Benthic Macroinvertebrate Communities of Brown and Crampton Lakes.

BIOS 569 - Practicum in Aquatic Biology

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ABSTRACT

Brown and Crampton Lakes lie in close proximity at the Notre Dame Environmental Research Center. Each summer they exhibit significantly different biological characteristics. Three undergraduate students under the direction of Dr. Ronald A. Hellenthal sought to qualify and quantify the biological differences between the lakes and offer possible explanations for them. A comparative survey of the littoral and profundal benthic macroinvertebrate communities of the two lakes was performed using an Ekman sampler during the summer of 1992. Substantial communities of Chironomids were found in both the littoral and profundal zones of Brown Lake. Crampton Lake, however, had diverse communities of Odonates, Ephemeroptera, and Chironomids in the shallow samples and exclusively Chironomids in the deep sediments. Sampling for crayfish in the two lakes resulted in two Orconectes propinquus, both from Crampton Lake.

INTRODUCTION

Brown Lake and Crampton Lake are both glacial-formed lakes located in the woodlands of Northern Wisconsin and Michigan's Upper Peninsula. Both are at the southeastern end of the property which comprises the University of Notre Dame Environmental Research Center (UNDERC). Both lakes are rarely encountered by people and it is presumed that their ecosystems have not been recently altered by human activity. Brown Lake has a surface area of 63 acres, is fed primarily by precipitation runoff, and drains to the northwest into Brown Creek. Brown Lake has a maximum depth of 5.0 meters. Crampton Lake lies one-quarter of a mile to the south of Brown Lake, straddling the Michigan-Wisconsin border. Crampton too has precipitation as its source of water, however, has no obvious surface drainage. It is suspected that Crampton may be a seepage lake. Crampton has a surface area of 72 acres and a maximum depth of 9.0 meters. Close in proximity, and similar in physical structure, the lakes differ most significantly in their deepest points. Considering these common basic features, it would be expected that Brown and Crampton Lakes would host similar biological communities.

Upon arrival at UNDERC in late May, Crampton was found to be noticably clearer than Brown. Crampton had a Secchi disk reading of 4.3 meters compared to Brown's 1.0 meter. It was observed also that Brown's water level is maintained nearly one meter higher than it naturally would be by a family of beaver that maintains a lodge and dam at about 50 meters from the mouth of Brown Creek. Freshwater otters were also observed on Brown and not on Crampton. Throughout the summer, and particularly during population surveying directed by Dr. Martin Berg, fish communities in the two lakes were found to be substantially different. Crampton hosted a community dominated by perch, bluegill and pumpkinseed with Smallmouth and Largemouth Bass as the primary predators. Brown's assemblage was dominated by dense populations of crappies along with perch, bluegill and pumpkinseed preyed upon by large mature walleye, northern pike, and muskellunge. It is believed that a portion of the large predator fish of Brown lake come and go from the lake via Brown Creek.

The Flora of the two lakes differ as well. Although formal surveying was not performed, basic observations revealed some characteristics. Crampton's macrophyte communities consist primarily of isolated patches of water-lilies and grass-like aquatic plants (many of which are truncated 2-10 cm from the sediments). Brown on the other hand, is choked with extensive patches of water lilies and reeds as well as leafy and grass-like macrophytes that often grow through the water column from the sediments to the surface. The most obvious difference in macrophyte assemblages is Brown's extensive patches of reeds versus the relative absence of these plants on Crampton. Crampton's phytoplankton population is well contained in the water column and on benthic substrates as they support a proportionate population of zooplankton. Brown on the other hand exhibits extensive blooming of its phytoplankton communities in the water column throughout the summer. This is the area in which the most stark and extensive biological differences of the lakes can be observed.

These observable differences in lakes of close geographical proximity and similar geological structure served as the motive for a three-part comparative study of the two lakes conducted under the direction of Dr. Ronald A. Hellenthal. During the summer of 1992, three undergraduate students enrolled in BIOS 569 (Practicum in Aquatic Biology) worked in cooperation to seek out some of the key biological factors which characterized and influenced the different ecosystems. The subject matter of this paper is one segment of that investigation. The other students focused on the chemical and planktonic differences between the two lakes, while the author of this paper sought to investigate the benthic macro-invertebrates of the two lakes.

The objective was to determine the differences in types and relative abundances of the benthic insects of Brown and Crampton lakes. In inland lakes, "benthic organisms contribute to the accumulation of metabolic products and selectively remove nutrients and organic compounds from the water; this biological activity can have large effects on the composition of the water." (Reid & Wood, 1976) In addition, "it is important to realize that benthic fauna and sediments constitute a complex feedback system in which numerous influences on benthos distribution and abundance can indirectly affect sediment properties." (McCall & Tevesz, 1982) Because the observable differences in the composition of the water of Brown and Crampton lakes is most likely due to biological processes, and because the water conditions themselves represent different habitats, it is logical that variations between the benthic communities of the two lakes would exist.

The benthic areas of freshwater lakes that most clearly define the ecosystem are shallow areas where the bottom is still within the photic zone and is inhabited by rooted hydrophytes (littoral bottom), and the deepest areas of the lake (profundal bottom) "contiguous with the hypolimnion of the limnetic region." (Reid & Wood, 1976) The littoral zone usually is characterized by a large variety of macro-invertebrate species in moderately populated communities, while the profundal zone is characterized by relatively few species in well populated communities. The actual total biomasses of the littoral and profundal zones tend to be equivalent while the number of different species tends to differ substantially. Both the shallow and deep areas are more productive than the area that divides them, the sublittoral bottom. The sublittoral "constitutes an ecotone, or 'buffer' zone, between two communities." (Reid & Wood, 1976) This is because the sublittoral zone benefits neither from the presence of autotrophs and the injection of terrestrial nutrients (littoral bottom) nor the collection of detritus that has fallen through the water column (profundal bottom). It is thus expected that differences will be found in the community composition and density of benthic organisms of the littoral zone versus the profundal zone.

MATERIALS AND METHODS

Surveying of benthic macro-invertebrates from Brown and Crampton lakes was conducted three times during the summer of 1992. The first sampling episode began June 8, the second began June 22, and the third began July 19. During each sampling five individual samples were taken from both the littoral and profundal zones of both lakes. The twenty samples were organized according to lake, depth, and time of day. A higher number of replicate samples for each zone would help to reduce variation. Samples of the top 15-20 centimeters of sediments were taken using a standard Ekman dredge (43.1 dredges per square meter) from a small aluminum boat. Sediment samples were then washed through a U.S. Standard No. 30 sieve (28 meshes per inch) fastened to the bottom of a bucket. Water taken from the lake surface near the location of the sampling was used for washing. The washed material was then removed from the sieve, placed in Zip-Lock Freezer Bags along with a fair amount of surface water, labeled, taken to the lab, and placed in the vegetable drawer of a refrigerator. Unfortunately, as it is potentially a significant source of error, some of the samples remained in the refrigerator for as long as 14 days before they were treated. Samples were then examined individually in white enamel pans as specimens were picked from the sample and preserved in alcohol. The treated samples were then identified and counted.

During the week of July 15, 1992 sampling for crayfish was conducted each night for five nights in both Brown and Crampton lakes. Each night 10 live-traps were baited with raw beef-liver and placed in water 0.5-1.0 meter deep. The traps were common wire-basket minnow traps that were adapted for trapping crayfish by enlarging the diameter of the end openings by approximately 2 centimeters. The traps were set in different areas of the lakes each night and were kept within 25 meters of shore and within 25 meters of one another. Each following morning the traps were removed and emptied. Live specimens were then identified and returned.

During the summer of 1992 three bodies of water were mapped by the author and the other undergraduates working under the direction of Dr. Ronald A. Hellenthal. These three bodies were Crampton Lake, Gilbert Lake, and an unnamed body of water directly west of Gilbert. The lakes were mapped according to the protocol outlined by R. Huftalen and M. Lavery (1991).

RESULTS

Figure 1 represents the results of the first episode of sampling on Crampton Lake. As the graph shows, there is considerable variety in the types of macroinvertebrates which inhabit the littoral zone (0.5-2.0 meters) of Crampton. The least abundant specimens are Chironomid bloodworms, only one of which was found in one sample. A single Hagenius *brevistylus* (Odonata: Gomphidae) larva was found at 1.5 meters and an Epithea *sp.* (Odonata: Corduliidae) at 1.0 meter. Litobrancha *recurvata* (Ephemeroptera: Ephemeridae) were more abundant than were the Odonates. Four of the five samples taken contained 2-4 specimens. Occurring in greater abundance were two types of case-building Trichoptera. Molanna *sp.* (Trichoptera: Molannidae) produces a cylindrical case with lateral flanges of course sand, while the more abundant Pseudostenophylax *uniformis* (Trichoptera: Limnephilidae) produces a tusk-shaped case of fine sand. Also found in the Crampton littoral zone, but not represented in the graphs, were two different unidentified woody Trichoptera cases, a single Sialis *sp.* (Megaloptera: Sialidae), and a single Polycentropus *sp.* (Trichoptera:). Five different orders and nine different families of specimens were found in Crampton's littoral zone. In the profundal zone (11-13 meters) white Chironomid midges that were 0.5-1.0 centimeters long had a calculated average density of 450 specimens per square meter. Significantly larger (1.5-3.0 cm) Chironomid bloodworms were found to have a density of 300 specimens per square meter. Two related types of macroinvertebrates were found in substantial numbers in the profundal zone of Crampton.

Figure 2 shows the results of the second period of sampling the benthos of Crampton on June 22, 1992. Again there is a significant variety of types of macroinvertebrates in the littoral zone. White Chironomid midges, Litobrancha *recurvata*, Pseudostenophylax *uniformis*, and Molanna *sp.* were all found in each of the five samples. In addition, three Hagenius *brevystylus* were found. The profundal communities were thoroughly dominated by Chironomid bloodworms averaging 2800 specimens per square meter. White Chironomid midges were found in three of the samples, posting a calculated average density of 130 per square meter. A single Polycentropus *sp.* was found in the deep water of Crampton.

Figure 3 is the result of the final sampling of Crampton on July 19, 1992. The littoral zone once again produced a variety of types of macroinvertebrates, however, combined population density was a low 300 specimens per square meter. In addition to those specimens in the graph, one Sialis *sp.* was found in the shallow water of Crampton. The profundal samples were again dominated by Chironomid bloodworms colonies with relatively low density of 480 per square meter. White Chironomid midges were found in only two of the samples, resulting in a calculated average density of only 100 per square meter.

Figure 4 is the graphical representation of the results of sampling Brown Lake June 9-12. The specimens found in Brown's littoral zone were most predominantly Chironomid bloodworms in substantial populations of approximately 800 specimens per square meter. Not represented graphically were two Hagenius *brevistylus* taken in the same Ekman sample, six unidentified small clams, and 14 unidentified snails. Very well populated communities of white Chironomid Midges averaging 5300 specimens per square meter were found in Brown's profundal zone. Also in the profundal were Chironomid Bloodworms averaging 400 specimens per square meter. One clam and one snail were found in the deep water samples.

The second sampling of Brown, performed June 22, is shown in figure 5. Chironomid bloodworms were the only type of macroinvertebrate found in the littoral zone. They averaged 340 organisms per square meter. Shallow water sampling also produced 9 small clams and 6 snails. The profundal zone was again dominated by white Chironomid midges averaging 1500 organisms per square meter. Chironomid bloodworms were also in the deep samples, averaging 230 per square meter.

As the summer progresses, the water of Brown lake became increasingly turbid while the water of Crampton remained very clear. A particularly significant blooming of algae occurred in mid-July which justified the naming of Brown lake. While the water of Brown Lake was deep green with algae through mid-July, it became so severely choked with organic matter that its surface appeared to have a texture when not disturbed by wind (this was observed several times at night using the headlamps of an automobile). Crampton's water was consistently clear while Brown's water progressed from deep green to opaque pea-green to dirty brown.

The final sampling of Brown was completed July 19 (after the algal bloom) and is shown in figure 6. Chironomid bloodworms were the only macroinvertebrates at shallow depths in communities of about 340 per square meter. 7 small clams and 11 snails were also found in the shallow samples. The deep sediments produced white Chironomid midges at 880 per square meter and Chironomid bloodworms at 170 per square meter.

Figures 7-12 are simply the same graphs as figures 1-6, with their y-axis adjusted so that they are all equal. This was done so that different samples could be easily and accurately compared. Figure 13a is the raw data from the individual benthic samples. Figure 13b is the data adjusted for density (43.1 Ekman grabs per square meter). Figure 14 is a list of the specimens caught and identified by the author in conjunction with the project.

The attempts to trap crayfish on Crampton and Brown resulted in two mature females both taken from the west shore of Crampton. The author identified the specimens as Orconectes *propinquus*. No specimens were trapped or observed on Brown Lake.

Figure 15 is the map of Crampton Lake which the author and the other two undergraduates under the direction of Dr. Ronald A. Hellenthal produced. Figure 16 is the map of Gilbert Lake made the same way. Figure 17 is the map of the body of water directly west of Gilbert Lake hereafter referred to as Softside Lake/Bog due to its bog-like edges.

DISCUSSION

The key factors in the comparison of benthic communities are the types of specimens found, and their population densities. In the context of this investigation, it is also interesting to compare the communities over time. The first sampling of Crampton Lake (figure 1) most clearly supports the hypothesis that shallow sediments tend to host a greater variety of macroinvertebrates than do deep sediments. As stated above there were at least 5 orders and 9 families of insects found during that sampling. The separate types were found in low densities (40-200 per square meter), however, their combined densities were moderate (600 per square meter). The deep sediments sampled at the same time, however, hosted only two closely related Chironomids with combined densities of 730 per square meter. The average densities agree with the earlier stated hypothesis that littoral sediments are home to less dense populations than the profundal. Considering the sizes of some of the Ephemeroptera and Odonata compared to Chironomids, the author thinks that the different zones produced nearly equivalent overall biomasses. This is also in agreement with current hypothesis.

Benthos of Brown and Crampton Lakes

Subsequent sampling episodes on Crampton Lake (figures 2,3) are in agreement with the first sampling when considering communal characteristics of littoral versus profundal. When considering whole-lake population densities, however, (figures 7, 8, 9) there was a significant increase in abundance of specimens found in the second episode (figure 8) than in the other two. The littoral community densities were 2-4 times greater while the profundal communities were 4-6 times more dense. This probably represents a seasonal population increase that was later curbed by maturation and subsequent emergence, predatorial feeding (fishes), nutrient limiting (though improbable), or simply natural mortality. It is also possible that location of sampling (i.e. landing on prime habitat) or sampling technique may have influenced the results.

Although few in numbers, it is important to mention that the dragonflies represent a substantial portion of the biomass of the samples due to their large size relative to the other specimens. In addition, the dragonflies consume living macroinvertebrates and may have a limiting effect on the number of smaller specimens colonizing in the same space. The author also fears that during storage prior to sorting, samples containing Odonates may have been altered due to their predation. Some of the Ephemeroptera were of the same degree of size as the Odonates, however, they are not predators.

The samples taken from Brown lake did not show strong support for the hypothesis discussed above. Although a small number of Odonata and a moderate number of snails and clams were found, Chironomids were the only well populated macroinvertebrate communities found on Brown (figures 4, 5, 6). The only distinctions between the littoral and profundal zones were the types of Chironomids and their comparative densities. The littoral zone produced Chironomid Bloodworms at moderate densities while the profundal zone hosted smaller white Chironomid midges at much higher densities.

The relatively low diversity found in Brown Lake's benthos is most likely due to Brown's lack of distinct zonation. Neither a significant photic zone nor a distinct profundal basin were found in Brown as they were in Crampton. Also, the more dense fish populations of Brown lake most certainly serve to limit populations of Chironomids as well as the survivability of larger macroinvertebrates in the open water sediments. Considering the assemblage of mature aquatic insects observed in flight and on the foliage around Brown Lake, it is surprising that more diversity was not discovered in the benthos. It is the author's suspicion that a higher diversity of aquatic macroinvertebrates would be found in the water protected by the reeds around much of the shore of Brown Lake, particularly near the mouth of Brown Creek.

The substrate sediments of the two lakes were distinctly different in the shallow areas, and nearly identical in the deepest areas. Crampton's shallow sediments were dominated by sand and gravel with small amounts of organic matter in the form of twigs/chips of wood, seeds, and macrophytes. Brown's shallow sediments, in contrast, were distinctly dominated by organic matter in the form of macrophytes and wood chips. There was usually more plant material by weight and volume in the Brown samples, than anything else. Both lakes produced deep water bottom sediments that were black with the consistency of chocolate pudding.

In conclusion, this investigation found that Crampton's distinct bottom zonation and extensive benthic area reached by light provide the habitat for well balanced macroinvertebrate communities that exhibit characteristics in agreement with accepted principles of freshwater ecosystems. In contrast, Brown Lake's apparent lack of photic zone and rather homogeneous depth are host to unconventional benthic communities. I believe that the difference in the bottom geographies of the two lakes alone is a significant factor in the distinct characteristics of the two lakes. The author is unable, however, to conclude from this investigation if the water conditions dictate the macroinvertebrate communities or if the reverse is true. Brown lake would certainly have a much greater photic zone if its water column were less turbid. It is generally accepted that both the water conditions and the insect fauna are interdependent and that they impose conditions on one another. In this situation, however, both are more dependent on environmental factors not considered in this investigation than on factors dictated by one another.

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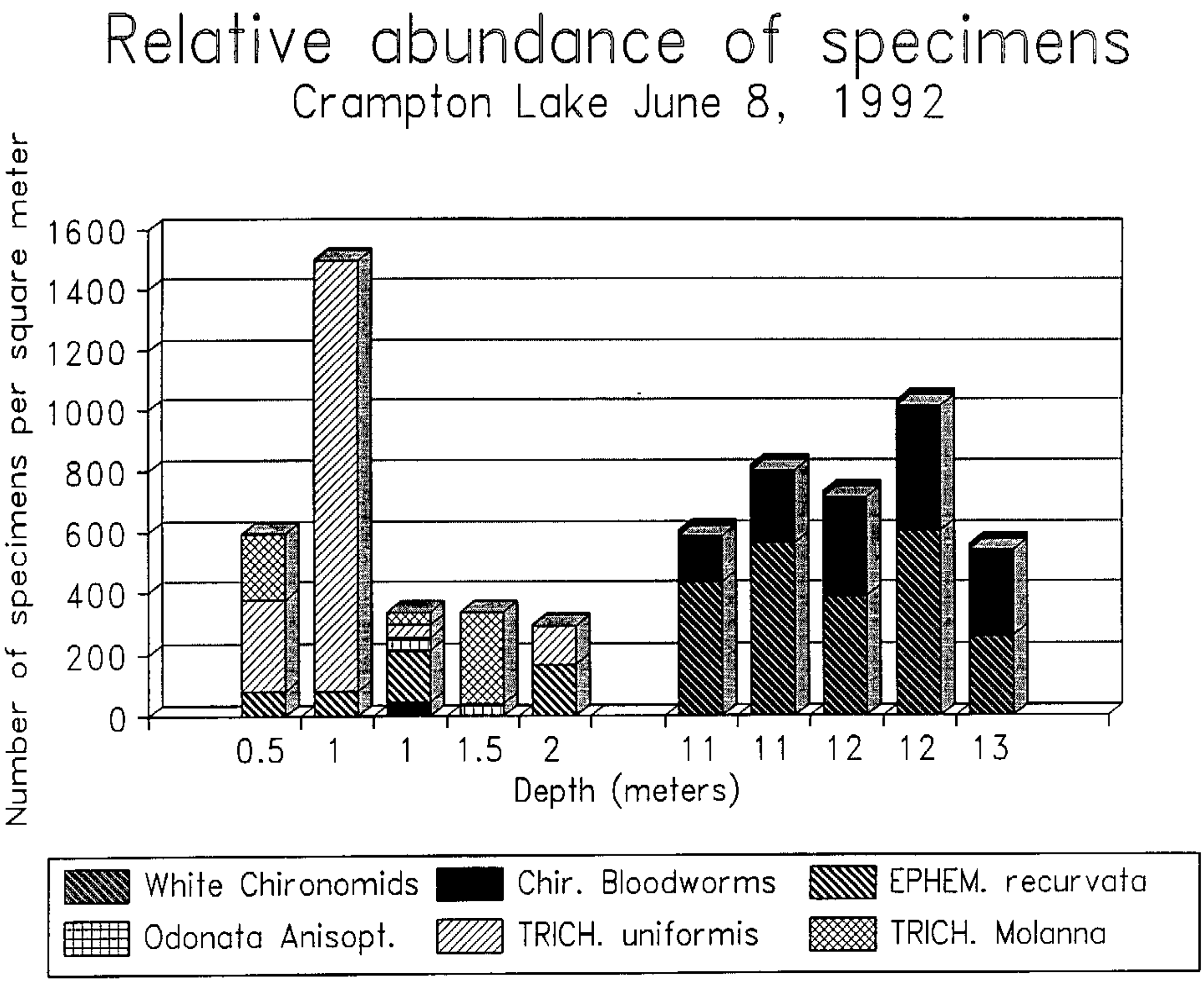
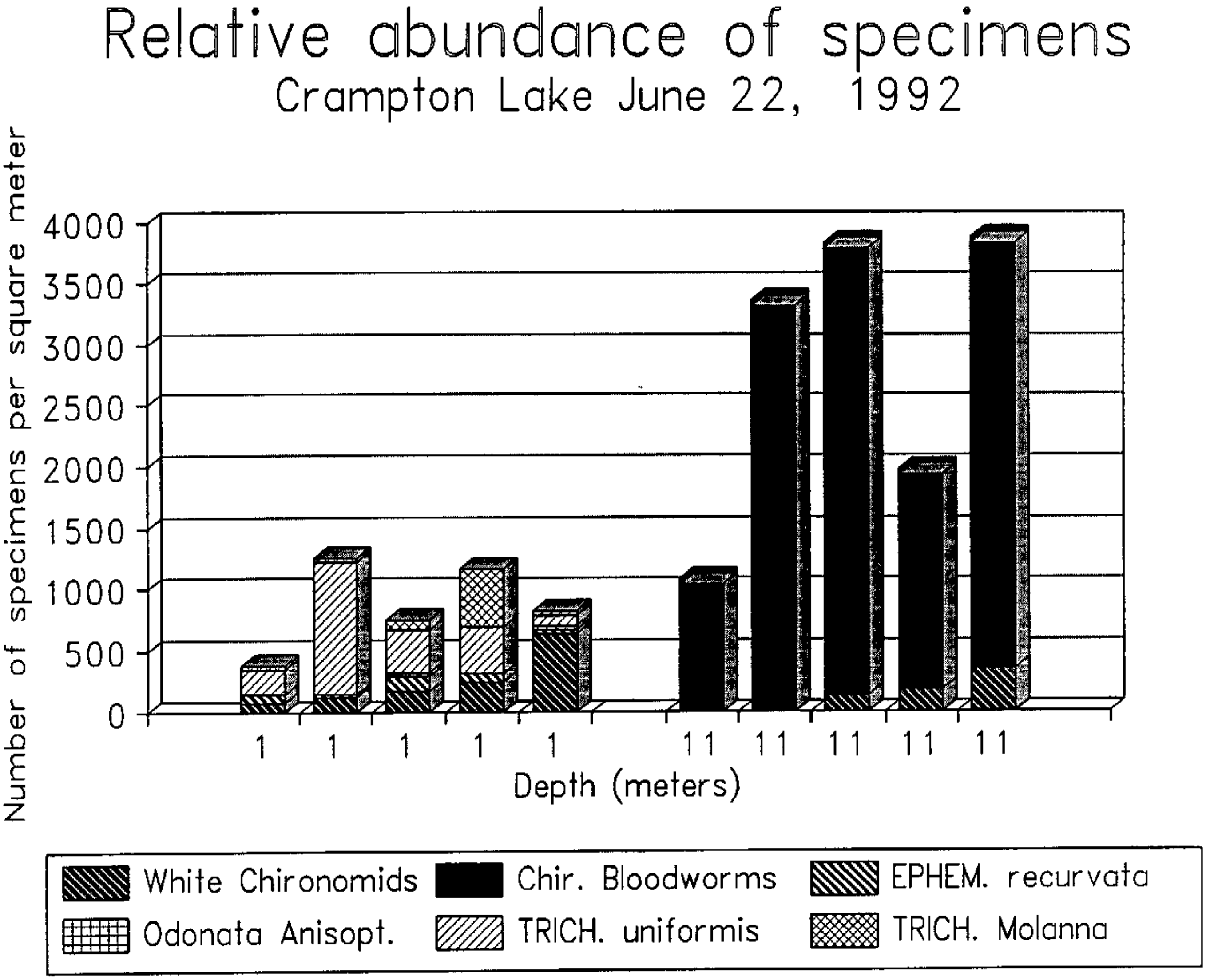
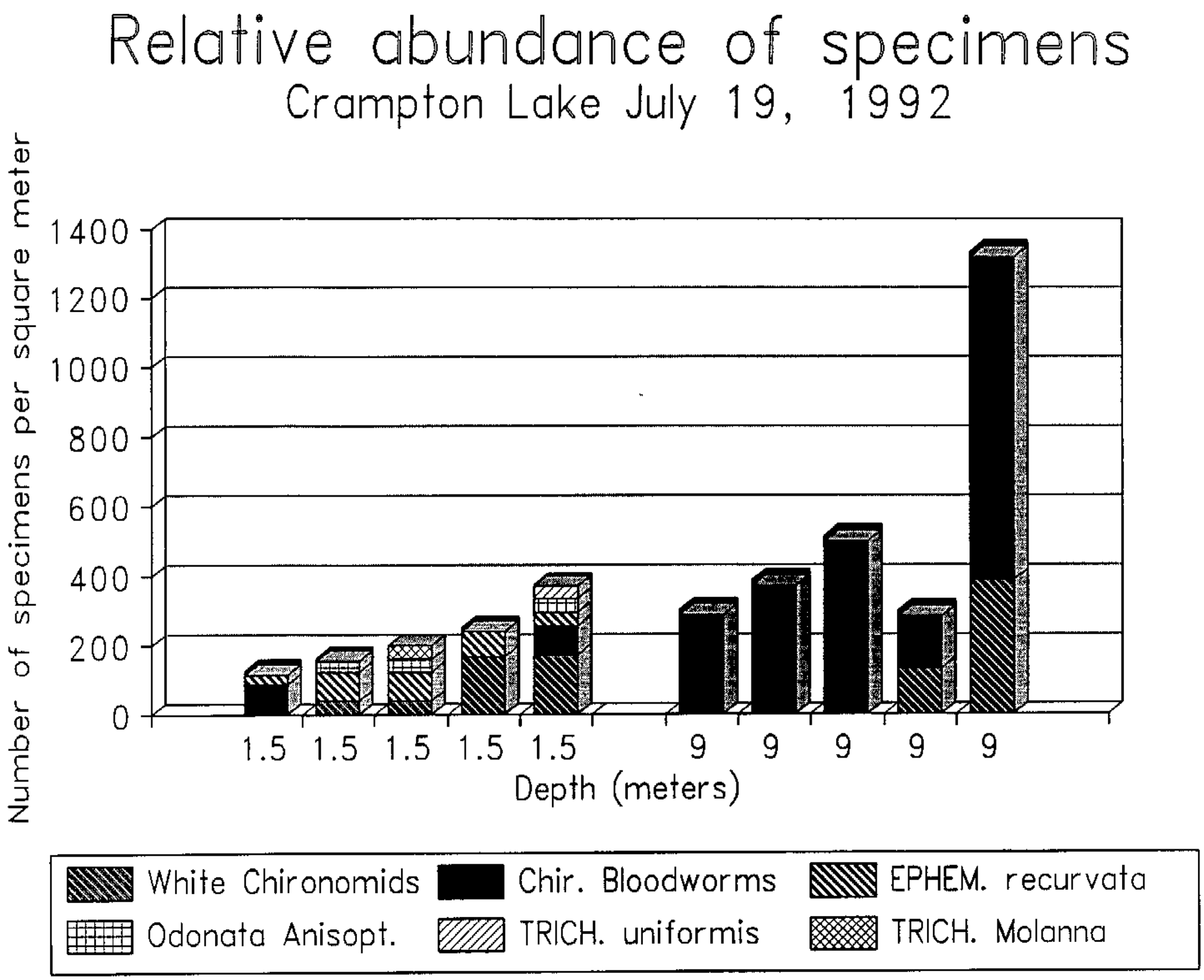


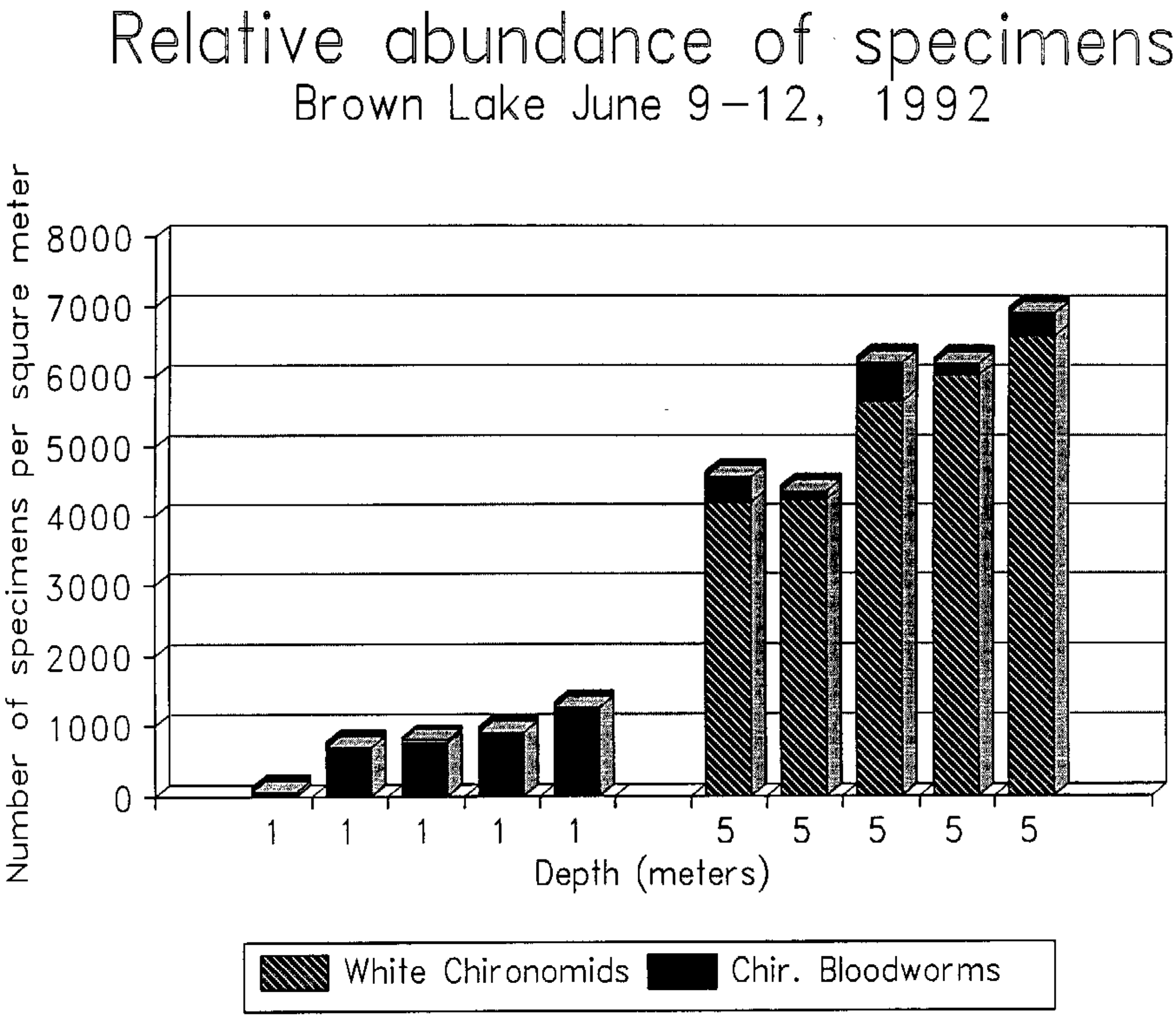
Relative abundance of specimens
Crampton Lake June 8, 1992
Number of specimens per square meter
1600
1400
1200
1000
800
600
400
200
0
0.5
1
1
1.5
2
11
11
12
12
13
Depth (meters)
White Chironomids
Chir. Bloodworms
EPHEM. recurvata
Odonata Anisopt.
TRICH. uniformis
TRICH. Molanna

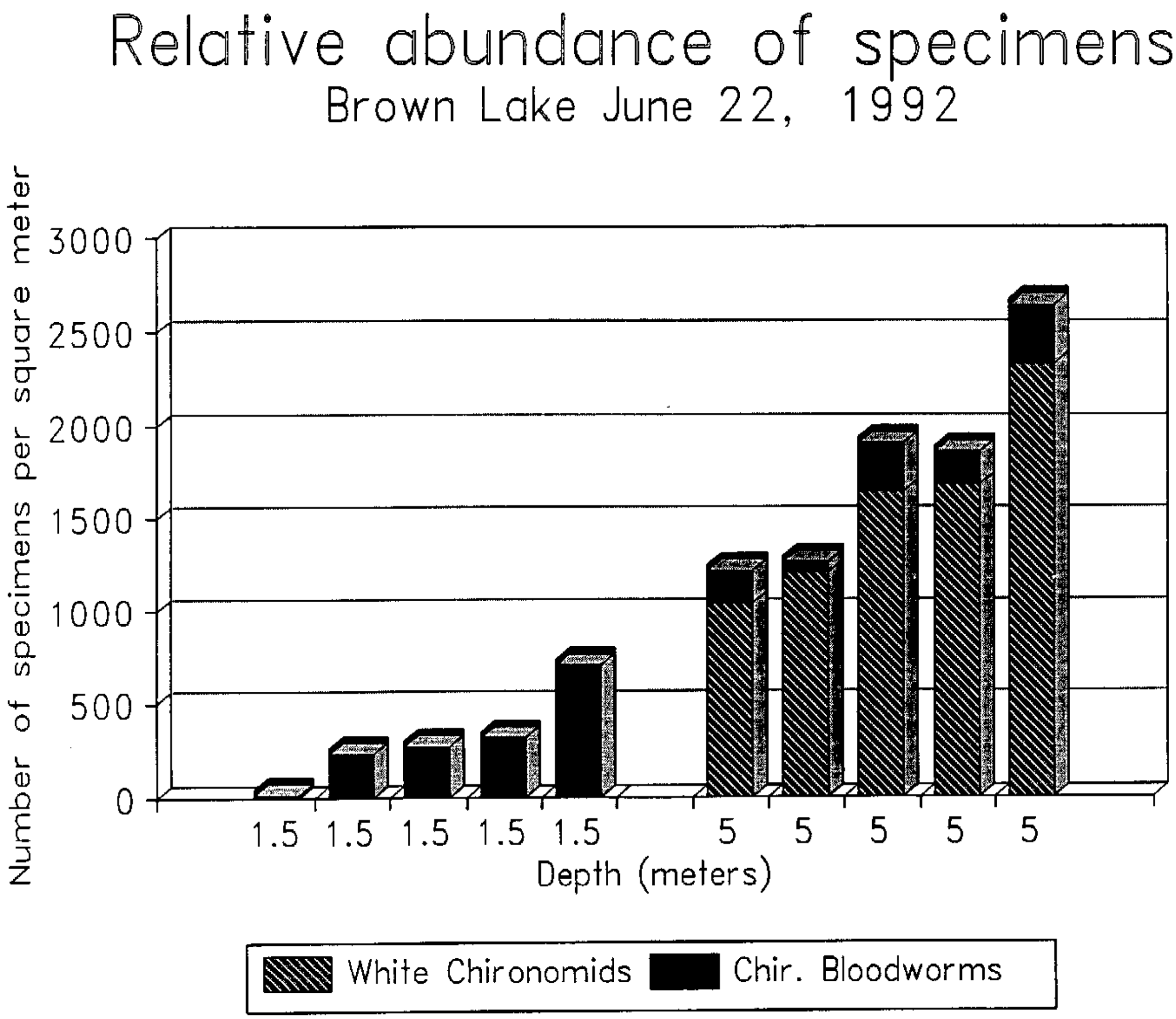


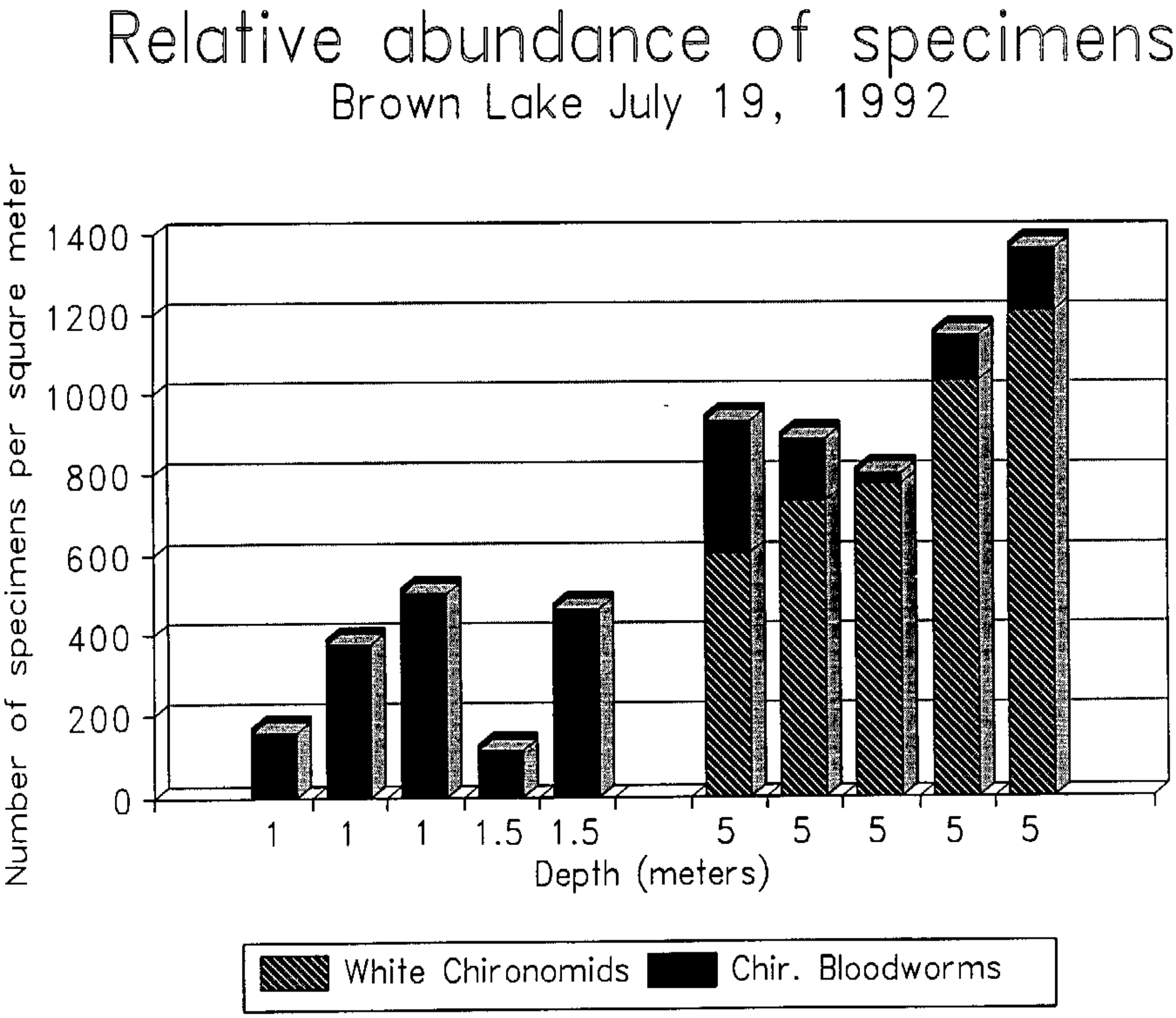
Relative abundance of specimens
Crampton Lake June 22, 1992
Number of specimens per square meter
4000
3500
3000
2500
2000
1500
1000
500
0
1
1
1
1
1
11
11
11
11
11
Depth (meters)
White Chironomids
Chir. Bloodworms
EPHEM. recurvata
Odonata Anisopt.
TRICH. uniformis
TRICH. Molanna



Relative abundance of specimens
Crampton Lake July 19, 1992
Number of specimens per square meter
0
200
400
600
800
1000
1200
1400
1.5 1.5 1.5 1.5 1.5
9 9 9 9 9
Depth (meters)
White Chironomids
Chir. Bloodworms
EPHEM. recurvata
Odonata Anisopt.
TRICH. uniformis
TRICH. Molanna


Relative abundance of specimens
Brown Lake June 9-12, 1992
Number of specimens per square meter
8000
7000
6000
5000
4000
3000
2000
1000
0
1
1
1
1
1
5
5
5
5
5
Depth (meters)
White Chironomids
Chir. Bloodworms


Relative abundance of specimens
Brown Lake June 22, 1992
Number of specimens per square meter
3000
2500
2000
1500
1000
500
0
1.5 1.5 1.5 1.5 1.5
5 5 5 5 5
Depth (meters)
White Chironomids
Chir. Bloodworms


Relative abundance of specimens
Brown Lake July 19, 1992
Number of specimens per square meter
1400
1200
1000
800
600
400
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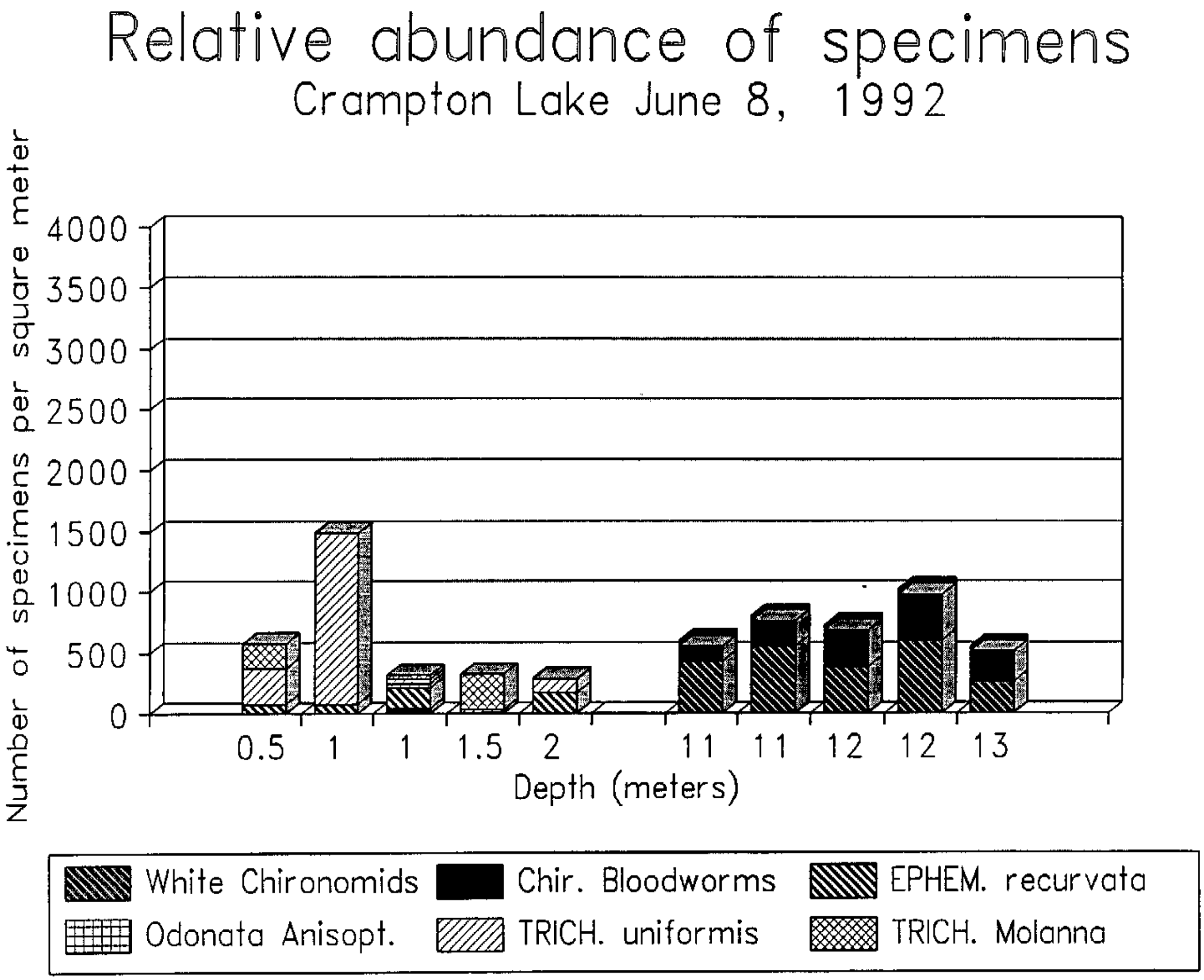
Depth (meters)
White Chironomids
Chir. Bloodworms


Relative abundance of specimens
Crampton Lake June 8, 1992
Number of specimens per square meter
4000
3500
3000
2500
2000
1500
1000
500
0
0.5
1
1
1.5
2
11
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12
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13
Depth (meters)
White Chironomids
Chir. Bloodworms
EPHEM. recurvata
Odonata Anisopt.
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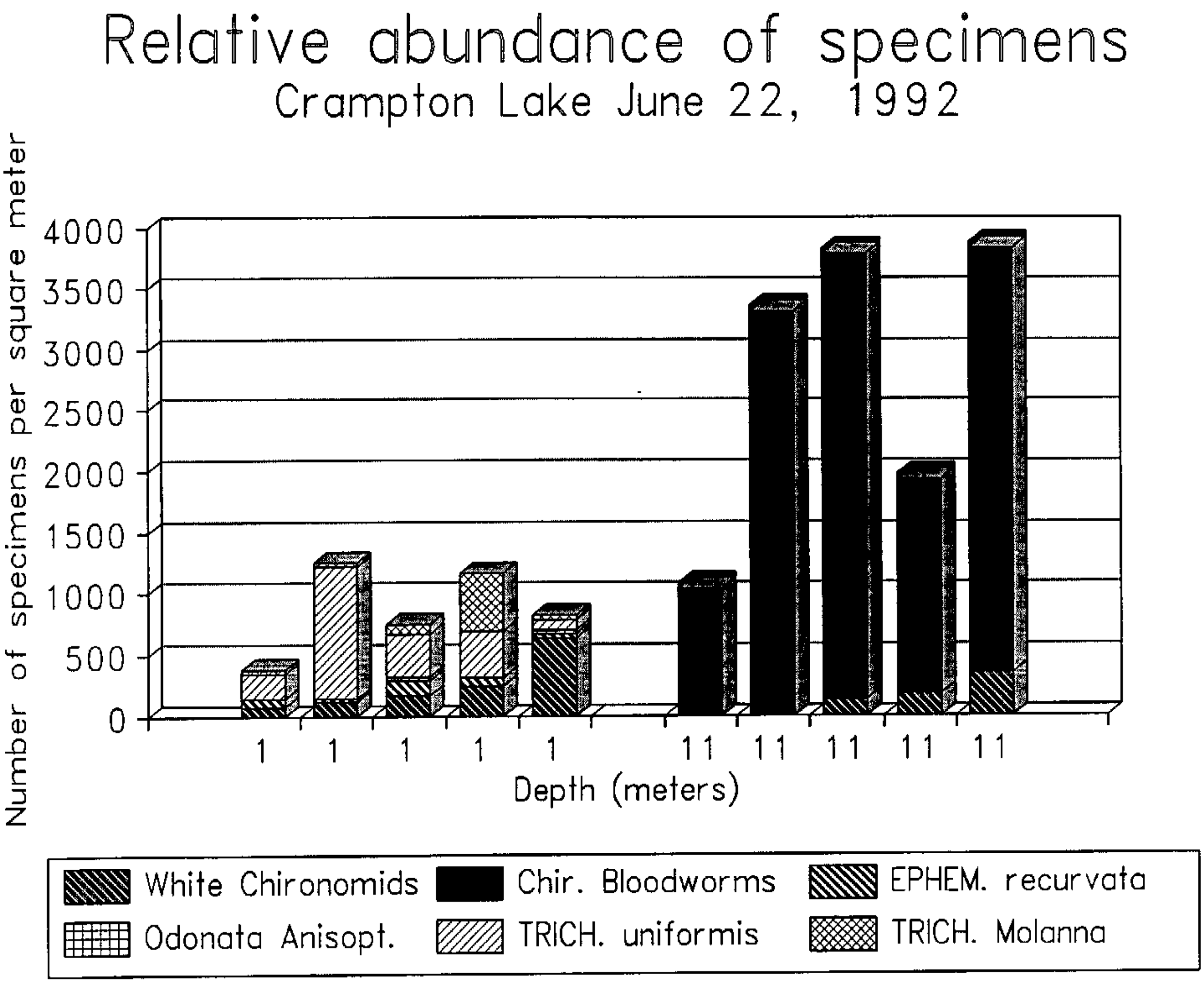
TRICH. Molanna



Relative abundance of specimens
Crampton Lake June 22, 1992
Number of specimens per square meter
4000
3500
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2000
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0
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1
1
1
1
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Depth (meters)
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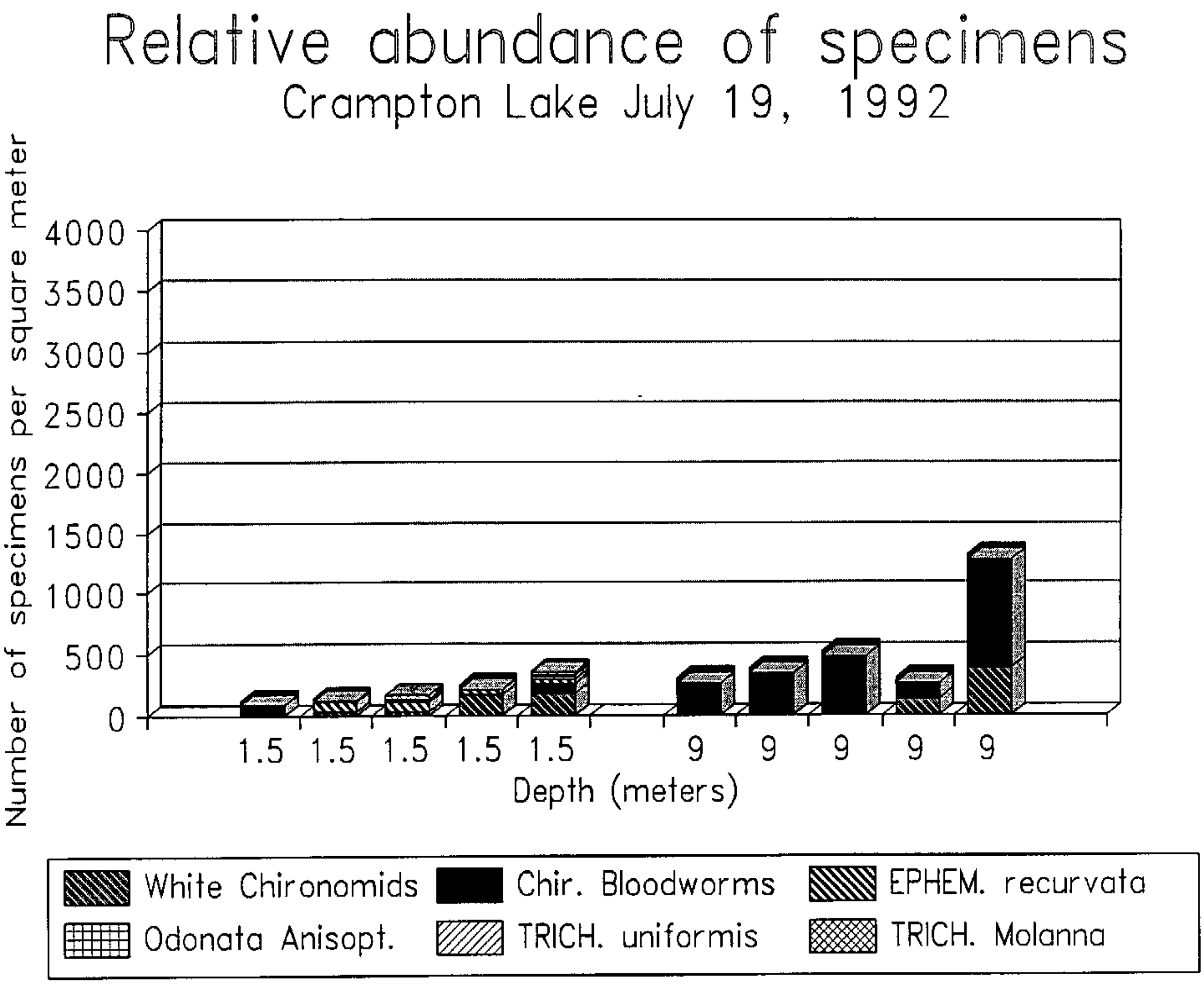
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Crampton Lake July 19, 1992
Number of specimens per square meter
4000
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500
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1.5
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1.5
1.5
9
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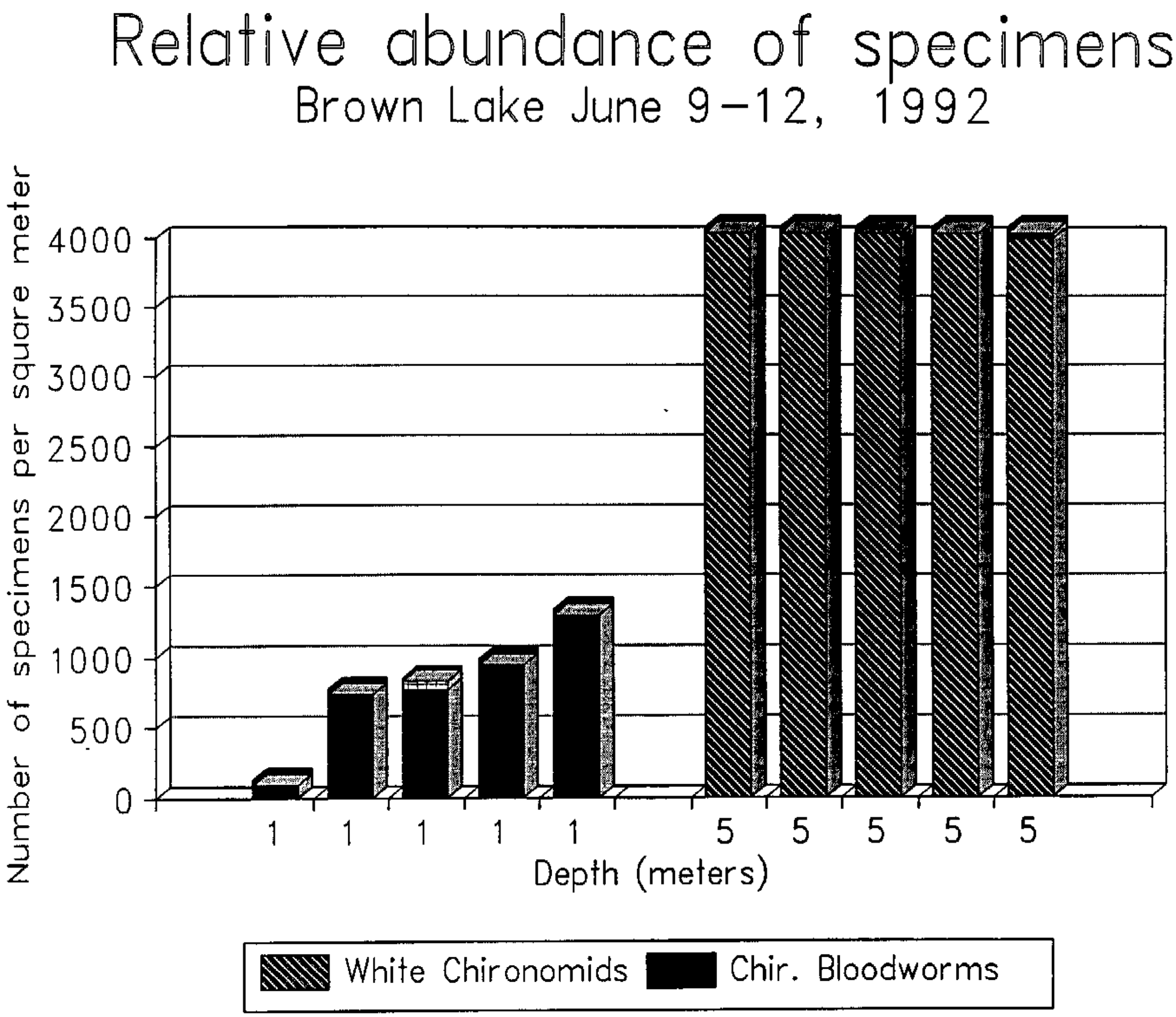
Relative abundance of specimens
Brown Lake June 9-12, 1992
Number of specimens per square meter
4000
3500
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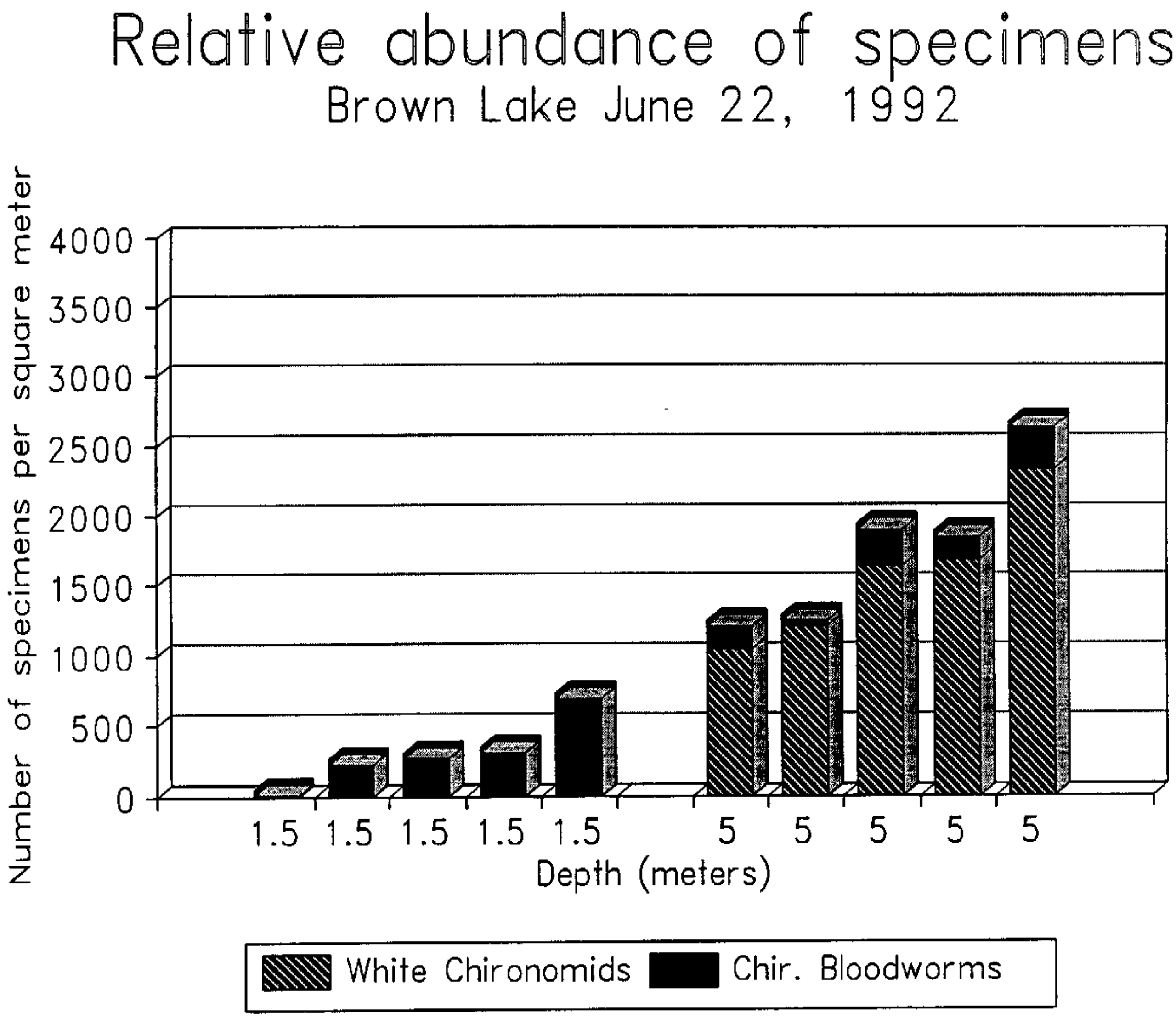
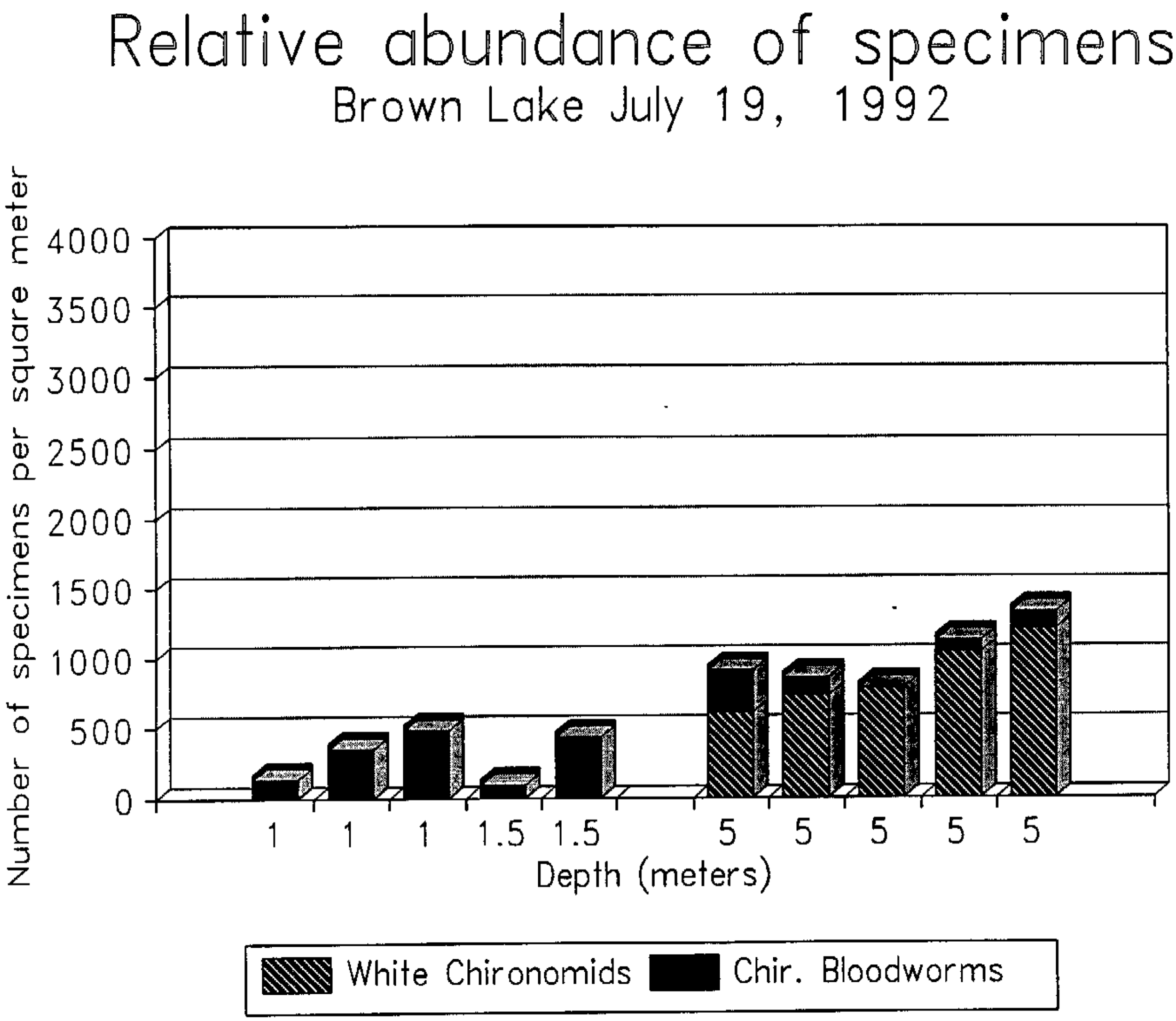
Depth (meters)
White Chironomids
Chir. Bloodworms



Relative abundance of specimens
Brown Lake June 22, 1992
Number of specimens per square meter
4000
3500
3000
2500
2000
1500
1000
500
0
1.5 1.5 1.5 1.5 1.5
5 5 5 5 5
Depth (meters)
White Chironomids
Chir. Bloodworms



Relative abundance of specimens
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4000
3500
3000
2500
2000
1500
1000
500
0
1
1
1
1.5
1.5
5
5
5
5
5
Depth (meters)
White Chironomids
Chir. Bloodworms

Date	Lake	Date	Lake	Depth(m)	Per Ekman									
					Midges	Bldworms	Mayflies	Odonata	Hrn case	Mum case	Org case	Clams	Snails	Unknown
June 8	Crampton	June 8	Crampton	0.5	0	0	2	0	7	5	1	0	0	0
June 8	Crampton	June 8	Crampton	1	0	0	2	0	33	0	0	0	0	0
June 8	Crampton	June 8	Crampton	1	0	1	4	1	1	1	1	0	0	1
June 8	Crampton	June 8	Crampton	1.5	0	0	0	1	0	7	0	0	0	1
June 8	Crampton	June 8	Crampton	2	0	0	4	0	3	0	0	0	0	0
June 8	Crampton	June 8	Crampton	11	10	4	0	0	0	0	0	0	0	0
June 8	Crampton	June 8	Crampton	11	13	6	0	0	0	0	0	0	0	0
June 8	Crampton	June 8	Crampton	12	9	8	0	0	0	0	0	0	0	0
June 8	Crampton	June 8	Crampton	12	14	10	0	0	0	0	0	0	0	0
June 8	Crampton	June 8	Crampton	13	6	7	0	0	0	0	0	0	0	0
June 12	Brown	June 12	Brown	1	0	3	0	0	0	0	0	0	3	0
June 12	Brown	June 12	Brown	1	0	18	0	0	0	0	0	1	0	0
June 12	Brown	June 12	Brown	1	0	18	0	2	0	0	0	1	8	0
June 12	Brown	June 12	Brown	1	0	23	0	0	0	0	0	2	1	0
June 12	Brown	June 12	Brown	1	0	31	0	0	0	0	0	2	2	0
June 9	Brown	June 9	Brown	5	97	11	0	0	0	0	0	0	0	0
June 9	Brown	June 9	Brown	5	98	5	0	0	0	0	0	0	1	0
June 9	Brown	June 9	Brown	5	131	15	0	0	0	0	0	0	0	0
June 9	Brown	June 9	Brown	5	140	6	0	0	0	0	0	0	0	1
June 9	Brown	June 9	Brown	5	153	10	0	0	0	0	0	0	0	0
June 22	Crampton	June 22	Crampton	11	0	78	0	0	0	0	0	0	0	0
June 22	Crampton	June 22	Crampton	11	3	86	0	0	0	0	0	0	0	0
June 22	Crampton	June 22	Crampton	11	4	42	0	0	0	0	0	0	0	1
June 22	Crampton	June 22	Crampton	11	0	25	0	0	0	0	0	0	0	0
June 22	Crampton	June 22	Crampton	11	8	82	0	0	0	0	0	0	0	0
June 22	Crampton	June 22	Crampton	1	4	0	3	1	8	2	0	0	0	0
June 22	Crampton	June 22	Crampton	1	15	0	1	1	2	1	0	0	0	0
June 22	Crampton	June 22	Crampton	1	2	0	2	0	5	1	0	0	0	0
June 22	Crampton	June 22	Crampton	1	6	0	2	0	9	11	0	0	0	0
June 22	Crampton	June 22	Crampton	1	3	0	1	0	25	1	0	0	0	0
June 22	Brown	June 22	Brown	5	24	5	0	0	0	0	0	0	0	0
June 22	Brown	June 22	Brown	5	28	2	0	0	0	0	0	0	0	0
June 22	Brown	June 22	Brown	5	38	7	0	0	0	0	0	0	0	0
June 22	Brown	June 22	Brown	5	54	8	0	0	0	0	0	0	0	0
June 22	Brown	June 22	Brown	5	39	5	0	0	0	0	0	0	0	0
June 22	Brown	June 22	Brown	1.5	0	6	0	0	0	0	0	8	1	0
June 22	Brown	June 22	Brown	1.5	0	17	0	0	0	0	0	0	1	0
June 22	Brown	June 22	Brown	1.5	0	7	0	0	0	0	0	0	1	0
June 22	Brown	June 22	Brown	1.5	0	1	0	0	0	0	0	0	1	0
June 22	Brown	June 22	Brown	1.5	0	8	0	0	0	0	0	1	2	0
July 19	Crampton	July 19	Crampton	9	3	4	0	0	0	0	0	0	0	0
July 19	Crampton	July 19	Crampton	9	0	12	0	0	0	0	0	0	0	0
July 19	Crampton	July 19	Crampton	9	0	7	0	0	0	0	0	0	0	0
July 19	Crampton	July 19	Crampton	9	9	22	0	0	0	0	0	0	0	0
July 19	Crampton	July 19	Crampton	9	0	9	0	0	0	0	0	0	0	0
July 19	Crampton	July 19	Crampton	1.5	1	0	2	1	0	1	0	0	0	0
July 19	Crampton	July 19	Crampton	1.5	1	0	2	1	0	0	0	0	0	0
July 19	Crampton	July 19	Crampton	1.5	4	2	1	1	1	0	0	0	0	1
July 19	Crampton	July 19	Crampton	1.5	0	2	1	0	0	0	0	0	1	0
July 19	Crampton	July 19	Crampton	1.5	4	0	2	0	0	0	0	0	0	0
July 19	Brown	July 19	Brown	5	28	4	0	0	0	0	0	0	0	0
July 19	Brown	July 19	Brown	5	24	3	0	0	0	0	0	0	0	0
July 19	Brown	July 19	Brown	5	18	1	0	0	0	0	0	0	0	0
July 19	Brown	July 19	Brown	5	17	4	0	0	0	0	0	0	0	0
July 19	Brown	July 19	Brown	5	14	8	0	0	0	0	0	0	0	0
July 19	Brown	July 19	Brown	1	0	12	0	0	0	0	0	0	1	0
July 19	Brown	July 19	Brown	1	0	4	0	0	0	0	0	2	1	0
July 19	Brpwm	July 19	Brpwm	1	0	9	0	0	0	0	0	0	2	0
July 19	Brown	July 19	Brown	1.5	0	3	0	0	0	0	0	1	6	0
July 19	Brown	July 19	Brown	1.5	0	11	0	0	0	0	0	4	1	0

Date	Lake	Per sq. m									
		Midges	Bldworms	Mayflies	Odonata	Hrn case	Mum case	Org case	Clams	Snails	Unknown
June 8	Crampton	0	0	86.2	0	301.7	215.5	43.1	0	0	0
June 8	Crampton	0	0	86.2	0	1422.3	0	0	0	0	0
June 8	Crampton	0	43.1	172.4	43.1	43.1	43.1	43.1	0	0	43.1
June 8	Crampton	0	0	0	43.1	0	301.7	0	0	0	43.1
June 8	Crampton	0	0	172.4	0	129.3	0	0	0	0	0
June 8	Crampton	431	172.4	0	0	0	0	0	0	0	0
June 8	Crampton	560.3	258.6	0	0	0	0	0	0	0	0
June 8	Crampton	387.9	344.8	0	0	0	0	0	0	0	0
June 8	Crampton	603.4	431	0	0	0	0	0	0	0	0
June 8	Crampton	258.6	301.7	0	0	0	0	0	0	0	0
June 12	Brown	0	129.3	0	0	0	0	0	0	129.3	0
June 12	Brown	0	775.8	0	0	0	0	0	43.1	0	0
June 12	Brown	0	775.8	0	86.2	0	0	0	43.1	344.8	0
June 12	Brown	0	991.3	0	0	0	0	0	86.2	43.1	0
June 12	Brown	0	1336.1	0	0	0	0	0	86.2	86.2	0
June 9	Brown	4180.7	474.1	0	0	0	0	0	0	0	0
June 9	Brown	4223.8	215.5	0	0	0	0	0	0	43.1	0
June 9	Brown	5646.1	646.5	0	0	0	0	0	0	0	0
June 9	Brown	6034	258.6	0	0	0	0	0	0	0	43.1
June 9	Brown	6594.3	431	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
June 22	Crampton	0	3361.8	0	0	0	0	0	0	0	0
June 22	Crampton	129.3	3706.6	0	0	0	0	0	0	0	0
June 22	Crampton	172.4	1810.2	0	0	0	0	0	0	0	43.1
June 22	Crampton	0	1077.5	0	0	0	0	0	0	0	0
June 22	Crampton	344.8	3534.2	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
June 22	Crampton	172.4	0	129.3	43.1	344.8	86.2	0	0	0	0
June 22	Crampton	646.5	0	43.1	43.1	86.2	43.1	0	0	0	0
June 22	Crampton	86.2	0	86.2	0	215.5	43.1	0	0	0	0
June 22	Crampton	258.6	0	86.2	0	387.9	474.1	0	0	0	0
June 22	Crampton	129.3	0	43.1	0	1077.5	43.1	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
June 22	Brown	1034.4	215.5	0	0	0	0	0	0	0	0
June 22	Brown	1206.8	86.2	0	0	0	0	0	0	0	0
June 22	Brown	1637.8	301.7	0	0	0	0	0	0	0	0
June 22	Brown	2327.4	344.8	0	0	0	0	0	0	0	0
June 22	Brown	1680.9	215.5	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
June 22	Brown	0	258.6	0	0	0	0	0	344.8	43.1	0
June 22	Brown	0	732.7	0	0	0	0	0	0	43.1	0
June 22	Brown	0	301.7	0	0	0	0	0	0	43.1	0
June 22	Brown	0	43.1	0	0	0	0	0	0	43.1	0
June 22	Brown	0	344.8	0	0	0	0	0	43.1	86.2	0
		0	0	0	0	0	0	0	0	0	0
July 19	Crampton	129.3	172.4	0	0	0	0	0	0	0	0
July 19	Crampton	0	517.2	0	0	0	0	0	0	0	0
July 19	Crampton	0	301.7	0	0	0	0	0	0	0	0
July 19	Crampton	387.9	948.2	0	0	0	0	0	0	0	0
July 19	Crampton	0	387.9	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
July 19	Crampton	43.1	0	86.2	43.1	0	43.1	0	0	0	0
July 19	Crampton	43.1	0	86.2	43.1	0	0	0	0	0	0
July 19	Crampton	172.4	86.2	43.1	43.1	43.1	0	0	0	0	43.1
July 19	Crampton	0	86.2	43.1	0	0	0	0	0	43.1	0
July 19	Crampton	172.4	0	86.2	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
July 19	Brown	1206.8	172.4	0	0	0	0	0	0	0	0
July 19	Brown	1034.4	129.3	0	0	0	0	0	0	0	0
July 19	Brown	775.8	43.1	0	0	0	0	0	0	0	0
July 19	Brown	732.7	172.4	0	0	0	0	0	0	0	0
July 19	Brown	603.4	344.8	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0
July 19	Brown	0	517.2	0	0	0	0	0	0	43.1	0
July 19	Brown	0	172.4	0	0	0	0	0	86.2	43.1	0
July 19	Brpwm	0	387.9	0	0	0	0	0	0	86.2	0
July 19	Brown	0	129.3	0	0	0	0	0	43.1	258.6	0
July 19	Brown	0	474.1	0	0	0	0	0	172.4	43.1	0

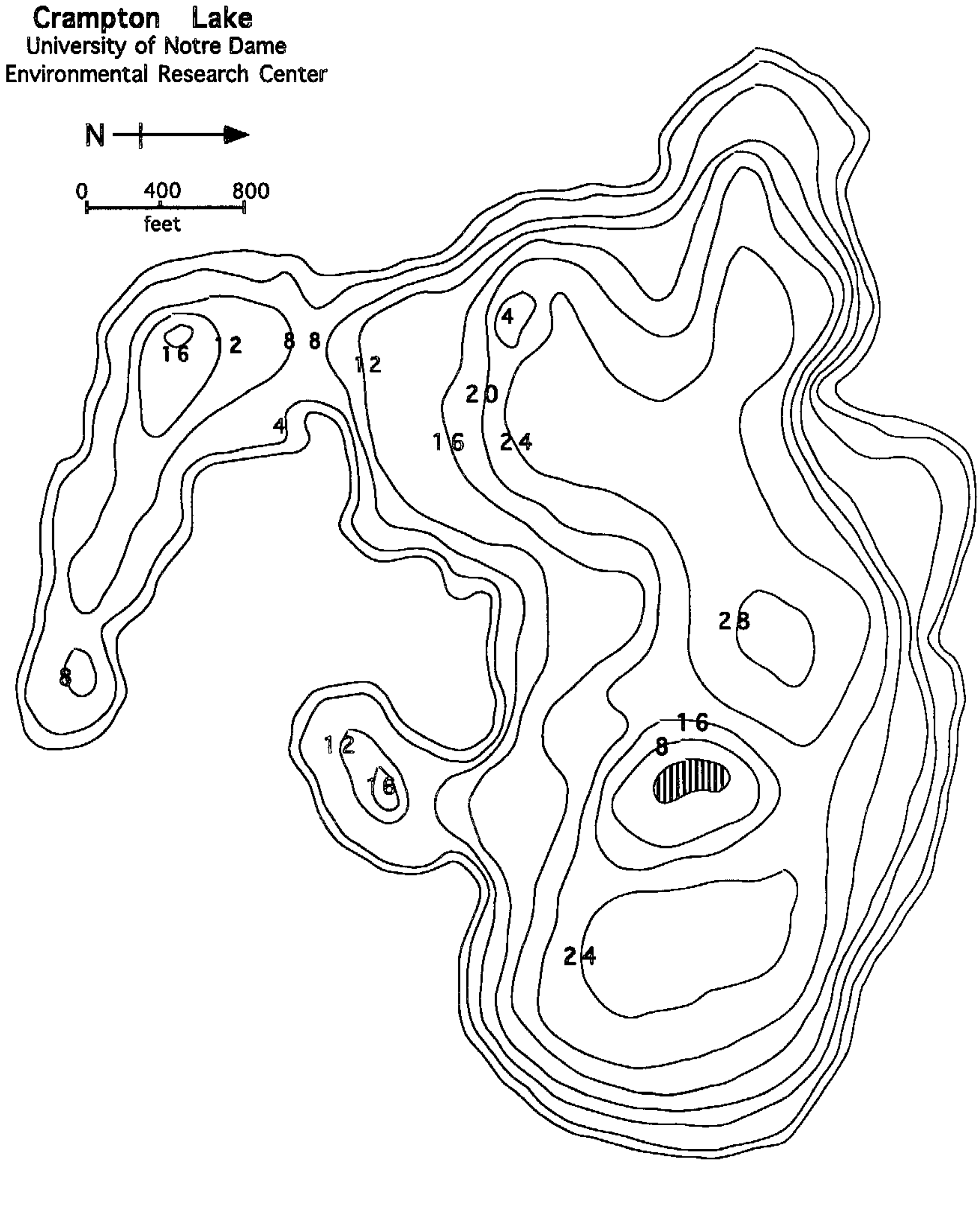
Benthos of Brown and Crampton Lakes

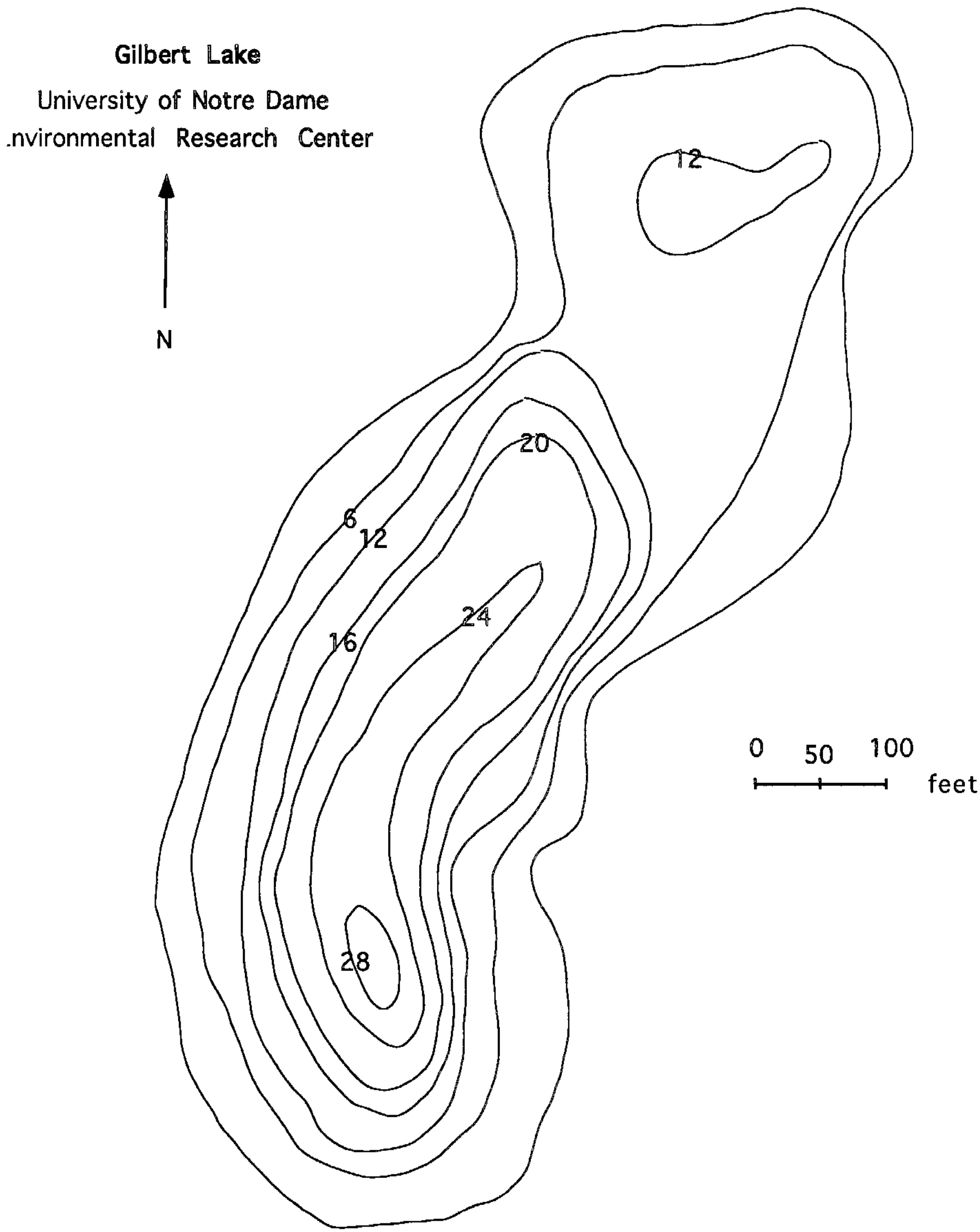
Types of specimens identified from Crampton Lake:

ODONATA GOMPHIDAE Hagenius *brevistylus*
ODONATA CORDULIIDAE Epithea *sp.*
EPHEMEROPTERA EPHEMERIDAE Litobrancha *recurvata*
TRICHOPTERA MOLANNIDAE Molanna *sp.*
TRICHOPTERA LIMNEPHILIDAE Pseudostenophylax *uniformis*
TRICHOPTERA Polycentropus *sp.*
MEGALOPTERA SIALIDAE Sialis *sp.*
DIPTERA Chironomidae *spp.*
Orconectes *propinquus*

Types of specimens identified from Brown Lake:

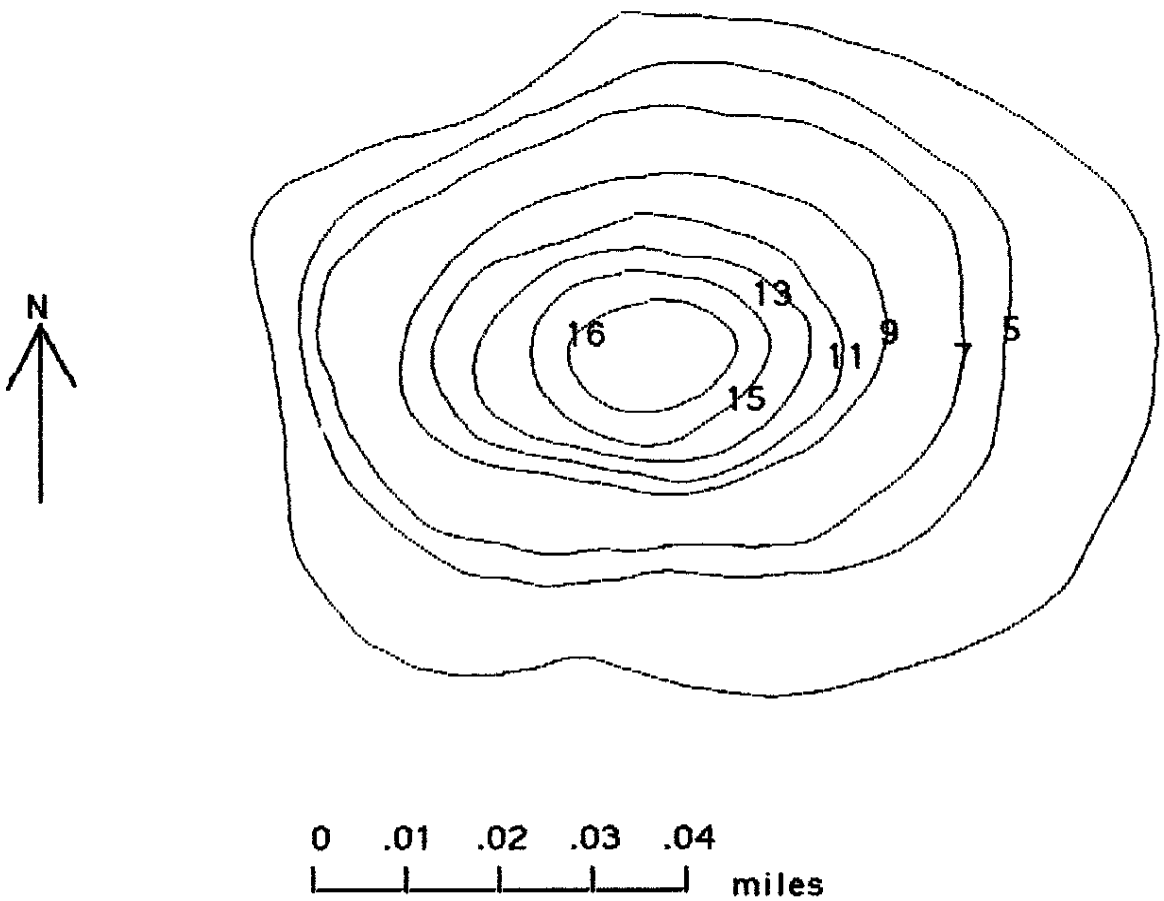
ODONATA GOMPHIDAE Hagenius *brevistylus*
DIPTERA Chironomidae *spp.*
Clams
Snails


Crampton Lake
University of Notre Dame
Environmental Research Center
N
0
400
800
feet
16
12
8
8
12
4
4
20
16
24
8
28
12
16
16
8
24


Gilbert Lake
University of Notre Dame
.nvironmental Research Center
N
12
20
6
12
24
16
28
0
50
100
feet

Appendix

Softside Lake



contours in feet