AN ABSTRACT OF THE THESIS OF

Robert Mason Hughes for the degree of Doctor of Philosophy

in Fisheries and Wildlife presented on April 23, 1979.

Title: Temperature, Interspecific Competition, and the Production of Juvenile Salmonids in Experimental Stream Communities.

Abstract approved: Redacted for privacy

Charles E. Warren

The objectives of this research were to learn how moderate temperature elevation together with interspecific competition may affect the production of juvenile salmonids and the biomasses and diversity of aquatic macroinvertebrates.

The effects of a 4°C temperature elevation were examined in two outdoor experimental stream communities for one year with only steelhead trout (*Salmo gairdneri*, Richardson) present and for one year with steelhead and coho salmon (*Oncorhynchus kisutch*, Walbaum) present. Temperatures were allowed to fluctuate dielly and seasonally. Both streams received identical amounts of unfiltered creek water that contained sediments and stream organisms and both streams contained resident macroinvertebrate communities. Midsummer insolation was about 25 percent greater and autumn leaf fall was about 150 percent greater in the treatment stream than in the control stream.

The salmonids were introduced as embryos immediately after fertilization and were retained for one year. Their numbers and individual biomasses were measured every three weeks and their behavior was observed weekly for seven months. Resident macroinvertebrate taxa, numbers, and biomasses were also obtained every three weeks by riffle,

pool, and drift samples. Macroinvertebrate emergence was sampled twice a week for one year and aufwuchs production and respiration were measured seasonally.

Lower production, biomass, and survival of the treatment salmonids resulted from the higher maintenance requirements of treatment fish coupled with lower biomasses of salmonid prey, especially during the late summer. Cumulative production of the control steelhead was 30 percent greater than that of the treatment fish when coho were absent and 13 percent greater with coho present. Control coho had 100 percent more cumulative production than the treatment coho. Final biomasses of the treatment steelhead were 80 percent of the control steelhead biomasses when coho were absent and 50 percent of the control steelhead biomasses when coho were present. The final biomass of the treatment coho was 30 percent of that of the control coho. The numbers of treatment steelhead were 18 percent fewer than the control steelhead when coho were absent and 65 percent fewer than the control steelhead when coho were present. Treatment coho were 69 percent fewer than control coho.

Steelhead production, final biomass, and survival averaged respectively 50, 31, and 28 percent less when coho were present than when coho were absent, presumably because the coho dominated most of the pool space and consumed many of the drifting invertebrates that otherwise would have been available to the steelhead. Salmonid habitat segregation, as determined by a canonical analysis of discriminance, was reduced in the treatment stream by a shift from a midwater position towards a benthic position by the coho. This probably resulted in closer competition for prey and space between the two treatment species than between the control coho and steelhead.

The highly variable biomasses of the salmonid's prey, chiefly chironomids, ephemeropterans, and ostracods, generally were half as great in the treatment stream as in the control stream. Invertebrate drift was similar and insect emergence was greater in the treatment stream compared to the control stream. These differences are believed to have resulted from direct temperature effects on metabolic rates and life histories of invertebrates, and indirectly from greater biomasses of an aquatic moss and lower biomasses of an aquatic snail in the control stream than in the treatment stream. The snails comprised most of the macroinvertebrate biomass in the riffles and pools of both streams, which resulted in higher total macroinvertebrate biomass in the treatment stream than in the control stream. Macroinvertebrate diversity and the biomass of macroinvertebrates other than the snail were higher in the control riffles than in the treatment riffles.

TEMPERATURE, INTERSPECIFIC COMPETITION, AND THE PRODUCTION OF JUVENILE SALMONIDS IN EXPERIMENTAL STREAM COMMUNITIES

by

Robert Mason Hughes

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Commencement June 1979

APPROVED:

Redacted for privacy

Professor of Fisheries in charge of major

Redacted for privacy

Head of Department of Fisheries and Wildlife

Redacted for privacy

Dean of Graduate School

Date thesis is presented April 23, 1979.

Typed by Nancy Lanpheare for Robert Mason Hughes

ACKNOWLEDGEMENTS

Dr. Gerald E. Davis suggested the research and was readily available for discussion and advice. Dr. Charles E. Warren contributed considerable time and thinking during the preparation of the manuscript. Dr. Norman H. Anderson aided in macroinvertebrate identification and reviewed the first draft of the manuscript. Dr. C. David McIntire helped with the multivariate analysis methods and computer programs. Other committee members who critically reviewed and commented on the manuscript included Drs. James D. Hall, John H. Lyford, Jr., and Michael Newton. Dr. Robert J. Naiman assisted with the primary production and community respiration apparatus and analysis. The Oak Creek Laboratory students and staff, especially Wayne Seim and Dr. William J. Liss, provided many useful suggestions and maintained the streams during my occasional absences. Barbara M. Buckley did two analyses of bacteria and Rick Snow spent many willing hours censusing fish and sampling emergent insects. My equipment and salary were funded by the United States Office of Water Research and Technology, Research Grant B-041-ORE. The Oregon State University Computer Center provided a grant for computer time. My parents always encouraged my study even during a difficult period of their lives. My wife, Mary, gave freely of her time, patience, encouragement, and career.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

Appendix | Page

TEMPERATURE, INTERSPECIFIC COMPETITION, AND THE PRODUCTION OF JUVENILE SALMONIDS IN EXPERIMENTAL STREAM COMMUNITIES

INTRODUCTION

Although many of the earth's inland waters may be slowly warming as a result of vegetation removal, irrigation, warm water discharges from power plants, and municipal and industrial effluents (Wagner, 1971), the effects of temperature elevation on the behavior and production of aquatic organisms remain poorly understood. Extensive research has been done on the impacts of temperature increases on fish, as indicated by the 651 page bibliography of Raney, Menzel, and Weller (1974) and a research review of thermal effects by Coutant and Pfuderer (1974). Temperature elevation has both direct and indirect effects on fish. The direct effects include changes in the behavior, metabolism, growth, survival, and reproduction. Indirect effects relate to changes in community structure, that is, in a population's prey, competitors, predators, parasites, and diseases.

Experimental streams were used to investigate these direct and indirect effects of moderate temperature elevation on juvenile steelhead trout in the presence and absence of coho salmon. The objective of this research was not to prove the effects of temperature elevation or competition on aquatic organisms. Instead it was hoped that this research would provide increased understanding of the general processes by which temperature elevation and interspecific competition might affect the productivity of natural streams for populations of interest.

Surveys examining the effects of thermal elevation on natural aquatic communities provide inconclusive evidence of changes in community structure or species abundance. For example, Patrick, Cairns, and Roback (1967) and Cairns and Kaesler (1971) found insignificant temporal and spatial changes in river biota as a result of power plant effluents. Conversely, Richards (1976) and Spence and Hynes (1971) felt that devegetation and river impoundments, respectively, altered temperatures enough to eliminate some riverine fish species. Smith (1972) associated change in Great Lakes fish species with similar alterations in Great Lakes tributaries. Studies of the effects of temperature changes on macroinvertebrates in natural streams have shown marked alterations of the fauna (Tarzwell, 1939; Armitage, 1961; Coutant, 1962). But in each case the changes were also associated with flow interruption, increased pH, or large temperature changes of 12 to 18°C. Evidently, temperature elevation creates different effects in different streams and temporal and spatial variability make subtle perturbations of natural aquatic communities difficult to recognize.

The effects of increased temperature at the organism level are more clearly established. In poilkilothermic organisms, temperature elevation tends to increase metabolic rates until near-lethal temperatures are reached (Prosser, 1973). Brett, Shelbourn, and Shoop (1969) and Brett (1971) found that the maximum growth of young sockeye salmon was at 15°C when the fish were fed to repletion, but when fed rations slightly above the maintenance level maximum growth occurred at 5°C. They suggested that, for fish on limited rations, reduced temperatures decreased maintenance costs and thus allowed for increased growth. Similarly, Elliott (1975) found that the maximum growth of brown trout on a near maintenance ration occurred at a temperature of 4°C, while maximum growth of trout on maximum rations occurred at 13°C. Elliott also found that a 50 gram trout on a 250 mg/day ration would not grow at 14.5°C, but at 8.5°C it had a growth rate of 0.4 percent per day. The impact of temperature elevation decreased with the increasing age and size of sockeye salmon and brown trout (Brett, Shelbourn, and Shoop, 1969; Elliott, 1975).

Averett (1969) and Everson (1973), using juvenile coho salmon, and Wurtsbaugh and Davis (1977), using juvenile steelhead trout, found that growth rates were lowered at aquaria temperatures slightly higher than controls at ration levels approximating those found seasonally in nature. Standard metabolism increased with increased temperature during all seasons and frequently most of the food consumed went into standard metabolism. Growth efficiencies and rates varied seasonally and with size, age, and available food. At consumption rates believed to be near those of wild fish, coho growth in aquaria was greatest at 5-8°C in early spring, 8-14°C in early summer, 14-17°C in late summer, 8-11°C in fall, and 5-8°C in late winter (Averett, 1969). Temperatures lower than these decreased food consumption, while higher temperatures increased standard metabolism. At ration sizes near those supposed to occur in nature, Wurtsbaugh and Davis (1977) found steelhead growth to be most efficient at 9°C in spring, 16°C in summer, 10°C in fall, and 7°C in winter. Limited food in conjunction with the increased maintenance requirements caused by elevated temperatures can reduce fish growth (Warren and Davis, 1967). Growth is vitally important to the survival of a population, since individuals must grow before reproducing. Standards for thermal discharges that are based only on the survival of animals or on the growth of animals fed to repletion thus may prove inadequate for the long-term protection of fish populations.

To evaluate the direct and indirect effects of 3-5°C temperature increases on juvenile salmonids, Iverson (1972) and Bisson and Davis (1976) conducted year-long experiments with salmonids in experimental streams. Iverson found coho production was much lower in the heated stream than in the control stream. He attributed this to reduced densities of the prey in the heated stream. Bisson and Davis observed reductions in chinook salmon production and benthic invertebrate biomasses in the treatment system, and high temperatures usually reduced prey abundance and salmonid growth rates. Other effects of increased temperature included higher invertebrate drift rates, lower incidence of parasitism (Bisson and Davis, 1976), and slightly higher growth rates when food was abundant in winter and early spring (Iverson, 1972).

The research herein reported was conducted in the outdoor model stream ecosystems used earlier by Iverson and Bisson and Davis. The effects of temperature elevation on community structure and on steelhead behavior, production, biomass, growth, and survival were studied for one year with coho absent and for one year with coho present. The research was conducted at the Oak Creek Laboratory of Biology, Oregon State University, near Corvallis, Oregon, from January 1975 through January 1977.

These experimental streams bore little resemblance to large, open rivers that receive heated effluents from factories, power plants, and municipalities. They more closely modeled small, partially shaded, cold water streams. However, unlike such streams, the water was recirculated, flow rates were generally constant, export was restricted, runoff and seepage were eliminated, there were no large obstructions producing cover or changes in flow patterns, and no piscivores were present. Such differences probably influence the effects of heating and interspecific competition on salmonid production. However, the intent of this experiment was not to determine the absolute effects of elevated temperatures and competitor introduction on a resident salmonid population. Instead, learning how production was changed was considered more important than measuring how much production changed, since the former would be more likely to provide general explanations that would be useful for anticipating production changes in nature.

Steelhead trout and coho salmon are commonly sympatric in headwater streams in the Pacific Northwest. Their behavioral ecology has been studied by Hartman (1965), Fraser (1969), Allee (1974), and Bustard and Narver (1975). These investigators usually found steelhead near the bottom and in riffles, where they were more aggressive than coho. The coho were generally farther from the bottom and in pools, where they were more aggressive than steelhead. Coho aggression was generally more intensely demonstrated than steelhead aggression. Aggression of both species was higher in summer than in winter, when steelhead were found among the pool rubble.

Coho typically spend only one year in fresh water before becoming smolts and migrating to the sea. Steelhead generally require two years of fresh water life before growing to smolt size. Steelhead feed on benthic as well as drifting invertebrates, but coho are predominately drift feeders. Juveniles of both species inhabit small, cold water streams, but landlocked races of rainbow trout may prosper in warm, eutrophic lakes (Soldwedel and Pile, 1968; Scott and Crossman, 1973). The ultimate upper incipient lethal temperature for steelhead and coho is 25-26°C (Bidgood and Berst, 1969; Brett, 1952). Since both species are territorial, respond to similar releasing stimuli, and have similar display patterns, they defend territories interspecifically as well as intraspecifically. By definition, if competition occurs between coho and steelhead, the competitor should reduce the availability of some limited resource, thereby reducing the productivity of the stream for the product of interest. Coho salmon and steelhead trout are closely related species with similar macrohabitats and food requirements. These characteristics make them good subjects for study of the impact of thermal elevation on the production of co-existing fish populations.

It is important to distinguish between production and productivity as used above. Ivlev (1966) considered production as the rate of elaboration of tissue by a population, regardless of the tissue's fate. But during the period over which production is estimated, weight loss by negative growth and production must be summed algebraically. This is because weight lost and later regained does not result in increased biomass, production, or potential yield of a population (Chapman, 1967). Consequently, temporary decreases in the cumulative production of the population may result. Productivity was defined by Ivlev as a system's capacity or potential for producing a population of interest, whatever the prevailing level of production. This distinction is not generally made by ecologists, and the result is considerable confusion in terminology and in ecological thinking and explanation.

To avoid the confusion, perhaps potential, or capacity, to produce should be used instead of productivity. Warren and Liss (1977) have described the capacity of an organismic system as all possible performances in all possible environments. Capacity is a theoretical concept that can be represented only partially with data because all possible population responses under all possible conditions cannot be determined. Production can be calculated as growth rate times biomass. Since growth rate declines with increasing biomass in food-limited systems, the highest production rates will be at intermediate biomasses and growth rates, and the lowest production rates will occur at high and low biomasses. Such hump-shaped production-biomass curves may provide useful empirical and theoretical representations of a system's capacity to produce a population. Knowledge of the capacity of a system is ultimately more useful for managers who frequently must differentiate between present and potential production of recreationally and economically valuable resources. Evaluation of capacities may allow comparisons of systems that would otherwise be difficult to understand because of their temporal and spatial variability. Relating production rate to biomass may make this evaluation possible.

Ivlev related production and productivity to the material and energy transfers in food webs leading to a product of interest. He believed this approach would yield far greater understanding of ecosystems than would the gross trophic level investigations stimulated by Lindeman's 1942 paper. Ivlev held that such approaches ignore too many of the differences between populations. The product of interest approach allows ecologists to evaluate the many possible outcomes of key populations in ecosystems with different productivities without having to lump the biota into a limited number of trophic levels or functional groups.

MATERIALS AND METHODS

EXPERIMENTAL STREAMS

The two experimental streams (Figure 1) used in this investigation had been in continual operation since October 1969, which allowed the establishment of a diverse diatom and invertebrate community. Each stream consisted of two parallel wooden channels elevated above the ground and connected by large irrigation pipes at either end. Each channel was 10 m long, 1.3 m wide, and 0.8 m deep, had an inner wall of plexiglass, and contained two equal-sized riffle-pool sections. Bottom composition in the riffles was primarily cobbles and gravel with fine sediments in the gravel. Pool substrate was mostly gravel with considerable accumulation of fine sediments and coarse organic material. Water depths ranged from 1 mm to 20 cm in the riffles and from 70 to 75 cm in the pools. The streams were mostly shaded by red and white alder (*Alnus rubra* and *Alnus rhombifolia*) and were open to precipitation and litter fall. The slopes of the channels allowed current velocities of 50-60 cm/s over the riffles, while velocities near the pool bottoms approached zero. Water was recirculated by a centrifugal pump from the downstream end of one channel to the upstream end of the other. A screen prevented large particles and fish from entering the pump and an effluent pipe provided an outlet for detritus and emigrating fish. Unfiltered stream water containing aquatic organisms was added at the rate of 30 l/min to each stream, which resulted in a turnover time of 2.4 days for the total stream volume.

Midsummer insolation in the control stream was 75 percent of that in the treatment stream, but little difference existed during most of the year. Although it originated from the same tributary, the water in the control stream was more turbid and contained more total organic carbon than the treatment stream (Table 1). With the exception of suspended and dissolved solids, the water quality values were within the

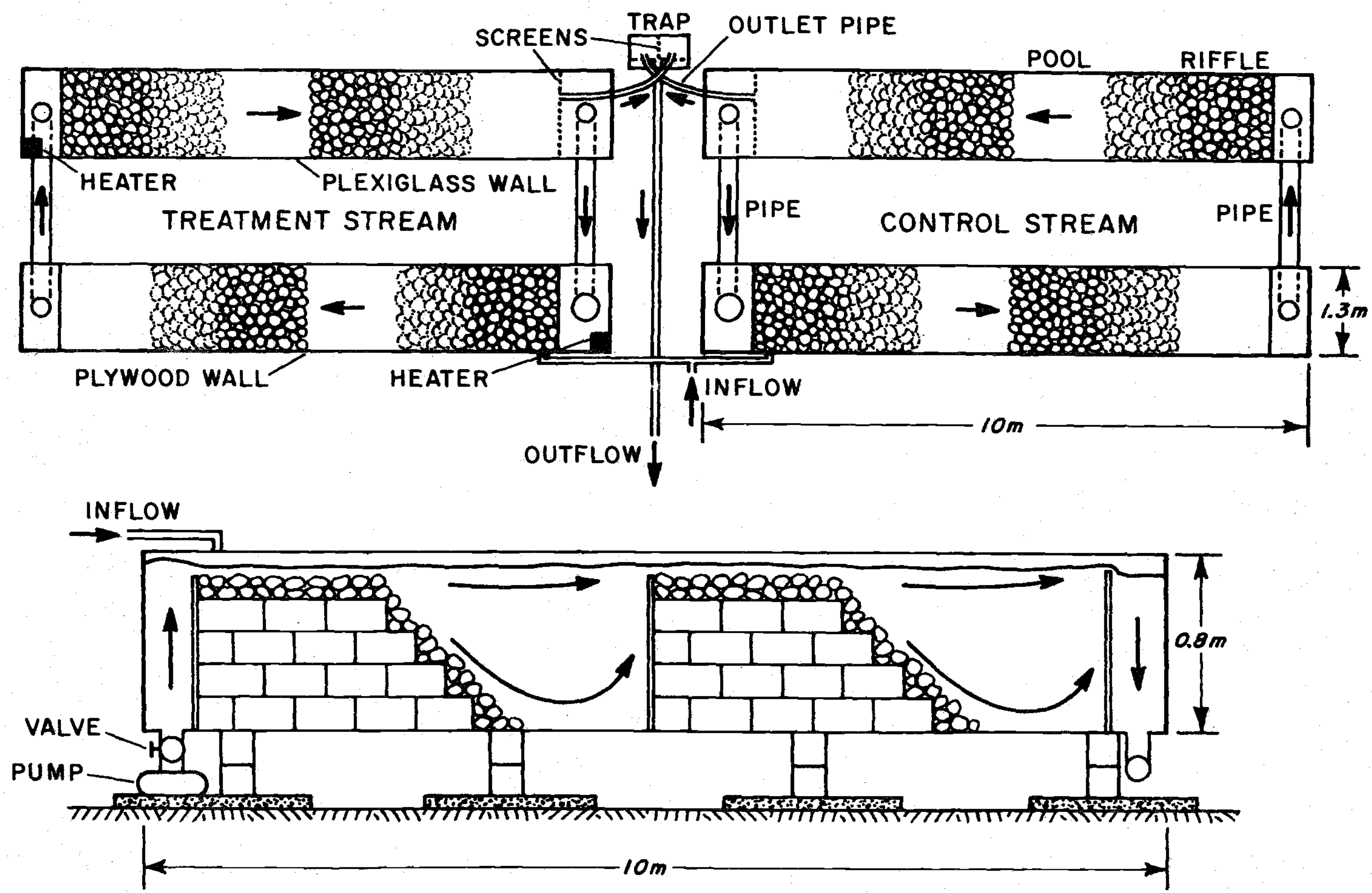

Figure 1. Diagram of the experimental streams (after Bisson, 1975): Top, view of both streams from above; bottom, lateral view of one channel; water flows indicated by arrows.

Table 1. Water quality in the experimental streams.[1]

Parameter	Treatment		Control	
pH	7.61		7.55	
Turbidity, J.T.U.	3.3		7.4	
Total Solids	162	mg/l	168	mg/l
Total Dissolved Solids	158		156	
Alkalinity, as $CaCO_3$				
Carbonate	0.0		0.0	
Bicarbonate	110		110	
Hardness, total as $CaCO_3$	99.2		101	
Magnesium (Mg)	9.08		9.42	
Silica (SiO_2)				
Total	42.2		48.4	
Dissolved	40.8		44.2	
Total Organic Carbon (T.O.C.)	1		3	
Nitrogen Forms as N:				
Ammonia	0.028		0.023	
Total Kjeldahl	1.51		1.12	
Nitrite	<0.002		<0.002	
Nitrate	0.114		0.101	
Phosphates as PO_4				
Ortho	0.06		0.06	
Total	0.06		0.23	

[1] Analyses were done on samples taken August 5, 1976, by CH_2M Hill: Engineers, Planners, Economists & Scientists. Corvallis, Oregon.

range of values for the tributary water from 1959 to 1967 as reported by Bisson (1975). No significant differences in bacteria counts were found between the two streams. Water temperatures were allowed to fluctuate dielly and seasonally. The treatment stream was heated 3-4°C above the control (Figure 2) by two 6 KW Chromalux immersion heaters. This was within the range of temperature elevations typical near heated discharges. Turbulence prevented unequal heating and abnormal gas concentrations.

FISH

The eggs and sperm of steelhead trout (*Salmo gairdneri*) were obtained from the Alsea hatchery during February 1975 and 1976. Coho salmon (*Oncorhynchus kisutch*) eggs and sperm were provided by the Fall Creek hatchery in November 1975. Both hatcheries are in the Alsea River drainage of Western Oregon. Gametes were obtained from three fish of each sex. The gametes were immediately brought to the Oak Creek Laboratory where the eggs were fertilized, and 500 embryos of each species were placed into the streams. In 1975, steelhead were incubated in gravel-filled boxes placed in the riffles to simulate natural redds. Because of the low number of emergents in 1975, presumably as a result of high sediment levels, in 1976 the coho and steelhead embryos were incubated in floating, gravel-filled boxes. High mortality of the steelhead emergents required additional stocking with fry from the Alsea hatchery to insure adequate numbers for study. The percent survival to emergence values were within the ranges of those found in studies in laboratories and in natural streams (Shirazi and Seim, MS).

The fish were censused every three weeks by seining each riffle-pool section until no fish were captured in three consecutive attempts. After the fish had been anesthesized with MS 222 (tricaine methanesulfonate), their individual lengths and weights were taken. Stomach contents were removed by flushing with a water-filled hypodermic syringe (Meehan and Miller, 1978). Usually 20 percent of the individuals of each species in a section were sampled, but the stomach contents of all fish were examined when fewer than five individuals of a species were caught in a riffle-pool section. The fish were then returned to the

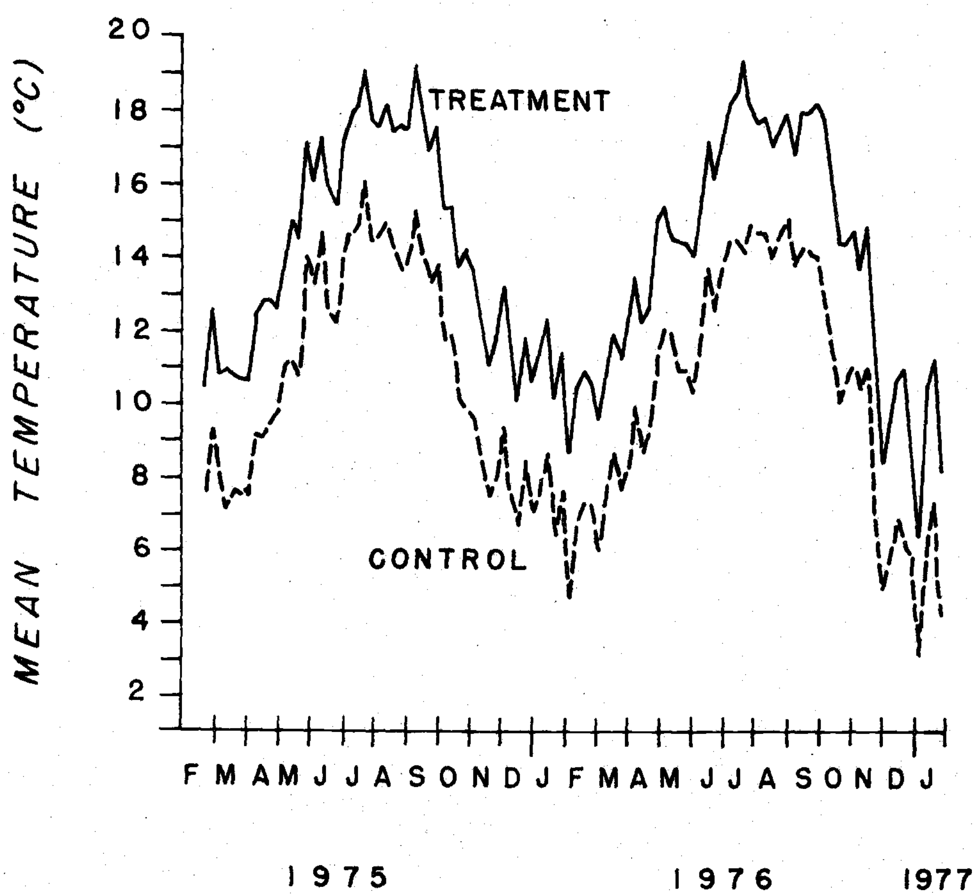

Figure 2. Weekly mean temperatures in the experimental streams.

same pools from which they were seined, where they appeared to resume their feeding positions within an hour. The food organisms were placed in ethanol and were later identified and counted. The samples were dried for two days at 65°C, cooled in a desiccator for one day, and then weighed to the nearest 0.0001 g.

Average relative growth rates of the fish were calculated as:

$$G = \frac{W_2 - W_1}{0.5\ (W_2 + W_1)(t_2 - t_1)}$$

where W_1 and W_2 are the mean weights of the fish at the beginning and end of the sampling interval and $t_2 - t_1$ is the interval in days. Production during each 21-day interval was estimated as the product of the average relative growth rate and the mean biomass during the interval. Cumulative production was obtained by summing algebraically the values for production of new tissue and negative production that occurred when individuals lost weight and mean biomass declined.

Ivlev's (1961) electivity index, $E = (r - p)/(r + p)$, was used to rate the prey taxa from -1 to +1 based upon their relative abundance in the ration, r, and their relative abundance in the environment, p. Electivity is a function of numerous characteristics of the predators, such as degree of satiation, predator density, and experience. It is also a function of such prey characteristics as absolute density, relative density, degree of aggregation, cover, behavior, and palatability (Ivlev, 1961). Electivity was used in this research only as an indicator of dietary importance to help discriminate among an array of benthic organisms. It is possible that differential digestibility of hard-to-digest snails and easily digestible oligochaetes resulted in errors in their electivity ratings.

From May 1976 until mid-December 1976, the behavior of all visible fish was observed at ten day intervals. Both streams were observed during the same period of the day, with several observation periods occurring during each daylight hour. All the fish in one-meter-long sections were simultaneously viewed for five minutes. Each fish's vertical and horizontal position, number of feeding attempts, and direction and intensity of aggression were recorded.

The behavioral data were divided into four groups: treatment steelhead, treatment coho, control steelhead, and control coho. Multivariate analysis of variance was used to examine seven behavioral variables: pool position, riffle position, benthic position, midwater position, number of feeding attempts, steelhead-directed aggression, and coho-directed aggression. By comparing the variance of all four groups, this analysis tested the null hypothesis that the centroid vectors of the four groups of fish were equal.

Since the multivariate analysis of variance revealed significant differences between groups, it was followed by a canonical analysis of discriminance. Canonical analysis of discriminance is a technique that selects canonical axes that maximize the among-group differences within a multidimensional data cluster. That is, orthogonal axes are selected that best discriminate differences among the groups. The two canonical variables which account for most of the among-group dispersion can then be plotted on a two dimensional figure. Correlations were calculated to provide comparisons between the canonical variables and the original behavioral variables. Mathematical explanations and computer programs for these techniques are available in Cooley and Lohnes (1971).

MACROINVERTEBRATES

Riffle, pool, and drifting macroinvertebrates were sampled triweekly. Each riffle was sampled with a wire basket that had been filled with substrate and left in place for three months. The four riffle samples from each stream covered a total surface area of 0.16 m^2, which was approximately one percent of the total riffle area of the stream. Pools were sampled by enclosing an area of substrate with a pipe that had an internal diameter of 15 cm and then a rubber hose with an internal diameter of 2 cm was used to siphon. Two samples were taken from each stream. Combined these amounted to approximately three percent of the pool bottom area. Drifting invertebrates were collected in nets with a rectangular opening and a mesh size of 333 μm (Anderson, 1967). All samples were sorted while the organisms were alive and thus most easily seen. Emerging insects were sampled twice weekly for one year with emergence traps (Kerst and Anderson, 1974) having a bottom area of

0.7 m^2. The traps were placed over different sections of the riffles each week.

The Shannon information measure of diversity (H') and a redundancy index (R') were estimated for the macroinvertebrate benthic samples. H' was estimated by:

$$H'' = \sum_{i=1}^{s} \frac{n_i}{N} \log_e \frac{n_i}{N}$$

where s equals the number of taxa in the sample, n_i is the number of individuals of a taxon, and N is the total number of individuals in the sample. H' is a species composition parameter which is based on the uncertainty with which the taxon of the next individual encountered can be predicted. H'' tends to underestimate H' (Pielou, 1966) but this bias is small for large sample sizes and the inclusion of rare species results in little change in the value of H'' (Wilhm and Dorris, 1968; Peet, 1974). H'' incorporates the taxonomic evenness and richness components of diversity while redundancy involves only the evenness component. H'' is increased by increased richness or by decreased redundancy. Redundancy, or unevenness, was calculated as:

$$R' = (H''_{max} - H''_{obs})/(H''_{max} - H''_{min})$$

where H''_{max} and H''_{min} are the maximum and minimum values of H'' given s and H''_{obs} is the observed value of H''. In a sample, R' varies from zero, when all taxa are equally represented, to one when all taxa but one are comprised of one individual.

AUTOCHTHONOUS AND ALLOCHTHONOUS MATERIALS

Litter inputs were estimated by collection from effluent traps and from the pump screens. Ash free dry weights were obtained for the allochthonous and autochthonous material collected during benthic sampling. Seasonal estimates of the production and respiration of aufwuchs were obtained by means of two, sealed plexiglass, 13-liter chambers containing trays of rocks and stream water (Bott et al., 1978). The chambers were submerged atop the riffles and constant water circulation in the chambers was provided by Teel electric bilge pumps. Dissolved oxygen was monitored with Y.S.I. Model 54 oxygen meters and continuously recorded on an Elnik Model BSC 6-1 recorder. Light was measured with either a hand-held Weston Model 756 illumination meter or a LiCor Model LI-185 quantum radiometer/photometer that was connected to the recorder. Data were obtained by simultaneously running one chamber in each stream for two 24-hour periods. The chambers were flushed every three to four hours to avoid gas supersaturation and nutrient depletion.

Community respiration and net community production were estimated, because aufwuchs assemblages cannot be physically partitioned into separate photosynthetic and heterotrophic components. Thus, production-respiration estimates of the aufwuchs simultaneously involved plants, invertebrates, and decomposers. Community respiration was estimated during the night by monitoring the dissolved oxygen concentration within the chambers. It was assumed that day and night hourly respiration occurred at nearly equal rates. This was likely to be most nearly true during the winter and early spring tests, because there was little difference between day and night temperatures and diurnal cloud cover was heavy. During the summer, the high light levels and considerable diel temperature differentials presumably resulted in lower nocturnal respiration rates than diurnal respiration rates in both streams. However, underestimating absolute daylight respiration rates was considered inconsequential, because production and respiration in the two streams were simply being compared. That is, the relative differences between streams were considered more important than actual production-respiration levels.

Net community production (NCP), or the net amount of solar energy converted to chemical energy by the periphyton, was estimated from the increase in dissolved oxygen in the chamber during the day. The increase in the amount of dissolved oxygen (NCP) is assumed to be equal to the difference between the total amount of oxygen released (GPP) and the amount respired diurnally by both the plants and the heterotrophs (CR_{day}), i.e., $NCP = GPP - CR_{day}$. The total amount of oxygen released, or the total rate of organic matter fixed from solar energy, is the gross primary production (GPP). Transposing the above equation gives $GPP = NCP + CR_{day}$. Thus, gross primary production can be calculated easily, whereas net primary production (NPP) cannot be measured or estimated because of the difficulty of separating plant and heterotrophic respiration.

Woodland stream communities include communities of heterotrophic microbes, especially aquatic hyphomycetes and bacteria. The relative importance of these microbes can be ascertained from comparisons of net daily metabolism (NDM). This parameter is the difference between GPP and 24-hour community respiration (CR_{24}). NDM thus allows estimates of the relative rates of decomposition of the aufwuchs community. Another indicator of autotrophy relative to heterotrophy is the production-respiration ratio (P/R), which is the ratio of GPP to CR_{24}. A P/R ratio greater than one or less than one indicates whether a system is respectively autotrophic or heterotrophic during that particular period. If consistently autotrophic, a stream is producing more biomass than it is reducing and thus biomass will accumulate or be exported downstream. The production efficiency (PE) is the ratio of GPP to total solar inputs, this allows comparisons of how efficiently periphyton communities convert solar energy to chemical energy.

RESULTS AND INTERPRETATIONS

CUMULATIVE SALMONID PRODUCTION

The total cumulative fish production (Figure 3) in both streams was greater in 1976, when both species were present, than in 1975 when only steelhead were present. During both phases of the experiment the cumulative production of fish in the control stream was greater than that in the heated stream. When the steelhead were the only fish present in the streams, the cumulative production of the control fish was 30 percent greater than the cumulative production of the treatment fish. But when both steelhead and coho were present, cumulative production of control steelhead was only 13 percent greater than that of the treatment steelhead, while the control coho had 100 percent more cumulative production than the treatment coho. Evidently, steelhead production was affected less by temperature elevation than was coho production.

Temperature elevation may result in either increased or decreased production, according to the season. In 1975 and 1976, production was greatest for both steelhead populations during June and July. In 1975, steelhead production never reached an asymptote, but in 1976, production of the treatment and control steelhead leveled off in August and September, respectively. In 1975 and 1976, production of control steelhead was negative during November and December. Production of treatment steelhead was negative in September, 1975 and in January, 1977. Production of control coho was greatest during April and May, 1976, but the production peaks of the treatment coho did not occur until June. Production of control coho did not level off until October but production of treatment coho began to level off in August. Negative production occurred from November until January with the control coho, and in September, October, and December with the treatment coho. Clearly, winter production of both species of treatment salmonids decreased less than winter production of the control fish. This suggests that moderate

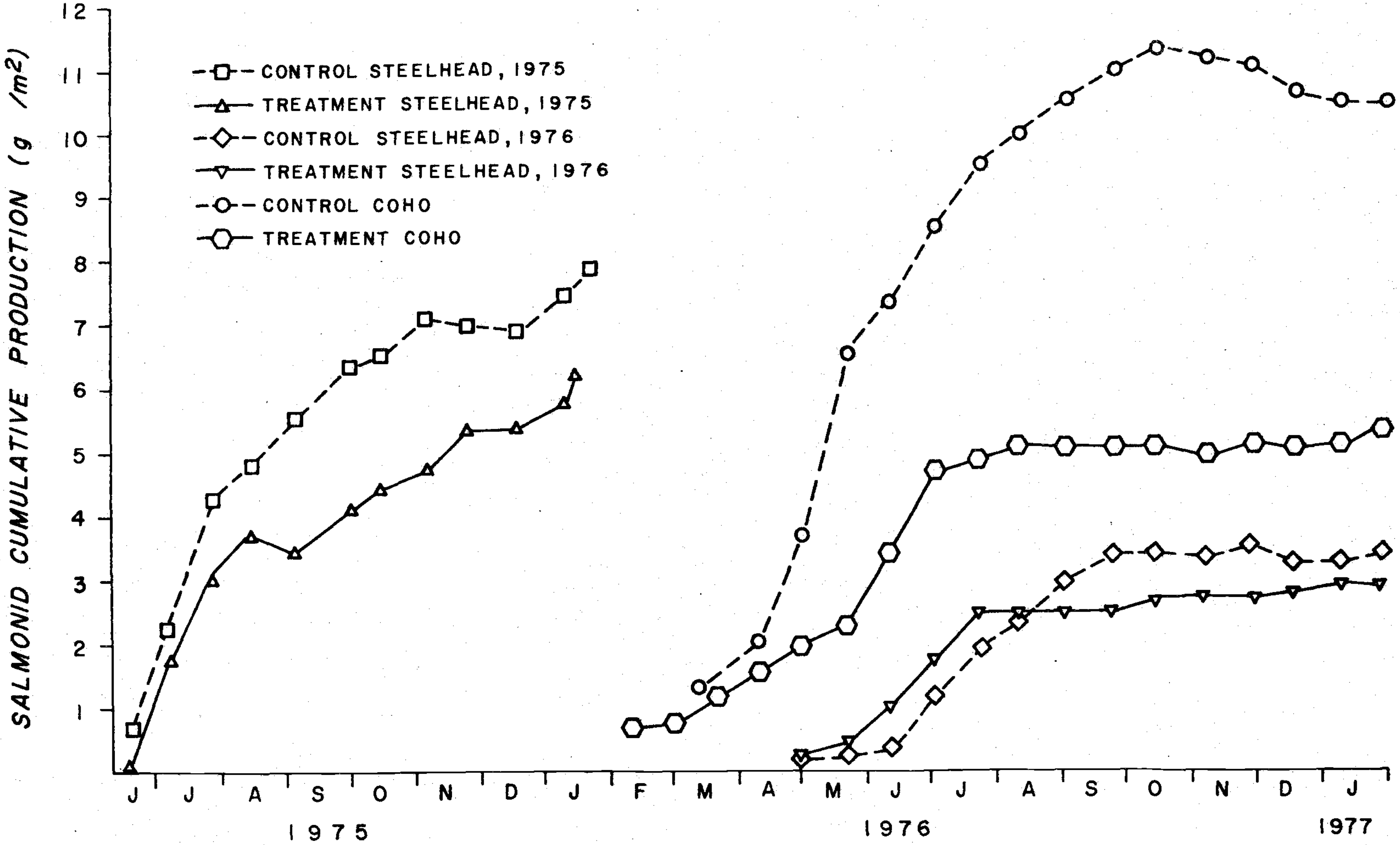

Figure 3. Cumulative production of juvenile salmonids in the experimental streams.

thermal additions in winter may occasionally result in increased fish production at prey densities similar to those occurring in nature. But the annual cumulative production of treatment fish was less than the annual cumulative production of the control salmonids, which suggests that even a moderate, year-long increase in temperature can lower annual production of cold water fish.

The addition of a competitor would be expected to lower the production of a product of interest, in this case steelhead. The cumulative production curves of steelhead for 1975 and 1976 reveal that cumulative production of steelhead was lower and reached an asymptote sooner when coho were present than when they were absent.

Because production was calculated as the product of biomass and average relative growth rate, these two parameters will be discussed in the following sections in an attempt to explain the observed trends in cumulative production.

SALMONID BIOMASSES, SURVIVAL, MEAN WEIGHTS, AND AVERAGE RELATIVE GROWTH RATES

During both years, salmonid biomasses peaked in late summer or early autumn and declined with the coming of winter (Figure 4). Control steelhead biomasses were not greater than treatment steelhead biomasses until late summer. Control coho biomasses remained well above the treatment coho biomasses throughout the experiment. In 1975 and in 1976, the control salmonids added biomass well into the autumn, whereas the populations in the treatment stream ceased biomass accumulation two to three months earlier. During both years the final steelhead biomasses were one gram less in the treatment stream than in the control stream.

The addition of coho had a considerable effect on final steelhead biomass and on the ratio of biomass to production. When coho were absent (1975) the final biomass of treatment steelhead was 80 percent of the final biomass of the control steelhead. But when coho were present (1976) the final biomass of treatment steelhead was only 50 percent of the final biomass of the control steelhead. In 1975, without coho, final steelhead biomasses were 75 and 80 percent of cumulative produc-

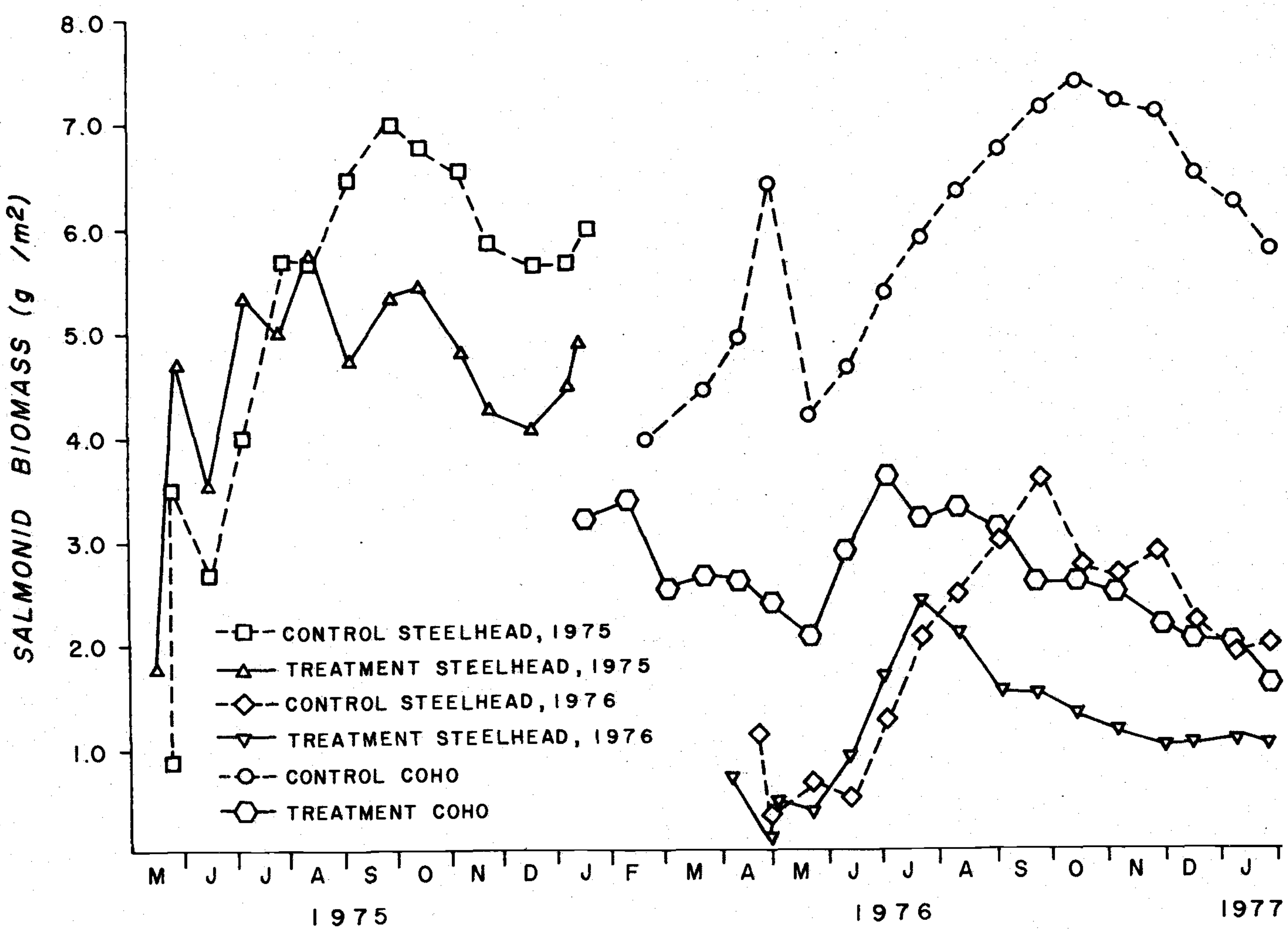

Figure 4. Biomasses of juvenile salmonids in the experimental streams.

tion in the control and treatment streams, respectively. In 1976, when coho were present, final biomasses were 61 and 33 percent of cumulative production in the control and treatment streams. When both coho and steelhead were present in the control stream in 1976, their combined final biomass was 25 percent greater than when steelhead were present alone in 1975. But the combined final biomass of coho and steelhead in the treatment stream in 1976 was 50 percent less than when only steelhead were present in 1975. Thus, the addition of coho was associated with much greater reductions of final steelhead biomasses and production and final combined biomasses of coho and steelhead in the treatment stream than in the control system.

In order to explain the differences in biomass shown in Figure 4, it is useful to examine changes in the components of biomass, i.e., the number of fish surviving during a time interval and their mean weight. All six populations began with 500 embryos. In 1976, survival to emergence was greater for the control salmonids than for the treatment salmonids (Figure 5). However, in 1975, control steelhead emergence was less than treatment steelhead emergence. The low survival to emergence of both control and treatment steelhead in 1975 probably resulted from the high sediment levels in the incubation boxes. The floating incubation boxes used the second year retained much less sediment and emergence rates were considerably higher than in 1975. Because of high mortality rates, additional steelhead fry were stocked both years, but the numbers again decreased rapidly. By the end of the experiments, there were nearly the same numbers of juvenile steelhead as before stocking. Also, many more coho emerged than the streams could support.

Differences in the number of survivors between streams and species were similar to the differences described for cumulative production and biomass. Both species of control fish outnumbered their treatment counterparts from summer until the end of the experiments. The coho outnumbered the steelhead during all of 1976. At the termination of the last phase of the study, the control and treatment steelhead had been reduced by 57 percent and 83 percent of their respective numbers the previous year.

The declines in steelhead numbers from 1975 to 1976 were not offset by increases in mean weights (Table 2). The final mean weight of con-

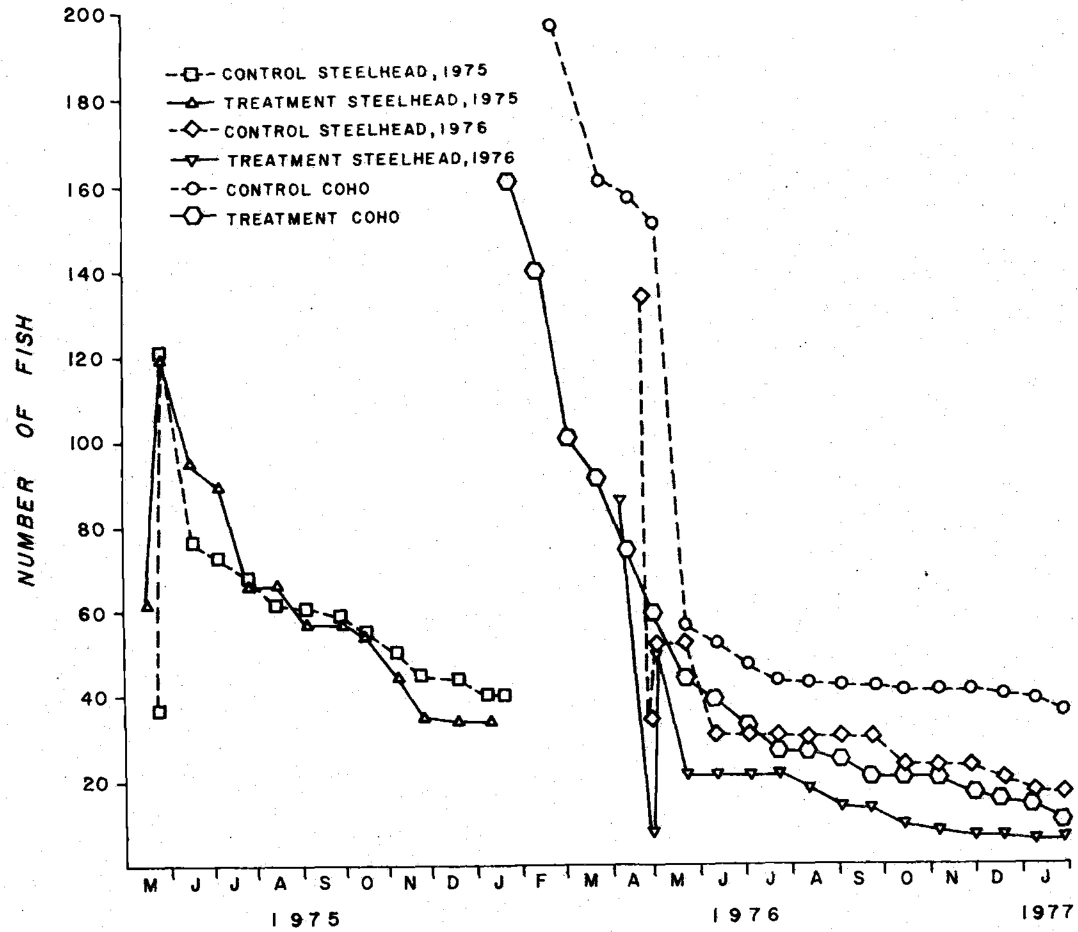

Figure 5. Population sizes of juvenile salmonids in the experimental streams. Additional steelhead fry were stocked in May, 1975 and 1976.

Table 2. Mean weights and average relative growth rates of juvenile salmonids in the experimental streams.

Census Date	1975 Steelhead Treatment Weight (g)	1975 Steelhead Treatment Growth (mg/g/day)	1975 Steelhead Control Weight (g)	1975 Steelhead Control Growth (mg/g/day)	1976 Steelhead Treatment Weight (g)	1976 Steelhead Treatment Growth (mg/g/day)	1976 Steelhead Control Weight (g)	1976 Steelhead Control Growth (mg/g/day)	1976 Coho Treatment Weight (g)	1976 Coho Treatment Growth (mg/g/day)	1976 Coho Control Weight (g)	1976 Coho Control Growth (mg/g/day)
1/20									0.43[2]			
										9.9		
2/10									0.53			
										1.8		
2/20-3/2									0.55		0.44[2]	
										7.6		9.9
3/22									0.64		0.60	
										7.6		8.1
4/5-25					0.18[2]		0.18[2]		0.74		0.70	
						18.0		17.5		8.2		13.9
5/1-16	0.62[1]		0.49[1]		0.20		0.20		0.88		0.94	
		----		----		33.9		15.7		7.0		25.8
5/22-28	0.87		0.61		0.39		0.27		1.02		1.64	
		-3.6		10.5		41.8		12.9		22.7		9.1
6/11-19	0.81		0.77		0.95		0.35		1.62		1.97	
		24.4		24.3		28.2		42.3		18.5		11.3
7/2-7	1.30		1.20		1.75		0.91		2.40		2.50	
		11.3		20.3		17.0		22.7		3.4		8.7
7/23-28	1.65		1.85		2.51		1.48		2.58		3.00	
		8.1		5.7		0.4		10.0		2.0		4.0
8/11-15	1.91		2.05		2.53		1.79		2.68		3.24	
		-2.3		5.9		0.7		10.0		0.3		3.8
9/2-5	1.82		2.32		2.57		2.23		2.70		3.52	
		4.6		4.2		-0.2		7.0		-0.3		2.8
9/24-10/1	2.06		2.59		2.56		2.60		2.68		3.74	
		4.4		2.5		5.4		-0.2		1.9		2.6
10/14-16	2.20		2.69		2.87		2.59		2.79		3.95	
		3.3		3.2		4.7		-1.4		-3.1		-1.1
11/6	2.36		2.88		3.20		2.51		2.60		3.85	
		6.5		-0.4		-0.3		3.8		2.6		-0.6
11/25-30	2.67		2.86		3.18		2.73		2.77		3.80	
		-0.2		-0.4		0.3		-6.6		-0.4		-3.3
12/18-19	2.66		2.83		3.20		2.39		2.75		3.56	
		3.8		4.3		9.8		0.4		1.4		-0.8
1/8-10	2.90		3.11		3.93		2.41		2.83		3.50	
		17.8		4.7		-3.7		3.4		5.3		0.3
1/22-29	3.17		3.29		3.66		2.59		3.13		3.52	

[1] Seined following 1-2 weeks of free swimming after emergence.

[2] Upon emergence in closed incubation boxes.

trol steelhead was less in 1976 than in 1975. Although the final mean weight of the treatment steelhead in 1976 was the greatest of all six groups of salmonids, their final biomass was the lowest, since only six large steelhead survived. With the addition of coho, the mean weights of control steelhead decreased by 21 percent while the mean weights of treatment steelhead increased by 34 percent. Thus, the reduction of steelhead biomass in the presence of coho was largely a result of decreased numbers rather than of decreased size.

Similarly, reductions in numbers rather than in average weights account for most of the reductions in biomass of the treatment fish in comparison with the controls. Final mean weights of treatment steelhead in 1975, and of treatment coho in 1976, were respectively 4 and 11 percent less than the control fish. But the numbers of treatment steelhead and coho were 18 and 69 percent less than the respective control steelhead and coho. In addition, although the treatment steelhead in 1976 had final mean weights that were 42 percent greater than the control steelhead of that year, the number of treatment steelhead was 65 per cent less than the control fish. Evidently, major differences in survival or emigration accounted for most of the differences between the biomasses of the treatment and control salmonids.

This is not to say that differences in mean weights were unimportant. The mean weights of the treatment and control coho fry were over three times greater than the steelhead mean weights when the steelhead emerged. Such a size difference has important effects on the outcome of interspecific competition since salmonid dominance is highly correlated with size.

Considerable insight into the cumulative production differences of the juvenile salmonids can be attained by examining their average relative growth rates. The salmonids in these experiments had relatively low biomasses and high growth rates in the spring and early summer. This was when the fish were small, food was relatively abundant, and temperatures were nearly optimal for growth. After July, increased fish biomasses, decreased prey, and increased temperature were generally accompanied by decreased average relative growth rates. With the onset of winter, there was a marked shift towards lower growth rates and lower biomasses and occasional periods of negative production. During winter the growth of treatment fish was sometimes higher than that of the controls, which indicates the possibility of positive effects of temperature increments on growth when temperatures are low and food levels adequate. In 1976, steelhead growth rates were frequently as great as or greater than the growth rates of the coho in the same stream. During the critical months of August and September 1976, growth rates of both species were lower in the treatment stream than in the control stream.

SALMONID BEHAVIORAL INTERACTIONS

It has been intimated in preceding sections that competition between the treatment trout and salmon may have been more intense than between the control fish. A multivariate analysis of variance of all behaviors indicated that each coho population was significantly different from the other and from both populations of steelhead (Table 3). However, the behaviors of the control and treatment steelhead were not significantly different, suggesting that temperature elevation had little direct or indirect effect on the observed steelhead behaviors.

Table 3. Multivariate analysis of variance of salmonid behavior[1,2].

	Treatment Coho	Treatment Steelhead	Control Coho
Treatment Steelhead	12.29		
Control Coho	7.24	34.85	
Control Steelhead	12.53	1.41	32.68

[1] F Matrix d. f., 7,86.

[2] Overall F, 10.33; d. f., 21, 248.

Following the multivariate analysis of variance, a canonical analysis of discriminance was employed to determine which behavioral parameters were most responsible for the variance. The canonical analysis of discriminance revealed that 99 percent of the variation among the four populations could be accounted for by the first two canonical variables. Canonical variables are vectors along the major axes of dispersion in a multidimensional cluster of points. The centroids are the centers of the clusters for each population. Consequently, to interpret the canonical variables, it was necessary to examine the correlations between the canonical variables and the original behavioral variables. The first, second, and third canonical variables had correlations of .89, .40, and .21 with midwater position, riffle position, and aggression towards steelhead, respectively.

A plot of the first two canonical variables (Figure 6) indicates that there was relatively little difference between the four groups of fish for canonical variable 2. This variable was most closely associated with riffle position and all four centroids (indicated by asterisks) fell between -0.6 and 0.6. However, considerable discrimination between groups was evident from canonical variable one, or midwater position. There was a greater likelihood of a benthic position for treatment coho compared with control coho as well as for steelhead compared with coho. This is indicated by the spread of the centroids between -3.0 and 1.5 along canonical variable one and by the small amount of overlap between the two coho clusters and between the coho and steelhead clusters. The distance separating the coho centroids is 2.5 times greater than that separating the steelhead centroids. Thus, multivariate analysis of variance and canonical analysis of discriminance suggest that temperature elevation may result in much greater disruption of coho behavior than of steelhead behavior.

The tendency for a benthic position by the treatment coho probably created greater competition for space and benthic prey between coho and steelhead in the treatment stream than in the control stream. More aggression by coho was directed towards the treatment steelhead than towards the control steelhead. Although aggression seemed less important than position from the canonical analysis of discriminance, the two behaviors are closely interrelated. In both streams, intraspecific and interspecific aggression were especially intense and frequent at the high densities of fry immediately following emergence. Both intraspecific and interspecific predation by larger fish upon smaller individuals was observed. After attacks by dominant fish, submissive fry were frequently observed burrowing into the gravel. This was assumed to be an escape response. Such individuals often remained buried, died, and

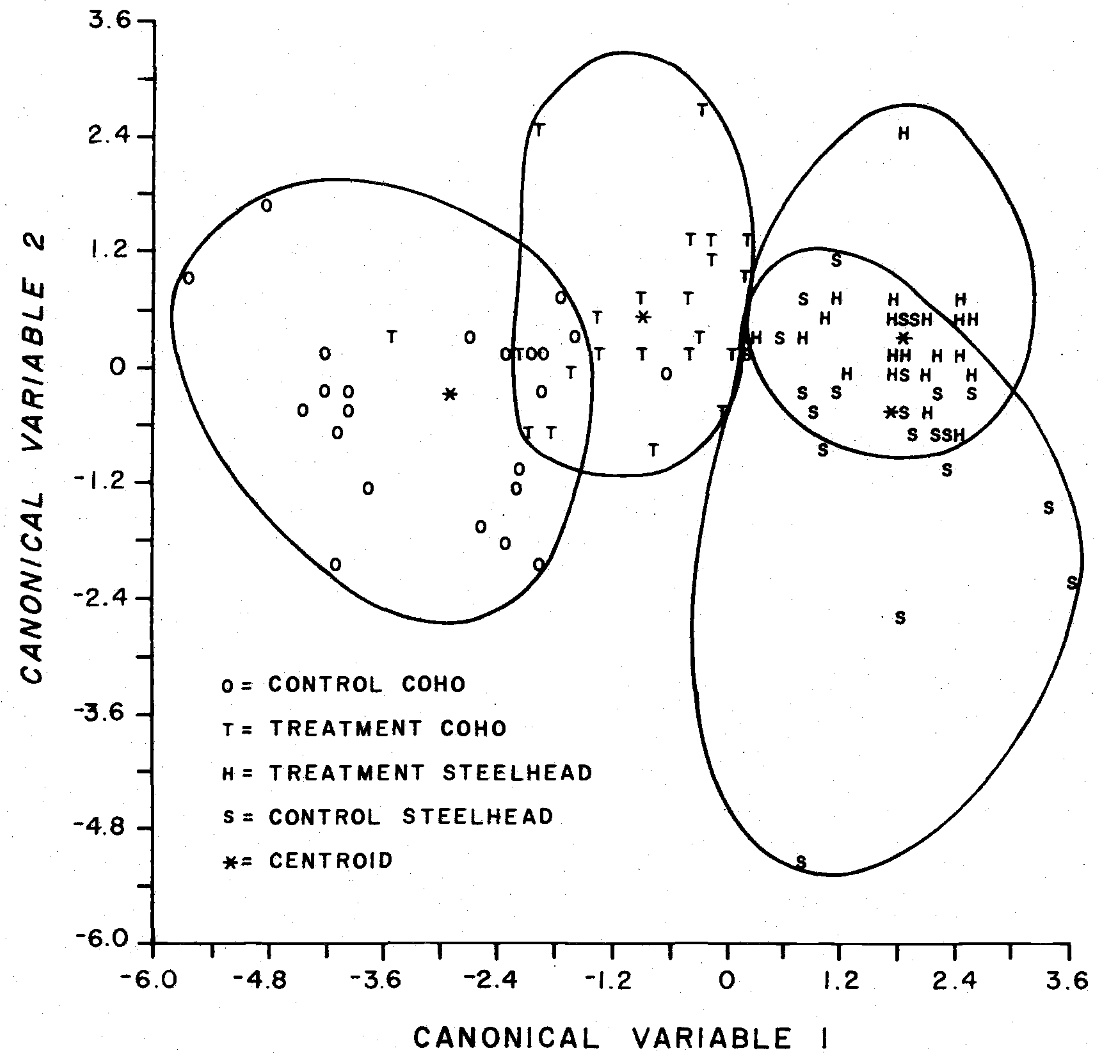

Figure 6. Canonical analysis of discriminance for coexisting juvenile steelhead and coho in the experimental streams. Canonical variables 1 and 2 respectively represent decreasing midwater position and decreasing riffle position with increased distance from the origin.

eventually decayed. In the absence of coho during 1975, the steelhead fed largely from the bottoms of the riffles and pools, but they frequently fed on the invertebrates drifting in the pools also. When coho were present, steelhead were rarely observed feeding on drifting invertebrates in the pools. In addition, searching behavior by small steelhead was more commonly observed during the year coho were present. In other words, steelhead territories appeared less fixed in the presence of coho than when coho were absent. This suggests a shift from a sit and wait towards a searching foraging strategy, at least on the part of the small steelhead. Thus, the presence of coho was associated with a reduction in the amount of territory occupied by steelhead, and temperature elevation was associated with increased interaction between coho and steelhead. Both factors may have contributed considerably to the reduced production of treatment steelhead during 1976.

PREY DENSITY AND COMPOSITION

An understanding of the dynamics of the prey of the salmonids helps to clarify the differences between the salmonid biomasses and growth rates in the two streams. The biomasses of taxa usually having positive electivity indices are plotted in Figure 7. Individual differences among the predators were disregarded, although at times some fish consumed specific taxa in considerably different amounts than did other individuals of either species. The two most important prey taxa were quite evenly distributed in the benthos and drift and coho and steelhead fed on nearly the same organisms. Most prey were 3-10 mm long, although occasionally much larger items were taken.

The chief prey items throughout both years could be represented by three taxa: the baetid mayflies, mostly *Baetis tricaudatus*; the chironomid midges, chiefly of the subfamily Orthocladiinae; and an ostracod, *Herpetocypris chevreuxi*. Other taxa having positive electivity indices only occasionally, and therefore not plotted, included: Collembola; the stoneflies, mostly *Nemoura*; the microcaddisfly, *Hydroptila*; Simuliidae, or black flies; and the planorbid snail, *Gyraulus*. The taxon that most consistently had a high, positive electivity index was the Chironomidae.

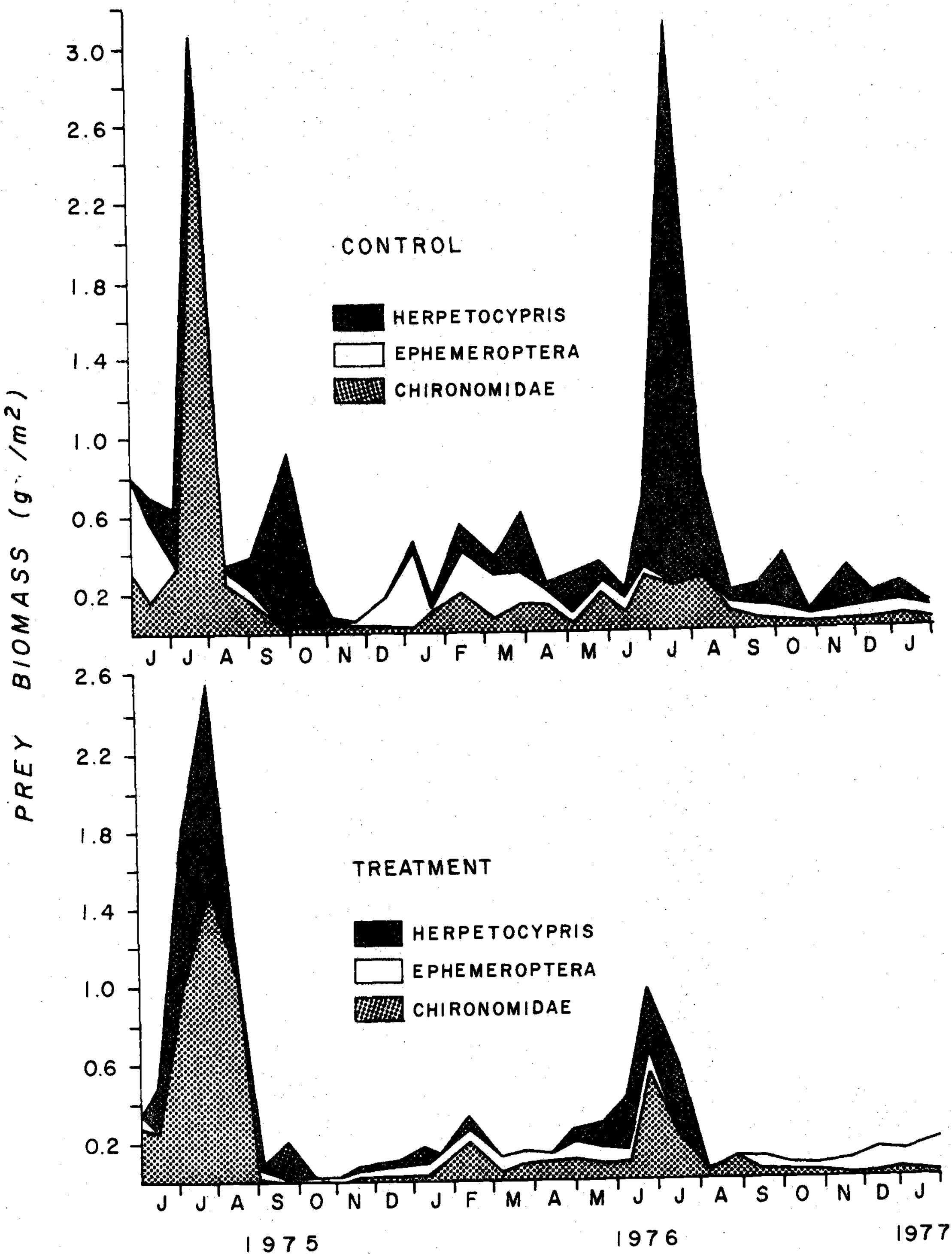

Figure 7. Biomasses of key benthic prey in the experimental streams.

In general, prey with consistently high or only occasionally positive electivity indices had greater densities throughout both years in the control stream than in the treatment stream. The midsummer peaks of prey biomasses coincided with high growth rates of both control and treatment salmonids. The prey biomasses immediately following these peaks were much higher in the control stream than in the treatment stream. This higher prey density, along with cooler water temperatures and lower maintenance costs, could have resulted in the higher production and biomasses of the control salmonids than of the treatment salmonids during late summer and early autumn. These factors also may have allowed the extra one to two months of critical summer growth in the control fish during 1976. The relatively high prey densities and low temperatures could have also resulted in greater numbers of fish in the control stream than in the treatment stream. This may have occurred if territory size was at least partly a function of food availability, or if more treatment fish than control fish died of starvation.

Although prey abundance was greater in the control stream than in the treatment stream, this does not necessarily mean that prey were more available in the former. Figure 8 reveals that invertebrate drift rates in the two streams were not consistently different. Since benthic prey densities were generally lower in the treatment stream than in the control, this means that drift rates relative to benthic biomasses were frequently higher in the treatment streams than in the control. In addition, invertebrate emergence rates were much higher in the treatment stream than in the control (Figure 9). The emergence rates in the treatment stream may have increased the drift rates, thereby increasing prey availability for the treatment fish above what was suggested by the benthos alone. Because invertebrate drift and emergence are generally associated with increased invertebrate activity, and because they were both elevated in the treatment stream, the treatment benthos may have also displayed more movement than the control benthos. It is likely that greater movement would have increased prey detection by fish feeding on the benthos.

Smaller invertebrates such as the Chironomidae show little diel periodicity in the drift. Nonetheless, invertebrate drift and emergence peak after dark for most stream species. Although fish were occasion-

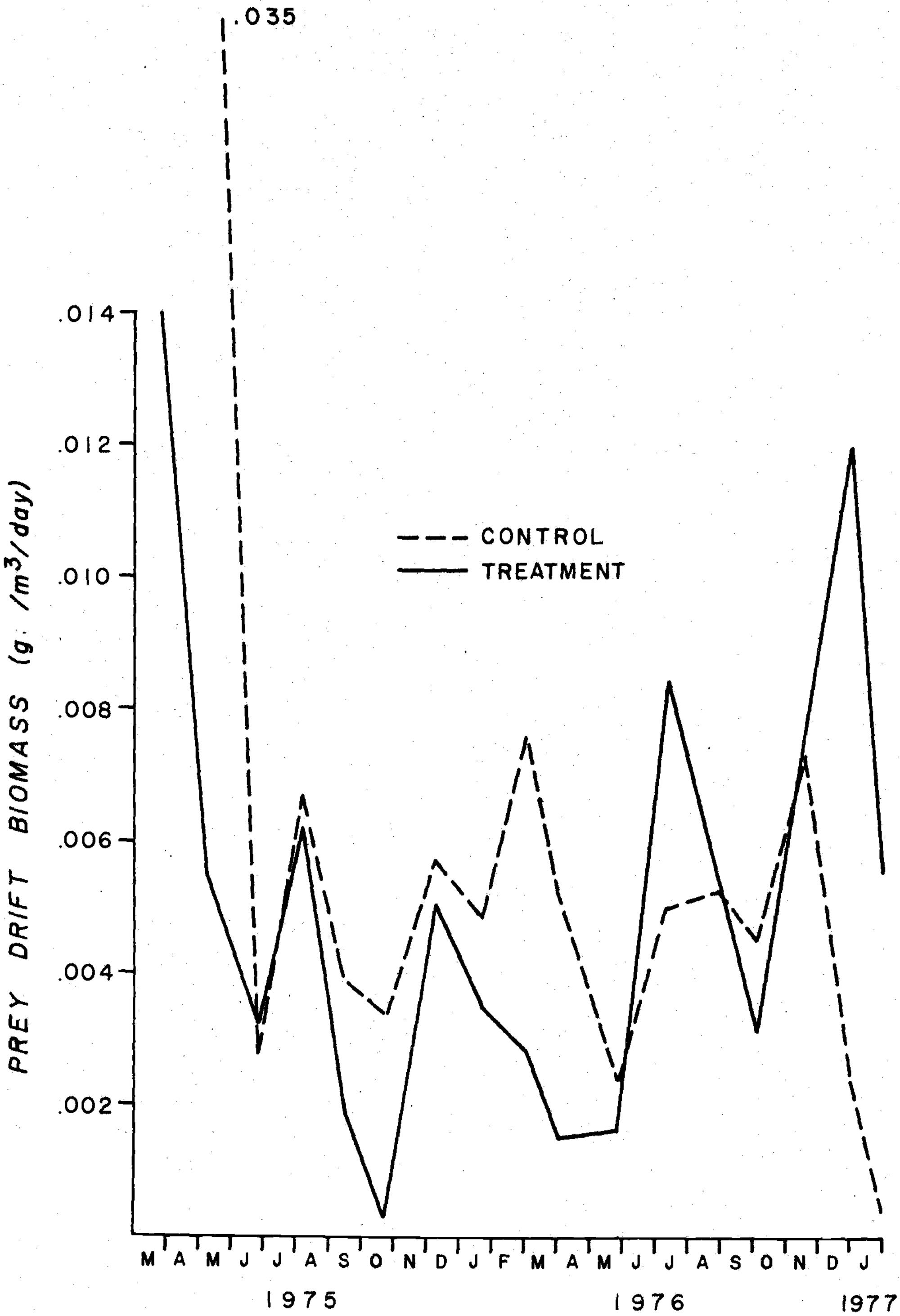

Figure 8. Biomasses of key prey in the 24 hour drift of the experimental streams. Each point is the mean of two samples taken during a six week period.

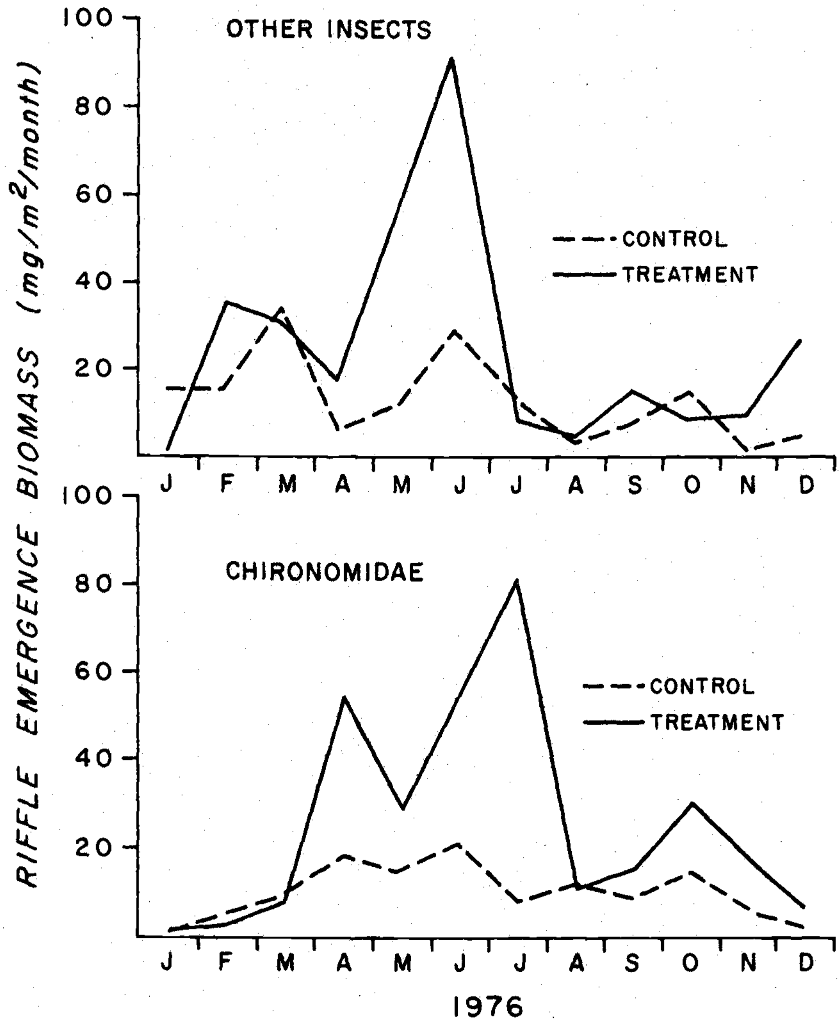

Figure 9. Biomasses of key prey emerging from the riffles of the experimental streams. Each point is the monthly total of semiweekly samples.

ally observed feeding on benthos at night, most individuals of both salmonid species appeared to be located in areas of little current near the bottoms of the pools where drift feeding was presumably minimal. It is, therefore, possible that the elevated emergence and drift rates in the treatment stream did not increase prey availability to the extent that might be suggested by their rates. Instead, the increased invertebrate drift and emergence may have resulted in greater nocturnal emigration and loss of potential prey from the treatment stream than from the control. Additional study of drifting invertebrates relative to the foraging behavior of salmonids is required before any conclusions can be drawn concerning the relative prey availability in the control and treatment streams of this experiment or in general.

COMMUNITY STRUCTURE

Macroinvertebrates

There were considerable differences between the macroinvertebrate densities of the control and treatment streams (Figure 10). The biomasses of *Juga plicifera* (Lea 1838), previously *Oxytrema silicula* (Gould), were three to four times greater in the riffles of the heated stream than in those of the control stream. This gastropod comprised over 95 percent of the macroinvertebrate biomasses in the riffles of both streams. The biomasses of macroinvertebrates other than *Juga plicifera* were generally greater in the control riffles than in the treatment riffles. *Juga plicifera* also comprised the major portion of the macroinvertebrate biomasses in the pools (Figure 11), with the greatest densities in the pools of the treatment stream. Other than for *Juga plicifera*, there were no consistent differences in the total invertebrate biomasses between the pools of the treatment and control streams.

The predaceous insects in the experimental streams usually represented about a tenth of the fish biomass and slightly less than a tenth of the biomasses of macroinvertebrates except *Juga* (Table 4). But the ratios of predators to macroinvertebrates other than *Juga* were only slightly greater in the treatment stream than in the control stream. The abundant snail, *Juga plicifera*, had a major influence on the stream

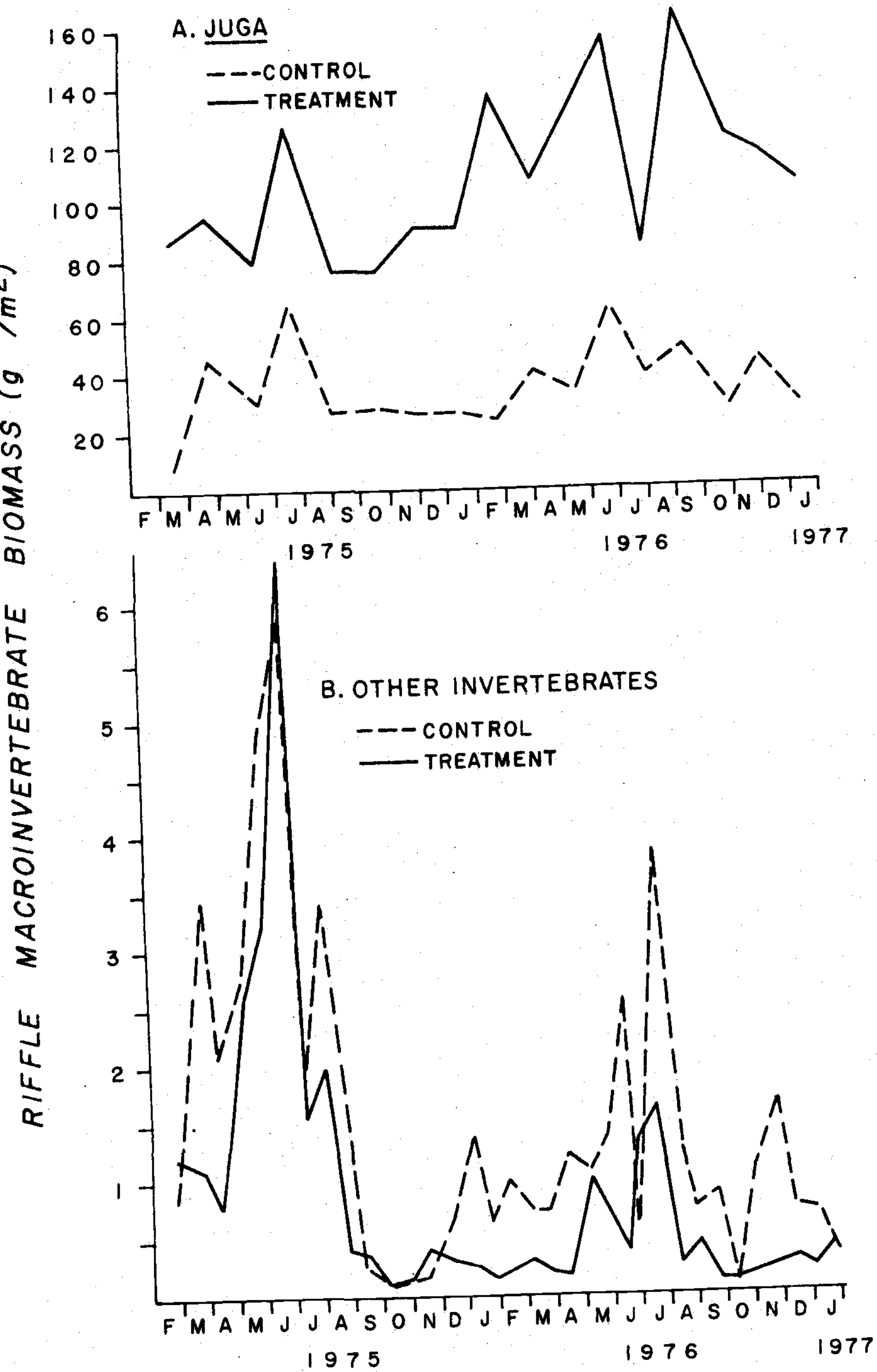

Figure 10. Biomasses of benthic macroinvertebrates in the riffles of the experimental streams. Each point in A is the mean of two samples taken during a six week period.

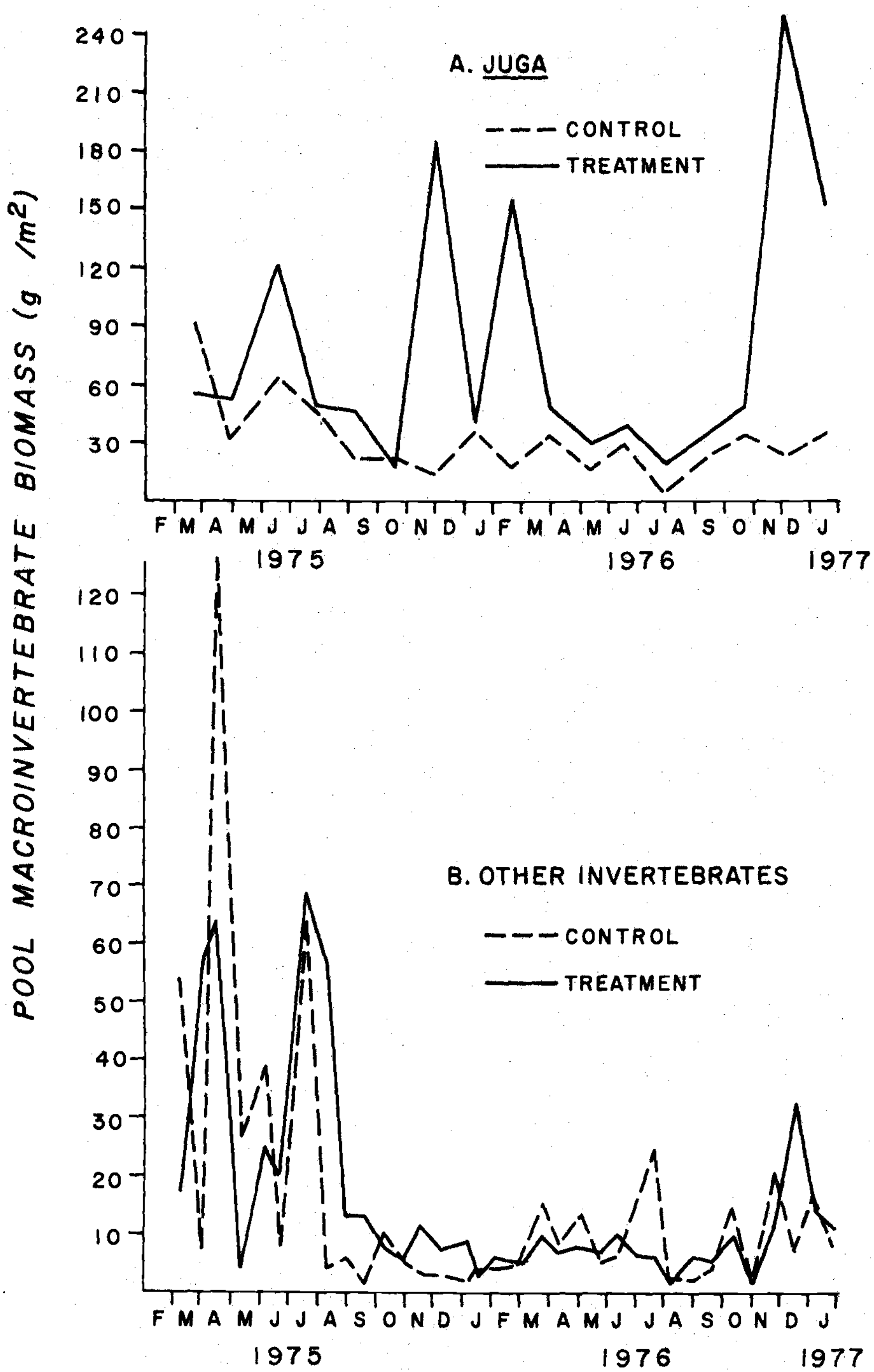

Figure 11. Biomasses of benthic macroinvertebrates in the pools of the experimental streams. Each point in A is the mean of two samples taken during a six week period.

Table 4. Biomasses of macroinvertebrate predators in the riffles and pools of the experimental streams.

	Treatment (g/m²)				Control (g/m²)			
	1975		1976		1975		1976	
	Riffle	Pool	Riffle	Pool	Riffle	Pool	Riffle	Pool
Cordulegaster[1]	-----	-----	0.002	-----	-----	-----	-----	-----
Octogomphus[1]	0.106	-----	0.014	0.214	-----	0.035	-----	-----
Isogenus[1]	0.019	-----	-----	-----	0.001	-----	-----	0.004
Isoperla[1]	0.003	0.013	----	-----	0.001	0.004	-----	0.008
Rickera[1]	-----	-----	0.001	0.008	-----	-----	0.003	0.006
Alloperla[1]	-----	-----	-----	0.003	0.001	-----	-----	0.015
Acroneuria[1]	-----	-----	-----	-----	0.001	-----	-----	-----
Sialis californica[1]	0.057	1.640	-----	0.134	0.019	0.542	-----	0.361
Sialis rotunda[1]	-----	0.385	-----	0.254	-----	0.164	0.004	0.222
Dymiscohermes[1]	-----	-----	-----	-----	-----	-----	0.103	-----
Rhyacophila[1]	-----	-----	-----	-----	0.001	------	-----	-----
Polycentropus[1]	0.006	0.051	0.004	0.005	0.009	0.181	0.002	-----
Tanypodinae[1]	0.011	0.248	0.005	0.083	0.027	0.159	0.017	0.059
Total	0.202	2.337	0.026	0.701	0.060	1.085	0.129	0.675
Mean Biomass of Macroinvertebrate Predators[2]	0.906		0.248		0.760		0.309	
Mean Biomass of All Macroinvertebrates except Juga[2]	9.69		3.38		9.78		4.15	
Ratio of Predators to All Macroinvertebrates except Juga	.09		.07		.08		.07	

[1] Mean biomass of the taxon.

[2] Mean biomass = 0.67 x riffle biomass + 0.33 x pool biomass. Riffles and pools comprised 67 and 33 percent, respectively, of the stream area.

community. Its abundance was presumably the result of the absence of freshets and the abundance of food. Because Juga plicifera represented such a large fraction of the invertebrate biomass and has consumption rates from 4-30 mg/g/day (Earnest, 1967), it is assumed that it was the major shredder and grazer of allochthonous and autochthonous materials. As such it was a temporary sink for energy and materials that otherwise might have been consumed by invertebrates that in turn could have been prey for the juvenile salmonids.

Continuously disrupted systems may demonstrate lower diversity and higher redundancy than undisturbed systems. Moderate temperature elevation was associated with those changes in the riffles (Figure 12). Diversity (H'') was almost always greater in the riffles of the control stream than in those of the treatment stream. With the exception of one period in November 1975, there were from two to ten more taxa in the control stream riffles than in the treatment stream riffles. The riffles of the control stream generally showed lower redundancy (R') than those of the treatment stream. Figure 12 thus indicates that diversity was higher in the riffles of the control stream than in those of the treatment stream because of the control stream's greater taxonomic richness and its lower redundancy. The differences in diversity between the pools of the control and treatment streams were neither as great nor as consistent as those between the riffles of the two streams (Figure 13). Perhaps pool macroinvertebrates were less sensitive to temperature elevation or had a more patchy distribution than did the riffle invertebrates.

No long term divergence in diversity between the two streams is suggested by Figures 12 and 13. That is to say, two years of continual heating appears to have been no more disruptive of community structure than the one year period. But it is also possible that changes in community structure that may have occurred from 1975 to 1977 were too subtle to be detected by H'', redundancy, or taxonomic richness.

Autochthonous and Allochthonous Materials

Partial explanations for the differences in invertebrate diversity and biomasses in the streams can be obtained from an examination of the

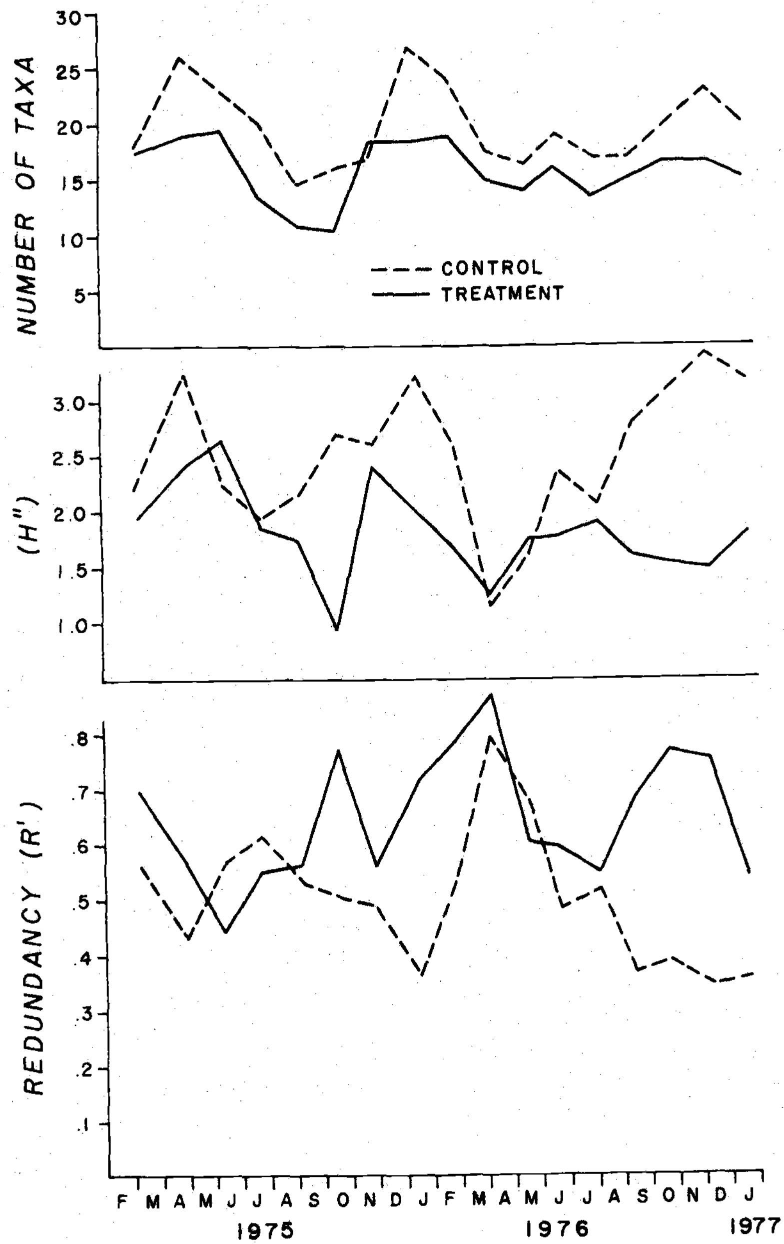

Figure 12. Number of taxa, diversity, and redundancy of riffle macroinvertebrates in the experimental streams. Each point is the mean of two samples taken during a six week period.

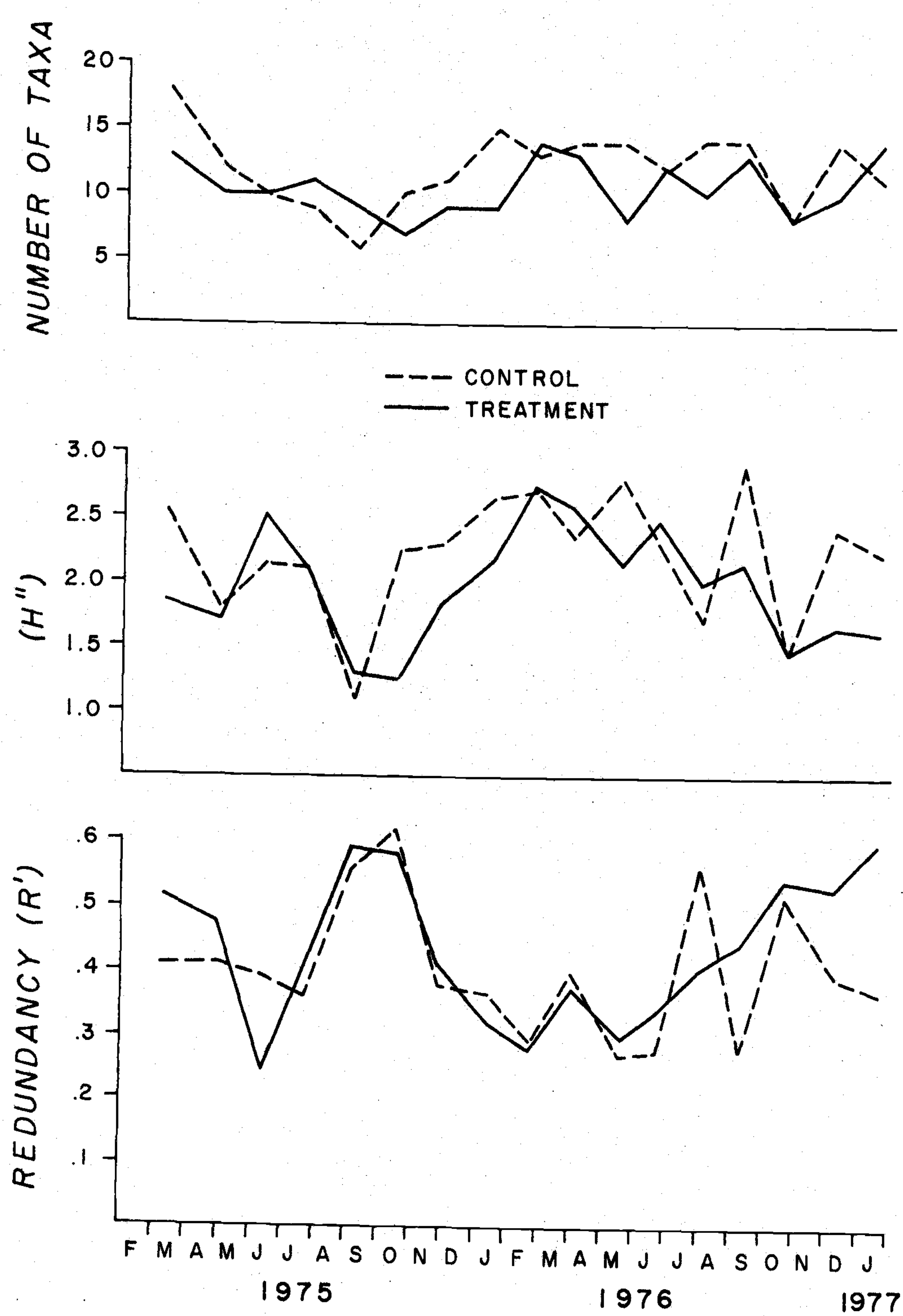

Figure 13. Number of taxa, diversity, and redundancy of pool macroinvertebrates in the experimental streams. Each point is the mean of two samples taken during a six week period.

amounts of coarse allochthonous detritus and plants in the two systems. Litter-fall in the treatment stream was usually one and a half to two times greater than in the control stream (Table 5). Pool detritus (Figure 14-A) was nearly equal between the two streams and it was generally many times greater than the allochthonous biomasses found in the riffles (Figure 14-B). From late autumn until late summer, litter was more abundant in the control riffles than in the treatment riffles. Although the patchy distribution of the litter makes conclusions uncertain, the control riffles were apparently retaining a greater proportion of litter than were the treatment riffles. Most of this litter consisted of alder leaves and catkins that are high quality foods for woodland stream invertebrates. The greater retention of litter in the control riffles than in the treatment riffles may have resulted from lower invertebrate feeding rates, lower microbial decomposition rates, and more abundant litter-retaining macrophytes in the control riffles than in the treatment riffles (Figure 15).

Nearly 100 percent of the control macrophytes were represented by the moss, Hygrohypnum bestii, which covered 90 percent of the control cobbles and trapped considerable amounts of leaf litter and sediments. Though grazed upon by very few macroinvertebrates, Hygrohypnum provided a substrate for many invertebrates, a collection site for food, and possibly increased invertebrate diversity. The high Hygrohypnum biomasses were associated with the lower temperatures and slightly greater turbidity of the control stream relative to the treatment stream.

The production respiration chambers reveal similar tendencies of the moss and aufwuchs (Table 6). Under cloudy conditions or when the water was turbid (3/16 & 17, 8/26, 12/3 & 4) the control stream had higher gross primary production (GPP), net community production (NCP), and net daily metabolism (NDM) than did the treatment stream. The treatment stream exhibited higher community respiration (CR) during all eight days and exceeded the control stream in GPP, NCP, and NDM on clear days (6/25 & 26, 8/25). The high community respiration in the treatment chambers presumably resulted from the temperature accelerated metabolism of the organisms in the chambers.

The effect of elevated CR is evident from a comparison of net daily metabolism, production efficiencies, and production respiration ratios

Table 5. Allochthonous and autochthonous material (g) removed from the traps and screens of the experimental streams. T = treatment, C = control.

	Jan		Apr		Jul		Aug		Sep		Oct		Nov		Dec	
	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C
All.	77	45	373	393	123	93	180	74	415	200	527	217	1095	807	444	321
Aut.	5	88	13	76	81	324	22	142	17	140	8	60	4	37	1	122

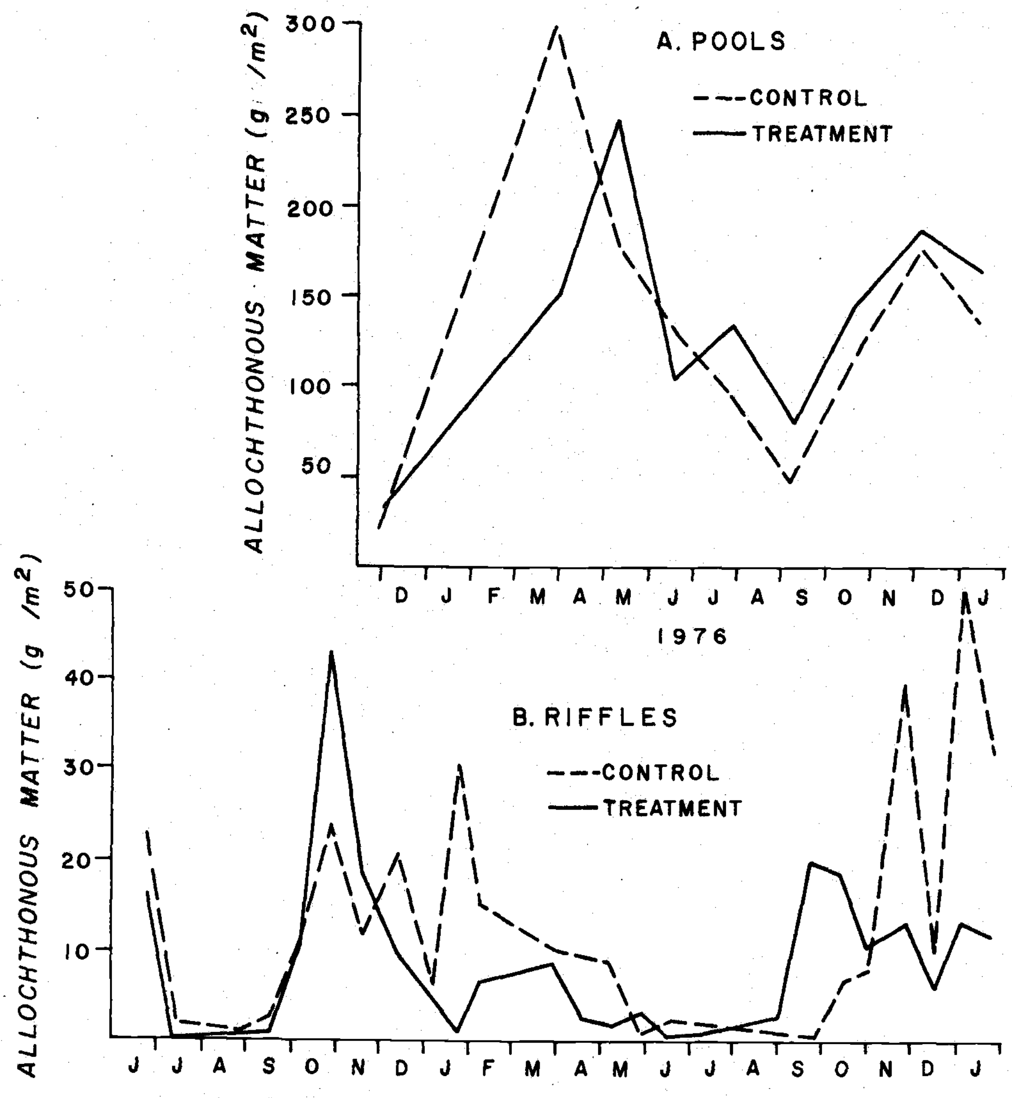

Figure 14. Biomasses of allochthonous matter in the pools and riffles of the experimental streams. Each point in A is the mean of two samples taken during a six week period.

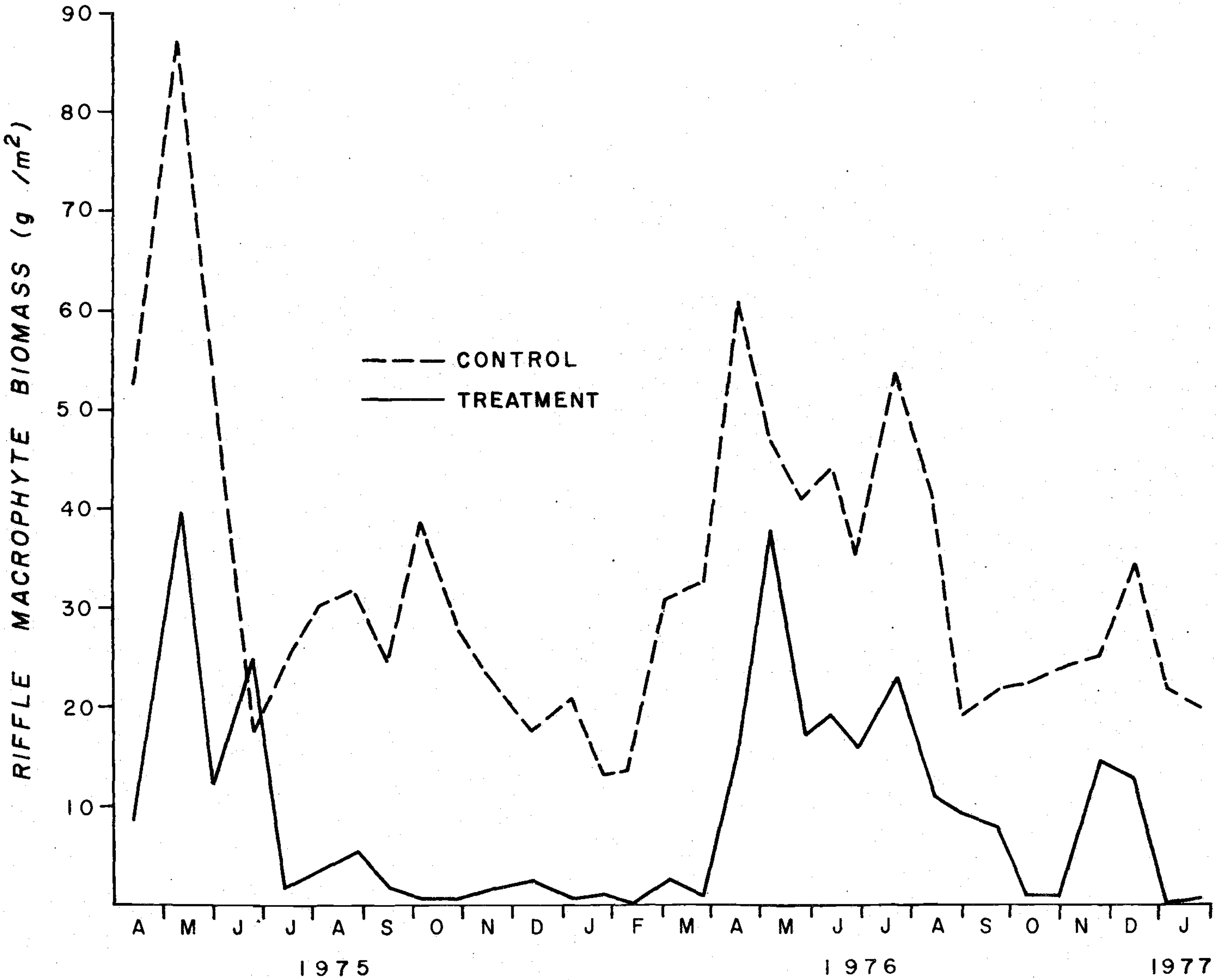

Figure 15. Macrophyte biomasses on the riffles of the experimental streams.

Table 6. Production and respiration of *aufwuchs* in the experimental streams. T = treatment, C = control.

Date	Light[1]		GPP[2]		NCPP[2]		CR[2]		NDM[2]		PE		P/R	
	T	C	T	C	T	C	T	C	T	C	T	C	T	C
3-16	6	6	.77	.83	.39	.57	-.76	-.52	.01	.31	.13	.14	1.01	1.60
3-17	6	6	.77	.89	.34	.64	-.86	-.52	-.09	.38	.13	.15	.90	1.71
6-25	193	144	1.80	.93	.95	.56	-1.27	-.53	.53	.41	.01	.01	1.42	1.76
6-26	193	144	1.58	.93	.71	.54	-1.31	-.55	.28	.38	.01	.01	1.21	1.69
8-25	47	43	1.52	.96	1.00	.50	-.91	-.73	.62	.23	.03	.02	1.68	1.31
8-26	43	43	1.12	1.19	.54	.67	-.92	-.77	.19	.42	.03	.03	1.21	1.55
12-3	2	2	.52	.51	.28	.41	-.44	-.27	.08	.24	.26	.26	1.18	1.89
12-4	2	2	.34	.42	.18	.21	-.42	-.28	-.08	.14	.17	.21	.81	1.50

[1] $Cal/cm^2/day$

[2] $g\ O_2/m^2/day$

GPP = Gross primary production = NCP + CR_{day} = total O_2. Estimate of rate inorganic carbon is reduced to organic form plus the organic carbon respired during the photoperiod.

NCP = Net community production = total O_2 released - CR_{day} = Net O_2 increase measured in chambers. Estimate of rate inorganic carbon is reduced to organic minus that respired during the photoperiod.

CR = Community respiration = O_2 consumed = CR_{night}, which is measured at night, + CR_{day} estimated using night respiration rates. Estimate of rate organic carbon is oxidized to inorganic.

NDM = Net daily metabolism = GPP - CR. Estimate of rate inorganic carbon is reduced to organic minus that oxidized to inorganic over 24 hours.

PE = Production efficiency = GPP/Cal light.

P/R = Production respiration ratio = GPP/CR.

between streams. NDM is the net amount of primary production following respiratory losses of the total community over 24 hours. It was greater in the treatment stream than in the control stream only on June 25 and August 25 and was negative in the treatment stream on March 17 and December 4. Production efficiencies or the ratios of GPP to light input were highest during cool weather when respiration was low. The P/R ratio, which is a means of scaling communities relative to autotrophy or heterotrophy, was greater in the treatment stream than in the control stream only on August 25. Both streams were autotrophic, generally having production respiration ratios greater than 1.0.

The elevated respiration and microbial processing rates in the treatment stream may have caused more rapid conditioning and decomposition of alder than normally occurred. Consequently, allochthonous material could have been processed more rapidly by invertebrates in the treatment stream than in the control. This possibly resulted in less allochthonous food in the treatment riffles than in the control riffles from winter to early summer (Figure 14). Any such reduced food supplies coupled with increased maintenance demands could be a partial cause of the lower prey biomasses in the treatment stream than in the control stream. It is apparent that elevated temperatures can affect community structure and processes. The close relationships between respiration, primary production, and detrital processing may have been disrupted by altering the synchronization of invertebrate life histories with seasonal food inputs and temperatures. The warmer water was also correlated with a tripling of snail biomass and a quartering of moss biomass. All of the above effects were associated with the lower prey biomasses, lower taxonomic richness, and higher redundancy of the treatment system.

CAPACITIES OF THE EXPERIMENTAL STREAMS TO PRODUCE STEELHEAD

It is possible to represent the different capacities of the experimental streams to produce juvenile steelhead by using a series of production-biomass curves for different environmental conditions (Figure 16). Salmonid production values conform imperfectly to only six such curves. This is because production is a function of a continuously varying stream capacity. Theoretically, the form of a production-

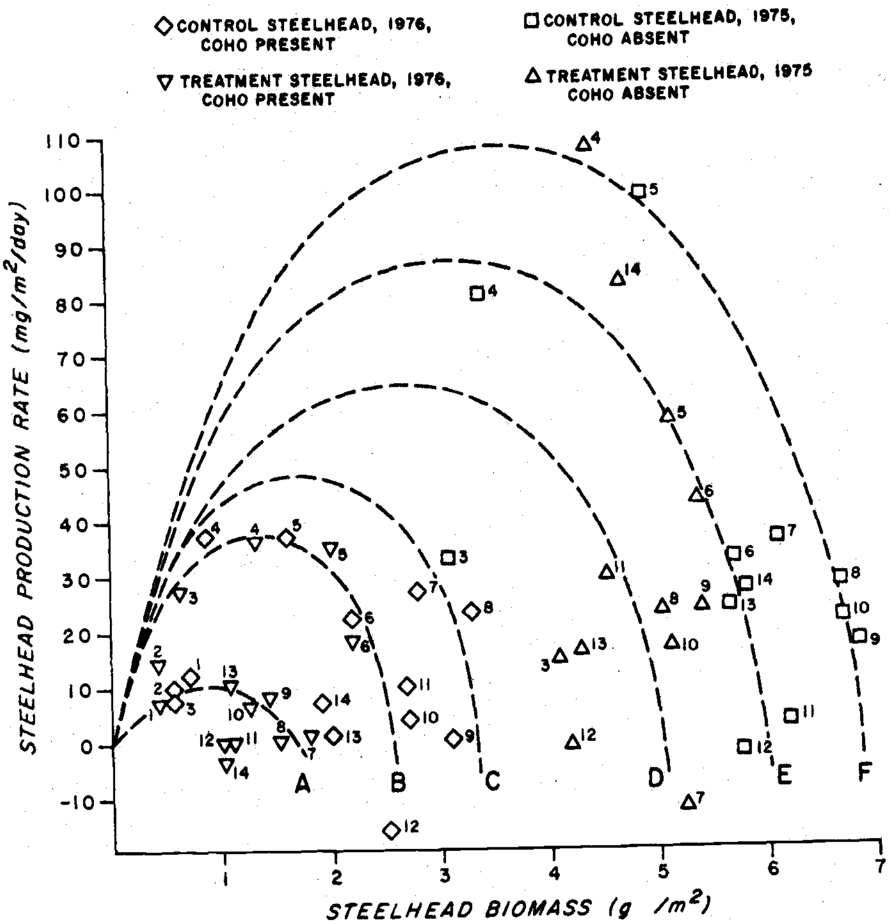

Figure 16. Theoretical relationships between steelhead production and biomass as functions of competition, moderate temperature elevation, and season.

The dotted curves were drawn by eye and represent six different capacities of the experimental streams to produce juvenile steelhead. The larger curves depict greater productivity. In curves A, B, and C, coho are present, in curves D, E, and F, coho are absent. In 1975 most control points were located near or to the right of curve E, and most treatment points were to the left of curve E. In 1976 most control points were located near or to the right of curve B, while most treatment points were to the left of curve B. A represents the treatment steelhead from September through January, and the control steelhead from May to mid-June and in January. B represents the treatment steelhead from May to mid-August, and the control steelhead from July to mid-August and in November and December. C represents the September to October control steelhead. D represents the treatment fish from September to January. E represents the treatment fish in July and August and the control fish from November to January. F represents the control fish from late July to November.

Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Date	M/1-16	M/22-28	J/11-19	J/2-7	J/25-28	A/11-15	S/2-5	S/24-O/1	O/14-16	N/6	N/25-30	D/18-19	J/8-10	J/22-29

biomass curve is determined by relative growth rate being a negative function of biomass, and production being the product of relative growth rate and biomass. Higher, wider curves represent greater capacities.

The reduced sizes of the production-biomass curves when coho were present suggest that the capacities of both streams for steelhead production were reduced by the addition of coho salmon. The capacity to produce steelhead also appeared to be lower in the heated stream than in the control stream, whether coho salmon were absent or present. Temperature elevation occasionally had positive effects but competitive effects were essentially negative. When coho were absent, the majority of points fell near the descending limbs of production curves. Such positions suggest that the streams were supporting near-maximum steelhead biomasses at these productivities. However, when coho were present, several of the points fell near the ascending limbs of the production curves. This suggests that the coho limited the biomasses of the steelhead, at least during the first three months of their coexistence in the experimental streams. Presumably, both predation by coho and competition with coho could have prevented the steelhead emergents from quickly reaching higher biomasses on the descending limbs of curves B and C.

Several points are located considerable distances from the curves. A point considerably above or to the right of a curve represents a period when the capacity to produce was greater than that depicted by the curve. In the heated stream these periods generally occurred from early to mid summer when the fish were relatively small, food was most abundant, and water temperatures were conducive to high feeding rates. A point below or to the left of a curve represents a time when the capacity to produce steelhead was lower than that depicted by the curve. These occurred at times in winter when water temperatures were especially low and not conducive to feeding, or in spring when large numbers of fry were emigrating. These intermediate points signify transitional periods when productivity levels were slightly different from those depicted. The overall effect of elevated temperature appeared to be negative when food was severely limiting. When food was unusually abundant or when low temperatures greatly depressed feeding rates, increased water temperatures temporarily resulted in an increased capacity to produce steelhead.

DISCUSSION

The experimental streams in which this research was conducted have been maintained continuously with the same temperature differential between them for eight years. During this time there has been an apparent reduction in the capacities of the streams to support salmonids and their major macroinvertebrate prey (Table 7). Averages of cumulative production, maximum biomass, and individual final weight of the salmonids declined from Iverson's initial study, through Bisson and Davis' work to the present investigation.

Iverson (1972) reared coho salmon in the experimental streams at an average temperature difference of 4.3°C. Large coho fry raised during the winter had similar total production in both streams but were able to prey upon small fry that had also been introduced. The small fry that were reared for one year had total production in the control stream that was nearly twice that in the treatment stream. Coho reared from eggs during one spring and summer had total production in the control stream that was five times that in the treatment stream. Biomasses and numbers of salmonids showed patterns similar to production, except that the numbers of coho in both streams were similar throughout the year-long experiment. Production of aquatic insects in the control stream was nearly twice that in the treatment stream. Using the same experimental streams, during two year-long experiments, Bisson (1975) found that production of juvenile chinook salmon in the control stream was 100 percent and 30 percent higher than in the treatment stream. The biomasses and numbers of chinook showed patterns similar to production. Biomasses of the prey of the chinook were greater in the control stream than in the treatment stream. Thus, the effects of moderate temperature elevation on the production, biomass, and numbers of coho and chinook salmon were similar to the effects on steelhead trout. During all three studies, production differences were greatest between streams when

Table 7. Changes in mean production (g/m^2), biomass (g/m^2), and mean final individual weight (g) of salmonids and in mean biomasses (g/m^2) of major macroinvertebrates from 1969 to 1977.

	Iverson (1969-1971)		Bisson (1972-1973)		Hughes (1975-1977)	
	Treatment	Control	Treatment	Control	Treatment	Control
Cumulative production of salmonids	11.5	29	12.73	20.09	7	11
Maximum biomass of salmonids	7.5	23.5	6.6	11.1	5.5	9
Final individual weight of salmonids	6.5	14.5	4.20	4.74	3.22	3.25
Juga plicifera biomass	6.36	2.80	6.04	4.10	44.58	18.16
Ostracoda biomass	-----	-----	0.36	0.32	0.08	0.15
Ephemeroptera biomass	1.09	3.14	0.09	0.73	0.02	0.05
Plecoptera biomass	0.54	1.87	0.05	0.07	0.01	0.04
Trichoptera biomass	0.11	0.07	0.37	1.00	0.24	0.41
Chironomidae biomass	0.71	0.85	1.96	2.52	0.12	0.14

survival of the newly emergent fry was much higher in the control stream than in the treatment stream.

The changes in macroinvertebrate community structure and biomass shown in Table 7 suggest fundamental changes in stream capacity for these organisms also. The biomasses of Juga plicifera found in this study were several times greater than those reported by Bisson (1975) or Iverson (1972). There was also an increase in Trichoptera biomass as a result of changes from smaller to larger taxa. The biomasses of Ostracoda, Ephemeroptera, Plecoptera, and Chironomidae were smaller than those reported by Iverson and Bisson. The lowered densities of invertebrate prey presumably resulted in decreased food consumption and growth of the juvenile salmonids. Drift densities of macroinvertebrates were also slightly less than those reported by Bisson (1975), presumably because of the lowered biomasses present. Thus, there was a reduction in the biomasses of most arthropods and increases in limnephilid and snail biomasses, i.e., a diminution in suitable prey for juvenile salmonids. This is the assumed cause of the declines in juvenile salmonid production, biomass, and individual weight that occurred from 1969 to 1977.

The long term reductions in the densities of arthropods can be related to stabilized flows in the streams. Inorganic sediments less than 65 μm accumulated in the pools at a rate of 0.90 to 1.10 $g/m^2/day$ from June 1978 to March 1979 (Mary Jo Wevers, pers. comm.). The absence of freshets prevented the resuspension of silt and clay particles, producing a continually more imbedded substrate and thereby decreasing the available habitat for typical, large arthropods found in woodland streams. Arthropods that mine sediments, such as some chironomids, may have been favored by such conditions. Constant flows also allowed increased Juga plicifera populations because the snails were not carried away or crushed by high discharges and bed movement. Juga biomasses increased sevenfold from 1969 to 1977 and were 1.5 to 2.5 times greater in the treatment stream than in the control stream. Because the heavy-shelled snails were rarely eaten by the salmonids, their feeding and biomasses directed energy and materials away from the juvenile fish. The snails processed large particulate organic matter into fine particulate organic matter that could be consumed by collectors (Cummins, 1974). But they also ate the material that could have maintained large insect shredders and grazers. This reduced the biomass and number of large insect prey potentially available to the juvenile salmonids. These reductions could explain the reduced capacities of both streams to produce salmonids since 1969. Also the high snail biomasses may have contributed to the lower productivity of the treatment stream relative to the control stream for salmonids and salmonid prey.

Regardless of the long term changes in both streams, the control stream had a greater capacity to produce salmonids than did the treatment stream. With the exception of the spring and early summer, biomasses, numbers of fish, and cumulative production of salmonids were usually all greater in the control stream than in the heated stream. Thus, at various levels of prey and during most seasons, elevated temperatures reduced the capacities of the streams for steelhead trout, coho salmon, and chinook salmon.

Further explanations of the lower productivity of the treatment stream can be based on earlier research at Oak Creek Laboratory. Averett (1969), Everson (1973), and Wurtsbaugh and Davis (1977) examined the growth of salmonids that consumed rations slightly above maintenance levels. They found that aquarium temperatures 3°C above seasonal ambient water temperatures resulted in decreased growth rates, regardless of the season. The elevated temperatures resulted in increased maintenance requirements although large fish required lower maintenance rations per gram of fish than did small fish. Wurtsbaugh and Davis found that a temperature increase of 3°C raised maintenance ration levels by 1 percent of the body weight per day. Their studies indicate that, unless food is very abundant, elevated temperatures result in lower growth rates because of increased maintenance requirements. Increased prey densities would have been required to meet the increased maintenance demands of the treatment salmonids in the treatment stream. However, seasonal prey densities were generally greater in the control system than in the treatment system.

The experimental streams resembled natural salmonid streams in important respects. Average insect biomasses were 1-2 g/m^2 in the riffles, peaked in early summer, and were lowest in late summer. Cumulative production of fish ranged from 6.3 to 14 g/m^2 per year. Final biomasses of fish were 2.5 to 7.75 g/m^2. Although invertebrate and salmonid biomasses are variable, these values are comparable to those found in salmonid streams as summarized by Hynes (1970) and Chapman (1967).

Interspecific competition between steelhead trout and coho salmon resulted in reduced growth rates, biomasses, numbers, and cumulative production of steelhead. Interspecific competition appeared to have a greater impact on production of steelhead than did moderate temperature elevation. The greatly reduced steelhead production in both streams in 1976 compared to 1975 apparently resulted from the addition of coho rather than from slight changes in the physical environment or macroinvertebrate densities. It is assumed that food was the limiting resource for the competing salmonid species both directly, and indirectly through territory. Many small fish were emaciated and presumably starved. During the day, the salmonids fed continuously except for occasional aggressive acts. Terrestrial insects that fell into the streams or insects displaced during sampling were immediately ingested by the salmonids. Both situations resulted in disruption of normal feeding territories and produced a scramble type of feeding. Territories were also limited. The largest, most dominant fish were along the sides of the streams slightly downstream from the riffles.

Hartman (1965) found that juvenile coho were generally more abundant than juvenile steelhead in the stream that he studied. During the late fall and winter both species occurred in pools with the steelhead under rocks and logs and the coho slightly off the bottom. This behavior was not observed in Hartman's artificial streams or in the control or treatment streams of this experiment, possibly because of the lack of high winter discharges in both cases. Like Hartman observed, the coho and steelhead were usually found in pools and riffles, respectively, when both species were present during the summer. In artificial streams, Hartman found that coho and steelhead occupied similar habitats when held separately, with only slight preferences for pools or riffles, respectively. Such a pattern was not as obvious in this experiment. Steelhead occupied the total stream habitat in the treatment and control streams during the year coho were absent. But coho fry rarely occupied the shallow riffles in either stream during the months before the steelhead emerged. This was possibly a result of the deeper riffles and relatively shallower pools of Hartman's artificial streams compared with the experimental streams of this study.

Fraser (1969) found that survival and mean weights of juvenile coho and steelhead in artificial channels were similar. This was not the case with the steelhead in either of the experimental streams. This difference possibly resulted from the greater riffle depth and riffle to pool ratio and the large number of obstructions in Fraser's streams. These conditions would have been more advantageous to the more rheophilic steelhead than to the pool dwelling coho. Allee (1974) observed age 0 coho and age 0 and 1+ steelhead in natural streams for two summers. He found that coho biomasses were greater than steelhead biomasses both years. As was found in the experimental streams, Allee usually observed coho towards the tops of pools and steelhead in the riffles and near the bottoms of pools and riffle-pool slopes. Both species emigrated downstream with the first major freshet in late autumn.

Allowing only one year of residence may have provided a misleading estimate of steelhead success, since juveniles of this species normally spend two years in streams before smolting. Although Allee (1974) found that coho dominated steelhead regardless of their respective sizes, the presence of steelhead of earlier year classes might have resulted in less difference between competing steelhead and coho populations in the experimental streams. The one year old steelhead would be expected to competitively dominate and possibly prey on the smaller emergents of both species. Such a strategy is not uncommon among stream salmonids. Presumably the smaller individuals that do not smolt their first year have a size advantage the following year.

The increase in total fish production when both species were present was presumably the result of more complete use of the streams' resources by the two species than by steelhead alone. Since steelhead typically occupy stream bottoms and riffles and coho typically occupy midwater areas of pools, individuals of each species are probably most efficient in the typical species habitat. When both species are present, the riffles and pools are more likely to be occupied by the most efficient individuals. Thus, growth efficiencies, total fish biomass, and total production occasionally may be increased. But the biomasses, and cumulative production of each species would be reduced during interspecific competition because of the loss of emigrant individuals or the decreased food availability.

The degree that temperature elevation and competition affect individuals depends on several factors, such as the genetic constitution, environmental history, and life history stage of the individuals, as well as the biophysical environment in which they exist. The growth rates and production of the treatment salmonids were occasionally higher than those of the control salmonids, indicating that temperature elevation may be beneficial when food is abundant or when temperatures are at winter minima. An additional species may increase total fish biomass, as in the control stream, or it may decrease total fish biomass as occurred in the heated stream. Aho (1976) found that cutthroat trout production in a stream section that ran through an eight year old clearcut forest was double that in the uncut section, but summer temperatures were only 0.1-1.0°C higher in the cut section. Presumably, the increased periphyton production resulting from increased insolation in the cleared section was the basis of this. Likens et al. (1970) reported that clear cutting and herbicide treatment of a northern hardwood forest on spodosolic soils increased nitrate levels as well as the temperature of streams. Increasing nutrients as well as insolation and temperature could heighten primary production and fish production, depending on previous levels of these factors and the species involved.

Other factors besides food density and temperature affect production of salmonids. Hartman (1965) and Chapman (1966) have discussed the importance of shelter from winter freshets. Hunt (1969) stressed the importance of shelter from predators as well as the importance of feeding sites formed by tongues of water below riffles and at the tails of pools. Because of the lack of predators and freshets, these spaces may have been less limiting in the experimental streams than in natural streams. In consequence, food may have been unusually important in limiting salmonid production and abundance in this experiment.

Prey densities were generally greater in the control stream than in the treatment stream, especially during late summer and early autumn. This period was apparently the most critical for the treatment salmonids, since their numbers declined sharply, biomasses began to decrease, and production leveled off, while production of the control salmonids continued for several weeks longer. In both streams, prey densities and salmonid production were greatest during the late spring and early summer. Peak densities of prey appeared to be largely determined by life history and seasonal phenomena.

Insect emergence was much greater from the heated stream, and emergence peaks in the treatment stream generally preceded those in the control stream by one week. These trends may have resulted from accelerated metabolism and growth and from temperature minima required for emergence. Emergence trends were positively associated with changes in benthic biomasses. It is uncertain whether the elevated emergence and drift rates of macroinvertebrates in the heated stream increased prey availability. Since macroinvertebrate drift and emergence are greatest at night, studies of nocturnal foraging by salmonids are required to remove the uncertainty concerning prey availability. Elliott (1970) and Allan (1978) suggested that trout ingest relatively fewer large insects and emergents at night than during the day. Thus, if the fish forage less or less efficiently at night, it is conceivable that night drift and emergence, along with night activity, are predator avoidance mechanisms of the invertebrates.

The differences in community structure between the control and treatment riffles and pools offer interesting insights. The treatment riffles and pools had much greater biomasses of the snail, Juga plicifera, than did the control riffles and pools. Other than Juga, macroinvertebrate biomasses were usually greater in the control riffles than in the treatment riffles. Except for Juga, biomasses of macroinvertebrates in the pools of both streams were nearly equal. Temperature elevation was also associated with lower macroinvertebrate diversity in the treatment riffles than in the control riffles. Fisher (1958) and Pianka (1974) have described how specialists with narrow tolerances would tend to experience greater reductions in fitness following environmental change than would generalists that have fairly high tolerances. Schoener (1969, 1971) suggested that generalists may be favored over specialists when metabolic rates are high and that larger animals may be favored during periods of food abundance. Most stream macroinvertebrates ingest a variety of materials (Hynes, 1970; Shapas and Hilsenhoff, 1976) but show considerable specialization for microhabitats

(Ruttner, 1963; Ulfstrand, 1967; Hynes, 1970) and particle size (Merritt and Cummins, 1978). From both a feeding and habitat standpoint, Juga plicifera appeared to be the most generalized species identified. It fed on periphyton, macrophytes, conditioned and unconditioned leaves, leaf fragments, flowers and fruits, and dead fish. Snails were found in fast and slow water, on the upper and lower surfaces of rocks, and in pools, riffles, and splash zones. Diamond (1977) observed similar behavior in natural populations of Juga plicifera. The mature snails were also among the largest individual macroinvertebrates in the streams. Thus, as predicted by the models of Fisher, Schoener, and Pianka, Juga plicifera was more successful in the treatment riffles than in the control riffles, while more specialized taxa, such as most of the insects, were more abundant in the control riffles than in the heated riffles.

Compared to the riffles, the changes in macroinvertebrate diversity and biomass were less obvious in the pools where the substrate was less stable, sediment levels were higher, macroinvertebrate feeding mechanisms were less specialized, and macrophyte and microphyte production was lower. This suggests that the more heat tolerant invertebrates may inhabit pools and soft bottomed streams rather than riffles and rubble bottomed streams. Some invertebrate species appear tolerant of a fairly wide range of temperatures in their different life history stages, provided that the high temperatures are not permanent (Langford, 1971). However, the reduced number of species in the heated riffles suggests that several local species were near their upper temperature limits and either failed to persist or occurred in such low numbers that they were not sampled. Had these streams been located in a region where colonizations by warm water macroinvertebrates were possible, the differences in diversity and biomass between the two streams may have been reduced or even reversed. That is, the effects of temperature elevation on the diversity and biomass of aquatic organisms is a function of the regional climatic regime and the genetic stock present in the stream and in nearby waters.

Although experimental streams cannot replicate natural streams, they can model key processes that occur in them (Warren and Davis, 1971). Problems of applicability from one system to another arise when comparing two natural streams in different regions or when comparing streams with considerably different flow characteristics or nutrient and energy budgets. Not even two sections of the same stream are identical. Thus, the fact that laboratory streams are not exact duplicates of natural streams should not be a major obstacle to using them to help understand the natural processes that occur in streams. Temperature is one of the most important environmental factors regulating the distribution, abundance, and production of fish or any organism. However, because of the complexity of biological systems, few changes can be attributed to single causes. Each case of temperature elevation in a stream is unique, depending on the type of effluent and the biophysical characteristics of the stream and its watershed. Nonetheless, an understanding of the general processes by which temperature elevation and species competition affect the production capacity of a system allows us to explain and predict the changes that may occur in a variety of natural systems under a variety of conditions.

BIBLIOGRAPHY

Aho, R. S. 1976. A population study of the cutthroat trout in an unshaded and shaded section of a stream. M. Sc. Thesis. Oregon State Univ., Corvallis, OR. 98 p.

Allan, J. D. 1978. Trout predation and the size composition of stream drift. Limnol. and Ocean. 23(6):1231-1237.

Allee, B. J. 1974. Spatial requirements and behavioral interactions of juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). Ph. D. Thesis. Univ. of Washington, Seattle, WA. 160 p.

Anderson, N. H. 1967. Biology and downstream drift of some Oregon Trichoptera. Can. Entomol. 99:507-521.

Armitage, K. B. 1961. Distribution of riffle insects of the Firehole River, Wyoming. Hydrobiologia 17:152-174.

Averett, R. O. 1969. Influence of temperature on energy and material utilization by juvenile coho salmon. Ph. D. Thesis. Oregon State Univ., Corvallis, OR. 74 p.

Bidgood, B. F. and A. H. Berst. 1969. Lethal temperatures for Great Lakes rainbow trout. J. Fish. Res. Board Can. 26:456-459.

Bisson, P. A. 1975. Elevated temperature and the production of juvenile chinook salmon (Oncorhynchus tshawytscha) in a model stream. Ph. D. Thesis. Oregon State Univ., Corvallis, OR. 80 p.

Bisson, P. A. and G. E. Davis. 1976. Production of juvenile chinook salmon, Oncorhynchus tshawytscha, in a heated model stream. Fish. Bull. 74(4):763-774.

Bott, T. L., J. T. Brock, C. E. Cushing, S. V. Gregory, D. King and R. C. Petersen. 1978. A comparison of methods for measuring primary productivity and community respiration in streams. Hydrobiologia. 60:3-12.

Brett, J. R. 1952. Temperature tolerance in young Pacific salmon, genus Oncorhynchus. J. Fish. Res. Board Can. 9:265-323.

Brett, J. R. 1971. Energetic responses of salmon to temperature. A study of some thermal relations in the physiology and freshwater ecology of sockeye salmon (Oncorhynchus nerka). Amer. Zool. 11:99-113.

Brett, J. R., J. E. Shelbourn and L. T. Shoop. 1969. Growth rate and body composition of fingerling sockeye salmon, Oncorhynchus nerka, in relation to temperature and ration size. J. Fish. Res. Board Can. 26(9):2363-2394.

Bustard, D. R. and D. W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). J. Fish. Res. Board Can. 32:667-680.

Cairns, J. Jr. and R. L. Kaesler. 1971. Cluster analysis of fish in a portion of the upper Potomac River. Trans. Am. Fish. Soc. 100:750-756.

Chapman, D. W. 1966. Food and space as regulators of salmonid populations in streams. Am. Nat. 100:345-357.

____________. 1967. Production in fish populations. p. 3-29. In S. D. Gerking (ed.). The biological basis of freshwater fish production. John Wiley & Sons. New York.

Cooley, W. W. and P. R. Lohnes. 1971. Multivariate data analysis. John Wiley & Sons, New York. 364 p.

Coutant, C. C. 1962. The effect of a heated water effluent upon the macroinvertebrate riffle fauna of the Delaware River. Proc. Pa. Acad. Sci. 36:58-71.

Coutant, C. C. and H. A. Pfuderer. 1974. Thermal effects. J. Wat. Poll. Contr. Fed. 46(6):1476-1540.

Cummins, K. W. 1974. Structure and function of stream ecosystems. Bioscience. 24(11):631-641.

Diamond, J. M. 1977. The population dynamics and reproductive strategy of the stream snail Oxytrema silicula (Gould) in relation to stream order. M. Sc. Thesis. Oregon State Univ., Corvallis, OR. 87 p.

Earnest, R. D. 1967. Production of the snail Oxytrema silicula in an experimental stream. M. Sc. Thesis. Oregon State Univ., Corvallis, OR. 61 p.

Elliott, J. M. 1970. Diel changes in invertebrate drift and the food of trout Salmo trutta L. J. Fish. Biol. 2:161-165.

Elliott, J. M. 1975. The growth rate of brown trout (Salmo trutta L.) fed on reduced rations. J. Anim. Ecol. 44:823-842.

Everson, L. B. 1973. Growth and food consumption of juvenile coho salmon exposed to natural and elevated fluctuating temperatures. M. Sc. Thesis. Oregon State Univ., Corvallis, OR. 68 p.

Fisher, R. A. 1958. The genetical theory of natural selection. Dover, New York. 291 p.

Fraser, F. J. 1969. Population density effects on survival and growth of juvenile coho salmon and steelhead trout in experimental stream channels. p. 253-256. In T. G. Northcote (ed). Symposium on salmon and trout in streams. Univ. British Columbia, Vancouver.

Hartman, G. F. 1965. The role of behavior in the ecology and interaction of underyearling coho salmon and steelhead trout. J. Fish. Res. Board Can. 22(4):1035-1081.

Hunt, R. L. 1969. Effects of habitat alteration on production, standing crops and yield of brook trout in Lawrence Creek, Wisconsin. p. 281-312. In T. G. Northcote (ed). Symposium on salmon and trout in streams. Univ. of British Columbia, Vancouver.

Hynes, H. B. N. 1970. The ecology of running waters. Univ. of Toronto Press. Toronto. 555 p.

Iverson, R. A. 1972. Effects of elevated temperature on juvenile coho salmon and benthic invertebrates in model stream communities. Ph. D. Thesis. Oregon State Univ., Corvallis, OR. 98 p.

Ivlev, V. S. 1945. The biological productivity of waters. Translated by W. E. Ricker. J. Fish Res. Bd. Can. 23:1707-1759.

Ivlev, V. S. 1961. Experimental ecology of the feeding of fishes. Translated by D. Scott. Yale Univ. Press, New Haven, CT. 302 p.

Kerst, C. D. and N. H. Anderson. 1974. Emergence patterns of Plecoptera in a stream in Oregon, U.S.A. Freshwater Biol. 4:205-212.

Langford, T. E. 1971. The distribution, abundance and life-histories of stoneflies (Plecoptera) and mayflies (Ephemeroptera) in a British river, warmed by cooling-water from a power station. Hydrobiologia 38:339-377.

Likens, G. E., F. H. Bormann, N. M. Johnson, D. W. Fisher and R. S. Pierce. 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed-ecosystem. Ecol. Monogr. 40:23-47.

Lindeman, R. L. 1942. The trophic dynamic aspect of ecology. Ecology. 24:399-418.

Meehan, W. R. and R. A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. J. Fish. Res. Board Can. 35(1):1359-1363.

Merritt, R. W. and K. W. Cummins (eds). 1978. An introduction to the aquatic insects of North America. Kendall/Hunt. Dubuque, IA. 441 p.

Patrick, R. J., Cairns, J. Jr., and S. S. Roback. 1967. An ecosystematic study of the fauna and flora of the Savannah River. Proc. Acad. Nat. Sci. Philadelphia. 118:109-407.

Peet, R. K. 1974. The measurement of species diversity. Ann. Rev. Ecol. Syst. 5:285-307.

Pianka, E. R. 1974. Evolutionary ecology. Harper and Row. New York. 356 p.

Pielou, E. C. 1966. Shannon's formula as a measure of specific diversity: its use and misuse. Am. Nat. 100:463-465.

Prosser, C. L. 1973. Comparative animal physiology. Saunders. Philadelphia. 966 p.

Raney, E. C., B. W. Menzel and E. C. Weller. 1974. Heated effluents and effects on aquatic life with emphasis on fishes: a bibliography. (Ichthyological Associates Bull. No. 9) (TID-3918) (U.S. Atomic Energy Commission). National Tech. Info. Serv., U.S. Dept. of Commerce, Springfield, VA. 651 p.

Richards, J. S. 1976. Changes in fish species composition in the Au Sable River, Michigan from the 1920's to 1972. Trans. Am. Fish Soc. 105(1):32-40.

Ruttner, F. 1963. Fundamentals of limnology. Translated by D. G. Frey and F. E. J. Fry. Univ. of Toronto Press, Toronto. 242 p.

Schoener, T. W. 1969. Optimal size and specialization in constant and fluctuating environments: an energy-time approach. Brookhaven Symposium Biol. 22:103-114.

__________. 1971. Theory of feeding strategies. Ann. Rev. Ecol. & Systematics. 2:369-404.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184. Ottawa, Ont. 966 p.

Shapas, T. J. and W. L. Hilsenhoff. 1976. Feeding habits of Wisconsin's predominant lotic Plecoptera, Ephemeroptera, and Trichoptera. Great Lakes Entomologist. 9(4):175-188.

Shirazi, M. A. and W. K. Seim. MS. Stream system criteria for monitoring spawning substrate. Workshop for developing stream criteria for salmonids. June 4-6, 1979. Salishan, OR. Sponsored by Corvallis Environmental Research Laboratory, Corvallis, OR. 25 p.

Smith, S. H. 1972. Factors of ecologic succession in oligotrophic fish communities of the Laurentian Great Lakes. J. Fish. Res. Board Can. 29:717-730.

Soldwedel, R. and A. B. Pile. 1968. The survival and growth of three strains of rainbow trout (<u>Salmo gairdneri</u>) under conditions of high natural temperatures with and without other fishes. New Jersey Dept. of Cons. & Econ. Development. Misc. Report 29. 10 p.

Spence, J. A. and H. B. N. Hynes. 1971. Differences in fish populations upstream and downstream of a mainstream impoundment. J. Fish. Res. Board Can. 28:45-46.

Tarzwell, C. M. 1939. Changing the Clinch River into a trout stream. Trans. Am. Fish. Soc. 68:228-233.

Ulfstrand, S. 1967. Microdistribution of benthic species (Ephemeroptera, Plecoptera, Trichoptera, Diptera:Simuliidae) in Lapland streams. Oikos 18:293-310.

Wagner, R. H. 1971. Environment and man. Norton. New York. 491 p.

Warren, C. E. and G. E. Davis. 1967. Laboratory studies on the feeding bioenergetics, and growth of fish. p. 175-214. In S. D. Gerking (ed). The biological basis of freshwater fish production. John Wiley & Sons. New York.

__________. 1971. Laboratory stream research: objectives, possibilities, and constraints. Ann. Rev. Ecol. & Systematics. 2:111-144.

Warren, C. E. and W. J. Liss. 1977. Design and evaluation of laboratory ecological system studies EPA-600/3-77-022. U.S. Environmental Protection Agency. Duluth, MN. 115 p.

Wilhm, J. L. and T. C. Dorris. 1968. Biological parameters for water quality criteria. Bioscience. 18:477-481.

Wurtsbaugh, W. A. and G. E. Davis. 1977. Effects of temperature and ration level on the growth and food conversion efficiency of Salmo gairdneri, Richardson. J. Fish. Biol. 11:87-98.

APPENDICES

Appendix I. Number (in parentheses) and masses (g) of taxa in the stomachs of juvenile steelhead trout (Stlhd) and coho salmon (Coho) in the control (C) and treatment (T) streams.

	19 June 1975		6-7 July 1975		27-28 July 1975		14-15 August 1975		4-5 Sept. 1975	
	Stlhd	Stlhd	Stlhd	Stlhd	Stlhd	Stlhd	Stlhd	Stlhd	Stlhd	Stlhd
	C	T	C	T	C	T	C	T	C	T
Annelida										
Limnodrilus sp.	(21).0072	---.0089	(2).0003	(7).0023				(1).0004		
Mollusca										
Gastropoda										
Gyraulus sp.		(32).0007	(6).0011	(1).0003		(4).0096	(22).0080	(25).0207	(2).0020	(15).0105
Physa sp.							(1).0002			
Ferrissia sp.			(50).01		(1).0001	(2).0002				
Juga plicifera			(1).0030							
Pelecypoda										
Pisidium sp.										
Arthropoda										
Ostracoda										
Herpetocypris chevreuxi	(5).0021	(69).0352	(7).0026	(21).0118	(45).0167	(104).0365	(85).0116	(40).0053	(111).0167	(33).0059
Isopoda										
Insecta										
Collembola										
Ephemeroptera	(5).0020	(3).0003	(11).0121		(1).0004		(2).0001	(5).0007	(13).0021	(1).0002
Baetis sp.				(1).0006						
Odonata										
Plecoptera										
Nemoura sp.	(4).0001	(2).0001	(4).0015						(1).0003	
Megaloptera										
Sialis sp.										
Trichoptera										
Agapetus sp.										
Hydroptila sp.	(1).0011	(10).0047	(4).0015	(4).0039	(4).0038	(12).0096	(4).0011	(3).0018	(6).0014	3).0010
Psychomyia sp.				(1).0121			(1).0000			
Polycentropus sp.										
Limnephilidae										
Lepidostoma sp.										
Coleoptera	(1).0001	(1).0010								
Diptera										
Limonia sp.			(1).0001				(1).0011	(2).0005		
Blephariceridae										
Dixa sp.										(2).0002
Simuliidae										
Chironomidae		(49).0022	(225).0381	(187).0286	(91).0122	(284).0498	(219).0076	(141).0066	(330).0106	(105).0042
Bezzia sp.		(5).0015		(1).0008	(2).0010					
Empididae				(1).0012						
Arachnida										
Hydracarina sp.				(2).0003			(1).0001	(1).0001	(1).0001	(1).0001
Terrestrials	(2).0057	(2).0087	(5).0074			(2).0021	(1).0001		(4).0008	(2).0007
Salmonidae								(1).0023		

Appendix I. (continued)

	25-26 Sept. 1975		16 October 1975		6 November 1975		25 November 1975		19 December 1975	
	Stlhd C	Stlhd T	Stlhd C	Stlhd T	Stlhd C	Stlhd T	Stlhd C	Stlhd T	Stlhd C	Stlhd T
Annelida										
Limnodrilus sp.		(1).0004	(12)---	(7)---	(3).0005	(5).0008	(1).0006	(1).0002	---.0054	---.0050
Mollusca										
Gastropoda										
Gyraulus sp.	(4).0018	(37).0351	(8).0081	(97).0925	(12).0117	(139).1177	(4).0092	(33).0785	(4).0019	(145).0456
Physa sp.					(1).0023					
Ferrissia sp.					(1).0044				(2).0015	
Juga plicifera			(5).0025	(3).0017	(10).0060	(11).0169	(10).0041	(9).0223	(1).0002	(13).0251
Pelecypoda										
Pisidium sp.										
Arthropoda										
Ostracoda										
Herpetocypris chevreuxi	(84).0148	(67).0135	(41).0071		(24).0039	(20).0034	(2).0003	(30).0045	(4).0008	(5).0001
Isopoda										
Insecta										
Collembola	(1).0001						(1).0002	(3).0004	(8).0007	
Ephemeroptera	(5).0003	(2).0004	(8).0016	(12).0022	(5).0023	(3).0008	(14).0038	(40).0063	(16).0050	(31).0085
Baetis sp.							(1).0004			
Odonata										
Plecoptera										
Nemoura sp.						(1).0004	(2).0002	(2).0001	(1).0001	(4).0004
Megaloptera										
Sialis sp.										
Trichoptera							(2).0003	(2).0002		(2).0003
Agapetus sp.										
Hydroptila sp.	(9).0032		(1).0003		(9).0040	(2).0007	(11).0035	(10).0032	(7).0028	(16).0073
Psychomyia sp.		(1).0064								
Polycentropus sp.										
Limnephilidae			(2).0273	(3).0111						
Lepidostoma sp.										
Coleoptera				(1).0006		(1).0011	(1).0024			
Diptera										
Limonia sp.				(2).0004			(1).0001			(2).0004
Blephariceridae								(1).0011		
Dixa sp.			(3).0004							
Simuliidae								(86).0450		(8).0037
Chironomidae	(181).0047	(64).0031	(191).0096	(61).0047	(37).0015	(61).0023	(56).0029	(66).0030	(10).0003	(38).0017
Bezzia sp.										
Empididae										
Arachnida										
Hydracarina sp.	(1).0001		(2).0001		(2).0001		(2).0001	(1).0001		
Terrestrials	(3).0005	(1).0026	(4).0016	(3).0006	(4).0018	(6).0021	(3).0078	(5).0014	(2).0039	
Salmonidae										

Appendix I. (continued)

	10 January 1976		2 March 1976		22 March 1976		10 April 1976		1 May 1976	
	Stlhd	Stlhd	Coho	Coho	Coho	Coho	Coho	Coho	Coho	Coho
	C	T	C	T	C	T	C	T	C	T
Annelida										
Limnodrilus sp.		---.0017		---.0003		(1).0001				
Mollusca										
Gastropoda										
Gyraulus sp.		(54).0153								
Physa sp.										
Ferrissia sp.										
Juga plicifera		(8).0148								
Pelecypoda										
Pisidium sp.										
Arthropoda										
Ostracoda										
Herpetocypris chevreuxi		(5).0005		(1).0001	(4).0008	(7).0012	(14).0025	(22).0034		(4).0007
Isopoda										
Insecta										
Collembola		(3).0005								
Ephemeroptera		(8).0041		(1).0001	(6).0030	(1).0002	(5).0029	(3).0041		
Baetis sp.										
Odonata										
Plecoptera										
Nemoura sp.					(1).0001		(1).0001			
Megaloptera										
Sialis sp.						(1).0014	(2).0052			(2).0071
Trichoptera					(1).0193					
Agapetus sp.										
Hydroptila sp.		(5).0024								(2).0008
Psychomyia sp.										
Polycentropus sp.										
Limnephilidae										
Lepidostoma sp.										
Coleoptera										
Diptera										
Limonia sp.		(1).0004								
Blephariceridae										
Dixa sp.										
Simuliidae		(1).0006								
Chironomidae		(15).0025		(10).0005	(11).0013	(9).0005	(82).0056	(39).0047		(509).0313
Bezzia sp.										
Empididae				(1).0001						
Arachnida										
Hydracarina sp.					(1).0001		(1).0001			
Terrestrials		(1).0091		(1).0001	(6).0026	(1).0001	(3).0010	(2).0017		
Salmonidae								(1).0021		

Appendix I. (continued)

	22 May 1976				11 June 1976			
	C		T		C		T	
	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho
Annelida								
<u>*Limnodrilus*</u> <u>sp</u>.				---.0018		---.0056		---.0015
Mollusca								
Gastropoda								
<u>*Gyraulus*</u> <u>sp</u>.				(1).0010	(6).0005	(4).0025	(3).0009	
<u>*Physa*</u> <u>sp</u>.								
<u>*Ferrissia*</u> <u>sp</u>.								
<u>*Juga plicifera*</u>						(1).0015		
Pelecypoda								
<u>*Pisidium*</u> <u>sp</u>.								
Arthropoda								
Ostracoda								
<u>*Herpetocypris*</u> <u>*chevreuxi*</u>		(18).0049	(2).0001	(20).0036	(3).0003	(9).0039	(103).0117	(190).0327
Isopoda								
Insecta								
Collembola								
Ephemeroptera		(4).0022		(2).0019				
<u>*Baetis*</u> <u>sp</u>.						(8).0046	(13).0020	(17).0017
Odonata								
Plecoptera		(3).0001						
<u>*Nemoura*</u> <u>sp</u>.				(1).0001		(6).0003		(1).0001
Megaloptera								
<u>*Sialis*</u> <u>sp</u>.								
Trichoptera				(1).0004				
<u>*Agapetus*</u> <u>sp</u>.						(1).0017		
<u>*Hydroptila*</u> <u>sp</u>.		(1).0002						(6).0020
<u>*Psychomyia*</u> <u>sp</u>.								(1).0001
<u>*Polycentropus*</u> <u>sp</u>.								
Limnephilidae								
<u>*Lepidostoma*</u> <u>sp</u>.								
Coleoptera							(1).0004	(1).0004
Diptera								
<u>*Limonia*</u> <u>sp</u>.					(1).0003	(1).0011	(3).0036	.0014
Blephariceridae								
<u>*Dixa*</u> <u>sp</u>.								
Simuliidae								
Chironomidae		(136).0074	(19).0010	(56).0042	(69).0026	(253).0105	(472).0267	(249).0167
<u>*Bezzia*</u> <u>sp</u>.		(1).0019		(2).0001			(10).0015	(2).0003
Empididae								
Arachnida								
<u>*Hydracarina*</u> <u>sp</u>.			(1).0005					(1).0001
Terrestrials		(13).0053		(22).0245		(4).0187		(10).0086
Salmonidae				(1).0066		(2).0141		

Appendix I. (continued)

	2 July 1976				20 July 1976			
	C		T		C		T	
	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho
Annelida								
Limnodrilus sp.	---.0008	---.0059	---.0031					
Mollusca								
Gastropoda								
Gyraulus sp.		(5).0106						(19).0153
Physa sp.								
Ferrissia sp.								
Juga plicifera		(1).0016						
Pelecypoda								
Pisidium sp.								
Arthropoda								
Ostracoda								
Herpetocypris chevreuxi	(14).0007	(13).0019	(64).0111	(93).0153	(50).0051	(63).0058	(29).0030	(70).0100
Isopoda								
Insecta								
Collembola								
Ephemeroptera	(7).0018	(11).0044	(4).0004	(3).0004				
Baetis sp.						(13).0016		(2).0001
Odonata								
Plecoptera								
Nemoura sp.						(2).0001		
Megaloptera								
Sialis sp.								
Trichoptera								
Agapetus sp.								
Hydroptila sp.			(3).0008		(1).0006		(3).0010	
Psychomyia sp.								
Polycentropus sp.								
Limnephilidae								
Lepidostoma sp.								
Coleoptera		(5).0020				(3).0013		
Diptera								
Limonia sp.								
Blephariceridae								
Dixa sp.								
Simuliidae		(1).0007						
Chironomidae	(458).0169	(84).0036	(406).0191	(263).0088	(208).0067	(123).0038	(200).0070	(70).0015
Bezzia sp.			(4).0004	(6).0007		(2).0002		(3).0004
Empididae								
Arachnida								
Hydracarina sp.								
Terrestrials		(5).0159		(1).0012				(1).0003
Salmonidae								

Appendix I. (continued)

	12 August 1976				2 Sept. 1976			
	C		T		C		T	
	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho
Annelida								
Limnodrilus sp.		---.0054						
Mollusca								
Gastropoda								
Gyraulus sp	(1).0003	(2).0025	(3).0019	(4).0031	(8).0097		(3).0028	
Physa sp.								
Ferrissia sp.								
Juga plicifera	(1).0028	(1).0036	(33).0112	(2).0003	(3).0021	(2).0091		
Pelecypoda								
Pisidium sp.								
Arthropoda								
Ostracoda								
Herpetocypris chevreuxi	(84).0162	(94).0369	(27).0043	(49).0087	(63).0114	(70).0152	(6).0006	(6).0010
Isopoda								
Insecta								
Collembola								
Ephemeroptera					(6).0019	(8).0016	(3).0009	(1).0010
Baetis sp.	(4).0004	(5).0012	(3).0001	(6).0009				
Odonata								
Plecoptera								
Nemoura sp.		(3).0005				(3).0018		
Megaloptera								
Sialis sp.								
Trichoptera								
Agapetus sp.								
Hydroptila sp.	(4).0018	(2).0009	(33).0099	(4).0006	(20).0047	(6).0013	(9).0028	(1).0001
Psychomyia sp.								
Polycentropus sp.								(1).0000
Limnephilidae								
Lepidostoma sp.								
Coleoptera		(3).0004						
Diptera								
Limonia sp.			(2).0009	(1).0001				(1).0006
Blephariceridae								
Dixa sp.								
Simuliidae				(1).0001				
Chironomidae	(612).0183	(201).0055	(321).0118	(87).0031	(598).0202	(129).0027	(104).0058	(31).0016
Bezzia sp.			(1).0001					
Empididae			(1).0001					
Arachnida								
Hydracarina sp.					(2).0001			
Terrestrials	(1).0004	(2).0006		(8).0120	(1).0001		(4).0038	(3).0018
Salmonidae								

Appendix I. (continued)

	24 Sept. 1976				14 October 1976			
	C		T		C		T	
	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho
Annelida								
Limnodrilus sp.							---.0022	---.0010
Mollusca								
Gastropoda								
Gyraulus sp.	(58).0191		(6).0047	(3).0022	(19).0110	(22).0073	(10).0075	(21).0106
Physa sp.								
Ferrissia sp.								
Juga plicifera	(4).0060	(4).0014	(1).0003	(2).0095	(5).0032	(138).0164	(6).0203	(4).0017
Pelecypoda								
Pisidium sp.					(1).0003			
Arthropoda								
Ostracoda								
Herpetocypris chevreuxi	(1).0019	(132) ?280	(12).0014	(20).0037	(18).0036	(25).0051		(19).0038
Isopoda								
Insecta								
Collembola			(1).0000		(1).0002	(1).0004	(1).0003	(1).0002
Ephemeroptera					(5).0009	(7).0010	(1).0004	(14).0058
Baetis sp.	(5).0009	(7).0016	(2).0005	(7).0011				
Odonata								
Plecoptera								
Nemoura sp.	(1).0004	(1).0003		(1).0001			(1).0001	
Megaloptera								
Sialis sp.								
Trichoptera	(1).0088							(3).0087
Agapetus sp.								
Hydroptila sp.	(6).0021	(3).0011	(3).0010		(8).0027	(1).0003	(1).0004	
Psychomyia sp.								
Polycentropus sp.								
Limnephilidae								
Lepidostoma sp.								
Coleoptera								
Diptera								
Limonia sp.				(2).0043				
Blephariceridae								
Dixa sp.								(1).0001
Simuliidae								
Chironomidae	(468).0184	(102).0026	(168).0076	(47).0016	(127).0066	(38).0013	(31).0072	(27).0017
Bezzia sp.								
Empididae								
Arachnida								
Hydracarina sp.		(1).0000						
Terrestrials		(1).0001		(1).0005	(1).0102			(4).0015
Salmonidae								

Appendix I. (continued)

	28-30 November 1976				18 December 1976			
	C		T		C		T	
	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho
Annelida								
Limnodrilus sp.	---.0267	---.0350	---.0006	---.0018		---.0082	---.0035	---.0012
Mollusca								
Gastropoda								
Gyraulus sp.	(33).0255	(17).0080	(23).0158	(15).0140	(80).0240	(29).0070	(25).0200	(2).0016
Physa sp.				(1).0004				
Ferrissia sp.								
Juga plicifera		(13).0030	(5).0053	(2).0092	(12).0024	(24).0046	(13).0191	(7).0048
Pelecypoda								
Pisidium sp.						(5).0026		
Arthropoda								
Ostracoda								
Herpetocypris chevreuxi	(4).0009				(6).0010			
Isopoda		(1).0001						
Insecta								
Collembola								
Ephemeroptera	(12).0023		(1).0001		(6).0028	(3).0008	(9).0020	(10).0026
Baetis sp.		(8).0020		(15).0033				
Odonata								
Plecoptera								
Nemoura sp.	(4).0056				(1).0019			(1).0006
Megaloptera								
Sialis sp.								
Trichoptera	(1).0004		(1).0005					
Agapetus sp.								
Hydroptila sp.	(15).0061	(1).0003	(1).0002	(2).0006	(5).0021			(1).0001
Psychomyia sp.								
Polycentropus sp.	(1).0002		(1).0001					
Limnephilidae								
Lepidostoma sp.				(2).0003				
Coleoptera				(1).0002				(1).0002
Diptera								
Limonia sp.								
Blephariceridae								
Dixa sp.				(1).0001				
Simuliidae					(1).0007		(1).0006	
Chironomidae	(21).0010	(19).0008	(5).0001	(25).0029	(7).0002	(30).0007	(14).0008	(11).0002
Bezzia sp.								
Empididae								
Arachnida								
Hydracarina sp.								
Terrestrials	(7).0056	(11).0101					(3).0005	(3).0024
Salmonidae								

Appendix I. (continued)

	8 January 1977 C		8 January 1977 T		27-29 January 1977 C		27-29 January 1977 T	
	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho	Stlhd	Coho
Annelida								
Limnodrilus *sp.*	---.0037	---.0086	---.0010	---.0025	---.0016		---.0054	---.0053
Mollusca								
Gastropoda								
Gyraulus *sp.*	(16).0055	(14).0160	(11).0090	(6).0044	(36).0120	(3).0014	(2).0008	(6).0048
Physa *sp.*								
Ferrissia *sp.*								
Juga plicifera	(4).0010	(3).0028	(6).0126	(3).0009	(20).0168	(31).0096	(4).0023	(2).0012
Pelecypoda								
Pisidium *sp.*								
Arthropoda								
Ostracoda								
Herpetocypris *chevreuxi*				(2).0004	(5).0011	(1).0001		(2).0004
Isopoda								
Insecta								
Collembola						(1).0002		
Ephemeroptera	(7).0025	(17).0061	(15).0078	(12).0028	(16).0065	(3).0006	(15).0050	(22).0061
Baetis *sp.*								
Odonata					(1).0004			
Plecoptera		(4).0029					(2).0017	(2).0002
Nemoura *sp.*			(3).0014	(1).0001				
Megaloptera								
Sialis *sp.*					(1).0047			(2).0027
Trichoptera								
Agapetus *sp.*								
Hydroptila *sp.*	(9).0044	(3).0011	(1).0002	(1).0004	(14).0073		(1).0005	(1).0004
Psychomyia *sp.*								
Polycentropus *sp.*				(2).0002				(2).0002
Limnephilidae								
Lepidostoma *sp.*								
Coleoptera								(1).0011
Diptera								
Limonia *sp.*								
Blephariceridae								
Dixa *sp.*				(3).0010				(3).0010
Simuliidae		(2).0009	(30).0020	(3).0013				(3).0013
Chironomidae	(8).0005	(15).0011	(12).0009	(6).0001	(39).0018	(29).0009	(13).0014	(20).0014
Bezzia *sp.*								
Empididae								
Arachnida								
Hydracarina *sp.*					(1).0002			
Terrestrials				(1).0034		(2).0009	(1).0005	(1).0034
Salmonidae								

Appendix II. Invertebrate numbers (in parentheses) and biomasses (in g /m^2) in the riffles of the control (C) and treatment (T) streams.

	27 February, March 1, 1975		22-23 March 1975		11-13 April 1975	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(14.1).0392	(55.7).1547	(11.6).0322	(226.2).6275	(12.6).0349	(3.3).0091
Mollusca						
Gastropoda						
Gyraulus sp.		(69).2366		(43).0185		(43.1).1457
Physa sp.						
Ferrissia sp.	(21.6).0482				(64.7).1810	
Juga plicifera	(51.7)9.6190	(86.2)22.2180	(11.5)2.7469	(659.4)139.7302	(224)42.0095	(495.7)68.7505
Pelecypoda						
Pisidium sp.				(12.9).0530		
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(4.3).0009	(43.1).0082				(8.6).0022
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum	(4.3).0228				(25.9).0802	
Epeorus nitidus	(17.2).1797				(47.4).6913	
Epeorus longimanus						
Ameletus sp.						
Paraleptophlebia temporalis				(4.3).0017	(17.2).0159	
Paraleptophlebia debilis						
Paraleptophlebia gregalis			(11.5).0023	(4.3).0022		
Ephemerella sp.				(4.3).0039		
Baetis tricaudatus	(69).0440	(12.9).0293	(23).0783	(17.2).0190	(30.2).0409	(8.6).0099
Baetis bicaudatus			(23).0679		(17.2).0789	(4.3).0078
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis						
Plecoptera						
Peltoperla brevis					(4.3).0138	
Nemoura sp	(12.9).0017		(149).0713	(4.3).0013	(112.).0771	(8.6).0001
Leuctra sp.						
Capnia sp.					(4.3).0026	
Brachyptera pacifica	(30.2).2043		(11.5).0035	(4.3).0155		
Pteronarcella regularis					(4.3).0004	(4.3).0172
Isogenus sp.				(4.3).0004	(4.3).0017	
Isoperla sp.						
Rickera sp.						
Alloperla sp.				(4.3).0004		(4.3).0001
Acroneuria sp.						
Megaloptera						
Sialis rotunda						
Sialis californica		(4.3).3918		(4.3).2664		(4.3).1440
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.						
Agapetus sp.						
Hydroptila sp.		(34.5).0315	(11.5).0035		(4.3).0052	(4.3).0040
Wormaldia sp.						
Psychomyia lumina			(23).0012		(4.3).0026	
Polycentropus sp.		(4.3).0013				
Parapsyche sp.						
Hydropsyche sp.						
Limnephilidae sp. 1			(23)2.6437		(4.3).5624	
Limnephilidae sp. 2						
Lepidostoma sp.					(4.3).0103	
Micrasema sp.						
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.		(12.9).0069		(43.1).0250	(4.3).0026	(8.6).0034
Diptera						
Holorusia sp.						
Dicranota sp.	(4.3).0022	(8.6).0116	(11.5).0104	(4.3).0147	(4.3).0138	
Limonia sp.						
Liriope sp.						
Blephariceridae	(4.3).0001					
Simuliidae	(4.3).0228	(38.8).0866	(23).0058			
Tanypodinae	(314.6).0250	(4.3).0017	(310.7).0184	(4.3).0125	(99.1).0142	(60.3).0440
Diamesinae						
Orthocladiinae	(1038.7).1728	(1297.3).2323	(632.9).1047	(176.7).0397	(474.1).1608	(625).3263
Chironominae	(409.5).0578		(1921.8).4051	(25.9).0009	(94.8).0401	(259).0190
Bezzia sp.	(17.2).0009	(4.3).0000	(34.4).0012	(12.9).0039	(43.1).0047	(4.3).0004
Empididae	(4.3).0009		(11.5).0035			(4.3).0043
Arachnida						
Hydracarina sp.	(73.3).0060	(56).0073	(91.7).0058	(38.8).0030	(99.1).0159	(38.8).0030

Appendix II. (continued)

	9-10 May 1975		May 30, 1 June 1975		23-24 June 1975	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(517.4)1.4352	(33.9).0940	(679.4)1.8848	(422.3)1.1715	(1135.7)3.1506	(63.7).1767
Mollusca						
Gastropoda						
Gyraulus sp.	(17.2).1241	(4.3).0159	(4.3).0116	(12.9).0457	(43.1).3189	
Physa sp.						
Ferrissia sp.	(47.4).1004		(21.6).0659			
Juga plicifera	(262.9)49.1986	(521.5)120.2500	(107.8)27.7659	(396.5)55.7757	(176.7)32.7516	(767.2)103.1600
Pelecypoda						
Pisidium sp.				(4.3).0129		
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(17.2).0091	(8.6).0034	(73.3).0340	(168.1).0470	(86.2).0603	(801.7).5880
Insecta						
Collembola				(4.3).0004		
Ephemeroptera						
Cinygma integrum	(8.6).0409		(21.6).1491			
Epeorus nitidus	(17.2).4319	(4.3).0004	(17.2).0879			
Epeorus longimanus						
Ameletus sp.						
Paraleptophlebia temporalis	(4.3).0056					
Paraleptophlebia debilis				(8.6).0009		
Paraleptophlebia gregalis		(30.2).0797				
Ephemerella sp.						
Baetis tricaudatus	(21.6).0642		(181).1621	(4.3).0009	(25.9).0535	(30.2).0260
Baetis bicaudatus	(4.3).0263			(4.3).0004		
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis		(8.6)1.4895				
Plecoptera						
Peltoperla brevis						
Nemoura sp.	(69).0233	(228.4).0879	(120.7).0573	(73.3).0207	(47.4).0461	(17.2).0134
Leuctra sp.						
Capnia sp.			(4.3).0009			
Brachyptera pacifica						
Pteronarcella regularis	(4.3).0091	(4.3).0034	(12.9).0288	(12.9).0392	(4.3).2396	(8.6).0732
Isogenus sp.		(4.3).2586				
Isoperla sp.	(4.3).0362	(4.3).0362	(4.3).0069			
Rickera sp.						
Alloperla sp.	(4.3).0013		(4.3).0022			(4.3).0043
Acroneuria sp.						
Megaloptera						
Sialis rotunda						
Sialis californica						
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.						
Agapetus sp.						
Hydroptila sp.	(8.6).0134	(5.6).0901	(17.2).0190	(125).1162	(215.3).1681	(340.5).4788
Wormaldia sp.						
Psychomyia lumina	(4.3).0116	(8.6).0198				
Polycentropus sp.			(8.6).1159	(4.3).0672	(4.3).0052	
Parapsyche sp	(4.3).1190					
Hydropsyche sp.						
Limnephilidae sp. 1	(4.3).0543		(21.6)1.9550	(8.6)1.3751	(17.2)2.1269	(25.9)3.1622
Limnephilidae sp. 2						
Lepidostoma sp.					(4.3).0543	
Micrasema sp.						
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.	(8.6).0052	(25.9).0134	(4.3).0025	(12.9).0961	(8.6).0146	(4.3).0013
Diptera						
Holorusia sp.						
Dicranota sp.	(4.3).0034		(8.6).0017	(4.3).0013	(4.3).0052	(38.8).2025
Limonia sp.						
Liriope sp.	(4.3).1384		(4.3).1371		(12.9).2819	
Blephariceridae						
Simuliidae	(8.6).0047	(8.6).0323	(8.6).0220	(81.9).0091	(8.6).0052	(12.9).0315
Tanypodinae	(271.5).0297	(293.1).0095	(349).0168	(69).0116	(517.2).1681	(155.2).0259
Diamesinae						
Orthocladiinae	(284.5).0673	(693.9).3099	(375).0828	(672.4).2077	(12369.7).2844	(3370.4)1.1396
Chironominae	(306.0).0767	(8.6).0013	(69).0108	(81.9).0184		(129.3).0457
Bezzia sp.	(21.6).0082	(77.6).0306	(81.9).0297	(34.5).0112	(4.3).0017	(8.6).0013
Empididae	(4.3).0022		(4.3).0013		(8.6).1603	
Arachnida						
Hydracarina sp.	(103.4).0151	(60.3).0116	(107.8).0129	(60.3).0073	(560.3).0819	(250).0448

Appendix II. (continued)

	13-14 July 1975		4 August 1975		25-26 August 1975	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(7.8).0216	(62.1).1724	(466.1)1.293	(35.7).0991	(160).4439	(20.2).0560
Mollusca						
Gastropoda						
Gyraulus sp.		(43.1).0603	(17.2).0802	(21.6).0500	(4.3).0078	
Physa sp.					(4.3).0017	
Ferrissia sp.	(4.3).0254					
Juga plicifera	(357.7)96.7207	(849.1)174.719	(150.8)31.5392	(422.4)80.5797	(168.1)24.7031	(525.8)78.4851
Pelecypoda						
Pisidium sp.	(43).5991		(21.6).2422	(4.3).0116		
Arthropoda						
Ostracoda						
Herpetocyrpis chevreuxi		(732.7).3922	(90.5).0405	(17.2).0099	(948.2).2241	(258.6).0474
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum	(4.3).0017					
Epeorus nitidus	(4.3).0147					
Epeorus longimanus						
Ameletus sp.						
Paraleptophlebia temporalis						
Paraleptophlebia debilis						
Paraleptophlebia gregalis						
Ephemerella sp.						
Baetis tricaudatus	(103.4).0737	(4.3).0082	(64.7).0603		(112.1).0703	(4.3).0078
Baetis bicaudatus	(21.6).0026		(17.2).0026	(4.3).0009	(25.9).0017	(43.1).0043
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis						
Plecoptera						
Peltoperla brevis						
Nemoura sp.	(81.9).0211	(4.3).0026	(12.9).0078		(8.6).0009	
Leuctra sp.						
Capnia sp.						
Brachyptera pacifica						
Pteronarcella regularis	(8.6).0198	(4.3).0146				
Isogenus sp.						
Isoperla sp.						
Rickera sp.						
Alloperla sp.			(4.3).0047			
Acroneuria sp.						
Megaloptera						
Sialis rotunda						
Sialis californica	(4.3).2664					
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.						
Agapetus sp.						
Hydroptila sp.	(43.1).0129	(129.3).0733	(8.6).0082	(64.6).0651	(86.2).0043	(129.3).0430
Wormaldia sp.						
Psychomyia lumina						
Polycentropus sp.			(4.3).0004			
Parapsyche sp.			(4.3).0091			
Hydropsyche sp.			(4.3).0095			
Limnephilidae sp. 1	(12.9).9973	(4.3).4913	(34.5)1.4123	(4.3).6258	(12.9).4870	
Limnephilidae sp. 2						
Lepidostoma sp.						
Micrasema sp.						
Heteroplectron californicum						(4.3).0844
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.			(12.9).0091	(8.6).0056	(4.3).0004	
Diptera						
Holorosia sp.						
Dicranota sp.	(4.3).0129			(12.9).0495	(43.1).0172	
Limonia sp.			(17.2).0263			
Liriope sp.						
Blephariceridae						
Simuliidae	(8.6).0026				(8.6).0022	(8.6).0043
Tanypodinae	(474.1).0517	(172.4).0129	(129.3).0129	(172.4).0216	(474.1).0216	(129.3).0086
Diamesinae		(344.8).0819				
Orthocladiinae	(5258.2)1.5085	(1120.6).2543	(1508.5).2414	(3146.3)1.0560	(3965.2).1681	(3448).1250
Chironominae	(431).0042					
Bezzia sp.				(43.1).0086		
Empididae	(8.6).0030					(43.1).0043
Arachnida						
Hydracarina sp.	(818.9).1509	(43.1).0043	(12.9).0017	(4.3).0009	(689.6).0560	(387.9).0172

Appendix II. (continued)

	15 Sept. 1975		7 October 1975		28 October 1975	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(1).0004	(2.5).0069		(1.1).0030		(1).0026
Mollusca						
Gastropoda						
Gyraulus sp.		(125).0853			(4.3).0047	(64.7).1030
Physa sp.						
Ferrissia sp.	(38.8).0969		(4.3).0262		(21.6).0612	(4.3).0116
Juga plicifera	(206.9)30.5104	(646.5)74.6750	(241.4)39.2470	(806)89.0833	(150.9)17.8166	(517.2)61.4515
Pelecypoda						
Pisidium sp.						
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(34.5).0069	(146.5).0328			(4.3).0001	
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum						
Epeorus nitidus					(4.3).0022	
Epeorus longimanus						
Ameletus sp.						
Paraleptophlebia temporalis					(8.6).0017	
Paraleptophlebia debilis					(4.3).0009	
Paraleptophlebia gregalis						
Ephemerella sp.						
Baetis tricaudatus	(56).0103	(8.6).0004	(56).0297	(21.6).0099	(43.1).0483	(43.1).0159
Baetis bicaudatus	(4.3).0004					(4.3).0001
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis						
Plecoptera						
Peltoperla brevis			(4.3).0047		(8.6).0060	
Nemoura sp.			(17.2).0069		(17.2).0034	
Leuctra sp.						
Capnia sp.						
Brachyptera pacifica						
Pteronarcella regularis			(4.3).0374			(4.3).0094
Isogenus sp.	(4.3).0056					
Isoperla sp.						
Rickera sp.						
Alloperla sp.					(4.3).0009	
Acroneuria sp.						
Megaloptera						
Sialis rotunda						
Sialis californica						
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.					(4.3).0103	
Agapetus sp.						
Hydroptila sp.		(4.3).0004	(12.9).0052		(77.6).0349	(12.9).0082
Wormaldia sp.			(12.9).0082			(4.3).0030
Psychomyia lumina						
Polycentropus sp.						
Parapsyche sp.			(4.3).0091			(4.3).0004
Hydropsyche sp.						
Limnephilidae sp. 1	(4.3).0793	(12.9).2236		(4.3).1172		
Limnephilidae sp. 2						
Lepidostoma sp.						
Micrasema sp.	(4.3).0017		(4.3).0047		(8.6).0091	
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.	(4.3).0603					
Diptera						
Holorusia sp.						
Dicranota sp.						
Limonia sp.						
Liriope sp.						
Blephariceridae						
Simuliidae					(8.6).0001	(12.9).0001
Tanypodinae	(34.5).0013	(4.3).0004	(21.6).0013	(8.6).0004	(232.7).0080	(56).0030
Diamesinae			(34.5).0009			
Orthocladiinae	(418.1).0103	(99.1).0056	(90.5).0056	(112.1).0039	(25.9).0001	(25.9).0001
Chironominae						
Bezzia sp.						
Empididae						
Arachnida						
Hydracarina sp.	(60.3).0030	(34.5).0022	(56).0022	(12.9).0004	(129.3).0047	(60.3).0013

Appendix II. (continued)

	18 November 1975		11 December 1975		5-6 January 1976	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(4.5).0125	(102.9).2853	(2.3).0065	(30).0832	(10.3).0284	(6.4).0177
Mollusca						
Gastropoda						
Gyraulus sp.		(38.8).0142		(172.4).1345	(12.9).0121	(25.9).0069
Physa sp.						
Ferrissia sp.	(4.3).0245		(4.3).0047		(34.5).0461	
Juga plicifera	(125)21.9012	(633.6)65.2030	(198.3)30.0928	(1064.6)117.7798	(219.8)35.4821	(913.7)110.2667
Pelecypoda						
Pisidium sp.		(4.3).0022				
Archropoda						
Ostracoda						
Herpetocypris chevreuxi	(215.5).0043	(64.6).0108	(47.4).0091	(112.1).0142	(60.34).0125	
Insecta						
Collembola				(12.9).0017		(4.3).0004
Ephemeroptera						
Cinygma integrum	(4.3).0009		(4.3).0039	(8.6).0013	(4.3).0009	(17.2).0039
Epeorus nitidus			(8.6).2613	(8.6).0019	(17.2).0246	(4.3).0001
Epeorus longimanus						
Ameletus sp.			(17.2).0069			
Paraleptophlebia temporalis			(17.2).0073		(21.6).0078	(4.3).0009
Paraleptophlebia debilis						
Paraleptophlebia gregalis				(4.3).0009		(4.3).0004
Ephemerella sp.						
Baetis tricaudatus	(43.1).0259	(150.9).0323	(362).1556	(112.1).0624	(862).4176	(150.9).0866
Baetis bicaudatus		(60.3).0026		(18.6).0017	(21.6).0017	(17.2).0022
Centroptilum sp.				(4.3).0008		
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis						
Plecoptera						
Peltoperla brevis	(4.3).0073				(34.5).0543	
Nemoura sp.	(4.3).0022	(4.3).0039	(12.9).0190	(8.6).0004	(69).0500	(8.6).0004
Leuctra sp.						
Capnia sp.						
Brachyptera pacifica					(43.1).0099	
Pteronarcella regularis	(4.3).0758		(4.3).0823		(17.2).4409	
Isogenus sp.						
Isoperla sp.						
Rickera sp.					(12.9).0046	
Alloperla sp.						
Acroneuria sp.						
Megaloptera						
Sialis rotunda						
Sialis californica						
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.						
Agapetus sp.						
Hydroptila sp.	(69).0453	(25.9).0172	(68.9).0405	(25.9).0190	(129.3).0763	(43.1).0289
Wormaldia sp.	(4.3).0022	(8.6).0022	(12.9).0052	(17.2).0078	(12.9).0047	
Psychomyia lumina						
Polycentropus sp.		(21.6).0121	(4.3).0004	(4.3).0013	(4.3).0056	
Parapsyche sp					(4.3).0022	(4.3).0009
Hydropsyche sp.						
Limnephilidae sp. 1						
Limnephilidae sp. 2						
Lepidostoma sp.					(4.3).0202	
Micrasema sp.			(4.3).0069		(30.2).0798	
Heteroplectron californicum				(4.3).0008	(4.3).0935	(4.3).1038
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Clepteimis sp.					(4.3).0017	
Diptera						
Holorusia sp.						
Dicranota sp.			(4.3).0013	(4.3).0004	(4.3).0017	
Limonia sp.						
Liriope sp.						
Blephariceridae					(4.3).0026	
Simuliidae		(12.9).0013	(17.2).0030	(17.2).0047	(103.4).0177	(8.6).0034
Tanypodinae	(77.6).0043	(25.9).0022	(137.9).0091	(21.6).0013	(150.9).0052	(21.6).0009
Diamesinae					(47.4).0039	
Orthocladiinae		(17.2).0026	(168.1).0116	(81.9).0030	(107.8).0052	(116.4).0030
Chironominae				(8.6).0017		
Bezzia sp.			(4.3).0001	(12.9).0004	(12.9).0004	
Empididae						
Arachnida						
Hydracarina sp.	(646.5).0034	(4.3).0001	(137.9).0065	(64.7).0026	(112.1).0047	(34.5).0017

Appendix II. (continued)

	21-23 January 1976		9-13 February 1976		4-5 March 1976	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(16.3).0453	(5.7).0159	(18.5).0513	(3.3).0091	(62.1).0172	(1.4).0039
Mollusca						
Gastropoda						
Gyraulus sp.	(21.6).0259)	(12.9).0168	(30.2).0856	(4.3).0069	(4.3).0072	(12.9).0129
Physa sp.						
Ferrissia sp.	(21.6).0396				(4.3).0034	
Juga plicifera	(150.9)17.0339	(823.2)71.3510	(150.9)25.7354	(849.1)119.0800	(133.6)22.6249	(1310.2)153.6
Pelecypoda						
Pisidium sp.			(4.3).0030			(4.3).0017
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(103.4).0172		(1435.2).3133	(8.6).0017	(56).0129	(4.3).0009
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum						(21.6).0254
Epeorus nitidus	(4.3).0272	(8.6).0543	(8.6).0353			
Epeorus longimanus					(4.3).0017	(4.3).0095
Ameletus sp.					(4.3).0138	
Paraleptophlebia temporalis	(21.6).0078				(4.3).0009	
Paraleptophlebia debilis						
Paraleptophlebia gregalis						
Ephemerella sp.			(4.3).0013		(4.3).0004	
Baetis tricaudatus	(422.4).2500	(51.7).0332	(366.4).2586	(73.3).0720	(310).3141	(47.4).0703
Baetis bicaudatus	(25.9).0022	(8.6).0013	(12.9).0039	(17.2).0017	(47.4).0211	(12.9).0004
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis						
Plecoptera						
Peltoperla brevis	(4.3).0091		(8.6).0190			(8.6).0241
Nemoura sp.	(64.7).0142	(30.2).0034	(4.3).0004	(64.7).0034	(12.9).0060	(12.9).0004
Leuctra sp.					(4.3).0004	
Capnia sp.						
Brachyptera pacifica	(56).0401		(51.7).0634		(30.2).0069	
Pteronarcella regularis				(4.3).0883		
Isogenus sp.						
Isoperla sp.						
Rickera sp.		(4.3).0034		(4.3).0194	(8.6).0056	
Alloperla sp.					(8.6).0082	
Acroneuria sp.					(4.3).0004	
Megaloptera						
Sialis rotunda						
Sialis californica						
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.					(4.3).0159	
Agapetus sp.						
Hydroptila sp.	(69).0414	(21.6).0138	(60.3).0353	(21.6).0151	(8.6).0522	(8.6).0047
Wormaldia sp.	(4.3).0004	(4.3).0017				
Psychomyia lumina						
Polycentropus sp.	(4.3).0065	(4.3).0001		(4.3).0009		(12.9).0034
Parapsyche sp.	(4.3).0043	(4.3).0008		(4.3).0116		
Hydropsyche sp.						
Limnephilidae sp. 1					(4.3).0001	
Limnephilidae sp. 2						(21.6).1340
Lepidostoma sp.			(4.3).0009		(4.3).0009	
Micrasema sp.						
Heteroplectron californicum	(4.3).0857		(4.3).0827		(8.6).1737	
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.					(4.3).0013	(8.6).0039
Diptera						
Holorusia sp.						
Dicranota sp.	(8.6).0001				(8.6).0009	(4.3).0026
Limonia sp.						
Liriope sp.						
Blephariceridae						
Simuliidae	(77.6).0280	(43.1).0134	(112.1).0569	(47.4).0155	(4.3).0004	
Tanypodinae	(137.9).0116	(8.6).0009	(69).0056	(21.6).0073	(137.9).0068	(17.2).0013
Diamesinae	(107.8).0073	(12.9).0004				
Orthocladiinae	(142.2).0099	(81.9).0039	(116.4).0125	(103.4).0177	(689.6).0530	(25.9).0086
Chironominae		(73.3).0030		(60.3).0047		(30.2).0026
Bezzia sp.	(12.9).0004	(12.9).0004			(8.5).0001	(4.3).0001
Empididae	(4.3).0004					
Arachnida						
Hydracarina sp.	(43.1).0017	(21.6).0009	(81.9).0034	(25.9).0022	(198.3).0095	(21.6).0017

Appendix II. (continued)

	24-26 March 1976		16-17 April 1976		6-7 May 1976	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(4.5).0125	(2.9).0082		(1.4).0039	(29.7).0823	(159).4422
Mollusca						
Gastropoda						
Gyraulus sp.	(4.3).0043	(4.3).0043			(17.2).0500	(38.8).0793
Physa sp.			(4.3).2676			
Ferrissia sp.		(12.9).0241				
Juga plicifera	(280.2)52.5005	(1081.8)117.6260	(168.1)28.6688	(1086.1)94.9484	(228.4)32.0207	(1267)121.0355
Pelecypoda						
Pisidium sp.						(4.3).0043
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi		(12.9).0034			(336.6).0734	(206.9).0474
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum	(4.3).0004			(17.2).0284		
Epeorus nitidus		(8.6).0198			(4.3).0073	
Epeorus longimanus						
Ameletus sp.						
Paraleptophlebia temporalis		(4.3).0017	(17.2).0172			
Paraleptophlebia debilis						(8.6).0026
Paraleptophlebia gregalis						
Ephemerella sp.						
Baetis tricaudatus	(206.9).2207	(60.3).0509	(47.4).0513		(56).0431	(60.3).0647
Baetis bicaudatus	(38.8).0315	(8.6).0069	(17.2).0151	(12.9).0095	(8.6).0095	
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis						
Plecoptera						
Peltoperla brevis	(8.6).0211		(21.6).0703	(8.6).0177	(8.6).0470	
Nemoura sp.	(51.7).0112	(12.9).0022	(121.9).0122	(12.9).0026	(61.2).0245	(189.6).0065
Leuctra sp.						
Capnia sp.						
Brachyptera pacifica	(4.3).0099	(4.3).0116				
Pteronarcella regularis	(4.3).0823		(12.9).5473		(4.3).2198	(4.3).2379
Isogenus sp.			(4.3).0775			
Isoperla sp.						
Rickera sp.						
Alloperla sp.						
Acroneuria sp.	(8.6).1948					
Megaloptera						
Sialis rotunda						
Sialis californica						
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.						
Agapetus sp.					(21.6).1689	(4.3).0353
Hydroptila sp.	(12.9).0073					(60.3).0259
Wormaldia sp.	(4.3).0043			(4.3).0013	(61.2).0031	(4.3).0001
Psychomyia lumina						
Polycentropus sp.						(17.2).0250
Parapsyche sp			(4.3).0521	(4.3).0319		
Hydropsyche sp.						
Limnephilidae sp. 1						
Limnephilidae sp. 2		(12.9).0913				
Lepidostoma sp.			(61.9).0122	(4.3).0017		
Micrasema sp.					(4.3).0013	
Heteroplectron californicum				(4.3).0413	(4.3).0612	
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.	(8.6).0043	(8.6).0034	(4.3).0026			(8.6).0453
Diptera						
Holorusia sp.						
Dicranota sp.	(4.3).0009					
Limonia sp.						
Liriope sp.						
Blephariceridae						
Simuliidae	(25.9).0052	(4.3).0004				
Tanypodinae	(155.2).0121			(17.2).0017	(4.3).0039	(17.2).0034
Diamesinae						
Orthocladiinae	(1715.4).1078	(73.3).0082	(16637.6).0802	(349.1).0388	(4865.6).2938	(51.7).0082
Chironominae		(4.3).0009				
Bezzia sp.	(4.3).0001		(60.9).0001	(12.9).0022		(25.9).0026
Empididae					(30.6).0092	
Arachnida						
Hydracarina sp.	(163.8).0078	(8.6).0013	(25.9).0013		(61.2).0031	

Appendix II. (continued)

	27-28 May 1976 C	27-28 May 1976 T	14 June 1976 C	14 June 1976 T	27 June 1976 C	27 June 1976 T
Annelida						
Limnodrilus sp.	(67.8).1880	(26.6).0739	(9.3).0258	(1.4).0040	(26.6).0739	(79.9).2216
Mollusca						
Gastropoda						
Gyraulus sp.	(12.9).0741		(123.5).0722	(11.5).0034	(12.9).0246	(86.2).0608
Physa sp.						
Ferrissia sp.			(49.4).0372			
Juga plicifera	(301.7)33.3033	(1724)136.6959	(2223.6)105.0443	(2046.4)209.6731	(155.2)19.3975	(2198.1)102.3950
Pelecypoda						
Pisidium sp.						(4.3).1052
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(201.5).0671	(470.1).0537	(345.9).0103	(378.3).0757	(90.5).0190	(56).0142
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum			(98.8).0258			
Epeorus nitidus			(49.4).0017			
Epeorus longimanus						
Ameletus sp.						
Paraleptophlebia temporalis						
Paraleptophlebia debilis					(4.3).0004	(4.3).0017
Paraleptophlebia gregalis						
Ephemerella sp.						
Baetis tricaudatus	(47.4).0414		(889.4).0676	(183.4).0745	(60.3).0336	(250).1194
Baetis bicaudatus	(4.3).0060				(4.3).0004	
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis		(4.3).2741				
Plecoptera						
Peltoperla brevis				(5.7).0011		
Nemoura sp.	(335.8).0403	(67.2).0269	(1087.1).0246	(34.4).0040	(60.3).0116	(34.5).0052
Leuctra sp.						
Capnia sp.						
Brachyptera pacifica						
Pteronarcella regularis			(24.7).0057		(21.6).0387	
Isogenus sp.						
Isoperla sp.						
Rickera sp.	(4.3).0121				(4.3).0306	
Alloperla sp.						
Acroneuria sp.						
Megaloptera						
Sialis rotunda						
Sialis californica						
Dymiscohermes sp.			(24.7)2.0578			
Trichoptera						
Rhyacophila sp.						
Agapetus sp.						
Hydroptila sp.	(25.9).0151	(4.3).0034	(24.7).0017	(17.2).0069	(38.8).0267	(224).1052
Wormaldia sp.	(4.3).0013				(4.3).0022	(4.3).0026
Psychomyia lumina						
Polycentropus sp.		(21.6).0263				
Parapsyche sp					(4.3).0392	
Hydropsyche sp.						
Limnephilidae sp. 1	(34.5).7046	(8.6).4103	(98.8).1926	(11.5).0871	(4.3).0525	(4.3).0517
Limnephilidae sp. 2						
Lepidostoma sp.	(4.3).0012	(8.6).0060				
Micrasema sp.						
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.			(24.7).0023			
Diptera						
Holorusia sp.						
Dicranota sp.						
Limonia sp.						
Liriope sp.	(4.3).0216	(4.3).0198				
Blephariceridae						
Simuliidae				(11.5).0029		(4.3).0026
Tanypodinae	(21.6).0026		(3557.7).0332	(504.4).0344	(1343).1544	(805.8).0336
Diamesinae						
Orthocladiinae	(1477.3).1477	(4566.2).0224	(5138.9).0355	(768.1).0676	(2014.5).0537	(10072).6177
Chironominae					(873).0537	(201.5).0067
Bezzia sp.			(98.8).0023	(23).0040	(8.6).0017	
Empididae				(5.7).0006	(8.6).0009	(4.3).0009
Arachnida						
Hydracarina sp.			(49.4).0011	(5.7).0006	(8.6).0009	(8.6).0017

Appendix II. (continued)

	21 July 1976		11 August 1976		1 Sept. 1976	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(798.3)2.2145	(359.6).9977	(133.9).3713		(66.1).1834	(65.4).1815
Mollusca						
Gastropoda						
Gyraulus sp.			(30.2).1060	(43.1).0440	(64.7).2965	(116.4).1237
Physa sp.						
Ferrissia sp.			(4.3).0103			
Juga plicifera	(318.9)45.9497	(573.2)55.3464	(331.9)31.9565	(1413.7)111.7755	(482.7)71.0369	(2732.5)208.0350
Pelecypoda						
Pisidium sp.	(44.7).0895		(4.3).0185			
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(7158.1).8455	(2236.9).1521	(2236.9).5100		(313.2).0536	(21.6).0034
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum						
Epeorus nitidus						
Epeorus longimanus						
Ameletus sp.						
Paraleptophlebia temporalis						
Paraleptophlebia debilis						
Paraleptophlebia gregalis						
Ephemerella sp.						
Baetis tricaudatus	(38.8).0116	(21.6).0043	(47.4).0138	(8.6).0009	(94.8).0371	(12.9).0022
Baetis bicaudatus						
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						(4.3).0351
Octogomphus specularis						
Plecoptera						
Peltoperla brevis					(4.3).0009	
Nemoura sp.	(44.7).1029		(21.6).0112	(8.6).0017	(25.9).0065	(12.9).0022
Leuctra sp.						
Capnia sp.						
Brachyptera pacifica						
Pteronarcella regularis		(4.3).0172		(4.3).0116		
Isogenus sp.						
Isoperla sp.						
Rickera sp.						
Alloperla sp.						
Acroneuria sp.						
Megaloptera						
Sialis rotunda		(12.9).0052				
Sialis californica						
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.						
Agapetus sp.						
Hydroptila sp.		(30.2).0133	(94.8).0560	(30.2).0078	(268.4).0626	(30.2).0095
Wormaldia sp.						(4.3).0004
Psychomyia lumina						
Polycentropus sp.		(8.6).0216			(4.3).0078	
Parapsyche sp						
Hydropsyche sp.						
Limnephilidae sp. 1	(30.2).3857		(8.6).1815			
Limnephilidae sp. 2				(17.2).1560		(12.9).1176
Lepidostoma sp.			(4.3).0193	(4.3).0012		
Micrasema sp.						
Heteroplectron californicum					(4.3).0538	
Coleoptera						
Lara sp.						
Heterlimnius sp.					(4.3).0009	(8.6).0039
Cleptelmis sp.	(12.9).0026		(21.6).0073	(4.3).0013		(4.3).0017
Diptera						
Holorusia sp.						
Dicranota sp.		(8.6).0026	(25.9).0116	(4.3).0009		
Limonia sp.			(8.6).0034			
Liriope sp.						
Blephariceridae						
Simuliidae		(25.9).0056	(4.3).0013	(12.9).0095		
Tanypodinae	(1163.2).0089	(44.7).0001	(357.9).0134		(581.6).0089	(4.3).0004
Diamesinae	(4.3).0052	(4.3).0043				
Orthocladiinae	(1968.5).0984	(2371.1).1208	(4250.1).2058	(671.1).0313	(2460.1).0582	(21.6).0013
Chironominae	(939.5).0537	(268.4).0580	(492.1).0134	(357.9).0134	(357.9).0045	(30.2).0013
Bezzia sp.	(44.7).0045					
Empididae	(44.7).0045					
Arachnida						
Hydracarina sp.	(313.2).0224		(8.6).0004			

Appendix II. (continued)

	22 Sept. 1976		10 October 1976		31 October 1976	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(81.7).2267	(2.2).0060	(10.3).0284		(67.6).1875	(12.1).0336
Mollusca						
Gastropoda						
Gyraulus sp.	(25.9).0293	(8.6).0039	(12.9).0069	(47.4).0401	(69).0948	(17.2).0207
Physa sp.	(8.6).0043				(4.3).0030	
Ferrissia sp.		(4.3).0025		(8.6).0103	(12.9).0340	(25.9).0237
Juga plicifera	(474.1)25.2543	(1060.3)118.992	(245.7)22.9710	(1202.5)121.6756	(530.1)30.4367	(1487)120.4662
Pelecypoda						
Pisidium sp.	(64.6).1689					
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(594.8).1345	(4.3).0009	(51.7).0099	(8.6).0009	(34.5).0078	(4.3).0004
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum			(4.3).0022			(8.6).0017
Epeorus nitidus			(12.9).0022	(8.6).0022		(4.3).0004
Epeorus longimanus						
Ameletus sp.						
Paraleptophlebia temporalis	(8.6).0009		(4.3).0013		(25.9).0060	
Paraleptophlebia debilis						
Paraleptophlebia gregalis						
Ephemerella sp.						
Baetis tricaudatus	(275.8).1009	(107.8).0504	(142.2).0470	(90.5).0401	(138).0629	(64.7).0259
Baetis bicaudatus	(34.5).0026		(17.2).0013	(21.6).0013	(25.9).0022	
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis						
Plecoptera						
Peltoperla brevis			(25.9).0052			(4.3).0013
Nemoura sp.	(25.9).0129	(25.9).0039	(4.3).0060	(4.3).0009	(21.6).0164	(21.6).0078
Leuctra sp.						
Capnia sp.						
Brachyptera pacifica						
Pteronarcella regularis					(4.3).0237	
Isogenus sp.		(4.3).0017				
Isoperla sp.						
Rickera sp.						
Alloperla sp.						
Acroneuria sp.						
Megaloptera						
Sialis rotunda					(4.3).0806	
Sialis californica		(4.3).0030				
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.						
Agapetus sp.						
Hydroptila sp.	(94.8).0293	(30.2).0091	(60.3).0138	(4.3).0026	(172.4).0647	(17.2).0108
Wormaldia sp.	(4.3).0065			(4.3).0001		(4.3).0004
Psychomyia lumina						
Polycentropus sp.					(12.9).0013	
Parapsyche sp						
Hydropsyche sp.						
Limnephilidae sp. 1					(4.3).1055	
Limnephilidae sp. 2						
Lepidostoma sp.	(12.9).1077					
Micrasema sp.						(4.3).0013
Heteroplectron californicum					(17.2).3232	
Coleoptera						
Lara sp.						(4.3).0284
Heterlimnius sp.		(8.6).0022	(4.3).0013		(21.6).0375	
Cleptelmis sp.	(34.5).0121					
Diptera						
Holorusia sp.						
Dicranota sp.	(8.6).0009		(4.3).0001			
Limonia sp.	(8.6).0147					
Liriope sp.				(4.3).0047		
Blephariceridae						
Simuliidae		(17.2).0022				
Tanypodinae	(146.5).0043	(43.1).0017	(306).0091	(112.1).0043	(353.4).0121	(47.4).0022
Diamesinae						
Orthocladiinae	(500).0250	(211.2).0168	(146.5).0121	(112.1).0095		(4.3).0009
Chironominae	(258.6).0207	(185.3).0082	(129.3).0047	(172.4).0099	(172.4).0108	(38.8).0125
Bezzia sp.			(4.3).0001		(4.3).0004	
Empididae						
Arachnida						
Hydracarina sp.	(17.2).0009		(8.6).0004	(12.9).0004	(12.9).0001	(4.3).0001

Appendix II. (continued)

	26 November 1976		16 December 1976		4 January 1977	
	C	T	C	T	C	T
Annelida						
Limnodrilus sp.	(46.6).0129	(1.6).0043	(18).0499	(1).0013	(84.7).2349	(5.4).0151
Mollusca						
Gastropoda						
Gyraulus sp.	(4.3).0147	(17.2).0198	(8.6).0194	(12.9).0138	(25.9).0414	
Physa sp.						
Ferrissia sp.				(12.9).0116		
Juga plicifera	(340.5)60.1284	(1810.2)137.562	(176.7)26.3341	(1655)92.3395	(573.2)41.1070	(1387.8)117.8306
Pelecypoda						
Pisidium sp.					(4.3).0043	
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(30.2).0060	(4.3).0004	(44.3).0013		(133.6).0306	
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum	(17.2).0030	(12.9).0043				(4.3).0172
Epeorus nitidus	(8.6).0017	(12.9).0091	(4.3).0013	(4.3).0004	(8.6).0073	(12.9).0030
Epeorus longimanus	(8.6).0017					
Ameletus sp.		(4.3).0001		(4.3).0004		(8.6).0017
Paraleptophlebia temporalis	(34.5).0095		(43.1).0159	(4.3).0009	(8.6).0030	
Paraleptophlebia debilis						
Paraleptophlebia gregalis						
Ephemerella sp.						
Baetis tricaudatus	(103.4).0315	(206.9).0582	(168.1).0703	(366.4).2064	(275.8).1099	(250).0896
Baetis bicaudatus	(107.8).0078	(181).0091	(25.9).0022	(21.6).0017	(56).0078	(112.1).0056
Centroptilum sp.						
Odonata						
Cordulegaster dorsalis						
Octogomphus specularis						
Plecoptera						
Peltoperla brevis	(8.6).0086		(4.3).0091		(4.3).0047	
Nemoura sp.	(116.4).1009	(4.3).0026	(94.8).1280	(8.6).0060	(25.9).0198	(17.2).0078
Leuctra sp.						
Capnia sp.						
Brachyptera pacifica					(21.6).0060	
Pteronarcella regularis	(17.2).2917		(8.6).1465		(4.3).0737	
Isogenus sp.						
Isoperla sp.						
Rickera sp.			(12.9).0073			
Alloperla sp.						
Acroneuria sp.						
Megaloptera						
Sialis rotunda						
Sialis californica						
Dymiscohermes sp.						
Trichoptera						
Rhyacophila sp.						
Agapetus sp.						
Hydroptila sp.	(168.1).0664	(4.3).0022	(349).1827	(21.6).0112	(125).0677	(4.3).0047
Wormaldia sp.	(25.9).0164		(34.5).0336		(8.6).0039	(4.3).0013
Psychomyia lumina						
Polycentropus sp.			(4.3).0129			
Parapsyche sp						
Hydropsyche sp.			(4.3).0013			
Limnephilidae sp. 1						
Limnephilidae sp. 2						
Lepidostoma sp.						
Micrasema sp.	(4.3).0052		(4.3).0026	(12.9).0172		
Heteroplectron californicum	(4.3).1168	(4.3).0603				
Coleoptera						
Lara sp.			(4.3).0238			
Heterlimnius sp.		(8.6).0026	(4.3).0060	(4.3).0013		
Cleptelmis sp.						
Diptera						
Holorusia sp.	(4.3).9611					
Dicranota sp.			(4.3).0013			(4.3).0004
Limonia sp.						
Liriope sp.						
Blephariceridae						
Simuliidae	(34.5).0022	(86.2).0168	(47.4).0108	(125).0384	(56).0203	(90.5).0198
Tanypodinae	(107.8).0034	(30.2).0022	(228).0099	(43.1).0030	(94.8).0052	(25.9).0043
Diamesinae						
Orthocladiinae			(21.6).0009		(90.5).0056	(8.6).0022
Chironominae	(90.5).0060	(21.6).0013	(176.7).0177	(17.2).0090	(349.1).0323	(142.2).0116
Bezzia sp.						
Empididae						
Arachnida						
Hydracarina sp.	(12.9).0009	(8.6).0004				

Appendix II. (continued)

	24-26 January 1977	
	C	T
Annelida		
Limnodrilus sp.	(95.6).0155	(1.6).0043
Mollusca		
Gastropoda		
Gyraulus sp.	(8.6).0082	
Physa sp.		
Ferrissia sp.		(4.3).0064
Juga plicifera	(168)13.2373	(1262.8)89.0823
Pelecypoda		
Pisidium sp.		
Arthropoda		
Ostracoda		
Herpetocypris chevreuxi	(4.3).0009	
Insecta		
Collembola		
Ephemeroptera		
Cinygma integrum		(17.2).0198
Epeorus nitidus		(17.2).0375
Epeorus longimanus		
Ameletus sp.	(4.3).0008	
Paraleptophlebia temporalis	(4.3).0030	(8.6).0043
Paraleptophlebia debilis		
Paraleptophlebia gregalis		
Ephemerella sp.		
Baetis tricaudatus	(159.5).0845	(517.2).1978
Baetis bicaudatus	(56).0039	(94.8).0060
Centroptilum sp.		
Odonata		
Cordulegaster dorsalis		
Octogomphus specularis		
Plecoptera		
Peltoperla brevis		
Nemoura sp.	(30.2).0272	(8.6).0001
Leuctra sp.		
Capnia sp.		
Brachyptera pacifica	(25.9).0073	
Pteronarcella regularis		
Isogenus sp.		
Isoperla sp.		
Rickera sp.	(4.3).0043	
Alloperla sp.		
Acroneuria sp.		
Megaloptera		
Sialis rotunda		
Sialis californica		
Dymiscohermes sp.		
Trichoptera		
Rhyacophila sp.		
Agapetus sp.		
Hydroptila sp.	(73.3).0474	
Wormaldia sp.	(4.3).0013	(8.6).0065
Psychomyia lumina		
Polycentropus sp.		
Parapsyche sp.		
Hydropsyche sp.		
Limnephilidae sp. 1		
Limnephilidae sp. 2		
Lepidostoma sp.		
Micrasema sp.		
Heteroplectron californicum	(4.3).1314	(4.3).0737
Coleoptera		
Lara sp.		
Heterlimnius sp.	(21.6).0069	
Cleptelmis sp.		
Diptera		
Holorusia sp.		
Dicranota sp.	(43).0001	
Limonia sp.		
Liriope sp.		
Blephariceridae		
Simuliidae	(30).0030	(69).0224
Tanypodinae	(306).0259	(8.6).0004
Diamesinae		
Orthocladiinae	(21.6).0026	
Chironominae	(47.4).0009	(112).0060
Bezzia sp.		
Empididae		
Arachnida		
Hydracarina sp.	(8.6).0013	

Appendix III. Invertebrate numbers (in parentheses) and biomasses (in g/m^2) in the pools of the control (C) and treatment (T) streams.

	8-9 March 1975		30 March 1975		16-18 April 1975	
	C	T	C	T	C	T
Nematoda						
Annelida						
Limnodrilus sp.	(4861.2)27.6391	(3333)9.1278	(722.2)3.5111	(4250)25.6224	(5277.8)74.5005	(5027.8)44.8614
Mollusca						
Gastropoda						
Gyraulus sp.	(194.4).3666	(111).3416	(166.6).7305	(2777.8)8.4306	(27.7).1138	(416.6)1.4222
Physa sp.						
Ferrissia sp.	(55.5).2027		(194.4).8777		(27.7).1055	
Juga plicifera	(111)16.0667	(111)2.8528	(972.2)165.9735	(1527.8)101.8508	(194.4)30.5002	(444)64.4171
Pelecypoda						
Pisidium sp.	(1222.2)9.6750	(305.5)2.3527	(83.3).3444	(555.5)5.5167	(1194.4)9.5972	(361)4.8444
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(472.2).2111	(277.7).1777	(194.4).1083	(55.5).0001	(27.7).0027	
Isopoda						
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum			(27.7).0222			(27.7).4666
Epeorus nitidus						
Ameletus sp.	(27.7).0138					
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis	(27.7).0444					
Paraleptophlebia debilis						
Paraleptophlebia gregalis				(27.7).2361		
Baetis tricaudatus						
Odonata						
Octogomphus specularis						
Plecoptera						
Nemoura sp.	(27.7).0027		(83.3).0250			
Brachyptera pacifica	(55.5).0055	(27.7).0916				
Isogenus sp.						
Isoperla sp.						(27.7).0694
Rickera sp.						
Alloperla sp.						
Megaloptera						
Sialis rotunda						
Sialis californica	(83.3)3.7305	(111)4.7917		(222)9.8500	(55.5)1.8222	(111)6.3250
Trichoptera						
Agapetus sp.						
Hydroptila sp.			(27.7).0333			
Psychomyia lumina						
Polycentropus sp.	(27.7).0360	(27.7).0944	(138.8).0216	(27.7).1305	(83.3).5916	(27.7).2611
Limnephilidae sp. 1			(27.7).2638	(27.7)2.4000	(666.6)28.3752	(55.5)3.4389
Lepidostoma sp.	(27.7).0083				(55.5).0722	
Micrasema sp.	(27.7).1083					
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.		(27.7).0111		(55.5).0250		
Diptera						
Dicranota sp.						
Limonia sp.						
Liriope sp.	(333.3)10.8584		(27.7)1.0805	(55.5).5583	(194.4)11.4612	(27.7)1.2055
Dixa sp.						
Simuliidae						
Tanypodinae	(138.8).1722	(55.5).0611	(138.8).4666		(250).7444	(111).0500
Diamesinae	(27.7).0001					
Chironominae	(1277.7).4055	(83.3).0333	(138.8).0416			
Orthocladiinae	(500).2666			(55.5).0001	(83.3).0611	(694.4).5138
Bezzia sp.	(55.5).0056	(83.3).0055		(27.7).0083		(27.7).0027
Arachnida						
Hydracarina sp.	(111).0111		(27.7).0027			

Appendix III. (continued)

	12 May 1975 C	12 May 1975 T	4-6 June 1975 C	4-6 June 1975 T	26 June 1975 C	26 June 1975 T
Nematoda						
Annelida						
Limnodrilus sp.	(3027.8)22.8335	(1027.7)2.3972	(3083.4)29.4446	(1611)12.0278	(250)1.4777	(2083.3)11.2862
Mollusca						
Gastropoda						
Gyraulus sp.	(388.8).6250	(250)1.3250	(55.5).5472	(388.8)2.0972	(333.3)3.1944	(611)1.3000
Physa sp.						
Ferrissia sp.			(27.7).1694		(111)1.5944	
Juga plicifera	(222.2)27.8891	(750)40.3003	(333.3)63.7505	(1833)77.6395	(361)60.4171	(916.6)164.4179
Pelecypoda						
Pisidium sp.	(55.5).3138		(694.4)7.5306	(27.7).2583		(472)4.7055
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi		(27.7).0055	(611).3500	(861).7111		(1416.6).8666
Isopoda						
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum						
Epeorus nitidus						
Ameletus sp.						
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis						
Paraleptophlebia debilis			(55.5).3583			
Paraleptophlebia gregalis	(55.5).3000		(55.5).5222			
Baetis tricaudatus						
Odonata						
Octogomphus specularis					(27.7).2722	
Plecoptera						
Nemoura sp.						
Brachyptera pacifica						
Isogenus sp.						
Isoperla sp.						
Rickera sp.						
Alloperla sp.						
Megaloptera						
Sialis rotunda						
Sialis californica						
Trichoptera						
Agapetus sp.						
Hydroptila sp.						(1944.4).3333
Psychomyia lumina						
Polycentropus sp.	(111).8250		(27.7).3722	(27.7).2305		
Limnephilidae sp. 1				(83.3)9.6000	(27.7)1.2638	
Lepidostoma sp.						(55.5).4527
Micrasema sp.						
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.						
Diptera						
Dicranota sp.						
Limonia sp.						
Liriope sp.	(27.7)1.0222				(27.7).2250	
Dixa sp.					(27.7).1944	
Simuliidae						
Tanypodinae	(194.4).5638	(27.7).0972	(83.3).1277	((27.7).0555		
Diamesinae						
Chironominae						(555.5).1388
Orthocladiinae	(444.4).1694		(55.5).0055	(138.8).0972		(1666.6).2777
Bezzia sp.	(35.5).0393		(55.5).0277			(55.5).3694
Arachnida						
Hydracarina sp.		(27.7).0277				

Appendix III. (continued)

	17 July 1975		8 August 1975		29 August 1975	
	C	T	C	T	C	T
Nematoda						
Annelida						
Limnodrilus sp.	(5000)41.667	(5555.6)23.4724	(222).6361	(5277.8)39.2500	(4444)4.7778	(6944.5)6.0556
Mollusca						
Gastropoda						
Gyraulus sp.		(7777.8)13.8890	(416.6)2.9778	(7611)11.6945	(277.7).1388	(2500)2.5555
Physa sp.						
Ferrissia sp.	(27.7).1111		(27.7).1166			
Juga plicifera	(250)41.4586	(194.4)18.6057	(361)56.0115	(444.4)77.2283	(111)9.6917	(388.8)22.4279
Pelecypoda						
Pisidium sp.	(1500)15.1306	(1027.7)12.7501	(27.7).2666	(388.8)3.3361	(250).4583	(833.3)2.8889
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(277.7).2222	(6111.1)2.5000	(83.3).0638	(833.3).5277	(305.5).0527	
Isopoda						
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum						
Epeorus nitidus						
Ameletus sp.						
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis						
Paraleptophlebia debilis		(27.7).0500				
Paraleptophlebia gregalis						
Baetis tricaudatus						
Odonata						
Octogomphus specularis						
Plecoptera						
Nemoura sp.						
Brachyptera pacifica						
Isogenus sp.						
Isoperla sp.						
Rickera sp.						
Alloperla sp.						
Megaloptera						
Sialis rotunda	(111).4111	(277.7)2.6666	(27.7).2305		(27.7).2055	(111).6583
Sialis californica				(83.3).2805	(138.8).2805	(27.7).1416
Trichoptera						
Agapetus sp.						
Hydroptila sp.				(27.7).0138	(55.5).0250	
Psychomyia lumina				(27.7).9027		
Polycentropus sp.	(27.7).6944					
Limnephilidae sp. 1						
Lepidostoma sp.						
Micrasema sp.						
Heteroplectron californicum	(27.7).6166					
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.						
Diptera						
Dicranota sp.						
Limonia sp.		(27.7).0138				
Liriope sp.						(27.7).0305
Dixa sp.						
Simuliidae						
Tanypodinae		(555.5)2.6666	(27.7).1472	(55.5).4250		(83.3).1111
Diamesinae	(277)2.7500			(27.7).1333		
Chironominae				(111.1).0416	(55.5).0166	(27.7).0027
Orthocladiinae	(4444)2.6944	(4444.4)1.2777		(222.2).0750		
Bezzia sp.						
Arachnida						
Hydracarina sp.						

Appendix III. (continued)

	19 Sept. 1975		9 October 1975		30 October 1975	
	C	T	C	T	C	T
Nematoda						
Annelida						
Limnodrilus sp.	(888.8).6333	(1583.3)1.0166	(5555)3.2500	(6944.5)5.4722	(7694.5)3.4639	(2861).7333
Mollusca						
Gastropoda						
Gyraulus sp.		(12694.5)11.6250	(55.5).1166	(55.5).0500	(527.7).8583	(2805.5)2.9305
Physa sp.						
Ferrissia sp.		(55.5).1555			(55.5).1444	
Juga plicifera	(222.2)30.8113	(1055.5)68.3033	(388.8)36.9640	(111)7.5306	(194.4)4.2583	(1777.7)21.3001
Pelecypoda						
Pisidium sp.		(361).6333	(172.2)4.9194	(250).6000	(111).3472	(805.5)1.5666
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi		(55.5).0138	(5833).8333		(638.8).1472	(55.5).0083
Isopoda						
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum						
Epeorus nitidus						
Ameletus sp.						
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis						
Paraleptophlebia debilis				(27.7).0194		
Paraleptophlebia gregalis					(27.7).0055	
Baetis tricaudatus						
Odonata						
Octogomphus specularis					(13.8).2180	
Plecoptera						
Nemoura sp.					(27.7).0388	
Brachyptera pacifica						
Isogenus sp.						
Isoperla sp.						
Rickera sp.						
Alloperla sp.						
Megaloptera						
Sialis rotunda		(55.5).4750	(111).8083	(111)1.3138		
Sialis californica	(27.7).0888		(55.5).2972		(55.5).2166	(27.7).3916
Trichoptera						
Agapetus sp.						
Hydroptila sp.					(27.7).0138	
Psychomyia lumina						
Polycentropus sp.						
Limnephilidae sp. 1						
Lepidostoma sp.						
Micrasema sp.						
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.						(55.5).0222
Diptera						
Dicranota sp.						
Limonia sp.						
Liriope sp.						
Dixa sp.						
Simuliidae						
Tanypodinae						
Diamesinae						
Chironominae						(27.7).0027
Chironominae						
Orthocladiinae						
Bezzia sp.						
Arachnida						
Hydracarina sp.						

Appendix III. (continued)

	21 November 1975		9 December 1975		7-8 January 1976	
	C	T	C	T	C	T
Nematoda						
Annelida						
Limnodrilus sp.	(527.7).5111	(6944.5)5.9167	(1361)1.0111	(3583.4)3.4750	(108).3722	(1261.8)4.3333
Mollusca						
Gastropoda						
Gyraulus sp.	(55.5).0527	(2777.8).9722	(27.7).0138	(4222.2)1.5166		
Physa sp.					(27.7).0527	
Ferrissia sp.	(27.7).0722		(194.4).6527			
Juga plicifera	(55.5)14.4556	(1583.3)134.1117		(4527.8)233.7296	(277.7)34.1197	(222.2)15.3333
Pelecypoda						
Pisidium sp.	(166.6).2694	(1944.4)3.3055	(305.5).7138	(166.6)1.3027	(305.5).3416	(888.8)1.3666
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(83.3).0138		(83.3).0166	(83.3).0027	(1055.5).1472	(611).3888
Isopoda						
Insecta						
Collembola			(55.5).0138			
Ephemeroptera						
Cinygma integrum					(27.7).1472	
Epeorus nitidus						
Ameletus sp.						
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis						
Paraleptophlebia debilis						
Paraleptophlebia gregalis						
Baetis tricaudatus						
Odonata						
Octogomphus specularis						
Plecoptera						
Nemoura sp.			(55.5).0360			
Brachyptera pacifica						
Isogenus sp.						
Isoperla sp.	(27.7).0638	(27.7).0666		(27.7).0250	(27.7).1583	
Rickera sp.						
Alloperla sp.					(27.7).0750	
Megaloptera						
Sialis rotunda	(55.5).4666	(27.7).2722	(27.7).1777			(83.3)1.2583
Sialis californica	(83.3)1.1555	(83.3).7972		(27.7).3916	(27.7).3972	(83.3)1.1111
Trichoptera						
Agapetus sp.						
Hydroptila sp.	(27.7).0166			(27.7).0027	(27.7).0138	
Psychomyia lumina						
Polycentropus sp.						
Limnephilidae sp. 1						
Lepidostoma sp.						
Micrasema sp.						
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.						
Diptera						
Dicranota sp.						
Limonia sp.						
Liriope sp.	(27.7).0833		(27.7).1194			
Dixa sp.						
Simuliidae						
Tanypodinae					(27.7).0138	
Diamesinae						
Chironominae			(83.3).0083			(222.2).0416
Orthocladiinae					(55.5).0305	
Bezzia sp.						
Arachnida						
Hydracarina sp.					(27.7).0001	

Appendix III. (continued)

	16 January 1976		6 February 1976		3 March 1976	
	C	T	C	T	C	T
Nematoda						
Annelida						
Limnodrilus sp.	(630.1)2.1639	(452.9)1.5555	(478)1.6416	(829.9)2.8500	(491)1.6861	(734.4)2.5222
Mollusca						
Gastropoda						
Gyraulus sp.	(1000).7000	(277.7).2333	(194.4).2500	(222.2).1500	(305.5).3833	(27.7).0277
Physa sp.						
Ferrissia sp.	(83.3).1972					
Juga plicifera	(277.7)36.2975	(1750)60.0635	(166.6)26.514	(1722.2)242.8000	(55.5)3.3721	(111)58.9643
Pelecypoda						
Pisidium sp.	(27.7).0527	(500).4472	(1305.5)1.9305	(611.1).9110	(555.5)1.6694	(1083)1.7444
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(444.4).0972	(55.5).0083	(1361.1).2861	(1833.3).2722	(1027.7).2388	(222.2).0361
Isopoda	(83.3).2250					
Insecta						
Collembola	(55.5).0111					
Ephemeroptera						
Cinygma integrum			(27.7).1333			
Epeorus nitidus	(27.7).0500					
Ameletus sp.	(27.7).0277					
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis			(55.9).0222			
Paraleptophlebia debilis						
Paraleptophlebia gregalis					(27.7).0027	
Baetis tricaudatus			(27.7).0222	27.7).0138		
Odonata						
Octogomphus specularis						
Plecoptera						
Nemoura sp.						
Brachyptera pacifica						
Isogenus sp.						
Isoperla sp.						
Rickera sp.						
Alloperla sp.	(55.5).1222		(27.7).0444			
Megaloptera						
Sialis rotunda					(27.7).5055	(27.7).3444
Sialis californica		(55.5).5722	(83.3).8194		(27.7).4166	(27.7).4027
Trichoptera						
Agapetus sp.						
Hydroptila sp.	(27.7).0194	(27.7).0138	(83.3).0611	(55.5).0277	(27.7).0111	(27.7).0166
Psychomyia lumina						
Polycentropus sp.						
Limnephilidae sp. 1	(55.5).1916	(27.7).0250		(111).5805		
Lepidostoma sp.				(55.5).0361		
Micrasema sp.						
Heteroplectron californicum						(27.7).0361
Coleoptera						
Lara sp.						(27.7).0472
Heterlimnius sp.						
Cleptelmis sp.						(27.7).0555
Diptera						
Dicranota sp.						
Limonia sp.						
Liriope sp.		(27.7).1305		(55.5).2611		(55.5).3694
Dixa sp.						
Simuliidae						
Tanypodinae	(27.7).0001	(27.7).0001	(27.7).0111	(555.5).1888	(138.8).0500	(194.4).0388
Diamesinae	(55.5).0027					
Chironominae	(83.3).0083	(27.7).0001	(138.8).0166	(2277.7).5111	(555.5).0416	(555.5).1250
Orthocladiinae	(83.3).0027				(55.5).0001	(166.6).0001
Bezzia sp.					(27.7).0027	
Arachnida						
Hydracarina sp.						

Appendix III. (continued)

	21-23 March 1976		12-14 April 1976		3-5 May 1976	
	C	T	C	T	C	T
Nematoda					(27.7).0194	
Annelida						
Limnodrilus sp.	(957.7)3.2889	(854.9)2.9333	(1284.5)4.4111	(1193.1)4.0972	(1001.4)3.4389	(673)2.3111
Mollusca						
Gastropoda						
Gyraulus sp.	(166.6).2722	(333.3).4277	(888.8)1.4166	(55.5).0472	(555.5)1.9222	
Physa sp.						
Ferrissia sp.						
Juga plicifera	(250)64.156	(1388.9)69.7838	(27.7)4.2694	(2000)23.5973	(333.3)11.3444	(750)13.2945
Pelecypoda						
Pisidium sp.	(2000)3.9333	(1444.4)2.4500	(55.5).1388	(1055.5)2.0027	(777.7)1.4222	(1500)4.7833
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(5666.7)1.1111	(1166.6).2000	(944.4).1277	(138.8).0361	(2277.7).5333	(388.8).0666
Isopoda						
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum		(27.7).0083				(55.5).2333
Epeorus nitidus						
Ameletus sp.						
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis						
Paraleptophlebia debilis		(27.7).0055		(55.5).0138	(27.7).0194	
Paraleptophlebia gregalis	(55.5).0055					
Baetis tricaudatus	(27.7).0001					
Odonata						
Octogomphus specularis						
Plecoptera						
Nemoura sp.						
Brachyptera pacifica	(55.5).0277					
Isogenus sp.						
Isoperla sp.						
Rickera sp.						
Alloperla sp.		(27.7).0527				
Megaloptera						
Sialis rotunda	(83.3)1.3277	(111)1.1333	(27.7).2694			
Sialis californica	(27.7).0138	(27.7).0833	(83.3)1.6972		(55.5)5.4440	
Trichoptera						
Agapetus sp.					(27.7).0805	
Hydroptila sp.						
Psychomyia lumina						
Polycentropus sp.						
Limnephilidae sp.	1(111)5.2778	(111)2.1055			(55.5)1.7361	
Lepidostoma sp.	(194.4).1305	(111).0444	(27.7).0555	(27.7).0138	(55.5).0055	
Micrasema sp.		(27.7).0388				
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.		(55.5).0222				
Diptera						
Dicranota sp.						
Limonia sp.						
Liriope sp.	(27.7).1166		(27.7).1472		(55.5).3166	
Dixa sp.						
Simuliidae						
Tanypodinae		(333.3).1333	(166.6).0888	(222.2).1777	(222.2).0500	(250).2583
Diamesinae						
Chironominae	(500).1166	(888.8).1277	(500).1277	(305.5).0527	(111).0166	(166.6).0222
Orthocladiinae	(111).0333			(27.7).0027		
Bezzia sp.			(27.7).0001			
Arachnida						
Hydracarina sp.	(111).0166					

Appendix III. (continued)

	24-26 May 1976 C	24-26 May 1976 T	13 June 1976 C	13 June 1976 T	30 June-1 July 1976 C	30 June-1 July 1976 T
Nematoda						
Annelida						
Limnodrilus sp.	(569.4)1.9555	(972.2)3.3389	(805.4)2.766	(1121.1)3.8500	(1310.4)4.5000	(757.1)2.6000
Mollusca						
Gastropoda						
Gyraulus sp.	(638.8)2.1444	(333.3).1888	(444.4)1.2222	(666.6).6111	(1944.4)5.7111	(861).6222
Physa sp.						
Ferrissia sp.	(55.5).2666				(55.5).1944	
Juga plicifera	(333.3)20.4556	(2250)47.3808	(305.5)8.2111	(805.5)33.5002	(527.7)50.6586	(1694.4)45.4586
Pelecypoda						
Pisidium sp.	(333.3).3722	(1000)1.9833	(555.5).7944	(2444.4)4.5555	(83.3).1611	(750)1.625
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(888.8).1444	(6722.2)1.0666	(666.6).1666	(4333.3).8333	(7333)1.2972	(3777.8).7611
Isopoda						
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum						
Epeorus nitidus						
Ameletus sp.						
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis						
Paraleptophlebia debilis			(27.7).0055	(111).1055	(55.5).0166	(55.5).0694
Paraleptophlebia gregalis	(55.5).1194	(111).1083				
Baetis tricaudatus						
Odonata						
Octogomphus specularis						
Plecoptera						
Nemoura sp.			(55.5).0083		(27.7).0055	(55.5).0277
Brachyptera pacifica						
Isogenus sp.						
Isoperla sp.						
Rickera sp.						
Alloperla sp.						
Megaloptera						
Sialis rotunda						
Sialis californica	(27.7).2194		(55.5).6944			
Trichoptera						
Agapetus sp.						
Hydroptila sp.				(27.7).0138		(27.7).0250
Psychomyia lumina						
Polycentropus sp.				(27.7).0500		
Limnephilidae sp. 1						
Lepidostoma sp.	(27.7).0166	(166.6).2666	(27.7).2027	(83.3).0861	(166.6).5250	(222.2).2166
Micrasema sp.						
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.						
Diptera						
Dicranota sp.						
Limonia sp.						
Liriope sp.						
Dixa sp.						
Simuliidae						
Tanypodinae	(194.4).1833	(55.5).0527	(138.8).1250		(250).2888	(111).1722
Diamesinae						
Chironominae	(55.5).0111	(222.2).0166	(111).0166	(444.4).0555	(83.3).0055	(277.7).0305
Orthocladiinae	(166.6).0111			(55.5).0333	(27.7).0027	(111).0083
Bezzia sp.						(27.7).0027
Arachnida						
Hydracarina sp.	(55.5).0001					

Appendix III. (continued)

	22 July 1976		9 August 1976		31 August 1976	
	C	T	C	T	C	T
Nematoda						
Annelida						
Limnodrilus sp.	(3283.)11.2739	(184.4).6333	(100.2).3444	(186.8).6416	(179.5).6166	(92.1).3166
Mollusca						
Gastropoda						
Gyraulus sp.	(576.6)1.5281	(288.3).3748	(638.8)1.5139	(83.3).1222	(194.4).6194	(611.1).7222
Physa sp.			(27.7).0222			
Ferrissia sp.	(288.3).6055					
Juga plicifera	(138.8)2.400	(1000)36.3114	(250)1.7444	(805.5).4333	(500)4.2139	(527.7)18.5473
Pelecypoda						
Pisidium sp.	(1153.3)1.9606	(2595)3.3158	(111).1583	(138.8).1583	(138.8).1916	(1277.7)1.7722
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(40367)8.0157	(4901.7)1.0091	(1277.7).2944	(166.6).0416	(777.7).1500	(166.6).0444
Isopoda						
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum						
Epeorus nitidus						
Ameletus sp.						
Paraleptophlebia bicornuta					(27.7).0388	
Paraleptophlebia temporalis						
Paraleptophlebia debilis	(27.7).0250		(27.7).0361		(27.7).0111	(27.7).0388
Paraleptophlebia gregalis						
Baetis tricaudatus						
Odonata						
Octogomphus specularis						(27.7)1.3889
Plecoptera						
Nemoura sp	(576.6).0288					
Brachyptera pacifica						
Isogenus sp.					(27.7).0638	
Isoperla sp.						
Rickera sp.						
Alloperla sp.						
Megaloptera						
Sialis rotunda				(55.5).1222	(27.7).0555	(27.7).0972
Sialis californica	(55.5).3416				(27.7).0138	(55.5).0861
Trichoptera						
Agapetus sp.						
Hydroptila sp.		(55.5).0250	(27.7).0111		(83.3).0305	
Psychomyia lumina						
Polycentropus sp.						(27.7).0250
Limnephilidae sp. 1						(27.7)1.2611
Lepidostoma sp.	(27.7).0500					
Micrasema sp.						
Heteroplectron californicum						
Coleoptera						
Lara sp.						
Heterlimnius sp.			(27.7).0111			
Cleptelmis sp.	(288.3).0576	(576.6).2306		(27.7).0111		
Diptera						
Dicranota sp.	(27.7).0027					
Limonia sp.						
Liriope sp.		(27.7).0111			(27.7).0222	(27.7).0305
Dixa sp.						
Simuliidae						
Tanypodinae	(27.7).0555	(83.3).1055	(194.4).2638	(111).1333	(55.5).0527	(222.2).3250
Diamesinae	(83.3).0861		(27.7).0138		(55.5).0638	
Chironominae	(1441.6).2306	(1730).2018		(55.5).0027	(277.7).0277	(138.8).0250
Orthocladiinae						
Bezzia sp.	(27.7).0083					
Arachnida						
Hydracarina sp.						

Appendix III. (continued)

	21 Sept. 1976		12 October 1976		2 November 1976	
	C	T	C	T	C	T
Nematoda						
Annelida						
Limnodrilus sp.	(371.2)1.2750	(648.7)2.2277	(1184.2)4.0666	(611.5)2.1000	(84.9).2916	(145.6).5000
Mollusca						
Gastropoda						
Gyraulus sp.	(527.7).9444	(1583.3)1.4889	(5444.4).8166	(3777.8)2.3277	(388.8).9916	(583.3).4666
Physa sp.						
Ferrissia sp.	(111).3583			(55.5).0444		
Juga plicifera	(416.6)40.4614	(4583.3)47.8420	(3111.1)40.2808	(7444.5)57.8892	(916.6)25.0140	(3249.9)37.8836
Pelecypoda						
Pisidium sp.	(27.7).0416	(166.6).3750	(4388.9)7.7500	(3888.9)4.9554		(55.5).0833
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(944.4).1833	(83.3).0166	(56513.8)1.0611	(111).0166	(55.5).0111	
Isopoda						
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum						
Epeorus nitidus						
Ameletus sp.						
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis						
Paraleptophlebia debilis	(27.7).0166	(27.7).0111				
Paraleptophlebia gregalis						
Baetis tricaudatus						
Odonata						
Octogomphus specularis						
Plecoptera						
Nemoura sp.	(27.7).0083	(27.7).0194		(55.5).0111	(83.3).0777	
Brachyptera pacifica						
Isogenus sp.						
Isoperla sp.						
Rickera sp.						
Alloperla sp.						
Megaloptera						
Sialis rotunda			(83.3).6083	(27.7).1277		
Sialis californica	(27.7).4972		(55.5).5333			(27.7).0472
Trichoptera						
Agapetus sp.						
Hydroptila sp.			(111).0500			
Psychomyia lumina						
Polycentropus sp.		(27.7).0166				
Limnephilidae sp. 1		(27.7).7555				
Lepidostoma sp.						
Micrasema sp.						
Heteroplectron californicum			(27.7).2472			
Coleoptera						
Lara sp.						
Heterlimnius sp.	(27.7).0083				(55.5).0194	
Cleptelmis sp.				(111).0001		
Diptera						
Dicranota sp.						
Limonia sp.						
Liriope sp.						
Dixa sp.						
Simuliidae						
Tanypodinae						
Diamesinae	(27.7).0305	(27.7).0166				
Chironominae	(111).0111	(83.3).0055	(222.2).0277	(111).0111		
Orthocladiinae	(27.7).0001					
Bezzia sp.						(27.7).0027
Arachnida						
Hydracarina sp.						

Appendix III. (continued)

	27 November 1976		17 December 1976		5-6 January 1977	
	C	T	C	T	C	T
Nematoda						
Annelida						
Limnodrilus sp.	(3149.8)10.8167	(2197)7.5445	(711.8)2.4444	(6988.9)24.0000	(1985.8)6.8194	(1519)5.2167
Mollusca						
Gastropoda						
Gyraulus sp.	(111).4611	(2500)1.6222	(1666.6)3.0833	(2166.6)1.2388	(500).9472	(2416.6)1.9916
Physa sp.						
Ferrissia sp.					(27.7).0583	
Juga plicifera	(638.8)23.139	(5972.1)109.97	(166.6)16.0278	(29139)370.7750	(249.9)5.8499	(10055.5)92.9118
Pelecypoda						
Pisidium sp.	(5055.5)7.1722	(1500)1.6166	(222.2).4776	(2833.3)6.8944	(7972.2)6.7556	(2555.5)3.9528
Arthropoda						
Ostracoda						
Herpetocypris chevreuxi	(3666.6).7222	(55.5).0111	(333.3).0833		(4666.7).9305	(83.3).0166
Isopoda						
Insecta						
Collembola						
Ephemeroptera						
Cinygma integrum	(55.5).0638		(27.7).0694			
Epeorus nitidus						
Ameletus sp.						
Paraleptophlebia bicornuta						
Paraleptophlebia temporalis			(55.5).0055			
Paraleptophlebia debilis						
Paraleptophlebia gregalis						
Baetis tricaudatus	(27.7).0027	(27.7).0083				(55.5).0194
Odonata						
Octogomphus specularis		(27.7).5777				(27.7)2.3222
Plecoptera						
Nemoura sp.	(250).3250		(138.8).2805		(55.5).0944	
Brachyptera pacifica						
Isogenus sp.						
Isoperla sp.						
Rickera sp.					(27.7).1194	(27.7).0111
Alloperla sp.	(27.7).0638					
Megaloptera						
Sialis rotunda	(27.7).5055	(27.7).2111	(55.5).8055	(27.7).7500	(27.7).1250	(55.5).6416
Sialis californica	(55.5).7277	(27.7).2722	(27.7).3000			(27.7).0944
Trichoptera						
Agapetus sp.						
Hydroptila sp.	(333.3).1166				(55.5).0222	
Psychomyia lumina						
Polycentropus sp.		(55.5).0166				(55.5).0222
Limnephilidae sp. 1						(27.7).0083
Lepidostoma sp.						
Micrasema sp.						
Heteroplectron californicum					(55.5).5694	
Coleoptera						
Lara sp.						
Heterlimnius sp.						
Cleptelmis sp.			(55.5).0222	(55.5).0222		
Diptera						
Dicranota sp.						
Limonia sp.			(27.7).1000	(27.7).0833		
Liriope sp.	(27.7).1138					
Dixa sp.						
Simuliidae						(27.7).0472
Tanypodinae		(27.7).0194				(55.5).0388
Diamesinae	(55.5).0333			(55.5).0166	(27.7).0333	
Chironominae	(111).0111		(166.6).0277	(111).0222	(166.6).0222	(194.4).0305
Orthocladiinae						
Bezzia sp.						
Arachnida						
Hydracarina sp.						

Appendix III. (continued)

	27 January 1977 C	T
Nematoda		
Annelida		
Limnodrilus sp.	(865.5)2.9722	(1619.4)5.5611
Mollusca		
Gastropoda		
Gyraulus sp.	(1111)3.3666	(500).5444
Physa sp.		
Ferrissia sp.		(55.5).0444
Juga plicifera	(416.6)62.8420	(16722.4)217.4540
Pelecypoda		
Pisidium sp.	(1000)1.9944	(2444.4)4.0888
Arthropoda		
Ostracoda		
Herpetocypris chevreuxi	(444.4).1055	(55.5).0166
Isopoda		
Insecta		
Collembola		
Ephemeroptera		
Cinygma integrum		
Epeorus nitidus		
Ameletus sp.		
Paraleptophlebia bicornuta		
Paraleptophlebia temporalis		
Paraleptophlebia debilis		
Paraleptophlebia gregalis		
Baetis tricaudatus		
Odonata		
Octogomphus specularis		
Plecoptera		
Nemoura sp.		
Brachyptera pacifica		
Isogenus sp.		
Isoperla sp.		
Rickera sp.		(27.7).1388
Alloperla sp.		
Megaloptera		
Sialis rotunda	(27.7).2333	(27.7).3944
Sialis californica		
Trichoptera		
Agapetus sp.		
Hydroptila sp.		
Psychomyia lumina		
Polycentropus sp.		
Limnephilidae sp. 1		
Lepidostoma sp.		
Micrasema sp.		
Heteroplectron californicum		
Coleoptera		
Lara sp.		
Heterlimnius sp.		
Clepteimis sp.		(111.1).0388
Diptera		
Dicranota sp.		
Limonia sp.		
Liriope sp.		
Dixa sp.		
Simuliidae		
Tanypodinae		(55.5).0055
Diamesinae		
Chironominae	(111).0055	(333.3).0388
Orthocladiinae		
Bezzia sp.	(55.5).0001	(111.1).0166
Arachnida		
Hydracarina sp.		