reflecting the environmental 78.6%. Viviparus is second in importance, reflecting its great increase in importance in the benthos from May to July (figure 13). Pumkinseed mouth morphology and dentition are particularly well adapted for preying upon hard-bodied molluscs (Keast and Webb, 1966). Anisoptera nymphs (<15 mm), Zygoptera nymphs and amphipods are taken in numerically similar numbers although the biomass of an Anisoptera nymph of 8 mm would be roughly equivalent to the biomass of 50 to 75 1 - 2 mm amphipods. Ephemerella nymphs are still consumed, again in greater than environmental abundance levels and a single, 20 mm Hexagenia nymph was found in a stomach.

Again, as for the Iowa Darter, it is not possible to assign a preferred foraging habitat to the Pumpkinseed on the basis of the proportions of prey consumed. The same tendancy to over-utilize Ephemerella and under-utilize amphipods suggests that foraging occurs outside the mats of Chara. This is likely in view of the gibbose body form of sunfishes which would not be maneouverable in dense Chara.

PART VI

THE IMPORTANCE OF THE MACROPHYTE, *Chara*

In Part I, the distribution of all the benthic taxocenes relative to the abundance of *Chara* is discussed. In part V an attempt is made to correlate the feeding of the Iowa Darter and the Pumpkinseed to the available resources. No definite statement can be made regarding the habitat in which these species feed based on the different benthic taxocenes associated with the different samplers (= habitats).

The trend seems to indicate , however, that prey items living in the dense *Chara* are relatively inaccessible to fish predators. This trend is supported by personal observations (during July) of larger fish leaping from dense *Chara* mats through the air to escape the path of the canoe. This suggests that the fish, as expected in light of their body size, are unable to penetrate areas of thick *Chara* although the forage is optimal there.

One of the local residents has undertaken an annual harvest of *Chara* in an attempt to remove nutrients from the lake. Harvesting is done in the latter half of August and early September when fish growth and feeding

is almost complete for the season. It involves scattered patches of Chara rather than large areas. With this in mind it would seem to be a valuable effort with regards to increasing fish prey availability. Maintenance of a sparser Chara distribution would still provide a refuge for fish fry and a habitat suitable for the benthic invertebrates now present in the lake. The high density of invertebrates in dense Chara appears to be relatively inaccesible to fish predators so a harvest will not destroy a resource upon which the fish are presently dependent. In fact, it may render prey and protection available to two and three year old fish now physically excluded from the Chara by their size. This could tend to decrease the mortality in these age classes and result in an overall increase in the numbers of larger fish in the lake. I would suggest a period of monitoring the benthic and fish populations in a harvest and in a control area to determine if harvesting, and the resultant, less dense Chara, are increasing the fish carying capacity of the area.

SUMMARY:

1) The benthic invertebrate resource base is distributed in Sunfish Lake in a pattern governed by the presence or absence of Chara, the abundant aquatic macrophyte, in an area. This parameter is more important in determining benthic invertebrate distributions than are either site or depth (in water less than three meters in depth).

2) The majority of the benthic invertebrate biomass is associated with abundant Chara. Only chironomid larvae, Viviparus, a gastropod, and Hexagenia,an ephemeropteran, are found in greater numbers when Chara is not present than when it is.

3) Below 4 m in depth the benthic invertebrates are very sparse and are not likely to contribute significantly to fish feeding. This corresponds to the lower limit of the Chara distribution.

4) There is a tendancy for the adults of some fish species, notably the Yellow Perch and the White Sucker, to retain the juvenile diet of cladocerans for a longer period of the life-span than has generally been found in other lakes in the same geographic range.

5) Predation of fish on benthic invertebrates is concentrated on the smaller individuals of all prey taxocenes. Larger individuals are not taken as prey.

6) Potential prey items such as Amphipoda and Hydracarina that are exclusively associated with Chara are not heavily predated upon, apparently as a result of the protection offered by the Chara.

7) Considering just the dietary items found in fish stomachs, the overall consumption of benthic invertebrates reflects the relative proportions of these prey items in the environment.

8) Six of the nineteen fish groups (size classes within a species) for which May stomach samples were available fed predominantly on benthic invertebrates. Seven groups consumed benthic invertebrates for 50% or more of their diet volume and six groups did not feed on the benthic resource. During July, six of twelve fish groups for which stomach samples were available fed predominantly on the benthos, three groups fed to a limited extent on benthic invertebrates, and two groups did not utilize the resource. Numerically, the most important prey taxocene is Cladocera during both months.

9) Closer examination of the benthic component of the Iowa Darter and the Yellow Perch diets shows a pattern of predation similar to proportionate abundances of prey in the environment. Exceptions are seen in the Amphipoda and Hydracarina, which are not heavily predated upon and Ephemerella, which is excessively utilized in the diets. This suggests that foraging is concentrated outside the Chara beds.

10) Harvesting Chara on a limited basis at the end of the summer is likely to have a beneficial impact on the growth of fish species in the lake but careful monitoring of the fish carrying capacity of harvested sites is suggested, at least for the initial years of the program.

11) The benthic invertebrates are utilized by the fish population as a food resource. The most abundant prey populations are associated with dense mats of Chara and are relatively inaccessible to the larger fish. Those fish that do not feed on the benthos tend to concentrate on planktonic species as prey.

Suggestions for Future Research

This thesis has been concerned solely with the utilization of the benthic invertebrates by the fish population. In the course of the data collection and processing, however, several points of interest have arisen regarding the exact status of the food chain. Some of these questions are directly testable in the field.

There is a preponderance of cladocerans in the diet of many of the fish species even when adult. One would expect to find an abundant source of the alternate food resource where it is utilized in order to make it energetically feasible for the fish to survive. The most likely candidate for this site is the chemocline. The density gradient of the chemocline is very steep during the summer months and supports thin, dense plaques of algae and bacteria. The Cladocera would feed on this resource and, in doing so, might become very concentrated themselves and provide easy forage for the fish. A net should be set at the level of the chemocline and sampling should be done with an eye to determining if there is any diurnal variation in the abundance of predators or of prey at any particular level in the water column.

Analysis of the age distribution of the fish population (by scales) would provide information on the growth rates of the different species and would enable comparisons with growth rates observed in other lakes. This might serve as an indication of how well the fish fare on the planktonic diet.

Minnow traps should be set in the mats of Chara to determine what fish are present and when.

Exclusion pens set-up in the littoral zone prior to the spring onset of feeding would aid in determining the extent of the fish predation on the benthic populations. There was a very noticeable increase in the benthic invertebrate numbers during November. This is unlikely to be solely the result of the recruitment of an overwintering generation as many of the individuals were relatively large bodied and as no taxocene had previously shown such a dramatic increase as the result of recruitment. Perhaps the increase was due to an absence of predation pressure because the fish had stopped feeding intensively. A control site that has no predation pressure should clarify this.

When a body of data from studies such as this one is available it may be possible to define the plastic-

ity of niche that different species are capable of inhabiting under different conditions and it will become possible to test the idea (Larkin , 1956) that there is considerably more niche overlap in the aquatic system than in the terrestrial system, particularily in temperate habitats where resources are temporary and relatively unpredictable and where specialization requires a permanence in the prey availability that is not found.

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Appendix 1:

Numerical Abundances of Benthic Invertebrates from all Sampling Dates, Sites, and Samplers.

(all values are Numbers/ m^2)

Samplers: P: pushnet D: deep ekman

S: shallow ekman Combined: Mean of all three sites

CHIRONOMIDS

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
239	-	-	655	2838	1316	252	817	1574	46	774	275	-	18903	2270	
Flag															
148.4	-	-	188	3810	3001	105	5031	593	-	2614	103	-	-	-	
RHS															
91.7	-	-	506	2864	602	45.6	766	327	58	1118	52	-	-	-	
Combined															
169	-	-	449	3171	1639	134	2204	831	52	1502	143	-	18903	2270	

DECAPODA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
4	-	-	Ø	9	9	.5	17	Ø	Ø	Ø	Ø	-	26	Ø	
Flag															
1.2	-	-	12.2	Ø	17	1	34	Ø	-	17	Ø	-	-	-	
RHS															
4	-	-	Ø	Ø	Ø	2.5	Ø	Ø	.5	9	Ø	-	-	-	
Combined															
3.1	-	-	4.1	3	8.7	1.3	17	Ø	.3	8.7	Ø	-	26	Ø	

ANISOPTERA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
3.6	-	-	.5	9	43	6.5	17	340	3.6	430	43	-	147	Ø	
Flag															
5.6	-	-	11.5	52	120	4.5	43	86	-	327	Ø	-	-	-	
RHS															
5.2	-	-	Ø	Ø	Ø	2.4	Ø	Ø	2	34	Ø	-	-	-	
<15 mm															
2	-	-	4	20.3	54.3	.4	10	19	2.0	170	12.3	-	110.3	Ø	
>15 mm															
2.8	-	-	Ø	Ø	Ø	4.1	10	123	.7	94	2	-	36.8	Ø	
Combined															
4.8	-	-	4	20.3	54.3	4.5	20	142	2.8	264	14.3	-	147	Ø	

ZYGOPTERA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
1	-	-		Ø	9	52	.5	17	9	3	163	78	-	6Ø	17
Flag															
2.8	-	-		7.6	26	17	.5	Ø	Ø	-	6Ø	Ø	-	-	-
RHS															
9.2	-	-		Ø	9	Ø	Ø	Ø	Ø	2	112	Ø	-	-	-
Combined															
6.9	-	-		3.9	18.4	23	.4	5.6	3	2.5	112	26	-	6Ø	17

HEXAGENIA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
3	-	-		1.5	Ø	9	2	9	Ø	1	Ø	Ø	-	Ø	Ø
Flag															
2.8	-	-		2	Ø	Ø	Ø	Ø	Ø	-	Ø	Ø	-	-	-
RHS															
1.2	-	-		7.6	Ø	Ø	Ø	Ø	Ø	.5	Ø	Ø	-	-	-
Combined															
2.3	-	-		3.7	Ø	3	.7	3	Ø	.8	Ø	Ø	-	Ø	Ø

EPHEMERELLA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
.5	-	-		28	17	155	3.6	34	448	17	95	17	-	224	69
Flag															
1.2	-	-		11	260	301	11.5	52	9	-	77	9	-	-	-
RHS															
4	-	-		5.6	396	Ø	.3	8.6	Ø	7	26	Ø	-	-	-
Combined															
1.9	-	-		14.9	224	152	5.1	31.5	152	12	66	8.7	-	224	69

TRICHOPTERA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
1.5	-	-		Ø	9	26	Ø	17	17	.5	292	Ø	-	370	9
Flag															
1.2	-	-		3	9	52	1	9.5	Ø	-	77	Ø	-	-	-
RHS															
6.4	-	-		Ø	60	Ø	Ø	Ø	Ø	.5	26	Ø	-	-	-
<9 mm															
Ø	-	-		.2	20	26	.2	Ø	Ø	.5	58.2	Ø	-	25.8	Ø
>9 mm															
3	-	-		.8	6	Ø	.1	8.8	5.7	Ø	73.5	Ø	-	344	9
Combined															
3.	-	-		1	26	26	.3	8.8	5.7	.5	131.7	Ø	-	370	9

OLIGOCHAETA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
7.6 -	-		22	34	129	6.4	34	17	4.5	9	17	-	Ø	52	
Flag															
1.2 -	-		1.6	Ø	Ø	1	Ø	Ø	-	Ø	17	-	-	-	
RHS															
4 -	-		21	9	9	Ø	34	26	Ø	17	9	-	-	-	
Combined															
4.3 -	-		14.9	14.3	46	2.5	22.7	8.7	2.3	8.7	14.3	-	Ø	52	

HYDRACARINA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
8.5 -	-		1	9	-	37.5	86	Ø	14.4	43	35	-	215	52	
Flag															
3.2 -	-		4.1	Ø	Ø	.5	207	9	-	310	Ø	-	-	-	
RHS															
8 -	-		1	17	Ø	.5	Ø	Ø	1.6	78	Ø	-	-	-	
Combined															
6.6 -	-		2.0	8.7	Ø	12.9	97.7	3	5.3	143.7	11.7	-	215	52	

OTHER

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
Ø -	-		1.5	Ø	35	2.5	26	61	1.5	Ø	18	-	293	43	
Flag															
2.4 -	-		5.5	26	9	2.	147	Ø	-	52	Ø	-	-	-	
RHS															
30.8-	-		2.7	Ø	Ø	.5	Ø	9	1	18	1	-	-	-	
Combined															
11.1-	-		3.1	8.7	14.7	1.2	57.7	23.3	1.3	23.3	6.3	-	293	43	

AMPHIPODA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
26 -	-		Ø	17	146	27	516	628	36	2374	1109	-	4481	396	
Flag															
1.2 -	-		29	103	327	10	1084	146	-	464	Ø	-	-	-	
RHS															
119 -	-		Ø	60	Ø	64	249	Ø	77	1557	Ø	-	-	-	
Combined															
48.7-	-		29	60	158	34	616	258	56.5	1465	370	-	4481	396	

GASTROPODA

	MAY			JUNE			JULY			SEPT.			NOV.	
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet 3.3	-	-		2	241	68.9	3	60.3	198	17	740.5	241	-	172	344
Flag 1.6	-	-		30	534	456	15	362	198	-	51.7	129	-	-	-
RHS Ø	-	-		Ø	913	431	32.5	68.9	Ø	37	396	34.4	-	-	-
Combined 1.6	-	-		10.7	562.7	318.6	16.8	163.7	132	27	396	154.8	-	172	344

OTHER GASTROPODS

	MAY			JUNE			JULY			SEPT.			NOV.	
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet .5	-	-		Ø	138	335	16.5	69	111	3.5	120	Ø	-	43	69
Flag 2	-	-		9.1	344	129	5	637	26	-	258	Ø	-	-	-
RHS 1.2	-	-		.5	Ø	Ø	1.6	68	Ø	1	35	Ø	-	-	-
Combined 1.2	-	-		3.2	160.7	378	7.7	258	45.7	1.5	137.7	Ø	-	43	69

Appendix 2:

Percent Volume Contributions by each Benthic Taxocene to Benthic Samples

Samplers P: pushnet

S: shallow ekman

D: deep ekman

Combined: The mean of the values for all three sites.

CHIRONOMIDS

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
	36.5	-	-	81.4	61.8	31.6	71.5	11.9	22.7	21	4.7	33	-	30.4	53
Flag															
	34.7	-	-	16	38.5	22.4	33.4	25.4	37.2	-	24.5	54	-	-	-
RHS															
	10.7	-	-	44.9	50.6	54	52.1	68.2	92.6	21.5	13.5	45	-	-	-
Combined															
	27.3	-	-	47.4	50.3	36	52.3	31.8	51	21.5	14.2	44	-	30.4	53

DECAPODA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
	32.4	-	-	0	10	4	6.3	31	0	0	0	00	-	21	0
Flag															
	13	-	-	28.8	0	6	8.8	46	0	-	14	0	-	-	-
RHS															
	20	-	-	0	0	0	10.6	0	0	3.8	7	0	-	-	-
Combined															
	21.8	-	-	9.6	3.3	3.3	8.5	25.7	0	1.9	7	0	-	21	0

ANISOPTERA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
	10	-	-	.6	4	4	11.3	2.4	23	14.4	16.6	11.6	-	11	0
Flag															
	22.5	-	-	.6	8	22	11.9	15	86	-	27	0	-	-	-
RHS															
	18.1	-	-	0	0	0	10.6	7.	0	6.3	22	0	-	-	-
Combined															
	39.7	-	-	.4	4	8.7	11.3	8.1	14.7	10.3	21.9	3.9	-	11	0

ZYGOPTERA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
2.3	-	-	Ø	.4	7	.1	8	4.	4.4	14.6	14.8	-	3.2	6	
Flag															
4	-	-	7.9	4	2	3.8	Ø	Ø	-	7.8	Ø	-	-	-	
RHS															
7.5	-	-	Ø	.8	Ø	Ø	Ø	Ø	4.8	8	Ø	-	-	-	
Combined															
4.6	-	-	2.8	1.7	3	1.3	2.7	1.3	4.6	10.1	4.9	-	3.2	6	

HEXAGENIA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
10.7	-	-	7.5	Ø	4	.1	10	Ø	4.4	Ø	Ø	-	Ø	Ø	
Flag															
7.5	-	-	4.1	Ø	Ø	Ø	Ø	Ø	-	Ø	Ø	-	-	-	
RHS															
5	-	-	37.5	Ø	Ø	Ø	Ø	Ø	3.8	Ø	Ø	-	-	-	
Combined															
7.7	-	-	16.4	Ø	1.3	tr	1.3	Ø	4.1	Ø	Ø	-	Ø	Ø	

EPHEMERELLA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
1.1	-	-	.6	.6	11	4.8	2.1	27	6.5	.8	1.4	-	.4	2.7	
Flag															
.6	-	-	10.1	19.6	14.8	6.9	1.2	6	-	1	5	-	-	-	
RHS															
13.3	-	-	6.3	5.6	Ø	.8	6	Ø	3.1	1	Ø	-	-	-	
Combined															
6.8	-	-	5.7	8.6	8.6	4.1	3.1	11	4.8	1	2.1	-	.4	2.7	

TRICHOPTERA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
Outlet															
4.3	-	-	Ø	.2	2	Ø	4	.8	.1	21.6	Ø	-	13.2	.6	
Flag															
3.5	-	-	1.5	.4	3.	1.3	.4	2	-	7.8	Ø	-	-	-	
RHS															
15	-	-	Ø	3.2	Ø	Ø	Ø	Ø	.1	7.4	Ø	-	-	-	
Combined															
7.6	-	-	.5	1.3	1.7	.4	1.4	.9	.1	12.3	Ø	-	13.2	.6	

a: OUTLET site b: FLAG site c: RHS site d: Combined (Mean of previous three)

OLIGOCHAETA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	1.7	–	–	5.8	1.8	12	.6	.4	1.1	5.3	.2	6.4	–	Ø	1.8
b	.6	–	–	.2	Ø	Ø	1.4	Ø	Ø	–	Ø	6	–	–	–
c	1	–	–	5.8	.6	2	Ø	2.4	6.6	Ø	.2	10	–	–	–
d	1	–	–	3.9	.8	4.7	.7	.9	2.6	2.6	.1	7.5	–	Ø	1.8

HYDRACARINA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	.3	–	–	.3	.1	Ø	1.8	.3	Ø	4.3	.5	1.6	Ø	.3	tr
b	.7	–	–	.4	Ø	Ø	.1	.1	.1	–	2.2	Ø	–	–	–
c	.2	–	–	.3	.2	Ø	.1	Ø	Ø	.1	1.6	Ø	–	–	–
d	.4	–	–	.3	.1	Ø	.6	.3	tr	1.5	1.4	.5	–	.3	tr

OTHER

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	Ø	–	–	1	Ø	1.6	1.6	21.	1.4	.6	Ø	.8	–	.6	tr
b	6.4	–	–	1.7	.7	.2	.2	2.9	Ø	–	.6	Ø	–	–	–
c	2.4	–	–	2.8	Ø	Ø	7.6	Ø	.8	3.8	1.8	20	–	–	–
d	2.9	–	–	1.7	.2	.6	3.1	8	.7	3.9	.8	6.9	–	.6	tr

AMPHIPODA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	1.9	–	–	Ø	.1	2.8	2.2	6.3	3.8	7.1	13.4	8.4	–	13.6	.6
b	.3	–	–	1.6	1.8	3.4	1.8	2.8	.2	–	3.4	Ø	–	–	–
c	4.3	–	–	Ø	.6	Ø	4.9	11.2	Ø	12.5	9.4	Ø	–	–	–
d	2.2	–	–	1.6	.8	2.1	.5	6.8	1.3	.1	8.7	2.8	–	13.6	.6

GASTROPODA

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	4.1	–	–	2.5	14.6	5	1.3	2.3	9.7	20	23	22	–	3	31
b	8.4	–	–	9	21	21	12.4	1.9	13.2	–	3.2	35	–	–	–
c	Ø	–	–	Ø	38.2	44	29.6	4.8	Ø	40.3	28.4	25	–	–	–
d	4.2	–	–	3.8	24.6	23.3	14.4	3	7.6	30.2	18.2	27.3	–	3	31

OTHER GASTROPODS

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	tr	–	–	Ø	5.4	15	1.9	.7	6.6	10.9	4.1	Ø	–	3	4.2
b	3.6	–	–	3.6	14	5.2	.5	2.3	.3	–	9.8	Ø	–	–	–
c	2	–	–	1.3	Ø	Ø	.7	.4	Ø	1.3	2.8	Ø	–	–	–
d	1.9	–	–	1.6	6.5	6.7	1	1.2	2.3	4.1	5.6	Ø	–	3	4.2

Appendix 3:

The composition of the Fish Diet: For each benthic taxocene there are two columns of data. The first is the mean number of individuals of that taxocene found in a single fish stomach. The second is the percent volume that the taxocene occupies in the stomach. The appendix reads horizontally across six pages.

		Month	Number of Fish	Cladocera #	Cladocera %	Copepoda #	Copepoda %	Chironomidae #	Chironomidae %
White Sucker	I	M	3	13.7	30.0	–	–	0.7	36.7
100-175		J	0	–	–	–	–	–	–
176-255	II	M	8	265.3	79.4	–	–	9.7	9.4
		J	0	–	–	–	–	–	–
340-370	III	M	5	818.2	79.6	–	–	31.6	4.2
		J	0	–	–	–	–	–	–
Yellow Perch	I	M	19	105.8	61.5	–	–	3.3	18.8
55-75		J	1	20.0	10.0	–	–	1.0	15.0
76-225	II	M	4	673.0	98.0	–	–	0.8	1.7
		J	5	428.4	72.0	–	–	1.6	2.0
226-260	III	M	1	250.0	90.0	–	–	1.0	10.0
		J	2	431.5	62.5	–	–	36.5	37.5
Golden Shiner	I	M	4	81.3	42.5	–	–	0.3	2.5
70-120		J	0	–	–	–	–	–	–
140-170	II	M	0	–	–	–	–	–	–
		J	9	–	–	–	–	–	–
Pumpkinseed	I	M	2	7.5	15.0	27.5	7.5	3.0	30.0
12-45		J	4	18.5	30.0	–	–	4.3	23.8
48-95	II	M	4	0.7	5.0	–	–	3.3	52.5
		J	9	–	–	–	–	14.9	71.1
96-145	III	M	1	–	–	–	–	–	–
		J	27	10.9	3.1	–	–	13.8	52.2
Bluntnose		M	14	0.2	5.0	–	–	0.1	7.8
Minnow 40-70		J	0	–	–	–	–	–	–
Rock Bass	I	M	26	26	13.9	2.1	0.1	3.4	26.7
30-50		J	0	–	–	–	–	–	–
120-145	II	M	0	–	–	–	–	–	–
		J	1	–	–	–	–	–	–
Largemouth	I	M	4	268.5	35.0	12.5	0.5	1.0	2.0
Bass 30-120		J	8	5.9	16.3	2.1	1.8	0.9	5.6
190-240	II	M	1	–	–	–	–	5.0	3.0
		J	8	–	–	–	–	0.4	4.4
Iowa Darter	I	M	5	2.2	5.4	3.0	6.6	3.4	58.0
28-40		J	1	–	–	–	–	9.0	80.0
41-54	II	M	19	1.3	5.3	–	–	21.4	79.7
		J	3	1.3	1.7	–	–	15.3	43.4
Brown	I	M	1	20.0	45.0	–	–	1.0	5.0
Bullhead		J	0	–	–	–	–	–	–
Tadpole	I	M	1	1.0	5.0	–	–	3.0	10.0
Madtom		J	0	–	–	–	–	–	–
Brook	I	M	2	475.0	50.0	1002.5	14.0	5.0	15.0
Stickleback		J	0	–	–	–	–	–	–

continued..2

Appendix 3 : continued....2

		Month	Number of Fish	Decapoda #	Decapoda %	Anisoptera #	Anisoptera %	Zygoptera #	Zygoptera %
White Sucker	I	M	3	-	-	-	-	-	-
		J	0	-	-	-	-	-	-
	II	M	8	-	-	-	-	-	-
		J	0	-	-	-	-	-	-
	III	M	5	-	-	-	-	-	-
		J	0	-	-	-	-	-	-
Yellow Perch	I	M	19	-	-	tr	0.5	0.4	13.4
		J	1	-	-	-	-	-	-
	II	M	4	-	-	-	-	-	-
		J	5	-	-	0.3	7.6	0.1	0.6
	III	M	1	-	-	-	-	-	-
		J	2	-	-	-	-	-	-
Golden Shiner	I	M	4	-	-	-	-	-	-
		J	0	-	-	-	-	-	-
	II	M	0	-	-	-	-	-	-
		J	9	-	-	-	-	0.2	5.0
Pumpkinseed	I	M	2	-	-	-	-	-	-
		J	4	-	-	-	-	-	-
	II	M	4	-	-	-	-	-	-
		J	9	-	-	-	-	-	-
	III	M	1	-	-	-	-	-	-
		J	27	-	-	0.3	13.3	0.3	3.7
Bluntnose Minnow		M	14	-	-	-	-	-	-
		J	0	-	-	-	-	-	-
Rock Bass	I	M	26	-	-	tr	2.8	0.1	3.0
		J	0	-	-	-	-	-	-
	II	M	0	-	-	-	-	-	-
		J	1	2.0	99.0	-	-	-	-
Largemouth Bass	I	M	4	-	-	0.3	10.0	0.3	10.0
		J	8	-	-	-	-	-	-
	II	M	1	-	-	-	-	-	-
		J	8	0.1	12.5	-	-	0.1	3.8
Iowa Darter	I	M	5	-	-	-	-	-	-
		J	1	-	-	-	-	-	-
	II	M	19	-	-	-	-	-	-
		J	3	-	-	-	-	-	-
Brown Bullhead	I	M	1	-	-	-	-	-	-
		J	0	-	-	-	-	-	-
Tadpole Madtom	I	M	1	-	-	-	-	-	-
		J	0	-	-	-	-	-	-
Brook Stickleback	I	M	2	-	-	-	-	-	-
		J	0	-	-	-	-	-	-

continued..3

Appendix 3 : continued.....3

		Month	Number of Fish	Hexagenia #	Hexagenia %	Ephemerella #	Ephemerella %	Trichoptera #	Trichoptera %
White Sucker	I	M	3	–	–	–	–	–	–
		J	Ø	–	–	–	–	–	–
	II	M	8	–	–	–	–	–	–
		J	Ø	–	–	–	–	–	–
	III	M	5	–	–	–	–	–	–
		J	Ø	–	–	–	–	–	–
Yellow Perch	I	M	19	–	–	tr	1.3	–	–
		J	1	–	–	1.Ø	35.Ø	–	–
	II	M	4	–	–	–	–	–	–
		J	5	–	–	Ø.3	Ø.3	–	–
	III	M	1	–	–	–	–	–	–
		J	2	–	–	–	–	–	–
Golden Shiner	I	M	4	–	–	–	–	–	–
		J	Ø	–	–	–	–	–	–
	II	M	Ø	–	–	–	–	–	–
		J	9	–	–	–	–	–	–
Pumpkinseed	I	M	2	–	–	–	–	–	–
		J	4	–	–	–	–	–	–
	II	M	4	–	–	–	–	–	–
		J	9	–	–	Ø.4	13.3	–	–
	III	M	1	–	–	2.Ø	25.Ø	–	–
		J	27	tr	3.3	Ø.1	2.3	–	–
Bluntnose Minnow		M	14	–	–	–	–	–	–
		J	Ø	–	–	–	–	–	–
Rock Bass	I	M	26	tr	2.4	–	–	Ø.1	2.Ø
		J	Ø	–	–	–	–	–	–
	II	M	Ø	–	–	–	–	–	–
		J	1	–	–	–	–	–	–
Largemouth Bass	I	M	4	–	–	8.Ø	17.5	–	–
		J	8	–	–	3.Ø	4.4	–	–
	II	M	1	–	–	–	–	–	–
		J	8	–	–	–	–	–	–
Iowa Darter	I	M	5	–	–	–	–	–	–
		J	1	–	–	–	–	–	–
	II	M	19	–	–	tr	Ø.8	–	–
		J	3	–	–	Ø.7	25.Ø	–	–
Brown Bullhead	I	M	1	–	–	–	–	–	–
		J	Ø	–	–	–	–	–	–
Tadpole Madtom	I	M	1	–	–	–	–	–	–
		J	Ø	–	–	–	–	–	–
Brook Stickleback	I	M	2	–	–	–	–	–	–
		J	Ø	–	–	–	–	–	–

Appendix 3 : continued..... 4

Month	Number of Fish		Viviparus #	Viviparus %	Amphipoda #	Amphipoda %	Oligochaeta #	Oligochaeta %
White Sucker	I	M	3		–	–	–	–
		J	Ø		–	–	–	–
	II	M	8		–	–	–	–
		J	Ø		–	–	–	–
	III	M	5		–	–	–	–
		J	Ø		–	–	–	–
Yellow Perch	I	M	19		–	–	Ø.5	2.3
		J	1		–	–	2.Ø	2Ø.Ø
	II	M	4		–	–	–	–
		J	5		–	–	–	–
	III	M	1		–	–	–	–
		J	2		–	–	–	–
Golden Shiner	I	M	4		–	–	–	–
		J	Ø		–	–	–	–
	II	M	Ø		–	–	–	–
		J	9		–	–	–	–
Pumpkinseed	I	M	2		–	–	Ø.5	27.5
		J	4		–	–	1.Ø	36.2
	II	M	4		–	–	–	–
		J	9		–	–	2.Ø	15.Ø
	III	M	1		–	–	3.Ø	15.Ø
		J	27		1.Ø	1Ø.Ø	Ø.3	Ø.7
Bluntnose Minnow		M	14		–	–	–	–
		J	Ø		–	–	–	–
Rock Bass	I	M	26		–	–	Ø.9	6.8
		J	Ø		–	–	–	–
	II	M	Ø		–	–	–	–
		J	1		1.Ø	Ø.5	–	–
Largemouth Bass	I	M	4		–	–	Ø.7	1Ø.Ø
		J	8		–	–	1.Ø	26.3
	II	M	1		–	–	–	–
		J	8		–	–	Ø.1	tr
Iowa Darter	I	M	5		–	–	–	–
		J	1		–	–	2.Ø	15.Ø
	II	M	19		–	–	1.3	1Ø.2
		J	3		–	–	1.3	21.3
Brown Bullhead	I	M	1		–	–	–	–
		J	Ø		–	–	–	–
Tadpole Madtom	I	M	1		–	–	–	–
		J	Ø		–	–	–	–
Brook Stickleback	I	M	2		–	–	–	–
		J	Ø		–	–	–	–

continued..5

Appendix 3 : continued..... 5

		Month	Number of Fish	Hydracarina #	Hydracarina %	Insect #	Insect %	Fish #	Fish %
White Sucker	I	M	3	–	–	–	–	–	–
		J	0	–	–	–	–	–	–
	II	M	8	–	–	–	–	–	–
		J	0	–	–	–	–	–	–
	III	M	5	–	–	–	–	–	–
		J	0	–	–	–	–	–	–
Yellow Perch	I	M	19	–	–	0.1	0.6	–	–
		J	1	–	–	–	–	–	–
	II	M	4	–	–	–	–	–	–
		J	5	–	–	–	–	0.1	7.5
	III	M	1	–	–	–	–	–	–
		J	2	–	–	–	–	–	–
Golden Shiner	I	M	4	–	–	0.5	1.3	–	–
		J	0	–	–	–	–	–	–
	II	M	0	–	–	–	–	–	–
		J	9	–	–	–	59.5	–	–
Pumpkinseed	I	M	2	–	–	–	–	–	–
		J	4	–	–	0.3	7.5	–	–
	II	M	4	–	–	–	–	–	–
		J	9	–	–	–	–	–	–
	III	M	1	–	–	–	–	–	–
		J	27	–	–	0.5	6.1	–	–
Bluntnose Minnow		M	14	–	–	–	–	–	–
		J	0	–	–	–	–	–	–
Rock Bass	I	M	26	0.5	4.4	0.8	8.5	–	–
		J	0	–	–	–	–	–	–
	II	M	0	–	–	–	–	–	–
		J	1	–	–	1.0	0.5	–	–
Largemouth Bass	I	M	4	–	–	–	–	–	–
		J	8	–	–	0.6	6.9	0.5	38.7
	II	M	1	–	–	–	–	2.0	95.0
		J	8	–	–	–	–	0.3	18.1
Iowa Darter	I	M	5	–	–	–	–	–	–
		J	1	–	–	–	–	–	–
	II	M	19	–	–	tr	0.8	–	–
		J	3	–	–	0.3	0.3	–	–
Brown Bullhead	I	M	1	–	–	1.0	20.0	–	–
		J	0	–	–	–	–	–	–
Tadpole Madtom	I	M	1	–	–	–	–	–	–
		J	0	–	–	–	–	–	–
Brook Stickleback	I	M	2	–	–	–	–	–	–
		J	0	–	–	–	–	–	–

continued..6

Appendix 3 : continued..... 6

		Month	Number of Fish	Animal Tissue	Plant Tissue	Organic Debris	Other
White Sucker	I	M	3	–	–	33.3	–
		J	0	–	–	–	–
	II	M	8	–	8.7	2.5	–
		J	0	–	–	–	–
	III	M	5	–	6.0	10.0	0.2
		J	0	–	–	–	–
Yellow Perch	I	M	19	–	–	1.6	–
		J	1	20.0	–	–	–
	II	M	4	–	–	–	0.5
		J	5	–	–	15.0	–
	III	M	1	–	–	–	–
		J	2	–	–	–	–
Golden Shiner	I	M	4	–	51.2	2.5	–
		J	0	–	–	–	–
	II	M	0	–	–	–	–
		J	9	–	33.3	–	2.2
Pumpkinseed	I	M	2	–	20.0	–	–
		J	4	–	–	–	–
	II	M	4	–	42.5	–	–
		J	9	–	–	–	–
	III	M	1	–	–	–	60.0*
		J	27	1.5	1.5	2.4	–
Bluntnose Minnow		M	14	17.9	6.1	63.2	–
		J	0	–	–	–	–
Rock Bass	I	M	26	1.0	24.4	4.0	–
		J	0	–	–	–	–
	II	M	0	–	–	–	–
		J	1	–	–	–	–
Largemouth Bass	I	M	4	–	11.3	2.5	1.2
		J	8	–	–	–	–
	II	M	1	–	–	–	–
		J	8	–	61.2	–	–
Iowa Darter	I	M	5	–	29.0	–	1.0
		J	1	–	–	–	5.0
	II	M	19	–	7.9	–	0.3
		J	3	–	–	–	8.3
Brown Bullhead	I	M	1	30.0	–	–	–
		J	0	–	–	–	–
Tadpole Madtom	I	M	1	75.0	–	5.0	5.0
		J	0	–	–	–	–
Brook Stickleback	I	M	2	10.0	–	–	–
		J	0	–	–	–	–

END.

*single coleopteran adult (see text)

Appendix 4:

Size Distributions of Viviparus[1]

(all values are numbers/ m^2)

Outlet

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	Ø	-	-	Ø	Ø	8.6	Ø	Ø	Ø	Ø	52	8.6	-	Ø	Ø
b	Ø	-	-	Ø	51.7	Ø	Ø	Ø	94.7	4.5	379	51.7	-	60.2	8.6
c	1.3	-	-	.5	26	26	3	60	103	6	189	112	-	69	60
d	1.3	-	-	1	155	17	Ø	Ø	Ø	6	103	77.5	-	43	155
e	.7	-	-	1	17	8.6	Ø	Ø	Ø	.5	17	8.6	-	Ø	103
f	Ø	-	-	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	17.2
g	3.3	-	-	2	241	69	3	60	198	17	740	241	-	172	344

Flag

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	Ø	-	-	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	-	-	-
b	Ø	-	-	5.5	181	138	Ø	60	60	-	8.6	Ø	-	-	-
c	Ø	-	-	2	77	43	12	250	138	-	8.6	69	-	-	-
d	.8	-	-	14	250	138	3	26	Ø	-	17	60	-	-	-
e	.8	-	-	9	26	138	Ø	Ø	Ø	-	17	Ø	-	-	-
f	Ø	-	-	Ø	Ø	Ø	Ø	Ø	Ø	-	Ø	Ø	-	-	-
g	1.6	-	-	30	534	456	15	362	198	-	51	129	-	-	-

RHS

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	Ø	-	-	Ø	Ø	Ø	Ø	Ø	Ø	.5	34	Ø	-	-	-
b	Ø	-	-	Ø	198	319	.5	43	Ø	7	78	8.6	-	-	-
c	Ø	-	-	Ø	310	94.7	26	26	Ø	10	60	8.6	-	-	-
d	Ø	-	-	Ø	181	8.6	5.	Ø	Ø	16	181	17	-	-	-
e	Ø	-	-	Ø	241	Ø	1	Ø	Ø	4	43	Ø	-	-	-
f	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	-	-	-
g	Ø	-	-	Ø	913	431	33	69	Ø	37	396	34	-	-	-

Combined

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
a	Ø	-	-	Ø	Ø	3	Ø	Ø	Ø	.3	29	2.9	-	Ø	Ø
b	Ø	-	-	1.8	144	152	.2	34	52	5.8	155	20	-	60	8.6
c	.4	-	-	.8	138	55	13.7	92	80	8.3	86.	63.2	-	68.9	60.3
d	.7	-	-	4.8	195	54.6	2.7	8.6	Ø	10.8	100	52	-	43	155
e	.5	-	-	3.3	95	49	.3	Ø	Ø	2.3	26	2.9	-	Ø	103
f	Ø	-	-	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	17.2
g	1.6	-	-	11	563	319	17	164	132	27	396	155	-	172	344

[1] a: 1mm b: 2mm c: 3mm d: 4mm e: 5mm f: 6mm

Samplers: P: pushnet S: shallow ekman D: deep ekman

Combined: The mean of the values for all three sites

Appendix 5:

SIZE DISTRIBUTION OF CHIRONOMIDS BY MONTH AND BY SITE [1]

	OUTLET					FLAG				RHS			
	M	J	J	S	N	M	J	J	S	M	J	J	S
0-2 mm													
P	.5	8	11	0	-	.4	.5	2.5	-	0	3	1	1
S	-	9	17	43	60	-	25	95	69	-	0	17.2	34
D	-	26	43	9	0	-	26	9	0	-	9	0	0
2-4 mm													
P	22	80	64	3.6	-	12.8	9	-	19	13.2	92	1	10.4
S	-	318	120	129	2322	-	1015	1436	473	-	206	86	318
D	-	198	421	120	370	-	920	69	9	-	138	9	0
4-6 mm													
P	39.6	230	91	11.6	-	30.4	6	32.4	-	26.8	257	4.4	20.4
S	-	740	439	421	12186	-	1643	2460	636	-	662	198	447
D	-	464	757	86	1109	-	1445	241	34	-	224	34	17
6-8 mm													
P	41.6	202	49	12.4	-	28.8	60	25.6	-	26.8	102	2	16.5
S	-	619	112	77	1651	-	654	550	783	-	404	181	198
D	-	206	189	26	344	-	344	120	17	-	120	43	17
8-10 mm													
P	16.4	104	21	13	-	14.4	27	15	-	9.2	35	5	5.6
S	-	499	43	43	1256	-	353	327	421	-	542	132	52
D	-	172	103	9	215	-	215	95	34	-	86	43	9
10-12 mm													
P	19	17	4	4	-	11.6	3	2.5	-	8	11	8	2.5
S	-	318	9	26	1032	-	43	103	120	-	611	77	26
D	-	129	26	9	129	-	9	17	9	-	9	77	0
12-14 mm													
P	32.4	8.4	7	.5	-	13.6	6	2.5	-	9.2	2	14	1
S	-	232	0	0	241	-	26	9	43	-	215	26	9
D	-	43	0	0	43	-	0	26	0	-	0	60	9
15+ mm													
P	56.6	1	4	1	-	28.8	20	3	-	0	.5	9.6	0
S	-	86	9	9	146	-	26	9	34	-	198	34	9
D	-	43	0	0	60	-	9	0	0	-	0	43	0
pupae													
P	12	6.4	1	0	-	4.8	4	2	-	1.2	.5	.5	2.5
S	-	17	17	26	9	-	34	43	34	-	198	34	9
D	-	34	34	17	0	-	34	17	0	-	17	17	0

[1]Samplers P: pushnet S: shallow ekman D: deep ekman
All values are numbers/ m^2

continued..

COMBINED SITE CHIRONOMIDS

Month		M	J	J	S	N
Ø-2 mm	P	3.5	3.8	4.8	2.5	-
	S	-	12	43	49	6Ø
	D	-	2Ø.3	17.3	3	Ø
2-4 mm	P	16	6Ø	28	11	-
	S	-	513	547	3Ø7	2322
	D	-	419	166	43	37Ø
4-6 mm	P	32.5	183	42	16	-
	S	-	1Ø15	1Ø32	5Ø1	12168
	D	-	711	344	45.6	11Ø9
6-8 mm	P	38.5	121	26	15	-
	S	-	559	281	353	1651
	D	-	223	117	53	344
8-1Ø mm	P	17	55	14	5	-
	S	-	465	167	172	1256
	D	-	158	8Ø.3	17.3	215
1Ø-12 mm	P	15	1Ø	4.8	.5	-
	S	-	324	63	57	1Ø32
	D	-	49	4Ø	6	129
12-14 mm	P	13	5	7.8	1	-
	S	-	158	11.6	17	241
	D	-	14.3	28.7	3	43
15+ mm	P	29	7	5.7	Ø	-
	S	-	1Ø3	17	17	146
	D	-	17	14.3	Ø	6Ø
pupae	P	4.4	3.5	1.2	24	-
	S	-	26	26	29	9
	D	-	28	23	6	Ø

[1]All values are numbers/ m^2

Combined : The Mean of the Values for OUTLET, FLAG, and RHS.

Samplers P: pushnet S: shallow ekman D: deep ekman

Appendix 6:

Size Distributions of Hyalella azteca

(a<2mm, b=2-3mm, c=>3mm, d=total)

(all values are numbers/ m^2)

	MAY			JUNE			JULY			SEPT.			NOV.		
	P	S	D	P	S	D	P	S	D	P	S	D	P	S	D
	OUTLET														
a	Ø	-	-	Ø	Ø	Ø	23.5	319	224	25	1911	956	-	172	25.8
b	26	-	-	Ø	8.6	52	3	181	353	175	1214	155	-	4245	370
c	Ø	-	-	Ø	8.6	95	.5	17	43	16.5	52	Ø	-	69	Ø
d	1.9	-	-	Ø	17	146	27	516	628	36	2374	1109	-	4481	396
	FLAG														
a	Ø	-	-	1.5	Ø	Ø	6	534	60	-	155	Ø	-	-	-
b	1.2	-	-	10	34	129	3	517	77.5	-	301	Ø	-	-	-
c	Ø	-	-	18	69	198	.5	34	8.6	-	8.6	Ø	-	-	-
d	1.2	-	-	29	103	327	10	1084	146	-	464	Ø	-	-	-
	RHS														
a	80	-	-	Ø	8.6	Ø	25.5	77.5	Ø	25.5	723	Ø	-	-	-
b	91	-	-	Ø	17	Ø	29	155	Ø	49	706	Ø	-	-	-
c	18	-	-	Ø	34	Ø	8	17	Ø	2.5	86	Ø	-	-	-
d	119	-	-	Ø	.6	Ø	4.9	11.2	Ø	12.5	9.4	Ø	-	-	-
	Combined														
a	3.3	-	-	1.5	2.9	Ø	18.3	310	94.7	14.6	63	318.6	-	172	25.8
b	39.4	-	-	10	19.9	60.3	11.7	284	143	33	7 40	51.6	-	4235	370
c	6	-	-	18	37.2	97.7	3	22.7	17.2	9.5	48.9	Ø	-	69	Ø
d	48.7	-	-	29	60	158	34	616	258	565	1465	370	-	4481	396

[1]Samplers P: pushnet S: shallow ekman D: deep ekman

Combined : The mean of the values for the three sites.