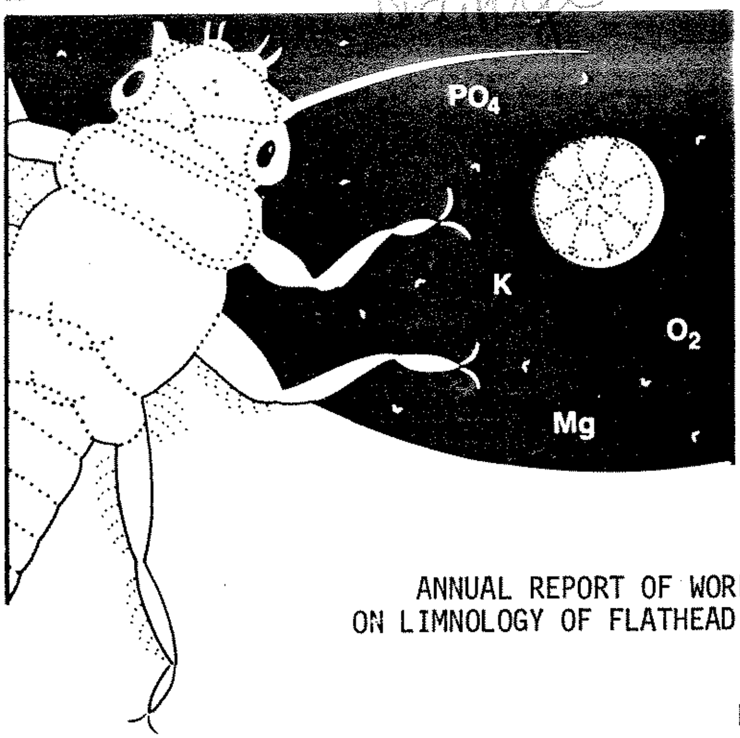

ANNUAL REPORT OF WORK COMPLETED DURING 1978-79 ON LIMNOLOGY OF FLATHEAD LAKE-RIVER ECOSYSTEM, MONTANA

by

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Submitted to:

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ANNUAL REPORT #1 (1978-79)

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I. EXECUTIVE SUMMARY

During the 1978-79 budget period, the Flathead Research Group began documentation of baseline limnological conditions in the Flathead Lake-River Ecosystem. Major research objectives included 1). quantification of temporal dynamics of important physico-chemical parameters (i.e. those compounds present in dissolved form that are often associated with pollution problems and cultural eutrophication) in the rivers and lake, and 2). association of fish food organisms and their productivity with these measured seasonal trends. Work toward these generalized objectives has been guilded by several a priori working hypotheses dealing with prediction of responses of aquatic biota to temperature, phosphorus concentration and clay turbidity in the water. Verification of these hypotheses requires consideration of field data and information derived from controlled experiments, in which the response of indigenous biota (marker species) to extremes in important environmental variables (i.e.those most likely to be changed by cultural practices in the drainage) are carefully quantified. We have studied baseline conditions in the ecosystem and report our preliminary findings in this report; the limnological studies on the lake and rivers will include additional baseline monitoring during the next budget period (1979-80), but experimental work will be emphasized.

Documentation of the life histories of the majority of aquatic insects in the rivers has largely been accomplished, although some work remains with the mayflies (Ephemeroptera) and true flies (Diptera). Insects are the predominant fauna in the rivers; over 120 species co-exist. Analysis of measured physico-chemical parameters in association with this tremendous diversity of benthic invertebrates indicates the rivers remain in an oligotrophic and relatively pristine state. No chemical parameters were present in high enough concentrations to be of harm to riverine biota. Some important specifics in our river research include:

1) Concentrations of all chemical parameters decrease significantly during spring runoff, except dissolved and particulate carbon, phosphorus, and clay turbidity. These parameters are positively correlated with discharge, except in the South Fork below Hungry Horse Dam. We have also documented significant differences in chemical composition of the three forks. In general, the Middle Fork carries higher dissolved solids and considerably higher suspended solids.

2) Significant differences in relative abundance of species of the major insect groups were observed when comparing species composition and productivity in the three forks and mainstream. Production (e.g. of <u>Hydropsyche</u>) is an order of magnitude higher in the Middle Fork in comparison to the North Fork; production is significantly greater in the North Fork than in the Mainstream. Production of bottom fauna in the South Fork below the Dam is limited to only a few species of Diptera and Ephemeroptera. By inference, it appears that the Middle Fork is more productive than the other river segments in spite of (or perhaps because of) higher TSS loading.

3) Life histories of all species studied in detail correlate with temperature regima, while biomass or productivity is closely related to richness of habitat and food. Many details are unclear here, however, and further analysis of data in association with planned experimental work are needed.

4) The single most important negative impact in the riverine environment, as it exists today, is apparently the hydropower discharge regime from Hungry Horse Dam. Limnological phenomena in the reservoir greatly alter the physico-chemical integrity of the water mass and river bottom. These

negative impacts extend downstream in the mainstream segment and probably into Flathead Lake as well. Summer, peaking discharges are most harmful by interferring with emergence of important insect species and periodically dewatering large areas of the river bottom rendering it unsuitable for even temporary colonization by fish and invertebrates.

Primary productivity in Flathead Lake did not decrease during and after the spring period of turbidity, as we had expected. Rather, it increased due to increased carbon fixation (i.e. photosynthesis) by very small microbes. In spring and summer, 1979, the hypothesized flocculation - stripping of detritus and nutrients from the water column of the lake was not observed. However, the runoff event and resulting turbidity plume was not as intense as has been observed in previous years; at least an additional year's data, coupled with results from experimental additions of nutrients and clay turbidity into microcosms placed in the lake, are needed before we are prepared to reject the hypothesis.

Data derived from measurement of chemical and inflow parameters permitted calculation of the first accurate phosphorus budget for the lake (see Fig. 51 pg 102). Because incoming phosphorus roughly equaled outgoing concentrations, it appears that the lake exhibited nutrient equilibrium. This means that productivity in the lake is balanced with respect to import and export of nutrients and that phosphorus is rapidly cycled by mineralization processes in the trophogenic (lighted) layers of the lake.

During the report period, little phosphorus reached the lake bottom: rather it was recycled continuously in the upper portion of the water column, where total (i.e. autotrophic and heterotrophic) biological activity was always greatest. This supports the notion that productivity is limited by pacuity of the growth nutrient, phosphorus. However, low nitrogen concentrations were continuously observed, which may mean that nutrient is an important limiting factor as well.

Preliminary observations are that the lake remains oligotrophic (on a par with Lake Superior) and not greatly influenced by river discharge. However, additional work is needed, especially since our river data indicates correlations between turbidity and phosphorus and carbon concentration. Productivity in the lake could greatly be influenced by river discharge on years when runoff pattern is more intense and sustained. Also, discharges from Hungry Horse Dam may move water masses through the lake that are having an impact we have not yet quantified.

We also initiated study of physico-chemical conditions in specified tributary streams in the drainage. It is evident from only two sampling periods that the streams draining Glacier National Park are very poorly buffered (i.e. are not resistant to acidification). Also, the streams all have differing thermal and ionic characteristics and therefore we expect to document major differences in biotic composition and productivity.

Most of the data generated in our limnological study are given in figures or tables included in the report. We have also summarized results and future plans for studies that indirectly support our research objectives. All of our work is being prepared for publication in scientific journals as the study progresses.

The work is proceeding exactly as proposed and within the planned timeframe. We have recently encountered a sample backlog, due to re-location of our analytical water analysis facility from North Texas State University to the Biological Station. A full-time, analytical chemist, Mr. John Lamb, has joined the research group and we should clear our sample backlog shortly.

II. INTRODUCTION

Limnological analyses of the Flathead Lake-River Ecosystem, Montana, were initiated in Spring, 1977, and funded 1/V/1978 by the U.S. Environmental Protection Agency (Region VIII, Water Division) through the auspices of the Flathead River Basin Environmental Study. This report basically encompasses progress on the research through the first funded year, ending 1/V/1979. Preliminary results, largely without detailed interpretations, are presented herein, along with descriptions of alterations in the research plan (see Stanford, 1977).

During the first year of the study, we were to provide a basic description of the limnology of the ecosystem by focusing research effort on two major topics: 1) nutrient-plankton dynamics in Flathead Lake; 2) life history ecology of insects (emphasizing the Trichoptera) in the mainstream Flathead Rivers and with respect to physico-chemical dynamics. We were also to begin study of physico-chemical dynamics and benthic ecology in selected tributary streams within the drainage basin. Although this latter research effort was not initiated until late Summer, 1979, some preliminary results of our 'creeks study' are reported below.

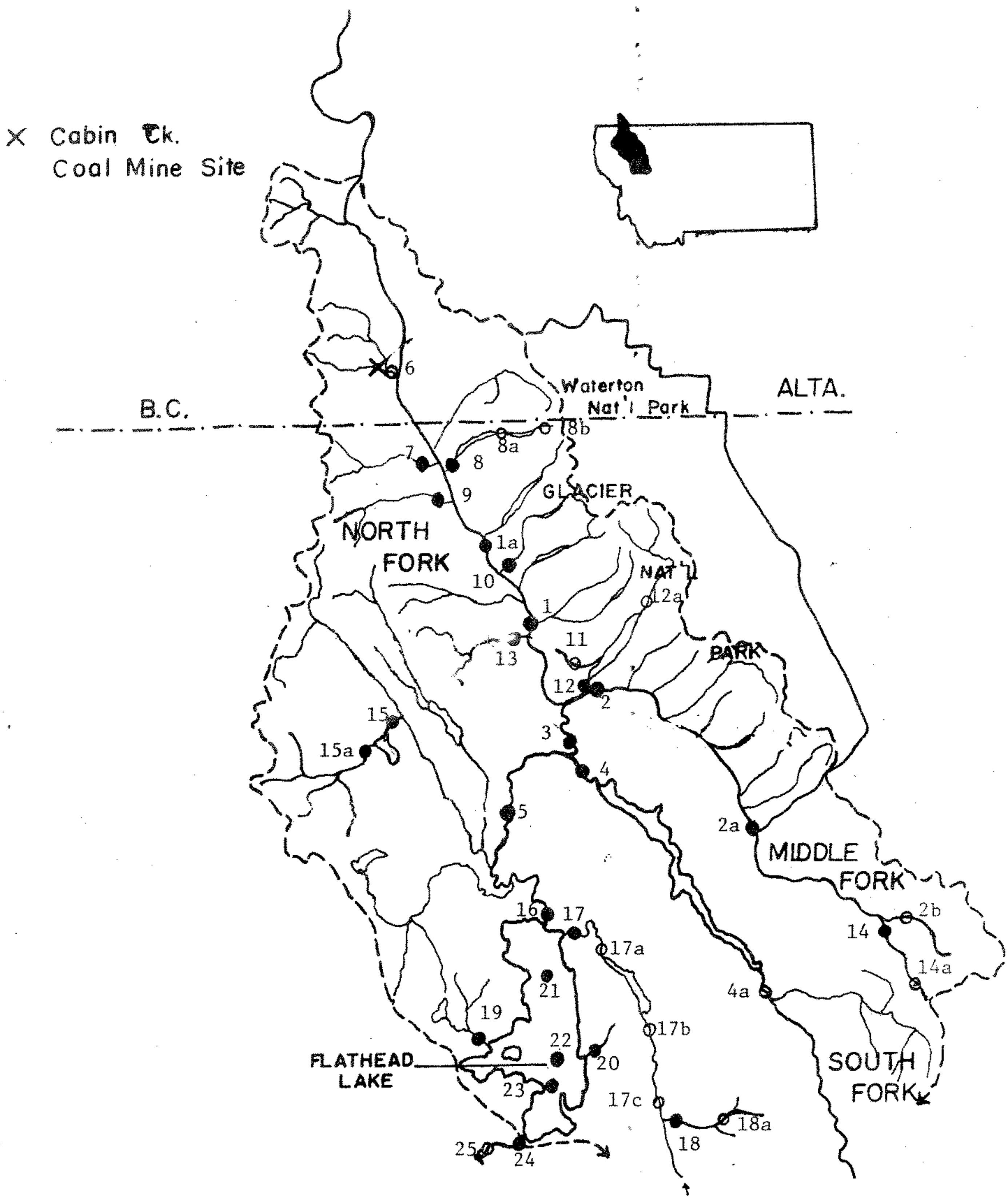
THE SAMPLING NETWORK

The research program has revolved around field work conducted at specific sites within the drainage basin, mostly upstream from Kerr Dam (Fig. 1). These sampling sites have been visited at least monthly; field data and appropriate samples for laboratory analyses (e.g. water, plankton, benthos, etc.) were collected.

Figure 1.

FLATHEAD RESEARCH GROUP SAMPLING STATIONS

1.	North Fork at Camus Creek
1a	North Fork at Polebridge
2.	Middle Fork at West Glacier
2a	Middle Fork at Walton
2b	Middle Fork at Shafer Meadows
3.	Mainstream at Hungry Horse
4.	South Fork below Hungry Horse Reservoir
4a	South Fork above Hungry Horse Reservoir
5.	Mainstream at Presentine Bar (Also sample at Kokanee Bend and Reserve Drive)
6.	Howell Creek
7.	Trail Creek
8.	Kintla Creek
8a	Kintla Creek
8b	Kintla Creek
9.	Whale Creek
10.	Quartz Creek
11.	Fish Creek
12.	McDonald Creek
13.	Big Creek
14.	Dolly Varden Creek
14a	Dolly Varden Creek
15.	Logan Creek below Tally Lake
15a	Logan Creek above Tally Lake
16.	Flathead River at Sportsman Bay
17.	Swan River at Bigfork
17a	Swan River below Swan Lake
17b	Swan River above Swan Lake
17c	Swan River at Goat Creek
18.	Lion Creek
18a	Lion Creek
19.	Dayton Creek
20.	Yellow Bay Creek
21.	Midlake North (Flathead Lake)
22.	Midlake South (Flathead Lake)
23.	Narrows (Flathead Lake) (Flathead Lake is also sampled at Skidoo Bay, Polson Bay, Yellow Bay, Big Arm Bay, Somers Bay, Bigfork Bay and elsewhere)
24.	Flathead River at Polson
25.	Flathead River below Kerr Dam



× Cabin Ck.
Coal Mine Site
B.C.
ALTA.
Waterton
Nat'l Park
GLACIER
NAT'L
PARK
NORTH
FORK
MIDDLE
FORK
SOUTH
FORK
FLATHEAD
LAKE
6
7
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8a
8b
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1a
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12a
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17a
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17b
17c
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2b
14a
4a

TIME FRAME

Our work to date has been largely of a descriptive nature, as per the research plan. The work has progressed mostly on or slightly ahead of schedule, and we are presently moving into the experimental phase of the project (see Stanford 1977). In our first progress report (29/I/79) a detailed time frame was presented. We have managed to work generally within that time frame, although some items of research have recently been delayed for logistic reasons (see below) and due to our recently completed re-location of the Analytical Water Quality Laboratory from North Texas State University to University of Montana Biological Station. All chemical analyses of water samples from 1/IV/79 through duration of the study will be completed at UMBS.

III. LIMNOLOGY OF FLATHEAD RIVERS

INTRODUCTION

Previous work on benthic ecology in the Flathead Rivers elucidated several important working hypotheses that are being addressed in the present study:

1) Aquatic insects sequence life histories (e.g. growth and emergence) by thermal criteria, but individual and population size is a function of food (and secondarily, habitat) availability;

2) Productivity or energy flow through successive trophic levels is controlled by food quantity and quality of clay-detrital aggregates that accumulate on the river bottom;

3) Heterotrophic processing of organic carbon (mostly allochthonous detritus) is the primary trophic event in the mainstream rivers.

In order to verify these hypotheses, it has been necessary to quantify key structural and functional relationships in the riverine ecosystem. Considerable effort has been directed toward documentation of distributional patterns of macrobenthos (mostly insects) on specific riffles in the North, Middle, and South Forks and Mainstream Flathead Rivers. These basic ecological inter-relationships have been analyzed concomittant with temporal dynamics of physicochemical parameters (e.g. C, P, N, ^{o}C, turbidity, metals).

The major goal of our riverine work is to fully elucidate the environmental requirements of insect species that are very abundant at all riverine sites. These may be considered 'marker' or 'type' species by which baseline ecology of the riverine environment may be monitored. Data on life histories are being used to verify the working hypotheses given above.

Work during the budget period was designed to elucidate life histories and distributions of macrobenthos in the rivers and establish baseline data on temporal dynamics of physicochemical parameters thought to be important environmental parameters for maintenance of observed bottom fauna. Efforts were to emphasize temporal sampling of the bottom communities at the major river sites (see Fig. 1); initial emphasis was given to the caddisflies (Trichoptera) in these bottom samples, since this order seemed dominant in the benthos and previous studies had delineated needed information on stoneflies (Plecoptera). Data collection followed methods prescribed in the research plan (Stanford 1977).

1. THE ECOLOGY AND DISTRIBUTIONAL RELATIONSHIPS OF ARCTOPSYCHE GRANDIS IN THE UPPER FLATHEAD RIVER, MONTANA

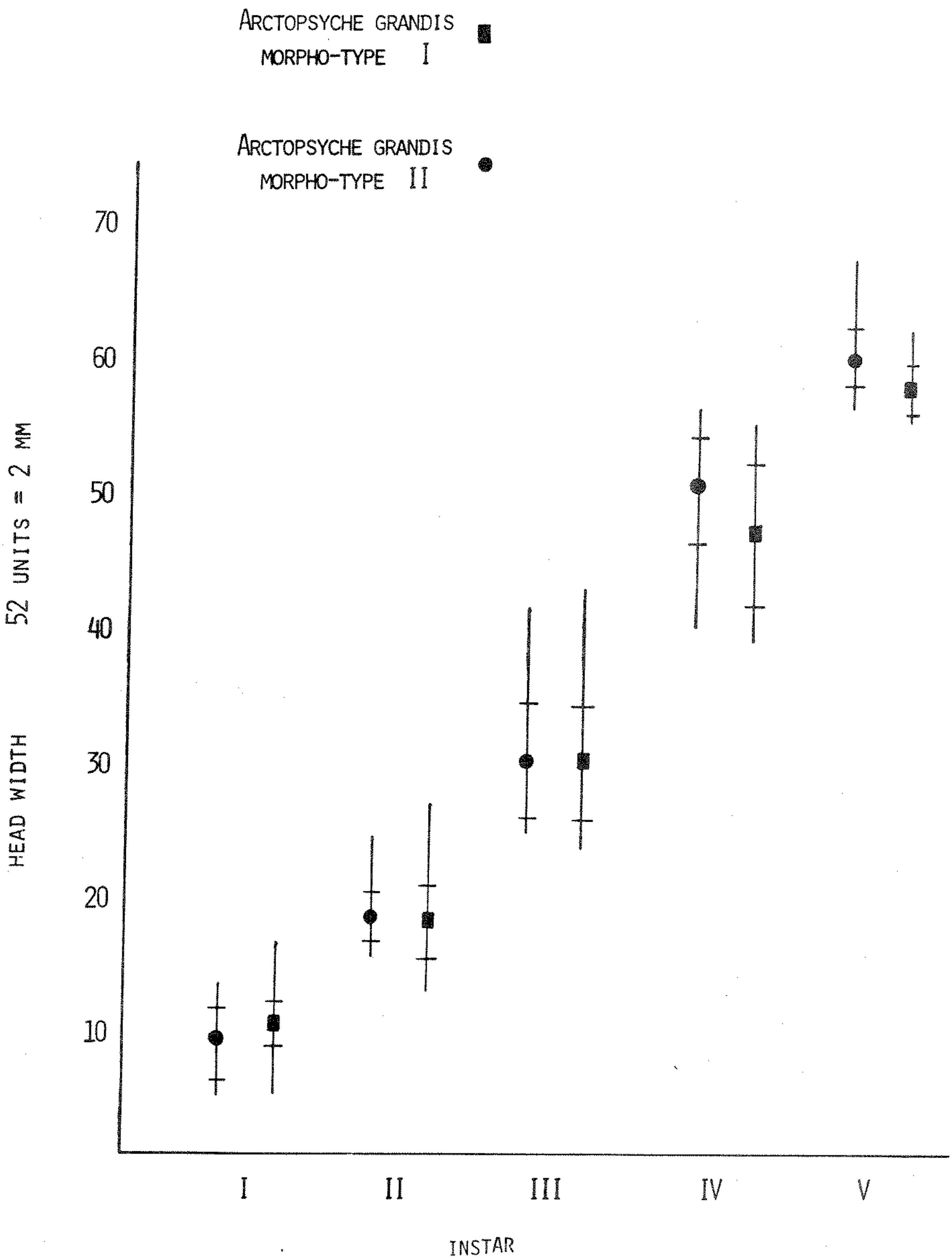
Morphological Considerations

Two morphologically distinct types of Arctopsyche grandis larvae occur abundantly throughout the mainstream Flathead Rivers above Flathead

Lake. Obvious morphological differentiation is restricted to pigmentation. One of the morphological types, which we have termed morpho-type I, has a light coloration or stripe running from the interior edge of the fronto-clypeal apotome posteriorly through the coronal suture and the mid dorsal ecdysial line of the pronotum and mesonotum. The other morphological type (morpho-type II) has no stripe. The two morpho-types are also different in the size obtained by each instar with the average morpho-type II larvae in the final instar being significantly larger than the average morphy-type I larvae (Fig. 2). In order to correlate the morphologically distinct larvae with adult characteristics, larvae of both morphy-types were reared in laboratory microcosms. To supplement the results from laboratory-reared material, pupae were also collected from the rivers with the intention of correlating the sterite pigmentation with adult characteristics being expressed by pupae in later stages of development. This method of larvae-adult associations has been in wide practice for many years (Voorhees, 1909; Milne, 1938; Ross, 1944). Fourteen morpho-type I and 9 morpho-type II individuals were successfully reared in the laboratory. Twenty-three late development morpho-type I and 12 morpho-type II pupae were also collected from the river. The results of these associations revealed that all of the morpho-type II were female, while morpho-type I associations proved to be both male and female.

Size sexual dimorphism in aquatic insects is common and is the situation for Arctopsyche grandis in the Flathead River. This sexual dimorphism is reflected in the larger size of the morpho-type II larvae; also the morpho-type I larvae appear to be bimodal in headwidth although not significantly differentiated. This would account for the observed size sexual dimorphism.

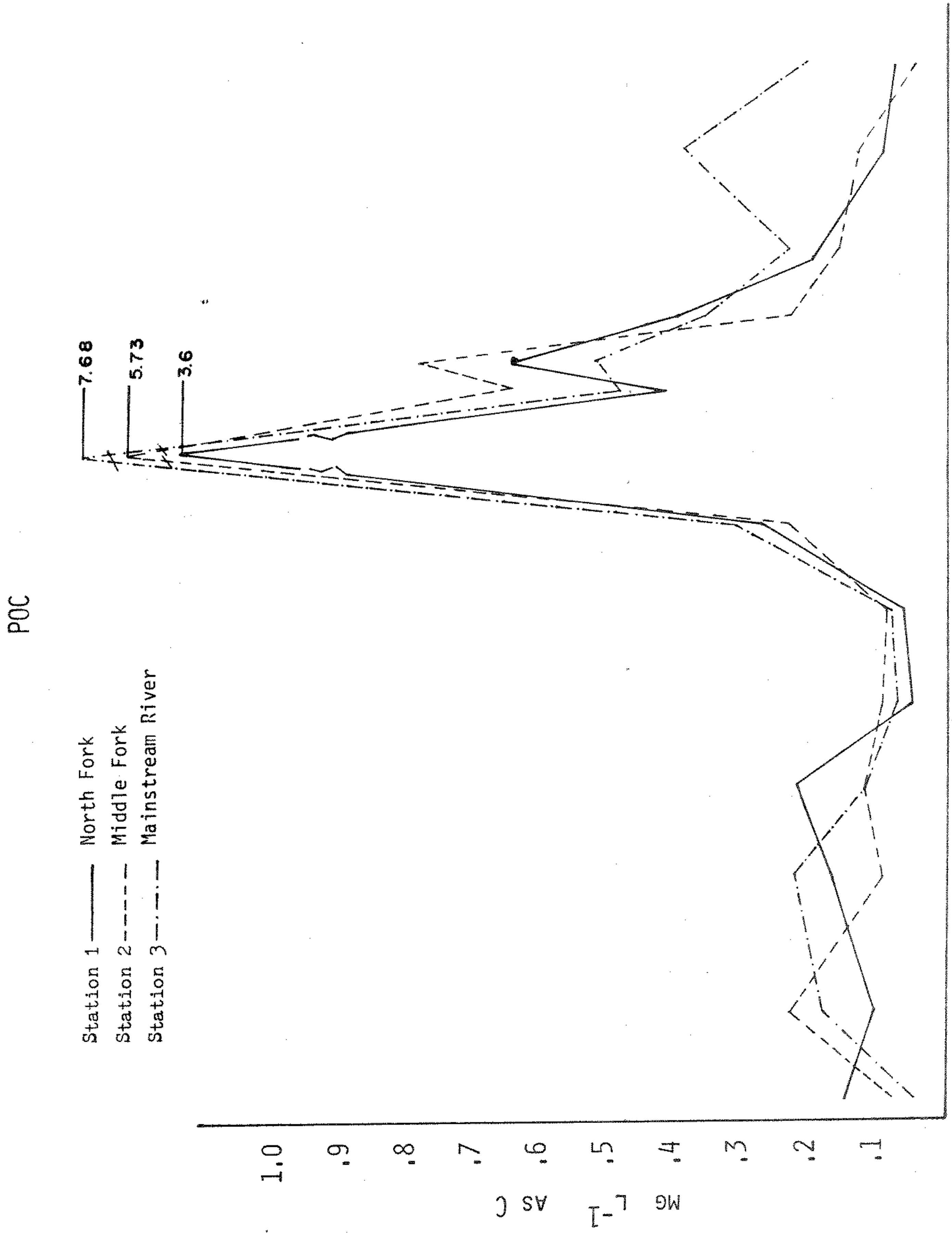
Figure 2. Growth of *Arctopsyche grandis* as a function of instar



Life Histories

Throughout the drainage Arctopsyche grandis has a two-year life cycle. Adult emergence is initiated in mid-June and continues to the end of July. Peak adult activity is during the first two weeks in July with actual emergence taking place at sunset. This is also the time of maximum daily activity. In the Upper Flathead Rivers the life history of Arctopsyche grandis is closely linked to physicochemical differentiation between the North Fork, Middle Fork, and Mainstream. The Middle Fork and subsequently, but to a lesser degree, the Mainstream carries a greater sediment load during spring runoff and remains turbid after peak runoff for a longer period of time than the North Fork. Also, the Mainstream Fork is more subject to periodic increases in turbidity and closely associated particulate organic carbon (POC) (Fig. 3), due to periodic fall rainstorms than the North Fork. In the North Fork the rubble bottom is very coarse grained and loosely associated, providing very large interstitial space within the rubble. In contrast, Middle Fork rubble is a smaller river and the large volume interstitial spaces are filled with coarse sand and gravel. Arctopsyche grandis is reported to build its retreat on the tops and exposed sides of large rocks; but, in the Upper Flathead Rivers retreat location is restricted to the bottom sides of the very large rubble or in very protected locations near the edge of large rocks. Presumably, this is in response to the tremendous amount of anchor ice and occasional scouring of the tops of exposed rubble by floating ice during the winter months. We have observed Arctopsyche grandis retreats on rock surfaces only in some of the lake outlet creeks in western Glacier National Park (tributaries of the North Fork), which develop anchor and floating ice only in the most extreme winters.

Figure 3. Dynamics of particulate organic carbon (POC) in the mainstream Flathead Rivers.



Life cycle analyses revealed that faunal response to the difference in environmental conditions between the North Fork, Middle Fork, and Mainstream Rivers is significant. In the North Fork 2nd year class morpho-type II larvae grow rapidly into later instars, while morpho-type I larvae are much slower in instar development (Figs. 4, 5). In the Middle Fork and Mainstream, however, both larvae morpho-types are much slower in growth, not proceeding into later instars as rapidly as either morpho-type, especially morpho-type II, in the North Fork (Figs. 6, 7, 8, 9).

Relative Abundance

The two morphological larvae types respond differentially in terms of relative abundance between the North Fork, Middle Fork, and Mainstream River (Figs. 10, 11, 12). Throughout all seasons there is a greater total abundance of *Arctopsyche grandis* at Stations 3, 2, and 1 respectively. In the North Fork, however, morpho-type II larvae are more abundant than morpho-type I larvae during all seasons, while in the Middle Fork and Mainstream morpho-type I is significantly more abundant than type II.

Trophic Relationships

Temporal, locational and morphological differentiation of trophic dynamics was readily apparent in *Arctopsyche grandis* in the Upper Flathead Rivers. In the North Fork (St. 1), which appears to have considerable autotrophy, diatoms contributed approximately 50 per cent of the gut contents. In the Middle Fork (St. 2), which has a large detrital component in the seston, amorphous detritus contributed significantly to the trophic relationships. During the fall the trophic relationships between morphological types of larvae are very similar yet distinctly different between locations (Fig. 13). During the winter, only at Station 1 (North Fork)

Figure 4. Growth of Arctopsyche grandis (I) in the North Fork.

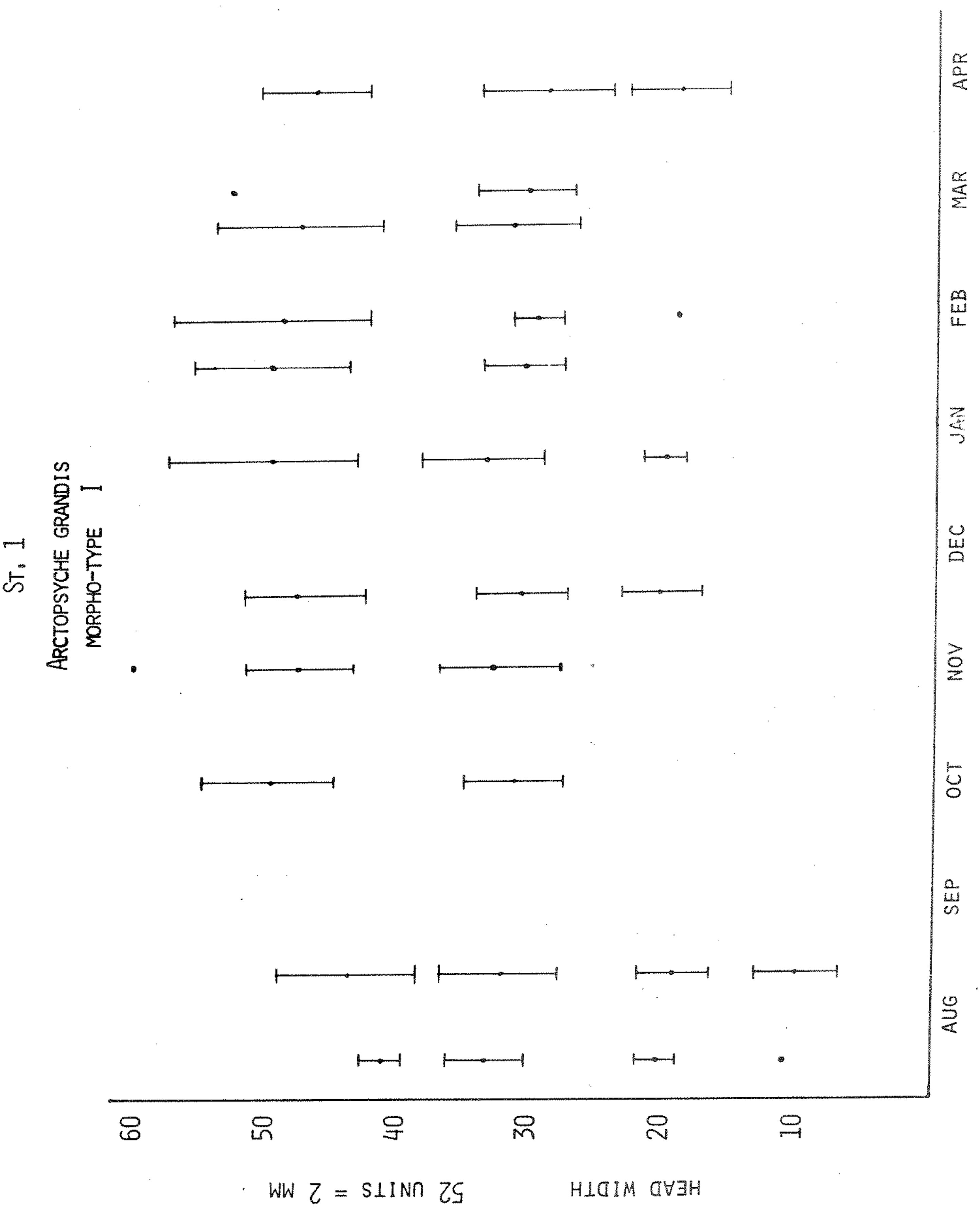


Figure 5. Growth of Arctopsyche grandis (II) in the North Fork.

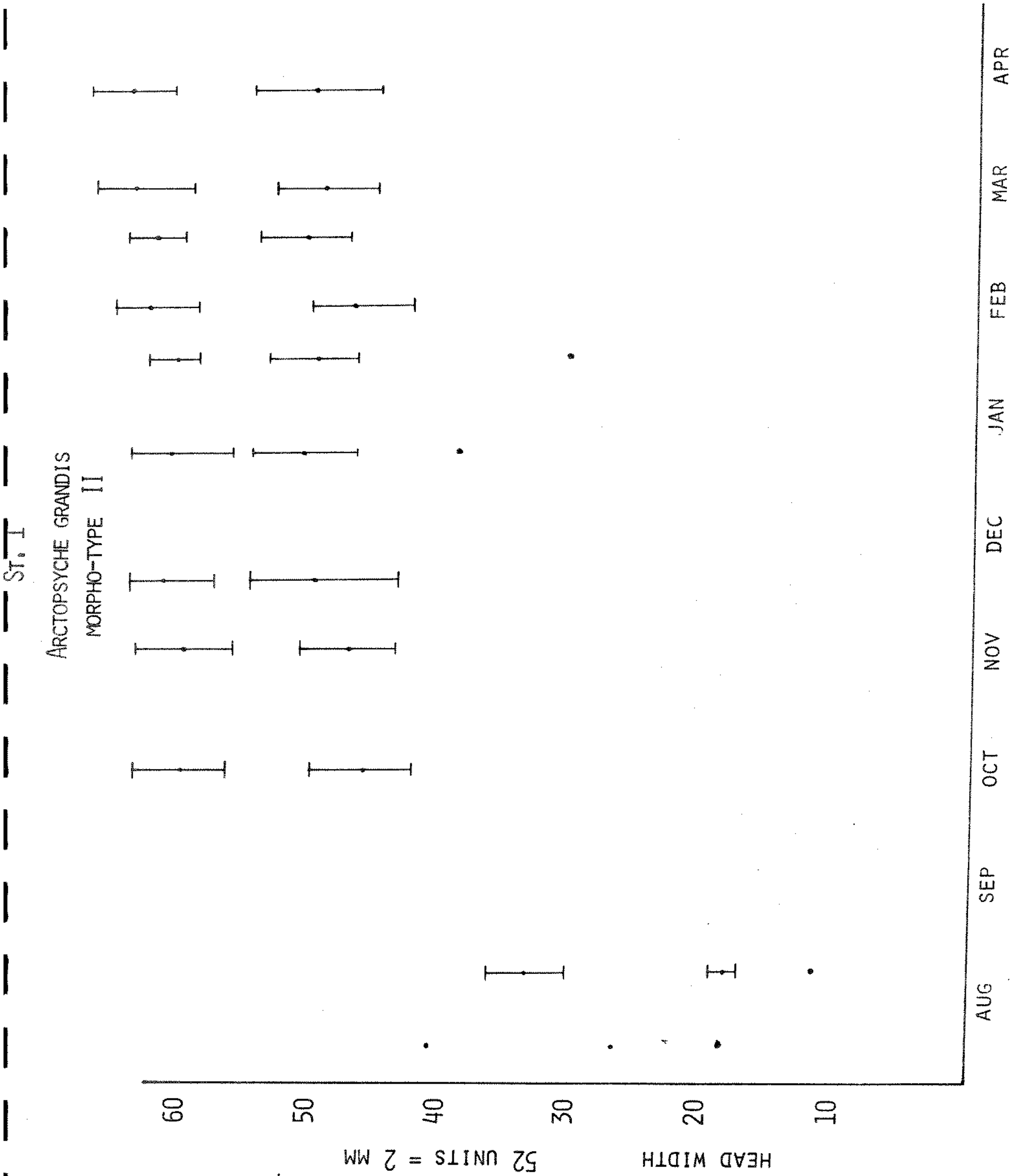


Figure 6. Growth of *Arctopsyche grandis* (I) in the Middle Fork.

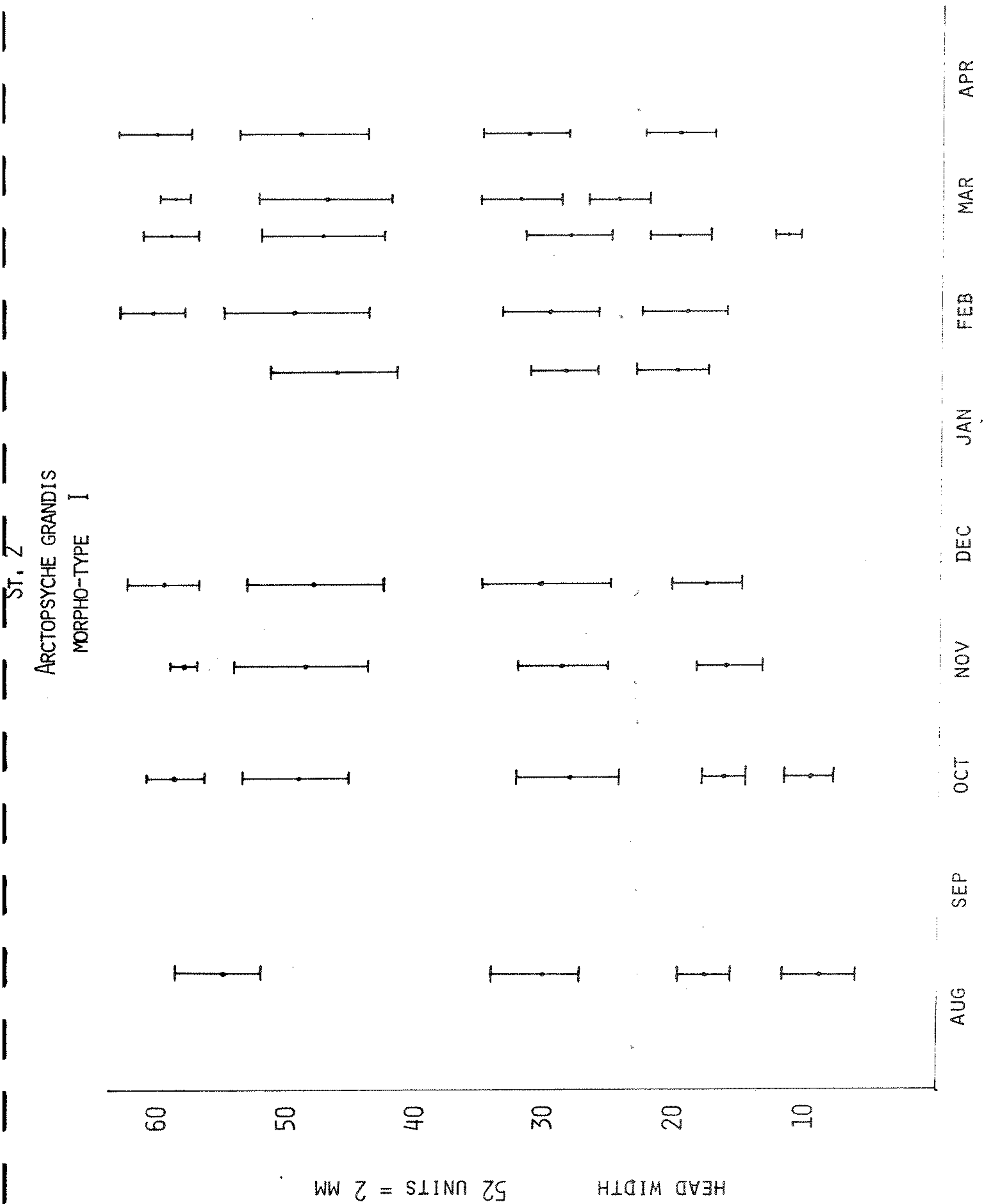


Figure 7. Growth of Arctopsyche grandis (II) in the Middle Fork.

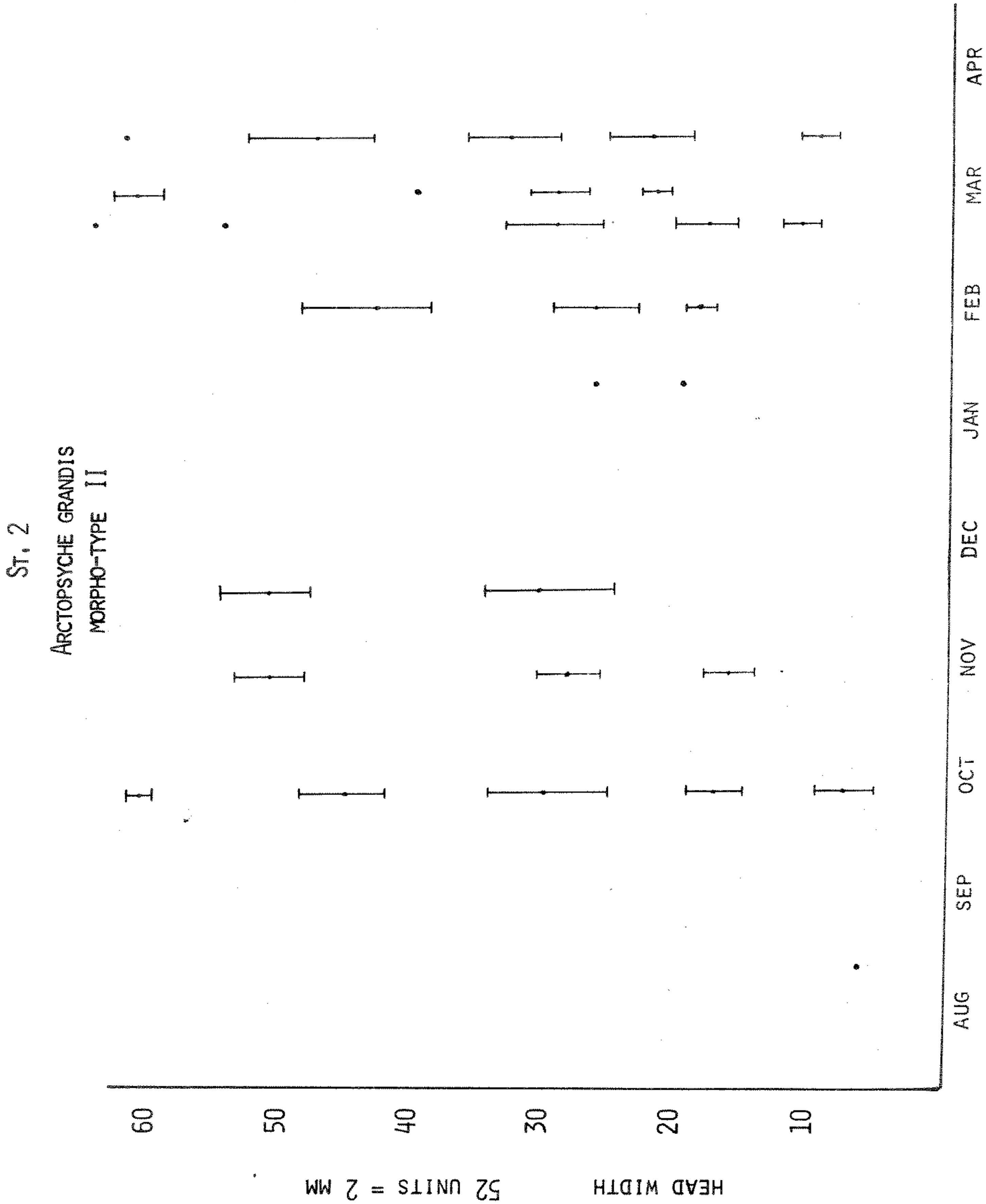


Figure 8. Growth of Arctopsyche grandis (I) in the Mainstream River at Presentine Bar (St 5).

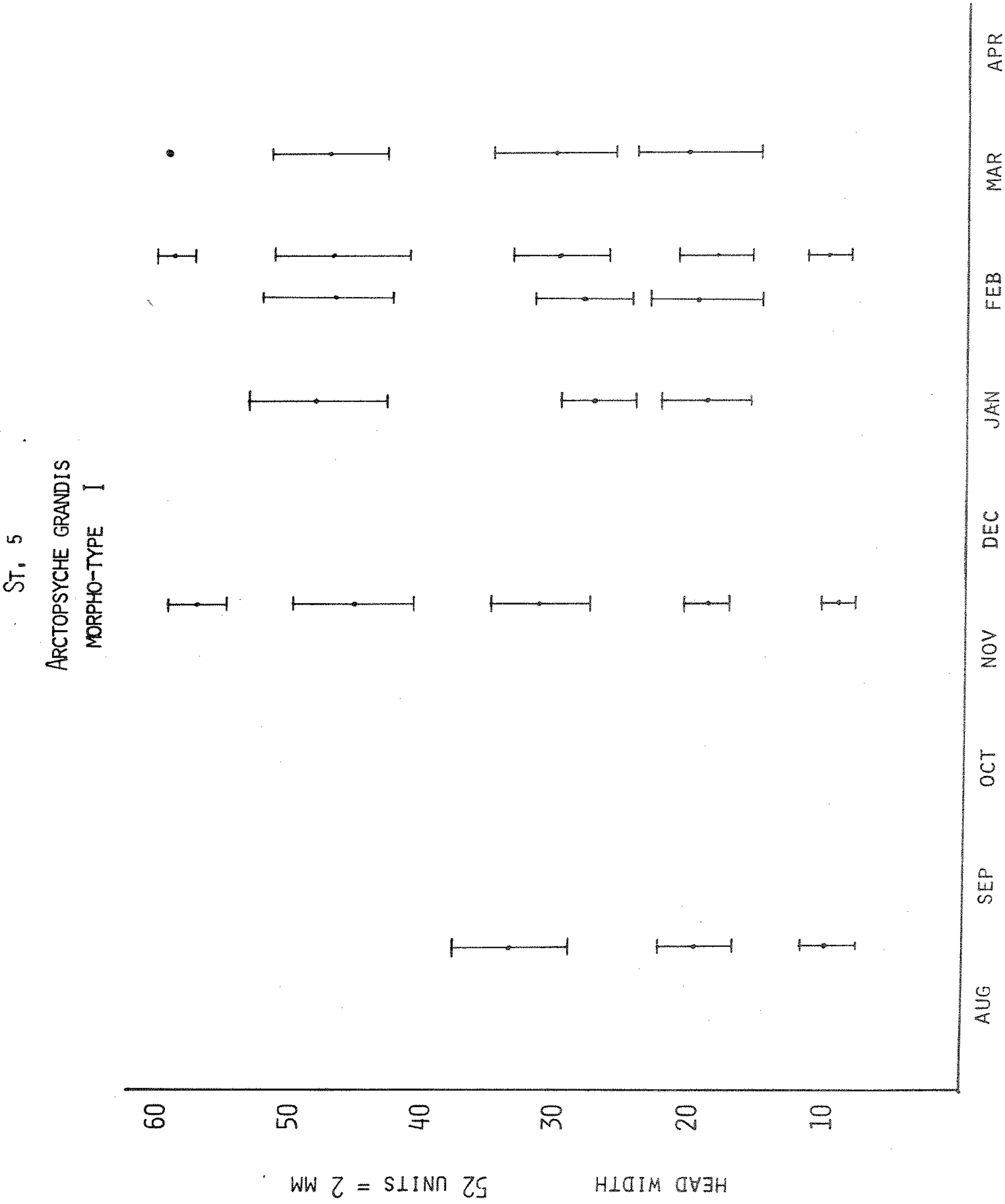


Figure 9. Growth of Arctopsyche grandis (II) in the Mainstream River at Presentine Bar (St 5).

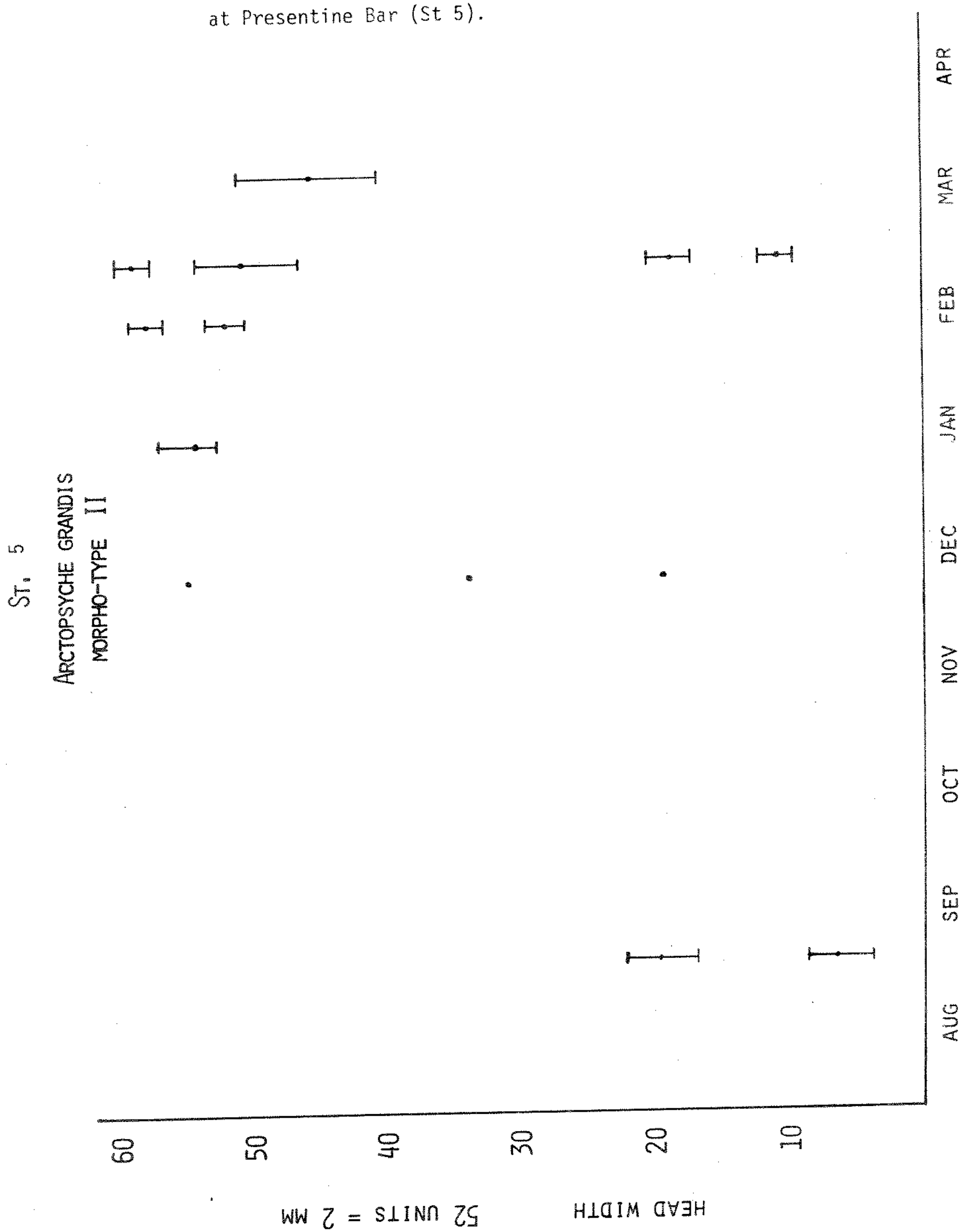


Figure 10. Relative abundance of Arctopsyche grandis in fall.

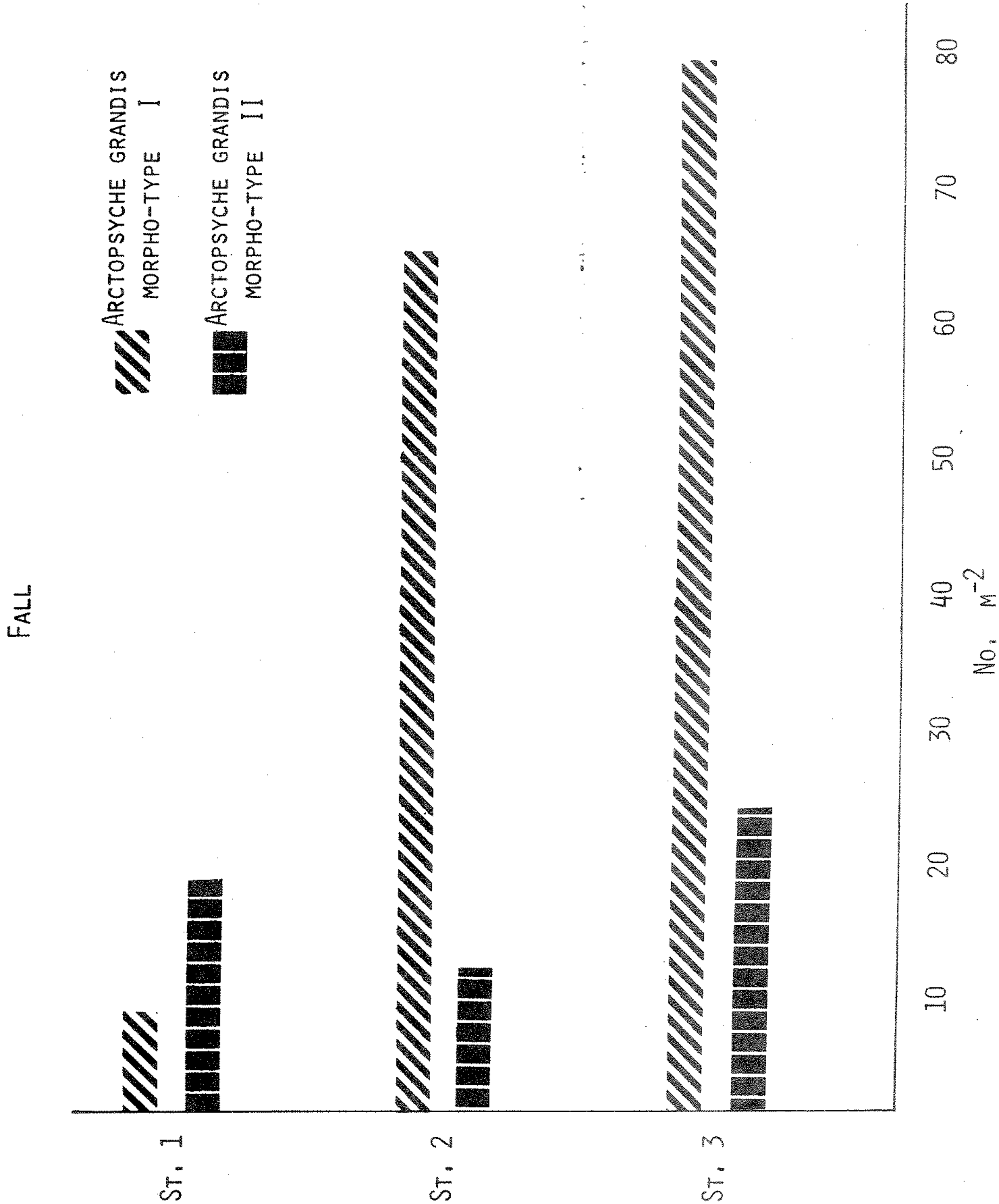


Figure 11. Relative abundance of _Arctopsyche grandis_ in winter.

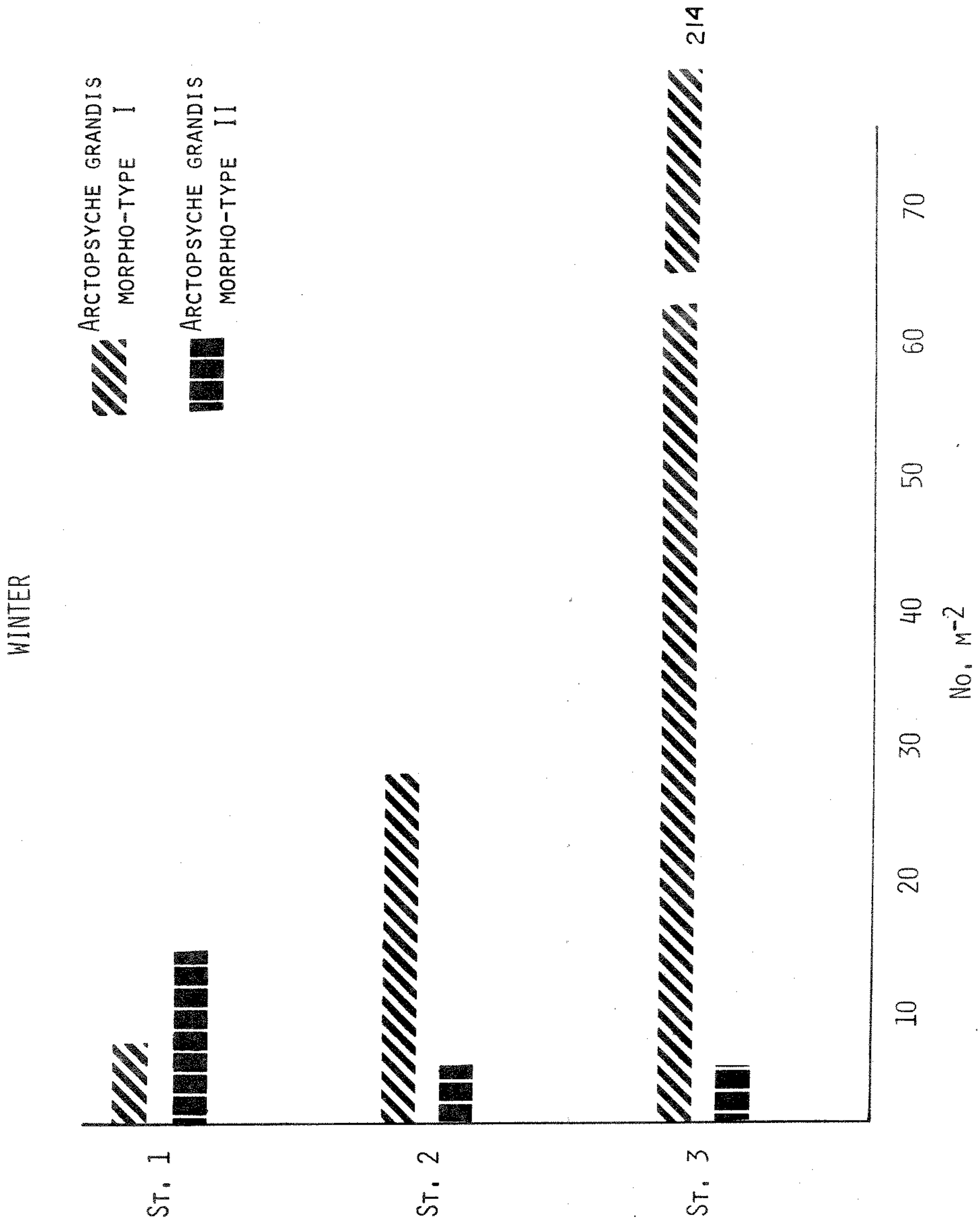
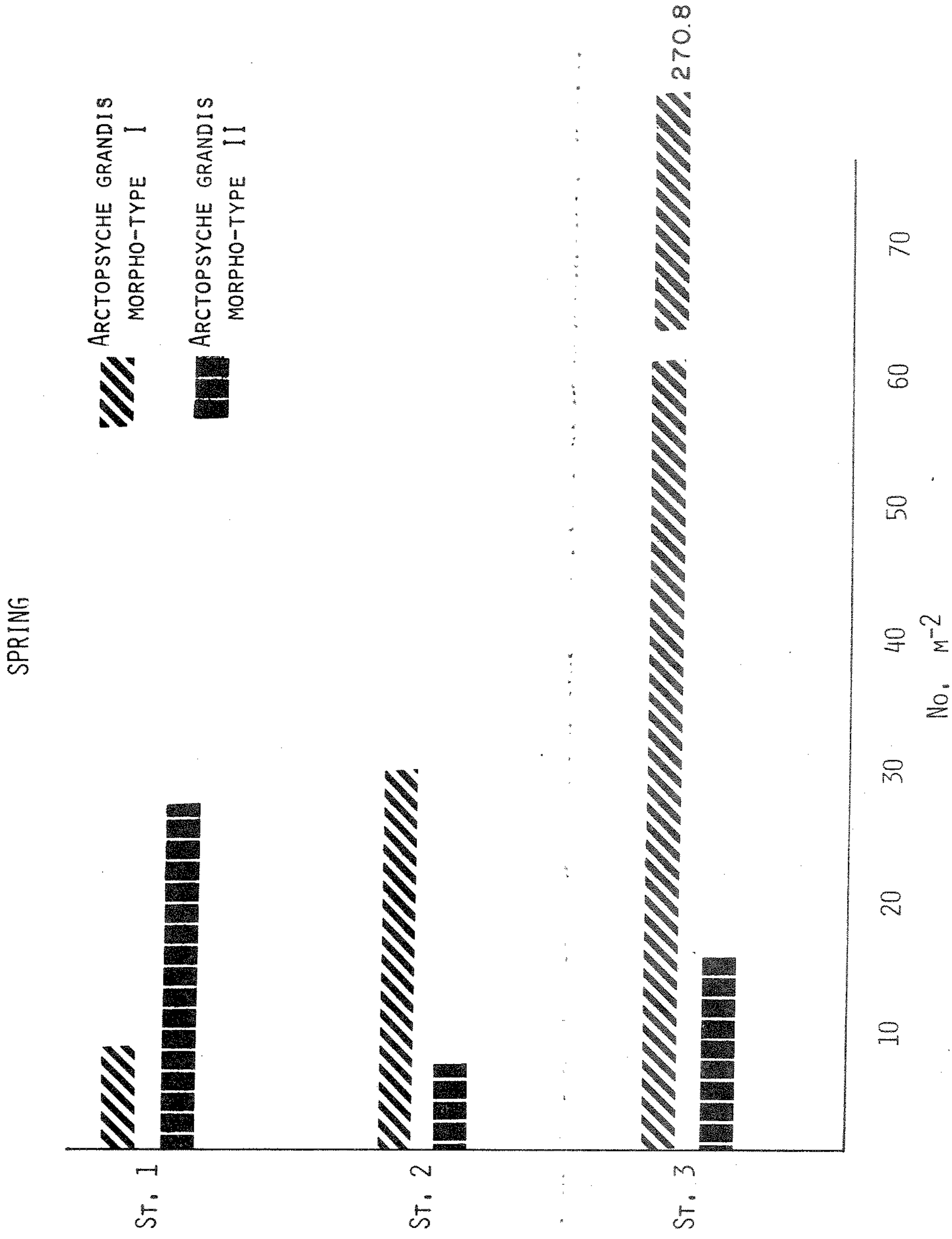


Figure 12. Relative abundance of Arctopsyche grandis in spring.



were the morphological types substantially different from each other in their trophic relationships, yet trophic relationships between locations were again distinctly different (Fig. 14). During the spring, animal tissue became the most important food item for both morpho-types at all three locations except for morpho-type I at Station 3 (Mainstream) where once again green algae constituted the largest percentage of the gut contents (Fig. 15).

Discussion

A unique aspect of the ecology of *Arctopsyche grandis* in the Upper Flathead Rivers is that it exists as two distinctly different morphological types which respond differentially to their environment. The North Fork is characterized by large rubble with much interstitial space, a low amount of turbidity, except during spring runoff, and appears to have a significant amount of autotrophy. The biotic response by *A. grandis* is that morphological type II larvae grow more rapidly and become more robust than type I larvae. The Middle Fork is characterized by smaller rubble with much less interstitial space, periodic increases in turbidity and associated particulate organic carbon, and appears to be more heterotrophic than the North Fork. The biotic response by *A. grandis* is that both morphological types grow at approximately the same rate; however, type I larvae are much more abundant than type II larvae. The Mainstream River (partially regulated) is characterized by rubble of a similar size as to that in the Middle Fork but with more interstitial space, a periodic slucing of hypolimnetic releases from Hungry Horse Reservoir, and significant growths of green algae which readily become a part of the seston. The biotic response by *A. grandis* is high productivity of type I larvae and rapid growth and robust type II larvae.

Figure 13. Trophic relationships of *Arctopsyche grandis* during the fall (mean percentage of gut filled under each chart).

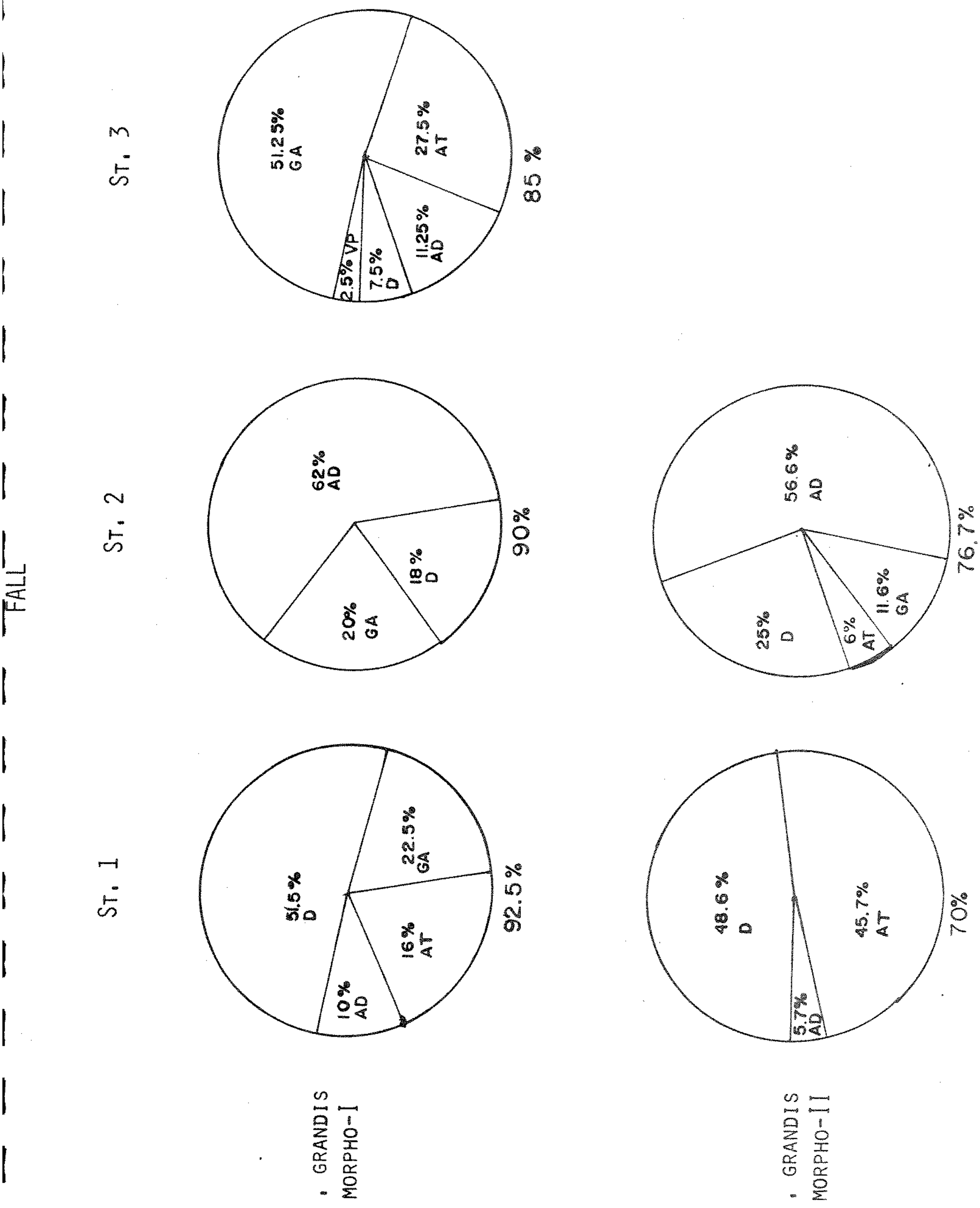
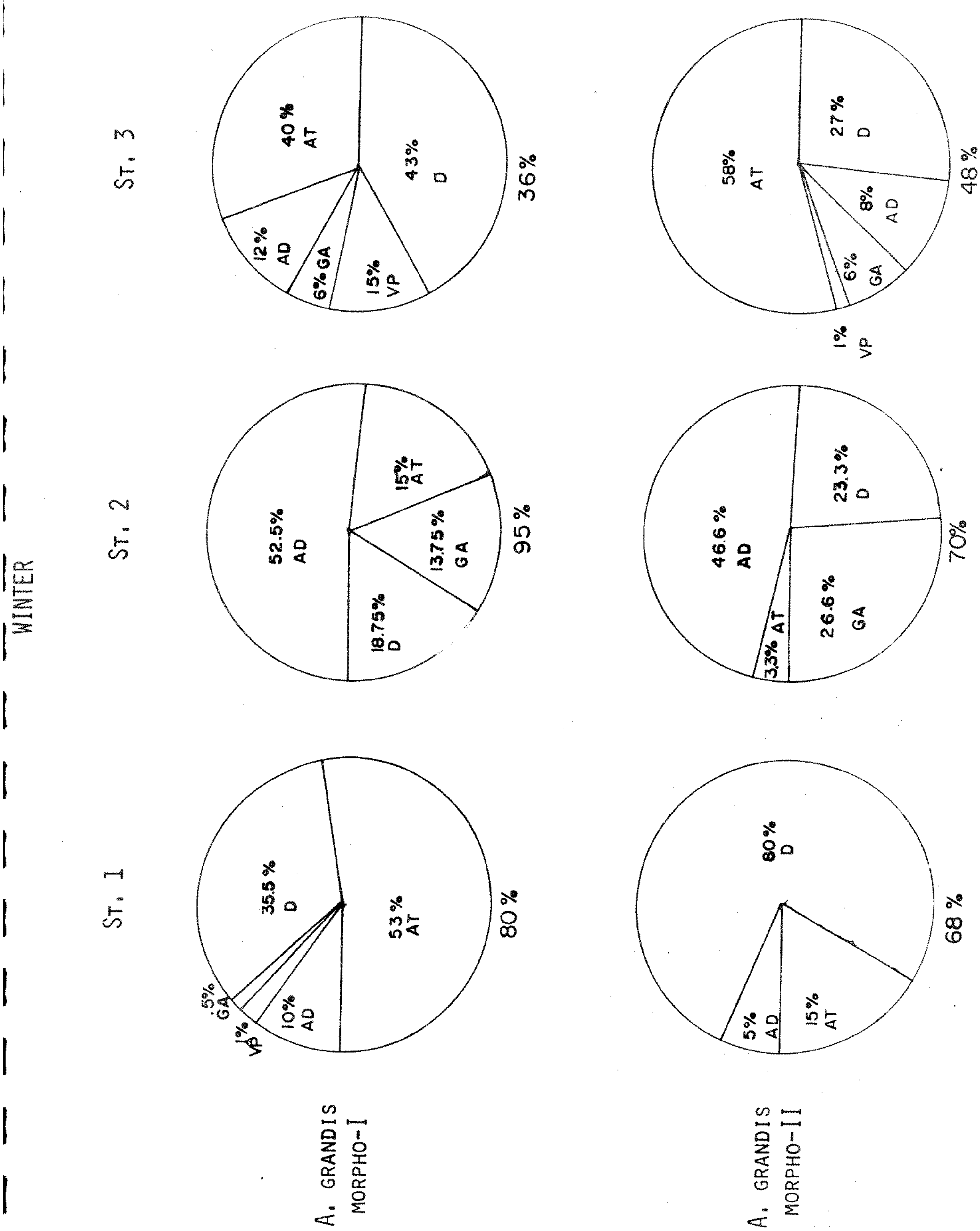
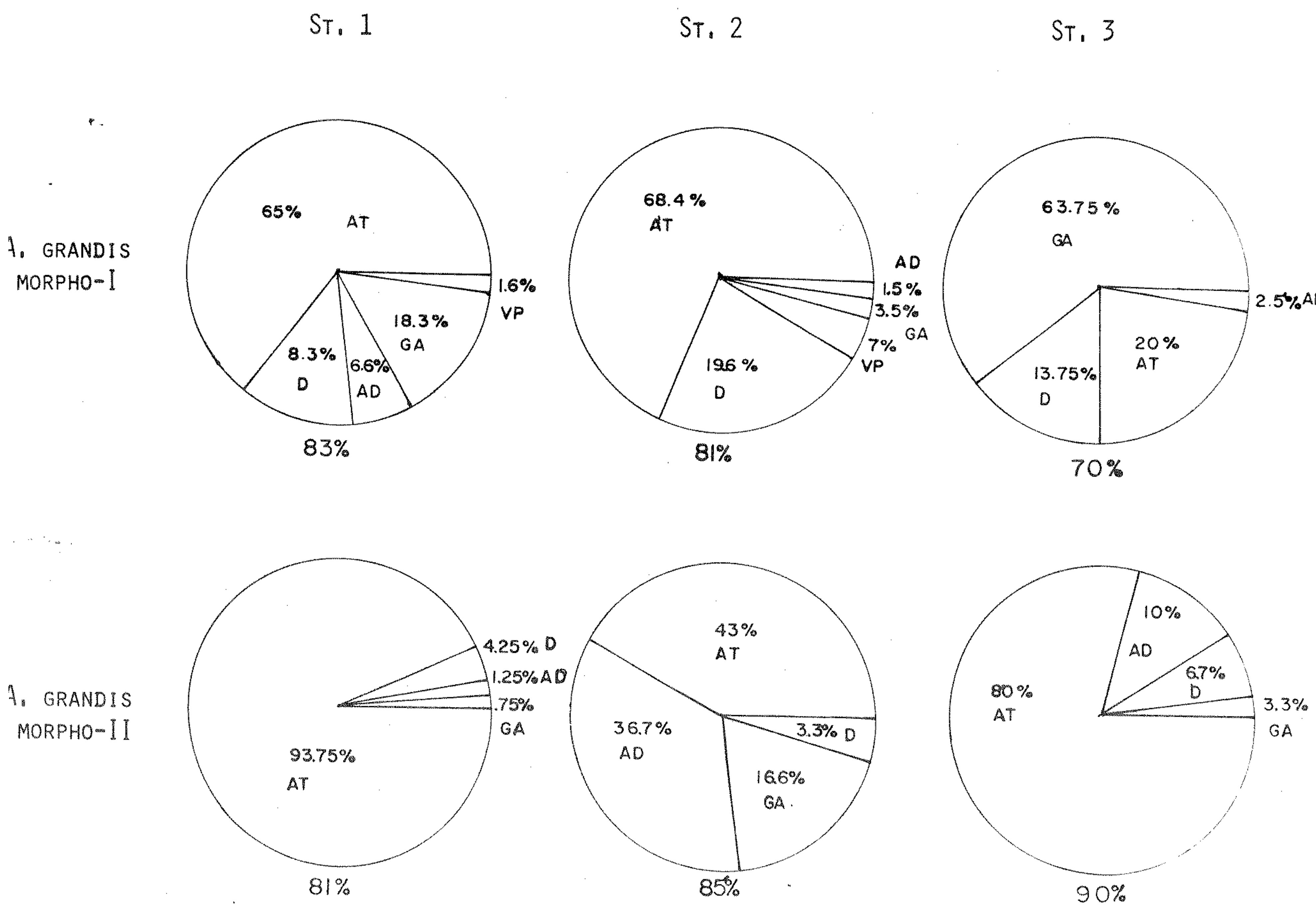


Figure 18. Trophic relationships of Arctopsyche grandis during the winter (mean percentage of gut filled under each chart).



SPRING



(mean percentage of cut filled under each chart).

2. ECOLOGY, GROWTH, AND PRODUCTION OF HYDROPSYCHIDAE IN THE UPPER FLATHEAD RIVER, MONTANA

The role of filter feeders and especially net spinning Trichoptera has been the subject of many studies over the past two decades. This has been due not only to the increased interest in lotic ecosystems in general, but also because filter feeders in some ecosystems are exceedingly important in the processing of organic carbon and play an integral role in the spiralling of energy and nutrients (Wallace et al., 1977). Since net spinning caddisflies are very specific in the size fractionation of seston POM, they tend to partition the trophic resources regardless as to whether those resources are limiting or not. Considerable effort has been placed on trying to understand filter-feeder inter-relationships and their role as processors of organic carbon (Williams and Hynes, 1973; Gordon and Wallace, 1975; Wallace, 1975a, 1975b). The concepts of spacial resource partitioning are just beginning to be looked into at both the macro level (Cummins, 1975; Wiggins and MacKay, 1978) and the micro level (Alstead, 1979).

Unlike eastern deciuous forest biome streams and rivers which have very fine particle filter feeders as an integral part of the macroinvertebrate community, such as *Dolophilodes*, the Mainstream Flathead Rivers have only two genera of Hydropsychidae, *Arctopsyche grandis* and three species of Hydropsyche: *H. cocherelli*, *H. oslari*, and *H. placoda*. This is not an unusual condition for western montane rivers.

Life History Relationships

Arctopsyche grandis is the largest of the Mainstream river Hydropsychids and has a two-year life cycle (see *Arctopsyche grandis* section). The three species of Hydropsyche deviate to a slightly positive degree from

4th to 5th instar from Dyar's Law of expected insect growth. Hydropsyche cocherelli is the largest of the Hydropsyche genus with a mean terminal instar head width of 1.09 mm (Fig. 16). H. oslari and H. placoda have similar mean terminal instar head widths of 0.99 mm (Fig. 17, 18).

There is much periodicity in Hydropsyche growth (Fig. 19). H. cocherelli grows very rapidly during the late summer and early fall after hatching, so that by the beginning of cool temperatures in the late fall most of H. cocherelli growth has been completed. The species overwinters as a final instar larvae and maintains a retreat and net. Presumably winter and spring are used to acquire the energy necessary for gonadal development. Emergence of H. cocherelli begins in early June and is completed by early July. H. placoda initiated growth immediately after hatching in August. Development into final instar takes place over the entire fall and into early winter with generalized growth delayed behind H. cocherelli. Adult H. placoda begin to emerge in late July and continue through most of August. H. oslari develop the most slowly of the three species and overwinter mostly as early to mid instar larvae. As temperatures warm in the spring, growth is reinitiated until pupation and emergence during mid-summer, from July to the first half of August. It is interesting to note that the two species of Hydropsyche which exhibit the most similarity in larvae growth (i.e., H. cocherelli and H. placoda) have non-overlapping emergence times. Hydropsyche oslari, in contrast, overlaps both of the other species emergence times.

Relative Abundance

Throughout this report the differences between the North Fork, Middle Fork, and Mainstream Rivers have been emphasized. The significant differences in environmental parameters, in terms of biotic response, is

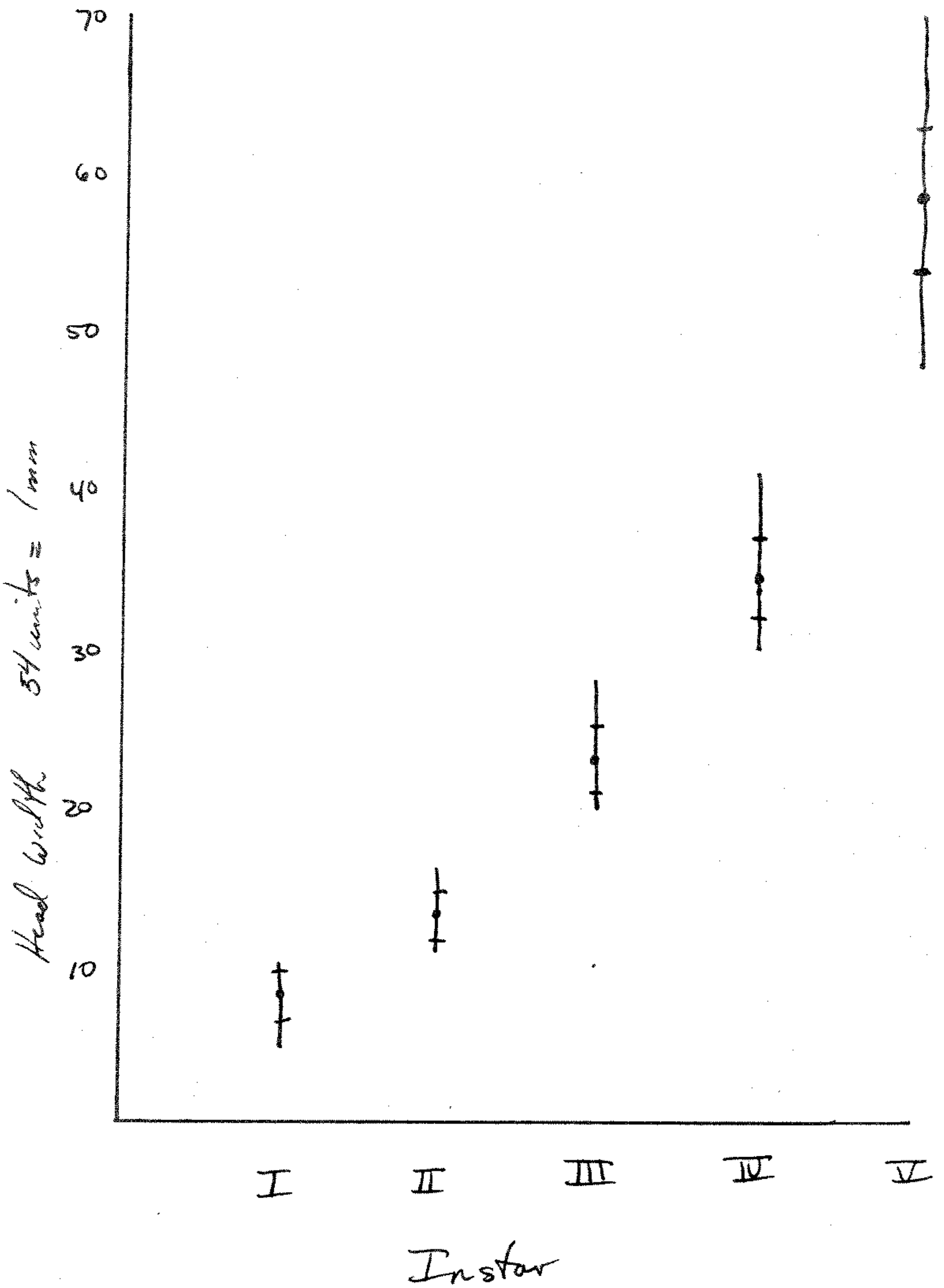


Figure 16. Growth of Hydropsyche cockerelli as a function of instar.

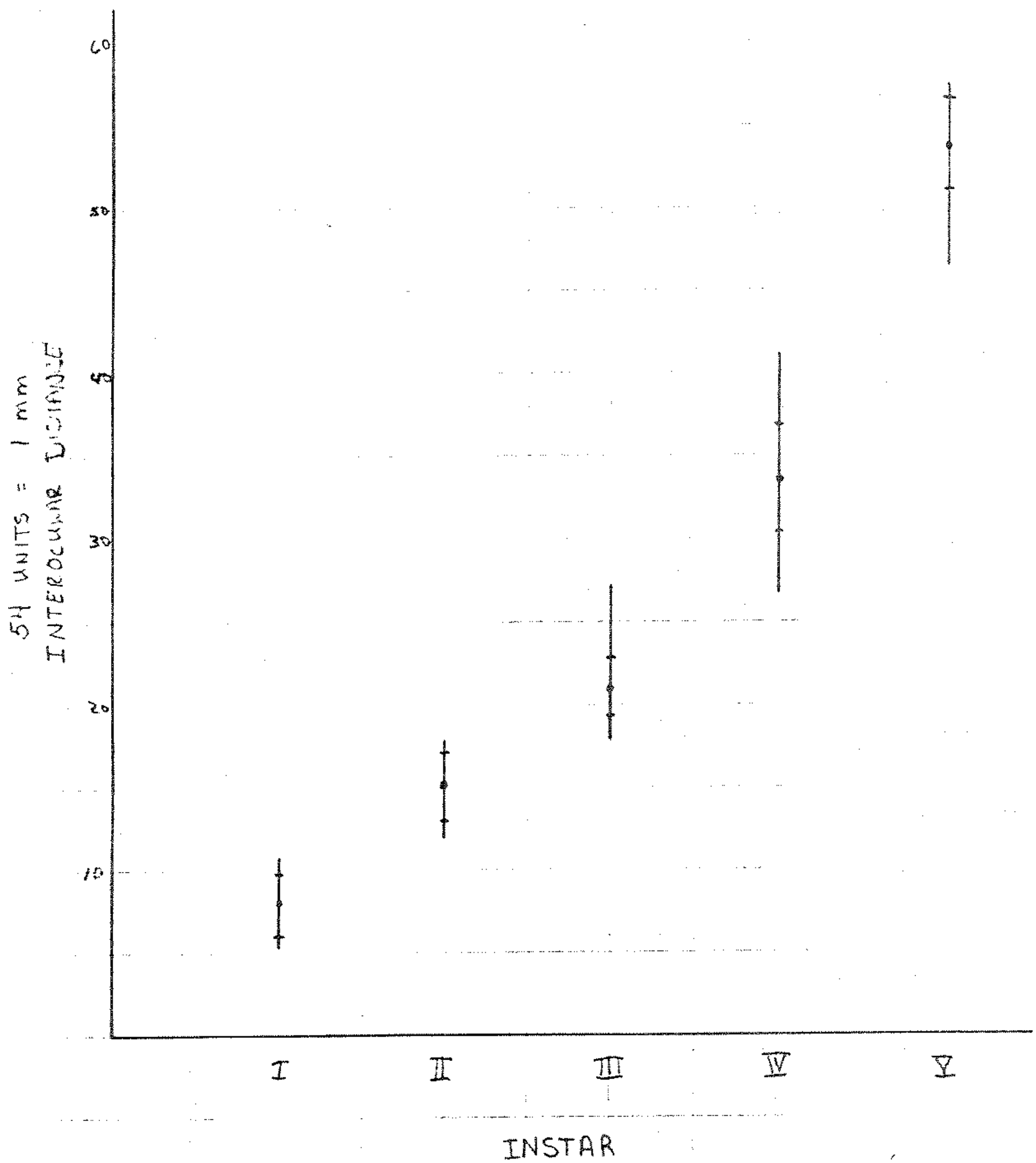


Figure 17. Growth of <u>Hydropsyche oslari</u> as a function of instar.

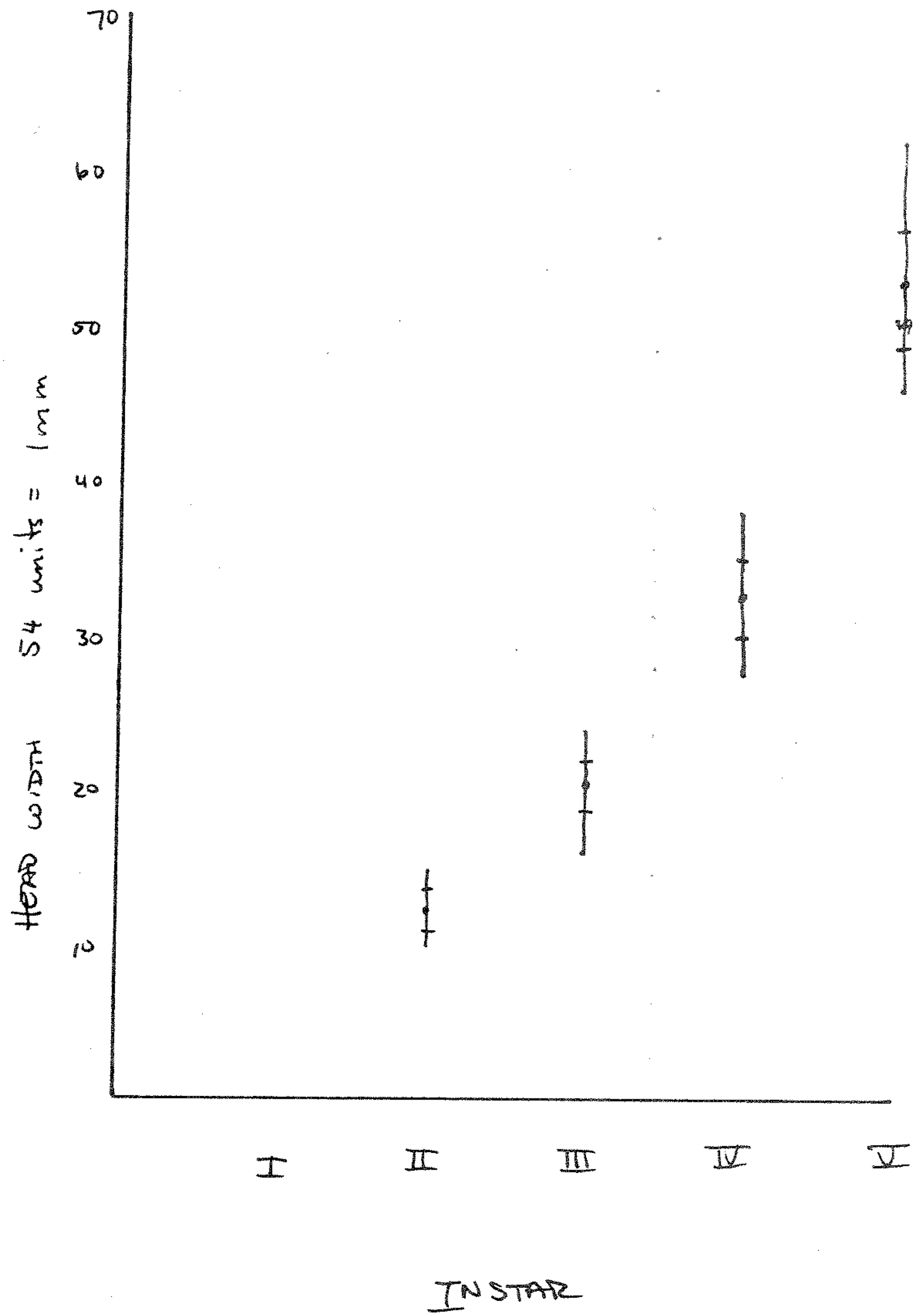
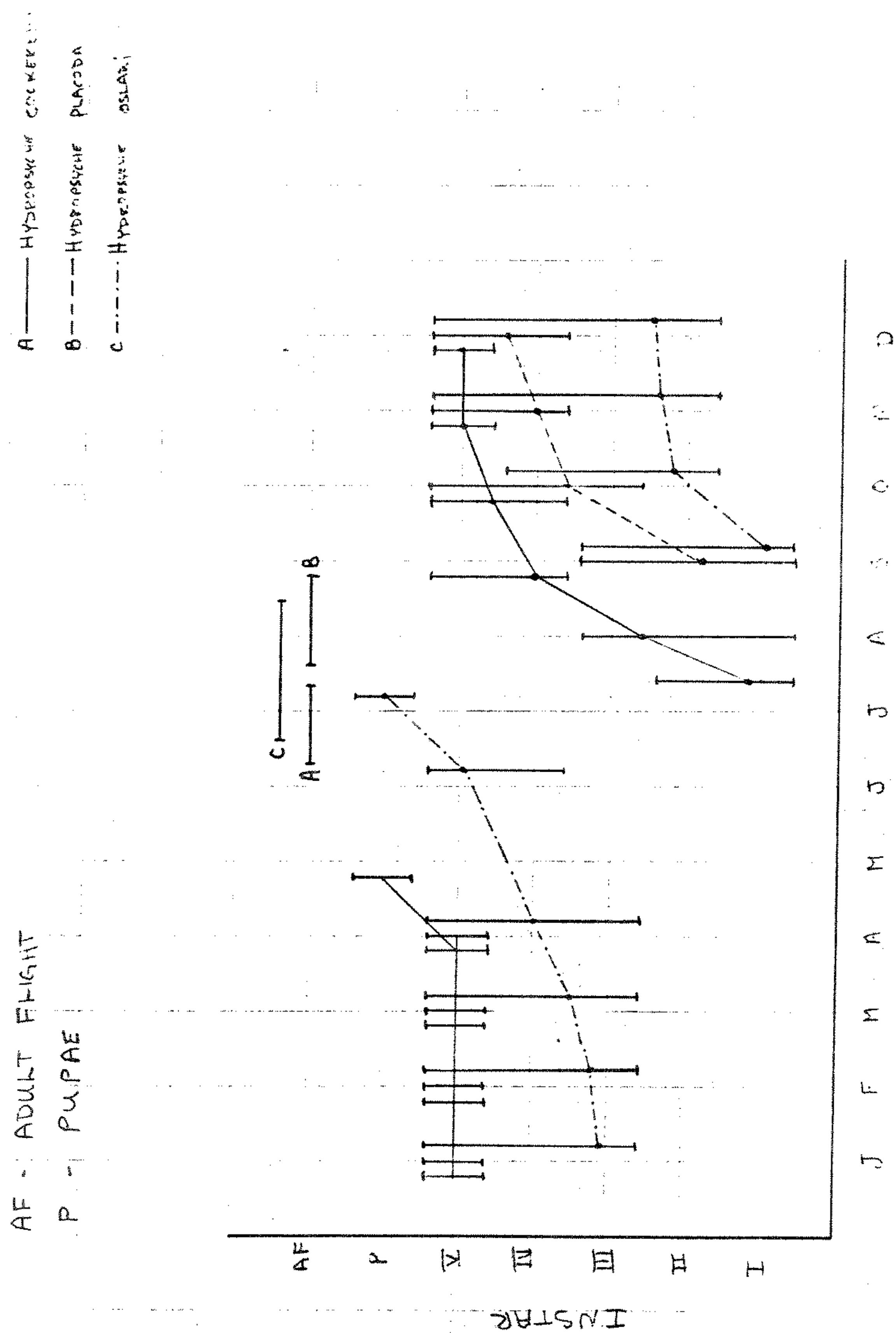


Figure 18. Growth of Hydropsyche placoda as a function of instar.

Figure 19. Life cycle dynamics of Hydropsyche spp.



most obvious among the Hydropsychids. The North Fork (Station 1) is much less productive of net spinning caddisflies than the Middle Fork (Station 2) (Fig. 20). Although the production of *A. grandis* is greater in the Middle Fork than the North Fork (see section on *A. grandis*), the greater production of Hydropsychids is most apparent for *H. cocherelli* and *H. oslari*, where in the North Fork the mean number M^{-2} is less than 60 individuals for both species for all seasons with maximum numbers of 242 *H. cocherelli* and 148 *H. oslari* M^{-2}. In the Middle Fork, however, the fall mean for *H. cocherelli* is greater than 250 with a maximum of 456; and for *H. oslari*, the spring mean greater than 200 with a maximum of 486 individuals M^{-2}. H. placoda is, by comparison, relatively rare.

The Mainstream River (Station 3), which is downstream from the confluence of the South Fork, is very high in *Arctopsyche grandis* production with fall, winter and spring means of 104, 220, and 257 M^{-2} respectively. *Hydropsyche* sp are greatly reduced, however, which is not what would be expected in relationship to the concepts of the river continuum. This may be caused by the autumnal hypolimnion releases from Hungry Horse Reservoir. This situation, however, needs additional clarification prior to making any definitive statement.

3. ECOLOGY OF BRACHYCENTRUS AMERICANUS IN THE UPPER FLATHEAD RIVERS

The caddisfly, *Brachycentrus americanus* is apparently very site selective in microhabitat selection. Although it is ubiquitous throughout the mainstream rivers, *B. americanus* is restricted to locations of moderate to slow current velocities, often at the edge between the lotic erosional and lotic depositional zones. It is very rare in locations of turbulence, preferring locations of smooth, almost laminar, water flow. Because of the highly clumped distributional patterns, parametric statistical analysis

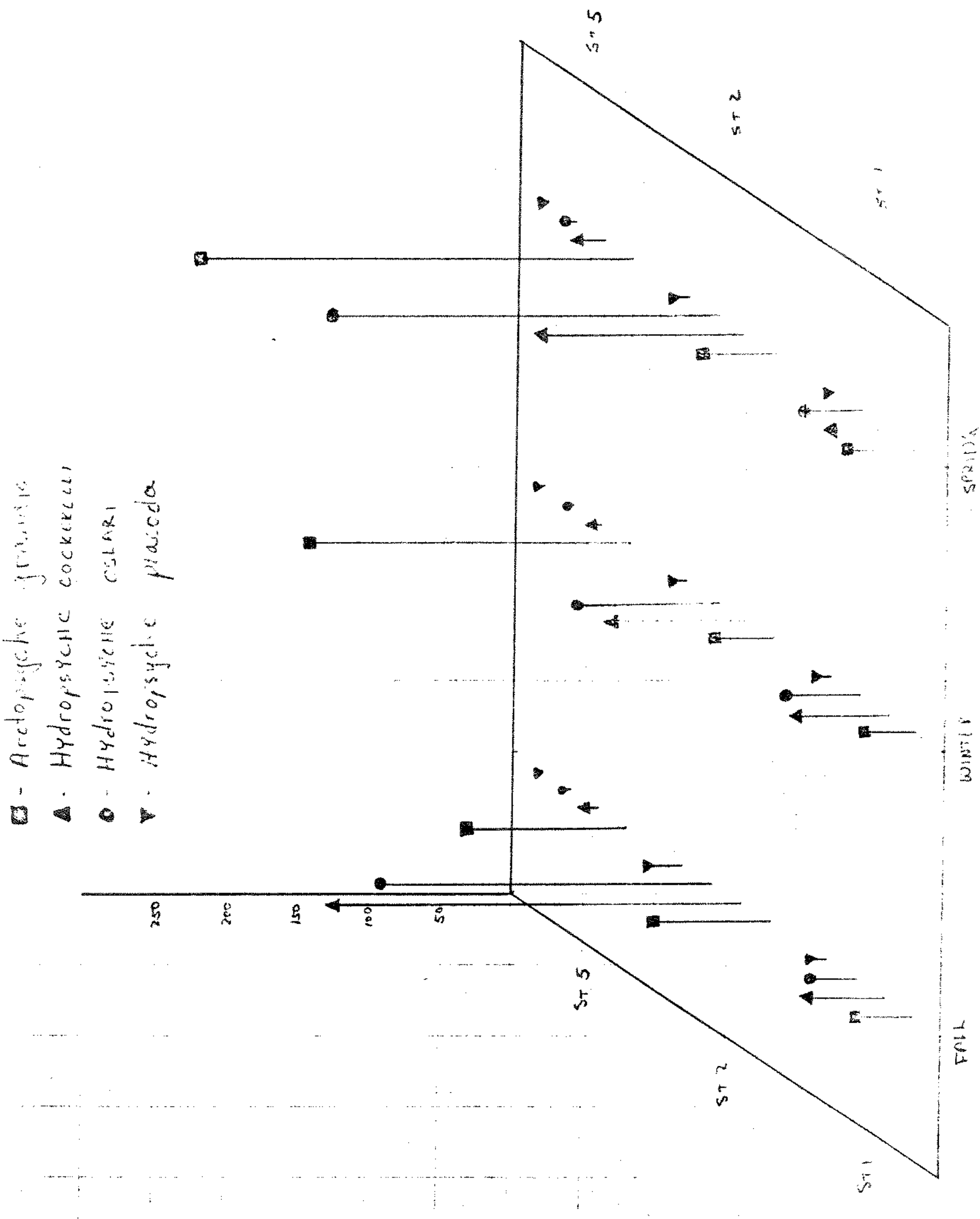


Figure 20. Relative abundance of the Hydropsychidae.

is inappropriate for this species. However, because this species is so widely distributed along the river continuum and has very specific environmental requirements in terms of habitat selections and food gathering, B. americanus will be used extensively in micro and macro habitat and river characterization.

Life History Relationships

Brachycentrus americanus has two cohorts in the Flathead River, with each cohort requiring one year to complete its life history (Fig. 21). There are two adult flight periods, one for each cohort. The first adult flight period is from early June to mid July, and the second is from late July to late September. The consequence of this is better resource utilization and reduced intraspecific competition for the level of production. Growth through instar development is apparently linear (Fig. 22) with no observable differences between cohorts.

4. ECOLOGY OF THE CADDISFLY GENUS, GLOSSOSOMA, IN THE UPPER FLATHEAD RIVER, MONTANA

There are four commonly occurring species of Glossosoma in the Flathead Rivers. One species, Glossosoma alascense, appears to be the most abundant, based upon flight records, adult collections and laboratory rearing. Since to date no morphological distinctions can be made between species during the larval stages, determination of instar growth is a collection of all Glossosoma (Fig. 23). First instar individuals are exceedingly small, with a mean head width of .055 mm. So few of these individuals were collected that it suggests that Glossosoma may not build cases and actively begin the grazing of periphytic growth until the end of their first instar. Fifth instar larvae are also relatively small, with a mean head width for all species of 0.346 mm.

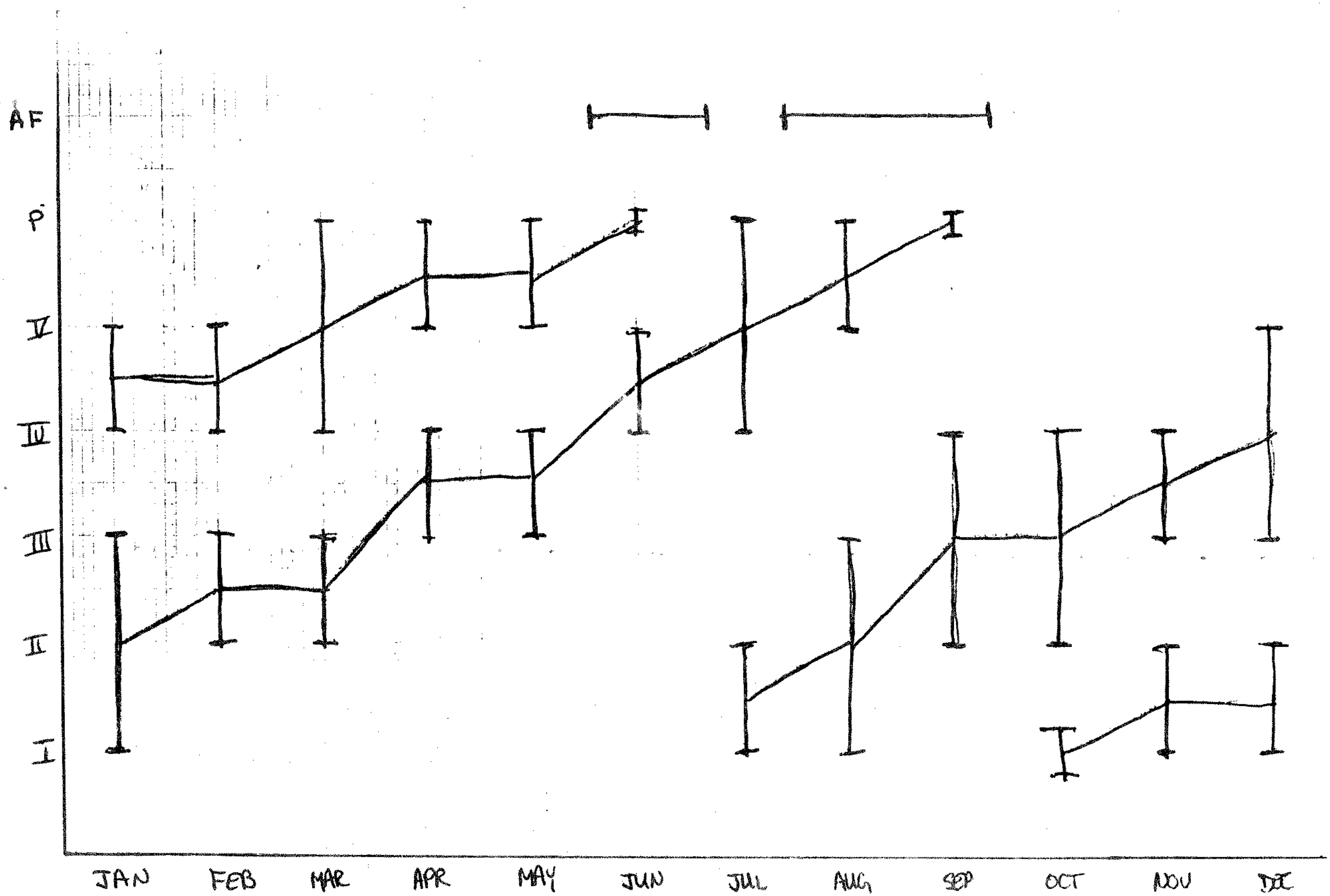


Figure 21. Life cycle dynamics of <u>Brachycentrus americanus</u>.

Figure 22. Growth of Brachycentrus americanus as a function of instar.

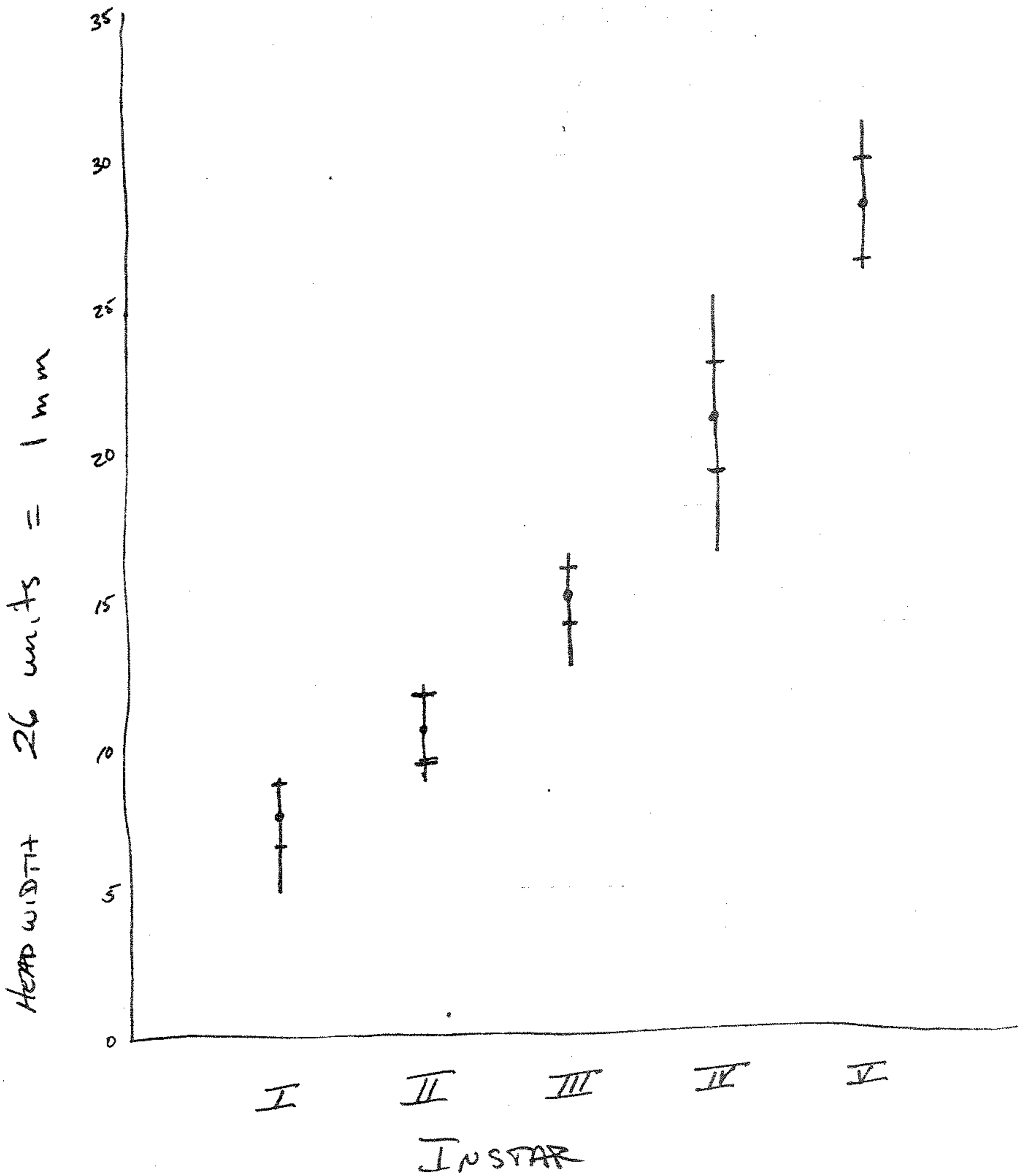
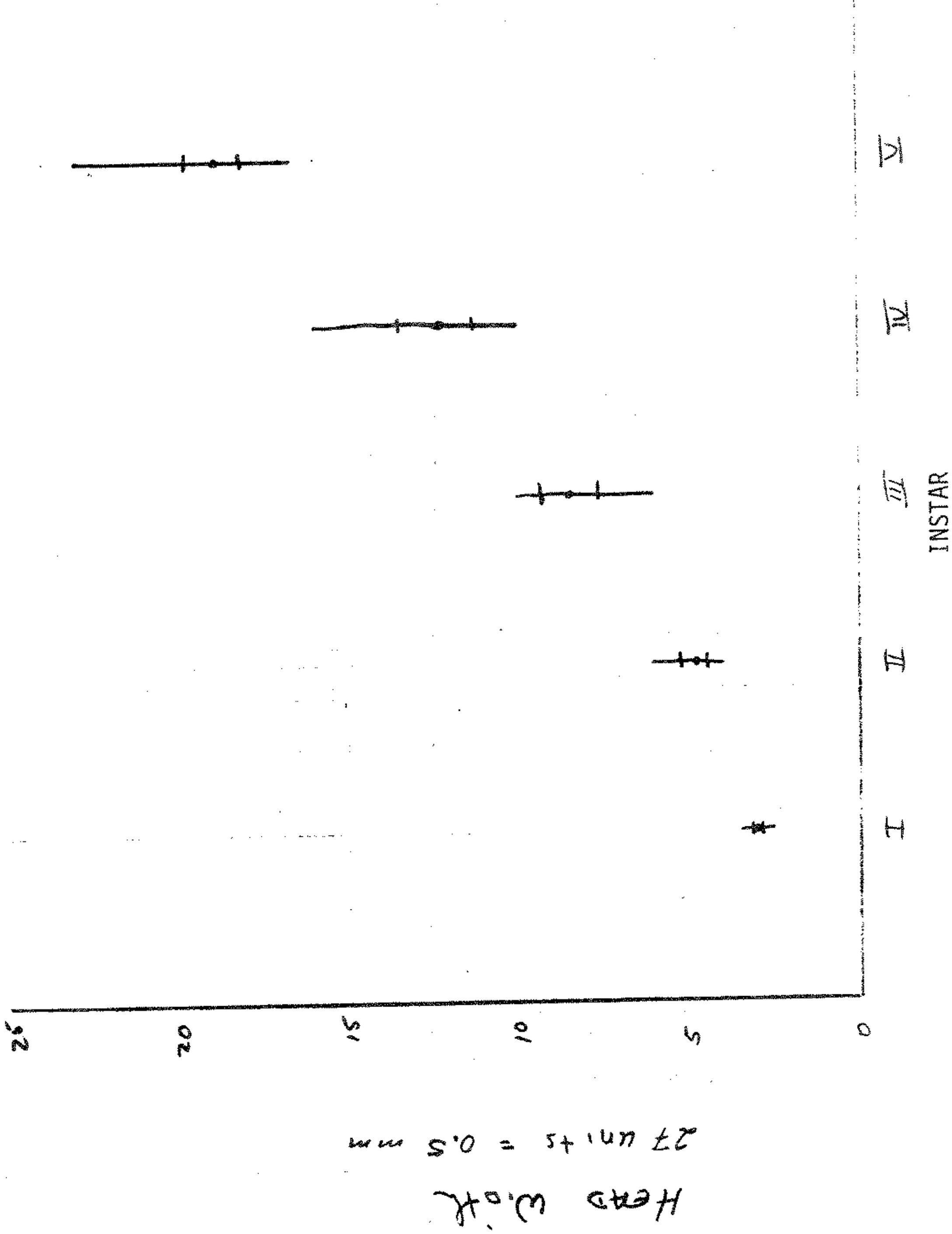


Figure 23. Growth of Glossosoma spp. as a function of instar



An analysis of major growth periods was divided into two categories, those larvae which are believed to be G. alascence based upon adult emergence and laboratory rearing, and the other species of Glossosoma treated collectively (Fig. 24). From these data it is obvious that G. alascence exhibits most of its growth during the fall, overwintering as the 4th and 5th instar larvae, with pupation beginning just after ice out in the early spring. In contrast, the other Glossosoma sp hatch and enter the system later than G. alascence and grow more slowly, thus spreading out their growth over the entire year with much occurring during the spring. Emergence of Glossosoma is very overlapping of all but two of the species, with emergence beginning in early June and continuing through July.

Relative Abundance

Similar to the caddisfly species previously mentioned in this report, Glossosoma sp are restricted in the type of environment in which they are located; consequently, interpretation of abundance data must be made judiciously. Trophic habits of Glossosoma dictate site selections within specific limiting factors. Glossosoma are nearly always observed on the top and sides of large stones where periphytic growth is abundant yet limited to a thin film of diatoms and associated fungi and bacteria. Glossosoma sp were never observed in association with filamentous algae or heavy diatom growth. Glossosoma sp are also restricted to lotic erosional areas. Deposition of clay and organic matter on the tops of rock precluded all Glossosoma.

Since Glossosoma sp are grazers of diatom growth, their abundance is an indication of the level of autotrophy within very specific environmental constraints. It is evident from Fig. 25 that the North and Middle Forks (St. 1 and 2) have a much higher production of Glossosoma in the fall than

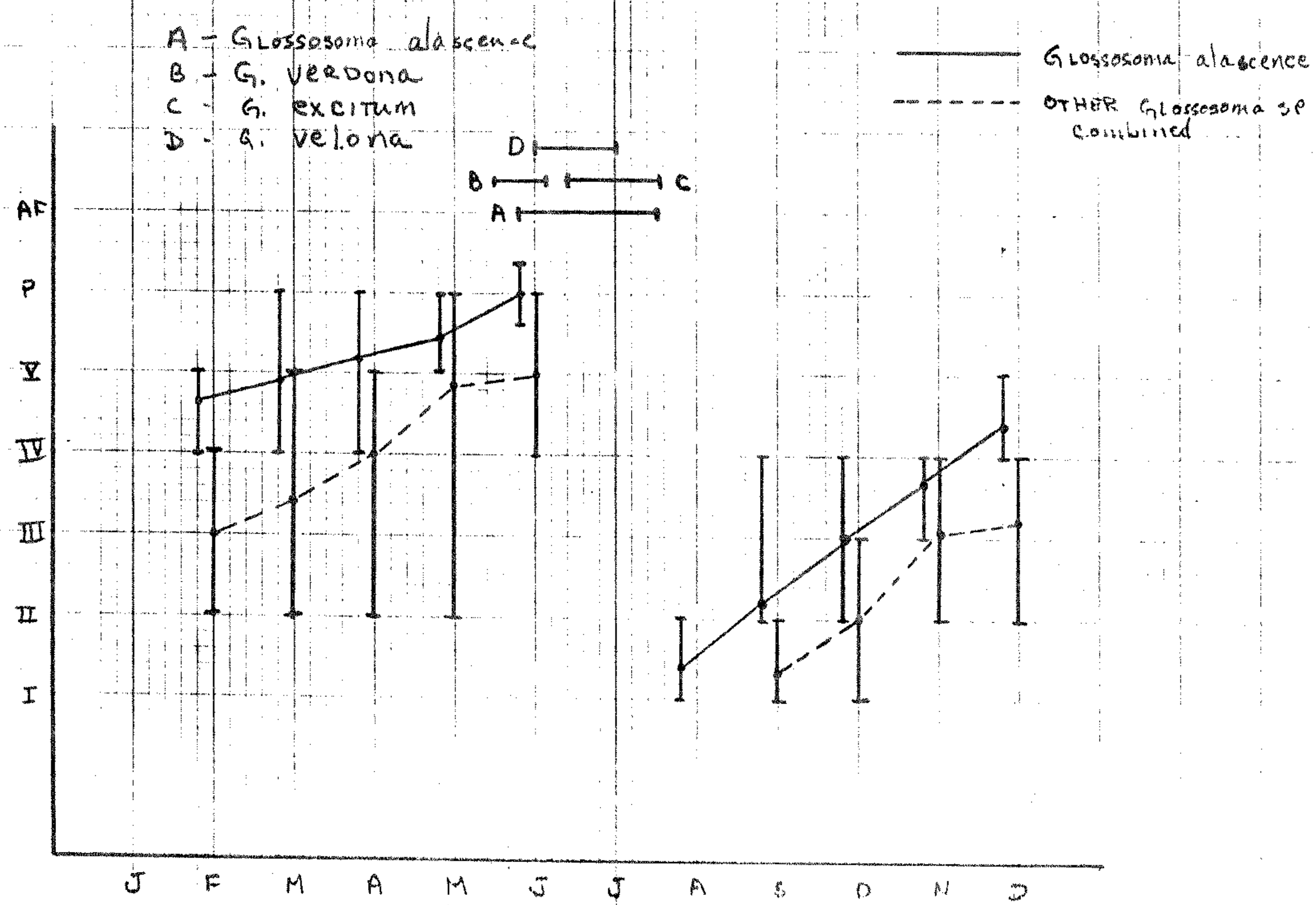


Figure 24. Life cycle dynamics of Glossosoma spp.

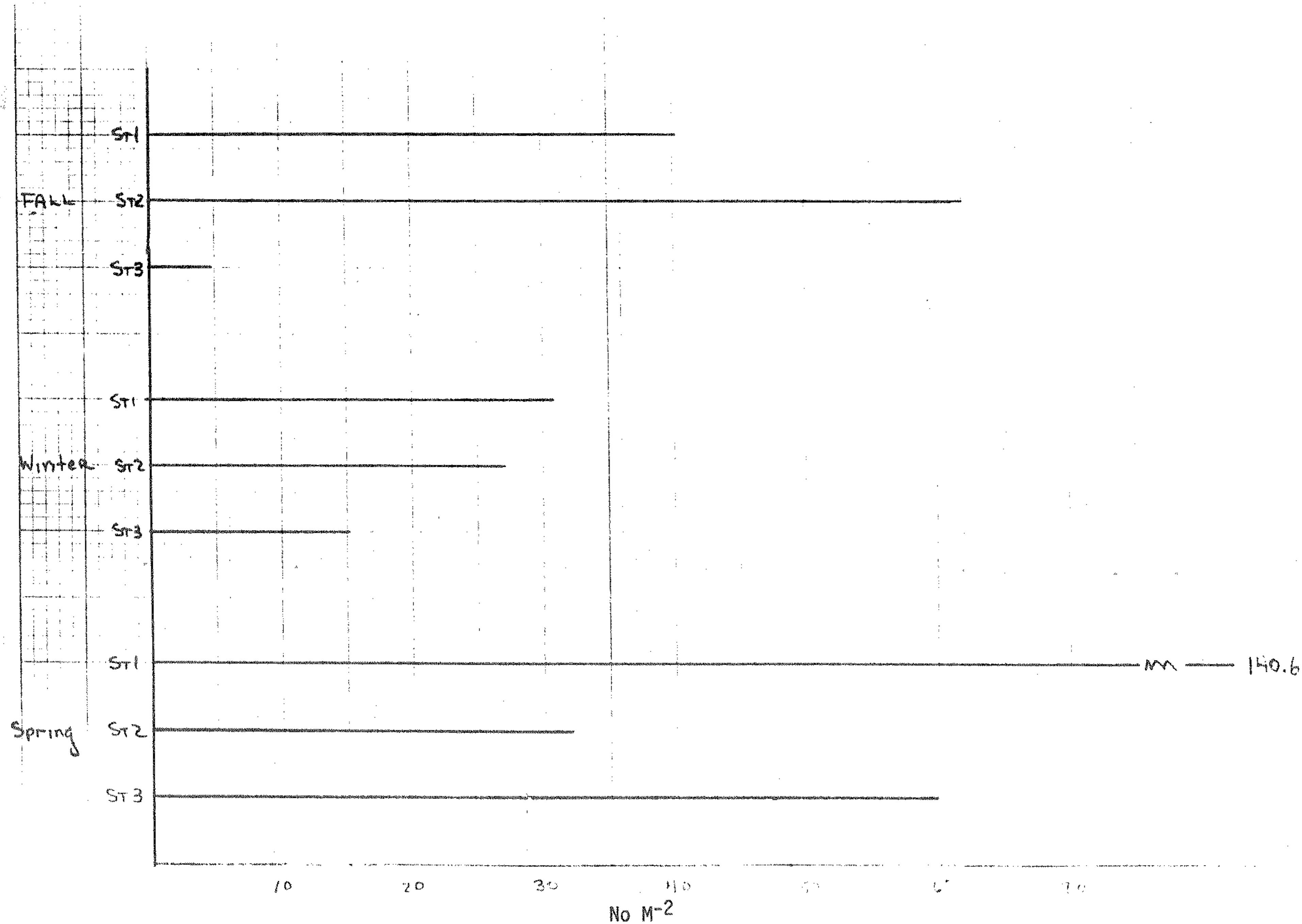


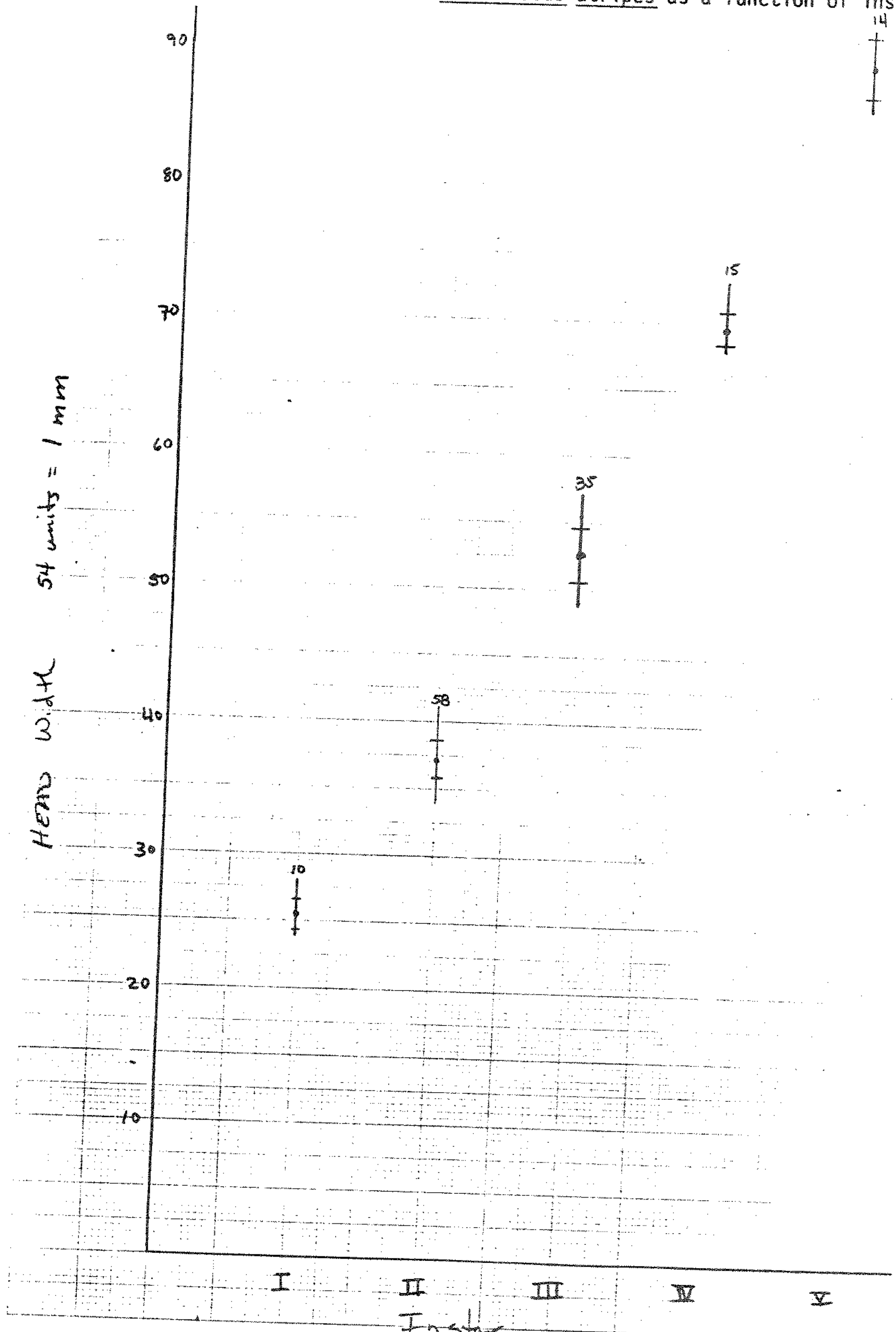
Figure 25. Relative abundance of all *Glossosoma* spp. combined.

the Mainstream (St. 3). During the fall, however, considerable quantities of filamentous algae and diatom growths, which preclude Glossosoma, build up in the Mainstream River below the South Fork. Therefore, autotrophic production which often stimulate Glossosoma production in this situation results in little production. During the spring, a very large production of Glossosoma are observable in the North Fork, presumably because of the resurgence of diatom growth after winter conditions of ice and reduced light. The lack of similar growth in the Middle Fork (St. 2) may be due to less autotrophic production caused by the periodic increase in turbidity that is very common in the Middle Fork in the spring.

5. ECOLOGY OF DICOSMOECUS ATRIPES IN THE UPPER FLATHEAD RIVERS

In the Flathead Rivers Dicosmoecus atripes has a two-year life cycle. First instar larvae are first observed in early spring with the loss of ice cover and anchor ice and warming of the river a few tenths of a degree above 0°C. Early instar larvae construct cases out of pine needles and fine particle detritus. As the larvae increase in size, case construction changes to stone materials so that in intermediate instar cases the front is stone and the posterior needles. By the final instar, cases are entirely constructed of stones. Growth from instar to instar is linear, closely following Dyar's law of predicted insect growth (Fig. 26). During the runoff period Dicosmoecus atripes larvae concentrate in back water and pool areas. As high runoff waters recede, larvae are no longer restricted to pool areas and can also be found in main current areas where currents are not turbulent; yet the area is lotic, erosional with little or no accumulation of sediments. Late in the fall, first year larvae have reached 4th and 5th instars and overwinter in the main river channel in diapause (Fig. 27) by attaching the opening to the underside of a large

Figure 26. Growth of Dicosmoecus atripes as a function of instar.



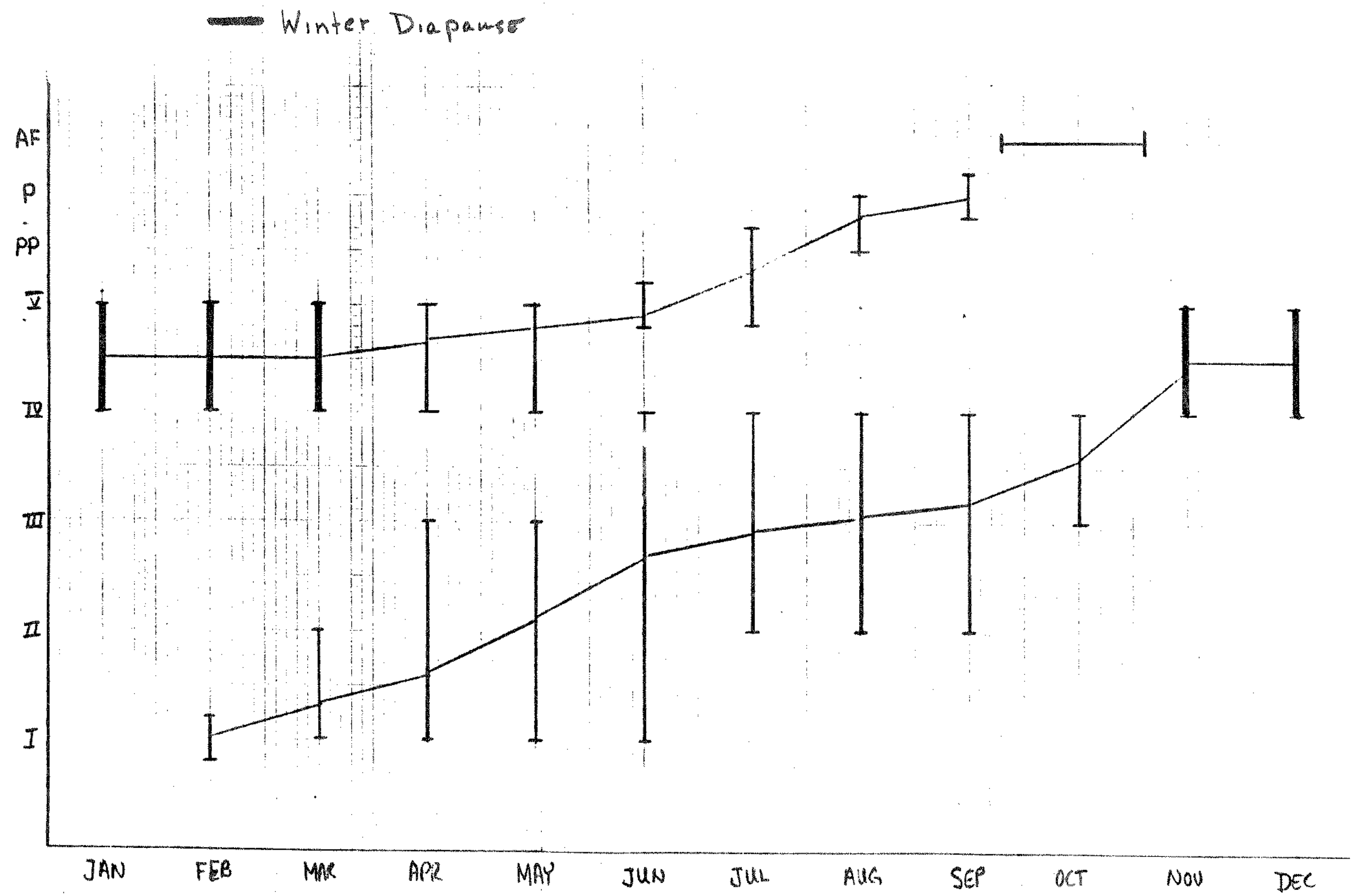


Figure 27. Life cycle dynamics of *Dicosmoecus atripes*.

stone resting on other stones, thus providing considerable interstitial space. The selectivity of current is such that diapausing larvae are found in areas of even flow with no turbulence, most commonly above riffle areas or well downstream from ripple turbulence. Larvae cease diapause in mid spring when temperatures have reached approximately 2°C, by disengaging case from rock. Frequently several larvae will congregate and attach their cases for overwintering under the same rock. Activity of 4th and 5th instar larvae resumes just prior to the beginning of runoff; therefore, most activity takes place in the back water area in the same areas as the 1st and 2nd instar larvae. In mid summer, 2nd year larvae that complete growth attach their case once again to the underside of rocks in a similar fashion and choice of location as for winter diapause. Larvae may then remain in a prepupae condition for several weeks prior to pupation. The length of time for the prepupal conditions appears to be a function of how soon 5th instar larvae cease activity. Pupation begins in mid to late August for all individuals that will be emerging that fall. Emergence begins in early to mid-September and continues until early November. Peak activity is in the late afternoon after a warm fall day when individuals can be observed emerging off the water surface and flying to stream-side vegetation. Dicosmoecus atripes is the largest of the Flathead River caddisflies and is readily identified even in flight because of its size and very dark black veined wings. Females have been observed ovipositing on the surface of slow reaches of the river usually making a hopping or skipping motion.

RIVERINE PHYSICOCHEMISTRY

All chemical data collected on the rivers is tabulated in Section IX below. However, some discussion of trends in certain parameters may be especially informative here.

Intensive study of total suspended solids (TSS) and particulate organic carbon (POC) dynamics have revealed that in the river ecosystem TSS and POC are very closely correlated. During the fall, winter and spring months prior to runoff, TSS average between 0.9 and 2.0 mg/l and POC between .05 and .2 mg/l. In late January and early February there was an increase in the level of POC without a corresponding increase in TSS. Since this occurred just at ice-out, the measured increase in POC at both Stations 1 (North Fork) and 2 (Middle Fork) may be related to possible release of particulate carbon trapped in or on river ice. Spring runoff peaked in early June with a corresponding peak in both TSS and POC at all stations (Fig. 28, 29, 30). After the peak runoff the North Fork cleared more rapidly than the Middle Fork and, consequently, the Mainstream River. During fall, the Middle Fork exhibited periodic increases in turbidity, which was associated with precipitation and subsequent bank erosion. The higher POC levels observed at Station 5 are most likely a function of discharge from Hungry Horse Dam, causing a sloughing of periphytic growths.

The inter-relationships of total phosphorus (Fig. 31), total kjeldahl nitrogen and nitrate nitrogen (Fig. 32) are not as definite. Nitrogen concentrations fell or remained the same at most locations on June 6, the date of maximum runoff, except at the mainstream (Presentine) station where TKN increased from .04 mg/l in May to .10 mg/l. Phosphorus appears to be more closely correlated with the runoff cycle. It appears that phosphorus concentration peaks approximately 3 to 5 weeks after the peak runoff. Exceptions to this were at Middle Fork West Glacier where total phosphorus concentrations were greatest in April and in the South Fork where concentrations were greatest in the fall and early winter. It may be

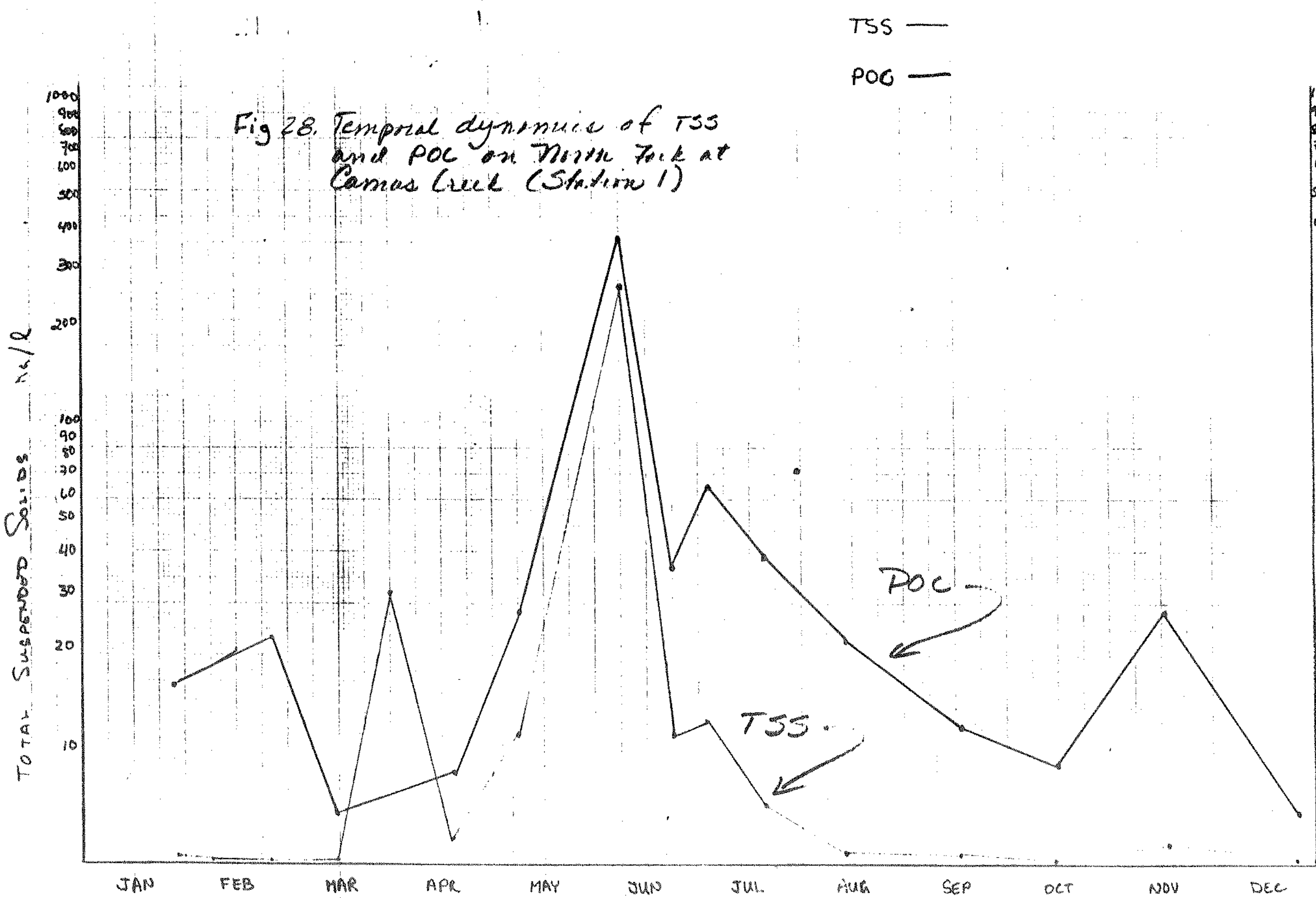
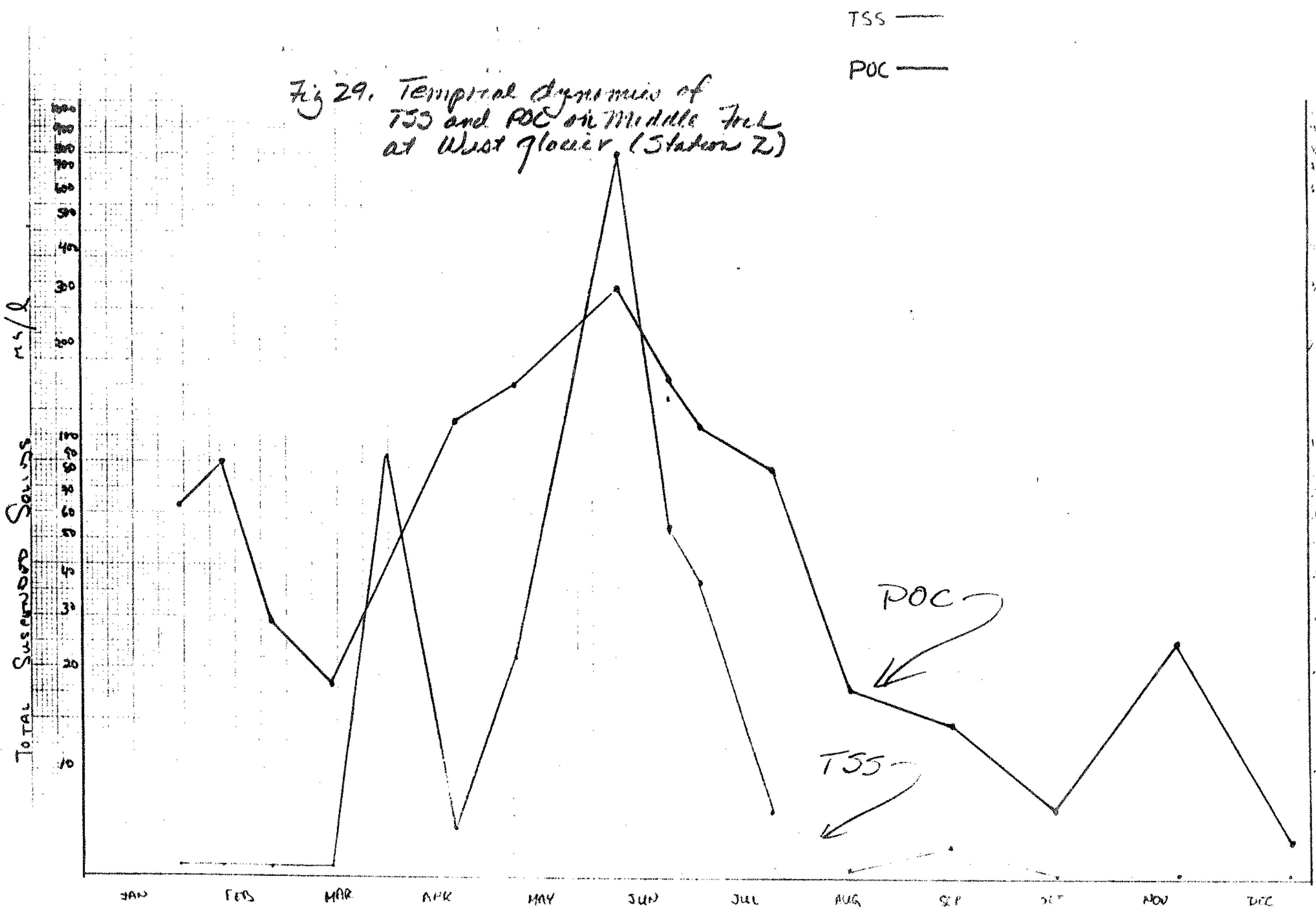


Fig 28. Temporal dynamics of TSS and POC on North Fork at Camas Creek (Station 1)

Fig 29. Temporal dynamics of TSS and POC in Middle Fork at West Glacier (Station 2)



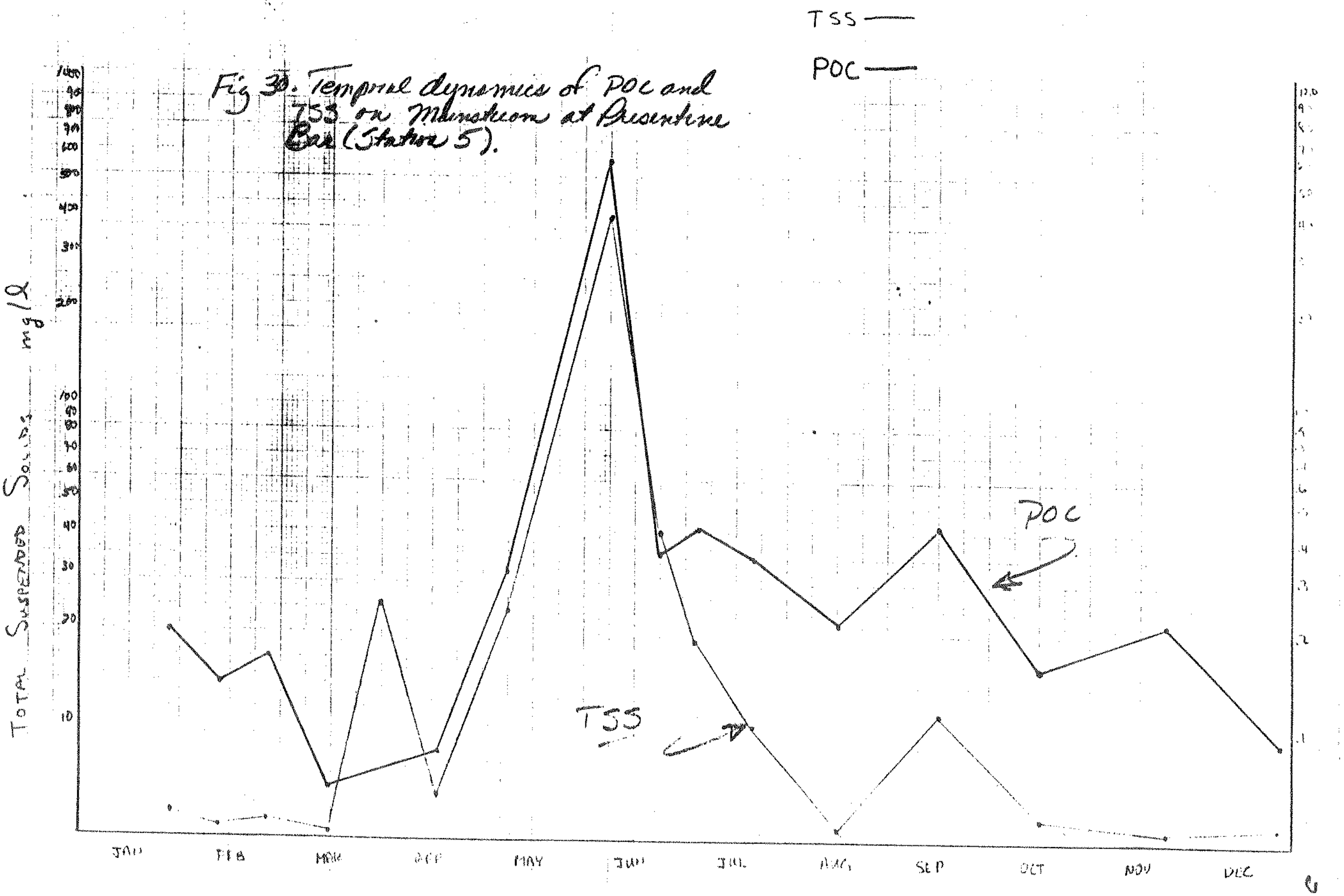


Fig 30. Temporal dynamics of POC and TSS on Menshkeom at Presentine Bar (Station 5).

Fig 31

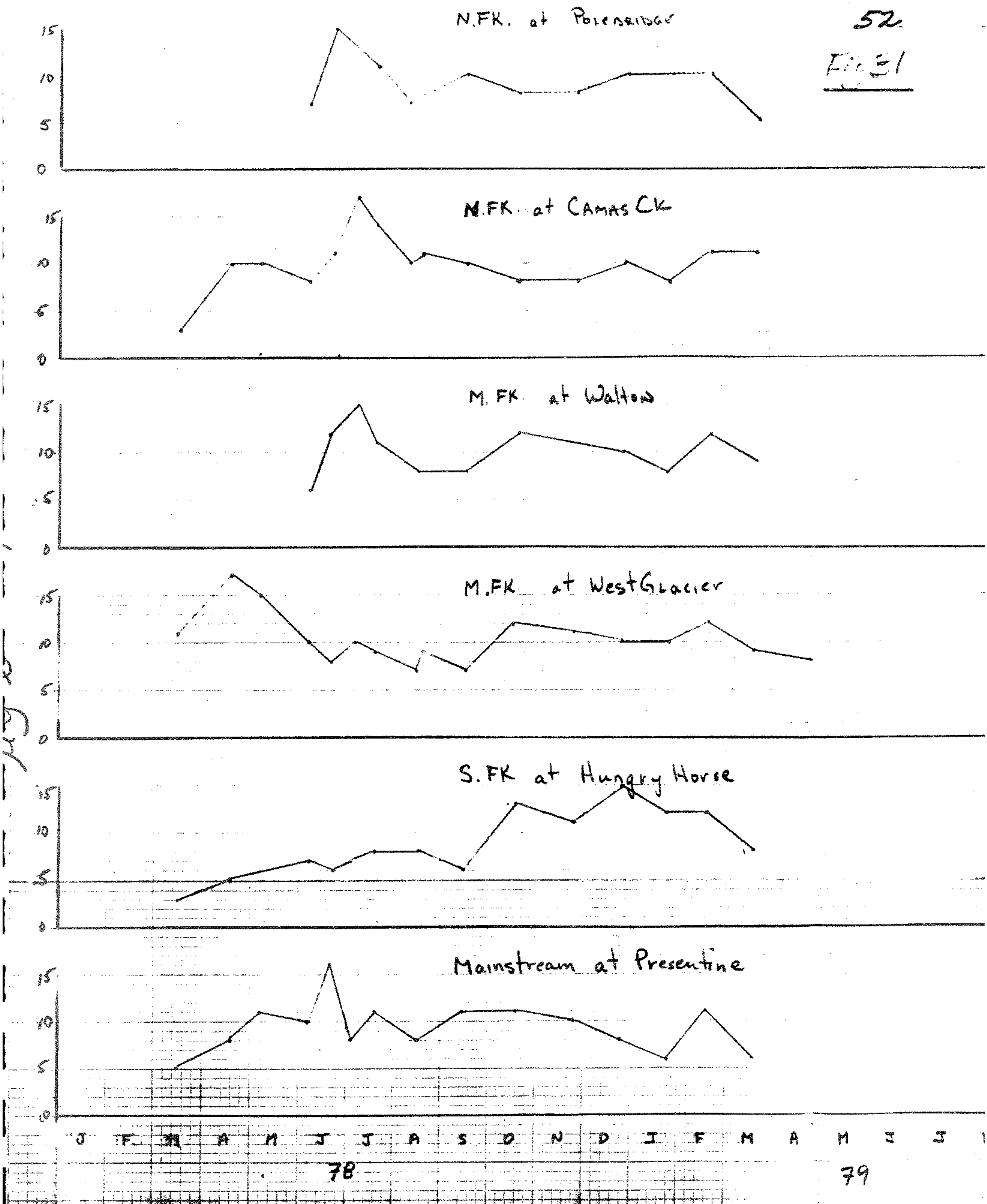
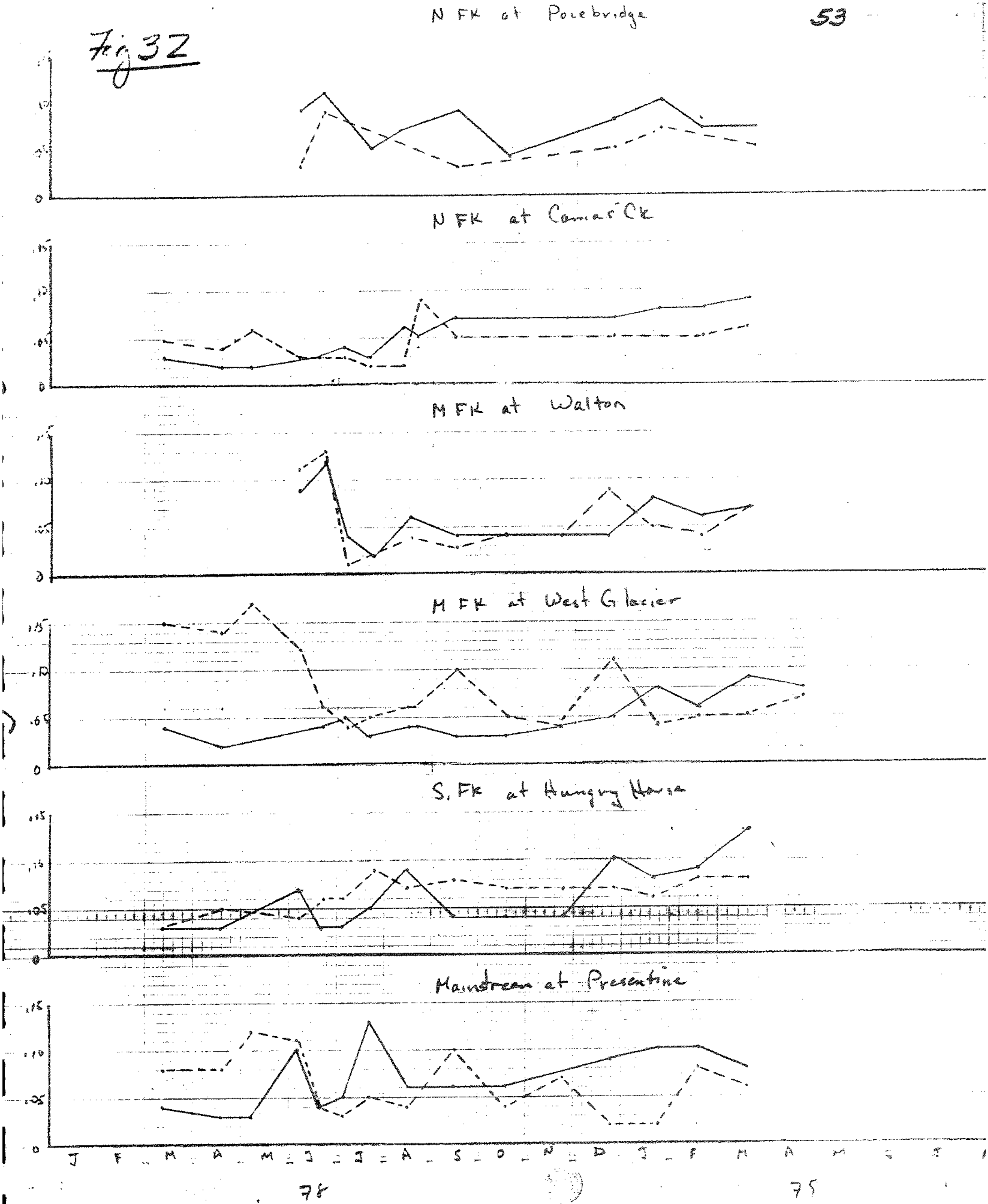

N.FK. at Polebridge
N.FK. at Camas Ck
M. FK. at Walton
M.FK. at West Glacier
S.FK at Hungry Horse
Mainstream at Presentine
0
5
10
15
J F M A M J J A S O N D J F M A M J J
78
79

Fig 32


N FK at Polebridge
N FK at Camas Ck
M FK at Walton
M FK at West Glacier
S. FK at Hungry Horse
Mainstream at Presentine
.15
.10
.05
0
J F M A M J J A S O N D J F M A M J J
74
75

that some inherent change occurs in the Middle Fork between Walton and West Glacier. This change may be due to a man-caused effect, such as erosion from Highway 2 or Burlington Northern Railroad road berns, or it may be a natural event since there are many exposed erosional banks in the canyon areas along the Middle Fork. In the South Fork below the dam the increased TP concentrations correlate with two events: a) increased discharging in the fall from Hungry Horse Reservoir and b) probable decline and precipitation of phytoplankton communities in the reservoir. These observations may explain TP dynamics observed at Station 5 (Presentine Bar).

Additional analyses of physicochemical dynamics in the rivers are forthcoming, especially as they relate to insect ecology.

RIVER SYNOPTICS

Time series data gathered in the routine sampling program (e.g., monthly) facilitate analysis of long-term trends. However, short-term (e.g., hourly or diurnal) events signal longer term trends and may be of valuable use for comparing ecological responses between sampling sites. We therefore initiated short-term (usually one-two day) sampling programs at specific sites within the study area. Many parameters are monitored diurnally. These short-term, but continuous, and intense sampling efforts are termed synoptics.

In the rivers our objective in synoptic studies is to thoroughly document microdistributional patterns per species and correlate these with observed diurnal dynamics in physicochemical parameters. Such data cannot be feasibly generated on a long-term basis.

Our first river synoptic was conducted in October, 1978, on the North Fork at Camus Creek. Diurnal changes in temperature, pH, conductivity, seston drift of organic carbon, and biomass estimates using ATP analysis were all conducted over 24-hour periods, measuring all parameters both above and below the riffle under investigation. Upon completion of this diurnal work, nine transects were established across the riffle. A total of 43 samples were taken along these transects. Each sample location was measured for water depth and current velocity.

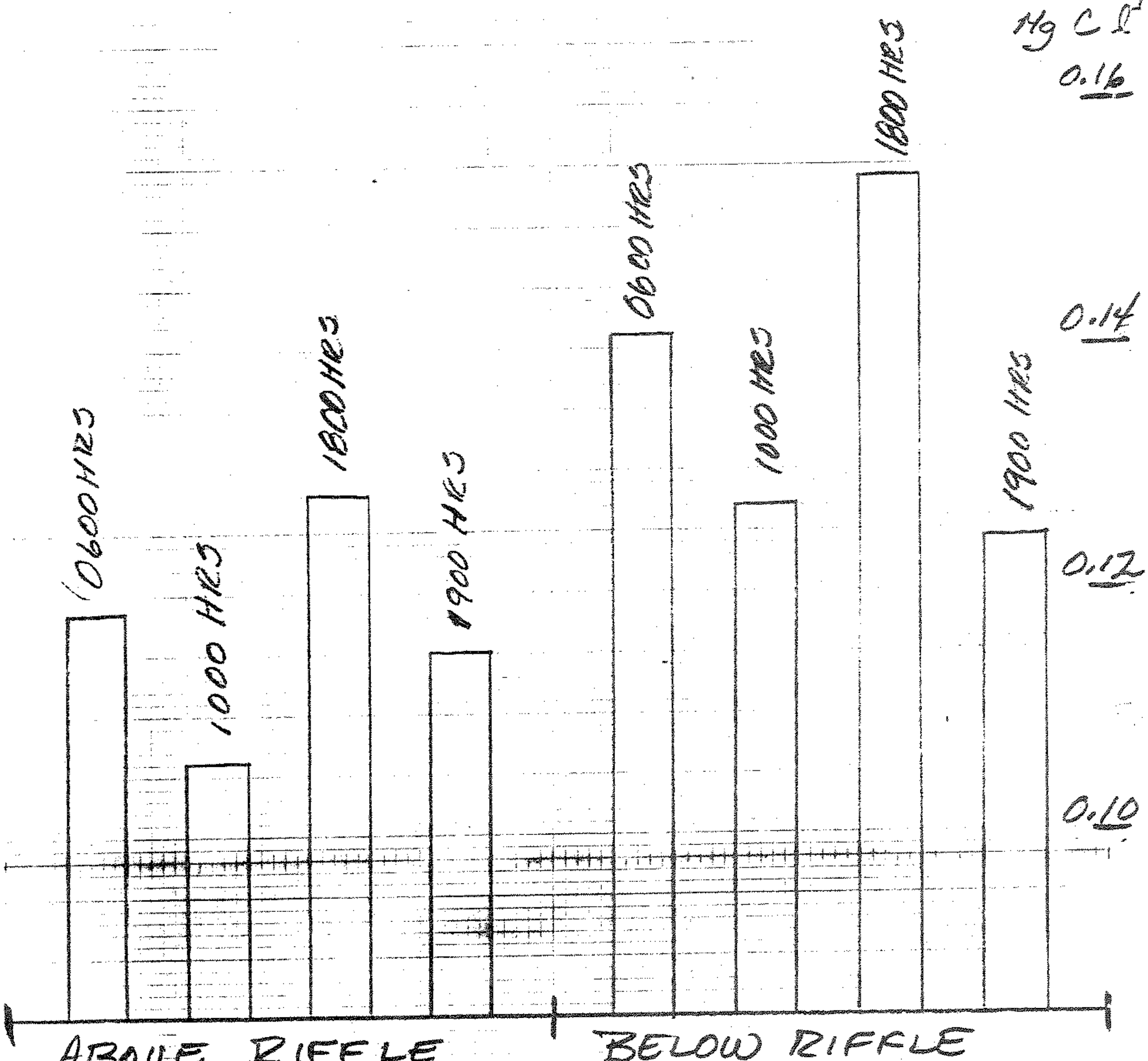
The results from this effort are still undergoing analysis; however, preliminary results of microdistribution patterns of benthic aquatic insects indicate that the tremendous heterogeneity of the river habitat results in a corresponding high variance in abundance estimates. For many of the aquatic insect species microdistribution and habitat requirements are highly tuned, due largely to resource partitioning at the trophic and spatial level. The results from the seston particulate organic carbon data (Fig. 33) reveal that distinct diurnal patterns in this parameter may be of great interest. The results show that in all cases there is a net movement of POC off of the riffle when comparing the locations above and below taken at the same time. Also movement of POC is greatest just before sunrise and just at dusk, in comparison to well after sunrise when the sun is well overhead and several hours after dark.

All of the data from the synoptic will be completed, analyzed and ready for publication by the end of 1979. An additional synoptic was conducted in Spring, 1979, at the same locality, but data are presently incompletely assembled. Synoptics are planned on the Middle Fork and Mainstream for Fall, 1979.

TIME FRAME AND RESEARCH PLAN

Routine field sampling remains ahead of schedule. We rescheduled additional synoptics until Fall, 1979, due to the massive amount of lab time required to work up the samples in addition to our regular sample load.

Fig 33. POC levels measured before and after sunrise and sunset on the Camas Riffle (Station 1) in Oct. 1978.



Laboratory analyses of field water samples for chemical parameters has also fallen behind schedule, due to installation delays on our new ion chromatography system. We expect this backlog to dissipate rapidly, however, when this instrument is on line. All samples have been stored frozen at UMBS.

Nearly all of the benthic samples taken to date have been sorted to order. All of the work with the caddisflies (Trichoptera) is complete and we are rapidly finishing needed work with the Ephemeroptera, Plecoptera and Diptera. This work is about 6 months ahead of schedule as given in the time frame in Progress Report No. 1 (1/I/79).

The river research will now move into the experimental phase as proposed. We will concentrate efforts heavily in the coming year on laboratory rearing of marker species in experimental thermal and food regima to verify field-derived conclusions. We will also begin measurement of autotrophic productivity and community metabolism in the field using plexiglas environmental chambers in situ (following recommendations of Bott et al., 1978: Hydrobiol. 60: 3-12.) These data will be coupled with results from on-going physicochemical monitoring, experimental rearing and delineation of life histories to permit statistical prediction of ecosystem functional processes. This will provide the basic framework for delineating any future environmental degradation (i.e., via modeling studies) and permit falsification or acceptance of our working hypotheses.

IV. LIMNOLOGY OF FLATHEAD LAKE

INTRODUCTION

Flathead Lake research 1973 - 74 by Dr. J. A. Stanford (Tibbs, Gaufin and Stanford, 1975) produced three basic hypotheses about key ecological phenomena which were related to annual influx of turbid water during spring runoff. The results of the 1973 - 74 study indicated that primary productivity was reduced and/or slowed after the culmination of turbid inflow. It further suggested that primary productivity was reduced and/or slowed, because the sedimenting clay turbidity stripped phosphorus from the water column and carried it permanently to the lake bottom. Qualitative observations during the 1974 runoff season led the observers to believe that sedimenting aggregates of clay and organic detritus are colonized by microbial organisms, and that they grow because of heterotrophic biomass increase and/or adsorption or agglomeration of organic detritus, serving in the process as major sources of energy rich food for higher trophic levels such as zooplankton.

Our lake research effort to date has been gathering data which was oriented toward documenting the preceding hypotheses. Field sampling began in Fall 1977 at four intensively studied stations where limnologically important physical, chemical and biological samples were gathered (Table 1). Three of these stations, the two river tributaries and the lake outflow, have been yielding information about basic budgetary aspects of water and nutrient recruitments and losses from the lake. The fourth station, in the deep, central pelagic area, has been extensively sampled to yield information on the lake's planktonic biomass and productivity

Table 1. Sampling Parameters for Flathead Lake Research

Physical	Biological
Secchi depth	^{14}C Primary Productivity m^{-2} and m^{-3}
Light Transmission	Biomass (ATP)
Temperature	Phytoplankton
Flow Data	Zooplankton
Depth	TSS - Percent Organic Carbon
Incident Radiation	TSS - Percent Biomass
	POC - Percent Biomass

Chemical

pH	Conductivity	D. O_2	Redox
TSS	Inorganic C	Alkalinity	SiO_2
SO_4	P-total	TKN	$NO_3^{=}$-N
TOC	DOC	POC	Ca
Mg	Na	K	Co
Cu	Fe	Mo	Mn
Zn			

and how it responds to seasonal fluctuations of certain physical and chemical entities. Less intensive sampling for predominantly chemical parameters occurred at Midlake North (M.L. No.), Midlake South (M.L. So.), Big Arm Bay and Yellow Bay.

Use of a submarine transmissometer, secchi disc and aerial surveying helped to follow and map turbidity plume development and ice cover.

Synoptic (whole lake, synchronous) productivity studies have begun (August, 1979)and will be continued in an effort to study plankton productivity in different areas of the lake. These studies will help us understand how areas of the lake differ in productivity and how this relates to human shoreline development.

A preliminary analysis of some of the processed data has been performed for the sampling period September 1977 to March 1979. At the Midlake station this analysis has been confined to investigation of generalized trends and water column means for parameters examined. No qualitative nor quantitative analyses of preserved phytoplankton nor zooplankton have been performed to date although the samples have been collected. Results reported in the next section address the working hypothesis, but we make no attempt in this preliminary report to finalize interpretation of data gathered to date. Statistical analyses which may illucidate unobserved relationships are not yet complete.

RESULTS

MIDLAKE PELAGIC STATION TRENDS

Primary productivity (mg C $m^{-2}hr^{-1}$) was fairly low after the Fall, 1977, overturn-mixing period and remained low during the mid-Winter period when trophogenic zone water temperatures were 2-3^{O}C and the water column was inversely stratified (Figure 34). During this period of time, the Total P concentrations in the trophogenic zone were 6 ug/l (Table 2), the TSS values of the trophogenic zone were relatively low (.86 mg/l; Table 3); the Organic C (both POC and DOC) of the trophogenic zone decreased to minimal values (Figures 35, 36 and 37); the absolute amount of ATP/liter was relatively low (Figure 38); and the percentage of the living suspended particulates was relatively low (Figure 39).

By mid-April the water column had destratified and was rapidly warming to 4^{O}C+ in the shallow layers. The high productivity in Spring 1978 (Figure 34) was probably the result of a vernal plankton bloom occurring in the pelagic regions. Correspondingly lower dissolved Si concentrations (Table 4 and Figure 40) and much greater TSS concentrations (Table 3 and Figure 41) were measured in the trophogenic zone during this period. Large increases in Total [P] concentration (Figure 42) and ATP concentration (Figure 38) occurred coincidentally with this Spring productivity peak. Calculations also yielded information that suggested large increases occurred in the percentage of living POC (Figure 43) and in the percentage of living TSS (Figure 39). Although not yet confirmed by visual, qualitative analysis of the particulate material, it appears that the mixing, warming and fertilizing of the trophogenic zone coincided with a large bloom of diatom biomass in Spring 1978. Previous studies of Flathead Lake

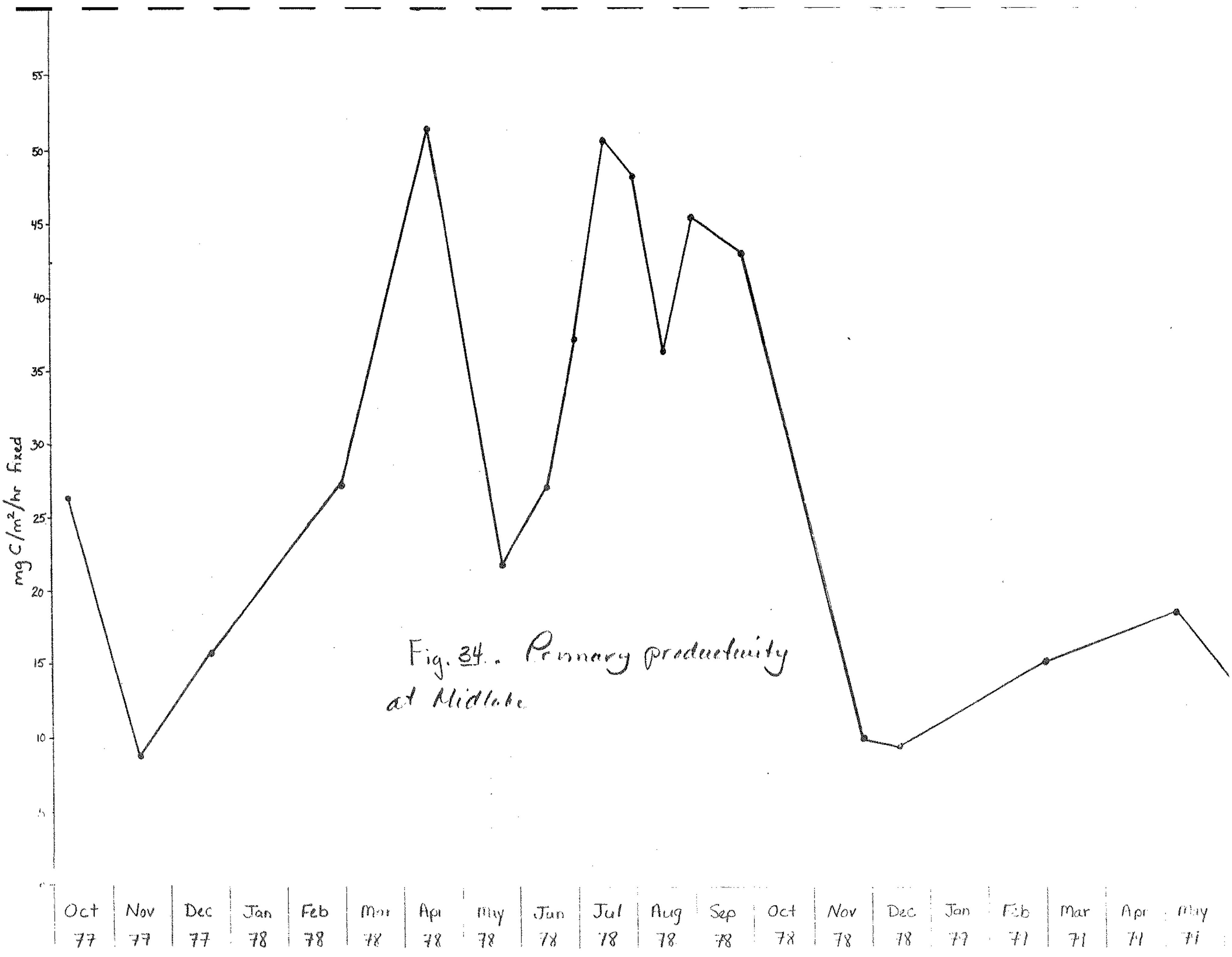


Fig. 34. Primary productivity at Midlake

Date	1m	5m	10m	15m	20m	25m	30m	40m	50m	60m	70m	80m	90m	$\bar{X}$	Upper 40m	Lower 40
20/XII/77	4.1	—	4	—	4.8	—	4.4	4.1	3.9	5.1	5.4	5.7	4.3	4.58	[illegible]	4.3
25/I/78	5.3	—	4.3	—	5.1	—	4.6	5.7	4.9	6.0	6.5	4.3	8.2	5.49	[illegible]	5.
1/III/78	3	—	5	—	3	—	7	7	7	5	5	5	5	5.2	5.0	5.
15/III/78	5	—	5	—	7	—	7	5	5	5	7	7	7	5.9	5.8	5.
18/IV/78	7	—	10	—	6	—	10	10	12	7	12	11	10	9.5	8.6	10.
24/V/78	8	—	8	—	5	—	7	8	9	8	7	6	9	7.5	7.2	7.8
5/VI/78	8	—	11	—	8	—	8	12	8	8	10	8	8	8.9	9.4	8.4
30/VI/78	9	12	11.5	9	9	—	14	8	12	9	8	8.5	8	9.8	10.4	9.
15/VII/78	8.5	5	7	11	15	—	8	8	15.5	7	6	6	11	9	8.9	9.
30/VII/78	7	8	20	16	16	12	12	13	15	21	16	13	14	14	13.0	15.
15/VIII/78	8	9	11.5	10	10	7	8	10	7	10	12	11	12	9.7	9.2	10.
30/VIII/78	7	4	7	6	6	6	4	5	7	4	6	7	4	5.6	5.6	5.
30/IX/78	13	8	7	7	7	10	[illegible]	8	12	13	9	10	17	10	8.6	12.
30/X/78	7	7.5	10	11	11	11	9.5	8	9	7	9	8	8	8.9	9.4	6.
30/XI/78	10	9	8	9	8	7	8	8	9	8	5	8	7	8	8.4	7.
18/XII/78	10	13	9	10	8	8	9	8	9	10	15	22	39	10.9	9.4	14.
28/II/79	13	8	8	9	6	11	8	7	8	10	9	—	—	8.8	8.75	9.
31/III/79	10	7	8	8.5	9	7	9	8	10.5	6	6	9	10	8.3	8.3	7.
														$\bar{x}$ = 8.34	$\bar{x}$ = 8.67	$\bar{x}$ = 8.76

Table 3. TSS (mg/l)

Date	1m	5m	10m	15m	20m	25m	30m	40m	50m	60m	70m	80m	90m	Upper 40m	Lower 50m	$\bar{x}$ for total H_2O Column
23/IX/77	1.2	—	1.2	—	1.8	—	1.6	1.4	.8	.8	—	1.0	—	1.44	.87	1.23
7/X/77	—	.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5/XI/77	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17/XI/77	.8	—	.6	—	.8	—	.8	.8	1.6	1.6	.80	1.8	1.3	.76	1.42	1.09
20/XII/77	.7	—	1.0	—	.8	—	.8	1.0	.8	.9	.80	1.2	.60	.86	.86	.86
25/I/78	.6	—	.7	—	.7	—	.8	.7	.6	.8	.90	.90	.90	.70	.82	.76
15/II/78	.35	—	.3	—	.55	—	.4	.45	.45	.2	.40	.40	.25	.41	.34	.38
1/III/78	.68	—	1.05	—	.88	—	.58	.6	.35	.43	.13	.40	.35	.76	.33	.55
15/III/78	.68	—	.6	—	.45	—	.5	.63	.55	.6	.60	.48	.60	.57	.57	.57
[illegible]/IV/78	1.9	—	1.9	—	1.9	—	1.8	1.4	1.2	1.2	1.30	1.0	.90	1.78	1.12	1.45
24/V/78	.9	—	.75	—	1.2	—	1.2	.88	.8	.8	.82	~~1.45~~	~~1.40~~	.99	.83	.91
15/VI/78	1.37	2.25	1.8	1.65	1.13	—	1.0	.64	.83	1.13	.85	.85	~~1.35~~	1.41	.91	1.16
30/VI/78	1.0	1.0	1.23	.8	.95	—	.85	.75	1.0	.98	1.05	1.1	1.18	.94	1.06	.99
15/VII/78	.5	.88	1.38	1.15	1.0	—	.83	.78	.85	.58	.73	.6	.73	.93	.70	.83
30/VII/78	.68	.6	.23	.55	1.0	.48	.68	.6	.6	.78	.75	.65	~~1.38~~	.60	.70	.65
15/VIII/78	.6	.53	.36	.86	.7	.5	.65	.45	.6	.58	.63	.85	.71	.58	.67	.62
30/VIII/78	—	.23	.17	.10	.2	.45	.15	.08	.23	.15	.23	.10	.18	.20	.18	.19
30/IX/78	.95	.83	.78	1.20	.58	.3	.53	.2	.23	.10	.78	~~2.78~~	~~5.61~~	.67	.37	.52
30/X/78	.55	.53	.31	.3	.28	.33	.2	.2	.15	.20	.23	.2	.45	.34	.25	.30
30/XI/78	.58	.63	.6	.48	.55	.43	.48	.48	.43	.68	.58	.58	.7	.53	.59	.55
18/XII/78	.55	.5	.4	.5	.6	.43	.65	.88	.88	.825	.80	.73	.68	.56	.78	.65
28/II/79	.225	.28	.23	.15	.18	.25	.25	.23	.25	.25	—	—	—	.22	.25	.23
31/III/79	—	—	—	—	—	—	—	—	—	—	—	—	—			
9/V/79	.38	.38	.23	.5	.33	.58	.48	.53	.53	.4	.30	.30	~~.83~~	.43	.38	.41
2/VI/79	2.18	1.15	1.78	1.63	1.3	.98	1.85	.85	.98	1.0	.63	1.20	1.1	1.46	.98	1.28
27/VI/79																
12/VII/79																
														$\bar{x}$=.78	$\bar{x}$=.68	$\bar{x}$=.74

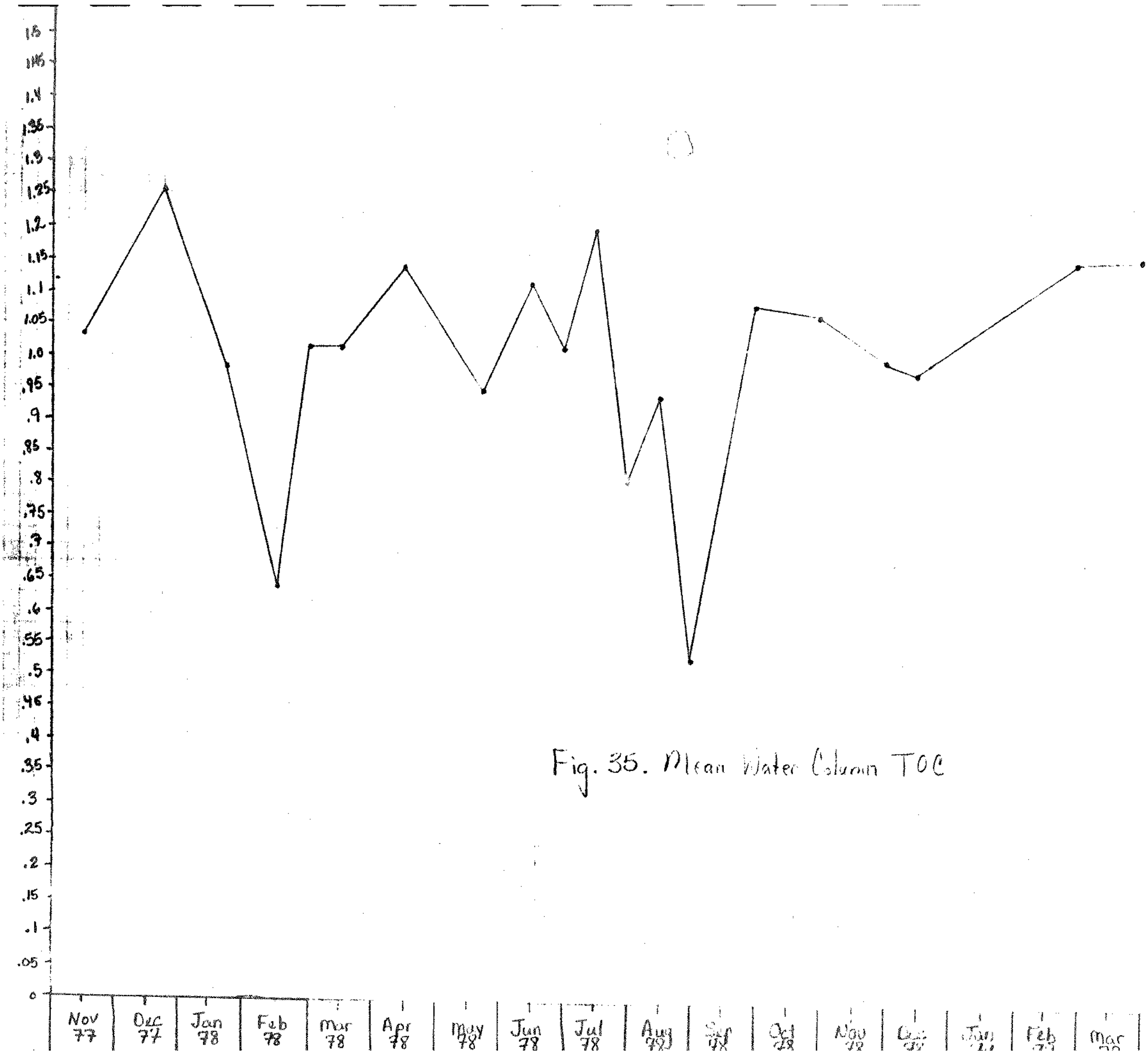


Fig. 35. Mean Water Column TOC

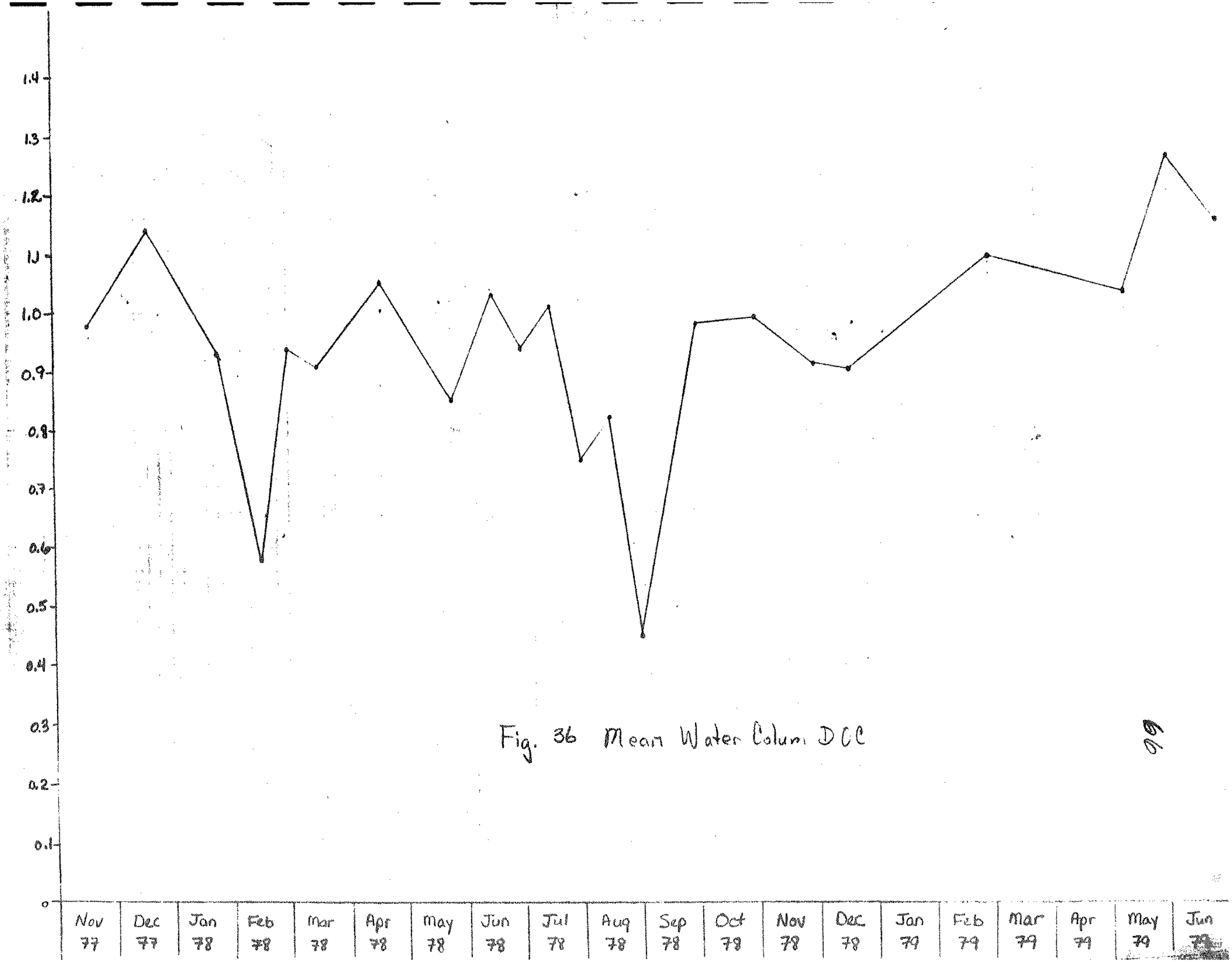


Fig. 36 Mean Water Colum DCC

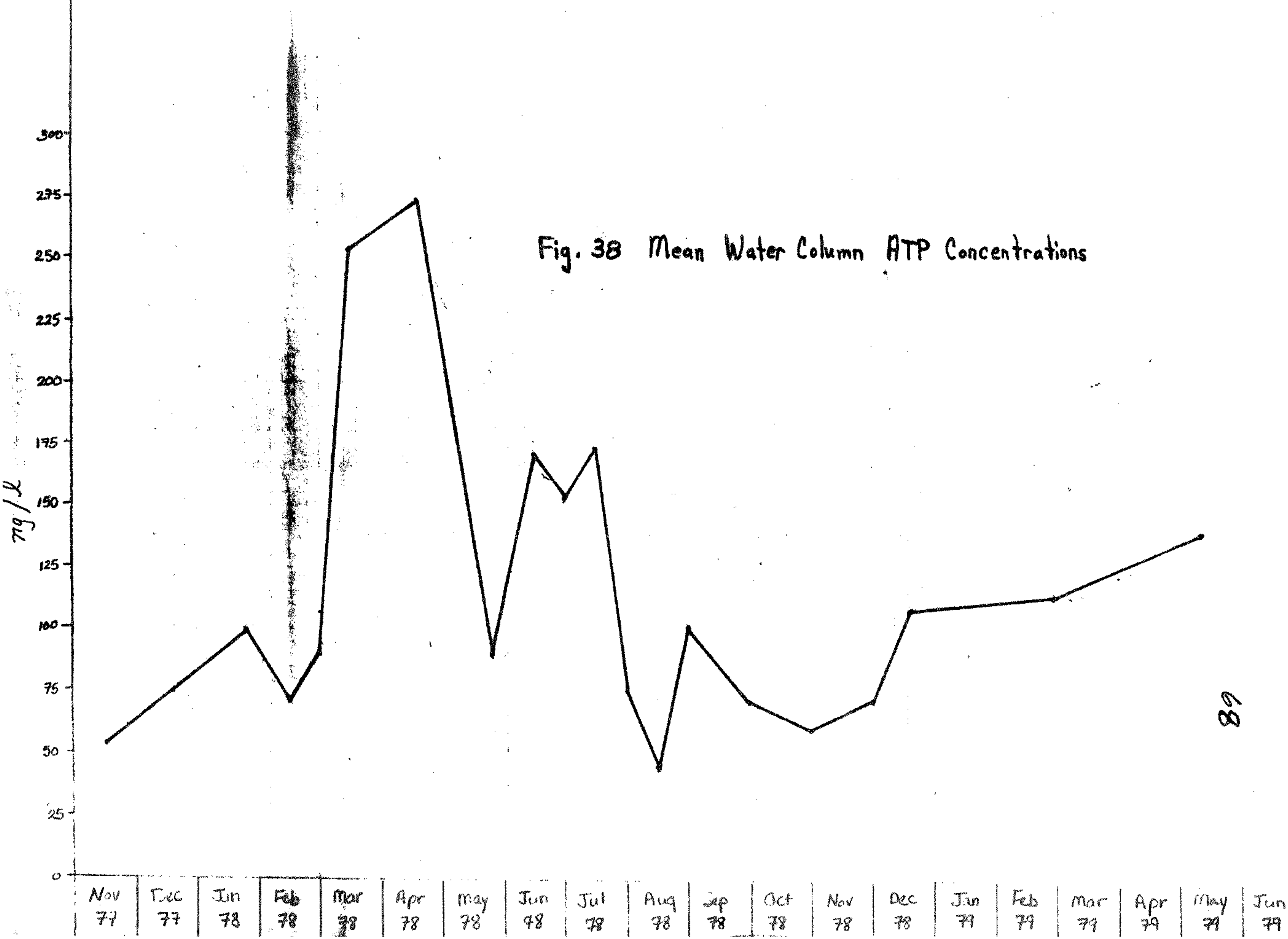


Fig. 38 Mean Water Column ATP Concentrations

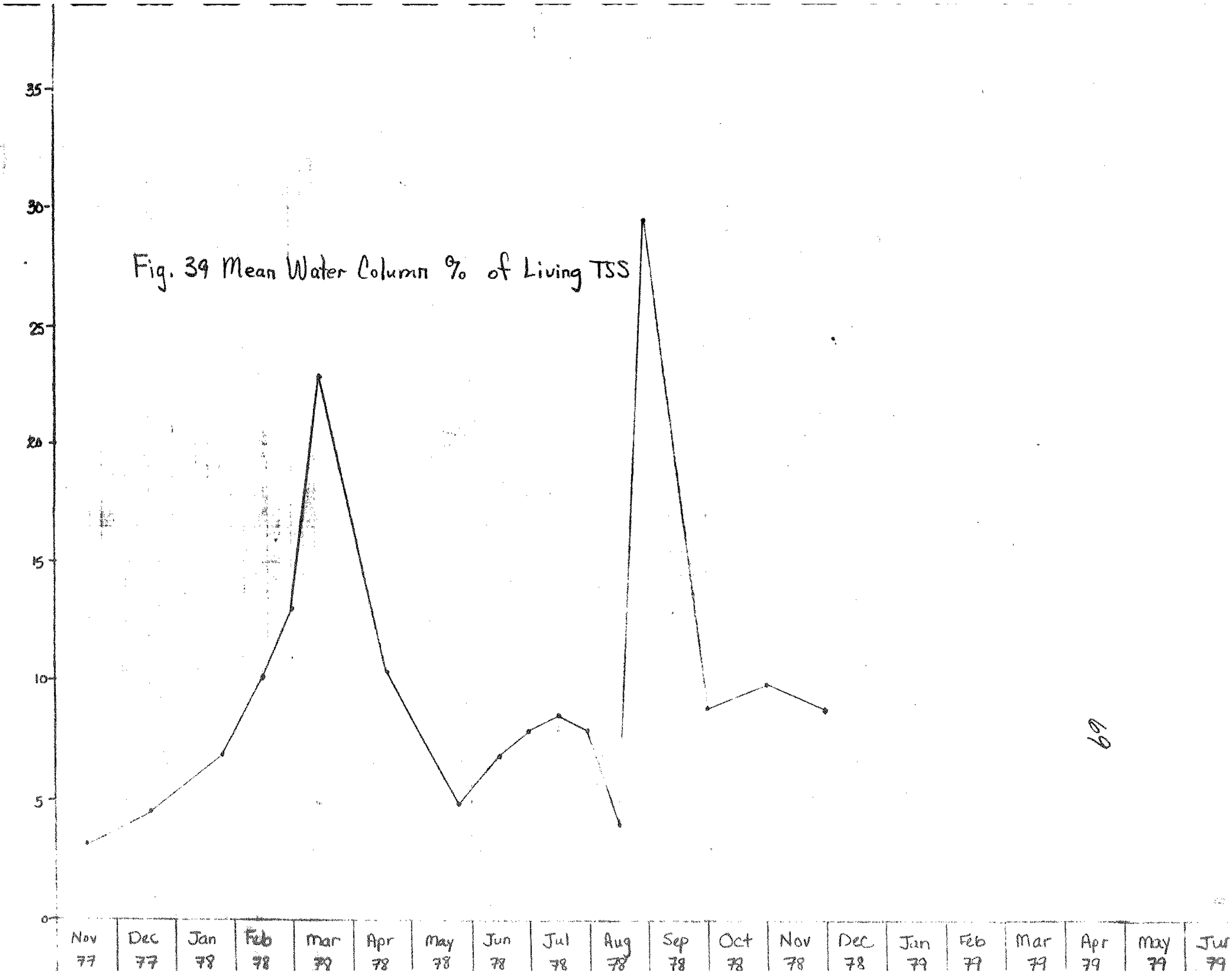


Fig. 39 Mean Water Column % of Living TSS

[illegible] O_2 Concentrations [illegible]

DATE	1m	5m	10m	15m	20m	25m	30m	40m	50m	60m	70m	80m	90m	$\bar{X}$ upper 40m	$\bar{X}$ lower 50m	$\bar{X}$ total water column
7/XI/77	3.97		4.38		4.00		4.29	4.31	4.34	4.60	4.75	5.68	4.79	4.2	4.8	4.5
0/XII/77	—		—		—		—	—	—	—	—	—	—	—	—	—
5/I/78	—		—		—		—	—	—	—	—	—	—	—	—	—
[illegible]/II/78	—		—		—		—	—	—	—	—	—	—	—	—	—
[illegible]/III/78	4.1		4.2		4.5		4.5	4.8	5.6	5.6	5.7	6.1	6.0	4.4	5.8	5.1
5/III/78	4.1		4.2		4.1		4.7	4.7	4.5	4.7	5.1	5.1	5.1	4.4	4.9	4.6
8/IV/78	4.1		4.2		4.3		3.9	4.1	3.9	4.0	4.3	[illegible]	4.1	4.1	4.1	4.1
14/V/78	4.2		4.0		4.2		4.0	3.8	4.4	5.2	4.9	[illegible]	4.2	4.0	4.7	4.4
5/[illegible]/78	4.6		4.7		4.2		4.5	5.0	5.2	4.5	4.2	[illegible]	4.7	4.6	4.7	4.6
[illegible]0/VI/78	4.5	4.8	5.1	4.5	4.9		4.6	4.5	4.3	4.7	4.7	5.4	4.9	4.7	4.8	4.7
[illegible]/VII/78	5.4	4.1	4.7	4.2	4.4		4.7	4.7	5.8	5.1	5.1	4.9	[illegible]	4.5	5.3	4.8
[illegible]	5.5	4.7	—	6.1	5.9	[illegible]	6.1	5.9	5.9	6.2	6.3	5.0	[illegible]	5.7	5.7	5.7
[illegible]	3.8	3.7	4.8	4.0	4.1	4.1	3.9	5.1	4.3	4.4	4.0	4.9	[illegible]	4.2	4.7	4.4
[illegible]	5.6	6.6	5.9	5.5	6.3	6.9	5.7	5.8	3.2	6.6	7.1	4.6	2.8	6.0	4.9	5.6
[illegible]	3.8	4.1	3.8	4.2	4.2	4.4	4.1	4.4	4.1	5.8	4.4	4.5	[illegible]	4.1	4.6	4.3
[illegible]/X/78	5.5	4.0	4.3	5.0	4.8	5.2	4.1	5.3	4.7	4.5	4.7	5.1	5.6	4.8	4.9	4.8
[illegible]0/XI/78	4.8	4.8	5.2	1.4	4.9	2.1	4.9	5.3	5.2	5.1	0.5	[illegible]	4.7	4.2	4.1	4.2
[illegible]/XII/78	4.9	6.9	4.9	2.1	5.2	4.4	6.5	4.7	4.5	5.1	5.0	7.0	[illegible]	5.0	5.5	5.1
[illegible]/II/79	5.6	3.8	3.9	3.8	3.0	6.0	3.7	3.7	3.8	3.6	5.4	—	—	4.2	4.3	4.2
[illegible]/III/79	4.3	4.4	4.5	4.45	4.5	4.5	4.5	4.3	4.2	4.5	4.5	4.4	4.5	4.4	4.4	4.4
[illegible]/V/79																
[illegible]/VI/79																
[illegible]7/VI/79																
[illegible]/VII/79																
													$\bar{X}$ =	4.6	4.8	4.7

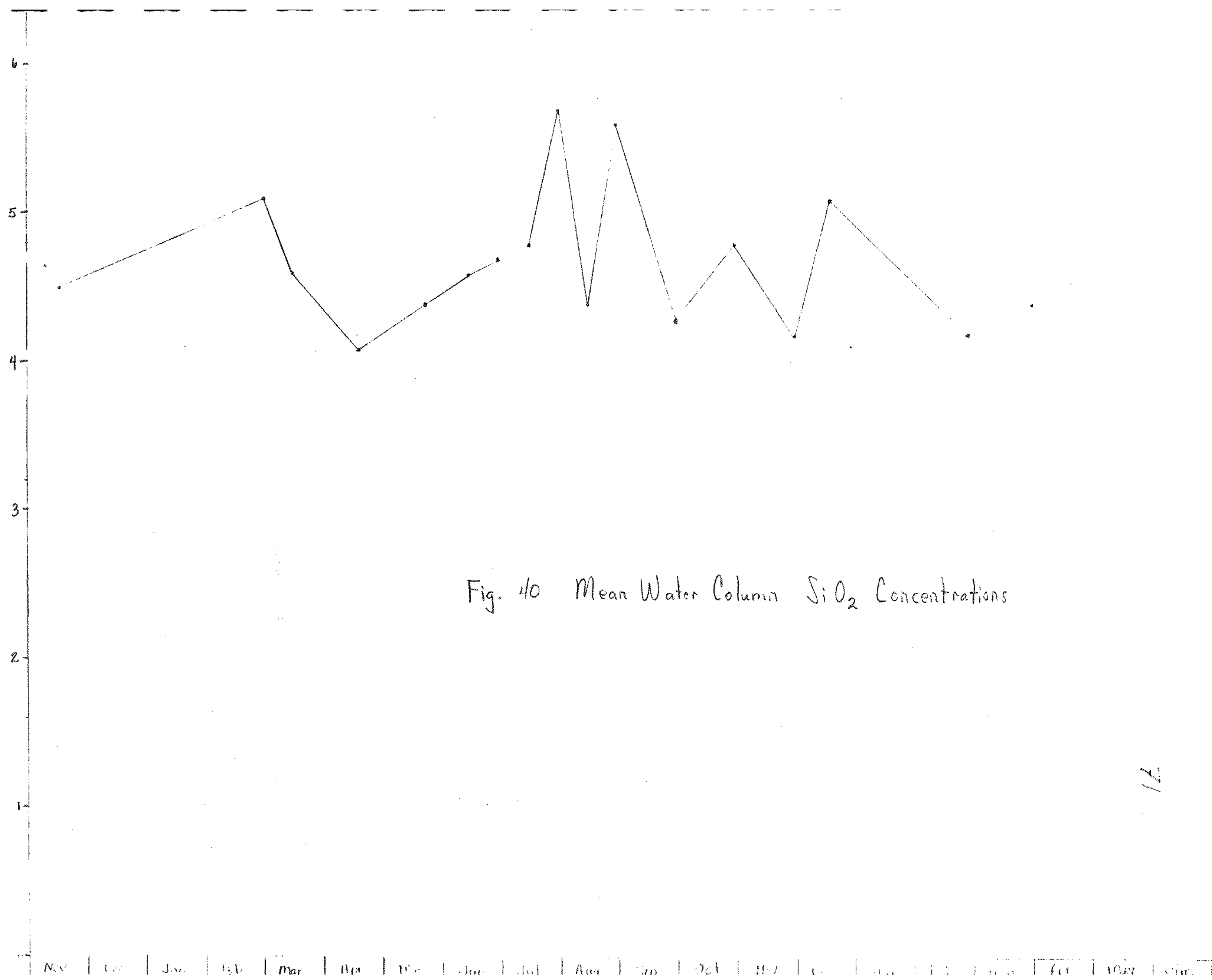


Fig. 40 Mean Water Column SiO_2 Concentrations

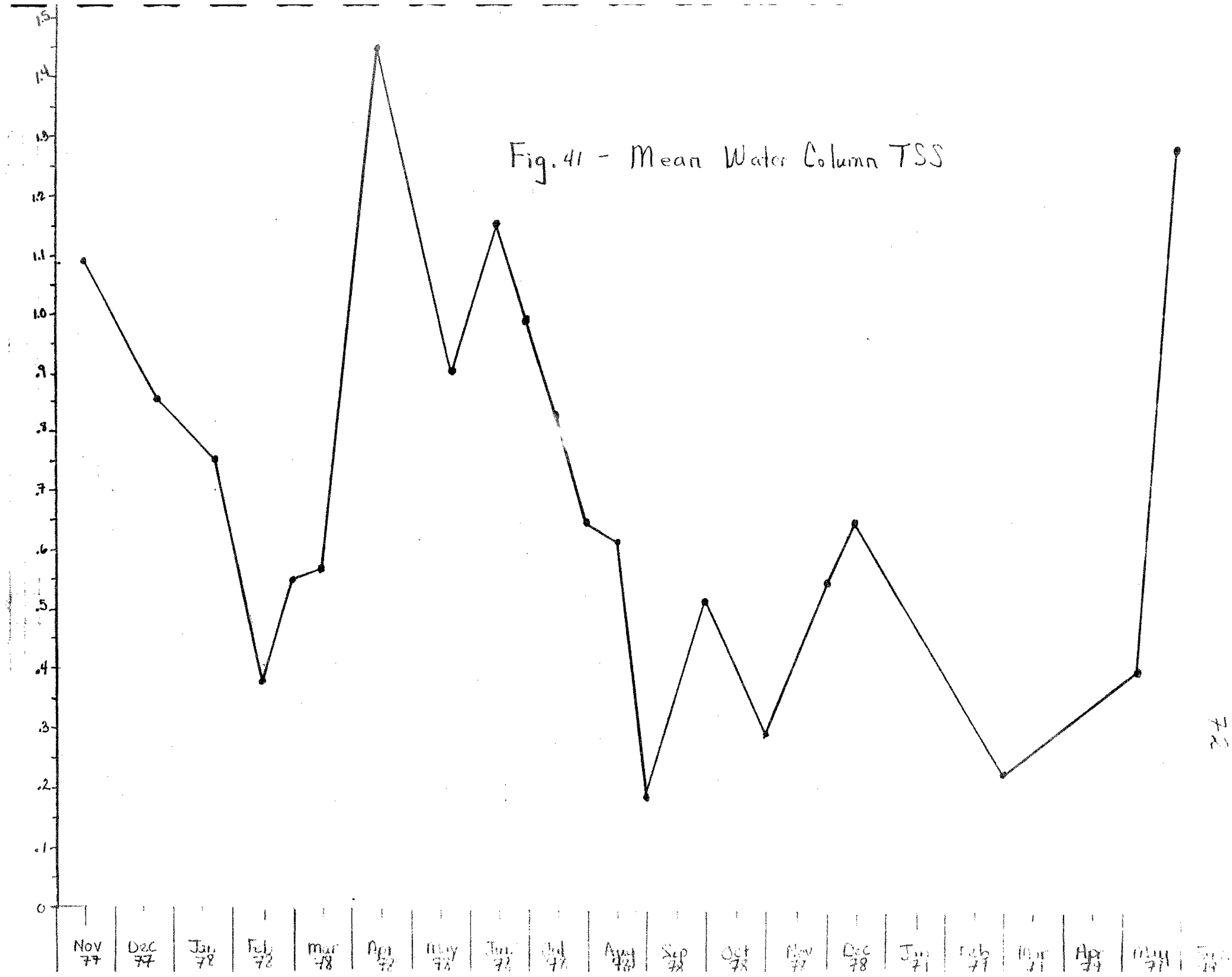


Fig. 41 - Mean Water Column TSS

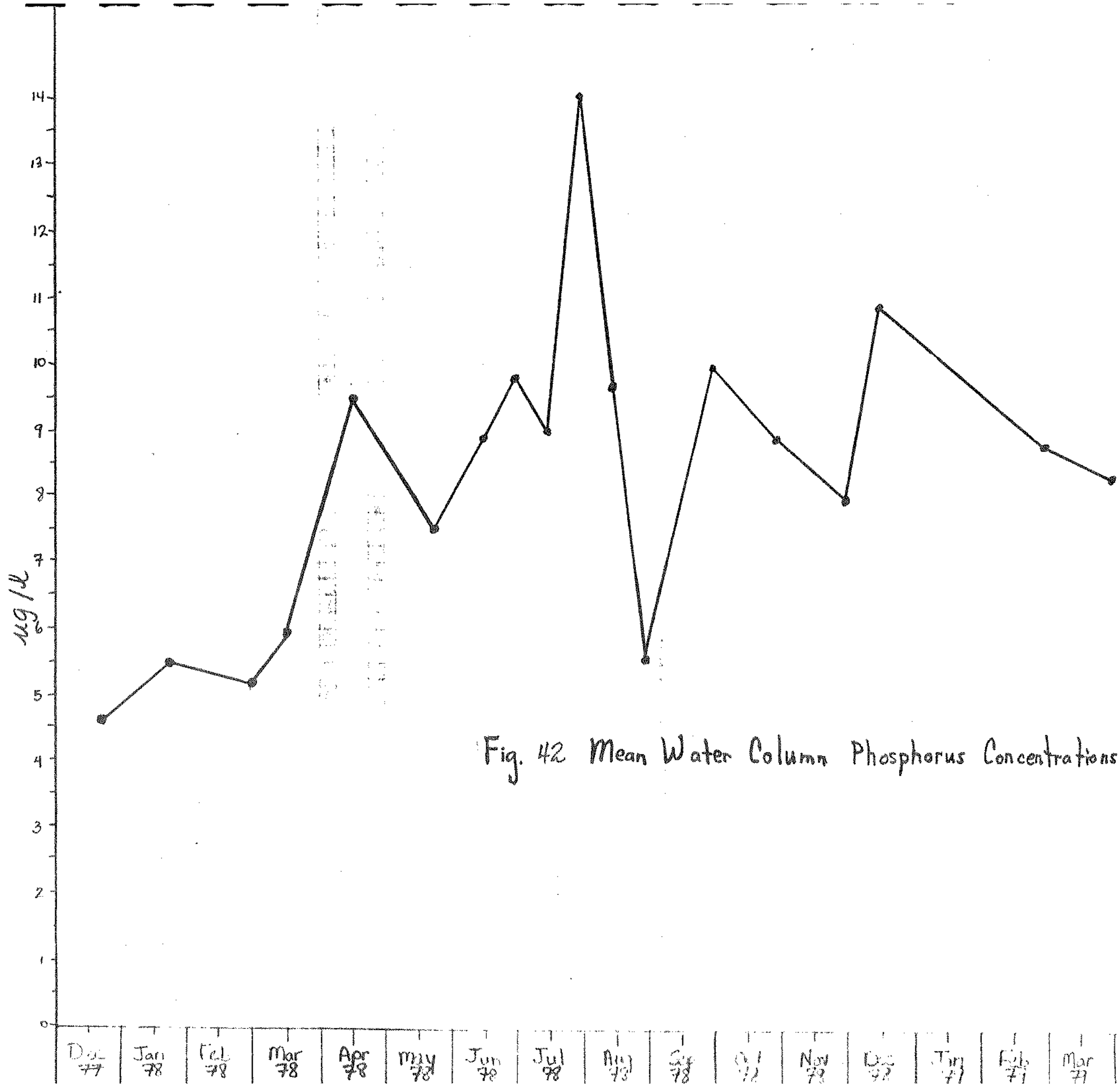


Fig. 42 Mean Water Column Phosphorus Concentrations

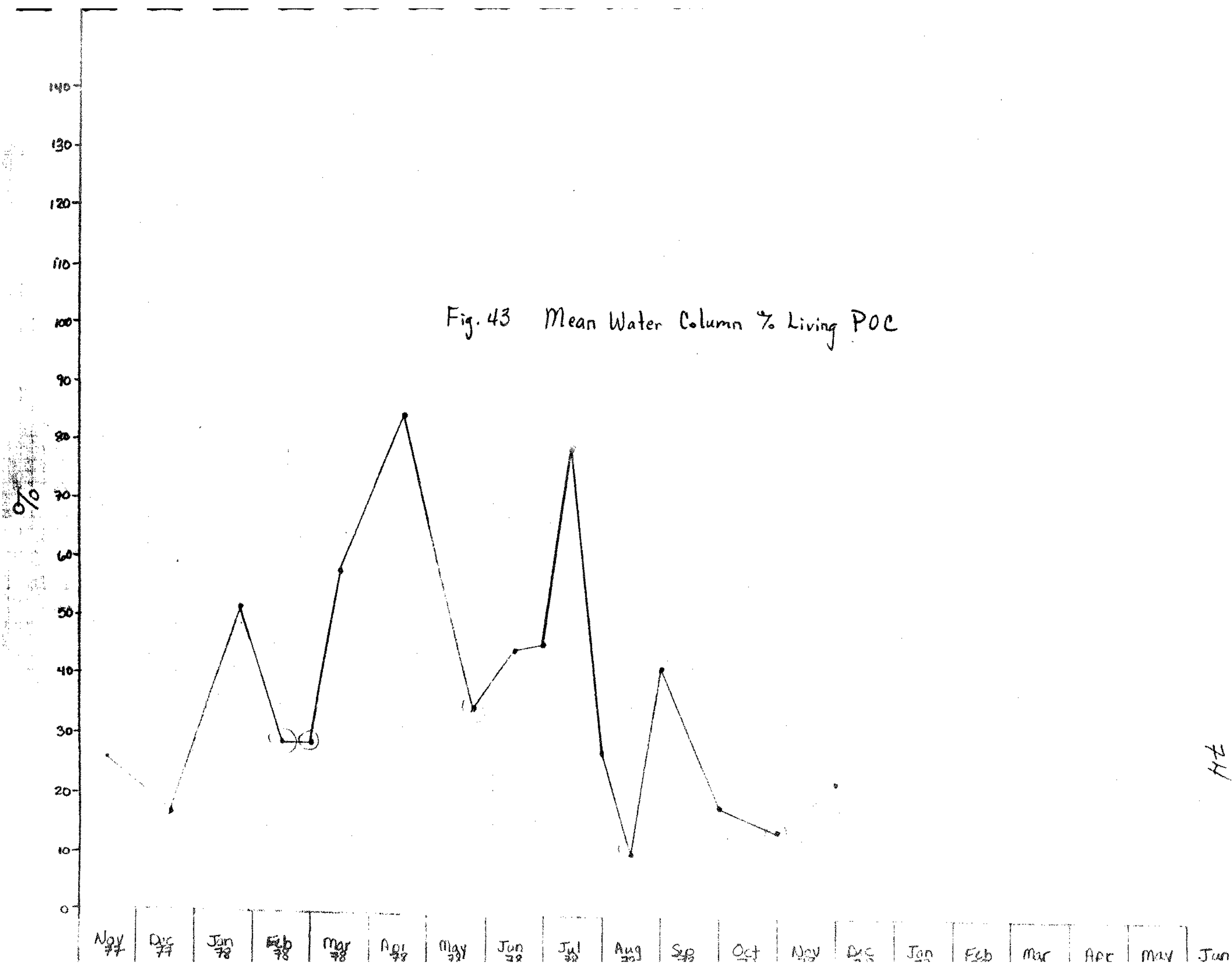


Fig. 43 Mean Water Column % Living POC
%
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Nov 77
Dec 77
Jan 78
Feb 78
Mar 78
Apr 78
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun

(1974 study confirmed this) plankters have also shown Spring diatom pulses. The hypothesized biomass bloom produced large amounts of TSS in the trophogenic zone, but the suspended particles had a relatively low percentage of organic carbon content (Figure 44) as might be expected from largely siliceous diatom frustrules.

The samples from late May, just two weeks prior to turbidity overflow into the Midlake station, contained evidence of a decline in planktonic biomass (Figure 38) and primary productivity (Figure 34). A large reduction in TSS was evident (Figure 41) and the particulates which remained in the water column contained considerably less living POC (Figure 43) and less living material (Figure 39). Phosphorus concentrations were slightly reduced (Figure 42) in the water column in May and Nitrogen concentrations reached minimal values (Figure 45) for the study. Dissolved Si concentrations reached minimal values for the study of 4.0 mgl^{-1} in the trophogenic zone (Table 4 and Figure 40), but were higher (4.7 mgl^{-1}) in the lower 50 meters of the water column.

The 1978 turbidity plume reached Midlake in the middle of June, and the secchi disc reading reached its minimum value (16 feet) for the 1977-1978 water year (Figure 46a). Primary productivity increased through the mid-July 1978 period (Figure 34) while the largely inorganic suspended particulates (Figure 44 and Table 5) sank through the water column. The content of POC in the entire water column as well as the trophogenic zone decreased (Figure 37 and Table 6). The concentration of ATP increased through this period (Figure 38) and was significantly greater in the trophogenic zone than it was in the tropholytic zone (Table 7). As the allocthanous sediments settled during the June-July period, the water

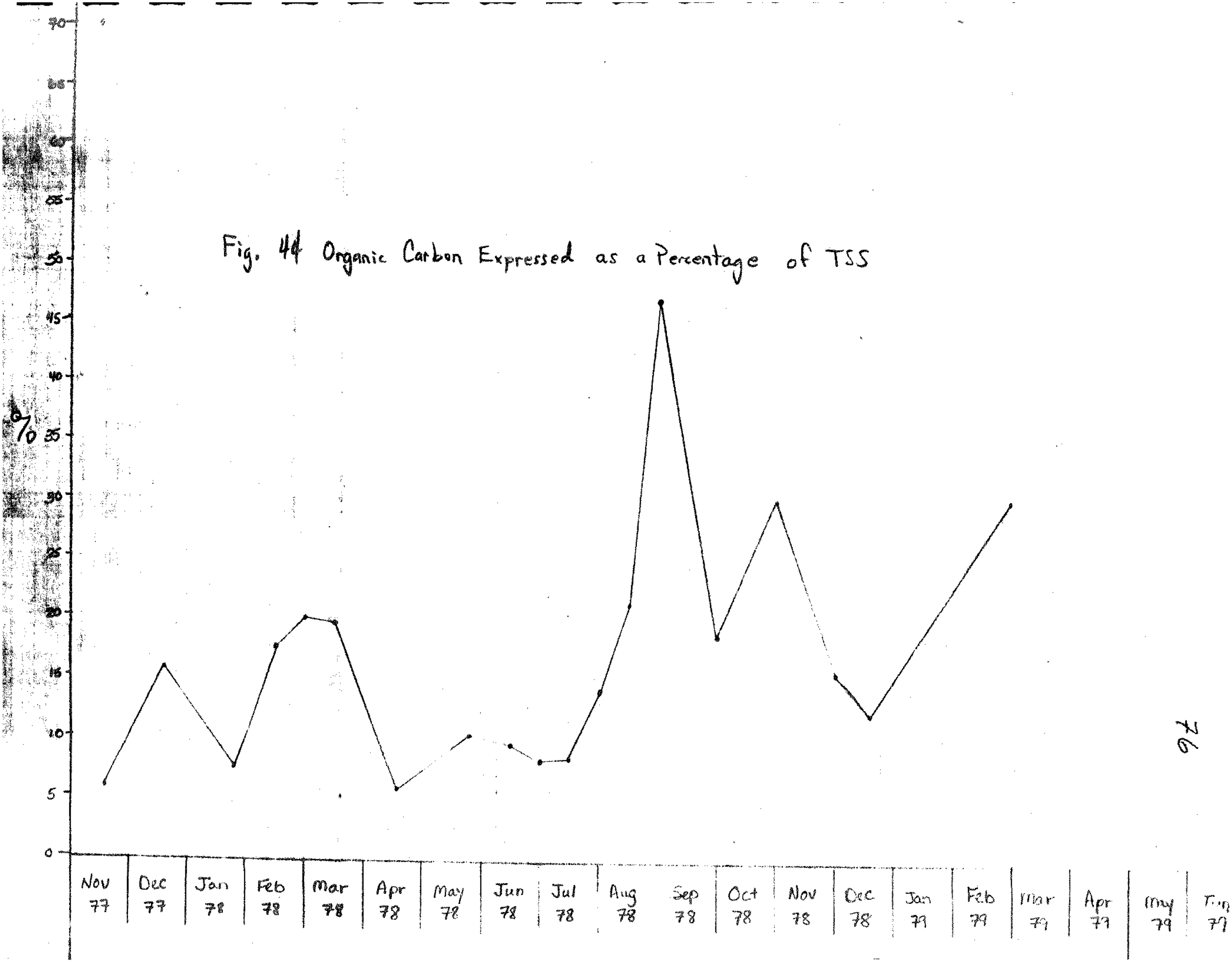


Fig. 44 Organic Carbon Expressed as a Percentage of TSS

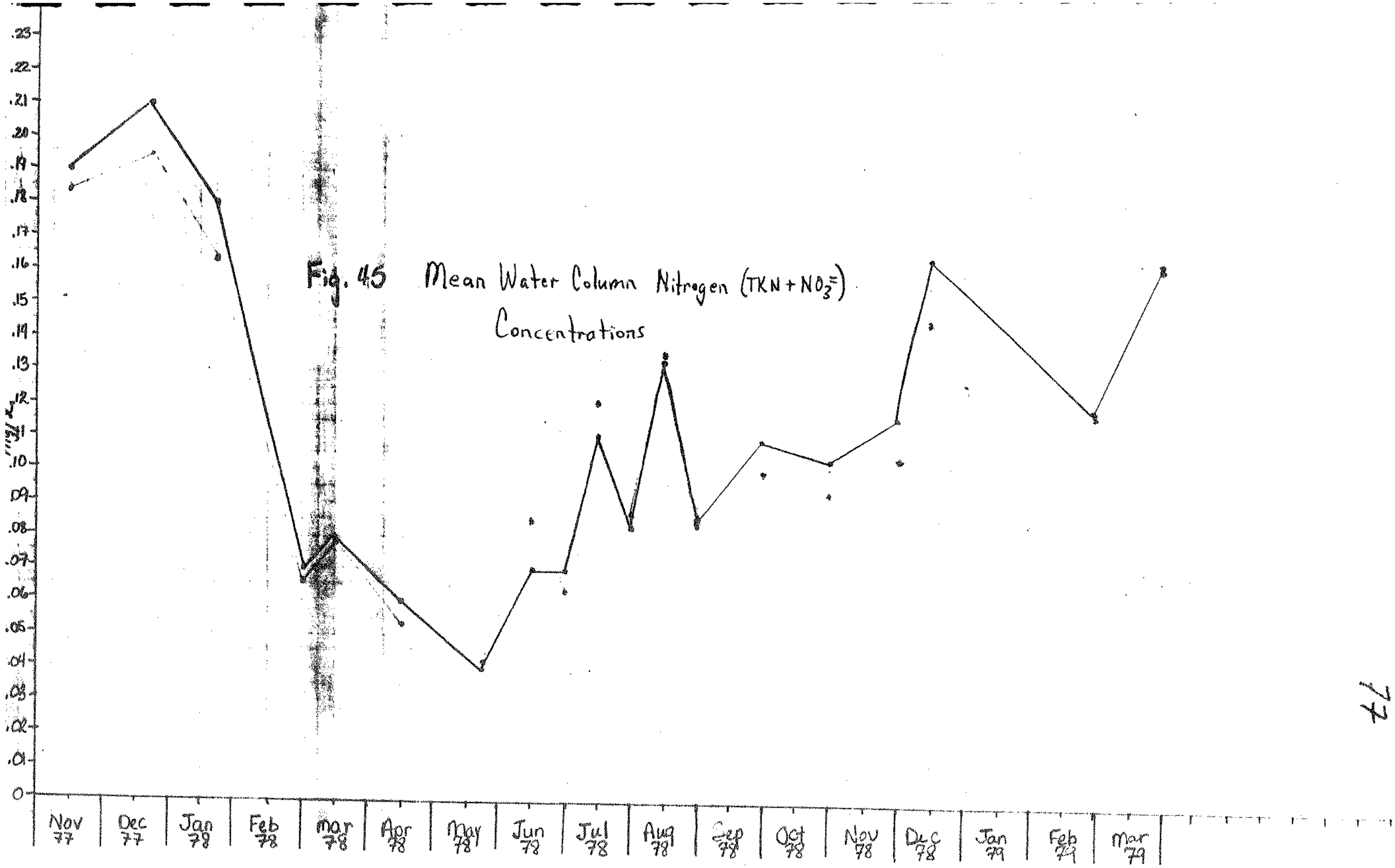


Fig. 45 Mean Water Column Nitrogen (TKN + $NO_3^=$) Concentrations

column cleared (Figure 46a) of the largely inorganic TSS (Figures 41 and 44), and the remaining POC and TSS increased in their percentage of living biomass (Figures 39 and 43).

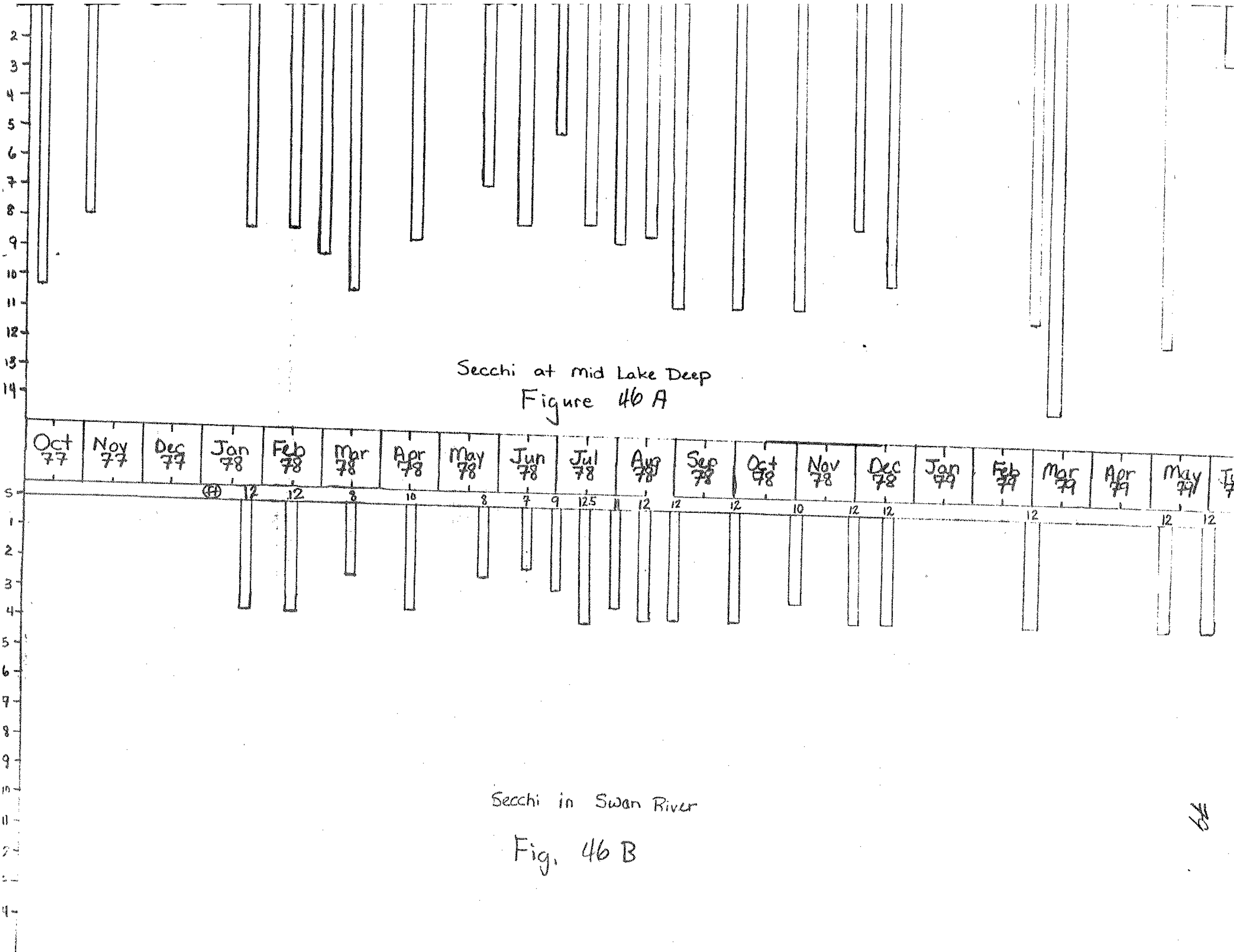
During the mid-June to mid-July period, concentrations of Phosphorus held relatively steady (Figure 42), Total Nitrogen concentrations increased (Figure 45) and soluble Silica increased (Figure 40).

From mid-July to the end of August 1978, TSS decreased (Figure 41) to minimal values in the entire water column. Secchi disc readings reflected a clearing of turbidity from the shallow depths (Figure 46a). DOC and TOC concentrations decreased (Figures 35 and 36) to minimal values. Primary productivity decreased (Figure 34) and then increased again, as did the concentrations of Biomass (Figure 38), and the relative percentages of living POC (Figure 43) and TSS (Figure 39). N and Si concentrations fluctuated up and down by relatively minor amounts but Phosphorus concentrations fell from 14 to 5.5 ugl^{-1}.

1978 FALL TO WINTER 1979

Primary productivity decreased from mid-Summer highs to low values through late Fall and into Winter 1979 (Figure 34). Water transparency reached maximum values (Figure 46a). The TSS content returned to relatively low values (Figure 41), both forms of organic carbon (POC and DOC) decreased (Figures 36 and 37), and Biomass (Figure 38), and relative amounts of POC and TSS which were living decreased (Figures 39 and 43). Concentrations of Nitrogen continued to increase (Figure 45) and phosphorus (Figure 42) and silica (Figure 40) both fluctuated.

Samples from the Midlake Pelagic Station have been analyzed for concentrations of ten important metallic cations from September 1978

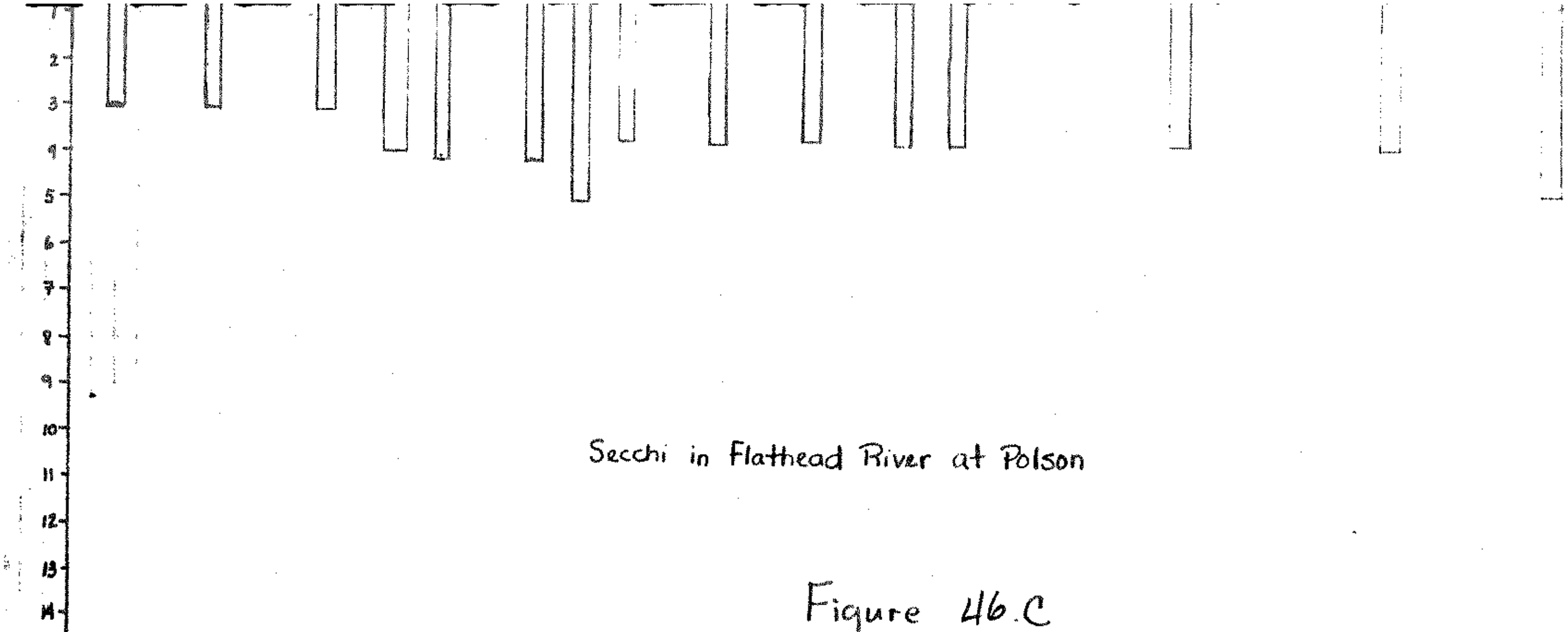


Secchi at mid Lake Deep

Figure 46 A

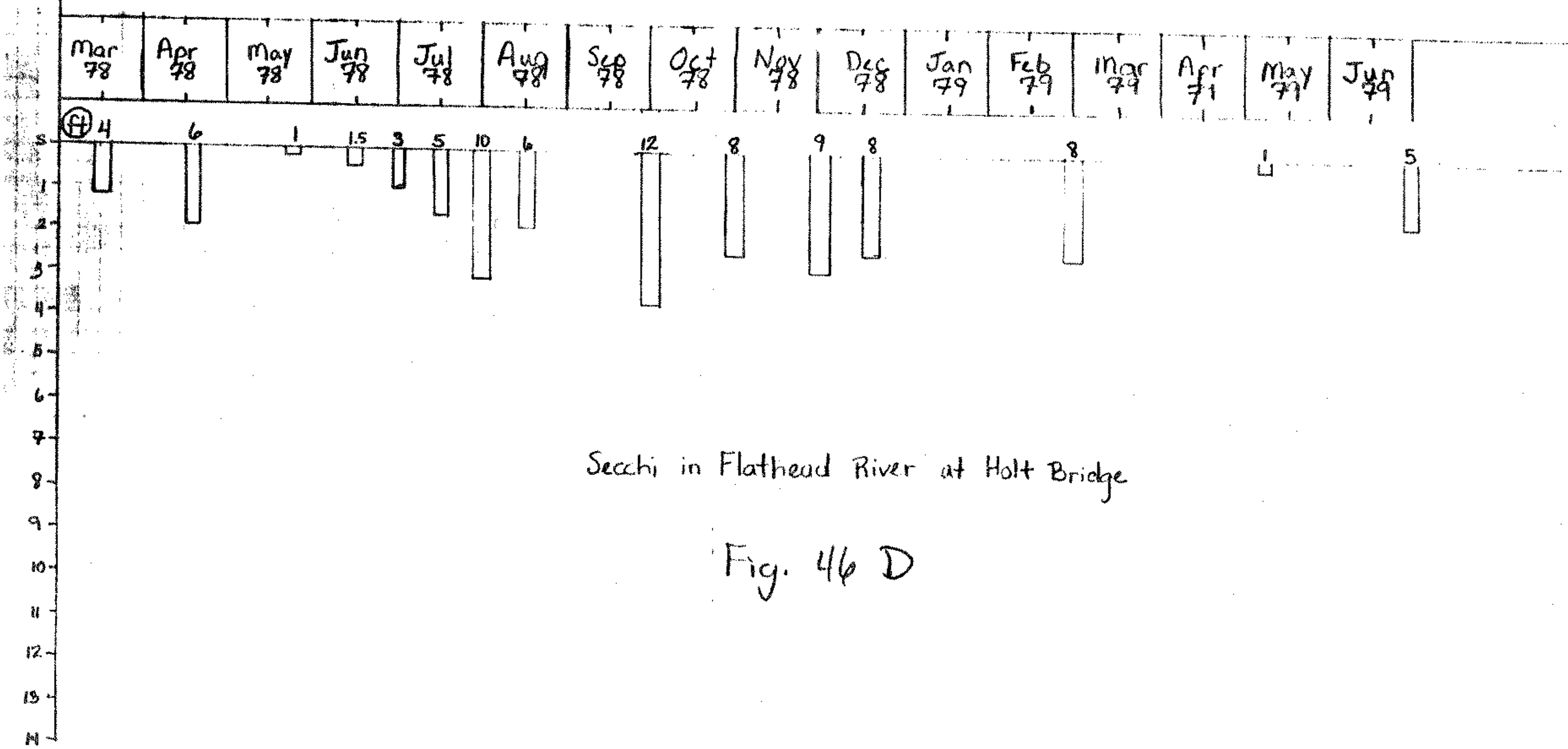
Secchi in Swan River

Fig. 46 B



Secchi in Flathead River at Polson

Figure 46.C



Secchi in Flathead River at Holt Bridge

Fig. 46 D

Table 5 - Org. C Expressed as % TSS

DATE	1m	5m	10m	15m	20m	25m	30m	40m	50m	60m	70m	80m	90m	$\bar{x}$ upper 40m	$\bar{x}$ lower 50m	$\bar{x}$ total water column
7/XI/77	9.6		10.6		7.9		8.3	11.0	1.9	2.9	2.3	2.2	3.5	9.5	2.6	6.0
20/XII/77	19		10.6		12.8		8.9	11.0	15.1	16.7	12.4	8.3	(43.2)	12.5	19.1	15.8
25/I/78	16		9.1		12		8.4	6.7	5.3	3.1	2.1	6.9	4.6	10.4	4.4	7.4
15/II/78	31		23.6		13.1		19.3	12.2	9.1	22.5	10.5	8.5	24	19.8	14.9	17.4
1/III/78	8.8		4.5		5.4		15.8	6	12	6.6	29.6	29	? (82.5)	8.1	31.9	20
15/III/78	11		17.6		29.3		26.4	15.8	18.7	18.3	17	22.7	19.3	20.0	19.2	19.6
18/IV/78	6		7.2		5.7		4.6	5.9	7.1	5.1	5.8	3.9	7.7	5.9	5.9	5.9
24/V/78	15		19.7		12		12.3	1.7	4.5	11.1	6.6	10.7	9.2	12.1	8.4	10.3
15/VI/78	26	7	8.3	5.5	8		9.8	17	8	3.4	9.3	5.2	6.1	11.7	6.4	9.5
30/VI/78	7	15	7.8	12.1	—		10.8	7.8	11.2	2.9	5.4	5.4	3.7	10.1	5.7	8.1
15/VII/78	17	13	11.5	7.7	6.8		3.9	4.6	18.4	4.1	0.8	10.9	2.0	9.2	7.1	8.3
30/VII/78	9	18	64.3	18.9	8.4	9.9	3.7	—	—	1	14.5	3.1	3.7	18.9	5.6	14.0
15/VIII/78	26	24	38	11.1	17.9	24.2	13.1	8.9	25.8	14.8	37.3	29.5	7.6	20.4	23.0	21.4
30/VIII/78	—	91.5	112	136	59	18.7	32	25.3	10.2	8	9.8	26	? (35.4)	67.8	17.9	47.0
30/IX/78	18	21	25.2	12.3	26.2	38.5	16	27.5	26.1	27	4.1	0.9	1.1	23.1	11.8	18.7
30/X/78	29.8	22.6	44.2	44	50	36.4	35.5	42.5	24	17	17.3	18	9.8	38.1	17.2	30.1
30/XI/78	12.9	12	14	18.1	16	24.9	30.5	15.4	18.8	9.2	11.3	10.1	10.6	18.0	12.0	15.7
18/XII/78	15.3	14.6	16	17	12.2	16.9	10.2	7.1	7.7	—	8.5	10.5	11.4	13.7	9.5	12.3
28/II/79	29.3	56	42.7	42.7	30.6	29.6	10.4	12.4	12.8	—	—	—	—	32.5	12.8	30.3
31/III/79													$\bar{x}$	19.0	12.4	16.7
9/IV/79																

Table 6 POC (mg/l)

DATE	1m	5m	10m	15m	20m	25m	30m	40m	50m	60m	70m	80m	90m	X̄ upper 40m	X̄ lower 50m	X̄ total water column
17/XI/77	.0765		.064		.063		.067	.088	.031	.046	.018	.039	.045	.072	.036	.054
20/XII/77	.133		.106		.103		.071	.110	.121	.150	.099	.100	.259	.105	.146	.125
25/I/78	.094		.064		.084		.067	.048	.032	.025	.019	.062	.041	.071	.036	.054
15/II/78	.107		.071		.072		.077	.055	.041	.045	.042	.034	.060	.076	.044	.060
1/III/78	.0572		.048		.048		.091	.036	.042	.028	.037	.116	.288	.056	.102	.079
15/III/78	.076		.106		.132		.132	.099	.103	.110	.102	.105	.116	.109	.108	.108
18/IV/78	.117		.137		.109		.083	.082	.085	.061	.076	.039	.067	.106	.066	.086
24/V/78	.133		.148		.144		.118	.015	.036	.089	.058	.155	.127	.118	.093	.106
15/VI/78	.099	.149	.149	.092	.090		.098	.109	.066	.038	.079	.044	.082	.112	.062	.091
30/VI/78	.071	.154	.096	.097	—		.092	.059	.112	.028	.057	.059	.043	.095	.060	.079
15/VII/78	.086	.115	.159	.089	.068		.032	.036	.016	.024	.036	.062	.014	.084	.030	.061
30/VII/78	.061	.109	.148	.104	.084	.047	.025	0.00	—	.008	.109	.020	.051	.072	.047	.064
15/VIII/78	.155	.127	.137	.096	.125	.121	.035	.040	.155	.085	.233	.251	.054	.111	.156	.128
30/VIII/78	.110	.206	.186	.136	.118	.084	.048	.019	.023	.012	.022	.026	.062	.113	.029	.081
30/IX/78	.174	.176	.197	.147	.152	.115	.085	.055	.060	.027	.032	.026	.058	.138	.041	.100
30/X/78	.164	.120	.137	.132	.140	.120	.071	.085	.036	.034	.039	.036	.044	.121	.038	.089
30/XI/78	.074	.075	.084	.086	.088	.106	.145	.073	.080	.062	.065	.058	.074	.091	.068	.082
3/XII/78	.084	.073	.064	.085	.073	.072	.066	.062	.067	.071	.068	.076	.077	.072	.072	.072
8/II/79	.066	.154	.096	.064	.054	.074	.041	.028	.032	.028	.039	—	—	.072	.033	.061
1/III/79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
/V/79	.092	.156	.175	.222	.170	.151	.123	.082	.110	.078	.084	.151	.089	.146	.102	.129
2/VI/79	.145	.194	.177	.144	.062	.113	.108	.093	.083	.200	.220	.146	.094	.130	.149	.137
7/VI/79	.161	.176	.163	.172	.136	.113	.116	.098	.080	.060	.070	.061	[illegible]	.142	.066	.113
2/VII/79																
													X̄ =	.101	.072	.089

Table 7. ATP (ng/l)

Date	1m	5m	10m	15m	20m	25m	30m	40m	50m	60m	70m	80m	90m	$\bar{x}$ for Upper 40m	$\bar{x}$ for Lower 50m	$\bar{x}$ Total H_2O Column
23/IX/77																
7/X/77	36.4															
5/XI/77	77.5															
17/XI/77	—	—	91.0	—	74.	—	70.0	99.0	38.0	31.5	24.0	26.5	33.5	83.5	30.7	54.2
20/XII/77	49.8	—	74.4	—	135.1	—	73.1	97.2	75.7	54.9	54.8	56.8	81.2	85.9	64.7	75.3
25/I/78	86.0	—	255.0	—	127.0	—	83.0	102.0	72.0	80.0	57.0	61.0	71.0	130.6	68.2	99.4
15/II/78	131.3	—	193.2	—	89.3	—	54.5	65.8	88.9	36.8	34.7	7.5	20.5	106.8	37.7	72.3
2/III/78	155.7	—	97.2	—	91.0	—	104.7	82.8	56.0	43.3	—	23.2	108.3	106.3	72.7	91.4
15/III/78	207.3	—	274.5	—	243.3	—	342.8	314.8	313.8	198.1	186.3	210.1	246.1	276.5	230.9	253.7
18/IV/78	263.6	—	386.5	—	284.9	—	167.9	259.1	208.9	200.6	241.8	208.9	515.3	272.4	275.1	273.8
24/V/78	36.6	—	313.3	—	83.3	—	83.3	108.3	45.0	45.0	41.7	71.7	66.7	125.0	54.0	89.5
15/VI/78	131.9	647.0	181.2	181.6	109.6	—	208.3	157.6	112.3	95.3	89.8	75.7	64.6	231.0	87.5	171.2
30/VI/78	102.2	316.5	333.4	273.3	151.6	—	200.9	125.1	94.7	56.1	56.8	67.3	55.5	214.7	66.1	152.8
15/VII/78	135.3	223.5	441.6	476.1	182.6	—	119.9	73.9	104.2	79.6	133.5	56.0	57.8	236.1	86.2	173.7
30/VII/78	38.6	114.9	180.2	217.9	92.2	122.0	52.1	11.7	42.1	37.1	40.4	5.8	28.2	104.5	30.7	76.1
15/VIII/78	84.1	76.7	71.8	90.6	63.7	69.3	45.5	46.3	11.5	6.7	6.1	8.4	9.4	68.5	8.4	45.4
30/VIII/78	180.5	194.4	180.0	148.7	124.5	137.4	80.7	58.3	43.3	40.2	38.1	47.7	46.7	138.1	43.2	101.6
30/IX/78	152.0	130.0	155.4	98.2	61.0	65.6	82.4	48.1	34.2	27.2	25.7	24.7	26.6	99.1	27.7	71.6
30/X/78	88.9	97.2	153.6	115.6	98.6	71.1	45.5	32.2	16.8	14.9	14.9	14.4	17.6	87.8	15.7	60.1
30/XI/78	75.4	87.4	72.4	81.3	56.7	94.6	77.8	73.2	82.6	75.8	71.9	41.2	43.6	77.4	63.0	71.8
12/XII/78	97.5	128.3	107.4	89.1	109.1	114.1	120.0	96.6	85.0	91.6	161.6	90.8	104.1	107.7	106.6	107.3
28/II/79	28.3	409.0	166.6	91.6	77.5	165.5	73.3	69.1	46.6	40.8	16.7	—	—	142.6	34.7	113.2
31/III/79	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9/V/79	74.14	208.25	167.43	181.59	248.23	132.45	214.91	97.46	80.8	86.63	104.13	83.3	129.12	165.6	96.8	139.1
2/VI/79																
27/VI/79																
12/VII/79																
													$\bar{x}$ =	143	75	114.67

through March 1979 (Table 8). Concentrations of the two major cations, Ca and Mg, are well within the expected concentrations for Flathead Lake. Concentrations of N, K, Co, Cu, Fe, Mn, Mo and Zn are very low and often are present at less than detectable levels (i.e. BDL; see data matrices below, page 122).

ALLOCHTHONOUS CONTRIBUTIONS TO AND LOSSES OF C, N, TSS AND P AND METALLIC CATIONS FROM FLATHEAD LAKE

The allocthanous contributions of suspended sediments TOC, Nitrogen and Phosphorus by the two major input sources (Flathead River and Swan River) have been calculated on a monthly basis and compared to inflowing water volumes (Figures 47, 48, 49 and 50 a, b, c; Tables 9, 10, 11 and 12). Inspection of those graphs reveal that contributions of the three major nutrients are highly correlated with the volume of inflow per month. Maximum water inflows occurred in April to July 1978, as expected. Absolute amounts and concentrations of phosphorus in the inflowing waters reached maximal values during the runoff period and appeared to be positively correlated with inflow volumes (Table 10).

Contributions of Nitrogen by the two major river sources were also positively correlated with inflowing volumes on a monthly basis. However, concentrations of [N] in the inflowing waters reached maximal values during late Fall - Winter 1978 and 1979 in both rivers. Nitrogen contributions appear to be inversely correlated with inflow volumes (Table 11).

Absolute contributions and concentrations of TOC are both positively correlated with inflow volumes (Table 9).

Loss of C, N and P in the outflow under Polson bridge is positively correlated with outflow volumes.

Table 8. Metallic Cations - Midlake Station
September 1978 to March 1979

Cation	$\bar{x}$ Concentration (mg/l)	Range (mg/l)
Ca	29	10 - 46
Mg	5.5	3 - 7.5
Na	1.5	.6 - 2.5
K	0.4	0.2 - 0.7
Co	0.011	BDL - 0.030
Cu	0.002	BDL - 0.013
Fe	0.014	BDL - 0.085
Mn	0.001	BDL - 0.02
Mo	BDL	BDL - 0.003
Zn	BDL	BDL - 0.003

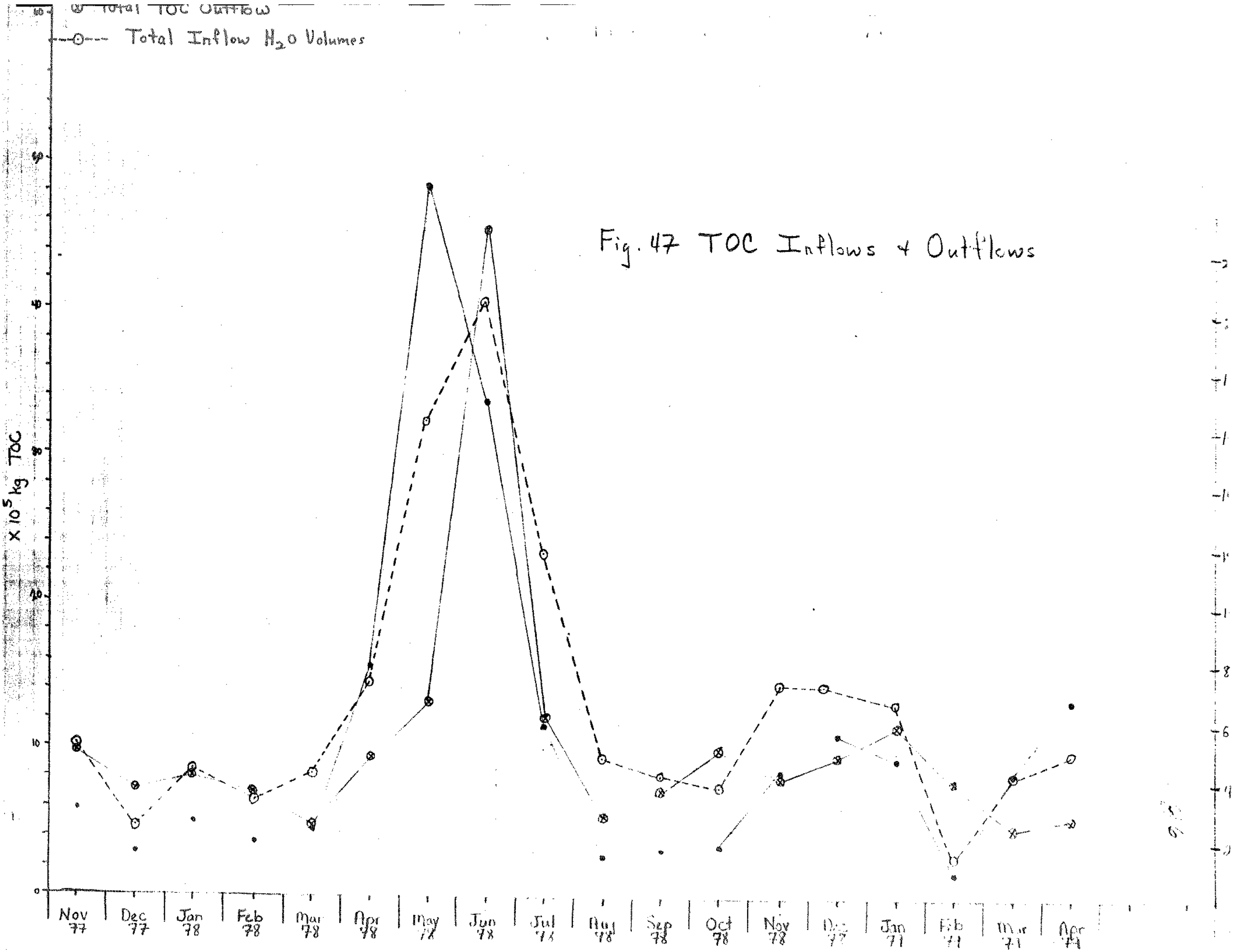


Fig. 47 TOC Inflows + Outflows

P- Budget - Flathead Lake

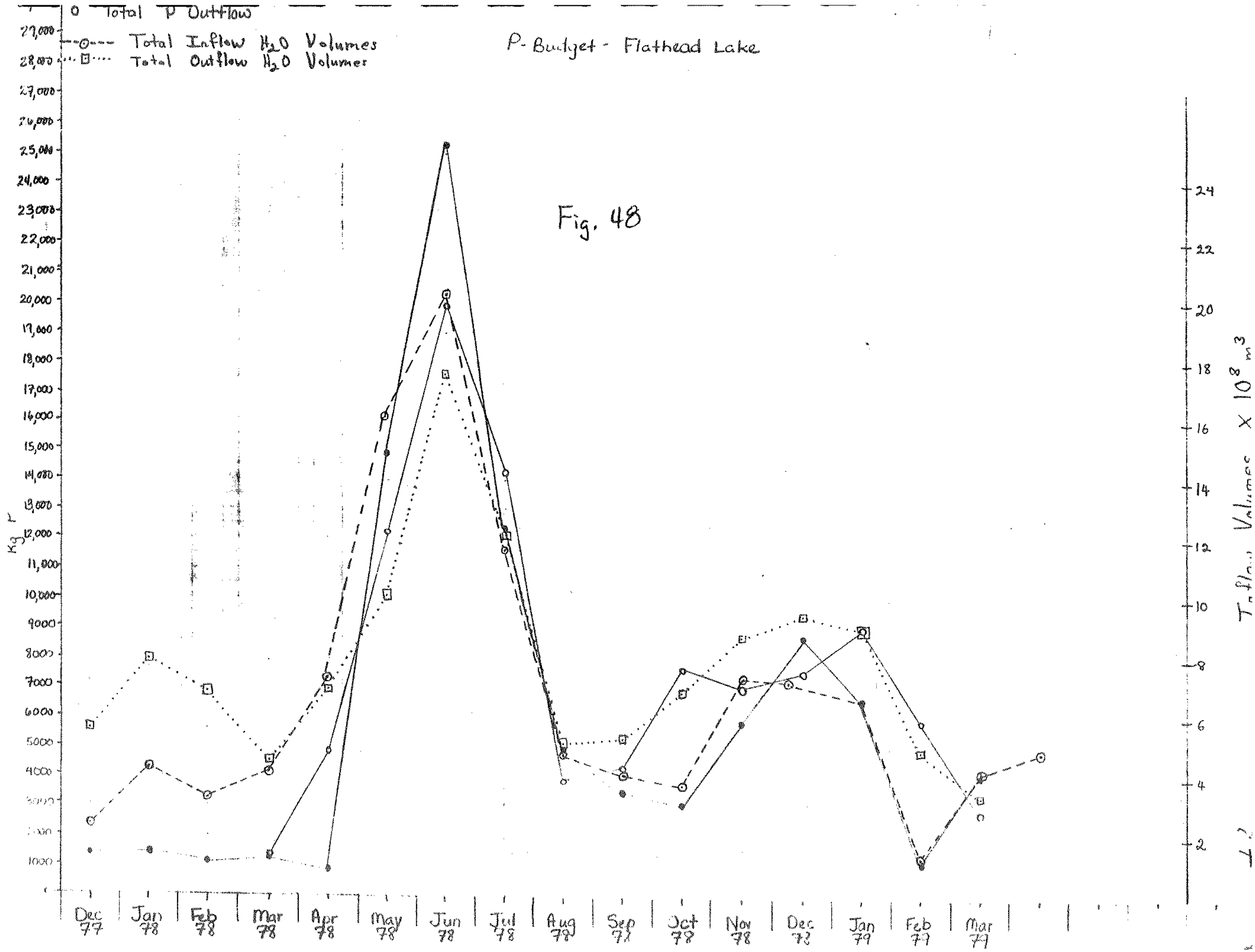


Fig. 48

N-Budget -- Flathead Lake

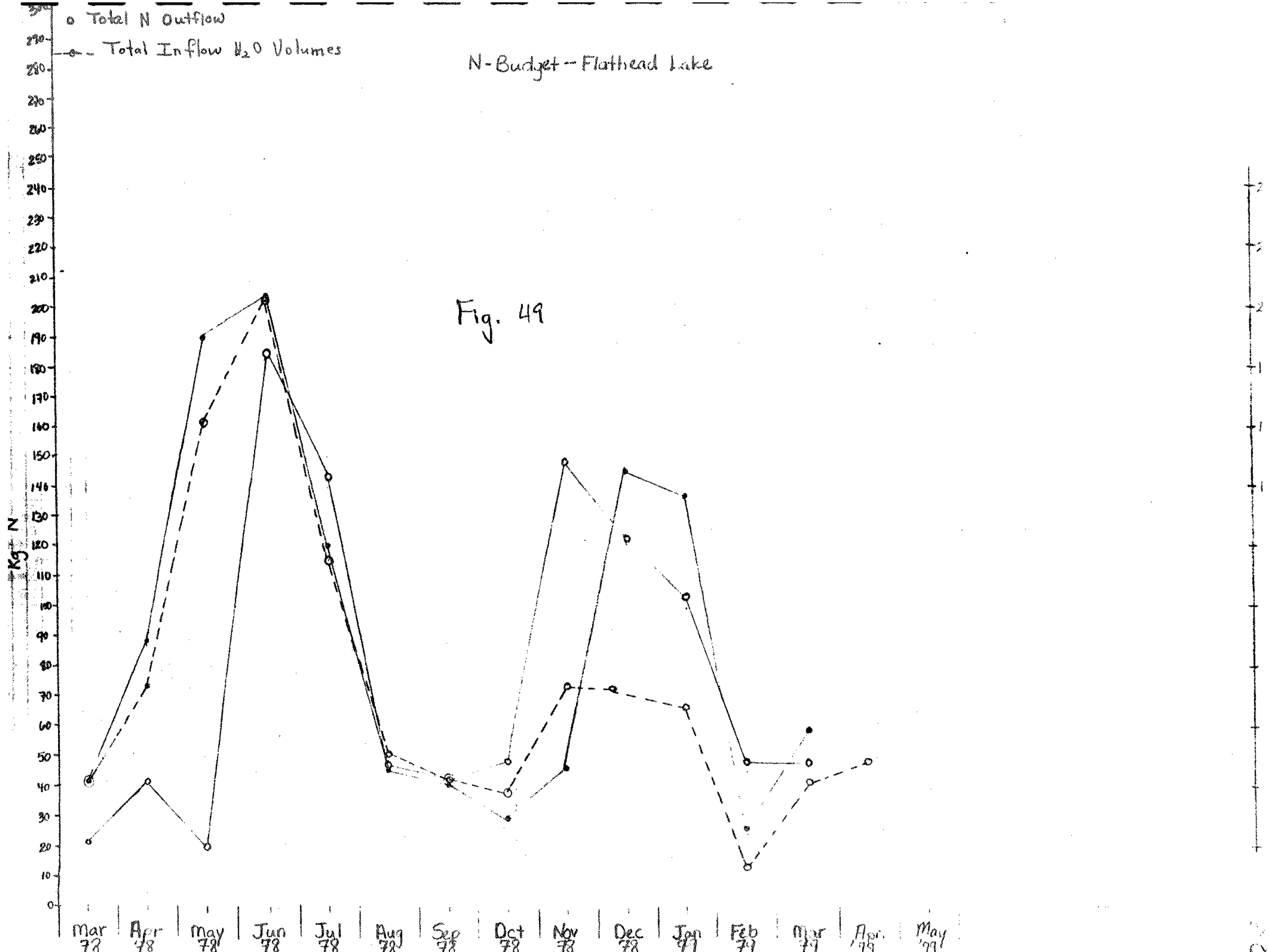


Fig. 49

Holt

Fig 50 A - Flathead River at Holt TSS

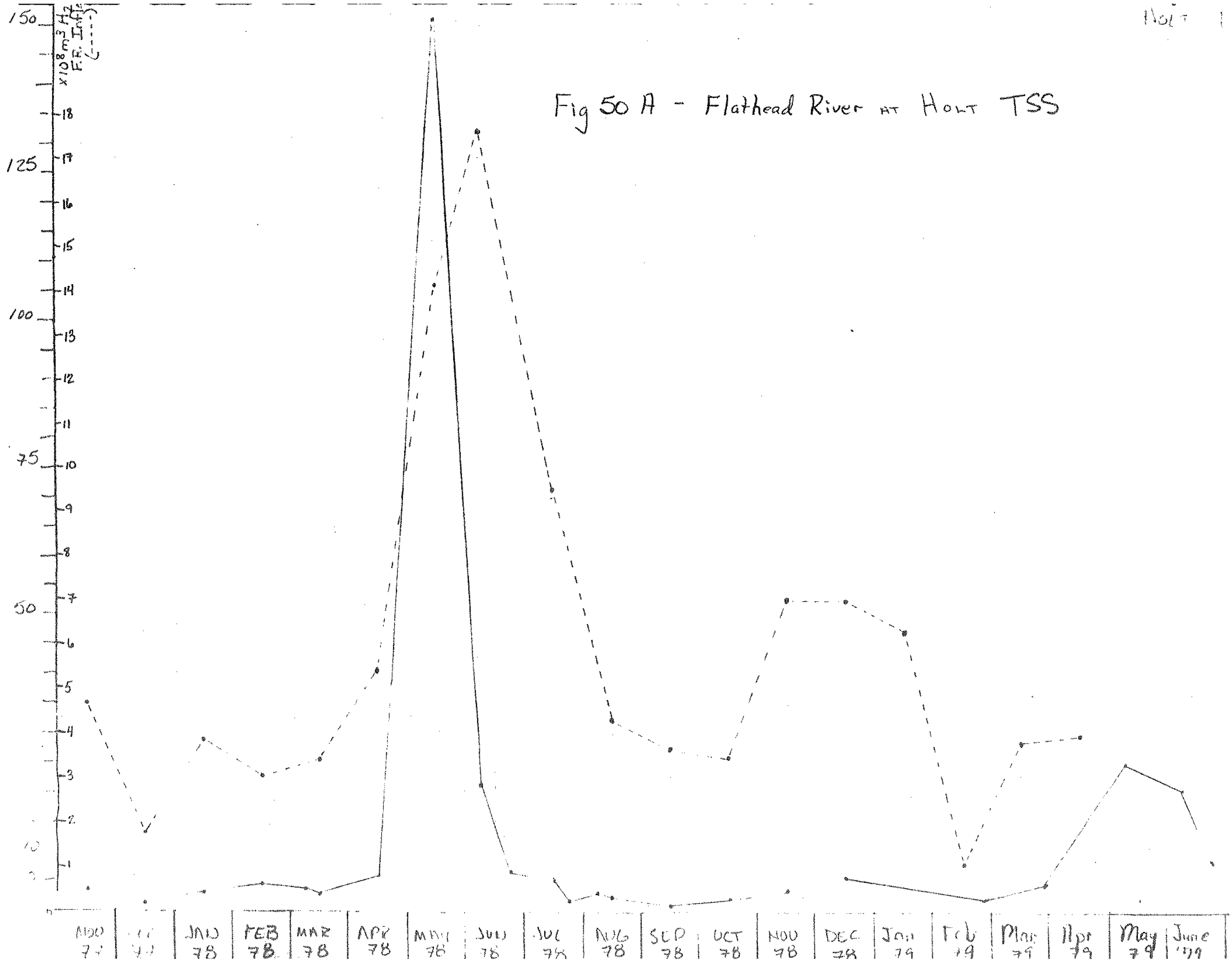
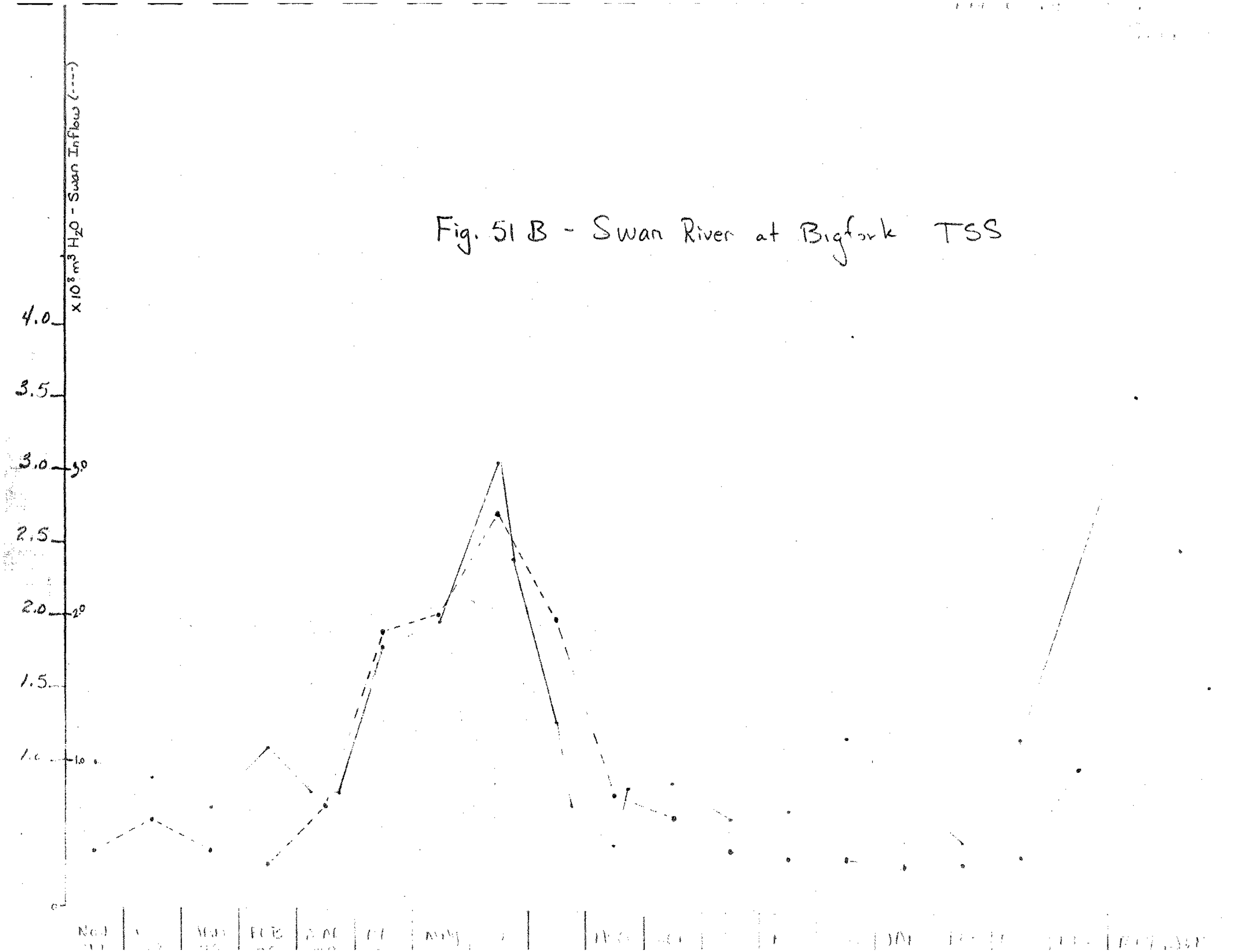


Fig. 51 B - Swan River at Bigfork TSS



Polson TSS

Fig. 52C - Lake Outlet TSS

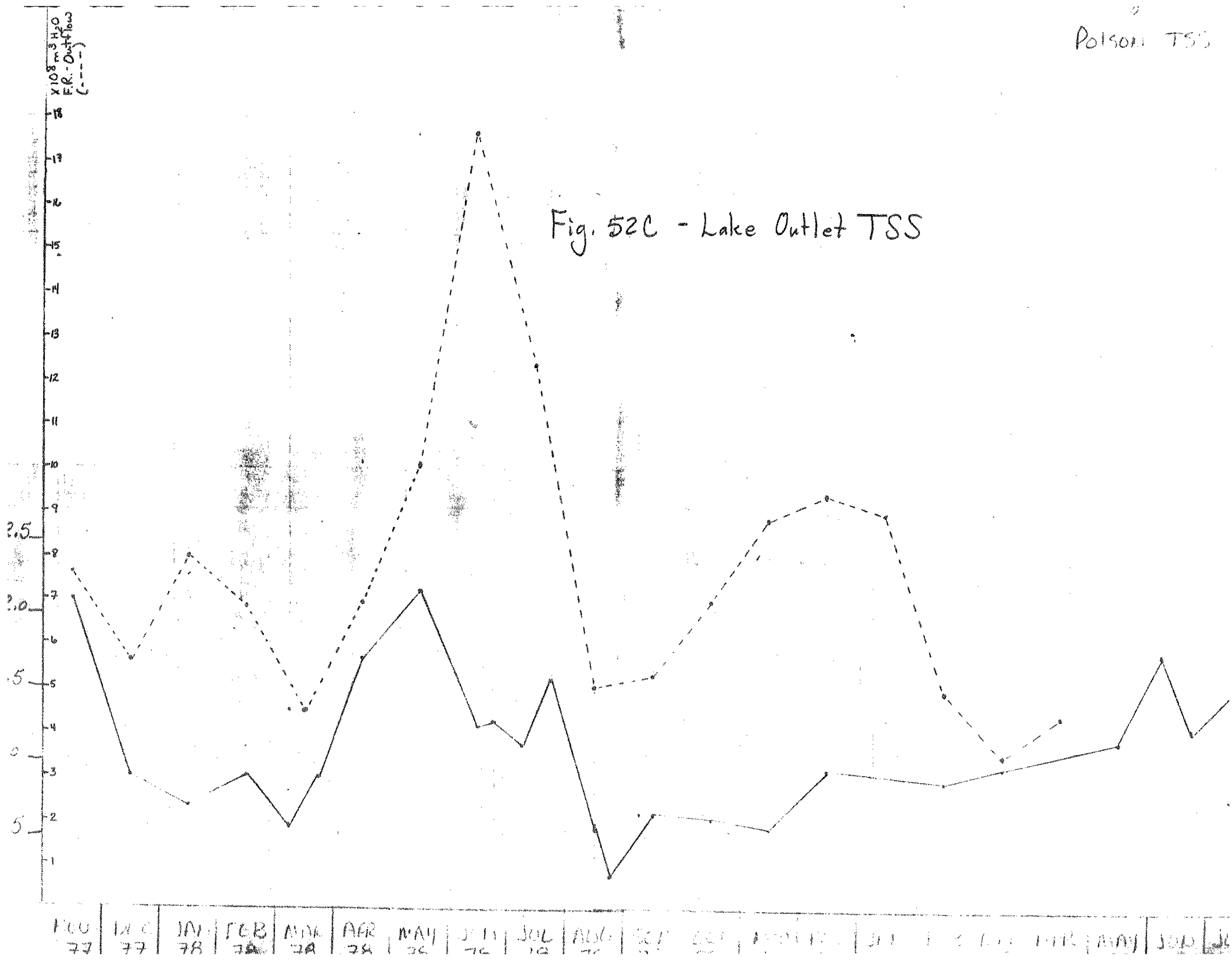


Table 9

...t '77 - May '79 TOC - Budget for Flathead Lake

Date	F.R. - H_2O	F.R.-TOC	Swan - H_2O	Swan-TOC	Total TOC Inflow	Outflow-H_2O	OutFlow-TOC	Total TOC Outfl
	$\times 10^8 m^3$	mg/l $\times 10^5$ kg	$\times 10^8 m^3$	mg/l $\times 10^5$ kg	$\times 10^5$ kg	$\times 10^8 m^3$	mg/l $\times 10^5$ kg	$\times 10^5$ kg
Oct 77	5.44		0.438			7.13		
Nov 77	4.68	1.169 5.47 1.211	0.379	1.209 0.458 1.368	5.93	7.61	1.292 9.83 1.296	9.83
Dec 77	1.74	2.11 1.142	0.625	0.855 1.586	2.97	5.60	7.26 1.018	7.26
Jan 78	3.83	4.37 es-1.099	0.409	0.649 es-1.383	5.02	7.95	8.09 es-1.0375	8.09
Feb 78	3.03	(3.33) 1.174	0.321	(0.444) 1.08 1.28	(3.77)	6.83	(7.09) 1.166 0.948	(7.09)
Mar 78	3.42	0.939 3.61 2.005	0.737	0.870 2.615	4.48	4.50	4.76 1.372	4.76
Apr 78	5.44	10.9 3.072	1.89	4.94 2.314	15.84	6.95	9.54 1.30	9.54
May 78	14.2	43.6 1.751	2.05	4.74 2.656	48.34	10.2	13.3 3.801 1.363	13.3
June 78	17.6	1.446 28.1 1.3707	2.73	1.578 5.78 1.9068	33.88	17.6	45.4 1.4756 0.496	45.4
July 78	9.53	0.519 8.99 0.490	1.99	0.968 2.86 1.025	11.85	12.4	12.2 1.276 0.936	12.2
Aug 78	4.33	0.551 2.25 0.657	0.794	0.762 0.709 1.110	2.96	5.11	5.65 1.375	5.65
Sept 78	3.64	2.39	0.657	0.729	3.12	5.34	7.34	7.34
Oct 78	3.45	0.866 2.99 1.162	0.438	1.232 0.540 1.062	3.53	6.98	1.456 10.2 0.929	10.2
Nov 78	7.05	8.19 1.553	0.368	0.391 1.089	8.58	8.75	8.13 1.022	8.13
Dec 78	6.95	10.8 es-1.4575	0.362	0.394 es-1.0885	11.19	9.43	9.64 es-1.3225	9.64
Jan 79	6.30	(9.18) 1.362	0.336	(0.366) 1.088	(9.55)	9.06	(11.98) 1.625	(11.98)
Feb 79	1.05	1.43 2.0705	0.355	0.386 1.85	1.82	4.97	8.07 1.4325	8.07
Mar 79	3.77	es- (7.81) 2.779	0.402	es- (0.744) 2.612	(8.55)	3.47	es- (4.97) 1.242	(4.97)
Apr 79	3.93	10.9	1.03	2.69	13.59	4.41	5.48	5.48
May 79								
		1.66×10^7 kg		2.85×10^6 kg	1.95×10^7 kg			1.89×10^7 kg

Totals = Nov '77 → Apr. '79

$1.63^{69} \times 10^7$ Kg
Mar '78 → Mar '79
=
16,300 metric Tons

1.51 ... $\times 10^7$ kg
Mar '78 → Mar '79
⇓
15,118 metric Tons

Table 10. P - Budget for Flathead Lake

Oct '77 - Sept '78

Date	F.R.-H_2O	F.R.-P	Swan-H_2O	Swan-P	Total P Inflow	Outflow-H_2O	Outflow-P	Total Outfl
	X 10^8 m^3	µg/l kg	X 10^8 m^3	kg	kg	X 10^8 m^3	kg	kg
Oct 77	5.44		.438			7.13		
Nov 77	4.68		.379			7.61		
Dec 77	1.74	6.1 1061.4	.625	5.3 331.25	1392.65	5.60		
Jan 78	3.83	3.4 1302.2	.409	4.4 179.96	1482.16	7.95		
Feb 78	3.03	3.2 969.6	.321	4.4 141.24	1110.84	6.83		
Mar 78	3.42	3.0 1026.0	.737	3.5 257.95	1283.95	4.50	3 1350.0	1350.
Apr. 78	5.44	15.0 8160.0	1.89	5 945.0	9105.0	6.95	7 4865.0	4865.
May 78	14.2	9.0 12780.0	2.05	10 2050.0	14,830.0	10.2	12 12240.0	12,240.
June '78	17.6	13.0 22,880.0	2.73	9.5 2593.5	25,473.5	17.6	11.3 19888.0	19,888
July '78	9.53	11.0 10483.0	1.99	11.5 2288.5	12,771.5	12.4	11.5 14260.0	14,260
Aug '78	4.33	10.0 4330.0	.794	8.5 674.9	5004.9	5.11	7.5 3832.5	3832
Sept. '78	3.64	8.0 2912.0	.657	9 591.3	3503.3	5.34	8 4272.0	4272.
Oct. '78	3.45	8.0 2760.0	.438	10 438.0	3198.0	6.98	11 7678.0	7678.
Nov. '78	7.05	8.0 5640.0	.368	7 257.6	5897.6	8.75	8 7000.0	7000.
Dec. '78	6.95	12.0 8340.0	.362	11 398.2	8738.2	9.43	8 7544.0	7544.
Jan. '79	6.30	10 6300	.336	10.5 352.8	6652.8	9.06	10 9060	9060
Feb. '79	1.05	8 840.0	.355	10 355.0	1195.0	4.97	12 5964.0	5964.
Mar. '79	3.77	10 3770.0	.402	10 402.0	4172.0	3.47	8 2776.0	2776.
Apr. '79	3.93		1.03		est'd total 101,825.75 for Mar '78 → Mar '79	4.41		est'd tota 100,729. for Mar '7 → Mar '7
May '79								

Totals = Mar '78 → Mar '79

◯ ⇒ Estimates

Table 11. N-Bu[illegible] [illegible] for Flath[illegible] Lake

[illegible] '77 - Sept. '78

Date	F.R.-H_2O	F.R.-N (g/m³)	Swan-H_2O	Swan-N (g/m³)	Total N Inflow	Outflow-H_2O	Outflow-N (g/m³)	Total N Outflow
	$\times 10^8\ m^3$	mg/l Kg	$\times 10^8\ m^3$	mg/l Kg	Kg	$\times 10^8\ m^3$	mg/l Kg	Kg
Oct. '77	5.44	.09 48.96	.435	.085 3.72	52.68	7.13		
Nov. '77	4.68	.175 81.90	.379	.212 8.03	89.93	7.61		
Dec '77	1.74	.174 30.28	.625	.154 9.63	39.91	5.60		
Jan '78	3.83	.214 81.96	.409	.145 5.93	87.89	7.95		
Feb '78	3.03	(.157) (47.57)	.321	(.127) (4.09)	51.66	6.23		
Mar '78	3.42	.100 34.20	.737	.110 8.11	42.31	4.50	.050 22.50 →	22.[illegible]
Apr. '78	5.44	.130 70.72	1.89	.09 17.01	87.73	6.95	.060 41.70 →	41.7[illegible]
May '78	14.2	.13 184.60	2.05	.03 6.15	190.75	10.2	.020 20.4[illegible]	20.4[illegible]
June '78	17.6	.107 188.32	2.73	.06 16.38	204.7	17.6	.105 184.80	184.80
July '78	9.53	.110 104.83	1.99	.08 15.92	120.75	12.4	.115 [illegible]	142.60
Aug. '78	4.33	.09 38.97	.794	.09 7.15	46.12	5.11	.09 45.99	45.9[illegible]
Sept. '78	3.64	.10 36.70	.657	.08 5.26	41.96	5.34	.08 42.72	42.72
Oct. '78	3.45	.08 27.60	.438	.06 2.63	30.23	6.98	.07 [illegible]	48.[illegible]6
Nov. '78	7.05	.06 42.30	.368	(.12) 4.42	46.72	8.75	.17 192.7[illegible]	[illegible]
Dec '78	6.95	.20 139.00	.362	.18 6.52	145.52	9.43	.13 [illegible]	122.5[illegible]
Jan. '79	6.30	(.21) 132.30	.336	(.15) 5.04	137.34	9.06	(.114) 103.2[illegible]	103.2[illegible]
Feb. '79	1.05	.22 23.10	.355	.12 4.26	27.36	4.97	.0[illegible] 42.46	42.46
Mar '79	3.77	.15 56.55	.402	.082 3.29	59.84	3.47	.14 48.58	4[illegible].5[illegible]
Apr. '79	3.93	Total = 2079,190 kg	1.03	Total = 102,140 kg	Total Inflow 2181,330 kg	4.41	Total = 2021,230 kg	Total Outflow 2021,230 Kg
May '79								

Totals = Mar '78 → Mar '79

( ) ⇒ estimates

Total Suspended Solids Budget Mar 78 – Mar 79

Table 12

DATE	F.R. H_2O	F.R. TSS mg/L (g/m³)	Swan H_2O	Swan TSS mg/L (g/m³)	Total TSS Inflow	Outflow	TSS Outflow (g/m³)	Total TSS Outflow
	$\times 10^8 m^3$	$\times 10^9 g$	$\times 10^8 m^3$	$\times 10^9 g$	$\times 10^9 g$	$\times 10^8 m^3$	$\times 10^9 g$	
Oct 77	5.44		.438			7.13		
		3.3		1.0			2.1	
Nov 77	4.60		.379			7.61		
		1.4		.9			.9	
Dec 77	1.74		.625			5.60		
		2.8		.7			.7	
JAN 78	3.52		.409			7.95		
		4.85		1.1			.9	
FEB 78	3.03		.321			6.85		
		3.313		.8			[illegible]	
MAR 78	3.42	1.17 $\times 10^9 g$	[illegible]	.059	1.189	[illegible]	.332	.332
		5.7		1.8			[illegible]	
APR 78	5.44	3.1	1.81	[illegible].34	3.44	[illegible]	1.18	1.18
		151.6		1.970			[illegible]	
[illegible] 78	14.2	215.55	[illegible]	.405	215.95	[illegible]	2.219	2.219
		19.64		2.738			[illegible]	
[illegible] 78	17.6	34.56	2.73	.747	35.31	17.6	2.222	2.222
		3.78		1.013			[illegible]	
[illegible] 78	[illegible]	3.60	1.99	.202	3.802	[illegible]	1.674	1.674
		2.65		.66			[illegible]	
[illegible] 78	[illegible]	1.15	.794	.052	1.202	[illegible]	0.203	.203
		1.75		.80			[illegible]	
[illegible] 78	[illegible]	.637	.657	.058	.695	[illegible]	0.347	.347
		2.45		.65			[illegible]	
[illegible] 78	3.45	.845	.438	.028	.873	[illegible]	0.439	.439
		3.2		.7			.575	
[illegible] 78	7.05	2.256	.360	.025	2.281	[illegible]	0.503	.503
		5.25		1.2			[illegible]	
[illegible] 78	6.75	3.648	[illegible]	.043	3.691	[illegible]	-0.896	.896
		3.75		.85			.413	
[illegible] 79	6.30	2.363	.336	.028	2.391	[illegible]	0.827	.827
		2.25		.5			.575	
[illegible] 79	1.05	.236	.355	.018	.254	[illegible]	0.435	.435
		4.4		1.2			[illegible]	
[illegible] 79	3.77	1.658	.402	.048	1.706	[illegible]	0.329	.329
[illegible] 79	3.93		1.03			4.41		
		24.9		3.55			1.15	
[illegible] 79								
		14.415		2.028			.988	
[illegible]								
		2.30		1.18			[illegible]	
[illegible]								
		270.73 $\times 10^9 g$		2.053 $\times 10^9 g$	Total Inflow 272.78 $\times 10^9 g$		11.606 $\times 10^9 g$	Total Outflow 11.606 $\times 10^9 g$
		270730 metric Tons		2053 metric Tons	272,780 metric Tons		11,606 metric Tons	11,606 metric Tons

The calculated amounts of C, N and P entering Flathead Lake from the two major rivers are only slightly greater than the amounts exiting under Polson birdge (Tables 9, 10 and 11) for the period March 1978 through March 1979.

A basic Flathead Lake water budget for USGS Water Years 1976-1977, 1977-1978 and the early part of 1978-1979 has been tabulated (Table 13).

1 km² = 100,000 m   Table 13

Water Budget for Flathead Lake (m^3/month)

Date	Flathead	Swan	Total	Flathead at Folsom	
Oct 76	5.76×10^8	3.64×10^7	6.12×10^8	5.16×10^8	
Nov 76	2.59×10^8	3.61×10^7	2.95×10^8	6.98×10^8	
Dec 76	5.75×10^8	3.45×10^7	6.10×10^8	7.93×10^8	
Jan 77	3.85×10^8	2.99×10^7	4.15×10^8	8.91×10^8	
Feb 77	2.31×10^8	2.83×10^7	2.60×10^8	5.29×10^8	
Mar 77	2.93×10^8	3.42×10^7	3.27×10^8	4.63×10^8	
Apr 77	5.47×10^8	8.69×10^7	6.34×10^8	3.17×10^8	
May 77	9.05×10^8	1.66×10^8	(= 10.7×10^8) 1.07×10^9	5.93×10^8	
June 77	8.21×10^8	1.43×10^8	9.64×10^8	4.71×10^8	
July 77	5.43×10^8	5.76×10^7	6.01×10^8	5.13×10^8	
Aug 77	5.61×10^8	3.46×10^7	5.96×10^8 670,000,000 m^3	5.44×10^8	
Sept 77	3.37×10^8	3.56×10^7	3.73×10^8 Total = $67.57 \times 10^8 m^3$	4.31×10^8	Total = 67.59×10^8
Oct 77	5.44×10^8	4.38×10^7	5.88×10^8	7.13×10^8	
Nov 77	4.68×10^8	3.79×10^7	5.06×10^8	7.61×10^8	
Dec 77	1.74×10^8	6.25×10^7	2.37×10^8	5.60×10^8	
Jan 78	3.83×10^8	4.09×10^7	4.24×10^8	7.95×10^8	
Feb 78	3.03×10^8	3.21×10^7	3.35×10^8	6.83×10^8	
Mar 78	3.42×10^8	7.37×10^7	4.15×10^8	4.50×10^8	
Apr 78	5.44×10^8	1.89×10^8	7.33×10^8	6.95×10^8	
May 78	1.42×10^9	2.05×10^8	(16.2×10^8) 1.62×10^9	(10.2×10^8) 1.02×10^9	
June 78	1.76×10^9	2.73×10^8	(20.3×10^8) 2.03×10^9	(17.6×10^8) 1.76×10^9	
July 78	9.53×10^8	1.99×10^8	(11.5×10^8) 1.15×10^9	(12.4×10^8) 1.24×10^9	
Aug 78	4.33×10^8	7.94×10^7	5.13×10^8	5.11×10^8	
Sept 78	3.64×10^8	6.57×10^7	4.30×10^8 89.81 $\times 10^8 m^3$	5.34×10^8	97.22 $\times 10^8 m^3$
Oct 78	3.45×10^8	4.38×10^7	3.89×10^8	6.98×10^8	
Nov 78	7.05×10^8	3.68×10^7	7.42×10^8	8.75×10^8	
Dec 78	6.95×10^8	3.62×10^7	7.31×10^8	9.43×10^8	

Water Budget for Flathead Lake (m^3/month)

Date	Flathead	Swan	Total	Flathead at Polson
Jan 79	6.30×10^8	3.36×10^7	6.64×10^8	9.06×10^8
Feb 79	1.05×10^8	3.55×10^7	1.41×10^8	4.97×10^8
Mar 79	3.77×10^8	4.02×10^7	4.17×10^8	3.47×10^8
Apr 79	3.93×10^8	1.03×10^8	4.96×10^8	4.41×10^8
			Total = $35.8 \times 10^8 m^3$	Total = $47.07 \times 10^8 m^3$
May 79	2.07×10^9			

Mar '78 → Mar '79

Inflows	Outflow
$99.75 \times 10^8 m^3$	$104.76 \times 10^8 m^3$

DISCUSSION

Two major periods of high plankton productivity and biomass were evident in the pelagic zone of Flathead Lake during Spring and Summer 1978. The first major productive period is suspected of being a normal vernal diatom pulse during which time the Midlake water column was characterized by low turbidity, high suspended solids with relatively low organic content and yet a relatively high biomass. This biomass pulse occurred after Spring 1978 mixing and warming of the water column. The Spring 1978 concentrations of phosphorus increased by more than 100 percent during the period in question, while concentrations of Nitrogen decreased. By late May the biomass and primary productivity had substantially decreased and the water column was becoming thermally stratified.

The Flathead River reached maximum flow stage during June 1978 but had contributed a large load of primarily inorganic sediments to the north end of the lake by that time. The turbidity plume which flowed across the Midlake station in mid-June 1978 settled through the water column by the middle or end of July. During the turbidity advent and sinking period at Midlake, which was very light compared to that of 1974, the trophogenic zone exhibited increased biomass and productivity until 15 August 1978.

Inflowing turbid waters which spread to the Midlake station coincide with a rise in Phosphorus concentration in the water column during early Summer 1978. In late Summer, phosphorus concentrations decreased by more than 100 percent from previous highs of 14 ug/l to low concentrations of of less than 6 ug/l. No analyses of particulate [P] or [N] have been made so far, therefore we know very little about the relative amounts of these nutrients associated with suspended particles through the Summer. So far our field data do not support a "nutrient stripping" type relationship between sedimenting inorganic TSS and Phosphorus in the pelagic water column, either because it didn't exist or because our detection limits for Phosphorus and TSS are causing precision problems with our data. It is presently an unexplained coincidence that an increase of TSS in April 1978 also corresponds to a rise in $\overline{x}$ water column [P], and that the inverse occurs in late August 1978. Budgets calculated for [P] inflow and outflow data suggest that the lake lost (101 metric tons) an amount of P roughly equivalent to what it gained (102 metric tons) from March 1978 to March 1979 (Table 10). However, during the same time period the two riverine sources contributed approximately 261,174 metric tons (Table 12 and Figure 50) of largely inorganic sediments which were not lost through outflow. Thus, during the period March 1978 to March 1979, the lake very definitely acted as a sediment trap (Figure 51).

Suspended particles in the Trophogenic zone of the Midlake water column were found to be different in quality and quantity from those in the deeper tropholytic zone. Trophogenic zone particulates were present in greater quantity, contained more organic material and ATP, and were also composed of a relatively greater percentage of organic and living materials than particles in the lower 50 meters of the water column.

Particles sampled from the water column often exhibited the following trends with increasing depth:

- loss of weight (Table 3);
- reduction in associated organic matter (Figure 52);
- reduction in biomass (ATP) content (Figures 52 and 53).

In general, it appeared that particles sedimenting through the water column were being mineralized in route toward the bottom sediments. The preceding trends were generally more pronounced during periods of water column stratification and tended to be disrupted during periods of mixing in Fall and Spring.

The estimated allocthanous contribution of organic C to the lake by both major rivers is 16,369 metric tons (March 1978 to March 1979). In contrast, the estimated contribution by autocthanous production is 73,043 metric tons during the same time period (Figure 51).

Positive correlations of Phosphorus concentration with inflow volumes suggests that Phosphorus may be physically linked with sediments or some other parameter which is positively correlated with river flow. Negative correlation of Nitrogen concentrations and inflow volumes suggest a diluting effect. Nitrogen inputs from the drainage may be primarily via soluble forms in ground water. Ground waters may be either diluted with fresh snowmelt or rain water, or their flow into the main river channels may be altered during high runoff periods.

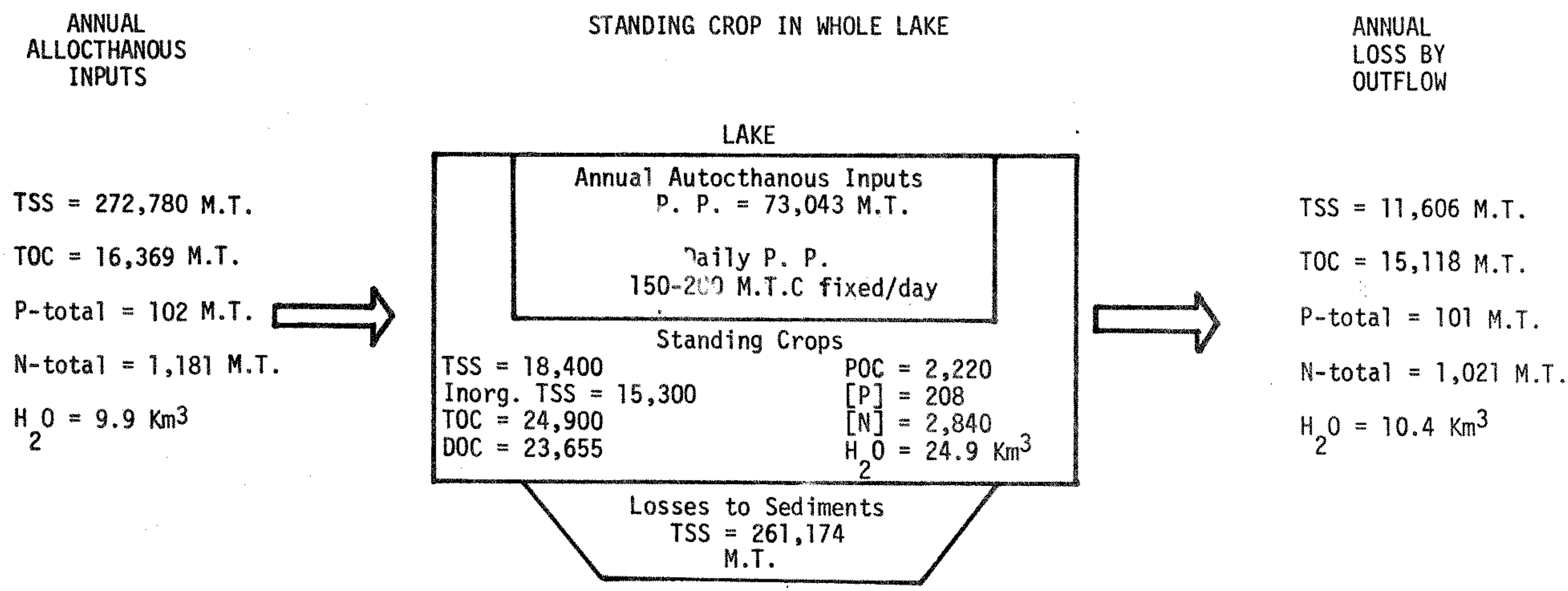


Figure 51. Budgetary Aspects for Flathead Lake
March '78 to March '79
(M.T. = Metric Tons)

FIG. 52- PRIMARY PRODUCTION, ATP, TSS ORGANIC CONTENT ON 30/VI/78

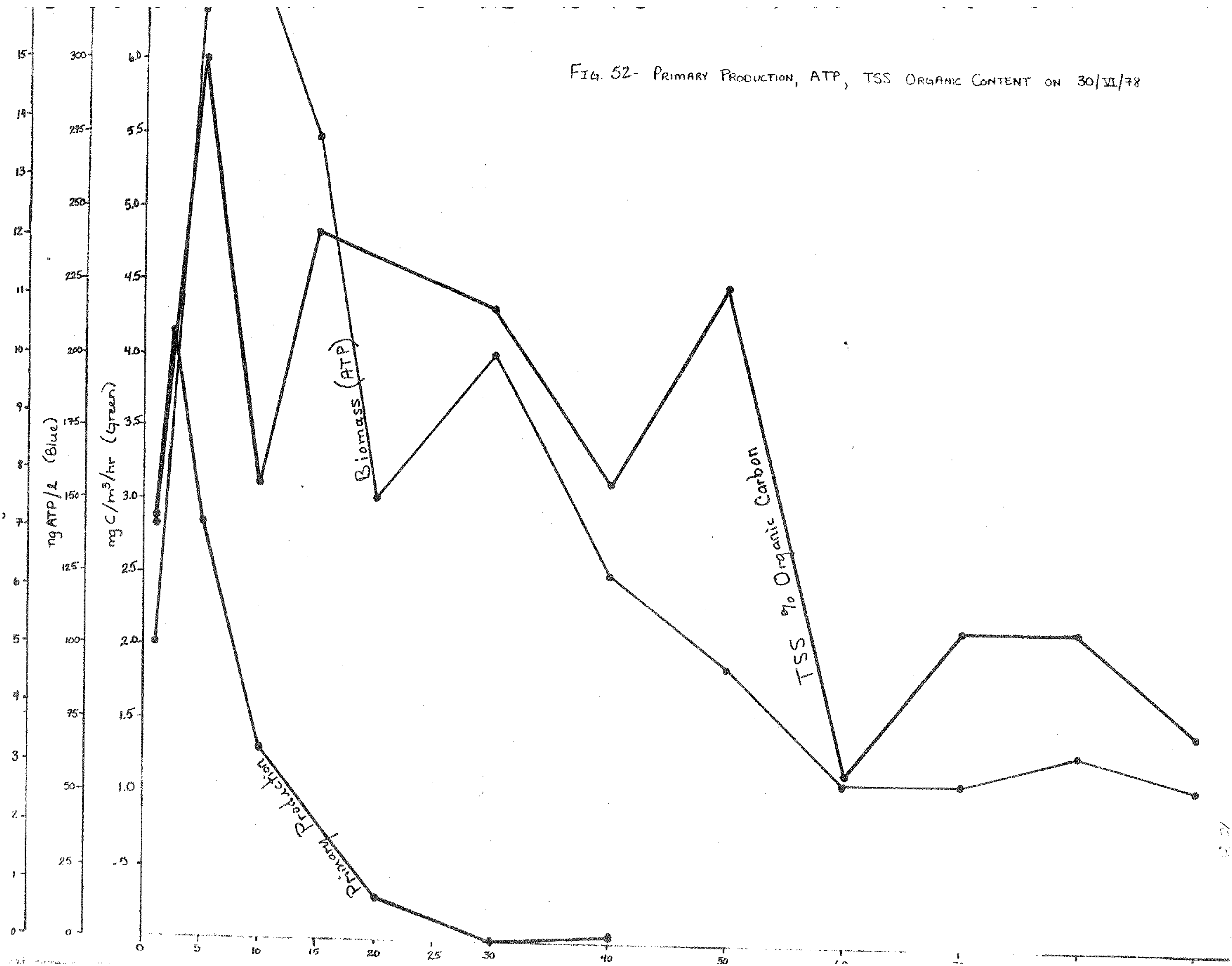
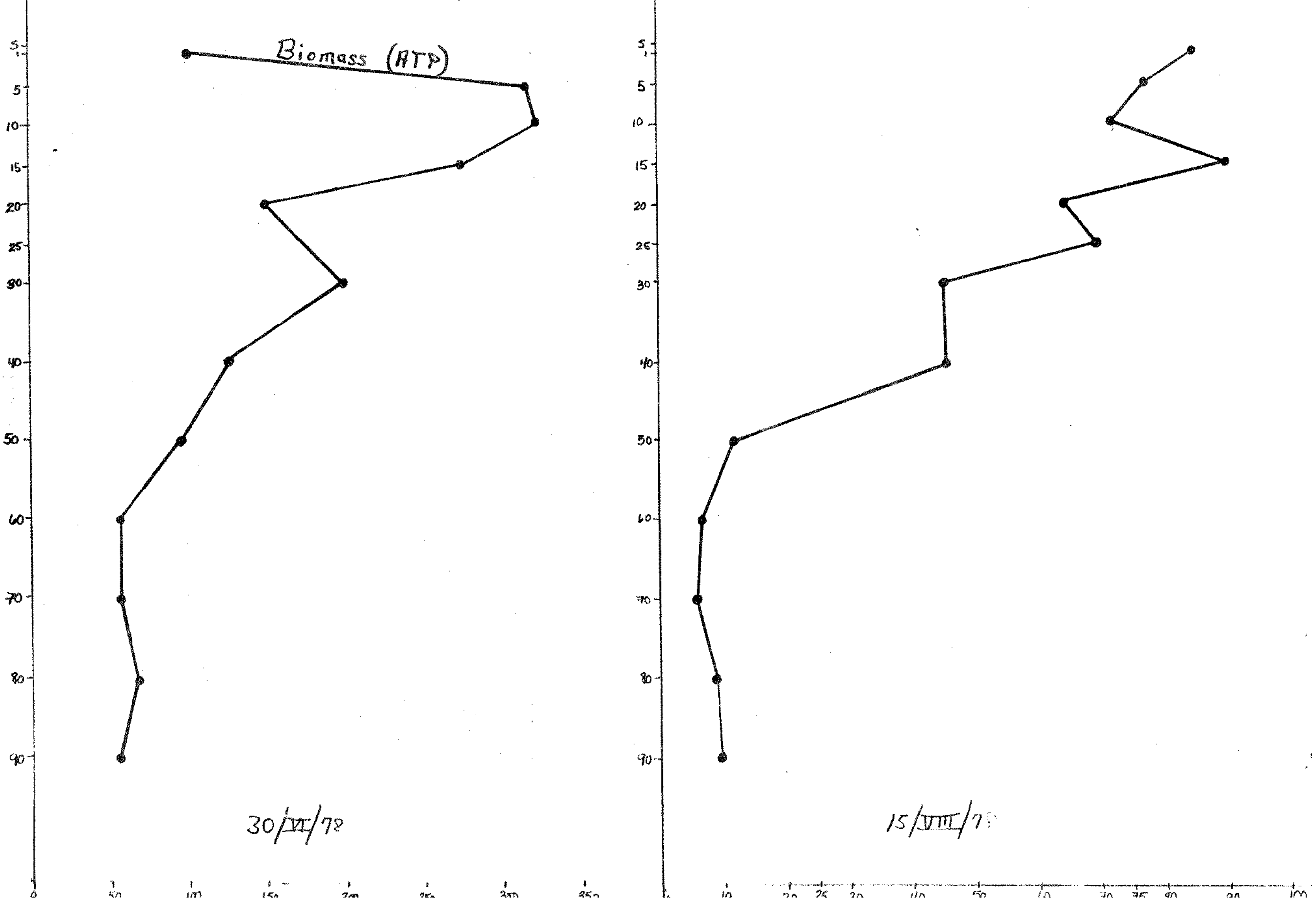


Fig. 53 - ATP Trends In A Stratified Water Column



PRELIMINARY CONCLUSIONS

The results presented in the previous sections indicated that primary production and biomass of pelagic plankters continued to increase after the advent of Spring turbidity at Midlake during 1978. No significant stripping of phosphorus or nitrogen was demonstrated from either the trophogenic zone or the entire water column when the turbidity cleared and the biomass and productivity decreased in late summer. Analysis of suspended particulates in the water column seemed to indicate a trend toward mineralization and recycling of their organic content and decreasing biomass content with increasing depth (Figures 52 and 53).

It appeared that essential nutrients in the water column were being recycled rapidly by the planktonic biomass. Standing crops of water, Phosphorus and Nitrogen were each present in amounts equal to two to three times the known allocthanous inputs, and were imported to and exported from the lake in practically equivalent amounts from March 1978 through March 1979.

Substantial amounts of inorganic erosional materials were trapped in the lake basin during the thirteen months thus far surveyed, just as they were in 1973-74. However, the allocthanous contribution of inorganic sediments in the 1973-74 study was apparently several times greater than during the Summer of 1978. Submarine light transmission and secchi disc data suggest that during runoff suspended sediments were 5 to 10 times more concentrated at Midlake in 1974 compared to 1978.

It is possible that a substantially different regime resulted in less suspended sediment being flushed across Midlake in 1978. Lower

TSS values measured during the present study may not have been sufficient to promote the hypothesized flocculation-stripping action in the water column. Thus, we will monitor effects of the spring, 1980, turbidity plume and conduct experimental work outlined below prior to concluding that the working hypothesis is, in fact, false.

LAKE SYNOPTIC

We presented plans in our first progress report (29/I/79) to conduct intensive, short-term study of comparative primary productivity of plankton at multiple sites on Flathead Lake. These synoptics were designed to illucidate which areas of the lake, if any, were most productive, thereby identifying areas potentially undergoing chronic cultural eutrophication.

The first of these whole-lake studies was conducted on 11/VIII/79. Data are not yet available. Additional synoptics will be conducted in the fall, 1979 and spring, 1980.

TIME FRAME AND RESEARCH PLAN

Research on the lake has proceeded basically on schedule, except that water samples for chemistry samples are backlogged from April, 1979. These will be cleared shortly by ion chromatography analysis. Also, we have not completed phytoplankton and zooplankton counts from field samples. These data, however, are low priority in terms of research objectives.

The lake research will continue on its present course, although field efforts during mid-winter will be minimized in favor or intensive sampling during spring, 1980 runoff. We will also initiate analysis of periphyton production at selected locations around the lake and in conjunction with synoptic studies.

The major thrust of our research effort on Flathead Lake, after September 1979, will encompass planning and initiation of experimental work. In order to shed additional light on the field derived relationships between plankton biomass, clays, and phosphorus, we intend to place several polyethylene enclosures in Yellow Bay. Known amounts of sediments and nutrients will be added to simmulate enhanced spring conditions. The effects of these experimental manipulations on the enclosed natural plankton populations will be closely monitored. Results will be extrapolated to field conditions. These data will be coupled with laboratory study of phosphorus sorption on clay sediments from the drainage basin. In this way, we hope to get a better picture of phenomena controlling primary productivity in the lake.

V. FLATHEAD CREEKS STUDY

The Flathead Research Group initiated study of limnology of selected tributary creeks (see Figure 1) in the Flathead River drainage in July,1979. The objective of this work is to document baseline physiochemical conditions in these important tributaries and provide initial data on benthic ecology in Trail, Kintla, Logan, Dolly Varden and McDonald Creeks. All of these streams were selected for study because they seem representative of those in geographical regions of the basin.

METHODS

Samples are obtained on a monthly schedule on all except the remote creeks (e.g. Dolly Varden). Field measurements of pH, conductivity, dissolved oxygen and discharge are gathered; samples for laboratory analysis of chemical parameters (i.e. TSS, C, N, P, Cu, Zn, Na, Fe, K, Mo, SiO_2, Ca, Co, Mn) are also collected and returned to UMBS for analysis.

For benthic samples, we employ the same procedures used in our riverine studies.

PRELIMINARY RESULTS

Initial results indicate significant differences between creeks in ion chemistry. For example, the streams draining the Flathead National Forest on the west side of the North Fork are more buffered than the streams draining Glacier National Park on the east side of the river (Table 14).

Table 14. Field physicochemistry of North Fork Tributary Streams.

	pH	Alkalinity (ppm)	Conductivity (umho cm^{-2})	Maximum °C (Aug)
GLACIER NATIONAL PARK				
Kintla Creek	8.1	21	80	19-21°
Quartz Creek	7.6	19	60	19-21°
McDonald Creek	7.9	23	70	19-21°
FLATHEAD NATIONAL FOREST				
Trail Creek	8.2	42	100	12°
Whale Creek	8.3	56	150-190	14°
Big Creek	8.0	56	150	16°

The Glacier Park streams drain mostly argilite formations that contribute few ions to solution. They also all flow through various natural lakes which tend to trap dissolved solids as well as elevate thermal regima. Streams on the National Forest side drain exposed limestone formations and do not flow through lakes. They are also shaded from afternoon solar insulation and the resultant thermal regime is much lower. The faunal response to these profound differences in physicochemistry is presently incomplete; but, in general, riverine forms are found in the Glacier Park streams, while the colder streams on the forest side of the North Fork contain specific, stenothermic forms.

The most significant, early conclusion from these data, however, relates to the poor buffer system in the very pure waters of Glacier National Park. These streams and alpine lakes contain very little inherent resistance to pH change. Perturbations promoting acid rain, such as smoke plumes from coal-burning power plants, would have an immediate, devastating effect on these waters by reducing pH to lethal levels.

TIME FRAME AND RESEARCH PLAN

We will continue sampling physicochemical parameters monthly and with greater emphasis on benthic ecology during spring, 1980 including comparative estimates of benthic primary productivity in those streams selected for more intense study (e.g. Trail, Kintla, McDonald).

VI. RELATED STUDIES

It has been the policy of the Flathead Research Group to involve interested colleagues in research efforts ancillary to the major objectives of the project. Someof these efforts involve researchers that have been members of the group for some time (e.g. Zimmerman, Shelton) and our joint work is nearly completed. Others have only recently become involved (e.g. Busby, Mills, Drenner, Vinyard) and studies are preliminary or planned.

SIZE FRACTIONATION STUDY OF METABOLICALLY ACTIVE PLANKTON

The objectives of this work are to measure rates of autotrophy and microbial heterotrophy simultaneously in the water column of oligotrophic Flathead Lake and hyper-eutrophic Lake Texoma. These data provide great insight into the attachment of microbes to detrital particles and algae and the amount of carbon processed through autotrophic versus heterotrophic pathways. The procedures involve use of radioactive tracers in samples incubated in situ and ultra-precise analysis of microbial standing crops using scanning electron microscopy and ATP assays. This work has been conducted by Bonnie K. Shelton in collaboration with other members of the group and has contributed to our understanding of the rate of microbial decomposition of detrital particles in Flathead Lake. The research project will be completed by December, 1979.

ECOLOGY OF KINTLA CREEK, GLACIER NATIONAL PARK

Kintla Creek originates on the continental divide in Glacier National Park. In collaboration with Dr. Earl Zimmerman (NTSU), we have documented physicochemical benthic community composition, plankton limnology, and fish distribution in this important creek-lake system. This work is nearing completion and will be a part of the Proceedings of the Second Symposium on Research in National Parks. Major findings include 1) discovery of specific altitudinal distribution of insect fauna, apparently in response to changing thermal regima as the stream flows through lakes on its course to the North Fork; and, 2) documentation of an isolated, genetically-segregated population of Dolly Varden in Upper Kintla Lake that are non-pisciverous, rather feeding exclusively on gammarid amphipods.

FISH FEEDING STUDIES IN FLATHEAD LAKE

Drs. Ray Drenner (Texas Christian University) and Gary Vinyard (University of Nevada at Reno) have developed a unique videographic technique for studying feeding behavior in fish. With the help of Delano Hanzel (MDFW&P), these researchers have begun study of planktiverous fishes in Flathead Lake. Preliminarily, they have found that Kokanee salmon are rather inefficient feeders on certain lake zooplankters (e.g. copepods), while Yellow Perch are significantly more efficient. Both species were found in high numbers in pelagic areas of the lake. This may suggest an important competitive interaction is occurring. Additional work, coupled with our limnological studies, during summer, 1980 should help delineate such relations.

BASELINE ANALYSIS OF CARCINOGENS

Known carcinogenic pollutants are present in all fossil fuel formations and in fly ash and smoke from coal burning power plants. Certain mixed function oxygenase enzymes (e.g. cytochrome P-450 and related aryl hydrocarbon hydroxylases (AHH)) can activate these carcinogens in specific metabolic pathways in organisms and man. Dr. David Busbee (NTSU) has shown that measurement of AHH levels in environmental samples (e.g. water sediments, fish) can be related to the potential for cancer if hydrocarbon pollutants (e.g. benzo (a) - pyrene, chaysene, benzanthrocene) are also present. The higher the AHH levels in the presence of these hydrocarbons, the higher is the occurance of cancers.

The Flathead Basin should be relatively free of hydrocarbon pollution at present. However, it would be quite valuable to establish a baseline of AHH in fish before possible pollution occurs. Dr. Busbee has offered to measure the amounts of AHH in fish from various points in the Flathead using procedures that he has pioneered. He will also quantify concentrations of polynucleur aromatic hydrocarbons (PAH) in water and sediments from the same localities using high pressure liquid chromatography analysis. The questions of interest include: 1) are these compounds present in measurable concentrations; and 2) what is the potential for harmful effects at measured and future levels? The preliminary work will be completed by spring, 1980.

LIMNOLOGY OF HUNGRY HORSE RESERVOIR

Ms. Kim Mills recently joined the Flathead Research Group and will begin limnological investigations in Hungry Horse Reservoir in spring, 1980 using methodology presently in use on Flathead Lake. This study will greatly aid the ongoing efforts to access the effects of discharges from the reservoir on downstream biota (see below). At present we do not have funding for Mills' work.

VII. COOPERATIVE STUDIES ON STREAM REGULATION WITH MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

FUNDING AND PERSONNEL

Studies funded by the Bureau of Reclamation and Army Corps of Engineers will investigate the effects of stream regulation on benthic invertebrates and fish in the Flathead and Kootenai Rivers. The Department of Fish, Wildlife and Parks is the lead agency for this work, and Ms. Sue Appert is employed to direct the limnological investigations. She is also a member of the Flathead Research Group and the work is closely interfaced with ongoing riverine studies.

OBJECTIVES AND METHODS

The objectives of the study are to illucidate effects of releases from Hungry Horse Dam and Libby Dam on the downstream aquatic invertebrates; to document post-impoundment changes in the species diversity and biomass of all taxonomic groups of benthic invertebrates in the Flathead and Kootenai Rivers, and to assess the probable effects of construction of the Hungry Horse and Libby re-regulatory dams on the aquatic invertebrates and chemical limnology of the Flathead and Kootenai Rivers. Changes in the life histories of benthic insects due to temperature and flow variations in the regulated areas of the Flathead River are being compared to similar responses in unregulated sections of that river (i.e. McDonald Creek and Swan River).

Monthly benthic invertebrate and water samples (for chemical analysis) will be taken on the Flathead River just above the mouth of the South Fork, at the Bible Camp and Hungry Horse, at the Kokanee Bend Fishing Access, and at the Quarter Circle Bridge on McDonald Creek (work commenced in July, 1979). Five sites on the Kootenai River downstream from Libby Dam will be sampled monthly (or bimonthly during the months when high flows necessitate cooperation from the Corps in providing controlled releases) beginning in September, 1979. The upper South Fork and upper McDonald Creek will be sampled periodically. Benthic invertebrate sampling methods will include the use of a kick net, two different modified Knapp-Waters circular samplers, drift nets, elutriation pumps, drag gear, basket samplers, and scuba gear for collecting in runs and deep pools. All invertebrates will be identified to the lowest taxonomic level possible, counted, and volumetric measurements will be made. Species diversity and biomass estimates will be made using computer programs at Montana State University at Bozeman.

The effects of various discharge rates from the dam on the drift of invertebrates will be assessed. The species of insects most affected by regulation will be selected for life history and experimental studies. These species will be reared under various temperature regimes to study the effects on growth rates and emergence times. Transplant experiments will be done in the field to study the effects of moving insects from un-regulated to regulated areas and vice versa. Adult insects will be collected by the use of light traps, pit traps, emergence traps, and sweep nets to document the effects of changed thermal environments on emergence times. Fish food habits will be studied on each river to tie the invertebrate work to fisheries studies being done under the same grants. Physical, chemical, and biological data will be integrated and correlations will be drawn. Differences in the benthic invertebrate composition in the two regulated rivers and between regulated and unregulated sections of the Flathead River will be assessed using principal components and canonical analysis.

VIII. SCIENTIFIC CONTRIBUTIONS OF THE FLATHEAD RESEARCH GROUP DURING BUDGET PERIOD

Perry, W.B. and J.A. Stanford. In manuscript. Flathead Lake, Montana: availability of sediment phosphorus to algae.

Perry, W.B., J.T. Boswell and J.A. Stanford. In press. Critical problems with adenosine triphosphate (ATP) assays of planktonic biomass. Hydrobiologia 59.

Ward, J.V. and J.A. Stanford. In press. Limnological considerations in reservoir operation: optimization strategies for protection of aquatic biota in the receiving stream. Proc. Mitigation Symposium. Tech. Report Series. Rocky Mtn. Forest and Exper. Station.

Stanford, J.A. In press. Proliferation of river deltas in reservoirs: a natural mitigative process? Proc. Mitigation Symposium. Tech. Report Series. Rocky Mtn. Forest and Exper. Station.

Ward, J.V. and J.A. Stanford. 1979. Ecological factors controlling stream zoobenthos with emphasis on thermal modification of regulated streams. In: J.V. Ward and J.A. Stanford (eds.) Ecology of Regulated Streams. Plenum Press, New York, N.Y.

Stanford, J.A. and J.V. Ward. 1979. Stream regulation in North America. In: J.V. Ward and J.A. Stanford (eds.) Ecology of Regulated Streams. Plenum Press, New York, N.Y.

IX. CHEMICAL DATA COLLECTED TO DATE

FLATHEAD RIVERS: Pgs 115 to 121 .

FLATHEAD LAKE: Pgs 122 to 156 .

FLATHEAD PROJECT - CHEMICAL DATA

	6/VI/78	22/VI/78	19/VII/78	9/VIII/78	13/IX/78	18/X/78	25/XI/78	27/XII/78	23/I/79	19/II/79	17/III/79	25/IV/79	9/V/79	25/V/79	17/VI/79	5/VII/79	
NTSU NO.			7300	7309	7318	7325	7332	7339	7349	7356	7363	7373	7380	7392	7400	7407	
pH	7.3*	8.1*	8.0*	7.9*	8.0*	7.3*	6.59*	7.1*	7.3*	7.2*	7.1*	8.0*	7.3*	8.0*	7.0*	8.5*	
TEMP	7	11	10	17	9	5.5	1	0	0	0	2	3	3.8	5.8		14.7	°C
COND.	110*	140*	148*	170*	160*	205*	245*	252*	274*	177*	233*						
TSS	325	14.1	11.5	1.0	2.0	.5	3.1	1.0	1.9	1.9	2.3	4.8	22.5	277	3.5		mg/l
POC	4.49	.359	.488	.266	.145	.119	.286	.071	.089	.097	.091		.434	3.83	.229	.163	mg/l
DOC	3.68	1.61	1.22	2.09	.633	.568	.542	.531	.357	.171	.278		2.35	2.70	.660	.523	mg/l
TOC	8.17	1.97	1.71	2.36	.778	.687	.928	.602	.446	.268	.369		2.78	6.53	.889	.686	mg/l
TP	7	15	11	7	10	8	8	10	10	10	5						mg/l
TKN	90	110	50	70	90	40	**	80	100	70	70						ug/l
NO_3^-N	30	90	**		30	**	**	50	70	80	50						ug/l
SiO_2	5.7	5.8	4.9	4.8	5.3	4.9	1.3	6.7	5.4	3.6	4.9						mg/l
Ca					41	55	43	50	40	20	39						mg/l
Mg					7.6	7.8	8.8	6.0	5.0	5.0	8.8						mg/l
Na					1.2	1.4	1.5	1.5	1.8	1.6	1.2						mg/l
K					0.3	0.3	0.4	0.4	0.4	0.3	0.3						mg/l
Co					**	8	12	**	11	**	62						ug/l
Cu					**	**	2	**	**	**	**						ug/l
Fe					**	200	190	**	**	**	**						ug/l
Mn					**	6	6	**	**	**	2						ug/l
Mo					**	**	**	**	**	**	**						ug/l
Zn					**	**	**	**	**	**	**						ug/l
SO_4		40	61	122	89	114	133	197	350	187	193						mg/l

* Laboratory Measurements
** Below Detection Limits

NORTH FORK FLATHEAD RIVER
(Polebridge)

FLATHEAD PROJECT - CHEMICAL DATA

	6/VI/78	21/VI/78	6/VII/78	19/VII/78	15/VIII/78	13/IX/78	18/X/78	25/XI/78	27/XII/78	23/I/79	19/II/79	17/III/79	23/IV/79	9/V/79	25/V/79	17/VI/79	17/VII/79	
NTSU NO.				7302	7311	7320	7327	7334	7341	7351	7358	7365	7375	7382	7394	7402	7409	
pH	7.2*	8.1*	8.0*	7.8*	7.9*	8.0*	7.2*	8.0*	8.2*	7.1*	7.2*	7.4*	7.9*	7.4*	7.8*	7.4*	8.0*	
TEMP	8	10	10	11	17	8	5.2	1	0	0	0	2	3	5.2	6.2		13.9	°C
COND.	124*	140*	130*	155*	185*	180*	198*	172*	175*	333*	198*	239*						
TSS	377	31.5	22.3	4.7	1.1	2.2	1.0	.9	.3	2.4	16.1	6.6	3.1	13.7	314	6.4	.163	mg/l
POC	5.08	.313	.599	.227	.176	.082	.068		.085	.105	.282	.137		.163	2.10	.199	.523	mg/l
DOC	3.30	1.79	2.47	1.47	1.12	.183	.135	.469	.422	.392	.166	.445		1.42	2.54	.826	.686	mg/l
TOC	8.28	2.00	3.07	1.70	1.30	.265	.203		.507	.497	.448	.582		1.58	4.64	1.03		mg/l
TP	6	12	15	11	8	8	2	20	10	8	12	9						mg/l
TKN	90	120	40	20	60	40	**	**	40	80	60	70						ug/l
NO_3^-N	110	130	10	**	40	30	40	40	90	50	40	70						ug/l
SiO_2	7.7	5.6	4.8	5.1	5.5	5.1	4.6	4.8	4.3	4.8	4.2	4.6						mg/l
Ca						35	39	41	40	37	30	41						mg/l
Mg						8.9	9.4	9.4	4.0	10.0	5.0	9.9						mg/l
Na						1.2	1.5	1.7	1.3	2.2	2.0	1.2						mg/l
K						0.4	0.4	0.8	0.3	0.4	0.4	0.4						mg/l
Co						**	10	11	13	20	29	55						ug/l
Cu						**	10	**	**	**	**	**						ug/l
Fe						**	49	**	90	**	150	20						ug/l
Mn						**	3		**	**	5	3						ug/l
Mo						**	5	1	**	**	**	**						ug/l
Zn						**	**	**	**	**	**	**						ug/l
SO_4		42	38	58	109	96	123	98	140	193	136	165						mg/l

* Laboratory Measurements
** Below Detection Limits

MIDDLE FORK FLATHEAD RIVER
(Walton Ranger Station)

	13/III/78	30/III/78	19/IV/78	7/V/78	6/VI/78	22/VI/78	2/VII/78	19/VII/78	15/VIII/78	18/VIII/78	22/VIII/78	13/IX/78	18/X/78	24/XI/78	27/XII/78	24/I/79	19/II/79	17/III/79	23/IV/79	9/V/79	25/V/79	17/VI/79	17/VII/79	
NTSU NO.								7303	7312	7317		7321	7328	7335	7342	7352	7359	7366	7376	7383	7395	7403	7410	
pH	7.0*		8.0*	8.0*	7.2*	8.1*	7.8*	8.2*	8.0*	8.0*		8.0*	7.3*	6.9*	7.1*	7.2*	7.1*	7.4*	7.9*	7.3*	7.6*	7.5*		
TEMP	2	4	3	4	8	10	11.5	11	17	17	17	8	5.5	1	0	0	.5	2	3.5	5.2	6.2		14.0	oC
COND.	140*		150*	114*	110*	130*	130*	122*	150*	128*		140*	183*	177*	179*	314*	176*	228*	182*					
TSS	1.1	89.1	4.9	23.4	800	56.9	39.5	6.0	1.2	1.8	1.1	5.3	.4	1.1	.8	2.6	2.7	7.3	5.9	51.0	637	17.2		mg/l
POC	.085		.085	.239	7.68	.611	.750	.232	.182			.146	.064	.235	.035	.079	.092	.148	.087	.377	3.44	.246	.262	mg/l
DOC	.185		1.09	1.46	2.94	1.52	1.20	.830	.640			.056	.039	.569	.262	.459	.136	.259	.771	1.36	2.12	.505	.337	mg/l
TOC	.270		1.18	1.70	10.6	2.13	1.95	10.6	.822			.202	.103	.804	.297	.538	.228	.407	.858	1.74	5.56	.751	.599	mg/l
TP	11		17	15	10	8	10	9	7	9		7	12	11	10	10	12	9	8					mg/l
TKN	40		20			40	50	30	40	40		30	30	40	50	80	60	90	80					ug/l
NO_3^-N	150		140	170	120	60	40	50	60	60		100	50	40	110	40	50	50	70					ug/l
SiO_2	6.0		4.5	5.1	8.3	4.7	4.7	4.3	4.0	4.0		4.3	5.0	4.9	4.2	5.5	2.2	4.6	4.8					mg/l
Ca												25	35	41	40	32	30	39	32					mg/l
Mg												6.4	8.2	7.8	4.0	8.6	4.0	8-9	7.2					mg/l
Na												1.5	1.5	1.4	1.7	1.9	1.5	1.2	1.6					mg/l
K												0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.3					mg/l
Co												**	8	9	16	47	**	42	**					ug/l
Cu												**	**	**	**	**	**	**	**					ug/l
Fe												**	79	24	85	**	**	64	**					ug/l
Mn												**	3	7	**	11	**	4	**					ug/l
Mo												**	1	**	**	**	**	**	**					ug/l
Zn												**	**	**	**	**	**	**	**					ug/l
SO_4						26	27	29	60	65		51	50	46	72	71	74	90	76					mg/l

*Laboratory Measurements
** Below Detection Limits

MIDDLE FORK FLATHEAD RIVER (McDonald Creek)

	7/V/78	6/VI/78	21/VI/78	19/VII/78	15/VIII/78	13/IX/78	18/X/78	25/XI/78	27/XII/78	24/I/79	19/II/79	17/III/79	25/IV/79	9/V/79	25/V/79	17/VI/79	17/VII/79	
NTSU NO.				7304	7313	7322	7329	7336	7343	7353	7360	7367	7377	7384	7396	7404	7411	
pH	7.8*	7.2*	8.1*	8.0*	8.0*	8.0*	7.2*	6.5*	7.0*	7.0*	7.2*	7.2*	7.8*	7.3*	7.6*	7.7*	8.0*	
TEMP	4	8	10	11	17	8	5.5	1	0	0	0	2	3	5.3	6		15.4	^oC
COND.	132*	102*	130*	128*	144*	140*	185*	237*	244*	288*	178*	198*						
TSS	21.1	453	26.3	6.0	1.0	3.3	.5	.8	.3	1.0	1.2	4.2	4.1	38.2	346	9.1	.178	mg/l
POC	.184		.486	.355	.205	.130	.078	.266	.038	.080	.064	.090	.188	.380	3.31	.257	.388	mg/l
DOC	1.46		1.79	1.39	1.05	.506	.264	.960	.407	.405	.329	.794	1.37	2.13	2.09	.652	.566	mg/l
TOC	1.64		2.17	1.75	1.26	.636	.342	1.13	.445	.485	.393	.884	1.56	2.51	5.40	.909		mg/l
TP	12	9	6	8	11	10	9	8	11	12	15	6						mg/l
TKN	20	80	40	70	50	20	40	**	180	120	80	160						ug/l
NO_3^-N	120	80	40	40	40	70	40	50	70	60	60	70						ug/l
SiO_2	4.6	5.9	5.1	4.9	3.8	5.0	4.9	4.6	4.5	5.6	2.9	4.7						mg/l
Ca							35	39	50	40	30	37						mg/l
Mg							6.8	7.8	5.0	5.0	4.0	8.3						mg/l
Na							1.5	1.7	1.8	1.7	1.5	1.3						mg/l
K							0.4	0.4	0.4	0.6	0.3	0.3						mg/l
Co							7	9	21	28	**	40						ug/l
Cu							**	**	6	**	**	**						ug/l
Fe							44	140	80	40	**	**						ug/l
Mn							3	5	**	**	**	3						ug/l
Mo							1	1	**	**	**	**						ug/l
Zn							**	**	**	**	**	**						ug/l
SO_4			56	38	85	32	186	62	83	92	71	86						mg/l

* Laboratory Measurements
** Below Detection Limits

MAINSTREAM FLATHEAD RIVER
(Hungry Horse)

FLATHEAD PROJECT - CHEMICAL DATA

	13/III/78	30/III/78	19/IV/78	7/V/78	6/VI/78	21/VI/78	2/VII/78	19/VII/78	15/VIII/78	13/IX/78	18/X/78	25/XI/78	27/XII/78	24/I/79	19/II/79	17/III/79	25/IV/79	9/V/79	25/V/79	17/VI/79	17/VII/79	
NTSU NO.								7305	7314	7323	7330	7337	7344	7354	7361	7368	7378	7385	7397	7405	7412	
pH	7.1*		7.6*		7.0*	8.1*	8.2*	7.8*	8.0*	8.0*	7.1*	6.47*	7.8*	7.2*	7.1*	7.3*	8.1*	7.3*	7.6*	7.7*		
TEMP	3	3	3		5	5.5	5.5	5	5	4	3	3	2	2	4	3	3	4.8	4.8	4.6	4.5	°C
COND.	100*		120*		141*	160*	160*	136*	138*	150*	180*	184*	169*	210*	15k*	202*						
TSS	1.1	2.0	.8		1.5	7.7	.65	1.0	1.5	.8	.1	.4	.9		.7	.7	.7	3.4	2.5	1.1	.174	mg/l
POC	.027		.047		.169	.095	.180	.122	.195	.184	.052	.220	.076	.066		.112	.054	.576	.110	.108	1.01	mg/l
DOC	1.13		.916		1.99	1.24		1.84	1.79	1.01	.965	1.66	1.26	1.33	1.25	1.14	1.55	1.15	1.23	.984	1.18	mg/l
TOC	1.16		.963		2.26	1.34		1.16	1.99	1.19	1.02	1.88	1.34	1.40		1.25	1.60	1.73	1.34	1.09		mg/l
TP	3		5		7	6	7	8	8	6	13	11	15	12	12	8						mg/l
TKN	30		30		70	30	30	50	90	40	40	40	100	80	90	130						ug/l
NO_3^-N	30		50		40	60	60	90	70	80	70	70	70	60	80	80						ug/l
SiO_2	4.5		3.9		4.5	4.7	4.2	4.5	3.4	3.9	4.2	4.5	3.1	3.5	2.2	3.2						mg/l
Ca										21	36	38	30	30	30	18						mg/l
Mg										6.1	6.8	6.5	3.0	3.0	3.0	4.3						mg/l
Na										1.5	2.0	1.3	1.2	1.2	1.0	.5						mg/l
K										0.4	0.4	0.5	0.4	0.3	0.3	0.2						mg/l
Co										**	4	3	**	8	**	9						ug/l
Cu										**	**	**	9	**	**	**						ug/l
Fe										**	84	134	85	**	**	**						ug/l
Mn										**	6	7	5	5	**	1						ug/l
Mo										**	**	**	**		**	**						ug/l
Zn										**	**	**	**	**	**	**						ug/l
SO_4						33	17	20	22		36	15	16	14	19	10						mg/l

* Laboratory Measurements
** Below Detection Limits

SOUTH FORK FLATHEAD RIVER
(Below Hungry Horse Dam)

FLATHEAD PROJECT - CHEMICAL DATA

	13/III/78	30/III/78	19/IV/78	7/V/78	6/VI/78	7/VI/78	13/VI/78	21/VI/78	2/VII/78	19/VII/78	15/VIII/78	31/IX/78	18/X/78	25/XI/78	27/XII/78	24/I/79	19/II/79	17/III/79	25/IV/79	9/V/79	25/V/79	17/VI/79	10/VII/79	
NTSU NO.										7306	7315	7324	7331	7338	7345	7355	7362	7369	7379	7386	7378	7406	7413	
pH	7.0*		8.0*	7.7*	7.4			8.0*	8.0*	7.9*	8.0*	7.8*	7.3*	7.18*	7.8*	7.7*	7.25*	7.0*	8.2*	7.3*	7.6*	7.7*	8.2*	
TEMP	3	4	6	7	8	8	8	10.5	11.5	11	17	8	5.5	1	0	0	2	5	3.2	5.5	6.3		13.0	°C
COND.	140*		142*	138*	104*			140*	130*	140*	150*	120*	177*	140*	170*	151*	169*	183*						
TSS	.7	26.4	3.8	25.6	404	272	53.7	42.6	17.3	10.5	1.15	13.0	2.1	1.1	2.7	1.5	1.5	1.7	3.1	32.8	311	6.2		mg/l
POC	.049		.073	.304	5.73			.394	.451	.356	.210	.412	.166	.213	.092	.090	.039	.089	.247	.348	3.24	.346	.212	mg/l
DOC	.333		1.75	1.68	2.95			1.28	1.36	1.75	1.27	.653	.454	.795	1.33	1.48	.416	.813	1.45	1.87	2.30	1.28	.805	mg/l
TOC	.382		1.82	1.98	8.68			1.67	1.81	2.11	1.48	1.06	.620	1.00	1.42	1.57	.455	.902	1.70	2.22	5.54	1.63	1.02	mg/l
TP	5		8	11	10			16	8	11	8	11	11	10	8	6	11	6						mg/l
TKN	40		30	30	100			40	50	130	60	60	60	**	85	100	100	80						ug/l
NO_3^-N	80		80	120	110			40	30	50	40	100	40	70	20	20	80	55						ug/l
SiO_2	6.2		5.6	4.9	6.9			5.0	4.2	4.3	4.0	4.1	5.0	4.6	4.1	4.0	2.7	4.5						mg/l
Ca												25	40	48	30	20	20	33						mg/l
Mg												6.4	8.2	7.9	3	4	3	7.3						mg/l
Na												2.6	2.2	2.8	1.4	1.6	1.1	1.2						mg/l
K												0.3	0.3	0.5	0.4	0.4	0.2	0.4						mg/l
Co												**	7	8	**	12	**	40						ug/l
Cu												**	**	**	**	**	**	**						ug/l
Fe												**	86	99	**	50	**	**						ug/l
Mn												**	4	4	**	7	**	2						ug/l
Mo												**	**	1	**	**	**	**						ug/l
Zn												**	**	**	**	**	**	**						ug/l
SO_4								25	26	34	74	38	54	45	16	25	17	74						mg/l

*Laboratory Measurements
** Below Detection Limits

FLATHEAD RIVER
(Presentine Bar)

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3841	4117	4280		4713	4723	4977	5002	5187	5168	5319	5300	5339	5374	5390	5424	5458	5492	5523	5542	5576	5610	5657	5691	
pH	7.2*				7.5*	8.1*	7.6*	7.9*	8.2*	8.1*	8.1*	8.0*	8.4	8.37	8.35	8.0	7.65	7.77	8.95		7.85	6.9	7.9		
TEMP		4.0	1.5	1.2	1.7	3.0	4.5	10.5	12.5	16.5	18.3	19.5	21.0	17.8	14.7	11.5	5.7	4.5	.2		4.7	13.7	18.9		°C
COND.		160	158	160	160	170	126*	112*	140*	160*	140	140*	160	160	147	130	130	152	155		167	120	130		
DIS. O_2		12.2	12.8	12.4	12.0	10.0	10.3						9.0	8.8	9.3	10.8	12.2	12.8	14.1		10.8	10.3	9.0		
TSS	.8	.7	.6	.35	.675	.682	1.9	.9	1.375	1.0	.5	.675	.6		.95	.55	.575	.55	.225		.375	1.38	.5	.48	mg/l
POC	.076	.133	.094	.107	.059	.076	.117	.133	.099	.071	.086	.061	.155	.110	.174	.164	.074	.084	.066		.092	.145	.161		mg/l
DOC	.940	1.21	.911	.492	.716	.842	.945	1.34		1.18	1.27	1.57	.968	.569	1.11	1.01	.884	.841	.722		1.84	1.46	1.45		mg/l
TOC	1.06	1.34	1.01	.599	.775	.918	1.07	1.47		1.2[illegible]	1.36	1.63	1.12	.679	1.28	1.17	.958	.925	.788		1.93	1.61	1.61		mg/l
INORG. C	21.1		19.2	19.2		17.5	16.6	16.7	8.43	16.5	17.6	15.8	18.9	18.7	19.6	12.3	9.62	19.8	18.4		20.6	19.7	21.0		mg/l
TP		4	5		3	5	7	8	8	9	8	7	8	7	13	7	10	10	13	10					mg/l
TKN	115	154	76		-20	30	20	20	50	40	130	80	80	30	60	70	**	80	105	90					ug/l
NO_3N	89		124		30	40	30	10	10		90	20	**	40	40	-20	**	30	45	50					ug/l
SiO_2	3.97				4.1	4.1	4.1	4.2	4.6	4.5	5.4	5.5	3.8	5.6	3.8	5.5	4.8	4.9	5.5	4.3					mg/l
Ca															27	29	30	40	10	30					mg/l
Mg															6.8	6.0	6.5	4.0	4.0	6.3					mg/l
Na										1.4					1.1	2.0	1.2	1.8	1.8	1.1					mg/l
K										.05					0.4	0.4	0.4	0.4	0.4	0.4					mg/l
Co															3	5	**	20	15	27					ug/l
Cu															2	3	**	**	**	**					ug/l
Fe															1	**	**	**	80	**					ug/l
Mn															**	1	**	4.5	**	**					ug/l
Mo															3	3	**	**	**	**					ug/l
Zn															2	**	2	**	**	**					ug/l
SO_4									32	23	35	27	36		24	15	20	38	40	21					mg/l

* Laboratory Measurement
** Below Detection Limits

MIDLAKE - 1 Meter

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.										5171	5320	5301	5340	5375	5391	5425	5459	5493	5524	5543	5577	5611	5658	5692	
pH										8.1*	7.9*	7.9*	8.0*	8.38	8.4	7.95	7.62	7.75	8.95		7.87	7.5	7.9		
TEMP				1.2	1.6	2.5	3.8		11.0	13.5	17.5	18.0		17.5	14.3	11.3	5.7	4.5	.4		4.5	12.7	14.2		°C
COND.				162	160	170				160*	140*	136*	132*	158	149	130	130	152	158		170	110	110		
DIS. O_2				11.8	11.5	10.5	10.5						8.65	8.9	9.35	10.8	12.0	12.7	13.6		10.8	10.0	10.1		
TSS									2.25	1.0	.875	.6	.53	.225	.83	.53	.625	.5	.275		.375	.83	.25	.38	mg/l
POC									.149	.154	.115	.109	.127	.206	.176	.120	.075	.073	.154		.156	.194	.176		mg/l
DOC									1.27	1.02	1.03	.882	.907	.665	1.15	1.07	.803	.906	1.20		.868	1.41	1.29		mg/l
TOC									1.42	1.17	1.15	.991	1.03	.871	1.33	1.19	.878	.979	1.35		1.02	1.60	1.47		mg/l
INORG. C									7.60	17.2	10.4	10.2	19.3	19.1	20.4	20.3	9.63	12.7	18.9		21.7	20.4	21.5		mg/l
TP										12	5	8	9	4	8	7	9	13	8	7					mg/l
TKN										40	60	90	90	40	60	110	210	150	60	90					ug/l
NO_3^-N										10	20	10	30	30	20	-20	**	60	40	40					ug/l
SiO_2										4.8	4.1	4.7	3.7	6.6	4.1	4.0	4.8	6.9	3.8	4.4					mg/l
Ca																28	17	30	10	29					mg/l
Mg																6.5	5.9	4.0	4.0	6.4					mg/l
Na												1.4				1.6	1.5	1.7	1.8	1.1					mg/l
K												.05				0.4	0.4	0.4	0.4	0.4					mg/l
Co																5	**	16	17	25					ug/l
Cu																4	3	**	**	**					ug/l
Fe																**	**	**	80	**					ug/l
Mn																2	**	4.5	**	**					ug/l
Mo																**	**	**	**	**					ug/l
Zn																**	3	**	**	**					ug/l
SO_4										27	29	47	40		28	15	23	40	34	17					mg/l

* Laboratory Measurement
** Below detection limits

MIDLAKE - 5 Meters

FLATHEAD PROJECT CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3838	4118	4281		4714	4724	4987	4998	5188	5181	5321	5302	5341	5376	5392	5426	5460	5494	5525	5544	5578	5612	5659	5693	
pH	8.1				8.2*	8.1*	8.3*	8.0	8.0*	8.0*	8.1*		8.35	8.38	8.42	7.9	7.62	7.75	8.9	6.45*	7.9	7.8	7.9		
TEMP	8.7	4.0	1.5	1.2	1.5	2.4	3.7	11.0	10.0	12.0	11.0	13.5	20.5	17.4	14.0	10.7	5.75	4.5	.7		4.5	12.1	10.3		°C
COND.	157	155	158	162	160	170	94*	126*	140*	160*	142*		134	159	150	135	137	152	155		170	110	100		
DIS. O_2	10.8	12.1	12.9	11.6	11.4	10.7	10.6							8.92	9.35	10.8	11.9	12.6	13.2		10.8	9.9	9.9		
TSS	.6	1.0	.7	.3	1.05	.6	1.9	.75	1.8	1.23	1.38	.23	.36	.166	.78	.31	.6	.4	.225		.225	1.3	.65	.48	mg/l
POC	.064	.106	.064	.071	.048	.106	.137	.148	.149	.096	.159	.148	.137	.186	.197	.137	.084	.064	.096		.175	.177	.163		mg/l
DOC	1.33	1.08	.919	.539	.683	.921	1.35	1.15	1.23	.866	1.81	.932	.868	.586	1.15	1.01	.817	.897	.967		1.10	1.35	1.49		mg/l
TOC	1.39	1.19	.983	.610	.731	1.03	1.49	1.30	1.38	.962	1.34	1.08	1.01	.772	1.34	1.15	.901	.961	1.06		1.27	1.53	1.65		mg/l
INORG. C	21.1		19.2	19.2	17.9	19.1	17.3	17.1	5.45	16.9	11.5	11.3	10.5	19.0	18.9	11.4	9.51	20.0	18.5		22.6	20.0	21.3		mg/l
TP		4	4.3		5	5	10	8	11	12	7	20	12	7	7	10	8	9	8	8					mg/l
TKN	69	278	37		-20	30	20	20	90	75	80		130	30	40	70	50	70	70	130					ug/l
NO_3^-N	48		123		40	50	30	30	70	60	20		100	50	40	30	**	60	40	30					ug/l
SiO_2	4.38				4.2	4.2	4.2	4.0	4.7	5.0	4.7		4.8	5.9	3.8	4.3	5.2	4.9	3.9	4.5					mg/l
Ca															24	26	23	40	30	34					mg/l
Mg															6.5	6.2	6.0	4.0	4.0	6.4					mg/l
Na												1.4			1.1	1.5	1.5	1.9	1.7	1.1					mg/l
K												.05			0.4	0.4	0.4	0.4	0.5	0.4					mg/l
Co															4	5	**	18	12	25					ug/l
Cu															1	4	4	3	**	**					ug/l
Fe															1	**	**	**	80	**					ug/l
Mn															**	1	**	4.5	**	**					ug/l
Mo															3	**	**	**	**	2					ug/l
Zn																**	**	**	**	**					ug/l
SO_4									35	36	38		50		34	16	23	36	39	20					mg/l

* Laboratory Measurement
** Below Detection Limits

MIDLAKE - 10 Meters

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.										5172	5322	5303	5342	5377	5393	5427	5461	5495	5526	5545	5579	5613	5660	5694	
pH										8.0*	8.1*	8.1*	8.05	8.37	8.37	7.85	7.6	7.75	8.3		7.87	7.9	7.9		
TEMP						2.0	3.7		6.5	7.7	8.7	9.0	9.35	16.4	13.6	10.5	5.75	4.5	1.0		4.5	8.2	8.9		°C
COND.						170				160*	138*	134*	175	160	152	137	148	155	155		170	100	100		
DIS. O_2						11.0	10.7						10.2	9.1	9.33	10.8	11.8	12.6	13.0		10.7	10.6	9.9		
TSS									1.65	.8	1.15	.55	.86	.10	1.20	.30	.475	.5	.15		.5	.38	.95	.45	mg/l
POC									.092	.097	.089	.104	.096	.136	.147	.132	.086	.085	.064		.222	.144	.172		mg/l
DOC									1.04	.969	1.16	.726	.971		.999	1.12	.932	.972	2.66		.855	1.21	1.16		mg/l
TOC									1.13	1.07	1.25	.830	1.07		1.15	1.26	1.02	1.06	2.72		1.08	1.35	1.33		mg/l
INORG. C									8.39	13.7	10.7	11.6	20.9	11.9	17.6	20.2	9.63	20.0	18.2		22.4	18.1	22.0		mg/l
TP										9	11	16	10	6	7	11	9	10	9	8					mg/l
TKN										40	90	70	70	40	40	60	**	80	70	130					ug/l
NO_3^-N										20	20	30	50	40	50	-20	**	60	60	5					ug/l
SiO_2										4.5	4.2	6.1	4.0	5.5	4.2	5.0	1.4	2.1	3.8	4.5					mg/l
Ca																26	27	30	30	31					mg/l
Mg																5.8	6.4	4.0	4.0	5.9					mg/l
Na										1.9						1.5	2.4	2.5	1.7	1.0					mg/l
K										.05						0.4	0.4	0.4	0.4	0.3					mg/l
Co																6	**	16	15	19					ug/l
Cu																7	**	**	**	**					ug/l
Fe																**	**	**	80	**					ug/l
Mn																2	1	6	**	**					ug/l
Zn																**	**	**	**	**					ug/l
SO_4										40	37	34	25		34	20	20	33	38	17					mg/l

* Laboratory Measurement
** Below Detection Limits

MIDLAKE - 15 Meters

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3840	4119	4282		4715	4725	4978	4990	5189	5169	5323	5304	5343	5378	5394	5428	5462	5496	5527	5546	5580	5614	5661	5695	
pH	8.10				7.3*	7.7*	8.0*	7.9*	8.0*	8.0*	8.0*	8.0*	8.05	8.10	8.08	7.65	7.6	7.75	8.9	6.9*	7.9	8.1	7.9		
TEMP	8.7	4.0	1.4	1.1	1.5	2.0	3.7	6.5	5.4	6.0	6.7	7.0	8.0	10.0	9.7	9.0	5.75	4.5	1.0		4.4	6.4	7.4		°C
COND.	160	155	159	165	160	170	126*	130*	150*	160*	140*	144*	175	160	154	139	149	160	158		170	90	90		
DIS. O_2	11.4	12.2	13.0	11.7	11.5	11.1	10.8						10.5	10.0	9.75	10.9	11.8	12.6	13.0		10.7	10.7	10.0		
TSS	.8	.8	.7	.55	.875	.45	1.9	1.2	1.13	.95	1.0	1.0	.7	.2	.58	.28	.55	.6	.175		.325	.35	1.03	.55	mg/l
POC	.063	.103	.084	.072	.048	.132	.109	.144	.090		.068	.084	.125	.118	.152	.140	.088	.073	.054		.170	.062	.136		mg/l
DOC	.789	1.18	.881	.434	.818	1.29	.924	.781	.965		1.25	.613	.623	.363	1.47	1.08	.828	.913	1.04		1.84	1.34	1.07		mg/l
TOC	.852	1.28	.965	.506	.866	1.42	1.03	.925	1.06		1.32	.697	.748	.481	1.62	1.22	.916	.986	1.10		2.01	1.40	1.20		mg/l
INORG. C	20.9		19.2	19.2	18.4	18.8	17.7	16.9	9.58	17.6	11.1	11.7	20.7	21.0	20.2	20.6	9.13	19.7	17.8		21.5	11.0	22.3		mg/l
TP		4.8	5.1		3	7	6	5	8	9	15	16	10	6	7	11	8	8	6	9					mg/l
TKN	56	213	69		-20	40	30	20	40	40	100	60	60	60	40	40	**	90	70	100					ug/l
NO_3^-N	104		64		40	40	20	20	30	10	40	40	70	40	50	-20	**	40	50	30					ug/l
SiO_2	4.0				4.5	4.1	4.3	4.2	4.2	4.9	4.4	5.9	4.1	6.3	4.2	4.8	4.9	5.2	3.0	4.5					mg/l
Ca																20	42	30	30	32					mg/l
Mg																6.6	7.5	4.0	4.0	6.3					mg/l
Na												1.8				1.8	1.8	1.7	1.6	1.1					mg/l
K												.10				0.4	0.7	0.4	0.4	0.4					mg/l
Co																8	21	15	15	20					ug/l
Cu																4	6	**	**	**					ug/l
Fe																**	**	**	80	**					ug/l
Mn																1		5	**	1					ug/l
Mo																**	**	**	**	**					ug/l
Zn																**	3	**	**	**					ug/l
SO_4									28	28	33	36	32		30	18	19	35	38	22					mg/l

* Laboratory Measurement
** Below Detection Limits

MIDLAKE - 20 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.												5352	5344	5379	5395	5429	5463	5497	5528	5547	5581	5615	5662	5669	
pH												8.0*	8.05	8.07	8.07	7.55	7.6	7.75	8.55	6.72*	7.9	8.1	7.9		
TEMP						2.0	3.7		4.6	5.5	5.5	5.0	6.7	8.0	7.9	7.7	5.75	4.5	1.5		4.3	5.6	6.1		°C
COND.						170						140*	175	163	155	145	150	168	160	176*	170	90	90		
DIS. O_2						11.1	10.9						10.5	10.2	10.0	11.0	11.8	12.6	12.8		10.7	10.8	10.2		
TSS												.475	.5	.450	.30	.33	.425	.425	.25		.575	.38	.70	.50	mg/l
POC												.047	.121	.084	.115	.120	.106	.072	.074		.151	.113	.113		mg/l
DOC												.604	.538	.463	1.05	.953	1.19	.851	.762		.773	1.19	1.18		mg/l
TOC												.651	.659	.547	1.17	1.07	1.30	.923	.836		.924	1.30	1.29		mg/l
INORG. C												14.3	21.1	21.3	18.3	21.6	9.16	12.9	18.7		21.8	20.-	21.8		mg/l
TP												12	7	6	10	11	7	8	11	7					mg/l
TKN												50	60	40	40	60	**	80	110	190					ug/l
NO_3^-N												40	40	50	60	-20	30	50	110	40					ug/l
SiO_2												6.0	4.1	6.9	4.4	5.2	2.1	4.4	6.1	4.5					mg/l
Ca															24	26	34	20	30	29					mg/l
Mg															6.6	6.0	6.5	3.0	4.0	4.7					mg/l
Na												1.8			1.8	1.8	1.4	1.1	1.6	1.1					mg/l
K												.05			0.5	0.4	0.4	0.2	0.4	0.2					mg/l
Co															2	6	3	**	110	110					ug/l
Cu															1	120	**	**	2	**					ug/l
Fe															1	**	**	**	80	**					ug/l
Mn															**	1	1	4.5	**	**					ug/l
Mo															3	**	**	**	**	**					ug/l
Zn															1	**	**	**	**	**					ug/l
SO_4												40	41		27	21	30	38	40	24					mg/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE - 25 Meters

FLATHEAD PROJECT CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3837	4120	4283		4716	4726	4988	4995	5190	5173	5324	5305	5345	5380	5396	5430	5464	5498	5529	5548	5582	5616	5663	5697	
pH	7.85*				7.2*	8.4*	7.6*	7.9*	8.1*	8.0*	8.0*	7.8*	8.05	8.03	8.07	7.55	7.6	7.75	8.5	7.25*	7.9	8.1	7.9		
TEMP	7.0	4.0	1.5	1.0	1.5	2.0	3.6	6.0	4.2	5.0	4.8	4.5	6.0	6.7	6.8	6.3	5.75	4.5	1.6		4.1	5.1	5.6		°C
COND.	160	155	159	165	160	170	126*	144*	140*	160*	140*	148*	176	165	155	150	150	168	165	117*	170	90	90		
DIS. O_2	11.6	12.2	12.7	11.7	11.6	11.2	10.9						10.7	10.3	10.0	11.2	11.8	12.6	12.7		10.8	10.7	10.2		
TSS	.8	.8	.8	.4	.575	.5	1.8	1.2	1.0	.85	.825	.675	.65	.15	.53	.2	.475	.65	.25		.475	.18	.88	.23	mg/l
POC	.067	.071	.067	.077	.091	.132	.083	.148	.098	.092	.032	.025	.085	.048	.085	.071	.145	.066	.041		.123	.108	.116		mg/l
DOC	.828	1.10	1.05	.603	.98	1.09	.729	.38	.981	.972	1.16	.378	.693	.301	.985	1.10	1.46	.927	.941		1.03	1.41	1.19		mg/l
TOC	.895	1.17	1.12	.680	1.07	1.22	.812	.528	1.08	1.06	1.19	.403	.778	.349	1.07	1.17	1.61	.993	.982		1.03	1.41	1.19		mg/l
INORG. C	20.9		19.2	19.2	12.9	18.0	16.9	16.2	9.93	17.7	11.5	19.8	13.2	21.6	18.1	21.6	9.93	19.8	19.0		22.5	20.3	22.5		mg/l
TP		4.4	4.6		7	7	10	7	8	14	8	12	8	4	9	10	8	9	8	9					mg/l
TKN	102	181	69		40	40	20	30	40	50	70	40	60	40	60	70	100	140	60	120					ug/l
NO3N	105		109		40	50	40	20	30	10	40	40	50	40	70	40	30	80	50	50					ug/l
SiO_2	4.29				4.5	4.7	3.9	4.0	4.5	4.6	4.7	6.1	3.9	5.7	4.1	4.1	4.9	6.5	3.7	4.5					mg/l
Ca															31	25	32	20	30	38					mg/l
Mg															6.6	6.0	6.6	4.0	4.0	6.0					mg/l
Na												1.5			1.7	1.5	1.6	1.4	1.6	1.0					mg/l
K												.05			0.5	0.4	0.4	0.3	0.4	0.4					mg/l
Co															4	3	**	**	12	25					ug/l
Cu															5	9	**	**	**	**					ug/l
Fe															1	**	**	**	85	**					ug/l
Mn															**	1	**	3.5	**	**					ug/l
Mo															3	**	**	**	**	**					ug/l
Zn															2	**	**	**	**	**					ug/l
SO_4									23	26	31	28	36		26	14	21	41	40	20					mg/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE - 30 Meters

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3842	4121	4284		4717	4727	4975	4991	5191	5176	5325	5306	5346	5381	5397	5431	5465	5499	5530	5549	5583	5617	5664	5698	
pH	7.75				7.5*	7.7*	7.6*	7.6*	8.0*	8.1*	8.0*	8.1*	8.05	8.05	8.05	7.55	7.6	7.75	8.18	6.61*	7.87	8.4	7.9		
TEMP	5.8	4.0	1.8	1.5	1.7	2.0	3.6	6.0	3.8	4.0	4.2	4.0	5.5	5.6	5.7	5.7	5.75	4.5	2.0		4.0	4.8	4.6		°C
COND.	160	160	159	165	160	170	124*	122*	150*	160*	138*	118*	177	170	157	150	152	168	170	137*	170	80	90		
DIS. O_2	11.8	12.2	12.6	11.8	11.5	11.2	10.8						11.0	10.5	10.3	11.3	11.7	12.5	12.6		10.7	10.3	10.3		
TSS	.8	1.0	.7	.45	.6	.625	1.4	.875	.64	.75	.775	.6	.45	.075	.2	.2	.475	.875	.225		.525	.2	.58	.70	mg/l
POC	.088	.110	.048	.055	.036	.099	.082	.015	.109	.059	.036	.000	.04	.019	.055	.085	.073	.062	.028		.082	.093	.098		mg/l
DOC	1.00	1.23	.972	.659	1.04	.923	.883	.859	1.03	.810	1.08	.646	.670	.322	.829	.921	.847	.914	1.00		.762	1.22	1.01		mg/l
TOC	1.09	1.34	1.02	.714	1.07	1.02	.965	.874	1.14	.869	1.11	.646	.710	.341	.884	1.01	.920	.976	1.03		.844	1.31	1.10		mg/l
INORG. C	21.1		19.2	19.2		17.0	17.0	17.0	8.40	17.7	21.1	18.5	11.1	20.3	20.4	17.9	17.5	19.5	16.1		20.3	20.2	22.5		mg/l
TP		4.1	5.7		7	5	10	8	12	8	8	13	10	5	8	8	8	8	7	8					mg/l
TKN	109	194	69		40	30	20	30	40	40	60	40	100	50	50	-40	80	100	60	120					ug/l
NO_3^-N	122		77		40	40	40	10	30	10	40	**	110	60	80	50	20	**	60	60					ug/l
SiO_2	4.31				4.8	4.7	4.1	3.8	5.0	4.5	4.7	5.9	6.1	5.8	4.4	5.3	5.3	4.7	3.7	4.3					mg/l
Ca																23	46	20	30	33					mg/l
Mg																6.1	6.1	4.0	4.0	6.1					mg/l
Na												1.7				1.7	1.8	1.6	1.6	1.1					mg/l
K												.06				0.4	0.4	0.4	0.4	0.4					mg/l
Co																6	**	12	15	27					ug/l
Cu																2	**	3	**	**					ug/l
Fe																**	**	**	8	**					ug/l
Mn																1	**	3.5	**	**					ug/l
Mo																**	**	**	**	**					ug/l
Zn																**	**	**	**	**					ug/l
SO_4									31	35	25	21	35		29	17	20	52	38	17					mg/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE - 40 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	1/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3836	4122	4285		4718	4728	4979	4996	5192	5167	5326	5307	5347	5382	5398	5432	5466	5500	5531	5550	5584	5618	5665	5699	
pH	7.75				7.4*	7.4*	8.1*	7.9*	8.0*	8.8*	8.0	8.0*	8.07	8.05	8.05	7.55	7.6	7.75	8.3		7.87	8.5	7.9		
TEMP	5.5	4.1	2.3	1.7	1.7	1.8	3.6	5.5		3.8	4.0		5.0	5.2	5.2	5.4	5.75	4.5	2.4		4.0	4.3	4.3		°C
COND.	160	160	160	165	160	170	120*	122*	150*	160*	143*	112*	177	179	158	151	152	168	170	143*	170	80	90		
DIS. O_2	11.8	12.3	12.4	11.6	11.7	11.3	11.0						11.2	10.6	10.4	11.4	11.7	12.5	12.4		10.7	10.3	10.3		
TSS	1.6	.8	.6	.45	.35	.55	1.2	.8	.825	1.0	.85	.6	.6	.225	.23	.15	.425	.875	.25		.525	.15	.38	.55	mg/l
POC	.031	.121	.032	.041	.042	.103	.085	.036	.066	.112	.016		.155	.023	.060	.036	.080	.067	.032		.110	.083	.080		mg/l
DOC	.962	1.10	1.00	.548	1.39	.576	.727	.781	1.09	1.05	1.20	.641	.813	.452	.766	.911	.995	.923	.878		.785	1.32	1.06		mg/l
TOC	.993	1.22	1.03	.589	1.43	.679	.812	.817	1.16	1.16	1.21	.641	.968	.475	.826	.947	1.08	.990	.938		.895	1.40	1.14		mg/l
INORG. C	21.1		19.2	19.2	18.8	16.9	17.2	17.1	15.4	17.7	[illegible]1.8	14.9	14.7	20.4	17.8	11.4	15.4	20.0	18.3		20.1	20.6	22.3		mg/l
TP		3.9	4.9		7	5	12	9	8	12	[illegible]	15	7	7	12	9	9	9	8	11					mg/l
TKN	102	200	69		40	30	30	40	40	40	90	40	70	30	40	-40	210	100	90	110					ug/l
NO_3^-N	95		115		50	50	20	10	10	40	65	50	80	40	60	30	**	40	40	90					ug/l
SiO_2	4.34				5.6	4.5	3.9	4.4	5.2	4.3	5.9	5.9	4.3	3.2	4.1	4.7	5.2	4.5	3.8	4.2					mg/l
Ca																28	45	20	30	35					mg/l
Mg																6.3	5.8	4.0	4.0	6.0					mg/l
Na												1.7				1.7	1.9	1.7	1.7	1.2					mg/l
K												0.5				0.4	0.4	0.4	0.4	0.3					mg/l
Co																5	6	10	12	22					ug/l
Cu																4	**	3	**	**					ug/l
Fe																**	**	**	85	**					ug/l
Mn																1	1	4.5	**	**					ug/l
Mo																**	**	**	**	**					ug/l
Zn																**	**	**	**	**					ug/l
SO_4									28	33	35	38	28		23	21	20	30	40	29					mg/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE - 50 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3834	4123	4286		4719	4729	4976	5000	5193	5170	5327	5308	5348	5383	5399	5433	5467	5501	5532	5551	5585	5619	5666	5700	
pH	7.73				7.5*	7.6*	7.6*	7.9*	8.0*	8.0*	8.2*	7.8*	8.1	8.07	8.05	7.55	7.6	7.75	7.01*	6.61*	7.87	8.6	7.9		
TEMP	5.25	4.1	2.5	2.3	1.7	1.8	3.6	5.5		3.7	3.7		4.8	5.0	5.0	5.2	5.75	4.5			3.8	4.1	4.2		°C
COND.	160	160	160	165	160	170	128*	114*	150*	160*	132*	140*	177	180	169	151	152	168	199*	141*	170	80	80		
DIS. O_2	11.8	12.3	12.3	11.4	11.8	11.4	11.1						11.3	10.7	10.5	11.5	11.7	12.5			10.7	10.4	10.2		
TSS	1.6	.9	.8	.2	.425	.6	1.2	.8	1.13	.975	.575	.775	.575	.15	.10	.2	.675	.825	.25		.4	.01	.33	.30	mg/l
POC	.046	.150	.025	.045	.028	.110	.061	.089	.038	.028	.024	.008	.085	.012	.027	.034	.062	.071	.028		.078	.200	.060		mg/l
DOC	.977	1.20	.881	.563	.890	.810	1.03	.930	1.03	.813	1.11	.797	.794	.385	.789	.890	.794	.848	.999		.833	1.10	1.06		mg/l
TOC	1.02	1.35	.906	.608	.918	.920	1.09	1.02	1.06	.841	1.14	.805	.879	.397	.816	.924	.856	.971	1.03		.911	1.30	1.12		mg/l
INORG. C	21.3		19.2	19.2	16.4	17.4	17.2	17.1	17.7	17.4	20.6	17.1	12.2	19.7	20.6	20.8	15.9	19.6	19.1		20.0	19.4	21.6		mg/l
TP		5.1	6		5	5	7	8	8	9	7	21	10	4	13	7	8	10	10	6					mg/l
TKN	109	311	89		30	30	20	20	40	40	30	40	50	50	40	90	120	120	50	90					ug/l
NO_3^-N	89		121		50	40	40	30	20	20	20	40	60	50	60	30	20	60	40	50					ug/l
SiO_2	4.6				5.6	4.7	4.0	5.2	4.5	4.7	5.1	6.2	4.4	6.6	5.8	4.5	5.1	5.1	3.6	4.5					mg/l
Ca															28	25	33	20	40	38					mg/l
Mg															6.6	5.9	7.1	4.0	3.0	6.7					mg/l
Na												1.8			1.1	1.5	.88	1.7	1.7	1.3					mg/l
K												.05			0.4	0.4	0.4	0.4	0.4	0.4					mg/l
Co															4	5	**	16	16	30					ug/l
Cu															2	6	**	6	**	**					ug/l
Fe															1	**	**	**	8	**					ug/l
Mn															**	1	**	4.5	**	**					ug/l
Mo															2	**	**	**	**	**					ug/l
Zn															1	**	**	**	**	**					ug/l
SO_4									28	36	30	30	31		25	**	24	31	39	26					mg/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE - 60 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3843	4124	4287		4720	4730	4980	4993	5195	5175	5328	5309	5349	5384	5400	5434	5468	5502	5533	5552	5586	5620	5667	5701	
pH	7.70				7.7*	7.7*	8.0*	7.8*	8.1*	8.0*	8.1*	8.0*	8.10	8.09	8.07	7.55	7.6	7.75	6.86*	6.45*	7.87	8.7	7.9		
TEMP	5.1	4.2	2.8	2.5	2.0	1.8	3.5	5.0					4.8	4.6	4.8	5.0	5.75	4.5			3.8	3.9	4.0		oC
COND.	163	160	160	165	160	170	114*	128*	150*	160*	138*	134*	177	180	172	151	153	168	211*	149*	170	80	80		
DIS. O_2	11.8	12.3	12.0	11.3	11.7	11.4	11.1						11.3	10.8	10.6	11.4	11.7	12.5			10.6	10.3	10.2		
TSS	.8	.8	.9	.4	.125	.6	1.3	.875	.85	1.05	.725	.75	.625	.225	.78	.225	.575	.8			.3	.25	.23	.15	mg/l
POC	.018	.099	.019	.042	.037	.102	.076	.058	.079	.057	.035	.109	.233	.022	.032	.039	.065	.068	.039		.084	.220	.070		mg/l
DOC	.969	1.14	.840	.579	.818	.933	1.01	.678	.644	1.04	1.10	.748	1.52	.497	.690	.893	.776	.903	.851		.821	1.10	1.01		mg/l
TOC	.987	1.24	.859	.621	.855	1.04	1.09	.736	.723	1.10	1.11	.857	1.75	.519	.722	.932	.841	.971	.890		.905	1.32	1.08		mg/l
INORG. C	21.3		19.2	19.2	16.9	17.8	17.1	17.3	10.0		2[illegible].9	10.0	12.6	19.7	12.2	11.4	17.8	20.0	19.1		21.4	20.7	21.0		mg/l
TP		5.4	6.5		5	7	12	7	10	8	6	16	12	6	9	9	5	15	9	6					mg/l
TKN	135	102	76		30	30	30	20	40	40	60	40	80	40	40	100	**	120	90	100					ug/l
NO_3^-N	84		104		50	40	30	20	10	20	40	30	50	50	90	40	**	70	75	50					ug/l
SiO_2	4.75				5.7	5.1	4.3	4.9	4.2	4.7	5.1	6.3	4.0	7.1	4.4	4.7	.5	5.0	5.5	4.5					mg/l
Ca																29	36	20	40	38					mg/l
Mg																6.5	6.7	4.0	4.0	6.9					mg/l
Na												1.8				2.1	1.5	1.6	1.6	1.2					mg/l
K												.05				0.5	0.4	0.4	0.4	0.4					mg/l
Co																6	3	16	16	30					ug/l
Cu																13	**	5	**	**					ug/l
Fe																**	**	**	80	**					ug/l
Mn																2	1	11	**	**					ug/l
Mo																**	**	**	**	**					ug/l
Zn																2.4	**	**	**	**					ug/l
SO_4									30	30	31	43	33		28	10	20	32	46	20					mg/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE - 70 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3833	4125	4288		4721	4731	4973	5001	5196	5180	5329	5310	5350	5385	5401	5435	5469	5503	5534	5553	5587	5621	5668	5702	
pH	7.68				7.4*	7.6*	7.8*	7.8*	8.1*	8.1*	8.1*	7.7*	8.1	8.08	8.07	7.55	7.6	7.75		6.71*	7.87	8.8	7.9		
TEMP	5.1	4.2	2.8	2.5	2.1	1.8	3.5	5.0					4.5	4.6	4.7	4.9	5.75	4.5			3.8	3.8	3.9		°C
COND.	163	160	160	165	160	170	128*	128*	150*	150*	140*	140*	177	180	172	151	153	168		147*	170	80	80		
DIS. O_2	11.7	12.3	12.0	11.2	11.7	11.3	11.1						11.3	10.9	10.6	11.4	11.7	12.5			10.6	10.3	10.0		
TSS	1.8	1.2	.9	.4	.4	.475	1.0	1.45	.85	1.1	.6	.65	.85	.10	2.78	.2	.575	.725			.3	.01	.25	.18	mg/l
POC	.039	.100	.062	.034	.116	.108	.039	.155	.044	.059	.062	.020	.251	.026	.026	.036	.058	.076			.151	.146	.061		mg/l
DOC	.992	1.05	.867	.699	1.17	1.01	1.36	.741	1.10	.846	1.05	.574	.825	.402	.793	.873	.769	.919			.972	1.18	1.02		mg/l
TOC	1.03	1.15	.929	.733	1.28	1.12	1.40	.896	1.14	.905	1.11	.594	1.08	.428	.819	.909	.827	.995			1.12	1.32	1.08		mg/l
INORG. C	21.2		19.2	19.2	18.1	16.8	17.0	17.4	10.4	18.5	22.0	10.7	12.3	12.5	21.0	15.0	13.9	12.5			20.0	19.1	21.8		mg/l
TP		5.7	4.3		5	7	11	6	8	8.5	6	13	11	7	10	8	8	22		9					mg/l
TKN	76	233	69		30	30	30	20	40	75	50	40	60	40	60	90	70	160		120					ug/l
NO_3^-N	81		115		40	50	40	20	10	80	30	40	50	60	130	35	20	120		70					ug/l
SiO_2	5.68				6.1	5.1	4.4	4.7	4.6	5.4	4.9	5.0	4.9	4.6	4.3	5.1	5.1	7.0		4.4					mg/l
Ca															24	25	41	20	40	40					mg/l
Mg															6.9	6.3	6.6	4.0	4.0	6.6					mg/l
Na												4.3			1.0	2.1	2.2	1.6	1.9	1.2					mg/l
K												.05			0.4	0.4	0.4	0.4	0.4	0.4					mg/l
Co															4	6	**	150	150	30					ug/l
Cu															1	3	**	5	**	**					ug/l
Fe															1	**	**	**	85	**					ug/l
Mn															**	1	**	20	**	**					ug/l
Mo															2	**	**	**	**	**					ug/l
Zn															1	**	3	**	**	**					ug/l
SO_4									23	31	25	40	25		28	11	22	39		24					mg/l

*Laboratory Measurements
** Below Detection Limits

MIDLAKE - 80 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3839	4126	4289		4722	4732	4969	4999	5197	5174	5330	5311	5351	5386	5402	5436	5470	5504	5535	5554	5588	5622	5669	5703	
pH	7.68				7.4*	7.7*	8.8*	7.8*	8.1*	8.1*	8.0*	8.0*	8.10	8.06	8.03	7.50	7.6	7.75		6.53*	7.85	8.8	7.9		
TEMP	5.0	4.2	3.0	2.7	2.4	2.3	3.5	5.0					4.5	4.5	4.6	4.8	5.75	4.5			3.8	3.8	3.9		^oC
COND.	163	160	160	165	160	170	90*	120*	140*	160*	148*	104*	177	180	175	152	153	168		146*	170	80	80		
DIS. O_2	11.7	12.3	11.9	11.2	11.6	11.1	11.1						11.3	10.7	10.4	11.2	11.7	12.5			10.5	10.1	9.9		
TSS	1.3	.6	.9	.25	.35	.6	.9	1.4	1.35	1.18	.725	1.38	.71	.175	5.51	.45	.7	.675			.825	.01	.45	.35	mg/l
POC	.045	.259	.041	.060	.288	.116	.069	.129	.082	.043	.014	.051	.054	.062	.058	.044	.074	.077			.089	.094	.060		mg/l
DOC	1.01	1.10	.937	.692	.929	.702	1.57	.832	.940	.805	1.00	.666	.431	.417	1.00	.981	.772	.914			1.08	1.20	1.08		mg/l
TOC	1.05	1.36	.978	.752	1.22	.818	1.64	.961	1.02	.848	1.11	.717	.485	.479	1.06	1.03	.846	.991			1.17	1.30	1.14		mg/l
INORG. C	21.5		19.2	19.2	18.4	17.9	17.1	16.9	10.0	18.3	[illegible]	10.7	13.0	11.9	20.8	21.1	9.4	19.7			21.5	18.4	21.5		mg/l
TP		4.3	8.2		5	7	10	9	8	8	11	14	12	4	17	8	7	39		10					mg/l
TKN	76	233	69		30	30	30	20	40	30	60	40	80	40	30	40	70	110		90					ug/l
NO_3^-N	136		117		40	60	40	20	20	30	50	20	60	40	70	50	20	90		50					ug/l
SiO_2	4.79				6.0	5.1	4.1	4.2	4.8	4.9	5.4	5.1	5.7	2.8	4.6	5.6	4.7	5.1		4.5					mg/l
Ca																26	36	20		32					mg/l
Mg																6.3	6.0	4.0		5.7					mg/l
Na												1.6				1.3	1.6	1.7		.6					mg/l
K												.05				0.4	0.3	0.4		0.3					mg/l
Co																4	**	16		17					ug/l
Cu																4	**	5		**					ug/l
Fe																**	**	**		**					ug/l
Mn																2	1	**		**					ug/l
Mo																**	**	**		**					ug/l
Zn																**	**	**		**					ug/l
SO_4									10	31	27	23	29		25	11		31		19					mg/l

* Laboratory Measurement
** Below Detection Limits

MIDLAKE - 90 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3845	4128	4290		4737	4738	4971	4992	5199	5178	5282	5312	5337	5371	5387	5421	5455	5489	5536	5539	5573	5607	5654	5688	
pH					7.3*	7.2*	8.4*	8.2*	7.75	8.1*	7.6*	8.1*	8.15	8.32	8.2	7.90	7.55	7.85	8.3	6.61*	7.75	7.6	8.0		
TEMP				3.5	2.5	5.5	7.0	6.0		13.0	12.0	19.0	17.0	15.0	12.0	7.0	3.7	3.2	1.5		5.5	11.4	12.7		°C
COND.				170	175	190	190	100*	130*	140*	120*	140*	170	158	165	155	133	148	220	162*	155	80	100		
DIS. O_2				10.7	11.8	11.0	9.7						9.2	9.6	10.0	10.6	12.6	12.6	12.8		10.5	10.6	9.8		
TSS	3.3	1.4	2.8	4.85	3.8	2.83	5.7	152.	21.1	7.15	5.55	2.0	2.7	2.6	1.75	2.45	3.2	5.25	2.25	4.4	24.9	20.2	8.63	2.38	mg/l
POC	.178	.161	.117		.164	.107	.111	1.58	.312	.205	.088	.181	.135	.113	.112	.111	.089	.120	.122		.468	.256	.148		mg/l
DOC	.991	1.05	1.03		1.01	.832	1.89	1.49	1.44	1.24	1.28	.336	.355	.438	.545	.755	1.07	1.43	1.24		2.31	1.75	.980		mg/l
TOC	1.17	1.21	1.14		1.17	.939	2.01	3.07	1.75	1.45	1.37	.517	.490	.551	.657	.866	1.16	1.55	1.36		2.78	2.00	1.13		mg/l
INORG. C			19.2		20.2	20.3	13.0	15.3	15.7	14.9	19.5	19.0	21.7	11.0	21.6	25.3	17.0	12.3	25.7		19.7	16.7	18.1		mg/l
TP		6.1	3.4		3	3	15	9	11	15	14	8	8	12	8	8	8	12	8	10					mg/l
TKN	37	174	83		30	20	30	20	40	70	90	50	70	40	40	-40	60	90	170	110					ug/l
NO_3^-N	138		131		70	70	100	110	20	85	85	**	40	30	60	40	**	110	50	40					ug/l
SiO_2	4.12				5.6	6.1	5.6	5.3	5.9	5.2	5.6	6.1	4.4	5.3	3.9	4.4	1.9	4.1	4.8	5.2					mg/l
Ca																33	39	30	50	33					mg/l
Mg																6.4	7.0	3.0	5.0	7.0					mg/l
Na												1.6				2.3	2.0	1.5	3.1	1.6					mg/l
K												.04				0.3	0.6	0.3	0.6	0.4					mg/l
Co																6	11	18	26	45					ug/l
Cu																5	10	10	**	**					ug/l
Fe																**	10	6	11	84					ug/l
Mn																10	11	8	20	16					ug/l
Mo																2	1	**	**	5					ug/l
Zn																**	3	**	**	**					ug/l
SO_4									49	42	34	42	34		38	**	11		57	24					mg/l

* Laboratory Measurements
** Below Detection Limits

INLET FLATHEAD RIVER (Holt Bridge)

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3844	4130	4292		4739	4740	4974	4997	5200	5177	5284	5313	5336	5372	5388	5422	5456	5490	5537	5540	5574	5608	5655	5689	
pH					7.6*	7.3*	8.0*	8.1*	7.83	8.0*	7.4*	8.1*	8.2	8.27	8.1	7.90	7.72	8.0	8.2	6.97*	7.85	8.1	7.9		
TEMP				1.7	1.0	3.5	6.0	9.0		16.5	16.0	21.5	21.5	17.3	14.2	9.4	1.9	.5	.6		7.7	12.5	14.4		^oC
CÔND.				183	170	180	175	110*	150*	130*	120*	114*	138	150	145	135	130	165	183	194*	180	100	100		
DIS. O_2				12.5	12.0	12.4	9.8						8.3	9.4	9.55	11.6	14.0	15.4	15.4		9.8	10.0	8.7		
TSS	1.0	.9	.7	1.1	.8	.8	1.8	1.98	3.08	2.4	1.3	.725	.46	.85	.88	.65	.7	1.2	.5	1.2	3.55	2.5	1.58	1.18	mg/l
POC	.210	.218	.107		.084	.062	.028	.127	.219	.145	.141	.138	.198	.101	.098	.103	.129	.158	.054		.240	.196	.171		mg/l
DOC	.999	1.15	1.48		.996	1.22	2.59	2.19	2.44	1.43	1.77	.830	.827	.661	1.01	1.13	.933	.931	1.03		2.37	2.19	1.44		mg/l
TOC	1.21	1.37	1.59		1.08	1.28	2.62	2.31	2.66	1.58	1.91	.968	1.03	.762	1.11	1.23	1.06	1.09	1.09		2.61	2.39	1.61		mg/l
INORG. C			19.2		24.0	22.1	11.3	16.9	16.5	14.7	14.8	13.7	18.9	10.8	18.1	17.9	18.2	14.0	25.4		23.2	16.7	17.7		mg/l
TP		5.3			2	5	5	10	10	9	15	8	9	8	9	10	7	11	10	10					mg/l
TKN	122	154	69		40	30	20		40	40	70	60	80	60	60	40		100	60	85					ug/l
NO_3^-N	90		76		60	90	70	30	30	10	10	20	20	20	20	20	**	80	60	80					ug/l
SiO_2	5.6				8.7	8.9	7.9	6.5	6.8	5.0	7.0	5.7	5.5	7.1	5.4	6.0	6.7	6.4	5.1	6.6					mg/l
Ca															27	25	26	40	40	32					mg/l
Mg															6.3	6.2	5.9	4.0	4.0	6.9					mg/l
Na												1.2			1.2	1.5	1.7	1.8	1.7	1.3					mg/l
K												.04			0.5	0.5	0.4	0.5	0.6	0.5					mg/l
Co															3	5	**	23	17	25					ug/l
Cu															2	5	2	6	**	**					ug/l
Fe															2	**	**	**	90	**					ug/l
Mn															**	3	2	6.5	5.5	3					ug/l
Mo															2	**	**	**	**	2					ug/l
Zn															1	**	3	**	**	**					ug/l
SO_4									26	18	10	14	39		20	**	23	25	25	29					mg/l

* Laboratory Measurements
** Below Detection Limits

INLET SWAN RIVER

FLATHEAD PROJECT - CHEMICAL DATA

	17/XI/77	20/XII/77	25/I/78	15/II/78	1/III/78	15/III/78	18/IV/78	24/V/78	15/VI/78	30/VI/78	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	28/II/79	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	3846	4129	4291		4742	4741	4989	4994	5198	5179	5283	5314	5338	5373	5389	5423	5457	5491	5538	5541	5575	5609	5656	5690	
pH					8.1*	7.2*	8.2*	8.2*	8.0*	8.1*	7.5*	8.0*	8.4	8.42	8.49	8.1	7.75	8.05	8.5	7.02*		8.1	8.2		
TEMP				3.5	1.5	5.3	5.5	9.0		17.0		22.0	25.5	18.5	14.6	10.5	5.5	2.5	3.0			13.7	16.4		^oC
COND.				165	160	165	170	110*	150*	145*	110*	138*	155	155	145	135	148	150	165	166*		120	130		
DIS. O_2				11.8	12.1	12.0	10.0						8.3	9.2	9.35	11.2	12.8	15.0	14.0			11.1	9.0		
TSS	2.1	.9	.7	.9	.575	.9	1.7	2.18	1.25	1.28	1.13	1.58	.56	.235	.65	.63	.575	.95	.875	.95	1.15	1.75	1.23	1.50	mg/l
POC	.210	.166	.108		.115	.113	.096	.101	.203	.135	.261	.159	.191	.124	.168	.156	.101	.106	.128		.151	.205	.186		mg/l
DOC	1.08	1.13	.910		1.05	.835	1.28	1.20	3.60	1.23	1.22	.337	1.09	.812	1.21	1.30	.828	.916	1.50		1.09	1.32	1.34		mg/l
TOC	1.29	1.30	1.02		1.17	.948	1.37	1.30	3.80	1.36	1.48	.496	1.28	.936	1.38	1.46	.929	1.02	1.62		1.24	1.53	1.53		mg/l
INORG. C			19.2		20.1	17.2	10.5	16.0	17.1	17.1	20.2	15.0	19.5	19.1	13.4	11.5	10.1	12.5	21.4		13.0	19.5	20.0		mg/l
TP					3	3	7	12	11	12	7	16	9	6	8	11	8	8	12	8					mg/l
TKN					30	30	20	20	40	75	70	60	80	60	60	-40	170	80	110	100					ug/l
NO_3^-N					10	40	40		40	55	90	10	20	20	20	30	**	50	90	40					ug/l
SiO_2					4.1	4.0	4.1	4.0	5.2	5.5	4.2	6.1	4.0	6.9	3.8	4.0	4.8	4.1	6.2	4.4					mg/l
Ca																35	33	30	40	29					mg/l
Mg																7.3	6.2	4.0	4.0	5.9					mg/l
Na												1.8				2.8	1.6	1.8	1.5	1.0					mg/l
K												.09				0.4	0.4	0.4	0.5	0.3					mg/l
Co																3	**	20	16	20					ug/l
Cu																6	**	3	**	**					ug/l
Fe																**	**	**	8.5	**					ug/l
Mn																2	**	4	**	1					ug/l
Mo																**	**	**	**	**					ug/l
Zn																3	3	**	**	**					ug/l
SO_4									33	31	24	40	32		20	22	22	35	42	19					mg/l

* Laboratory Measurements
** Below Detection Limits

OUTLET FLATHEAD RIVER (Polson Bridge)

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5315			5370	5411	5445	5479	5513	5563	5593	5627	5674	5708	
pH	7.9*		8.5	8.2*	8.38	8.05	7.58	7.9		7.93	8.2			
TEMP			20.5		15.0	11.6	5.5	4.0		6.2	13.9			°C
COND.	144*		165	140*	147	130	130	150		170	110			
DIS. O_2			9.3		9.3	10.9	12.3	13.8		10.4	10.2			
TP	8				8	10	8	15	14					mg/l
TKN	70			40	50	75	70	140	100					ug/l
NO_3^-N	10				40	20	**	80	60					ug/l
SiO_2	4.3			5.9	4.3	4.0	4.3	5.6	4.9					mg/l
SO_4	27				30	17	23	32	16					mg/l
Ca					24	39	31	30		20				mg/l
Mg					7.1	7.3	6.3	4.0		3.5				mg/l
Na					3.0	1.6	1.3	1.7		.5				mg/l
K					0.5	0.4	0.4	0.5		0.2				mg/l
Co					9	**	8	16		5				ug/l
Cu					2	2	**	**		**				ug/l
Fe					1	**	**	80		**				ug/l
Mn					**	1	2	4		**				ug/l
Mo					3	2	**	**		**				ug/l
Zn					2	**	2	**		**				ug/l

*Laboratory Measurements
** Below Detection Limits

MIDLAKE NORTH - 1 Meter

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
HTSU NO.	5316			5353	5412	5446	5480	5514	5564	5594	5628	5675	5709	
pH	8.1*		8.35	8.2*	8.37	8.0	7.57	7.85	6.44*	7.92	8.2			
TEMP			17.0		14.1	11.6	5.5	4.0		5.5	12.9			°C
COND.	138*		160	134*	150	135	130	158	135*	170	110			
DIS. O_2			9.75		9.3	10.7	11.9	13.0		10.2	9.9			
TP	10			7	10	10	9	11	8					mg/l
TKN	40			30	40	-40	50	60	110					ug/l
NO_3^-N	40			50	35	20	**	60	60					ug/l
SiO_2	4.9			8.7	3.6	3.9	5.2	5.8	4.4					mg/l
SO_4	32				14	16	18	49	17					mg/l
Ca						39	24	30		32				mg/l
Mg						7.4	6.1	4.0		5.4				mg/l
Na						1.4	1.4	1.6		1.0				mg/l
K						0.4	0.4	0.4		0.3				mg/l
Co						3	**	16		19				ug/l
Cu						**	**	**		**				ug/l
Fe						**	**	**		**				ug/l
Mn						1	1	**		1				ug/l
Mo						1	**	**		**				ug/l
Zn						**	**	**		**				ug/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE NORTH - 10 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5317			5354	5413	5447	5481	5515	5565	5595	5629	5676	5710	
pH	8.1*		8.1	8.2*	8.12	7.98	7.57	7.83	6.31*	7.92	8.3			
TEMP			8.0		11.5	11.4	5.6	4.0		5.3	6.8			^oC
COND.	138*		175	134*	151	147	130	168	148*	171	90			
DIS. O_2			10.4		9.6	10.6	11.8	12.9		10.1	10.5			
TP	11			10	10	9	8	8	12					mg/
TKN	70			40	40	-40	**	110	140					ug/
NO_3^-N	40			40	40	20	20	60	110					ug/l
SiO_2	5.1			7.2	3.9	4.0	4.4	5.1	4.5					mg/l
SO_4	21				17	20	25	46	17					mg/l
Ca						38	30	30		28				mg/l
Mg						7.0	6.4	4.0		3.6				mg/l
Na						1.9	1.5	1.6		.5				mg/l
K						0.4	0.4	0.5		0.1				mg/l
Co						4	6	17		2				ug/l
Cu						2	**	**		**				ug/l
Fe						**	**	80		**				ug/l
Mn						1	2	**		**				ug/l
Mo						1	**	**		**				ug/l
Zn						**	**	**		**				ug/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE NORTH - 20 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.				5355	5414	5448	5482	5516	5566	5596	5630	5677	5711	
pH			8.05	8.2*	7.98	7.57	7.57	7.8	6.92*	7.91	8.3			
TEMP			5.5		6.9	7.7	5.6	4.0		5.2	4.2			°C
COND.			177	142*	153	150	145	168	180*	170	80			
DIS. O_2			10.9		10.0	10.8	11.8	12.8		10.0	10.7			
TP				7	10	7	7	8	10					mg
TKN				**	40	-40	110	100	100					ug
NO_3^-N				50	50	20	20	70	70					ug
SiO_2				6.2	4.0	4.2	4.6	4.1	5.1					mg
SO_4					21	29	22	42	20					mg
Ca					22	41	28	40		24				mg/
Mg					7.0	7.4	6.1	4.0		3.7				mg/
Na					1.1	1.9	1.5	1.7		0.4				mg/
K					0.4	0.4	0.3	0.4		0.1				mg/
Co					4	3	3	**		1				ug/
Cu					1	3	**	**		**				ug/
Fe					1	**	**	**		**				ug/
Mn					**	1	1	**		3				ug/
Mo					3	**	**	**		**				ug/
Zn					2	**	**	**		**				ug/

* Laboratory Measurements
** Below Detection Limits

MIDLAKE NORTH - 30 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5318			5356	5415	5449	5483	5517	5567	5597	5631	5678	5712	
pH	7.9*			8.2*	7.91	7.52	7.6	7.24*						
TEMP					5.5	6.0	5.6							^oC
COND.	146*			142*	155	151	145	179*						
DIS. O_2					10.1	10.9	11.8							
TP	10			7	10	9	8	12						mg/l
TKN	40			30	40	30	80	80						mg/l
NO_3^-N	40			60	70	50	**	60						ug/l
SiO_2	4.4			6.2	4.3	4.1	4.4	5.2						mg/l
SO_4	32				11	16	20	46						mg/l
Ca						40	34	50						mg/l
Mg						6.6	6.8	4.0						mg/l
Na						5.9	1.8	1.8						mg/l
K						0.4	0.4	0.4						mg/l
Co						5	4	13						ug/l
Cu						2	**	**						ug/l
Fe						**	100	90						ug/l
Mn						1	2	8						ug/l
Mo						1	**	**						ug/l
Zn						**	**	**						ug/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE NORTH - 40 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5331			5361	5416	5450	5484	5518	5568	5602	5636	5683	5717	
pH	8.2*		8.45	8.1*	8.43	8.1	7.6	7.83		8.0	8.2			
TEMP			22.0		14.7	11.5	5.6	4.2		5.4	13.0			°C
COND.	130*		160	140*	149	135	137	155		168	110			
DIS. O_2			8.5		9.3	11.4	12.2	13.1		10.8	10.3			
TP	8			6	10	8	8	11						mg/l
TKN	90			90	60	40	60	145						ug/l
NO_3^-N	40			70	30	-20	**	90						ug/l
SiO_2	4.6			7.3	3.7	4.0	2.6	6.8						mg/l
SO_4	43				3	19	27	41						mg/l
Ca						38	38	60						mg/l
Mg						6.2	6.7	4.0						mg/l
Na						2.3	1.8	1.7						mg/l
K						0.4	0.4	0.5						mg/l
Co						**	8	15						ug/l
Cu						4	1	**						ug/l
Fe						**	**	80						ug/l
Mn						1	2	**						ug/l
Mo						**	**	**						ug/l
Zn						**	**	**						ug/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE SOUTH - 1 Meter

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5332			5362	5417	5451	5485	5519	5569	5603	5637	5684	5718	
pH	8.0*		8.5	8.2*	8.45	8.06	7.55	7.8		8.0	8.3			
TEMP			15.0		14.2	11.4	5.6	4.3		4.4	10.3			°C
COND	134*		168	138*	149	135	137	158		170	100			
DIS. O_2			10.0		9.3	10.7	12.0	12.8		10.7	10.4			
TP	11			8	10	8	9	8						mg/l
TKN				40	50	40	40	140						ug/l
NO_3^-N	20			60	30	-20	**	50						ug/l
SiO_2	4.8			6.0	3.8	4.1	5.2	4.4						mg/l
SO_4	49				3	23	33	38						mg/l
Ca					23	36	31	30						mg/l
Mg					6.2	7.3	6.1	4.0						mg/l
Na					1.1	1.7	4.0	1.7						mg/l
K					0.4	0.3	0.4	0.4						mg/l
Co					5	6	**	19						ug/l
Cu					1	11	**	**						ug/l
Fe					1	**	**	**						ug/l
Mn					**	1	1							ug/l
Mo					3	1	**	**						ug/l
Zn					2	**	**	**						ug/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE SOUTH - 10 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5333			5363	5418	5452	5486	5520	5570	5604	5638	5685	5719	
pH	8.0*		8.1	8.2*	8.1	8.01	7.6	7.77		8.0	8.3			
TEMP			8.3		10.3	11.3	5.6	4.3		4.2	6.3			°C
COND.	142*		170	146*	152	149	150	160		170	90			
DIS. O_2			10.4		9.57	10.5	11.8	12.7		10.7	10.6			
TP	8			6	10	8	8	12						mg/l
TKN	130			30	40	60	**	100						ug/l
NO_3^-N	75			40	60	-20	**	60						ug/l
SiO_2	5.2			6.4	4.0	4.0	4.8	5.2						mg/l
SO_4	36				16	23	26	39						mg/l
Ca						66	36	30						mg/l
Mg						8.3	6.3	4.0						mg/l
Na						4.4	1.5	1.8						mg/l
K						0.4	0.4	0.4						mg/l
Co							**	190						ug/l
Cu						2	**	**						ug/l
Fe						**	**	80						ug/l
Mn						**	1	**						ug/l
Mo						1	**	**						ug/l
Zn						**	**	**						ug/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE SOUTH - 20 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5334			5364	5419	5453	5487	5521	5571	5605	5639	5686	5720	
pH	8.0*		8.07	8.2*	7.99	7.55	7.6	7.75		8.0	8.4			
TEMP			5.0		6.0	5.6	5.6	4.3		4.1	4.3			°C
COND	144*		178	114*	157	155	152	168		170	80			
DIS. O_2			10.9		10.0	10.8	11.8	12.6		10.7	10.5			
TP	7			6	11	8	8	12						mg/
TKN	80			**	40	60	50	130						ug/
NO_3^-N	20			40	70	60	**	60						ug/
SiO_2	4.8			5.5	4.1	4.3	4.8	4.8						mg/
SO_4	36				28	16	22	37						mg/
Ca					22	49	28	10						mg/
Mg					6.3	7.0	6.3	4.0						mg/
Na					1.0	3.4	3.3	1.6						mg/
K					0.4	0.5	0.4	0.5						mg/
Co					5	9	**	15						ug/l
Cu					2	3	**	**						ug/l
Fe					1	**	**	**						ug/l
Mn					**	2	1	**						ug/l
Mo					4	**	**	**						ug/l
Zn					1	**	**	**						ug/l

* Laboratory Measurements
** Below Detection Limits

MIDLAKE SOUTH - 40 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5277			5357	5407	5441	5475	5509	5559	5598	5632	5679	5713	
pH	7.7*		8.4	8.3*	8.45	8.2	7.75	7.9		8.1	8.5			
TEMP	20.0		21.0		14.7	10.7	4.8	3.5		7.5	12.7			^{o}C
COND	140*		160	128*	150	133	137	150		170	110			
DIS. O_2			8.5		9.3	11.6	12.6	13.5		10.6	10.7			
TP	13			6	6	8	8	10						mg/l
TKN	80			85	40	-40	100	100						ug/l
NO_3^-N	40			85	120	-20	**	100						ug/l
SiO_2	4.1			5.8	4.1	4.0	4.6	4.4						mg/l
SO_4	27				22	16	20	31						mg/l
Ca					25		40	10						mg/l
Mg					6.4		6.2	1.0						mg/l
Na					1.1	1.4	3.0	1.0						mg/l
K					0.4	0.5	0.4	0.1						mg/l
Co					4	**	**	**						ug/l
Cu					2	**	**	**						ug/l
Fe					3	**	**	**						ug/l
Mn					**	**	**	**						ug/l
Mo					2		**	**						ug/l
Zn					3		**	**						ug/l

* Laboratory Measurements
** Below Detection Limits

BIG ARM BAY - 1 Meter

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.				5358	5408	5442	5476	5510	5560	5599	5633	5680	5714	
pH			8.35	8.2*	8.49	8.1	7.75	7.85		8.1	8.3			
TEMP	13.2		13.2		14.7	10.7	4.8	3.6		7.0	7.3			^oC
COND			160	140*	152	133	137	150		170	90			
DIS. O_2			10.1		9.48	10.9	12.6	13.1		10.6	10.9			
TP				5	8	8	8	10						mg/l
TKN				30	20	40	110	120						ug/l
NO_3^-N				50	90	30	**	100						ug/l
SiO_2				6.2	3.8	4.1	4.3	4.8						mg/l
SO_4					28	11	19	36						mg/l
Ca						17	41	20						mg/l
Mg						6.8	7.4	4.0						mg/l
Na						1.5	1.6	1.7						mg/l
K						0.4	0.3	0.4						mg/l
Co						5	**	12						ug/l
Cu						4	**	10						ug/l
Fe						**	**	**						ug/l
Mn						1	2	**						ug/l
Mo						2	**	**						ug/l
Zn						**	**	**						ug/l

* Laboratory Measurements
** Below Detection Limits

BIG ARM BAY - 10 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5278			5359	5409	5443	5477	5511	5561	5600	5634	5681	5715	
pH	7.5*		8.0	8.2*	8.07	7.6	7.75	7.85		8.0	8.2			
TEMP	6.7		7.5		9.0	7.4	4.8	3.7		5.4	5.9			°C
COND	140*		175	144*	155	140	145	163		170	90			
DIS. O_2			10.2		9.6	10.6	12.3	13.0		10.6	10.5			
TP	13			8	10	8	9	12						mg/
TKN	85			40	40	100	160	80						ug/
NO_3^-N	65			60	110	40	**	110						ug/
SiO_2	5.0			5.7	3.9	5.3	4.6	2.2						mg/
SO_4	26				24	16	21	11						mg/
Ca					25	14	33	10						mg/l
Mg					6.5	7.1	6.0	2.0						mg/l
Na					1.1	1.6	1.6	2.0						mg/l
K					0.4	0.4	0.4	0.2						mg/l
Co					3	6	4	**						ug/l
Cu					1	5	**	**						ug/l
Fe					2	**	**	**						ug/l
Mn					**	2	1	**						ug/l
Mo					2	3	**	**						ug/l
Zn					1	**	**	**						ug/l

* Laboratory Measurements
** Below Detection Limits

BIG ARM BAY - 20 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5276			5360	5410	5444	5478	5512	5562	5601	5635	5682	5716	
pH	7.6*		7.8		7.8	7.35	7.75	7.8		7.95	8.3			
TEMP	5.0		6.2		6.4	6.6	4.8	3.7		4.5	4.9			^oC
COND	140*		177	152*	159	150	150	165		170	90			
DIS. O_2			9.7		8.9	10.2	12.2	12.9		10.6	10.5			
TP	14			8	8	8	9	15						mg
TKN	110			30	30	100	110	90						ug
NO_3^-N	60			80	80	70	**	120						ug
SiO_2	4.7			6.7	5.2	5.4	4.5	5.4						mg/
SO_4	30				20	16	20	37						mg/
Ca					29		42	20						mg/
Mg					5.9		7.0	4.0						mg/
Na					0.9		1.7	1.5						mg/
K					0.4		0.4	0.5						mg/
Co					5		**	9						ug/
Cu					1		**	**						ug/
Fe					2		**	40						ug/
Mn					**		1	15						ug/
Mo					2		**	**						ug/
Zn					1		**	**						ug/l

* Laboratory Measurements
** Below Detection Limits

BIG ARM BAY - 30 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5273			5366	5403	5437	5471	5505	5555	5589	5623	5670	5704	
pH	7.7*		8.45	8.2*	8.35	8.05	7.6	7.8	6.7*	8.05	8.2	8.0		
TEMP	18.6		19.7		14.7	11.4	5.5	4.4		5.2	14.5	18.6		°C
COND	140*		155	137*	147	135	135	155	168*	120	130			
DIS. O_2			9.5		9.48	11.1	12.6	13.1		11.2	10.5	8.3		
TP	14			7	10	8	10	12	11					mg/
TKN	80			90	60	-40	80	100	115					ug/l
NO_3^-N	20			20	40	-20	40	60	90					ug/l
SiO_2	4.2			7.7	5.2	3.8	4.9	3.8	4.2					mg/l
SO_4	20				34	18	21	31	27					mg/l
Ca					24	24	40	20		23				mg/l
Mg					6.4	5.9	6.6	4.0		3.3				mg/l
Na					0.9	1.9	1.8	2.0		0.5				mg/l
K					0.4	0.4	0.4	0.4		0.1				mg/l
Co					5	5	6	17		**				ug/l
Cu					2	15	**	**		**				ug/l
Fe					1	**	**	**		**				ug/l
Mn					**	1	2	**		**				ug/l
Mo					3	**	**	**		**				ug/l
Zn					2	**	**	**		**				ug/l

* Laboratory Measurements
** Below Detection Limits

YELLOW BAY - 1 Meter

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.				5367	5404	5438	5472	5506	5556	5590	5624	5671	5705	
pH			8.45	8.2*	8.35	8.03	7.6	7.77	6.65*	8.1	8.1	8.0		
TEMP	12.5		19.5		14.2	11.3	5.6	4.5		4.1	14.1	12.9		°C
COND			158	138*	149	143	137	157	146*	170	120	110		
DIS. O_2			8.78		9.4	10.8	12.1	12.8		10.9	10.0	9.7		
TP				7	11	7	9	8	7					mg
TKN				40	60	-40	100	100	100					ug
NO_3^-N				40	30	-20	50	50	50					ug
SiO_2				5.6	5.0	4.9	0.9	5.6	4.2					mg
SO_4					21	17	26	31	17					mg
Ca						26	36	20		20				mg
Mg						6.2	6.5	4.0		2.5				mg
Na						2.3	2.8	1.6		0.4				mg
K						0.4	0.4	0.5		0.1				mg
Co						5	4	15		**				ug
Cu						6	**	**		**				ug
Fe						**	**	**		**				ug
Mn						1	2	**		**				ug
Mo						**	**	**		**				ug
Zn						**	**	**		**				ug

* Laboratory Measurements
** Below Detection Limits

YELLOW BAY - 10 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5275			5368	5405	5439	5473	5507	5557	5591	5625	5672	5706	
pH	7.8*		8.37	8.2*	8.1	8.02	7.58	7.75	6.51*	8.1	8.1	8.1		
TEMP	8.0		12.3		11.3	11.3	5.6	4.5		4.0	7.6	8.6		°C
COND	140*		162	146*	150	149	150	157	144*	170	90	100		
DIS. O_2			9.65		9.83	10.6	11.9	12.7		10.8	10.8	10.1		
TP	12			8	10	11		12	10					mg/l
TKN	135			30	40	-40	**	90	100					ug/l
NO_3^-N	90			50	40	-20	60	60	60					ug/l
SiO_2	5.8			5.1	4.2	4.0	4.6	4.1	4.0					mg/l
SO_4	30				35	18	20	30	22					mg/l
Ca						34	38	20		22				mg/l
Mg						9.6	6.4	4.0		2.7				mg/l
Na						2.1	1.5	1.6		0.4				mg/l
K						0.4	0.4	0.4		0.1				mg/l
Co						4	3	15		2				ug/l
Cu						3	**	**		**				ug/l
Fe						**	**	**		**				ug/l
Mn						1	1	**		**				ug/l
Mo						**	**	**		**				ug/l
Zn						**	**	**		**				ug/l

* Laboratory Measurements
** Below Detection Limits

YELLOW BAY - 20 Meters

FLATHEAD PROJECT - CHEMICAL DATA

	15/VII/78	30/VII/78	15/VIII/78	30/VIII/78	30/IX/78	30/X/78	30/XI/78	18/XII/78	31/III/79	9/V/79	2/VI/79	27/VI/79	12/VII/79	
NTSU NO.	5281			5369	5406	5440	5474	5508	5558	5592	5626	5673	5707	
pH	7.4*			8.2*	7.95	7.55	7.58	7.75	6.35*	8.1	8.1			
TEMP	6.7				8.6	6.2	5.6	4.5		4.0	6.6			^oC
COND	140*			146*	151	152	150	162	152*	170	90			
DIS. O_2					10.0	10.8	11.8	12.6		10.7	10.7			
TP	10			6	8	12	8	10	8					mg/l
TKN	60			30	50	75	90	190	90					ug/l
NO_3^-N	30			60	50	40	**	125	70					ug/l
SiO_2	4.2			5.7	4.3	4.3	4.7	7.1	4.4					mg/l
SO_4	26				25	25	22	37	17					mg/l
Ca						17	35	30		20				mg/l
Mg						6.5	7.0	4.0		2.8				mg/l
Na						3.5	1.7	1.9		0.5				mg/l
K						0.4	0.3	0.4		0.1				mg/l
Co						**	4	17		**				ug/l
Cu						6	**	**		**				ug/l
Fe						**	**	**		**				ug/l
Mn						**	1	**		**				ug/l
Mo						**	**	**		**				ug/l
Zn						**	**	**		**				ug/l

* Laboratory Measurements
** Below Detection Limits

YELLOW BAY - 30 Meters