Continued monitoring of Moe Pond after the unauthorized stocking of smallmouth and largemouth bass

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INTRODUCTION

Moe Pond (Figure 1) was constructed in 1939 and is surrounded by a northern hardwood and coniferous forest (Harman, 1972). The pond is located in Otsego County, New York on the Biological Field Station's Upper Site and is a part of the Otsego Lake watershed. This property is owned by SUNY Oneonta and is used for research and educational purposes. The pond has a maximum depth of 3.8 meters, a mean depth of 1.8 meters and a surface area of 15.6 ha (Sohacki, 1972). It has been previously established that the pond has eutrophic characteristics (McCoy *et al,* 2000).

Historic work described the basic limnology of Moe Pond in 1971 (Harman, 1972). Chronic blooms of blue-green algae reduced transparencies to < 0.5 m during much of the summer. It was noted that vascular plants were practically nonexistent. An intensive survey was conducted in 1994-95 (McCoy et al., 2000). That work provides a detailed assessment of the ecological characteristics in and around the pond, including limnological analyses and population estimates of fishes. It was determined that the fish community was composed only of brown bullhead (*Ictalurus nebulosus*) and golden shiner (*Notemigonus crysolucas*). McCoy et al. (2000) hypothesized that the abundance of golden shiner, a planktivorous fish, was responsible for the lack of large zooplankton which in turn allowed for high algal densities It was suggested that if predators of golden shiner were introduced, the zooplankton would proliferate and algal grazing would increase, thereby increasing transparencies. Before this hypothesis could be studied further, it was discovered that the unauthorized stocking of predator fish, both largemouth bass (*Micropterous salmoides*) and smallmouth bass (*M. dolomieui*), had occurred by the spring of 1999 (Wilson et al., 1999).

This study is a continuation of those previously done to evaluate changes that may be ascribed to the addition of gamefish. The fish community was analyzed, as was the zooplankton and benthic communities, algal densities (estimated by chlorophyll *a* determinations) and water quality parameters.

METHODS AND MATERIALS

Chemical and physical analyses of the pond's limnology were conducted weekly from 7 June 2002 until 25 July 2002. Attempts were made to collect data at the deepest part of the pond (see Figure 1). A Hydrolab® Reporter, calibrated prior to operation

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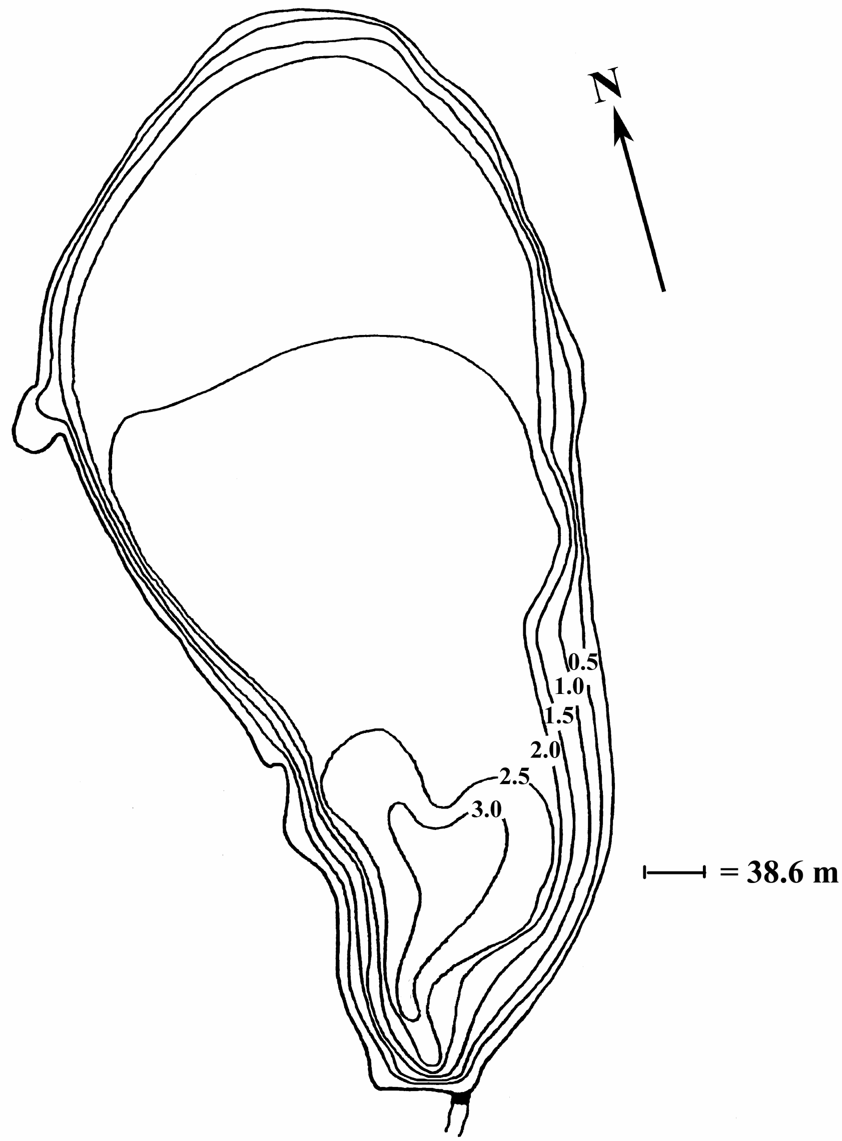

Figure 1. Basin morphometry of Moe Pond, Otsego County, NY. Contours in meters (modified from Sohacki, 1972).

following the manufacturer's directions (Hydrolab Corp., 1995), was used to determine dissolved oxygen (mg/l), conductivity (µS/cm), pH and temperature (ºC). Data were collected from surface to bottom at 1 m intervals.

Samples of water were retrieved using a Van Dorn bottle at 1 meter depth. This water was analyzed for nitrite+nitrate-N using the cadmium reduction method (APHA, 1987), total phosphorous using persulfate digestion followed by the single reagent ascorbic acid technique (APHA, 1987), alkalinity by titration with 0.02 N HCL (APHA, 1987), calcium using the EDTA titrimetric method (APHA, 1987) and chlorides by titration with mercuric nitrate (APHA, 1987). Samples were also collected to evaluate the zooplankton community. For that, a 2 liter sample collected at 1 m depth was returned to the lab where it was passed through a 63 µm mesh. After the sample was filtered, it was preserved to 70% with ethanol and the volume of the concentrated sample was recorded so that population densities could be determined. Sub-samples of 1ml were transferred to a Sedgewick-rafter cell and the zooplankton were identified to family according to Pennak (1989) and measured in micrometers using an optic micrometer. Typically 3 sub-samples were examined. Chlorophyll *a* was also examined at 1 m depth. The water was passed through Whatman GF/A glass filters which were then cut into small pieces and added to a grinding tube with buffered acetone. Chlorophyll *a* was extracted using a pestle grinder on an electric drill. After being ground to a homogenous slurry, the volume was taken to 10 ml with buffered acetone and centrifuged. Chlorophyll *a* concentrations in the supernatant were then determined fluorometrically using methods described by Welshmeyer (1994).

A semi-qualitative analysis of the invertebrate community was done on two occasions. On 7 June 2002 invertebrates were collected on only the south end of the pond and on 19 July 2002 they were retrieved on both the north and the sounth ends. The collection process included dragging a triangle net along the substrate and through submergent plants and emptying its contents into a large plastic pan. The invertebrates were removed and preserved using 70% ethanol. A catch-per-unit-effort was determined by how many individuals of a given taxa were captured per unit of time searched.

In previous years, fish were collected using a 200' haul seine at the south end of the pond and their populations estimated by areal extrapolation (i.e. Tibbits, 2001). However, extensive beds of vascular plants (see below) precluded that approach. Instead, population estimates were attempted using a mark-recapture method using a Smith-Root™ electro-fishing boat. After sunset on both 17 July 2002 and 29 July 2002, the pond was fished. On the first survey, the entire shoreline was fished twice, for a total of 1 hour. Both bass species and golden shiners were measured using a measuring board, and all fish over 100 mm were marked using a whole punch on their soft ray dorsal fin and were then released. On the second survey, two full laps of the pond's shoreline were fished, again for a total of 1 hour. All captured fish were again measured and the previously marked fish were noted. The intention was to estimate the population using a modified Petersen equation (Bailey, 1951). However, the recapture rate was too low to provide reasonable estimates, so densities were reported as numbers collected per hour fished. The stomach contents and the age of bass were also evaluated. Thirty bass were brought back to the lab and frozen. These fish were later defrosted in a bucket of warm water and dissected. The stomach contents were emptied into individual jars and were evaluated at a later date. The contents were determined using Smith (2001). For each species, percent composition was determined as the number of times each item occurred divided by the total number of pray items found times 100 (Bowen, 1983).

RESULTS AND DISCUSSION

Results of the water quality parameters collected in Moe Pond are given in Table 1. There was an overall water temperature increase throughout the summer, which was inversely correlated with decreasing dissolved oxygen. Near bottom concentrations were occasionally depressed, though never below 3.0 mg/l, indicating frequent mixing. On 4 of the 8 dates sampled, Secchi readings were not obtainable because the disk was visible when on the pond's bottom. Transparency was lowest in the later half of July, coinciding with the highest chlorophyll *a* concentrations encountered (see Table 2).

Date	Depth (m)	Temp (ºC)	Cond (mS/cm)	pH	DO (mg/l)	SD (m)
6/7/02	0	18.70	0.042	8.23	9.21	2.2
6/14/02	0	20.55	0.438	8.84	9.61	>2.4
	1	20.57	0.046	8.79	9.49	
	2	20.34	0.045	8.47	9.02	
	2.4	20.17	0.044	8.30	8.64	
6/20/02	0	23.59	0.051	9.12	9.41	>2.8
	1	22.76	0.050	9.12	9.22	
	2	20.37	0.051	9.30	10.18	
	2.8	19.44	0.050	9.11	9.80	
6/28/02	0	24.27	0.048	9.20	9.07	>2.8
	1	24.33	0.048	9.15	8.83	
	2	24.17	0.045	8.03	7.32	
	2.8	24.13	0.045	7.94	6.84	
7/3/02	N/A	N/A	N/A	N/A	N/A	2.2
7/11/02	0	22.29	0.043	8.97	8.21	>1.9
	1	22.32	0.045	8.93	7.84	
	2	22.11	0.045	9.03	7.91	
	2.3	22.04	0.045	9.07	7.82	
7/19/02	0	25.20	0.051	9.62	8.85	1.8
	1	24.72	0.050	9.51	8.49	
	2	23.57	0.045	7.45	3.61	
	2.2	23.43	0.044	7.01	3.16	
7/25/02	0	23.97	0.050	9.60	9.35	1.6
	1	23.84	0.050	9.48	9.24	

Table 1. Water quality monitored in Moe Pond (Cond = conductivity, DO = dissolved oxygen, and SD = Secchi depth reading).

The concentrations of chlorides, calcium, alkalinity, phosphorous and nitrates of the pond are given in Table 2. The concentrations of the former three parameters are quite consistent to values collected since 1994 (McCoy, 2000; Wilson et al., 2000; Tibbits, 2001; Wojnar, 2002). Low alkalinity values indicate that Moe Pond has a very low buffering capacity which does not prevent the pH levels fluctuating.

While historic information on nutrient levels is sparse, total phosphorus concentrations averaged lower than in 1994 (26 vs. 37 ug/l). Conversely, nitrite+nitrate-N, which was below detection throughout the summer of 1994 (<0.05 mg/l), averaged 0.14 mg/l during this study. A striking difference was seen in chlorophyll *a* concentrations. Throughout the summer of 1994, concentrations were between 32-43 *u*g/l, averaging 37 *u*g/l. This summer, concentrations never exceeded 21 *u*g/l, the average being 12 ug/l. The summers of 2000 and 2001 were intermediate between these values, at 26 and 21 mg/l, respectively (Tibbits, 2001; Wojnar, 2002)

Date	**T..Phos.** (*u*g/l)	**Nitrates** (mg/l)	**Alkalinity** (mg/l)[1]	**Chlorides** (mg/l)	**Calcium** (mg/l)	**Chlorophylla (ppb)**
6/7/2002	33	0.16	14	0.5	16.0	14.7
6/14/2002	24	0.20	14	1.5	8.8	7.8
6/20/2002	18	0.14	16	1.0	8.8	6.7
6/28/2002	21	0.14	17	1.5	9.6	10.2
7/3/2002	18	0.16	16	1.0	11.6	3.7
7/11/2002	N/A	0.17	17	1.5	9.6	N/A
7/19/2002	33	0.04	17	1.0	10.4	20.9
7/25/2002	35	N/A	17	0.5	8.8	20.2

([1] as $CaCO_3$)

Table 2. Water chemistry of Moe Pond, samples taken at 1 m depth.

Information on the zooplankton community (mean length and densities) is presented in Table 3. The species diversity was similar to that found by in 2000 (Tibbits, 2001) and 2001 (Wojnar, 2002), but the abundance appears to have proliferated since past years. Because zooplankton sampled in 1994 (McCoy, 2000) and 1999 (Wilson et al., 2000) were not identified beyond Rotifera/Cladacera/Copepoda, densities of those broad taxa were combined for all years available to allow for comparison and are given in Table 4. In 2002, the number of crustacean zooplankton (cladocerans and copepods) decreased over the summer months, while the rotifers appeared to increase and then level off. The decline of crustaceans, which are most responsible for algal grazing, is likely responsible for declining Secchi readings towards the end of the summer.

Taxa	6/11/2002 Mean Length (*u*m)	6/11/2002 Per Liter	6/14/2002 Mean Length (*u*m)	6/14/2002 Per liter
Cladocerans:				
Bosmina longirostris	347	296	0	0
Daphnia pulex	0	0	0	0
Daphnia sp.	0	0	0	0
Copepods:				
Diacyclops bicuspidatus	333	111	0	0
Cyclopoid copepodite	0	0	0	0
Senecella calanoides	0	0	0	0
Cyclops varicans	0	0	0	0
Nauplius sp.	190	259	114	182
Rotifers:				
Asplanchna priodontus	0	0	135	30
Gastropus stylifer	0	0	0	0
Kellicotia longispina	0	0	0	0
Keratella cochlearis	159	667	110	182
Keratella quadrata	0	0	83	30
Polyartha vulgaris	124	1778	65	636
Other				
Unknown	0	0	0	0
Seed shrimp	0	0	0	0

Taxa	6/20/2002 Mean Length (*u*m)	6/20/2002 Per Liter	6/28/2002 Mean Length (*u*m)	6/28/2002 Per Liter
Cladocerans:				
Bosmina longirostris	305	1694	354	22
Daphnia pulex	0	0	NA	22
Daphnia sp.	0	0	0	0
Copepods:				
Diacyclops bicuspidatus	137	221	0	0
Cyclopoid copepodite	227	368	129	45
Senecella calanoides	0	0	0	0
Cyclops varicans	0	0	0	0
Nauplius sp.	99	368	191	470
Rotifers:				
Asplanchna priodontus	0	0	0	0
Gastropus stylifer	0	0	0	0
Kellicotia longispina	0	0	67	22
Keratella cochlearis	177	5155	107	157
Keratella quadrata	208	884	148	67
Polyartha vulgaris	72	589	73	112
Other				
Unknown	0	0	0	0
Seed shrimp	0	0	168	336

Table 3. Zooplankton densities (numbers per liter) and mean length (*u*m), summer 2002.

Taxa	7/3/2002 Mean Length (*u*m)	7/3/2002 Per Liter	7/11/2002 Mean Length (*u*m)	7/11/2002 Per Liter
Cladocerans:				
Bosmina longirostris	321	914	325	567
Daphnia pulex	725	81	200	33
Daphnia sp.	0	0	0	0
Copepods:				
Diacyclops bicuspidatus	650	108	333	33
Cyclopoid copepodite	0	0	0	0
Senecella calanoides	0	0	0	0
Cyclops varicans	167	27	133	33
Nauplius sp.	196	376	58	100
Rotifers:				
Asplanchna priodontus	358	54	261	200
Gastropus stylifer	0	0	0	0
Kellicotia longispina	545	349	156	167
Keratella cochlearis	150	3387	130	2700
Keratella quadrata	251	242	142	67
Polyartha vulgaris	136	511	116	1700
Other				
Unknown	0	0	0	0
Seed shrimp	46	54	0	0

Taxa	7/19/2002 Mean Length (*u*m)	7/19/2002 Per liter	7/25/2002 Mean Length (*u*m)	7/25/2002 Per Liter
Cladocerans:				
Bosmina longirostris	284	5825	306	525
Daphnia pulex	649	325	367	75
Daphnia sp.	111	75	0	0
Copepods:				
Diacyclops bicuspidatus	625	50	0	0
Cyclopoid copepodite	0	0	0	0
Senecella calanoides	460	150	42	38
Cyclops varicans	420	225	0	0
Nauplius sp.	154	3275	154	263
Rotifers:				
Asplanchna priodontus	0	0	0	0
Gastropus stylifer	50	25	0	0
Kellicotia longispina	0	0	0	0
Keratella cochlearis	134	950	120	1013
Keratella quadrata	148	175	0	0
Polyartha vulgaris	96	75	115	375
Other				
Unknown	95	50	0	0
Seed shrimp	0	0	0	0

Table 3 (cont.). Zooplankton densities (numbers per liter) and mean length (*u*m), summer 2002.

TAXA	1994[1]	1999	2000	2001	2002
Rotifera	222	673	425	1251	2842
Cladacera	0	378	785	234	1307
Copepoda	6	370	276	174	838

[1] 24 August sample only

Table 4. Mean summer densities of rotifers, cladocerans and copepods in Moe pond, 1994 (McCoy, 2000), 2000 (Tibbits, 2001), 2001 (Wojnar, 2002) and 2002.

Total numbers of benthic invertebrate species by taxa and catch per unit effort (CPUE) is indicated in Tables 5-7. The invertebrate population is important to the ecology of the pond and can reflect some characteristics of the pond. For example, the abundance of odonates and trichopterans in Moe Pond may be the result of higher abundance of vascular plants in the pond in recent years (see below). It is also important to note that there was an increase of species between June and July. It is important to study the invertebrate population two or more times over the summer because of the variability of the life cycles of the different species. Many of these organisms likely are important food sources for fish in the pond.

Phylum	**Class**	**Order**	**Family**	**Quantity**	**CPUE**
Annelida	Hirudinea			4	4
Arthropoda	Crustacea	Amphipoda	Talitradae	6	6
Arthropoda	Insecta	Odonata	Coenagrionidae	54	54
Arthropoda	Insecta	Odonata	Libellylidae	4	4
Arthropoda	Insecta	Ephemeroptera	Baetiscidae	2	2
Arthropoda	Insecta	Coleoptera	Haliplidae	5	5
Arthropoda	Insecta	Coleoptera	Dytiscidae	16	16
Arthropoda	Insecta	Hemiptera	Notonectidae	2	2
Arthropoda	Insecta	Trichoptera		22	22
Mollusca	Gastropoda	Pulmonata	Physidae	2	2
Mollusca	Gastropoda	Pulmonata	Planorbidae	16	16
			Total	133	133

Table 5. Benthic macroinvertebrate populations by total numbers and CPUE organized by taxa, 7 June 02 at the south end of Moe Pond.

Phylum	**Class**	**Order**	**Family**	**Quantity**	**CPUE**
Annelida	Oligochaeta			12	24
Arthropoda	Crustacea	Ostracoda		94	188
Arthropoda	Crustacea	Amphipoda		6	12
Arthropoda	Hydrachnida	Acariformes		10	20
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	1	2
Arthropoda	Insecta	Odonata	Coenargrionidae	55	110
Arthropoda	Insecta	Odonata	Libellulidae	2	4
Arthropoda	Insecta	Hemiptera	Corixidae	1	2
Arthropoda	Insecta	Coleoptera	Elmidae	1	2
Arthropoda	Insecta	Coleoptera	Hydrophilidae	2	4
Arthropoda	Insecta	Trichoptera		19	38
Arthropoda	Insecta	Diptera	Chironomidae	11	22
Arthropoda	Insecta	Diptera	Athericidae	1	2
Arthropoda	Insecta	Coleoptera	Dytiscidae	1	2
Arthropoda	Insecta	Ephemeroptera	Ephemerellidae	24	48
Mollusca	Bivalvia	Schizodonta	Sphearidae	5	10
Mollusca	Gastropoda	Pulmonata	Physidae	25	50
Mollusca	Gastropoda	Pulmonata	Planorbidae	8	16
Nematoda				1	2
			Total	279	558

Table 6. Benthic macroinvertebrate populations by total numbers and CPUE organized by taxa, 19 June 02 at the south end of Moe Pond.

Phylum	Class	Order	Family	Quantity	CPUE
Annelida	Hirudinea			6	9
Annelida	Oligochaeta			4	6
Arthropoda	Crustacea	Cladocera	Daphnidae	1	1
Arthropoda	Crustacea	Ostracoda		6	9
Arthropoda	Crustacea	Amphipoda		58	87
Arthropoda	Hydrachnidia	Acariformes		13	19
Arthropoda	Insecta	Ephemeroptera	Caenidae	1	1
Arthropoda	Insecta	Ephemeroptera	Siphlonuridae	1	1
Arthropoda	Insecta	Odonata	Libellulidae	2	3
Arthropoda	Insecta	Odonata	Coenagrionidae	38	57
Arthropoda	Insecta	Hemiptera	Gerridae	1	1
Arthropoda	Insecta	Coleoptera	Gyrinidae	3	4
Arthropoda	Insecta	Coleoptera	Hydrophilidae	3	4
Arthropoda	Insecta	Coleoptera	Haliplidae	3	4
Arthropoda	Insecta	Coleoptera	Dytiscidae	2	3
Arthropoda	Insecta	Trichoptera		9	13
Arthropoda	Insecta	Diptera	Chironomidae	13	19
Mollusca	Gastropoda	Pulmonata	Physidae	42	63
Mollusca	Gastropoda	Pulmonata	Planorbidae	12	18
Mollusca	Gastropoda	Pulmonata	Lymnaeidae	1	1
Mollusca	Gastropoda	Pulmonata	Anyclidae	1	1
Nematoda				1	1
			Total	221	334

Table 7. Benthic macroinvertebrate populations Inv by total numbers and CPUE organized by taxa, 19 June 02 at the north end of Moe Pond.

Fish electroshocking on 17 July yielded 34 smallmouth bass, 189 largemouth bass and 1 golden shiner; all those fish were clipped. On 29 July, 7 smallmouth bass, 223 largemouth bass and 2 golden shiners were collected. Of those, only 6 of the largemouth bass and none of the smallmouth bass or golden shiners had been clipped. Table 8 provides population estimates for each species in 1995 and 1999-2002, including confidence intervals. Because of the low number of recaptured fish in 2002, estimates using the Peterson equation have excessively high variances. However, the mean catch-per-hour of largemouth bass, at 206, implies that this species is abundant.

Year	**Golden Shiner**	**Largemouth Bass**	**Smallmouth Bass**
1994 (McCoy et al., 2000)	7,154: +12,701;-6,356	0	0
1999 (Wilson et al., 2000)	3,210 +/- 1,760	1,588 +/- 650	958 +/- 454
2000 (Tibbits, 2001)	381 +/- 296	2,536 +/- 1,177	945 +/- 296
2001 (Wojnar, 2002)	1,708 +/- 1693	3,724 +/- 3,447	504 +/- 473
2002 (Hamway, 2003)[a]	3	206	20

[a] mean catch·hr^{-1} during electrofishing survey

Table 8. Population estimates of golden shiner, largemouth bass and smallmouth bass in Moe Pond, 1995 and 1999-2002.

Length frequency histograms illustrate interactions of reproduction, recruitment, growth and mortality. Figure 2 shows the length frequency histogram for smallmouth bass. It is apparent that there are more large fish than small to medium sized fish. This indicates low recruitment, which is consistent with that observed in 2001 (Tibbits, 2002). However, a larger sample size is necessary to better understand the dynamics of this population. The length at age was determined using back calculations due to the inaccurate reading of the fish scales (Figure 3).

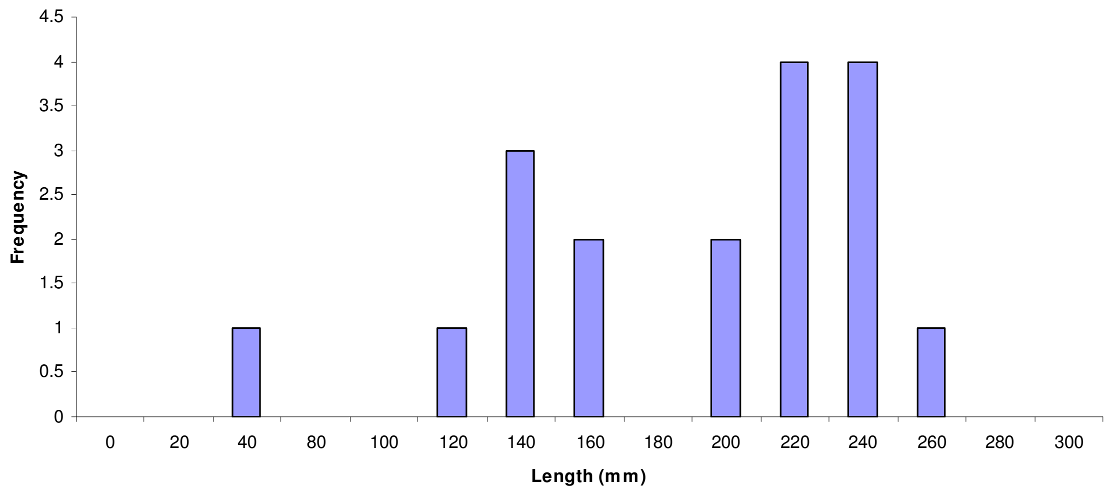

Figure 2. Length versus frequency of smallmouth bass in Moe Pond, summer 2002.

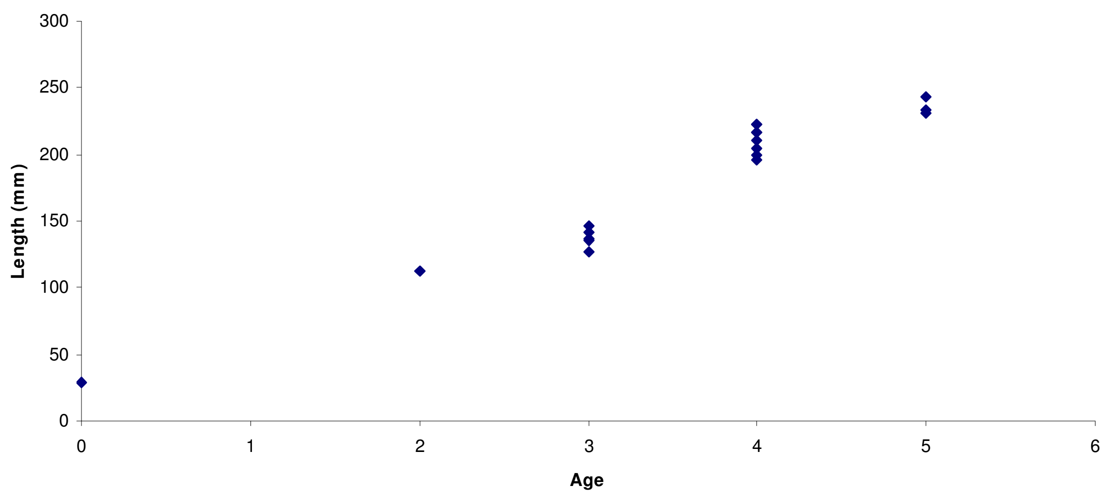

Figure 3. Smallmouth bass length versus age (years) growth curve for Moe Pond, summer 2002.

Figure 4 illustrates that there is a stronger recruitment of largemouth bass. There was an abundance of young-of-year fish which depicts a healthy bass population (Kohler, 1993). As was the case in the study done in 2000, the decrease in golden shiner still appears to have had little effect on the survival and reproduction of the largemouth bass. It would be expected that, if golden shiner was the bass' main food source, that this decrease would directly affect the bass. Length at age is given in Figure 5.

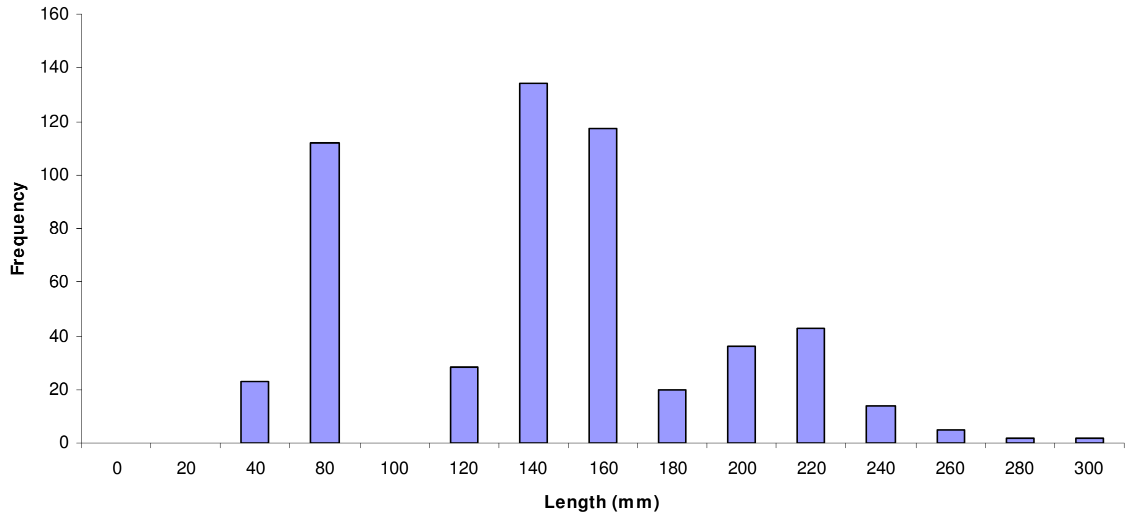

Figure 4. Largemouth bass length versus frequency of occurrence for Moe Pond.

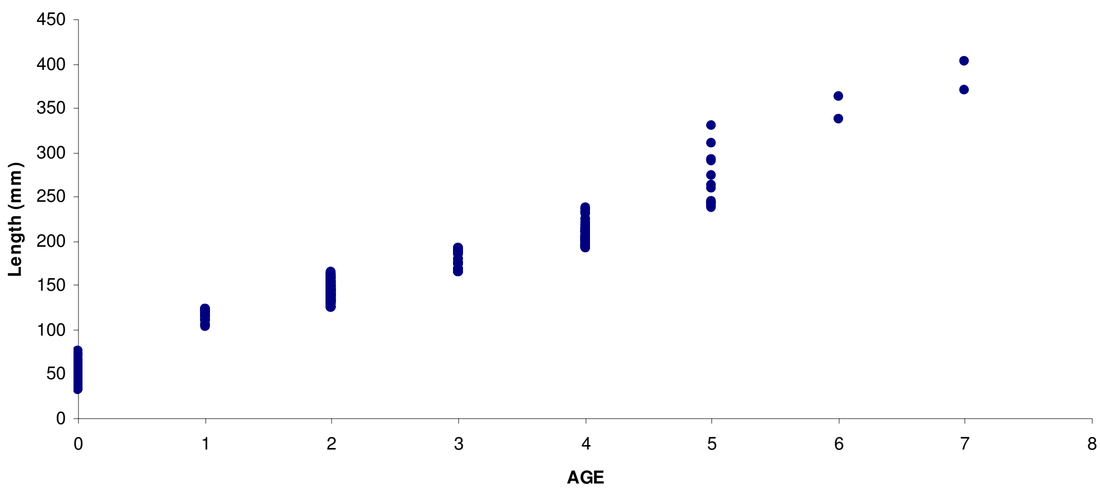

Figure 5. Largemouth bass length versus age (years) growth curve for Moe Pond.

The percent occurrence of prey found in the stomachs of smallmouth bass that were identifiable consisted solely of ephemeropterans and dipterans (Table 5). However, only two individuals were analyzed. The lack of specimens was due to the low abundance of smallmouth bass in the pond.

Conversely, 23 largemouth bass stomachs were analyzed (see Table 5). The most prevalent species in their diet included young-of-year bass. This result is similar to what Tibbits (2001) found in 2000 and Wojnar (2002) found in 2001. Apparently, by 2000 golden shiner had already been reduced, likely due to previous predation by bass, so that they were not available as food. Essentially no recruitment by shiners has been documented since 1999. In this study, two nights of electrofishing the entire pond yielded only three golden shiner, and they were between the sizes of 167mm and 182mm.

While vascular plants have never been quantified in Moe Pond, many anecdotal observations have been recorded. In 1971, Harman (1972) noted "…a paucity of aquatic macrophytes…as scattered individuals in a few restricted areas". In 1994, McCoy (2000) echoed that observation. By 2000, a slight increase in plants was noted (Tibbits, 2001); by 2001 the increase was more obvious (Wojnar, 2002). In 2002, *Elodea Canadensis* practically covered the entire pond to depths of up to 2 meters. It was for this reason that fish were surveyed by electrofishing rather than using a haul seine as had been done in the past. Plant densities precluded conventional seining.

% Occurrence Largemouth Bass		**% Occurrence Smallmouth Bass**	
Taxa	**29-Jul-02**	**Taxa**	**29-Jul-02**
Micropeterous (bass)	46	Micropeterous (bass)	0
Zygoptera	15	Zygoptera	0
Anisoptera	0	Anisoptera	0
Decapoda	4	Decapoda	0
Ephemeroptera	0	Ephemeroptera	66
Diptera	11	Diptera	33
Hymenoptera	11	Hymenoptera	0
Coleoptera	4	Coleoptera	0
Aranaea	4	Aranaea	0
Homoptera	2	Homoptera	0
N (Stomachs)	23	**N (Stomachs)**	2
# Items Identifiable	45	**# Items Identifiable**	3

Table 5. Smallmouth and Largemouth bass stomach analysis by percent occurrence.

CONCLUSIONS

Between 1971 and 1994, Moe Pond regularly experienced dense algal blooms, often dominated by blue-greens, throughout the summer. Rooted plants were virtually nonexistent. Brown bullhead and golden shiner were the only two species of fish present, both of which were stunted due to their high abundance (McCoy, 2000). Zooplankton densities were low and dominated by rotifers.

Following the unauthorized introduction of largemouth and smallmouth bass by 1999, golden shiner populations declined sharply. Essentially no recruitment has been documented since that time. In 2002, only three golden shiner were collected, all large.

Concurrent with the decline of golden shiners, zooplankton densities have increased substantially, particularly crustaceans. Algal densities (assessed by chlorophyll *a* concentrations) were lower in 2002 than ever before recorded and Secchi transparencies the highest. For the first time, rooted plants dominated the autotrophic community. It is possible that the decline of golden shiners released crustacean zooplankton from planktivory, leading to an increase in algal grazing, and the resultant increased transparency stimulated the growth of rooted plants. Changes in nutrient dynamics, also brought about by trophic modifications, may also have influenced these changes.

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