Continued monitoring of the dynamics of Moe Pond after the introduction of Smallmouth bass (*Micropterous salmoides*) and Largemouth bass (*Micropterous dolomieui*)

Kyle Dresser[1]

ABSTRACT

Moe Pond is a shallow eutrophic body of water owned by the SUNY Oneonta Biological Station. Historically, the pond was characterized as being eutrophic, having low transparency and high algal standing crops. Zooplankton densities were low, presumably because of dominance by golden shiners (*Notemigonus crysoleucas)*, an efficient planktivore. Rooted macrophytes were nonexistent, believed to be because of shading by, and competition with, algae. In 1999, both largemouth bass (*Micropterous salmoides*) and smallmouth bass (*M. dolomieui*) were discovered in the pond. Over the ensuing years, those gamefish effectively eliminated the shiners through piscivory. As plankivory declined, zooplankton recovered and algal grazing by them increased significantly, as did water transparency. This allowed for the establishment of rooted plants; by 2003, as much as 50% of the pond's surface area was covered by *Elodea canadensis*. Following the elimination of shiners, the overabundant population of largemouth bass became stunted, with 75% of those collected being 180-220 mm. Stomach analysis of fish in 2004 revealed that, on average, each bass had recently consumed 12 *Daphnia.* In 2005, that number had increased to 66. That year, zooplankton counts in the water column were low, algal standing crops were high and transparency was low. Rooted plants were once again lacking. It appears that stunted bass have functionally replaced golden shiners as a dominant planktivore, reverting the pond to a waterbody similar to what it had been before the bass introduction.

INTRODUCTION

Moe Pond (Figure 1) is a 38.6 acre (15.6 ha) (Sohacki 1972), eutrophic body of water that is owned by the SUNY Oneonta Biological Field Station. It was created in 1939 when a concrete abutment spillway was constructed at the west end of a wetland creating what is now Moe Pond. The pond has an average depth of 1.8m and is 3.8m at the deepest point (Albright et al. 2004). The pond was acquired in 1967 and is a part of the Biological Field Station's Upper Site and is located northwest of the Village of Cooperstown, NY.

General surveys have been periodically conducted since 1971, but the most in depth survey was conducted in 1994 and 1995 by McCoy et al. (2000). McCoy's research concentrated on both ecological and limnological aspects of Moe Pond. At the time of his research the only two fish species present were brown bullhead (*Ictalurus*

[1] Biological Field Station Intern, summer 2005. Present Affiliation: SUNY Oneonta, Oneonta, NY.

nebulosis) and golden shiner (*Notemigonus crysoleucas*). Chlorophyll *a* concentrations were high, transparency was low and rooted plants were essentially nonexistent.

In 1999 both largemouth bass (*Micropterous salmoides*) and smallmouth bass (*M. dolomieui)* were discovered in Moe Pond, presumably the result of an unauthorized introduction.

The change in the pond's fish community warranted annual limnological and ecological surveys of the pond. The objective of this survey of Moe Pond is to document physical, chemical and biological attributes of the pond that might be affected by the trophic cascading effects of the introduction of bass into a Moe Pond.

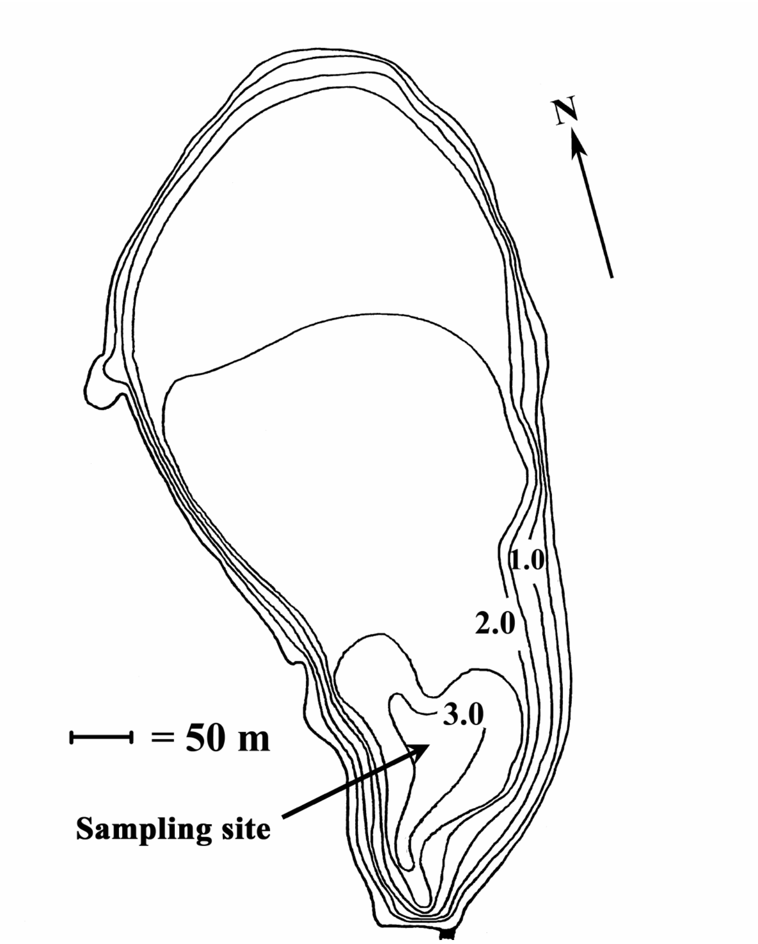

Figure 1. Bathymetry of Moe Pond, Otsego County, NY showing the sampling location. Contours in meters (modified from Sohacki 1972).

METHODS

Water quality

Moe Pond was visited weekly between 30 May and 28 July; data were collected at the deepest location (Figure 1). Temperature, dissolved oxygen, pH and conductivity were measured from the surface to the bottom at 1 m intervals using a Hydrolab Reporter® which had been calibrated prior to use following the manufacturers instruction. Transparency was measured with a standard Secchi disk. Water samples were collected from the deepest location at 1 m depth with a 4 l Van Dorn sampler.

For the analysis of water chemistry and chlorophyll *a,* 500 ml were placed in a clean Nalgene bottle; samples were kept on ice and in the dark to prevent chlorophyll degradation. Total phosphorus was determined using the ascorbic acid method following persulfate digestion (Liao and Marten 2001), total nitrogen was measured using the cadmium reduction method (Pritzlaff 2003) following peroxodisulfate digestion (Ebina et. al 1983), ammonia was measured using the phenolate method (Liao 2001), and nitrate+nitrite was analyzed following the cadmium reduction method on undigested samples (Pritzlaff 2003). All of these parameters were analyzed using a Lachat QuikChem FIA+ Water Analyzer®.

Chlorophyll *a* samples were analyzed by passing 100ml of the sample through a Whatman GG/C filter in replicate. The filters were blotted dry and were cut into small pieces into a grinding tube. Buffered acetone was added and the filter was ground into a slurry using a pestle on an electric drill. After being centrifuged (10 minutes at 1000 g), chlorophyll *a* was determined using flourometric techniques (Welschmeyer 1994).

Zooplankton

For the evaluation of the zooplankton community, a Van Dorn bottle was used to collect water at 1 m depth. On site, 5 l were passed through a plankton filter with 63 µm mesh. Samples were then preserved with a 70% ethanol solution. Sub-samples of 1 ml were placed onto a Sedgewich-rafter cell, and organisms were identified, measured and enumerated under a dissecting microscope. A minimum of 50 zooplankton from each sample were examined so that the community could be adequately described. Initial and final volumes were recorded in order to back calculate the abundance per liter (Lopata 2005).

Invertebrate Collection

A collection of aquatic invertebrates was conducted on July 18. Collection took place at one site at both the North and South ends, as has been done in past years. A 7 m stretch of shoreline was used as a collection area at each site. The sites were chosen due to their similar benthic characteristics, with both sites including rocky substrate. Triangle nets were used for a period of three minutes at each of the sites. The samples were then taken to the lab and all invertebrates were identified according to Peckarsky (1990), and were quantified.

Fish Collection

Fish collection took place on five separate dates: 1, 3, 29 and 30 May and 4 August 2005. A 200ft haul seine was used to collect fish. All fish collected were measured for length (mm) using a fish measuring board. Largemouth and smallmouth bass had scale samples taken and their stomachs pumped. Scale samples were taken in order to age the bass. The scales were placed under a microprojector and then annual rings were counted. A gastric lavage was used to pump each bass' stomach; contents were stored in a Nasco Whirl Pak. Stomach samples were preserved in 70% ethanol and later identified according to Peckarsky (1990).

A population estimate was calculated for Moe Pond by using the area extrapolation method. The average area with in the haul seine was estimated to equal 300m². For each of the seines conducted the number of fish caught per species was divided by the area seined to get the number of fish per m², then multiplied by the area of the pond (155,800 m²). Along with the mean extrapolated number a value of +/- 95% confidence interval was also calculated and reported. This is not expected to necessarily provide an accurate population estimate, it is consistent with work in past years and should track changes in abundance.

RESULTS AND DISCUSSION

Limnology

A summary of the limnological data collected on Moe Pond from 1972 to the present survey is provided in Table 1. The table shows the changes that have occurred in Moe Ponds water chemistry since the introduction of bass in 1999. An apparent trend in improving water quality, indicated by decreasing total phosphorus and chlorophyll a and increasing transparency, for the first 3-4 years following the introduction of bass, seems to have reversed in the past two years.

	1972[a]	1994	2000	2001	2002	2003	2004	2005
Secchi Depth (m)	NA	0.85 (0.1)	1.2 (0.2)	1.1 (0.1)	>2.2[c]	>2.33 [c]	1.4 (0.2)[c]	1.26 (0.13)
Total Phosphorus-P (u g/l	40-70	36.7 (3.7)	NA	NA	26.4 (2.6)	29.1 (2.12)	42.5 (2.04)	56.64 (7.44)
Nitrite+Nitrate-N (mg/l)	NA	<0.05[b]	NA	NA	0.14 (0.02)	0.11 (0.02)	0.10 (0.01)	0.01 (.006)
Chlorophyll *a* (u g/l)	NA	37.1 (2.2)	26.5 (0.2)	20.4 (8.1)	12.0 (2.4)	9.76(2.49)	22.9 (4.4)	17.03 (2.41)
Alkalinity (mg/l as $CaCO_3$	26-37	18.0 (0.4)	NA	17.0 (0.2)	16.0 (0.5)	NA	NA	NA
pH	6.8-10.2	7.93 (0.37)	8.63 (0.35)	8.66 (0.32)	9.08 (0.18)	6.84 (.44)	7.3 (0.07)	7.66 (0.62)

[a] only ranges available
[b] all samples below detection
[c] Secchi disk visible on pond bottom 50% of samples

Table 1. Summer mean values (+/- standard error) for Secchi depth, total phosphorus, nitrite-nitrate, chlorophyll a, alkalinity, and pH in Moe Pond (adapted from Albright et al. 2004).

Fish Community

Consistent with recent years, the shiner population seems to be nonexistent (Table 2). With no golden shiners being captured for the second year in a row, there has been no apparent recruitment of shiners in Moe Pond.

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+/-1,693	3,724+/-3,447	504+/-473
2002 (Hamway, 2003)*	3	206	20
2003 (Hamway, 2004)*	2	318	1
2004 (Lopata, 2005)	0	6,924+/-2,912	0
2005 (Current Survey)	0	12,019+/-3,577	223+/-257

Table 2. Fish population estimates 1994, 1999-2001, and 2004 calculated by extrapolation method, +/- 95% confidence interval. (*) denoted dates when electro fishing was necessary and numbers are presented in catch per hour of effort (adapted from Hamway 2003).

While smallmouth bass have been in decline each year since the early stages of their establishment, 3 were collected in the seines this summer. This is the most that have been recorded since 2002 (Hamway 2003). It has been suggested that the conditions present in Moe Pond would likely favor largemouth bass (Tibbits 2001), and this seems to be the case, though some remnant population of smallmouth bass persists.

Data collected indicate that Moe Pond's largemouth bass population is stunted, with 74% of those collected ranging from 180-210mm in length (Figure 2). This is considered stunted because the fish with in that size range are not all of the same age class; they range from 3-7 years of age. Stunting is likely due to the lack of an adequate food supply. The high density of bass and the competition for the limited food source that is available limits growth.

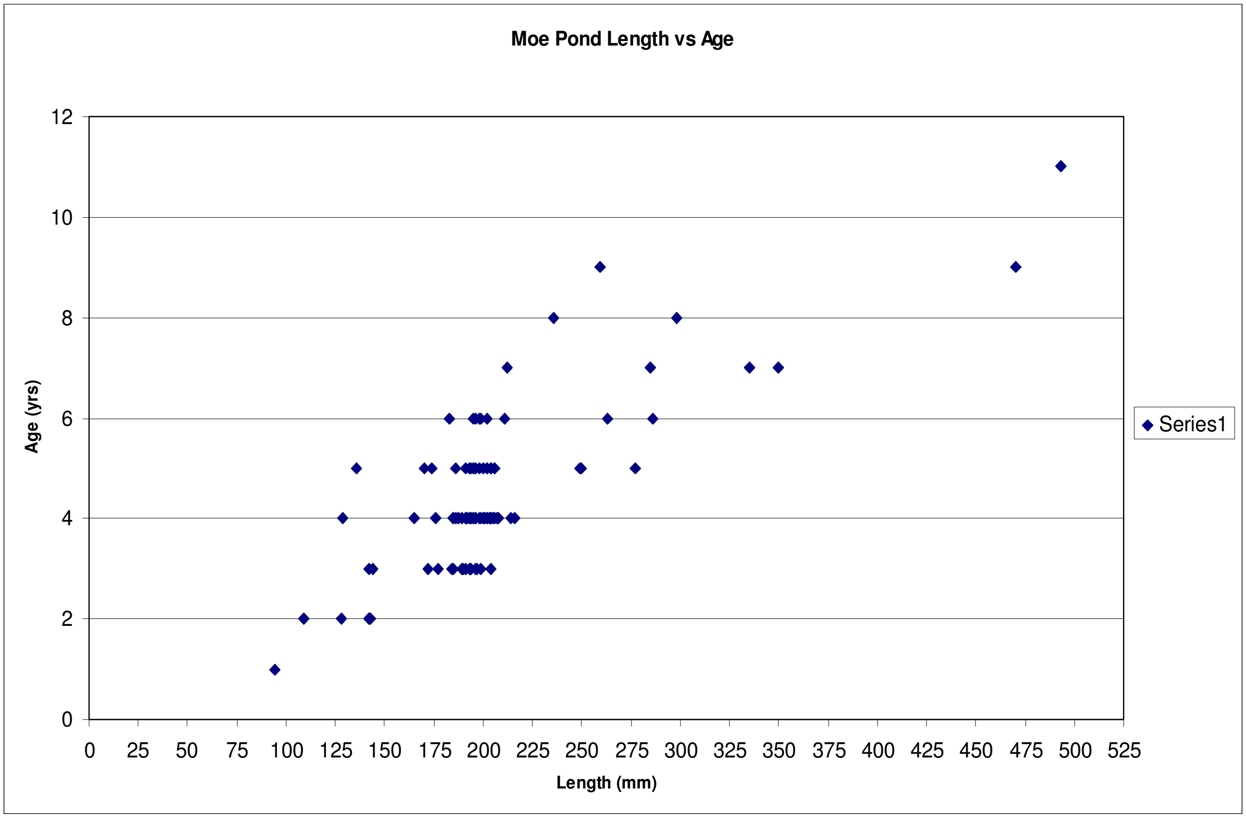

Figure 2. Largemouth bass length vs. age for Moe Pond, summer 2005.

As seen in past years, insects have been an important component of the bass' diet. Similar to 2004, *Daphnia* spp. was also a common diet item, with 18% of the bass having one or more of these organisms (Table 3). The average bass had 66 daphnids in its stomach, implying that those bass which fed upon *daphnia* spp. did so frequently. Prior to 2004, daphnia were not encountered in bass stomachs.

Zooplankton

The mean number per liter of various zooplankton taxa collected over the summers of 2004 (Lopata 2005) and 2005, as well as their mean lengths, are given in Table 4. The mean number per liter of broader taxa (cladacerns, copepods and rotifers) over the summers of 1999-2005 is given in Table 5. The densities of crustacean plankton through 2005 were substantially lower than those of any other year, implying that planktivory by stunted bass is suppressing their numbers.

Taxa	Mean per stomach	% Occurrence Largemouth Bass
Hirudinea	0.03	1.9
Acariformes	0.41	15.7
Daphnia spp.	65.99	18.5
Amphipoda	8.49	23.1
Decapoda	0.12	8.3
Ephemeroptera	2.01	43.5
Odonata	0.96	21.3
Hemiptera	0.94	17.5
Tricoptera	0.08	3.7
Coleoptera	0.17	9.25
Hymenoptera	0.31	11.1
Diptera	14.09	48.1
Ictaluria nebulosus	0.27	4.6

Table 3. Largemouth bass stomach contents arranged by mean number per stomach and percent occurrence.

Summer 2004			**Summer 2005**		
Species	#/liter	Mean Length (µm)	**Species**	#/liter	Mean Length (µm)
Cladoceran			**Cladoceran**		
Bosmina longirostris	225	323	*Bosmina longirostris*	32	304
Dapnia pulex	151	677	*Dapnia pulex*	15	801
Copepods			**Copepods**		
Cylopoid sp.	71	430	*Cylopoid sp.*	43	541
Calanoid sp.	22	559	*Calanoid sp.*	8	466
Nauplius sp.	187	184	*Nauplius sp.*	26	218
Rotifers			**Rotifers**		
Asplanchna priodontus	66	410	*Kellicotia longspina*	10	185
Gastropus stylifer	120	105	*Keratella cochlearis*	321	103
Kellicotia longspina	57	199	*Ostracoda*	8	577
Keratella cochlearis	2367	95	*Unknown Rotifers*	17	139
Polyartha vulgaris	138	159	**Mean Total/L:**	479	
Dicehocesa	97	202			
Microeodon	6	155			
Mean Total/L:	3506				

Table 4. Mean numbers of zooplankton per liter, length (µm) for 2004 summer (Lopata 2005), and for the current survey.

TAXA	1999	2000	2001	2002	2003	2004	2005
Cladacera	378	785	234	1307	194	375	47
Copepoda	370	276	174	838	193	279	77
Rotifera	673	425	1251	2842	264	2851	357

Table 5. Mean summer cladacera, copepoda and rotifera zooplankton abundances (number per l) in Moe Pond, 1999-2005 (modified from Albright et al. 2004).

Invertebrates

This year's survey found more total invertebrates at Moe Pond's north end (total = 838) as compared to its south end (total = 287) (Table 5), in contrast to the 2004 survey, which collected 325 benthic organisms at the north end and 755 at the south end (Lopata 2005). This may be due to a more sheltered substrate at the north end containing more suitable habitat than that of the south end. Amphipods, snails, true flies and damsleflies were the most common organisms collected during both years.

Southern End	
Taxa	**# Collected**
Hirudinea (Leeches)	4
Planorbidae (Rams Horn Snails)	1
Valvatidae (Valve Snails)	9
Sphaeriidae (Finger Nail Clams)	39
Amphipoda (Scuds)	108
Acariformes (Water Mites)	0
Ephemeroptera (Mayflies)	12
Trichoptera (Cadisflies)	40
Hemiptera	7
Anisoptera (Dragonflies)	5
Zygoptera (Damsleflies)	28
Coleoptera (Beetles)	7
Diptera (True Flies)	27

Total: 287

Northern End	
Taxa	**# Collected**
Hirudinea (Leeches)	2
Planorbidae (Rams Horn Snails)	2
Valvatidae (Valve Snails)	6
Sphaeriidae (Finger Nail Clams)	1
Amphipoda (Scuds)	463
Acariformes (Water Mites)	7
Ephemeroptera (Mayflies)	46
Trichoptera (Cadisflies)	162
Hemiptera	71
Anisoptera (Dragonflies)	2
Zygoptera (Damsleflies)	58
Coleoptera (Beetles)	2
Diptera (True Flies)	16

Total: 838

Table 5. Invertebrates sampling for July 18 by sampling site and by number of individuals captured per taxa.

CONCLUSIONS

The population of bass in Moe Pond has influenced many aspects Moe Pond's ecology and limnology. Golden shiner, which historically were abundant, began to decline 2000-2001 as the bass became dominant; they have not been collected since 2003 (Hamway 2004) (see Table 2). During that period, crustacean zooplankton became more abundant (Table 5), presumably due to a release from planktivory by shiners (Table 2), and chlorophyll *a* concentrations decreased while transparencies increased (Table 1). Albright et al. (2004) surmised that this exemplified classic trophic cascading which resulted from the addition of a top predator. Coincident with the above changes, *Elodea Canadensis* proliferated in Moe Pond; rooted macrophytes had been virtually absent in this waterbody prior to 2002 (Albright et al. 2004).

Since 2003, many attributes of Moe Pond indicate that it is reverting back to what it had been prior to the bass introduction. Transparencies have declined and chlorophyll *a* concentrations have rebounded (Table 1) as the abundance of crustacean zooplankton declined markedly (Table 5). *Elodea Canadensis* is once again sparse (personal observation). Prey selection by bass seems to have shifted to large bodied crustacean zooplankton, particularly *Daphnia* spp., in 2004 and 2005. The bass densities in 2005 were considerably higher than during any year since their establishment (see Table 2). It seems that in response to a paucity of prey items in the pond, bass have functionally taken over the role once played by the ponds native golden shiners. As the density of bass continues to increase we are beginning to see that the population is becoming stunted due to competition for both food and space.

REFERENCES

Albright, M.F., W.N. Harman, W.T. Tibbits, M.S. Gray, D.M. Warner and R.J. Hamway. 2004. Biomanipulation: A classic example in a shallow eutrophic pond. Lake and Reserv. Manage. 2(3):181-187.

APHA, AWWA, WPCF 1989. Standard methods for the examination of water and wastewater, 17th ed. Washington, D.C. American Public Health Association.

Hamway, R.J. 2003. Continued monitoring of Moe Pond after the unauthorized stocking of smallmouth and largemouth bass. *In* 35th Ann. Rept. (2002). SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.

Hamway, R.J. 2004. Continued observations of Moe Pond after the unauthorized stocking of smallmouth and largemouth bass. *In* 36th Ann. Rept. (2003). SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.

Harman, W.N. 1972. Aquatic biology studies. *In* 4th Ann. Rept. (1971). SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.

Hydrolab Corp. 1995. Reporter^{TM} operating manual. Hydrolab Corp. Austin, TX.

Lopata, 2005. Fifth annual report on the status of Moe Pond following the stocking of *Micropterous salmaoides and M. dolomieui. In* 37th Ann. Rept. (2004). SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.

McCoy, M.C.P., C.P. Madenjian, J.V. Adams, W.N. Harman, D.M. Warner, M.F. Albright and L.P. Sohacki. 2000. Moe Pond limnology and fish population biology: an ecosystem approach. 33rd Occasional Paper. SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.

Peckarsky, B.L., P.R. Fraissinet, M.A. Penton and D.J. Conklin. 1990. Freshwater macroinvertebrates of northeastern North America. Cornell University Press, Ithaca.

Sohacki, L.P. 1972. Limnological studies on Moe Pond. *In* 5th Ann. Rept. SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.

Tibbits, W.T. 2001. Consequences and management strategies concerning the unauthorized stocking of smallmouth and largemouth bass in Moe Pond. *In* 33rd Ann. Rept. (2000) SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.

Welschmeyer, N.A. 1994. Fluorometric analysis of chlorophyll a in the presence of chlorophyll and pigments. Limnol. and Oceanogr. 39: 1985-1992.

Wilson, B.J., D.M. Warner and M.S.Gray. 2000. An evaluation of Moe Pond following the unauthorized stocking of small mouth and largemouth bass. *In* 32nd Ann. Rept. (1999). SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.

Wojnar, K.A. 2002. The continuing evaluation of Moe Pond after the unauthorized stocking of smallmouth and largemouth bass. *In* 34th Ann. Rept. (2001). SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.