A STUDY OF THE FISH POPULATIONS OF RUNYAN LAKE

DAVID J. JUDE, FISHERY BIOLOGIST, LIMNOLOGIST
FRESHWATER PHYSICIANS, INC.
5293 DANIEL DR.
BRIGHTON, MI 48114

INTRODUCTION

I was asked by the Runyan Lake Association to assess the fish population of the lake based on a review of the historical data from 1979, 1982, and 1996. There were also some concerns expressed about the unknown impact of stocking walleyes into the lake in recent years and whether that should continue. I also wanted to assess the biodiversity of the fish population in the lake and whether it has continued based on prey and top predator assessments. Of particular concern was the lake herring, a bellwether of ecosystem integrity. Lake herring are native to the lake and I collected large numbers in 1995 and fewer in 1979 and wanted to know if they were still in the lake. I was also concerned about how well walleyes would survive and grow adequately in the lake. I examined dissolved oxygen – temperature profiles that I collected previously and in 2007-2008 to determine if the oxygen environment has deteriorated, thereby affecting the three species of concern: lake herring, walleye, and northern pike, which are all cool water species, requiring cold water temperatures and high dissolved oxygen in the lake during maximum summer stratification when conditions on the bottom can deteriorate. Our 2008 effort involved the deployment of trap nets, which turned out to be unsuccessful, seines, which collected large numbers of fishes, and gill nets which were deployed in early 2008 and later in 2008, when earlier efforts were deemed inadequate to assess the population well.

I hoped to address several questions: 1.) were lake herring still in the lake, 2.) how common were walleyes in the lake and how fast are they growing since being stocked, and 3.) were there any fish population changes based on comparing our 2008 dataset with those collected prior to this study in 1979 and 1995.

It should also be noted that a one-time fish study has several drawbacks, but should provide a reasonable assessment of the current state of the fish population. It is difficult to assess fish populations. I did not want to kill very many fish since they are so valuable to the stability of the fish community and to the lake residents, hence I went with trap nets to begin with, since you can release fish alive. When they did not catch any fish, I used gill nets, which are very effective gear. I do not have any long term seasonal data to gain a perspective on how abundant some of the fish species in the lake are. I will rely on professional judgment augmented with the data I collected on the fish and dissolved oxygen levels from the various gear deployed and historical information to reach conclusions presented in this study.

METHODS

Dissolved Oxygen-Temperature Profiles

The study had two major components: measure the dissolved oxygen and temperature profiles in the lake so I could determine the suitability of the habitat for three species of coldwater fishes: lake herring (natives), northern pike (natives which spawn successfully), and walleyes (stocked species). I used an YSI dissolved oxygen-temperature probe, which provided data on these parameters by 1-m depth stratum. I collected data once during late 2007 and twice in 2008 when we set the gill nets and trap nets in Runyan Lake. The dissolved oxygen and temperature data were obtained from surface to bottom to determine if there was loss of dissolved oxygen on the bottom and at what stratum cool water fishes might be found during the stratification period of the lake.

Fish

I collected fishes using three different gear types. Trap nets, seines, and gill nets. Three trap nets (see Trap net on Fig. 1) and one gill net (near station K – Gill net in Fig. 1) were set on 31 May 2008 then retrieved on 1 June during which time we also seined at three sites (SA, SB, SC) (Fig. 1). We also set gill nets, which are 125-ft long, with various mesh sizes from ½ inch to 2.5 inches square or bar mesh. One was set near station H – gill net (Fig. 1) on 31 May 08 and then three were set at the other three sites (Gillnet on Fig. 1). Because I got no fish in the trap nets and few in the gill net set on 1 June, I returned to the lake on 28 June and set three gill nets at various sites in about 20-30 ft of water. The seine used was 50 ft long with a 10-ft bag; mesh was 1.4-inch mesh. This seine was deployed at three stations during August 2008 (SA, SB, SC - Fig. 1). Only example specimens were kept for confirmation of field identifications, although a range in sizes of some species of interest (bluegill, pumpkinseed, walleyes, northern pike, and largemouth bass) were kept so as to examine stomachs for diet and to age them. An assessment was made on field log sheets of the relative abundance of the species collected (see Table 1). Scales were taken from specific fishes to determine how fast they were growing compared with Michigan averages. Fish scales were taken back to the laboratory, examined under a microscope, and ages assigned according to the number of rings (annuli) found. Fish were measured to the nearest mm, weighed to the nearest gram (converted to English units), and diet assessed after removal of stomach contents.

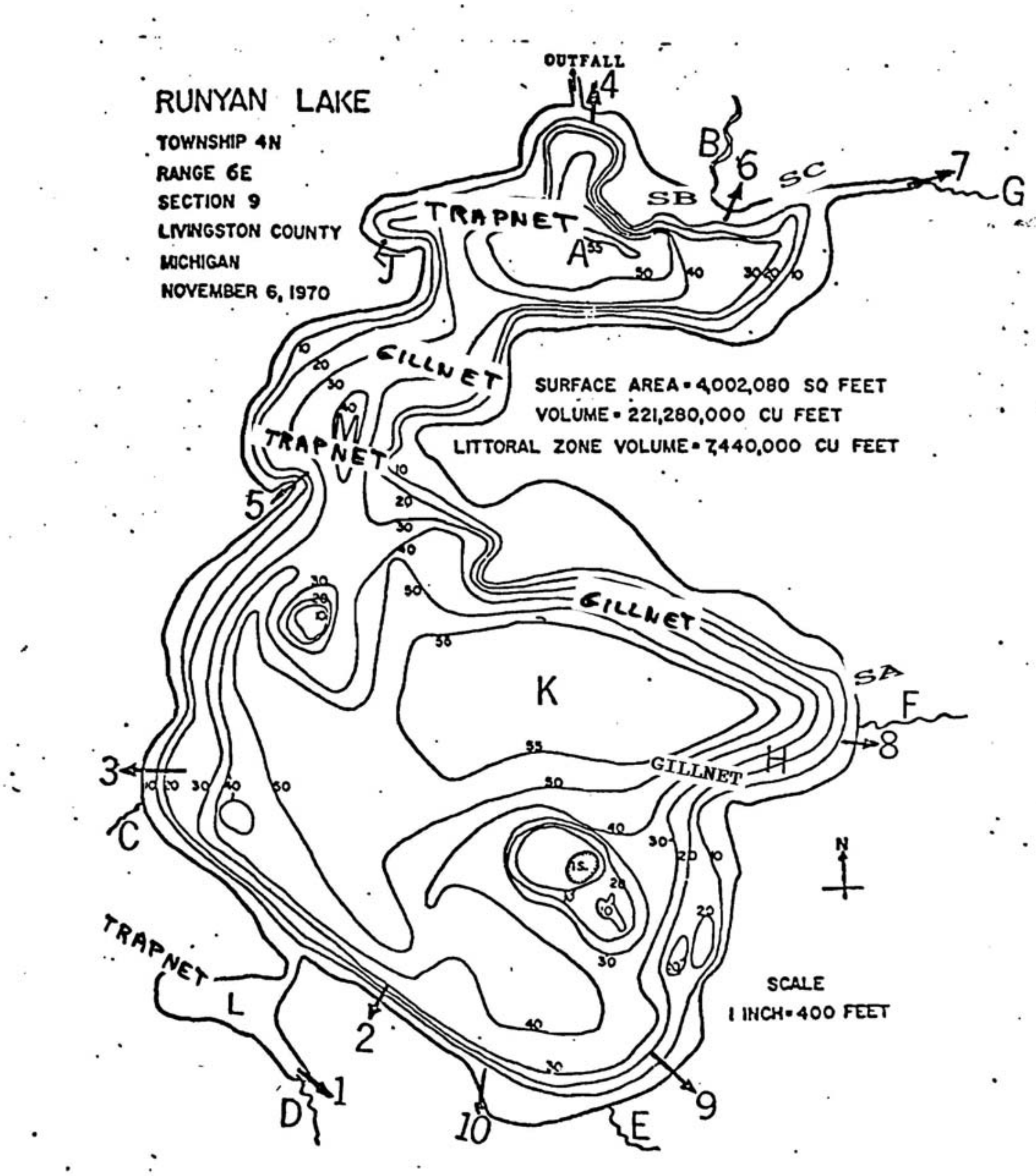

Figure 1. Map of Runyan Lake (T4N R6E S9) Livingston County, near Fenton, MI showing sampling stations for dissolved oxygen (station K) and fishing stations for trap nets, gill nets, and seining (SA, SB, SC).

RESULTS

Dissolved Oxygen Profiles

I examined dissolved oxygen profiles from 30 September 2007 and on 28 June 2008 (Table 2). I observed some depletion of dissolved oxygen on the bottom during 30 September 2007 as dissolved oxygen was 0.1 to 1.2 mg/L from the bottom upwards to 43 ft. This probably represents maximum deterioration of the dissolved oxygen in recent times, as September is late in the year. The other profile in 28 June 2008 showed much more dissolved oxygen on the bottom – the lowest level was 3.4 mg/L which would support lake herring. There were ample areas in the vertical water column then, where the dissolved oxygen levels were still high (5-6 mg/L) and water temperature was cold enough (ca. 15 C) to support the three species of interest. These samples and the historical samples (see Table 2) showed the same pattern.

Table 1. List of fish species collected at various times at Runyan Lake, Livingston County, MI.
R= RARE, C = COMMON, A = ABUNDANT, F = reported by fisherman to be present.

Fish Code	Taxon	Scientific Name	11-Aug 1979	16-Sep 1995	May-Jun 2008
BK	BANDED KILLIFISH	*Fundulus diaphanus*	C	C	C
BB	BLACK BULLHEAD	*Amerius melas*		F	
BA	BLACKNOSE SHINER	*Notropis heterolepis*			R
BC	BLACK CRAPPIE	*Pomoxis nigromaculata*		R	
BG	BLUEGILL	*Lepomis macrochirus*	A	A	A
BM	BLUNTNOSE MINNOW	*Pimephales notatus*	C	C	C
BF	BOWFIN	*Amia calva*	F	F	
SV	BROOK SILVERSIDES	*Labidesthes sicculus*	A	A	C
GL	GOLDEN SHINER	*Notemigonus crysoleucas*		R	
GP	GRASS PICKEREL	*Esox americanus*	R		
GN	GREEN SUNFISH	*Lepomis cyanellus*	R		
ID	IOWA DARTER	*Etheostoma exile*	C		C
JD	JOHNNY DARTER	*Etheostoma nigrum*	C	C	C
LH	LAKE HERRING	*Coregonus artedii*	R	C	
LB	LARGEMOUTH BASS	*Micropterus salmoides*	C	C	C
LP	LOGPERCH	*Percina caprodes*		C	
LR	LONGNOSE GAR	*Lepisosteus osseus*	F	R	
NP	NORTHERN PIKE	*Esox lucius*	C	C	C
PS	PUMPKINSEED	*Lepomis gibbosus*	A	C	C
RB	ROCK BASS	*Ambloplites rupestris*	C	C	
SH	SAND SHINER	*Notropis stramineus*		C	C
SB	SMALLMOUTH BASS	*Micropterus dolomieui*			F
SF	SPOTFIN SHINER	*Notropis spilopterus*		C	R
WL	WALLEYE	*Sander vitreus*		F	R
WM	WARMOUTH	*Lepomis gulosus*	R	R	
WS	WHITE SUCKER	*Catostomus commersoni*	R		

YP	YELLOW PERCH	*Perca flavescens*	C	C	
YB	YELLOW BULLHEAD	*Ameirus natalis*	C		
		TOTAL NO. SPECIES	**17**	**16**	**10**

Fish Distribution and Diets

Overall I collected fewer fish and fewer species than what we collected during 1979 with less effort. I noted that 17 fishes were present in 1979, 16 in 1995, while I only collected 11 during 2008 (Table 1). Two of the species that were common in previous collections in 1979 and 1995 and not collected in 2008 were lake herring and yellow perch. White suckers, rock bass, golden shiner, grass pickerel, and warmouth were also not observed during the recent collections.

Despite setting four gill nets at four different sites at two different times, we only collected one walleye (19.7 inches). Reports from fisherman indicate that they are routinely caught at specific sites in the lake. Our data suggest this species is rare in the lake.

We collected about five northern pike, some of which were fairly large (28 inches). These fish seemed in good condition, but were growing at below state averages. They appeared to be at least common in the lake based on the reports from fisherman and our catch data.

Lake herring were collected in 1979 in Runyan Lake, some 29 years ago and more recently during 1995 (Table 1). However, we set gill nets near the place where we captured them earlier and at other places that I believed optimal habitat for these fish existed, but no lake herring were found in any of the four gill nets that were set in 2008 (Table 1). This is an unfortunate sign for Runyan Lake.

We also collected other species in our fishing gear. Bluegill seemed to be abundant, of good size, and growing well above state averages in Runyan Lake. Diets I checked showed them to be consuming dragonflies from the luxurious macrophyte growth along the shoreline. We also collected large numbers of pumpkinseeds, which were growing well and also eating dragonflies (Table 3).

Table 2. Listing of the dissolved oxygen/temperature levels from various past studies (Freshwater Physicians, Inc. 1982, 1995) on Runyan Lake, Livingston Co., Michigan and this study (2008). See Fig. 1 for station locations.

Depth (ft)	Water Temp. – C	Water Temp. - F	Diss. Oxy (mg/L)
		11 August 1979 - Station A	
0	22	71.6	7.9
17	13	55.4	8.9
33	11.2	52.2	12.1
50	11.2	52.2	1.5
		14 September 1982 - Station K	
0	22	71.6	8.4
10	22	71.6	7.9
20	21	69.8	8.7
30	16.5	61.7	10
40	16.5	61.7	7
50	16	60.8	4
		4 August 1995 - Station K	
1	28.1	82.5	8.1
10	27.8	82.0	8
20	22.8	73.0	8.7
30	14.4	58.0	7.4
40	12.2	54.0	1.2
55	9.4	49.0	0.6
		4 August 1995 - Station A	
1	27.5	81.5	8.1
10	27.2	81.0	8
20	22.2	72.0	8.6
30	12.8	55.0	7.6
40	12.2	54.0	7
55	9.4	49.0	0.2
		4 August 1995 - Station M	
1	27.8	82.0	8
10	27.5	81.5	7.6
20	22.2	72.0	10
30	13.6	56.5	8.3
40	11.7	53.0	3.8
		30 September 2007 - Station K	
0	21.8	71.2	9.0
3	21.8	71.2	9.0
7	21.3	70.3	8.9

10	21.0	69.8	8.8
13	20.8	69.4	8.8
16	20.3	68.5	8.8
20	20.1	68.2	8.8
23	19.5	67.1	10.0
26	17.0	62.6	10.8
30	14.0	57.2	8.9
33	12.8	55.0	7.8
36	11.5	52.7	6.6
39	10.5	50.9	4.8
43	9.8	49.6	2.6
46	9.0	48.2	1.2
49	8.5	47.3	0.2
52	8.0	46.4	0.2
56	7.9	46.2	0.1
	28 June 2008 - Station K		
0	25	77.0	8.1
3	25	77.0	8.2
7	25	77.0	8.2
10	25	77.0	8.2
13	24	75.2	7.9
16	22.1	71.8	8.6
20	20	68.0	8.8
23	18	64.4	9.2
26	15.8	60.4	9.8
30	14.1	57.4	9.2
33	13.1	55.6	9.8
36	12.1	53.8	9.4
39	11.1	52.0	9
43	10.4	50.7	8.2
46	10	50.0	7.8
49	9.3	48.7	7.2
52	9.2	48.6	3.6
56	8.2	46.8	3.4

Table 3. Diets of selected species of fishes collected from Runyan Lake, June and July 2008. BG = bluegill, PS = pumpkinseed, LB = largemouth bass. M= male, F = female, 1 = gonads poorly developed, 2 = moderately developed, and 3 = well developed. MT = empty stomach. T = total length, MT = empty.

Species	T. Len. (inches)	Weight (ounces)	Sex	Diet
		31-May-08		
BG	7.7	4.9	M3	DRAGONFLIES

BG	7.6	4.7	F3	DRAGONFLIES
BG	7.3	4.0	M3	AMPHIPODS
PS	7.4	5.5	F3	MT
BG	6.3	2.5	F2	DRAGONFLIES
PS	6.5	3.7	F2	MT
BG	5.8	2.0	F1	2 DRAGONFLIES
LB	7.7	3.2	CC	2 DRAGONFLIES
LB	5.9	1.5	II	MINNOW
LB	6.4	1.8	II	3 IOWA DARTERS
LB	5.8	1.2	II	FISH SLIME
		28-Jun-08		
NP	20.0	Released	Na	na
NP	28.0	4.5 #		MT
WL	19.7	2.26#		*Hyallela*, crayfish
BG	7.8	4.7		Chironomids, zooplankton
BG	8.0	4.5		MT
BG	6.9	3.3		Zooplankton, chironomids
BG	6.7	2.6		Algae
BG	3.0	0.2		Zooplankton, chironomids
BG	2.8	0.2		MT
BG	2.9	0.2		Zooplankton
BG	3.0	0.4		Chironomids
BG	2.7	0.2		Zooplankton

We did not collect large numbers or big largemouth bass from Runyan Lake, since largemouth bass are difficult to catch in gill nets and avoid seines most times. I did put out a call to fisherman to collect stomachs of large predators they caught if they were not releasing these fishes, but response was very low. Hence it is difficult to asses their abundance and growth at larger sizes. However, I believe that they are common in Runyan Lake based on previous data I collected, reports from fisherman, and the Runyan Lake website, which showed some sizeable largemouth bass collected during the summer fishing tournament. The few small individuals I aged were growing below state averages. The largemouth bass we did collect during seining were eating Iowa darters, a species we also collected during seining. One resident on the east side of the lake reported that he had caught smallmouth bass near his residence.

We also collected two species of darters (diminutive members of the perch family), the Iowa darter and the johnny darter (Table 1). This is a good sign of the diversity of the fish community in Runyan Lake. These species were also present in previous surveys and provide food for small largemouth bass, and probably other predators as well, such as yellow perch and rock bass (if still present).

Yellow perch was a species I thought was common in the lake based on previous collections and a few large individuals were caught by sport fisherman during the summer fishing tournament and were observed on the website. However, we did not collect any yellow perch in our seine or gill nets, which is very strange and unexpected. This may indicate that the population is reduced considerably in Runyan Lake.

We collected four minnow species in our seine hauls: bluntnose minnow, blacknose shiner, spotfin shiner, and sand shiner (Table 1). There are therefore minnows that are common near shore, which will provide an additional food supply for predators (one largemouth bass was eating a minnow). Many lakes I sample do not have any minnows left, so this is an excellent sign of biodiversity in the lake.

Brook silversides were collected in our near shore seine hauls and were judged to be common in the lake. They too will act as a forage fish for top predators in the lake.

Fish Growth

We collected one 19.7-inch walleye which was 5 years old and growing at or above state averages (5 yr old fish should be 18.9 inches) (Table 4). Walleyes were stocked into Runyan Lake on 27 October 1999 when 1,650 young-of-the-year walleyes from 6-8 inches long were planted, while on 15 October 2004 another 1,255 walleyes from 6 to 8 inches long (fingerlings) were stocked into the lake from Laggis Fish Farms, Inc. in Gobles, MI. The 2004 stocking resulted in about 6 walleyes/acre; the 1999 stocking would be about 8/acre.This fish was probably stocked during 2004 as a fingerling young of the year (6- 8 inches) and if so it should be 4-yr old. According to state averages a 4-yr old should be 17.8 inches. The other option might be that this fish is from the 1999 stocking and as fish grow older and if they are not growing well, it is difficult to age them. Interestingly enough, a 9–yr old walleye according to state averages should be 19.7 inch, perfectly matching the size of the fish we collected. I need more walleyes to draw any meaningful conclusions, but based on this fish, they are rare in the lake and growing well if this was a recently planted fish. Collection of this fish and reports of fisherman catching them demonstrate that fish are surviving in the lake and growing to a catchable size.

We collected two northern pike that both were growing below state averages (Table 4). One fish was aged to be 5 years old and was 20 inches (state average is 25.4 inches). The second one was bigger (8 yr old) and also was growing below state averages (28 inches vs. 37.1 state average).

Largemouth bass were also growing slightly below state averages (Table 3). We only collected small specimens and not very many (3) of them, but those I analyzed were slightly smaller than the mean size of state averaged fish (Runyan 6 inches vs. MI 6.1 and Runyan 7.7 vs. 8.7 inches).

Bluegills were one of two fishes I aged that were growing faster than state averages (Table 4). Fish from Runyan Lake grew at or longer than state averages. Pumpkinseeds also grew about an inch longer than state average fish (Runyan Lake 4 yr: 6.5 inches vs. 5.7 inches and Runyan Lake 5 yr: 7.4 inches vs. 6.2 inches) (Table 4).

Table 4. Comparison of the ages of fishes collected in Runyan Lake (R. Lk; ages in bold) with the state average lengths in inches (MI) for fishes of similar ages (From Latta 1958). WL = walleye, NP = northern pike, LB = largemouth bass, BG = bluegill, and PS = pumpkinseed.

Age Group	WL R. Lk	WL MI	NP R. Lk	NP MI	LB R. Lk	LB MI	BG R. Lk	BG MI	PS R. Lk	PS MI
0		6.6		7.9		3.3		2.1		2
1		9.1		15.5	**6.0**	6.1	**2.9**	2.9		2.9
2		12		19.4	**7.7**	8.7	**6.4**	4.3		4.1
3		15.9		22.2		10	**7.1**	5.5		4.9
4		17.8		23.9		12.1	**7.2**	6.5	**6.5**	5.7
5	**19.7**	18.9	**20**	25.4		13.7	**7.3**	7.3	**7.4**	6.2
6		18.8		27.7		15.1	**8.0**	7.8		6.8
7		18.8		32.5		16.1		8		7.3
8		21.4	**28**	37.1		17.7		8.5		7.8
9		19.7		34.8		17.9		8.5		
10		22.6		44.4				9.2		

DISCUSSION

Dissolved Oxygen Profiles

The dissolved oxygen profiles I collected in previous years and in 2007-2008 were similar. The most critical profile was taken on 30 September 2007 and represents the maximum deterioration of the bottom waters. During this time the dissolved oxygen was almost zero on the bottom and was somewhat higher (1.2 mg/L) up to 43 ft or 14 m. This bottom zone of the lake would be a dead zone and no fish would stay in this area for very long before dying. There was therefore a stratum available from 20 to 43 ft that contained sufficient dissolved oxygen (>2 mg/L) and cold water temperature (>68 F or 20 C) that would support lake herring living in this area. Historical dissolved oxygen profiles show a similar pattern. This indicates that there was not a dramatic change in the dissolved oxygen conditions in the lake, leading to the demise of the lake herring and possibly poor growth conditions for walleye and northern pike. I would expect improvement in the dissolved oxygen conditions in the lake because of the diversion of septic tanks to the sewage treatment facility, while on the other hand global climate change would tend to exacerbate the lowered dissolved oxygen conditions in the lake. It appears that there has been no dramatic change in the amount of lowered dissolved oxygen that occurs in the bottom waters of Runyan Lake. Therefore, I concluded that oxygen and temperature conditions were sufficient to allow survival of lake herring, walleyes, and northern pike in this stratum of habitat to which they would be confined during the summer stratification period.

Walleye

Walleyes were stocked in Runyan Lake in 1999 (1,650) and in 2004 (1,600) to establish a put and take fishery. Usually several criteria need to be satisfied before stocking fish is attempted. These include: 1. Lake Rehabilitation, where there might have been only forage fish present perhaps due to winterkill of most fish or the lake was reclaimed with rotenone. Here top predators can be stocked to help control prey fish and provide a walleye fishery for a year or two. Planting of alewives into Lake Michigan is one successful example of a top predator controlling a nonindigenous prey fish. 2. There might be a situation where the fish community is destabilized, requiring some help for the native predators. For example, often stunted bluegills become abundant after Eurasian milfoil enters a lake since it provides too much cover for prey and then bluegills can often eat the eggs and fry from spawning largemouth bass, reducing their abundance. In this case, stocking bass is justified to bolster the native predators and attempt to establish a balanced fish community. 3. to attempt to provide a fishery in a lake that has an established population of top predators. In this case, the whole issue of stocking must take into consideration another principle in fishery science, carrying capacity. Lakes, like gardens, can only support a certain amount of biomass of plants or fish. A typical Michigan lake (Schneider 1995) can support about 100 pounds of all fish per acre; sport fish harvest averages about 30 pounds/acre. Runyan Lake is probably different and probably would have fewer pounds per acre because it is less fertile than the average Michigan eutrophic lake (a positive aspect of the lake). To increase that carrying capacity, one can harvest fish lower in the food chain or fertilize the garden or lake to increase productivity (something you just spent a lot of money on reversing when the sewage treatment plant was established). Stocking fish into an existing, balanced fish community is similar to planting sweet corn among the plants already growing in your garden in mid summer. The overall capacity of the garden does not increase, but what may happen is that adjacent plants do not grow well and neither does the introduced fish or plant.

Studies that have been done in Wisconsin (Nate et al. 2003) suggest that the best walleye survival occurs in lakes that are over 1,000 acres in size, are deep or turbid so as to provide walleyes with refugia to go to so as to avoid light, and had sandy bottoms. To this list should be added, sufficient dissolved oxygen and temperature conditions during maximum stratification to provide optimal habitat for walleyes. Christie and Regier (1988) quantified thermal habitat space (the amount of lake bottom and pelagic volume with temperatures within the walleyes optimal thermal niche) and found a strong correlation with yield for this species. In addition, the lake should not be stocked if there is a well balanced, native fish community present. The optimal range of water temperatures for walleye growth and development is 20-28 C (Hokanson 1977). The three populations of walleyes that are most famous in Michigan include Lake Erie, Saginaw Bay, and Muskegon Lake. All of these ecosystems are large, diverse habitats, with a place for walleyes to go spawn (reef, tributary, or marshes), a nursery area where larval walleyes can grow and flourish (Lake Erie, Saginaw Bay, Muskegon Lake), and then an ability of the adult fish to leave these areas and wander sometimes up to 100 miles away and then return (home) to spawning sites with great fidelity. Inland lakes seldom have these characteristics, unless they are very large systems. Studies done in Oneida Lake show that young yellow perch are the main prey of walleyes and that survival of young walleyes was directly related to the abundance of yellow perch (Forney 1976). When abundance of yellow perch was low, then cannibalism by walleyes on walleyes increased in these populations.

Past studies have shown that when top predators are stocked into a lake with established predators that there can be a range of responses from total disaster, to competitive interactions due to impacts on prey fish, to the fish being eaten by native predators (Santucci and Wahl 1993), to small returns. Genetic fitness of fish can also be impacted (Dexter and O'Neal 2004). For example, often northern pike that are introduced to eat bluegills will eat largemouth bass or yellow perch instead (Colby et al. 1987), because they prefer the topedo-shaped form of bass/perch to the larger ovid bluegills. Northern pike were shown to directly compete with and reduce the growth of walleyes in some lakes because of this competition for food aspect. A study of stocking walleyes into a lake in Illinois resulted in poor survival because of predation by largemouth bass in this centrachid (sunfish) - dominated lake. On the other hand, Schneider (1995) found that stocking walleyes can improve lakes with stunted bluegills or yellow perch. Other studies have shown that walleyes through predation reduced the abundance of salmon and trout and largemouth bass. This has implications for Runyan Lake, as the yellow perch population appears to have diminished substantially, northern pike are growing poorly (and walleyes might be too), while bluegills and pumpkinseeds are growing better than state averages. This response by bluegills is expected when their numbers are reduced through increased predation by predators, there is more food available and they grow faster. The management recommendations from the Nate et al. study was that walleyes should only be stocked into lakes with optimal characteristics (large, gravel bottom, ideal dissolved oxygen conditions) and with fish communities that are likely to support walleye reproduction, which included the presence of muskellunge, but not northern pike or largemouth bass.

Whenever I think about stocking a fish and putting them into a lake with an established, balanced fish community it is usually considered unjustifiable (Dexter and O'Neal 2004) or at best allowable as an experiment or justified due to special circumstances. The MDNR (Dexter and O'Neal 2004) lists three criteria and one of them must be met to justify any stocking into an existing fish community. 1. Natural reproduction is inadequate, 2. There must be a reasonable expectation that the quality of the existing fish community or fishery will not be diminished, and 3. The fishery produced must justify the cost of the stocked fish. In the case of Runyan Lake, stocking of walleyes could be considered based on the above criteria, because no natural reproduction of walleyes is expected nor as far as can be ascertained is currently ongoing. However, the other two criteria are probably violated, as I believe there was damage to the existing fish community and suspect that the cost to stock the walleyes far exceeded the value returned to the few fishermen who caught them. Given these considerations there are still other factors that suggest stocking walleyes could be considered on an experimental basis: 1.) the lake is mesotrophic to oligotrophic and has some coldwater habitat which would support cool water fish such as northern pike, walleye, and lake herring, 2.) it does have a sandy bottom in places and is deep enough to provide a refugia to walleyes from light, and 3.) Runyan Lake has a proven record of survival of walleyes from past plantings.

However, there are several drawbacks as noted above. It was my recommendation in 1979 not to stock any walleyes into Runyan Lake (Freshwater Physicians, Inc. 1979). I still think this is the best approach to managing the fishery for the lake. However, I can support stocking of walleyes only if it is recognized that there are potential impacts to the native species (yellow perch, lake herring, reduced forage for the other top predators) and it should be considered experimental so if any detrimental impacts are perceived the amount of stocking or no stocking at all should be the outcome. I do have two indications that walleyes may have impacted two species in the lake. The first of these is lake herring, which appear to be no longer present and yellow perch, which is considerably reduced in abundance, since the last studies done in 1979. Yellow perch is a preferred species by northern pike and walleyes, especially when other non-spiny rayed fishes are scarce or not present in the habitat that these species frequent. As noted there are several minnows and darters in the near shore zone, but these fishes may not be vulnerable to predation by northern pike and walleyes that are confined to a stratum in the middle of the lake away from shore during maximum stratification of the lake.

The Michigan Department of Natural Resources has guidelines for stocking walleyes (Dexter and O'Neal 2004). Usually it is recommended that 50-100 fingerling walleyes total be stocked for the first time and if some survive in subsequent years, then it is recommended that more be stocked in later years. They then recommend that about 10-40 fall fingerlings (5 inches) be stocked per acre. Survival should be monitored, but if it cannot be measured, then no stocking should be conducted for at least 3 years so that the effect of the stocking can be evaluated. One way to measure this is to measure the length of the walleyes and compare their length at age with Michigan averages (see Table 4). If they are growing poorly, then one can assume there are too many and growth is poor. Eliminate or reduce stocking rates in year 4. Considering that I believe that too many walleyes were stocked in the past, I recommend a more conservative approach using the minimum number (5/acre) or even fewer (1-2/acre) so as to reduce the impact they have on native fishes.

<u>Northern Pike</u>

We collected what I consider to be a representative sample of the northern pike in the lake. However, we did not get any young of the year fish. I also did not see any yearlings, hence, spawning success may be insufficient. One other recommendation is to check the tributaries for spawning fish during the spring. If there are any obstructions or other improvements that could be made to the streams to increase survival of northern pike, it should be done. Northern pike usually spawn over aquatic vegetation or flooded terrestrial plants; eggs stick to the vegetation. The larvae have an adhesive disk with which they stick to the vegetation early in their life cycle. After spending some time in the place where they are hatched, they move to the lake as a nursery area.

I note that the northern pike we collected were growing poorly; even so Runyan Lake appears to have a high diversity of fish in the community, with the exception of the lack of lake herring and reduced numbers of yellow perch. No stocking of northern pike is recommended at this time. Some method of determining whether they are spawning (were small northern pike caught by fishermen?) or finding them in the tributaries would help with the northern pike assessment.

<u>Largemouth bass</u>

Largemouth bass were collected in good numbers in the past and the few we collected were growing slightly below state averages. I needed more and larger fish to adequately assess their health. No stocking of largemouth bass is recommended, since bass make nests and usually prosper in well balanced communities where the sunfish are not stunted.

Yellow perch

Despite extensive seining and gill netting, we found no yellow perch in Runyan Lake, suggesting that their populations are very low. Some large individuals were caught during the summer fishing tournament, so they are not extinct in the lake, but they must be in very low abundance not to have any collected in our gear which are very selective for the spiny-rayed perch. This indicates that the likely possibility to explain this is predation. The likely predators that would prey on small yellow perch would include northern pike, walleyes, and large yellow perch, which are known to be cannibalistic. Even though these predators would prefer minnows, which are mainly near shore, these prey may not occur in the same habitat that the predators are usually found in during the summer stratification period – the cool, well oxygenated offshore portion of the lake. At other times when the lake is not stratified, the minnows and the predators would be more widely spread out in the lake and subject to predation. Reasons that might explain the lack of yellow perch in Runyan Lake include: 1.) Predation by adult yellow perch, walleyes, and northern pike (largemouth bass seldom prey on yellow perch), 2.) Some global climate change related phenomenon. Therefore, although it is speculation, the scarcity of yellow perch seems to be related to the stocking of walleyes which occurred back in 1999 and 2004. This is not unexpected when you introduce a predator into an existing fish community, since that predator will consume prey usually eaten by native predators or it may have other capabilities to exploit prey that were not exploited by the native predators. In this case, the high numbers stocked also exacerbated this situation.

Lake Herring

Lake herring is another species of concern and is an endangered species in Michigan (Latta 1995) only occurring in 153 lakes, some of which have lost their populations. Lake herring require water of >2 mg/L of dissolved oxygen and <20 C water temperatures to survive. MDNR (Dexter and O'Neal 2004) advise attempting to re-establish them in waters where they were once present and which have water quality conditions noted above. Lake herring is a sentinel species in Runyan Lake, since it indicates you have very good water quality and in addition, it is an excellent prey species, especially for northern pike (one 5 – inch lake herring was eaten by a northern pike in 1979). In our 1979 (Freshwater Physicians, Inc. 1979) and 1995 study (Freshwater Physicians, Inc. 1995) we collected two lake herring (7.4-7.8 inch) and 29 lake herring that ranged from 187 to 237 mm TL respectively. Studies have shown that the growth of large northern pike that exist in many Minnesota lakes is related to the presence of lake herring, which provide a large, energy-rich fish which grows to large sizes and provides large northern pike with a size of prey that is related to their gape width. In addition, northern pike (and walleye) co occur in the same oxygen-rich, cool environment in these lakes. Those conditions of optimal dissolved oxygen and cool temperatures were present in 1979 when we collected lake herring in the gill nets we set. In 2008 we did not collect any lake herring, nor were any of the fishers I spoke with able to confirm their presence by catching them or observing them in the stomachs of top predators they caught. This indicates to us that the lake herring population may be extirpated or at least at a very low abundance in the lake. Because the dissolved oxygen – temperature profiles have indicated little change since 1979, I believe that predation from the stocked walleyes is the likely cause of the scarcity of lake herring in the lake. Walleyes would prey heavily on lake herring since they prefer the same type of habitat and lake herring are not spiny-rayed fish and would be preferred over other available species such as yellow perch. The fact that northern pike have co occurred with lake herring in the past, suggests that they were not responsible for their demise, although they would certainly be another source of predation along with walleyes.

Bluegill and Pumpkinseed

Panfish from Runyan Lake grew longer than state averages. A reduction in numbers through predation and a decline in the number of smaller sunfish and other competitors would explain such a shift.

Other Species

I did not collect all the species in 2008 that I did in 1979 and 1982 (10 - 2008 vs. 17 - 1979 vs. 16 - 1995). Several species we did not collect (e.g., white suckers, longnose gar, rock bass, bowfin, green sunfish, warmouth, yellow bullheads) are expected to not have had dramatic changes in abundance as they were fairly rare in the lake during 1979 and 1995. These species although rare, add to the diversity of the fish population in the lake. One of the reasons that the fish community is so diverse is that there is a diversity of habitats within the lake, from the shallow wetland area (embayment on the south side), to the near shore vegetated areas – some with open sandy flats, to open water habitat (pelagic zone) providing an environment for cool water fishes, to the tributaries which provide spawning and nursery areas for species such as white suckers and northern pike, minnows, and darters. It is imperative that the association continues to ensure the integrity of these habitats, since their degradation will lead to a diminished fish community in the lake.

Fish Growth

The pattern I observed with fish growth, although based on very few samples, was that top predators-- northern pike and largemouth bass-- all were growing below state averages. Depending on how old the one walleye we got was, it too may be growing slowly in the lake. Further support of this was that the suspected main prey of these species, lake herring and yellow perch, were not collected at all in the extensive netting we did in 2008, while they were common in previous sampling in 1979 and 1995. Certainly we could have missed the main population, but this appears unlikely. Secondly, another group, which would be preyed on heavily after lake herring and yellow perch prey were reduced, would be the sunfish. In fact, these species both were growing faster than state averages, supporting a density-dependent (low density populations will grow faster) response.

Mercury in Fish

As is well known, most of Michigan's inland lakes are contaminated with mercury. Most mercury comes to the watersheds of lakes through deposition from the air with most coming from power plants burning coal. The elemental mercury is converted to methyl mercury through bacterial action or in the guts of invertebrates and animals that ingest it. It becomes rapidly bioaccumulated in the food chain, especially in top predators. The older fishes or those high on the food chain will carry the highest levels. Studies I have done in Michigan lakes and studies by the MDNR have shown that large bluegills, largemouth bass, black crappies, northern pike, and walleyes all contain high levels of mercury. This suggests that fishers should consult the Michigan fishing guide for recommendations on consumption, limit their consumption of large individuals, and try to eat the smaller ones. It also suggests that a trophy fishery be established for large northern pike, walleye, and largemouth bass, and some of the larger individual panfish in the lake, such as rock bass. Such a practice would also help to keep Runyan Lake in good balance with its prey populations.

RECOMENDATIONS

1. At some point additional gill netting should be done in Runyan Lake during maximum stratification when lake herring are concentrated in known strata of the lake to determine if they are still present in the lake. This would be late August or September.
2. I do not enthusiastically support stocking walleyes into the lake, because they appear to have diminished the lake herring and yellow perch populations of the lake, are not native, and the habitat for them, although adequate, is not ideal. However, if the association wants to continue the stocking, I could support it on an experimental basis. According the MDNR recommendations, 10-40/acre is the recommended level every 3 years. I suggest fewer (2-3/acre) be stocked (you stocked 6-8/acre) to reduce impacts on native species. Monitor walleye growth and compare the size of the fish caught via hook and line with Michigan averages for that age group (see Table 4) and if they are growing poorly or there are poor returns, I think stocking should be discontinued.
3. Monitor northern pike spawning in the spring spawning run; check out the tributaries to determine if there are any impediments to movement and whether suitable habitat is available for reproduction. Have fisherman report any small northern pike that are caught as an indicator of spawning success.
4. Do not stock any yellow perch, largemouth bass, or other species into Runyan Lake as these are native species that should reproduce well in the lake and if they are not (e.g., yellow perch) they are being eaten by top predators and stocking will have little impact on these populations.

5. Protect the diversity of the many habitats in the lake from destruction, degradation, or diversion by development, modification of the land through building more impermeable surfaces (tennis courts, driveways, giant swimming pools, etc.), or agricultural or local resident runoff of nutrients and other toxic substances.

ACKNOWLEDGEMENTS

I want to thank Stephen Hensler for help with fish collections and presenting the material in this report to the Runyan Lake Association in my absence, while I was saving the Great Lakes. It has been a pleasure working with Ivan Quinn, who arranged to use his pontoon boat on several occasions to assist us in setting the nets. He also coordinated the use of the association's vessel, commandeered a driver, and an assistant (thank you Steve Wells), who helped us pull nets and more importantly, provided us on-lake guide service about where to set nets and what species of fishes they have caught and where. Their assistance was congenial and invaluable. I also want to thank Tim Polakowski who provided fish stomachs, anecdotal information on fish distribution and presence, and stocking records. The association should be pleased that there are interested individuals who have the best interests of the lake in mind and who volunteer their time and equipment to attain the best advice for the health of the lake.

LITERATURE CITED

Colby, P., P. Ryan, D. Schupp, and S. Serns. 1987. Interactions in north-temperate lake fish communities. Can. J. Fish. Aquat. Sci. 44(Supl. 2):104-128.

Dexter, J. and R. O'Neal (editors). 2004. Michigan fish stocking guidelines. Michigan Department of Natural Resources Special Report no. 32. Institute for Fisheries Research, Lansing, MI. (HTTP://WWW.MICHIGAN.GOV.DNR/0,1607,7-153-10364-10951_19056-46270--,00.HTML)

Forney, J. 1976. Year-class formation in the walleye (*Stizostedion vitreum vitreum)* population of Oneida Lake, New York, 1966-73. J. Fish. Res. Board Can. 33:783-792.

Freshwater Physicians, Inc. 1979. A limnological and fisheries survey of Runyan Lake with recommendations and a management plan. FP Special Report 79-2. Brighton, MI 48114.

Freshwater Physicians, Inc. 1982. Studies of the limnology and bacteriology of Runyan Lake and its inlet streams during September 1982. FP Special Report 82-5. Brighton, MI 48114.

Freshwater Physicians, Inc. 1995. A fisheries survey of Runyan Lake, 1995 with recommendations and a management plan. FP Special Report 95-12. Brighton, MI 48114.

Fox, M. 1989. Effect of prey density and prey size on growth and survival of juvenile walleye (*Stizostedion vitreum).* Can. J. Fish. Aquat. Sci. 46:1323-1328.

Hokanson, K. 1977. Temperature requirements of some percids and adaptations to the seasonal temperature cycle. J. Fish. Res. Board Can. 34:1524-1550.

Latta, W. C. 1995. Distribution and abundance of lake herring in Michigan. Michigan Department of Natural Resources, Fish Division Special Report no. 2014. Lansing, MI.

Latta, William C. 1958. Age and growth of fish in Michigan. Michigan Department of Natural Resources, Fish Division Pamphlet no. 26. Lansing, MI.

Nate, N, M. Bozedk, M. Hansen, C. Ramm, M. Bremigan, and S. Hewett. 2003. Predicting the occurrence and success of walleye populations from physical and biological features of northern Wisconsin lakes. N. Amer. J. Fish. Mgt. 23:1207-1214.

O,Neal, R. 1997. Muskegon River watershed assessment. Michigan Department of Natural Resources, Fisheries Division Special Report no. 19, 187 pp.

Ryder, D. 1965. Dynamics and exploitation of mature walleyes, *Stizostedion vitreum vitreum*, in the Nipigon Bay region of Lake Superior. J. Fish. Res. Board Canada 25:1347-1376.

Schneider, J. 1995. Dynamics of a bluegill, yellow perch and walleye community. Michigan Department of Natural Resources, Fisheries Division Special Report no. 2020, Lansing, MI.

Santucci, Jr., V. and D. Wahl. 1993. Factors influencing survival and growth of stocked walleye (*Stizostedion vitreum*) in a centrarchid-dominated impoundment. Can. J. Fish. Aquat. Sci. 50:1548-1558.