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The benthic communities of the eastern rocky shore areas of Goshen Bay, Utah Lake

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THE BENTHIC COMMUNITIES OF THE EASTERN ROCKY SHORE AREAS OF GOSHEN BAY, UTAH LAKE

A Thesis

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This thesis, by Thomas Whitney Toole, is accepted in its present form by the Department of Zoology of Brigham Young University as satisfying the thesis requirement for the degree of Master of Science.

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INTRODUCTION

In estimating the production or standing crop of a lake or reservoir, the importance of the littoral zone should not be underestimated. The littoral production in relation to the total production increases in importance as the ratio of the shoreline to lake area increases and as the slope of the shoreline decreases. The production or standing crop of any littoral zone is influenced by such factors as depth of water, vertical transmission of light, substrate type, fluctuations in water level, wave action and nutrient supply. The flora and fauna of the littoral zone play an important role in influencing the rate and direction of eutrophicational succession. Littoral flora, for example, has the potential of making major contributions to the total production of the lake and regulate, at least in part, the entire metabolism of the lake (Wetzel and Allen, 1972).

In shallow eutrophic lakes, such as Utah Lake, the large littoral areas usually have a high primary producer standing crop consisting mainly of aquatic macrophytes and epibenthic algae. These littoral areas usually support a high macroinvertebrate standing crop.

The most extensive rocky shore littoral zone in Utah Lake is found along the eastern shore of Goshen Bay. In this area there are two main substrate types, compacted calcareous tufa and rubble (Bissell, 1963). The biology of this area has received little attention. Only the standing crop of the macroinvertebrate communities from the calcareous tufa area have been estimated (Brown, 1968).

The main purposes of this study were to describe and compare the macroinvertebrate community structure from both the shallow calcareous tufa and rubble littoral areas along the eastern shore of Goshen Bay, estimate the macroinvertebrate standing crop from both areas and determine the annual population trends of the dominant macroinvertebrates.

As part of the Bonneville Unit of the Central Utah Project, the Bureau of Reclamation has proposed placing a dike across the mouth of Goshen Bay. This dike would remove from the lake the extensive littoral area along the eastern shore of Goshen Bay. The data from this study will help, in part, evaluate the importance of this littoral area to the entire lake.

DESCRIPTION OF STUDY AREAS

Utah Lake is a shallow, eutrophic lake located in Utah County, Utah. It has a surface area of 360 km^2 and the average depth of the lake is approximately three meters. The lake is used as a storage reservoir and the water level may fluctuate more than 1.5 m in a 12-month period (U. S. Bureau of Reclamation, 1973). Bradshaw, et al. (1969) described in detail the water chemistry. Water temperatures of the lake range from 0.0° C in the winter to 30° C in the summer. The temperature decreases rapidly in the fall and increases rapidly in the spring due to the shallowness of the lake. The lake is usually covered with 10-15 cm of ice from mid-December to late February.

RUBBLE AND LACUSTRINE AREA

This area extends to 9.6 km along the eastern shore of Goshen Bay and averages 0.25 km in width. Sampling station number 1 was located 1 km south of Lincoln Point. Sampling station number 2 was 6 km south of station number 1 (Figure 1).

The substrate at station 1 is compacted calcareous tufa and is referred to as lacustrine in this study. The top layer is broken up in pieces 20 cm in diameter or less, and the pockets between the pieces are filled with silt.

The substrate at station 2 is mainly rubble which ranges in size from 10 to 30 cm in diameter. Under the rubble there is a sand-gravel-silt substrate. Small, saline springs are interspersed throughout the littoral area around station 2. The water chemistry of the spring water is quite different from the lake water (Table 1). A small spring located at station 2 had a pH of 6.9 as compared to an average of 8.7 for the surrounding lake water. The spring water had five times as much free carbon dioxide as the lake water and the bicarbonate alkalinity was three times higher in the spring area. The total conductivity was 7250 umhos/cm for the spring water as compared to 1400 umhos/cm for the lake.

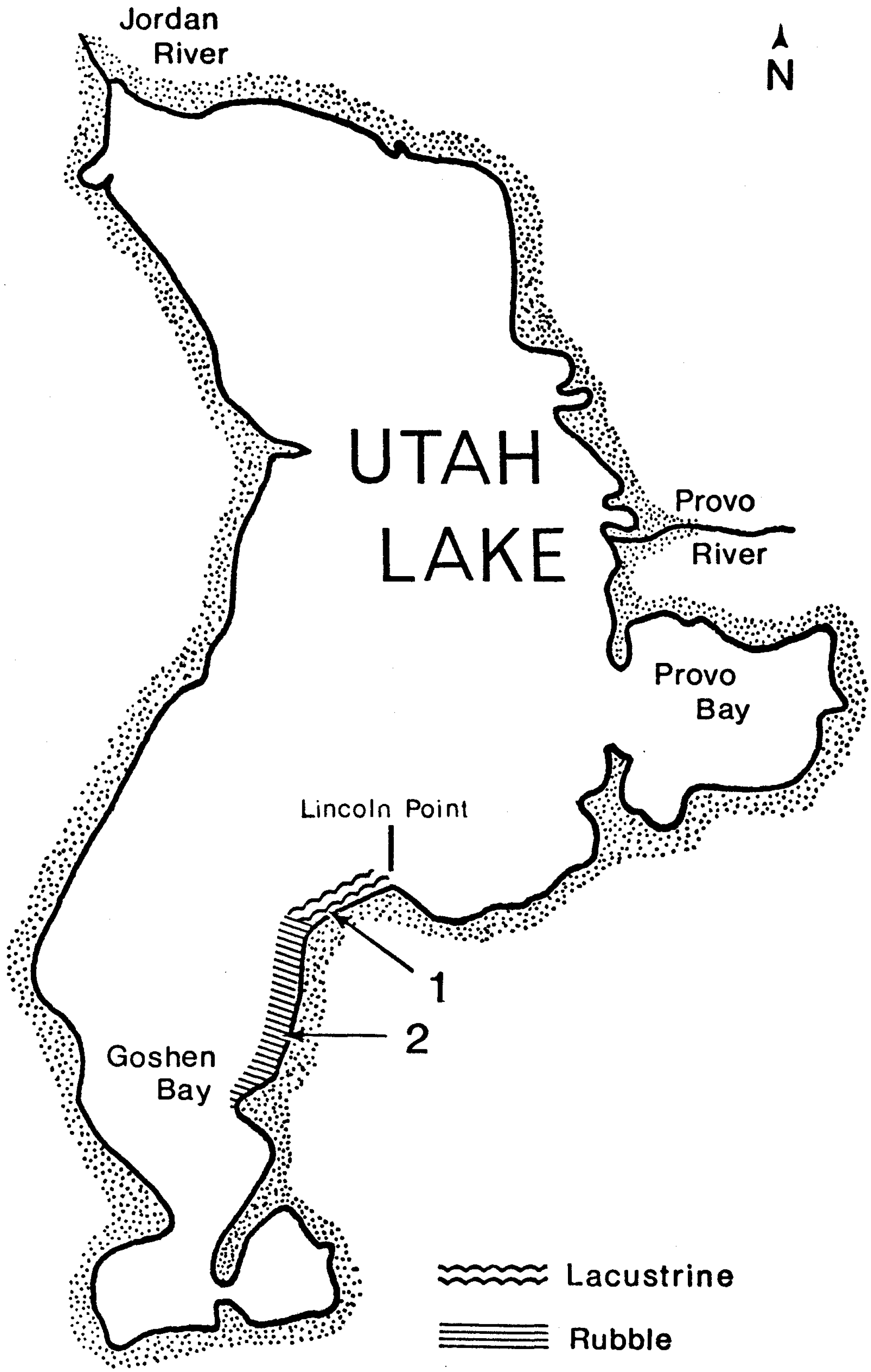

Figure 1. Map of Utah Lake showing the location and extent of the lacustrine and rubble substrates and the sampling stations

Table 1. Spring and lake water chemistry - October 30, 1972

Test	Spring Water	Lake Water
pH	6.9	8.7
Carbonate Alkalinity (mg/1)	0.0	0.0
Free Carbon Dioxide (mg/1)	230.0	6.0
Bicarbonate Alkalinity (mg/1)	870.0	310.0
Nitrogen, Nitrate (mg/1)	6.0	18.0
Ortho-phosphate (mg/1)	0.0	0.33
Sulfate (mg/1)	1.320.0	246.0
Oxygen, Dissolved (mg/1)	2.0	11.0

(mg/1) = milligrams per liter

MATERIALS AND METHODS

RUBBLE AND LACUSTRINE AREAS

The lacustrine and rubble littoral zone communities were sampled from March 1972 to May 1973 with cement block artificial substrate samplers. Each block was 30.48 cm x 30.48 cm x 5.08 cm and weighed 10-11 kg (Figure 2). A group of five samplers was placed in the rubble and flat lacustrine areas and retrieved after 6 weeks. Each group was attached to two 15.45 kg mushroom anchors by nylon ropes (Figure 3). This anchoring and the weight of the samplers prevented disturbance of the samplers by wave action. Five samplers were retrieved monthly from each area; therefore, it was necessary to have two sets of samplers down at each sampling station to allow for sufficient colonization time (6 weeks). Later in the study, to determine the effects of a small spring on the macroinvertebrate standing crop, ten samplers were retrieved in November 1972, and fifteen samplers in April and May 1973, from the rubble area. Canvas haul bags were used in the retrieval of the samplers. To prevent a significant loss of organisms during retrieval each sampler was lifted two to three inches from the substrate and the bag was immediately slipped over the sampler by an assistant. The bag was large enough to contain the sampler and designed with nitex netting screen in one corner to allow water to excape as the bag was pulled through the water column (Figure 2). The screen in the bag was the same mesh size used in the sieving of the samples. The samplers were returned to the laboratory in the haul bags.

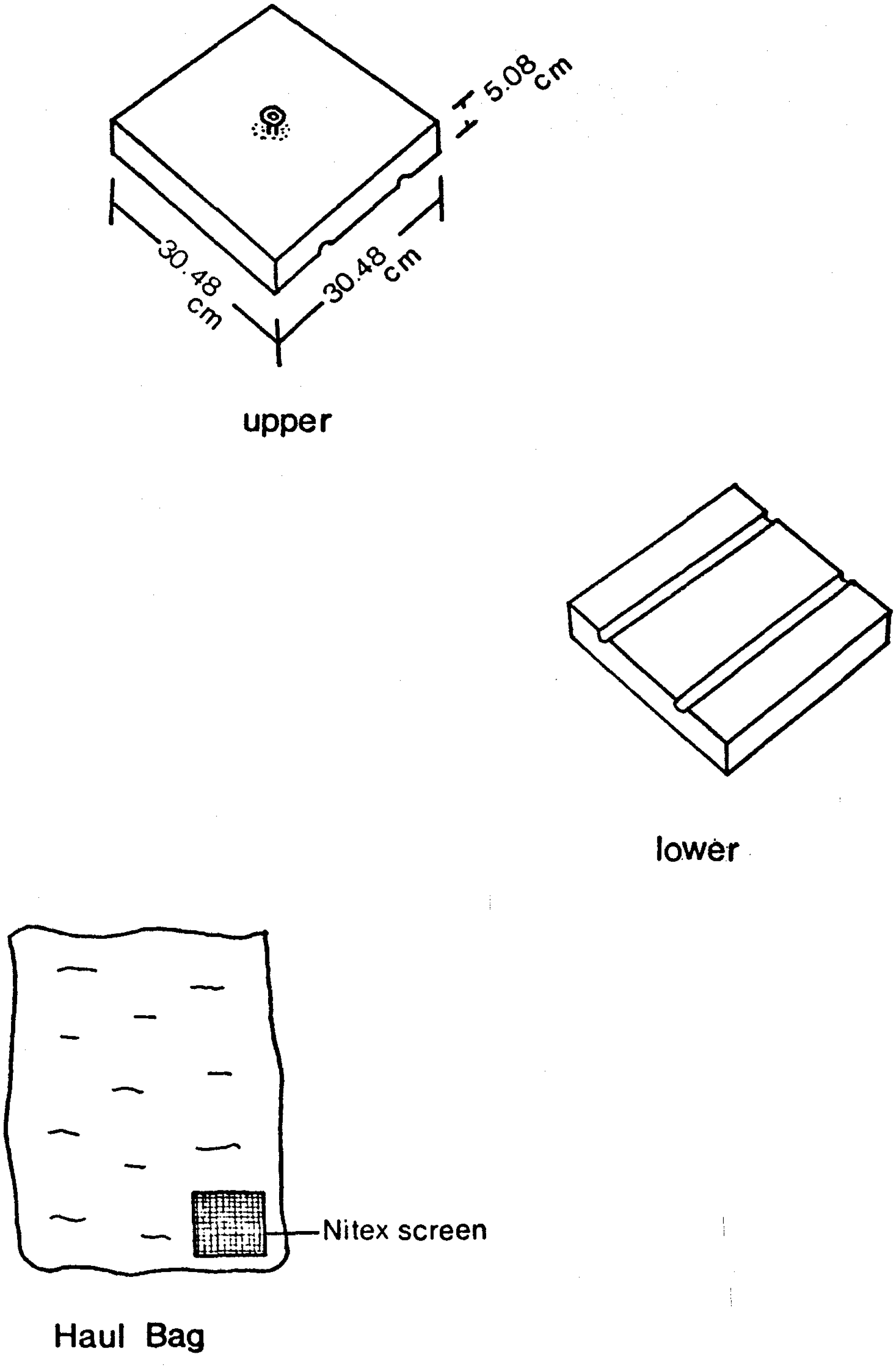

Figure 2. Upper and lower view of cement artificial substrate sampler. Haul bag used in retrieval of samples.

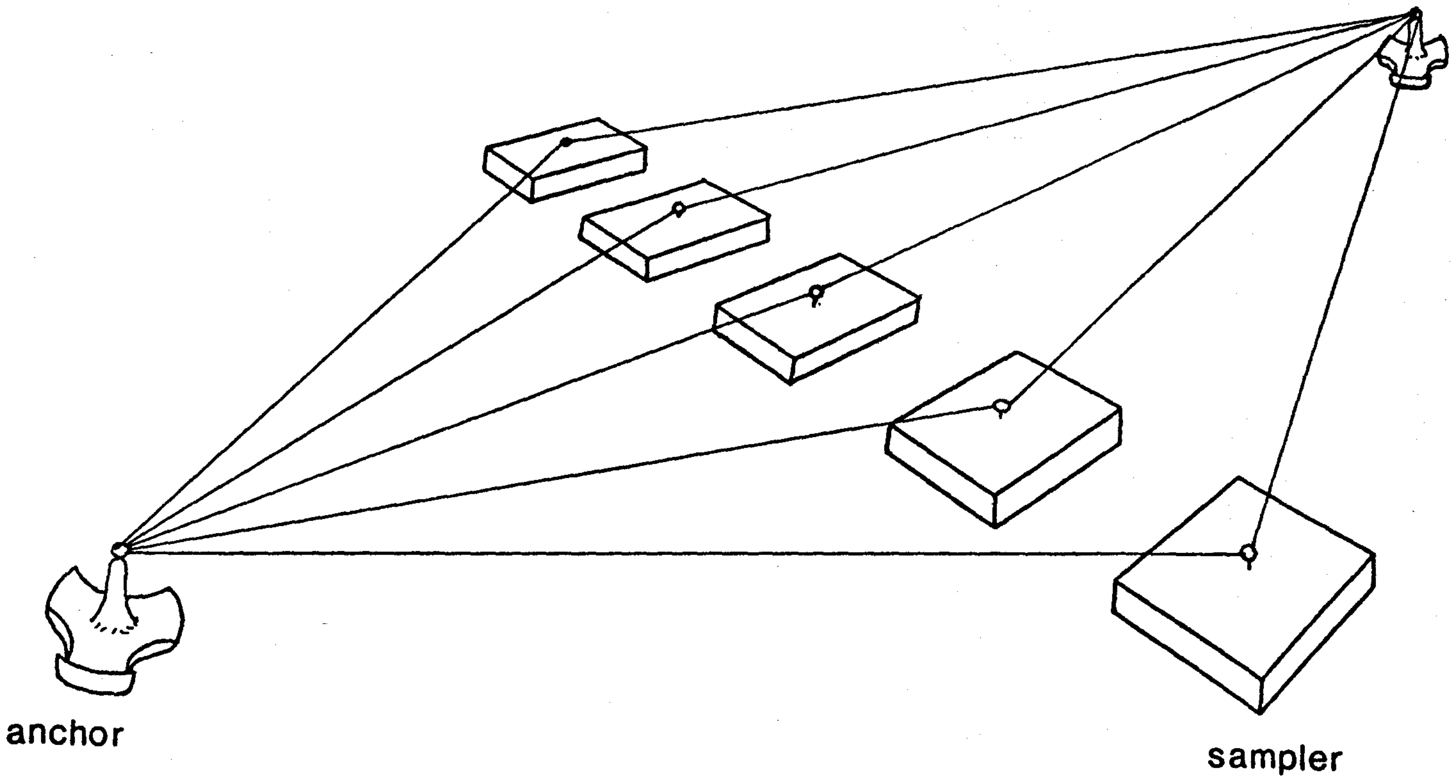

Figure 3. Position of concrete samples in relation to anchors.

To collect the organisms each sampler and haul bag was washed with tap water and then each sampler was placed in a concentrated saline solution to float the remaining organisms. These washings were sieved through a Nitex 280 (280 micron openings) screen. All samples were then preserved in a 10 percent formalin solution containing Fast Green stain to facilitate picking. Because of the large number of organisms, a subsampling technique was used (Waters, 1969). Two randomly selected subsamples from each sample were handpicked and counted.

Age classes (immatures, first and second year adults) of the amphipod Hyalella azteca were determined by body size and the sum of the first and second antennal segments (Cooper, 1965). Chironomid instars were determined using the techniques of Mason (1968) and LaRow and Marzolf (1970).

Standing crop biomass estimates for the amphipod Hyalella azteca and the chironomid Dicrotendipes fumidus were obtained using wet weights adjusted for weight loss in preservative. Live and preserved wet weights were determined by spin drying the above organisms from one subsample in a clinical centrifuge at 4000 rpm for a total elapsed time of three minutes (start to stop) and then weighing to the nearest milligram. Weight loss due to preservation was determined for 70 percent ethyl alcohol and 10 percent formalin solutions. Three samples each of chironomid larvae and amphipods were placed in 10 percent formalin for one, two, three and four week periods and then transferred to 70 percent ethyl alcohol. Weight loss measurements were made weekly during the first 6 to 7 weeks of the experiment and terminated at day 342 for the chironomid larvae and at day 371 for the amphipods.

WATER CHEMISTRY

Water chemistry data were obtained using a Hatch Chemical water chemistry kit. All water samples were collected near the substrate using a water sample bottle and analyzed in the field. The following tests were run on each sample: pH, carbonate alkalinity, bicarbonate alkalinity, free carbon dioxide, nitrate nitrogen, ortho-phosphate, sulfate, and dissolved oxygen. Conductivity and salinity measurements were taken with a Y.S.I. Model 33 Salinity-Conductivity-Temperature meter. Continuous water temperatures were recorded with a Ryan underwater thermograph at the rubble area.

STATISTICAL TREATMENTS

Ninety-five percent confidence limits for numbers and weights of organisms were calculated using a computer program that first determined if the organisms were "effectively" random or contagiously distributed using the Chi-Square test (variance to mean ratio) for agreement with a Poisson series. A logarithmic transformation was used if nonagreement with a Poisson series was determined. The log transformation is usually the most suitable with small samples (Elliott, 1971). The log (x + 1) transformation was used when "0" counts were present in the data. Confidence limits were obtained by applying the factor from the log transformation to the arithmetic mean (letter dated 5 July 1973 from J. Malcolm Elliott, Freshwater Biologidal Association, The Ferry House, Ambleside Westmorland, England).

RESULTS

RUBBLE SUBSTRATE

The concrete samplers were retrieved from an average depth of 0.9 meters during the period of this study. Seven species of macroinvertebrates were found on the samplers. The amphipod *Hyalella azteca* and the chironomid *Dicrotendipes fumidus* were the dominant organisms.

As mentioned there were always two sets of samplers placed about 30 meters apart in each study area to allow sufficient colonization time. In general during the period from March 1972 to August 1972, the north samplers had higher numbers of *Hyalella azteca* and lower numbers of *Dicrotendipes fumidus* than the south set of samplers (Figure 4). It was later discovered that during this time period, the north set of samplers were being placed in an area where the water chemistry of the lake was influenced by the small spring previously described. Because I feel that this influenced the population trends, the standing crop estimates from the north and south rubble areas will be treated separately. The October 1972 samplers were placed beyond the region of the spring's influence due to the dropping water level. In November 1972, samplers were retrieved from both the north and south sampling areas. Because of the rising water level, the north set of samplers was within the influence of the spring. The small springs that are found along the eastern shore of Goshen Bay are transitory. The spring at the north area could not be located after the ice came off

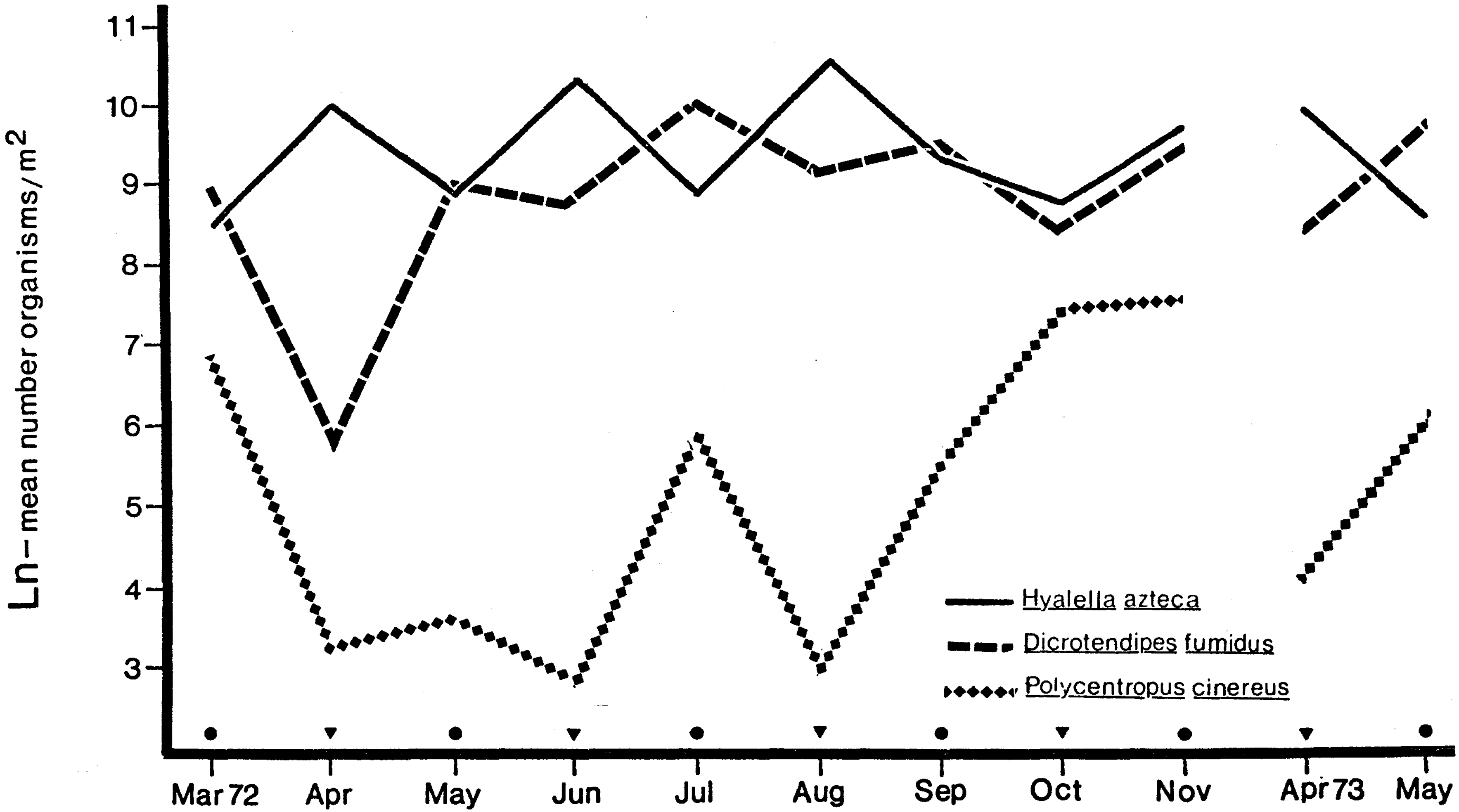

Figure 4. Natural log of the mean number per square meter of the dominant macroinvertebrates - rubble substrate. The symbols above each month indicate the sample location. Circle = south, triangle = north.

the lake. It was detected in the south sampling area during the spring of 1973. Three sets of samplers were placed in the rubble area (north, south and center) in the spring of 1973 to determine if a gradient of standing crop between the north and south sample areas could be detected.

Amphipoda

The population trends for *Hyalella azteca* are shown in Figure 5. Standing crop estimates in numbers and biomass for each sampling period are given in Table 2. At the north sampling area, the number increased steadily from April 1972 (21,967/M^2) to August 1972 (37,898/M^2). By October the numbers in the north area had dropped to 6,708/M^2. As previously mentioned, the samplers for this month were not located in the spring area. The November numbers increased over the October figure to 24,017/M^2. During October the lake level had risen sufficiently enough that the north samplers were within the influence of the spring. Between March 1972 and September 1972, the standing crop from the south sampling area was always less than the northern area. In November the standing crop was similar at the north and south sampling areas (Figure 5).

In April 1973, when samplers were retrieved from the north, south and center sampling areas, a gradient in numbers, was found. The mean numbers at the north, center, and south areas respectively were 20,460, 31,895, and 36,477 (Table 2). By May 1973, the numbers in all three sampling areas had decreased significantly (Figure 5).

The highest biomass estimates were obtained from the north sampling area in April 1972 (57.0 grams/M^2) and from the south area in April 1973 (66.5 grams/M^2). During these times, each area was under the influence of the spring. The biomass at the north area decreased from April 1972 to August 1972 while the standing crop in numbers was increasing (Table 2). In April 1972, the population consisted mainly of first year adults with some second year adults present. In August 1972, the population was composed mainly of immatures and first year adults with a few second year adults present. The biomass estimates for the south area also declined between May and September of 1972, while the standing crop in numbers increased (Table 2). A biomass gradient similar to the numbers gradient was found in April 1973 between the south, center and north sampling areas with the south having the greatest biomass.

The age class distribution of Hyalella azteca is shown in Figure 6 and was similar for all rubble sampling areas. During the first three months of sampling in 1972, only first and second year adults were present in the population. The first year adults comprised an average of 62 percent of the population during these months. Immatures did not appear until June 1972. Between June and November, they comprised an average of 47.9 percent of the population and from July to October, were the dominant group. In November, first year adults were dominant. In the spring of 1973, immatures were present in the April sample but not in the May sample. Those present in April were probably overwintering immatures and by May had become first year adults.

Chironomidae

The population trends for Dicrotendipes fumidus are shown in Figure 7. Standing crop estimates in numbers and biomass are given in

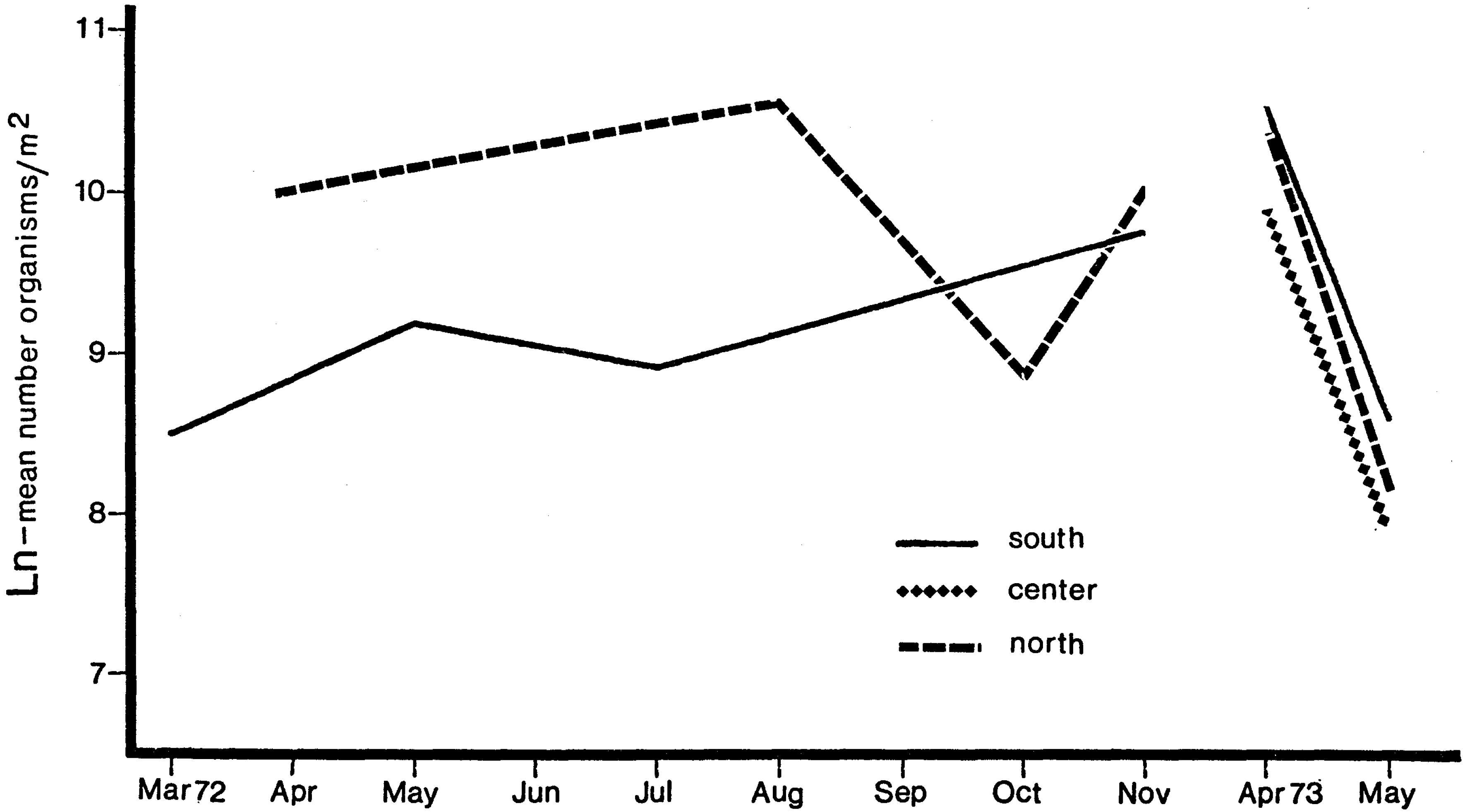

Figure 5. Natural log of the mean number per square meter of Hyalella azteca - rubble substrate.

Table 2. Standing crop estimates of Hyalella azteca - rubble substrate.

Month	Position of Sampler	Mean Number/M^2	95% Confidence Limits	Mean Wet Weight Grams/M^2	95% Confidence Limits
March 1972	South	4,831	1,414- 9,733	10.6	0.0- 23.3
April	North	21,967	14,869-30,357	57.6	31.4- 84.8
May	South	7,388	4,215-11,472	21.2	6.3- 37.0
June	North	28,779	14,948-46,358	38.7	18.6- 60.7
July	South	7,388	5,089-10,090	5.6	3.1- 8.0
August	North	37,898	33,798-42,218	18.8	5.8- 21.6
September	South	11,185	6,484-17,068	9.9	1.0- 19.2
October	North	6.708	3,613-10,678	5.8	1.4- 10.2
November	South	16,809	4,263-25,365	21.1	11.6- 30.9
	North	24,017	17,440-31,637	27.2	16.5- 38.4
April 1973	South	36,477	22,420-53,612	66.5	35.3-100.6
	Center	31,895	9,513-67,571	48.7	5.4- 97.5
	North	20,460	5,731-44,816	34.5	4.0- 68.6
May 1973	South	5,321	1,525-12,354	14.8	2.4- 28.0
	Center	2,695	739- 6,176	6.4	1.1- 11.8
	North	3,574	1,685- 5,109	9.4	4.4- 14.4

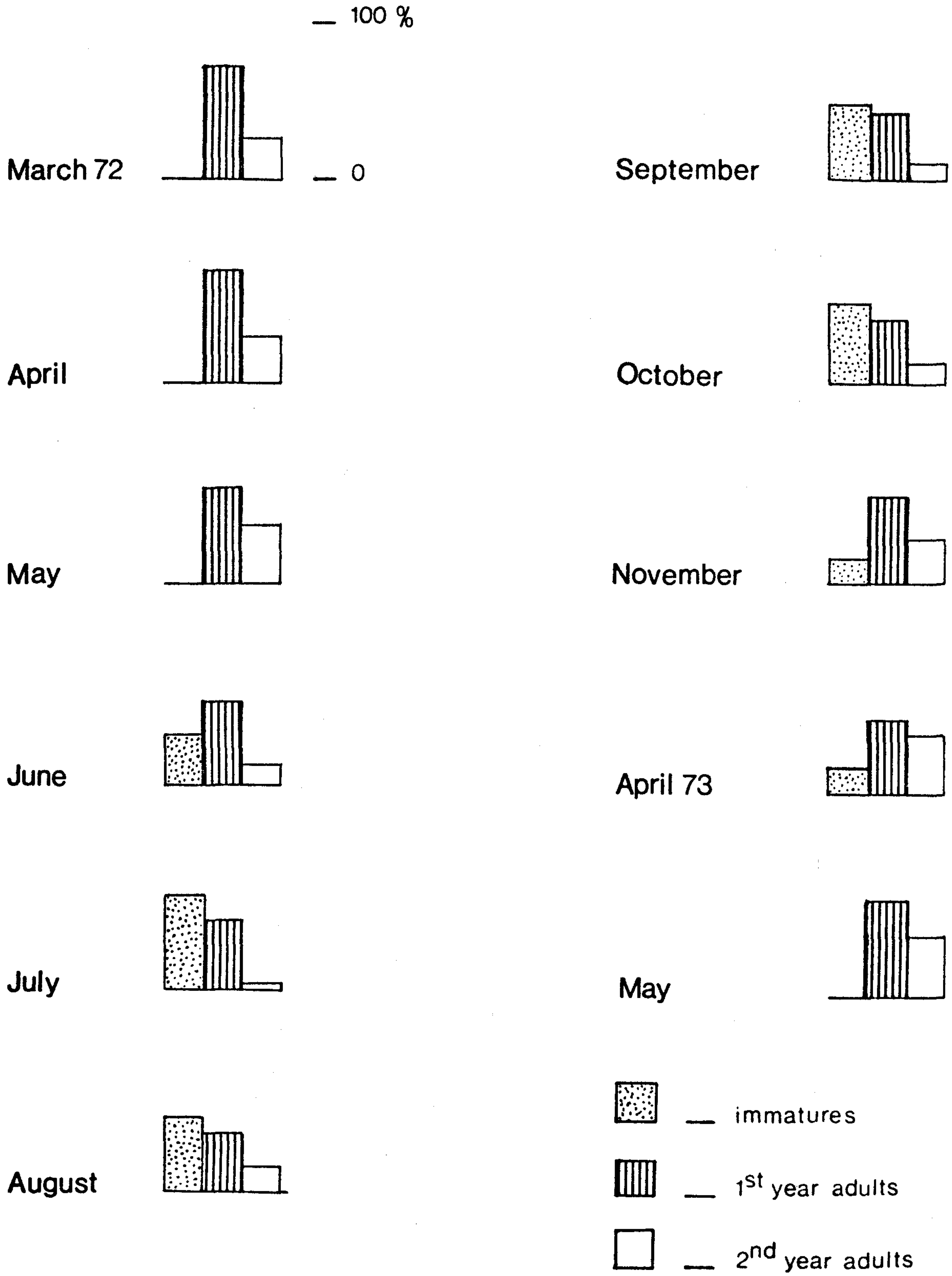

Figure 6. Age class distribution of Hyalella azteca.

Table 3. Throughout this study higher standing crop estimates in numbers and biomass were obtained from the south sampling area with the exception of the April 1973 samples. The first sample (March 1972) was from the south sampling area and the numbers estimate was 8,344/M^2. By the next sample (April), from the north area, the numbers dropped to 344/M^2. Between the April and the May samples an emergence of D. fumidus took place (Figure 7). After the emergence, the numbers increased rapidly until July and August when the maximum estimates were obtained for the south (July - 21,421/M^2) and north (August - 9,300/M^2) areas. At the time of the next sample from the south area (September) the standing crop had dropped to 10,368/M^2 and by October the standing crop at the north area had declined to 2,747/M^2. Adults were common in the collecting areas from mid-summer through the November collecting period indicating a continual emergence during this period.

Between the April 1973 and May 1973 samples there was a rapid increase in the standing crop (Figure 7). During the last of April adults were observed swarming along the shore by the sampling area indicating an emergence during this period. This major emergence as well as the 1972 emergence occurred about three weeks after the ice broke up over the sampling area.

Biomass followed a similar pattern as numbers (Table 3). The lowest biomass estimates were obtained in April 1972 after the March emergence. After the emergence the biomass increased steadily until the maximum estimates were obtained at the south area in September (9.5 grams/M^2) and the north area in August (6.5 grams/M^2). After the maxima were reached, biomass decreased at both the north and south locations during October and November.

The instar successional pattern is shown in Figure 7. At the time of the major emergence in March 1972, there were a few third instars present in the population, but the dominant instar was the fourth. Two months later the dominant instar was the third with a few seconds present. Fourth instars appeared again in the population by June. During July, August and September, second, third and fourth instars were all present with the third dominant in July and August and the third and fourth dominant in August and September. In October and November only a few second instars were present and the third and fourth instars were dominant. Although second and third instars were present in the first sample of 1973, the dominant instar was the fourth. By May a few third and fourth instars were present but the dominant instar was the second. A few first instars were collected in May. Mean head-capsule width and length for the different instars and ratios of the second to third and third to fourth instar headcapsule width and length are given in Table 4.

Trichoptera

The population trends for Polycentropus cinereus are shown in Figure 8. Standing crop estimates in numbers are given in Table 5. In March 1972 the numbers estimate from the south area was $1,016/M^2$. By May the numbers from the same area dropped to $35/M^2$ indicating that an emergence had taken place. The numbers increased steadily at the south area until September when there was a slight decrease in the population density. By November the population in the south area had increased to a high of $1,937/M^2$. The April, June and August samples from the north were low in density; 26, 17, and $17/M^2$ respectively.

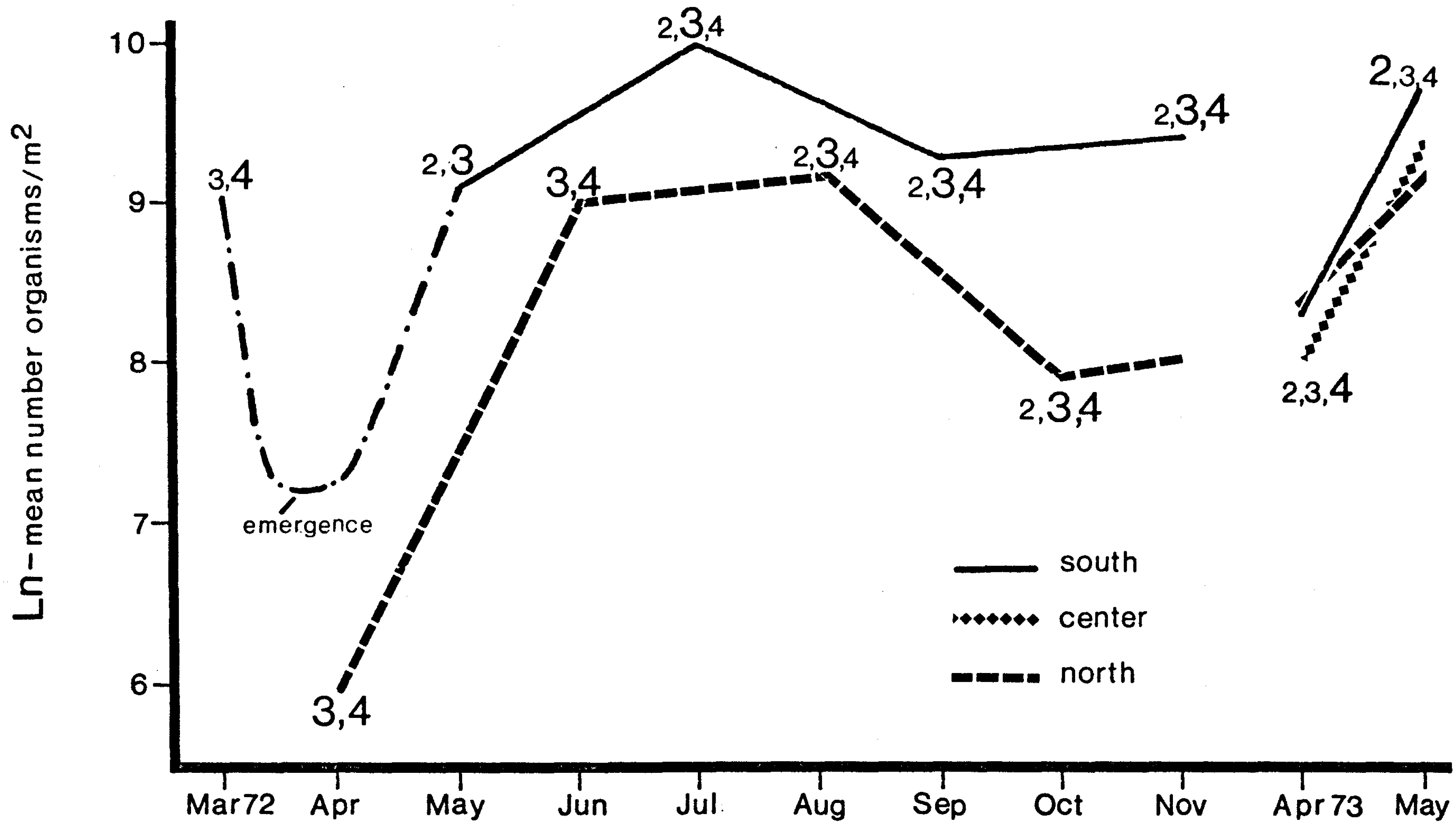

Figure 7. Natural log of the mean number per meter square of Dicrotendipes fumidus - rubble substrate. Large numbers indicate dominant instars.

Table 3. Standing crop estimates of <u>Dicrotendipes</u> <u>fumidus</u> - rubble substrate

Month	Position of Sampler	Mean Number/M^2	95% Confidence Limits	Mean Wet Weight Grams/M^2	95% Confidence Limits
March 1972	South	8,344	4,846-12,744	-	
April	North	344	193- 496	0.5	0.0-11.5
May	South	8,835	5,153-13,407	7.3	0.0-37.0
June	North	7,948	6,856- 9,119	5.3	0.0-40.6
July	South	21,421	19,337-23,397	8.3	0.0-52.4
August	North	9,330	5,988-13,348	6.5	0.0-45.3
September	South	10,368	8,672-12,205	9.5	0.0-56.8
October	North	2,747	2,063- 3,523	1.4	0.0-19.6
November	South	12,425	7,969-17,794	7.0	0.0-47.3
	North	3,048	1,821- 4,593	1.8	0.0-22.4
April 1973	South	3,970	2,971- 5,109	6.0	0.0-43.5
	Center	3,023	2,164- 4,021	4.5	0.0-37.2
	North	4,314	3,515- 5,189	7.6	0.0-49.4
May 1973	South	15,879	9,886,23,353	5.3	0.0-40.2
	Center	11,763	8,807-15,141	4.8	0.0-38.7
	North	9,213	6,314-12,703	2.1	0.0-24.6

Table 4. Mean head capsule width and length for the instars of *Dicrotendipes fumidus*.

Instar	Mean Head Capsule Width	Standard Deviation	Mean Head Capsule Length	Standard Deviation
Second	.173 mm	.0213	.199 mm	.0250
Third	.299 mm	.0251	.345 mm	.0302
Fourth	.511 mm	.0348	.587 mm	.0384
Ratio 2nd/3rd	.58		.58	
Ratio 3rd/4th	.59		.59	

During this period the north area was influenced by the spring water. The October estimate from the north area was $1,705/M^2$ to a 100 fold increase over the August sample. In October the north samplers were no longer under the influence of the spring. In May and April of 1973, the densities were considerably higher than the densities of April and May 1972 (Table 5).

Hirudinea

Three species of leeches, *Helobdella stagnalis*, *Dina parva*, and *Erobdella punctata*, were collected by the samplers in the rubble area. The latter were found so infrequently and in such low numbers that insufficient data were available to conclude anything concerning their population. *H. stagnalis* were found on the samplers during every sampling period except two. *E. punctata* and *D. parva* are found in very high numbers next to the shoreline in water less than 0.5 meters depth. The samplers were rarely in this depth of water.

Others

Two other species were only occasionally found on the samplers. These were the naucorid hemipteran *Ambrysus mormon* and the Gastropod *Physella utahensis*. No quantitative data are available on these species.

LACUSTRINE SUBSTRATE

The concrete samplers were retrieved from an average depth of 0.6 m. No samples were collected in the spring of 1973 from this area. The species of macroinvertebrates found on the samplers in the lacustrine area were the same as for the rubble area except for the planarian, *Dugesia dorotocephala*, which appeared in the samples during September,

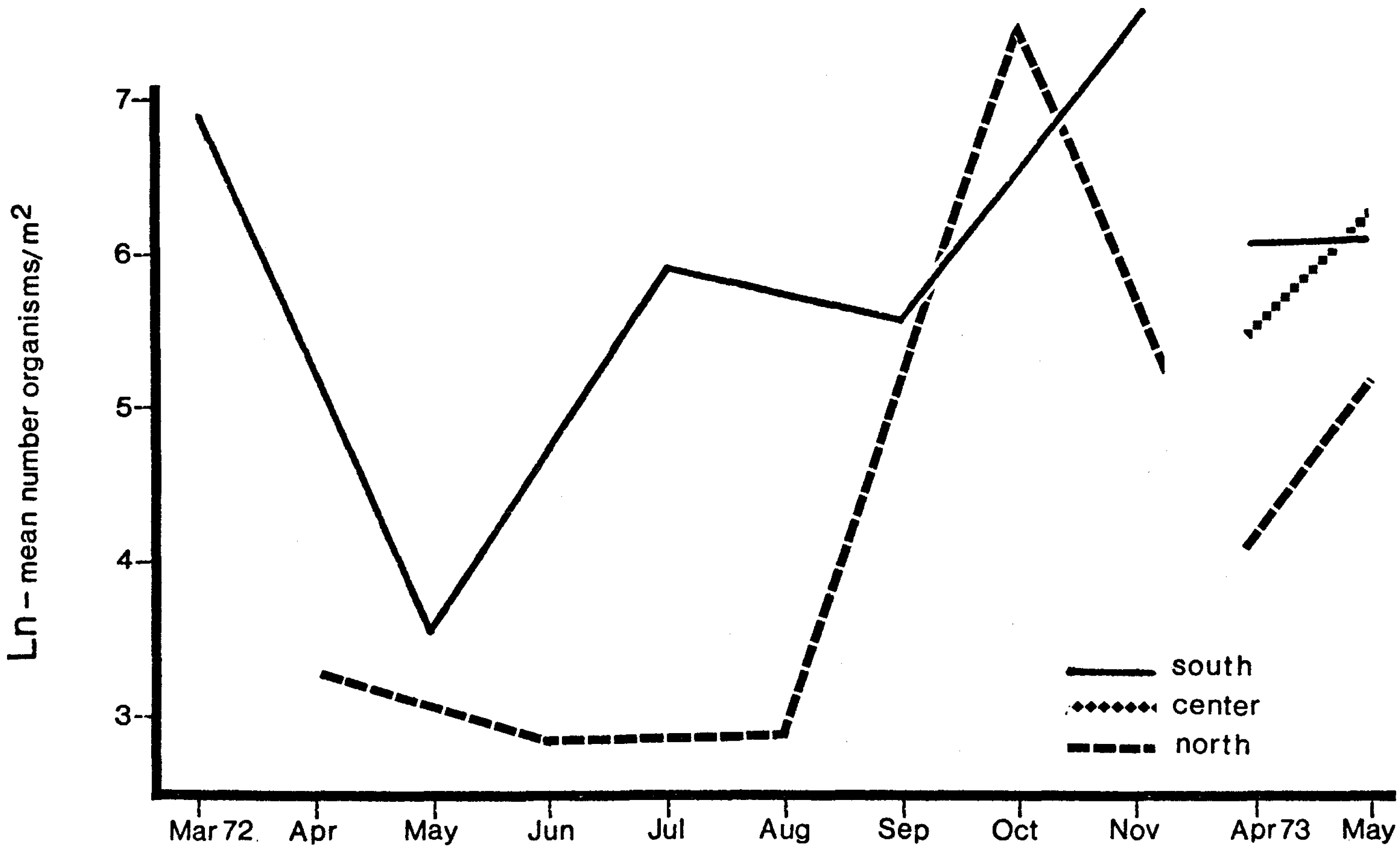

Figure 8. Natural log of the mean number per square meter of *Polycentropus cinereus* - rubble substrate.

Table 5. Standing crop estimates of Polycentropus cinereus - rubble substrate.

Month	Position of Sampler	Mean Number/M^2	95% Confidence Limits
March 1972	South	1,016	671-1,426
April	North	26	0- 67
May	South	35	0- 82
June	North	17	0- 56
July	South	361	361- 517
August	North	17	0- 56
September	South	258	97- 482
October	North	1,705	1,105-3,007
November	South	1,937	1,105-3,007
	North	258	127- 390
April 1973	South	422	223- 670
	Center	250	89- 470
	North	60	0- 124
May	South	431	262- 599
	Center	500	224- 886
	North	172	65- 279

October, and November 1972. The amphipod Hyalella azteca and the chironomid Dicrotendipes fumidus were the dominant organisms in the lacustrine area except in September when D. dorotocephala was the dominant organism.

Amphipoda

The standing crop (numbers/M^2 and biomass) of Hyalella azteca was much less in the lacustrine area than in the rubble area. The population trends are shown in Figure 9. Standing crop estimates in numbers and biomass are given in Table 6. The highest numbers were recorded in August. In September and October, there was a large reduction in numbers, but in November the population again started to increase (Figure 9). During the major decline in September, observations showed that the population was reduced over an area covering one-half km north and south of the sampling station. It is not known if this reduction took place over the entire lacustrine area. In the spring of 1973, no H. azteca could be found in the area of the sampling station. Some were located close to shore in a small rubble area that is separated from the lacustrine area by an area of reeds.

All age classes were present in the samples from March to August. Only first year adults were found in September and October. In November immatures were in large numbers with the rest of the population being first year adults. Immatures made up 66 percent of the total numbers in August prior to the reduction in September.

Chironomidae

Only one species of chironomid, Dicrotendipes fumidus, was collected by the samplers. The population trends are shown in Figure 9.

Standing crop estimates in numbers and biomass are given in Table 7. As in the rubble area there was an initial emergence in March and then some emergence throughout the summer. In September, the population dropped very sharply as did the H. azteca population, although the D. fumidus population, unlike H. azteca began to recover immediately (Figure 9).

Third and fourth instars were the dominant instars present in the April sample. Second instars were first collected in May. During the summer months the dominant instars were the second and third with very few fourth present. The October sample contained predominantly third and fourth instars while in November the second and third were the dominant instars. Mean headcapsule length, width, and the various ratios of the instars are given in Table 4.

Trichoptera

Polycentropus cinereus was the only trichopteran collected in the lacustrine area. Standing crop estimates in numbers are given in Table 8. The highest population density was in April and May. In June, there was a sharp decline indicating an emergence. During the rest of the study, the number remained low in comparison to the April and May estimates. In September, there were no P. cinereus collected.

Hirudinea

Dina parva and Erobdella punctata were present in low numbers and only rarely collected. Helobdella stagnalis was the most abundant leech in the lacustrine area. H. stagnalis were not present in the September and October samples. The highest numbers were found in May 1972 ($267/M^2$).

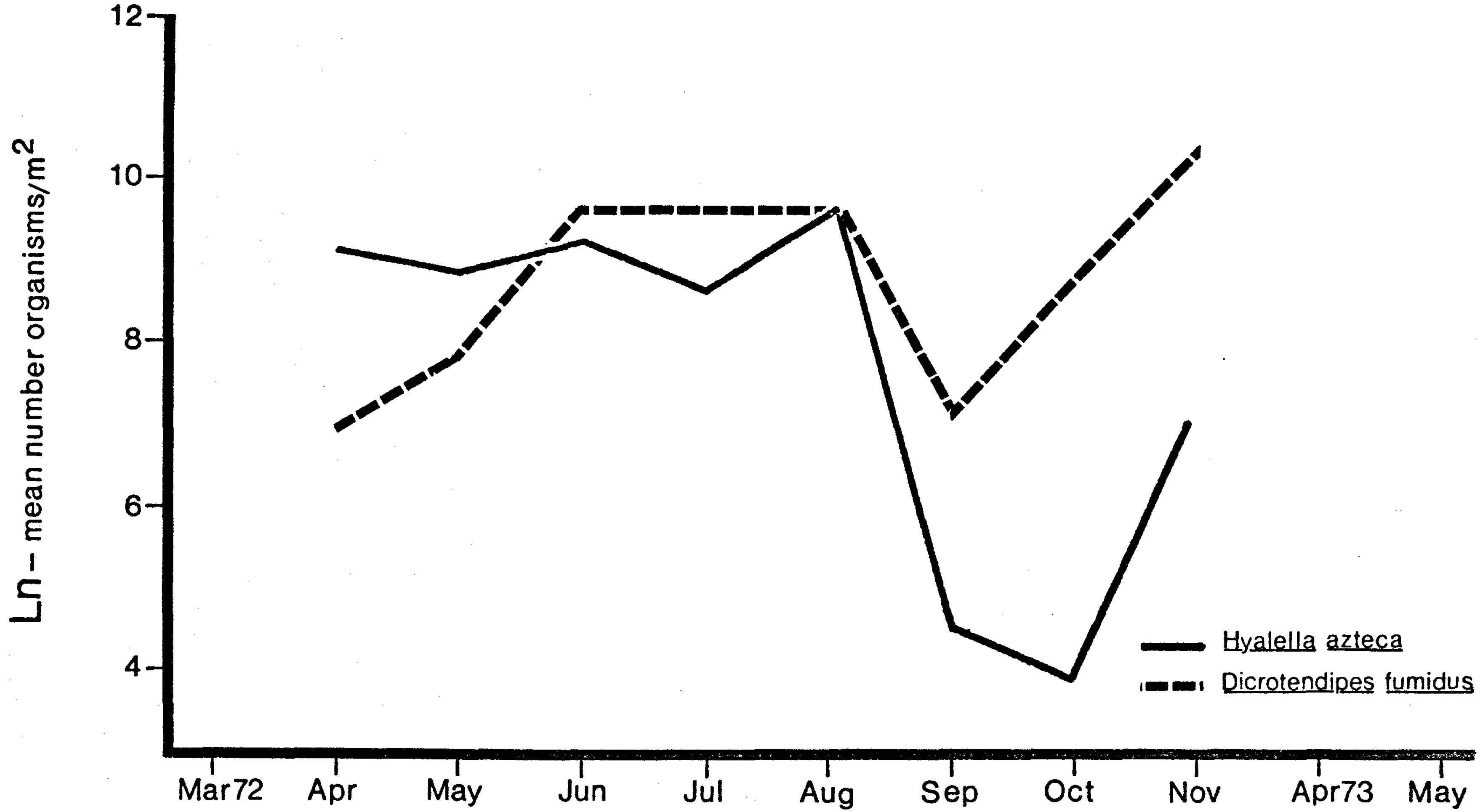

Figure 9. Natural log of the mean number per square meter of the dominant macroinvertebrates - lacustrine substrate.

Table 6. Standing crop estimates of Hyalella azteca - lacustrine substrate.

Month	Mean Number/M^2	95% Confidence Limits	Mean Wet Weight Grams/M^2	95% Confidence Limits
April 1972	9,309	2,497-18,312	21.3	0.0-52
May	6,734	4,334- 9,597	13.0	6.9- 9.3
June	10,721	7,765-14,121	15.0	11.4-13.5
July	6,260	3,945- 9,060	5.5	2.4- 8.7
August	15,121	7,765-14,121	14.6	0.0-32.4
September	86	0- 234	-	-
October	52	0- 149	-	-
November	1,119	0- 2,812	-	-

Table 7. Standing crop estimates of _Dicrotendipes fumidus_ - lacustrine substrate.

Month	Mean Number/M^2	95% Confidence Limits	Mean Wet Weight Grams/M^2	95% Confidence Limits
April 1973	1,042	388- 2,170	1.7	0.0-21.3
May	2,566	2,056- 3,130	2.3	0.0-25.5
June	14,183	11,941-16,603	8.5	0.0-52.7
July	14,699	9,495-21,125	7.0	0.0-47.0
August	14,097	8,649-20,951	6.2	0.0-44.1
September	1,223	841- 1,668	-	-
October	5,787	3,636- 8,466	5.0	0.0-38.8
November	33,773	29,238-38,623	11.6	0.0-63.6

Table 8. Standing crop estimates of Polycentropus cinereus - lacustrine substrate.

Month	Mean Number/M^2	95% Confidence Limits
April 1972	241	69-490
May	258	66-490
June	35	0- 98
July	78	6-149
August	95	15-174
September	0	0
October	26	0- 67
November	8	0- 33

Turbellaria

The planarian worm Dugesia dorotocephala appeared in the samples for the first time in September and was the dominant organism in numbers ($1,507/M^2$). They were also collected in October ($1,929/M^2$) and November ($525/M^2$).

PRESERVATIVE WEIGHT LOSS EXPERIMENTS

Amphipoda: Hyalella azteca lost weight for 35 days in all four time combinations of 10 percent formalin and 70 percent ethyl alcohol. After 35 days, there was no significant weight loss. A T-test for the difference between two means showed that there was no significant difference between the weights at 35 days and at 371 days for the four different groups at the 95 percent confidence level.

Chironomidae: Weight loss continued to be significant in all four different groups until day 53. After this time only two groups showed a significant loss of weight; group 2 and 4 (Table 9). This loss in weight was due to the deterioration of the organism caused by handling rather than loss due to preservative. Day 53 was accepted as the stabilizing time and there was no significant difference in the weight loss of the four groups (95 percent confidence level) after this time.

Table 9. Weight loss due to preservatives (expressed as percent of original weight remaining).

Organism	Days in Preservative	Percent of Original Weight Group 1	Group 2	Group 3	Group 4
Hyalella azteca	7	93.1	96.5	93.7	97.3
	14	84.9	93.9	90.2	95.2
	21	84.1	89.4	89.6	94.2
	28	81.0	88.8	84.4	91.1
	35	79.9	85.2	82.8	85.9
	42	79.3	85.4	80.9	83.9
	49	81.5	85.7	80.7	83.6
	371	83.3	84.4	80.0	83.4
Dicrotendipes fumidus	7	92.9	92.5	96.5	91.2
	14	79.7	86.7	79.4	82.2
	21	74.1	72.5	77.4	77.2
	29	70.6	69.5	71.2	76.5
	42	65.1	62.6	61.8	64.1
	53	61.5	60.5	59.3	62.3
	83	62.4	58.6	54.8	59.7
	342	62.7	55.7	55.7	57.0

Group 1 - In 10% formalin for 7 days, then transferred to 70% EtOH.

Group 2 - In 10% formalin for 14 days, then transferred to 70% EtOH.

Group 3 - In 10% formalin for 21 days, then transferred to 70% EtOH.

Group 4 - In 10% formalin for 28 days, then transferred to 70% EtOH.

DISCUSSION

ARTIFICIAL SUBSTRATE SAMPLING

To be effective, an artificial substrate sampler must meet the following criteria: (1) the sampler should duplicate, as nearly as possible, the natural substrate, (2) it should be designed to prevent disturbance by natural phenomena, while in place, (3) it must be retrievable without excessive effort, (4) loss of organisms must be prevented by some method when the sampler is retrieved. The most important considerations in designing a sampler for this study were: (1) it had to weigh enough to not be disturbed by the extensive wave action in the study area, and (2) because of the very sudden drops in water level, the sampler had to be thin enough so that it would not be exposed during the six-week period that sampler was in place.

Standing crop estimates obtained using an artificial substrate sampler must be evaluated from the standpoint of design of the sampler and the preferred habitat and behavior of the individual organisms. The amphipod *Hyalella azteca* was found in the greatest numbers on the upper and lower faces although the sides were also colonized. The larvae of *Dicrotendipes fumidus*, a chironomid, burrowed in the algal mat and sediment on the top and sides of the sampler. The standing crop estimates for *D. fumidus* are probably more accurate than those for *H. azteca* because of its burrowing behavior which would prevent eescape of the larvae during the retrieval of the sampler. In the natural substrate there are areas between rocks without any organisms.

The estimates obtained from the samplers do not take into account these areas in figuring number/M^2 and thus possibly overestimated all populations.

The sampler did not effectively sample the three leech populations. This was due more to the habitat of the leeches than the design of the sampler. Dina parva and Erobdella punctata are found in greatest numbers next to the shore in less than 0.5 meters of water. These leeches are probably concentrated in this area by the rapid dropping of the lake level. The samplers could not be placed at this shallow depth because of the possibility of exposure due to the lake level dropping during the summer. Helobdella stagnalis is found predominantly on rocks that are partially buried in the finer substrates. It was impossible to get the sampler next to this type of substrate without partially burying the sampler.

Standing crop estimates for the planarian Dugesia dorotocephala are probably greater than the natural population as the sampler provided more suitable habitat than the natural substrate for the same unit of area. Being photonegative, they were found on the bottom and edges of the sampler.

Polycentropus cinereus, a trichopteran, were found in the grooves on the undersurface of the sampler. It is not possible to determine if the samplers over or underestimated the population because of the few numbers collected and the few observations of their natural habitat. They must be considered a rare species.

WEIGHT LOSS EXPERIMENTS

The problem of weight loss due to preservatives has been overlooked in the majority of benthic standing crop estimates. As shown in this study, 20 to 45 percent of the total weight is lost, depending on the organism, in the preservative. The standing crop biomass estimates can be significantly below real values if this weight loss is not accounted for. Howmiller (1971) found a 49 percent weight loss in 70 percent ethyl alcohol and 5 percent glycerine for the larvae of the chironomid *Anatopynia sp.* after 57 days.

RUBBLE SUBSTRATE

Macroinvertebrate standing crop estimates for the rubble substrate were different for the north and south sampling areas and were dependent upon the amount of algae on the samplers. The "algal mat" on each sampler consisted of algae, detritus, and sediments. Visual comparisons of the samples indicated 1.5 to 2 times more "algal mat" material on the samplers that were within the influence of the spring water. Visual comparisons also indicated that the increase in "algal mat" was caused by the increase in the amount of algae. The north samplers were under the influence of the spring between March 1972 and September 1972. The highest numbers of *Hyalella azteca* were always found on those samplers with the greatest amount of "algal mat". It is known that *H. azteca* feeds on filamentous green and blue-green algae and has the ability to digest sediment microflora that contains diatoms (Cooper, 1965; Hargrave, 1970). Hargrave (1970) found they have the ability to select sediments that contain viable microflora. The correlation between the high algal standing crop and the high numbers of Hyalella azteca is probably due to the influence of the spring. The high concentration of free carbon dioxide and bicarbonate alkalinity in the spring water was possibly responsible for the higher algal standing crop. Dickman (1973) found that additions of less than 50 mg/liter sodium bicarbonate significantly increased algal standing crop on glass slides exposed in the treated protion of a small stream during a two-month period. Bicarbonate alkalinity for the spring water was 870 mg/liter.

Numbers of Hyalella azteca increased during the summer, but the biomass estimates decreased during this time for both the north and south areas. This is attributed to the age class composition of the population (Figure 7). During the summer months and early fall approximately 50 percent of the population was composed of immatures, whereas at other times, the population was composed almost entirely of larger first and second year adults.

In April 1973, the population contained immatures while in 1972, immatures were not collected until June. Those collected in April 1973 probably overwintered as immatures. The disappearance of immatures in May 1973 could be attributed to the growth of these individuals into the next age class. Strong (1972) studied the reproductive cycle of Hyalella azteca in a hot spring, coastal lake, and a mountain lake. In the hot spring, reproduction occurred throughout the year while in the lakes, reproduction occurred only when the water temperature was above 12° C. In Utah Lake the water temperature is at or above 12° C from April through September. Since in 1972 the first immatures appeared in the June samples, this would mean that the initial reproduction in

1972 took place in April or May, and then a lower rate of reproduction probably occurred throughout the summer.

Several authors have studied the standing crop and population dynamics of *Hyalella azteca* (Anderson and Hooper, 1956; Buscemi, 1961; Cooper, 1965; Gerking, 1962; Brown, 1968). Anderson and Hooper, and Buscemi reported winter population maximum, but Cooper states that their results may have been biased by their sorting technique and size specific mortality. Cooper (1965) reported a maximum in July. In the rubble area the maximum population numbers occurred during August at the north area and in November at the south area.

The numbers of *Hyalella azteca* reported in this study from the rubble area are higher than any other found in the literature. The maximum estimate was $37,898/M^2$ (August, 1972), and if you considered that *H. azteca* were only found on one side of the concrete sampler and divided all estimates in half, they would still be greater than any in the literature. All other estimates (Cooper, 1965; Anderson and Hooper, 1956; Buscemi, 1961; and Gerking, 1962) were from soft sediments using some type of dredge sampler. The estimates obtained by Cooper (1965) and Gerking (1962) are the most reliable. In the other studies (Anderson and Hooper, 1956; Buscemi, 1961), the size of screen used in sieving was too large to collect the youngest immatures. The high standing crop estimates of *H. azteca* found in the rocky littoral area of Utah Lake can probably be attributed to three factors: (1) the rubble and pieces of lacustrine substrate provide an excellent substrate for epibenthic algae, (2) the eutrophic condition of Utah Lake and the extra algal nutrients provided by the small saline springs, (3) the combined effect of the shallow water depth over most of the littoral area and the high water temperatures. Tillman and Barnes (1973) in studying the annual reproductive cycle of the leech Helobdella stagnalis from the rubble area found that the majority of adult leeches produce two generations of young during the summer months. All other descriptions of the reproductive cycle indicate that only one generation is produced.

Dicrotendipes fumidus overwinters as second, third, and fourth instars. When the ice breaks up, the dominant instar is the fourth and about three weeks later a major emergence occurs. Adults were found in the sampling area throughout the summer indicating a long emergence period. However, the emergences that took place throughout the summer probably were not as large as the initial emergence.

Unlike Hyalella azteca, as the numbers increased for Dicrotendipes fumidus the biomass increased (Table 3). The dominant instars collected in the summer months were third and fourth. These larger instars increased in numbers during the summer; thus, the increase in biomass. Number estimates of D. fumidus are underestimates as first instars, and some second instars were lost in sieving. The screen size used in sieving was .280 mm and the mean headcapsule width of second instars was .171 mm and the calculated mean head width of first instars was .099 mm.

It appears that Hyalella azteca may influence the numbers of Dicrotendipes fumidus found on the samplers. When high numbers of H. azteca occur, lower numbers of D. fumidus are observed and vice versa (Figure 4). This is especially evident in April and May 1973 on the rubble substrate and in November 1972 on the lacustrine substrate. Whether this phenomena is a result of a competitive interaction is not known.

Polycentropus cinereus is a rare organism in comparison to Hyalella azteca and Dicrotendipes fumidus. The decrease in numbers between March and May 1972 indicate that an emergence occurs in April and May (Figure 8). Emergence occurs from May to September according to Ross (1944). P. cinereus overwinters at maximum numbers as the population maximum occurred in November. During 1972 when the north samplers were influenced by the spring, lower numbers were found in the north area than in the south area. In October when the north samplers were outside the influence of the spring, the numbers collected increased significantly, but in November when the north samplers were again within the spring's influence, the numbers decreased. The high algal and H. azteca standing crop found on the samplers influenced by the spring might in some way affect the numbers of P. cinereus, although in April and May 1973 when the spring was located in the south area, the lowest numbers still occurred in the north area.

LACUSTRINE SUBSTRATE

Except for the sudden decline in September 1972, the population trends and emergence patterns of Dicrotendipes fumidus and Hyalella azteca follow the same general pattern as those found for the rubble area (Figure 9). Prior to retrieving the samplers in September, an extensive algal bloom developed on the lake. A barrier of reeds between the location of the samplers and the shore prevented the algae from being washed ashore, and it remained over the area of the samplers for three weeks. Although no water chemistry was done, the reduction of the macroinvertebrate populations was believed to be caused by a reduction in oxygen due to the decaying algae. At this time, the planarian

Dugesia dorotocephala was collected for the first time on the samplers. It was the dominant organism in numbers in September, but its numbers decreased in November.

The standing crop estimates by Brown (1968) from the lacustrine area for *Hyalella azteca* are difficult to compare with those obtained in this study as his sampling method limited him to a water depth of 0.5 meters or less. The maximum estimate from the lacustrine area in this study was $15{,}121/M^2$ in August 1972. This estimate is ten times greater than Brown's maximum estimate for the lacustrine area.

Polycentropus cinereus numbers were less than on the rubble substrate. The decrease in numbers between May and June 1972 indicates a major emergence at this time.

Standing crop estimates for all the dominant species were greater on the rubble area than in the lacustrine area. The samplers retrieved from the lacustrine area always had less algae on them, and more silt than the samplers from the rubble area.

CONCLUSION AND SUMMARY

Cement block artificial substrate samplers were used to sample the rocky littoral zone along the eastern shore of Goshen Bay, Utah Lake, Utah. The blocks were placed in sets of five attached to two mushroom anchors. The rocky area is composed of two types of substrate: rubble and lacustrine (compacted calcareous tufa). The area is approximately 9.6 km long and extends outward from the shore line 25 m. The rubble substrate comprises the majority of the area.

Eight species of macroinvertebrates were collected on the samplers: an amphipod, *Hyalella azteca*; a chironomid, *Dicrotendipes fumidus*; three leeches, *Helobdella stagnalis*, *Dina parva*, *Eropdella punctata*; a naucorid, *Ambrysus mormon*; a trichopteran, *Polycentropus cinereus*; and a gastropod *Physella utahensis*.

Standing crop estimates from the rubble area for *Hyalella azteca* are higher than any previously reported in the literature. They range from 2,695 to 37,898/M^2 on the rubble substrate. *Hyalella azteca* standing crop is directly related to the amount of algal standing crop. Those samplers with the greatest amount of "algal mat" on them collected the greatest numbers. The high estimates can be attributed to three factors: (1) the rubble and pieces of lacustrine substrate provide an excellent substrate for epibenthic algae, (2) the eutrophic condition of Utah Lake and the extra algal nutrients provided by the small, saline springs, (3) the combined effect of the shallow depth over most of the littoral area and the high water temperatures. Standing crop estimates for *Dicrotendipes fumidus*, the other dominant organism in the rubble area ranged from 344 to 21,421/M^2. Standing crop estimates were less on the lacustrine substrate for both H. azteca and D. fumidus.

Biomass estimates for Hyalella azteca were higher in the spring and late fall than in the summer due to larger numbers of first and second year adults comprising most of the population at these times. Estimates in wet weight ranged from 5.8 to 66.5 grams/M^2. Lower biomass estimates were obtained from the lacustrine substrate for both organisms.

Dicrotendipes fumidus has one large emergence three to four weeks after the ice melts from the lake and smaller emergences occur throughout the summer. Numbers and biomass increase during the summer.

The trichopteran Polycentropus cinereus is rare compared to Dicrotentipes fumidus and Hyalella azteca. A major emergence takes place in April and May. Maximum numbers are found in the fall before the lake ices over.

To remove the littoral area along the eastern shore would eliminate what is probably the most productive macroinvertebrate area in Utah Lake. The loss of this area could affect the trophic structure of the lake by effectively reducing the benthic macroinvertebrate population of the lake.

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THE BENTHIC COMMUNITIES OF THE EASTERN ROCKY SHORE

AREAS OF GOSHEN BAY, UTAH LAKE

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ABSTRACT

Information about the benthic macroinvertebrate populations along the eastern shore of Goshen Bay, Utah Lake, Utah, can be used, in part, to determine future management of the lake. In the project herein reported, cement artificial substrate samplers were used to sample two types of substrate: rubble and compacted calcareous tufa. Monthly samples were obtained from each type of substrate from March 1972 to May 1973. An amphipod, Hyalella azteca and a chironomid, Dicrotendipes fumidus were the dominant organisms in numbers and tiomass. Amphipod numbers were dependent upon the amount of algal standing crop. Elimination of this area could affect the trophic structure of the lake by effectively reducing the macroinvertebrate population of the lake.