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WATER INVESTIGATIONS
ALONG THE
ALASKA HIGHWAY PIPELINE ROUTE
IN THE YUKON TERRITORY

APPENDIX F

MICROBIAL WATER QUALITY OF THE OGILVIE AND SWIFT RIVER BASINS

by

L.J. Albright, K.V. Masuda and G.L. Ennis

December 1978

Inland Waters Directorate
Pacific and Yukon Region
Vancouver, B.C.

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by

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ABSTRACT

The sub-Arctic Ogilvie and Swift Rivers are characterized by annual cycles of microalgal and bacterial standing crops and activities which are maximal in late spring (following ice "break up") and summer with minimal values noted in late winter. Levels of algal standing crops and phytosynthetic rates appear to be regulated by available light whereas numbers and activities of heterotrophic bacteria are probably controlled by DOC content of the water.

Perturbations of those two river waters by streambank materials alter microbial activities, such that Biological Oxygen Demand tends to be increased by streamside materials additions at levels in excess of 0.10 g/litre.

These rivers tend to be most sensitive to streambank materials additions in winter and least sensitive in late spring (following ice "break up") and early summer.

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INTRODUCTION

This biological study was initiated by the Water Quality Branch as part of a much larger Inland Water Directorate program to obtain information necessary to adequately review the Alaska Highway gas pipeline environmental impact statement. This study was restricted to a one-year (Oct. 1977 - Aug. 1978) in-depth investigation of two river basins. Emphasis was placed on understanding processes in these two northern rivers rather than on establishing baseline water quality information on the hundreds of waterways which will be affected by the pipeline.

The study areas were (1) the Swift River Basin ($59^{\circ}45'$-60° 50'N $130^{\circ}45'$-132°W) in the Southeast Yukon and (2) the Ogilvie River Basin (65°-$65^{\circ}45'$N, $132^{\circ}30'$-$138^{\circ}30'$W) which is located along the Dempster lateral pipeline route in the northern Yukon. Maps of these two basins showing our sampling sites are presented in Figs. 1 and 2. Criteria used in selecting these basins are listed in Schreier (1978). The most important criterion for this study was that both rivers have a high biological productivity. The Swift River, located in the Yukon River drainage is in a chinook salmon spawning area (Chinook Fry were captured while sampling for invertebrates). Slimy sculpins and arctic grayling are also abundant. Aquatic plants in the Swift River consist of aquatic mosses (*Dicramella palustris,* and *Dichodontium pellucidum*), macrophytes, (dominated by *Hippuris* sp.) and benthic algae. The Ogilvie River, on the other hand, is located in the Mackenzie River drainage basin and has no salmon, although we have captured arctic grayling and sculpins. Algae were the only type of flora observed in the Ogilvie River. Benthic invertebrates, and planktonic and epilithic bacteria are present in both river basins.

The present study is limited in scope to a microbial (algae, bacteria, invertebrates) investigation. A study of the fisheries resource along the pipeline route has been conducted by Northern Natural Resource Services Ltd. for the Federal Fisheries and Marine Service (1977). At present there is little information on microbial standing crops and productivities in Canadian sub-Arctic and Arctic rivers and, in general, studies which have been done are limited to spring and summer months.

Objectives of this study were (1) assessment of biological activity during the winter months, when pipeline construction is scheduled to occur (2) development of techniques for winter under-ice experiments (3) establishment of seasonal variations and between river differences (4) the relationships of these variations to chemical (see Schreier, 1978) and physical conditions and (5) the evaluation of the sensitivities of the two rivers to disturbance (by performing *in situ* and laboratory perturbation experiments).

MATERIALS AND METHODS

Periphytic algae were sampled by removing representative rocks (usually four from each site, each ca. 20 cm in diameter) from the streambed of each river or creek, at locations noted (Figs. 1 and 2) and ca. 100 cm^2 areas were immediately scrubbed with a nylon nailbrush. The detached microflora on the rock and brush were then sluiced into a container with the aid of a wash bottle containing distilled water; this entire procedure was repeated twice. See Sheehan *et al.* for a more detailed description of this technique.

The area of each rock sampled was determined by fitting aluminum foil to the scrubbed contour, removing the foil, pressing it flat and measuring its area with a polar planimeter.

Each periphyton suspension was wet filtered, within 3 h, onto either 5.5 or 10 cm diameter Whatman GF/C glass fibre filters using a maximal vacuum of 18 cm Hg. Immediately following this filtration each filter was bisected and the cells of one half of the filter washed into a sterile container, and preserved with acid Lugol's solution till assayed for algal species and numbers. The remaining half of each filter was treated with a $MgCO_3$ suspension, frozen (Dec., Mar., May (Swift) and June (Swift) samples were not frozen) and kept in the dark until used for chlorophyll a extraction and analysis.

Chlorophyll a content of each sample was assayed by extracting each GF/C filter (with filtered algae) in an acid free acetone: water (9:1)

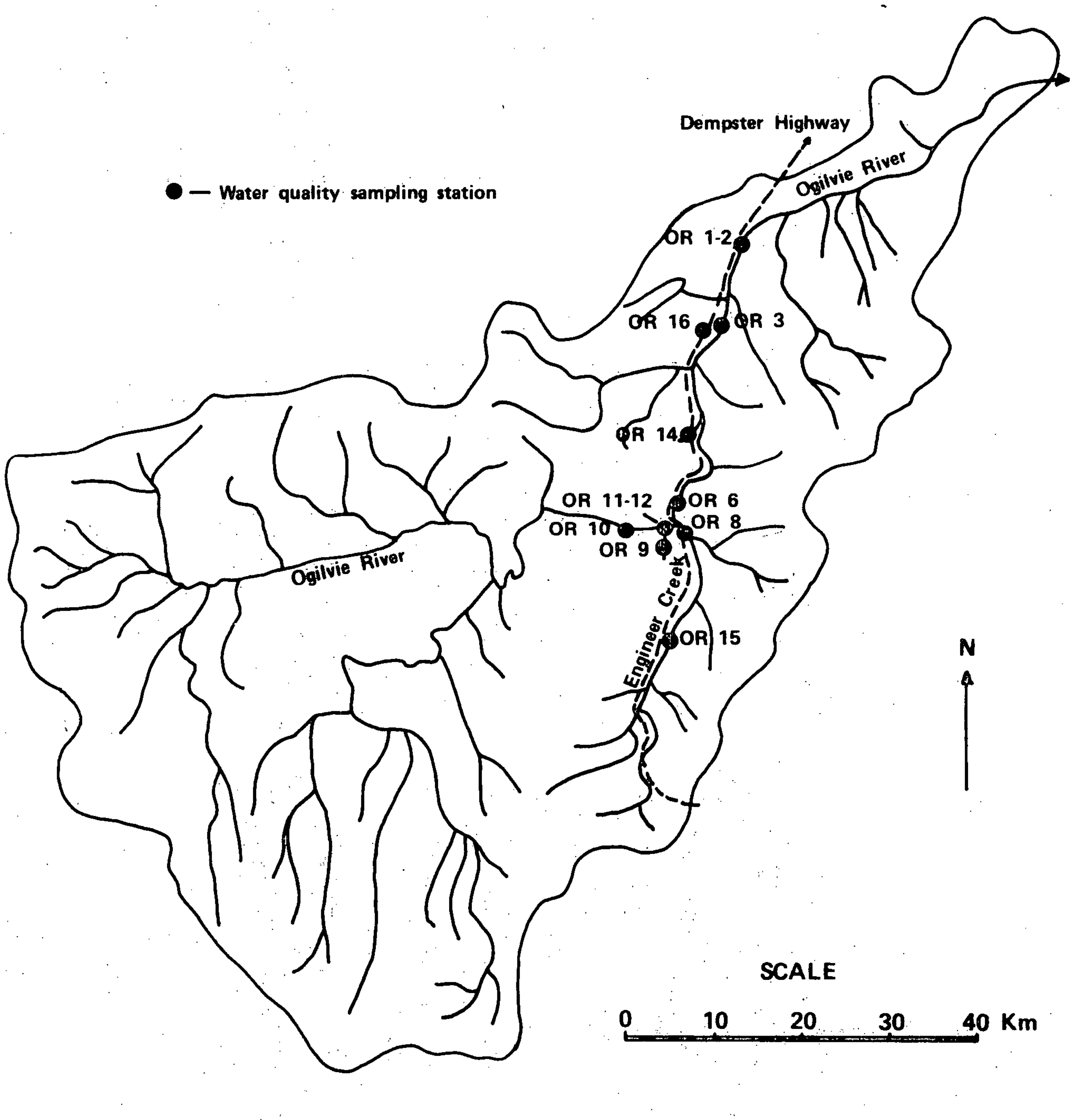


Figure 1 Sampling stations in the Ogilvie River drainage basin, Yukon Territory.

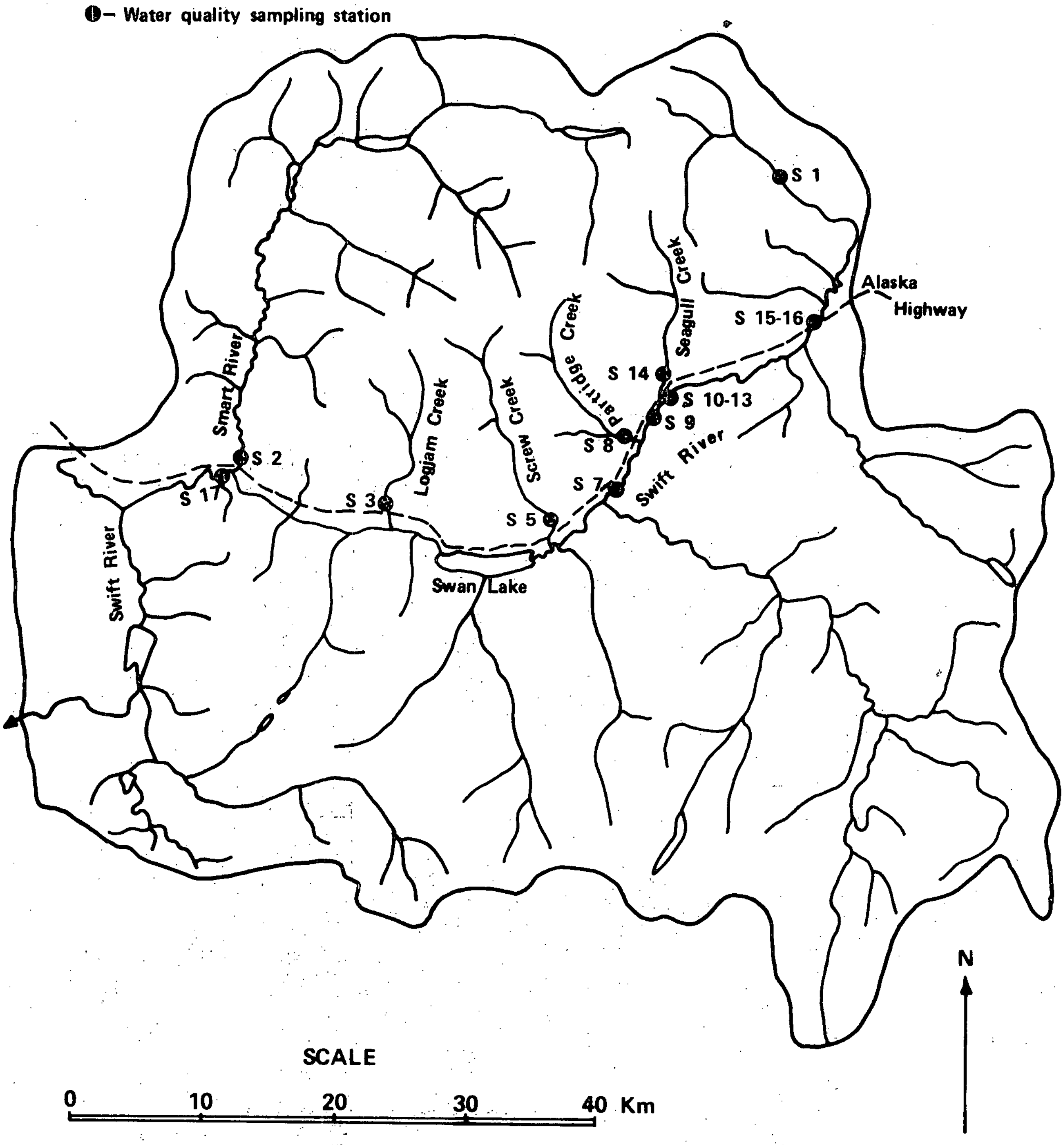


Figure 2 Sampling stations in the Swift River drainage basin, Yukon Territory.

mixture using a High-Speed Polytron homogenizer followed by filtration (0.45 um Gelman Alpha-6 material filter) of the sample to remove debris and particulate matter. The residue was then re-homogenized and filtered again. Both filtrates were combined and made to 15 ml with 90% acetone; chlorophyll a content was measured spectrophotometrically (corrected for phaeophytin) using extinction values of Lorenzen (1967) as described by Strickland and Parsons (1968).

Periphytic diatom identifications and cell counts were made on sub-samples which were first cleaned in H_2O_2 or nitric acid (Patrick and Reimer, 1966), evaporated onto cover slips (Battarbee, 1973) and then mounted on microscope slides with Hyrax medium. Microscope transects were then examined using phase contrast microscopy (1000 X magnification); all diatoms were identified and counted till there was a total count of 200 frustules. Suitable conversion factors were then used to transform counts to cells/cm^2.

The works of Patrick and Reimer (1966), Cleve-Euler (1951-1955), Hustedt (1930, 1931-1959) Huber-Pestalozzi (1942), Sreenivasa and Duthie (1973) and Weber (1966) were consulted for identification of the diatoms. The species classification outlined by Van Landingham (1967-1975) was followed except that *Cymbella caespitosa* was recognized as a distinct species. For genera not covered by Van Landingham (starting after the genus *Navicula*), the species taxonomy of Patrick and Reimer (1966), Cleve-Euler (1951-1955), Hustedt (1930), and Huber-Pestalozzi (1942) was followed.

The relative abundance of each algal phyla was measured in another subsample with an inverted microscope using methods detailed in Northcote *et al.* (1975). Cyanophyta and Chlorophyta species were qualitatively measured for relative abundance and identified using Prescott (1962), Hoek (1963), and Bourrelly (1966, 1968, 1970).

Samples for phytoplankton analyses were obtained by allowing water to flow into a clean 100 ml container placed 5 - 10 cm below the surface of each river or creek sampled. Approximately two ml of acid Lugol's solution were then added to preserve each sample which were subsequently analyzed using the Utermohl (1958) technique which involved sample transfer to 5, 10, or 25 ml settling chambers (depending upon algal density) and enumeration with an inverted phase contrast microscope. Microscope transects were examined at 500 times magnification and all phytoplankters identified and counted until there was a total count of 200 cells (except; colonies composed of small cells were counted as individual colonies). Suitable conversion factors were used to transform counts to cells/ml.

Planktonic diatoms were identified using the reference works described above as well as Patrick and Reimer (1975). Geitler (1932) and Prescott (1962) were used to identify planktonic algae from other planktonic classes.

In all cases both live and dead planktonic microalgae were counted separately.

Phytoplankton and Periphyton diatom species volumes were determined as follows. The dimensions of ten representative cells of each species were microscopically measured and these values used to determine average cell sizes for that species. Surface area of each diatom species (drawn to scale) was then determined using a polar planimeter. This value was then multiplied by the cell's depth to determine the average cell volume in um^3 (Appendix 1). Phytoplankton volumes from other algal classes were calculated by the use of geometric formulae.

Viable heterotrophic bacterial numbers were determined by spreading water and epilithic samples upon the following medium: Bacto-beef extract, 3g; Bacto-peptone, 5g; Bacto-agar, 15g; distilled water, 1 liter; pH 7.2 within several hours of sampling. The Petri plates were then maintained at temperatures of from 1 - 10 C whilst being transported to a laboratory at which time they were incubated at 5 C for 3 weeks before colonies were counted.

One-tenth ml samples of water were plated directly to assay planktonic bacterial numbers whereas epilithic bacterial counts were determined using the "scrub water" obtained as outlined above and before the addition of Lugol's solution.

Total planktonic and epilithic bacterial counts using water and "scrub water" respectively were done using epifluorescent microscopy, as described by Daley and Hobbie (1975) and Hobbie *et al.* (1977).

Benthic invertebrates were sampled by placing a Surber sampler (1 mm mesh size) on a streambed (water depth of ca. 20 cm) and picking up all larger rocks and scrubbing them in front of the net. The remaining fine material was thoroughly stirred to dislodge organisms which were subsequently washed into the net. In this way streambed material was sampled to a depth of ca. 10 cm. At each location 4 or 5 samples were collected and then combined in a single plastic bag, preserved with a 5% formaldehyde solution and transported to the laboratory for analysis by J. Keays, Powell River, British Columbia.

Laboratory analyses were done by placing each sample in a white enamel tray and first removing organisms larger than ca. 1 cm. Each sample was then sorted in Petri plates and organisms smaller than 1 cm were removed. All organisms were identified with the aid of dissecting and compound microscopes. The texts used in identifications were (Johannsen, 1969; Usinger, 1956; Needham *et al.*, 1935; Smith, 1968; Ross, 1944; Edmondson, 1959; Ricker, 1943, and Classen, 1931). Suitable conversion factors were applied to convert counts to number of organisms per square meter.

Dissolved organic carbon (DOC) was assayed by the wet oxidation technique of Menzel and Vaccaro (1964) whereas particular organic carbon (POC) values were determined using a Beckman CHN analyzer. Gelman A/E filters were used to separate DOC from POC and all samples were frozen till assayed.

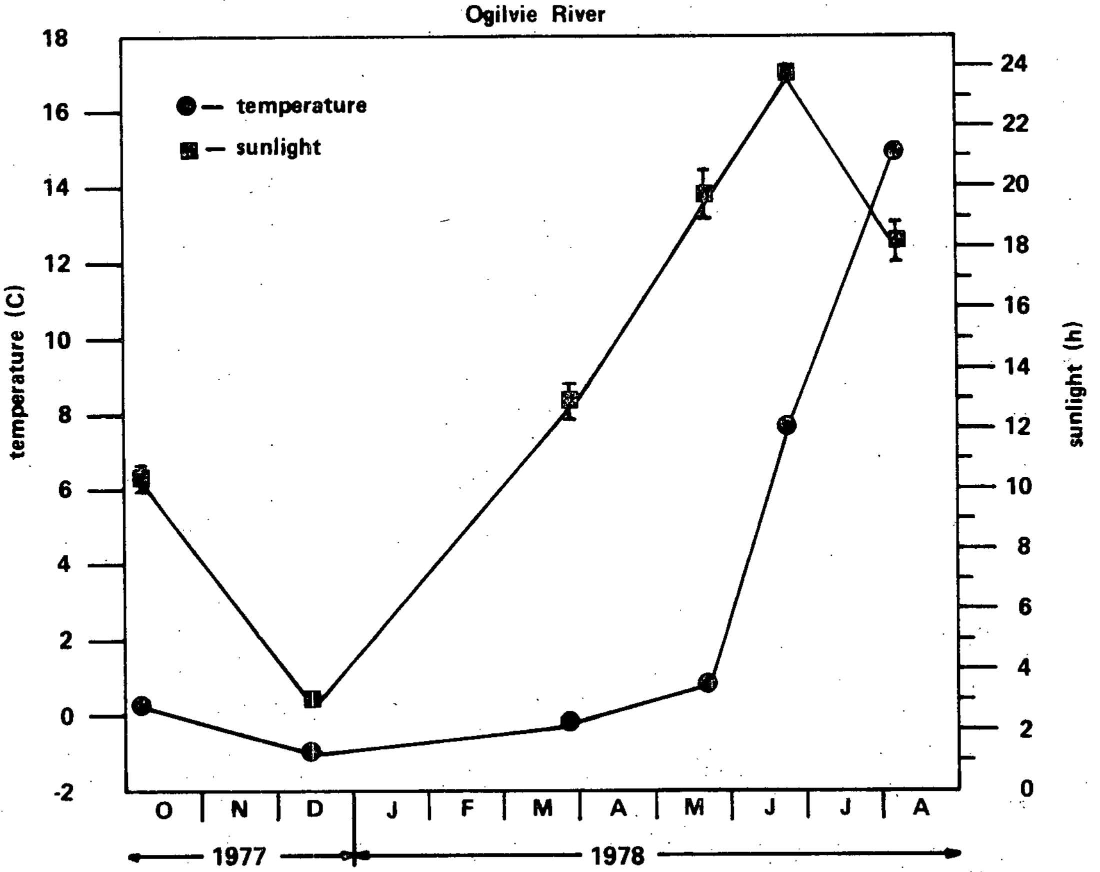
Total inorganic carbon (TIC) values of sampled river waters were determined with the use of a dual channel carbon analyzer - Beckman model 915 equipped with a Beckman model 215B infrared analyzer. Aliquots of blended water were injected into a combustion tube heated to 175 C containing

85% H_3PO_4 on quartz chips. The CO_2 liberated was quantitatively assayed using an infrared analyzer and standard inorganic carbon solutions.

Theoretical maximum hours of sunlight at each river were determined using the Nautical Almanac (1976, 1977) (Fig. 3). The actual energy available from the sunlight would be less due to mountain shading, cloud cover, angle of the sun, river ice, snow cover, water turbidity, etc.

Concentrations of non filterable residues were determined by filtering water samples through tared Whatman GF/C filters (previously heated to 450 C for 4 hours). This dried residue remaining upon each filter was considered to be non filterable.

Glucose heterotrophic potentials (V_{max}), turnover times (T_t) and $K_t + S_n$ (K_t refers to the transport constant whereas S_n denotes the natural concentration of substrate) values were determined by aspirating water samples into ten-50 ml disposable plastic syringes (with attached Beckton-Dickinson two way valves). Each syring contained an appropriate concentration of tritiated glucose (D-[6-^{3}H] glucose, specific activity 10 Ci/mmol; Amersham/Searle Corp.) and was inverted several times following water addition to mix the sample. Controls consisted of samples poisoned with 5% glutaraldehyde before addition of water. In this study tritiated glucose was added to yield a final concentration range in the various water samples of from 0.001 uCi/ml (10^{-10}M glucose) to 1 uCi/ml (10^{-7}M glucose). Water samples were incubated *in situ* for periods of 30 - 240 minutes, depending upon water temperatures; care was taken to ensure substrate utilization was linear with time. The incubations were stopped by filtering the contents of each syringe



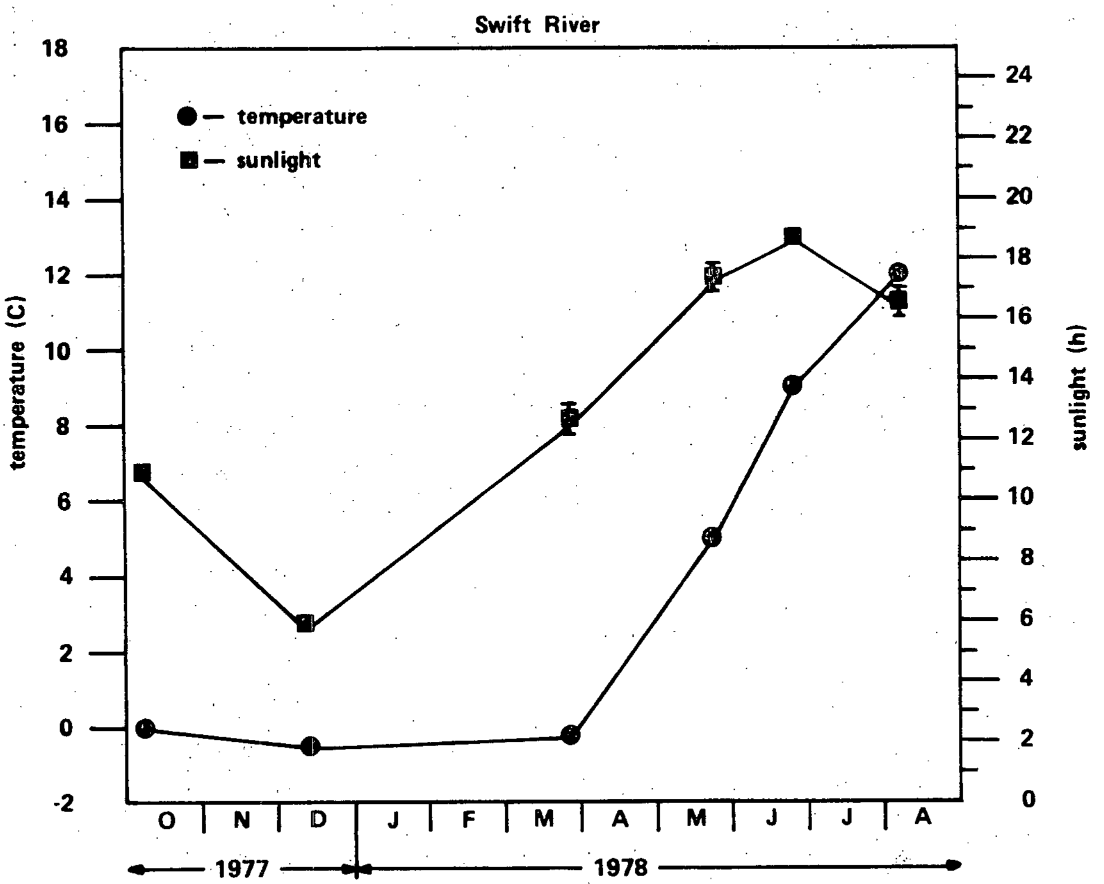


Figure 3 Water temperatures (C) and time of sunlight (h) of the Ogilvie and Swift Rivers.

through 0.45 um pore size membrane filters, Millipore Corp. (25 mm) in diameter contained within a Swinnex filter holder attached to the exit port of each two way valve. Each filter was then washed with an approximately 30 ml volume of river or creek water by repeating the refilling and evacuation procedure. Care was taken to do all manipulations under water as exposure to ambient air temperatures (in some cases as low as -40C) might immediately freeze the contents of each reaction vessel. The device used for sampling and incubating the water samples is described in Fig. 4. Counter-clockwise rotation of the handle fills each syringe with water whereas a clockwise rotation empties each syringe.

Filters were placed in scintillation vials containing 15 ml of Aquasol scintillation cocktail (New England Nuclear Corp.) with 10% ethyl acetate. All samples were counted in a Beckman LS-250 liquid scintillation spectrometer. Counts per minute (cpm) were corrected for quench (by the external standard method), machine efficiency and half-life decay and were reported as disintegrations per minute (dpm). The tritiated glucose was diluted in carbon-free water prepared by the method of Strickland and Parsons (1968) and filtered through sterile membrane filters (0.22 um pore size, 25 mm diameter, Millipore Corp.) prior to use. No attempt was made to quantitate glucose respiration. See Dietz *et al.* (1977) and Wright and Hobbie (1966) for a more complete description of the technique as well as equations for calculation of V_{max}, $K_t + S_n$ and T_t. Bacterial specific activities were calculated as the glucose heterotrophic activity per viable heterotrophic bacterium.

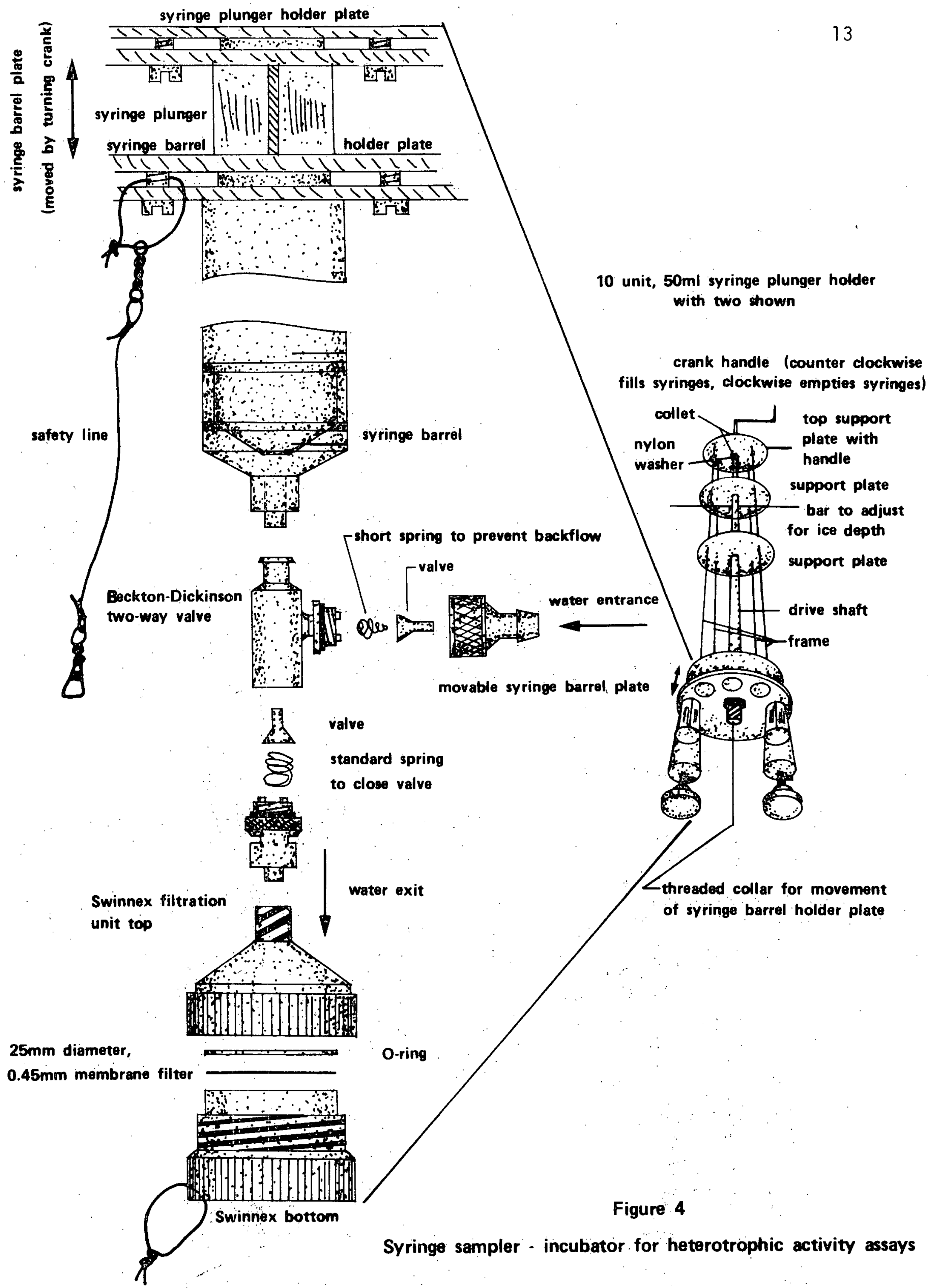


Figure 4

Syringe sampler - incubator for heterotrophic activity assays

Light (algal) and dark (mainly bacterial) productivities of the plankton were determined with the use of $^{14}CO_2$. Two light, two dark and two killed (1 ml of 5% glutaraldehyde added to each) BOD bottles (300 ml capacity) were filled with river or creek water and 5 uCi of $^{14}CO_2$ (as bicarbonate or carbonate - pre-membrane filtered (0.22 um)) added to each. The bottles were stoppered, inverted to mix the contents and incubated *in situ* for 4 hours (incubation times between 1000 and 1500 h were chosen). This procedure was used for all but the December 1977 samples when 24 h incubation periods were used. Following incubation, the reactions were stopped by adding 1 ml of 5% glutaraldehyde to the light and dark bottles and filtering the contents of each through 0.45 um pore size membrane filters (Millipore Corp.) Following this, each filter was washed with 50 ml of pre-filtered river or creek water, placed in scintillation cocktail, as described above, and the dpm determined.

The light minus dark dpm values were used to calculate algal productivities whereas the dark minus killed values were used to determine heterotrophy productivities. See Romanenko *et al.* (1972) for a more complete description of this technique.

Ten-litre plexiglass containers (see Fig. 5) similar to those described by Schindler *et al.* (1973) were used to assay benthic light and dark productivities. River or creek bottom rocks (4-5) of average volume of 400-700 ml each were gently placed into each of one light, one dark and one killed (with 30 ml of 25% glutaraldehyde) control boxes and the remaining space filled with river or creek water. Each box was then placed on the

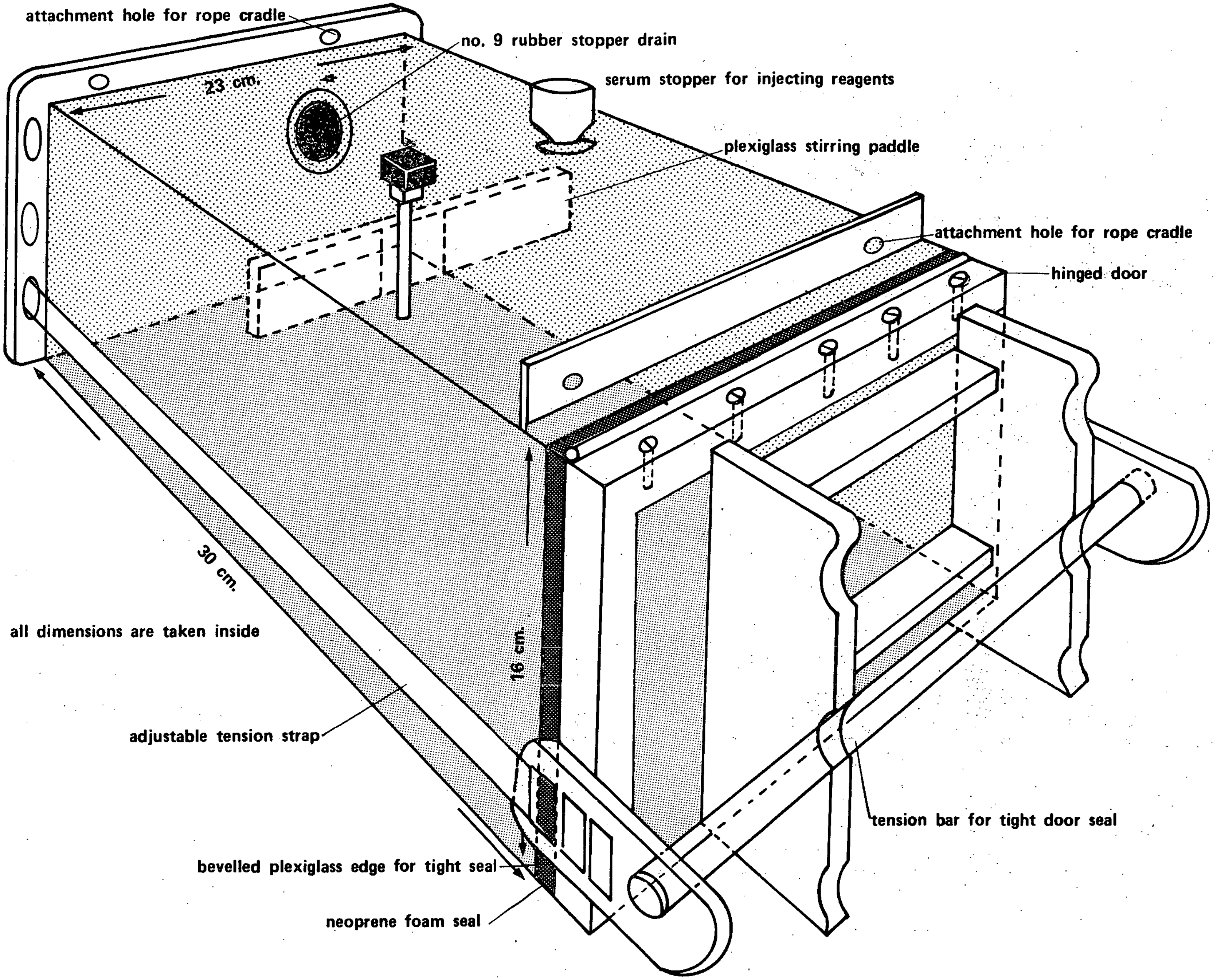


Figure 5 Epilithic algae/bacteria productivity box.

river bed for ca. 30 min. to allow a resettlement of the partially disturbed material. Following this 55 uCi of ^{14}C-bicarbonate or carbonate (new England Nuclear Corp.) was injected into each box, the contents mixed, and the entire system was allowed to incubate for 4 h (between the hours of 1000 to 1500). The reactions in each light and dark box were then stopped with the addition of 30 ml of 25% glutaraldehyde. Known areas (see above for description of areal determination technique) of incubated rocks were scrubbed (see above) to obtain ^{14}C-labelled microflora which was then preserved with glutaraldehyde, filtered onto membrane filters, oxidized with the use of a SEARLE combustor, and the released $^{14}CO_2$ collected in scintillation fluor and the dpm of each assayed as described above. The volumes of the water which occupied each box were also determined at this time. Algal (based upon light minus dark dpm) and heterotrophic (dark minus killed control dpm) productivities were subsequently calculated on a per m^2 basis.

Waters for determinations of biochemical oxygen demand (BOD) values were placed in sterile 5-litre polyprophylene carbouys and shipped to Vancouver. Whilst in transit (for periods up to 2 weeks) the temperature of this water varied between 0 and 10 C. BOD values were obtained with the use of standard BOD bottles which were incubated in the dark for periods of up to 55 days at 1 ± 1 C. At times zero (the time at which the waters were added to the bottles in Vancouver), 21 and 55 days dissolved oxygen (DO) contents were assayed by the Winkler technique (Amer. Pub. Health Assoc., Amer. Water Wks. Assoc., and Water Poll. Con. Fed. (1965)).

Streambank materials for nutrient (DOC and POC) analyses and perturbation experiments were selected from one soil profile located near the stream bank in the alluvial floodplain in the Swift River basin. As is common in floodplain situations, the soil profile has been influenced by polygenesis. In principle, the soil profile belongs to the Brunisolic soil order, in the early stages of development and made up of the following five horizons: LFH, Ae, Bm(t), Bf and C.

The LFH, Ae, and Bm(t) horizons (Plate 1.) were used for the experiments and each can be described as follows:

<u>LFH</u>: an organic horizon characterized by accumulation of organic material in various stages of decomposition.

L = Litter: predominantly sphagnum moss, labrador tea, and spruce needles.

F = Partly decomposed litter, mainly leaves, needles and twigs and the original structure is difficult to recognize.

H = Humus: decomposed organic matter with no evidence of original structure.

(The L and F portions were dominant in the sample with only a small fraction of humus visible.)

<u>Ae</u>: A leached mineral horizon with coarse sandy texture from which salts and clays have been removed by eluviation.

<u>Bm(t)</u>: A slightly altered mineral horizon with evidence of illuviation, and changes in texture.

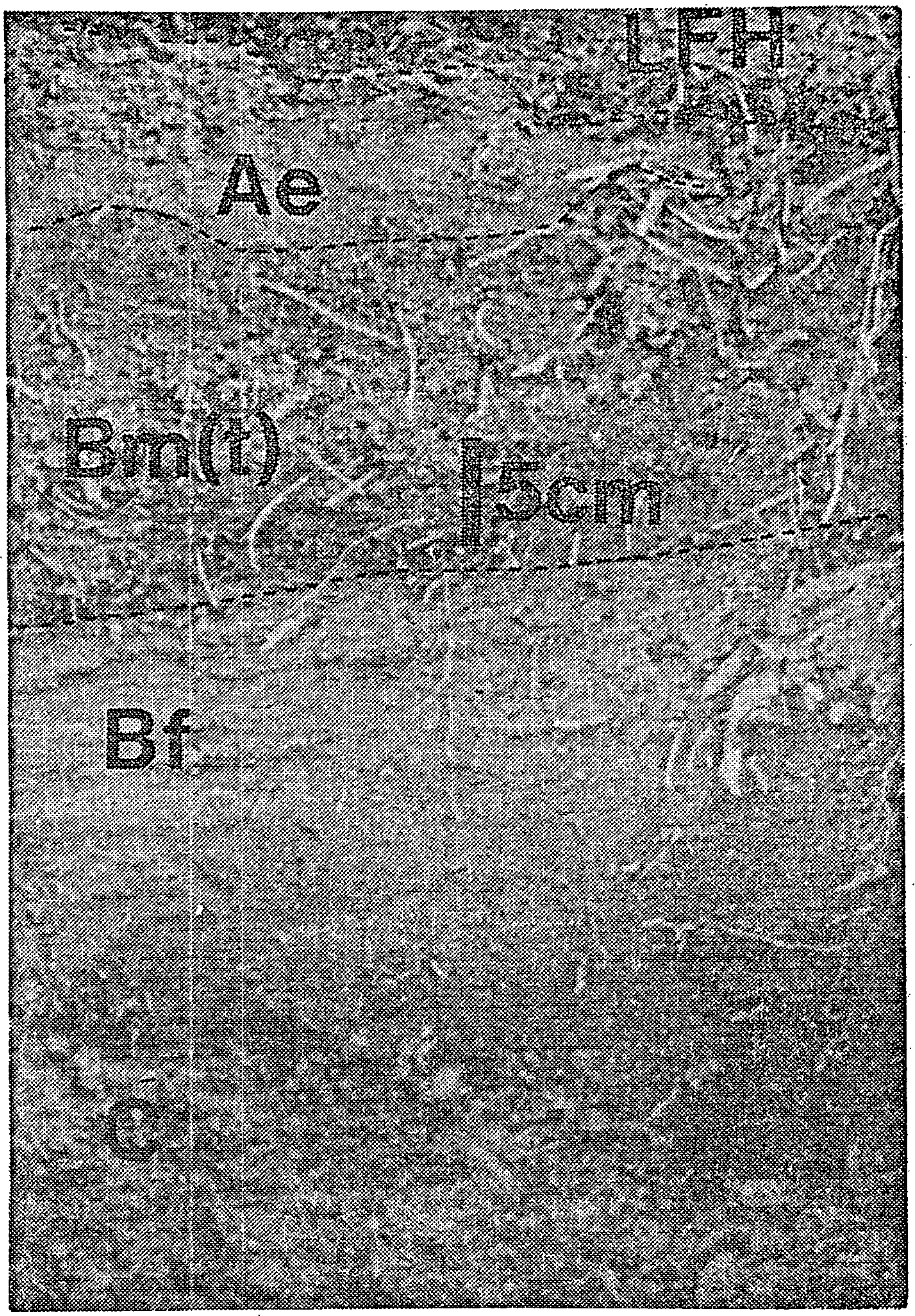


Plate 1. Vertical view of the soil pit adjacent to the Swift River showing the location of the LFH, Ae and Bm(t) horizons.

RESULTS AND DISCUSSION

A significant feature of both the Ogilvie and Swift Rivers was the seasonal changes in the values of many of the microbial (standing crops and activities) as well as chemical and physical parameters assayed. These included microalgal, bacterial and invertebrate cell numbers, algal and bacterial activities, as well as TIC, DO AND DOC concentrations. Generally, maximum and minimum values of each parameter occured in late spring-summer and fall-winter respectively*.

Algal, Bacterial and Invertebrate Standing Crops

Relatively larger concentrations of both planktonic and periphytic microalgae were present in these sub-Arctic Canadian rivers during the spring, summer and fall of 1977 - 1978 as compared to the winter of 1978 (Figs. 6 and 7, Table 1). Massive declines in standing stocks of these cells occured in early winter; generally the phytoplankton values decreased to approximately 1%

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* In this manuscript sampling dates which correspond with seasons are 4-10 October, fall; 10-20 December, early winter; 22-30 March, late winter; 15-26 May, late spring; 17-30 June and 1-8 Aug., summer. "Freeze-up" occurred on the Ogilvie and Swift Rivers in the first weeks of October and November 1977 respectively. Ice "break up" occurred in early May 1978 (Ogilvie River, ca. 7.5 months of ice cover) and early April 1978 (Swift River, ca. 6.5 months of ice cover).

Table 1. Periphytic (mg/m^2) and planktonic (mg/m^3) chlorophyll a concentrations of several streams of the Ogilvie and Swift River drainage basins.

River	Date of Sampling					
	4-10 Oct.1977	10-20 Dec.1977	22-30 Mar.1978	15-26 May 1978	17-30 June 1978	1-8 Aug.1978
<u>Ogilvie</u>						
Periphytic	7.7	1.0	10.4	4.5	-	1.8
Planktonic	0.6	0.1	0.1	0.7	1.4	0.1
Periphytic phaeophytin to chl. a ratio	1.53	1.40	1.45	1.57	-	1.50
<u>Swift</u>						
Periphytic	2.7	<0.5	0.6	2.9	2.7	13.8
Planktonic	0.2	<0.5	0.1	0.3	0.1	0.1
Periphytic phaeophytin to chl. a ratio	1.49	1.26	1.55	1.62	1.58	1.38
<u>S 14</u> *						
Periphytic	1.5	-	0.5	0.9	0.8	-
Periphytic phaeophytin to chl. a ratio	1.51	-	1.57	1.63	1.39	-
<u>OR 8</u>						
Periphytic	2.6	-	-	0.1	-	3.2
Periphytic phaeophytin to chl. a ratio	1.62	-	-	1.32	-	1.64
<u>S 5</u>						
Periphytic	-	-	-	1.4	1.4	-
Periphytic phaeophytin to chl. a ratio	-	-	-	1.59	1.57	-

*For locations refer to Figures 1 and 2

Continued .....

Table 1. (continued)

River	Date of Sampling					
	4-10 Oct.1977	10-20 Dec.1977	22-30 Mar.1978	15-26 May 1978	17-30 June 1978	1-8 Aug.1978
S 8						
Periphytic	-	-	-	3.4	1.1	-
Periphytic phaeophytin to chl. a ratio	-	-	-	1.57	1.65	-
S 3						
Periphytic	-	-	-	1.7	0.8	-
Periphytic phaeophytin to chl. a ratio	-	-	-	1.67	1.66	-
S 2						
Periphytic	-	-	-	5.6	-	-
Periphytic phaeophytin to chl. a ratio	-	-	-	1.55	-	-
OR 14						
Periphytic	-	-	-	4.6	143.7	33.8
Periphytic phaeophytin to chl. a ratio	-	-	-	1.59	1.49	1.54

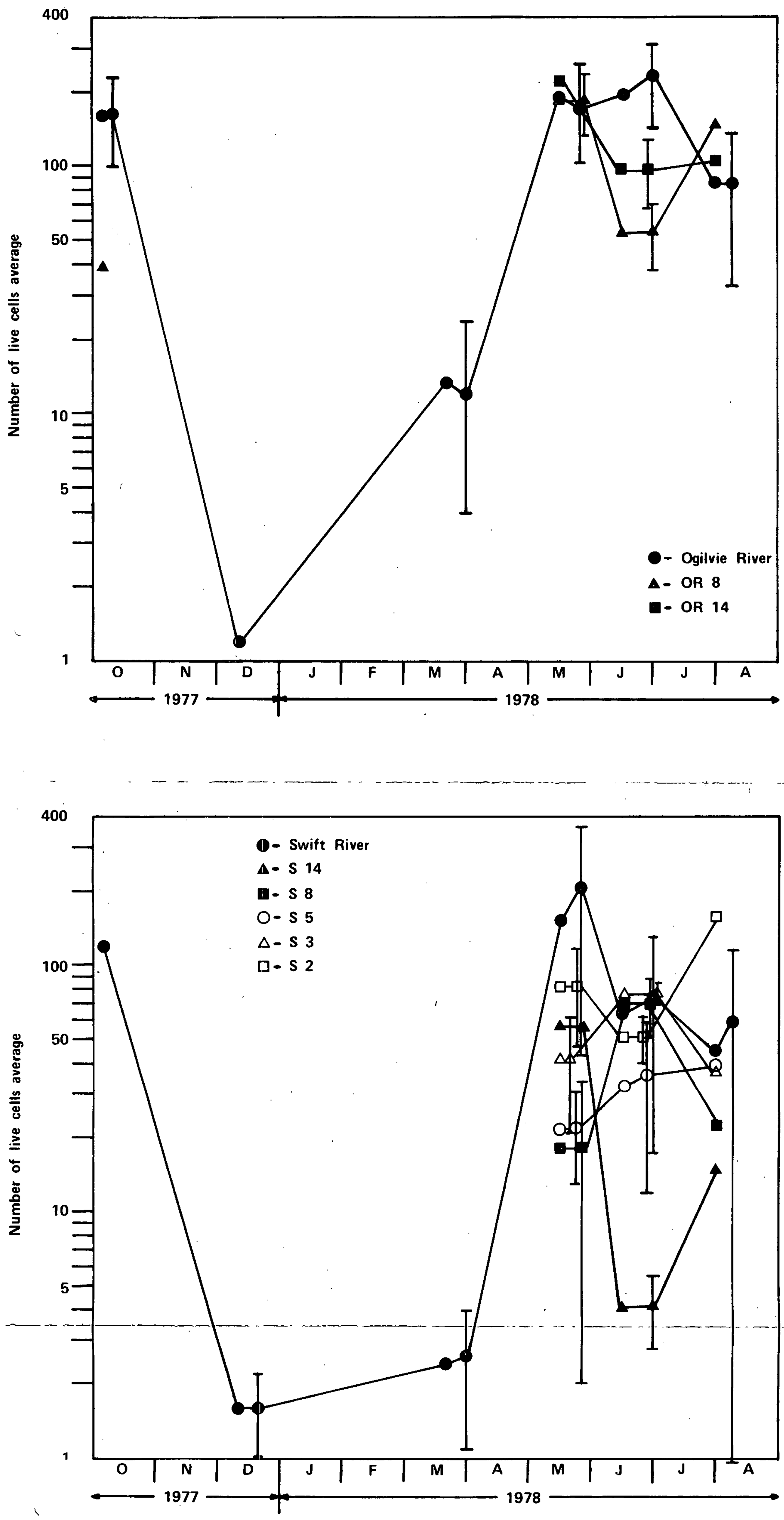


Figure 6 Viable Phytoplankton concentrations (cells/ml - 500 x magnification) of several streams of the Ogilvie and Swift River drainage basins.

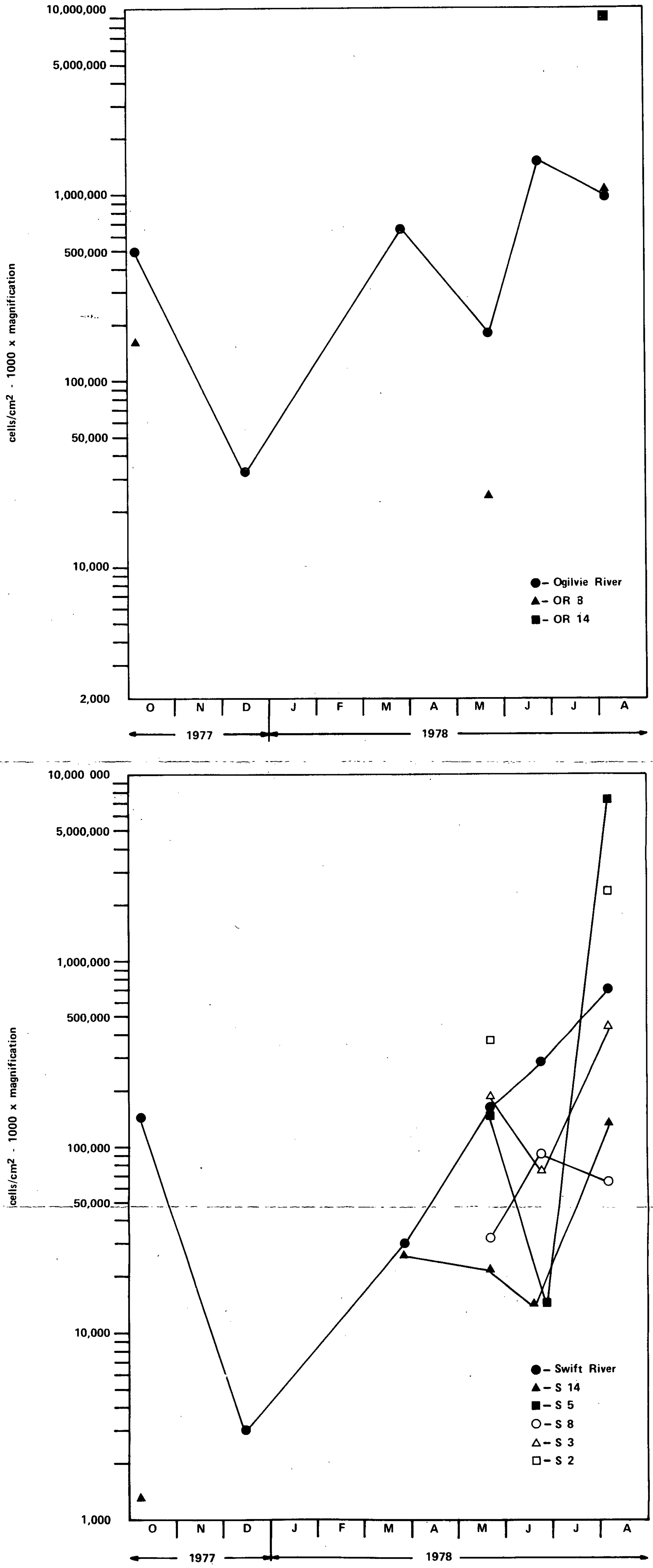


Figure 7 Total periphytic diatom concentrations (cells/cm² - 1000 x magnification) of several streams of the Ogilvie and Swift River drainage basins.

of their spring and summer levels (the percent viable (containing chloroplasts) phytoplanktonic cell numbers of both the Ogilvie and Swift Rivers remained relatively constant throughout the year with mean values of 75.3 and 67.7% respectively) whereas the decline was somewhat less amonst the periphyton (Figs. 6 and 7, Table 1). The periphyton declines noted between October and December 1977 were ca. 93% and 98% for the Ogilvie and Swift Rivers respectively. However, due to difficulty in quantitatively sampling periphyton these values should be interpreted with caution (see Tett *et al.* (1978) for a discussion of adequately sampling benthic microalgae).

Karlstrom and Backlund (1977) noted similar fluctuations in numbers of planktonic diatoms of the river Ricklean (Sweden, lat. of ca. 64° 5' N.). These authors found that cell concentrations were greatest during spring and summer and declined quite abruptly during late autumn and early winter whereas a slight recovery in numbers was noted between January and March. In both the Ogilvie and Swift Rivers we noted a modest recovery in numbers of both phytoplankton and periphyton occurred between early and late winter.

The factors which cause the massive decline in phytoplankton and periphyton numbers in late fall are not known with certainty. However, two significiant features were probably (1) low insolation and (2) low temperatures. By late December daylight lengths in the Ogilvie and Swift River watersheds had decreased to ca. 3 and 6 h from summer values of ca. 18 and 16 h respectively (Fig. 3). Water temperatures in both rivers had decreased to ca. 0 C from summer values of ca. 15 C (Ogilvie River) and ca. 12 C (Swift River) (Fig. 3).

Several investigators have noted that many microalgae are able to withstand exposure to both low temperatures and darkness. Jansz and MacLean (1973) found that when the blue-green alga *Anacystis nidulans* was exposed to 0 - 5 C culture viability was reduced. However, residual numbers of viable cells remained, even at these low temperatures. Talling (1955) found that two diatom genera (*Asterionella* and *Fragilaria*) grew throughout the year in Lake Windermere with the division rates lowest in January. As winter progressed, the division rates increased from January to March. This author concluded that "the mean relative growth rates of cells at 1 m. depth are primarily determined by daylength and temperature". Antia and Cheng (1970) showed that although 31 species of marine unicellular algae showed no significant growth in darkness at 20 C., several species were able to survive up to 24 weeks and resume normal growth rates upon transfer to light. It is possible that some algal cells treated in this fashion, including the microalgae of the Ogilvie and Swift Rivers, may have (1) decreased their endogenous metabolism and (2) shifted to a heterotrophic pattern of cellular maintenance. Many diatoms are able to survive in the absence of light using heterotrophic processes (Hellebust, 1968, Hellebust and Lewin, 1972 and Lewin and Hellebust, 1975).

There is no facile explanation for the minor increase in numbers of both planktonic and epilithic microalgae between early and late winter noted in both this study (Figs. 6 and 7) and by Karlstrom and Backlund (1977) in the river Ricklean. Water temperatures remained approximately the same. However, daylength increased during this time period (see Fig. 3) and it is possible that photosynthetic rates increased which resulted in slow algal growth.

Analysis of planktonic algal species data suggests that most cells of the phytoplankton community actually originated in the periphyton. Of the 85 phytoplankton species with chloroplasts which were identified, 73 species were also found in the periphyton samples. Sixty-two of the diatom dominated planktonic species are considered to be ecologically more important in the periphyton with only 9 species being considered primarily planktonic. The other 14 species are about equally important in both periphyton and phytoplankton assemblages (Appendix 2).

Most phytoplankton species were spotty in occurrence and were only observed a few times from October 1977 till August 1978. *Achnanthes minutissima*, *Diatoma tenue* v. *elongatum*, *Fragilaria construens* v. *binodis*, *Fragilaria vaucheriae*, and *Synedra ulna* were observed more frequently and their seasonal distribution in the Ogilvie and Swift Rivers is plotted in Fig. 8.

The periphytic algal species composition data showed similar trends in all rivers assayed, ie. the spring - summer - fall populations were predominantly Bacillariophyceae or Chlorophyceae whereas the bulk of the overwintering cells were diatoms (Table 2). The reason for this is not known.

There were 96 species of periphytic diatoms identified in samples removed from the Swift and Ogilvie River Basins (Appendix 3). Eighty-nine of these species were found in the Swift River Basin while only 63 species were found in the more northerly Ogilvie River Basin. The lower number of species in the Ogilvie is probably related to the harsher physical environment rather than to chemical conditions. Higher nutrient levels and a more diverse

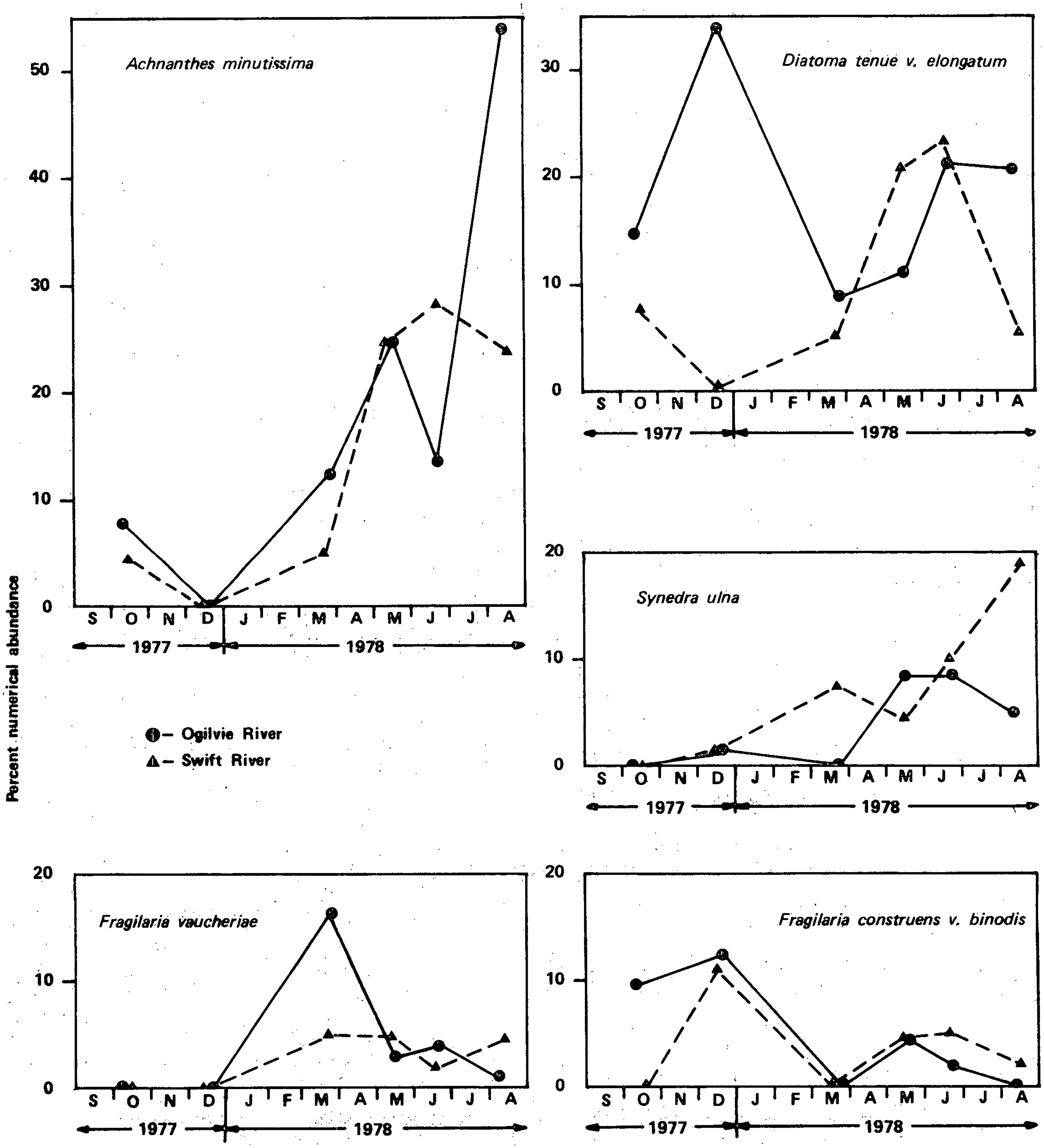


Figure 8 Seasonal distributions of five major phytoplankton species in the Ogilvie and Swift Rivers.

Table 2. Percent composition of periphytic algae of several streams of the Ogilvie and Swift River drainage basins.

River	Date of Sampling					
	4-10 Oct.1977	10-20 Dec.1977	22-30 Mar.1978	15-26 May 1978	17-30 June 1978	1-8 Aug.1978
<u>Ogilvie</u>						
Bacillariophyceae	94	100	96	100	99	86
Chlorophyceae	5	0	4	0	1	14
Cyanophyceae	1	0	0	0	0	0
<u>Swift</u>						
Bacillariophyceae	37	100	100	100	63	73
Chlorophyceae	62	TR*	0	TR	37	27
Cyanophyceae	1	0	0	0	TR	TR
<u>S 14</u>						
Bacillariophyceae	39	-	100	100	97	60
Chlorophyceae	60	-	0	0	3	39
Cyanophyceae	1	-	0	0	TR	1
<u>OR 8</u>						
Bacillariophyceae	95	-	-	100	-	98
Chlorophyceae	5	-	-	0	-	2
Cyanophyceae	0	-	-	0	-	0
<u>S 5</u>						
Bacillariophyceae	-	-	-	100	100	100
Chlorophyceae	-	-	-	0	0	0
Cyanophyceae	-	-	-	0	TR	0

Continued .....

* Trace

Table 2. (continued)

River	Date of Sampling					
	4-10 Oct.1977	10-20 Dec.1977	22-30 Mar.1978	15-26 May 1978	17-30 June 1978	1-8 Aug.1978
S 3						
Bacillariophyceae	-	-	-	100	90	80
Chlorophyceae	-	-	-	0	10	15
Cyanophyceae	-	-	-	0	0	5
S 2						
Bacillariophyceae	-	-	-	95	-	89**
Chlorophyceae	-	-	-	1	-	1
Cyanophyceae	-	-	-	0	-	TR
S 8						
Bacillariophyceae	-	-	-	-	99	60
Chlorophyceae	-	-	-	-	0	0
Cyanophyceae	-	-	-	-	1	40

** 9% of sample belonged to class Chrysophyceae (*Hydrarus foetidus*) chemical environment in the Ogilvie (Schreier, 1978) should actually favour a greater species diversity. Also, in the Ogilvie a few dominant species accounted for almost all of the diatom numbers. All the rare species (a rare species is one which accounts for less than 5% of the total diatom number at all times) made up only 24% of the total numbers in the Ogilvie whereas in the Swift River rare species made up 41% of the total diatom numbers.

Achnanthes minutissima was the most abundant diatom in both the Ogilvie and Swift Rivers (Fig. 9), although more common in the Ogilvie. This diatom is also very abundant in temperate waters, being absent only in regions of gross pollution. *Anomoeoneis vitrea, Fragilaria crotonensis* and *Diatoma hiemale* v. *mesodon* were abundant in the Ogilvie but rare in the Swift River. These species showed distinct seasonal abundance patterns and it is interesting to note that *Anomoeoneis vitrea,* an Arctic species, was at its most dominant during winter. *Achnanthes* sp., *Cocconeis placentula,* and *Diatoma tenue* v. *elongatum* were abundant only in the Swift River. These species also exhibited definite seasonal abundance patterns (Fig. 9). Most of the other diatom species enumerated were rare, and only 12 other species even accounted for as much as five percent of the numbers at particular seasons.

The distribution of the "non-diatom" forms was much more patchy than that noted for the diatom species. At various times there were nine species of green algae, six blue-green algal species and one Chrysophyceae alga identified in quantitative collections from the Ogilvie and Swift River Basins (Appendix 4). The most abundant green algae were: *Mougeotia* sp., *Oedogonium* sp., *Ulothrix* sp., and *Stigeoclonium* sp. The most common epilithic

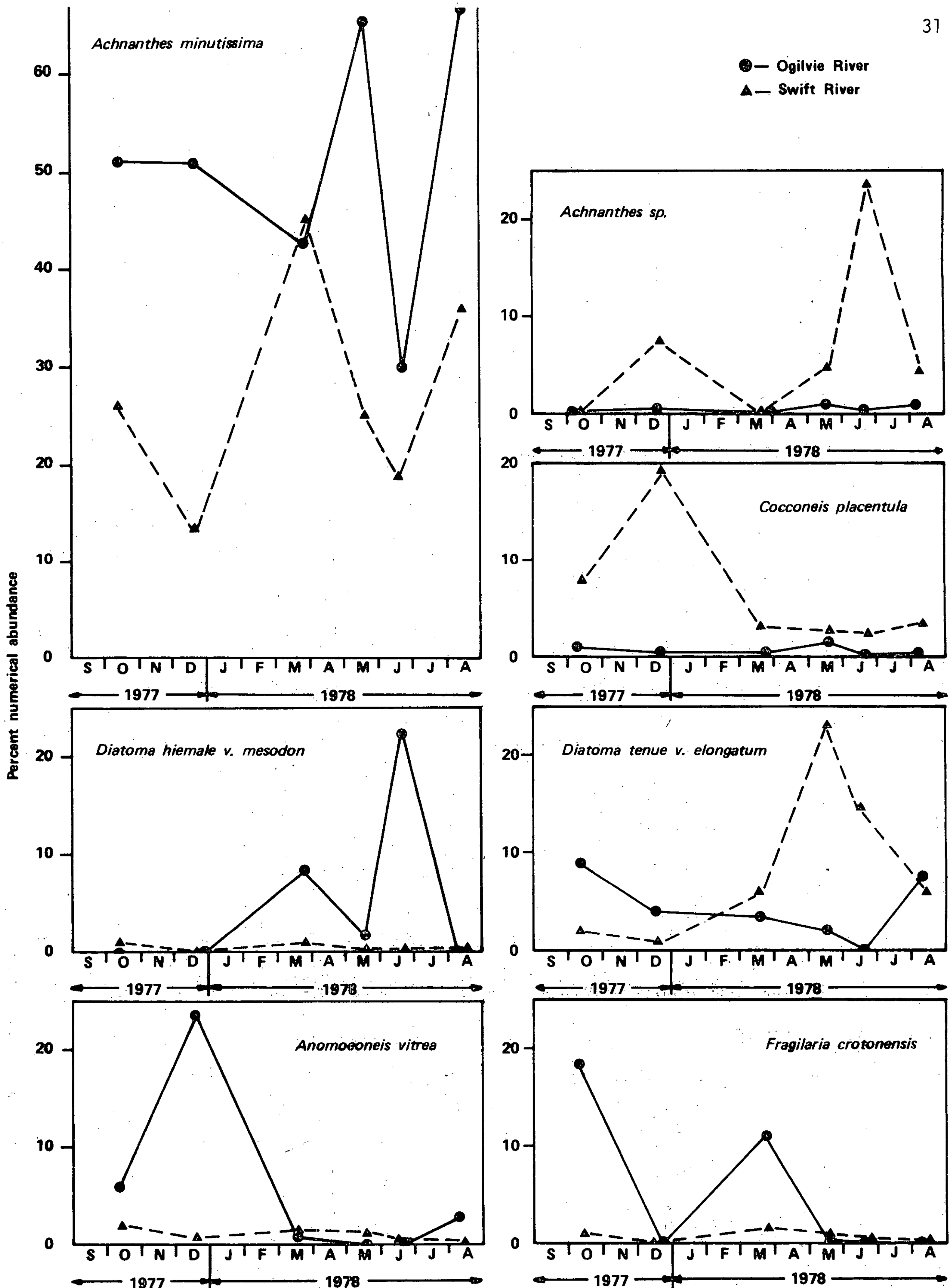


Figure 9 Seasonal distributions of the seven major periphytic diatoms in the Ogilvie and Swift Rivers.

blue-green alga was *Oscillatoria* sp.

Besides the non-diatom species observed in the quantitative samples (Appendix 4) there were also several other species enumerated in qualitative collections from unusual habitats. In the Ogilvie River the red alga, *Lemanea fucina* Bory was extremely abundant at all the bedrock sills that crossed the river (see Schreier, 1978). These sills created higher current velocities and groundwater influxes also occurred there, which caused the river to remain ice free in these spots, even during mid-winter. The blue-green algae *Chamaesiphon incrustans* Grun. and *Clastidium setigerum* Kirchn. grew epiphytically on the *Lemanea*. *Hydrurus foetidus* was extremely abundant in springs which flowed into the Ogilvie. And, in Engineer Creek Euglenoid flagellates grew in the acid drainage areas where PH values were as low as 2.8. In the Swift River, the green alga *Tetraspora cylindrica* (Wahl.) C.A. Agardh was sometimes abundant. The blue-green alga *Nostoc verrucosum* grew on large boulders in several creeks flowing into the Swift River.

The levels of both planktonic and periphytic chlorophyll a in these two lotic systems (Table 1) follow a pattern similar to that of the algal standing crops (Fig. 6 and 7). That is, a marked decrease in early winter followed by a partial recovery in late winter and a rapid increase to sping and summer values.

The seasonal changes of bacterioplankton cell numbers in both rivers were remarkably similar to those of the phytoplankton (Table 3, cf. Fig.6). That is, the viable bacteria numbers as determined by plate counts were minimal in winter and increased to greater numbers in spring and summer.

Table 3. Epilithic and planktonic bacterial counts of Ogilvie and Swift River water and stream bottom material, as determined by epifluorescent microscopy and nutrient agar plate counts.

River	4-10 Oct.1977	10-20 Dec.1977	22-30 Mar.1978	15-26 May 1978	17-30 June 1978	1-8 Aug.1978
	Date of Sampling					
Ogilvie						
Periphytic (cells/cm^2)*	-	-	-	-	-	2.1×10^7
Planktonic (cells/ml)*	-	1.6×10^4	-	1.6×10^6	8.4×10^5	3.5×10^5
Periphytic (CFU/cm^2)**	-	-	3.6×10^5	-	-	3.8×10^6
Planktonic (CFU/ml)**	2.4×10^3	2.5×10^2	9.0×10^2	1.5×10^4	7.0×10^3	1.6×10^3
Swift						
Periphytic (cells/cm^2)	-	-	-	8.0×10^7	5.3×10^7	1.6×10^7
Planktonic (cells/ml)	-	1.0×10^4	-	8.4×10^4	4.3×10^4	2.7×10^5
Periphytic (CFU/cm^2)	-	-	1.4×10^5	2.1×10^5	5.7×10^4	9.1×10^4
Planktonic (CFU/ml)	6.5×10^2	3.2×10^2	9.9×10^2	1.0×10^3	3.9×10^2	1.9×10^3

* epifluorescent counts

** plate counts, CFU = colony forming units

In both lotic systems, a slight increase in numbers was noted between early and late winter.

Other investigators have noted numbers of both planktonic and epilithic bacteria which were similar to those observed in these two rivers (Table 3). Geesey *et al.* (in press) found that the epilithic and planktonic bacterial numbers (assayed by epifluorescent microscopy) of a pristine subalpine. stream system in the Canadian Rocky Mountains ranged seasonally from 1×10^6 to 1×10^8 cell/cm^2 and from 2×10^3 to 2×10^5 cells/ml respectively. Both planktonic and epilithic bacterial numbers were minimal in the winter and maximal in the summer. The sessile bacteria numbers were greater than those of the bacterioplankton by approximately 2 order of magnitude.

Total bacterial numbers, as assayed by epifluerescent microscopy, were only done on material collected in later field trips and hence these data were not sufficient to interpret seasonal trends. However, the ratio between planktonic bacterial/ml and sessile bacteria/cm^2 were between 10^2 and 10^3 in all waters assayed by this technique (Table 3). These are somewhat greater than the values obtained by Geesey *et al.* (see above). Assuming that the average depths of the Ogilvie and Swift River were approximately 1 m, the calculated ratios of the planktonic to epilithic bacterial cell numbers vary from 1.690 to 0.080. The ratios of the phytoplankton to periphyton cell numbers vary from 0.167 to 0.007 (based upon calculation of the chlorophyll a data of Table 1 and an average river depth of 1 m). Within the limites of these experimental data it would appear that a somewhat greater proportion of the total bacterial cells may be suspended in water as compared to the microalgae. However, in most instances, greater levels of microbial numbers were present in the stream bottoms as compared to overlying waters.

The numbers of invertebrates /m^2 of river or stream bottom sampled using a Surber sampler ranged from 5 to 1038 with a mean value for all samples of 227 (Table 4, detailed data in Appendix 5). These densities are somewhat lower than those which have been found by other investigators in similar streams and creeks in both the Yukon and North West Territories. Brunskill *et al.* (1973) found that "zoobenthos density in the Yukon and North Slope areas ranged from a few hundred to a few thousand organisms /m^2. Hoos and Holman (1973) found the numbers of organisms to be ca. 3,600/m^2 at a site in Rose Creek which was not perturbed by mine tailings. Because of the limited number of samples it is difficult to compare invertebrate species and numbers in the Swift River and Ogilvie River drainage basins, although benthic invertebrate numbers appear to be greater in the Ogilvie River (May to August, 1978) (Table 4). The chironomidae were the most numerous macroinvertebrates in the majority of samples, an observation which has also been noted by other investigators (Brunskill *et al.*, 1973 and Hoos and Holman, 1973).

Physico-Chemical Parameters

The average water temperatures of both the Ogilvie and Swift Rivers varied between winter lows of ca. 0 C and summer highs of 12 - 15 C during 1977 - 78. For at least 7 months of the year the temperatures were at or near freezing (Fig.3). Hence, this physical parameter may have had a large influence upon the numbers (see above), as well as activities (see below) of the microflora of these rivers.

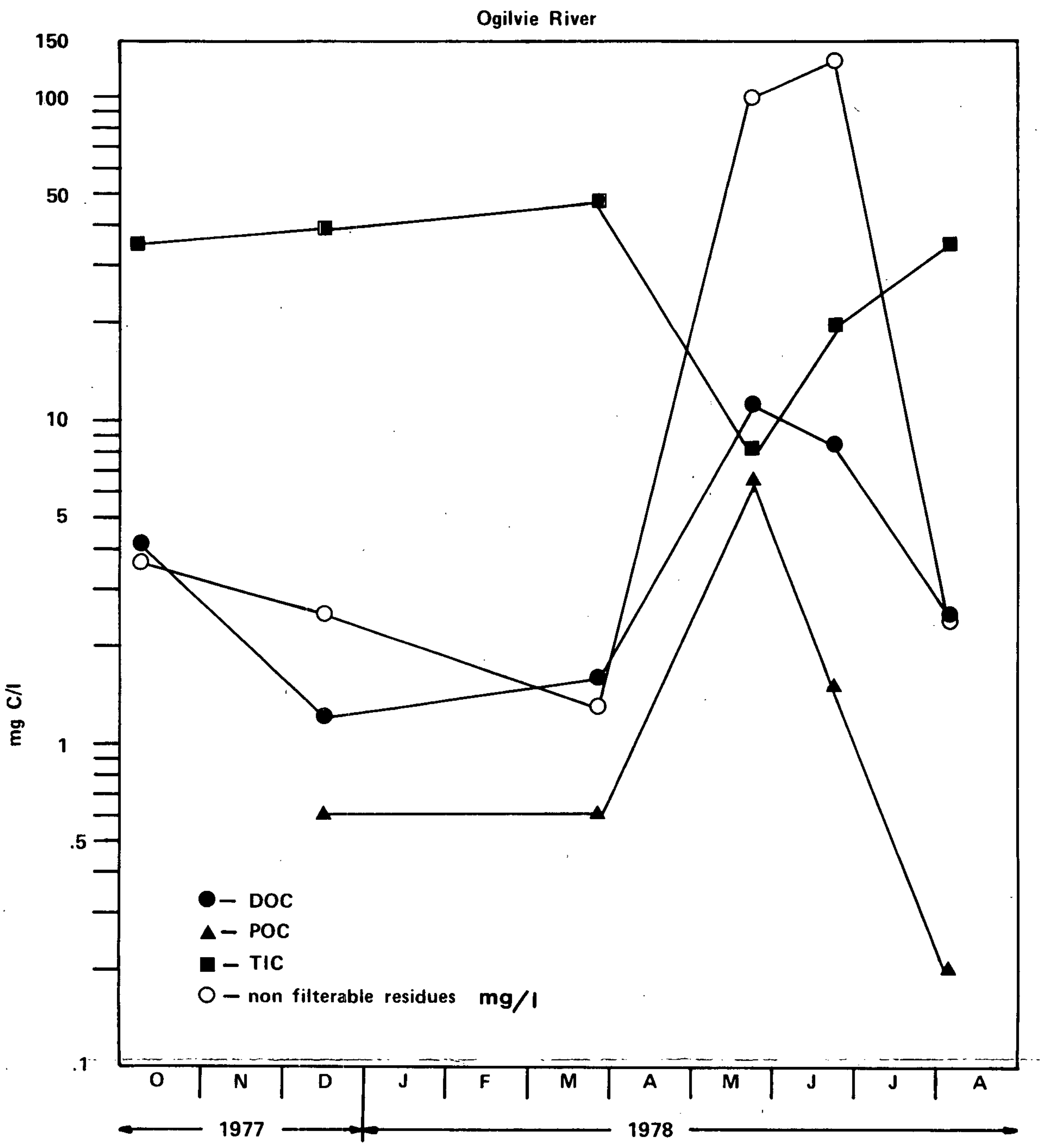
Table 4. Invertebrates (numbers/m^2) of several streams of the Ogilvie and Swift River drainage basins.

	Date of Sampling				
River	4-10 Oct. 1977	28-29 Mar. 1978	22-30 May 1978	17-30 June 1978	1-8 Aug. 1978
Ogilvie	15	*	528	485	227
Swift	424	114	90	195	95
S 14	55	-	19	73	-
OR 8	25	-	5	-	39
S 5	-	-	207	422	291
S 8	-	-	139	287	193
S 3	-	-	153	335	212
OR 14	-	-	-	-	1038

*Qualitative sample only

DOC values increased in spring and decreased as the seasons progressed through summer, fall and winter (Fig.10) These spring increases were probably due to both allo- and autochthnous addition of organic matter to the two rivers, although a distinction between the relative importance of each to the total DOC levels cannot be made on the basis of these data. However, the contributions by both of these sources are probably decreased in fall, lowest in winter and highest in spring and summer since (1) freezing conditions would greatly slow tributary and land run-off into these rivers (allochthnous addition) and (2) phytoplankton and periphytic algal productivities were lowest in fall and winter (autochthonous addition) (see below).

TIC values of Ogilvie River water are almost always greater than those of the Swift River (at similar times of the year). Since the Ogilvie River system flows over extensive limestone substratum whereas the Swift River does not, there is probably a much greater non-biological contribution of CO_2, HCO_3^- and $CO_3^=$ to the former river. However, both rivers displayed marked seasonal variations in TIC. These values increased from summer to their highest concentrations in later winter prior to ice "break-up" (Fig. 10). A reasonable explanation is that this increase may be partially due to community respiration. That is, during the ca. 7 months of ice cover a significant portion of the planktonic and benthic DOC and POC were metabolized with the concomitant release of CO_2 which tended to collect under the ice as TIC. At spring break-up a sudden drop in TIC values were noted in each river (Fig. 10). This may be due to the abrupt release of TIC to the atmosphere as CO_2 as well as its fixation by biological processes. See below.



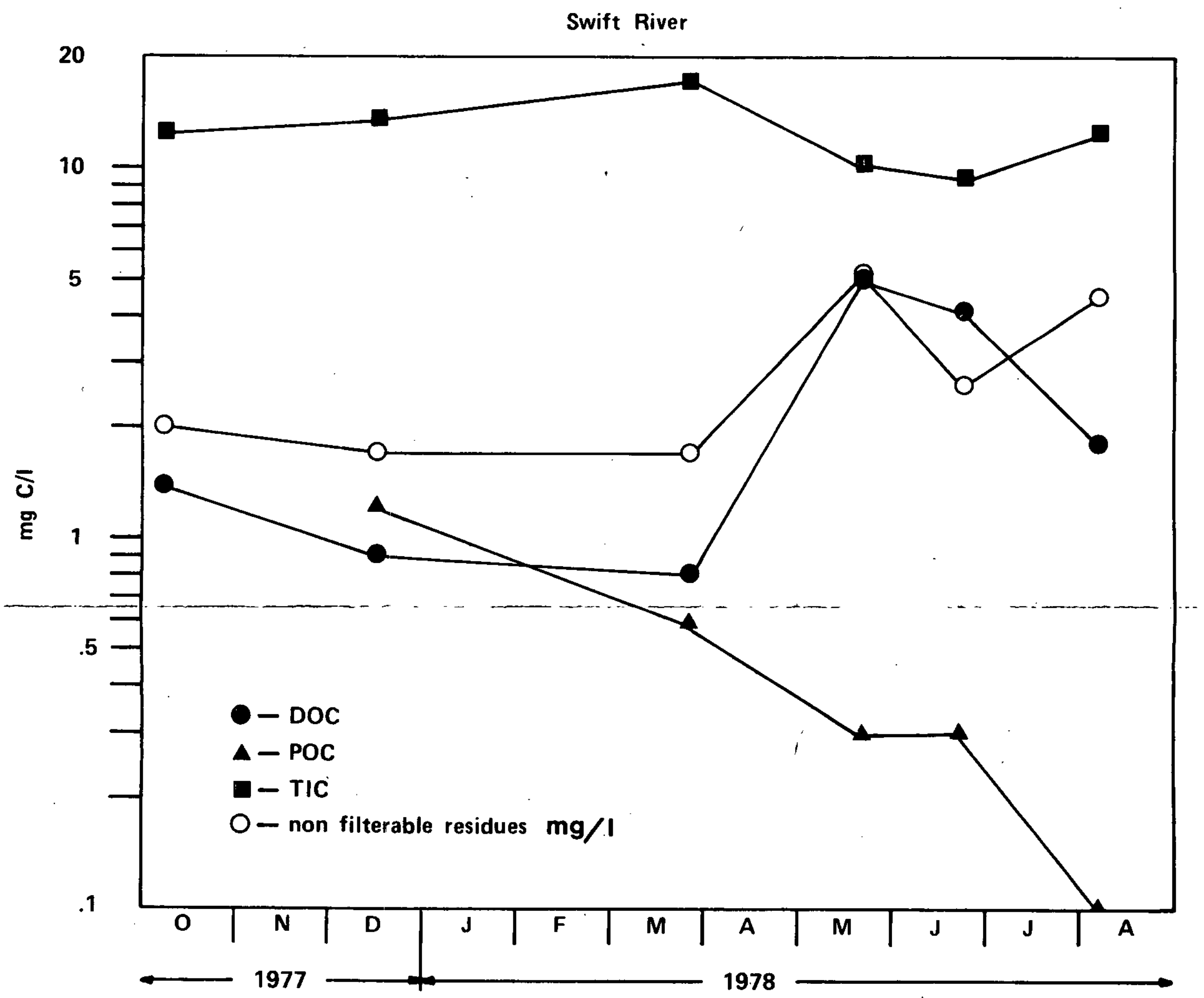


Figure 10 Dissolved (DOC, mg C/l), particulate (POC, mg C/l) and total inorganic (TIC, mg C/l) carbon concentrations, and non filterable residues (mg /l) of the Ogilvie and Swift Rivers.

POC values were generally greater in the Ogilvie than in the Swift River water (Fig. 10). Since these concentrations are a function of both microbial (cf. data of Figs. 6 and 7, Table 3) and detritus content of these waters, the concentrations of which in turn are regulated by many biotic and abiotic factors, it is difficult to interpret these data in a simple fashion other than to state that the Ogilvie River water column appears to be the more productive of the two systems.

Microbial Activities

The planktonic microflora of both the Ogilvie and Swift Rivers displayed glucose heterotrophic activities for most of the year, the exception being late winter of 1978. At that time glucose heterotrophic uptake versus time kinetics by the microorganisms of the water were linear with time, but Michaelis-Menten uptake kinetics were not observed (Fig.11). This phenomenon has been noted previously in other aquatic ecosystems and it is the experience of one of us (L.J.A.) that this occurs under at least three conditions, viz. (1) the microbial contents of the waters are exremely low (2) the concentrations of naturally occurring metabolites are minimal or (3) the microbial ecosystem is stressed by pollutants (e.g. mercury) or by unfavourable physico-chemical conditions (e.g. low temperatures). The bacterial content of these waters were not decreased excessively in winter (Table 3), but, both DOC levels and temperatures did decrease appreciably as compared to summer values. However, linear Michaelis-Menten curves were obtained during the fall and early winter when the temperatures were ca. OC which would tend to eliminate low temperatures as a cause of scattered uptake of glucose in later winter. A more likely cause may be the quantity and quality of DOC present in late winter (Fig.10). As winter progressed the DOC levels of both rivers decreased, probably due to microbial utilization. Since allochthonous and autochthonous production of DOC is minimal in winter, the DOC remaining in later winter may be highly refractile, and not readily available for heterotrphic microbial utilization. Hence, the bacterial cells may not have been able to readily metrabolize this material and displayed non-linear heterotrophic activity plots. Following spring "break-up" allo- and autochthonous production greatly increased the quantity and quality of DOC. This, coupled with higher water temperatures may have greatly increased glucose heterotrophic activities in spring and summer (Fig.11).

Both DOC concentrations and temperatures have been shown to influence heterotrophic bacterial activities in other aquatic ecosystems (Albright, 1977, Wright and Hobbie, 1965, Hamilton *et al.* 1966 and Dietz *et al.* 1977).

Values of glucose $K_t + S_n$ tended to decrease significantly during the fall and winter months as compared to the spring (following ice "break-up") and summer months which is indirect evidence that glucose utilization rates may exceed production rates from ca. October to March (prior to ice "break-up"). That is, the DOC of the water may have become more refractile during the fall and winter months.

Since the streamside materials of the Swift River have a large organic matter content* addition of this to the Swift River would probably increase

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* LFH and Bm (t) contain 0.32 and 1.38 mg DOC, 158 and 13 mg organic carbon and 9 mg and trace (<1mg) organic nitrogen /g dry weight respectively.

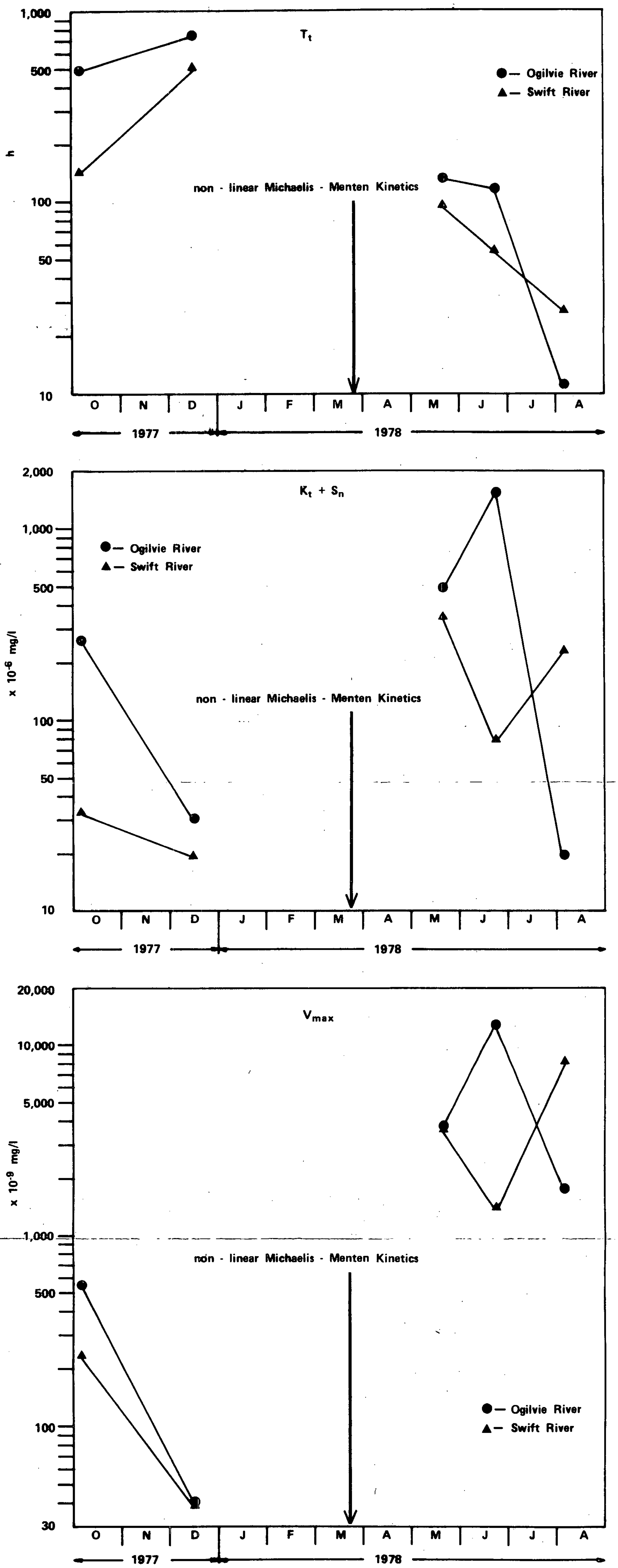

Figure 11 Glucose turnover time (T_t), maximum velocity of uptake (V_{max}) and $K_t + S_n$ values of the Ogilvie and Swift River waters.

the heterotrophic activities of the microflora at all times of the year. A predicted result would be increased oxygen demands of these aquatic ecosystems.

The glucose hetrotrophic potentials assayed in this study fall within the lower part of the range noted for several other freshwater rivers and lakes - and it would appear that the more northerly the water body, the less the glucose heterotrophic potentials (Table 5). However, this generalization must be treated with a great deal of caution at this time since so few Arctic and sub-Arctic freshwater bodies have been assayed for hetrotrophic activities.

Phytoplankton photosynthesis occurred throughout the year in these two rivers with maximal activity in the late spring and summer and minimal activity during winter (Table 6). These data are highly variable which is probably due to changing daily conditions within each watershed. These include silt level, temperature, water discharge (which may tend to suspend periphytic algae in the water column) and sunlight. An example of the results of one of these natural perturbations is that of the minimal photosynthetic rate which was observed on 23 June, 1978 (Table 6) in the Ogilvie River. Heavy rainfall naturally perturbed this river with suspended matter (non filterable residue, 117 mg / litre) which resulted in heavy turbidity and little light penetration beyond a water depth of ca. 0.1 m. Hence, photosynthesis did not appreciably occur (Table 6) although phytoplankton concentrations were high (Figs. 6 and 7).

Table 5. A comparison of glucose heterotrophic potentials (V_{max}) of several lakes and rivers.

Water Body	Range in glucose heterotrophic potentials (mg glucose/ℓ/h) ($\times 10^{-4}$)	Latitude	Source
Fraser River	0.27 - 9	ca. 49° N	Albright (1977)
Lake Erken	24 - 400	ca. 60° N	Hobbie & Wright (1968)
Lappland Lake	3.2*	-	Hobbie & Wright (1968)
Char Lake	0.01 - 0.08**	ca. 75° N	Morgan and Kalf (1972)
Chilliwack River	0.04	ca. 49° N	Albright & Wentworth (1973)
Capilano River	0.02	ca. 49° N	" "
Nicomekyl River	7	ca. 49° N	" "
Serpentine River	1.8	ca. 49° N	" "
Ogilvie River	0.00041 - 0.131	ca. 65° N	This study
Swift River	0.00039 - 0.036	ca. 60° N	This study

* Result of one assay only.

** Assays from mid-November to mid-October were not reported.

Table 6. Periphytic (mg $C/m^2/day$) and planktonic (mg $C/m^3/day$) algal productivities of the Ogilvie and Swift Rivers.

River	Date of Sampling					
	4-10 Oct. 1977	10-20 Dec. 1977	22-30 Mar. 1978	15-26 May 1978	17-30 June 1978	1-8 Aug. 1978
Ogilvie						
Periphytic	-	-	80.2	-[1]	-[1]	56.4
Planktonic	-	0.8	0.2	17.4	ND[2]	12.8
Swift						
Periphytic	-	-	0.1	23.7	-	282.0
Planktonic	-	4.4	1.8	21.6	1.9	10.1

1. No assay because of high water conditions.

2. No detectable activity.

Table 7. Epilithic (mg C/m^2/day) and planktonic (mgC/m^3/day) heterotrophic microbial productivities of the Ogilvie and Swift Rivers.

River	Date of Sampling					
	4-10 Oct. 1977	10-20 Dec. 1977	22-30 Mar. 1978	15-26 May 1978	17-30 June 1978	1-8 Aug. 1978
Ogilvie						
Epilithic	-	-	0.4	-[1]	-[1]	0
Planktonic	-	1.8	1.5	25.5	70.2	1.6
Swift						
Epilithic	-	-	0.1	0.01	-	0
Planktonic	-	1.3	ND[2]	0.9	0.7	3.9

1. No assay because of high water conditions.

2. No detectable activity.

The planktonic dark productivities were generally greater than light productivities for much of the year in the Ogilvie River whereas the opposite was noted for the Swift River (light productivities generally exceeded dark productivities) (Tables 6 and 7). In addition, the dark productivities of the Ogilvie River exceeded those of the Swift during the yearly cycle assayed (Table 7). The reasons for this are not known although there are several observations which may be pertinent: (1) DOC levels of the Ogilvie River water were greater than those of the Swift River during the annual cycle of Oct. 1977 - August 1978. (2) Ogilvie River bacterioplankton biomasses exceeded those of the Swift River throughout the year and (3) glucose $K_t + S_n$ values of the Ogilvie River were generally greater than those of Swift River water. Thus, bacteriorplankton productivities (which are a major portion of the total dark productivities of aquatic microbial ecosystems) should on the basis of these observations be greater in the Ogilvie as compared to the Swift River.

Assays of benthic algal and bacterial productivities of stream bed materials of both the Ogilvie and Swift Rivers were not always possible because of either (1) extensive ice cover (winter) or (2) high water conditions (spring). Therefore, although the benthic productivitiy values reported were only for spring through summer of 1978 (Tables 6 and 7) it is probable that both periphytic algal and epilithic heterotrophic bacterial productivities occur throughout the year based upon observed levels of both algal and bacterial standing crops and planktonic productivities (Tables 2 and 3, Figures 6 and 7). Although these data are highly variable (due to fluctuating environmental river conditions as outlined above as well as inherent patchiness of benthic microorganisms in lotic ecosystems) they nevertheless indicate that the periphytic algal productivities exceeded those of the epiphytic bacterial productivities (often by several order of magnitude). Thus, upon comparison of total bacterial (planktonic and epilithic) and total microalgal (planktonic and periphytic) productivities of each river, microbial productivities of the Ogilvie and Swift Rivers appear to be algal dominated (Tables 6 and 7).

In summary, microbial (microalgal and bacterial) biomasses and activities of these two lotic ecosystems were greatest in spring and summer with decreasing values noted through fall and winter. The data support the hypothesis that light and DOC may be the major factors controlling standing crops and activities of microalgae and bacteria respectively.

The Ogilvie River appears to be more productive than the Swift River with regard to microorganisms since generally both standing crops and activities of microalgae and bacteria were greater in the former throughout the year. The reasons for this are not know although this difference may be a reflection of the greater levels of both TIC (microalgal substrate) and DOC (heterotrophic bacterial substrate) noted in the Ogilvie as compared to the Swift River at equivalent times of the year (Table 7).

Perturbation Experiments

The foregoing data and observations may be useful in predicting general influences of streamside and sediment additions to the river waters upon standing crops and activities of microalgae and bacteria. Increased loadings by these materials would probably reduce light levels thereby lowering phytoplankton photosynthetic rates (see natural example in Table 6) which in turn would adversely influence algal standing crops. Since stream-bank material contains relatively large amounts of DOC (see above) and stream sediments probably also have a large DOC component the results of these addtions may be increased standing crops and activities of hetero-trophic bacteria (and hence increased BOD) in the water column. The activities of the bacterioplankton of these two lotic systems may be mainly DOC limited (see above, cf. Table 3 and Fig.10). Hence, DOC added at any time of year (including winter) via stream bank material and sediment would probably increase heterotrophic activities. In addition, oxygen levels of these two rivers are lowest in late winter (Schreier, 1978) and therefore these two lotic systems may be most stressed by DOC addition at that time.

Most particulate streambank and sediment materials would tend to settle to the stream bottoms within several km of its site of addition, over-lying and smothering some of the benthic flora (mosses, periphyton and epilithic bacteria) which would tend to lower their standing crops, produc-tivities and activities. Recolonization of these stressed areas would even-taully occur with the rates in winter being the slowest.

Thus, the least sensitive time for perturbation of these two lotic systems by streambank and seditment materials would probably be late spring following "break up" since microbial productivities are high and natural perturbation by streambank materials and sediments occur at this time. The most sensitive time with regard to influcences upon algal and bacterial activities (which in turn would influence DO levels) as well as recolonization rates would be winter. The remainder of this manuscript deals with a quantitative evaluation of DO levels and BOD values of the Ogilvie and Swift Rivers at various times of the year as influenced by streambank and sediment additions in the context of microalgal and bacterial biomasses and activities.

Data of Scheier (1978) and that of others (Schallock and Lotspeich, 1974) indicate that many Alaskan and Canadian Arctic and sub-Arctic Rivers have similar annual DO concentration trends. That is "the waters are near saturation during spring "break up" and fall "freeze up" when water temperatures are near 0 C, somewhat lower DO concentrations during warm summer periods; and yearly minimum concentration during the winter (January - March) interval ..... Data indicate that DO depression begins in October and continues into February" (Schallock and Lotspeich, 1974). A second important observation of these authors was that DO depletion may become more severe as the river water flows from its headwaters to its mouth under an ice cover. This is probably due to continued biological and chemical utilization of DO of each water mass as its travels the length of the river. In several rivers these DO depletions may be severe, e.g. the Yukon River from the Alaska - Canadian border to its mouth displayed DO levels of ca. 10.5 mg/l and 1.9 mg/l respectively during March of 1971 (Schallock and Lotspeich, 1974).

In both of our study areas the levels of the DO dropped significantly from early fall (Swift River, ca.11 - 14 ppm; Ogilvie River, ca. 9 - 15 ppm) to late winter (Swift River, ca. 3 - 10 ppm; Ogilvie River, ca. 5 - 11 ppm) and remained at relatively high concentrations during the ice-free seasons of late spring following ice "break up" (Swift River, ca. 8 - 15 ppm; Ogilvie River, ca.11 - 12 ppm) and summer (Swift River, ca.10 - 12 ppm; Ogilvie River, ca.10 - 12 ppm) (Data of Schreier, 1978) Large spatial variations in DO were found in both rivers during winter (Schreier, 1978). The drop in average DO levels under ice cover was probably due to a variety of physical, chemical and biological influences such as dilution of river water by ground water, abiotic reduction by various types of organic and inorganic materials and respiration by the aquatic micro- and macroorganisms. When these data are used to calculate the *in situ* rate of DO depletion in the Swift River during the period of ice cover (October to March) a net respiration value of 0.041 mg $O_2/\ell/d$ is obtained. This value is of the same order of magnitude of net respiration rate values reported by Welch (1974) for three Canadian Arctic and sub-Arctic lakes during ice cover (Table 8).

In late winter the experimentally determined BOD values of both the Ogilvie and Swift Rivers were in the range of ca. 0.5 to 1.0 mg $O_2/\ell/21$ d (ca. 0.023 to 0.048 mg $O_2/\ell/d$) (Table 9). These were probably maximum values of BOD since the treatments that the waters underwent would tend to increase BOD values. These are (1) on incubation temperature of 1±1C, as compared to ca. 0 C at the time of sampling - this temperature increase would tend to increase biological activity (2) enclosure of natural waters in glass containers tends to accelerate biological activities, including oxygen utilization (bottle effect) and (3) the storage times of the waters at temperatures > 1 C

Table 8. Respiration rates for several Arctic and sub-Arctic Canadian water bodies.

Water Body	Respiration Rate ($mg\ O_2/\ell/day$)	Source
Char Lake	0.011	Welch (1974)
Resolute Lake	0.021	Welch (1974)
Eleanor Lake	0.010	Welch (1974)
Swift River	0.041 *	This study
	0.023 **	This study
Ogilvie River	0.048 **	This study

* Assays *in situ*.

** BOD laboratory assays for 21 days at 1 ± 1 C.

Table 9. Biological oxygen demand* (mg O_2/ℓ) of waters removed from several streams from the Ogilvie and Swift River drainage basins and incubated in the laboratory at 1 ± 1 C.

	Date of Sampling		
River	10-20 Dec. 1977	22-30 Mar. 1978	15-26 May 1978
Ogilvie	-	1.0	3.2
Swift	<0.1 (55 days)	0.5	0.7
OR 8	-	<0.1	-

* 21 day incubation unless otherwise noted.

prior to BOD assays would tend to increase bacterial numbers.

The *in situ* (0.041 mg O_2/ℓ/d) and experimentally assayed (0.023 to 0.048 mg O_2/ℓ/d) rates of DO depletion in the Swift River and its water respectively are approximately the same. However, these data comparisons must be interpreted with a great deal of caution since BOD values assayed *in vitro* are subject to experimental errors which tend to bias the results upwards (see above discussion). In addition, these *in vitro* BOD values do not take into consideration both biological and chemical oxygen demands of the stream bottom as well as oxygen utilization by planktonic macroorganisms (including fish). Benthic bacteria, fungi, insect larvae and other invertebrates may exert a considerable oxygen demand upon the overlying water. McDonnell and Hall (1969), for example, noted that ca. 50% of the benthic oxygen utilization by organisms was due to invertebrates in a river system.

Treatments of both Ogilvie and Swift River waters with several (LFH, Ae and Bm (t)) soil horizon materials (from the Swift Riverbank) markedly influenced BOD values (Table 10). All treatments greater than 0.10g streambank material/litre of stream water significantly increased oxygen utilization by the native microorganisms of these two waters beyond that of the untreated control values.

Both planktonic algal and heterotrophic productivities of the Swift River waters were also influenced by these streambank materials additions (Table 11). Bm (t) and LFH additions at 10 g/ℓ and 1 g/ℓ (LFH additions at other concentrations were not done) respectively significantly increased microbial productivities, particularly by heterotrphic microorganisms. However, these

Table 10 The influences of three Swift River streamside soil horizons upon Biological Oxygen Demand of Swift and Ogilvie River Waters. (Sampled 10 March 1978). Incubation temperature = 1 ± 1 C.

Sediment Addition	Swift River Water		Ogilvie River Water	
	Days of Incubation at 1 ± 1 C.			
	21	51	21	45
None	0.4	1.7*	0.0	0.4
0.01 g/ℓ LFH**	0.5	1.3	-	-
0.10 g/ℓ LFH	1.7	9.3	0.0	0.8
1.00 g/ℓ LFH	4.5	10.3	1.2	4.4
10.00 g/ℓ LFH	10.5	10.8	9.6	10.4
0.01 g/ℓ Ae***	0.9	1.7	-	-
0.10 g/ℓ Ae	1.0	2.6	0.0	0.6
1.00 g/ℓ Ae	3.1	9.9	0.3	1.8
10.00 g/ℓ Ae	9.4	10.7	9.4	10.1
0.01 g/ℓ Bm(t) ****	0.7	1.1	-	-
0.10 g/ℓ Bm(t)	0.7	1.4	0.0	0.6
1.00 g/ℓ Bm(t)	1.4	5.9	0.3	1.0
10.00 g/ℓ Bm(t)	5.5	10.4	1.9	6.4

* all values expressed as mg O_2/ℓ

** leaf, ferment and humus horizon

*** leached mineral horizon

**** mineral horizon

Table 11 - The influence of two streamside soil horizons upon planktonic algal (mg C/m^3/day) and heterotrophic (mg C/m^3/day) productivities of the Swift River.

Sediment Addition	Algal Productivity (23 June 1978)	Heterotrophic Productivity (7 Aug. 1978)
None	1.4	3.0
0.10 g/ℓ Bm(t)*	3.3	8.1
1.00 g/ℓ Bm(t)	1.4	4.9
10.00 g/ℓ Bm(t)	16.8	20.0
1.00 g/ℓ LFH**	6.1	27.7

* mineral horizon

** leaf, ferment and humus horizon

phytoplankton productivity data may be misleading since all perturbant material was contained within BOD assay bottles which were then replaced in the clear stream water for incubation. If sediment and streambank material had been added to the entire river system light penentration into the water would have been markedly less with resultant decreases in algal productivities (see Microbial Activity Section dealing with a natural perturbation by silt of the Ogilvie River in June). Addition research needs to be done on the influence of silt loads upon both planktonic and periphytic activities. Since heterotrophic productivities are not light dependent the greatly increased activities noted at Bm(t) levels of 10 g/ℓ may be significant in the context of BOD by these rivers in winter (see previous discussion).

It is difficult to forcast the sediment loads which will occur in the Ogilvie and Swift River waters downstream of a construction site as a result of trenching and backfilling operations since these loads will be greatly influenced by factors such as water velocity, trench depth and substrate size(s). One study which attempted to determine downstream sediment loading of river waters as influenced by streambottom trenching and backfilling was that of Landeen and Brandt (1975) in the La Biche and Kotaneelee Rivers, tributaries of the Liaid River. These authors found that suspended sediment concentrations rose abruptly downstream of river trenching and backfilling activities. The La Biche River suspended sediment concentrations rose to between 100 and 200 mg/ℓ from background levels of less 10 mg/ℓ. Twenty-four hours after trenching had ceased the suspended sediment loads were $<$ 10 mg/ℓ (similar to levels noted prior to construction activity).

Schreier (1978) noted that the total non filterable residue of the water of the Ogilvie River varied greatly from ca. 2 to 270 mg/ℓ during May - July 1978 (cf. the non filterable residue data of (Fig.10). The Swift River did not display these large variations in non filterable residue levels; these remained below 5.2 mg/ℓ (Fig.10) (The Swift River was not sampled at freshet when non filterable residue levels were probably much greater.

Perturbation Summary

Additions of several Swift River streambank materials (LFH, Ae and Bm(t) to Swift River water increased BOD values and heterotrophic productivities. Depending upon the biological process, significant influence of streambank materials were noted over the concentration range of 0.10 g/ℓ to 10 g/ℓ (Tables 10 and 11).

The time of year at which streamside and sediment additions to river and creek waters occurs is of great importance since these materials increase bacterial activities and BOD values which result in accelerated oxygen depletion rates. These rivers tend to be most sensitive to streambank materials and sediment additions in winter and least sensitive in late spring (following ice "break up") and early summer.

Many swamps and bogs contain waters of relatively high organic matter content which may greatly increase BOD of receiving waters.

LITERATURE CITED

Albright, L.J. (1977). Heterotrophic bacterial dynamics in the lower Fraser River, its Estuary and Georgia Strait, British Columbia, Canada. Mar. Biol. 39:203-211.

Albright, L.J. and J.W. Wentworth (1973). Use of the heterotrophic activity technique is a measure of eutrophication. Environ. Pollut. 5:59-72.

American Public Health Association, American Water Works Association and Water Pollution Control Federation (1965). Standard methods for examination of water and waste water. 12th ed. New York. 769 p.

Antia, N.J. and J.Y. Cheng (1970). The survival of axenic cultures of marine planktonic algae from prolonged exposure to darkness at 20 C. Phycologia 9:179-183.

Battarbee, R.W. (1973). A new method for the estimation of absolute microfossil numbers, with reference especially to diatoms. Limnol. Oceanogr. 18:647-653.

Bourrelly, P. (1966). Les Algues d'Eau Douce. I. Les Algues Vertes. N. Boubee et Cie, Paris. 672 p.

Bourrelly, P. (1968). Les Algues d'Eau Douce. II. Les Algues Jaunes et Brunes, Chrysophycees, Pheophycees, Xanthophycees et Diatomees. N. Boubee et Cie, Paris. 438 p.

Bourrelly, P. (1970). Les Algues d'Eau Douce. III. Les Algues Bleues et Rouges, Les Eugleniens, Peridiniens et Cryptomonadines. N. Boubee et Cie, Paris. 512 p.

Bowden, W.B. (1977). Comparison of two direct-count techniques for enumerating aquatic bacteria. Appl. Environ. Microbiol. 33:1229-1232.

Brunskill, G.J., D.M. Rosenberg, N.B. Snow, G.L. Vascotto, and R.W. Wagemann (1973). Ecological studies of aquatic systems in the Mackenzie-Porcupine drainages in relation to proposed pipeline and highway developments. Canada Task Force N. Oil Dev. Env. Soc. Comm. Vol.I. Report 73-40. Information Canada Cat. No. R72-10073/1-1. QS-1533-010-EE-A1. 131 p. Vol.I.

Burnison, B.K. and R.Y. Morita (1974). Heterotrophic potential for amino acid uptake in a naturally eutrophic lake. Appl. Microbiol. 27:488-495.

Claasen, P.W. (1931). Plecoptera nymphs of America (north of Mexico). Thos. Say Foundation of the Entomol. Soc. Am. Publ. No. 3:1-199.

Cleve-Euler, A. (1951-1955). Die Diatomeen von Schweden und Finnland. Kungl. Svenska Vetensk. Handl. NS 2 (1951), 163 p.: 3 (1952), 153 p.: 4i (1953), 154 p.: 4ii (1954), 158 p.: 5 (1955), 232 p.

Daley, R.J. and J.E. Hobbie (1975). Direct counts of aquatic bacteria by a modified epifluorescence technique. Limnol. Oceanogr. 20:875-882.

Dietz, A.S., L.J. Albright and T. Tuominen (1977). Alternative model and approach for determining microbial heterotrophic activities in aquatic systems. Appl. Envir. Microbiol. 33:817-823.

Edmondson, W.T. (1959). Fresh water biology, Wiley, N.Y.

Geesey, G.G., R. Mutch and J.W. Costerton. Sessile bacteria: an important component of the microbial population in small mountain streams. Limnol. Oceanogr. In press.

Geitler, L. (1932). Cyanophyceae. In L. Rabenhorst (ed) Kryptogamen - Flora von Deutschland, Osterreich und der Schweiz. 14 Akad. Verlags., Leipzig. 1196 p.

Hellebust, J.A. and J. Lewin (1972). Transport systems for organic acids induced in the dark in the marine pennate diatom *Cylindrotheca fusiformes*. Can. J. Microbial. 18:225-233.

Hellebust, J.A. (1968). The uptake and utilization of organic substrates by marine phytoplankters. *In*. Proceedings of symposium on organic matter in natural waters (Univ.of Alaska, College) Edited by D. Hood, pp. 225-256.

Hamilton, R.D., K.M. Morgan and J.D.H. Strickland (1966). The glucose uptake kinetics of some marine bacteria. Can. J. Microbiol. 12:995-1003.

Hobbie, J.E., R.J. Daley and S. Jasper (1977). Use of nuclepore filters for counting bacteria by fluorescence microscopy. Appl. Environ. Microbiol. 33:1225-1228.

Hobbie, J.E. and R.T. Wright (1968). A new method for the study of bacteria in lakes: description and results. Mitt. int. Verein theor. Angew. Limnol. 14:64-71.

Hoek, C. van den. (1963). Revision of the European Species of *Cladophora*. E.J. Brill, Leiden, The Netherlands. 248 p. + 55 pl.

Hoos, R.A.W. and W.N. Holman (1973). A preliminary assessment of the effects of Anvil mine on the environmental quality of Rose Creek, Yukon. Environ. Prot. Ser. Man. Rep. No. 5-PR-73-8, 49 pp.

Huber-Pestaloozi, G. (1942). Das Phytoplankton des Susswassers. p. 347-549. In A. Thienemann (ed.) Die Binnengewasser. 16 (2:2). Diatomeen. E. Schweizerbart. Verlags., Stuttgart.

Hustedt, F. (1930). Bacillariophyta (Diatomeae). In A. Pascher (ed.) Die Susswasser-flora Mitteleuropas. 10. Gustav Fischer, Jena. 468 p.

Hustedt, F. (1931-1959). Die Kieselalgen. In L. Rabenhorst (ed.) Kryptogamen-Flora von Deutschland, Osterreich und der Schweiz. 7 (2). Akad. Verlags., Leipzig. 845 p.

Jansz, E.R. and F.I. Maclean (1973). The effect of cold shock on the blue-green alga *Anacystis nidulans*. Can.J. Microbiol. 19:381-387.

Johannsen, O.A. (1969). Aquatic Diptera Entomological Reprint Specialists, Los Angeles.

Karlstrom, U. and S. Backlund (1977). Relationship between algae cell number, chlorophyll a and fine particulate organic matter in a river in Northern Sweden. Arch. Hydrolbiol. 80:192-199.

Landeen, B.A. and C.W. Brandt (1975). Impressions of the construction of the Pointed Mountain gas pipeline. Northern Operations Branch, Fish and Mar. Service, Environment Canada, 58 pp.

Larsson, K., C.Weibull, and G. Cronberg (1978). Comparison of light and election microscopic determinations of the number of bacteria and algae in lake water. Appl. Environ. Microbiol. 35:397-404.

Lewin, J. and J.A. Hellebust (1975). Heterotrophic nutrition of the marine pennate diatom *Navicula pavillardi* Hustedt. Can. J. Microbiol. 21: 1335-1342.

Lorenzen, C. (1967). Determination of chlorophyll and pheo-pigments: Spectrophotometric equations. Limnol. Oceanogr. 12:343-346.

McDonnell, A.J. and S.E. Hall (1969). Effect of environmental factors on benthic oxygen uptake. J. Water Pollution Control Federat. Supp. 41, pp. 353-363.

Menzel, D.W. and R.F. Vaccaro (1964). The measurement of dissolved organic particulate carbon in seawater. Limnol. Oceanogr. 9:138-142.

Morgan, K.C. and J. Kalff, (1972). Bacterial dynamics in two high arctic lakes. Freshwat. Biol. 2:217-228.

Nautical Almanac Office.(1976). The nautical almanac for the year 1977. London, Her Majesty's Sationary Office. 276 pp.

Nautical Almanac Office.(1977). The nautical almanac for the year 1978. London, Her Majesty's Stationary Office. 276 pp.

Needham, J.G., J.R. Traver and Y -C. Hsu (1935). The biology of mayflies, Cornstock, Ithica, N.Y.

Northcote, T.G., G.L. Ennis, and M.H. Anderson (1975). Periphytic and planktonic algae of the Lower Fraser River in relation to water quality conditions. Westwater Research Centre, Univ. Brit. Col., Tech. Rep. No. 8. 61 p.

Northern Natural Resources Ltd. (1977). A collection of fisheries information from water bodies associated with pipeline routes in the Yukon Territroy from Dawson to Watson Lake. 3535 E. 45th Ave. Van. B.C. Prepared for Fish and Mar. Serv. Dept. of Fish and Environ. Vancouver, 403 pp.

Overbeck, J. and R.J. Daley (1973). Some precautionary comments on the Romanenko Techniques for estimating heterotrophic bacterial production. Bull. Ecol. Res. Comm. (Stockholm) 17:342-344.

Parsons, T.R. and J.D.H. Strickland (1962). On the production of particulate organic carbon by beterotrophic processes in sea water. Deep-Sea Res. 8:211-222.

Patrick, R., and C.W. Reimer (1966). The diatoms of the United States, exclusive of Alaska and Hawaii. I. Acad. Nat. Sci. Philadelphia, Monogr. 13. 688 pp.

Patrick, R. and C.W. Reimer (1975). The diatoms of the United States, exclusive of Alaska and Hawaii. II. Acad. Nat. Sci. Philadelphia, Monogr. 13. 213 pp.

Prescott, G.W. (1962). Algae of the Western Great Lakes Area. Wm. C. Brown Co. Inc., Dubuque, Iowa. 977 pp.

Ricker, W.E. (1943). Stoneflies of southwestern British Columbia. Indiana Univ. Publ. Sci. Ser. No. 12:1-145.

Romanenko, V.I., J. Overbeck and Y.I. Sorokin (1972). Estimation of production of heterotrophic bacteria using ^{14}C. In:Microbial production and decomposition in fresh waters, pp. 82-85. Ed. by Y.I. Sorokin and H. Kadota. Oxford: Blackwell Scientific.

Ross, H.W. (1944). The caddisflies or tricoptera of Illinois. Bull Illinois, Nat. Hist. Survey, 23:1-326.

Schallock, E.W. and F.B. Lotspeich (1974). Low winter dissolved oxygen in some Alaskan rivers. U.S. Environ. Protection Agency rep. no. EPA-666/3-74-008. Corvallis, OR. 33 pp.

Schindler, D.W., V.E. Frost and R.V. Schmidt (1973). Production of epilithophyton in two lakes of the experimental lakes area, Northwestern Ontario. J.Fish, Res. Bd.Can. 30:1511-1524.

Schreier, H. (1978). Water quality processes and conditions in the Ogilvie and Swift river basins Yukon territory. Water Quality Branch, Inland Water Directorate, Department of the Environment, Vancouver. 108 pp.

Sheehan, S.W., G.L. Ennis and R.L. Hallam. A water quality study of the Flathead River basin in B.C. prior to proposed coal mining. Inland Waters Directorate, Water Quality Branch, Vancouver. In Press

Smith, S.D. (1968). The *Rhyacophila* of the salmon river drainage of Idaho with special reference to larvae. Ann. Enomolog. Soc. Am. 61:655-674.

Sreenivasa, M.R., and H.C. Duthie (1973). Diatom flora of the Grand River, Ontario, Canada. Hydrobiol. 42:161-224.

Strickland, J.D.H. and T.R. Parsons (1968). A practical handbook of seawater analysis. Fish.Res. bd. Can. Bull.167. 311pp.

Talling, J.F. (1955). The relative growth rates of three plankton diatoms in relation to underwater radiation and temperature. Ann. Bot. 19:329-341.

Tett, P., C. Gallegos, M.G. Kelly, G.M. Hornberger and B.J. Cosby (1978). Relationships among substrate, flow and benthic microalgal pigment density in the Mechums River, Virginia. Limnol. Oceanogr. 23:785-797.

Usinger, R.L. (ed.) (1956). Aquatic insects of California. Univ. of Cal. Berkley.

Utermohl, H. (1958). The improvement of quantitative phytoplankton methodology. Mitt. Internat. Verein. Limnol. 9:1-39 (Transl. from German). Fish Res. Board Can. Transl. Ser. 2713.

Van Landingham, S.L. (1969-1975). Catalogue of the Fossil and Recent Genera and Species of Diatoms and their Synonyms. Parts I-V. J. Cramer, Lehre. p.1-2963.

Watson, S.W., T.J. Novitsky, H.L. Quinby and F.W. Valois (1977). Determination of bacterial number and biomass in the marine environment. Appl. Environ. Microbiol 33:940-946.

Weber, C.I. (1966). A Guide to the Common Diatoms at Water Pollution Surveillance System Stations. U.S. Environmental Protection Agency, Cincinnati, Ohio. 101 pp.

Welch, H.E. (1974). Metobolic rates of Arctic lakes. Limnol Oceanogr. 19:65-73.

Wright, R.T. and J.E. Hobbie (1965). The uptake of organic solutes in lake water. Limnol. Oceanogr. 10:22-28.

Wright, R.T. and J.E. Hobbie (1966). Use of glucose and acetate by bacteria and algae in aquatic ecosystems. Ecology 47:447-453.

APPENDIX 1: Cellular volumes of algal species listed in Appendices 2 and 3.

Species	Volume: μm^3
Bacillariophyceae:	
Achnanthes clevei Grun.	150
inflata (Kutz.) Grun.	160
flexella (Kutz.) Grun.	1270
lancelota (Breb.) Grun.	120
microcephala (Kutz.) Cl.	100
minutissima Kutz.	60
sp.	210
Amphipleura pellucida (Kutz.) Kutz.	1920
Amphora sp.	50
Anomoeoneis vitrea (Grun.) Ross	280
zellensis (Grun.) Cl.	370
Asterionella formosa Hass.	220
Cocconeis placentula Ehr.	700
Cyclotella bodanica Eulenst.	1520
comta (Ehr.) Kutz.	845
glomerata Bachm.	200
ocellata Pant.	900
Cymatopleura solea (Breb.) W. SM.	2970
Cymbella affinis Kutz.	4525
caespitosa (Kutz.) Grun.	2070
cistula (Ehr.) Kirchn.	16090
prostrata (Berk.) Cl.	3990
sinuata Greg.	100
turgida Greg.	1760
ventricosa Kutz.	260
sp. "A"	37470
sp.	530
Diatoma hiemale (Lyngb.) Heib.	250
hiemale v. *mesodon* (Ehr.) Grun.	1210
tenue v. *elongatum* Lyngb.	110
vulgare Bory	1460
Diploneis decipiens A. Cl.	630
Denticula elegans Kutz.	350
sp.	430
Frustulia rhomboides (Ehr.) DeT.	960

Species	Volume: μm^3
Epithemia sorex Kutz.	1720
turgida (Ehr.) Kutz.	25030
Eunotia pectinalis (O.F. Mull.?) Rabh.	1830
sp.	440
Fragilaria capucina Desm.	1850
construens v. *construens* (Ehr.) Grun.	210
construens v. *binodis* (Ehr.) Grun.	480
construens v. *venter* (Ehr.) Grun.	250
crotonensis Kitton	360
leptostauron (Ehr.) Hust.	520
vaucheriae (Kutz.) Peters	170
Frustulia rhomboides (Ehr.) DeT	960
Gomphonema acuminatum Ehr.	620
intricatum Kutz.	690
lanceolatum (Ag.) Ehr.	630
olivaceum (Lyngb.) Kutz.	370
parvulum Kutz.	980
ventricosum Greg.	700
Gomphoneis herculeana (Ehr.) Cl. *(Gomphonema herculeanum)*	4750
Didymosphenia geminata (Lyngb.) M. Schmidt. *(Gomphonema geminatum)*	21260
Gomphonema sp.	300
Gyrosigma sciotense (Sulliv. & Wormley) Cl.	14190
Hannaea arcus (Ehr.) Patr.	2520
arcus v. *amphioxys* (Rabh.) Patr.	1070
Meridion circulare (Grev.) Ag.	1670
Melosira granulata (Ehr.) Ralfs	1800
granulata v. *angustissima* O.F. Mull.	750
Navicula bicephala Hust.	360
convergens Patr.	350
cryptocephala Kutz.	780
pupula Kutz.	420
radiosa Kutz.	550
salinarum v. *intermedia* (Grun.) Cl.	830
scutelloides W. Sm.	970

Species		Volume: µm^3
Navicula tripunctata	(O.F. Mull.) Bory	1480
viridula	(Kutz.) Kutz.	1690
sp. A		540
sp. B		280
sp. C		480
Neidium sp.		1400
Nitzschia acicularis	W. Sm.	280
angustata	(W. Sm.	920
dissipata	(Kutz.) Grun.	410
frustulum	(Kutz.) Grun.	170
hantzschia	Rabh.	250
linearis	W. Sm.	3370
palea	(Kutz.) W. Sm.	645
sigma	(Kutz.) W. Sm.	500
sp.		660
Pinnularia sp.		940
Rhoicosphenia curvata	(Kutz.) Grun.	510
Rhopalodia gibba	(Ehr.) O. F. Mull	13470
Stauroneis phoenicentron	(Nitz.) Ehr.	3020
anceps	Ehr.	560
sp.		150
Surirella angustata	Hust.	3030
ovata	Kutz.	15350
sp.		1200
Synedra delicatissima	W. Sm.	4590
ulna	(Nitz.) Ehr.	3460
ulna v. *oxyrhychus*	(Forti) Hust. *(Synedra angustata)*	3520
radians	Kutz.	1240
acus	Kutz.	1400
Stephanodiscus astraea	(Ehr.) Grun.	2280
tenuis	Hust.	230
Tabellaria fenestrata	(Lyngb.) Kutz.	840
flocculosa	(Roth) Kutz.	520

Species	Volume: μm^3
Chlorophyta:	
Ankistrodesmus falcatus (Corda) Ralfs.	260
Chlamydomonas sp.	160
Ulothrix sp.	669,660 μm^3/mm of algae
Oedogonium sp.	951,200 μm^3/mm of algae
Mougeotia sp.	473,630 μm^3/mm of algae
Closterium sp.	14380
Cosmarium sp.	5870
Cryptophyta:	
Chroomonas acuta Utermohl	100
sp.	440
Cryptomonas borealis Skuja	1800
Cryptomonas sp.	400
Chrysophyta:	
Dinobryon sertularia Ehr.	1140
Cyanophyta:	
Oscillatoria sp.	13,850 μm^3/mm of algae
Anabaena sp.	10,180 μm^3/mm of algae

APPENDIX 2

Appendix 2a - Viable phytoplankton concentrations (4-10 October 1977) (cells/ml) of several streams of the Ogilvie and Swift River drainage basins. Species that are typically periphytic are indicated with a check (√), typically planktonic with a solid circle (o) and those equally important in both habitats are indicated with a plus (±) sign. (analyzed using 500 X magnification). (1 of 2 pages)

	SPECIES	SAMPLE LOCATION		
		Ogilvie River	Swift River	OR 8
√	*Achnanthes flexella*	2.94*	0	0
√	*Achnanthes lancelota*	0	7.7	.884
√	*Achnanthes minutissima*	12.4	5.5	7.5
√	*Amphipleura pellucida*	0	1.1	0
√	*Amphora* sp.	2.0	0	0
√	*Anomoeoneis vitrea*	42.4	13.2	3.1
√	*Cocconeis placentula*	0	2.2	.884
o	*Cyclotella ocellata*	0	0	0
√	*Cymatopleura solea*	0	0	0
√	*Cymbella caespitosa*	0.7	5.5	0
√	*Cymbella sinuata*	0.7	0	0
√	*Diatoma hiemale*	1.47	4.4	.442
±	*Diatoma tenue* v. *elongatum*	23.4	8.8	18.1
√	*Fragilaria construens* v. *binodis*	15.5	0	0
±	*Fragilaria crotonensis*	0.4	0	0
±	*Fragilaria vaucheriae*	0	0	0
√	*Gomphonema olivaceum*	1.47	0	0
√	*Navicula pupula*	0	0	0
√	*Navicula punctata*	0	0	0
√	*Navicula* sp.	1.47	2.2	0
√	*Nitzschia acicularis*	.736	0	0
√	*Nitzschia frustulum*	0	2.2	0
√	*Nitzschia* sp.	44.9	34.1	6.63
±	*Synedra ulna* v. *oxyrhychus*	0	0	.884

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Appendix 2a - Continued: (2 of 2 pages)

SPECIES	SAMPLE LOCATION		
	Ogilvie River	Swift River	OR 8
√ *Tabellaria flocculosa*	1.1	0	0
o *Ankistrodesmus falcatus*	0	6.6	0
o *Chlamydomonas* sp.	2.9	20.9	0
o *Chroomonas acuta*	4.42	5.5	0
o *Chroomonas* sp.	1.1	0	0
o *Cryptomonas* sp.	.245	0	0
TOTAL	160.3	114.4	38.4

* Only figures to the first decimal place are significant. The remainder are carried for calculation purposes only.

Appendix 2b - Viable Phytoplankton Concentrations (December 10-20 1977) (cells/ml) of several streams of the Ogilvie and Swift River drainage basins. Species that are typically periphytic are indicated with a check (✓), typically planktonic with a solid circle (o) and those equally important in both habitats are indicated with a plus (±) sign. (analyzed using 500 X magnification). (1 of 2 pages)

SPECIES	SAMPLE LOCATION	
	Ogilvie River	Swift River
✓ *Achnanthes flexella*	.0084*	0
✓ *Amphipleura pellucida*	0	.0238
✓ *Cymatopleura solea*	0	.0076
✓ *Cymbella ventricosa*	0	.0115
✓ *Cymbella* sp.	.0252	.0141
✓ *Cocconeis placentula*	0	.0141
✓ *Diatoma hiemale*	0	.0238
✓ *Diatoma hiemale* v. *mesodon*	.0252	0
± *Diatoma tenue* v. *elongatum*	.4116	.0038
✓ *Epithemia turgida*	0	.0101
✓ *Eunotia pectinalis*	0	.0069
✓ *Diatoma vulgare*	.0168	0
± *Fragilaria capucina*	.0588	.0612
✓ *Fragilaria construens* v. *binodis*	.1512	.188
✓ *Frustulia rhomboides*	0	.0206
✓ *Didymosphenia geminatum*	0	.031
✓ *Gomphonema olivaceum*	0	.035
✓ *Hannaea arcus*	.0084	0
± *Melosira granulata*	0	.183
✓ *Meridion circulare*	.0252	0
✓ *Navicula cryptocephala*	0	.0052
✓ *Navicula pupula*	0	.006
✓ *Navicula radiosa*	0	.0032
✓ *Navicula tripunctata*	0	.0152

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Appendix 2b - Continued: (2 of 2 pages)

SPECIES	SAMPLE LOCATION Ogilvie River	Swift River
√ *Navicula* sp.	.0252	.0133
√ *Neidium* sp.	0	.0038
√ *Nitzschia dissipata*	0	.0103
√ *Pinnularia* sp.	0	.0032
√ *Rhopalodia gibba*	0	.0310
√ *Stauroneis* sp.	0	.0038
√ *Surirella* sp.	0	.0038
± *Synedra ulna*	.0168	.0258
± *Synedra ulna* v. *oxyrhychus*	0	0
± *Tabellaria fenestrata*	.0168	0
± *Synedra acus*	.4284	.889
± *Synedra* sp.	0	.038
√ *Cymbella turgida*	0	.0063
√ *Cymbella caespitosa*	0	.0063
TOTAL	1.218	1.699

* Only figures to the first decimal place are significant. The remainder are carried for calculation purposes only.

Appendix 2c - Viable Phytoplankton Concentrations (22-30 March 1978) (cells/ml) of several streams of the Ogilvie and Swift River drainage basins. Species that are typically periphytic are indicated with a check (√), typically planktonic with a solid circle (o) and those equally important in both habitats are indicated with a plus (±) sign. (analyzed using 500 X magnification). (1 of 2 pages)

SPECIES	SAMPLE LOCATION	
	Ogilvie River	Swift River
√ *Achnanthes flexella*	.275*	0
√ *Achnanthes microcephala*	0	0
√ *Achnanthes minutissima*	1.65	.122
√ *Achnanthes* sp.	0	.122
√ *Cymbella affinis*	0.092	0
√ *Cymbella sinuata*	0.000	0.061
√ *Cymbella ventricosa*	.184	.122
√ *Cymbella* sp. A	0.092	0
√ *Cymbella* sp.	0.000	0
√ *Diatoma hiemale*	3.85	0
± *Diatoma tenue* v. *elongatum*	1.192	.122
√ *Epithemia turgida*	0.000	.061
± *Fragilaria capucina*	.275	0
± *Fragilaria crotonensis*	1.009	0
± *Fragilaria vaucheriae*	2.20	.122
√ *Gomphonema acuminatum*	0.000	.061
√ *Gomphonema olivaceum*	0.184	.061
± *Melosira granulata*	0.092	0
√ *Meridion circulare*	0.367	0
√ *Navicula radiosa*	0.000	.122
√ *Navicula* sp.	0	0
√ *Nitzschia linearis*	.092	0
√ *Nitzschia palea*	.275	.061
± *Synedra acus*	1.468	.244
± *Synedra* sp.	0.092	.244

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Appendix 2c - Continued (2 of 2 pages)

SPECIES	SAMPLE LOCATION	
	Ogilvie River	Swift River
± *Tabellaria fenestrata*	0.000	0
√ *Cocconeis placentula*	0.000	.1835
± *Synedra ulna*	0.000	.1835
o *Chlamydomonas* sp.	0.184	.549
o *Dinobryon sertularia*	0.000	.061
TOTAL	13.573	2.502

* Only figures to the first decimal place are significant. The remainder are carried for calculation purposes only.

Appendix 2d - Viable Phytoplankton Concentrations (15-26 May, 1978) (cells/ml) of several streams of the Ogilvie and Swift River drainage basins. Species that are typically periphytic are indicated with a check (√), typically planktonic with a solid circle (o) and those equally important in both habitats are indicated with a plus (±) sign. (analyzed using 500 X magnification). (1 of 2 pages)

SPECIES	SAMPLE LOCATION							
	Ogilvie River	Swift River	S 14	OR 8	S 5	S 8	S 3	S 2
√ *Achnanthes minutissima*	48.8	37.8	0	24.6	4.6	1.84	5.9	18.4
√ *Achnanthes flexella*	1.65*	.46	0	.92	0	0	0	0
√ *Achnanthes* sp.	1.38	.613	0	0	0	.92	.92	0
√ *Amphipleura pellucida*	.46	.55	0	0	0	0	.46	0
√ *Cocconeis placentula*	0	.46	0	0	4.6	0.92	11.0	1.38
√ *Cymbella caespitosa*	2.2	1.3	0	0	2.8	0	0	0
√ *Cymbella cistula*	1.47	0.3	0	0	0	0	0	0.9
√ *Cymbella ventricosa*	5.6	2.6	0	2.3	0	0	0	1.84
√ *Cymbella sinuata*	0	0	0	0	0	0	0	0
√ *Cymbella* sp.	0	0	0	0.7	0	0.5	0	0.9
√ *Diatoma hiemale*	.552	2.3	0	2.8	0	0	1.84	0
√ *Diatoma hiemale* v. *mesodon*	9.9	5.5	4.6	4.4	0	2.8	9.7	7.8
± *Diatoma tenue* v. *elongatum*	21.7	32.4	0	53.3	0	0	0	33.2
√ *Diatoma vulgare*	0.5	1.4	17.9	8.6	0	0	0	1.9
√ *Fragilaria construens* v. *binodis*	8.1	7.3	0	22.6	1.38	0	.92	4.6
√ *Fragilaria construens* v. *venter*	10.8	1.2	0	0.7	2.8	1.4	0	3.2
± *Fragilaria capucina*	14.5	5.2	0	0	0	0	0	7.82
± *Fragilaria vaucheriae*	5.52	7.1	0	12.9	0.5	0	0	11.96
√ *Gomphonema acuminatum*	0	.46	0	0	0	0	0.5	0
√ *Didymosphenia geminatum*	0	0	0	0	0	0	0.5	0
√ *Gomphonema olivaceum*	12.15	6.9	0	10.0	1.38	3.68	2.3	3.68
√ *Hannaea arcus*	9.38	8.81	26.7	10.0	0.5	1.38	0.9	14.7
√ *Hannaea arcus* v. *amphioxys*	1.84	.76	3.22	3.68	0	0	0	0
± *Melosira granulata*	0	10.4	0	0	0	0	0	0
± *Melosira granulata* v. *angustissima*	0	0.2	0	0	0	0	0.5	0
√ *Meridion circulare*	9.5	1.4	0	1.6	0	0	0.9	1.4
√ *Navicula cryptocephala*	0	.92	0	.92	0	0	0	0
√ *Navicula salinarum* v. *intermedia*	1.1	1.84	0	2	0.5	0	0	0
√ *Navicula* sp.	4.7	2.6	0.5	4.6	0.5	.46	0.9	.92
√ *Neidium* sp.	0.3	0.8	0	1.3	0	0	0	1.9
√ *Nitzschia hantzschia*	0	0.9	0	0	0	0	0	0
√ *Nitzschia palea*	4.5	3.4	0	1.4	0	0.5	0.5	1.84
√ *Nitzschia sigma*	0	0.2	0	0	0	0	0	0
± *Synedra ulna*	16.9	7.1	2.3	12.8	1.8	0.5	0	3.68
± *Synedra ulna* v. *oxyrhychus*	2.5	0	0	0	0	0	0.5	0.5

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Appendix 2d - Continued (2 of 2 pages)

SPECIES	SAMPLE LOCATION							
	Ogilvie River	Swift River	S 14	OR 8	S 5	S 8	S 3	S 2
± *Tabellaria fenestrata*	0	.15	0	1.4	0	0	0	0
√ *Nitzschia acicularis*	0	0.3	0	0	0	0	0	.92
√ *Anomoeoneis vitrea*	1.1	0	0	0	0	0	0	0
√ *Fragilaria leptostauron*	0.5	0	0	0	0	0	0	0
√ *Nitzschia linearis*	0	0	0	0	0	0.2	0	0
√ *Oscillatoria* sp. *(mm)*	0	0	0	0	0	0	0	0
o *Ankistrodesmus falcatus*	0	0.2	0	0	0	0	0	0
√ *Oedogonium* sp. *(mm)*	0	0.1	0	0	0	0	0	0
√ *Ulothrix* sp. *(mm)*	0	0	0	0.2	0	0	0	0
o *Chlamydomonas* sp.	0	0.6	0	0	0	0.9	0.5	1.4
o *Cryptomonas borealis*	0	0.2	0	0	0	0	0	0
o *Chroomonas acuta*	0	0.2	0.5	0	0.5	0.9	0	0
TOTAL	197.6	154.9	55.7	183.7	21.9	16.9	38.7	124.8

* Only figures to the first decimal place are significant. The remainder are carried for calculation purposes only.

Appendix 2e - Viable Phytoplankton Concentrations (17-30 June, 1978) (cells/ml) of several streams of the Ogilvie and Swift River drainage basins. Species that are typically periphytic are indicated with a check (✓), typically planktonic with a solid circle (o) and those equally important in both habitats are indicated with a plus (±) sign. (analyzed using 500 X magnification). (1 of 2 pages)

SPECIES	SAMPLE LOCATION							
	Ogilvie River	Swift River	S 14	OR 8	S 5	S 8	S 3	S 2
✓ *Achnanthes flexella*	.23*	0.63	0	0.9	0	0	0	0
✓ *Achnanthes minutissima*	27.3	19.5	.5	15.6	10.1	6.0	11.5	14.7
✓ *Achnanthes* sp.	2.1	.3	0	0	1.8	0.5	0	.9
✓ *Amphipleura pellucida*	0	0	0	0	0	0	0	1.4
✓ *Amphora* sp.	0	0	0	0	0	0	.5	0
✓ *Anomoeoneis vitrea*	.6	.5	0	0	0	0	0	0
✓ *Cocconeis placentula*	0	.4	0.5	0	1.4	0	3.2	0.5
o *Cyclotella ocellata*	0	0.2	0	0	0	0	0	0
✓ *Cymbella caespitosa*	1.8	.9	0.5	0	1.8	.9	0.5	1.8
✓ *Cymbella cistula*	0.6	0.2	0	0	0	0	0	0
✓ *Cymbella sinuata*	2.5	0.3	0	0	0.9	0	1.4	0.9
✓ *Cymbella ventricosa*	5.7	2.0	0	0	2.8	0	1.8	0
✓ *Cymbella* sp.	0	0	0	0	0.5	0	0	0
✓ *Diatoma hiemale* v. *mesodon*	13.5	.6	0	0	0.9	7.4	12.0	0
o *Diatoma tenue* v. *elongatum*	43.6	16.1	0	18.4	2.8	0	5.1	8.3
✓ *Diatoma vulgare*	0	0	0.9	0	0	0.5	3.7	0.5
✓ *Diploneis decipiens*	0	0	0	0	0	0	0.5	0
± *Fragilaria capucina*	12.2	1.6	0	3.7	1.4	3.2	5.1	3.7
✓ *Fragilaria construens* v. *construens*	1.1	0.9	0	0	0	0	0	0.9
✓ *Fragilaria construens* v. *binodis*	4.1	3.5	0	0	2.8	3.7	5.1	0
✓ *Fragilaria construens* v. *venter*	4.9	.9	0	0	0	0	0	0
± *Fragilaria vaucheriae*	7.7	1.3	0	8.3	1.4	8.7	1.8	1.8
✓ *Gomphonema acuminatum*	0	0.4	0	0	0	0	0	0
✓ *Didymosphenia geminatum*	0	0	0	0	0.5	0	0	0
✓ *Gomphonema olivaceum*	3.3	2.4	0	1.8	6.0	1.4	2.8	.92
✓ *Gomphonema paruulum*	0	1.7	0	0	0	0	0	0
✓ *Hannaea arcus*	14.1	1.5	0	0	.9	20.2	2.3	0.9
✓ *Hannaea arcus* v. *amphioxys*	0	0	0	0	0.9	5.5	1.4	0.5
± *Melosira granulata*	0	1.7	0	0	0	1.8	0	0.5
± *Meridion circulare*	8.7	.1	0	0	0	.9	6.4	0.5
✓ *Navicula cryptocephala*	0.2	0.3	0	0	0	0	0	0.5
✓ *Navicula salinarum* v. *intermedia*	0	.1	0	0	0.5	0	0	.5
✓ *Navicula* sp.	0	0	0	0	0	0	0	0
✓ *Neidium* sp.	.2	.1	0	0	0	0.5	0.5	1.4
✓ *Nitzschia acicularis*	0	0.2	0	0	0	0	0	0
✓ *Nitzschia hantzschia*	0.3	0	0	0	0	0	0	0

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Appendix 2e - Continued (2 of 2 pages)

SPECIES	SAMPLE LOCATION							
	Ogilvie River	Swift River	S 14	OR 8	S 5	S 8	S 3	S 2
✓ *Nitzschia linearis*	0.4	0	0	0	0	0	0	0.5
✓ *Nitzschia palea*	0.2	.4	0	0	0	0.5	1.4	0
✓ *Nitzschia sigma*	0.4	0	0	0	0	0	0	0
✓ *Rhopalodia gibba*	0	0.1	0	0	0	0	0	0.9
± *Stephanodiscus astreae*	0	0	0	0	0	0	0	0.5
± *Synedra ulna*	17.1	7.0	0	.9	0	1.4	3.2	2.8
± *Synedra ulna* v. *oxyrhychus*	6.9	1.7	0	3.7	0	0	0	0
± *Tabellaria fenestrata*	0.5	0	0	0	0	.9	0	0
o *Chlamydonomas* sp.	0	0	0.5	0	0	0.5	0	0
o *Dinobryon sertularia*	0	0.2	0.5	0	0	0	0	0
o *Chroomonas acuta*	0.6	0.1	0.5	0	0	0	0	0
o *Cryptomonas borealis*	0	0.2	0	0	0	0	0	0
TOTAL	205.3	69.2	4.4	54.2	36.5	64.5	71.1	47.7

* Only figures to the first decimal place are significant. The remainder are carried for calculation purposes only.

Appendix 2f - Viable Phytoplankton Concentrations (1-8 Aug., 1978) (cells/ml) of several streams of the Ogilvie and Swift River drainage basins. Species that are typically periphytic are indicated with a check (√), typically planktonic with a solid circle (o) and those equally important in both habitats are indicated with a plus (±) sign. (analyzed using 500 X magnification) (1 of 2 pages)

SPECIES	SAMPLE LOCATION									
	Ogilvie River	Swift River	S 14	OR 8	S 5	S 8	S 3	S 2	OR 14	S 5
√ *Achnanthes flexella*	.37*	0	0	1.1	0	0	0	2.8	2.8	0
√ *Achnanthes minutissima*	45.5	7.6	1.8	72.6	8.3	.92	49.5	44.2	8.3	16.6
√ *Achnanthes* sp.	0	0	0	0	0	0	4.4	0	0	0
√ *Amphipleura pellucida*	0	0	0	0	0	0	0	1.4	0	0
√ *Amphora coffeiformis*	0.2	0	0	0	0	0	0	0	0	0
√ *Amphora* sp.	0.2	0	0	0	0	0	0	0	1.8	0
√ *Anomoeoneis vitrea*	.6	.2	0	0	0	0	2.2	0	0	0
√ *Cocconeis placentula*	0	.4	0.9	0	3.7	0	1.1	1.4	0	0
√ *Cymbella affinis*	0	0.2	0	0	0	0	3.3	0	0	0
√ *Cymbella caespitosa*	1.7	0.2	0	0	1.8	0	5.5	2.8	2.8	.9
√ *Cymbella sinuata*	0.2	0	0	2.2	0	0	5.5	0	0	0
√ *Cymbella ventricosa*	1.7	1.1	0.9	3.3	0	0	0	1.4	0	1.8
√ *Cymbella* sp.	0.2	.2	0	0	0	0	0	2.8	0	0
√ *Diatoma hiemale* v. *mesodon*	0	0	1.8	0	0.9	0.9	0	2.8	24.8	0
± *Diatoma tenue* v. *elongatum*	17.3	1.8	0	77.0	0	0	25.3	13.8	0	1.8
√ *Diatoma vulgare*	0.2	0.7	0	0	0	0	0	0	2.8	0
± *Fragilaria capucina*	2.2	2.2	5.5	7.7	0.9	1.8	4.4	4.1	1.8	0
√ *Fragilaria construens* v. *binodis*	0	.7	0	0	0	2.8	0	4.7	33.1	1.8
√ *Fragilaria construens* v. *venter*	0	0	0	0	0	0	0	11.0	0	0
± *Fragilaria vaucheriae*	0.6	1.5	0	1.1	0	0	11.0	0	4.6	1.8
√ *Didymosphenia geminatum*	0.4	0	0	0	0	0	0	0	0	0
√ *Gomphoneis herculeana*	0	0	0	0	3.7	0	0	1.4	0	.9
√ *Gomphonema olivaceum*	2.4	.70	0	2.2	3.7	0.9	0	2.76	0.9	2.8
√ *Gomphonema parvulum*	0	.4	0	0	0	0	7.7	2.8	0	0
√ *Hannaea arcus* v. *amphioxys*	0	0	2.8	0	1.8	0	0	0	0	2.8
√ *Meridion circulare*	0	0	0	0	0	0	0	1.4	7.4	0
√ *Navicula cryptocephala*	0.6	0	0	0	0	0	0	0	0	0
√ *Navicula tripunctata*	0	.92	0	0	0	0	1.1	0	0	0
√ *Navicula viridula*	0	0	0	0	0	0	0	0	0.9	0
√ *Navicula* sp.	0.2	.4	0	0	0	0	0	2.8	0	0
√ *Nitzschia linearis*	0.5	0.2	0	0	0	0	0	0	0	0
√ *Nitzschia palea*	.9	.4	0	1.1	1.8	0	4.4	2.8	0.9	0
√ *Nitzschia sigma*	0	0.2	0	0	0	0	0	0	0.9	0
√ *Stauroneis* sp.	0.2	0	0	0	0	0	0	0	0	0

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Appendix 2f - Continued: (2 of 2 pages)

SPECIES	SAMPLE LOCATION									
	Ogilvie River	Swift River	S 14	OR 8	S 5	S 8	S 3	S 2	OR 14	S 5
√ *Surirella angustata*	0.2	0.5	0	0	0	0	0	0	0	0
± *Synedra ulna*	4.1	6.1	0	4.4	1.8	9.2	15.4	2.8	5.5	0
± *Synedra ulna* v. *oxyrhychus*	0	.2	0	0	7.4	2.8	9.9	9.6	0	7.4
√ *Hannaea arcus*	0	.6	0.9	0	0	0	0	0	0	0
√ *Nitzschia acicularis*	0	1.6	0	0	0.9	0	0	0	0	0
√ *Navicula pupula*	0	0.5	0	0	0	0	0	0	0	0
√ *Tabellaria flocculosa*	0	0	0	0	0	.9	0	0	0	0
o *Ankistrodesmus falcatus*	0	0.6	0	0	0	0	0	1.8	0	0
o *Chlamydomanos* sp.	0.6	0.6	0	0	0	0	0	0	0	0
± *Cosmarium* sp.	1.7	0.7	0.9	1.1	0	0	0	0	0.9	0
± *Closterium* sp.	0	0.2	0	0	0	1.8	0	0	0	0
o *Dinobryon sertularia*	0	0.8	0	0	0	0	0	0	0	0
o *Chroomonas acuta*	0.7	0	0	0	0	0	0	0	3.7	0
o *Cryptomonas borealis*	0.2	0.2	0	0	0	0	0	0	0	0
o *Cryptomonas* sp.	0.7	0.3	0	0	0	0	0	0	0	0
TOTAL	84.4	31.9	15.5	173.8	36.7	22.0	150.7	121.4	103.9	39.6

* Only figures to the first decimal place are significant. The remainder are carried for calculation purposes only.

APPENDIX 3

Appendix 3a - Periphytic Diatom Concentrations (4-10 October, 1977) (cells/cm^2) of several streams of the Ogilvie and Swift River drainage basins (analyzed using 1000 X magnification). (1 of 4 pages)

SPECIES	SAMPLE LOCATION			
	Ogilvie River	Swift River	S 14	OR 8
Achnanthes clevei	0	7734	30	2232
Achnanthes inflata	0	256	0	0
Achnanthes flexella	6654	174	0	1116
Achnanthes lancelota	0	768	0	0
Achnanthes microcephala	10295	5603	0	0
Achnanthes minutissima	251379	37360	538	82011
Achnanthes sp.	884	297	6	0
Amphipleura pellucida	386	0	0	0
Amphora sp.	776	0	0	0
Anomoeoneis vitrea	27770	3059	0	1674
Anomaeoneis zelleneis	0	111	0	0
Anomoeoneis sp.	0	0	0	0
Asterionella formosa	0	0	0	0
Cocconeis placentula	4540	11101	0	0
Cyclotella bodanica	0	0	0	0
Cyclotella glomertata	0	3184	0	0
Cyclotella ocellata	0	0	0	0
Cymatopleura solea	0	0	0	0
Cymatopleura sp.	0	0	0	0
Cymbella caespitosa	3728	1818	30	3347
Cymbella cistula	0	222	0	0
Cymbella sinuata	2855	881	0	0
Cymbella turgida	0	0	0	0
Cymbella ventrisosa	9466	2953	55	8369
Cymbella sp. "A"	202	0	0	0

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Appendix 3a - Continued: (2 of 4 pages)

SPECIES	SAMPLE LOCATION			
	Ogilvie River	Swift River	S 14	OR 8
Cymbella sp.	1282	0	0	0
Diatoma hiemale	2550	819	0	5021
Diatoma hiemale v. *mesodon*	0	1131	30	0
Diatoma tenue v. *elongatum*	43824	2867	24	27895
Diatoma vulgare	2587	546	0	0
Diploneis decipiens	0	767	0	0
Denticula sp.	386	0	0	0
Epithemia turgida	0	142	0	0
Eunotia pectinalis	0	0	0	0
Eunotia sp.	0	1013	67	0
Fragilaria capucina	733	5051	36	0
Fragilaria construens v. *binodis*	1031	5073	0	0
Fragilaria construens v. *construens*	0	1598	0	0
Fragilaria construens v. *venter*	0	1056	0	0
Fragilaria crotonensis	91121	1574	0	0
Fragilaria leptostauron	0	398	0	0
Fragilaria vaucheriae	1900	13217	212	9484
Didymosphenia geminatum	130	471	0	0
Gomphoneis herculeana	0	533	0	0
Gomphonema intricatum	0	0	0	0
Gomphonema olivaceum	4508	8971	0	0
Gomphonema parvulum	260	371	0	1116
Gyrosigma sciotense	0	0	0	0
Hannaea arcus	1557	266	26	1116
Hannaea arcus v. *amphioxys*	0	0	0	0

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Appendix 3a - Continued: (3 of 4 pages)

SPECIES	SAMPLE LOCATION			
	Ogilvie River	Swift River	S 14	OR 8
Meridion circulare	0	192	65	0
Melosira granulata	0	2219	13	0
Navicula bicephala	0	0	0	0
Navicula pupula	0	534	0	0
Navicula radiosa	0	111	0	0
Navicula salinarum v. *intermedia*	1279	2768	65	1116
Navicula scutelloides	0	111	0	0
Navicula tripunctata	1086	447	20	558
Navicula sp.	445	266	13	0
Navicula sp.	0	434	26	558
Navicula sp.	0	0	7	0
Neidium	0	0	0	0
Nitzschia acicularis	367	224	0	0
Nitzschia angustata	1442	0	0	0
Nitzschia dissipata	0	1708	0	0
Nitzschia frustulum	4479	1326	0	1116
Nitzschia hantzschia	0	1026	0	0
Nitzschia linearis	666	0	0	0
Nitzschia palea	7428	4395	33	3347
Nitzschia sp.	0	0	0	0
Pinnularia sp.	0	0	0	0
Rhopalodia gibba	0	557	0	0
Stauroneis phoenicentron	0	0	0	0
Stauroneis anceps	130	0	0	0
Stauroneis sp.	367	59	0	0

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Appendix 3a - Continued: (4 of 4 pages)

SPECIES	SAMPLE LOCATION			
	Ogilvie River	Swift River	S 14	OR 8
Surirella angustata	0	0	0	0
Surirella ovata	0	0	0	0
Synedra ulna	5639	4137	0	8926
Synedra	0	0	0	0
Synedra delicatissima	733	0	0	0
Synedra radians	1135	0	0	0
Tabellaria fenestrata	0	237	0	0
Tabellaria flocculosa	0	739	20	0
TOTAL	496,000	142,875	1,316	159,002

Appendix 3b - Periphytic Diatom Concentrations (10-20 December, 1977) (cells/cm^2) of several streams of the Ogilvie and Swift River drainage basins (analyzed using 1,000 X magnification).

SPECIES	SAMPLE LOCATION	
	Ogilvie River	Swift River
Achnanthes flexella	2322	0
Achnanthes lancelota	0	55
Achnanthes microcephala	791	32
Achnanthes minutissima	17563	407
Achnanthes sp.	144	233
Amphipleura pellucida	0	54
Amphora coffeaformis	68	14
Amphora sp.	127	63
Anomoeoneis vitrea	8147	31
Cocconeis placentula	133	581
Cyclotella ocellata	273	131
Cyclotella comta	0	68
Cymbella affinis	76	0
Cymbella caespitosa	817	108
Cymbella cistula	468	0
Cymbella sinuata	0	79
Cymbella ventricosa	151	0
Diatoma tenue v. *elongatum*	1323	30
Denticula elegans	51	0
Fragilaria capucina	68	0
Fragilaria construens v. *binodis*	29	179
Fragilaria construens v. *construens*	0	62
Fragilaria construens v. *venter*	43	74
Fragilaria leptostauron	0	48
Fragilaria vaucheriae	67	32
Frustulia rhomboides	0	3

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Appendix 3b - Continued: (2 of 2 pages)

SPECIES	Ogilvie River	Swift River
Gomphonema acuminatum	0	21
Gomphonema olivaceum	388	161
Gomphonema parvulum	57	0
Gomphonema sp.	193	108
Hannaea arcus	51	0
Melosira granulata	0	8
Navicula bicephala	0	21
Navicula salinarum v. *intermedia*	101	19
Navicula tripunctata	68	0
Navicula sp.	0	30
Neidium sp.	0	17
Nitzschia frustulum	0	86
Nitzschia palea	0	18
Nitzschia sp.	205	70
Rhopalodia gibba	0	6
Synedra acus	671	167
Nitzschia dissipata	133	0
TOTAL	32,556	3,016

Appendix 3c - Periphytic Diatom concentrations (22-30 March, 1978) (cells/cm^2) of several streams of the Ogilvie and Swift River drainage basins (analyzed using 1000 X magnification).

SPECIES	SAMPLE LOCATION		
	Ogilvie River	Swift River	S 14
Achnanthes flexella	44,966	1,688	1,419
Achnanthes lancelota	379	0	20
Achnanthes microcephala	0	0	141
Achnanthes minutissima	279,783	13,688	14,500
Achnanthes sp.	353	111	305
Amphipleura pellucida	0	0	0
Amphora sp.	6,590	22	492
Anomoeoneis vitrea	5,143	416	742
Cocconeis placentula	3,655	955	661
Cyclotella comta	0	228	0
Cyclotella glomerata	1,589	376	569
Cyclotella ocellata	0	0	0
Cymbella affinis	0	7	0
Cymbella caespitosa	949	76	0
Cymbella cistula	2,278	0	0
Cymbella sinuata	477	307	179
Cymbella ventricosa	8,690	702	120
Cymbella sp.	0	290	199
Diatoma hiemale	0	0	0
Diatoma hiemale v. *mesodon*	54,089	216	0
Diatoma tenue v. *elongatum*	23,351	1,856	1,482
Diatoma vulgare	8,891	188	0
Fragilaria capucina	12,787	0	0
Fragilaria construens v. *construens*	477	687	13
Fragilaria construens v. *binodis*	9,141	907	369
Fragilaria construens v. *venter*	6,136	1,358	1,622
Fragilaria crotonensis	73,785	452	559
Fragilaria leptostauron	1,571	203	105
Fragilaria vaucheriae	6,122	76	171
Frustulia rhomboides	0	15	0
Gomphonema lanceolotum	5,550	0	0
Didymosphenia geminatum	2,508	0	0
Gomphoneis herculeana	0	6	0
Gomphonema olivaceum	12,025	1,399	813
Gomphonema parvulum	0	82	0
Gyrosigma sciotense	0	6	67
Hannaea arcus	2,031	0	0
Hannaea arcus v. *amphioxys*	0	15	0

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Appendix 3c - Continued (2 of 2 pages)

SPECIES	SAMPLE LOCATION		
	Ogilvie River	Swift River	S 14
Melosira granulata	0	3	0
Meridion circulare	9,479	82	0
Navicula radiosa	0	3	0
Navicula salinarum v. *intermedia*	1,931	409	82
Navicula viridula	0	188	0
Navicula sp.	1,515	0	141
Neidium sp.	0	0	0
Nitzschia dissipata	2,741	640	13
Nitzschia frustulum	6,334	607	180
Nitzschia hantzschia	176	0	0
Nitzschia linearis	10,415	7	0
Nitzschia palea	30,979	1,282	389
Nitzschia sigma	353	15	0
Rhopalodia gibba	0	236	45
Synedra delicatissima	379	44	0
Synedra ulna	21,821	198	156
Synedra ulna v. *oxyrhychus*	0	0	45
Stephanodiscus astraea	0	152	0
Tabellaria fenestrata	0	11	0
TOTAL	659,439	30,230	25,599

Appendix 3d - Periphytic diatom concentrations (15-25 May, 1978) (cells/cm^2) of several streams of the Ogilvie and Swift River drainage basins (analyzed using 1000 X magnification).

SPECIES	SAMPLE LOCATION							
	Ogilvie River	Swift River	S14	OR 8	S 5	S 8	S 3	S 2
Achnanthes flexella	937	1,293	129	77	0	0	0	0
Achnanthes lancelota	483	102	0	0	0	0	0	4,686
Achnanthes microcephala	0	0	0	0	0	0	0	6,248
Achnanthes minutissima	117,691	41,383	3,336	1,017	120,382	14,801	104,728	110,454
Achnanthes sp.	1,688	7,782	54	0	4,607	429	0	0
Amphipleura pellucida	0	774	0	0	38	0	0	0
Amphora sp.	2,527	1,492	0	77	0	0	0	0
Anomoeoneis vitrea	0	2,089	0	0	0	196	0	7,016
Cocconeis placentula	2,385	4,412	0	0	8,548	881	37,218	384
Cymbella caespitosa	2,453	471	129	0	0	156	0	0
Cymbella sinuata	681	157	0	0	750	466	9,405	768
Cymbella ventricosa	2,471	1,876	345	0	1,510	588	1,876	3,124
Cymbella sp.	61	0	366	154	0	196	0	0
Denticula sp.	179	157	0	0	0	0	0	0
Diatoma hiemale	3,541	313	129	77	38	196	0	0
Diatoma hiemale v. *mesodon*	2,384	198	582	0	0	783	7,862	768
Diatoma tenue v. *elongatum*	3,031	38,086	162	39	3,101	0	0	160,108
Diatoma vulgare	2,107	0	623	149	0	979	0	0
Epithemia turgida	0	469	0	0	0	196	0	0
Eunotia sp.	0	0	129	0	0	0	0	0
Fragilaria capucina	0	7,636	2,819	0	1,510	0	1,520	3,892
Fragilaria construens v. *construens*	2,536	10,522	257	0	0	0	0	0
Fragilaria construens v. *binodis*	5,568	2,429	216	0	3,020	2,056	1,520	3,839
Fragilaria construens v. *venter*	4,172	6,839	0	308	0	0	0	2,687
Fragilaria crotonensis	300	1,586	0	0	0	0	0	0
Fragilaria vaucheriae	2,404	3,816	1,022	32	3,058	4,797	2,280	31,982
Fragilaria leptostauron	7,954	0	0	154	0	0	0	0
Didymosphenia geminatum	0	0	0	0	755	0	0	0
Gomphonema olivaceum	263	1,450	129	154	307	1,482	10,499	9,730
Gomphonema parvulum	3,151	5,143	386	32	38	392	0	768
Hannaea arcus	0	3,009	6,680	16	0	294	0	1,152
Hannaea arcus v. *amphioxys*	0	0	1,850	0	0	0	0	0
Melosira granulata	0	0	129	0	0	196	0	0
Meridion circulare	316	0	0	0	0	0	2,233	0
Navicula radiosa	0	235	0	0	0	0	0	0
Navicula salinarum v. *intermedia*	1,320	1,910	0	0	0	0	0	1,545
Navicula tripunctata	28	0	0	0	0	0	0	0
Navicula sp.	0	2,324	129	115	0	0	5,629	0

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Appendix 3d - Continued (2 of 2 pages)

SPECIES	Ogilvie River	Swift River	S 14	OR 8	S 5	S 8	S 3	S 2
Nitzschia acicularis	61	682	0	0	0	0	0	0
Nitzschia dissipata	1,976	1,620	0	0	0	0	0	3,124
Nitzschia frustulum	0	198	0	32	0	0	0	0
Nitzschia hantzschia	227	1,364	0	0	0	0	0	0
Nitzschia linearis	765	0	0	0	36	0	0	0
Nitzschia palea	4,413	5,997	1,030	0	77	196	1,117	15,567
Nitzschia sigma	179	667	0	0	0	0	0	0
Rhoicosphenia curvata	909	0	0	0	0	0	0	0
Stauroneis sp.	0	469	0	0	0	0	0	0
Surirella angustata	84	682	0	0	0	0	0	0
Synedra delicatissima	56	198	0	0	0	233	0	0
Synedra ulna	90	6,919	968	0	793	0	1,117	768
Synedra ulna v. *oxyrhychus*	283	1,078	129	0	0	881	0	384
Tabellaria fenestrata	0	0	0	0	0	0	0	3,124
TOTAL	179,674	165,077	21,728	2,433	148,568	30,214	187,004	372,118

Appendix 3e - Periphytic diatom concentrations (17-30 June, 1978) (cells/cm^2) of several stream of the Ogilvie and Swift River drainage basins (analyzed using 1000 X magnification).

SPECIES	SAMPLE LOCATION					
	Ogilvie River	Swift River	S 14	S 5	S 8	S 3
Achnanthes flexella	0	2,029	0	0	0	0
Achnanthes minutissima	460,963	53,031	4,591	6,711	63,120	51,288
Achnanthes sp.	10,695	68,283	403	0	0	462
Amphora sp.	15,782	1,469	0	0	0	0
Amphipleura pellucida	0	1,706	0	0	0	66
Anomoeoneis vitrea	0	1,259	564	0	0	0
Cocconeis placentula	0	6,851	60	3,108	1,249	9,591
Cyclotella bodanica	0	0	60	0	0	0
Cyclotella comta	0	988	0	0	0	0
Cyclotella ocellata	0	0	0	0	0	363
Cymbella caespitosa	0	0	0	0	882	0
Cymbella cistula	0	309	0	0	0	0
Cymbella prostrata	0	155	0	0	0	0
Cymbella sinuata	0	1,014	0	0	142	1,848
Cymbella ventricosa	131,740	3,865	310	0	2,646	1,583
Cymbella sp.	0	2,031	689	0	0	0
Diatoma hiemale	0	1,861	90	0	0	33
Diatoma hiemale v. *mesodon*	344,765	194	1,629	138	0	1,583
Diatoma tenue v. *elongatum*	0	42,071	90	207	0	0
Diatoma vulgare	7,766	126	251	0	0	0
Denticula sp.	3,946	0	0	0	0	0
Epithemia sorex	0	0	0	0	0	726
Epithemia turgida	0	0	0	0	0	132
Eunotia sp.	0	107	275	0	0	0
Fragilaria capucina	0	1,745	0	0	41	0
Fragilaria construens v. *construens*	0	3,659	0	0	0	0
Fragilaria construens v. *binodis*	117,677	8,594	1,282	0	923	66
Fragilaria construens v. *venter*	106,426	16,891	126	0	121	1,054
Fragilaria crotonensis	0	931	0	0	0	0
Fragilaria leptostauron	28,510	1,464	0	0	0	0
Fragilaria vaucheriae	9,924	7,950	1,861	402	3,628	1,643
Frustulia rhomboides	0	0	0	0	0	66
Gomphonema lanceolotum	0	0	0	0	882	0
Didymosphenia geminatum	0	0	0	0	0	0
Gomphoneis herculeana	0	0	0	0	0	99
Gomphonema olivaceum	49,328	8,571	156	3,476	14,436	2,571
Gomphonema parvulum	54,764	3,718	0	0	0	0
Gyrosigma sciotense	0	75	0	0	0	0

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Appendix 3e - Continued (2 of 2 pages)

SPECIES	SAMPLE LOCATION					
	Ogilvie River	Swift River	S 14	S 5	S 8	S 3
Hannaea arcus	0	2,179	376	207	243	197
Hannaea arcus v. *amphioxys*	7,766	0	0	0	1,764	0
Melosira granulata	0	0	0	0	0	0
Melosira granulata v. *angustissima*	0	238	0	0	0	0
Meridion circulare	69,004	0	376	0	0	0
Neidium sp.	0	1,550	126	0	0	0
Navicula convergens	0	1,464	0	0	0	0
Navicula cryptocephala	0	44	314	0	0	0
Navicula radiosa	0	233	0	0	0	0
Navicula scutelloides	0	1,464	0	0	0	0
Navicula tripunctata	0	2,549	0	0	0	0
Navicula salinarum v. *intermedia*	4,962	155	0	0	0	0
Navicula sp.	41,428	2,622	30	0	0	0
Nitzschia dissipata	0	1,032	60	0	0	66
Nitzschia frustulum	19,728	5,054	0	63	41	0
Nitzschia hantzschia	3,946	0	60	0	0	0
Nitzschia linearis	0	44	0	0	0	0
Nitzschia palea	10,695	4,424	248	0	0	923
Rhopalodia gibba	0	226	0	0	0	0
Surirella angustata	0	0	185	0	0	0
Stephanodiscus tenuis	0	232	0	0	0	0
Synedra delicatissima	0	1,464	0	0	0	0
Synedra ulna	46,972	19,571	0	0	41	66
Synedra ulna v. *oxyrhychus*	0	931	0	0	41	0
Tabellaria flocculosa	0	0	0	0	0	0
TOTAL	156,787	286,423	14,212	14,312	90,200	74,426

Appendix 3f - Periphytic Diatom concentrations (1-8 August, 1978) (cells/cm^2) of several streams of the Ogilvie and Swift River drainage basins (analyzed using 1000 X magnification).

SPECIES	SAMPLE LOCATION								
	Ogilvie River	Swift River	S 14	OR 8	S 5	S 8	S 3	S 2	OR 14
Achnanthes flexella	29,269	15,649	0	0	0	0	0	55,803	0
Achnanthes lancelota	0	2,227	0	0	0	0	0	22,321	0
Achnanthes minutissima	646,293	260,519	50,784	293,315	5,897,160	33,534	37,802	1,473,186	2,582,384
Achnanthes sp.	10,559	30,765	0	0	0	0	0	0	415,026
Emphipleura pellucida	0	7,428	0	0	0	0	21,263	22,321	0
Amphora sp.	0	4,454	0	0	0	0	0	0	0
Anomoeoneis vitrea	26,921	267	1,270	0	0	0	0	22,321	0
Cocconeis placentula	643	23,600	0	0	379,646	737	59,065	22,321	0
Cyclotella glomerata	0	12,561	0	0	0	0	0	0	0
Cyclotella ocellata	0	0	0	0	0	0	0	0	0
Cymbella affinis	0	1,467	0	0	0	0	0	0	0
Cymbella caespitosa	1,134	0	1,270	0	151,858	0	0	0	0
Cymbella cistula	0	3,217	0	0	0	0	0	0	0
Cymbella prostrata	0	3,217	0	0	0	0	0	0	0
Cymbella sinuata	2,657	1,467	0	0	50,619	0	14,176	0	0
Cymbella ventricosa	23,272	11,365	5,078	69,837	101,239	737	0	0	553,368
Denticula sp.	6,490	0	0	0	0	0	0	0	0
Diatoma hiemale v. *mesodon*	0	3,295	2,539	0	50,619	0	11,813	0	876,166
Diatoma v. *elongatum*	71,632	43,364	0	479,547	0	737	30,714	145,087	0
Epithemia turgida	0	0	0	0	0	737	18,901	0	0
Eunotia sp.	0	267	0	0	0	0	0	0	0
Fragilaria capucina	52,271	32,917	27,931	0	101,239	1,843	0	22,321	0
Fragilaria construens v. *construens*	0	5,945	0	0	0	0	4,725	0	184,456
Fragilaria construens v. *binodis*	26,614	62,064	3,174	0	253,097	3,865	0	0	184,456
Fragilaria construens v. *venter*	0	43,702	0	0	0	1,474	0	44,642	645,596
Fragilaria vaucheriae	2,329	18,338	20,948	74,493	50,619	13,266	56,702	66,963	92,228
Fragilaria leptostauron	0	1,114	0	0	0	0	0	0	553,368
Didymosphenia geminatum	1,146	0	0	0	50,619	1,474	0	0	0
Gomphonema intricatum	0	0	0	0	0	0	0	0	0
Gomphonema olivaceum	18,281	35,648	0	0	151,858	1,474	54,346	133,926	1,475,648
Gomphonema ventricosum	0	0	0	0	0	0	9,450	0	0
Gyrosigma sciotense	0	4,684	0	0	0	0	0	0	0
Hannaea arcus	2,858	1,734	3,809	0	101,239	1,843	0	22,321	0
Hannaea arcus v. *amphioxys*	0	0	0	18,623	0	0	0	22,321	0
Melosira granulata	0	5,885	0	0	0	369	0	0	0
Meridion circulare	0	0	0	0	0	0	0	0	276,684
Navicula cryptocephala	0	3,694	0	0	0	0	9,450	44,642	0
Navicula pupula	0	0	0	0	0	0	0	0	0

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Appendix 3f - Continued (2 of 2 pages)

SPECIES	SAMPLE SOLUTION								
	Ogilvie River	Swift River	S 14	OR 8	S 5	S 8	S 3	S 2	OR 14
Navicula salinarum v. *intermedia*	0	3,217	0	0	0	0	0	0	0
Navicula sp.	4,543	653	0	0	0	737	2,363	22,321	0
Navicula sp. B	0	1,467	0	0	0	0	0	0	0
Neidium sp.	0	0	0	0	0	0	0	0	0
Nitzschia dissipata	0	3,217	0	0	0	0	0	0	184,456
Nitzschia frustulum	3,213	4,256	0	0	0	0	14,176	0	0
Nitzschia hantzschia	0	5,580	0	0	0	0	0	0	0
Nitzschia palea	6,131	36,208	2,539	9,312	0	0	18,901	111,605	276,684
Rhopalodia gibba	0	4,761	0	0	0	0	0	0	0
Stauroneis sp.	0	3,000	0	0	0	0	0	0	0
Surirella angustata	0	3,217	0	0	0	0	0	0	0
Synedra delicatissima	4,828	0	0	0	0	0	0	0	0
Synedra ulna	24,894	14,355	0	130,362	177,168	2,211	66,153	44,642	1,152,850
Synedra ulna v. *oxyrhychus*	1,134	0	0	0	50,619	0	14,176	0	0
Tabellaria flocculosa	0	934	2,539	0	0	0	0	0	0
Cymbella sp.	1,146	1,068	11,426	0	0	0	0	22,321	0
TOTAL	968,258	722,787	133,307	1,075,489	7,339,811	64,858	444,176	2,320,279	8,900,002

Appendix 4 - Cyanophyta, Chlorophyta and Chrysophyceae species occurring in the periphyton of the Ogilvie and Swift River basins.

SPECIES	OCCURRENCE								
	Ogilvie River	OR 8	OR 14	Swift River All sites	S 2	S 3	S 5	S 8	S 14
Cyanophyta									
Anabaena sp.	X			X		X			
Lyngbya sp.				X					
Merismopedia sp.	X								
Nostoc verrucosum						X			
Oscillatoria sp.			X	X	X	X	X	X	X
Tolypothrix sp.	X			X					
Chlorophyta									
Closterium sp.	X	X		X	X	X			
Cosmarium sp.	X			X	X				X
Mougeotia sp.			X	X					
Oedogonium sp.	X	X		X		X			X
Scenedesmus sp.			X						
Spirogyra sp.	X			X					
Stigeoclonium sp.	X			X		X			
Ulothrix sp.	X		X	X	X	X			X
Zygnema sp.	X	X		X					X
Chrysophyta									
Hydrurus foetidus				X	X				

Appendix 5. Invertebrate concentrations (numbers/m^2, length ranges and feeding types) of several streams of the Ogilvie and Swift River drainage basins. (October 1977 - August 1978)

Date: October 4-10, 1977 and March 28-29, 1978

	Length range (mm)	Feeding Type*	OR 1-2	OR 11-12	S 15-16	S 9	S 14	OR 8	March OR 6	March S 9
Insecta										
Diptera										
?Dolichopidae larvae 1	4-7	?G	2	0	0	0	0	0	0	0
Larvae 2	14-15	?G	0	0	0	0	0	0	0	0
Larva 3	9-10	?G	0	0	0	0	0	0	0	0
Pupa 1	2-4		0	0	0	0	0	0	0	0
Blepharoceridae										
Bibiocephala	4-6	G	0	2	0	0	0	0	0	0
Chironomidae										
Larva	1-6	G	0	0	0	0	0	0	21%	47
Adult	3-4		0	0	0	0	0	0	0	0
Chironominae										
Larvae	1-6	G	0	0	0	0	0	0	0	2
Tanytarsus	2-8	?C	0	0	178	0	0	0	0	0
T. pupa	4-5		0	0	0	0	0	0	0	0
T. exiguus houses	3-5		0	0	0	0	0	0	0	0
T. (Stempellina) pupa	3-4		0	0	0	0	0	0	0	0
Diamesinae larvae	4-14	G	0	0	0	0	0	0	2%	0
pupa 1	6-8		0	0	0	0	0	0	0	0
pupa 2	7-8		0	0	0	0	0	0	2%	0
Orthocladiinae larvae	3-6	G	0	0	62	4	2	0	31%	4
?*Brillia larvae*	3-5	G	0	0	0	0	0	0	0	0
Pupa 1	4-7		0	0	0	0	0	0	0	0
Pupa 2	2-3		0	0	0	0	0	0	0	0
Spaniotoma (Sordidella) pupa	2-3		0	0	0	0	0	0	0	0
S. (Smittia) pupa	3-5		0	0	0	0	0	0	8%	0
Culicidae										
Adult	4-5		0	0	0	0	0	0	0	0
Empididae										
?Larva 1	11-12	?G	0	0	0	0	0	0	0	0
?Pupa 1	3-4		0	0	0	0	0	0	0	0
Hemerodromia larvae	3-6	G	0	0	0	0	0	0	0	0
H. pupa	3-4		0	0	0	0	0	0	0	0

May 22-30, 1978

	OR 14	S 15-16	S 14	S 14	S 5	S 8	S 3	OR 8
Insecta								
Diptera								
?Dolichopidae larvae 1	0	0	0	4	4	8	0	0
Larvae 2	0	0	0	0	0	0	0	2
Larva 3	0	0	0	0	0	0	0	0
Pupa 1	2	0	0	0	0	0	0	0
Blepharoceridae								
Bibiocephala	0	0	0	0	0	0	0	0
Chironomidae								
Larva	27	0	0	0	19	0	5	0
Adult	0	0	0	0	0	0	0	0
Chironominae								
Larvae	0	0	0	0	0	0	0	0
Tanytarsus	41	12	0	0	16	9	10	0
T. pupa	4	0	0	0	0	0	0	0
T. exiguus houses	0	0	0	0	0	0	0	0
T. (Stempellina) pupa	2	0	0	0	0	0	0	0
Diamesinae larvae	261	0	0	0	7	0	0	0
pupa 1	2	0	0	0	0	0	0	0
pupa 2	0	0	0	0	0	0	0	0
Orthocladiinae larvae	0	0	2	2	5	9	2	0
?*Brillia larvae*	0	0	0	2	5	5	0	0
Pupa 1	0	0	0	0	0	0	0	0
Pupa 2	0	0	0	0	0	0	0	0
Spaniotoma (Sordidella) pupa	0	0	2	0	0	0	0	0
S. (Smittia) pupa	0	0	0	0	0	0	0	0
Culicidae								
Adult	0	0	0	0	0	0	0	0
Empididae								
?Larva 1	0	0	0	0	0	0	0	0
?Pupa 1	0	0	0	0	0	0	0	0
Hemerodromia larvae	12	0	0	0	0	0	0	0
H. pupa	0	0	0	0	0	0	0	0

June 17-30, 1978

	OR 14	OR 14	S 15-16	S 9	S 14	S 5	S 8	S 3
Insecta								
Diptera								
?Dolichopidae larvae 1	0	0	0	4	0	9	9	0
Larvae 2	0	0	0	0	0	0	0	0
Larva 3	0	0	0	0	0	2	0	0
Pupa 1	11	6	0	0	0	0	0	0
Blepharoceridae								
Bibiocephala	0	0	0	0	0	11	0	15
Chironomidae								
Larva	28	0	41	0	2	41	17	13
Adult	2	0	0	0	0	0	0	0
Chironominae								
Larvae	0	0	0	2	0	0	0	0
Tanytarsus	0	0	107	0	0	2	32	45
T. pupa	0	2	0	0	0	0	0	0
T. exiguus houses	0	0	0	0	0	0	0	0
T. (Stempellina) pupa	0	0	0	0	0	0	0	0
Diamesinae larvae	60	101	2	0	0	9	0	2
pupa 1	9	6	2	0	0	0	0	0
pupa 2	2	0	0	0	0	0	0	0
Orthocladiinae larvae	219	227	26	0	0	0	15	4
?*Brillia larvae*	0	0	0	0	2	0	0	0
Pupa 1	49	17	0	0	0	0	0	0
Pupa 2	0	0	4	0	2	0	0	0
Spaniotoma (Sordidella) pupa	0	0	0	0	0	0	0	0
S. (Smittia) pupa	0	0	0	0	0	0	0	0
Culicidae								
Adult	0	0	0	0	0	0	2	0
Empididae								
?Larva 1	0	0	0	0	2	0	0	2
?Pupa 1	0	0	0	0	0	0	4	0
Hemerodromia larvae	9	28	0	0	0	4	0	0
H. pupa	0	0	0	0	0	2	0	0

August 1-8, 1978

	OR 11-12	OR 6	OR 1-2	OR 14	S 15-16	S 9	S 5	S 8	S 3	OR 8
Insecta										
Diptera										
?Dolichopidae larvae 1	0	0	0	0	0	0	0	0	0	0
Larvae 2	0	0	0	0	0	0	0	0	0	0
Larva 3	0	0	0	0	0	0	0	0	0	0
Pupa 1	0	0	0	2	0	0	0	0	0	0
Blepharoceridae										
Bibiocephala	0	2	0	0	0	0	0	0	0	0
Chironomidae										
Larva	0	6	6	24	0	0	0	0	2	0
Adult	0	0	0	0	0	0	0	0	0	0
Chironominae										
Larvae	0	0	0	0	0	0	0	0	0	0
Tanytarsus	0	0	0	0	0	0	0	2	0	0
T. pupa	0	0	0	0	0	0	0	0	0	0
T. exiguus houses	0	0	0	0	4	0	0	0	0	0
T. (Stempellina) pupa	0	0	0	0	0	0	0	0	0	0
Diamesinae larvae	0	19	0	609	0	0	0	0	0	0
pupa 1	0	0	0	0	0	0	0	0	0	0
pupa 2	0	0	0	0	0	0	0	0	0	0
Orthocladiinae larvae	0	0	0	0	0	0	0	0	0	0
?*Brillia larvae*	0	0	0	0	0	0	0	0	0	0
Pupa 1	0	0	0	30	0	0	0	0	0	0
Pupa 2	0	0	0	0	0	0	0	0	0	0
Spaniotoma (Sordidella) pupa	0	0	0	0	0	0	0	0	0	0
S. (Smittia) pupa	0	0	0	0	0	0	0	0	0	0
Culicidae										
Adult	0	0	0	0	0	0	0	0	2	0
Empididae										
?Larva 1	0	0	0	0	0	0	0	0	0	0
?Pupa 1	0	0	0	0	0	0	0	0	0	0
Hemerodromia larvae	0	0	0	0	0	0	0	0	0	0
H. pupa	0	0	0	0	0	0	0	0	0	0

Appendix 5 continued

Date October 4-10, 1977

Taxon	Length range (mm)	Feeding Type*	OR 1-2	OR 11-12	S 15-16	S 9	S 14	OR 8
Family Muscidae - larvae	9-10	G	0	0	0	0	0	0
Suborder Cyclorrapha - larvae	4-5	?G	0	0	0	0	0	0
- adult	9-10		0	0	0	0	0	0
Family Psychodidae								
Telmatoscopus larvae	4-6		0	0	24	0	0	0
Family Simuliidae								
cf. Prosimulium larvae	3-7	C	0	2	9	0	0	0
pupae	2-3		2	0	2	0	0	0
Family Tipulidae - larvae	8-14	?G	0	0	4	2	0	0
Dicranota larvae	9-14	?G	0	0	0	0	0	2
Larva 2	-20	?G	0	0	0	0	0	0
Larva 3	6-7	?G	0	0	0	0	0	0
Family Tabanidae	7-9	?G	0	0	0	0	4	0
Order Ephemeroptera								
Family Baetidae	3-6	G	2	0	15	4	0	0
?Nymph	7-8	G	0	0	0	0	0	0
Emerging Adult	6-7		0	0	0	0	0	0
Baetis 1 nymphs	3-7	G	0	0	0	0	0	0
Baetis 2 nymphs	1-4	G	0	0	0	0	0	0
Ephemerella nymphs	2-6	G-S	0	2	43	0	0	0
E. cf. *aurivilli*	4-10	G-?S	0	2	11	0	0	0
E. doddsi	4-12	G	0	0	13	0	2	0
E. Group Fuscata	6-10	G-?S	0	0	0	0	0	0
E. Group Needhami	5-13	G-?S	0	0	0	0	0	0
Family Heptageniidae-nymphs			0	0	0	0	0	0
Heptagenia	4-8	G	0	0	0	0	0	0
Ironopsis	4-10	G	0	0	7	0	0	0
Rhithrogena	2-10	G	0	0	15	0	0	0
R. doddsi	2-10	G	0	0	69	2	2	0
Family Leptophlebiidae								
Paraleptophlebia	5-7	G	0	0	0	0	0	0
Family Siphlonuridae								
Ameletus cf. *shepherdi*	4-12	G	0	0	0	2	0	0
Order Plecoptera								
Fragment			0	0	2	0	0	0
Filipalia (Herbivores)								
Family Nemouridae								
Capnia or *Eucapnopsis*	4-6	G	0	0	2	0	0	0

March 28-29, 1978

Taxon	OR 6	S 9
Family Muscidae - larvae	0	0
Suborder Cyclorrapha - larvae	0	0
- adult	0	0
Family Psychodidae		
Telmatoscopus larvae	0	0
Family Simuliidae		
cf. Prosimulium larvae	0	0
pupae	0	0
Family Tipulidae - larvae	0	0
Dicranota larvae	1%	0
Larva 2	0	0
Larva 3	0	0
Family Tabanidae	0	0
Order Ephemeroptera		
Family Baetidae	0	0
?Nymph	1%	0
Emerging Adult	0	0
Baetis 1 nymphs	0	2
Baetis 2 nymphs	7%	0
Ephemerella nymphs	0	0
E. cf. *aurivilli*	1%	9
E. doddsi	0	2
E. Group Fuscata	0	0
E. Group Needhami	0	0
Family Heptageniidae-nymphs	3%	2
Heptagenia	4%	2
Ironopsis	0	0
Rhithrogena	9%	0
R. doddsi	0	0
Family Leptophlebiidae		
Paraleptophlebia	0	2
Family Siphlonuridae		
Ameletus cf. *shepherdi*	0	0
Order Plecoptera		
Fragment	0	0
Filipalia (Herbivores)		
Family Nemouridae		
Capnia or *Eucapnopsis*	0	0

May 22-30, 1978

Taxon	OR 14	S 15-16	S 14	S 14	S 5	S 8	S 3	OR 8
Family Muscidae - larvae	10	0	0	0	0	0	0	0
Suborder Cyclorrapha - larvae	0	0	0	0	0	0	0	0
- adult	0	0	0	0	0	0	0	0
Family Psychodidae								
Telmatoscopus larvae	0	0	0	0	0	0	0	0
Family Simuliidae								
cf. Prosimulium larvae	0	0	0	0	0	0	0	0
pupae	0	0	0	0	0	0	0	0
Family Tipulidae - larvae	0	0	0	0	0	0	0	0
Dicranota larvae	2	0	0	0	0	0	0	0
Larva 2	0	0	0	0	0	0	0	0
Larva 3	0	0	0	0	0	0	0	0
Family Tabanidae	0	0	0	0	0	0	0	0
Order Ephemeroptera								
Family Baetidae	0	0	0	0	0	0	0	0
?Nymph	0	0	0	0	0	0	0	0
Emerging Adult	0	0	0	0	0	0	0	0
Baetis 1 nymphs	127	67	0	0	50	0	10	4
Baetis 2 nymphs	0	0	0	0	0	0	0	0
Ephemerella nymphs	0	0	0	0	0	0	2	0
E. cf. *aurivilli*	0	14	5	0	0	0	0	0
E. doddsi	0	0	2	0	0	4	0	0
E. Group Fuscata	0	0	0	0	0	0	0	0
E. Group Needhami	0	0	0	0	0	0	0	0
Family Heptageniidae-nymphs	0	0	0	0	0	0	0	0
Heptagenia	0	12	0	0	0	0	0	0
Ironopsis	0	0	0	0	4	5	19	0
Rhithrogena	0	5	2	4	26	24	26	0
R. doddsi	0	0	0	0	0	0	0	0
Family Leptophlebiidae					2			
Paraleptophlebia	0	0	0	0	0	0	0	0
Family Siphlonuridae								
Ameletus cf. *shepherdi*	0	0	0	0	2	4	0	0
Order Plecoptera								
Fragment	0	0	0	0	0	2	0	0
Filipalia (Herbivores)								
Family Nemouridae								
Capnia or *Eucapnopsis*	0	0	0	2	0	0	0	0

June 17-30, 1978

Taxon	OR 14	OR 14	S 15-16	S 9	S 14	S 5	S 8	S 3
Family Muscidae - larvae	0	0	0	0	0	0	0	0
Suborder Cyclorrapha - larvae	0	0	0	0	2	2	0	0
- adult	0	0	0	0	0	0	2	0
Family Psychodidae								
Telmatoscopus larvae	0	0	0	0	0	0	0	0
Family Simuliidae								
cf. Prosimulium larvae	2	0	0	0	0	0	0	0
pupae	0	0	0	0	0	0	0	0
Family Tipulidae - larvae	0	0	0	0	0	0	0	0
Dicranota larvae	0	2	0	0	0	0	0	0
Larva 2	0	0	0	0	0	0	0	0
Larva 3	0	0	0	0	0	0	0	0
Family Tabanidae	0	0	0	0	0	0	0	0
Order Ephemeroptera								
Family Baetidae	0	0	0	0	0	0	0	0
?Nymph	0	0	0	0	0	0	0	0
Emerging Adult	0	0	0	0	0	2	0	0
Baetis 1 nymphs	17	39	9	15	32	60	22	136
Baetis 2 nymphs	0	0	0	0	0	0	0	0
Ephemerella nymphs	0	0	2	0	0	0	0	0
E. cf. *aurivilli*	0	0	13	0	0	0	0	0
E. doddsi	0	0	0	2	4	0	0	2
E. Group Fuscata	0	0	0	0	0	0	0	0
E. Group Needhami	0	0	0	0	0	0	0	0
Family Heptageniidae-nymphs	0	0	11	2	6	15	0	6
Heptagenia	0	0	15	4	0	0	2	2
Ironopsis	0	0	2	0	0	19	9	7
Rhithrogena	0	0	4	22	11	105	73	49
R. doddsi	0	0	0	0	0	0	0	0
Family Leptophlebiidae								
Paraleptophlebia	0	0	2	0	0	0	0	0
Family Siphlonuridae								
Ameletus cf. *shepherdi*	0	0	13	0	0	0	15	0
Order Plecoptera								
Fragment	0	0	0	0	0	0	0	0
Filipalia (Herbivores)								
Family Nemouridae								
Capnia or *Eucapnopsis*	0	0	6	0	0	2	6	4

August 1-8, 1978

Taxon	OR 11-12	OR 6	OR 1-2	OR 14	S 15-16	S 9	S 5	S 8	S 3	OR 8
Family Muscidae - larvae	0	0	0	0	0	0	0	0	0	0
Suborder Cyclorrapha - larvae	0	0	0	0	0	0	0	0	0	0
- adult	0	0	0	0	0	0	0	0	0	0
Family Psychodidae										
Telmatoscopus larvae	0	0	0	0	0	0	0	0	0	0
Family Simuliidae										
cf. Prosimulium larvae	0	69	425	49	0	0	2	2	11	0
pupae	0	2	0	0	0	0	0	0	0	0
Family Tipulidae - larvae	0	0	0	0	0	0	0	0	0	0
Dicranota larvae	0	0	0	2	0	0	0	0	0	0
Larva 2	0	2	0	0	0	0	0	0	0	0
Larva 3	0	0	0	0	0	0	0	0	0	0
Family Tabanidae	0	0	0	0	0	0	0	0	0	0
Order Ephemeroptera										
Family Baetidae	0	0	0	0	0	0	0	0	0	0
?Nymph	0	0	0	0	0	0	0	0	0	0
Emerging Adult	0	0	0	0	0	0	0	0	0	0
Baetis 1 nymphs	2	4	0	26	9	0	6	0	6	0
Baetis 2 nymphs	2	0	0	0	0	0	0	0	0	0
Ephemerella nymphs	0	0	2	2	11	0	0	0	0	0
E. cf. *aurivilli*	0	0	0	0	0	0	0	0	0	0
E. doddsi	0	0	0	0	2	0	0	0	0	0
E. Group Fuscata	0	0	0	0	0	4	0	0	0	0
E. Group Needhami	0	0	0	0	0	6	0	0	0	0
Family Heptageniidae-nymphs	0	0	0	0	0	0	0	0	0	0
Heptagenia	2	6	2	0	13	0	9	0	0	0
Ironopsis	0	2	0	0	9	0	141	129	66	2
Rhithrogena	4	30	2	0	9	2	28	4	9	0
R. doddsi	0	0	0	0	0	0	0	0	0	0
Family Leptophlebiidae										
Paraleptophlebia	0	0	0	0	0	0	0	0	0	0
Family Siphlonuridae										
Ameletus cf. *shepherdi*	0	0	0	0	0	0	0	0	0	0
Order Plecoptera										
Fragment	0	0	0	0	0	0	0	0	0	0
Filipalia (Herbivores)										
Family Nemouridae										
Capnia or *Eucapnopsis*	0	0	0	0	0	0	0	0	0	0

Appendix 5 continued

	Length range (mm)	Feeding Type*	Date: October 4-10, 1977						March 28-29, 1978	
			OR 1-2	OR 11-12	S 15-16	S 9	S 14	OR 8	OR 6	S 9
Family Nemouridae cont'd,nymphs										
Nemoura (Subg. Zapada)	3-6	G-?S	0	0	15	13	17	0	0	0
N. cataractae	4-5	"	0	0	0	0	0	0	0	2
N. cinctipes	3-4	"	0	0	0	0	0	0	0	4
N. columbiana	4-5	"	0	0	0	0	0	0	0	11
N. oregonensis (incl. *hayei*)	3-8	"	0	0	0	0	0	0	0	9
Nemoura 2.	3-4	"	0	0	0	0	0	0	0	0
Taeniopteryx	4-9	G	0	0	0	0	0	0	8%	0
Setipalpia (Carnivores)										
Family Perlodidae	5-9	C	0	0	13	2	0	0	0	0
Isoperla 1	4-14	C	0	0	0	0	0	0	0	0
Isoperla 2	16-18	C	0	0	0	0	0	0	0	0
Arcynopteryx signata	14-20	C	0	0	7	2	0	0	0	0
Isogenus	7-8	C	0	0	0	0	0	0	0	0
Family Chloroperlidae										
Alloperla	4-8	C	0	2	0	0	0	0	0	0
Alloperla cf. *borealis*	3-12	C	0	0	0	0	0	0	0	2
A. cf. *coloradensis*	8-9	C	0	0	0	0	0	0	0	0
?Alloperla	4-5	C	0	0	0	0	0	0	0	0
Paraperla frontalis	16-18	C	0	0	0	0	0	0	0	0
Order Trichoptera.										
Pupa 1	7-9		0	0	0	0	0	0	0	0
Pupa 2	4-5		0	0	0	0	0	0	0	0
Pupa 3	5-6		0	0	0	0	0	0	0	2
Pupa 4	8-10		0	0	0	0	0	0	0	0
Family Brachycentridae-larvae										
Brachycentrus	2-3	G-?S	0	0	69	11	2	2	0	0
B. cf. *americanus*	5-10	G-?S	0	0	124	2	2	2	0	0
Family Glossosomatidae (included as subfamily in Rhyacophilidae by some authors)										
Glossosoma larvae	1-5	G	0	0	39	0	0	0	0	0
Glossosoma pupa	4-6		0	0	0	2	0	0	0	0
Family Hydropsychidae										
Larva 1	3-4	C	0	0	0	0	0	0	0	0
Larva 2	4-8	C	0	0	0	0	0	0	0	0
Arctopsyche 1	4-25	C	0	7	41	2	0	0	2%	24
Arctopsyche 2	9-10	C	0	0	0	0	0	0	0	2
Parapsyche 1	4-22	C	0	0	14	4	22	0	0	0
Parapsyche 2	5-6	C	0	0	0	0	0	0	0	0
Family Limnephilidae										
cf. *Radema*	4-6		0	7	0	0	0	0	0	0
Apatania	3-5	G	0	0	0	0	0	0	0	0
Ecclisomyia	4-5	?G	0	0	0	0	0	0	0	0
Oligophlebodes	3-5	G	0	0	0	0	0	0	0	0

	May 22-30, 1978								June 17-30, 1978							
	OR 14	S 15-16	S 14	S 14	S 5	S 8	S 3	OR 8	OR 14	OR 14	S 15-16	S 9	S 14	S 5	S 8	S 3
Family Nemouridae cont'd,nymphs																
Nemoura (Subg. Zapada)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N. cataractae	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
N. cinctipes	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
N. columbiana	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
N. oregonensis (incl. *hayei*)	0	9	2	2	5	7	5	0	11	6	0	0	0	0	2	0
Nemoura 2.	0	7	0	0	2	0	0	0	0	0	0	0	0	0	0	2
Taeniopteryx	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Setipalpia (Carnivores)																
Family Perlodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isoperla 1	7	12	0	0	0	2	0	0	0	4	7	0	0	4	2	0
Isoperla 2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Arcynopteryx signata	0	0	2	0	2	2	5	0	0	0	0	0	0	0	0	2
Isogenus	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Family Chloroperlidae																
Alloperla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alloperla cf. *borealis*	0	0	0	2	7	7	15	0	0	0	4	4	4	41	17	15
A. cf. *coloradensis*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
?Alloperla	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paraperla frontalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Order Trichoptera.																
Pupa 1	0	7	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Pupa 2	0	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0
Pupa 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pupa 4	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0
Family Brachycentridae-larvae																
Brachycentrus	0	7	0	0	0	2	0	0	0	0	6	0	0	0	0	0
B. cf. *americanus*	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Glossosomatidae (included as subfamily in Rhyacophilidae by some authors)																
Glossosoma larvae	0	0	2	0	10	38	10	0	0	0	6	0	0	11	15	4
Glossosoma pupa	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Family Hydropsychidae																
Larva 1	0	0	0	0	0	0	10	0	0	0	0	0	0	4	6	2
Larva 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Arctopsyche 1	0	0	2	0	0	0	0	0	0	0	0	9	0	0	0	0
Arctopsyche 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parapsyche 1	0	0	0	4	7	9	26	0	0	0	0	0	2	32	11	17
Parapsyche 2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family Limnephilidae																
cf. *Radema*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apatania	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0
Ecclisomyia	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligophlebodes	0	0	0	0	9	0	2	0	0	0	0	0	0	0	0	0

	August 1-8, 1978									
	OR 11-12	OR 6	OR 1-2	OR 14	S 15-16	S 9	S 5	S 8	S 3	OR 8
Family Nemouridae cont'd,nymphs										
Nemoura (Subg. Zapada)	0	0	0	54	0	0	0	9	4	0
N. cataractae	0	0	0	0	0	0	0	0	0	0
N. cinctipes	0	0	0	0	0	0	0	0	0	0
N. columbiana	0	0	0	0	0	0	0	0	0	0
N. oregonensis (incl. *hayei*)	0	0	0	120	4	2	13	9	13	0
Nemoura 2.	0	0	0	0	0	0	0	0	0	0
Taeniopteryx	0	0	0	0	0	0	0	0	0	0
Setipalpia (Carnivores)										
Family Perlodidae	0	0	0	0	0	0	0	0	0	0
Isoperla 1	15	4	17	11	0	0	2	0	0	2
Isoperla 2	0	0	0	0	0	0	0	0	0	0
Arcynopteryx signata	0	0	0	0	0	0	0	0	0	0
Isogenus	0	0	0	0	0	0	0	0	0	0
Family Chloroperlidae										
Alloperla	0	0	0	0	0	0	0	0	0	0
Alloperla cf. *borealis*	0	9	0	0	4	0	2	2	2	2
A. cf. *coloradensis*	0	0	0	0	0	0	0	0	0	0
?Alloperla	0	0	0	0	0	0	0	0	0	0
Paraperla frontalis	0	0	0	0	0	0	0	0	0	0
Order Trichoptera.										
Pupa 1	0	0	0	0	0	0	0	0	0	0
Pupa 2	0	0	0	0	0	0	0	0	0	0
Pupa 3	0	0	0	0	0	0	0	0	0	0
Pupa 4	0	0	0	0	0	0	0	0	0	0
Family Brachycentridae-larvae										
Brachycentrus	0	0	0	0	0	0	0	0	0	0
B. cf. *americanus*	0	0	2	0	294	0	0	0	0	0
Family Glossosomatidae (included as subfamily in Rhyacophilidae by some authors)										
Glossosoma larvae	0	0	2	0	2	0	4	2	2	0
Glossosoma pupa	0	0	0	0	2	2	0	0	0	0
Family Hydropsychidae										
Larva 1	0	0	0	0	0	0	0	0	0	0
Larva 2	0	0	2	0	2	0	4	0	4	0
Arctopsyche 1	0	0	4	0	9	0	0	0	0	0
Arctopsyche 2	0	0	0	0	0	0	0	0	0	0
Parapsyche 1	0	0	0	0	0	0	52	13	69	0
Parapsyche 2	0	0	0	0	0	0	0	0	0	0
Family Limnephilidae										
cf. *Radema*	0	0	0	0	0	0	0	0	0	0
Apatania	0	0	0	0	0	0	0	0	0	0
Ecclisomyia	0	0	0	0	0	0	0	0	0	0
Oligophlebodes	0	0	0	0	0	0	0	0	0	0

Appendix 5 continued

Date: October 4-10, 1977

	Length range (mm)	Feeding Type*	OR 1-2	OR 11-12	S 15-16	S 9	S 14	OR 8
Family Limnephilidae cont'd.								
Pupa	9-10		0	0	0	0	0	0
Family Rhyacophilidae								
Rhyacophila larvae	4-14	P	0	0	26	7	0	0
R. 2	3-5	P	0	0	0	0	0	0
R. type *fuscula* of Ross								
type I fuscula	3-14	P	0	0	0	0	0	0
type 2 fuscula	3-8	P	0	0	0	0	0	0
type 3 fuscula	10-12	P	0	0	0	0	0	0
R. type *vaccua* of Smith	6-14	P	0	0	0	0	0	0
R. type *vao-acropedes* of Smith	5-12	P	0	0	0	0	0	0
R. type *vepulsa* of Smith	7-8	P	0	0	0	0	0	0
R. type *verrula* of Smith	10-12	P	0	0	0	0	0	0
Rhyacophila pupa	7-9		0	0	0	0	0	0
Various taxa-miscellaneous.								
Amphipoda-*Hyalella azteca*	4-5		0	0	0	0	0	0
Ostracoda	1-2	?G	0	0	0	0	0	0
Acari - *Hygrobates*	-2	?G	0	0	0	0	0	2
type 2 (orange)	-1		0	0	0	0	0	0
Thysanoptera adult	-2		0	0	0	0	0	0
Bryozoa			0	0	0	0	0	0
Oligochaeta	4-20		9	0	4	0	2	17
Eggs type 1 (clumped)			0	0	0	0	0	0
type 2 - 3mm. diam.			0	0	0	4	0	0
Nematoda	3-7		0	0	7	0	0	0
Fish-Family Cottidae - fork lengths in mm.								

March 28-29, 1978

	OR 6	S 9
Pupa	0	0
Rhyacophila larvae	0	0
R. 2	0	0
type I fuscula	0	0
type 2 fuscula	0	0
type 3 fuscula	0	0
R. type *vaccua* of Smith	0	0
R. type *vao-acropedes* of Smith	0	0
R. type *vepulsa* of Smith	0	0
R. type *verrula* of Smith	0	0
Rhyacophila pupa	0	0
Amphipoda-*Hyalella azteca*	0	0
Ostracoda	0	0
Acari - *Hygrobates*	0	0
type 2 (orange)	0	0
Thysanoptera adult	0	0
Bryozoa	0	0
Oligochaeta	0	0
Eggs type 1 (clumped)	0	0
type 2 - 3mm. diam.	0	0
Nematoda	0	0
Fish-Family Cottidae - fork lengths in mm.		

May 22-30, 1978

	OR 14	S 15-16	S 14	S 14	S 5	S 8	S 3	OR 8
Pupa	7%	0	0	0	0	0	0	0
Rhyacophila larvae	0	0	0	0	0	0	0	0
R. 2	0	0	0	0	2	0	0	0
type I fuscula	0	0	0	0	2	0	4	0
type 2 fuscula	0	0	0	0	0	0	2	0
type 3 fuscula	0	0	0	0	0	0	0	0
R. type *vaccua* of Smith	0	0	0	0	0	0	0	0
R. type *vao-acropedes* of Smith	0	0	0	0	5	2	2	0
R. type *vepulsa* of Smith	0	0	0	0	0	0	2	0
R. type *verrula* of Smith	0	0	0	0	0	0	0	0
Rhyacophila pupa	0	0	0	0	0	0	0	0
Amphipoda-*Hyalella azteca*	0	0	0	0	0	0	0	0
Ostracoda	2%	0	0	2	0	0	0	0
Acari - *Hygrobates*	9%	0	0	0	0	4	0	0
type 2 (orange)	0	0	0	0	0	0	0	0
Thysanoptera adult	0	0	0	0	0	0	0	0
Bryozoa	0	0	0	0	0	0	0	0
Oligochaeta	10%	0	0	0	0	0	0	0
Eggs type 1 (clumped)	0	0	0	0	0	0	0	0
type 2 - 3mm. diam.	0	0	0	0	0	0	0	0
Nematoda	0	0	0	0	0	0	0	0
Fish-Family Cottidae - fork lengths in mm.			29mm					

June 17-30, 1978

	OR 14	OR 14	S 15-16	S 9	S 14	S 5	S 8	S 3
Pupa	0	0	0	0	0	2	0	0
Rhyacophila larvae	0	0	2	0	0	0	0	0
R. 2	0	0	0	0	0	0	0	0
type I fuscula	0	0	0	0	0	15	2	2
type 2 fuscula	0	0	0	0	0	9	9	0
type 3 fuscula	0	0	0	0	0	0	0	0
R. type *vaccua* of Smith	0	0	0	0	0	4	0	0
R. type *vao-acropedes* of Smith	0	0	0	0	0	0	9	4
R. type *vepulsa* of Smith	0	0	0	0	0	0	0	0
R. type *verrula* of Smith	0	0	0	0	0	4	2	0
Rhyacophila pupa	0	0	0	0	0	0	4	0
Amphipoda-*Hyalella azteca*	0	0	0	0	0	0	0	0
Ostracoda	0	0	0	0	0	0	2	0
Acari - *Hygrobates*	6	0	0	0	0	0	0	0
type 2 (orange)	9	0	0	0	0	0	0	0
Thysanoptera adult	0	0	0	0	0	0	2	0
Bryozoa	0	0	0	0	0	0	0	0
Oligochaeta	47	32	0	0	0	0	2	0
Eggs type 1 (clumped)	0	0	0	2	0	0	0	0
type 2 - 3mm. diam.	0	0	0	0	0	0	0	0
Nematoda	2	0	0	0	0	0	0	0
Fish-Family Cottidae - fork lengths in mm.			21mm 23mm 18mm					

August 1-8, 1978

	OR 11-12	OR 6	OR 1-2	OR 14	S 15-16	S 9	S 5	S 8	S 3	OR 8
Pupa	0	0	0	0	0	0	0	0	0	0
Rhyacophila larvae	0	0	0	0	0	0	0	0	0	0
R. 2	0	0	0	0	0	0	0	0	0	0
type I fuscula	0	0	0	0	0	0	15	11	13	0
type 2 fuscula	0	0	0	0	0	0	0	0	0	0
type 3 fuscula	0	0	0	0	0	0	2	0	0	0
R. type *vaccua* of Smith	0	0	0	0	0	6	4	6	0	0
R. type *vao-acropedes* of Smith	0	0	0	0	0	0	0	0	0	0
R. type *vepulsa* of Smith	0	0	0	0	0	0	0	0	0	0
R. type *verrula* of Smith	0	0	0	0	0	0	0	0	0	0
Rhyacophila pupa	0	0	0	0	0	0	0	0	0	0
Amphipoda-*Hyalella azteca*	0	0	0	0	0	0	0	0	0	2
Ostracoda	0	0	0	0	0	0	0	0	0	0
Acari - *Hygrobates*	0	2	0	6	0	0	2	0	0	0
type 2 (orange)	0	4	0	45	0	0	0	0	0	0
Thysanoptera adult	0	0	0	0	0	0	0	0	0	0
Bryozoa	0	0	4	0	0	0	0	0	0	0
Oligochaeta	2	4	4	58	0	0	0	4	0	30
Eggs type 1 (clumped)	0	0	0	0	0	0	0	0	0	0
type 2 - 3mm. diam.	0	0	0	0	0	0	0	0	0	0
Nematoda	0	0	0	2	0	0	0	0	0	0
Fish-Family Cottidae - fork lengths in mm.	19mm.		33mm		56mm. 31mm.					60mm.

* C = Collector, G = Grazer, P = Predator, S = Shredder