BENTHIC INVERTEBRATES IN SOFT-SUBSTRATE, SHALLOW-WATER HABITATS IN LOWER GRANITE RESERVOIR, 1994-95

by

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EXECUTIVE SUMMARY

In an effort to recover dwindling Snake River salmon runs, a drawdown or lowering of the water level in Lower Granite Reservoir has been proposed. Some fisheries managers believe that reservoir drawdown would help restoration efforts for depleted upriver stocks of Snake River chinook (*Oncorhynchus tshawytscha*) and sockeye salmon (*O. nerka*). The drawdown would simulate a free-flowing river, which would theoretically decrease downstream travel time and thus increase the survival of juvenile salmonids (*Oncorhynchus* spp.) (U.S. Army Corps of Engineers 1992a). However, possible adverse effects of a drawdown include changes in the benthic invertebrate community, which has been found to be an important constituent of juvenile salmonid diet in the Columbia River system (Becker 1973, Kirn et al. 1986, Muir and Emmett 1988, Muir and Coley 1996).

Several drawdown scenarios have been proposed for selected Columbia and Snake River reservoirs. Each scenario involves the operation of reservoirs at or below minimum operating pool (MOP) for several months each year. Any extended drawdown at or below MOP would be an unprecedented event in the operation of these reservoirs and would have undetermined impacts on reservoir and associated riverine ecosystems.

For Lower Granite Reservoir, a drawdown to depths of 10, 13, and 16 m below MOP during the spring and summer juvenile salmonid outmigration periods (April-August) has been suggested. A drawdown to depths of 33.5 to 35 m below MOP to simulate a free-flowing river has also been suggested. Such a drawdown would substantially reduce existing shallow-water habitat (U.S. Army Corps of Engineers 1992a). Furthermore, the biological productivity of current deepwater habitats may not sufficiently replace the existing

shallow-water habitats after a drawdown, and this may result in a decrease in available food for juvenile salmonids.

To better understand possible changes that may occur as a result of a drawdown, limnological studies commenced in 1994 to document pre-drawdown conditions (Ledgerwood et al. 1996, Juul et al. 1997, Bennett et al. 1997). One objective of these studies covered by this report was to document the species composition and densities of benthic invertebrates inhabiting soft-substrate, shallow-water habitats.

Benthic invertebrate samples were collected from three soft-substrate, shallow-water sampling areas within the reservoir. Sampling areas were located near the upstream end of the reservoir at River Kilometer (RKm) 212 near Silcott Island, near mid-reservoir at RKm 193 near Centennial Island, and near the terminus of the reservoir at RKm 177 about 3 km upstream from Offield Landing. At each sampling area, four benthic invertebrate samples were collected from three depth contours (3, 9, and 18 m). Between March 1994 and October 1995, benthic invertebrate samples were collected monthly, except in April and December 1994 and February 1995, using a Ponar grab to sample about 0.05 m^2. A total of 647 benthic invertebrate samples was collected, and more than 4,000 hours were required to process all the samples.

A total of 76 taxa/categories was identified from the processed samples. Oligochaeta, Chironomidae larva (order Diptera), and to a lesser extent Bivalvia were numerically dominant in both density and frequency of occurrence at all sampling areas and depths; overall these 3 taxa/categories, which were found throughout the reservoir, comprised 93% of all organisms enumerated. Mean densities of all benthic invertebrates, except oligochaetes, tended to decrease with depth in all sampling areas. Oligochaete densities did not decrease with depth except near Silcott Island.

There was no strong seasonal trend in oligochaete or chironomid larva density at any sampling area; overall mean densities were 6,231 and $845/m^2$ (data pooled by date, sampling area, and depth), respectively. Bivalves (generally immature) were the third most abundant benthic invertebrates (overall mean = $235/m^2$) and at Offield accounted for about 75% of all bivalves recovered. Amphipods were the predominant benthic crustaceans in the reservoir (overall mean = $14/m^2$). Amphipods were present sporadically at all areas and depths sampled and five species were identified.

At the upper reservoir sampling area near Silcott Island, densities of oligochaetes and chironomid larvae decreased with depth, a trend possibly correlated with the percentages of sandy and fine sediment composition in the area. In contrast, at the mid-reservoir sampling area at Centennial Island, densities of oligochaetes and chironomid larvae were not apparently correlated with depth, and the percentages of fines at different depths were fairly consistent. The lower reservoir sampling area at Offield was the only area with gravel substrate, a component which may have been related to increased bivalve densities in that area.

CONTENTS

INTRODUCTION

Historical estimates of adult salmon abundance in the Columbia River basin before hydroelectric dams were built range from 8 to 16 million, but since then estimates range from 2 to 2.5 million (U.S. Army Corps of Engineers 1992a). Snake River sockeye salmon (*Oncorhynchus nerka*) was listed as endangered in 1991 and spring/summer and fall chinook salmon (*O. tshawytscha*) were listed as threatened in 1992 under the Federal Endangered Species Act of 1973. A "Salmon Summit" was held in 1990 and 1991 between regional fishery and power agencies, tribes, and river users to develop a restoration plan for declining salmon runs. At the summit, one suggestion was to draw the river water level down during juvenile salmon migration, which would theoretically increase downstream water velocity and thus decrease travel time for salmon smolts migrating to the ocean. A 1-month test drawdown of Lower Granite Reservoir occurred during March 1992.

In 1994, personnel of the Coastal Zone and Estuarine Studies (CZES) Division of the National Marine Fisheries Service and other entities began limnological investigations to assess possible impacts of a drawdown on Lower Granite Reservoir (Ledgerwood et al. 1996, Juul et al. 1997, Bennett et al. 1997). This report covers CZES limnological investigations dealing with soft-substrate, shallow-water benthic invertebrate populations sampled between March 1994 and October 1995.

Benthic invertebrates are an important food source for juvenile salmon in the Columbia River system (Becker 1973, Kirn et al. 1986, Muir and Emmett 1988, Muir and Coley 1996). The overall importance of soft-substrate, shallow-water habitat to outmigrating juvenile salmonid population is unclear. Bennett et al. (In prep.) reported that age-0 fall chinook salmon had higher abundance over sand and mud/sand substrates in Lower Granite Reservoir. If drawdown were to reduce the availability of such habitat, then it could be detrimental to recovery efforts for these endangered fish. The goal of this study was to document the species composition, spatial variation, and temporal distribution of benthic invertebrates inhabiting soft-substrate, shallow-water habitats in the reservoir during the pre-drawdown conditions and to compare these with results during or following a possible drawdown.

METHODS

Study Area

Lower Granite Reservoir was created in 1975 when Lower Granite Dam was constructed for hydroelectric power, navigation, and irrigation (U.S. Army Corps of Engineers 1992b). The reservoir is located in southeastern Washington and western Idaho near Clarkston, Washington, and Lewiston, Idaho. The reservoir extends 61.8 km from the dam to Asotin, Washington on the Snake River and 7.3 km upstream from the confluence of the Snake and Clearwater Rivers on the Clearwater River (U.S. Army Corps of Engineers 1992b). Following construction of the dam, the hydrography of this segment of the Snake River changed from free-flowing river to a pool with a maximum depth of 35 m (Dorband 1980).

Collection

Three soft-substrate, shallow-water areas in Lower Granite Reservoir were chosen for sampling (Fig. 1). These areas were at River Kilometer (RKm) 212 near Silcott Island, at RKm 193 near Centennial Island, and at RKm 177 near Offield Landing. The sampling area near Silcott Island was located about 39 km upstream from Lower Granite Dam and about 11 km downstream from the confluence of the Snake and Clearwater Rivers at Lewiston, Idaho and Clarkston, Washington. Centennial Island was created near the middle of the reservoir in 1989 as a result of dredging activity by the U.S. Army Corps of Engineers (U.S. Army Corps of Engineers 1992b) and is about 20 km upstream from the dam. The Offield sampling area is about 4 km upstream from Lower Granite Dam (RKm 173).

From March 1994 through October 1995, benthic invertebrate samples were collected monthly, except in April and December 1994 and February 1995. A Ponar grab (Word 1976) was used to collect samples of about 0.05 m^2 along four transects perpendicular to shore at 3-, 9-, and 18-m depths (Fig. 2). A total of 12 samples was taken from each sampling area each month. Although the 18-m sample depth lies beyond the shallow-water zone defined for this study, samples from this depth were necessary to determine conditions in the existing deepwater zone, which will become a shallow-water zone after a drawdown of up to 16 m. At Centennial Island, two samples from the 3-m depth were collected from the inside passage along the island: one from the middle upstream transect and the other from the middle downstream transect (Fig. 2).

Samples were initially washed in the field through a 0.5-mm sieve (U.S.A. Standard Testing Sieve no. 35) and then preserved in a solution of about 10% buffered formalin. The

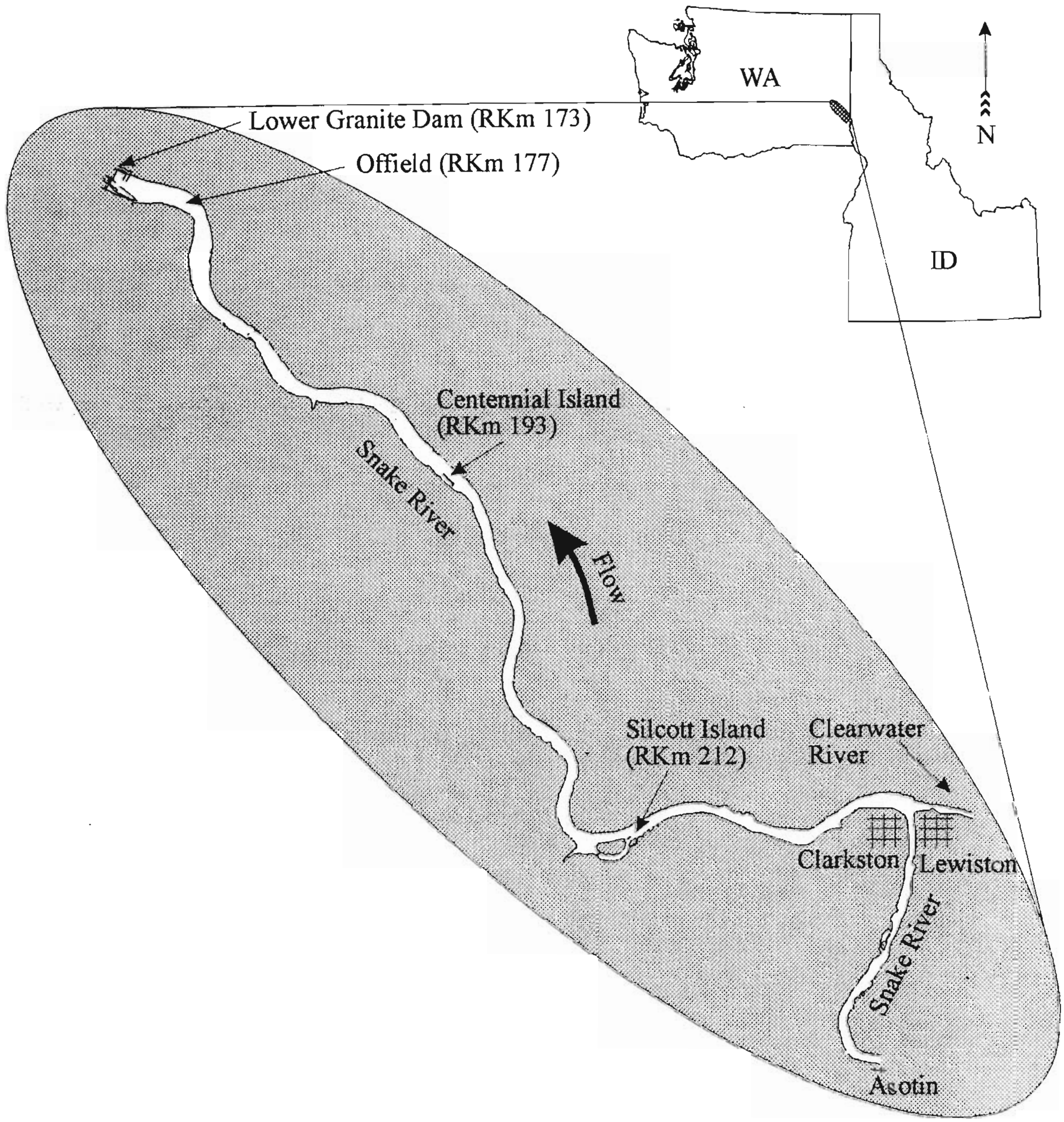

Figure 1. Location of Lower Granite Reservoir and locations of three selected soft-substrate, shallow-water sampling areas.

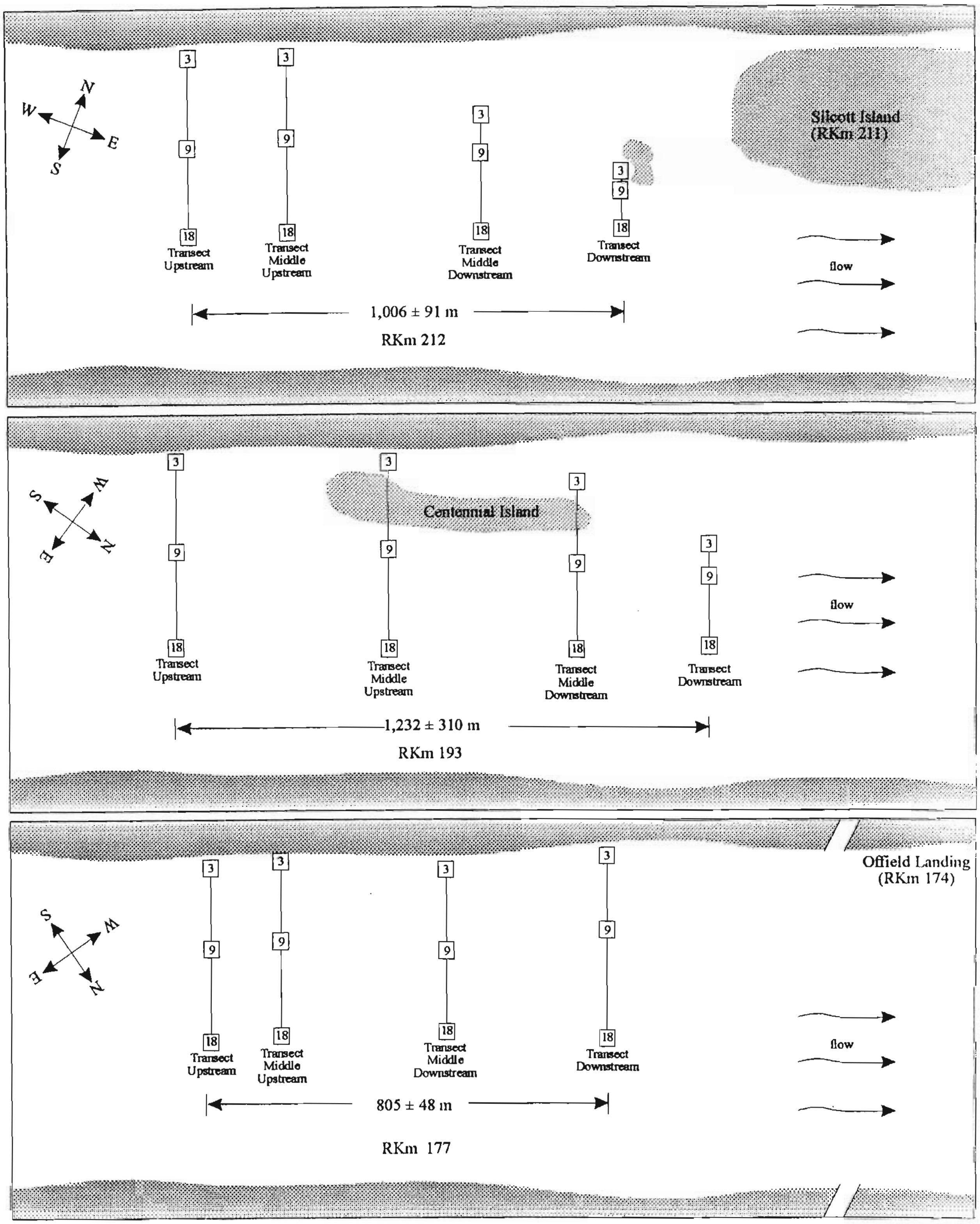

Figure 2. Schematic drawings (not to scale) of the benthic invertebrate sampling areas in Lower Granite Reservoir in 1994-1995. Four transects perpendicular to shoreline were established in each sampling area and numbered boxes indicate a station and depth (m). Boundaries of sampling areas ± SE are shown based on hand-held Global Positioning System recordings.

preservative contained rose bengal which stained organisms to speed processing in the laboratory.

Sample Processing

In the laboratory, each sample was washed again with tap water through a 0.5-mm sieve (U.S.A. Standard Testing Sieve no. 35) to remove formalin and fine sediments prior to processing. Dissecting microscopes with up to 40X magnification were used to sort through the sieved residue, and we recovered at least 90% of all organisms, except eggs and cladocerans. Organisms removed from each sample were stored in a small vial with ethanol and a drop of glycerin. Eggs were not included in the recovery process because it was not feasible to determine whether they were of invertebrate or vertebrate origin. Cladocerans are mainly planktonic, not benthic invertebrates; hence, they were not included.

Generally, identifications were made to the lowest practical taxon (Barnard 1969, Smith and Carlton 1975, Borror et al. 1976, Pennak 1978, Bousfield 1979, Rudy and Rudy 1983, Barnes 1987). Insects were further identified by life history stage (larva/nymph, pupa, and adult). Only heads of fragmented organisms were counted. Fragmented oligochaetes were commonly found and often had phenotypically similar ends, rather than a distinct head. Therefore, in the case of fragmented oligochaetes, parts of similar widths and with a terminal end were paired together and counted as one individual.

For each benthic invertebrate sample, we recorded the identification and enumeration of the organisms recovered, the sample's labelling information, the processor's name, the date(s) the sample was processed, and the number of processing hours (Appendix Fig. D1).

To ensure the removal of at least 90% of all organisms except eggs and cladocerans from processed samples, a minimum of 10% of all samples were verified.

Three to five samples collected each sampling period were large in volume (1-2 L after sieving). These large samples required an estimated 20 to 40 hours each to process using standard procedures. To use laboratory time more efficiently, a 4-L capacity plankton splitter was utilized to split a large sample into 6 equivalent subsamples (Appendix A). Two of the six subsamples were subsequently processed and the counts used to estimate total tallies for the entire sample; 56 large samples were subsampled and processed using this procedure.

Sediment Analysis

In July 1995, a sediment sample was collected from each of the 36 benthic invertebrate sampling stations. Sediment analyses for particle grain size, soil classification, and percent volatile solids were conducted under contract to the U.S. Army Corps of Engineers North Pacific Division Materials Laboratory, Troutdale, Oregon. We used these analyses to evaluate possible differences in sediment composition as related to benthic invertebrate populations among transects at each sampling area.

Data Analysis

The National Oceanographic Data Center (NODC) taxonomic codes (version 7.0) were assigned to each organism based on its taxonomic classification.[1] Taxonomic information is contained in the hierarchy of each code and allows data for organisms to be grouped and summed into a desired taxonomic classification. Computer programs were developed to allow organisms to be grouped into five possible taxonomic levels for data analysis; for example, *Hexagenia* spp., Caenidae nymphs, and other Ephemeroptera nymphs could be combined into the Ephemeroptera order, and total tallies for this insect order could be compared with those of other insect orders. Mean densities were calculated for each grouped or ungrouped taxon/category for comparisons among sampling areas, depths, and dates. Density was expressed as number of organisms/m^2. Although terrestrial, planktonic, epibenthic, and benthic organisms were found in our benthic invertebrate samples, analysis focused on benthic and epibenthic invertebrates (Appendix Tables B1 and B2). We further focused our presentations in this report on the three most abundant taxa/categories found in the sampling areas. In addition, benthic invertebrates grouped into subphyla Insecta and Crustacea were further analyzed at the subphylum taxonomic level.

Potential Drawdown Effects

Drawdown was removed as an option for the Lower Granite Reservoir in the fall of 1995. As a result, sampling of the pre-drawdown condition was discontinued. Lacking

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[1] National Oceanographic Data Center, NOAA/NESDIS E/OC1, SSMC3, Room 4649, 1315 East-West Highway, Silver Spring, MD 20910-3282

information on a drawdown or post-drawdown condition, we could not conduct detailed statistical analyses of the benthic invertebrate data for this report.[2] Temporal changes in the pre-drawdown soft-substrate, shallow-water benthic invertebrate community of Lower Granite Reservoir between March 1994 and October 1995 are presented.

RESULTS

Benthic Invertebrate Community

A total of 647 benthic invertebrate samples was collected from our 3 sampling areas during 1994-95. These required an average of 6.5 hours per sample for processing (over 4,000 hours total). All samples were processed within 2 years of collection. Over 250,000 organisms were recovered and enumerated during sample processing (Appendix C). Details of taxonomic groupings and electronic formats of the data are available upon request.

Overall, a total of 76 taxa/categories was found within the sampling areas. Of the sampling areas, Silcott Island had the highest density of organisms (12,578/m^2) compared to Centennial Island (7,069/m^2) and Offield (3,842/m^2). Each taxon/category of organisms found in the reservoir with its associated NODC code is listed in Table 1. Most of the benthic invertebrates recovered were in the Oligochaeta, Insecta, Bivalvia, and Crustacea taxa/categories (Fig. 3).

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[2] The data presented for the pre-drawdown condition would benefit from statistical analyses (cluster analyses, diversity indices, and possibly other tests) but cancellation of the study compromised our ability to complete these analyses at this time.

Table 1. Taxa/categories found in benthic invertebrate samples collected from Lower Granite Reservoir, 1994-1995.

Taxon/category	NODC code[a]	Taxon/category	NODC code[a]
Platyhelminthes		Insecta	620000000000
Turbellaria	390100000000	Insecta adult	620000000093
Nemertea	430000000000	Coleoptera	630200000000
Nematoda	470000000000	Coleoptera adult	630200000093
Nematomorpha	480000000000	Coleoptera larvae	630200000091
Mollusca		Elmidae adult	631604000093
Gastropoda	510000000000	Collembola	620800000000
Archaeogastropoda	510200000000	Ephemeroptera nymph	621500000091
Bivalvia	550000000000	Caenidae nymph	621802000091
Annelida		*Caenis* spp.	621802020000
Oligochaeta	500300000000	*Ephemera* spp.	622003020000
Polychaeta	500100000000	*Hexagenia* spp.	622003030000
Hirudinea	501200000000	Leptophlebiidae nymph	621701000000
Crustacea		Hemiptera	627100000000
Cladocera	610800000000	Hemiptera adult	627100000093
Leptodoridae	610906000000	Homoptera adult	628200000093
Leptodora kindtii	610906010100	Formicidae adult	657307000093
Ostracoda	611000000000	Lepidoptera larvae	642000000091
Gammaridae	616921000000	*Sialis* spp.	640601010000
Corophium spp.	616915020000	Plecoptera	625100000000
Corophium salmonis	616915020900	Plecoptera adult	625100000093
Corophium spinicorne	616915021500	Plecoptera nymph	625100000091
Ramellogammarus	616921460200	Psocoptera	625600000000
oregonensis		Thysanoptera adult	626800000093
Ramellogammarus	616921460100	Diptera	648100000000
ramellus		Diptera adult	648100000093
Hyalella azteca	616923040100	Diptera larvae	648100000091
Isopoda	615800000000	Diptera pupae	648100000092
Porcellio spp.	616604040000	Chironomidae adult	648933000093
Mysidacea	615100000000	Chironomidae larvae	648933000091
Copepoda	611700000000	Chironomidae pupae	648933000092
Cyclopoida	612000000000	Chironominae pupae	648959000092
Harpacticoida	611900000000	Orthocladiinae pupae	648956000092
Calanoida	611800000000	Tanypodinae pupae	648938000092
Chelicerata		Ceratopogonidae larvae	648920000091
Araneae	591100000000	Culicidae adult	648906000093
Prostigmata	592900000000	Simuliidae larva	648915000091
Ixodides	592800000000	Tanyderidae larvae	648804000091

Table 1. Continued.

Taxon/category	NODC code	Taxon/category	NODC code[a]
Insecta continued		Insecta continued	
Orthoptera adult	623100000093	Isoptera	624600000000
Trichoptera adult	641800000093	Miscellaneous	
Trichoptera larvae	641800000091	Eggs (unidentified)	
Psychomyiidae larvae	641803000091	Unidentified	

[a] The NODC codes listed are taxonomic numerical codes assigned by the National Oceanographic Data Center. For insects, the last two digits were used to indicate the life history stage. Except at the genus level, 91, 92, and 93 were used to represent the larval/nymph, pupa, and adult stages respectively.

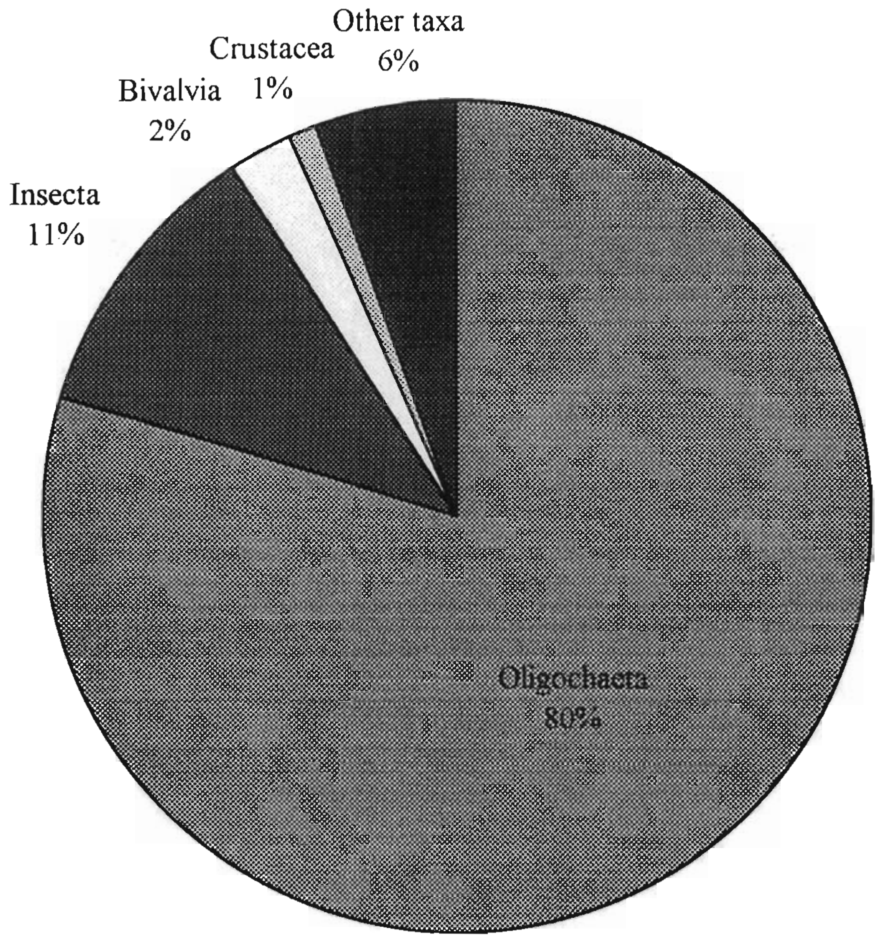

Figure 3. Relative composition of major benthic taxa found in three soft-substrate, shallow-water sampling areas (pooled data) of Lower Granite Reservoir, 1994-95.

Dominant Benthic Invertebrates

Three taxa/categories were found in the reservoir: Oligochaeta, Chironomidae larvae, and Bivalvia, and these comprised 93% of all organisms enumerated (Table 2). Oligochaetes and chironomid larvae were also numerically dominant in each sampling area. Bivalves were the third most abundant benthic invertebrates at Centennial Island and Offield, but not at Silcott Island.

Oligochaetes--Oligochaeta was the most abundant taxon/category at all sampling areas and appeared to increase in abundance from 1994 to 1995 at all depths at each sampling area (Fig. 4). Oligochaetes were most abundant at Silcott Island, especially at the 3-m depth. At Silcott Island, respective mean oligochaete densities at the 3-, 9-, and 18-m depths were as follows: 18,220, 10,865 and 4,819/m^2. This apparent decrease in oligochaete density with depth at Silcott Island was consistent throughout the study period. At all sampling areas, temporal changes in oligochaete density were not apparent.

Unlike at Silcott Island, densities of oligochaetes at Centennial Island and Offield were higher along the 18-m depth contour (Fig. 4). Respective mean oligochaete densities at the 3-, 9-, and 18-m depths were as follows: 5,891, 3,166, and 6,565/m^2 at Centennial Island and 1,803, 1,698, and 3,047/m^2 at Offield.

There were apparent differences in oligochaete densities among transects at each depth in each sampling area. These differences appeared greatest at the 3-m depth at Silcott Island and the 9- and 18-m depths at Centennial Island (Appendix Fig. D2-D3). Of the three sampling areas, Offield had the least differences in oligochaete densities among transects at

Table 2. Mean densities (no./m^2) and standard deviations (SD) of benthic taxa/categories by year and sampling area in the Lower Granite Reservoir.

	Silcott Island RKm 212				Centennial Island RKm 193				Offield RKm 177			
	1994		1995		1994		1995		1994		1995	
Taxon/category	No./m^2	SD	No./m^2	SD	No./m^2	SD	No./m^2	SD	No./m^2	SD	No./m^2	SD
Platyhelminthes												
Turbellaria	3	13	59	401	4	24	3	13	1	8	2	8
Nemertea	15	106	10	51	14	61	15	35	9	39	4	24
Mollusca												
Gastropoda	1	6	1	6	<1	2	0	0	<1	2	0	0
Bivalvia	10	22	36	75	123	304	111	297	461	796	399	660
Annelida												
Oligochaeta	8,523	9,442	14,096	15,394	4,134	3,894	6,281	5,593	1,462	1,915	2,904	3,147
Polychaeta	5	22	4	19	<1	2	<1	3	2	6	5	18
Hirudinea	1	3	1	6	1	4	<1	4	<1	3	<1	3
Crustacea												
Ostracoda	32	64	24	53	22	63	26	50	49	130	24	46
Unidentified Gammaridae[a]	0	0	0	0	0	0	0	0	<1	4	<1	4
Corophium spp.	4	29	2	13	1	5	2	8	20	101	55	283
Ramellogammarus spp.	1	3	0	0	1	6	0	0	<1	3	0	0
Hyalella azteca	0	0	0	0	0	0	0	0	<1	2	0	0
Isopoda	<1	2	0	0	0	0	0	0	1	7	0	0
Mysidacea	0	0	0	0	1	10	0	0	0	0	0	0
Copepoda[b]	42	113	32	81	68	201	54	151	39	116	32	109

Table 2. Continued.

	Silcott Island RKm 212				Centennial Island RKm 193				Offield RKm 177			
	1994		1995		1994		1995		1994		1995	
Taxon/category	No./m^2	SD	No./m^2	SD	No./m^2	SD	No./m^2	SD	No./m^2	SD	No./m^2	SD
Chelicerata												
Prostigmata	4	11	15	72	24	67	19	41	45	75	40	66
Insecta												
Coleoptera[c]	1	4	1	6	0	0	<1	2	<1	3	1	4
Ephemeroptera nymph	2	8	5	16	5	15	9	32	80	243	39	83
Lepidoptera larvae	0	0	2	14	0	0	0	0	0	0	0	0
Megaloptera larvae	0	0	0	0	0	0	0	0	<1	2	0	0
Plecoptera nymph	1	3	4	26	1	4	<1	2	0	0	0	0
Unidentified Diptera larvae	<1	2	0	0	<1	2	0	0	0	0	0	0
Unidentified Diptera pupae	1	6	4	29	0	0	0	0	<1	4	0	0
Chironomidae larvae	917	1,132	727	924	1,014	925	846	755	916	1,116	649	729
Chironomidae pupae	7	18	4	16	13	31	5	17	16	47	5	12
Ceratopogonidae larvae	<1	2	<1	2	<1	2	<1	2	2	9	<1	2
Tanyderidae larvae	0	0	1	6	0	0	0	0	0	0	0	0
Trichoptera larvae	2	7	5	17	5	18	2	6	3	10	3	12

[a] Unidentified Gammaridae exclusive of *Corophium* spp.

[b] Includes harpacticoids and unidentified copepods.

[c] Includes all life history stages.

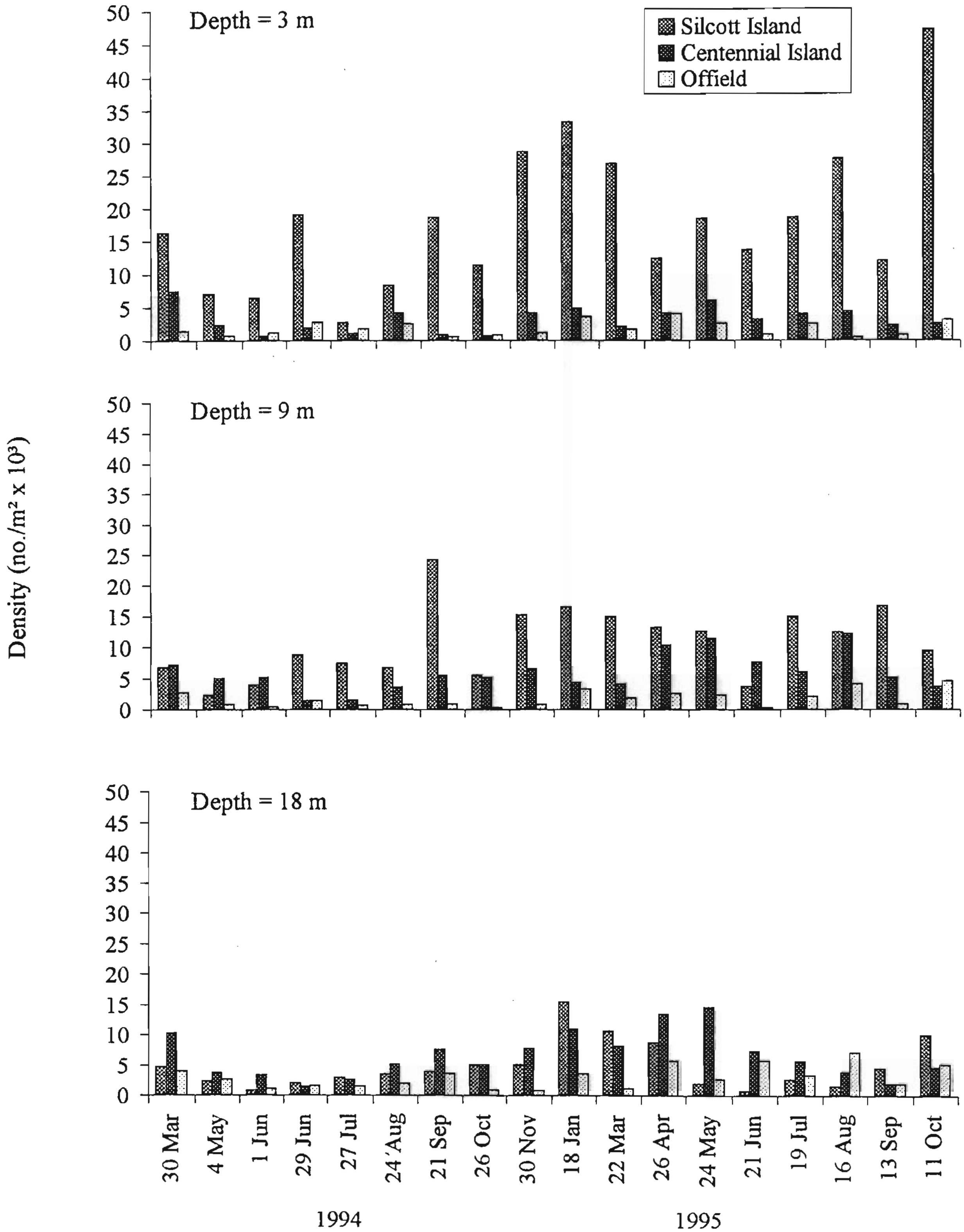

Figure 4. Densities (no./m²) of Oligochaeta by depth at three sampling areas in Lower Granite Reservoir, 1994-1995.

all depths with the greatest difference observed in 1995 along the 18-m depth contour (Appendix Fig. D4).

Chironomid larvae--Chironomid larvae ranked second in abundance at each sampling area. At Silcott Island, mean chironomid larva densities decreased with depth (Fig. 5). Respective mean chironomid larva densities at the 3-, 9-, and 18-m depths were as follows: 1,191, 905, and 394/m^2 at Silcott Island; 943, 953, and 894/m^2 at Centennial Island; and 986, 544, and 816/m^2 at Offield.

Differences among transects for each sampling depth in each sampling area were greater for chironomid larvae than for oligochaetes. At Silcott Island, differences in chironomid larva densities among transects were small at the 18-m depth and large at the 3- and 9-m depths (Appendix Fig. D5). At Centennial Island, differences in chironomid larva densities among transects were similar at all sample depths (Appendix Fig. D6). At Offield, the greatest variation of chironomid larva densities among transects was along the 3-m depth contour (Appendix Fig. D7).

Bivalves--Bivalves were the third most abundant organisms in the sampling areas (data pooled by sampling areas, date, and depths). Offield had the highest abundance of bivalves, accounting for about 75% of bivalves in all three sampling areas (Fig. 6). Respective mean bivalve densities at the 3-, 9-, and 18-m depths were as follows: 23, 18, and 28/m^2 at Silcott Island; 321, 26, and 4/m^2 at Centennial Island; and 665, 378, and 248/m^2 at Offield. At Offield, mean bivalve densities were higher from October 1994 to May 1995 (mean = 665/m^2) at all sampling depths than during other months, and mean densities were lowest from June to September (mean = 294/m^2).

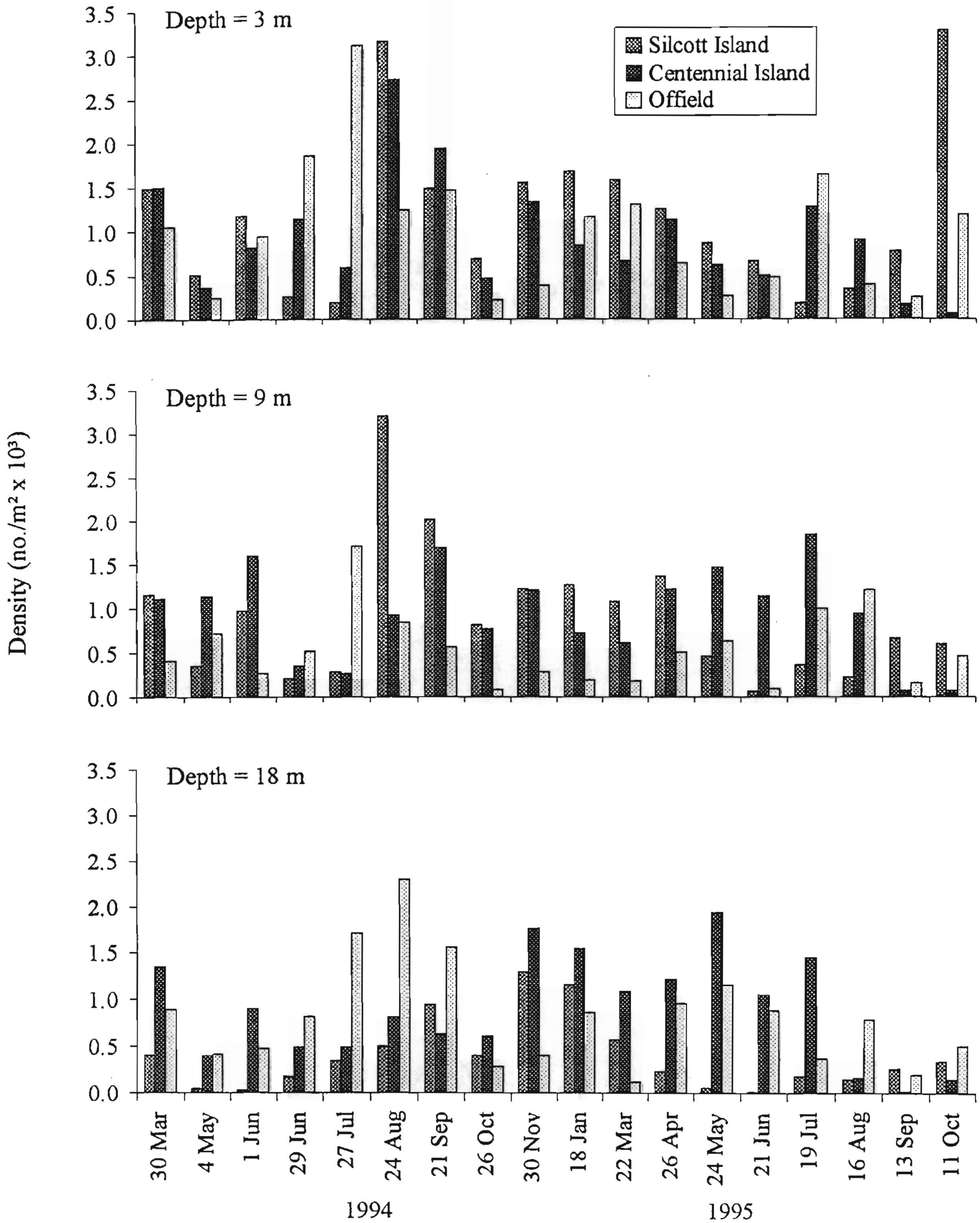

Figure 5. Densities (no./m^2) of Chironomidae larvae by depth at three sampling areas in Lower Granite Reservoir, 1994-1995.

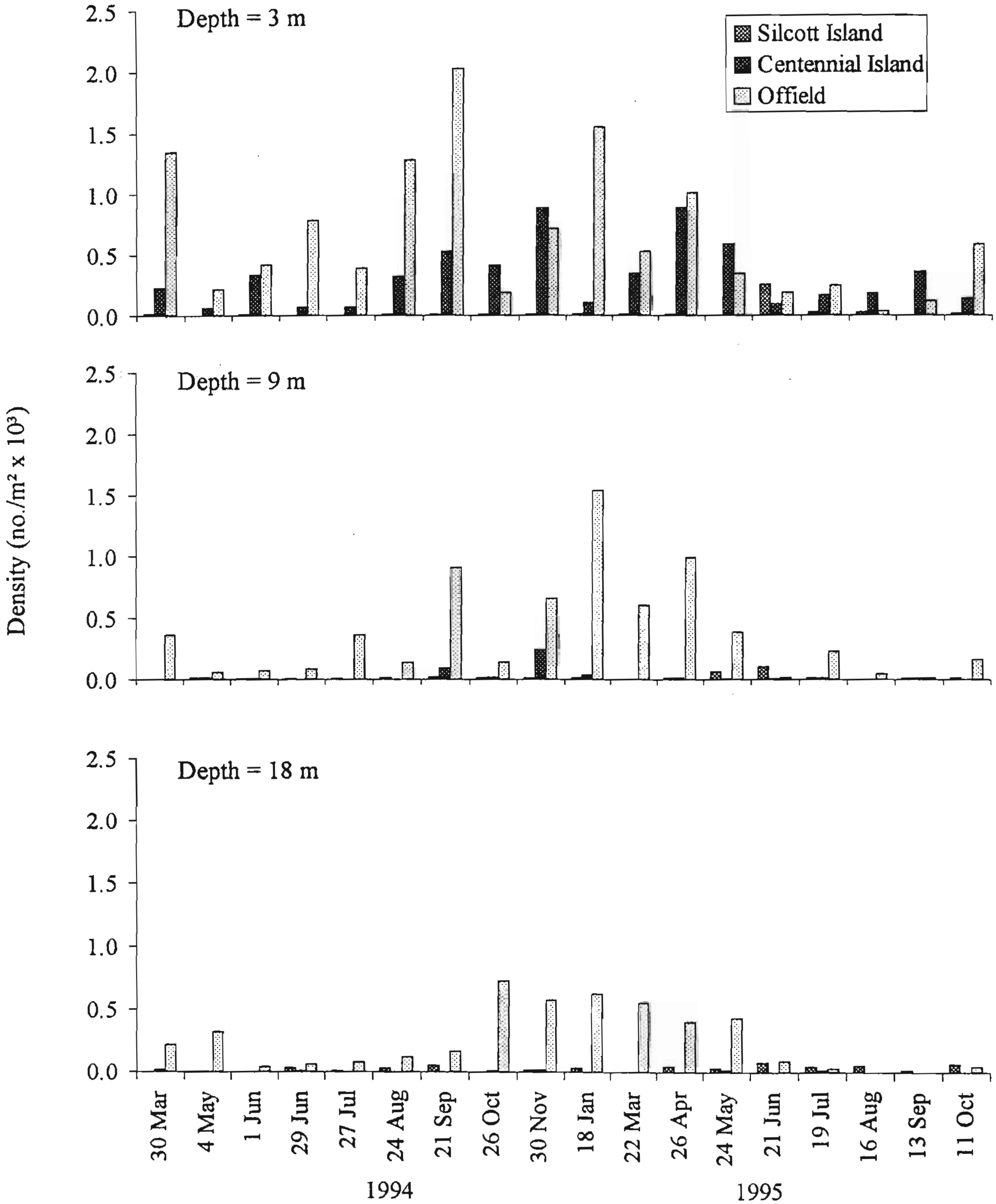

Figure 6. Densities (no./m²) of Bivalvia by depth at three sampling areas in Lower Granite Reservoir, 1994-1995.

Differences in bivalve densities among transects for each sampling depth were not apparent except at the 3-m depth contour at Offield (Appendix Figs. D8-D10). At Silcott Island and Centennial Island, bivalve densities were generally less than $0.5/m^2$ in our samples at all depth contours. At the 9- and 18-m depth contours at Offield, though bivalve densities often exceeded $0.5/m^2$, there was no obvious pattern of difference among transects.

Other Benthic Invertebrates

Aquatic Insects--Aquatic insects comprised 11% of all organisms enumerated. Included in decreasing order of abundance were the following seven orders of aquatic insects: Diptera, Ephemeroptera, Trichoptera, Plecoptera, Coleoptera, Lepidoptera, and Megaloptera (Table 3). Dipteran and ephemeropteran insects were generally abundant and found at all sampling areas and depths throughout the study period. The remaining insect orders had densities generally less than $10/m^2$ and were present only sporadically during the study period (Table 3).

The most abundant insects were dipterans (Table 3), which included the Chironomidae larvae and pupae, Ceratopogonidae larvae, and Tanyderidae larvae taxa/categories. Mean dipteran densities ranged from 20 to $3{,}230/m^2$ for all sampling areas and depths, with mean densities pooled by depth at Silcott Island, Centennial Island, and Offield of 832, 940, and $794/m^2$, respectively (Fig. 7). There was large seasonal variation in dipteran densities at all sampling areas and depths.

Ephemeroptera (mayfly nymphs) was the second most abundant order of aquatic insects (Table 3). Temporally, mean mayfly nymph densities ranged from 0 to $725/m^2$, with highest densities at Offield (Appendix Table C). Mean mayfly nymph densities at Silcott

Table 3. Mean density (no./m^2) of Insecta orders collected at three soft-substrate, shallow-water sampling areas in Lower Granite Reservoir, 1994-1995. Data from all sampling dates are pooled for each sampling area and water depth.

Sampling area	Depth (m)	Coleoptera	Diptera	Ephemeroptera	Lepidoptera	Megaloptera	Plecoptera	Trichoptera
Silcott Island	3	1	1,184	7	3	0	2	6
	9	1	914	3	0	0	4	3
	18	0	398	1	0	0	1	1
Centennial Island	3	0	961	16	0	0	0	9
	9	0	959	2	0	0	<1	<1
	18	<1	899	3	0	0	1	1
Offield	3	<1	1,013	141	0	0	0	6
	9	<1	549	35	0	<1	0	2
	18	1	820	3	0	0	0	<1

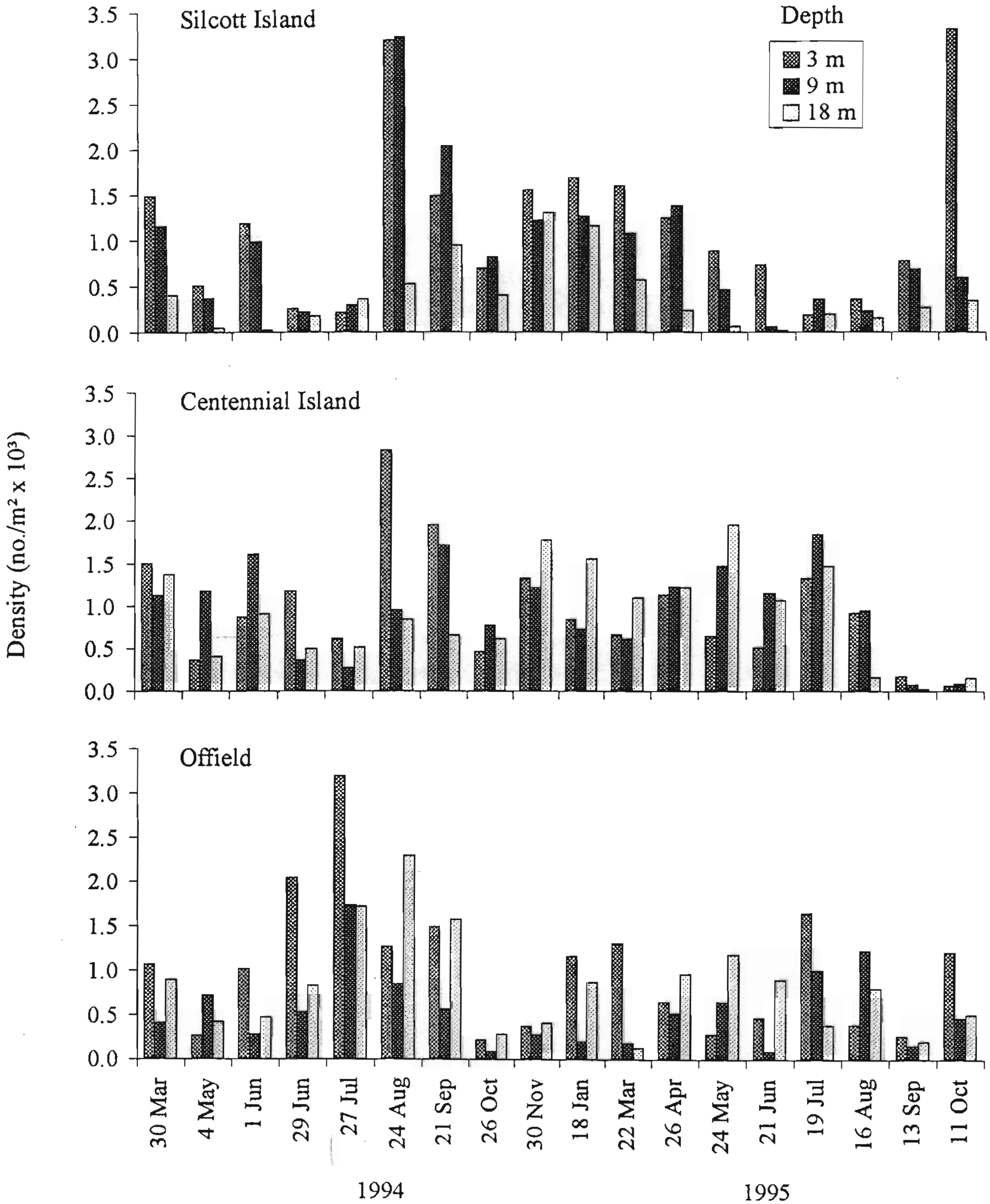

Figure 7. Densities (no./m²) of Diptera by depth at three sampling areas in Lower Granite Reservoir, 1994-1995.

Island, Centennial Island, and Offield were 4, 7, and 59/m^2, respectively. At all sampling areas, the highest mayfly nymph density was at the 3-m depth, and mayfly nymphs were rare at the 18-m depth.

Crustaceans--Five taxa of crustaceans were found that can be included as benthic invertebrates. These taxa were as follows, in decreasing order of abundance: Copepoda, Ostracoda, Amphipoda, Isopoda, and Mysidacea (Appendix Table B1). Copepods and ostracods were the two most abundant crustaceans and were found at each sampling area and depth (Appendix Table B3). Isopods and mysids were rare (Appendix Table B3). Isopods were present during three sampling periods and mysids were present once.

Mean copepod densities pooled by depths ranged from 0 to 390/m^2 (Appendix Table B3). Respective mean copepod densities at the 3-, 9-, and 18-m depths were as follows: 71, 25, and 14/m^2 at Silcott Island; 38, 92, and 54/m^2 at Centennial Island; and 24, 28, and 54/m^2 at Offield. At Silcott Island 9- and 18-m depths and at the Centennial Island 18-m depth, copepod densities peaked in August 1994. At Offield 9- and 18-m depths and at the Centennial Island 3-m depth, copepod densities peaked in November 1994. During other months, mean copepod densities were generally less than 100/m^2.

Ostracods were next in abundance to copepods, and in samples from some months, ostracods had higher densities than copepods (Appendix Table B3). Respective mean ostracod densities at Silcott Island, Centennial Island, and Offield were 28, 24, and 37/m^2. Generally, mean ostracod densities were less than 100/m^2 throughout the study.

Although amphipods were sporadically present at all areas and depths sampled, they were higher in density at times than the copepods and ostracods (Appendix Table B3). For example, at Offield in April 1995, amphipod densities at the 3- and 9-m depths were 620 and 430/m^2, respectively. At least five species of amphipods were identified: *Corophium salmonis*, *C. spinicorne*, *Ramellogammarus oregonensis*, *R. ramellus*, and *Hyalella azteca*. The predominant genus of amphipods present in the study areas was *Corophium*. Overall, the mean amphipod density was 14/m^2.

Sediment Samples

There were apparent differences in sediment composition among sampling areas, between depths within sampling areas, and along transects within sampling areas (Appendix Table B4-B5). Percentages of gravel (grain sizes 75 to 4.75 mm) were zero at all stations at Silcott Island and Centennial Island, whereas at Offield, percentages of gravel in the sediments ranged from 0 to 38.8. Percentages of sand (grain sizes 4.75 to 0.074 mm) ranged from 12.9 to 94.0 at Silcott Island, from 4.3 to 79.6 at Centennial Island, and from 6.2 to 58.0 at Offield. At Silcott Island, the percentages of sand were highest at the 18-m depth, while at Centennial Island they were highest at the 3-m depth. Percentages of sand at Offield appeared more variable than at the other two sampling areas.

Percentages of fines (grain sizes < 0.074 mm) ranged from 6.0 to 87.1 at Silcott Island, from 20.4 to 95.7 at Centennial Island, and from 54.6 to 93.8 at Offield. At Silcott Island, percentages of fines were higher at the 3-m depth than at the 9- and 18-m depths. At Centennial Island and Offield, percentages of fines were higher at the 9- and 18-m depths than at the 3-m depth. The median grain size ranged from 0.03 to 0.18 mm at Silcott Island, from 0.02 to 0.28 mm at Centennial Island, and from 0.01 to 0.36 mm at Offield.

Percentages of silt/clay ranged from 5.4 to 84.5 at Silcott Island, from 20.3 to 95.0 at Centennial Island, and from 32.4 to 90.6 at Offield. Centennial Island had the highest percentages of silt/clay, especially at the 9- and 18-m depths. Percentages of volatile solids ranged from 0.4 to 48.3 at Silcott Island, from 2.1 to 15.8 at Centennial Island, and from 3.8 to 10.0 at Offield. There was no consistent pattern of sediment composition among transects within sampling areas.

DISCUSSION

Benthic invertebrate fauna in the three selected soft-substrate, shallow-water habitats of Lower Granite Reservoir during 1994-95 was numerically dominated by oligochaetes and to a lesser extent, chironomid larvae and bivalves; a distribution similar to results reported for 1976-77 (Dorband 1980). Mean oligochaete densities in our sampling areas ranged from 1,698 to 18,220/m^2 and the mean chironomid larva density was about 850/m^2 with a peak density over 3,000/m^2. Dorband (1980) reported that densities for both oligochaetes and chironomids were similar in 1976 and 1977 (500 to 13,000/m^2 and 492 to 1,292/m^2, respectively). Insect orders recovered from our benthic invertebrate samples included all of those reported by Dorband (1980). Bennett et al. (1990, 1993) found that oligochaetes and chironomids dominated the benthic fauna during June, October, and December 1988, July 1989, and September 1991. They reported ratios of 45% oligochaetes to 55% chironomids in standing crop estimates for the reservoir and a mean numerical density for chironomids of about 500/m^2 with chironomid densities occasionally reaching at 2,000/m^2. It appears that the benthic invertebrate community in Lower Granite Reservoir has been fairly stable for the past 20 years.

We chose to index our benthic invertebrate data analyses by a single variable, numerical density. Multiple variables like number, weight, and frequency of occurrence in multivariant analysis are difficult to interpret, require extra effort to collect, and increase sensitivity to violations of assumptions (Macdonald and Green 1983). Dorband (1980) reported numerical densities and frequency of occurrence for organisms recovered from benthic invertebrate samples collected from Lower Granite, Little Goose, and Ice Harbor Reservoirs. Bennett et al. (1993) reported both density and weights of chironomids in Lower Granite Reservoir but did not report numerical data for oligochaetes due to problems associated with counting fragmented oligochaetes. We also had difficulty with enumerating fragmented oligochaetes; therefore, our reported oligochaete densities are possibly biased high. However, we believe the degree of possible bias would not compromise comparisons required for assessment of a possible drawdown.

We did not attempt further taxonomic identification of oligochaetes because it was considered beyond the scope of this study. For accurate identification of oligochaetes to genera and species, it is necessary to serially section and mount fresh specimens on slides for examination of the anatomical arrangement (Pennak 1978). However, Dorband (1980) reported that most oligochaetes in Lower Granite Reservoir were identified as either *Tubifex tubifex* or *Limnodrilus hoffmeisteri*. Changes in genera or species of oligochaetes or other benthic invertebrates could be important to fully understand possible impacts of a drawdown on the benthic invertebrate community in the reservoir.

The abundance of some taxa/categories in the upper reservoir may be due in part to the sharp, wide turn of the reservoir at Silcott Island, where the westerly and downstream water flow turns sharply northwest and continues through the steep-sloped canyon to the dam. Silcott Island probably receives more turbid and silty waters from the convergence of the Clearwater and Snake Rivers because this area is closest to the riverine-to-reservoir transition than the two downstream sampling areas. Hence, the higher percentages of sand and fines at Silcott Island provides improved habitat for oligochaetes and chironomids.

Differences in species composition and abundance and temporal changes in densities of benthic invertebrates at our sampling areas were undoubtedly affected by differences in sediment composition. The predominantly sand and fine sediment composition in the soft-substrate, shallow-water habitats we studied probably contributed to the dominance of oligochaetes and chironomid larvae. Some freshwater species of oligochaetes prefer mud and silt for burrow-making and feed on organic matter and bacteria present in those sediments (Brinkhurst and Cook 1974, Barnes 1987, Brinkhurst and Gelder 1991).

Chironomid larvae have been found in almost all aquatic habitats, including mud, sand, and rocks (Roback 1974, Pennak 1978). Aquatic insects, in addition to chironomid larvae, have habitat preferences which also depend on sediment types. For example, some mayfly nymphs are more adapted to gravel than other invertebrates (Roback 1974, Pennak 1978). This adaptation to gravel may explain the higher mayfly nymph densities at Offield, the only sampling area with gravel. However, other mayfly nymphs we found, such as *Hexagenia* spp. and *Caenis* spp., prefer soft mud bottoms and slow, silty water areas (Roback 1974, Pennak 1978). Other factors possibly affecting aquatic insect densities include emergence of subadults and predation. Populations of bivalves are reportedly higher in habitats where the benthos is stabilized with gravel and sand, rather than shifting sand and mud (Pennak 1978). The gravel and sand substrate at Offield may contribute to higher bivalve densities in that sampling area. Amphipods, the predominant benthic crustaceans in our sampling areas, generally live in and among debris and stones and burrow into sediments (Pennak 1978, Barnes 1987). Amphipods were present at low densities in all sampling areas (mean = $14/m^2$), but the reported densities may also be affected by concentration of carbonate in the water, dissolved oxygen concentration, or other biotic and abiotic factors (Pennak 1978).

The proposed drawdown would expose much existing shallow-water habitat of the reservoir, as was discovered during a drawdown test in March 1992 (U.S. Army Corps of Engineers 1992a). This exposure may have important impacts on the diets of juvenile salmonids and other fishes if there was a net loss of such habitat following a drawdown.

Insects, primarily emerging subadult chironomids, are an important prey of juvenile salmonids in the Columbia River system (Becker 1973, Kirn et al. 1986, Muir and Emmett 1988, Muir and Coley 1996). Chironomid larva also constitutes one of major food resources for juvenile and adult fishes in freshwater habitats (Pennak 1978). In their analysis of stomach contents of migrating juvenile chinook salmon passing through Lower Granite Dam, Muir and Coley (1996) reported six orders of aquatic and terrestrial insects, with chironomids as the dominant prey. Each of the insect orders observed by Muir and Coley (1996) was also recovered from our benthic invertebrate samples. Therefore, it is possible that temporal densities of insects in Lower Granite Reservoir were affected by predation as well as emergence of subadults, and that loss of benthic fauna could affect food resources of juvenile salmonids.

Oligochaetes, though the most abundant benthic invertebrates in the reservoir, have not to our knowledge been reported as a major diet constituent for juvenile salmonids. Muir and Emmett (1988) reported that bivalves (*Corbicula manilensis*) were rarely found in stomachs of juvenile salmonids. Hence, neither oligochaetes nor bivalves, which were among the most abundant benthic invertebrates in our sampling areas, are likely important dietary components for salmonids. Crustaceans, except amphipods, were reportedly less important than insects as prey of juvenile salmonids in the Columbia River system (Becker 1973, Kirn et al. 1986, Muir and Emmett 1988, Muir and Coley 1996). Amphipods, especially *Corophium* spp., were reported to be the dominant prey of juvenile salmonids at Bonneville Dam (Muir and Emmett 1988). At Lower Granite Dam, outmigrating juvenile chinook salmon prey included amphipods (*Corophium spinicorne*) (Muir and Coley 1996). The potential contribution of these benthic invertebrates to juvenile salmonids in Lower Granite Reservoir should not be overlooked.

CONCLUSIONS

1) The selected soft-substrate, shallow-water areas sampled during 1994-95 were numerically dominated by oligochaetes, aquatic insects, primarily chironomid larvae, and bivalves. Although 76 taxa/categories of benthic invertebrates were present in these areas, mean densities at each sampling area were <13,000 organisms/m^2.

2) Densities of benthic invertebrates decreased from the upper reservoir sampling area near Silcott Island (mean = 12,578/m^2) to the mid-reservoir sampling area at Centennial Island (mean = 7,069/m^2) and decreased further from Centennial Island to the lower reservoir sampling area near Offield Landing (mean = 3,842/m^2). These density differences were possibly related to differences in sediment composition among sampling areas.

2) At present reservoir pool levels, soft-substrate, shallow-water habitats are rare due to the steep-sloped canyon of the reservoir. The overall impact of a drawdown on benthic invertebrates present will depend in part on the net gain or loss of these habitats following a drawdown.

RECOMMENDATIONS

1) Activities affecting production of food resources for juvenile salmonids could affect restoration efforts for threatened or endangered Snake River salmon. Benthic invertebrates are an important dietary component of juvenile salmonids and activities, such as drawdown, which could affect food availability should be carefully monitored.

2) Statistical analyses to examine possible differences in composition and abundance of benthic invertebrates among dates, depths, transects, and sampling areas are needed. Analyses to evaluate species diversity and relationships between benthic invertebrates

and other limnological parameters monitored during this pre-drawdown period are also recommended.

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APPENDICES

Appendix A

Subsampling procedure

Appendix B

Habitat preferences of organisms
Crustacean densities
Sediment types and characteristic data

Appendix C

Species compositions and densities

Appendix D

Data analysis sheet
Spatial distribution

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APPENDICES

Appendix A

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Appendix A1. Methodology used for subsampling large volume benthic invertebrate samples containing fine sediments.

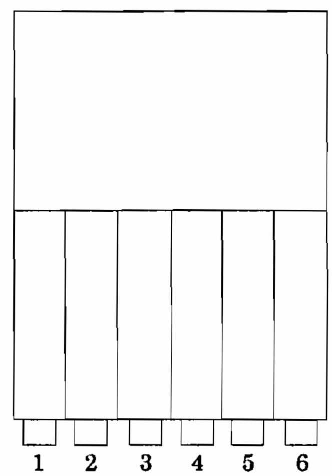
A. Description

1. We used a modified Motoda plankton splitter to divide a large benthic invertebrate sample into six equivalent subsamples. Samples chosen for splitting had volumes about 1 to 2 L after sieving. Two or six subsamples were chosen for analysis. Each subsample was processed as an independent sample using standard procedures. In addition to the standard procedures, the subsample number and a comment clarifying that the sample processed was a subsample were included on the data sheet.

2. After each subsample was processed, tallies from each taxon/category were added then mathematically adjusted to estimate total tallies for the entire sample. The adjusted tallies were recorded on an independent data sheet, with the subsample data sheets attached.

B. Equipment

1. Motoda plankton splitter with 4-L capacity, 6 sub-divisions, 6 - 31.8 mm diameter rubber stoppers, and plastic vent covers.
2. U.S.A. Standard Testing Sieve no. 35 (0.5 mm)
3. Spoon
4. Wash bottle with tap water (500 ml)
5. Six jars with caps (250 to 500 ml)
6. Waterproof labels
7. Pencil
8. Scissors
9. Ethanol solution (80%)
10. Sink



Split compartment numbers

C. Rinse

1. Rinse the sample with tap water over a U.S.A. Standard Testing Sieve no. 35 (0.5 mm) to remove formalin.

2. Transfer the washed sample from the sieve to a holding jar. Add sufficient ethanol to cover the sediment.

3. Place the base of the plankton splitter on the counter so that the vents hang over the edge of the sink. Make the base of the splitter level using the corner screws and the lever indicator on the base.

4. Close each vent on the splitter with rubber stoppers and cover each stopper with a plastic vent cover to further seal the drains. Tilt the non-divided end of the splitter down on its rest.

5. Transfer the sample from the holding jar into the non-divided end of the splitter using the spoon.

D. Mixing and Splitting

1. Add sufficient tap water to the sample in the splitter to create a homogeneous slurry. Mix the slurry by rocking the splitter up and down several times.

2. Conclude mixing with the divided end of the splitter tilted down on its rest and the six vents extending over the edge of the sink. Check to see that each division has an equivalent amount of slurry, and if not, mix again.

3. Using the wash bottle with tap water, rinse the remaining sediment from the non-divided end of the splitter into the divided end. Use a side to side motion during this rinse to move the sediment into the divisions equally.

E. Subsample Acquisition

1. Hold the 0.5 mm sieve immediately under side vent number 1. Remove the stopper and plastic vent cover to let the subsample drain out onto the sieve. Restopper the vent, rinse completely, and drain again to remove all the sediment from the subcompartment.

2. Transfer the sample from the sieve to an appropriate sized jar. Add sufficient ethanol to the sample jar to cover the sediment. Place two waterproof paper labels with the original sample data and subsample number into the sample jar, and cap tightly.

3. The remaining subsamples are obtained from the other subcompartments in a similar manner.

Appendix B

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Appendix Table B1. Non-insect taxa recovered from benthic invertebrate samples collected in Lower Granite Reservoir, 1994-1995. For data analysis purposes, the habitat type is noted for each organism (Barnard 1969, Smith and Carlton 1975, Borror et al. 1976, Pennak 1978, Bousfield 1979, Rudy and Rudy 1983, Barnes 1987).

Non-insect taxon	Benthic	Epibenthic	Planktonic	Terrestrial	Comments
Araneae				x	
Archaeogastropoda	x				
Bivalvia	x				
Calanoida			x		Mostly planktonic (Barnes 1987).
Cladocera	x		x		Was not consistently enumerated, therefore excluded from data analysis. It is mainly planktonic.
Copepoda	x		x		Habitat types vary between orders (Barnes 1987).
Corophium salmonis	x	x			Associates with muddy substrate (Rudy and Rudy 1983).
Corophium spinicorne	x	x			Associates with sandy substrate (Rudy and Rudy 1983).
Corophium spp.	x	x			Associates with mud and sand (Rudy and Rudy 1983).
Cyclopoida		x	x		Associates with substrate but also swims (Pennak 1978).
Eggs (unidentified)					Excluded from data analysis.
Gammaridae	x	x			Associates with substrate (Pennak 1978).
Gastropoda	x				
Harpacticoida	x				Crawls or runs on substrate and is restricted to bottom debris (Pennak 1978).
Hirudinea		x			Adheres to substrate for protection and for resting (Pennak 1978).
Hyalella azteca	x	x			Associates with substrate (Pennak 1978).
Isopoda	x				

Appendix Table B1. Continued.

Non-insect taxon	Benthic	Epibenthic	Planktonic	Terrestrial	Comments
Ixodides				x	
Leptodora kindtii			x		Excluded from data analysis.
Leptodoridae			x		Excluded from data analysis.
Mysidacea	x		x		Both benthic and planktonic forms exist (Barnes 1987).
Nematoda	x				Was not consistently enumerated, therefore excluded from data analysis.
Nematomorpha		x			Nematomorpha was misidentified as Nematoda, so it was excluded from analysis.
Nemertea	x				
Oligochaeta	x				
Ostracoda	x				
Polychaeta	x				
Porcellio spp.				x	
Prostigmata	x				
Ramellogammarus oregonensis	x	x			
Ramellogammarus ramellus	x	x			
Turbellaria		x			

Appendix Table B2. Insects recovered from benthic invertebrate samples collected in Lower Granite Reservoir, 1994-1995. For data analysis purposes, the life stages of each insect taxon is noted as to whether it is benthic (Borror et al. 1976, Pennak 1978, Barnes 1987).

Taxon	Larva/ nymph	Pupa	Adult	Comments
Caenidae	x	n/a[a]		
Caenis spp.	x	n/a		
Ceratopogonidae	x	x		The aquatic immature stages are generally benthic.
Chironomidae	x	x		The aquatic immature stages are generally benthic.
Chironominae	x	x		The aquatic immature stages are generally benthic.
Coleoptera	x		x	
Collembola				Some species are aquatic and restricted to the water surface. No reference to benthic species were found.
Culicidae				The larval form generally stays at the water surface. Hence, no life stage was included as benthic.
Diptera	x	x		
Elmidae	x		x	
Ephemera spp.	x	n/a		
Ephemeroptera	x	n/a		
Formicidae				
Hemiptera				Most species are terrestrial and some are aquatic.
Hexagenia spp.	x	n/a		
Homoptera		n/a		
Insecta	x	x	x	Organisms recorded as Insecta were not further identified due to fragmentation, therefore all of these were marked as benthic invertebrates.
Isoptera				
Lepidoptera larvae	x			
Leptophlebiidae	x	n/a		
Orthocladiinae	x	x		The aquatic immature stages are generally benthic.
Orthoptera	x	x		
Plecoptera	x	n/a		
Psocoptera		n/a		
Psychomyiidae	x	x		

Appendix Table B2. Continued

Taxon	Larva/ nymph	Pupa	Adult	Comments
Sialis spp.	x			*Sialis* spp. can be associated with substrate (Pennak 1978).
Simuliidae				The immature life stages are found in shallow water of mostly swift streams (Pennak 1978).
Tanyderidae larvae	x			
Tanypodinae	x	x		The aquatic immature stages are generally benthic.
Thysanoptera				
Trichoptera	x	x		

[a] The "n/a" in the pupa column denotes insects having a nymphal, not pupal life stage.

Appendix Table B3. Mean densities (no./m²) of Crustacea taxa recovered from the benthic invertebrate samples collected in Lower Granite Reservoir, 1994-1995.

Sampling area	Depth (m)	Date	Amphipoda	Copepoda	Isopoda	Mysidacea	Ostracoda
Silcott Island	3	30 Mar 94	0	25	0	0	5
		4 May 94	0	135	0	0	0
		1 Jun 94	10	0	0	0	0
		29 Jun 94	0	275	0	0	10
		27 Jul 94	0	5	0	0	0
		24 Aug 94	0	40	0	0	35
		21 Sep 94	0	50	5	0	15
		26 Oct 94	0	30	0	0	15
		30 Nov 94	5	60	0	0	70
		18 Jan 95	0	255	0	0	30
		22 Mar 95	0	25	0	0	50
		26 Apr 95	0	65	0	0	0
		24 May 95	0	30	0	0	0
		21 Jun 95	45	15	0	0	45
		19 Jul 95	0	0	0	0	80
		16 Aug 95	0	210	0	0	15
		13 Sep 95	0	15	0	0	10
		11 Oct 95	0	50	0	0	35
		Mean:	3	71	<1	0	23
Centennial Island	3	30 Mar 94	5	0	0	0	15
		4 May 94	0	5	0	0	145
		1 Jun 94	15	0	0	0	10
		29 Jun 94	0	10	0	0	0
		27 Jul 94	0	0	0	0	5
		24 Aug 94	0	185	0	0	85
		21 Sep 94	0	0	0	0	30
		26 Oct 94	0	0	0	0	0
		30 Nov 94	0	295	0	0	25
		18 Jan 95	5	0	0	0	30
		22 Mar 95	0	0	0	0	55
		26 Apr 95	0	10	0	0	60
		24 May 95	10	105	0	0	25
		21 Jun 95	0	5	0	0	0
		19 Jul 95	0	15	0	0	25
		16 Aug 95	0	50	0	0	50
		13 Sep 95	10	5	0	0	40
		11 Oct 95	0	0	0	0	10
		Mean:	3	38	0	0	34
Offield	3	30 Mar 94	10	10	0	0	0
		4 May 94	0	30	0	0	100
		1 Jun 94	5	65	0	0	5
		29 Jun 94	5	100	10	0	5
		27 Jul 94	0	10	0	0	25
		24 Aug 94	10	10	10	0	30
		21 Sep 94	0	25	0	0	10
		26 Oct 94	0	0	0	0	5
		30 Nov 94	0	5	0	0	30

Appendix Table B3. Continued.

Sampling area	Depth (m)	Date	Amphipoda	Copepoda	Isopoda	Mysidacea	Ostracoda
		18 Jan 95	0	10	0	0	30
		22 Mar 95	5	0	0	0	10
		26 Apr 95	620	40	0	0	35
		24 May 95	0	0	0	0	15
		21 Jun 95	0	0	0	0	10
		19 Jul 95	0	65	0	0	30
		16 Aug 95	10	70	0	0	15
		13 Sep 95	10	0	0	0	10
		11 Oct 95	20	0	0	0	5
		Mean:	39	24	1	0	21
Silcott Island	9	30 Mar 94	0	0	0	0	0
		4 May 94	0	0	0	0	0
		1 Jun 94	0	25	0	0	5
		29 Jun 94	0	20	0	0	5
		27 Jul 94	0	50	0	0	0
		24 Aug 94	10	115	0	0	35
		21 Sep 94	5	25	0	0	115
		26 Oct 94	5	0	0	0	5
		30 Nov 94	5	20	0	0	90
		18 Jan 95	0	50	0	0	45
		22 Mar 95	0	5	0	0	0
		26 Apr 95	0	45	0	0	5
		24 May 95	0	30	0	0	0
		21 Jun 95	0	0	0	0	0
		19 Jul 95	0	10	0	0	135
		16 Aug 95	0	25	0	0	25
		13 Sep 95	0	0	0	0	15
		11 Oct 95	0	25	0	0	0
		Mean:	1	25	0	0	27
Centennial Island	9	30 Mar 94	10	25	0	0	15
		4 May 94	5	0	0	0	25
		1 Jun 94	0	205	0	0	40
		29 Jun 94	0	85	0	0	0
		27 Jul 94	0	0	0	0	0
		24 Aug 94	0	180	0	0	50
		21 Sep 94	0	10	0	25	0
		26 Oct 94	5	0	0	0	5
		30 Nov 94	0	100	0	0	30
		18 Jan 95	10	0	0	0	10
		22 Mar 95	5	0	0	0	10
		26 Apr 95	0	355	0	0	50
		24 May 95	0	390	0	0	25
		21 Jun 95	5	195	0	0	0
		19 Jul 95	0	50	0	0	25
		16 Aug 95	0	25	0	0	25
		13 Sep 95	0	15	0	0	10
		11 Oct 95	0	15	0	0	0
		Mean:	2	92	0	1	18

Appendix Table B3. Continued.

Sampling area	Depth (m)	Date	Amphipoda	Copepoda	Isopoda	Mysidacea	Ostracoda
Offield	9	30 Mar 94	5	15	0	0	0
		4 May 94	0	0	0	0	0
		1 Jun 94	0	10	0	0	5
		29 Jun 94	5	65	0	0	0
		27 Jul 94	0	0	10	0	0
		24 Aug 94	5	0	0	0	55
		21 Sep 94	15	0	0	0	50
		26 Oct 94	15	0	0	0	0
		30 Nov 94	195	275	0	0	365
		18 Jan 95	120	0	0	0	115
		22 Mar 95	5	0	0	0	5
		26 Apr 95	430	25	0	0	25
		24 May 95	25	50	0	0	25
		21 Jun 95	0	0	0	0	20
		19 Jul 95	10	40	0	0	10
		16 Aug 95	10	5	0	0	15
		13 Sep 95	0	5	0	0	0
		11 Oct 95	0	5	0	0	10
		Mean:	47	28	1	0	39
Silcott Island	18	30 Mar 94	5	0	0	0	0
		4 May 94	5	0	0	0	0
		1 Jun 94	0	0	0	0	0
		29 Jun 94	0	0	0	0	0
		27 Jul 94	0	0	0	0	35
		24 Aug 94	0	230	0	0	125
		21 Sep 94	75	0	0	0	150
		26 Oct 94	0	0	0	0	0
		30 Nov 94	0	15	0	0	140
		18 Jan 95	0	0	0	0	90
		22 Mar 95	0	0	0	0	10
		26 Apr 95	0	0	0	0	45
		24 May 95	0	0	0	0	15
		21 Jun 95	0	0	0	0	0
		19 Jul 95	0	5	0	0	0
		16 Aug 95	5	0	0	0	0
		13 Sep 95	0	0	0	0	0
		11 Oct 95	0	5	0	0	0
		Mean:	5	14	0	0	34
Centennial Island	18	30 Mar 94	0	210	0	0	10
		4 May 94	0	0	0	0	5
		1 Jun 94	0	20	0	0	5
		29 Jun 94	0	105	0	0	15
		27 Jul 94	0	0	0	0	0
		24 Aug 94	0	370	0	0	25
		21 Sep 94	0	0	0	0	15
		26 Oct 94	0	5	0	0	0
		30 Nov 94	0	35	0	0	35
		18 Jan 95	0	0	0	0	10

Appendix Table B3. Continued.

Sampling area	Depth (m)	Date	Amphipoda	Copepoda	Isopoda	Mysidacea	Ostracoda
		22 Mar 95	0	0	0	0	0
		26 Apr 95	0	10	0	0	170
		24 May 95	0	175	0	0	40
		21 Jun 95	0	20	0	0	5
		19 Jul 95	0	15	0	0	20
		16 Aug 95	5	0	0	0	5
		13 Sep 95	0	0	0	0	5
		11 Oct 95	0	0	0	0	0
		Mean:	<1	54	0	0	20
Offield	18	30 Mar 94	0	25	0	0	40
		4 May 94	0	0	0	0	5
		1 Jun 94	0	0	0	0	0
		29 Jun 94	0	5	0	0	20
		27 Jul 94	180	15	0	0	80
		24 Aug 94	5	65	0	0	230
		21 Sep 94	15	0	0	0	185
		26 Oct 94	55	0	0	0	10
		30 Nov 94	45	310	0	0	70
		18 Jan 95	140	175	0	0	50
		22 Mar 95	45	70	0	0	35
		26 Apr 95	15	50	0	0	65
		24 May 95	0	5	0	0	65
		21 Jun 95	0	0	0	0	15
		19 Jul 95	40	5	0	0	5
		16 Aug 95	0	225	0	0	0
		13 Sep 95	0	10	0	0	15
		11 Oct 95	5	5	0	0	15
		Mean:	30	54	0	0	50

Appendix Table B4. Percentages of gravel, sand, and fines in sediments collected in July 1995 from all benthic invertebrate sampling stations in Lower Granite Reservoir.

			Benthic invertebrate transect[a]			
Sampling area	Depth (m)	Sediment type[b]	Upstream	Middle upstream	Middle downstream	Downstream
Silcott Island (RKm 212)	3	Gravel (%)	0.0	0.0	0.0	0.0
		Sand (%)	15.7	40.0	25.8	12.9
		Fines (%)	84.3	60.0	74.2	87.1
	9	Gravel (%)	0.0	0.0	0.0	0.0
		Sand (%)	61.1	24.2	55.9	17.8
		Fines (%)	38.9	75.8	44.1	82.2
	18	Gravel (%)	0.0	0.0	0.0	0.0
		Sand (%)	94.0	93.9	91.5	37.3
		Fines (%)	6.0	6.1	8.5	62.7
Centennial Island (RKm 193)	3	Gravel (%)	0.0	0.0	0.0	0.0
		Sand (%)	72.4	79.6	72.5	71.1
		Fines (%)	27.6	20.4	27.5	28.9
	9	Gravel (%)	0.0	0.0	0.0	0.0
		Sand (%)	4.3	6.9	61.6	10.6
		Fines (%)	95.7	93.1	38.4	89.4
	18	Gravel (%)	0.0	0.0	0.0	0.0
		Sand (%)	5.4	6.7	6.7	7.5
		Fines (%)	94.5	93.3	93.3	92.5
Offield (RKm 177)	3	Gravel (%)	3.7	0.0	2.2	7.4
		Sand (%)	28.6	19.1	31.0	58.0
		Fines (%)	67.6	80.9	66.8	34.7
	9	Gravel (%)	2.6	0.0	0.0	38.8
		Sand (%)	42.9	8.3	6.2	19.2
		Fines (%)	54.6	91.7	93.8	42.0
	18	Gravel (%)	3.0	0.0	28.5	0.0
		Sand (%)	13.0	32.4	8.5	7.1
		Fines (%)	84.0	67.6	63.0	92.9

[a] Refer to Figure 2 in main text for details.

[b] Analysis under contract by the U.S. Army Corps of Engineers North Pacific Division Materials Laboratory, Troutdale, Oregon.

Appendix Table B5. Median grain sizes (mm), silt/clay (%), and volatile solids (%) in sediments collected in July 1995 from benthic invertebrate sampling stations in Lower Granite Reservoir.

			Benthic invertebrate transect[a]			
Sampling area	Depth (m)	Sediment characteristic[b]	Upstream	Middle upstream	Middle downstream	Downstream
Silcott Island (RKm 212)	3	Median grain size (mm)	0.06	0.07	0.06	0.03
		Silt/clay (%)	82.0	47.0	63.1	84.5
		Volatile solids (%)	6.6	6.2	6.4	17.8
	9	Median grain size (mm)	0.09	0.06	0.08	0.04
		Silt/clay (%)	27.4	73.0	28.8	74.6
		Volatile solids (%)	3.5	3.4	3.1	7.4
	18	Median grain size (mm)	0.18	0.18	0.18	0.05
		Silt/clay (%)	5.4	5.4	8.4	58.6
		Volatile solids (%)	0.4	0.7	0.7	48.3
Centennial Island (RKm 193)	3	Median grain size (mm)	0.26	0.21	0.28	0.14
		Silt/clay (%)	27.5	20.3	26.8	24.9
		Volatile solids (%)	3.4	2.1	3.8	3.4
	9	Median grain size (mm)	0.02	0.02	0.14	0.02
		Silt/clay (%)	95.0	91.0	37.0	86.8
		Volatile solids (%)	13.4	15.8	4.2	11.6
	18	Median grain size (mm)	0.02	0.02	0.02	0.02
		Silt/clay (%)	93.5	90.9	91.1	90.4
		Volatile solids (%)	12.1	11.3	10.9	13.0
Offield (RKm 177)	3	Median grain size (mm)	0.05	0.05	0.05	0.15
		Silt/clay (%)	59.9	77.5	59.7	32.4
		Volatile solids (%)	5.2	4.9	3.8	5.1
	9	Median grain size (mm)	0.06	0.04	0.03	0.36
		Silt/clay (%)	52.1	90.6	93.5	41.3
		Volatile solids (%)	6.2	6.1	6.6	6.8
	18	Median grain size (mm)	0.03	0.04	0.03	0.01
		Silt/clay (%)	79.5	62.3	61.6	90.6
		Volatile solids (%)	7.3	6.8	9.6	10.0

[a] Refer to Figure 2 in main text for details.

[b] Analysis under contract by the U.S. Army Corps of Engineers North Pacific Division Materials Laboratory, Troutdale, Oregon.

Appendix C

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Appendix Table C1. Species compositions and densities (no./m²) by date, depth, and sampling area in Lower Granite Reservoir, 1994-1995.

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Sampling area / Date / Depth (m)	Taxon/category	Total number	Density (no./m²)
Silcott Island			
30 Mar 94			
3 m	No. samples processed:	4	
	Oligochaeta	3,261	16,305
	Chironomidae larvae	297	1,485
	Nematoda	24	120
	Cyclopoida	14	70
	Copepoda	5	25
	Prostigmata (water mites)	4	20
	Bivalvia	3	15
	Nemertea	2	10
	Ephemeroptera nymph	1	5
	Ostracoda	1	5
	Turbellaria	1	5
	Subtotal:	3,613	18,065
30 Mar 94			
9 m	No. samples processed:	3	
	Oligochaeta	1,018	6,787
	Chironomidae larvae	174	1,160
	Nematoda	4	27
	Cyclopoida	1	7
	Ephemeroptera nymph	1	7
	Subtotal:	1,198	7,987
30 Mar 94			
18 m	No. samples processed:	4	
	Oligochaeta	931	4,655
	Chironomidae larvae	81	405
	Cladocera	2	10
	Turbellaria	2	10
	Araneae (spiders)	1	5
	Corophium spinicorne	1	5
	Subtotal:	1,018	5,090
	Subtotal all depths for this sampling area and date period:	5,829	10,381
4 May 94			
3 m	No. samples processed:	4	
	Oligochaeta	1,406	7,030
	Chironomidae larvae	101	505
	Cladocera	39	195
	Nematoda	29	145
	Copepoda	27	135
	Eggs (unidentified)	27	135
	Nemertea	8	40
	Insecta	3	15
	Turbellaria	3	15
	Diptera pupae	1	5
	Subtotal:	1,644	8,220
[illegible]	...ssed:	4	
	[illegible]	455	2,275
	[illegible]	70	350
	[illegible]	6	30
	[illegible]	4	20
	[illegible]	3	15
	...ia	2	10
	Diptera adult	2	10
	Nematoda	1	5
	Nematomorpha	1	5
	Nemertea	1	5
	Polychaeta	1	5
	Prostigmata (water mites)	1	5
	Subtotal:	547	2,735
4 May 94			
18 m	No. samples processed:	4	
	Oligochaeta	468	2,340
	Eggs (unidentified)	17	85
	Chironomidae larvae	8	40
	Corophium salmonis	1	5
	Trichoptera larvae	1	5
	Subtotal:	495	2,475
	Subtotal all depths for this sampling area and date period:	2,686	4,477
1 Jun 94			
3 m	No. samples processed:	4	
	Oligochaeta	1,275	6,375
	Chironomidae larvae	235	1,175
	Nematoda	16	80
	Cladocera	7	35
	Prostigmata (water mites)	5	25
	Ephemeroptera nymph	4	20
	Collembola	3	15
	Nemertea	3	15
	Simuliidae larvae	3	15
	Porcellio spp.	2	10
	Archaeogastropoda	1	5
	Bivalvia	1	5
	Chironomidae pupae	1	5
	Corophium salmonis	1	5
	Corophium spp.	1	5
	Cyclopoida	1	5
	Plecoptera nymph	1	5
	Trichoptera larvae	1	5
	Subtotal:	1,561	7,805

Appendix Table C1. Continued.

Sampling area / Date / Depth (m)	Taxon/category	Total number	Density (no./m²)
	Oligochaeta	604	3,020
	Chironomidae larvae	70	350
	Ostracoda	7	35
	Cyclopoida	5	25
	Chironomidae pupae	2	10
	Bivalvia	1	5
	Ephemeroptera nymph	1	5
	Nematoda	1	5
	Polychaeta	1	5
	Prostigmata (water mites)	1	5
	Subtotal:	693	3,465
	Subtotal all depths for this sampling area and date period:	2,866	4,777
24 Aug 94			
3 m	No. samples processed:	4	
	Oligochaeta	1,659	8,295
	Chironomidae larvae	632	3,160
	Cladocera	81	405
	Eggs (unidentified)	37	185
	Leptodora kindtii	13	65
	Copepoda	7	35
	Ostracoda	7	35
	Chironomidae pupae	5	25
	Cyclopoida	3	15
	Nematoda	3	15
	Diptera pupae	2	10
	Bivalvia	1	5
	Chironomidae adult	1	5
	Harpacticoida	1	5
	Subtotal:	2,452	12,260
24 Aug 94			
9 m	No. samples processed:	4	
	Oligochaeta	1,346	6,730
	Cladocera	1,094	5,470
	Chironomidae larvae	641	3,205
	Cyclopoida	65	325
	Leptodora kindtii	34	170
	Copepoda	20	100
	Ostracoda	7	35
	Chironomidae pupae	4	20
	Harpacticoida	3	15
	Nematoda	3	15
	Bivalvia	2	10
	Polychaeta	2	10
	Corophium spinicorne	1	5
	Orthocladiinae pupae	1	5
	Ramellogammarus oregonensis	1	5
	Turbellaria	1	5
	Subtotal:	3,225	16,125
24 Aug 94			
18 m	No. samples processed:	4	
	Oligochaeta	693	3,465
	Chironomidae larvae	100	500
	Copepoda	46	230
	Ostracoda	25	125
	Cyclopoida	18	90
	Eggs (unidentified)	13	65
	Cladocera	6	30
	Bivalvia	5	25
	Diptera pupae	2	10
	Ceratopogonidae larvae	1	5
	Chironomidae pupae	1	5
	Diptera larvae	1	5
	Hirudinea	1	5
	Polychaeta	1	5
	Subtotal:	913	4,565
	Subtotal all depths for this sampling area and date period:	6,590	10,983
21 Sep 94			
3 m	No. samples processed:	4	
	Oligochaeta	3,708	18,540
	Chironomidae larvae	295	1,475
	Harpacticoida	9	45
	Cyclopoida	5	25
	Nematoda	5	25
	Ostracoda	3	15
	Bivalvia	2	10
	Chironomidae pupae	1	5
	Copepoda	1	5
	Isopoda	1	5
	Subtotal:	4,030	20,150
21 Sep 94			
9 m	No. samples processed:	4	
	Oligochaeta	4,854	24,270
	Chironomidae larvae	402	2,010
	Ostracoda	23	115
	Nematoda	10	50
	Chironomidae pupae	5	25
	Cyclopoida	5	25
	Bivalvia	4	20
	Harpacticoida	4	20
	Araneae (spiders)	1	5
	Copepoda	1	5
	Corophium salmonis	1	5
	Prostigmata (water mites)	1	5
	Subtotal:	5,311	26,555
21 Sep 94			
18 m	No. samples processed:	4	

Appendix Table C1. Continued.

Sampling area / Date / Depth (m)	Taxon/category	Total number	Density (no./m²)
	Nematoda	81	405
	Cyclopoida	63	315
	Copepoda	38	190
	Harpacticoida	13	65
	Ostracoda	6	30
	Bivalvia	3	15
	Nemertea	3	15
	Subtotal:	7,391	36,955
18 Jan 95			
9 m	No. samples processed:	4	
	Oligochaeta	3,306	16,530
	Chironomidae larvae	253	1,265
	Nematoda	43	215
	Cyclopoida	19	95
	Copepoda	10	50
	Ostracoda	9	45
	Nemertea	4	20
	Bivalvia	3	15
	Hirudinea	3	15
	Prostigmata (water mites)	3	15
	Araneae (spiders)	1	5
	Calanoida	1	5
	Ephemeroptera nymph	1	5
	Trichoptera larvae	1	5
	Subtotal:	3,657	18,285
18 Jan 95			
18 m	No. samples processed:	4	
	Oligochaeta	3,099	15,495
	Chironomidae larvae	232	1,160
	Ostracoda	18	90
	Nematoda	7	35
	Bivalvia	6	30
	Cyclopoida	3	15
	Nemertea	3	15
	Trichoptera larvae	1	5
	Subtotal:	3,369	16,845
	Subtotal all depths for this sampling area and date period:	14,417	24,028
22 Mar 95			
3 m	No. samples processed:	4	
	Oligochaeta	5,354	26,770
	Chironomidae larvae	316	1,580
	Nematoda	111	555
	Turbellaria	72	360
	Cyclopoida	41	205
	Nemertea	25	125
	Ostracoda	10	50
	Prostigmata (water mites)	7	35
	Ephemeroptera nymph	5	25
	Harpacticoida	5	25
	Diptera pupae	3	15
	Trichoptera larvae	3	15
	Bivalvia	2	10
	Hirudinea	1	5
	Subtotal:	5,955	29,775
22 Mar 95			
9 m	No. samples processed:	4	
	Oligochaeta	2,997	14,985
	Chironomidae larvae	215	1,075
	Nematoda	128	640
	Turbellaria	24	120
	Cyclopoida	7	35
	Prostigmata (water mites)	6	30
	Plecoptera nymph	3	15
	Trichoptera larvae	3	15
	Ceratopogonidae larvae	1	5
	Ephemeroptera nymph	1	5
	Gastropoda	1	5
	Harpacticoida	1	5
	Nemertea	1	5
	Subtotal:	3,388	16,940
22 Mar 95			
18 m	No. samples processed:	4	
	Oligochaeta	2,140	10,700
	Chironomidae larvae	114	570
	Nematoda	5	25
	Nemertea	5	25
	Ostracoda	2	10
	Subtotal:	2,266	11,330
	Subtotal all depths for this sampling area and date period:	11,609	19,348
26 Apr 95			
3 m	No. samples processed:	4	
	Oligochaeta	2,467	12,335
	Chironomidae larvae	249	1,245
	Nematoda	46	230
	Prostigmata (water mites)	11	55
	Copepoda	10	50
	Lepidoptera larvae	9	45
	Cyclopoida	6	30
	Coleoptera larvae	3	15
	Harpacticoida	3	15
	Trichoptera larvae	2	10
	Bivalvia	1	5
	Hemiptera adult	1	5
	Turbellaria	1	5
	Subtotal:	2,809	14,045

Appendix Table C1. Continued.

Sampling area Date Depth (m)	Taxon/category	Total number	Density (no./m²)
21 Jun 95			
18 m	No. samples processed:	4	
	Oligochaeta	143	715
	Bivalvia	16	80
	Chironomidae larvae	2	10
	Diptera pupae	1	5
	Ephemeroptera nymph	1	5
	Subtotal:	163	815
	Subtotal all depths for this sampling area and date period:	4,094	6,823
19 Jul 95			
3 m	No. samples processed:	4	
	Oligochaeta	3,715	18,575
	Nematoda	47	235
	Chironomidae larvae	36	180
	Ostracoda	16	80
	Bivalvia	6	30
	Cyclopoida	6	30
	Hemiptera	6	30
	Prostigmata (water mites)	3	15
	Trichoptera larvae	3	15
	Diptera	1	5
	Subtotal:	3,839	19,195
19 Jul 95			
9 m	No. samples processed:	4	
	Oligochaeta	2,994	14,970
	Chironomidae larvae	72	360
	Ostracoda	27	135
	Polychaeta	8	40
	Bivalvia	2	10
	Copepoda	2	10
	Ephemeroptera nymph	2	10
	Nematoda	1	5
	Nemertea	1	5
	Prostigmata (water mites)	1	5
	Subtotal:	3,110	15,550
19 Jul 95			
18 m	No. samples processed:	4	
	Oligochaeta	533	2,665
	Chironomidae larvae	37	185
	Polychaeta	12	60
	Bivalvia	9	45
	Unidentified	7	35
	Chironomidae pupae	1	5
	Copepoda	1	5
	Plecoptera adult	1	5
	Subtotal:	601	3,005
	Subtotal all depths for this sampling area and date period:	7,550	12,583
16 Aug 95			
3 m	No. samples processed:	4	
	Oligochaeta	5,490	27,450
	Chironomidae larvae	69	345
	Cyclopoida	47	235
	Copepoda	24	120
	Nematoda	19	95
	Harpacticoida	18	90
	Bivalvia	5	25
	Ostracoda	3	15
	Tanyderidae larvae	3	15
	Turbellaria	3	15
	Subtotal:	5,681	28,405
16 Aug 95			
9 m	No. samples processed:	4	
	Oligochaeta	2,487	12,435
	Chironomidae larvae	45	225
	Cyclopoida	24	120
	Plecoptera nymph	12	60
	Turbellaria	12	60
	Copepoda	5	25
	Ostracoda	5	25
	Nematoda	3	15
	Chironomidae pupae	1	5
	Subtotal:	2,594	12,970
16 Aug 95			
18 m	No. samples processed:	4	
	Oligochaeta	299	1,495
	Chironomidae larvae	29	145
	Bivalvia	10	50
	Corophium salmonis	1	5
	Nematoda	1	5
	No invertebrates present	0	0
	Subtotal:	340	1,700
	Subtotal all depths for this sampling area and date period:	8,615	14,358
13 Sep 95			
3 m	No. samples processed:	4	
	Oligochaeta	2,404	12,020
	Chironomidae larvae	154	770
	Nematoda	5	25
	Harpacticoida	3	15
	Nemertea	3	15
	Ostracoda	2	10
	Calanoida	1	5
	Cyclopoida	1	5
	Subtotal:	2,573	12,865
13 Sep 95			
9 m	No. samples processed:	4	
	Oligochaeta	3,337	16,685

Appendix Table C1. Continued.

Sampling area / Date / Depth (m)	Taxon/category	Total number	Density (no./m²)
	Plecoptera	2	10
	Araneae (spiders)	1	5
	Cyclopoida	1	5
	Plecoptera nymph	1	5
	Trichoptera larvae	1	5
	Subtotal:	2,516	12,580
	Subtotal all depths for this sampling area and date period:	6,166	10,277
4 May 94			
3 m	No. samples processed:	4	
	Oligochaeta	471	2,355
	Chironomidae larvae	72	360
	Ostracoda	29	145
	Bivalvia	12	60
	Nematoda	12	60
	Eggs (unidentified)	3	15
	Prostigmata (water mites)	2	10
	Trichoptera larvae	2	10
	Copepoda	1	5
	Ephemeroptera nymph	1	5
	Psychomyiidae larvae	1	5
	Subtotal:	606	3,030
4 May 94			
9 m	No. samples processed:	4	
	Oligochaeta	1,010	5,050
	Chironomidae larvae	228	1,140
	Eggs (unidentified)	34	170
	Nematoda	9	45
	Chironomidae pupae	5	25
	Ostracoda	5	25
	Cyclopoida	3	15
	Bivalvia	2	10
	Corophium salmonis	1	5
	Ephemeroptera nymph	1	5
	Subtotal:	1,298	6,490
4 May 94			
18 m	No. samples processed:	4	
	Oligochaeta	757	3,785
	Chironomidae larvae	80	400
	Nemertea	32	160
	Cladocera	14	70
	Nematoda	5	25
	Cyclopoida	3	15
	Ostracoda	1	5
	Prostigmata (water mites)	1	5
	Subtotal:	893	4,465
	Subtotal all depths for this sampling area and date period:	2,797	4,662
1 Jun 94			
3 m	No. samples processed:	4	
	Chironomidae larvae	163	815
	Oligochaeta	147	735
	Bivalvia	67	335
	Prostigmata (water mites)	16	80
	Nematoda	12	60
	Chironomidae pupae	7	35
	Chironominae pupae	3	15
	Eggs (unidentified)	3	15
	Ramellogammarus oregonensis	3	15
	Cyclopoida	2	10
	Ostracoda	2	10
	Trichoptera larvae	2	10
	Collembola	1	5
	Diptera larvae	1	5
	Nemertea	1	5
	Subtotal:	430	2,150
1 Jun 94			
9 m	No. samples processed:	4	
	Oligochaeta	1,025	5,125
	Chironomidae larvae	321	1,605
	Nematoda	45	225
	Harpacticoida	41	205
	Ostracoda	8	40
	Turbellaria	5	25
	Prostigmata (water mites)	2	10
	Bivalvia	1	5
	Calanoida	1	5
	Subtotal:	1,449	7,245
1 Jun 94			
18 m	No. samples processed:	4	
	Oligochaeta	668	3,340
	Chironomidae larvae	179	895
	Nematoda	18	90
	Nemertea	17	85
	Cyclopoida	4	20
	Harpacticoida	4	20
	Cladocera	3	15
	Turbellaria	3	15
	Chironomidae pupae	1	5
	Ostracoda	1	5
	Prostigmata (water mites)	1	5
	Subtotal:	899	4,495
	Subtotal all depths for this sampling area and date period:	2,778	4,630
29 Jun 94			
3 m	No. samples processed:	4	
	Oligochaeta	387	1,935

Appendix Table C1. Continued.

Sampling area Date Depth (m)	Taxon/category	Total number	Density (no./m²)
26 Oct 94			
18 m	No. samples processed:	4	
	Oligochaeta	1,038	5,190
	Chironomidae larvae	123	615
	Homoptera adult	4	20
	Cyclopoida	2	10
	Bivalvia	1	5
	Harpacticoida	1	5
	Nematoda	1	5
	Subtotal:	1,170	5,850
	Subtotal all depths for this sampling area and date period:	2,747	4,578
30 Nov 94			
3 m	No. samples processed:	4	
	Oligochaeta	828	4,140
	Chironomidae larvae	265	1,325
	Bivalvia	178	890
	Copepoda	59	295
	Prostigmata (water mites)	54	270
	Cyclopoida	10	50
	Psychomyiidae larvae	8	40
	Caenis spp.	6	30
	Ostracoda	5	25
	Ephemeroptera nymph	3	15
	Nematoda	3	15
	Gastropoda	1	5
	Subtotal:	1,420	7,100
30 Nov 94			
9 m	No. samples processed:	4	
	Oligochaeta	1,308	6,540
	Chironomidae larvae	242	1,210
	Bivalvia	49	245
	Copepoda	20	100
	Ostracoda	6	30
	Ephemeroptera nymph	2	10
	Nematoda	2	10
	Prostigmata (water mites)	2	10
	Cladocera	1	5
	Hirudinea	1	5
	Subtotal:	1,633	8,165
30 Nov 94			
18 m	No. samples processed:	4	
	Oligochaeta	1,549	7,745
	Chironomidae larvae	353	1,765
	Copepoda	7	35
	Ostracoda	7	35
	Bivalvia	3	15
	Ephemeroptera nymph	2	10
	Subtotal:	1,921	9,605
	Subtotal all depths for this sampling area and date period:	4,974	8,290
18 Jan 95			
3 m	No. samples processed:	4	
	Oligochaeta	971	4,855
	Chironomidae larvae	168	840
	Bivalvia	21	105
	Prostigmata (water mites)	8	40
	Ostracoda	6	30
	Nematoda	5	25
	Cyclopoida	4	20
	Corophium spp.	1	5
	Ephemeroptera nymph	1	5
	Psocoptera	1	5
	Subtotal:	1,186	5,930
18 Jan 95			
9 m	No. samples processed:	4	
	Oligochaeta	871	4,355
	Chironomidae larvae	144	720
	Bivalvia	8	40
	Prostigmata (water mites)	5	25
	Nematoda	4	20
	Corophium spp.	2	10
	Ostracoda	2	10
	Calanoida	1	5
	Cyclopoida	1	5
	Subtotal:	1,038	5,190
18 Jan 95			
18 m	No. samples processed:	4	
	Oligochaeta	2,204	11,020
	Chironomidae larvae	310	1,550
	Cyclopoida	2	10
	Nematoda	2	10
	Ostracoda	2	10
	Subtotal:	2,520	12,600
	Subtotal all depths for this sampling area and date period:	4,744	7,907
22 Mar 95			
3 m	No. samples processed:	4	
	Oligochaeta	429	2,145
	Chironomidae larvae	132	660
	Bivalvia	70	350
	Prostigmata (water mites)	19	95
	Ephemeroptera nymph	15	75
	Ostracoda	11	55
	Cyclopoida	5	25
	Nemertea	2	10
	Nematoda	1	5
	Trichoptera larvae	1	5

Appendix Table C1. Continued.

Sampling area / Date / Depth (m)	Taxon/category	Total number	Density (no./m²)
	Turbellaria	1	5
	Subtotal:	686	3,430
22 Mar 95			
9 m	No. samples processed:	4	
	Oligochaeta	825	4,125
	Chironomidae larvae	123	615
	Nematoda	31	155
	Nemertea	7	35
	Prostigmata (water mites)	3	15
	Cyclopoida	2	10
	Ostracoda	2	10
	Bivalvia	1	5
	Corophium spp.	1	5
	Subtotal:	995	4,975
22 Mar 95			
18 m	No. samples processed:	4	
	Oligochaeta	1,648	8,240
	Chironomidae larvae	218	1,090
	Nematoda	7	35
	Turbellaria	2	10
	Cyclopoida	1	5
	Subtotal:	1,876	9,380
	Subtotal all depths for this sampling area and date period:	3,557	5,928
26 Apr 95			
3 m	No. samples processed:	4	
	Oligochaeta	824	4,120
	Chironomidae larvae	225	1,125
	Bivalvia	177	885
	Prostigmata (water mites)	21	105
	Ostracoda	12	60
	Ephemeroptera nymph	10	50
	Nemertea	8	40
	Nematoda	3	15
	Copepoda	2	10
	Trichoptera larvae	2	10
	Araneae (spiders)	1	5
	Chironomidae pupae	1	5
	Collembola	1	5
	Cyclopoida	1	5
	Polychaeta	1	5
	Subtotal:	1,289	6,445
26 Apr 95			
9 m	No. samples processed:	4	
	Oligochaeta	2,068	10,340
	Chironomidae larvae	244	1,220
	Harpacticoida	71	355
	Nematoda	42	210
	Cyclopoida	18	90
	Nemertea	11	55
	Ostracoda	10	50
	Prostigmata (water mites)	5	25
	Turbellaria	5	25
	Bivalvia	2	10
	Ephemeroptera nymph	1	5
	Trichoptera larvae	1	5
	Subtotal:	2,478	12,390
26 Apr 95			
18 m	No. samples processed:	4	
	Oligochaeta	2,692	13,460
	Chironomidae larvae	243	1,215
	Ostracoda	34	170
	Cyclopoida	18	90
	Nematoda	9	45
	Prostigmata (water mites)	3	15
	Turbellaria	3	15
	Harpacticoida	2	10
	Ephemeroptera nymph	1	5
	Nemertea	1	5
	Subtotal:	3,006	15,030
	Subtotal all depths for this sampling area and date period:	6,773	11,288
24 May 95			
3 m	No. samples processed:	4	
	Oligochaeta	1,206	6,030
	Chironomidae larvae	122	610
	Bivalvia	118	590
	Harpacticoida	21	105
	Nematoda	20	100
	Nemertea	12	60
	Chironomidae pupae	6	30
	Cyclopoida	5	25
	Ostracoda	5	25
	Prostigmata (water mites)	5	25
	Ephemeroptera nymph	4	20
	Corophium spp.	2	10
	Trichoptera larvae	2	10
	Subtotal:	1,528	7,640
24 May 95			
9 m	No. samples processed:	4	
	Oligochaeta	2,290	11,450
	Chironomidae larvae	293	1,465
	Nematoda	95	475
	Harpacticoida	59	295
	Copepoda	19	95
	Nemertea	14	70
	Ostracoda	5	25
	Prostigmata (water mites)	4	20

Appendix Table C1. Continued.

Sampling area / Date / Depth (m)	Taxon/category	Total number	Density (no./m²)
19 Jul 95			
18 m	No. samples processed:	4	
	Oligochaeta	1,131	5,655
	Chironomidae larvae	291	1,455
	Nematoda	4	20
	Ostracoda	4	20
	Bivalvia	3	15
	Copepoda	3	15
	Nemertea	1	5
	Prostigmata (water mites)	1	5
	Subtotal:	1,438	7,190
	Subtotal all depths for this sampling area and date period:	4,203	7,005
16 Aug 95			
3 m	No. samples processed:	4	
	Oligochaeta	882	4,410
	Chironomidae larvae	179	895
	Bivalvia	36	180
	Harpacticoida	10	50
	Ostracoda	10	50
	Nematoda	5	25
	Prostigmata (water mites)	5	25
	Chironomidae pupae	3	15
	Cyclopoida	3	15
	Polychaeta	1	5
	Subtotal:	1,134	5,670
16 Aug 95			
9 m	No. samples processed:	4	
	Oligochaeta	2,435	12,175
	Chironomidae larvae	188	940
	Nematoda	6	30
	Ostracoda	5	25
	Harpacticoida	3	15
	Nemertea	3	15
	Copepoda	2	10
	Cyclopoida	2	10
	Hirudinea	2	10
	Bivalvia	1	5
	Chironomidae pupae	1	5
	Plecoptera nymph	1	5
	Subtotal:	2,649	13,245
16 Aug 95			
18 m	No. samples processed:	4	
	Oligochaeta	788	3,940
	Chironomidae larvae	32	160
	Nematoda	4	20
	Nemertea	2	10
	Corophium spp.	1	5
	Ostracoda	1	5
	Subtotal:	828	4,140
	Subtotal all depths for this sampling area and date period:	4,611	7,685
13 Sep 95			
3 m	No. samples processed:	4	
	Oligochaeta	442	2,210
	Bivalvia	72	360
	Chironomidae larvae	32	160
	Ostracoda	8	40
	Prostigmata (water mites)	5	25
	Collembola	2	10
	Corophium spinicorne	2	10
	Chironomidae pupae	1	5
	Copepoda	1	5
	Diptera adult	1	5
	Ephemeroptera nymph	1	5
	Nematoda	1	5
	Subtotal:	568	2,840
13 Sep 95			
9 m	No. samples processed:	4	
	Oligochaeta	1,031	5,155
	Chironomidae larvae	15	75
	Cyclopoida	3	15
	Bivalvia	2	10
	Copepoda	2	10
	Ostracoda	2	10
	Harpacticoida	1	5
	Nematoda	1	5
	Subtotal:	1,057	5,285
13 Sep 95			
18 m	No. samples processed:	4	
	Oligochaeta	394	1,970
	Chironomidae larvae	4	20
	Collembola	2	10
	Nemertea	1	5
	Ostracoda	1	5
	Subtotal:	402	2,010
	Subtotal all depths for this sampling area and date period:	2,027	3,378
11 Oct 95			
3 m	No. samples processed:	4	
	Oligochaeta	515	2,575
	Bivalvia	28	140
	Chironomidae larvae	13	65
	Ephemeroptera nymph	5	25
	Ostracoda	2	10
	Chironomidae pupae	1	5
	Subtotal:	564	2,820
11 Oct 95			
9 m	No. samples processed:	4	

Appendix Table C1. Continued.

Sampling area / Date / Depth (m)	Taxon/category	Total number	Density (no./m²)
	Eggs (unidentified)	1	5
	Ephemeroptera nymph	1	5
	Subtotal:	328	1,640
4 May 94 / 18 m	No. samples processed:	4	
	Oligochaeta	530	2,650
	Chironomidae larvae	83	415
	Bivalvia	63	315
	Eggs (unidentified)	16	80
	Cyclopoida	8	40
	Nemertea	8	40
	Nematoda	2	10
	Chironomidae pupae	1	5
	Ostracoda	1	5
	Prostigmata (water mites)	1	5
	Subtotal:	713	3,565
	Subtotal all depths for this sampling area and date period:	1,327	2,212
1 Jun 94 / 3 m	No. samples processed:	4	
	Oligochaeta	247	1,235
	Chironomidae larvae	187	935
	Bivalvia	84	420
	Nematoda	40	200
	Ephemeroptera nymph	17	85
	Harpacticoida	13	65
	Chironomidae pupae	12	60
	Prostigmata (water mites)	10	50
	Cyclopoida	4	20
	Ceratopogonidae larvae	2	10
	Collembola	1	5
	Hexagenia spp.	1	5
	Ostracoda	1	5
	Ramellogammarus ramellus	1	5
	Subtotal:	620	3,100
1 Jun 94 / 9 m	No. samples processed:	4	
	Oligochaeta	71	355
	Chironomidae larvae	53	265
	Bivalvia	14	70
	Nematoda	6	30
	Cyclopoida	4	20
	Copepoda	2	10
	Diptera pupae	2	10
	Eggs (unidentified)	2	10
	Ephemeroptera nymph	2	10
	Nemertea	2	10
	Prostigmata (water mites)	2	10
	Chironomidae pupae	1	5
	Ostracoda	1	5
	Subtotal:	162	810
1 Jun 94 / 18 m	No. samples processed:	4	
	Oligochaeta	204	1,020
	Chironomidae larvae	95	475
	Eggs (unidentified)	24	120
	Bivalvia	8	40
	Prostigmata (water mites)	4	20
	Nematoda	2	10
	Ephemeroptera nymph	1	5
	Nemertea	1	5
	Subtotal:	339	1,695
	Subtotal all depths for this sampling area and date period:	1,121	1,868
29 Jun 94 / 3 m	No. samples processed:	4	
	Oligochaeta	556	2,780
	Chironomidae larvae	371	1,855
	Bivalvia	156	780
	Chironomidae pupae	33	165
	Cladocera	22	110
	Copepoda	19	95
	Eggs (unidentified)	19	95
	Ephemeroptera nymph	17	85
	Prostigmata (water mites)	10	50
	Cyclopoida	8	40
	Hexagenia spp.	5	25
	Isopoda	2	10
	Nematoda	2	10
	Orthocladiinae pupae	2	10
	Trichoptera larvae	2	10
	Araneae (spiders)	1	5
	Ceratopogonidae larvae	1	5
	Chironominae pupae	1	5
	Diptera adult	1	5
	Harpacticoida	1	5
	Nemertea	1	5
	Ostracoda	1	5
	Polychaeta	1	5
	Ramellogammarus ramellus	1	5
	Subtotal:	1,233	6,165
29 Jun 94 / 9 m	No. samples processed:	4	
	Oligochaeta	270	1,350
	Chironomidae larvae	104	520
	Cladocera	26	130
	Eggs (unidentified)	22	110
	Bivalvia	17	85

Appendix Table C1. Continued.

Sampling area / Date / Depth (m)	Taxon/category	Total number	Density (no./m²)
	Cyclopoida	16	80
	Ostracoda	11	55
	Nematoda	9	45
	Hexagenia spp.	4	20
	Leptodora kindtii	4	20
	Prostigmata (water mites)	3	15
	Ephemeroptera nymph	2	10
	Chironomidae pupae	1	5
	Corophium salmonis	1	5
	Nemertea	1	5
	Sialis spp.	1	5
	Subtotal:	432	2,160
24 Aug 94			
18 m	No. samples processed:	4	
	Chironomidae larvae	458	2,290
	Oligochaeta	400	2,000
	Cladocera	66	330
	Ostracoda	46	230
	Bivalvia	24	120
	Cyclopoida	17	85
	Copepoda	13	65
	Leptodora kindtii	5	25
	Nematoda	5	25
	Chironomidae adult	1	5
	Chironomidae pupae	1	5
	Corophium spinicorne	1	5
	Hirudinea	1	5
	Nemertea	1	5
	Polychaeta	1	5
	Subtotal:	1,040	5,200
	Subtotal all depths for this sampling area and date period:	2,669	4,448
21 Sep 94			
3 m	No. samples processed:	4	
	Bivalvia	405	2,025
	Chironomidae larvae	292	1,460
	Ephemeroptera nymph	125	625
	Oligochaeta	108	540
	Cyclopoida	31	155
	Caenis spp.	19	95
	Prostigmata (water mites)	17	85
	Nematoda	12	60
	Calanoida	6	30
	Chironomidae pupae	5	25
	Copepoda	4	20
	Ostracoda	2	10
	Harpacticoida	1	5
	Leptophlebiidae nymph	1	5
	Trichoptera larvae	1	5
	Subtotal:	1,029	5,145
21 Sep 94			
9 m	No. samples processed:	4	
	Oligochaeta	190	950
	Bivalvia	182	910
	Cladocera	147	735
	Chironomidae larvae	112	560
	Cyclopoida	41	205
	Nematoda	26	130
	Calanoida	24	120
	Ostracoda	10	50
	Ephemeroptera nymph	9	45
	Hexagenia spp.	4	20
	Prostigmata (water mites)	4	20
	Corophium spinicorne	2	10
	Leptodora kindtii	2	10
	Corophium salmonis	1	5
	Subtotal:	754	3,770
21 Sep 94			
18 m	No. samples processed:	4	
	Oligochaeta	718	3,590
	Chironomidae larvae	311	1,555
	Cyclopoida	148	740
	Ostracoda	37	185
	Bivalvia	32	160
	Calanoida	28	140
	Nematoda	10	50
	Prostigmata (water mites)	5	25
	Chironomidae pupae	3	15
	Corophium spinicorne	3	15
	Ephemeroptera nymph	1	5
	Hirudinea	1	5
	Subtotal:	1,297	6,485
	Subtotal all depths for this sampling area and date period:	3,080	5,133
26 Oct 94			
3 m	No. samples processed:	4	
	Oligochaeta	177	885
	Chironomidae larvae	44	220
	Bivalvia	38	190
	Ephemeroptera nymph	15	75
	Cyclopoida	6	30
	Nematoda	2	10
	Prostigmata (water mites)	2	10
	Gastropoda	1	5
	Ostracoda	1	5
	Subtotal:	286	1,430
26 Oct 94			
9 m	No. samples processed:	4	

Appendix Table C1. Continued.

Sampling area Date Depth (m)	Taxon/category	Total number	Density (no./m²)
	Polychaeta	2	10
	Chironomidae pupae	1	5
	Corophium salmonis	1	5
	Turbellaria	1	5
	Subtotal:	1,208	6,040
18 Jan 95 18 m	No. samples processed:	4	
	Oligochaeta	721	3,605
	Chironomidae larvae	172	860
	Bivalvia	125	625
	Cyclopoida	107	535
	Copepoda	35	175
	Prostigmata (water mites)	24	120
	Corophium spp.	17	85
	Ostracoda	10	50
	Corophium salmonis	9	45
	Gammaridae	2	10
	Nematoda	2	10
	Hirudinea	1	5
	Nemertea	1	5
	Subtotal:	1,226	6,130
	Subtotal all depths for this sampling area and date period:	3,852	6,420
22 Mar 95 3 m	No. samples processed:	4	
	Oligochaeta	325	1,625
	Chironomidae larvae	259	1,295
	Bivalvia	106	530
	Prostigmata (water mites)	21	105
	Nematoda	15	75
	Ephemeroptera nymph	14	70
	Cyclopoida	11	55
	Trichoptera larvae	6	30
	Ostracoda	2	10
	Coleoptera larvae	1	5
	Corophium spp.	1	5
	Nemertea	1	5
	Polychaeta	1	5
	Subtotal:	763	3,815
22 Mar 95 9 m	No. samples processed:	4	
	Oligochaeta	365	1,825
	Bivalvia	121	605
	Nematoda	71	355
	Cyclopoida	47	235
	Chironomidae larvae	36	180
	Prostigmata (water mites)	12	60
	Ephemeroptera nymph	10	50
	Corophium salmonis	1	5
	Hexagenia spp.	1	5
	Ostracoda	1	5
	Trichoptera larvae	1	5
	Subtotal:	666	3,330
22 Mar 95 18 m	No. samples processed:	4	
	Oligochaeta	244	1,220
	Bivalvia	111	555
	Chironomidae larvae	25	125
	Copepoda	14	70
	Cyclopoida	13	65
	Corophium spp.	9	45
	Ostracoda	7	35
	Prostigmata (water mites)	4	20
	Chironomidae pupae	1	5
	Polychaeta	1	5
	Subtotal:	429	2,145
	Subtotal all depths for this sampling area and date period:	1,858	3,097
26 Apr 95 3 m	No. samples processed:	4	
	Oligochaeta	811	4,055
	Bivalvia	201	1,005
	Chironomidae larvae	126	630
	Corophium salmonis	123	615
	Ephemeroptera nymph	40	200
	Prostigmata (water mites)	33	165
	Nematoda	28	140
	Copepoda	8	40
	Ostracoda	7	35
	Cyclopoida	3	15
	Chironomidae pupae	2	10
	Turbellaria	2	10
	Ceratopogonidae larvae	1	5
	Corophium spp.	1	5
	Subtotal:	1,386	6,930
26 Apr 95 9 m	No. samples processed:	4	
	Oligochaeta	524	2,620
	Bivalvia	198	990
	Chironomidae larvae	102	510
	Corophium spp.	86	430
	Nematoda	32	160
	Ephemeroptera nymph	10	50
	Prostigmata (water mites)	7	35
	Copepoda	5	25
	Cyclopoida	5	25
	Ostracoda	5	25
	Polychaeta	3	15

Appendix Table C1. Continued.

Sampling area Date Depth (m)	Taxon/category	Total number	Density (no./m²)
	Subtotal all depths for this sampling area and date period:	1,787	2,978
19 Jul 95 3 m	No. samples processed:	4	
	Oligochaeta	492	2,460
	Chironomidae larvae	327	1,635
	Bivalvia	50	250
	Nematoda	25	125
	Copepoda	13	65
	Ephemeroptera nymph	12	60
	Ostracoda	6	30
	Prostigmata (water mites)	6	30
	Cyclopoida	3	15
	Chironomidae adult	1	5
	Chironomidae pupae	1	5
	Hirudinea	1	5
	Homoptera adult	1	5
	Polychaeta	1	5
	Thysanoptera adult	1	5
	Subtotal:	940	4,700
19 Jul 95 9 m	No. samples processed:	4	
	Oligochaeta	419	2,095
	Chironomidae larvae	199	995
	Bivalvia	46	230
	Nematoda	22	110
	Cyclopoida	13	65
	Copepoda	8	40
	Homoptera adult	8	40
	Ephemeroptera nymph	7	35
	Prostigmata (water mites)	4	20
	Trichoptera larvae	3	15
	Corophium salmonis	2	10
	Ostracoda	2	10
	Polychaeta	1	5
	Subtotal:	734	3,670
19 Jul 95 18 m	No. samples processed:	4	
	Oligochaeta	685	3,425
	Chironomidae larvae	74	370
	Homoptera adult	24	120
	Corophium salmonis	8	40
	Bivalvia	5	25
	Chironomidae adult	4	20
	Hemiptera	4	20
	Nematoda	4	20
	Chironomidae pupae	2	10
	Coleoptera adult	2	10
	Diptera adult	2	10
	Thysanoptera adult	2	10
	Cyclopoida	1	5
	Harpacticoida	1	5
	Ostracoda	1	5
	Trichoptera adult	1	5
	Subtotal:	820	4,100
	Subtotal all depths for this sampling area and date period:	2,494	4,157
16 Aug 95 3 m	No. samples processed:	4	
	Oligochaeta	94	470
	Chironomidae larvae	78	390
	Copepoda	14	70
	Bivalvia	7	35
	Ostracoda	3	15
	Corophium spp.	2	10
	Cyclopoida	2	10
	Nematoda	2	10
	Subtotal:	202	1,010
16 Aug 95 9 m	No. samples processed:	4	
	Oligochaeta	817	4,085
	Chironomidae larvae	242	1,210
	Cyclopoida	17	85
	Bivalvia	9	45
	Ephemeroptera nymph	3	15
	Nematoda	3	15
	Ostracoda	3	15
	Corophium spp.	2	10
	Chironomidae pupae	1	5
	Copepoda	1	5
	Polychaeta	1	5
	Prostigmata (water mites)	1	5
	Subtotal:	1,100	5,500
16 Aug 95 18 m	No. samples processed:	4	
	Oligochaeta	1,424	7,120
	Chironomidae larvae	157	785
	Copepoda	45	225
	Turbellaria	3	15
	Nematoda	2	10
	Chironomidae pupae	1	5
	Subtotal:	1,632	8,160
	Subtotal all depths for this sampling area and date period:	2,934	4,890
13 Sep 95 3 m	No. samples processed:	4	
	Oligochaeta	157	785
	Chironomidae larvae	49	245

Appendix Table C1. Continued.

Sampling area Date Depth (m)	Taxon/category	Total number	Density (no./m^2)	Sampling area Date Depth (m)	Taxon/category	Total number	Density (no./m^2)
Grand total all sampling areas, dates, depths:		253,045					
Total samples processed (all sampling areas):		647					

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Appendix D

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Benthic Invertebrates–limnology studies

Processor name: ____________________

Process Date (dd/mm/yy): ____________

Process Time (Hrs.): ________________

Collection information

Reservoir: ____________________

Date: ____________________

Site: ____________________

Replicate no.: ____________________

ID code: ____________________

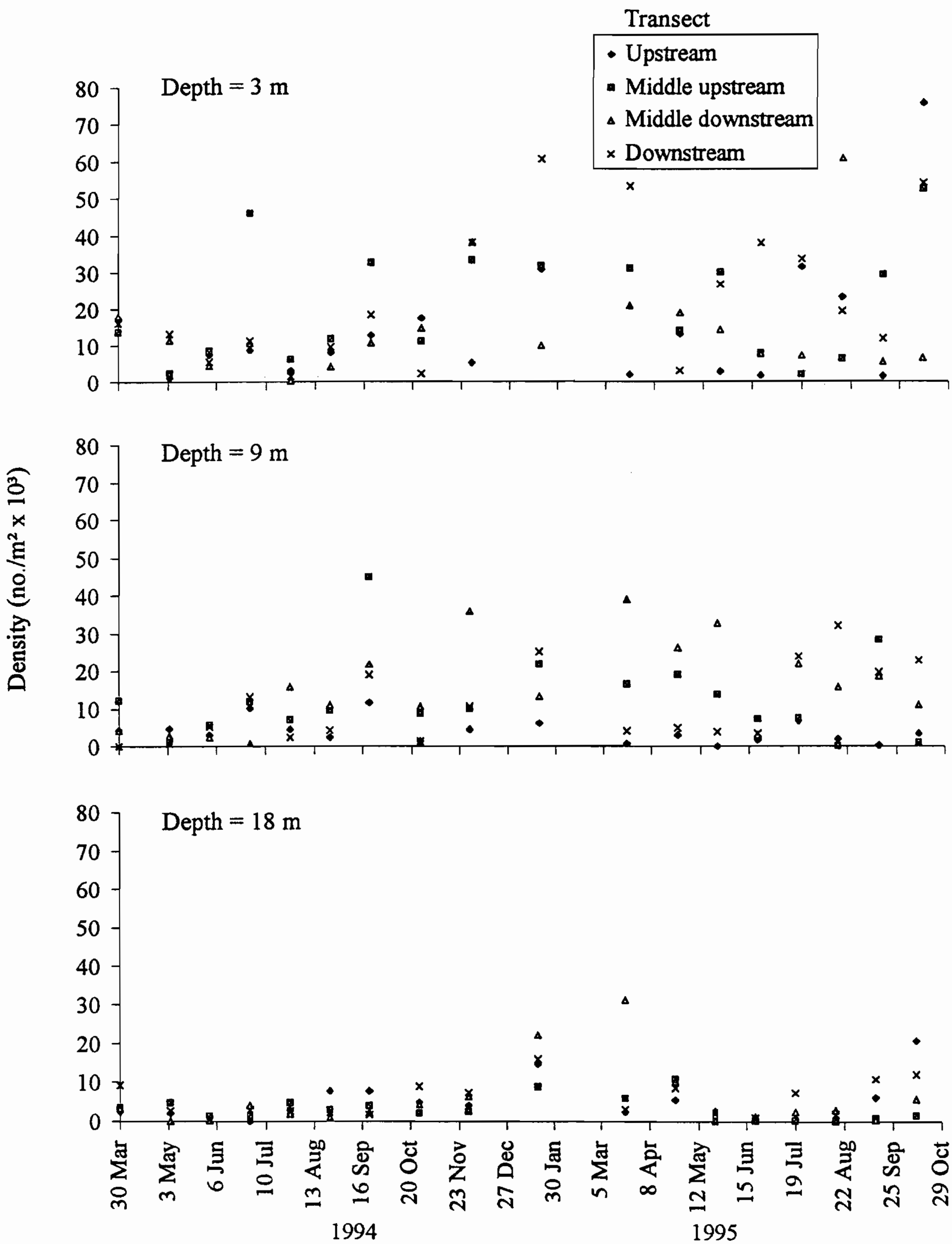
Depth (m): ____________________

Log ID (from tblWorkLog): ____________

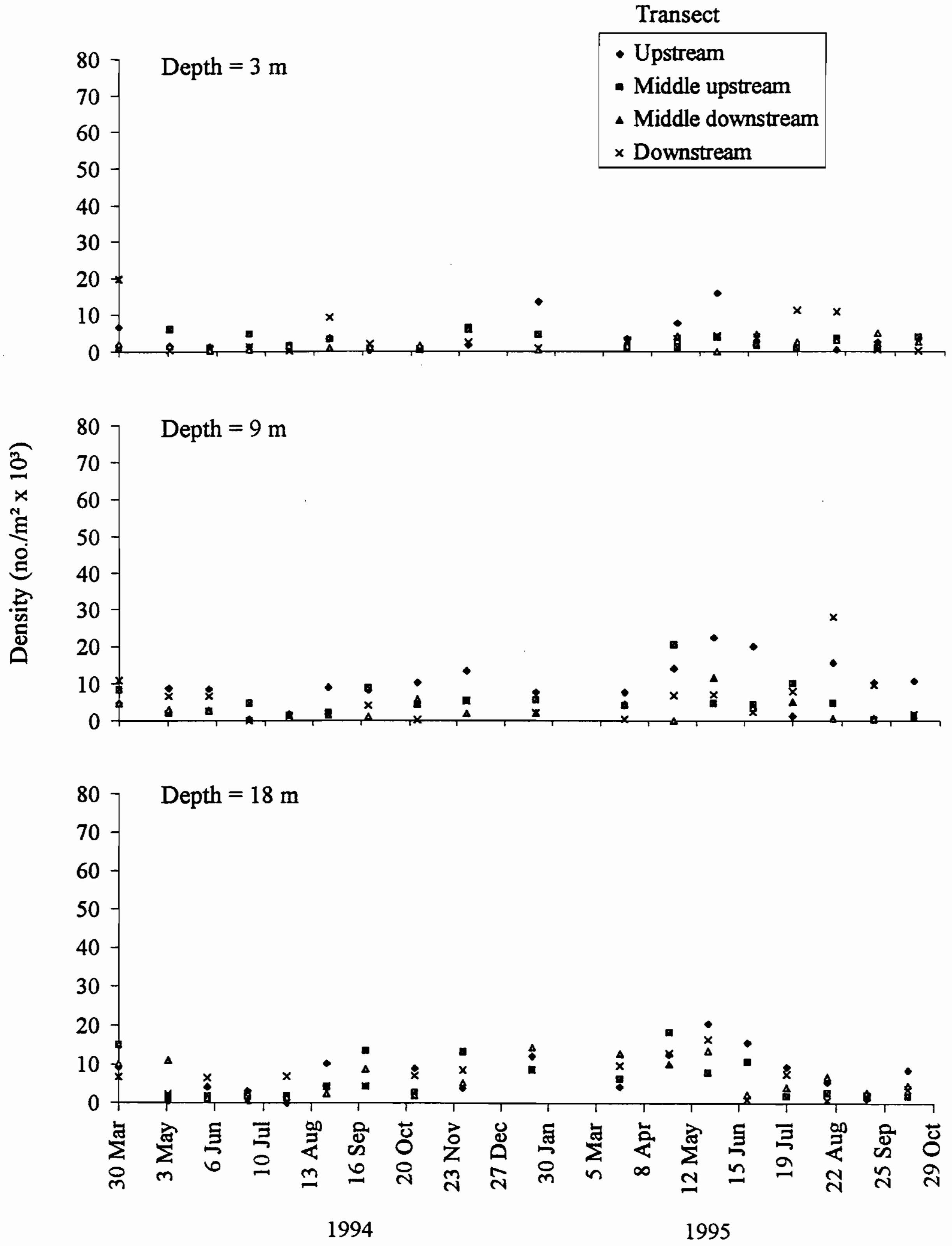
Comments

Number	Name of organism

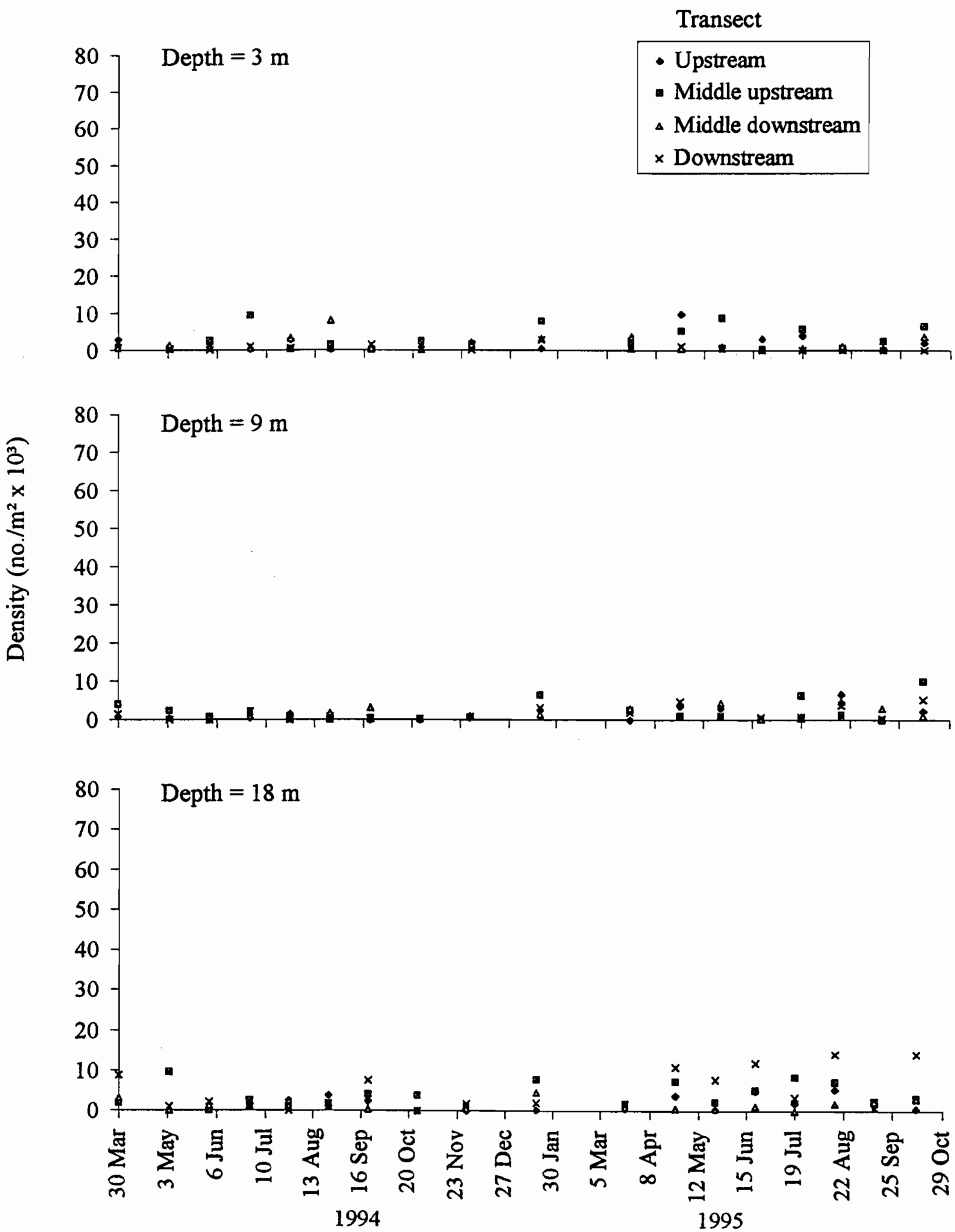
Appendix Figure D1. Data analysis sheet used to record organisms recovered from a benthic invertebrate sample.



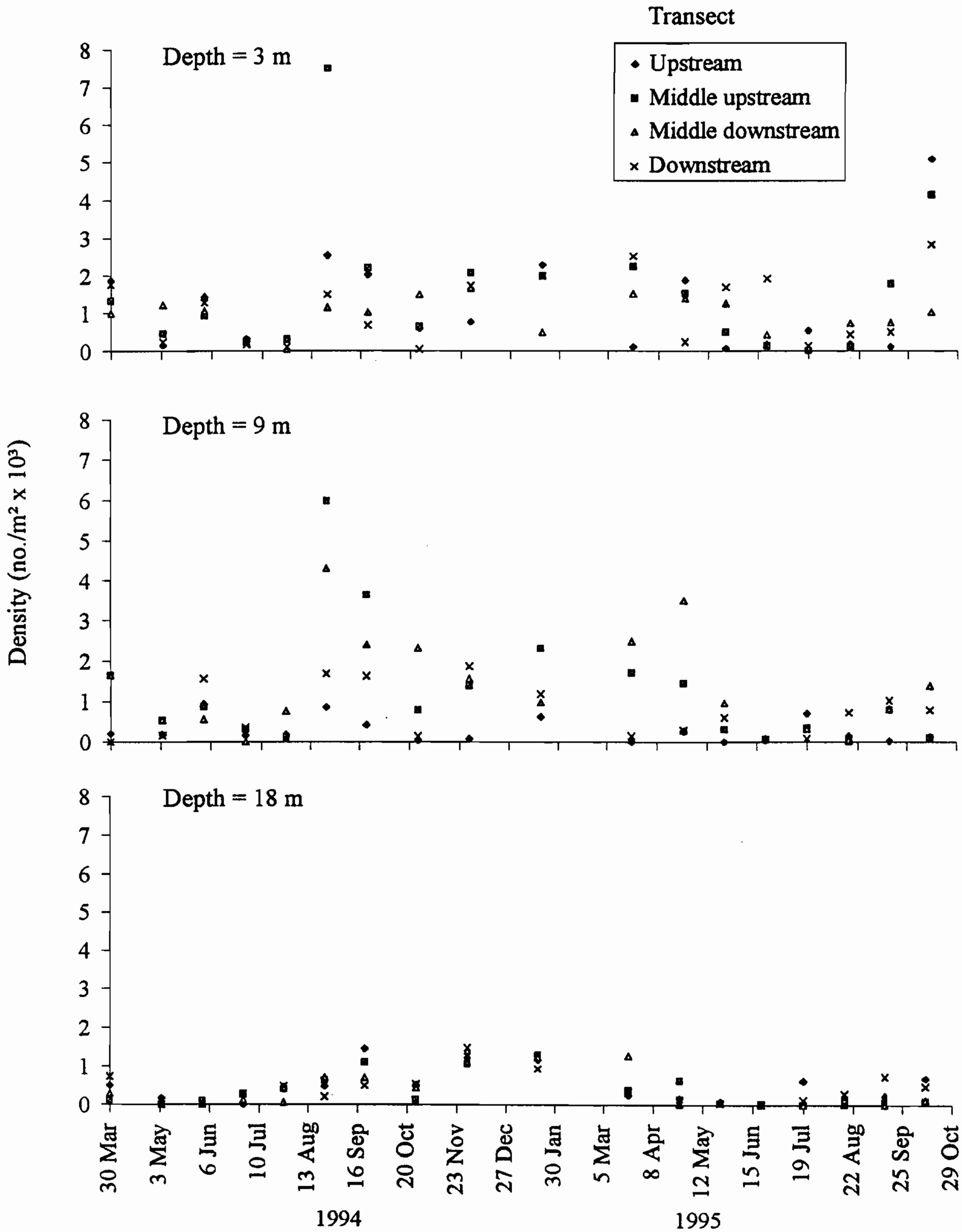
Appendix Figure D2. Spatial distribution of Oligochaeta on each transect by depth at Silcott Island in Lower Granite Reservoir.



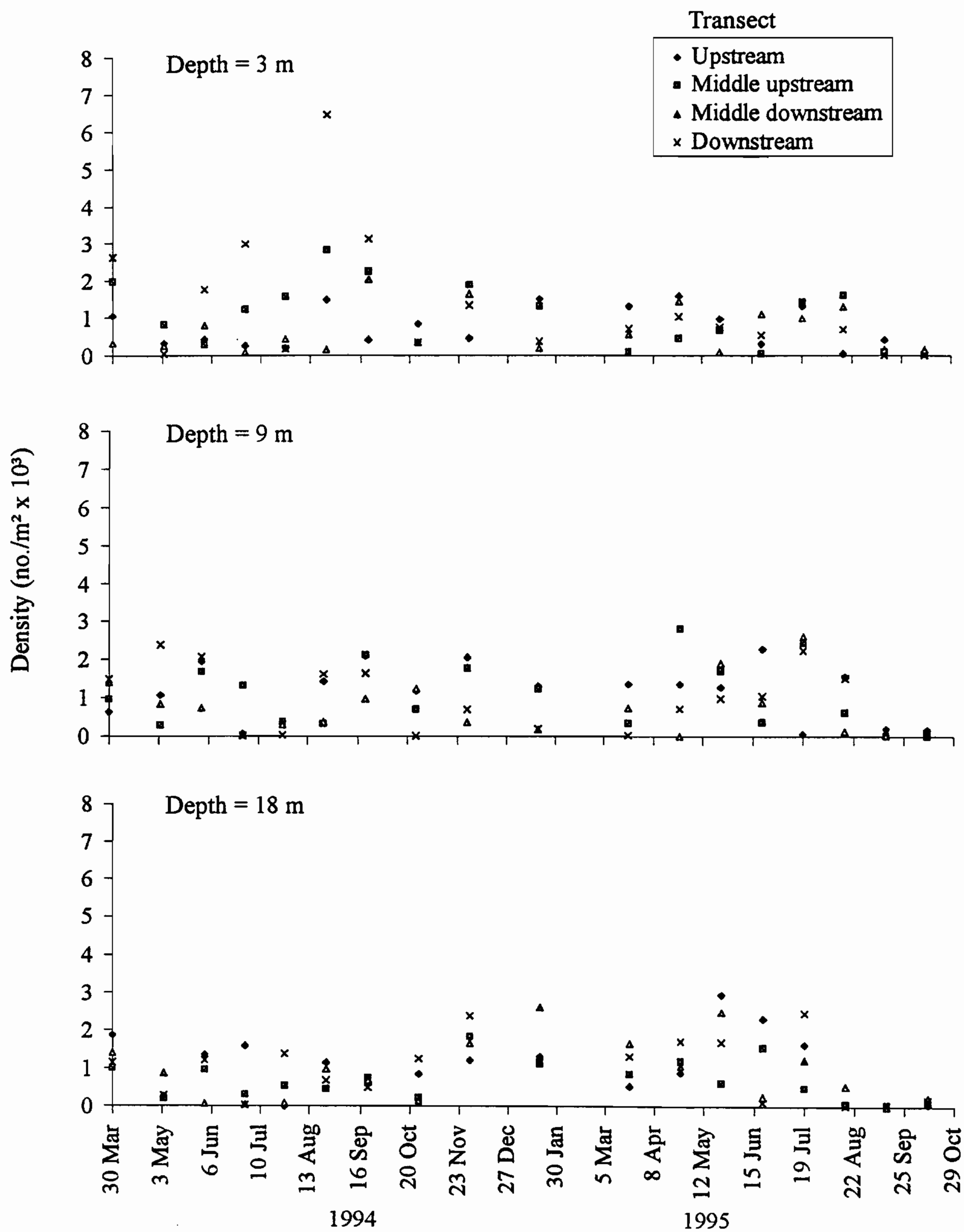
Appendix Figure D3. Spatial distribution of Oligochaeta on each transect by depth at Centennial Island in Lower Granite Reservoir.



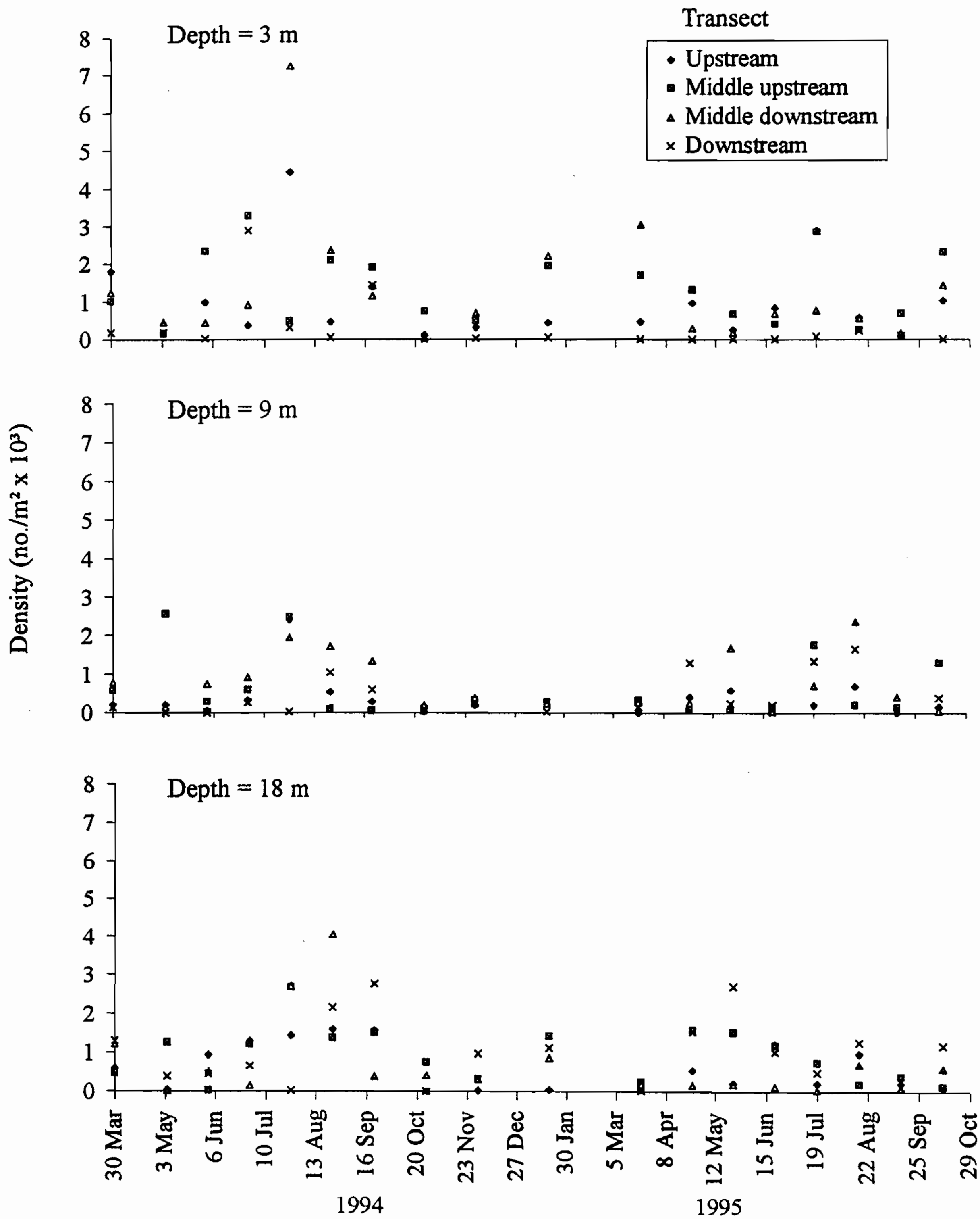
Appendix Figure D4. Spatial distribution of Oligochaeta on each transect by depth at Offield in Lower Granite Reservoir.



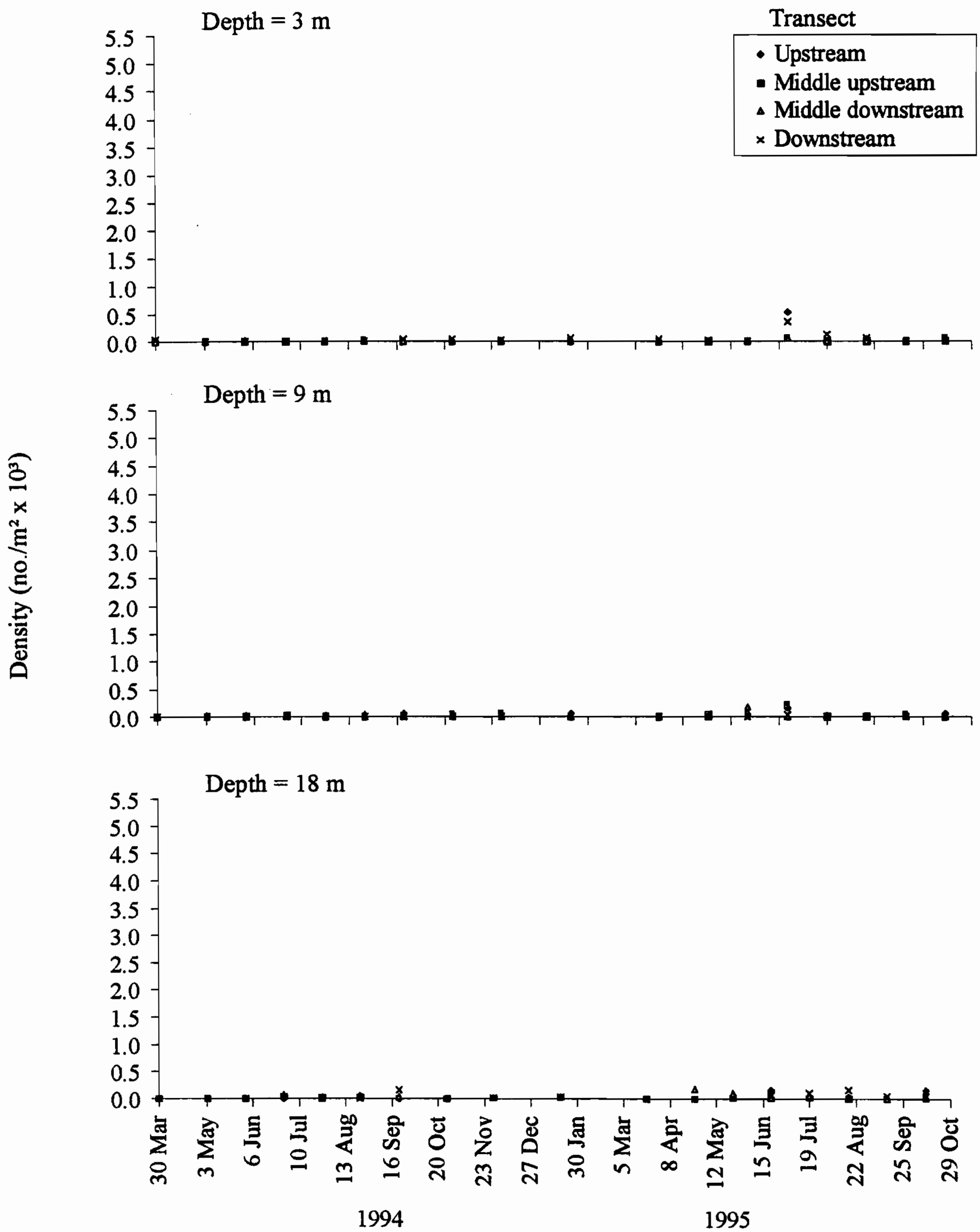
Appendix Figure D5. Spatial distribution of Chironomidae larvae on each transect by depth at Silcott Island in Lower Granite Reservoir.



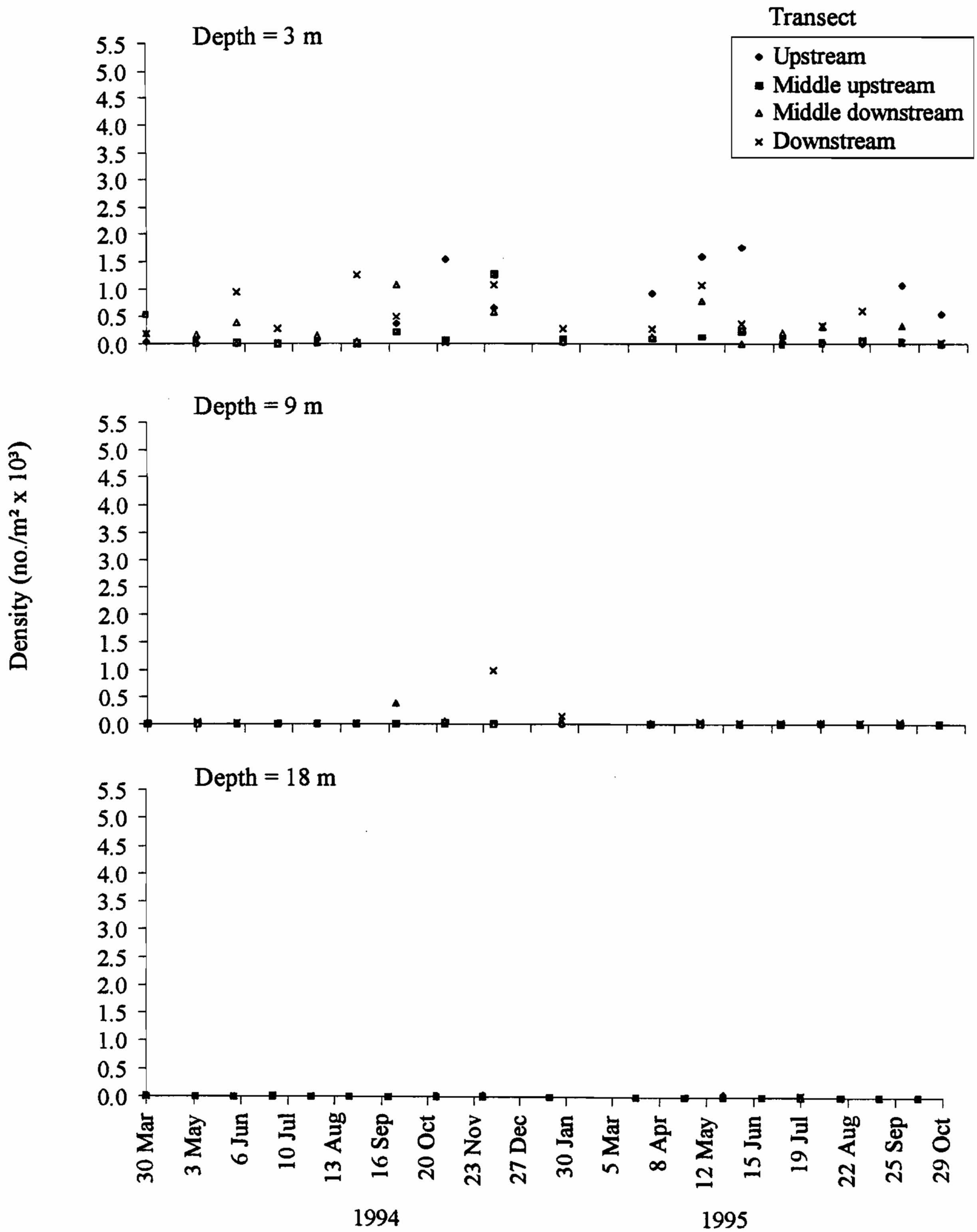
Appendix Figure D6. Spatial distribution of Chironomidae larvae on each transect by depth at Centennial Island in Lower Granite Reservoir.



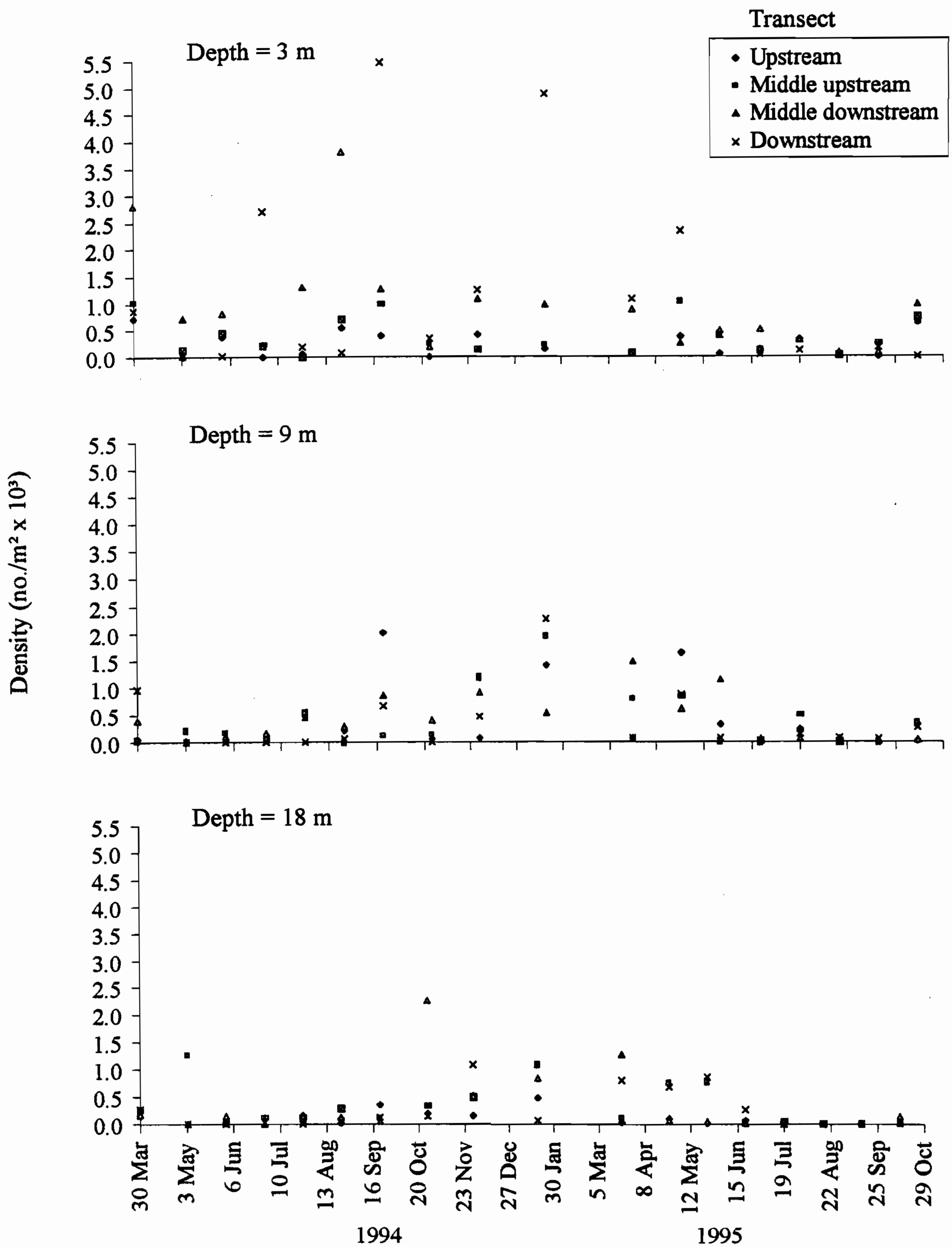
Appendix Figure D7. Spatial distribution of Chironomidae larvae on each transect by depth at Offield in Lower Granite Reservoir.



Appendix Figure D8. Spatial distribution of Bivalvia on each transect by depth at Silcott Island in Lower Granite Reservoir.



Appendix Figure D9. Spatial distribution of Bivalvia on each transect by depth at Centennial Island in Lower Granite Reservoir.



Appendix Figure D10. Spatial distribution of Bivalvia on each transect by depth at Offield in Lower Granite Reservoir.