1997

Trichoptera, Ephemeroptera, Megaloptera and Water Chemistry in Ten Sites at UNDERC

BIOS 569 - Practicum in Aquatic Biology

Amy Zulich

Fifth Year

728 N. Scott Street

South Bend IN, 46616

Advisor: Dr. Ronald Hellenthal

Abstract

This paper gives the results of sampling for immature ephemeroptera, trichoptera, and megaloptera in eight lakes and two streams during two separate sampling periods. We attempted to correlate presence or absence of the insects with water chemistry characteristics: oxygen content, temperature, pH, color, conductivity, sulfide, Secchi depth, alkalinity, and lake parameters: depth, surface area, and shoreline length. Possible correlations were seen between oxygen content and all three orders, and pH, shoreline length and surface area for trichoptera and ephemeroptera.

Additionally, a light trap sampling was done on the perimeter of Tenderfoot Lake in attempt to chart emerging adults of the three orders. Three species of trichoptera, Polycentropodidae Nyctiophylax sp., Hydroptilidae Neotrichia vibrans, and Leptoceridae Oecetis inconspicua, were found in large enough numbers to correlate with an emergence. They were found in lower numbers than expected.

Introduction

Trichoptera, Megaloptera, and Ephemeroptera are three orders of insects which spend most of their lives in the immature form. Collectively, they comprise 38 families, and exist over the entire globe. (Merritt and Cummins, 1978) For this project we sampled ten sites at UNDERC for these three orders of insects. The ten sites consisted of 8 lakes, and 2 streams. The sites vary in water characteristics such as pH, sulfide, alkalinity, color, conductivity, Secchi depth, oxygen content and temperature. The goal was to ascertain correlations between these characteristics and the presence or absence of Trichoptera, Megaloptera, and Ephemeroptera. It has already been shown that there exists a correlation between presence of both Trichoptera and Ephemeroptera and the amount of oxygen in the water (Wiggins 1996, Campbell 1990) Trichoptera are case-making insects, and their capability to survive in areas with less oxygen has been shown to correlate to the type of case they are capable of creating. The order is divided into subordinal groups according to the cases they make -- closed-cocoon, fixed retreat, and portable-case. The less oxygen, the less families of Trichoptera are capable of living in a given environment. All 26 families of Trichoptera are capable of living in cool, lotic waters where oxygen levels are high, but only 21 are capable of living in warm lotic sites with less oxygen, 8 in standing waters, and only 3 in temporary ponds with the least oxygen of all. Two of the three temporary pond inhabitants are portable-case makers and six of the eight standing water inhabitants are portable-case makers. This has been shown to be correlated to the ability of the portable case to create their own current of water through the case (Wiggins 1996). It was hypothesized that Trichoptera and Ephemeroptera will be found more abundantly in the stream environments as well as more commonly in lake environments with high oxygen levels. In order to obtain additional information about what taxa are present, a light trap was used at Tenderfoot Lake to collect adult insects. This enabled me to identify insects to species and also chart the emergence schedule of the species in one lake.

Materials and Methods

Ten sites were sampled on the UNDERC property. Eight of the sites were lakes including Bay Lake, Bergner Lake, Kickapoo Lake, Mullahy Lake, Nansen Lake, Raspberry Lake, Tenderfoot Lake, and Ward Lake. The other two sampling sites were Brown Creek and Tenderfoot Creek. Samples were taken from all sites in two separate sampling periods, the first spanning four days: 6/1/97-6/4/97 and the second spanning three days: 6/29/97-7/1/97.

Water Chemistry

For the eight lakes sampled, rafts, row boats, or canoes depending on the site were used in combination with previously compiled aquatic habitat descriptions of the UNDERC lakes (Elser 1987, S.R. Carpenter, unpublished; UNDERC, unpublished) to travel to a point approximately over the deepest part of the lake. Here we tested temperature (C) and dissolved oxygen (mg/L) in one meter increments down to the lake bottom by lowering the probe of a oxygen/temperature meter. We then used a Secchi disc to measure the secchi depth (m) -- the point at which the white disc is last visible from above the surface of the water. Ph and conductivity (umhos/cm) were measured in the lakes as well, using pH and conductivity meters. We then obtained four water samples, two using a Van Dorn Sampler at one half the secci depth, and two just below the lake surface. These samples were taken to the laboratory and analyzed for sulfide, alkalinity (mg/l), and color using the Hach water chemistry kit.

Due to the nature of streams, secchi depth was not obtained in the two stream sites. Only two water samples were taken just below the water surface at these sites, but the samples were tested in the same way as the lake samples for sulfide, alkalinity, and color. Ph and conductivity were also determined with pH and conductivity meters at the stream sites.

Trichoptera, Megaloptera, and Ephemeroptera Sampling

Sampling was carried out in the water around the vegetation growing on the edges of the lakes. Sampling in lakes was done on foot or from a raft if there was insufficient footing. Each site was sampled by the four team members for two hours during the first sampling period and for one and one-half hours during the second sampling period. Our objectives during sampling were to sample in a fairly even distribution around the entire lake and also to sample in areas where the habitat differed from other areas of the lake. In the two stream sites, we sampled on foot, again using dip nets in the vegetation along the stream edges, and using a kick net in the channel. The insects we obtained were placed in vials of ethanol, brought back to the laboratory, and identified to genus.

Light Trap Sampling

The other part of the project consisted of using a light trap to sample for adult megaloptera, ephemeroptera, and trichoptera. The trap was situated sufficiently near to Tenderfoot Lake to assume most of the trapped adults had emerged from this lake. The trap was run twice each week beginning May 25, 1997 and ending the week of July 17, 1997. The week was divided into Monday - Thursday and Friday - Sunday periods. The trap was run on the first relatively clear and calm day during each period, or if no clear or calm day came, the trap was run on the last day of that period. The trap ran from 8:00 p.m. until 6:00 a.m. Insects trapped fell into a container of ethanol which was taken to the laboratory and sorted. The adult megaloptera, ephemeroptera, and trichoptera were then identified to species.

Results

Water Chemistry

Data from the water chemistry tests are shown in table 1a. The pH readings taken during the first sample were unusable due to problems with the pH meter. The alkalinity readings from the first sample were unusable due to incorrect procedure during testing, and the oxygen-temperature meter used during the second sampling period gave questionable, and therefore unusable numbers. We did not obtain Secchi depth or oxygen-temperature readings for Nansen Lake during the first sampling period because of physical difficulty getting the rafts out to the lake. All sulfide tests found no sulfide, so this is not included in the table.

Alkalinity and color data in the water chemistry table are the averages taken from the four water samples obtained for each lake and the two samples obtained for each stream.

Trichoptera, Ephemeroptera, and Megaloptera Sampling

Trichoptera collected were identified to genus and are listed in tables 1-3. Eleven different geni were found belonging to five families: 6 Limnephilidae, 2 Hydropsychidae, and one each of Leptoceridae, Phryganeide and Psychomyiide. Five of the geni were

found in the lakes or both lakes and streams, whereas six were found only in the streams. Geni found were very different in the two sampling periods. Limnephilidae Anabolia and Phryganeide Agrypnia were the most widespread trichoptera found in the first sampling, with each being found in six of the twelve sites. Neither were found in the second sampling. Here the most prevalent trichoptera was the Limnephilidae Limnephilus with a total of 25 insects spread between two lakes.

Ephemeroptera were also identified to genus and are listed in tables 4-6. Nine geni were found belonging to seven different families. In the first sampling period, ephemeroptera were found only in Tenderfoot Lake, Bay Lake, and Tenderfoot Creek. In the second sampling ephemeroptera were found at every site. The most prevalent and abundant ephemeroptera found was the Caenidae Caenis who was not found during the first sampling period, but found in seven of ten sites during the second period. With the exception of Caenidae Caenis, individual geni of ephemeroptera were found in small numbers at a small number of sites.

Megaloptera were also identified to genus and are listed in tables 7-9. Two geni were found, Corydalidae Nigronia and Sialiadae Sialis. Megaloptera were found only in the stream sites, with Nigronia found in Tenderfoot Creek during both sampling periods, and Sialis found in Brown Creek in the first sampling period.

Light Trap

Only trichoptera adults were found in the light trap in significant numbers to consider emergence. Adults were identified to species. Three species of trichoptera were found in significant numbers, Leptoceridae Oecetis inconspicua, Hydroptilidae Neotrichia vibrans, and Polycentopodidae Nyctiophylax sp. Figures 31-33 show the numbers of these species found during each night the trap was run.

Discussion

Lakes

All eight lakes sampled were found to be fairly neutral, in the 6.0 - 7.9 range. In terms of oxygen, the oxygen saturation figures, (Figures 1-5) show that the oxygen saturation level was generally fully saturated at the surface, but decreased with decreasing depth. The lakes are all fairly active, therefore, since they would have retained the 100% saturation that builds up through the winter if no biological activity taking place. At the same time, we found no sulfide in any of the lakes. If all the oxygen was used, sulfide would have been produced. Therefore, the lakes were found to be fairly productive, but not eutrophic. Also, as seen in figure 6-10, all eight lakes during the first sampling period, were in the process of stratification with the three zones fairly delineated.

Trichoptera

It was predicted that trichoptera would be found abundantly in stream sites because of the higher oxygen content of streams. The highest number (46) was found in Tenderfoot Creek, but only six were found in Brown Creek. This may have been a result of Tenderfoot Creek being higher in oxygen content than Brown. Also, Tenderfoot Creek had a higher pH than Brown (Table 1a) and there were more trichoptera found in lakes with higher pH as well (see below). In the lakes, trichoptera were most abundant in Kickapoo and Bay. It was predicted trichoptera would be most abundant in lakes with higher oxygen content, but interestingly, Bay and Kickapoo did not have significantly higher oxygen content than the other lake sites. (Figures 1-20) Bay and Kickapoo were the second and fourth largest in terms of shoreline length and surface area. (Tables 10 and 12) It is

possible that the higher numbers of trichoptera in these sites had to do with their being more habitat available or more variation in habitat. Bay, specifically, had great variation in shoreline habitat and this may be explanation for greater numbers of trichoptera.

Additionally, the trichoptera were primarily found in lakes with pH in the 7.6-7.9 range. (see table sorted for pH (13)) Only eleven insects were found in the four lakes in the 6.0-7.3 range, whereas 100 were found in the six 7.6-7.9 lakes.

One of the most significant factors determining which taxa are found appears to be when they are collected. During the first sampling period, Phraganeide Agrypnia and Limnephilidae Anabolia dominated the collection. Neither of these were found in the second sampling period, here the most abundant was the Limnephilidae Limnephilus. (Tables 2 and 3) An interesting further study would be a consistent sampling throughout the summer to find variations in predominant taxa correlated with time of year.

Ephemeroptera

Ephemeroptera were found most abundantly in Tenderfoot Creek, Bay, Tenderfoot Lake, and Kickapoo. (Tables 4-6) In the first sampling, insects were predominantly found in Tenderfoot Creek, correlating with the high oxygen content of the stream. In the second sampling, six different geni were found, but Caenidae Caenis was by far the most abundant, appearing in eight of the ten sites. In terms of the lakes sites, the most ephemeroptera were found most abundantly in lakes with greater surface area and greater shoreline length. (Tables 10-11) This, similarly to trichoptera, may have been due to greater habitat available and greater variation in habitat in these larger lakes.

Megaloptera

Megaloptera were found only in the two stream sites, Brown and Tenderfoot. As predicted, these insects were more abundant in streams than lakes because of higher oxygen contents which they need to live. (Tables 7-9)

Light Trap

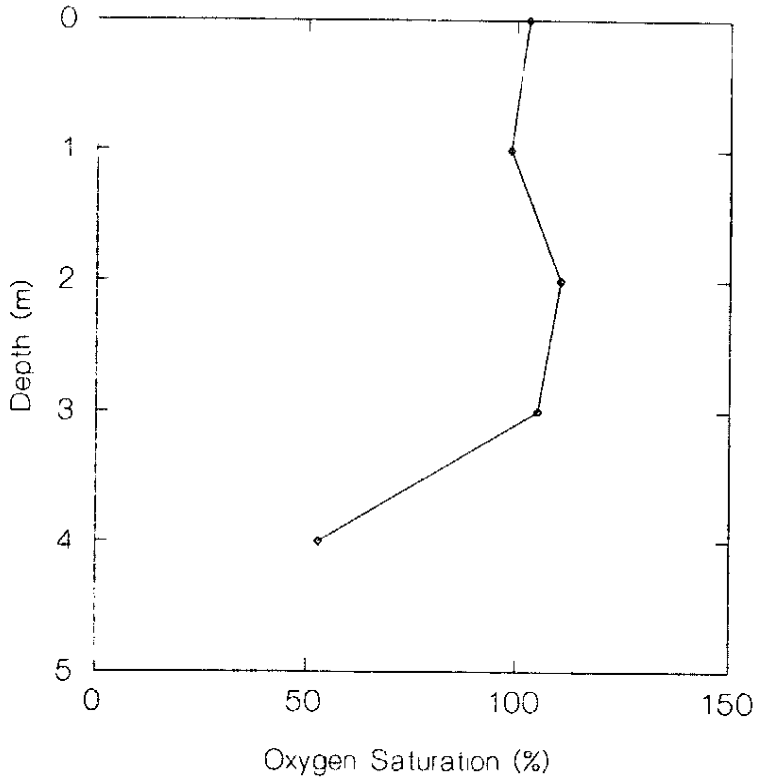
Adults were found in the light trap in lower numbers than expected. (Figures 31-33) The increase in adults towards the end of the sampling period may be a sign that the emergences from Tenderfoot Lake were beginning as the sampling period ended. Further investigation should involve trapping throughout the entire season. Interestingly, none of the three taxa found in largest numbers, Polycentropodidae Nytiophylax sp., Hydroptilidae Neotrichia vibrans, and Leptoceridae Oecetis inconspicua were found in immature form during the dip net sampling at Tenderfoot Lake. This points to either difficulty in finding these immatures with our method of sampling, or the possibility that the trap was catching adults from somewhere besides Tenderfoot Lake.

Water Chemistry Data

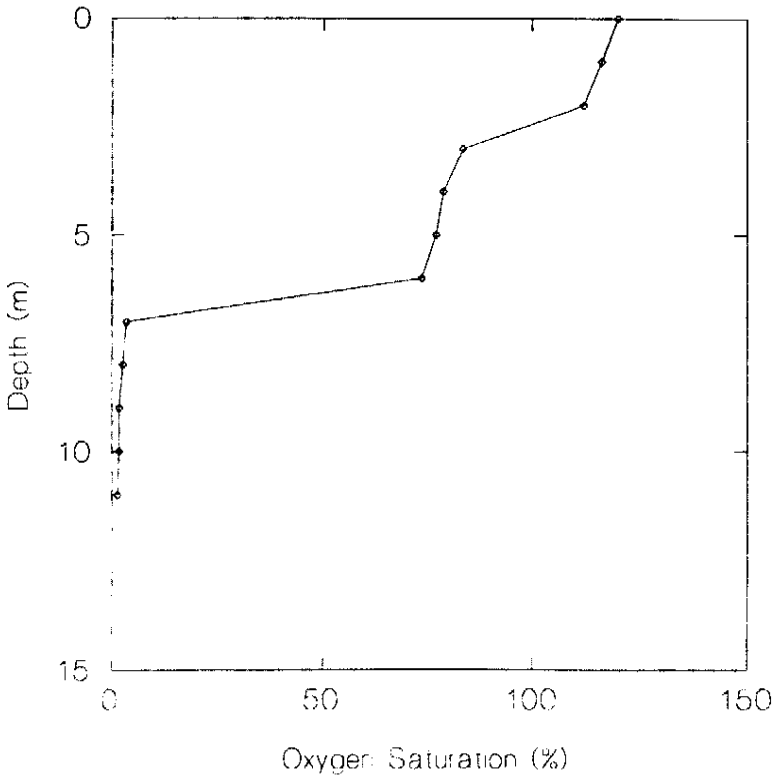
site	per	date	time	cond.	secchi	pH	color	surf O2	sur tem	alk
Raspberry Lake	1	6/1/97	11:30 AM	11.4	2.6		37.3	9.35	20	
Bergner Lake	1	6/1/97	3:00 PM	10.7	2.2		70	10.5	22	
Mullahy Lake	1	6/2/97	9:20 AM	86	1.6		80.3	8.95	20	
Ward Lake	1	6/2/97	1:45 PM	135.4	2.7		58	8.8	23	
Kickapoo Lake	1	6/2/97	3:45 PM	42.4	1.4		90	8.9	22.5	
Nansen Lake	1	6/3/97	9:30 AM	27.1			138		20.1	
Tenderfoot Creek	1	6/3/97	1:15 PM	77.5			69.5	8.15	21.7	
Brown Creek	1	6/3/97	2:25 PM	78.8			104	6.6	22	
Bay Lake	1	6/4/97	8:50 PM	14.7	3.7		13.5	9.2	19	
Tenderfoot Lake	1	6/4/97	2:45 PM	76.7	2.7		36.5	9.35	20	
Raspberry Lake	2	6/29/97	8:30 AM	11.3	2.7	7.3	35		24	0
Bergner Lake	2	6/29/97	10:55 AM	11.6	2.2	6	54.8		29.5	0
Kickapoo Lake	2	6/29/97	2:50 PM	73.6	1.6	7.6	66		25.5	39.5
Brown Creek	2	6/29/97	3:30 PM	105.4		7.1	76.5		25	47
Mullahy Lake	2	6/30/97	9:10 AM	110.3	1.3	7.6	79.4		23.5	36
Ward Lake	2	6/30/97	10:50 AM	144.5	2.25	7.6	56.5		25	58
Bay Lake	2	6/30/97	1:30 PM	14.8	2.4	7.6	16		25	0
Nansen Lake	2	7/1/97	10:15 AM	31.6	1.4	7	132		24	10.5
Tenderfoot Lake	2	7/1/97	1:55 PM	7.9	3.5	7.9	43.5		25	33.5
Tenderfoot Creek	2	7/1/97	4:15 PM	95.5		7.6	71		28	38

Table 1a. Data obtained at the ten sites during the two sampling periods.

1. Raspberry 06/01/97

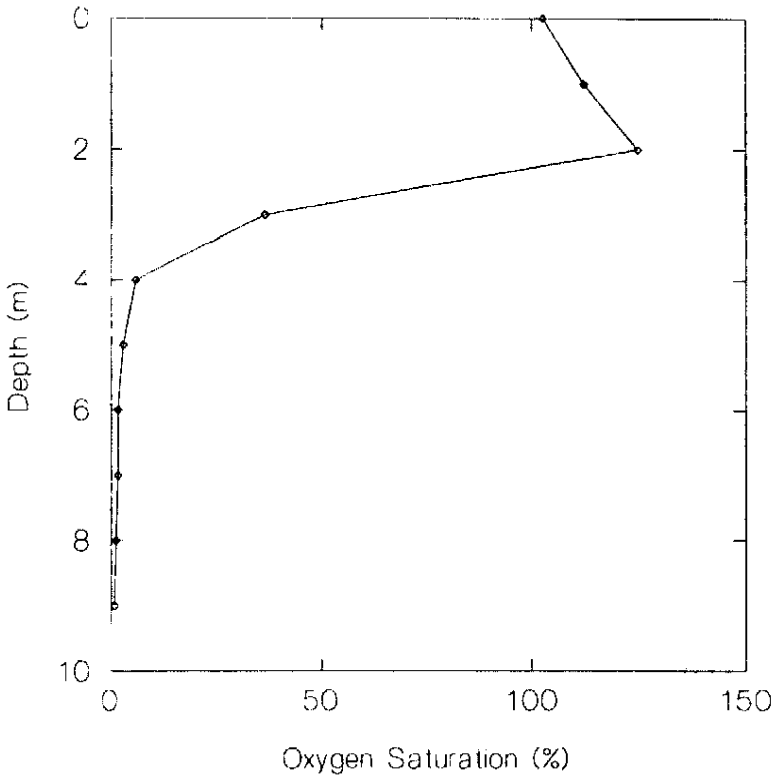


2. Bergner 06/01/97

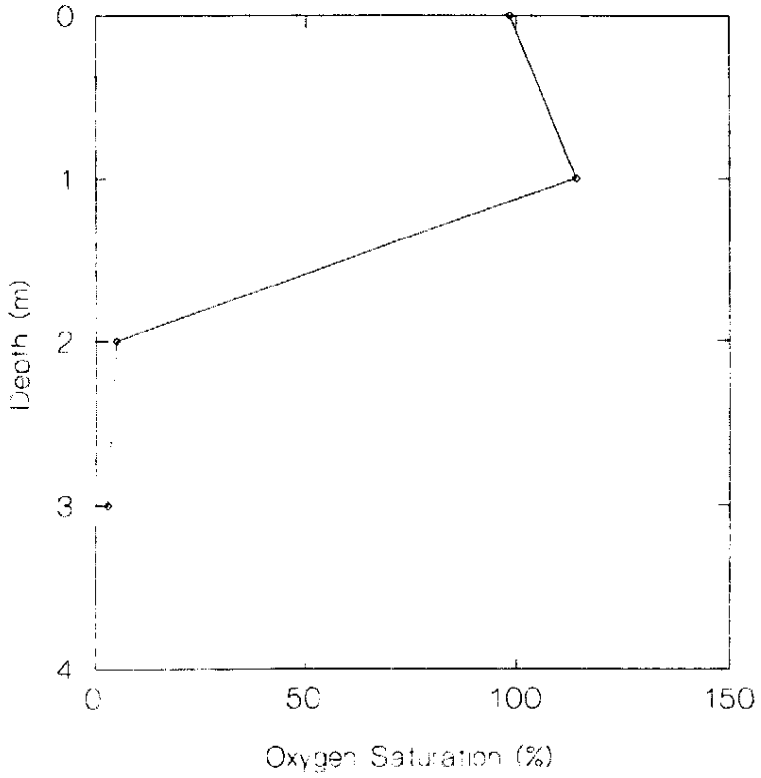


Figures 1-10. Oxygen saturation (%) versus depth in one meter increments for each of the sampling sites during the first sampling period.

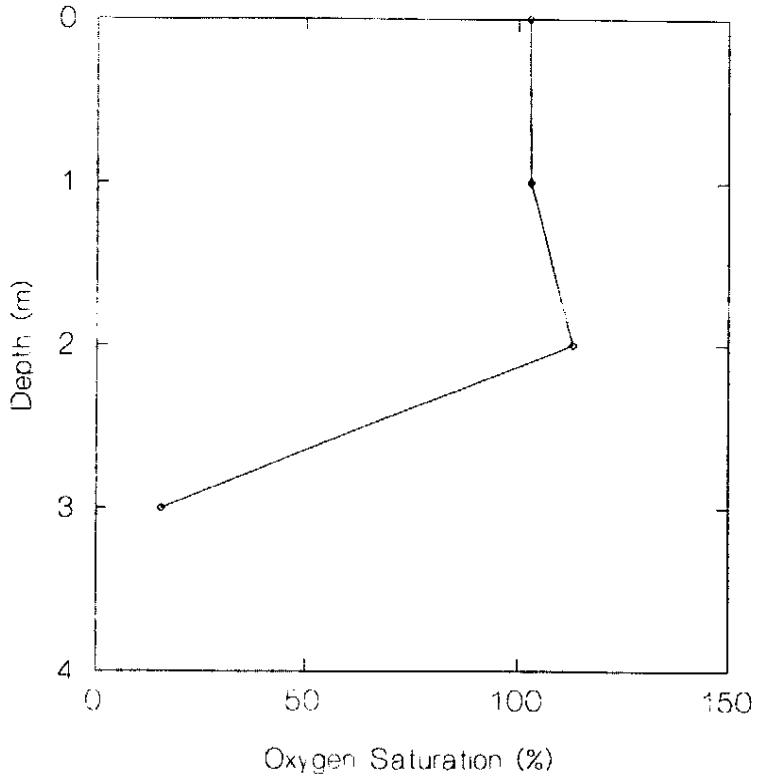
3. Ward 06/02/97



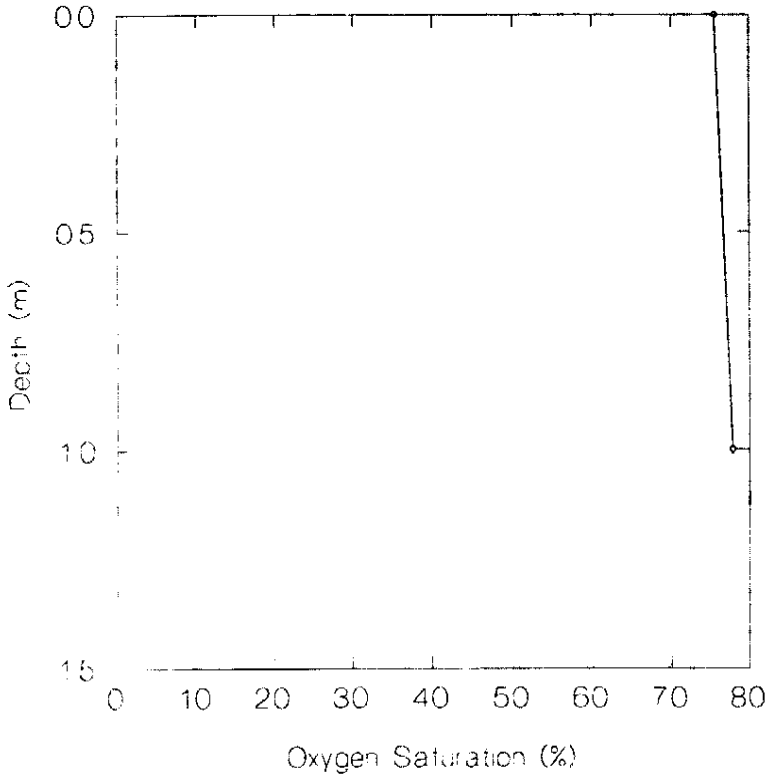
4. Mullahy 06/02/97



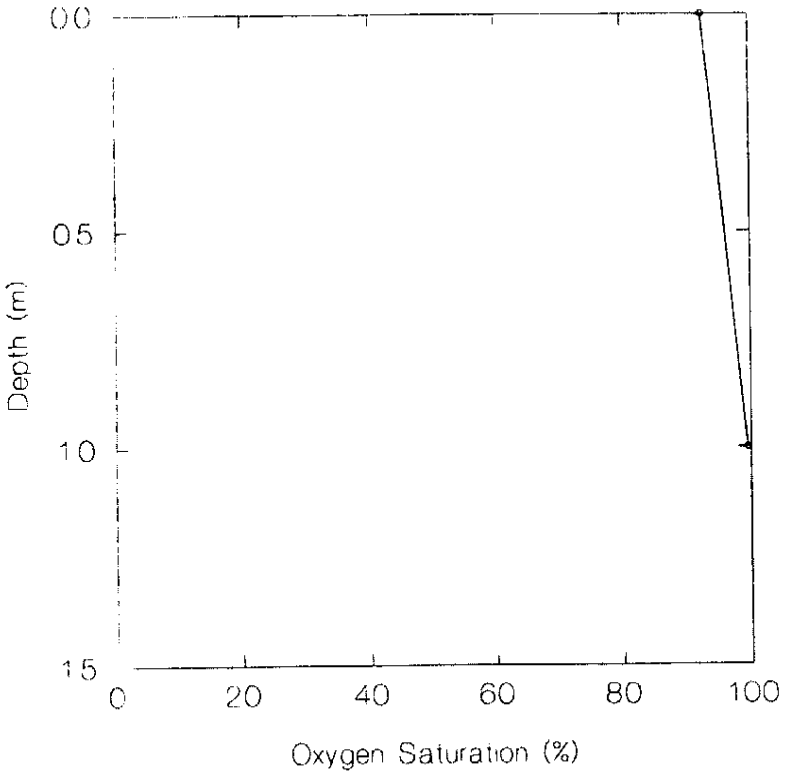
5. Kickapoo 06/03/97



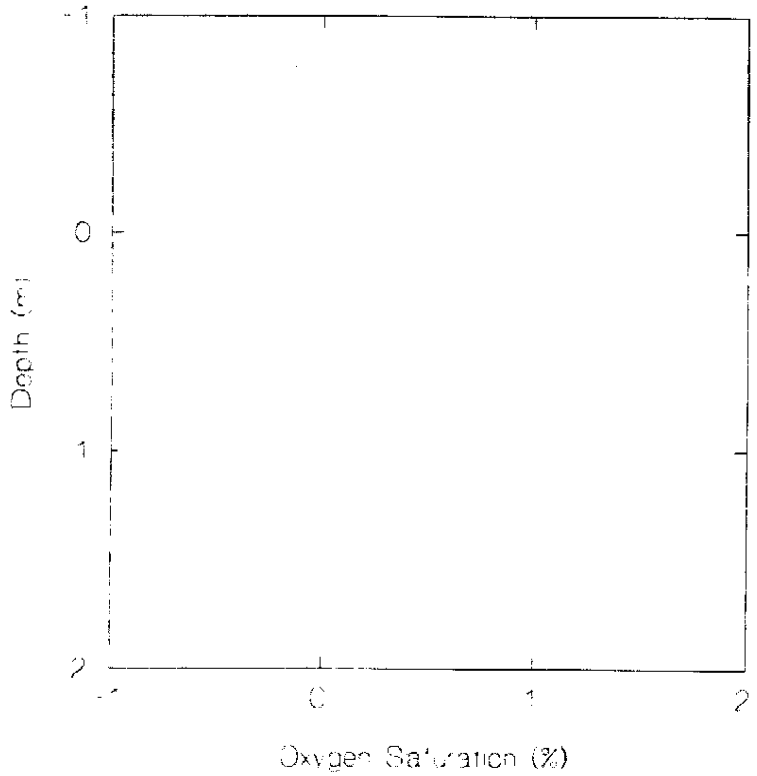
6. Brown Creek 06/03/97



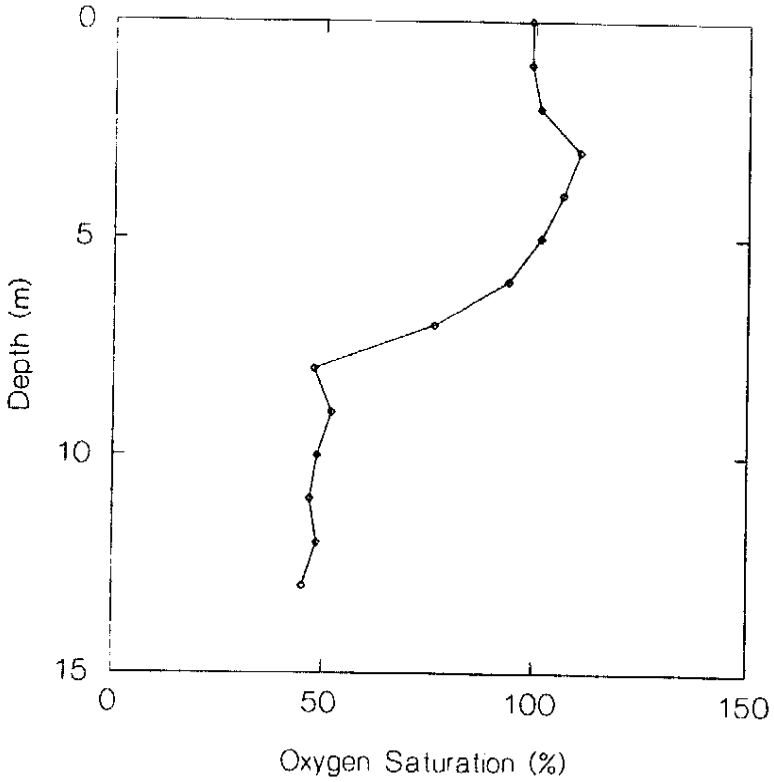
7. Tenderfoot Creek 06/03/97



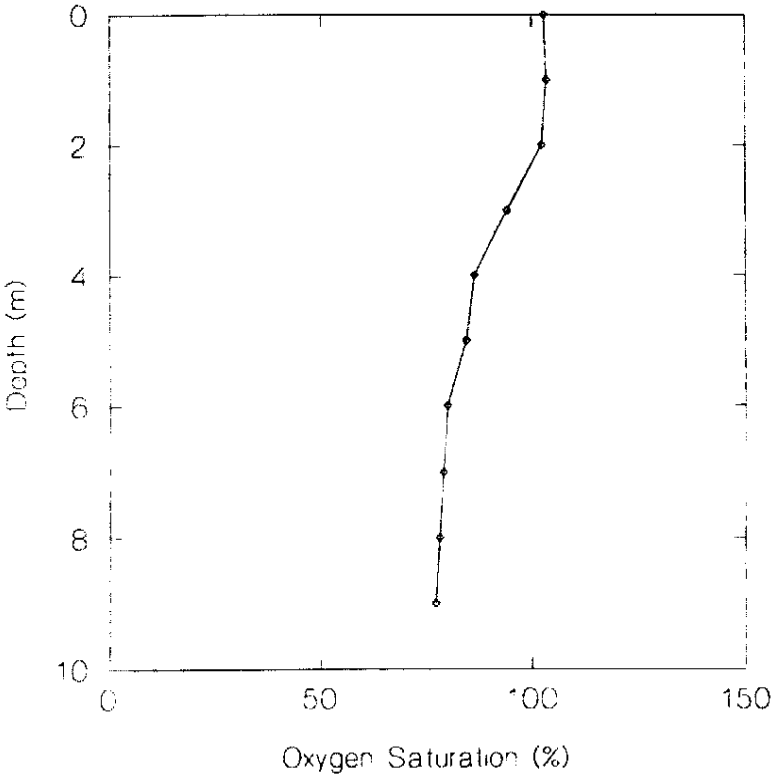
8. Nansen 06/03/97



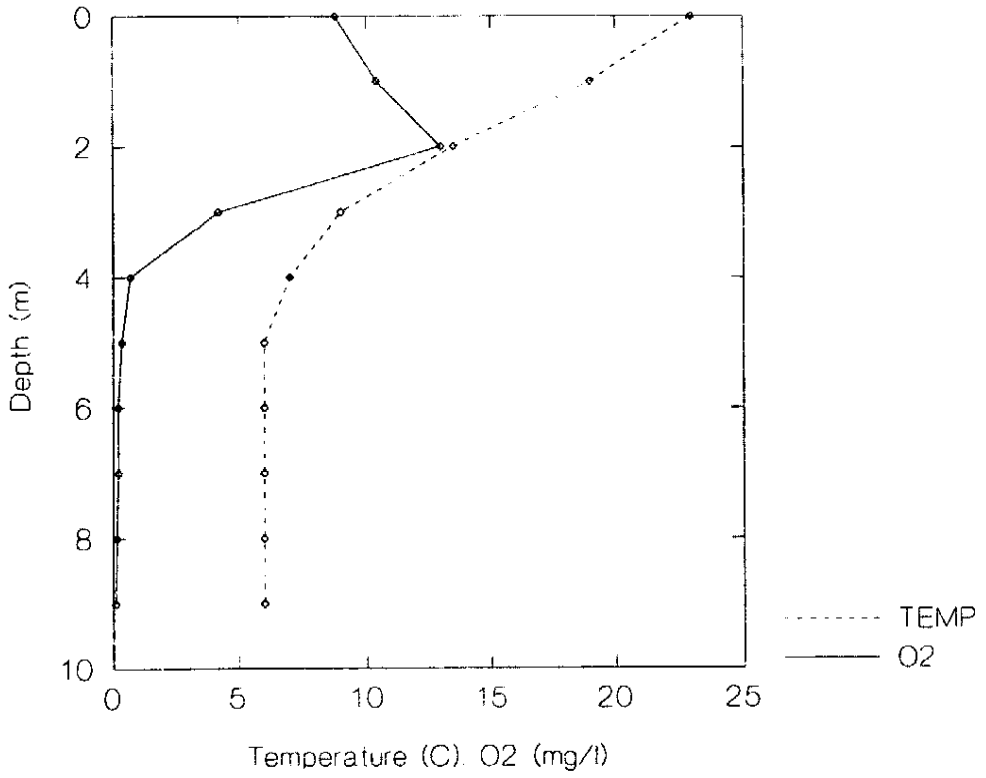
9. Bay 06/04/97



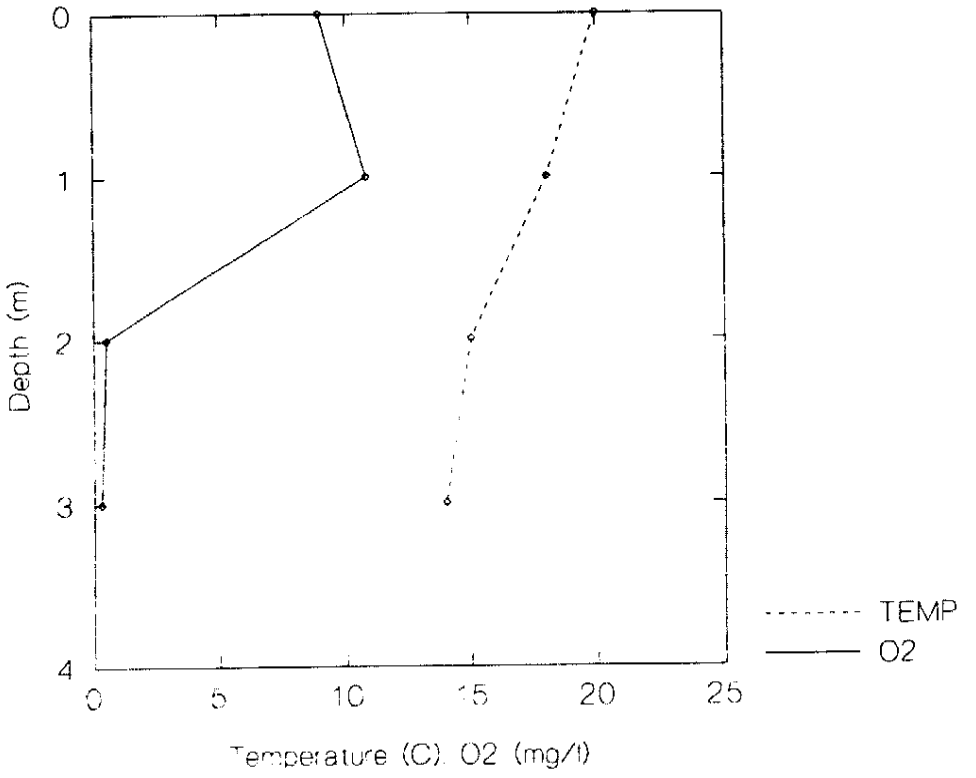
10. Tenderfoot Lake 06/04/97



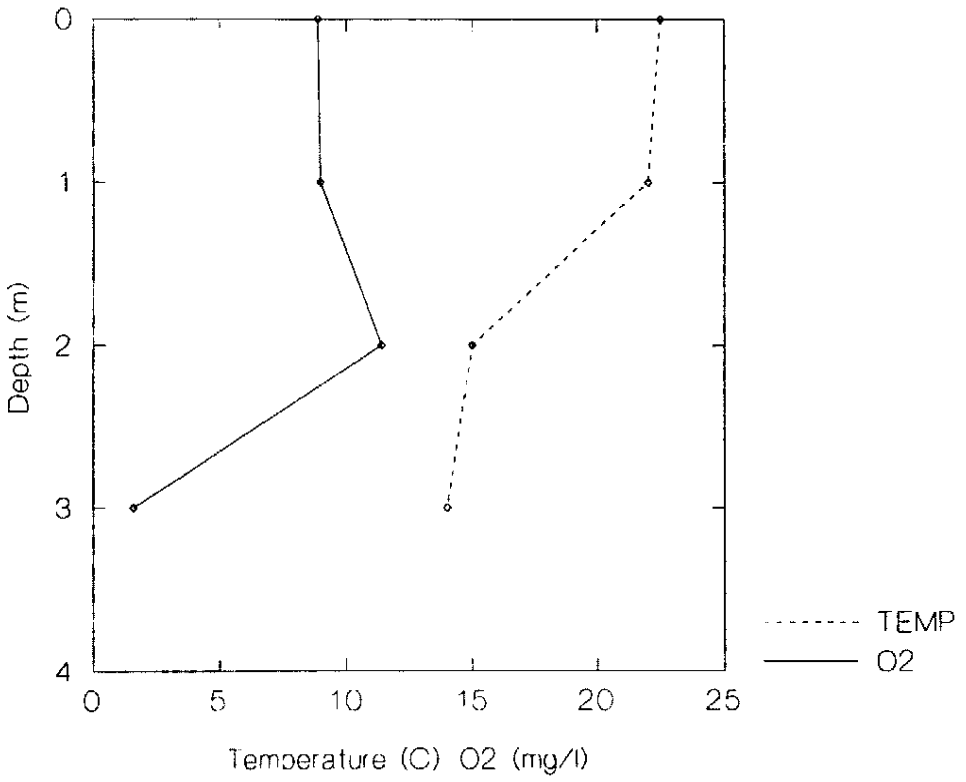
13. Ward 06/02/97



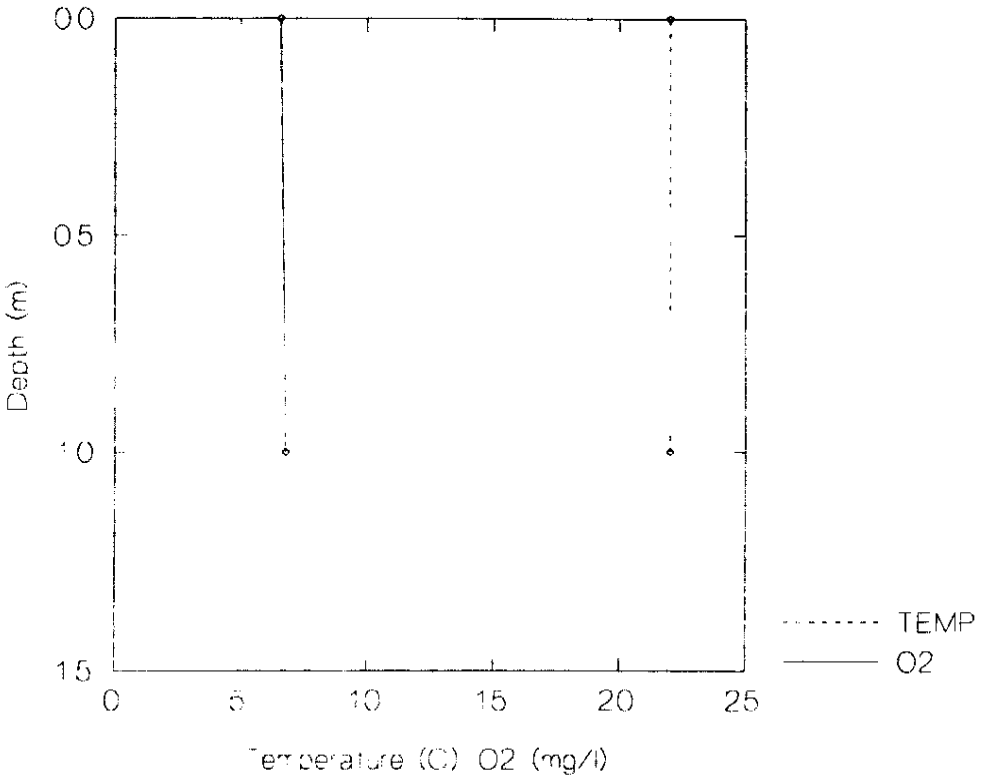
14. Mullahy 06/02/97



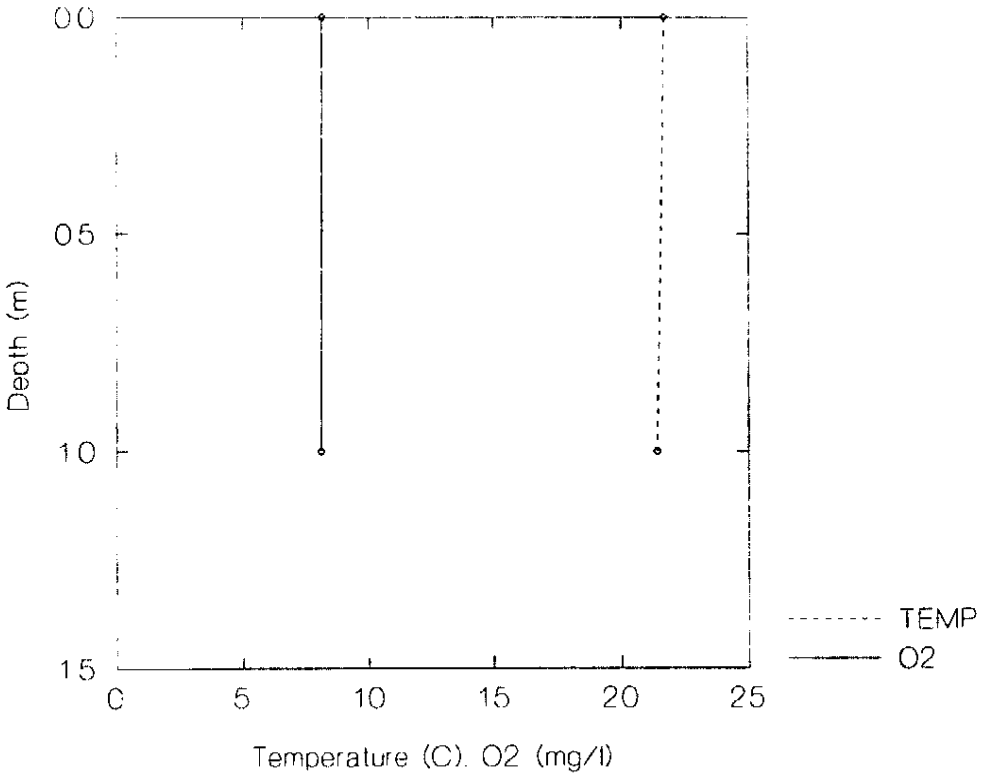
15. Kickapoo 06/03/97



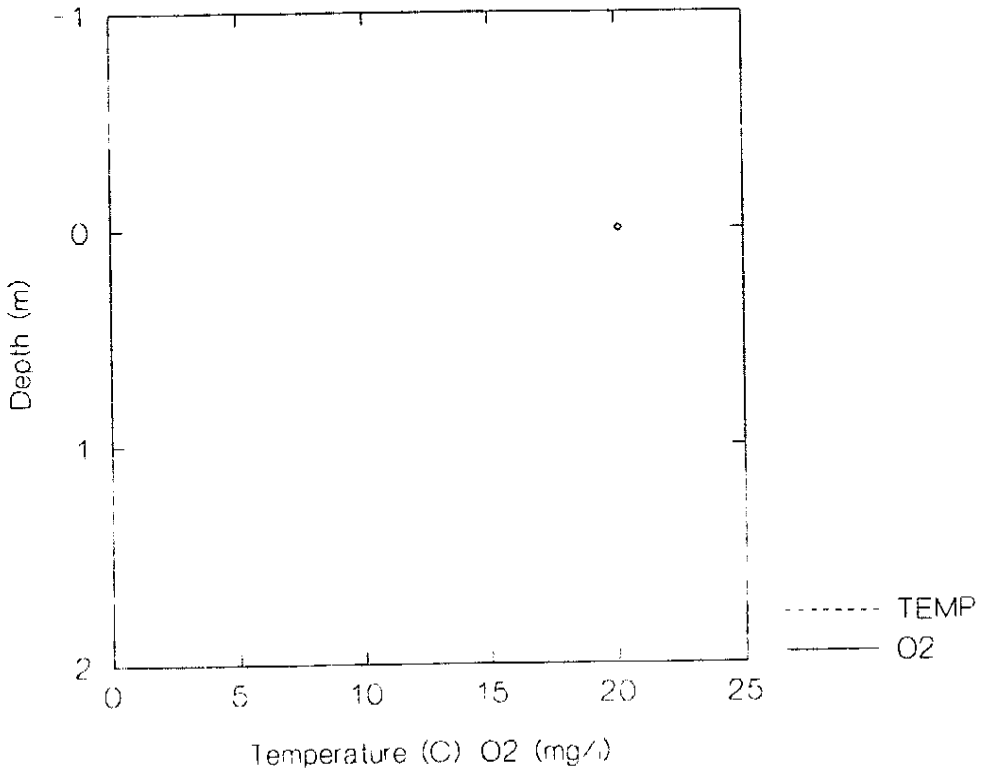
16. Brown Creek 06/03/97



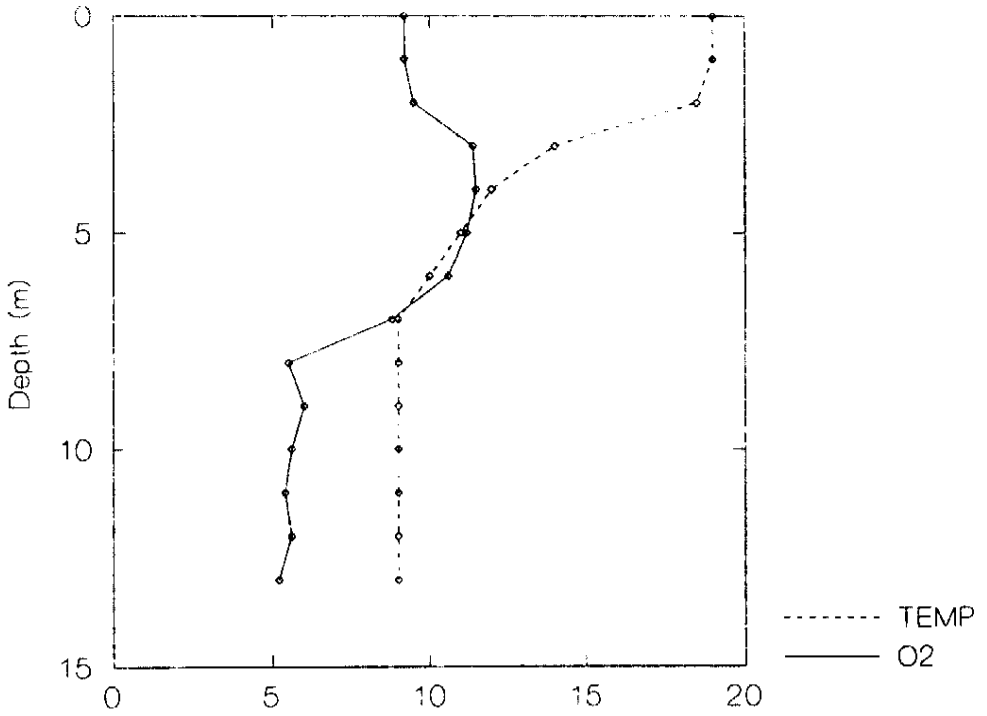
17. Tenderfoot Creek 06/03/97



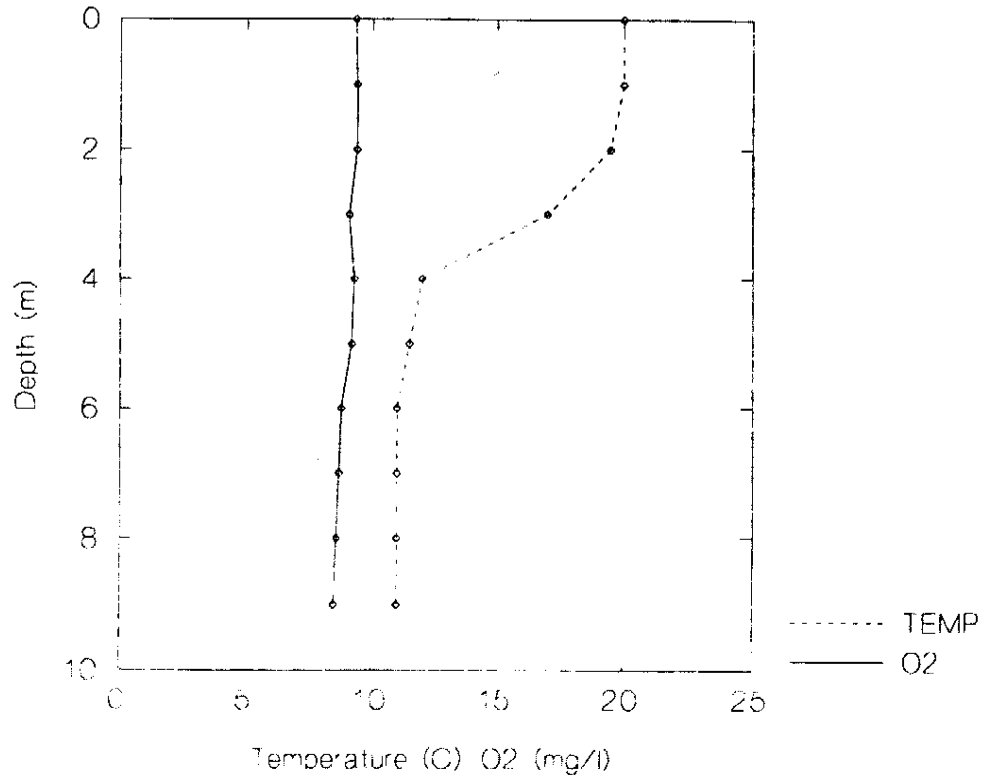
18. Nansen 06/03/97



19. Bay 06/04/97



20. Tenderfoot Lake 06/04/97



Total Trichoptera Collected

	Berg	Rasp	Mull	Ward	Kick	Nan	TL	Bay	Brown	TC		Total
HYCH									1			1
HYHY										26		26
Total HY	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**26**		**27**
LIAN	3	1		2	4		6	1				17
LIAS									4			4
LIHY										11		11
LILI					14			19				33
LIPL					1							1
LIPY										4		4
Total LI	**3**	**1**	**0**	**2**	**19**	**0**	**6**	**20**	**4**	**15**		**70**
LENE							3					3
PHAG			2	2	1	1		2	1			9
PSLY										5		5
Total Trich	**3**	**1**	**2**	**4**	**20**	**1**	**9**	**22**	**6**	**46**		**114**

Table 1. This table shows the total number of trichoptera collected in sampling periods 1 (6/1/97-6/4/97) and 2 (6/29/97-7/1/97), divided according to family.

Trichoptera Abbreviations

HYCH Hydropsychidae Cheumatopsyche
HYHY Hydropsychidae Hydropsyche
LENE Leptoceridae Nectopsyche
LIAN Limnephilidae Anabolia
LIAS Limnephilidae Asynarchus
LIHY Limnephilidae Hydatophylax
LILI Limnephildidae Limnephilus
LIPL Limnephilidae Platycentropus
LIPY Limnephilidae Pycnopsyche
PHAG Phryganeide Agrypnia
PSLY Psychomyiidae Lype

Site Abbreviations

Berg Bergner
Rasp Raspberry
Mul Mullahy
Ward Ward
Kick Kickapoo
Nan Nansen
TL Tenderfoot Lake
Bay Bay
Brown Brown Creek
TC Tenderfoot Creek

Trichoptera Collected in Sampling Period 1
(6/1/97-6/4/97)

	Berg	Rasp	Mull	Ward	Kick	Nan	TL	Bay	Brown	TC		Total
HYCH												0
HYHY										24		24
Total HY	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**24**		**24**
LIAN	3	1		2	4		6	1				
LIAS									4			4
LIHY										11		11
LILI								8				8
LIPL					1							1
LIPY												0
Total LI	**3**	**1**	**0**	**2**	**5**	**0**	**6**	**9**	**4**	**11**		**41**
LENE												0
PHAG			2	2	1	1		2	1			9
PSLY										5		5
Total Trich	**3**	**1**	**2**	**4**	**6**	**1**	**6**	**11**	**5**	**40**		**79**

Table 2. This table shows the total number of trichoptera collected in sampling period 1 (6/1/97-6/4/97), divided according to family.

Trichoptera Collected in Sampling Period 2
(6/29/97-7/1/97)

	Berg	Rasp	Mull	Ward	Kick	Nan	TL	Bay	Brown	TC		Total
HYCH									1			1
HYHY										2		2
Total HY	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**		**3**
LIAN												0
LIAS												0
LIHY												0
LILI					14			11				25
LIPL												0
LIPY										4		4
Total LI	**0**	**0**	**0**	**0**	**14**	**0**	**0**	**11**	**0**	**4**		**29**
LENE							3					3
PHAG												0
PSLY												0
Total Trich	**0**	**0**	**0**	**0**	**14**	**0**	**3**	**11**	**1**	**6**		**35**

Table 3. This table shows the total number of trichoptera collected in sampling period 2 (6/29/97-7/1/97), divided according to family.

Total Ephemeroptera Collected

	Berg	Rasp	Mull	Ward	Kick	Nan	T L	Bay	Brown	T C		Tota l
BACA			2									**2**
CACA		2		3	10	6	8	1	4			**34**
EPEL	1						1					**2**
EPEU								10				**10**
EPEA										1		**1**
HESC							1		1			**2**
HESM										9		**9**
OLIS										3		**3**
Total	**1**	**2**	**2**	**3**	**10**	**6**	**10**	**11**	**5**	**13**		**63**

Table 4. This table shows the total number of ephemeroptera collected in sampling periods 1 (6/1/97-6/4/97) and 2 (6/29/97-7/1/97).

Ephemeroptera Abbreviations (Family and Genus)

BACA Baetidae Callibaetis
CACA Caenidae Caenis
EPEL Ephemerellidae Ephemerella
EPEU Ephemerellidae Eurylopella
EPEA Ephemeridae Ephemera
HESC Heptageniidae Stenacron
HESM Heptageniidae Stenonema
OLIS Oligoneuriidae Isonychia

Ephemeroptera Collected in Sampling Period 1
(6/1/97-6/4/97)

	Berg	Rasp	Mull	Ward	Kick	Nan	TL	Bay	Brown	TC		Total
BACA												0
CACA												0
EPEL												0
EPEU								9				9
EPEA										1		1
HESC							1					1
HESM										7		7
OLIS										3		3
Total Ephem	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**9**		**11**		**21**

Table 5. This table shows the total number of ephemeroptera collected in sampling period 1 (6/1/97-6/4/97).

Ephemeroptera Collected in Sampling Period 2
(6/29/97-7/1/97)

	Berg	Rasp	Mull	Ward	Kick	Nan	TL	Bay	Brown	TC		Total
BACA			2									2
CACA		2		3	10	6	8	1	4			34
EPEL	1						1					2
EPEU								1				1
EPEA												0
HESC									1			1
HESM										2		2
OLIS												0
Total Ephem	**1**	**2**	**2**	**3**	**10**	**6**	**9**	**2**	**5**	**2**		**42**

Table 6. This table shows the total number of ephemeroptera collected in sampling period 2 (6/29/97-7/1/97).

Megaloptera Collected

Sampling Period 1 (6/1/97-6/4/97)

	Berg	Rasp	Mull	Ward	Kick	Nan	T L	Bay	Brown	T C		Total
CONI										15		15
SISI									4			4
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**15**		**19**

Sampling Period 2 (6/29/97-7/1/97)

CONI										10		10
SISI												0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**10**		**10**

Total Megaloptera Collected

CONI										25		25
SISI									4			4
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**25**		**29**

Tables 7-9. Tables 7 and 8 show megaloptera found in the first and second sampling periods, respectively. Table 9 shows the total megaloptera found in both sampling periods.

Megaloptera Abbreviations (Family and Genus)

CONI Corydalidae Nigronia
SISI Sialiadae Sialis

10. Surface Area (ha)

Surface Area	1.11	2.74	4.04	4.63	7.87	17.8	67.34	194.25		
Trichoptera	Mull	Ward	Nan	Rasp	Kick	Berg	Bay	TL		Total
HYCH										0
HYHY										0
Total HY	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**0**
LIAN		2		1	4	3	1	6		17
LIAS										0
LIHY										0
LILI					14		19			33
LIPL					1					1
LIPY										0
Total LI	**0**	**2**	**0**	**1**	**19**	**3**	**20**	**6**		**54**
LENE								3		3
PHAG	2	2	1		1		2			8
PSLY										0
Total Trich	**2**	**4**	**1**	**1**	**20**	**3**	**22**	**6**		**62**
Surface Area	1.11	2.74	4.04	4.63	7.87	17.8	67.34	194.25		
Ephemeroptera	**Mull**	**Ward**	**Nan**	**Rasp**	**Kick**	**Berg**	**Bay**	**T L**		**Total**
BACA	2									2
CACA		3	6	2	10		1	8		30
EPEL						1		1		2
EPEU							10			10
EPEA										0
HESC								1		1
HESM										0
OLIS										0
Total	**2**	**3**	**6**	**2**	**10**	**1**	**11**	**10**		**45**

Tables 10-14. Here the total trichoptera and ephemeroptera collected are sorted by values for lake parameters and water chemistry. Values are in the top row of each table in ascending order. Values for lake parameters: surface area (ha), shoreline length (m), and maximum lake depth (m), tables 10-12 are from Elser, 1987, Carpenter, unpublished, and UNDERC, unpublished. Values for pH and surface O2 (mg/l) are from our water chemistry data.

11. Shoreline Length (m)

Shoreline	531	613.8	907.3	910.3	1307.1	2083.2	7697.7	9453		
Trichoptera	**Mull**	**Ward**	**Nan**	**Rasp**	**Kick**	**Berg**	**Bay**	**TL**		**Total**
HYCH										**0**
HYHY										**0**
Total HY	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**0**
LIAN		2		1	4	3	1	6		**17**
LIAS										**0**
LIHY										**0**
LILI					14		19			**33**
LIPL					1					**1**
LIPY										**0**
Total LI	**0**	**2**	**0**	**1**	**19**	**3**	**20**	**6**		**51**
LENE								3		**3**
PHAG	2	2	1		1		2			**9**
PSLY										**5**
Total Trich	**2**	**4**	**1**	**1**	**20**	**3**	**22**	**6**		**114**

Shoreline	531	613.8	907.3	910.3	1307.1	2083.2	7697.7	9453		
Ephemeroptera	**Mull**	**Ward**	**Nan**	**Rasp**	**Kick**	**Berg**	**Bay**	**T L**		**Total**
BACA	2									**2**
CACA		3	6	2	10		1	8		**30**
EPEL						1		1		**2**
EPEU							10			**10**
EPEA										**0**
HESC								1		**1**
HESM										**0**
OLIS										**0**
Total	**2**	**3**	**6**	**2**	**10**	**1**	**11**	**10**		**45**

12. Maximum Lake Depth (m)

Max Depth	NA	3.3	3.3	6	7	9.14	12	13.7		
Trichoptera	**Mull**	**Kick**	**Nan**	**Rasp**	**Ward**	**TL**	**Berg**	**Bay**		**Total**
HYCH										**0**
HYHY										**0**
Total HY	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**0**
LIAN		4		1	2	6	3	1		**17**
LIAS										**0**
LIHY										**0**
LILI		14						19		**33**
LIPL		1								**1**
LIPY										**0**
Total LI	**0**	**19**	**0**	**1**	**2**	**6**	**3**	**20**		**51**
LENE						3				**3**
PHAG	2	1	1		2			2		**8**
PSLY										**0**
Total Trich	**2**	**20**	**1**	**1**	**4**	**6**	**3**	**22**		**62**
Max Depth	NA	3.3	3.3	6	7	9.14	12	13.7		
Ephemeroptera	**Mull**	**Kick**	**Nan**	**Rasp**	**Ward**	**T L**	**Berg**	**Bay**		**Total**
BACA	2									**2**
CACA		10	6	2	3	8		1		**30**
EPEL						1	1			**2**
EPEU								10		**10**
EPEA										**0**
HESC						1				**1**
HESM										**0**
OLIS										**0**
Total	**2**	**10**	**6**	**2**	**3**	**10**	**1**	**11**		**45**

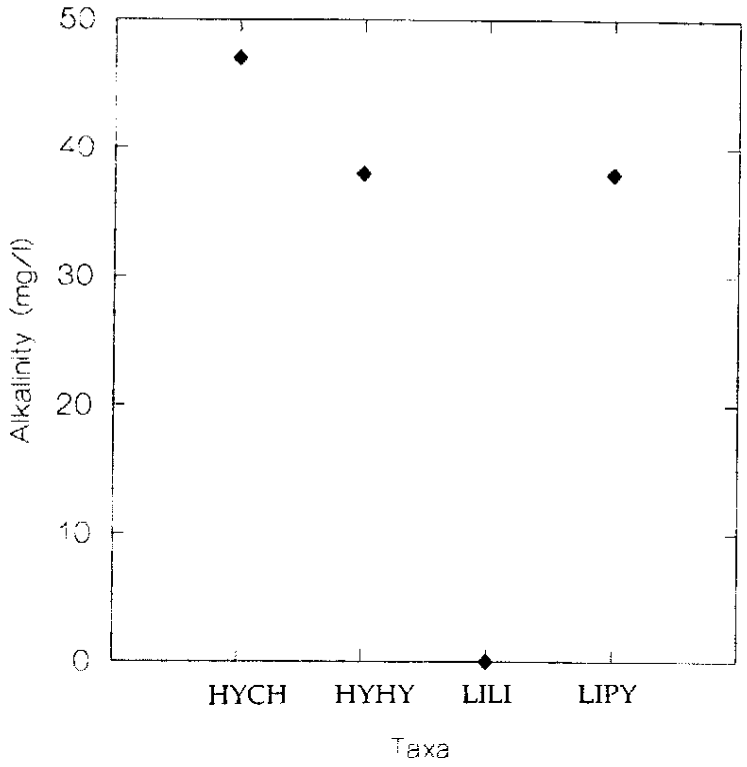
13. pH

pH	6	7	7.1	7.3	7.6	7.6	7.6	7.6	7.6	7.9		
Trichoptera	**Berg**	**Nan**	**Brown**	**Rasp**	**Mull**	**Ward**	**Kick**	**Bay**	**TC**	**TL**		**Total**
HYCH			1									**1**
HYHY									26			**26**
Total HY	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**26**	**0**		**27**
LIAN	3			1		2	4	1		6		**17**
LIAS			4									**4**
LIHY									11			**11**
LILI							14	19				**33**
LIPL							1					**1**
LIPY									4			**4**
Total LI	**3**	**0**	**4**	**1**	**0**	**2**	**19**	**20**	**15**	**6**		**70**
LENE										3		**3**
PHAG		1	1		2	2	1	2				**9**
PSLY									5			**5**
Total Trich	**3**	**1**	**6**	**1**	**2**	**4**	**20**	**22**	**46**	**6**		**114**
pH	6	7	7.1	7.3	7.6	7.6	7.6	7.6	7.6	7.9		
Ephemeroptera	**Berg**	**Nan**	**Brown**	**Rasp**	**Mull**	**Ward**	**Kick**	**Bay**	**T C**	**T L**		**Total**
BACA					2							**2**
CACA		6	4	2		3	10	1		8		**34**
EPEL	1									1		**2**
EPEU								10				**10**
EPEA									1			**1**
HESC			1							1		**2**
HESM									9			**9**
OLIS									3			**3**
Total	**1**	**6**	**5**	**2**	**2**	**3**	**10**	**11**	**13**	**10**		**63**

14. Surface O2 (mg/l)

Surface O2	NA	6.6	8.15	8.8	8.9	9	9.2	9.35	9.4	10.5		
Trichoptera	**Nan**	**Brown**	**TC**	**Ward**	**Kick**	**Mull**	**Bay**	**Rasp**	**TL**	**Berg**		**Total**
HYCH		1										**1**
HYHY			26									**26**
Total HY	**0**	**1**	**26**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**27**
LIAN				2	4		1	1	6	3		**17**
LIAS		4										**4**
LIHY			11									**11**
LILI					14		19					**33**
LIPL					1							**1**
LIPY			4									**4**
Total LI	**0**	**4**	**15**	**2**	**19**	**0**	**20**	**1**	**6**	**3**		**70**
LENE									3			**3**
PHAG	1	1		2	1	2	2					**9**
PSLY			5									**5**
Total Trich	**1**	**6**	**46**	**4**	**20**	**2**	**22**	**1**	**6**	**3**		**114**
Surface O2	NA	6.6	8.15	8.8	8.9	9	9.2	9.35	9.4	10.5		
Ephemeroptera	**Nan**	**Brown**	**T C**	**Ward**	**Kick**	**Mull**	**Bay**	**Rasp**	**T L**	**Berg**		**Total**
BACA						2						**2**
CACA	6	4		3	10		1	2	8			**34**
EPEL									1	1		**2**
EPEU							10					**10**
EPEA			1									**1**
HESC		1							1			**2**
HESM			9									**9**
OLIS			3									**3**
Total	**6**	**5**	**13**	**3**	**10**	**2**	**11**	**2**	**10**	**1**		**63**

21. Alkalinity (mg/l)

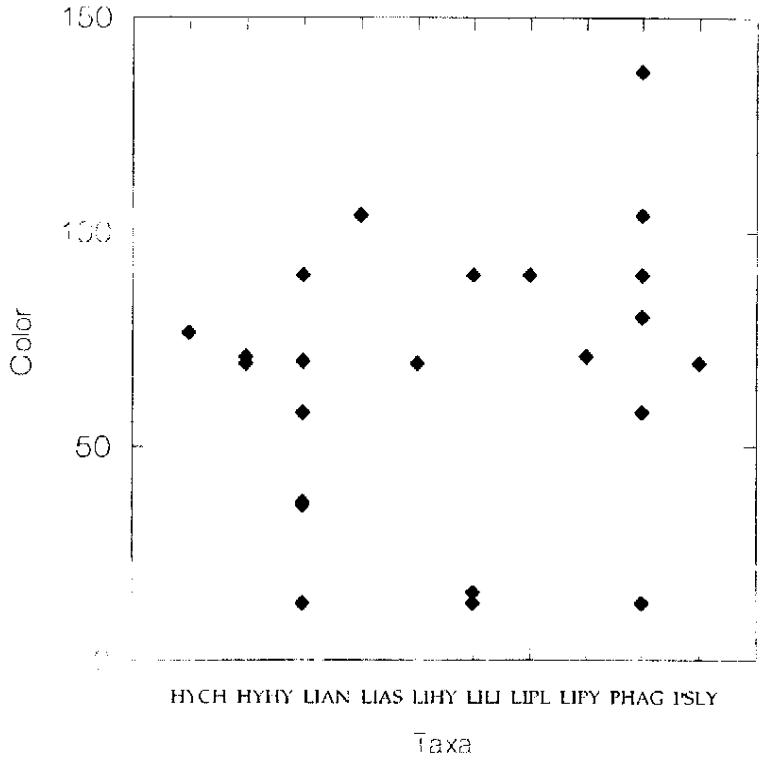


Figures 21-25. Each of these five graphs correlates trichoptera geni with the values of one water chemistry characteristic (alkalinity, color, conductivity, pH, or Secchi depth) from each site where it was found.

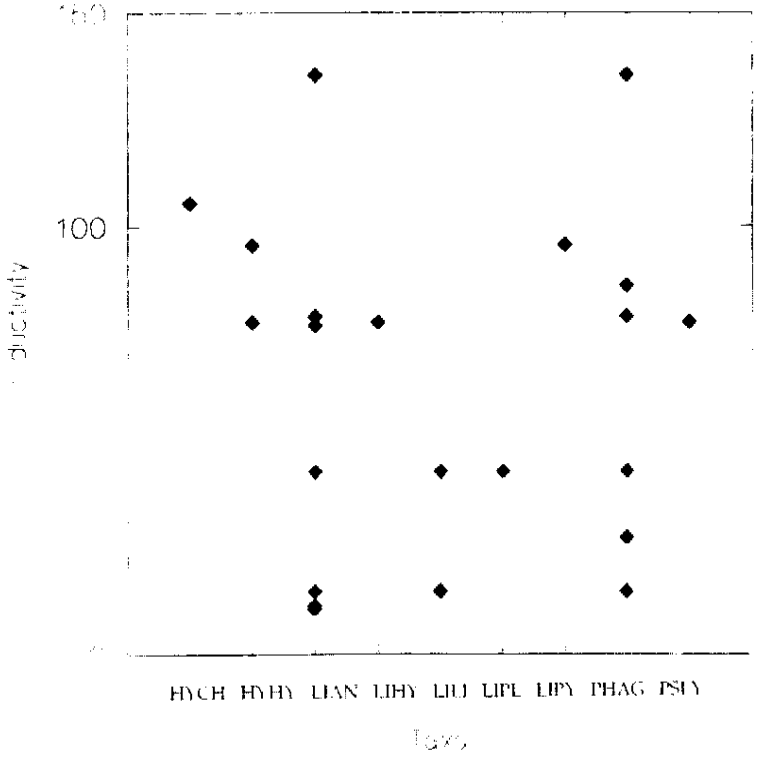
Trichoptera Abbreviations (Family and Genus)

HYCH Hydropsychidae Cheumatopsyche
HYHY Hydropsychidae Hydropsyche
LENE Leptoceridae Nectopsyche
LIAN Limnephilidae Anabolia
LIAS Limnephilidae Asynarchus
LIHY Limnephilidae Hydatophylax
LILI Limnephilidae Limnephilus
LIPL Limnephildae Playtcentropus
LIPY Limnephilidae Pycnopsyche
PHAG Phryganeide Agrypnia
PSLY Psychomiidae Lype

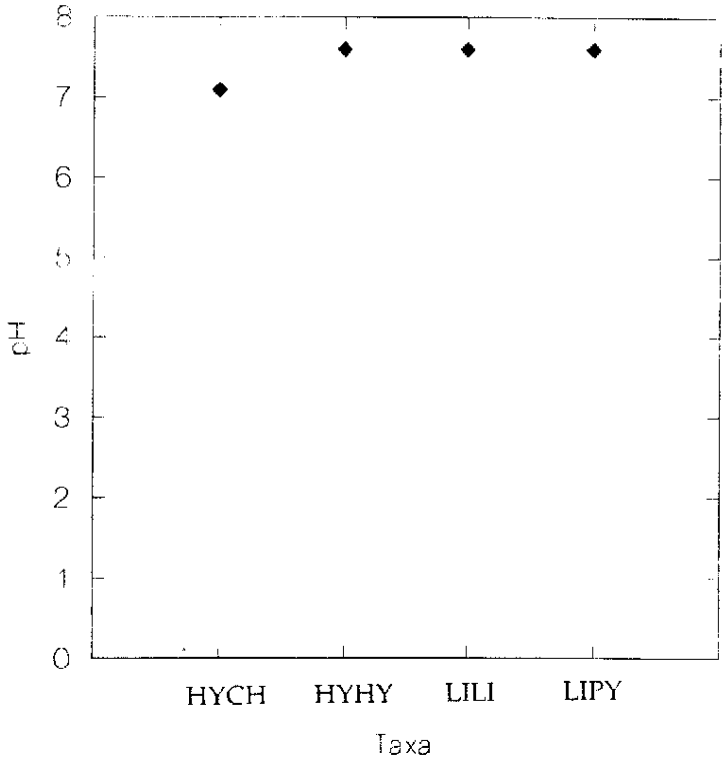
22. Color (Pt/CO)



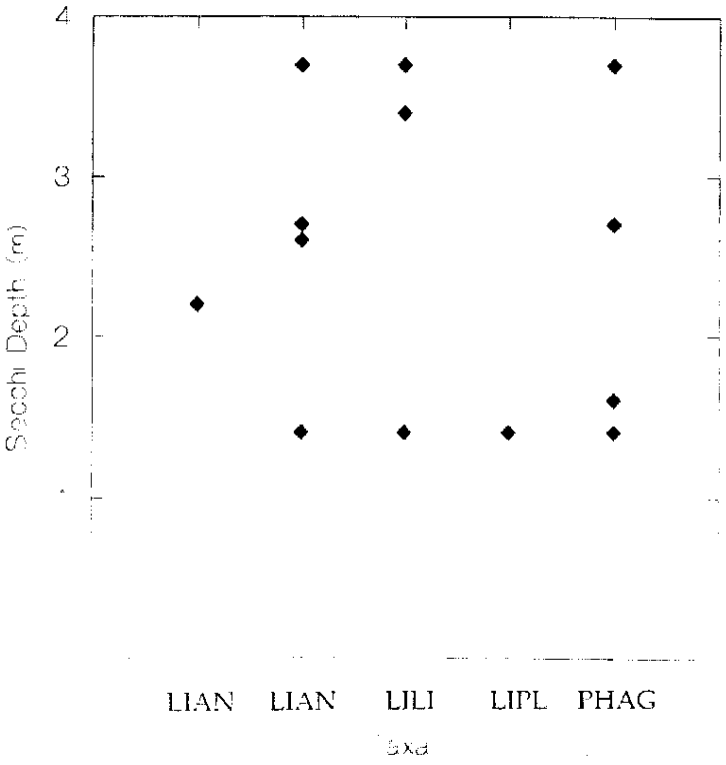
23. Conductivity (umhos/cm)



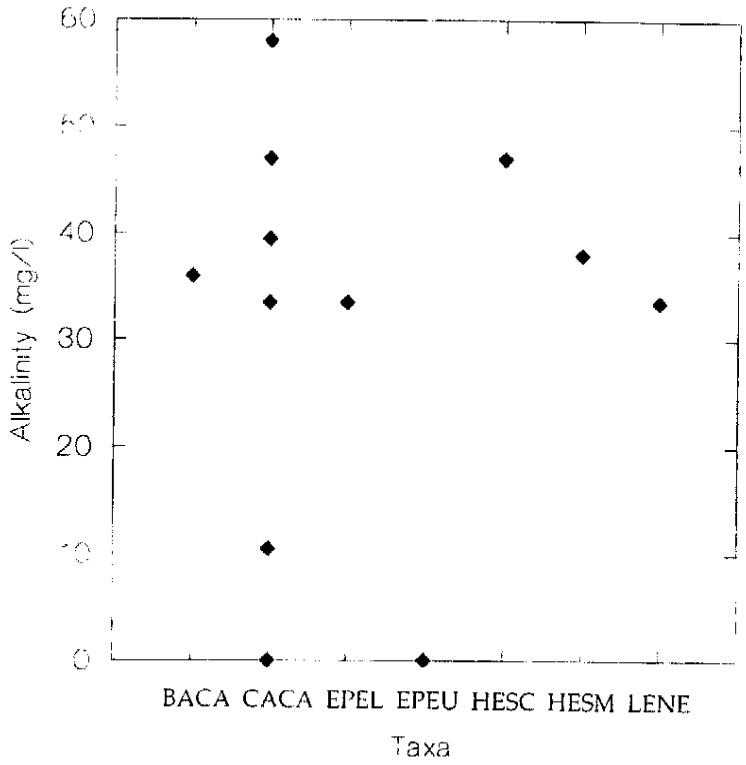
24. pH



25. Secchi Depth (m)



26. Alkalinity (mg/l)

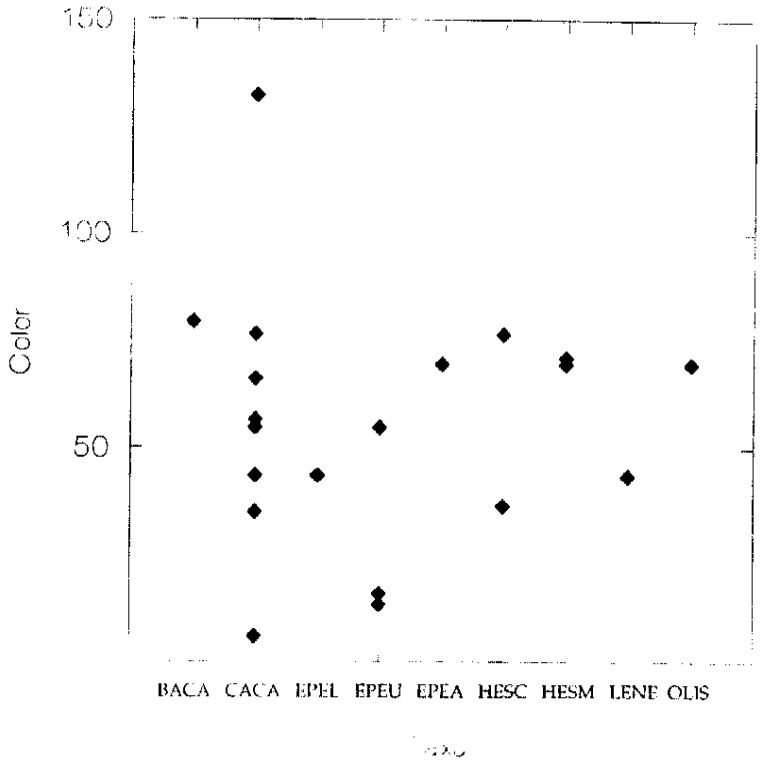


Figures 26-30. Each of these five graphs correlates ephemeroptera geni with the values of one water chemistry characteristic (alkalinity, color, conductivity, pH, or Secchi depth) from each site where it was found.

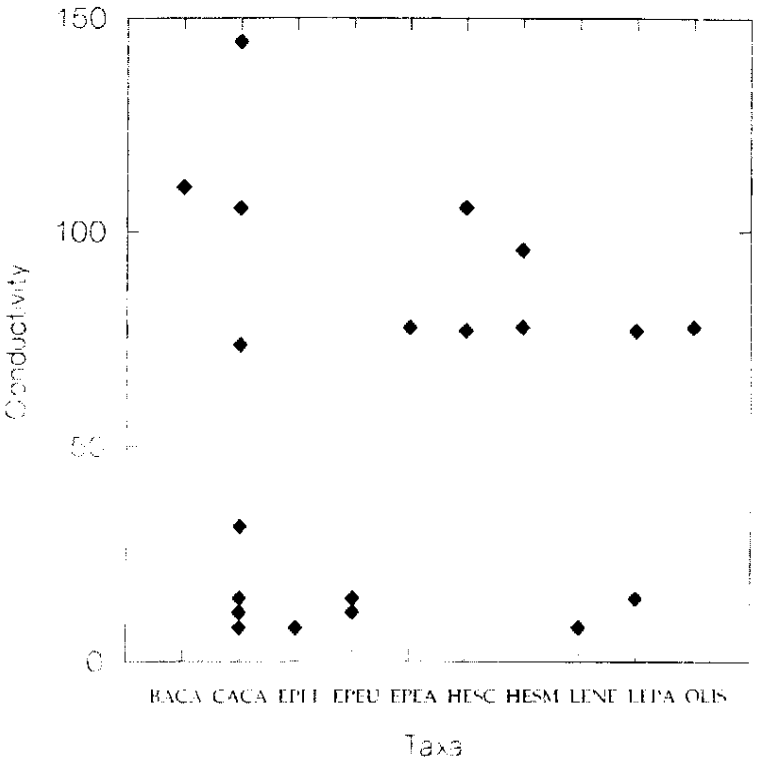
Ephemeroptera Abbreviations (Family and Genus)

BACA Baetidae Callibaetis
CACA Caenidae Caenis
EPEL Ephemerellidae Ephemerella
EPEU Ephemerellidae Eurylopella
EPEA Ephemerellidae Ephemera
HESC Heptageniidae Stenacron
HECM Heptageniidae Stenonema
OLIS Oligoneuriidae Isonychia

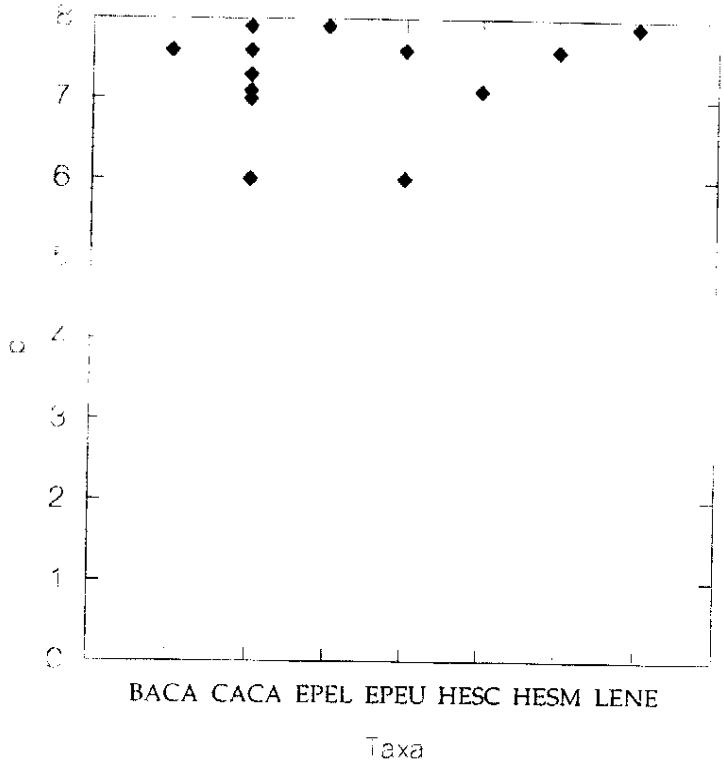
27. Color (Pt/CO)



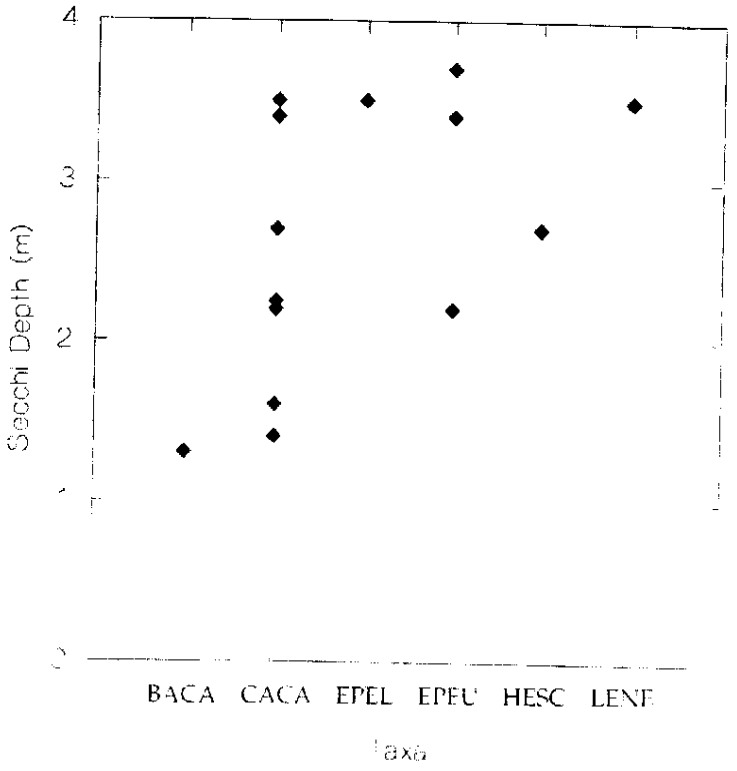
28. Conductivity (umhos/cm)



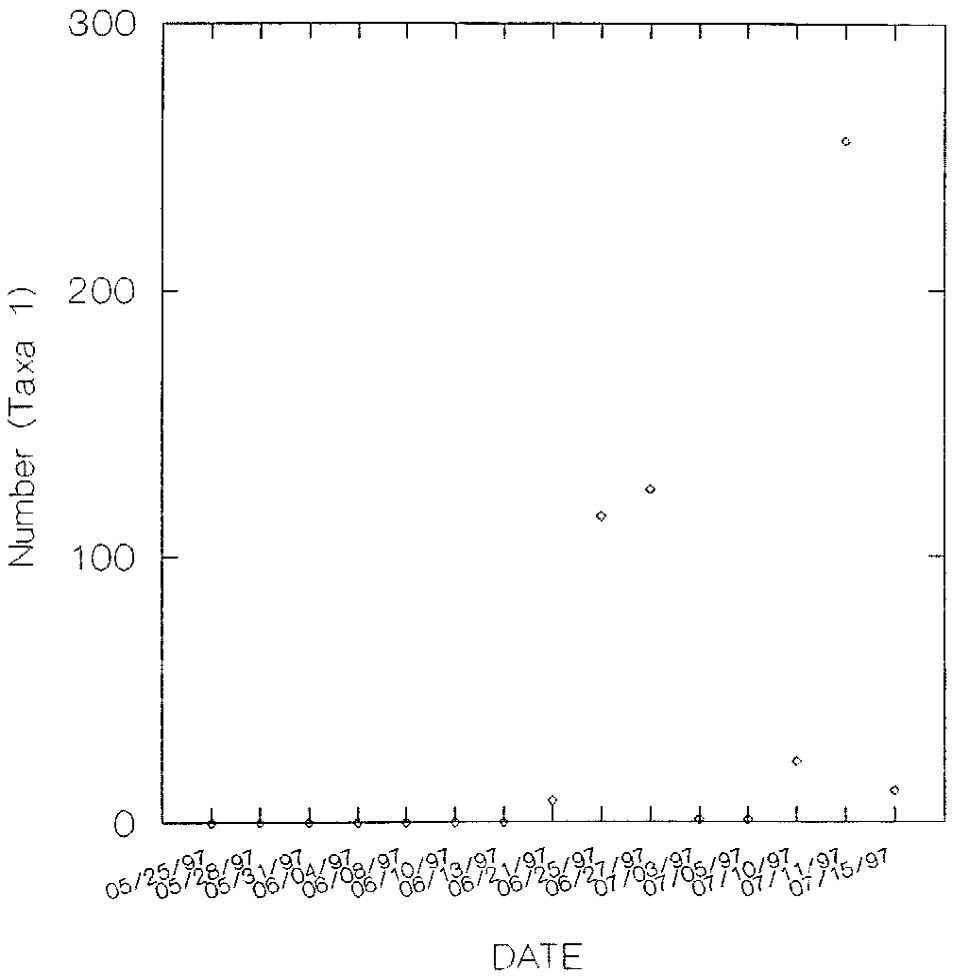
29. pH



30. Secchi Depth (m)

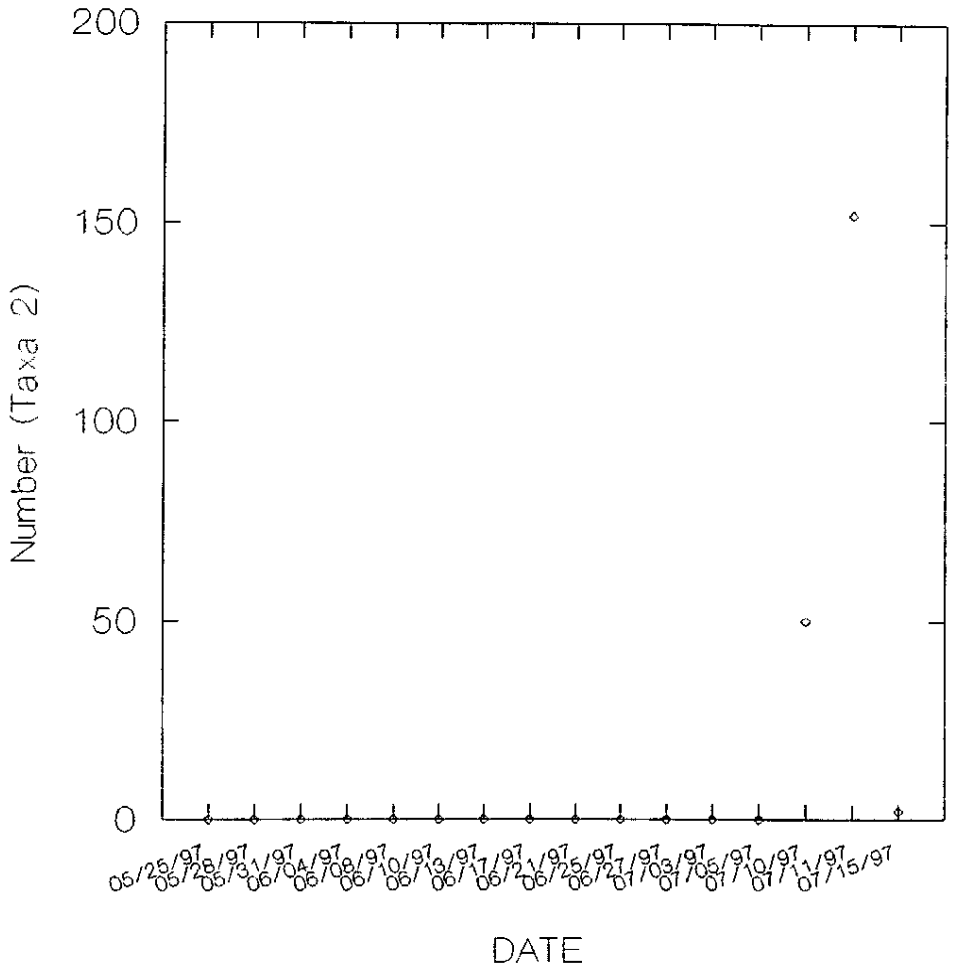


31. Light Trap
Polycentropodidae Nyctiophylax sp.



Figures 31-33. Three species found in light trap in largest numbers, number found vs. date.

32. Light Trap
Hydroptilidae Neotrichia vibrans



Acknowledgements

This paper would not have been possible without the field work and help of Maria Goodrich, Hollis Janowak, and Christie Brown. Additionally, thanks go to my advisor Dr. Ronald Hellenthal for all the help and Jeff Runde for help with the graphs. Moral support from Jenifer Mason, Allison Vogt, and Kristine was intrinsic to this paper's existence as well.

And last, but definately not least, I am extremely grateful to the Bernard J. Hank Family Endowment for making this class and research possible. I can't thank them enough for making this experience possible.

References Cited

Campbell, Ian C. 1990. Mayflies and Stoneflies: Life Histories and Biology. Klumwer Academic Publishers.

Merritt, R.W and Cummins, K.W. 1978. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company