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MEASUREMENT OF LAKE ROOSEVELT BIOTA IN RELATION TO RESERVOIR OPERATIONS

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ABSTRACT

The purpose of this study was to collect biological data from Lake Roosevelt to be used in the design of a computer model that would predict biological responses to reservoir operations as part of the System Operation Review program. Major components of the Lake Roosevelt model included: Quantification of impacts to phytoplankton, zooplanktons, benthic invertebrates, and fish caused by reservoir drawdowns and low water retention times; quantification of number, distribution, and use of fish food organisms in the reservoir by season; determination of seasonal growth of fish species as related to reservoir operations, prey abundance and utilization; and quantification of entrainment levels of zooplankton and fish as related to reservoir operations and water retention times.

This report summarized the data collected on Lake Roosevelt for 1991 and includes limnological, zooplankton, benthic macroinvertebrate, fishery, and reservoir operation data. Discussions cover reservoir operation affect upon zooplankton, benthic macroinvertebrates, and fish.

Reservoir operations brought reservoir elevations to a low of 1221.7 in April, the result of power operations and a flood control shift from Dworshak Dam, in Idaho, to Grand Coulee Dam. Water retention times were correspondingly low reaching a minimum of 14.7 days on April 27th.

Zooplankton density and biomass levels were the lowest seen in Lake Roosevelt after 3.5 years of study, and were lower than levels reported in 1982 by Beckman (1985). High densities of zooplankton were found in the lower end of the reservoir supporting the hypothesis that low water retention times entrain zooplankton through the reservoir.

Benthic macroinvertebrate data was collected from July to October of 1991 and showed high recolonization rates of benthic macroinvertebrates in dewatered areas. Results did not find low densities in dewatered areas vs non-exposed areas as found by other researchers. Data collected for an entire year would be more beneficial in determining densities at different reservoir levels.

Fish growth in 1991 showed overall decreases in length, weight and condition factors for kokanee, rainbow and walleye. While improved data collection is needed to sort out seasonal differences in growth, current data indicated that reservoir operations have not provided sufficient forage base for the target species hence the decline in growth.

Entrainment data showed that low water retention times in the spring increase the entrainment levels of rainbow trout. An additional influence on entrainment levels may be a smoltification type process the rainbow undergo in the spring. Tag returns from summer releases found decreased entrainment levels while having similar water retention times as spring months.

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1.0 INTRODUCTION

The purpose of this research project is to collect data to model resident fish requirements for Lake Roosevelt as part of the BPA, Bureau of Reclamation, and U.S. Army Corps of Engineer's System Operation Review. The System Operation Review is a tri-agency team functioning to review the use and partitioning of Columbia Basin waters. User groups of the Columbia River System have been defined as power, irrigation, flood control, anadromous fish, resident fish, wildlife, recreation, water quality, navigation, and cultural resources.

Once completed the model will predict biological responses to different reservoir operation strategies. The model being developed for resident fish is based on Montana Department of Fish, Wildlife, and Parks model for resident fish requirements within Hungry Horse and Libby Reservoirs. While the Montana model predicts fish growth based on the impacts of reservoir operation and flow conditions on primary and secondary production levels, the Lake Roosevelt model will also factor in the affects of water retention time on phytoplankton levels, zooplankton production levels, and fish entrainment. Major components of the Lake Roosevelt model include: Quantification of impacts to phytoplankton, zoopiankton, benthic invertebrates, and fish caused by reservoir drawdowns and low water retention times; 2) quantification of number, distribution, and use of fish food organisms in the reservoir by season; 3) determination of seasonal growth of fish species as related to reservoir operations, prey abundance, and utilization; and, 4) quantification of entrainment levels of zooplankton and fish as related to reservoir operations and water retention times.

In July 1991, BPA entered into a contract with the Spokane Indian Tribe to initiate the System Operation Review process with continued research through 1995. The SOR project is a modification of the Lake Roosevelt Monitoring Project contract with Bonneville that studies the affects of kokanee reintroduction into Lake Roosevelt. This report contains the results of the resident fish system operation review program for Lake Roosevelt from January to December 1992.

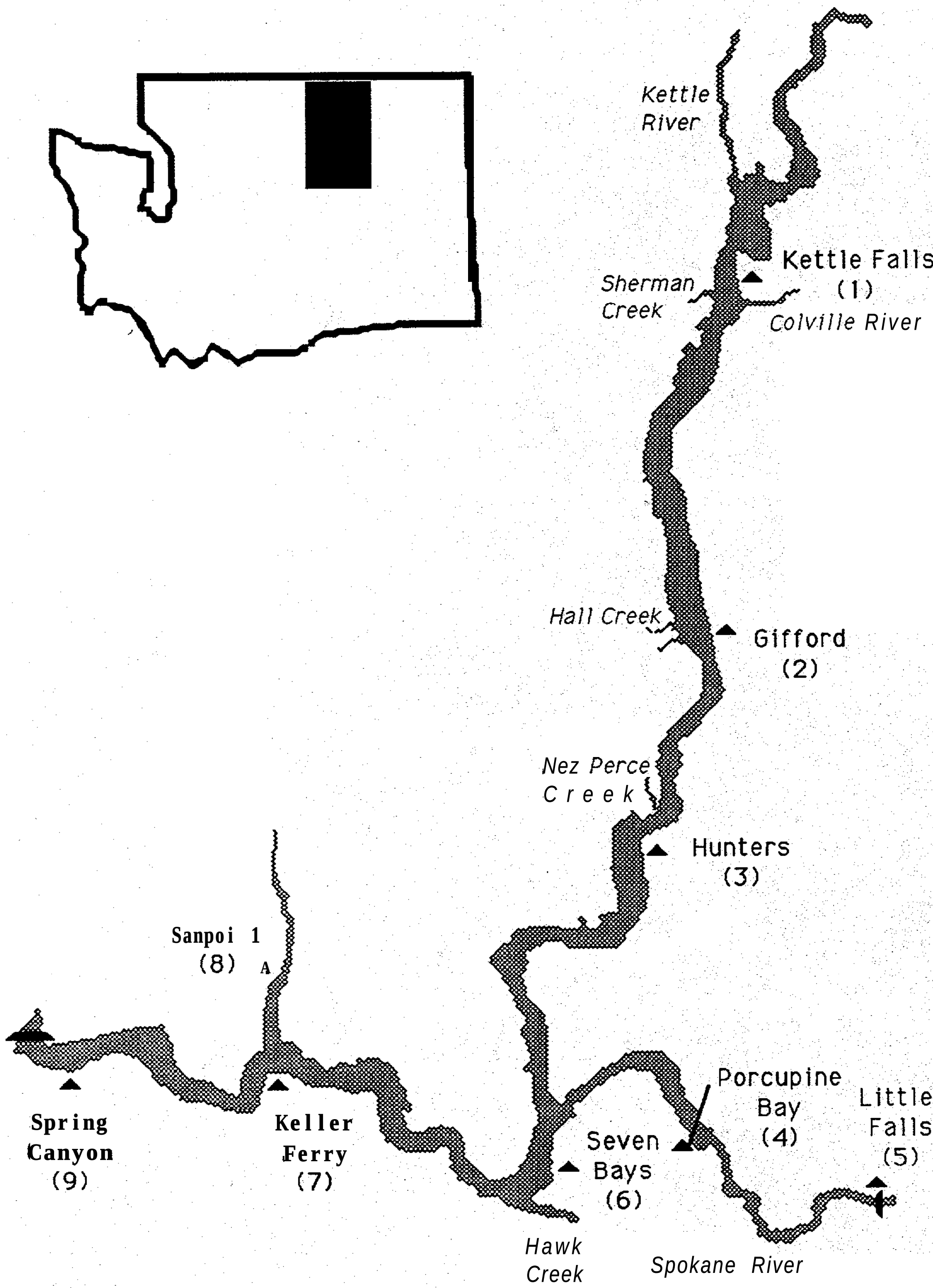

Figure 1.1.1 Lake Roosevelt, Washington and the nine sampling stations used for data collection.

1.1 DESCRIPTION OF STUDY AREA

Lake Roosevelt is a mainstem Columbia River impoundment formed by the construction of Grand Coulee Dam in 1939 (Figure 1.1.1). Filled in 1941, the reservoir inundated 33,490 hectares at a full pool elevation of 393 m above mean sea level. It has a maximum width of 3.4 km and a maximum depth of 122 m (Stober et *al.* 1981). Grand Coulee Dam is a Bureau of Reclamation storage project operated primarily for power, flood control, and irrigation with secondary operations for recreation, fish, and wildlife.

1.2 STUDY OBJECTIVES - 1991

The objectives of the project were to determine how reservoir operations affect reservoir biology:

#1. Development of surface area vs. elevation and volume vs elevation tables to calculate wetted bottom at each elevation;

#2. Determination of reservoir hydrology, downstream flow constraints and how these affect reservoir operations:

#3. Collection of temperature profile data to develop a longitudinal thermal structure in the forebay of Lake Roosevelt;

#4. Collection of light penetration data at four sites to describe annual shifts in euphotic zone depth and light availability for photosynthetic use at depth intervals;

#5. Determination of carbon fixation levels of phytoplankton using a C^{14} liquid scintillation technique at Gifford (site 2), Porcupine Bay (site 4), Seven Bays (site 6), and Spring Canyon (site 9). Concurrently collect solar input data using a recording light meter;

#6. Determine zooplankton biomass, density, vertical distribution, and entrainment;

#7. Determine benthic macroinvertebrate production levels and densities at differing reservoir strata;

#8. Determine benthic insect emergence levels at differing reservoir strata;

#9. Determine terrestrial insect deposition levels at differing reservoir strata;

#10. Determination of target species seasonal feeding habits, and utilization of zooplankton, benthic macroinvertebrates, terrestrial insects, and other fish in relation to prey abundance in reservoir;

#11. Determination of target species growth based upon backcalculations as related to seasonal food habits, seasonal food availability, and seasonal temperatures;

#12. Determination of entrainment levels via placement of coded wire and floy tags in target species, and a reservoir wide creel survey of Rufus Woods Reservoir to determine entrainment levels of rainbow and kokanee salmon from Lake Roosevelt.

2.0 MATERIALS AND' METHODS

2.1 RESERVOIR ELEVATION AND WATER RETENTION

Reservoir elevation and water retention time were calculated by obtaining daily midnight reservoir elevation (ft) and total outflow (kcfs) from daily summary reports for Grand Coulee Dam prepared monthly in 1991 by the U.S. Army Corps of Engineers, Reservoir Control Center in Portland, OR. Reservoir elevation (ft) was converted to volume of water stored (kcfsd) using a. U.S. Army Corps of Engineers (1981) reservoir water storage table. Water retention time was calculated using the formula:

$$\text{Water retention time (days)} = \frac{\text{Reservoir volume (kcfsd)}}{\text{Outflow (kcfs)}}$$

Mean reservoir elevation and water retention time for the month were calculated by adding the daily values for each category and dividing by the number of days in each month.

2.2 ZOOPLANKTON SURVEYS

Zooplankton samples were collected mid-channel at Location 2 (Gifford), Location 4 (Porcupine Bay), Location 6 (Seven Bays), and Location 9 (Spring Canyon) monthly and at each index station in May, August, and October in 1991 (Figure 2.2.1). Samples were taken using a Wisconsin vertical tow plankton net with an 8C µm silk net and bucket. Duplicate tows were made from 25-33 m to the surface at each location. Organisms were washed into a 253 ml bottle containing 10 ml of 37% formaldehyde and 0.5 g sugar (Rigler 1978). Organisms were stained with 1 .0 ml of five percent Lugol's solution and 1 .O ml of saturated eosin-y ethanol stain.

In the lab, zooplankton were identified to species using taxonomic keys of Brandlova et *al.* (1972), Brooks (1957), Edmondson (1959), Pennak (1978;1989), Ruttner-Kolisko (1974), and Stemberger (1979). A Nikon SMZ-10 dissecting microscope with a ring illuminator system and Nikon Optiphot phase contrast microscope were used for identification. Three sub-samples were counted using a modified counting chamber (Ward 1955) until 100 organisms or 25 ml of sample had been counted (Edmondson and Winberg 1971, Downing and Rigler 1984). Volume of rub-sample was dependant upon organism density in the sample.

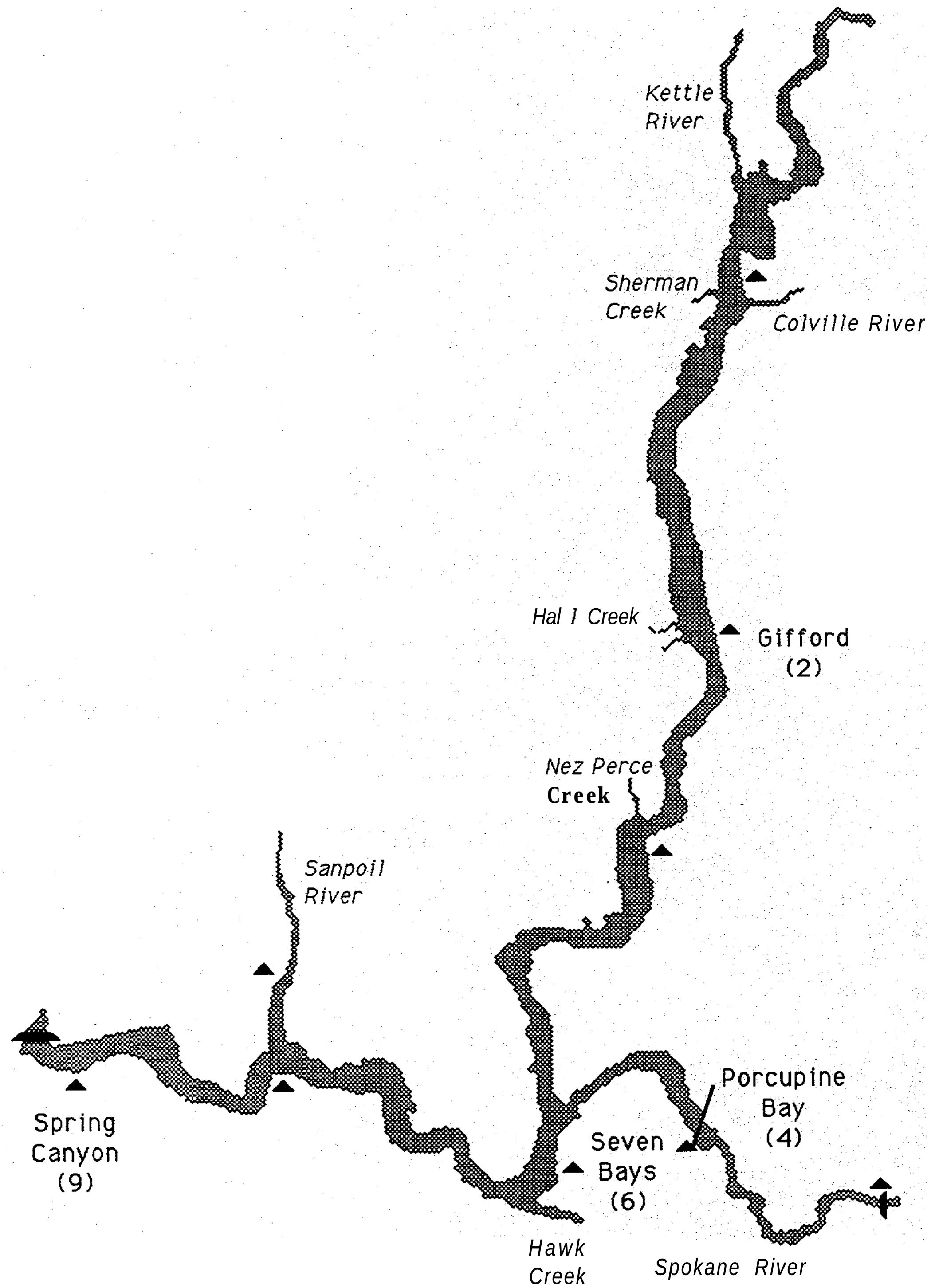

Figure 2.2.1 Lake Roosevelt, WA indicating location of four index stations used for zooplankton.

Species counts in each sub-sample were recorded in Microsoft Excel on a Macintosh SE computer. Density (# organisms/m^3) was calculated in the program using the following sets of equations. Volume of the sample collected by the Wisconsin plankton sampler was calculated using the following formula:

$$v = \Pi r^2 h$$

where:

V = volume of the sample;
Π = pi (3.414);
r^2 = radius of sampler; and
h = depth of sample.

Microcrustacean zooplankton density (# organisms/m^3) was calculated using the following calculation:

$$D = \frac{\left(\frac{Tc}{Sn} x \frac{SV}{SSV}\right)}{V} DF^{*}1000$$

where:
D = density (# organisms/m^3) ;
Sn = number of sub-samples;
sv = sample volume;
SSV = sub-sample volume;
v = volume of entire sample;
DF = dilution factor; and
Tc = total number counted of each species of organisms.

Predominant cladocerans were randomly chosen and measured from the top ‘of the head to the base of the carapace, excluding the spine. Cladocera biomass was determined using length-weight regression equations summarized by Downing and Rigler (1984). The formula used to calculate dry weight estimate was:

$$\ln w = \ln a + (b)(\ln L)$$

where:

ln w = natural log of the dry weight estimate (μg) for the Cladocera species;

$\ln a$ = natural log of the intercept for the Cladocera species;

b = slope value for the Cladocera species; and

$\ln L$ = natural log of the mean length value of the Cladocera species.

The following slope (b) and intercept ($\ln$ a) values were used with the dry weight estimate calculation:

Cladocera Species	In a	b
Daphnia ambigua	1.54	2.29
Daphnia *galeata* mendotae	1.51	2.56
Daphnia retrocurva	1.4322	3.129
Daphnia *schødleri*	2.30	3.10
Daphnia *thora* ta	2.64	2.54
Leptodora kindti	-0.822	2.670

Cladocera biomass was calculated using the formula:

$$B = (\ln w)(D)$$

where:

B = biomass ($\mu g/m^3$);

$\ln w$ = log of the dry weight estimate for the Cladocera species (μg); and

D = density (# organisms/m^3).

2.3 BENTHIC MACROINVERTEBRATE DENSITY

Quantitative samples of benthic macroinvertebrates were collected using a Ponar dredge with an opening of 0.053 m2. Benthos were collected from July through October at index stations 2 (Gifford), 4 (Porcupine Bay), 6 (Seven Bays), and 9 (Spring Canyon) (see Figure 2.2.1). Three replicate samples were taken from each of the following reservoir elevations at each station: Area 1 below elevation 1210 ft, Area 2 1240 to 1211 ft, and Area 3 1290 ft (full pool) to 1241 ft.

Benthic samples were sub-sampled by stirring the grab mixture and allowing it to settle. Top water was poured through a series of U.S. Standard sieves measuring 4 mm, 2 mm, and 0.5 mm. Material remaining on the final screen was retained and preserved in 10% formalin solution, labeled “top water”, and later transferred to 70% alcohol. The remaining grab was weighed. If weight of the remaining sample was less than 1 kg the entire sample was filtered through the sieves and preserved, if the sample was greater than 1 kg three sub-samples of 10% by weight were taken. Each sub-sample was filtered through the series of sieves, labeled accordingly, and preserved in the same manner.

Organisms were sorted, identified to family using the taxonomic keys of Brooks (1957), Ward and Whipple (1966), Borror et al. (1976), Ruttner-Kolisko (1974), Edmonds et al. (1976), Wiggins (1977), Pennak (1978;1989), and Merritt and Cummins (1984).

Dry weights were obtained by drying sorted organisms in an oven at 105° for 24 hours and weighing them on a Sartorius Model H51 analytical balance to the nearest 0.0001 g (Weber 1973, APHA 1976).

Number and weight values obtained were converted to density and expressed as number/m2 and grams/m^2. Number and weight density values were averaged for each season to obtain seasonal means and seasonal percent occurrence. Mean seasonal data were averaged to obtain unbiased annual means.

2.4 FISHERIES SURVEYS

2.4.1 Field Collection

Fishery samples were collected in May, August, and October 1991 at nine index stations in the reservoir, which included: 1. Kettle Falls; 2. Gifford; 3. Hunters; 4. Porcupine Bay; 5. Little Falls Dam; 6. Seven Bays; 7. Keller Ferry; 8. Sanpoil, and 9. Spring Canyon (Figure 2.4.1). Fishery data was collected at each index station over 24 hour periods broken down into morning, afternoon, and night stratum. Principle target species included kokanee salmon, rainbow trout, and walleye, although all fish were captured in proportion to their abundance.

2.4.2 Relative Abundance

Relative abundance surveys were performed in littoral areas and tributaries by electrofishing 10 minute transects along 0.5 km

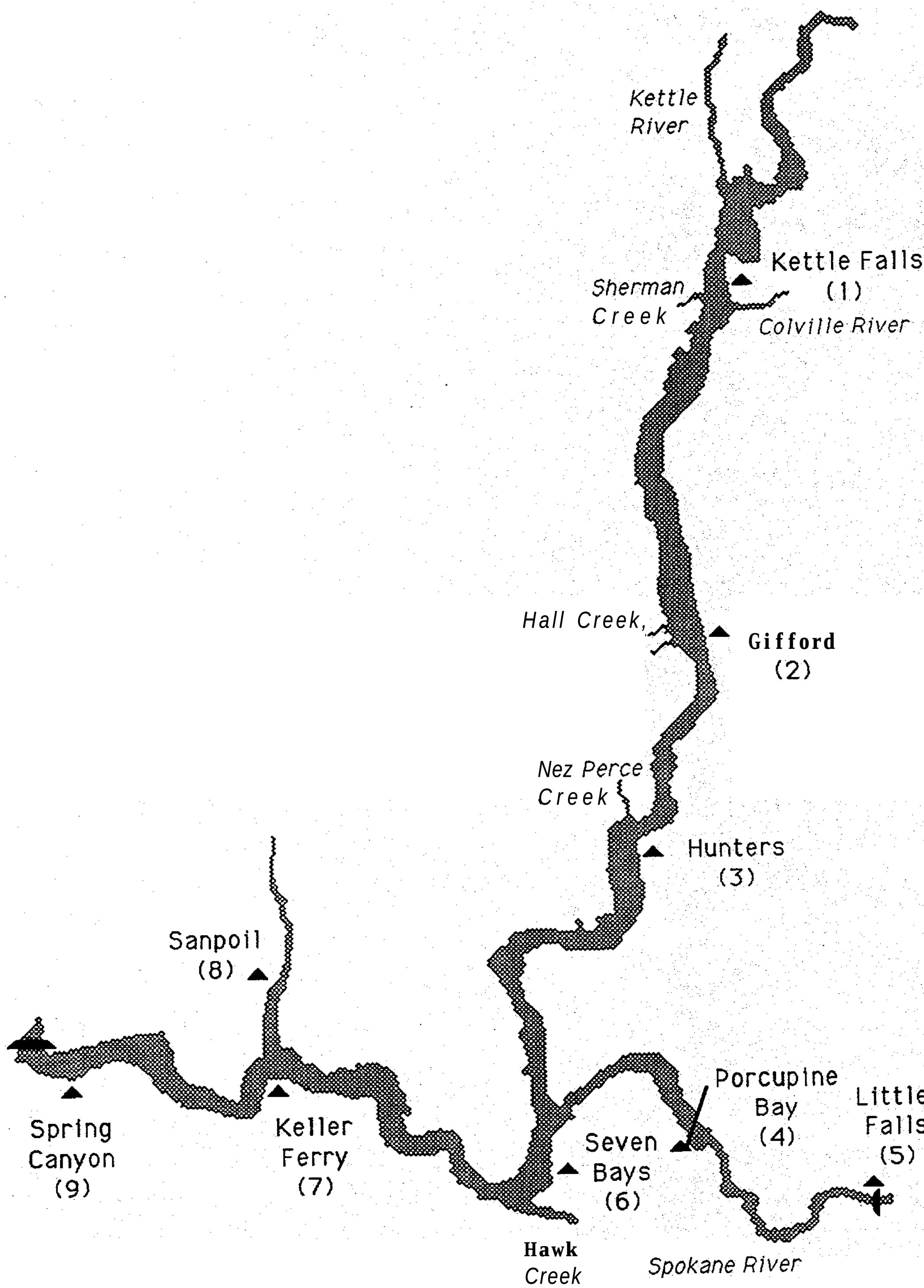

Figure 2.4.1 Lake Roosevelt, WA indicating location of nine index stations used for fisheries surveys.

of shoreline using a SR-23 electrofishing boat (Smith Root, Inc., Vancouver, WA) according to procedures outlined by Reynolds (1983) and Novotany and Prigel (1974). Voltage was adjusted to produce a pulsating DC current of approximately 5 amperes. Fish were collected using dip nets and placed into live wells on the boat for examination and data collection. A minimum of two 10 minute transects were performed during morning, afternoon, and night stratum.

Additional relative abundance surveys were performed in pelagic zones with bottom and surface monofilament gillnets using methodologies described by Hubert (1983). The following gillnets were used: two horizontal surface set gillnets measuring 61 m in length by 6.1 m deep, with four 15.2 m long panels graded from 1.3 to 7.6 cm stretch mesh; and two horizontal bottom set gillnets measuring 61 m in length by 6.1 m deep, with four 15.2 m long panels graded from 1.3 to 8.9 cm stretch mesh. Gillnets were set from early afternoon (2:00 p.m.), checked at sunset, and pulled at 10:00 p.m. Nets were managed this way to collect fresh fish for stomach samples.

Fish captured were identified to species using the taxonomic key of Wydoski and Whitney (1979). Total lengths were measured to the nearest millimeter using a metric measuring board and scale samples were removed from target fish species to determine age and growth. Target species were weighed to the nearest gram using an electronic balance. Sexes were determined when possible. Stomach samples were collected from representative sizes of target species. Remaining fish were marked with floy tags and released.

2.4.3 Diet Analysis

Fish stomachs were collected from kokanee, rainbow and walleye at each index station in May, August, and October 1991. Additional kokanee stomachs were obtained by creel clerks from anglers throughout the year. Stomachs from representative sizes of fish were collected by making an incision into the body cavity, cutting the esophagus, and pinching pyloric sphincter. The esophagus was clamped to keep prey items from being expelled and the stomach placed in 10% formalin.

In the lab, stomachs were transferred to a 70% isopropyl alcohol solution. Contents were identified to family for benthic macroinvertebrates and to species for zooplankton using the taxonomic keys of Brooks (1957), Ward and Whipple (1966), Borror et *al.* (1976), Ruttner-Kolisko (1974), Edmonds et *al.* (1976), Wiggins (1977), Pennak (1978;1989), and Merritt and Cummins (1984).

Food organisms were identified using a Nikon SMZ-1 B dissecting microscope equipped with a fiber optics illumination system and 5 mm ocular micrometer.

Stomachs containing large numbers of zooplankton were sub-sampled or counted, depending on diversity of prey organisms. Sub-samples were made by diluting zooplankton contents to 100 ml in a beaker, stirring contents to uniformity, and collecting three 2 ml samples with a calibrated pipet. The following formula was used to determine the total number of a particular zooplankton species:

$$\text{Total No.} = \frac{\sum_{n=1}^{3}\left(\frac{Dv}{Sv} \times Tn\right)}{3}$$

where:

Dv = total diluted volume (100 ml);
Sv = total sub-sample volume (2 ml); and
Tn = total number of zooplankton in the sub-sample.

Length measurements of randomly chosen Cladocera were made from the top of the head to the base of the carapace, excluding the spine. This permitted calculation of electivity indices.

Sorted stomach contents were dry weighted in the same manner used for benthic dry weights (Section 2.3).

Number and Weight Indices

Numerical and weight frequencies of prey items (± standard deviation) were obtained for each age class of target species collected during each sampling season to obtain seasonal mean values. Unidentifiable prey items and organic detritus were discarded and non-measurable trace amounts of food items. were given the value of 0.0001 grams for calculating percentages by weight.

Seasonal mean data were combined to obtain unbiased estimates of annual average number and weight, percent composition by number and weight, frequency of occurrence, and index of relative importance for each age class of target species.

Index of Relative Importance (IRI)

Index of relative importance was used to compensate for numerical estimate biases that tend to overemphasize small prey groups consumed in large numbers and weight estimate biases that overemphasize large prey items consumed in small numbers (Bowen 1983). The index of relative importance (George and Hadley 1979) was calculated using the formula:

$$RIa = \frac{100AI_a}{\sum_{a=1}^{n} AI_a}$$

where:

RIa = relative importance of food item .a;
AIa = absolute importance of food item a (Le., frequency of occurrence + numerical frequency + weight frequency of food item a); and
n = number of different food types.

Relative importance values range from zero to 100% with prey items near zero being relatively less important than those prey items near one hundred percent.

2.4.4 Electivity Index

The electivity index is a method of measuring the degree of selection that a fish has for a particular prey item compared to the availability of the same prey item in the environment (Ivlev 1961). Data obtained seasonally from zooplankton, benthic and relative abundance surveys were used to compute electivity indices for different prey items found in the stomachs of kokanee, rainbow trout, and walleye (Strauss 1979). The electivity index was calculated using the formula:

$$L = r_i - P_i$$

where:

L = measure of food selection;
r_i = relative abundance of prey i in the gut; and
P_i = relative abundance of same prey i in the environment.

Food selection values range from +1.0 to -1.0. Values near zero indicate fish are feeding on a prey item in relation to its abundance, or randomly. Positive values indicate fish are selecting that prey item and negative values indicate fish are not utilizing that prey item.

Advantages of using this index are: it is not biased by unequal sample sizes, and extreme values are obtained only when a prey item is very abundant in the environment and rare in the diet or when a prey item is rare in the environment and very abundant in the diet (Strauss 1979).

2.4.5 AGE DETERMINATION, BACK-CALCULATION, AND CONDITION

In the field, scales were taken from appropriate locations for each species as described by Jearld (I 983) and placed in coin envelopes labeled with fish number, length, weight, location, date, and specie for later analysis. In the laboratory, back-calculation measurements and age class of each fish were determined simultaneously. To obtain data, scales were removed from the envelope and placed between two microscope slides. Slides were then placed in a Realist Vantage 5, Model 3315 microfiche reader which projected scale images onto the screen. A non-regenerated, uniform scale was selected to determine age and back-calculation using the following procedures:

1. Age was determined by counting the number of annuli (Jearld 1983).

2. Backcalculation measurements were determined using a T-square metric ruler.

a. Scale length was determined by placing the 0 mm mark at the center of the focus with the T perpendicular to the longitudinal axis of the scale.

b. Annulus distance was measured from the same origin to the last circuli of each annulus with the T square in the same position.

Each measurement was made under constant magnification to the nearest millimeter.

Capture length, scale length, and length of each annulus of all fish of same species were entered into StatView 512 (Brainpower 1986) on the Apple Macintosh SE computer for linear regression calculations. Lee's back-calculation method was used to determine the length of the fish at the formation of each annulus. (Carlander 1950;1981, Hile 1970).

Back-calculations were computed using the formula:

$$L_i = a + \left(\frac{L_c - a}{S_c}\right) S_i$$

where:

L_i	=	length of fish (in mm) at each annulus formation;
a	=	intercept of the body-scale regression line;
L_c	=	length of fish (in mm) at time of capture;
S_c	=	distance (in mm) from the focus to the edge of the scale; and
S_i	=	scale measurement to each annulus.

Age, size, and measurements used for back-calculations for each target species are listed. in Appendix D.

Condition factors were determined for each fish to serve as an indicator of fish condition (Hile 1970, Everhart and Youngs 1981). Condition factor describes how a fish adds weight in relation to incremental changes in length. The relationship is shown by the formula:

$$K_{TL} = \left(\frac{W}{L^3}\right)10^5$$

where:

K_{TL} = condition factor;
w = weight of fish (g); and
L = total length of fish (mm).

2.5 TAGGING STUDIES

Tagging studies were conducted with net-pen rainbow trout by inserting individually numbered floy tags into the musculature at the posterior base of the dorsal fin. Rainbow trout were marked, measured, and released at Kettle Falls and Seven Bays net-pens in 1991. One thousand fish were tagged and released at Kettle Falls in April, 1991. Thirteen hundred fish were tagged and released at Seven Bays net-pen in April, 296 were released in June, and 1,749 were released in July. Representative samples of approximately 50 fish from each group were weighed to determine. the average length and weight of the group at time of release. Scale samples were also taken to aid in determination of check marks laid down by fish at time of release.

A poster campaign was conducted ‘by distributing posters at locations frequented by anglers in the area surrounding Lake Roosevelt. Posters contained information about the Lake Roosevelt monitoring program and requested that anglers return tags with the following information: recapture date and location, and. length and weight of fish. Anglers returning tag information were sent a letter informing them of the release date and location, and length of fish at time of release.

Tag return data were compiled and analyzed to determine movement with Lake Roosevelt. Movement was analyzed by noting recapture location and plotting it against release location and date.

2.6 OBJECTIVES NOT ADDRESSED IN 1991

Due to time constraints and project initiation setbacks, some of the objectives outlined in section 1 .O were not begun in 1991. For example, primary productivity work is useful only if collected during a growing season (March through August), therefore work was not initiated in 1991. Additionally, some of the work to be performed is in cooperation with other agencies and is data that will be part of the computer model and therefore will not appear in this report. Examples of this data are the hydrology, flow constraints, and reservoir morphometry. A trip was taken to Hungry Horse reservoir in Montana to learn sampling techniques applied by Montana Department of Fish, Wildlife, and Parks. This knowledge was then used to construct benthic macroinvertebrate sampling devises for use in 1992.

3.0 RESULTS

3.1 RESERVOIR OPERATIONS

Table 3.1.1 summarizes mean monthly reservoir operations in 1991. Appendix A summarizes the daily reservoir operations from January to December 1991.

3.1.1 Elevation, Outflow, and Water Retention Time

Mean reservoir elevations were 1,284 feet in January, 1,285 feet in February, 1,267 feet in March, 1,235 feet in April, 1,235 feet in May, 1,275 feet in June, 1,288 feet in July, 1,288 feet in August, 1,287 feet in September, 1,287 feet in October, 1,287 feet in November, and 1,287 feet in December (Table 3.1.1). Mean yearly reservoir elevation was 1,275 feet.

Mean outflow was 142 kcfs in January, 131 kcfs in February, 151 kcfs in March, 153 kcfs in April, 146 kcfs in May, 146 kcfs in June, 130 kcfs in July, 126 kcfs in August, 78 kcfs September, 85 kcfs in October, 88 kcfs in November, and 88 kcfs in December (Table 3.1.1). Mean yearly outflow was 122 kcfs.

Mean water retention times were 32 days in January, 34 days in February, 25 days in March, 18 days in April, 19 days in May, 29 days in June, 36 days in July, 37 days in August, 59 days in September, 56 days in October, 53 days in November and 53 days in December (Table 3.1.1). The yearly average water retention time for the reservoir was 38 days.

3.2 ZOOPLANKTON

3.2.1 Zooplankton Density

A total of 44 species from 36 genera of zooplankton were identified in Lake Roosevelt during 1991 (Table 3.2.1). Order Cladocera was the most diverse group, comprised of 19 species, followed by the Order Plioma with 15 species. Order Eucopepoda contained 6 species, Order Flosulariacea had 3 species, and one specie of Order Collethecacea was identified.

Monthly mean densities (#/m^3) of microcrustacean zooplankton collected at Gifford, Porcupine Bay, Seven Bays, and Spring Canyon are shown in Tables 3.2.2 through 3.2.5. Rotifers were

Table 3.1.1 Monthly 'and annual means for reservoir inflow, outflow, elevation, storage capacity, and water retention time for Lake Roosevelt in 1991.

DAY OF MONTH	INFLOW (KCFS)	OUTFLOW (KCFS)	RESERVOIR ELEVATION (FT)	STORAGE CAPACITY (KCFSD)	WATER RETENTION TIME (D)
January	143.8	142.0	1,283.9	4,342.9	32.2
February	130.6	131.3	1,285.1	4,392.0	34.1
March	119.2	151.0	1,267.5	3,734.9	25.0
April	129.9	153.4	1,235.4	2,696.2	17.7
May	186.1	146.4	1,234.9	2,685.3	18.5
June	194.3	145.7	1,275.2	4,020.7	29.2
July	137.8	129.6	1,288.3	4,521.7	35.8
August	129.1	125.7	1,288.5	4,529.9	37.0
September	83.9	78.0	1,287.0	4,469.2	59.1
October	91.0	84.7	1,287.0	4,470.8	55.8
November	88.6	87.9	1,286.7	4,456.1	53.2
December	88.6	87.9	1,286.7	4,456.1	53.2
Annual	126.9	122.0	1,275.5	4,064.7	37.6

Table 3.2.1. Synoptic list of zooplankton taxa identified in Lake Roosevelt during the 1991 study period.

Phylum Anthropoda
- **Class Crustacea**
  - **Subclass Brachiopoda**
    - **Order Ciadocera**
      - **Family Daphnidae**
        1. *Ceriodaphnia quadranqula*
        2. *Daphnia galeata mendotae*
        3. *Daphnia retrocurva*
        4. *Daphnia schødleri*
        5. *Daphnia thora ta*
        6. *Megafenestra aurita*
        7. *Simocephalus serrula tus*
      - **Family Chydoridae**
        8. *Alona guttata*
        9. *Alona quadrangularis*
        10. *Chydorus sphaericus*
        11. *f urycerus lamella tus*
        12. *Pleuroxus denticulatus*
      - **Family Sididae**
        13. *Diaphanosoma brachyurum*
        14. *Diaphanosoma birgei*
        15. *Sida crystallina*
      - **Family Macrothricidae**
        16. *Macrothrix laticornis*
        17. *Streblocerus serricaudatus*
      - **Family Bosminidae**
        18. *Bosmina longirostris*
      - **Family Leptodoriidae**
        19. *Leptodora kindti*
  - **Subclass Copepoda**
    - **Order Eucopepoda**
      - **Suborder Calanoida**
        - **Family Diaptomidae**
          20. *Leptodiaptomus ashlandi*
          21. *Skistodiaptomus oregonensis*
        - **Family Temoridae**
          22. *fpischura nevadensis*
      - **Suborder Cyclopoida**
        - **Family Cyclopoidae**
          23. *Diacyclops bicuspidatus thomasi*
          24. *Mesocyclop edax*
      - **Suborder Harpacticoida**
        - **Family Harpacticoidae**
          25. *Bryocamptus* **spp.**

Phylum Rotifera
- **Class Monogononta**
  - **Order Floscularíacea**
    - **Family Conochilidae**
      26. *Conochilus unicornis*
    - **Family Testudinellidae**
      27. *Testudinella* **spp.**
    - **Family Fitiniidae**
      26. *Filinia terminalis*
  - **Order Collothecacea**
    - **Family Collothecidae**
      29. *Collotheca mutabilis*
  - **Order Plioma**
    - **Family Synchaetidae**
      30. *Pleosoma truncatum*
      31. *Polyarthra* **spp.**
      32. *Synchaeta pectinata*
    - **Family Asplanchnidae**
      33. *Asplanchna herricki*
      34. *Asplanchna priodonta*
    - **Family Brachionidae**
      35. *Brachionus quadridentata*
      36. *Kellicottia longispina*
      37. *Keratella* **spp.**
      38. *Notholca* **spp.**
    - **Family Epiphanidae**
      39. *fpiphanes* **spp.**
    - **Family Euchlanidae**
      40. *f uchlanis dila ta ta*
      41. *E uchlanis triquetra*
    - **Family Trichotriidae**
      42. *Trichotria tetractis*
    - **Family Trichocercidae**
      43. *Trichocerca* **spp.**
    - **Family Lecanidae**
      44. *Monostyla lunaris*

not enumerated in 1991 or included in density or biomass calculations. Mean density/species for each location can be found in Appendix B.

Mean microcrustacean zooplankton densities at Gifford and Spring Canyon were not collected until July, 1991 when the System Operation Review project was initialized.

No data was collected at Porcupine Bay in January due to inclimate weather. Mean microcrustacean zooplankton density at Seven Bays in January was estimated at $61/m^3$ (Table 3.2.4). This volume was comprised of 65% Copepoda nauplii ($40/m^3$), 29% adult. Copepoda ($18/m^3$), and 6% Cladocera ($3/m^3$). Daphnia spp. comprised 18% ($1/m^3$) of mean Cladocera density.

Mean microcrustacean zooplankton density at Porcupine Bay in February was estimated at $873/m^3$ (Table 3.2.3). This volume was comprised of 88% Copepoda nauplii ($767/m^3$), 11% adult Copepoda ($96/m^3$), and 1% Cladocera ($10/m^3$). Daphnia spp. comprised 0% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Seven Bays in February was estimated at $1{,}819/m^3$ (Table 3.2.4). This volume was comprised of 76% Copepoda nauplii ($1{,}388/m^3$), 23% adult Copepoda ($424/m^3$), and <1% Cladocera ($7/m^3$). Daphnia spp. comprised 0% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Porcupine Bay in March was estimated at $619/m^3$ (Table 3.2.3). This volume was comprised of 59% Copepoda nauplii ($365/m^3$), 40% adult Copepoda ($246/m^3$), and 1% Cladocera ($7/m^3$). Daphnia spp. comprised 0% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Seven Bays in March was estimated at $137/m^3$ (Table 3.2.4). This volume was comprised of 78% Copepoda nauplii ($107/m^3$), 22% adult Copepoda ($30/m^3$), and <0% Cladocera ($0.2/m^3$). Daphnia spp. comprised 0% of the mean Cladocera density.

No data was collected in April at Porcupine Bay. Mean microcrustacean zooplankton density at Seven Bays in April was estimated at $1{,}179/m^3$ (Table 3.2.4). This volume was comprised of

Table 3.2.2 Mean monthly density values (#/m³) and standard deviations of different categories of zooplankton at Gifford (Index Station 2) in 1991.

Taxon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Mean
Daphnia spp.													
$\#/m^3$	-	-	-	-	0.0	-	14.7	78.0	102.3	-	-	1.6	39
± S.D.					± 0.0	-	± 4.1	± 13.0	± 31.5	-	-	± 0.7	
Leptodora													
$\#/m^3$	-	-	-	-	0.0	-	0.1	1.0	0.1	-	-	[illegible]	0.2
± S.D.	-	-			± 0.0	-	± 0.2	± 1.0	± 0.2	-	-	± [illegible]	
Cladocera													
$\#/m^3$	-	-	-	-	4.2	-	52.9	81.0	105.6	-	2.0		49
± S.D.					f3.1	-	± 0.2	± 14.0	± 31.4	-	± 0.9		
Adult Copepoda													
$\#/m^3$	-	-	-	-	18.4	-	108.5	62.0	22.0	-	-	5.5	43
± S.D.	-	-	-	-	f1.4	-	± 20.7	± 16.0	± 2.6	-		± 4.1	
Nauplii													
$\#/m^3$		-	-	-	240.0	-	510.3	28.0	22.2	-	-	7.6	162
± S.D.	-				± 5.5	-	± 124.4	± 13.0	± 6.3	-	-	± 6.7	
Total Zooplankton													
$\#/m^3$	-	-	-	-	263	-	672	171	150	-	-	15	254
± S.D.	-	-			± 4	-	± 145	± 17	± 22	-		± 12	

(- represents no samples were collected).

79% Copepoda nauplii ($926/m^3$), 20% adult Copepoda ($239/m^3$), and 1% Cladocera ($15/m^3$). Daphnia spp. comprised 40% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Gifford in May was estimated at $263/m^3$ (Table 3.2.2). This volume was comprised of 91% Copepoda nauplii ($240/m^3$), 7% adult Copepoda ($18/m^3$), and 2% Cladocera ($4/m^3$). Daphnia spp. comprised 0% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Porcupine Bay in May was estimated at $413/m^3$ (Table 3.2.3). This volume was comprised of 78% Copepoda nauplii ($323/m^3$), 20% adult Copepoda ($81/m^3$), and 2% Cladocera ($9/m^3$). Mean Cladocera densities were comprised of 5% for both Daphnia spp. and *L. kindti.*

Mean microcrustacean zooplankton density at Seven Bays in May was estimated at $224/m^3$ (Table 3.2.4). This volume was comprised of 85% Copepoda nauplii ($191/m^3$), 14% adult Copepoda ($32/m^3$), and 1% Cladocera ($2/m^3$). Mean Cladocera densities were comprised of 74% Daphnia spp. and 11% *L. kindti.*

Mean microcrustacean zooplankton density at Spring Canyon in May was estimated at $193/m^3$ (Table 3.2.5). This volume was comprised of 57% Copepoda nauplii ($109/m^3$), 41% adult Copepoda ($79/m^3$), and 2% Cladocera ($5/m^3$). Mean Cladocera densities were comprised of 63% Daphnia spp. and 20% *L. kindti.*

Mean microcrustacean zooplankton density at Porcupine Bay in June was estimated at $833/m^3$ (Table 3.2.3). This volume was comprised of 69% Copepoda nauplii ($578/m^3$), 17% adult Copepoda ($142/m^3$), and 14% Cladocera ($112/m^3$). Mean Cladocera densities were comprised of 6% Daphnia spp. and 1% *L. kindti.*

Mean microcrustacean zooplankton density at Seven Bays in June was estimated at $668/m^3$ (Table 3.2.4). This volume was comprised of 55% Copepoda nauplii ($365/m^3$), 37% adult Copepoda ($249/m^3$), and 8% Cladocera ($54/m^3$). Mean Cladocera densities were comprised of 37% Daphnia spp. and 1% L. *kindti.*

Table 3.2.3 Mean monthly density values ($\#/m^3$) and standard deviations of different categories of zooplankton at Porcupine Bay (Index Station 4) in 1991.

Taxon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Mean
Daphnia spp. $\#/m^3$	-	0.0	0.0	-	0.4	7.3	111.3	165.7	112.9	220.0	3.9	180.5	80
± S.D.	-	± 0.0	± 0.0	-	± 0.6	± 0.0	± 9.6	± 14.5	± 6.2	f91.3	± 0.4	± 35.1	
Leptodora $\#/m^3$	-	0.0	0.0	-	0.4	1.2	0.8	0.1	1.0	0.2	1.0	0.0	0.5
± S.D.	-	± 0.0	± 0.0	-	± 0.6	± 1.2	± 0.1	± 0.2	± 1.1	± 0.1	± 0.1	± 0.0	
Cladocera $\#/m^3$	-	9.6	7.3	-	8.6.	112.5	154.7	179.4	116.3	224.6	4.9	226.0	104
± S.D.	-	± 6.8	± 3.4	-	± 7.6	± 52.5	± 1.4	± 15.8	± 2.3	± 89.4	± 0.2	± 37.1	
Adult Copepoda $\#/m^3$	-	96.3	246.0	-	80.5	142.3,	475.2	501.5	403.3	517.7	9.5	155.4	263
± S.D.		± 68.1	± 53.6	-	± 16.8	± 19.0	± 34.2	± 62.2	± 10.4	± 14.5	± 0.1	± 0.0	
Nauplii $\#/m^3$	-	767.3	365.4	-	323.4	578.3	1,619.2	1,058.8	768.4	523.5	12.1	214.1	623
± S.D.	-	± 542.6	± 39.9	-	± 5.6	± 17.1	± 146.5	± 4.1	± 0.0	± 105.8	± 0.3	± 45.6	
Total Zooplankton $\#/m^3$	-	873	619	-	413	833	2,249	1,740	1,288	1,266	27	596	990
± S.D.	-	+ 618	± 90	-	± 19	± 89	± 111	± 51	± 8	±210	± 0	± 8	

(- represents no samples were collected).

Mean microcrustacean zooplankton density at Gifford in July was estimated at 672/m^3 (Table 3.2.2). This volume was comprised of 76% Copepoda nauplii (51 0/m^3), 16% adult Copepoda (108/m^3), and 8% Cladocera (53/m^3). Daphnia spp. comprised 28% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Porcupine Bay in July was estimated at 2,249/m^3 (Table 3.2.3). This volume was comprised of 72% Copepoda nauplii (1,619/m^3), 21% adult Copepoda (475/m^3), and 7% Cladocera (155/m^3). Mean Cladocera densities were comprised of 72% Daphnia spp. and 1% L. kindti.

Mean microcrustacean zooplankton density at Seven Bays in July was estimated at 41 1/m^3 (Table 3.2.4). This volume was comprised of 49% Copepoda nauplii (202/m^3), 29% adult Copepoda (117/m^3), and 22% Cladocera (92/m^3). Daphnia spp. comprised 42% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Spring Canyon in July was estimated at 2,332/m^3 (Table 3.2.5). This volume was comprised of 46% Copepoda nauplii (1,062/m^3), 28% adult Copepoda (658/m^3), and 26% Cladocera (612/m^3). 'Mean Cladocera densities were comprised of 93% Daphnia spp. and 2% L. kindti.

Mean microcrustacean zooplankton density at Gifford in August was estimated at 171/m^3 (Table 3.2.2). This volume was comprised of 17% Copepoda nauplii (28/m^3), 36% adult Copepoda (62/m^3), and 47% Cladocera (81 /m^3). Mean Cladocera densities were comprised of 96% Daphnia spp. and 1% L. kindti.

Mean microcrustacean zooplankton density at Porcupine Bay in August was estimated at 1,740/m^3 (Table 3.2.3). This volume was comprised of 61% Copepoda nauplii (1,059/m^3), 29% adult Copepoda (502/m^3), and 10% Cladocera (179/m^3). Daphnia spp. comprised 92% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Seven Bays in August was estimated at 1,481/m^3 (Table 3.2.4). This volume was comprised of 39% Copepoda nauplii (576/m^3), 23% adult Copepoda

Table 3.2.4 Mean monthly density values (#/m^3) and standard deviations of different categories of zooplankton at Seven Bays (Index Station 6) in 1991.

Taxon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Mean
Daphnia spp.													
#/m^3	0.6	0.0	0.0	6.4	1.4	19.7	38.4	491.0	196.7	110.0	486.9	9.7	113
± S.D.	± 0.3	± 0.0	± 0.0	± 4.3	± 0.5	± 6.8	± 0.5	± 192.6	± 0.2	± 56.0	± 41.5	± 0.8	
Leptodora													
#/m^3	0.0	0.0	0.0	0.0	0.2	0.4	0.4	0.7	0.3	0.8	0.1	0.0	0.2
± S.D.	± 0.0	± 0.0	± 0.0	± 0.0	± 0.2	± 0.2	± 0.1	± 0.4	± 0.4	± 0.1	± 0.2	± 0.0	
Cladocera													
#/m^3	3.4	6.7	0.2	14.7	1.9	53.7	91.6	562.2	205.7	121.0	492.7	10.9	130
± S.D.	1± . 4	± 1.2	± 0.2	± 2.2	± 0.7	± 10.1	± 17.5	± 187.6	± 0.6	± 58.2	± 49.6	± 0.3	
Adult Copepoda													
#/m^3	17.8	423.9	29.8	238.5	31.9	249.2	117.2	343.0	268.4	321.2	105.6	5.3	179
± S.D.	± 8.0	± 18.5	± 2.3	± 8.8	± 12.3	± 78.7	± 4.2	± 21.4	± 2.1	± 134.7	± 4.1	± 0.9	
Nauplii													
#/m^3	39.9	1,388.5	106.6	925.6	190.5	365.4	202.1	575.5	1,063.2	695.1	137.8	3.6	474
± S.D.	± 7.2	± 51.9	± 3.7	± 65.9	± 0.0	± 136.9	± 51.9	± 24.6	± 114.1	± 232.3	± 12.4	± 2.5	
Total Zooplankton													
#/m^3	61	1,819	137	1,179	224	668	411	1,481	1,537	1,137	736	20	784.2
± S.D.	± 17	+ 69	± 6	± 73	± 13	± 226	± 74	± 191	± 116	± 425	± 41	± 4	

(- represents no samples were collected).

($343/m^3$), and 38% Cladocera ($562/m^3$). Daphnia spp. comprised 87% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Spring Canyon in August was estimated at $4,378/m^3$ (Table 3.2.5). This volume was comprised of 80% Copepoda nauplii ($3,483/m^3$), 14%. adult Copepoda ($597/m^3$), and 7% Cladocera ($298/m^3$). Daphnia spp comprised 75% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Gifford in September was estimated at $150/m^3$ (Table 3.2.2). This volume was comprised of 15% Copepoda nauplii ($22/m^3$), 15% adult Copepoda ($22/m^3$), and 70% Cladocera ($106/m^3$). Daphnia spp. comprised 97% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Porcupine Bay in September was estimated at $1,288/m^3$ (Table 3.2.3). This volume was comprised of 60% Copepoda nauplii ($768/m^3$), 31% adult Copepoda ($403/m^3$), and 9% Cladocera. ($116/m^3$). Mean Cladocera densities were comprised of 97% Daphnia spp. and 1% L. *kindti.*

Mean microcrustacean zooplankton density at Seven Bays in September was estimated at $1,537/m^3$ (Table 3.2.4). This volume was comprised of 69% Copepoda nauplii ($1,063/m^3$), 17% adult Copepoda ($268/m^3$), and 13% Cladocera ($206/m^3$). Daphnia spp. comprised 96% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Spring Canyon in September was estimated at $1,257/m^3$ (Table 3.2.5). This volume was comprised of 47% Copepoda nauplii ($597/m^3$), 34% adult Copepoda ($433/m^3$), and 18% Cladocera ($227/m^3$). Daphnia spp comprised 97% of the mean Cladocera density.

Data was not collected in October at Gifford due to inclimate weather conditions.

Mean microcrustacean zooplankton density at Porcupine Bay in October was estimated at $1,266/m^3$ (Table 3.2.3). This volume was comprised of 41% Copepoda nauplii ($524/m^3$), 41% adult Copepoda ($518/m^3$), and 18% Cladocera ($225/m^3$). *Daphnia* spp. comprised 98% of the mean Cladocera density.

Table 3.2.5 Mean monthly density values ($\#/m^3$) and standard deviations of different categories of zooplankton at Spring Canyon (Index Station 9) in 1991.

Taxon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Mean
Daphnia spp. $\#/m^3$ ± S.D.	-	-	-	-	2.9 ± 2.1	- -	572.0 ± 88.0	224.4 ± 14.5	220.0 ± 20.7	109.0 ± 21.0	- -	29.0 ± 3.0	193
Leptodora $\#/m^3$ ± S.D.	-	- -	-	- -	0.9 ± 0.2	- -	10.0 ± 0.0	0.5 ± 0.7	0.1 ± 0.1	0.0 ± 0.0	- -	2.0 ± 3.0	2
Cladocera $\#/m^3$ ± S.D.	-	- -	-	-	'4.6 f1.2	- -	612.0 ± 104.0	298.2 ± 7.0	227.4 4 18.5	113.0 ± 27.0	- -	38.0 ± 1.0	215
Adult Copepoda $\#/m^3$ ± S.D.	-	-	-	-	79.2 ± 10.4	- -	658.0 ± 15.0	596.7 ± 56.0	432.6 ± 105.8	245.0 ± 64.0	- -	95.0 ± 5.0	351
Nauplii $\#/m^3$ ± S.D.	- -	- -	- -	- -	109.3 ± 15.6	- -	1,062.0 ± 29.0	3,482.8 ± 615.9	596.7 ± 126.5	328.0 ± 17.0	- -	93.0 ± 4.0	945
Total Zooplankton $\#/m^3$ ± S.D.	- -	- -	- -	- -	193 ± 6	- -	2,332 ± 61	4,378 ± 567	1,257 ± 251	686 ± 75	- -	226 ± 1	1,512

(- represents no samples were collected).

Mean microcrustacean zooplankton density at Seven Bays in October was estimated at $1,137/m^3$ (Table 3.2.4). This volume was comprised of 61% Copepoda nauplii ($695/m^3$), 28% adult Copepoda ($321/m^3$), and 11% Cladocera ($121/m^3$). Mean Cladocera densities were comprised of 91% Daphnia spp. and 1% L. *kindti.*

Mean microcrustacean zooplankton density at Spring Canyon in October was estimated at $686/m^3$ (Table 3.2.5). This volume was comprised of 48% Copepoda nauplii ($328/m^3$), 36% adult Copepoda ($245/m^3$), and 16% Cladocera ($113/m^3$). Daphnia spp. comprised 96% of the mean Cladocera density.

Data was not collected in November at Gifford due to inclimate weather conditions.

Mean microcrustacean zooplankton density at Porcupine Bay in November was estimated at $27/m^3$ (Table 3.2.3). This volume was comprised of 45% Copepoda nauplii ($12/m^3$), 35% adult Copepoda ($10/m^3$), and 18% Cladocera ($5/m^3$). Mean Cladocera densities were comprised of 80% Daphnia spp. and 20% L. *kindti.*

Mean microcrustacean zooplankton density at Seven Bays in November was estimated at $736/m^3$ (Table 3.2.4). This volume was comprised of 19% Copepoda nauplii ($138/m^3$), 14% adult Copepoda ($106/m^3$), and 67% Cladocera ($493/m^3$). Daphnia spp. comprised 99% of the mean Cladocera density.

No data was collected from Spring Canyon in November due to inclimate weather conditions.

Mean microcrustacean zooplankton density at Gifford in December was estimated at $15/m^3$ (Table 3.2.2). This volume was comprised of 51% Copepoda nauplii ($8/m^3$), 37% adult Copepoda ($6/m^3$), and 13% Cladocera ($2/m^3$). Daphnia spp. comprised 80% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Porcupine Bay in December was estimated at $596/m^3$ (Table 3.2.3). This volume was comprised of 36% Copepoda nauplii ($214/m^3$), 26% adult Copepoda ($155/m^3$), and 38% Cladocera ($226/m^3$). Daphnia spp. comprised 80% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Seven Bays in December was estimated at $20/m^3$ (Table 3.2.4). This volume was comprised of 18% Copepoda nauplii ($4/m^3$), 27% adult Copepoda ($5/m^3$), and 55% Cladocera ($11/m^3$). Daphnia spp. comprised 89% of the mean Cladocera density.

Mean microcrustacean zooplankton density at Spring Canyon in December was estimated at $226/m^3$ (Table 3.2.5). This volume was comprised of 41% Copepoda nauplii ($93/m^3$), 42% adult Copepoda ($95/m^3$), and 17% Cladocera ($38/m^3$). Mean Cladocera densities were comprised of 76% Daphnia spp. and 5% L. *kindti.*

Annual mean microcrustacean zooplankton density was estimated to be $254/m^3$ at Gifford in 1991 (Table 3.2.2). Mean microcrustacean zooplankton density was comprised of 64% Copepoda nauplii ($162/m^3$), 17% Cladocera ($49/m^3$), and 17% adult Copepoda ($43/m^3$). The mean Cladocera density was comprised of 82% Daphnia spp. and <1 % L. *kindti.* Highest densities occurred in July ($672/m^3$), followed by May ($263/m^3$). Lowest densities occurred in December ($16/m^3$) followed by September ($150/m^3$). Mean densities of Daphnia spp. were highest in September ($102/m^3$) and lowest in May ($0/m^3$). Mean densities of L. *kindti* were highest in August ($1/m^3$) and lowest in December and May ($0/m^3$).

Annual mean microcrustacean zooplankton density was estimated to be $990/m^3$ at Porcupine Bay in 1991 (Table 3.2.3). Mean microcrustacean zooplankton density was comprised of 63% Copepoda nauplii ($623/m^3$), 27% adult Copepoda ($263/m^3$), and 11% Cladocera ($104/m^3$). The mean Cladocera density was comprised of 77% Daphnia spp. and <1 % L. *kindti.* Highest densities occurred in July ($2,249/m^3$), followed by August ($1,740/m^3$). Lowest densities occurred in November ($27/m^3$) and May ($413/m^3$). Mean densities of Daphnia spp. were highest in October ($220/m^3$) and lowest in February and March ($0/m^3$). Mean densities of L. *kindti* were highest in June ($1.8/m^3$) and lowest in February, March, and December ($0/m^3$).

Annual mean microcrustacean zooplankton density was estimated to be $784/m^3$ at Seven Bays in 1991 (Table 3.2.4). Mean microcrustacean zooplankton density was comprised of 61%

Copepoda nauplii (474/m^3), 23% adult Copepoda (179/m^3), and 16% Cladocera (130/m^3). The mean Cladocera density was comprised of 87% Daphnia spp. (113/m^3) and <1 % L. kindti. Highest densities occurred, in September (1,537/m^3), followed by August (1,481/m^3). Lowest densities occurred in December (20/m^3) and January (61/m^3). Mean densities of Daphnia spp. were highest in August (491/m^3) and lowest in February and March (0/m^3). Mean densities of L. kindti were highest in October (0.8/m^3) and lowest in January, February, March, April, and December (0/m^3).

Annual mean microcrustacean zooplankton density was estimated to be 1,512/m^3 at Spring Canyon in 1991 (Table 3.2.5). Mean microcrustacean zooplankton density was comprised of 63% Copepoda nauplii (945/m^3), 23% adult Copepoda (351/m^3), and 14% Cladocera (215/m^3). The mean Cladocera density was comprised of 89% Daphnia spp. and 1 % L. kindti. Highest densities occurred in August (4,378/m^3), followed by July (2,332/m^3). Lowest densities occurred in May (193/m^3) and December (226/m^3). Mean densities of Daphnia spp. were highest in July (572/m^3) and lowest in May (3/m^3). Mean densities of L. kindti were highest in July (10/m^3) and lowest in October (0/m^3).

3.2.2. Microcrustacean Zooplankton Lengths

Monthly mean lengths (mm) of microcrustacean zooplankton collected from Gifford, Porcupine Bay, Seven Bays, and Spring Canyon are shown in Tables 3.2.6 through 3.2.9. Individual specie length ranges can be found in Appendix B.

Mean microcrustacean zooplankton length at Seven Bays in April was estimated at 0.7 mm for Daphnia *schødleri* (Table 3.2.8). Lengths ranged from 0.66 mm to 0.80 mm. No other Cladocera species were found.

Mean microcrustacean zooplankton lengths at Porcupine Bay in May were estimated at 0.8 mm for D. *schødleri* and 0.9 mm for *Leptodora* kindti (Table 3.2.7). There were no ranges in length values.

Mean microcrustacean zooplankton lengths at Seven Bays in May were estimated at 0.7 mm for Daphnia *galeata* mendotae, 1.0 mm

Table 3.2.6 **Mean monthly size values (mm) (± S.D.) of different Cladocera species at Gifford (Index Station 2) in 1991.**

	D. *galeata mendotae* (mm)	Daphnia *retrocurva* (mm)	Daphnia *schødleri* (mm)	Daphnia *thorata* (mm)	*Leptodora kindti* (mm)
Jan.	-	-			
± S.D.			-	-	
Feb.	-				
± S.D.		-		-	
Mar.	-				
± S.D.					
Apr.					
± S.D.					
May					
± S.D.				-	-
Jun.					
± S.D.					
Jul.	0.6		0.6		10.0
± S.D.	± 0.2		± 0.3		± 0.0
Aug.	1.1	1.3	1.1	1.3	6.1
± S.D.	± 0.4	± 0.3	± 0.4	± 0.2	± 3.2
Sep.	1.0	1.4	1.0	1.2	2.2
± S.D.	± 0.3	± 0.4	± 0.3	± 0.1	± 0.0
Oct.	-				
± S.D.		-	-	-	-
Nov.					
± S.D.					
Dec.			1.3		
± S.D.			± 0.5		
Yearly Mean	**0.9**	**1.35**	**1.0**	**1.25**	6.1

(- indicates no data were obtained due to lack of sample or organisms in sample.)

for *D. schødleri* and 0.9 mm for *L.* kindti (Table 3.2.8). Lengths for *D.* galeata mendutae ranged from 0.58 mm to 0.74 mm. Lengths for *D. schødleri* ranged from 0.76 mm to 1.22 mm. There were no ranges in length values for L. kindti.

Mean microcrustacean zooplankton lengths at Spring Canyon in May were estimated at 1.2 mm for *D. schødleri* and 1.7 mm for *L.* kindti (Table 3.2.9). Lengths for *D. schødleri* ranged from 0.68 mm to 1.5 mm. Lengths for L. kindti ranged from 1.44 mm to 1.96 mm.

Mean microcrustacean zooplankton lengths at Porcupine Bay in June were estimated at 1.0 mm for Daphnia retrocurva, and 2.5 mm for L. kindti (Table 3.2.7). Lengths for D. retrocurva ranged from 0.54 mm to 1.76 mm. Lengths for L. kindti ranged from 2.20 mm to 2.30 mm.

Mean microcrustacean zooplankton lengths at Seven Bays in June were estimated at 0.8 mm for *D.* galeata mendotae, 0.9 mm for D. retrocurva, 0.9 for D. *schødleri*, and 2.5 for L. kindti (Table 3.2.8). Lengths. for *D.* galeata mendutae ranged from 0.70 mm to 1.10 mm. Lengths for D. retrocurva ranged from 0.50 mm to 1.96 mm. Lengths for *D. schødleri* ranged from 0.60 mm to 1.96 mm. Lengths for L. kindti ranged from 1.75 mm to 3.75 mm.

Mean microcrustacean zooplankton lengths at Gifford in July were estimated at 0.6 mm for D. galeata mendotae, 0.6 mm for *D. schødleri* and 10. mm for L. *kindti* (Table 3.2.6). Lengths for *D.* galeata mendotae ranged from 0.42 mm to 1.16 mm. Lengths for *D. schødleri* ranged from 0.42 mm to 1.30 mm. There were no ranges in length values for L. *kindti*.

Mean microcrustacean zooplankton lengths at Porcupine Bay in July were estimated at 0.8 mm for *D. galeata* mendotae, 1.2 mm for D. *retrocurva,* 0.8 mm for D. *schødleri* and 6.3 mm for L. kindti (Table 3.2.7). Lengths for D. *galeata* mendotae ranged from 0.78 mm to 1 .10 mm. Lengths for 5. retrocurva ranged from 0.56 mm to 2.60 mm. Lengths for D. *schødleri* ranged from 0.76 mm to 0.84 mm. Lengths for L. kindti ranged from 2.50 mm to 10.00 mm.

Mean microcrustacean zooplankton lengths at Seven Bays in July were estimated at 1.0 mm for D. galeata mendotae, 1.2 mm for D. retrocurva, 1 .O mm for D. *schødleri*, 0.9 mm for Daphnia *thorata*, and 4.0 mm for L. *kindti* (Table 3.2.8). Lengths for D. galeata mendotae ranged from 0.68 mm to 2.08 mm. Lengths for *D.*

Table 3.2.7 **Mean monthly' size values (mm) (± S.D.) of different Cladocera species at Porcupine Bay (Index Station 4) in 1991.**

	D. *galeata mendotae* (mm)	Daphnia *retrocurva* (mm)	Daphnia *schødleri* (mm)	Daphnia *thorata* (mm)	*Leptodora kindti* (mm)
Jan.	-				
± S.D.					
Feb.					
± S.D.					
Mar.					
± S.D.					
Apr.					
± S.D.					
May			0.8		0.9
± S.D.			± 0.0		± 0.0
Jun.		1.0			2.5
± S.D.		± 0.4		-	± 0.5
Jul.	0.8	1.2	0.8		6.3
± S.D.	± 0.1	± 0.5	± 0.0		± 2.5
Aug.	1.5	1.6	1.3		4.1
± S.D.	± 0.7	± 0.8	± 0.6	-	± 1.9
Sep.	1.7		1.5		5.8
± S.D.	± 0.5		± 0.5		± 2.7
Oct.	1.4	1.6	1.7	2.0	6.2
± S.D.	± 0.4	± 0.0	± 0.6	± 0.0	± 1.7
Nov.	1.5		1.1		
± S.D.	± 0.0		± 0.4		
Dec.	1.2		1.6		
± S.D.	± 0.0		± 0.4		
Yearly Mean	1.3	1.3	1.3	2.0	4.3

(- indicates no data were obtained due to lack of sample or organisms in sample.)

retrocurva ranged from 0.66 mm to 2.40 mm. Lengths for *D.* schodleri ranged from 0.72 mm to 2.16 mm. Lengths for *D.* thorata ranged from 0.86 mm to 0.90 mm. Lengths for L. kindti ranged from 2.10 mm to 8.20 mm.

Mean microcrustacean zooplankton lengths at Spring Canyon in July were estimated at 1.5 mm for D. galeata mendotae, 1.7 mm for *D*. retrucurva, 1.4 mm for *D. schødleri*, 2.2 mm for *D.* thorata, and 9.1 mm for *L.* kindti (Table 3.2.9). Lengths for *D. galeata* mendotae ranged from 0.62 mm to 2.32 mm. Lengths for *D.* retrocurva ranged from 0.52 mm to 2.42 mm. Lengths for D. *schødleri* ranged from 0.64 mm to 3.30 mm. Lengths for *D.* thorata ranged from 1.84 mm to 2.40 mm. Lengths for L. kindti ranged from 3.00 mm to 14.00 mm.

Mean microcrustacean zooplankton lengths at Gifford in August were estimated at 1 .1 mm for *D.* galeata mendotae, 1.3 mm for D. retrocurva, 1 .1 for *D.* schodleri, 1.3 mm for *D.* thorata, and 6.1 mm for L. kindti (Table 3.2.6). Lengths for *D.* galeata mendotae ranged from 0.60 mm to 2.00 mm. Lengths for D. retrocurva ranged from 0.82 mm to 2.00 mm. Lengths for D. schodleri ranged from 0.60 mm to 2.80 mm. Lengths for *D.* thorata ranged from 0.98 mm to 1.80 mm. Lengths for L. kindti ranged from 3.00 mm to 11 .OO mm.

Mean microcrustacean zooplankton lengths at Porcupine Bay in August were estimated at 1.5 mm for D. galeata mendotae, 1.6 mm for D. retrccurva, 1.3 mm for *D. schødleri*, and 4.1 mm for L. kindti (Table 3.2.7). Lengths for *D.* galeata mendutae ranged from 0.60 mm to 3.40 mm. Lengths for *D.* retrucurva ranged from 0.73 mm to 3.40 mm. Lengths for *D. schødleri* ranged from 0.88 mm to 3.48 mm. Lengths for *L.* kindti ranged from 2.00 mm to 7.00 mm.

Mean microcrustacean zooplankton lengths at Seven Bays in August were estimated at 1.4 mm for *D.* galeata mendotae, 1.4 mm for *D*. retrccurva, 1.4 mm for D. *schødleri*, 1.7 mm for *D.* thorata, and 4.3 mm for L. kindti (Table 3.2.8). Lengths for *D.* galeata mendotae ranged from 0.66 mm to 2.68 mm. Lengths for *D.* retrucurva ranged from 0.60 mm to 2.28 mm. Lengths for D. *schødleri* ranged from 0.82 mm to 3.20 mm. Lengths for D. thorata ranged from 0.66 mm to 2.70 mm. Lengths for L. kindti ranged from 1.20 mm to 9.50 mm.

Mean microcrustacean zooplankton lengths at Spring Canyon in August were estimated at 1.2 mm for 5. galeata mendutae, 1.1 mm for *D*. retrocurva, 1.1 mm for *D.* schodleri, and 7.2 mm for L. kindti (Table 3.2.9). Lengths for *D.* galeata mendotae ranged from 0.66 mm

Table 3.2.8 **Mean monthly size values (mm) (± S.D.) of different Cladocera species at Seven Bays (Index Station 6) in 1991.**

	D. *galeata* mendotae (mm)	Daphnia retrocurva (mm)	Daphnia *schødleri* (mm)	Daphnia *thorata* (mm)	Leptodora kindti (mm)
Jan. ± S.D.					
Feb. ± S.D.					
Mar. ± S.D.		-			
Apr. ± S.D.			0.7 ± 0.1		
May ± S.D.	0.7 ± 0.1		1.0 ± 0.2	-	0.9 ± 0.0
Jun. ± S.D.	0.8 ± 0.2	0.9 ± 0.4	0.9 ± 0.3	-	2.5 ± 1.1
Jul. ± S.D.	1.0 ± 0.4	1.2 ± 0.5	1.0 ± 0.4	0.9 ± 0.0	4.0 ± 2.0
Aug. ± S.D.	1.4 ± 0.6	1.4 ± 0.5	1.4 ± 0.7	1.7 ± 0.7	4.3 ± 2.5
Sep. ± S.D.	1.3 ± 0.5		1.3 ± 0.4	1.6 ± 1.0	4.9 ± 2.1
Oct. ± S.D.	1.0 ± 0.2		1.5 ± 0.5		7.2 ± 2.1
Nov. ± S.D.	1.5 ± 0.7		1.4 ± 0.5		15.0 ± 0.0
Dec. ± S.D.	1.3 ± 0.4		1.3 ± 0.5	-	
Yearly Mean	1.0	0.8	1.2	1.4	5.5

(- indicates no data were obtained due to lack of sample or organisms in sample.)

to 2.60 mm. Lengths for *D.* retrocurva ranged from 0.46 mm to 2.12 mm. Lengths for D. *schødleri* ranged from 0.66 mm to 2.60 mm. Lengths for L. kindti ranged from 4.50 mm to 13.00 mm.

Mean microcrustacean zooplankton lengths at Gifford in September were estimated at 1 .O mm for *D.* galeata mendotae, 1.4 mm for D. retrocurva, 1 .0 mm for *D. schødleri*, 1.2 mm for D. thorata, and 2.2 mm for L. kindti (Table 3.2.6). Lengths for D. galeata mendotae ranged from 0.60 mm to 1.96 mm. Lengths for *D.* retrocurva ranged from 0.98 mm to 2.20 mm. Lengths for D. schodleri ranged from 0.70 mm to 2.32 mm. Lengths for D. thorata ranged from 1 .OO mm to 1.42 mm. There were no ranges for length values for L. kindti.

Mean microcrustacean zooplankton lengths at Porcupine Bay in September were estimated at 1.7 mm for D. galeata mendotae, 1.5 mm for D. schodleri, and 5.8 for L. *kindti* (Table 3.2.7). Lengths for *D. galeata* mendutae ranged from 0.70 mm to 2.50 mm. Lengths for *D.* schodleri ranged from 0.68 mm to 2.30 mm. Lengths for *L.* kindti ranged from 4.00 mm to 11 .OO mm.

Mean microcrustacean zooplankton lengths at Seven Bays in September were estimated at 1.3 mm for D. galeata mendotae, 1.3 for *D. schødleri*, 1.6 mm for D. thorata, and 4.9 mm for L. kindti (Table 3.2.8). Lengths for D. galeata mendotae ranged from 0.66 mm to 2.50 mm. Lengths for *D. schødleri* ranged from 0.82 mm to 2.48 mm. Lengths for *D.* thorata ranged from 0.21 mm to 2.24 mm. Lengths for L. kindti ranged from 2.50 mm to 8.00 mm.

Mean microcrustacean zooplankton lengths at Spring Canyon in September were estimated at 1.8 mm for D. galeata mendutae, 1.4 mm for D. schodleri, and 3.7 mm for L. kindti (Table 3.2.9). Lengths for D. galeata mendotae ranged from 0.92 mm to 2.40 mm. Lengths for *D. schødleri* ranged from 0.70 mm to 2.44 mm. Lengths for *L.* kindti ranged from 3.00 mm to 4.50 mm.

Samples were not collected in October at Gifford due to inclimate weather conditions.

Mean microcrustacean zooplankton lengths at Porcupine Bay in October were estimated at 1.4 mm for D. galeata mendutae, 1.6 mm for D. retrocurva, 1.7 mm for D. schodleri, 2.0 mm for D. thorata, and 6.2 for L. kindti (Table 3.2.7). Lengths for *D.* galeata mendotae ranged from 0.82 mm to 2.18 mm. Lengths for *D. schødleri* ranged

Table 3.2.9 **Mean monthly size values (mm) (± S.D.) of different Cladocera species at Spring Canyon (Index Station 9) in 1991.**

	D. galeata mendotae (mm)	Daphnia retrocurva (mm)	Daphnia *schødleri* (mm)	Daphnia fhora*ta* (mm)	Leptodora kindti (mm)
Jan.	-				
± S.D.		-			
Feb.				-	
± S.D.	-			-	
Mar.					
± S.D.				-	
Apr.	-				
± S.D.					
May			1.2		1.7
± S.D.		-	± 0.3		± 0.2
Jun.					
± S.D.					
Jul.	1.5	1.7	1.4	2.2	9.1
± S.D.	± 0.5	± 0.4	± 0.6	± 0.3	± 3.6
Aug.	1.2	1.1	1.1		7.2
± S.D.	± 0.4	± 0.4	± 0.4		± 3.9
Sep.	1.8		1.4		3.7
± S.D.	± 0.3		± 0.4		± 1.1
Oct.	-		1.5		
± S.D.			± 0.3	-	
Nov.					
± S.D.					
Dec.	1.2		1.3		
± S.D.	± 0.3		± 0.4		
Yearly Mean	**1.5**	**1.4**	**1.3**	2.2	5.4

(- indicates no data were obtained due to lack of sample or organisms in sample.)

from 0.80 mm to 3.10 mm. Lengths for L. kindti ranged from 4.00 mm to 7.50 mm. There were no ranges for length values for *D.* retrocurva or D. *thorata.*

Mean microcrustacean zooplankton lengths at Seven Bays in October were estimated at 1.0 mm for *D.* galeata mendotae, 1.5 mm for *D. schødleri,* and 7.2 mm for *L.* kindti (Table 3.2.8). Lengths for *D.* galeata mendotae ranged from 0.78 mm to 1.58 mm. Lengths for *D. schødleri* ranged from 0.78 mm to 1.58 mm. Lengths for L. kindti ranged from 3.50 mm to 10.00 mm.

Mean microcrustacean zooplankton lengths at Spring Canyon in October was estimated at 1.50 mm for *D. schødleri* (Table 3.2.9). Lengths for *D. schødleri* ranged from 1.04 mm to 2.28 mm.

Samples were not collected in November at Gifford due to inclimate weather conditions.

Mean microcrustacean zooplankton lengths at Porcupine Bay in November were estimated at 1.5 mm for D. galeata mendotae, and 1 .1 mm for *D. schødleri* (Table 3.2.7). Lengths for *D. schødleri* ranged from 0.64 mm to 1.96 mm. There were no ranges for length values for D. galeata mendotae.

Mean microcrustacean zooplankton lengths at Seven Bays in November were estimated at 1.5 mm for *D.* galeata mendotae, 1.4 mm for D. schodleri, and 15.0 mm for *L.* kindti (Table 3.2.8). Lengths for *D.* galeata mendotae ranged from 0.96 mm to 1.98 mm. Lengths for *D.* schodleri ranged from 0.66 mm to 2.46 mm. There were no ranges for length values for L. kindti.

Samples were not collected in November at Spring Canyon due to inclimate weather conditions.

Mean microcrustacean zooplankton lengths at Gifford in December was estimated at 1.30 mm for *D. schødleri* (Table 3.2.6). Lengths for *D. schødleri* ranged from 0.60 mm to 2.50 mm.

Mean microcrustacean zooplankton lengths at Porcupine Bay in December were estimated at 1.2 mm for D. galeata mendotae, and 1.6 mm for D. *schødleri* (Table 3.2.7). Lengths for *D. schødleri* ranged from 0.80 mm to 2.40 mm. There were no ranges for length values for D. galeata *mendotae.*

Mean microcrustacean zooplankton lengths at Seven Bays in December were estimated at 1.3 mm for D. galeata mendutae, and 1.3 mm for D. *schødleri* (Table 3.2.8). Lengths for D. *galeata* mendotae ranged from 0.64 mm to 1.80 mm.. Lengths for D. *schødleri* ranged from 0.60 mm to 2.38 mm.

Mean microcrustacean zooplankton lengths at Spring Canyon in December were estimated at 1.2 mm for D. galeata mendotae, and 1.3 mm for *D. schødleri* (Table 3.2.9). Lengths for *D.* galeata mendotae ranged from 0.96 mm to 1.40 mm. Lengths for *D. schødleri* ranged from 0.76 mm to 2.42 mm.

Annual mean microcrustacean zooplankton lengths at Gifford in 1991 were estimated at 0.9 mm for D. galeata mendotae, 1.35 mm for D. *retrocurva*, 1 .O mm for D. *schødleri*, 1.25 mm for D. thorata, and 6.1 mm for *L. kindti* (Table 3.2.6). Mean lengths for D. galeata mendotae ranged from 0.6 mm in July to 1.1 mm in August. Mean lengths for D. retrocurva ranged from 1.3 mm in August to 1.4 mm in September. Mean lengths for D. *schødleri* ranged from 0.6 mm in July to 1.3 mm in December. Mean lengths for D. thorata ranged from 1.2 mm in September to 1.3 mm in August. Mean lengths for L. kindti ranged from 10.00 mm in July to 2.20 mm in September.

Annual mean microcrustacean zooplankton lengths at Porcupine Bay in 1991 were estimated at 1.3 mm for D. galeata mendutae, 1 .3 mm for *D.* retrocurva, 1.3 mm for D. schodleri, 2.0 mm for *D.* thorata, and 4.3 mm for L. kindti (Table 3.2.7). Mean lengths for D. galeata mendotae ranged from 0.8 mm in July to 1.7 mm in September. Mean lengths for D. retrocurva ranged from 1.0 mm in June to 1.6 mm in August and October. Mean lengths for D. *schødleri* ranged from 0.8 mm in May and July to 1.7 mm in October. Mean lengths for *D.* thorata were 2.0 mm in October. Mean lengths for *L.* kindti ranged from 0.92 mm in May to 6.3 mm in July.

Annual mean microcrustacean zooplankton lengths at Seven Bays in 1991 were estimated at 1 .O mm for D. galeata mendotae, 0.8 mm for *D.* retrocurva, 1.2 mm for D. *schødleri*, 1.4 mm for D. thorata, and 5.5 mm for L. kindti (Table 3.2.8). Mean lengths for *D.* galeata mendotae ranged from 0.7 mm in May to 1.5 mm in November. Mean lengths for D. retrocurva ranged from 0.9 mm in June to 1.4 mm in August. Mean lengths for *D. schødleri* ranged from 0.7 mm in April to 1.5 mm in October. Mean lengths for *D.* thorata ranged from 0.9 mm in July to 1.7 mm in August. Mean lengths for L. kindti ranged from 0.9 mm in May to 15.0 mm in November.

Annual mean microcrustacean zooplankton lengths at Spring Canyon in 1991 were estimated at 1.5 mm for *D. galeata* mendotae, 1.4 mm for D. retrocurva, 1.3 mm for D. *schødleri*, 2.2 mm for *D.* thorata, and 5.4 mm for L. kindti (Table 3.2.9). Mean lengths for *D. galeata* mendotae ranged from 1.2 mm in August and December to 1.8 mm in September. Mean lengths for D. retrocurva ranged from 1 .1 mm in August to 1.7 mm in July. Mean lengths for *D. schødleri* ranged from 1 .1 mm in August to 1.5 mm in October. Mean lengths for D. thorata were 2.2 mm in July. Mean lengths for L. kindti ranged from 1.7 mm in May to 9.1 mm in July.

3.2.3 Microcrustacean Zooplankton Biomass

Monthly biomass values ($\mu g/m^3$) of Daphnia spp., Leptodora kindti, and total Cladocera collected from Gifford, Porcupine Bay, Seven Bays, and Spring Canyon are shown in Tables 3.2.10 through 3.2.13.

Mean microcrustacean zooplankton biomass values could not be calculated for Gifford or Spring Canyon monthly until July of 1991.

Mean microcrustacean zooplankton biomass values could not be calculated for Porcupine Bay in January due to inclimate weather.

Mean microcrustacean zooplankton biomass values at Seven Bays in January were estimated at 13 $\mu g/m^3$ for Daphnia spp., 0 $\mu g/m^3$ for L. kindti, and 13 $\mu g/m^3$ for total Cladocera (Table 3.2.12).

Mean microcrustacean zooplankton biomass values were 0 $\mu g/m^3$ at both Porcupine Bay and Seven Bays in February and March.

Mean microcrustacean zooplankton biomass values at Seven Bays in April were estimated at 23 $\mu g/m^3$ for Daphnia spp., 0 $\mu g/m^3$ for L. kindti, and 23 $\mu g/m3$ for total Cladocera (Table 3.2.12).

Mean microcrustacean zooplankton biomass values at Porcupine Bay in May were estimated at 2 $\mu g/m^3$ for Daphnia spp., 0.1 $\mu g/m^3$ for L. kindti, and 2 $\mu g/m^3$ for total Cladocera (Table 3.2.11).

Table 3.2.10 Mean monthly biomass values ($\mu g/m^3$) of different Cladocera at Gifford (Index Station 2) in 1991.

	Daphnia spp. $\mu g/m^3$	Leptodora kindti $\mu g/m^3$	Total Cladocera $\mu g/m^3$
Jan.			
Feb.			
Mar.			
Apr.			
May	0.0	0.0	0.0
Jun.			
Jul.	29.1	25.2	54.3
Aug.	35.5	51.1	86.6
Sep.	846.3	0.4	846.7
Oct.			
Nov.			
Dec.	44.5	0.0	44.5
Reservoir Mean	**191**	**15**	206

(- represents no samples were collected).

Mean microcrustacean zooplankton biomass values at Seven Bays in May were estimated at 7 $\mu g/m^3$ for Daphnia spp., 0.1 $\mu g/m^3$ for L. kindti, and 7 $\mu g/m^3$ for total Cladocera (Table 3.2.12).

Mean microcrustacean zooplankton biomass values at Spring Canyon in May were estimated at 53 $\mu g/m^3$ for Daphnia spp., 2 $\mu g/m^3$ for L. kindti, and 54 $\mu g/m^3$ for total Cladocera (Table 3.2.13).

Mean microcrustacean zooplankton biomass values at Porcupine Bay in June were estimated at 28 $\mu g/m^3$ for Daphnia spp., 5 $\mu g/m^3$ for L. kindti, and 34 $\mu g/m^3$ for total Cladocera (Table 3.2.11).

Mean microcrustacean zooplankton biomass values at Seven Bays in June were estimated at 88 $\mu g/m^3$ for Daphnia spp., 3 $\mu g/m^3$ for L. kindti, and 91 $\mu g/m^3$ for total Cladocera (Table 3.2.12).

Mean microcrustacean zooplankton biomass values at Gifford in July were estimated at 29 $\mu g/m^3$ for Daphnia spp., 25 $\mu g/m^3$ for L. kindti, and 54 $\mu g/m^3$ for total Cladocera (Table 3.2.10).

Mean microcrustacean zooplankton biomass values at Porcupine Bay in July were estimated at 197 $\mu g/m^3$ for Daphnia spp., 46 $\mu g/m^3$ for L. kindti, and' 243 $\mu g/m^3$ for total Cladocera (Table 3.2.11).

Mean microcrustacean zooplankton biomass values at Seven Bays in July were estimated at 1,302 $\mu g/m^3$ for Daphnia spp., 6 $\mu g/m^3$ for L. kindti, and 308 $\mu g/m^3$ for total Cladocera (Table 3.2.12).

Mean microcrustacean zooplankton biomass values at Spring Canyon in July were estimated at 11,902 $\mu g/m^3$ for Daphnia spp., 1,505 $\mu g/m^3$ for L. kindti, and 13,407 $\mu g/m^3$ for total Cladocera (Table 3.2.13).

Mean microcrustacean zooplankton biomass values at Gifford in August were estimated at 36 $\mu g/m^3$ for Daphnia spp., 51 $\mu g/m^3$ for L. kindti, and 87 $\mu g/m^3$ for total Cladocera (Table 3.2.10).

Table 3.2.11 **Mean monthly biomass values ($\mu g/m^3$) of different Cladocera at Porcupine Bay (Index Station 4) in 1991.**

	Daphnia spp. $\mu g/m^3$	Leptodora kindti $\mu g/m^3$	Total Cladocera $\mu g/m^3$
Jan.			
Feb.	0.0	0.0	0.0
Mar.	0.0	0.0	0.0
Apr.			
May	1.7	0.1	1.8
Jun.	28.3	5.5	33.8
Jul.	197.4	45.6	243.0
Aug.	3,113.9	2.3	3,116.2
Sep.	3,313.6	46.3	3,359.9
Oct.	9,885.3	9.9	9,895.3
Nov.	57.1	0.0	57.1
Dec.	7,338.8	0.0	7,338.8
Yearly Mean	**2,394**	**11**	2,405

(- represents no samples were collected).

Mean microcrustacean zooplankton biomass values at Porcupine Bay in August were estimated at 3,114 $\mu g/m^3$ for Daphnia spp., 2 $\mu g/m^3$ for L. kindti, and 3,116 $\mu g/m^3$ for total Cladocera (Table 3.2.11).

Mean microcrustacean zooplankton biomass values at Seven Bays in August were estimated at 9,956 $\mu g/m^3$ for Daphnia spp., 14 $\mu g/m^3$ for L. kindti, and 9,970 $\mu g/m^3$ for total Cladocera (Table 3.2.12).

Mean microcrustacean zooplankton biomass values at Spring Canyon in August were estimated at 937 $\mu g/m^3$ for Daphnia spp., 43 $\mu g/m^3$ for L. kindti, and 981 $\mu g/m^3$ for total Cladocera (Table 3.2.13).

Mean microcrustacean zooplankton biomass values at Gifford in September were estimated at 846 $\mu g/m^3$ for Daphnia spp., 0.4 $\mu g/m^3$ for L. kindti, and 847 $\mu g/m^3$ for total Cladocera (Table 3.2.10).

Mean microcrustacean zooplankton biomass values at Porcupine Bay in September were estimated at 33,316 $\mu g/m^3$ for Daphnia spp., 46 $\mu g/m^3$ for L. kindti, and 33,360 $\mu g/m^3$ for total Cladocera (Table 3.2.11).

Mean microcrustacean zooplankton biomass values at Seven Bays in September were estimated at 4,154 $\mu g/m^3$ for Daphnia spp., 8 $\mu g/m^3$ for L. kindti, and 4,162 $\mu g/m^3$ for total Cladocera (Table 3.2.12).

Mean microcrustacean zooplankton biomass values at Spring Canyon in September were estimated at 5,555 $\mu g/m^3$ for Daphnia spp., 1 $\mu g/m^3$ for *L.* kindti, and 5,557 $\mu g/m^3$ for total Cladocera (Table 3.2.13).

Mean microcrustacean zooplankton biomass values could not be calculated at Gifford in October due to inclimate weather.

Mean microcrustacean zooplankton biomass values for Porcupine Bay in October were estimated at 9,885 $\mu g/m^3$ for

Table 3.2.12 **Mean monthly biomass values (yglm3) of different Cladocera at Seven Bays (Index Station 6) in 1991.**

	Daphnia spp. µg/m³	*Leptodora* kindti µg/m³	Total Cladocera µg/m³
Jan.	12.7	0.0	12.7
Feb.	0.0	0.0	0.0
Mar.	0.0	0.0	0.0
Apr.	23.4	0.0	23.4
May	7.0	0.1	7.1
Jun.	87.8	3.4	91.2
Jul.	1,302.0	6.0	308.1
Aug.	9,955.6	14.1	9,969.7
Sep.	4,154.i	7.6	4,161.7
Oct.	3,857.3	63.4	3,920.7
Nov.	15,211.6	74.3	15,285.9
Dec.	218.8	0.0	218.8
Yearly Mean	3,383	**17**	3,400

(- represents no samples were collected).

Daphnia spp., 10 $\mu g/m^3$ for L. kindti, and 9,895 $\mu g/m^3$ for total Cladocera (Table 3.2.11).

Mean microcrustacean zooplankton biomass values at Seven Bays in October were estimated at 3,857 $\mu g/m^3$ for Daphnia spp., 63 $\mu g/m^3$ for L. kindti, and 3,921 $\mu g/m^3$ for total Cladocera (Table 3.2.12).

Mean microcrustacean zooplankton biomass values at Spring Canyon in October were estimated at 3,524 $\mu g/m^3$ for Daphnia spp., 0 $\mu g/m^3$ for L. kindti, and 3,524 $\mu g/m^3$ for total Cladocera (Tabte 3.2.13).

Mean microcrustacean zooplankton biomass was could not be calculated at Gifford in November due to inclimate weather.

Mean microcrustacean zooplankton biomass values. at Porcupine Bay in November were estimated at 57 $\mu g/m^3$ for Daphnia spp., 0 $\mu g/m^3$ for L. kindti, and 57 $\mu g/m^3$ for total Cladocera (Table 3.2.11).

Mean microcrustacean zooplankton biomass values at Seven Bays in November were estimated at 15,212 $\mu g/m^3$ for Daphnia spp., 74 $\mu g/m^3$ for L. kindti, and 15,286 $\mu g/m^3$ for total Cladocera (Table 3.2.12).

Mean microcrustacean zooplankton biomass values could not be calculated at Spring Canyon in November due to inclimate weather.

Mean microcrustacean zooplankton biomass values at Gifford in December were estimated at 44 $\mu g/m^3$ for Daphnia spp., 0 $\mu g/m^3$ for L. kindti, and 44 $\mu g/m3$ for total Cladocera (Table 3.2.10).

Mean microcrustacean zooplankton biomass values at Porcupine Bay in December were estimated at 7,339 $\mu g/m^3$ for Daphnia spp., 0 $\mu g/m^3$ for L. kindti, and 7,339 $\mu g/m^3$ for total Cladocera (Table 3.2.11).

Mean microcrustacean zooplankton biomass values at Seven Bays in December were estimated at 219 $\mu g/m^3$ for Daphnia spp., 0 $\mu g/m^3$ for L. kindti, and 219 $\mu g/m^3$ for total Cladocera (Table 3.2.12).

Table 3.2.13 **Mean monthly biomass values ($\mu g/m^3$) of different Cladocera at Spring Canyon (Index Station 9) in 1991.**

	Daphnia spp. $\mu g/m^3$	Leptodora kindti $\mu g/m^3$	Total Cladocera $\mu g/m^3$
Jan.			
Feb.			
Mar.			
Apr.			
May	52.8	1.7	54.5
Jun.			
Jul.	11,902.1	1,505.2	13,407.3
Aug.	937.2	43.5	980.7
Sep.	5,555.4	1.3	5,556.7
Oct.	3,523.5	0.0	3,523.5
Nov.			
Dec.	662.7	0.0	662.7
Yearly Mean	**3,772**	**259**	**4,061**

(- represents no samples were collected).

Mean microcrustacean zooplankton biomass values at Spring Canyon in December were estimated at 663 $\mu g/m^3$ for Daphnia spp., 0 $\mu g/m^3$ for L. kindti, and 663 $\mu g/m^3$ for total Cladocera (Table 3.2.13).

Mean microcrustacean zooplankton biomass values for the entire year at Gifford were estimated at 191 $\mu g/m^3$ for Daphnia spp., 15 $\mu g/m^3$ for L. kindti, and 206 $\mu g/m^3$ for total Cladocera (Table 3.2.10). Biomass values of Daphnia spp. ranged from a low of 0 $\mu g/m^3$ in May to a high of 846 $\mu g/m^3$ in September. Biomass values of L. kindti ranged from a low of 0 $\mu g/m^3$ in May and December to a high of 51 $\mu g/m^3$ in August. Total Cladocera biomass values ranged from a low of 0 $\mu g/m^3$ in May to a high of 847 $\mu g/m^3$ in September.

Mean microcrustacean zooplankton biomass values for the entire year at Porcupine Bay were estimated at 2,394 $\mu g/m^3$ for Daphnia spp., 11 $\mu g/m^3$ for L. kindti, and 2,405 $\mu g/m^3$ for total Cladocera (Table 3.2.11). Biomass values of Daphnia spp. ranged from a low of 0 $\mu g/m^3$ in February and March to a high of 9,885 $\mu g/m^3$ in October. Biomass values of L. kindti ranged from a low of 0 $\mu g/m^3$ in February, March, November, and December to a high of 46 $\mu g/m^3$ in September. Total Cladocera biomass values ranged from a low of 0 $\mu g/m^3$ in February and March to a high of 9,895 $\mu g/m^3$ in October.

Mean microcrustacean zooplankton biomass values for the entire year at Seven Bays were estimated at 2,902 $\mu g/m^3$ for Daphnia spp., 14 $\mu g/m^3$ for L. kindti, and 2,833 $\mu g/m^3$ for total Cladocera (Table 3.2.12). Biomass values of Daphnia spp. ranged from a low of 0 $\mu g/m^3$ in February and March to a high of 15,212 $\mu g/m^3$ in November. Biomass values of L. kindti ranged from a low of 0 $\mu g/m^3$ in January, February, March, April, and December to a high of 74 $\mu g/m^3$ in November. Total Cladocera biomass values ranged from a low of 0 $\mu g/m^3$ in February and March to a high of 15,286 $\mu g/m^3$ in November.

Mean microcrustacean zooplankton biomass values for the entire year at Spring Canyon were estimated at 3,772 $\mu g/m^3$ for

Daphnia spp., 259 $\mu g/m^3$ for L. kindti, and 4,061 $\mu g/m^3$ for total Cladocera (Table 3.2.13). Biomass values of Daphnia spp. ranged from a low of 53 $\mu g/m^3$ in May to a high of 11,902 $\mu g/m^3$ in July. Biomass values of L. kindti ranged from a low of 0 $\mu g/m^3$ in. October . and December to a high of 1,505 $\mu g/m^3$ in July. Total Cladocera biomass values ranged from a low of 54 $\mu g/m^3$ in May to a high of 13,407 $\mu g/m^3$ in July.

3.3 BENTHIC MACROINVERTEBRATES

3.3.1 Annual and Seasonal Benthic Density

A total of 8 benthic macroinvertebrate families from 5 orders were found in the substrate samples from Lake Roosevelt (Appendix C). Tables 3.3.1 to 3.3.4 show the mean benthic macroinvertebrate densities from Gifford, Porcupine Bay, Seven Bays and Spring Canyon from July to October 1991.

Gifford

At depths of 80 feet or greater at full pool (area I), mean benthic macroinvertebrate density at Gifford ranged- from $2{,}012/m^2$ in August to $9{,}453/m^2$ in September (Table 3.3.1). Oligochaeta had the highest density in July with $2{,}096/m^2$ followed by Diptera at $357/m^2$. Pelecypoda and Trichoptera tied for the lowest density with $21/m^2$ each. Diptera had the highest density in August with I ,$446/m^2$ followed by Oligochaeta at $545/m^2$. Pelecypoda and Trichoptera tied for the lowest density with O/m2 each. Diptera had the highest density in September with $6{,}750/m^2$ followed by Oligochaeta at $2{,}033/m^2$. Basommatophora and Trichoptera tied for the lowest density with O/m2 each. Diptera had the highest density in October with $3{,}270/m^2$ followed by Oligochaeta at $314/m^2$. Basommatophora had the lowest density at $0/m^2$.

At depths of 50 to 79 feet at full pool (area 2), mean benthic macroinvertebrate density at Gifford ranged from $1{,}760/m^2$ in August to $4{,}968/m^2$ in July (Table 3.3.1). Oligochaeta had the highest density in July with $4{,}088/m^2$ followed by Diptera $786/m^2$. Basommatophora and Trichoptera tied for the lowest density with O/m2 each. Diptera had the highest density in August with

Table 3.3.1 Mean density values (#/m^2) for groups of benthic organisms at Gifford sampling locations on Lake Roosevelt, WA in 1991.

Month/Area	Basommatophora (Snails)	Pelecypoda (Clams)	Diptera (Midges)	Trichoptera (Caddisflies)	Oligocheata (Worms)	Area Sum
July						
Area 1 Wetted Bottom	63	21	357	21	2,096	2,558
Area 2 Semi Dewatered	0	94	786	0	4,088	4,968
Area 3 Freq. Dewatered	136	0	922	0	660	1,728
August						
Area 1	21	0	1,446	0	545	2,012
Area 2	0	0	1,729	0	31	1,760
Area 3	42	0	1,949	0	1,279	3,270
September						
Area 1	0	670	6,750	0	2,033	9,453
Area 2	63	0	2,882	63	189	3,197
Area 3	0	0	3,474	94	94	3,662
October						
Area 1	0	126	3,270	125	314	3,835
Area 2	0	0	2,075	0	0	2,075
Area 3	3,805	0	6,415	126	314	10,660

1,729/m^2 followed by Oligochaeta with 31/m^2. Basommatophora, Pelecypoda, and Trichoptera tied for the lowest density with 0/m^2 each. Diptera had the highest density in September with 2,882/m^2. followed by Oligochaeta with 189/m? Pelecypoda had the lowest density with O/m^2. Diptera had. the highest density in October with 2,075/m^2 followed by all other prey categories with O/m2 each.

At depths of O-49 feet at full pool (area 3), mean benthic macroinvertebrate density at Gifford ranged from 1,728/m^2 in July to 10,660/m^2 in October (Table 3.3.1). Diptera had the highest density in July with 922/m2 followed by Oligochaeta at' 660/m^2. Pelecypoda and Trichoptera tied for the lowest density with O/m2 each. Diptera had the highest density in August with 1,949/m^2 followed by Oligochaeta with 1,279/m2. Pelecypoda and Trichoptera tied for the lowest density with 0/m^2 each. Diptera had the highest density in September with 3,474/m^2 followed by Oligochaeta and Trichoptera each with 94/m2. Basommatophora and Pelecypoda had the lowest density with O/m2 each. Diptera had the highest density in October with 6,415/m^2 followed by Basommatophora at 3,805/m^2. Pelecypoda had the lowest density with 0/m^2.

Porcupine Bay

At depths of 80 feet or greater (area I), mean benthic macroinvertebrate density at Porcupine Bay ranged from 3,962/m^2 in July to 12,117/m^2 in August (Table 3.3.2). Diptera had the highest density in July with 3,490/m^2 followed by Oligochaeta at 472/m^2. Basommatophora, Pelecypoda, and Trichoptera tied for the lowest density with O/m2 each. Diptera had the highest density in August with 11,792/m^2 followed by Oligochaeta at 231/m^2. Basommatophora and Trichoptera tied for the lowest density with O/m2 each. Pelecypoda had the highest density in September with 2,815/m^2 followed by Diptera at 2,704/m^2. Basommatophora and Trichoptera tied for the lowest density with O/m2 each. No samples were collected at area one in October.

At depths of 50 to 79 feet at full pool (area 2), mean benthic macroinvertebrate density at Porcupine Bay ranged from 2,641 O/m2 in September to 5,304/m^2 in August (Table 3.3.2). Oligochaeta had

Table 3.3.2 **Mean density values (#/m^2) for groups of benthic organisms at Porcupine Bay sampling locations on Lake Roosevelt, WA in 1991.**

Month/Area	Basommatophora (Snails)	Pelecypoda (Clams)	Diptera (Midges)	Trichoptera (Caddisflies)	Oligocheata (Worms)	Area Sum
July						
Area 1 Wetted Bottom	0	0	3,490	0	472	3,962
Area 2 Semi Dewatered	0	503	1,635	0	2,138	4,276
Area 3 Freq Dewatered	63	0	189	0	63	315
August						
Area 1	0	94	11,792	0	231	12,117
Area 2	0	0	4,990	0	314	5,304
Area 3	314	0	3,145	0	2,579	6,038
September						
Area 1	0	2,815	2,704	0	1,331	6,850
Area 2	31	0	1,384	63	1,163	2,641
Area 3	126	0	2,086	0	3,522	5,734
October						
Area 1			-			
Area 2				-		-
Area 3						-

the highest density in July with $2,138/m^2$ followed by Diptera $1,635/m^2$. Basommatophora and Trichoptera 'tied for the lowest density with $0/m^2$ each. Diptera had the highest density in August with $4,990/m^2$ followed by Oligochaeta with $314/m^2$. Basommatophora, Pelecypoda, and Trichoptera tied for the lowest density with $0/m^2$ each. Diptera had the highest density in September with $1,384/m^2$ followed by Oligochaeta with $1,163/m^2$. Pelecypoda had the lowest density with $0/m^2$. No benthic samples were collected at area two in October.

At depths of 0-49 feet at full pool (area 3), mean benthic macroinvertebrate density at Porcupine Bay ranged from $315/m^2$ in July to $6,038/m^2$ in August (Table 3.3.2). Diptera had the highest density in July with $189/m^2$ followed by Basommatophora and Oligochaeta each with $63/m^2$. Pelecypoda and Trichoptera tied for the lowest density with $0/m^2$ each. Diptera had the highest density in August with $3,145/m^2$ followed by Oligochaeta with $2,579/m^2$. Pelecypoda and Trichoptera tied for the lowest density with $0/m^2$ each. Oligochaeta had the highest density in September with $3,522/m^2$ followed by Diptera with $2,086/m^2$. Pelecypoda and Trichoptera had the lowest density with $0/m^2$ each. No benthic samples were collected at area three in October.

Seven Bays

At depths of 80 feet or greater at full pool (area I), mean benthic macroinvertebrate density at Seven Bays ranged from $870/m^2$ in July to $3,260/m^2$ in September (Table 3.3.3). Diptera had the highest density in July with $629/m^2$ followed by Oligochaeta at $199/m^2$. Basommatophora and Trichoptera tied for the lowest density with. $0/m^2$ each. Diptera had the highest density in August with $1,761/m^2$ followed by Oligochaeta at $533/m^2$. Basommatophora, Pelecypoda, and Trichoptera tied for the lowest density with $0/m^2$ each. Diptera had the highest density in September with $2,327/m^2$ followed by Oligochaeta at $839/m^2$. Pelecypoda had the lowest density at $0/m^2$. No benthic samples were collected at area one in October

Table 3.3.3 Mean density values (#/m^2) for groups of benthic organisms at Seven Bays sampling locations on Lake Roosevelt, WA in 1991.

Month/Area	Basommatophora (Snails)	Pelecypoda (Clams)	Diptera (Midges)	Trichoptera (Caddisflies)	Oligocheata (Worms)	Area Sum
July						
Area 1 Wetted Bottom	0	42	629	0	199	870
Area 2 Semi Dewatered	0	0	314	0	119	433
Area 3 Freq. Dewatered		0	2,924	63	63	3,052
August						
Area 1	0	0	1,761	0	533	2,327
Area 2	0	0	2,316	0	818	3,314
Area 3		0	4,528	0	94	4,622
September						
Area 1	21	0	2,327	94	839	3,260
Area 2	0	0	587	0	168	755
Area 3	0	0	2,453	94	849	3,396
October						
Area 1			-	-		-
Area 2	-		-	-		
Area 3				-		

At depths of 50 to 79 feet at full pool (area 2), mean benthic macroinvertebrate density at Seven Bays ranged from 433/m^2 in July to 3,314/m^2 in August (Table 3.3.3). Diptera had the highest density in July with 314/m^2 followed by Oligochaeta 119/m^2. Basommatophora, Pelecypoda, and Trichoptera tied for the lowest density with 0/m^2 each. Diptera had the highest density in August with 2,316/m^2 followed by Oligochaeta with 81 8/m^2. Basommatophora, Pelecypoda and Trichoptera tied for the lowest density with 0/m^2 each. Diptera had the highest density in September with 587/m^2 followed by Oligochaeta with 1 68/m^2. Basommatophora, Pelecypoda, and Trichoptera tied for the lowest density with 0/m^2 each. No benthic samples were collected at area one in October.

At depths of O-49 feet at full pool (area 3), mean benthic macroinvertebrate density at Seven Bays ranged from 3,052/m^2 in July to 4,622/m^2 in August (Table 3.3.3). Diptera had the highest density in July with 2,924/m^2 followed by Trichoptera and Oligochaeta with 63/m^2 each. Basommatophora and Pelecypoda tied for the lowest density with 0/m^2 each. Diptera had the highest density in August with 4,528/m^2 followed by Oligochaeta with 94/m^2. Basommatophora, Pelecypoda, and Trichoptera tied for the lowest density with 0/m^2 each. Diptera had the highest density in September with 2,453/m^2 followed by Oligochaeta 849/m^2. Basommatophora and Pelecypoda had the lowest density with 0/m^2 each. No benthic macroinvertebrates were collected at area three in October.

Spring Canyon

At depths of 80 feet or greater at full pool (area 1), mean benthic macroinvertebrate density at Spring Canyon ranged from 503/m^2 in October to 4,843/m^2 in August (Table 3.3.4). Trichoptera had the highest density in July with 283/m^2 followed by Oligochaeta at 252/m^2. Basommatophora had the lowest density with 63/m^2. Diptera had the highest density in August with 4,465/m^2 followed by Basommatophora at 252/m^2. Pelecypoda and Trichoptera tied for the lowest density with 0/m^2 each. Oligochaeta had the highest density in September with 714/m^2 followed by Pelecypoda and

Table 3.3.4 **Mean density values (#/m^2) for groups of benthic organisms at Spring Canyon sampling locations on Lake Roosevelt, WA in 1991.**

Month/Area	Basommatophora (Snails)	Pelecypoda (Clams)	Diptera (Midges)	Trichoptera (Caddisflies)	Oligocheata (Worms)	Area Sum
July						
Area 1 Wetted Bottom	63	94	189	283	252	598
Area 2 Semi Dewatered	63	0	629	63	126	881
Area 3 Freq. Dewatered	692	0	5,219	0	126	6,037
August						
Area 1	252	0	4,465	0	126	4,843
Area 2	63	0	1,174	0	0	1,237
Area 3	21	0	3,480	0	2,516	6,017
September						
Area 1	0	314	314	0	714	1,342
Area 2	378	0	922	0	398	1,698
Area 3	21	0	168	0	0	189
October						
Area 1	63	0	0	314	126	503
Area 2	278	0	818	377	63	1,636
Area 3	6	0	0	0	0	6

Diptera with $314/m^2$ each. Basommatophora and Trichoptera tied for the lowest density with $0/m^2$ each. Trichoptera had the highest density in October with 314/m* followed by Oligochaeta at $126/m^2$.. Pelecypoda and Diptera had the lowest density with $0/m^2$ each.

At depths of 50 to 79 feet at full pool (area 2), mean benthic macroinvertebrate density at Spring Canyon ranged from $881/m^2$ in July to $1,698/m^2$ in September (Table 3.3.4). Diptera had the highest density in July with $629/m^2$ followed by Oligochaeta with $126/m^2$. Pelecypoda had the lowest density at $0/m^2$. Diptera had the highest density in August with 1,174/m* followed by Basommatophora with 63/m2. Pelecypoda, Trichoptera, and Oligochaeta tied for the lowest density with O/m2 each. Diptera had the highest density in September with $922/m^2$ followed by Oligochaeta with 398/m2. Pelecypoda' and Trichoptera tied for the lowest density with $0/m^2$ each. Diptera had the highest density in October with $818/m^2$ followed by Trichoptera with $377/m^2$. Pelecypoda had the lowest density at $0/m^2$.

At depths of O-49 feet at full pool (area 3), mean benthic macroinvertebrate density at Spring Canyon ranged from $6/m^2$ in October to $6,037/m^2$ in July (Table 3.3.4). Diptera had the highest density in July with $5,219/m^2$ followed by Basommatophora at $692/m^2$. Pelecypoda and Trichoptera tied for the lowest density with $0/m^2$ each. Diptera had the highest density in August with $3,480/m^2$ followed by Oligochaeta with $2,516/m^2$. Pelecypoda and Trichoptera tied for the lowest density with $0/m^2$ each. Diptera had the highest density in September with $168/m^2$ followed by Basommatophora with $94/m^2$. Pelecypoda, Trichoptera, and Oligochaeta had the lowest density with $0/m^2$ each. Basommatophora had the highest density at $6/m^2$. All other benthic organisms had a density of $0/m^2$ each.

Mean Indices

At depths of 80 feet or greater at full pool (area 1), mean benthic macroinvertebrate density ranged from $2,068/m^2$ in July to $5,317/m^2$ in August (Table 3.3.5). Diptera had the highest density in July with $1,166/m^2$ followed by Oligochaeta at $755/m^2$.

Table 3.3.5 **Mean density values (#/m^2) for groups of benthic organisms for each sampling location on Lake Roosevelt, WA in 1991.**

Month/Area	Basommatophora (Snails)	Pelecypoda (Clams)	Diptera (Midges)	Trichoptera (Caddisflies)	Oligocheata (Worms)	Area Sum
July						
Area 1 Wetted Bottom	32	39	1,166	76	755	2,068
Area 2 Semi Dewatered	16	149	841	16	1,618	2,640
Area 3 Freq. Dewatered'	223	0	2,314	16	228	~2,781
August						
Area 1	68	24	4,866	0	359	5,317
Area 2	16	0	2,552	0	291	2,859
Area 3	94	0	3,276	0	1,617	4,987
September						
Area 1	5	950	3,024	24	1,229	5,232
Area 2	118	0	1,444	32	480	2,073
Area 3	37	0	2,045	47	1,116	3,245
October						
Area 1	32	63	1,635	220	220	2,169
Area 2	139	0	1,447	189	32	1,806
Area 3	1,906	0	3,208	63	157	5,333

Basommatophora had the lowest density with $32/m^2$. Diptera had the highest density in August with $4,866/m^2$ followed by Oligochaeta at $359/m^2$. Trichoptera had the lowest density with $0/m^2$. Diptera had the highest density in September with $3,024/m^2$ followed by Oligochaeta with $1,229/m^2$. Basommatophora had the lowest density with $5/m^2$. Diptera had the highest density in October with $1,635/m^2$ followed by Trichoptera and Oligochaeta with $220/m^2$ each. Basommatophora had the lowest density with $32/m^2$.

At depths of 50 to 79 feet at full pool (area 2), mean benthic macroinvertebrate density ranged from $1,806/m^2$ in October to $2,859/m^2$ in August (Table 3.3.5). Oligochaeta had the highest density in July with $1,618/m^2$ followed by Diptera with $841/m^2$. Basommatophora and Trichoptera tied for the lowest density with $16/m^2$ each. Diptera had the highest density in August with $2,552/m^2$ followed by Oligochaeta with $291/m^2$. Pelecypoda and Trichoptera tied for the lowest density with $0/m^2$ each. Diptera had the highest density in September with $1,444/m^2$ followed by Oligochaeta with $480/m^2$. Pelecypoda had the lowest density with $0/m^2$. Diptera had the highest density in October with $1,447/m^2$ followed by Trichoptera with $189/m^2$. Pelecypoda had the lowest density at $0/m^2$.

At depths of O-49 feet at full pool (area 3), mean benthic macroinvertebrate density ranged from $2,781/m^2$ in July to $5,333/m^2$ in October (Table 3.3.5). Diptera had the highest density in July with $2,314/m^2$ followed by Oligochaeta at $228/m^2$. Pelecypoda had the lowest density with $0/m^2$. Diptera had the highest density in August with $3,276/m^2$ followed by Oligochaeta with $1,617/m^2$. Pelecypoda and Trichoptera tied for the lowest density with $0/m^2$ each. Diptera had the highest density in September with $2,045/m^2$ followed by Oligochaeta with 1 $,116/m^2$. Pelecypoda had the lowest density with $0/m^2$. Diptera had the highest density at $3,208/m^2$ followed by Basommatophora at $1,906/m^2$. Pelecypoda had the lowest density at Olm2.

3.4 FISHERIES SURVEYS

3.4.1 Relative Abundance

A total of 8,107 fish were caught from 22 species and 8 families during relative abundance surveys performed in May, August, and October of 1991 (Table 3.4.1). Largescale sucker had the highest relative abundance at 34% followed by yellow perch at 29%, and smallmouth bass at 15%. Appendix D shows total number and relative abundance of electrofishing and gillnet catch broken down into sampling seasons.

In May 1991, 2,412 fish were captured during electrofishing surveys, and 80 fish were captured during gillnet surveys for a total of 2,492 fish (Table 3.4.2). Total number and relative abundance of fish captured in May of 1991 included: 1,680 largescale sucker (67%), 271 walleye (1 1%), 232 rainbow trout (9%), 125 squawfish (5%), 65 smallmouth bass (3%), 41 carp (2%), 40 lake whitefish (2%), 9 kokanee salmon (<1%), 6 mountain whitefish (<1%), 5 each yellow perch and brown trout (<1%), 4 burbot (<1%), 2 each bridgelip sucker and longnose sucker (<1%), 1 each black crappie, piute sculpin, peamouth, tench, and chinook salmon (~1%).

In August 1991, 1,51 1 fish were captured during electrofishing surveys, and 132 fish were captured during gillnet surveys for a total of 1,643 fish (Table 3.4.3). Total number and relative abundance of fish captured in August of 1991 included: 504 largescale sucker (31 %), 374 smallmouth bass (23%), 312 yellow perch (19%), 286 walleye (17%), 68. squawfish (4%), 27 rainbow trout (2%), 17 carp (1%), 14 piute sculpin (1%), 12 lake whitefish (<1%), 8 kokanee salmon (<1%), 6 bridgelip sucker (<1%), 3 each burbot and mountain whitefish (<1%), 2 each longnose sucker and brown trout (<1%), 1 each largemouth bass, tench, brown bullhead, brook trout, and chinook salmon (<1%).

In October 1991, 3,893 fish were captured during electrofishing surveys, and 80 fish were captured during gillnet surveys for a total of 3,973 fish (Table 3.4.4). Total number and relative abundance of fish captured in October of 1991 included: 2,029 yellow perch (51%), 741 smallmouth bass (19%), 566 largescale sucker (14%), 395 walleye (10%), 114 rainbow trout (3%), 23 each squawfish and lake whitefish (1%), 22 mountain whitefish (1%), 17 carp (<1%), 14 kokanee salmon (<1%), 12 burbot (<1%), 6

Table 3.4.1 Synoptic list of fish species, total numbers and % relative abundance of fish collected during electrofishing and gillnet surveys on Lake Roosevelt, in May, August, and October of 1991.

FAMILY	COMMON NAME	SCIENTIFIC NAME	TOTAL No.	% REL. ABUND.
Catostomidae	Bridgelip sucker	*Ca tos tomus columbianus*	10	0.1%
	Inngnose sucker	*Catostomus catostomus*	4	<0.1%
	Largescale sucker	*Ca tostomus macrocheilus*	2,750	33.9%
Centrarchidae	Black crappie	*Pomoxis nigromacuia tus*	1	<0.1%
	Largemouth bass	*Micropterus salmoides*	4	<0.1%
	Smallmouth bass	*Micropterus dolomieui*	1,180	14.6%
Cottidae	Piute sculpin	*Cottus beldingi*	21	0.3%
Cyprinidae	Carp	*Cyprinus cafpio*	75	0.9%
	Peamouth	*Mylocheilus caurinus*	1	co.1 %
	Squawfish	*Ptychocheilus oregonensis*	216,	2.7%
	Tench	*Tinca tinca*	2	<0.1%
Gadidae	Burbot	*Lota lota*	19	0.2%
Ictaluridae	Brown bullhead	*Ictalurus nebulosus*	1	<0.1%
Percidae	Walleye	*Stizostedion vitreum vitreum*	952	11.7%
	Yellow perch	*Perca flavescens*	2,346	28.9%
Salmonidae	Brook trout	*Salvelinus fon tinalis*	1	<0.1%
	Brown trout	*Salmo trutta*	13	0.2%
	Chinook salmon	*Oncorhynchus tshawytscha*	'2	<0.1%
	Kokanee salmon	*Oncorhynchus nerka*	31	0.4%
	Lake whitefish	*Coregonus clupeaformis*	75	0.9%
	Mountain whitefish	*Prosopium williamsoni*	31	0.4%
	Rainbow trout	*Oncorhynchus mykiss*	373	4.6%
TOTAL			8,107	

Table 3.4.2 Relative abundance of fish species caught via electrofishing and gillnetting on Lake Roosevelt in May of 1991.

Species	Elect. #	Gillnet #	Total #	% Relative Abundance
Bridgelip sucker		2	2	0%
Longnose sucker	1	1	2	0%
Largescaie sucker	1,663	17	1,680	67%
Black crappie	1		1	0%
Largemouth bass			0	0%
Smallmouth bass	59	6	65	3%
Piute sculpin	1		1	0%
Carp	41		41	2%
Peamouth	1		1	0%
Squawfish	123	2	125	5%
Tench	1		1	0%
Burbot	3	1	4	0%
Brown bullhead			0	0%
Walleye	263	8	271	11%
Yellow perch	5		5	0%
Brown trout	5		5	0%
Brook trout			0	0%
Chinook salmon	1		1	0%
Kokanee salmon	9		9	0%
Lake whitefish	4	36	40	2%
Mountain whitefish	6		6	0%
Rainbow trout	225	7	232	9%
Totals	**2,412**	80	2,492	

Table 3.4.3 Relative abundance of fish species caught via electrofishing and gillnetting on Lake Roosevelt in August of 1991.

Species	Elect. #	Gillnet #	Total #	% Relative Abundance
Bridgelip sucker	6		6	0%
Longnose sucker	1	1	2	0%
Largescale sucker	503	1	504	31%
Black crappie			0	0%
Largemouth bass	1		1	0%
Smallmouth bass	373	1	374	23%
Piute sculpin	14		14	1%
Carp	17		17	1%
Peamouth			0	0%
Squawfish	61	7	68	4%
Tench	1		1	0%
Burbot	2	1	3	0%
Brown bullhead	1		1	0%
Walleye	203	83	286	17%
Yellow perch	304	8	312	19%
Brown trout	2		2	0%
Brook trout	1		1	0%
Chinook salmon	1		1	0%
Kokanee salmon	8		8	0%
Lake whitefish		12	12	1%
Mountain whitefish	3		3	0%
Rainbow trout	9	18	27	2%
Totals	**1,511**	132	**1,643**	

Table 3.4.4 Relative abundance of fish species caught via electrofishing and gillnetting on Lake Roosevelt in October of 1991.

Species	Elect. #	Gillnet #	Total #	% Relative Abundance
Bridgelip sucker	2		2	0%
Longnose sucker			0	0%
Largescale sucker	553	13	566	14%
Black crappie			0	0%
Largemouth bass	3		3	0%
Smallmouth bass	729	12	741	19%
Piute sculpin	6		6	0%
Carp	17		17	0%
Peamouth			0	0%
Squawfish	17	6	23	1%
Tench			0	0%
Burbot	11	1	12	0%
Brown bullhead			0	0%
Walleye	373	22	395	10%
Yellow perch	2,027	2	2,029	51%
Brown trout	6		6	0%
Brook trout			0	0%
Chinook salmon			0	0%
Kokanee salmon	12	2	14	0%
Lake whitefish	3	20	23	1%
Mountain whitefish	22		22	1%
Rainbow trout	112	2	114	3%
Totals	**3,893.**	80	3,973	

each piute sculpin and brown trout (<1%), 3 largemouth bass (<1%), and 2 bridgelip sucker (<1%).

3.4.2 Seasonal Feeding Habits

Kokanee Salmon

Spring feeding habits

Information on spring feeding habits of kokanee salmon is presented in Table 3.4.5.

Number frequency value was highest for *Daphnia schodleri* with 83 per stomach, followed by Chironomidae larvae with 8 per stomach, and *Epischura nevadensis* with 6 per stomach. Percent composition by number value was highest for *D. schødleri* at 85%, followed by Chironomidae larvae at 8%, and *E. nevadensis* at 6 percent.

Weight frequency value was highest for *D. schodleri* with 0.0080 grams per stomach, followed by terrestrial insects with 0.0009 g per stomach, and Chironomidae larvae with 0.0003 g per stomach. Percent composition by weight value was highest for *D. schødleri* at 84%, followed by terrestrial insects at 10%, and Chironomidae larvae at 3 percent.

Frequency of occurrence value was highest for *D. schødleri* at 98%, followed by *E. nevadensis* at 41%, and Chironomidae larvae at 30 percent.

Index of relative importance was highest for *D. schodleri* at 69%, followed by *E. nevadensis* at 13%, and Chironomidae larvae at 11 percent.

Summer feeding habits

Information on summer feeding habits of kokanee salmon is presented in Table 3.4.6.

Number frequency value was highest for *Daphnia schodleri* with 52 per stomach, followed by Chironomidae larvae with 24 per stomach, and Chironomidae pupa with 2 per stomach. Percent composition by number value was highest for *D. schodleri* at 66%,

Table 3.4.5 The mean seasonal feeding habits of all kokanee salmon captured in March through May of 1991 in Lake Roosevelt, WA.

	KOKANEE (N=64)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
'REY ITEM	$\bar{x}$	%	$\bar{x}$	%	%	%
;LADOCERA (water fleas)						
Daphnia schødleri	32.54	85.07	(l.0080	84.21	97.58	68.79
:UCOPEPODA						
Cyclopoidae	0.28	0.29	0.0000	0.00	3.23	0.91
Epischura nevadensis	5.94	6.12	(1.0002	2.11	41.13	12.72
'ELECYPODA (clam)						
Sphaeridae	0.03	0.03	0.0001	1.05	0.81	0.49
)IPTERA (midges)						
Chironomidae pupa	0.11	0.11	0.0000	0.00	7.26	1.90
Chironomidae larvae	7.60	7.83	0.0003	3.16	29.84	10.53
Tipulidae larvae	0.03	0.03	0.0000	0.00	0.81	0.22
Tabanidae	0.02	0.02	0.0000	0.00	0.81	0.21
›LECOPTERA (stoneflies)						
Nemouridae	0.01	0.01	0.0000	0.00	0.81	0.21
·IYDRACHNELLLAE (spider)						
Hydracarina	0.26	0.27	0.0000	0.00	2.42	0.69
ΓERRESTRIAL	0.21	0.22	0.0009	9.47	3.23	3.33

Table 3.4.6 The mean seasonal feeding habits of all kokanee salmon captured in June through August of 1991 in Lake Roosevelt, WA.

	KOKANEE (N=5)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
PREY ITEM	$\bar{x}$	%	$\bar{x}$	%	%	%
CLADOCERA (water fleas)						
Daphnia schødleri	52.00	66.33	0.0073	48.67	87.50	49.09
EUCOPEPODA						
Epischura nevadensis	0.50	0.64	0.0001	0.67	50.00	12.44
BASOMMATOPHORA (snail)						
Physidae	0.13	0.17	0.0000	0.00	12.50	3.07
DIPTERA (midges)						
Chironomidae pupa	1.63	2.08	0.0002	1.33	25.00	6.89
Chironomidae larvae	23.88	30.46	0.0074	49.33	12.50	22.37
HYDRACHNELLLAE (spider)						
Hydracarina	0.13	0.17	0.0000	0.00	12.50	3.07
TERRESTRIAL	0.13	0.17	0.0000	0.00	12.50	3.07

followed by Chironomidae larvae at 30%, and Chironomidae pupa at 2 percent.

Weight frequency value was highest for Chironomidae larvae with 0.0074 grams per stomach, followed by *D. schødleri* with 0.0073 grams per stomach, and Chironomidae pupae with 0.0002 g per stomach. Percent composition by weight value was highest for Chironomidae larvae at 49%, followed by *D. schødleri* at 48.6%, and Chironomidae pupa at 1 percent.

Frequency of occurrence value was highest for *D. schødleri* at 87%, followed by *Epischura nevadensis* at 50%, and Chironomidae pupae at 25 percent.

Index of relative importance was highest for *D. schodleri* at 49%, followed by Chironomidae larvae at 22%, and *E. nevadensis* at 12 percent.

Fall feeding habits

Information on fall feeding habits of kokanee salmon is presented in Table 3.4.7.

Number frequency value was highest for *Daphnia schodleri* with 102 per stomach, followed by Chironomidae pupae with 1 per stomach, and terrestrial insects with 1 per stomach. Percent composition by number value was highest for *D. schødleri* at 98%, followed by Chironomidae pupae at 1%, and terrestrial insects at 1 percent.

Weight frequency value was highest for *D. schødleri* with 0.0167 grams per stomach, followed by terrestrial insects and Chironomidae pupa each with 0.0001 g per stomach. Percent composition by weight value was highest for *D. schødleri* at 99%, followed by terrestrial insects and Chironomidae pupae each at 1 percent.

Frequency of occurrence value was highest for terrestrial insects at 39%, followed by *D. schødleri* at 32%, and Chironomidae pupae at 29 percent.

Index of relative importance was highest for *D. schødleri* at 73%, followed by terrestrial insects at 13%, and Chironomidae pupae at 9 percent.

Table 3.4.7 The mean seasonal feeding habits of all kokanee salmon captured in September through November of 1991 in Lake Roosevelt, WA.

	KOKANEE (N=9)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
ITEMY	x̄	%	x̄	%	%	%
CLADOCERA (water fleas)						
Daphnia schødleri	101.86	98.30	0.0167	98.82	32.15	72.95
DIPTERA (midges)						
Chironomidae pupa	0.72	0.69	0.0001	0.59	28.57	9.50
Chironomidae larvae	0.43	0.41	0.0000	0.00	14.29	4.68'
TERRESTRIAL	0.61	0.59	0.0001	0.59	39.29	12.88

Table 3.4.8 The mean seasonal feeding habits of all kokanee salmon captured in December, January, and February of 1991 in Lake Roosevelt, WA.

	KOKANEE (N=33)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
PREY ITEM	x̄	%	x̄	%	%	%
CLADOCERA (water fleas)						
Daphnia schødleri	107.39	98.15	0.0063	*95.45*	81.67	85.58
EUCOPEPODA						
Cyclopoidae	0.04	0.04	0.0000	*0.00*	3.34	1.05
Epischura nevadensis	1.42	1.30	0.0002	3.03	15.00	6.01
DIPTERA (midges)						
Chironomidae larvae	0.04	0.04	0.0001	1.52	3.34	1.52
TERRESTRIAL	0.52	0.48	0.0000	0.00	18.33	5.85

Winter feeding habits

Information on winter feeding habits of kokanee salmon is presented in Table 3.4.8.

Number frequency value was highest for *Daphnia schødleri* with 107 per stomach, followed by *Epischura nevadensis* with 1 per stomach, and terrestrial insects with 1 per stomach. Percent composition by number value was highest for *5. schødleri* at 98%, followed by *E. nevadensis* at 1%, and terrestrial insects at 1 percent.

Weight frequency value was highest for *5. schødleri* with 0.0063 grams per stomach, followed by *E. nevadensis* with 0.0002 g per stomach, and Chironomidae larvae with 0.0001 g per stomach. Percent composition by weight value was highest for *5. schødleri* at 95%, followed by *E. nevadensis* at 3%, and Chironomidae larvae at 2 percent.

Frequency of occurrence value was highest for *D. schødleri* at 82%, followed by terrestrial insects at 18%, and *E. nevadensis* at 15 percent.

Index of relative importance was highest for D. *schødleri* at 86%, followed by *E. nevadensis* at 6%, and terrestrial insects at 6 percent.

Annual feeding habits

Information on annual feeding habits of kokanee salmon is presented in Table 3.4.9.

Number frequency value was highest for *Daphnia schødleri* with 86 per stomach, followed by Chironomidae larvae with 8 per stomach, and *Epischura nevadensis* with 2 per stomach. Percent composition by number value was highest for *5. schødleri* at 88%, followed by Chironomidae larvae at 8%, and *E. nevadensis* at 2 percent.

Weight frequency value was highest for *5. schødleri* with 0.0096 grams per stomach, followed by Chironomidae larvae with 0.0020 g per stomach, and terrestrial insects with 0.0003 g per stomach. Percent composition by weight value was highest for *D.*

Table 3.4.9 The mean annual feeding habits of all kokanee salmon captured in 1991 in Lake Roosevelt, WA.

	KOKANEE (N=111)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
PREY ITEM	x̄	%	x̄	%	%	%
CLADOCERA (water fleas)						
Daphnia schødleri	85.95	88.48	0.0096	79.34	74.73	67.54
EUCOPEPODA						
Cyclopoidae	0.08	0.08	0.0000	0.00	1.64	0.48
Epischura nevadensis	1.97	2.03	0.0001	0.83	26.53	8.18
BASOMMATOPHORA (snail)						
Physidae	0.03	0.03	0.0000	0.00	3.13	0.88
PELECYPODA (clam)						
Sphaeridae	0.01	0.01	0.0000	0.00	0.20	0.06
DIPTERA (midges)						
Chironomidae pupa	0.62	0.64	0.0001	0.83	15.21	4.64
Chironomidae larvae	7.99	8.23	0.0020	16.53	14.99	11.07
Tipulidae larvae	0.01	0.01	0.0000	0.00	0.20	0.06
Tabanidae	0.01	0.01	0.0000	0.00	0.20	0.06
PLECOPTERA (stoneflies)						
Nemouridae	0.00	0.00	0.0000	0.00	0.20	0.06
HYDRACHNELLLAE (spider)						
Hydracarina	0.10	0.10	0.0000	0.00	3.73	1.07
TERRESTRIAL	0.37	0.38	0.0003	2.48	18.34	5.90

schødleri at 79%, followed by Chironomidae larvae at 17%, and terrestrial insects at 2 percent.

Frequency of occurrence value was highest for *D. schødleri* at 75%, followed by *E. nevadensis* at 27%, and terrestrial insects at 18 percent.

Index of relative importance was highest for *D. schødleri* at 68%, followed by Chironomidae larvae at 1 1%, and *E. nevadensis* at 8 percent.

Rainbow Trout

Spring feeding habits

Information on spring feeding habits of rainbow trout is presented in Table 3.4.10.

Number frequency value was highest for fish eggs with 27 per stomach, followed by terrestrial insects with 12 per stomach, and Chironomidae larvae with 7 per stomach. Percent composition by number value was highest for fish eggs at 48%, followed by terrestrial insects at 22%, and Chironomidae larvae at 13 percent.

Weight frequency value was highest for fish eggs with 0.2024 grams per stomach, followed by terrestrial insects with 0.0911 g per stomach, and unidentifiable fish with 0.0163 g per stomach. Percent composition by weight value was highest for fish eggs at 58%, followed by terrestrial insects at 26%, and unidentifiable fish at 5 percent.

Frequency of occurrence value was highest for- terrestrial insects at 54%, followed by Chironomidae larvae at 43%, and Corixidae at 30 percent.

Index of relative importance was highest for fish eggs at 29%, followed by terrestrial insects at 24%, and Chironomidae larvae at 14 percent.

Summer feeding habits

Information on summer feeding habits of rainbow trout is. presented in Table 3.4.11.

Table 3.4.10 The mean seasonal feeding habits of all rainbow trout captured in March through May of 1991 in Lake Roosevelt, WA.

PREY ITEM	RAINBOW (N=49) NUMBER $\bar{x}$	NUMBER %	WEIGHT (g) $\bar{x}$	WEIGHT (g) %	FREQ. OCC. %	IRI %
OSTEICHTHYES (fish)						
Unidentifiable fish .	0.09	0.16	0.0163	4.65	9.98	3.52
Fish eggs	26.54	47.84	0.2024	57.73	16.70	29.11
ISOPODA (sow bugs)						
Asellus	0.02	0.04	0.0001	0.03	1.52	0.38
CLADOCERA (water fleas)						
Daphnia schødleri	0.71	1.28	0.0001	0.03	0.93	0.53
BASOMMATOPHORA (snail)						
Planorbidae	0.03	0.05	0.0002	0.06	1.85	0.47
Physidae	0.03.	0.05	0.0000	0.00	3.33	0.81
PELECYPODA (clam)						
Sphaeridae	0.24	0.43	0.0009	0.26	4.26	1.18
DIPTERA (midges)						
Chironomidae pupa	4.57	8.24	0.0069	1.97	24.80	8.33
Chironomidae larvae	7.43	13.39	0.0139	3.96	43.05	14.38
Simuliidae larvae	0.18	0.32	0.0001	0.03	2.59	0.70
Tabanidae	0.01	0.02	0.0001	0.03	0.93	0.23
TRICHOPTERA (caddisflies)						
Hydropsychidae	0.06	0.11	0.0004	0.11	4.88	1.21
Hydroptilidae	0.03	0.05	0.0001	0.03	3.33	0.81
HEMIPTERA (bugs)						
Corixidae	2.83	5.10	0.0111	3.17	30.07	9.13
PLECOPTERA (stoneflies)						
Perlodidae	0.24	0.43	0.0001	0.03	5.68	1.46
EPHEMEROPTERA (mayflies						
Ephemerellidae	0.09	0.16	0.0001	0.03	3.03	0.77
OLIGOCHAETA (worms)						
Lumbriculidae	0.06	0.11	0.0018	0.51	3.96	1.09
HYDRACHNELLLAE (spider)						
Hydracarina	0.09	0.16	0.0049	1.40	5.19	1.61
TERRESTRIAL	12.23	22.04	0.0911	25.98	53.99	24.29

Table 3.4.11 The mean seasonal feeding habits of all rainbow trout captured in June through August of 1991 in Lake Roosevelt, WA.

	RAINBOW (N=23)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
PREY ITEM	$\bar{x}$	%	$\bar{x}$	%	%	%
OSTEICHTHYES (FISH)						
Percidae	1.37	0.37	0.1865	53.33	40.00	20.98
Unidentifiable fish	0.07	0.02	0.0012	0.34	3.33	0.83
CLADOCERA (water fleas)						
Daphnia schødleri	36.67	23.31	0.0097	2.77	41.67	15.17
Leptodora kindti	264.45	71.13	0.0754	21.56	38.89	29.46
EUCOPEPODA						
Epischura nevadensis	0.03	0.01	0.0023	0.66	2.78	0.77
BASOMMATOPHORA (snail)						
Physidae	0.03	0.01	0.0000	0.00	2.78	0.62
DIPTERA (midges)						
Chironomidae pupa	6.29	1.69	0.0025	0.71	35.56	8.50
Chironomidae larvae	2.99	0.80	0.0010	0.29	18.33	4.35
Tipulidae larvae	0.09	0.02	0.0000	0.00	6.11	1.37
HEMIPTERA (bugs)						
Corixidae	2.36	0.63	0.0115	3.29	2.78	1.50
TERRESTRIAL	7.46	2.01	0.0596	17.04	54.44	16.45

Number frequency value was highest for *Leptodora kindti* with 264 per stomach, followed by *Daphnia schødleri* with 87 per stomach, and terrestrial insects with 7 per stomach. Percent composition by number value was highest for *L. kindti* at 71%; followed by *D. schødleri* at 23%, and terrestrial insects at 2 percent.

Weight frequency value was highest for Percidae with 0.1865 grams per stomach, followed by *L. kindti* with 0.0754 g per stomach, and terrestrial insects with 0.0596 g per stomach. Percent composition by weight value was highest for Percidae at 53%, followed by *L. kindti* at 22%, and terrestrial insects at 17 percent.

Frequency of occurrence value was highest for terrestrial insects at 54%, followed by *D. schødleri* at 42%, and Percidae at 40 percent.

Index of relative importance was highest for *L. kindti* at 29%, followed by Percidae at 21%, and terrestrial insects at 16 percent.

Fall feeding habits

Information on fall feeding habits of rainbow trout is presented in Table 3.4.12.

Number frequency value was highest for *Daphnia schødleri* with 295 per stomach, followed by *Leptodora kindti* with 107 per stomach, and Chironomidae larvae with 3 per stomach. Percent composition by number value was highest for *D. schødleri* at 72%, followed by *L. kindti* at 26%, and Chironomidae larvae at 3 percent.

Weight frequency value was highest for *D. schødleri* with 0.0363 grams per stomach, followed by Percidae with 0.0341 g per stomach, and *L. kindti* with 0.0264 g per stomach. Percent composition by weight value was highest for *D. schødleri* at 31%, followed by Percidae at 29%, and *L. kindti* at 23 percent.

Frequency of occurrence value was highest for *D. schødleri* at 73%, followed by Chironomidae pupae at 60%, and terrestrial insects at 37 percent.

Index of relative importance was highest for *D. schødleri* at 38%, followed by *L. kindti* at 18%, and Chironomidae pupa at 14 percent.

Table 3.4.12 The mean seasonal feeding habits of all rainbow trout captured in September through November of 1991 in Lake Roosevelt, WA.

	RAINBOW (N=17)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
PREY ITEM	x̄	%	x̄	%	%	%
OSTEICHTHYES (fish)						
Percidae	0.03	0.01	0.0341	'29.12	3.33	6.96
Unidentifiable fish	0.03	0.01	0.0001	0.09	3.33	0.73
AMPHIPODA (scuds)						
Gammarus	0.20	0.05	0.0001	0.09	6.67	1.46
CLADOCERA (water fleas)						
Daphnia schødleri	!94.9(	71.76	0.0363	'31 .oo	73.33	37.74
Leptodora kindti	06.61	25.95	0.0264	'22.54	33.33	17.53
EUCOPEPODA						
Epischura nevadensis	0.93	0.23	0.0001	0.09	10.00	2.21
BASOMMATOPHORA (snail)						
Physidae	0.03	0.01	0.0001	0.09	3.33	0.73
DIPTERA (midges)						
Chironomidae pupa	1.07	0.26	0.0073	6.23	60.00	14.25
Chironomidae larvae	3.27	0.80	0.0032	2.73	20.00	5.04
Tipulidae larvae	0.07	0.02	0.0000	0.00	6.67	0.72
HEMIPTERA (bugs)						
Corixidae	0.07	0.02	0.0002	0.17	2.78	1.47
EPHEMEROPTERA (mayflies						
Baetidae	0.10	0.02	0.0001	0.09	3.33	0.74
ODONATA (dragonflies)						
Zygoptera	2.63	0.64	0.0058	4.95	3.33	1.91
TERRESTRIAL	0.97	0.24	0.0033	2.82	36.67	8.51

Annual feeding habits

Information on annual feeding habits of rainbow trout is presented in Table 3.4.13.

Number frequency value was highest for *Daphnia schødleri* with 127 per stomach, followed by *Leptodora kindti* with 124 per stomach, and fish eggs with 9 per stomach. Percent composition by number value was highest for *D. schødleri* at 46%, followed by *L. kindti* at 44%, and fish eggs at 3 percent.

Weight frequency value was highest for Percidae with 0.0735 grams per stomach, followed by fish eggs with 0.0675 g per stomach, and terrestrial insects with 0.0513 g per stomach. Percent composition by weight value was highest for Percidae at 27%, followed by fish eggs at 25%, and terrestrial insects at 19 percent.

Frequency of occurrence value was highest for terrestrial insects at 48%, followed by Chironomidae pupae at 40%, and *D. schødleri* at 39 percent.

Index of relative importance was highest for *D. schødleri* at 20%, followed by *L. kindti* at 18%, and terrestrial insects at 16 percent.

Walleye

Spring feeding habits

Information on spring feeding habits of walleye is presented in Table 3.4.14.

Number frequency value was highest for Chironomidae larvae with 1 per stomach, followed by unidentifiable fish with 1 per stomach, and Simuliidae larvae with 1 per stomach. Percent composition by number value was highest for Chironomidae larvae at 37%, followed by unidentifiable fish at 18%, and Simuliidae larvae at 16 percent.

Weight frequency value was highest for Cottidae with 0.1365 grams per stomach, followed by Salmonidae with 0.1072 g per stomach, and unidentifiable fish with 0.0696 g per stomach. Percent composition by weight value was highest for Cottidae at 43%,

Table 3.4.13 The mean annual feeding habits of rainbow trout captured 'in 1991 in Lake Roosevelt, WA.

	RAINBOW (N=89)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
PREY ITEM	x̄	%	x̄	%	%	%
OSTEICHTHYES (fish)						
Percidae	0.47	0.17	0.0735	27.01	14.44	9.36
Unidentifiable fish	0.06	0.02	0.0059	2.17	5.55	1.74
Fish eggs	8.85	3.17	0.0675	24.81	5.57	7.55
AMPHIPODA (scuds)						
Gammarus	0.07	0.03	0.0000	0.00	2.22	0.51
'SOPODA (sow **bugs)**						
Asellus	0.01	0.00	0.0000	0.00	0.51	0.12
CLADOCERA (water **fleas)**						
Daphnia schødleri	127.43	45.61	0.0154	5.66	38.64	20.23
Leptodara kindti	123.69	44.27	0.0339	12.46	24.07	18.18
EUCOPEPODA						
Epischura nevadensis	0.32	0.11	0.0008	0.29	4.26	1.05
3ASOMMATOPHORA **(snail)**						
Planorbidae	0.01	0.00	0.0001	0.04	0.62	0.15
Physidae	0.03	0.01	0.0000	0.00	3.15	0.71
?ELECYPODA **(clam)**						
Sphaeridae	0.08	0.03	0.0003	0.11	1.42	0.35
DIPTERA (midges)						
Chironomidae pupa	3.98	1.42	0.0056	2.06	40.12	9.81
Chironomidae larvae	4.56	1.63	0.0060	2.21	27.13	6.97
Tipulidae larvae	0.05	0.02	0.0000	0.00	3.15	0.71
Simuliidae	0.06	0.02	0.0000	0.00	0.86	0.20
Tabanidae	0.00	0.00	0.0000	0.00	0.31	0.07
TRICHOPTERA (caddisflies)						
Hydropsychidae	0.02	0.01	0.0001	0.04	1.63	0.38
Hydroptilidae	0.01	0.00	0.0000	0.00	1.11	0.25
HEMIPTERA (bugs)						
Corixidae	1.75	0.63	0.0076	2.79	13.17	3.73
PLECOPTERA **(stoneflies)**						
Perlodidae	0.08	0.03	0.0000	0.00	1.89	0.43
EPHEMEROPTERA **(mayflies)**						
Baetidae	0.03	0.01	0.0000	0.00	1.11	0.25
Ephemerellidae	0.03	0.01	0.0000	0.00	1.01	0.23
DDONATA (dragonflies)						
Zygoptera	0.88	0.31	0.0019	0.70	1.11	0.48
OLIGOCHAETA (work)						
Lumbriculidae	0.02	0.01	0.0006	0.20	1.32	0.35
HYDRACHNELLLAE (spider)						
Hydracarina	0.03	0.01	0.0016	0.59	1.73	0.52
TERRESTRIAL	6.89	2.47	0.0513	18.85	48.37	15.68

Table 3.4.14 The mean seasonal feeding habits of all walleye captured in March through May of 1991 in Lake Roosevelt, WA.

	WALLEYE (N=20)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
PREY ITEM	x̄	%	x̄	%	%	%
OSTEICHTHYES (fish)						
Cottidae	0.31	9.72	0.1365	43.24	31.31	24.20
Salmonidae	0.07	2.19	0.1072	33.96	3.33	11.34
Unidentifiable fish	0.56	17.55	0.0696	22.05	49.52	25.59
DIPTERA (midges)						
Chironomidae pupa	0.34	10.66	0.0002	0.06	22.38	9.51
Chironomidae larvae	1.18	36.99	0.0022	0.70	35.00	20.88
Simuiiidae pupae	0.23	7.21	0.0000	0.00	3.33	3.03
Simuliidae larvae	0.50	15.67	0.0000	0.00	3.33	5.46

Table 3.4.15 The mean seasonal feeding habits of all walleye captured in June through August of 1991 in Lake Roosevelt, WA.

	WALLEYE (N=40)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
PREY ITEM	x̄	%	x̄	%	%	%
DSTEICHTHYES (fish)						
Cottidae	3.57	35.45	0.0818	37.75	47.19	39.81
Percidae	0.28	2.78	0.0691	31.89	23.75	19.32
Unidentifiable fish	0.33	3.28	0.0634	29.26	23.81	18.63
CLADOCERA (water fleas)						
Leptodora kindti	5.89	58.49	0.0024	1.11	7.68	22.25

Table 3.4.16 The mean seasonal feeding habits of all walleye captured in September through November of 1991 in Lake Roosevelt, WA.

	WALLEYE (N=38)					
	NUMBER		WEIGHT (g)		FREQ. OCC.	IRI
PREY ITEM	$\bar{x}$	%	$\bar{x}$	%	%	%
OSTEICHTHYES (fish)						
Cottidae	0.19	5.32	0.0705	5.24	6.11	4.84
Cyprinidae	0.46	12.89	0.4026	29.93	15.56	16.94
Percidae	0.80	22.41	0.2916	21.68	26.11	20.37
Salmonidae	0.07	1.96	0.1644	12.22	6.67	6.05
Unidentifiable fish	1.61	45.10	0.4158	30.91	61.03	39.77
DIPTERA (midges)						
Chironomidae pupa	0.28	7.84	0.0003	0.02	13.49	6.20
Chironomidae larvae	0.01	0.28	0.0000	0.00	1.11	0.40
TERRESTRIAL	0.15	4.20	0.0001	0.01	14.45	5.42

value was highest forunidentifiable fish at 45%, followed by Percidae at 22%, and Cyprinidae at 13 percent.

Weight frequency value was highest for unidentifiable fish with 0.4158 grams per stomach, followed by Cyprinidae with 0.4026 g per stomach, and Percidae with 0.2916 g per stomach. Percent composition by weight value was highest for unidentifiable fish at 31%, followed by Cyprinidae at 30%, and Percidae at 22 percent.

Frequency of occurrence value was highest for unidentifiable fish at 61%, followed by Percidae at 26%, and Cyprinidae at 16 percent.

Index of relative importance was highest for unidentifiable fish at 40%, followed by Percidae at 20%, and Cyprinidae at 17 percent.

Annual feeding habits

Information on annual feeding habits of walleye is presented in Table 3.4.17.

Number frequency value was highest for *Leptodora kindfi* with 2 per stomach, followed by Cottidae with 1 per stomach, and unidentifiable fish with 1 per stomach. Percent composition by number value was highest for *L. kindti* at 35%, followed by Cottidae at 24%, and unidentifiable fish at 15 percent.

Weight frequency value was highest for unidentifiable fish with 0.1829 grams per stomach, followed by Cyprinidae with 0.1342 g per stomach, and Percidae with 0.1202 g per stomach. Percent composition by weight value was highest for unidentifiable fish at 30%, followed by Cyprinidae at 21%, and Percidae at 19 percent.

Frequency of occurrence value was highest for unidentifiable fish at 45%, followed by Cottidae at 28%, and Percidae at 13 percent.

Index of relative importance was highest for unidentifiable fish at 27%, followed by Cottidae at 20%, and Percidae at 13 percent.

Table 3.4.17 The mean annual feeding habits of walleye captured in 1991 in Lake Roosevelt, WA.

	WALLEYE (N=20)					
PREY ITEM	NUMBER $\bar{x}$		WEIGHT (g) $\bar{x}$	%	FREQ. OCC. %	IRI %
OSTEICHTHYES (fish)						
Cottidae	1.36	24.20	*0.0963*	*15.39*	28.20	20.43
Cyprinidae	0.15	2.67	0.1342	21.44	5.19	8.83
Percidae	0.36	6.41	0.1202	19.21	16.62	12.73
Salmonidae	0.05	0.89	0.0905	14.46	3.33	5.63
Unidentifiable fish	0.83	14.77	0.1829	29.23	44.79	26.76
CLADOCERA (water fleas)						
Leptodora kindti	1.96	34.88	0.008	0.13	2.56	11.32
DIPTERA (midges)						
Chironomidae pupa	0.21	3.74	0.002	0.03	11.96	4.74
Chironomidae larvae	0.40	7.12	0.0007	0.11	12.04	5.81
Simuliidae pupae	0.08	1.42	0.0000	0.00	1.11	0.76
Simuliidae larvae	0.17	3.02	0.0000	0.00	1.11	1.25
TERRESTRIAL	0.05	0.89	0.0000	0.00	4.82	1.72

3.4.3 Electivity Indices

Seasonal and Annual electivity indices for kokanee, rainbow, and walleye are shown in Tables 3.4.18 through 3.4.21.

Spring Electivity Indices

Spring kokanee demonstrated positive electivity indices for Cladocera (0.8) and Diptera (0.1) (Table 3.4.18). Negative indices were found for Cyprinidae, Percidae and Salmonidae (-0.1 each) and Catostomidae (-0.6). Spring rainbow demonstrated positive electivity indices for Terrestrials and Diptera (0.2 each) and Hemiptera (0.1). Negative indices were found for Cyprinidae, Percidae, Salmonidae, and Eucopepoda (-0.1 each) and Catostomidae (-0.6). Spring walleye demonstrated positive electivity indices for Diptera (0.7) and Unidentified fish (0.2). Negative indices were found for Cyprinidae, Percidae Salmonidae and Eucopepoda (-0.1 each) and Catostomidae (-0.6). Positive electivity indices were found for Cladocera (0.5) Diptera and Terrestrial (0.1 each) for all fish combined. Negative indices were found for Cyprinidae, Percidae, and Salmonidae (-0.1 each), and Catostomidae (-0.6).

Summer Electivity Indices

Spring kokanee demonstrated positive electivity indices for Cladocera (0.6) (Table 3.4.19). Negative indices were found for Catostomidae, Centrarchidae, Percidae, Diptera, and Oligochaeta (-0.1 each). Summer rainbow demonstrated positive electivity indices for Cladocera (0.9). Negative indices were found for Catostomidae, Centrarchidae, Percidae, Eucopepoda, and Oligochaeta (-0.1 each), and Diptera (-0.4). Summer walleye demonstrated positive electivity indices for Cladocera (0.5) and Cottidae (0.4). Negative indices were found for Catostomidae, Centrarchidae, Percidae, Eucopepoda, Oligochaeta (-0.1 each), and Diptera (-0.4). Positive electivity indices were found for Cladocera (0.9) for all fish combined. Negative indices were found for Catostomidae Centrardhidae, Percidae, Eucopepoda, and Oligochaeta (-0.1 each), and Diptera (-0.4).

Fall Electivity Indices

Fall kokanee demonstrated positive electivity indices for Cladocera (1 .O) (Table 3.4.20). Negative indices were found for

Table 3.4.18 Spring electivity indices for prey items chosen by kokanee, rainbow, walleye and all fish combined.

Prey Item	Kokanee Electivity	Rainbow Electivity	Walleye Electivity	All Fish Electivity
Catostomidae	-0.6	-0.6	-0.6	-0.6
Centrarchidae	0.0	0.0	0.0	0.0
Cottidae	0.0	0.0	0.1	0.0
Cyprinidae	-0.1	-0.1	-0.1	-0.1
Gadidae	0.0	0.0	0.0	0.0
Ictaluridae	0.0	0.0	0.0	0.0
Percidae	-0.1	-0.1	-0.1	-0.1
Salmonidae	-0.1	-0.1	-0.1	-0.1
Unidentified fish	0.0	0.0	0.2	0.0
Amphipoda	0.0	0.0	0.0	0.0
Isopoda	0.0	0.0	0.0	0.0
Cladocera	0.8	0.0	0.0	0.5
Eucopepoda	0.0	-0.1	-0.1	0.0
Basommatophora	0.0	0.0	0.0	0.0
Pelecypoda	0.0	0.0	0.0	0.0
Diptera	0.1	0.2	0.7	0.1
Trichoptera	0.0	0.0	0.0	0.0
Oligochaeta	0.0	0.0	0.0	0.0
Hemiptera	0.0	0.1	0.0	0.0
Plecoptera	0.0	0.0	0.0	0.0
Ephemeroptera	0.0	0.0	0.0	0.0
Odonata	0.0	0.0	0.0	0.0
Hydrachnelllae	0.0	0.0	0.0	0.0
Terrestrial	0.0	0.2	0.0	0.1

Table 3.4.19 Summer electivity indices for prey items chosen by kokanee, rainbow, walleye and all fish combined.

Prey Item	Kokanee Electivity	Rainbow Electivity	Walleye Electivity	All Fish Electivity
Catostomidae	-0.1	-0.1	-0.1	-0.1
Centrarchidae	-0.1	-0.1	-0.1	-0.1
Cottidae	0.0	0.0	0.4	0.0
Cyprinidae	0.0	0.0	0.0	0.0
Gadidae	0.0	0.0	0.0	0.0
Ictaluridae	0.0	0.0	0.0	0.0
Percidae	-0.1	-0.1	-0.1	-0.1
Salmonidae	0.0	0.0	0.0.	0.0
Unidentified fish	0.0	0.0	0.0	0.0
Amphipoda	0.0	0.0	0.0	0.0
lsopoda	0.0	0.0	0.0	0.0
Cladocera	0.6	0.9	0.5	0.9
Eucopepoda	0.0	-0.1	-0.1	-0.1
Basommatophora	0.0	0.0	0.0	0.0
Pelecypoda	0.0	0.0	0.0	0.0
Diptera	-0.1	-0.4	-0.4	-0.4
Trichoptera	0.0	0.0	0.0	0.0
Oligochaeta	-0.1	-0.1	-0.1	-0.1
Hemiptera	0.0	0.0	0.0	0.0
Plecoptera	0.0	0.0	0.0	0.0
Ephemeroptera	0.0	0.0	0.0	0.0
Odonata	0.0	0.0	0.0	0.0
Hydrachnelllae	0.0	0.0	0.0	0.0
Terrestrial	0.0	0.0	0.0	0.0

Table 3.4.20 Fall electivity indices for prey items chosen by kokanee, rainbow, walleye and all fish combined.

Prey Item	Kokanee Electivity	Rainbow Electivity	Walleye Electivity	All Fish Electivity
Catostomidae	-0.1	-0.1	-0.1	-0.1
Centrarchidae	-0.1	-0.1	-0.1	-0.1
Cottidae	0.0	0.0	0.1	0.0
Cyprinidae	0.0	0.0	0.1	0.0
Gadidae	0.0	0.0	0.0	0.0
Ictaluridae	0.0	0.0	0.0	0.0
Percidae	-0.3	-0.3	-0.1	-0.3
Salmonidae	0.0	0.0	0.0	0.0
Unidentified fish	0.0	0.0	0.5	0.0
Amphipoda	0.0	0.0	0.0	0.0
Isopoda	0.0	0.0	0.0	0.0
Cladocera	1.0	1.0	0.0	0.9
Eucopepoda	0.0	0.0	0.0	0.0
Basommatophora	0.0	0.0	0.0	0.0
Pelecypoda	0.0	0.0	0.0	0.0
Diptera	-0.3	-0.3	-0.2	-0.3
Trichoptera	0.0	0.0	0.0	0.0
Oligochaeta	-0.1	-0.1	-0.1	-0.1
Hemiptera	0.0	0.0	0.0	0.0
Plecoptera	0.0	0.0	0.0	0.0
Ephemeroptera	0.0	0.0	0.0	0.0
Odonata	0.0	0.0	0.0	0.0
Hydrachnelllae	0.0	0.0	0.0	0.0
Terrestrial	0.0	0.0	0.0	0.0

Catostomidae, Centrarchidae, and Oligochaeta (-0.1 each), Percidae and Diptera (-0.3 each). Fall rainbow demonstrated positive electivity indices for Cladocera (1 .0). Negative indices were found for Catostomidae, Centrarchidae, and Oligochaeta (-0.1 each) Percidae and Diptera (-0.3 each). Fall walleye demonstrated positive electivity indices for Unidentified fish (0.5). Negative indices were found for Catostomidae, Centrarchidae; Percidae,. and Oligochaeta (-0.1 each), and Diptera (-0.2). Positive electivity indices were found for Cladocera (0.9) for all fish combined. Negative indices were found for Catostomidae, Centrarchidae, and Oligochaeta (-0.1 each) Percidae and Diptera (-0.3 each).

Annual **Electivity** Indices

Annual kokanee demonstrated positive electivity indices for Cladocera (0.3) (Table 3.4.21). Negative indices were found for Centrarchidae and Oligochaeta (-0.1 each), Catostomidae, Percidae, and Diptera (-0.2 each). Annual rainbow demonstrated positive electivity indices for Cladocera (0.9). Negative indices were found for Centrarchidae and Oligochaeta (-0.1 each), Catostomidae and Percidae (-0.2 each), and Diptera (-0.3). Annual walleye demonstrated positive electivity indices for Cladocera (0.3), Cottidae (0.2), and Unidentified fish (0.1). Negative indices were found for Centrarchidae, Percidae, Diptera, and Oligochaeta (-0.1 each), and Catostomidae (-0.2). Positive electivity indices were found for Cladocera (0.9) for all fish combined. Negative indices were found for Centrarchidae and Oligochaeta (-0.1 each), Catostomidae, Percidae, and Diptera (-0.2 each).

3.4.4 Annual Age, Growth and Condition

Kokanee Salmon

Table 3.4.22 lists the mean lengths, weights and condition factors of three age classes of kokanee salmon determined from 1991 scale samples collected during the May, August, and October sampling seasons. Estimated mean back-calculated lengths at annulus formation are shown in Table 3.4.23. Regression and regression line intercept information is contained in Appendix D.

Mean lengths, weights, and condition factors were determined from 9 kokanee salmon collected at the nine index stations during the May, August, and October sampling seasons (Table 3.4.22). The

Table 3.4.21 **Annual electivity indices for prey items chosen by kokanee, rainbow, walleye and all fish combined.**

Prey Item	Kokanee Electivity	Rain bow Electivity	Walleye Electivity	All Fish Electivity
Catostomidae	-0.2	-0.2	-0.2	-0.2
Centrarchidae	-0.1	-0.1	-0.1	-0.1
Cottidae	0.0	0.0	0.2	0.0
Cyprinidae	0.0	0.0	0.0	0.0
Gadidae	0.0	0.0	0.0	0.0
Ictaluridae	0.0	0.0	0.0	0.0
Percidae	-0.2	-0.2	-0.1	-0.2
Salmonidae	0.0	0.0	0.0	0.0
Unidentified fish	0.0	0.0	0.1	0.0
Amphipoda	0.0	0.0	0.0	0.0
Isopoda	0.0	0.0	0.0	0.0
Cladocera	0.8	0.9	0.3	0.9
Eucopepoda	0.0	0.0	0.0	0.0
Basommatophora	0.0	0.0	0.0	0.0
Pelecypoda	0.0	0.0	0.0	0.0
Diptera	-0.2	-0.3	-0.1	-0.2
Trichoptera	0.0	0.0	0.0	0.0
Oligochaeta	-0.1	-0.1	-0.1	-0.1
Hemiptera	0.0	0.0	0.0	0.0
Plecoptera	0.0	0.0	0.0	0.0
Ephemeroptera	0.0	0.0	0.0	0.0
Odonata	0.0	0.0	0.0	0.0
Hydrachnelllae	0.0	0.0	0.0	0.0
Terrestrial	0.0	0.0	0.0	0.0

Table 3.4.22 **Mean lengths (mm), weights (g), and condition factors (K_{TL}) ± standard deviation of kokanee salmon collected during the 1991 sampling season. N = sample size.**

Age class	N	$\bar{X}$ Length mm	± S.D.	$\bar{X}$ Weight g	± S.D.	$\bar{X}$ K_{TL}	± S.D.
1+	1	367	± 0.0	504	± 0.0	1.02	± 0.00
2+	7	399	± 48.7	598	± 290.7	0.88	± 0.09
3+	1	466	± 0.0	887	±0.0	0.88	± 0.00
TOTAL	9					0.93	

Table 3.4.23 **Estimated mean total lengths (mm) ± standard deviation at annulus formation back-calculated for each age class of kokanee collected during the 1991 sampling season. N = sample size.**

		Mean Back-Calculated Length (mm) at Annulus		
Cohort	N	1	2	3
1990	1	206 ± 0.0		
1989	7	193 ± 58.3	338 ± 37.9	
1988	18	174 ± 0.0	334 ± 0.0	451 ± 0.0
Grand Mean	33	191	336	451
Mean Annual Growth		178	145	115

mean lengths were 367 mm, 399 mm, and 466 mm for age class 1+, 2+ and 3+ respectively. The mean weights were 504 g, 596 g, and 887 g for age class 1+, 2+, and 3+ respectively. The mean condition factors were 1.02, 0.88, and 0.88 for age class 1+, 2+, and 3+ respectively. The annual mean condition factor for all age classes combined was 0.93.

Estimated total lengths at annulus formation were calculated for each age class of kokanee salmon captured (Table 3.4.23). Back-calculated lengths for all cohorts at the formation of the first annulus ranged from 174 mm to 206 mm with a grand mean of 191 mm. Lengths at the formation of the second annulus were 334 and 338 mm with a grand mean of 336 mm. Length of the third annulus was 451 mm which represented one fish. The mean annual growth increments were 178 mm from 0+ to 1+, 145 mm from 1+ to 2+, and 115 mm from 2+ to 3+.

Rain bow Trout

Because of an observed difference in growth between native rainbow and net-pen reared rainbow, mean lengths, weights, and condition factors were determined for each rainbow type. Native rainbow trout lengths, weights, and condition factors are summarized in Tables 3.4.24 and 3.4.25. Net-pen reared rainbow trout lengths, weights and condition factors are summarized in Tables 3.4.26 and 3.4.27. Regression and regression line intercept information is contained in Appendix D.

Mean lengths, weights, and condition factors of 40 native rainbow trout were collected in 1991 (Table 3.4.24). The mean lengths were 96 mm, 223 mm, 207 mm, 336 mm, 434 mm, and 495 mm for age class 0+, 1+, 2+, 3+, 4+, and 5+ respectively. The mean weights were 6 g, 192 g, 101 g, 447 g, 333 g, and 1,230 g for age class 0+, 1+, 2+, 3+, 4+, and 5+ respectively. The condition factors were 0.71, 0.93, 0.96, 1.17, 0.97, and 1.02 for age class 0+, 1+, 2+, 3+, 4+, and 5+ respectively. The annual mean condition factor for all age classes combined was 0.96.

Total lengths at annulus formation were estimated for each age class of native rainbow trout captured (Table 3.4.25). Back-calculated lengths for all cohorts at the formation of the first annulus ranged from 101 mm to 131 mm with a grand mean of 111 mm. Lengths at the formation of the second annulus ranged from

Table 3.4.24 Mean lengths (mm), weights (g), and condition factors (K_{TL}) ± standard deviation of native rainbow trout collected during the 1991 sampling season. N = sample size.

Age class	N	$\bar{X}$ Length mm	± S.D.	$\bar{X}$ Weight g	± S.D.	$\bar{X}$ K_{TL}	± S.D.
0+	2	96	± 13.0	6	± 0.0	0.71	± 0.28
1+	5	223	± 94.6	192	± 245.2	0.93	± 0.18
2+	16	207	± 50.7	101	± 90.4	0.98	± 0.10
3+	7	336	± 74.4	447	± 200.7	1.27	± 0.88
4+	7	434	±48.8	833	± 334.2	0.97	± 0.09
5+	3	495	± 13.2	1230	± 308.0	1.02	± 0.28
TOTAL	40					0.98	

Table 3.4.25 Estimated mean total lengths (mm) ± standard deviation at annulus formation back-calculated for each age class of native rainbow trout collected during the 1991 sampling season. N = sample size.

		Mean Back-Calculated Length (mm) at Annulus				
Cohort	N	1	2	3	4	5
1990	5	131 ± 24.8				
1989	16	101 ±13.4	178 ± 48.2			
1988	7	110 ± 9.5	208 ± 69.1	311 ± 66.2		
1987	7	109 ± 14.6	191 ± 34.8	316 ± 54.3	399 ± 42.3	
1986	3	105 ± 5.4	179 ± 3.6	311 ± 76.0	384 ± 54.2	455 ± 26.1
Grand Mean	38	111	189	313	392	455
Mean Annual Growth		64	78	124	79	63

178 to 208 mm with a grand mean of 189 mm. Lengths at the formation of the third annulus ranged from 311 to 316 mm with a grand mean of 313 mm. Lengths at the formation of the fourth annulus ranged from 384 to 399 mm with a grand mean of 392 mm. Lengths at the formation of the fifth annulus had a grand mean of 455 mm which represented one fish. The mean annual growth increments were 64 mm from 0+ to 1+, 78 mm from 1+ to 2+, 124 mm from 2+ to 3+, 79 mm from 3+ to 4+, and 63 mm from 4+ to 5+.

Mean lengths, weights, and condition factors of 73 net-pen rainbow trout were collected in 1991 (Table 3.4.26). The mean lengths were 311 mm, and 369 mm for age class 1+, and 21+ respectively. The mean weights were 357 g, and 611 g for age class 1+, and 2+ respectively. The condition factors were 1.17 and 1.1 6 for age class 1+, and 2+ respectively. The annual mean condition factor for all age classes combined was 1.165.

Total lengths at annulus formation were estimated for each age class of net-pen rainbow trout captured (Table 3.4.27). Back-calculated lengths for all cohorts at the formation of the second annulus was 333 mm. The mean annual growth increment was 244 mm from 1+ to 2+. Note that no annulus was present to calculate lengths for 1+ cohort due to a constant growth rates though the winter and summer months while in the net-pens.

Walleye

Mean lengths, weights, and condition factors determined for nine age classes of walleye collected in 1991 are summarized in Table 3.4.28. Estimated mean back-calculated lengths are shown in Table 3.4.29. Regression and regression line intercept information is contained in Appendix D.

Mean lengths, weights, and condition factors of 247 walleye were collected in 1991 (Table 3.4.28). The mean lengths were 129 mm, 225 mm, 320 mm, 375 mm, 467 mm, 485 mm, 500 mm, and 725 mm for age class 0+, 1+, 2+, 3+, 4+, 5+, 6+, and 8+ respectively. No fish from age class 7+ were collected. The mean weights were 23 g, 99 g, 266 g, 457 g, 889 g, 971 g, 1012 g, and 6155 g for age class 0+, 1+, 2+, 3+, 4+, 5+, 6+,and 8+ respectively. The condition factors were 0.79, 0.80, 0.77, 0.83, 0.86, 0.76, 0.83, and 1.62 for age class 0+, 1+, 2+, 3+, 4+, 5+, 6+, and 8+ respectively. The annual mean condition factor for all age classes combined was 0.91.

Table 3.4.26 Mean lengths (mm), weights (g), and condition factors (K_{TL}) ± standard deviation of net-pen rainbow trout collected during the 1991 sampling season. N = sample size.

Age class	N	X Length mm	± S.D.	X Weight g	± S.D.	$\bar{X}$ K_{TL}	± S.D.
1+	39	311	± 39.1	357	± 129.6	1.17	± 0.37
2+	34	369	± 70.8	611	± 291.3	1.16	± 0.36
TOTAL	73					1.17	

Table 3.4.27 Estimated mean total lengths (mm) ± standard deviation at annulus formation back-calculated for each age class of net-pen rainbow trout collected during the 1991 sampling season. N = sample size.

		Mean Back-Calculated Length (mm) at Annulus
Cohort	N	2
1990	34	333 ± 64.9
Grand Mean	34	333
Mean Annual Growth		244

Table 3.4.28 Mean lengths. (mm), weights (g), and condition factors (K_{TL}) ± standard deviations of walleye collected during the 1991 sampling season. N = sample size.

Age class	N	X Length mm	± S.D.	X Weight g	± S.D.	$\bar{X}$ K_{TL}	± S.D.
0+	24	129	±45.1	23	± 22.7	0.79	± 0.31
1+	57	225	± 42.4	99	± 55.2	0.80	± 0.12
2+	90	320	± 34.6	266	± 113.3	0.77	± 0.11
3+	34	375	± 61.5	457	± 176.2	0.83	± 0.13
4+	24	467	± 33.1	889	± 256.7	0.86	± 0.13
5+	12	485	± 68.2	971	± 487.6	0.76	± 0.13
6+	5	500	± 93.5	1012	± 695.9	0.83	± 0.10
7+							
8+	1	725	± 0.0	6155	± 0.0	1.62	± 0.00
TOTAL	247					0.91	

Estimated total lengths at annulus formation were estimated for each age class of walleye captured (Table 3.4.29). Back-calculated lengths for all cohorts at the formation of the first annulus ranged from 166 mm to 206 mm with a grand mean of 183 mm. Lengths at the formation of the second annulus ranged from 266 to 302 mm with a grand mean of 282 mm. Lengths at the formation of the third annulus ranged from 328 to 465 mm with a grand mean of 366 mm. Lengths at the formation of the fourth annulus ranged from 384 to 545 mm with a grand mean of 438 mm. Lengths at the formation of the fifth annulus ranged from 433 to 583 mm with a grand mean of 493 mm. Lengths at the formation of the sixth annulus ranged from 479 to 620 mm with a grand mean of. 550 mm. Lengths of the seventh and eighth annuli were estimated at 662 mm and 700 mm respectively, which represented one fish. The mean annual growth increments were 111 mm from 0+ to 1+, 99 mm from 1+ to 2+, 84 mm from 2+ to 3+, 72 mm from 3+ to 4+, 55 mm from 4+ to 5+, 57 mm from 5+ to 6+, 112 mm from 6+ to 7+, and 38 mm from 7+ to 8+.

3.5 TAGGED FISH RECOVERY

Tables 3.5.1 through 3.5.4 summarize fish tag recoveries from each net-pen tagging effort on Lake Roosevelt from 1988 to present. Fish tagging effort and seasonal recoveries are listed in Appendix E.

Kettle Falls

On September 27, 1989, 584 fish were tagged and released from the Kettle Falls net-pen (Table 3.5.1). Subsequent tag returns found I fish recaptured in 1989, 11 fish in 1990, and 1 fish in 1991 for a 93% recovery above Grand Coulee. Below Grand Coulee, one fish was recaptured in 1990 for 7% recovery. On March 27, 1990, 508 fish were tagged and released. Subsequent tag returns found one fish recaptured in 1990 and 1 in 1991 for a 100% recovery above Grand Coulee. On April 14, 1990, 498 fish were tagged and released. Tag returns found 12 fish recaptured in 1990 and 2 fish in 1991 for a 70% recovery above Grand Coulee. Below Grand Coulee, 3 fish were recaptured in 1990, and 3 in 1991 for a 30% recovery. On April 17, 1991, 1,000 fish were tagged and released. Tag returns found 37 fish recaptured in 1991 for a 79% recovery rate above Grand Coulee. Below Grand Coulee, 10 fish were recaptured for a 21% recovery.

Table 3.4.29 Estimated mean total lengths (mm) ± standard deviation at annulus formation back-calculated for each age class of walleye collected during the 1991 sampling season. N = sample size.

		Mean Back-Calculated Length (mm) at Annulus							
Cohort	**N**	**1**	2	3	4	5	6	7	8
1990	57	166 ± 22.2							
1989	90	192 ± 19.2	287 ± 32.2						
1988	34	184 ± 24.4	270 ± 46.3	338 ± 58.7					
1987	24	194 ± 35.8	286 ± 62.2	352 ± 76.3	410 ± 90.4				
1986	15	199 ± 46.5	281 ± 41.2	347 ± 47.6	412 ± 49.1	462 ± 59.4			
1985	5	196 ± 27.9	266 ± 60.8	328 ± 66.2	384 ± 81.5	433 ± 82.5	479 ± 82.9		
1984	0								
1983	1	206 ±0.0	302 ±0.0	465 ± 0.0	545 ± 0.0	583 ± 0.0	620 ± 0.0	662 ± 0.0	700 ± 0.0
Grand Mean	226	183	282	366	438	493	550	662	700
Mean Annual Growth		111'	99	84	72	5 5	57	112	38

Table 3.5.1 Summary of fish tag recoveries from the Kettle Falls net-pens.

		Number of tagged fish recovered above Grand Coulee							Number of tagged fish recovered below Grand Coulee						
Tag Date	No. Tagged	86	87	88	89	90	91	% Caught Above	86	87	88	89	90	91	% Caught Below
9/27/89	584				1	11	1	93%				0	1	0	7%
3/27/90	508					1	1	100%					0	0	0%
4/14/90	498					12	2	70%					3	3	30%
4/17/91	1,000						37	79%						10	21%

Hunters

On May 10, 1989, 768 fish were tagged and released from the Hunters net-pens (Table 3.5.2). Tag returns found 1 fish recaptured in 1989 and 1 fish in 1990 for a 29% recovery above Grand Coulee. Below Grand Coulee, 5 fish were recaptured in 1989 for a 71% recovery. On October 7, 1989, 447 fish were tagged and released. Subsequent tag returns found 10 fish recaptured in 1990 for a 100% recovery above Grand Coulee. On March 29, 1990, 490 fish were tagged and released. Tag returns found 1 fish recaptured in 1990 for a 33% recovery above Grand Coulee. Below Grand Coulee, 2 fish were recaptured in 1990 for a 67% recovery. On April 19, 1990, 498 fish were tagged an released. Subsequent tag returns found 5 fish recaptured in 1990, and 2 fish in 1990 for a 78% recovery above Grand Coulee. Below Grand Coulee, 1 fish was recaptured in 1990, and 1 in 1991 for a 22% recovery. On May 19, 1990, 492 fish were tagged and released. Tag returns found 3 fish recovered in 1990 and 2 fish in 1991 for a 83% recovery above Grand Coulee. Below Grand Coulee, 1 fish was recaptured in 1990 for a 17% recovery. On October 24, 1990, 366 fish were tagged and released. Tag returns found 1 fish recaptured in 1991 for a 33% recovery above Grand Coulee. Below Grand Coulee, 2 fish were recaptured for a 67% recovery.

Seven Bays

On May 4, 1988, 1,171 fish were tagged and released from the Seven Bays net-pen (Table 3.5.3). Subsequent tag returns found 76 fish recaptured in 1988, 16 fish in 1989, and 1 fish in 1991 for a 100% recovery above Grand Coulee. On April 12, 1989, 985 fish were tagged and released. Tag returns found 10 fish recaptured in 1989 and 1 fish in 1990 for a 55% recovery above Grand Coulee. Below Grand Coulee, 8 fish were recaptured in 1989 and 1 in 1990 for a 45% recovery. On May 22, 1990, 443 fish were tagged and released. Tag returns found 1 fish recaptured for a 50% recovery above Grand Coulee. Below Grand Coulee, on fish was recaptured in 1990 for a 50% recovery. On. April 17, 1990, 474 fish were tagged and released. Tag returns found 10 fish recaptured in 1990 and 2 fish in 1991 for a 67% recovery above Grand Coulee. Below Grand Coulee 5 fish were recaptured in 1990 and 1 in 1991 for a 33% recovery. On May 26, 1990, 499 fish were tagged and released. Subsequent tag returns found 17 fish recaptured in 1990 and 4 in 1991 for a 78% recovery

Table 3.5.2 Summary of fish tag recoveries from the Hunters net-pens.

		Number of tagged fish recovered above Grand Coulee							Number of tagged fish recovered below Grand Coulee						
Tag Date	No. Tagged	86	87	88	89	90	91	% Caught Above	86	87	88	89	90	91	% Caught Below
3/10/89	768				1	1	0	29%				5	0	0	71%
10/7/89	447				0	10	0	100%				0	0	0	0%
3/29/90	490					1	0	33%					2	0	67%
4/19/90	498					5	2	78%					1	1	22%
5/19/90	492'					3	2	83%					1	0	17%
10/24/90	366					0	1	33%					0	2	67%

Table 3.5.3 Summary of fish tag recoveries from the Seven Bays net-pens.

		Number of tagged fish recovered above Grand Coulee							Number of tagged fish recovered below Grand Coulee						
Tag Date	No. Tagged	86	87	88	89	90	91	% Caught Above	86	87	88	89	90	91	% Caught Below
5/4/88	1,171			76	16	0	1	100%			0	0	0	0	0%
4/12/89	985				10	1	0	55%				8	1	0	45%
3/22/90	443					1	0	50%					1	0	50%
4/17/90	474					10	2	67%					5	1	33
5/26/90	499					17	4	78%					5	1	22%
4/17/91	1,300						8	40%						12	60%
6/6/91	296						23	82%						5	18%
7/13/91	1,749						113	95%						6	5%

above Grand Coulee. Below Grand Coulee, 5 fish were recaptured in 1990 and 1 fish in 1991 for a 22% recovery. On April 17, 1991, 1,300 fish were tagged and released. Tag returns found 8 fish recaptured in 1991 for a 40% recovery above Grand Coulee. Below Coulee, 12 fish were recaptured in 1991 for a 60% recovery. On June 6, 1991, 296 fish were tagged and released. Tag returns found 23 fish recaptured in 1991 for a 82% recovery above Grand Coulee. Below Grand Coulee, 5 fish were recaptured in 1991 for a 18% recovery. On July 13, 1991, 1,749 fish were tagged and released. Subsequent tag returns found ii3 fish recaptured in 1991 for a 95% recovery above Grand Coulee. Below Grand Coulee, 6 fish were recaptured for a 5% recovery.

Keller Ferry

On May 12, 1990, 459 fish were. tagged and released from the Keller Ferry net-pen (Table 3.5.4). Subsequent tag returns found ii fish recaptured in 1990 for a 79% recovery above Grand Coulee. Below Grand Coulee, 3 fish were recaptured in 1990 for a 21% recovery.

Table 3.5.4 Summary of fish tag recoveries from the Keller Ferry net-pens.

		Number of tagged fish recovered above Grand Coulee							Number of tagged fish recovered below Grand Coulee						
Tag Date	No. Tagged	86	87	88	89	90	91	% Caught Above	86	87	88	89	90	91	% Caught Below
5/12/90	459					i i	0	79%					3	0	21%

4.0 DISCUSSION

4.1 RESERVOIR OPERATIONS

For the water year 1990/1 991 the reservoir was operated primarily for power production and augmentation of river flows for anadromous fish (Columbia River Water Management Group 1991, CBFWA 1991).

Lake Roosevelt's annual spring drawdown began on March 1st and included a 400 KAF flood control shift from Dworshak to Grand Coulee. This shift occurred to allow Dworshak to increase its springtime release of water for Snake River juvenile fish migration. According to the Columbia River Water Management Group (1991) the flood control shift affected Lake Roosevelt from March 1st to April 30th however, the reservoir reached a low of 1221.7 on April 29th roughly halfway between the flood control rule curve and the variable energy content curve for power. The additional drawdown was for power marketing (CBFWA 1991) as additional water was not requested for water budget purposes.

Table 4.1 .1 shows the affect a flood control shift has on Lake Roosevelt elevations. As elevation decreases within Lake Roosevelt the greater the changes in elevation become with the flood control shift. Table 4.1.2 shows that a 400 KAF flood control shift represents a 2 to 3 day decrease in water retention time at each reservoir elevation. This table also shows that current operations produce water retention times that represent adverse conditions for the fishery. This table used the mean outflow for March and April of 1991, 151 and 153 (kcfs) respectively. Water retention times were then calculated using different reservoir elevations and the mean outflows. The resulting water retention times were very poor for Lake Roosevelt without the flood control shift, ranging from 30 days at elevation 1290 to 13 days at elevation 1210. Previous reports by Beckman *et al.* (1985), Peone et *al.* (1 990) and Griffith and Scholz (1990) have shown that reduced water retention times have adverse affects on zooplankton density and fish entrainment levels. Table 4.1.3 shows the maximum outflows needed to achieve water retention times of 30, 35, 40, 45, and 50 days for different reservoir elevations. It is recommended that these outflow constraints be used on Grand Coulee to promote sufficient water retention levels to reduce zooplankton and fish entrainment through the dam.

Table 4.1.1 Changes in Lake Roosevelt reservoir elevation and total storage with a 400 KAF flood control shift from Dworshak.

Elevation (Feet)	Total Storage (KAF)	Storage - 400 KAF Flood Shift	New Elevation (Feet)	Elevation Change (Feet)
1290	**4592**	4192	1280	IO
1280	4193	3793	1269	11
1270	3820	3420	1259	i i
1260	3466	3066	1248	12
1250	3133	2733	1237	13
1245	2974	2574	1231	14
1240	2821	2421	1226	14
1235	2673	2273	1220	15
1230	2532	2132	1215	15
1225	2396	1996	1209	16
1220	2267	1867	*	
1215	2143	1743	*	
1210	2024	1624	*	
1205	1909	1509	*	

* A 400 MAF **flood control shift** cannot occur at these elevations.

Table 4.1.2 Difference in water retention time with a 400 KAF flood control shift from Dworshak to Grand Coulee using the mean outflow from Coulee in March (151 kcfs) and April (153 kcfs) of 1991.

Elevation without Flood Shift	Mean March WRT (days)	Mean April WRT (days)	New Elevation w/ Flood Shift	Mean March WRT (days)	Mean April WRT (days)
1290	30	30	1280	28	27
1280	28	27	1269	25	25
1270	25	25	1259	23	22
1260	23	23	1248	20	20
1250	21	20	1237	18	18
1245	20	19	1231	17	17
1240	19	18	1226	16	16
1235	18	17	1220	15	15
1230	17	17	1215	14	14
1225	16	16	1209	13	13
1220	15	15			
1215	14	14			
1210	13	13			

- Turbines at Grand Coulee no longer function at 1208 ft.

Table 4.1.3 Maximum outlfows from Grand Coulee to maximize water retention time and decrease the entrainment of nutrients, zooplankton, and salmonid species.

Elevation (feet)	Maximum Outflow (kcfs) for 30 Day WRT	Maximum Outflow (kcfs) for 35 Day WRT	Maximum Outflow (kcfs) for 40 Day WRT	Maximum Outflo'w (kcfs) for 45 Day WRT	Maximum Outflow (kcfs) for 50 Day WRT
1290	153	131	115	102	92
1285	146	125	110	98	88
1280	140	120	105	93	84
1275	133	114	100	89	80
1270	127	109	96	85	76
1265	121	104	91	81	73
1260	116	99	87	77	69
1255	110	94	82	73	66
1250	104	90	78	70	63
1245	99	85	74	66	59
1240	94	81	71	63	56
1235	89	76	67	59	53
1230	84	72	63	56	51
1225	80	68	60	53	48
1220	76	65	57	50	45
1215	71	61	54	48	43
1210	67	58	51	45	41

After May 1st the reservoir was operated for power and began actively refilling on May **10th,** however, the reservoir did not have relatively low outflows (78 kcfs) until September.

4.2 ZOOPLANKTON

4.2.1 Affect of Reservoir Operations on Zooplankton Dynamics

Mean microcrustacean zooplankton density (including nauplii) was determined for May, August, and October, 1991, to be $875/m^3$ and was much lower than previous years of study (Thatcher et *al.* 1993). Highest recorded *Daphnia* spp. was $572/m^3$ at Spring Canyon in July (Figure 4.2.1). Spring Canyon also had the highest total zooplankton density in August at $4,378/m^3$ (Figure 4.2.2). The high density values in the lower end of the reservoir were thought to be a result of low water retention times which washed the zooplankton from the upper reaches of the reservoir to the **forebay.** Future studies will aid in determining ‘if this is the case since data collection at Gifford and Spring Canyon did not begin monthly until July of 1991.

The reservoir as a whole experienced two peaks of *Daphnia* spp. density. The first peak occurred between July and August due to reservoir filling which provided a large quantity of nutrients for phytoplankton which increased the forage base for zooplankton. As the nutrients and forage base were used up, *Daphnia* spp. density decreased. As more nutrients were washed into the reservoir and became part of the food chain a second peak in density occurred, this time between October and November.

Daphnia spp. biomass values were highest in November at Seven Bays with 15,212 $\mu g/m^3$ (Figure 4.2.3). Total Cladocera biomass was also highest at Seven Bays with 15,386 $\mu g/m^3$ in November (Figure 4.2.4). Again, the peaks in biomass are thought to be related to increased reservoir elevations and water retention times which made nutrients available to the system.

Reduced water retention times were thought to be the cause of the significant decreases in density and biomass values found in 1991 when compared to values found in 1989 and 1990 (Table 4.2.1). When May, August, and October density and biomass values of 1989,

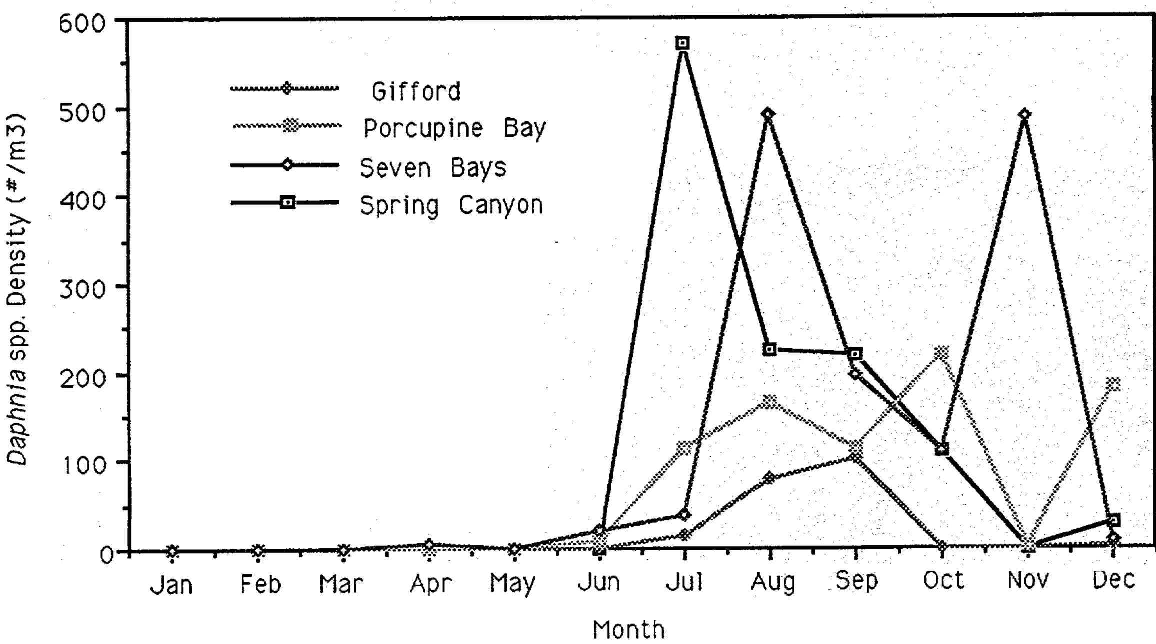

Figure 4.2.1 **Mean montly *Daphnia* spp. density (#/m3) for Gifford, Porcupine Bay, Seven Bays, and Spring Canyon in 1991.**

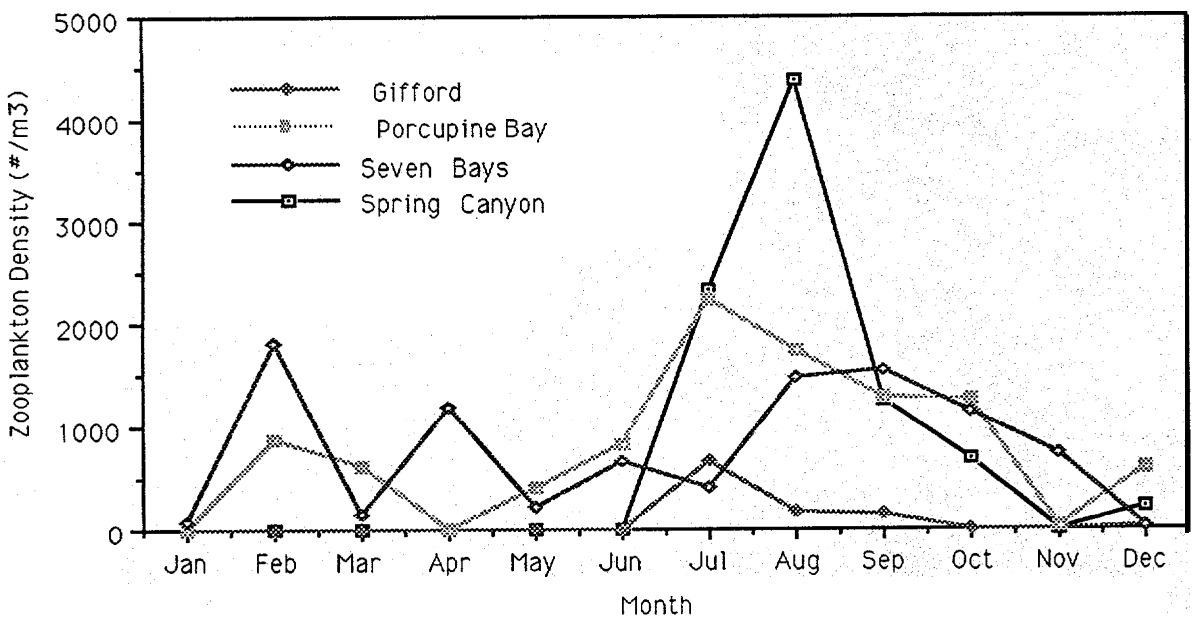

Figure 4.2.2 **Mean monthly zooplankton density (#/m3) for Gifford, Porcupine Bay, Seven Bays, and Spring Canyon in 1991.**

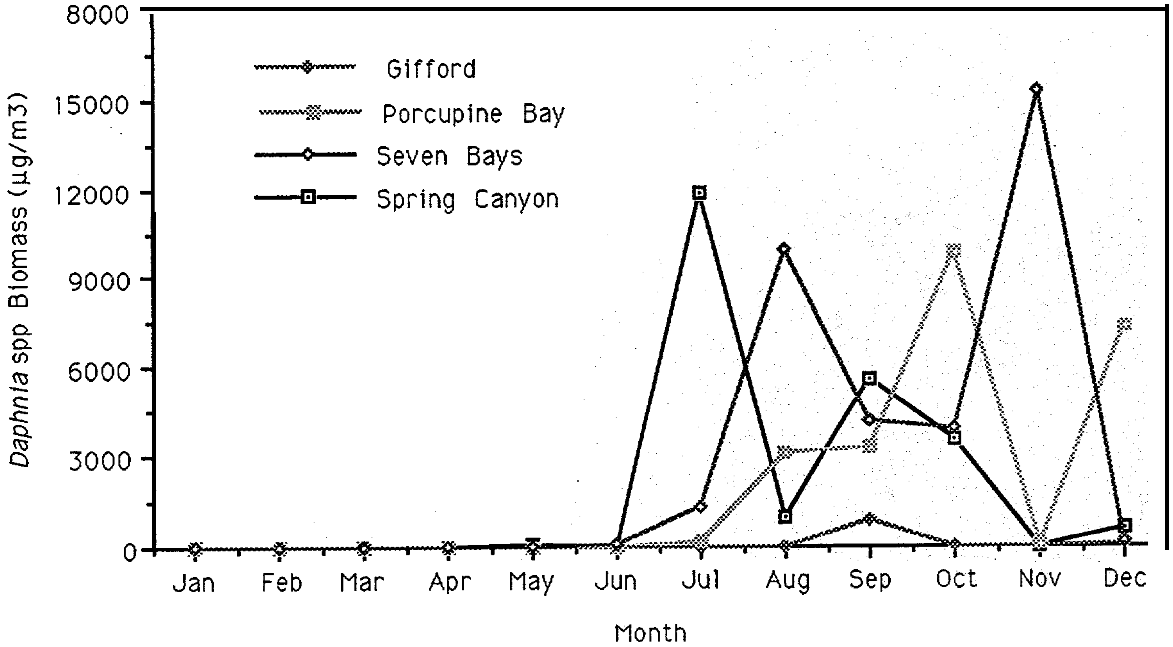

Figure 4.2.3 **Mean montly *Daphnia* spp. biomass (µg/m3) for Gifford, Porcupine Bay, Seven Bays, and Spring Canyon in 199 1.**

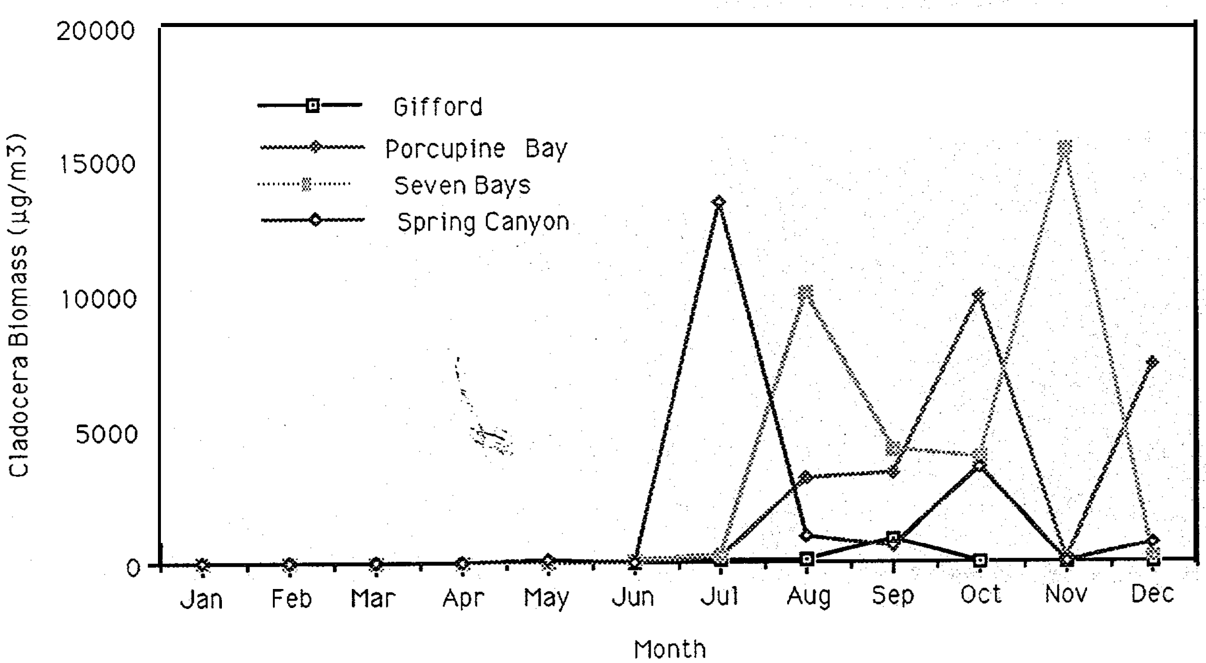

Figure 4.2.4 **Mean monthly Cladocera biomass (µg/m3) for Gifford, Porcupine Bay, Seven Bays, and Spring Canyon in 199 1.**

Table 4.2.1 Mean values of different catagories of zooplankton collected in May, August, and October from Lake Roosevelt, 1989 through 1991.

	May			August			October		
	89	90	91	89	90	91	89	90	91
Water Retention Time (days)	23	29	19	70	45	37	60	66	56
Daphnia spp. (#/m^3)	43	94	3	6,894	3,439	257	4,935	3,698	98
Cladocera (#/m^3)	147	285	6	7,657	3,634	288	5,392	4,216	103
Copepoda (#/m^3)	1,937	1,400	77	9,710	7,579	351	7,018	6,520	298
Total Zooplankton (#/m^3)	90,048	3,658	245	48,093	30,618	1,647	24,630	16,772	732
Daphnia spp. (μg/m^3)	285	2,139	37	230,436	141,039	3,075	155,067	128,809	3,215
Cladocera (μg/m^3)	299	2,205	38	259,408	142,758	3,345	155,224	130,190	3,226

1990 and 1991 are compared to each other differences in water retention times are reflected in zooplankton values. These numbers become more significant when compared as percentage differences found between study years (Table 4.22). Between 1989 and 1991, the water retention time decrease between April and September was 34 percent. This resulted in a 99% decrease in zooplankton density and a 98% decrease in biomass at Porcupine Bay and Seven Bays between the months of April and September. Water retention time for the mean of May, August, and October showed a 28% decrease between 1989 and 1991. This resulted in a 98% decrease in both the total reservoir microcrustacean density and *Daphnia* spp. biomass. Between 1990 and 1991, the reservoir experienced a 20% decrease in water retention time (Table 4.2.3). This resulted in a 95% decrease in zooplankton density at Porcupine Bay and a 96% decrease at Seven Bays between April and September. Similarly, *Daphnia* spp. biomass decreased 99 and 96% at Porcupine Bay and Seven Bays respectively. A 20% decrease in water retention time was also found for the means of May, August, and October. Again, decreases of 95 and 94% were found between total reservoir density and *Daphnia* spp. biomass.

In the past, Lake Roosevelt *Daphnia* spp. biomass compared favorably to biomass values reported for other kokanee producing waters in the Pacific Northwest (Table 4.2.4). However, 1991 *Daphnia* spp. biomass values show the potential for a collapse in the fishery if reservoir operations do not allow *Daphnia* spp. biomass values to increase.

The kokanee hatcheries on Lake Roosevelt now completed and in operation were built on the premise that there was and abundance of zooplankton within the reservoir to support a kokanee fishery (Beckman et *al.* 1985, Peone et *al.* 1990). Beckman et *al. (1985)* stated *"Assuming that fingerling sockeye salmon consume 180 mg wet weight of plankton per day (Foerster 1968) and that an estimated 0.59 mg/l of zooplankton was available during the summer months in Lake Roosevelt the maximum potential number of fingerlings the reservoir could support was estimated to be 1 6 million or 490/ha. Adults consume approximately 7 - 10% of their body weight in zooplankton per day (Foerster 1968), hence Lake Roosevelt could hypothetically support about 5.9 million adults (mean wt = 500 g) during the summer months".* According to 1991 figures there was a mean Cladocera biomass of 2,203 $\mu g/m^3$ which

Table 4.2.2 Comparisons of total microcrustacean zooplankton density (including nauplii), *Daphnia* spp. biomass values, and water retention time between 1989 and 1991.

Location	1989 Totals	1991 Totals	Percent Difference
Porcupine Bay Density	85,571/m^3	1,305/m^3	99%
Seven Bays Density (Mean of April to September)	99,016/m^3	917/m^3	99%
Porcupine Biomass	237,829 $\mu g/m^3$	1,331 $\mu g/m^3$	98%
Seven Bays Biomass (Mean of April to September)	128,291 $\mu g/m^3$	2,588 $\mu g/m^3$	98%
Water Retention Time (Mean of April to September)	50 days	33 days	3 4 %
Entire Reservoir Microcrustacean zooplankton Density (Mean of May, August, and October)	54,257/m^3	875/m^3	98%
Entire Reservoir *Daphnia* spp. Biomass (Mean of May, August, and October)	128,596 $\mu g/m^3$	2,109 $\mu g/m^3$	98%
Water Retention Time (Mean of May, August, and October)	51 days	37 days	28%

Table 4.2.3 Comparisons of total microcrustacean zooplankton density (including nauplii), ***Daphnia*** spp. biomass values, and water retention time between 1990 and 1991.

Location	1990 Totals	1991 Totals	Percent Difference
Porcupine Bay Density	28,307/m^3	1,305/m^3	95%
Seven Bays Density (Mean of April to September)	21,848/m^3	917/m^3	96%
Porcupine Biomass	78,075 $\mu g/m^3$	1,331 $\mu g/m^3$	99%
Seven Bays Biomass (Mean of April to September)	60,152 $\mu g/m^3$	2,588 $\mu g/m^3$	96%
Water Retention Time (Mean of April to September)	41 days	33 days	20%
Entire Reservoir Microcrustacean zooplankton Density (Mean of May, August, and October)	17,016/m^3	875/m^3	95%
Entire Reservoir *Daphnia* spp. Biomass (Mean of May, August, and October)	90,662 $\mu g/m^3$	2,109 $\mu g/m^3$	98%
Water Retention Time (Mean of May, August, and October)	46 days	37 days	20%

Table 4.2.4 Comparisons of Lake Roosevelt *Daphnia* spp. to biomass values reported for area lakes in Reiman and Bowler (1980).

Body of Water	Time period	Biomass
Lake Pend Oreille	5 year mean	38.7 mg/m^3
Lake Coeur d'Alene	3 year mean	36.8 mg/m^3
Priest Lake		27.7 mg/m^3
Upper Priest Lake		25.5 mg/m^3
Spirit Lake		39.7 mg/m^3
Lake Roosevelt	1989[a]	128.6 mg/m^3
Lake Roosevelt	1990[b]	90.6 mg/m^3
Lake **Roosevelt**	**1991**	**2.1 mg/m^3**

a Peone et *al.* (1990)
b Griffith *et al.* (1 990)

converts to 0.002 mg/l. Clearly 1991 reservoir operations were not conducive to the kokanee reintroduction program begun on Lake Roosevelt which require a zooplankton biomass of 0.59 mg/l to support the fishery. If a kokanee fishery is expected to develop at Lake Roosevelt, reservoir operations will have to be modified to ensure a sufficient forage base for the fish.

To determine what reservoir operations would be needed to develop and/or maintain a good kokanee fishery, the mean *Daphnia* spp. biomass from Northwest kokanee producing lakes was calculated from Table 4.2.4. Next biomass and corresponding water retention times from Lake Roosevelt were entered into a Statview II statistic program and subjected to linear regression analysis. Resulting equations and R squared values are located in- Table 4.2.5. Once the equations were obtained the *Daphnia* spp. biomass value of 33.68 mg/m^3 was substituted for y and x (WRT) was solved for (Table 4.2.6). Equations show water retention times ranging from 36 to 40 days. This data suggests that the original water retention time estimate of 30 days may- be too low to keep sufficient quantities of zooplankton in the reservoir to support the kokanee fishery now being re-established. While further data needs to be collected to help refine the biomass/water retention time relationship, it is our current recommendation that the reservoir be operated in such a way to ensure water retention time minimums are between 36 and 40 days.

4.3 BENTHIC MACROINVERTEBRATES

4.3.1 Affect of Reservoir Operations on Benthic Macroinvertebrates

Chironomidae larvae was found to be most abundant benthic macroinvertebrate at all depth locations throughout the reservoir with the exception of depth three at Porcupine Bay (Table 4.3.1). Gifford had the highest densities of Lymnaeidae, Planorbidae, and Chironomidae pupae. Porcupine Bay had the highest densities of Sphaeridae, Chironomidae larvae, and Lumbriculidae. Spring Canyon had the highest densities of Physidae, Simuliidae, and Limnephilidae. Porcupine Bay had the highest grand mean for the year with density of 5,252 organisms/m 3. Diptera had the highest densities at all locations followed by Lumbriculidae.

Table 4.2.5 **Linear regression analysis equations for *Daphnia* spp. biomass and water retention time.**

Category X	Category Y	Regression Equation	R2
WRT (days)	Porcupine Bay *Daphnia* spp. biomass (mg/m^3) (x March - Oct.)	y = 13.991x-472.571	.973
WRT (days)	Seven Bays *Daphnia* spp. biomass (mg/m^3) (x April - Sept.)	y = 7.398x-242.071	1
WRT (days)	Total Reservoir *Daphnia* spp. biomass (mg/m^3) (x May, Aug., & Oct.)	y = 9.132x-334.1 01	.996

Table 4.2.6 **Results of y value substitution to determine optimum water retention times for *Daphnia* spp. biomass.**

Y Value (biomass)	Regression Eauations	X Value (WRT)
33.68 (mg/m^3)	***y = 13.991 x-472.571***	*36* (days)
33.68 (mg/m^3)	y = 7.398x-242.071	37 (days)
33.68 (mg/m^3)	y = 9.132x-334.1 01	40 (days)

Table 4.3.1 **Mean density values (#/m2) of benthic organisms collected at sampling locations between July and October 1991 in Lake Roosevelt.** (Area 1 represents reservoir depth intervals greater than 80 feet below full pool, area 2 represents depths between 79 and 50 feet below full pool, and area 3 represents depths between 49 and 0 feet below full pool.)

	Gifford			Porcupine			Seven Bays			Spring Canyon		
Area ⇒ **Taxon ⇓**	1	2	3	1	2	3	1	2	3	1	2	3
Lymnaeidae			401			91	7			16	47	
Planorbidae	2		584		10	77				47	126	185
Physidae		16	10							31	47	
Sphaeridae	204	24		982	168		14			102		
Chironomidae pupae	332	332	469	185	356	80	279	174	314	157	31	110
Chironomidae larvae	2,623	1,546	2,721	5,811	2,313	1,726	1,293	898	2,987	1,069	854	2,107
Simuliidae										16		
Limnephilidae	37	16	55		21		31		52	149	110	
Lumbriculidae	1,247	1,077	587	678	1,205	2,054	353	727	335	312	147	660
Total	4,445	3,011	4,827	7,656	4,073	4,028	1,977	1,799	3,688	1,899	1,365	3,062

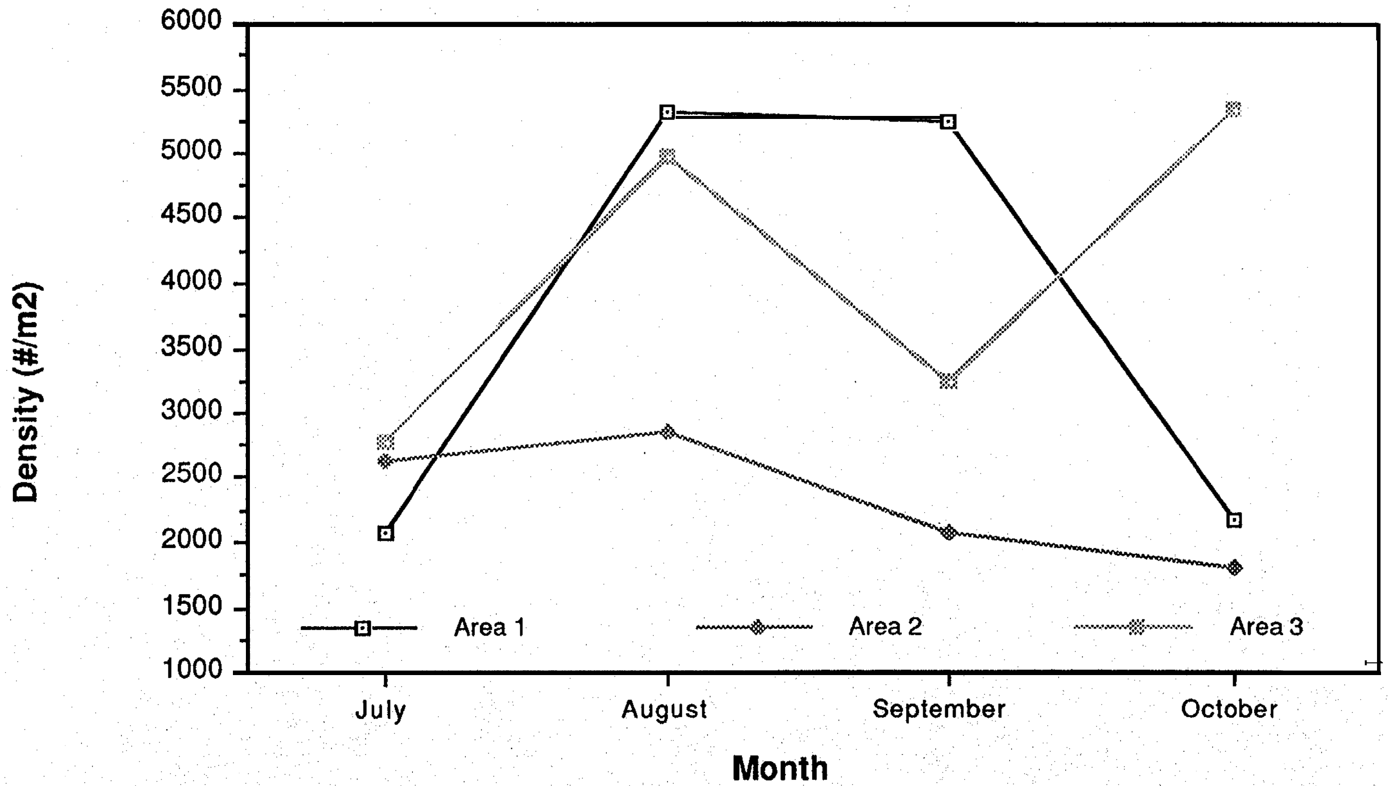

Figure 4.3.1 Mean monthy density for all benthic macroinvertebrates collected at different reservoir depths in 1991.

Density of organisms in exposed vs non-exposed substrate did not show the degree of difference expected (Figure 4.3.1). In July, area 1 had the lowest mean density followed by area two, while area three had the highest density, with similar results found in August and September. These results are unusual in the respect that Beckman et *al.* (1985) found densities never to be as high in the dewatered areas as those in the unexposed areas in Lake Roosevelt. May et *al.* (1988) found similar results in Hungry Horse Reservoir in Montana. The recolonization of benthic macroinvertebrates appears to have occurred rather rapidly, with area three (dewatered area) being recolonized to a greater density than in area one (unexposed area) in approximately a one month period. Subsequent years of study will provide further information about the dynamics of benthic recolonization on Lake Roosevelt.

The mean weights of benthic organisms did vary according to sampling area depth, although not to the degree expected (Figure 4.3.2). Reports by Beckman et *al.* (1985) and May et *al. (1988)* have shown the weights of benthic -organisms in dewatered areas to be less than the weights of benthic organisms in submerged areas. Benthic macroinvertebrates in area 2 had the highest weight density values in 3 out of the four study months. Again, future years of study should demonstrate whether this trend is correct.

4.4 AFFECT OF RESERVOIR OPERATIONS ON FISHERY

4.4.1 Comparisons Between Food Selection and Prey Abundance

There were no major differences in feeding habits of kokanee, rainbow, or walleye in 1991 compared to previous years of study (Peone et *al.* 1990, Griffith and Scholz 1990).

Kokanee were primarily planktivorous demonstrating seasonal IRI values ranging from 49 to 73% for Cladocera and 13 to 29% Diptera (Figure 4.4.1). Annually, Cladocera had a IRI value of 67% followed by Diptera with 15% which are roughly equal to the. annual kokanee IRI values found in 1990 (Figure 4.4.4). Kokanee demonstrated electivity indices of +0.8 for Cladocera and -0.2 for Diptera which means Cladocera were actively selected for in the diet while Diptera were selected in numbers as they occurred- in the environment.

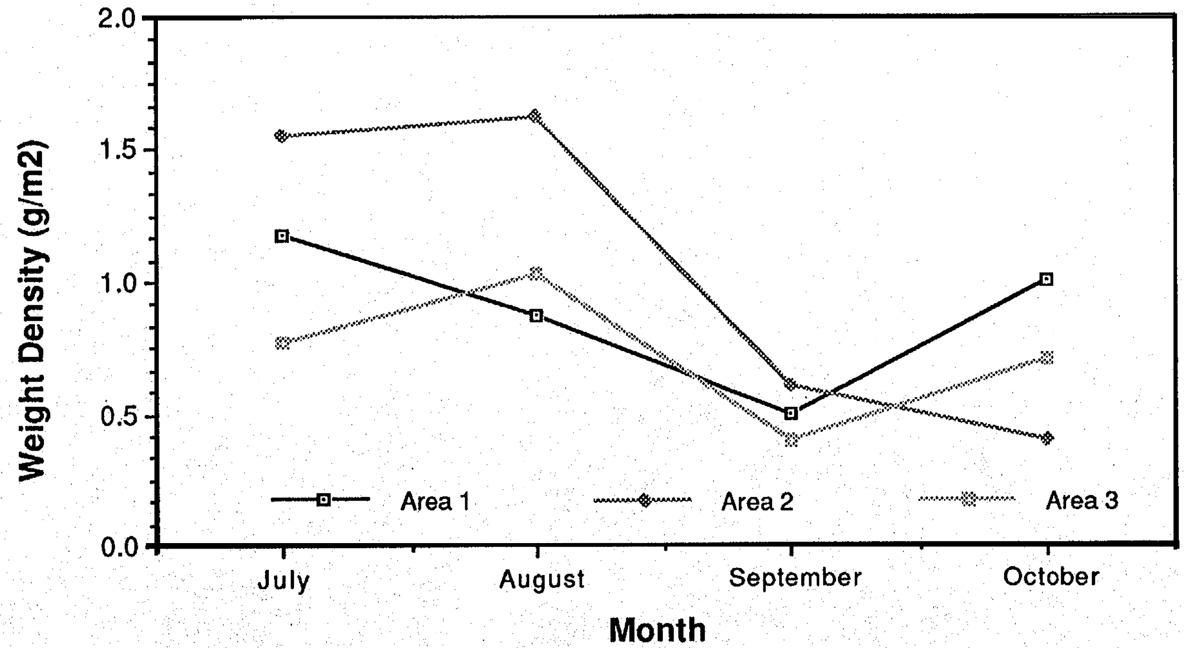

Figure 4.3.2 Mean monthly weight density for all benthic macroivertebrates collected at different depths in 1991.

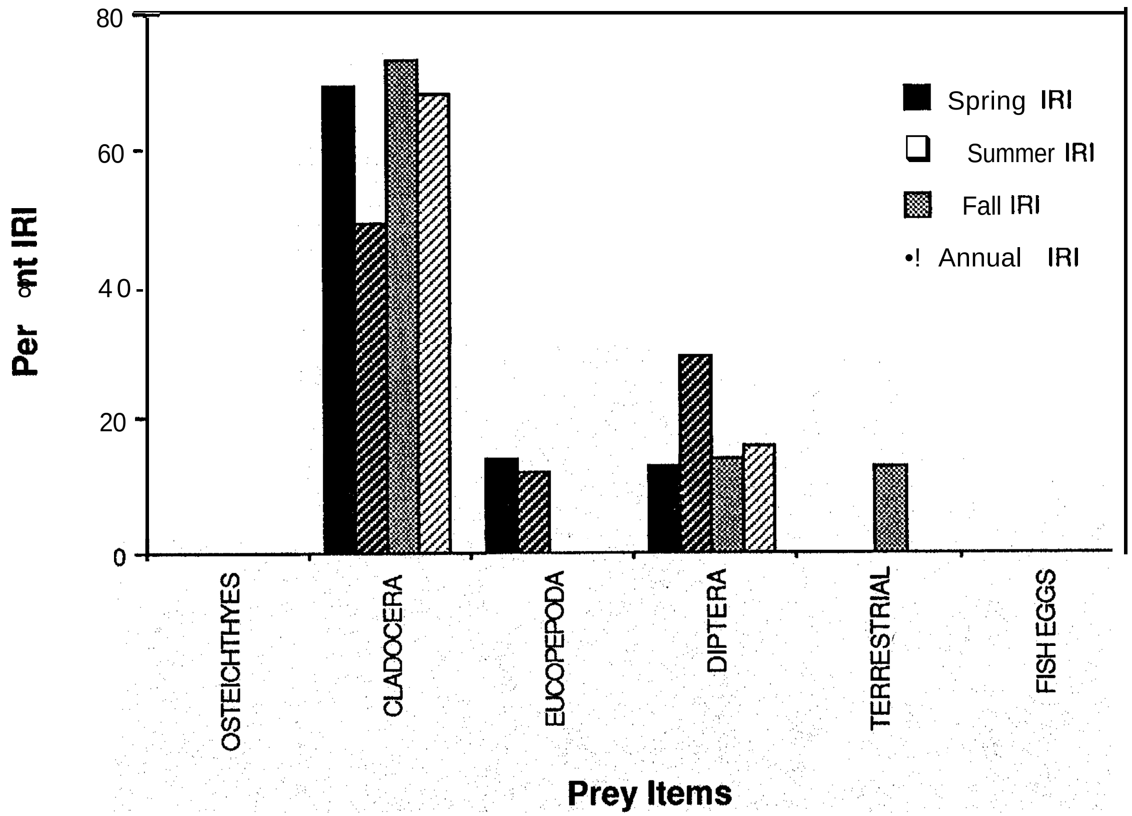

Figure 4.4.1 **Index of relative importance values greater than 10% for prey items consumed by kokanee seasonally and annually in Lake Roosevelt in 1991.**

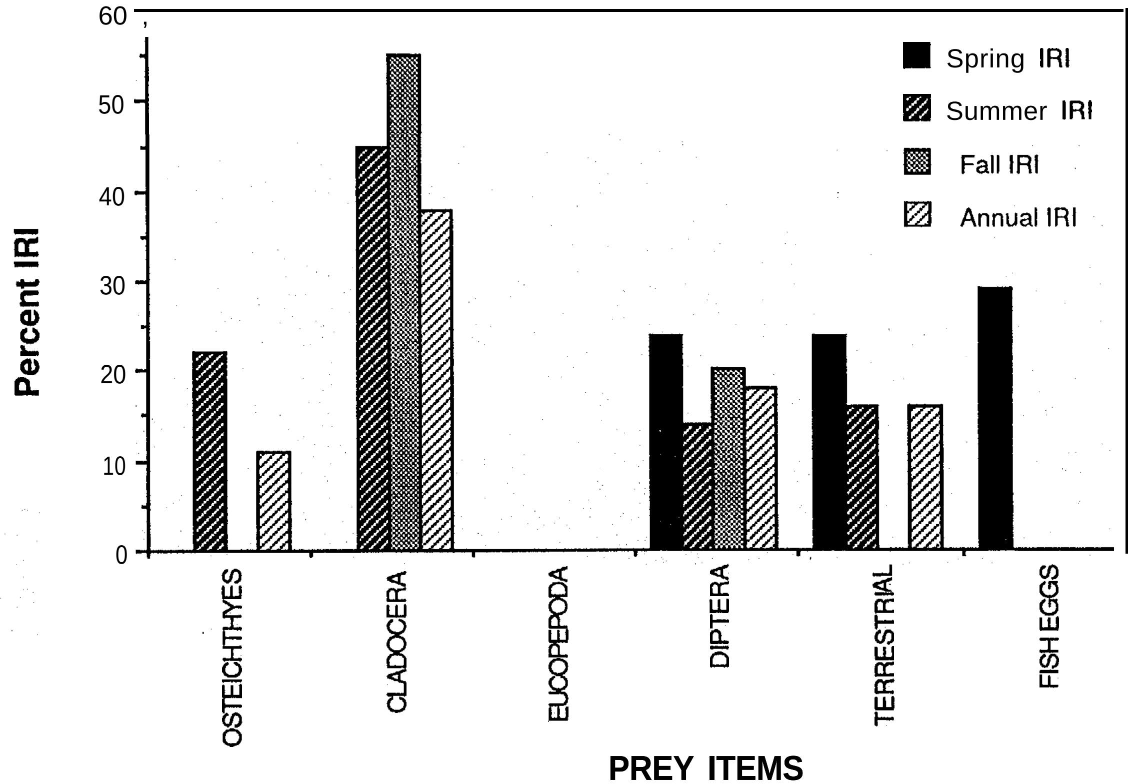

Figure 4.4.2 Index of relative importance values greater than 10% for prey items consumed by rainbow trout seasonally and annually in Lake Roosevelt in 1991.

Rainbow were primarily omnivorous feeding upon Osteichthyes, Cladocera, Diptera and Terrestrials (Figure 4.4.2). Seasonal IRI values ranged 37 to 56% for Cladocera, 13 to 24% for Diptera and 18 to 24% for Terrestrials. Annually, Cladocera had a IRI value of 38% followed by Diptera with 18%, Terrestrials with 16% and Osteichthyes with 11% (Figure 4.4.4). These IRI values were similar to the values found in 1990 with the exception of Osteichthyes. Rainbow demonstrated electivity indices of +0.9 for Cladocera and high negative values (-0.1 to -0.3) for all other prey items selected.

Walleye were primarily picivorous feeding upon Osteichthyes, with some selection for Cladocera and Diptera (Figure 4.4.3). Seasonal IRI values ranged 60 to 89% for Osteichthyes, 22% for Cladocera, and 42% for Diptera. Annually, Osteichthyes had an IRI value of 73%, followed by Diptera with 14%, and Cladocera with 11% (Figure 4.4.4). These IRI values were similar to the values found in 1990 with the exception of a higher selection for Diptera. Walleye demonstrated low positive electivity indices (+0.3 to 0.1) for Cladocera and Osteichthyes and high negative values (-0.1 to -0.3) for all other prey items selected.

From the data collected it appears that kokanee and rainbow are actively feeding upon the Cladocera of Lake Roosevelt while the walleye are feeding upon forage fish in relation to their abundance in the reservoir. This data is further documentation that Lake Roosevelt and Grand Coulee Dam must be operated to ensure adequate Cladocera (*Daphnia* spp.) forage base if kokanee reintroduction is to succeed. Resident fish concerns must be given a higher priority in the decision making process of reservoir operations. Current operations clearly show significant decreases in zooplankton density and biomass compared to previous years and is well below the zooplankton levels reportedly required to support current stocking levels (Section 4.2). If the current operational trend is continued (Section 4.1) there will no longer be a sufficient forage base for the kokanee or rainbow and stocking programs will have to end.

4.4.2 Trends in Fish Growth

Kokanee lengths over the past three years have been similar for age 1 and 2+ fish but have increased greatly for 3+ fish (Table 4.4.1). Weight data increased for 1+ fish, remained stable for 2+ fish and fluctuated for age 3+ fish. Condition factors were

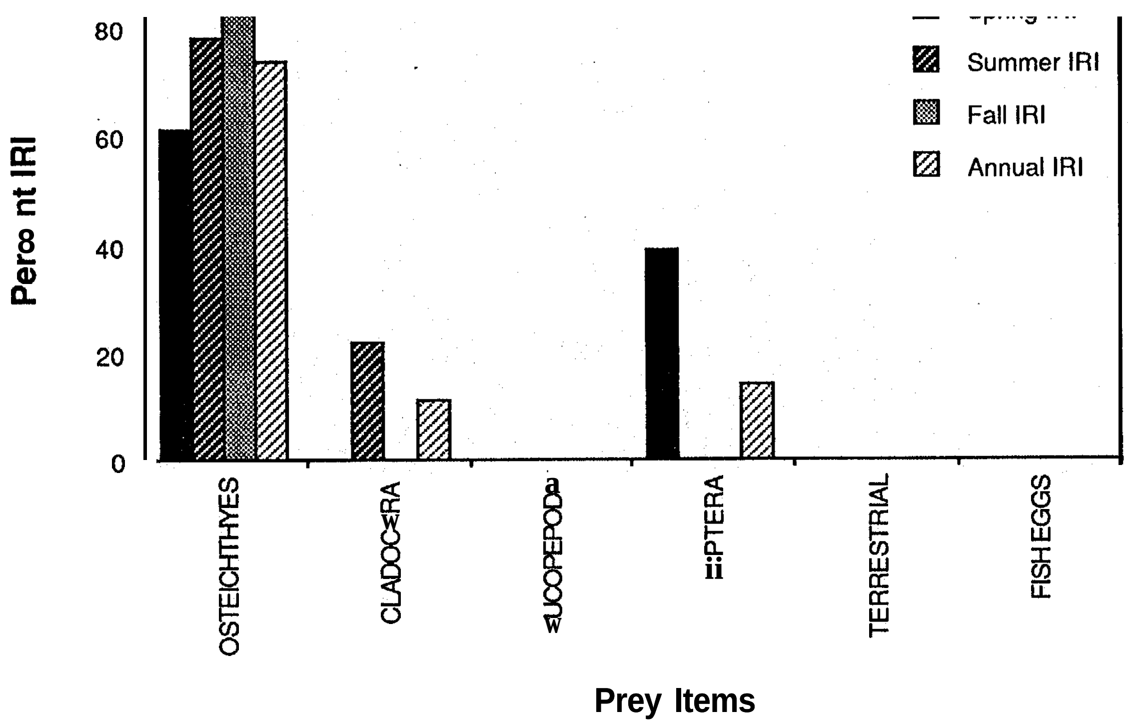

Figure 4.4.3 **Index of relative importance values greater than 10% for prey items consumed by walleye seasonally and annually in Lake Roosevelt in 1991. .**

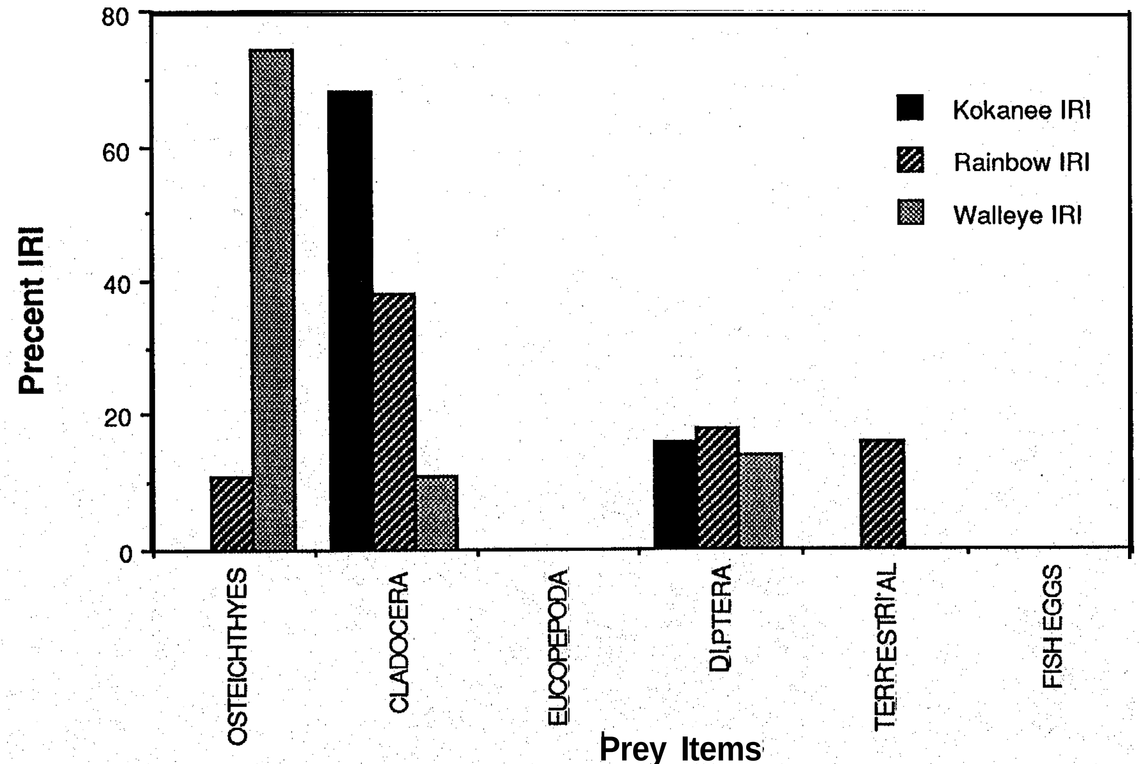

Figure 4.4.4 Index of relative Importance values greater than 10% for prey Items consumed by kokanee, rainbow, and walleye in Lake Roosevelt, WA 1991.

Table 4.4.1 Mean lengths, weights, and condition factors of kokanee salmon collected during sampling seasons and creel surveys on Lake Roosevelt from 1989 to 1991.

	LENGHTS		
Age Class	1989	1990	1991
1+	240	276	367
2+	385	380	399
3+	413	447	466

	WEIGHTS		
Age Class	1989	1990	1991
1+	111	301'	504
2+	590	607	598
3+	823	923	887

	CONDITION FACTORS		
Age Class	1989	1990	1991
1+	0.70	0.98	1.02
2+	1.01	1.06	0.88
3+	1.02	1.00	0.88

considerably decreased for age 2 and 3+ fish. Overall kokanee lengths increased in all three age classes, while weight and condition factors decreased in 2 out of 3 age classes between 1990 and 1991.

Rainbow growth in 1991 for age 1 and 2+ fish was not comparable to previous data due to the separation of native and net-pen fish in 1991 (Table 4.4.2). Age 3 and 4+ fish show decreased growth while 5+ fish growth increased. Weight data was not comparable between the 1 and 2+ fish. Age 3+ fish showed a marked decrease in weight moving from 902 grams in 1989 to 447 grams in 1991. Condition factors were similar in all years.

Walleye demonstrated the most evident decreases in lengths, weights, and conditions factors (Table 4.4.3). Lengths and weights decreased in 4 out of 5 age classes between 1990 and 1991. Condition factors decreased in 3 out of 5 years between 1990 and 1991.

Length, weight and condition factor data to date did not show clearly identifiable trends in fish, growth that were expected. However, overall decreases in fish length and weight over the past three years showed that reservoir operations were not conducive to growth.

Because seasonal trends could not be extrapolated from the current data collection regime, we recommend more emphasis be placed on obtaining length, weight and scale samples throughout the year from creel data. This would provide a larger sample base upon which to obtain seasonal growth patterns of target species.

4.5 AFFECT OF RESERVOIR OPERATIONS ON STOCKED FISH

Trends in tag return indicate Lake Roosevelt suffers high entrainment losses of net-pen fish during certain times of the year as evidenced by tag returns from Chief Joseph, Rock Island, and McNary Dams (Table 4.5.1.). Percent of fish recovered below Grand Coulee Dam has ranged from 0 to 71% over the past three years. Degree of entrainment in relation to water retention time is still not fully understood as regression line analysis met with poor results. A smoltification type process in Lake Roosevelt net-pen

Table 4.4.2 Mean lengths, weights, and condition factors of rainbow trout collected during sampling seasons and creel surveys on Lake Roosevelt from 1989 to 1991 (native and net-pen).

	LENGHTS		
Age Class	1989	1990	1991 Nat. / NP.
1+	255	292	223 / 311
2+	384	338	207 / 369
3+	429	375	336 / -
4+	482	452	434 / -
5+	495	453	495 / -

	WEIGHTS		
Age Class	1989	1990	1991 Nat. / NP.
1+	218	407	192 / 357
2+	572	551	101 / 611
3+	902	599	447 / -
4+	1058	828	833 / -
5+	1154	921	1,230 / -

	CONDITION FACT'ORS		
Age Class	1989	1990	1991 Nat. / NP.
1+	1.23	1.09	0.93 / 1.17
2+	1.24	1.04	0.98 / 1.16
3+	1.12	1.05	1.27 / -
4+	0.97	0.91	0.97 / -
5+	0.96	0.96	1.02 / -

Table 4.4.3 Mean lengths, weights, and condition factors of walleye collected during sampling seasons and creel surveys on Lake. Roosevelt from 1989 to 1991.

	LENGHTS		
Age Class	1989	1990	1991
1+	245	231	225.
2+	300	327	320
3+	395	403	375
4+	4 1 9	454	467
5+	496	521	485

	WEIGHTS		
Age Class	1989	1990	1991
1+	142	113	99
2+	262	303	266
3+	569	553	457
4+	750	792	889
5+	1,037	1,317	971

	CONDITION FACTORS		
Age Class	1989	199.0	1991
1+	0.90	1.05	0.80
2+	0.89	0.81	0.77
3+	0.88	0.81	0.83
4+	0.87	0.82	0.86
5+	0.85	0.89	0.76

Table 4.5.1 Summary of release dates, locations of numbers of rainbow trout released from Lake Roosevelt net-pens, and their subsequent capture locations.

Release Date	Release Location	Total # Tagged	Total # Recovered	Percent Recovered	Number Recovered in FDR	Percent Recovered in FDR	Recoveries Below Grand Coulee		
							Number Recovered in Rufus Woods	Number Recovered at Rock Is. or McNary	Percent Recovered Below FDR
May 88	7-Bays	1,171	95	8%	95	100%	0	0	0%
Mar. 89	Hunters	768	7	1%	2	29%	0	5	71%
Apr.89	7-Bays	985	20	2%	11	55%	3	6	45%
Sep. 89	Kettle	584	14	2%	13	93%	1	0	7%
Oct. 89	Hunters	447	10	2%	10	100%	0	0	0%
Mar. 90	Kettle	508	2	0%	2	100%	0	0	0%
	Hunters	490	3	1%	1	33%	0	2	67%
	7-Bays	443	2	0%	1	50%	0	1	50%
Apr. 90	Kettle	498	20	4%	14	70%	5	1	30%
	Hunters	498	9	2%	7	78%	2	0	22%
	7-Bays	474	18	4%	12	67%	3	3	33%
May 90	Hunters	492	6	1%	5	83%	1	0	17%
	'T-Bays	499	28	8%	22	79%	5	1	21%
	Keller	459	14	3%	11	78%	2	1	22%
Oct. 90	Hunters	366	4	1%	2	50%	1	1	50%
Apr. 91	Kettle	1,000	47	5%	37	79%	8	2	21%
	7-Bays	1,300	20	2%	8	40%	1	11	60%
Jun. 91	7-Bays	296	2-8	9%	23	82%	5	0	18%
Jul. 91	7-Bays	1,749	121	7%	115	95%	6	0	5%

fish and low water retention times are thought to be the major factors influencing entrainment (Peone et ***al. 7990).***

When tag returns are grouped seasonally and paired with mean water retention time for the season, trends in entrainment are seen more easily (Table 4.5.2). In the case of spring releases where water retention times were below 40 days, percent of fish entrained ranged from 26 to 52% with the average being 37 percent. A spring release in 1988 where water retention times were 43 days showed 0% entrainment through Grand Coulee. Further documentation for the water retention time/smoltification influence may be seen in the entrainment levels of summer 1991 releases. Water retention time for this period averaged 34 days however, entrainment was only 7 percent. This would indicate that as the smoltification process ends the fish are able to tolerate low water retention times without suffering the degree of entrainment as seen while undergoing the smoltification process in the spring.

Fall entrainment data shows both low and high entrainment values with water retention times of 59 and 60 days (Table 4.5.2). Tag returns from fall of 1989 show an entrainment level of 4% while tag returns from fall of 1990 show an entrainment level of 50%. The reliability of this data is questioned due to the low number of tag returns collected for the fall 1990 release (4) vs the number collected for the fall of 1989 (24).

Tagging needs to be carried out monthly from March to July at all net-pen sites in future years to aid in determining the exact relationship between smoltification, water retention time, and entrainment.

Table 4.5.2 Summary of seasonal releases, mean water retention time and numbers of rainbow trout released from Lake Roosevelt net-pens, and their subsequent capture locations.

Release Date	Mean WRT	Total # Tagged	Total # Recovered	Percent Recovered	Number Recovered in FDR	Percent Recovered in FDR	Recoveries Below Grand Coulee: Number Recovered in Rufus Woods	Recoveries Below Grand Coulee: Number Recovered at Rock Is. or McNary	Recoveries Below Grand Coulee: Percent Recovered Below FDR
Spring 88	43	1,171	95	8%	95	100%	0	0	0%
Spring 89	31	1,753	27	1%	13’	48%	3	11	52%
Fall 89	59	1,031	24	2%	23	96%	1	0	4%
Spring 90	31	4,361	102	2%	75	74%	18	9	26%
Fall 90	60	366	4	1%	2	50%	1	1	50%
Spring 91	20	2,300	67	3%	45	67%	9	13	33%
Summer 91	34	2,045	149	7%	138	93%	11	0	7%

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