.93
6/19/98	23	0.0773	0.6353	2478.19
6/19/98	25	0.0889	0.5690	2677.69
6/19/98	25	0.1101	0.7046	4245.56
6/19/98	24	0.0725	0.5244	29.93
6/19/98	23	0.0767	0.6304	0.00
6/19/98	24	0.0869	0.6286	2073.20
6/19/98	26	0.1155	0.6571	2502.01
6/19/98	23	0.0773	0.6353	2478.19
6/20/98	24	0.0924	0.6684	88.29
6/20/98	25	0.0943	0.6035	4020.15
6/20/98	25	0.1002	0.6413	3560.17
6/20/98	26	0.1036	0.5894	2449.86
6/20/98	25	0.1192	0.7629	6435.86
6/20/98	22	0.0687	0.6452	0.00
6/20/98	23	0.0758	0.6230	0.00
6/20/98	24	0.0764	0.5527	718.32
6/20/98	23	0.0789	0.6485	0.00
6/20/98	24	0.0828	0.5990	2950.37

Appendix Table 3.2. Cont.

Capture Date	Total Length	Weight	Condition Factor	Prey Biomass
6/20/98b	26	0.1124	0.6395	2628.18
6/20/98	24	0.0700	0.5264	0.00
6/20/98	25	0.0888	0.5683	862.08
6/20/98	25	0.0898	0.5747	2110.52
6/20/98	23	0.0705	0.5794	2818.13
6/20/98	23	0.0753	0.6189	1691.50
6/20/98	23	0.0775	0.6370	2664.68
6/20/98	24	0.0817	0.5910	2933.03
6/20/98	24	0.0865	0.6257	584.09
6/20/98	27	0.1598	0.8119	5317.83
6/20/98				966.38
6/20/98	25	0.1131	0.7238	3210.63
6/20/98	24	0.0984	0.7118	3175.20
6/20/98	29	0.1898	0.7782	9135.25
6/20/98	22	0.0573	0.5381	0.00
6/23/98	23	0.0626	0.5145	0.00
6/23/98	24	0.0778	0.5629	0.00
6/23/98	25	0.0818	0.5235	666.17
6/23/98	28	0.1539	0.7011	2662.48
6/23/98				3087.12
6/23/98	26	0.1090	0.6202	353.16
6/23/98	28	0.1635	0.7448	3123.85
6/23/98	24	0.0822	0.5946	2638.07
6/23/98	32	0.2422	0.7391	8706.61
6/23/98	25	0.0773	0.4947	2614.83
6/23/98	24	0.0741	0.5360	3235.35
6/23/98	24	0.0694	0.5020	2446.76
6/23/98	22	0.0571	0.5363	0.00
6/23/98	22	0.0609	0.5719	823.53
6/23/98	22	0.0661	0.6208	0.00
6/23/98	23	0.0815	0.6682	2000.00
6/23/98	24	0.0816	0.5903	0.00
6/23/98	24	0.0858	0.6207	875.68
6/23/98				696.27
6/23/98	23	0.0873	0.7175	1703.01
6/23/98	22	0.0544	0.5109	0.00
6/23/98	22	0.0584	0.5485	389.09
6/23/98	24	0.0655	0.4738	1269.69
6/23/98	23	0.0759	0.6238	0.00
6/23/98	23	0.0765	0.6288	29.93
6/23/98	23	0.0829	0.6814	1229.85
6/23/98	23	0.0835	0.6863	59.86
6/23/98	24	0.0860	0.6221	763.67
6/23/98	25	0.0861	0.5510	29.93
6/23/98	25	0.0923	0.5907	2374.86
6/23/98	24	0.0930	0.6727	1719.93
6/23/98	26	0.1209	0.6879	1865.19
6/23/98	26	0.1216	0.6918	2281.80
6/23/98	26	0.1271	0.7231	2096.92
6/23/98	27	0.1542	0.7834	4457.97
6/23/98	22	0.0633	0.5945	29.93
6/23/98	24	0.0970	0.7017	3158.98
6/23/98	25	0.0902	0.5773	4407.58
6/23/98	23	0.0750	0.6164	0.00
6/23/98	26	0.1433	0.8153	3745.37
6/23/98	34	0.3276	0.8335	4089.79
6/23/98	24	0.0806	0.5830	2089.62
6/23/98	24	0.0746	0.5396	209.51
6/24/98	26	0.0750	0.4267	269.37

Appendix Table 3.2. Cont.

Capture Date	Total Length	Weight	Condition Factor	Prey Biomass
6/24/98	25	0.0790	0.5056	2473.41
6/24/98	25	0.0800	0.5120	2433.86
6/24/98	24	0.0849	0.6141	2505.82
6/24/98	25	0.0979	0.6266	4338.67
6/24/98	26	0.1060	0.6031	16611.15
	0.0887			
6/24/98	25	0.093	0.5952	2733.05
6/24/98	26	0.1204	0.6850	4967.83
6/24/98	28	0.1249	0.5690	6000.00
6/24/98	28	0.1373	0.6255	8030.37
6/24/98	27	0.1416	0.7194	4205.24
6/24/98	30	0.1693	0.6270	2521.45
6/24/98	24	0.0892	0.653	0.00
6/24/98	26	0.1109	0.6310	5362.39
6/24/98	25	0.0865	0.5536	2966.2
	0.0892			
6/24/98	26	0.1088	0.6190	6416.57
6/24/98	28	0.1555	0.7084	14029.93
6/24/98	24	0.0913	0.6604	0.00
6/24/98	25	0.0762	0.4877	3186.01
6/24/98	25	0.0961	0.6150	3232.38
6/24/98	23	0.0662	0.5441	2544.18
6/24/98	24	0.0869	0.6286	0.00
6/24/98	25	0.0901	0.5766	97.50
6/24/98	24	0.0873	0.6315	1903.13
6/24/98	26	0.1046	0.5951	3889.23
6/24/98	23	0.0897	0.7372	5099.05
6/24/98	24	0.0779	0.5635	1001.02
6/24/98	27	0.1191	0.6051	4661.20
6/24/98	25	0.0731	0.4678	119.72
6/27/98	23	0.0813	0.6682	4083.32
6/27/98	24	0.0859	0.6214	1385.40
6/27/98	24	0.0910	0.6583	3046.06
6/27/98	25	0.1037	0.6637	2155.87
6/27/98	28	0.1535	0.6993	2179.00
6/27/98				1436.64
6/27/98	24	0.0824	0.5961	5263.54
6/27/98	32	0.2240	0.6836	8338.42
6/28/98	25	0.1046	0.6694	5537.05
6/28/98	24	0.0852	0.6163	2619.64

Appendix Table 3.3. Percent of each food type to the total food items eaten (%N), percent wet biomass to the total mass of food items eaten (%M), and frequency of occurrence (FO) for age-0 kokanee captured in Lake Pend Oreille in May and June, 1998.

Prey Item	5/21 to 5/30 (n=3)			5/31 to 6/6 (n=15)			6/7 to 6/13 (n=75)			6/14 to 6/20 (n=144)			6/21 to 6/28 (n=85)		
	(%N)	(%M)	(FO)	(%N)	(%M)	(FO)	(%N)	(%M)	(FO)	(%N)	(%M)	(FO)	(%N)	(%M)	(FO)
<i>Daphnia spp.</i> ^a							0.09	0.23	2.67	1.54	3.37	19.31	5.32	11.14	48.24
<i>Bosmina</i>				0.64	0.68	6.67	0.05	0.05	1.33	0.12	0.12	4.83	0.28	0.26	10.59
<i>Diaphanasoma</i>													0.06	0.13	3.53
<i>Leptodora</i>															
<i>Chydorus</i>													0.02	0.02	1.18
<i>Cyclops</i>	100.00	100.00	33.33	82.80	68.42	26.67	95.79	80.86	57.33	91.24	66.81	73.79	88.43	62.06	83.53
<i>Diaptomus</i>				16.56	30.90	20.00	2.76	5.27	26.67	6.01	9.88	56.55	6.00	9.74	64.71
<i>Epischura</i>							0.18	0.82	4.00	0.08	0.30	3.45	0.02	0.08	1.18
nauplii										0.06	0.001	2.76	0.12	0.003	5.88
<i>Mysis</i>							0.23	12.78	5.33	0.39	19.45	8.28	0.34	16.56	7.06

^a *Daphnia thorata* and *D. galeata mendotae*.

Appendix Table 3.4. Prey selectivity index values for individual zooplankton species. Zooplankton sampling and age-0 kokanee capture were conducted in Scenic and Idlewilde bays, Lake Pend Oreille.

Zooplankton Sampling Dates	Kokanee Capture Dates	<i>Selectivity Index^a</i>								
		<i>Daphnia spp.</i> ^b	<i>Bosmina</i>	<i>Diaphanasoma</i>	<i>Leptodora</i>	<i>Chydorus</i>	<i>Diaptomus</i>	<i>Cyclops</i>	<i>Epischura</i>	nauplii
5/30/98	5/21 to 5/30/98	-0.001	-0.006	0	0	-0.003	-0.116	0.199	-0.004	-0.067
6/6/98	6/1 to 6/8/98	0.000	0.003	0.000	0	0.000	0.083	-0.056	-0.001	-0.029
6/12/98	6/11 to 6/14/98	-0.002	-0.017	0.000	0	0.000	-0.059	0.108	0.000	-0.033
6/17 ^c & 6/20 ^d	6/16 to 6/20/98	0.016	-0.011	0.000	0	0.000	-0.166	0.174	0.000	-0.018
6/26/98	6/23 to 6/28/98	0.002	0.028	0.000	0	0.000	0.264	0.695	0.000	0.007

^a Selectivity Index values range from -1 to 1 (Strauss 1979). Table values of 0.000 indicate results < 0.001.

^b *Daphnia thorata* and *D. galeata mendotae*.

^c Samples collected in Scenic Bay.

^d Samples collected in Idlewilde Bay.