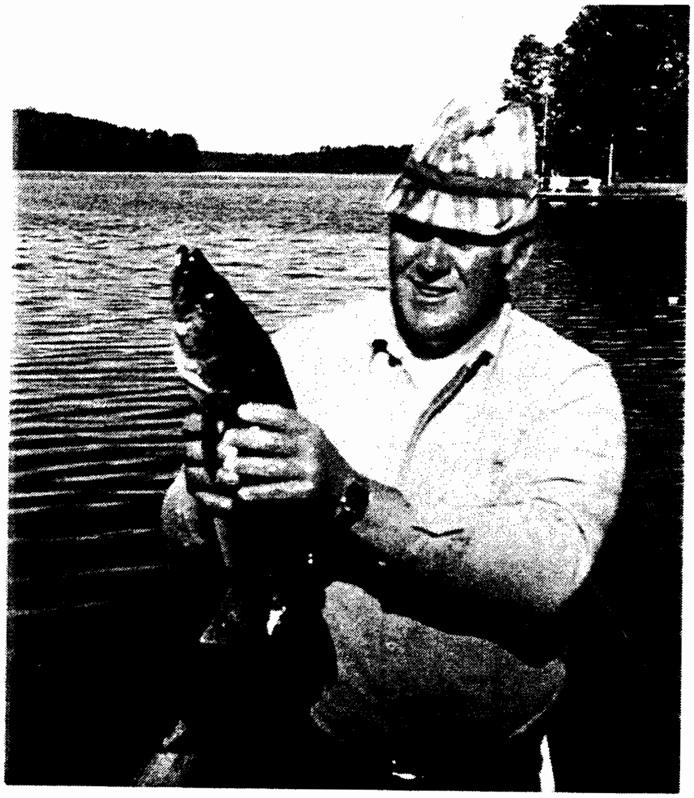
Bear Lake, Oneida County, Wisconsin
Comprehensive Lake Management Plan 1997

Table of Contents

Acknowledgments

Since 1985 I have had the good fortune to work with the Bear Lake District on a variety of projects.

Some of the personnel of the Bear Lake crew are shown on the next several pages.

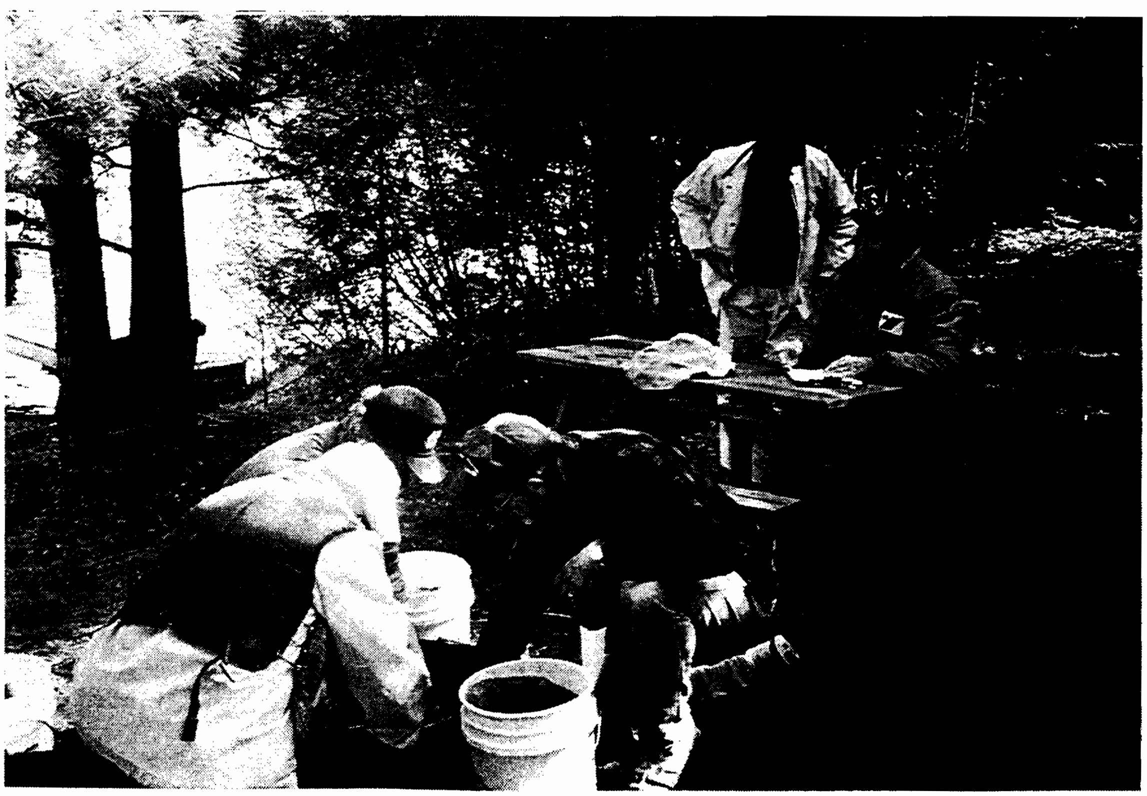


Dale Jalinski, Bear Lake fish removal project, 1985.

Bear Lake fish removal project, 1992.

Bear Lake outlet, 1992.

Bear Lake (and Big Bearskin) fish survey crew, 1993



top: Working up panfish in 1988.
bottom: Still working up panfish in 1996.

Part of the Bear Lake work force that contributed many hours in carrying out a variety of projects.

Bear Lake, Oneida County, Wisconsin
Comprehensive Lake Management Plan, 1996

Summary

Bear Lake is a 312 acre moderately fertile (mesotrophic) lake in Oneida County, Wisconsin. Bear Lake is managed for walleyes and has a macrophyte community that covers roughly 90% of the lake area although plants are not considered a major nuisance. The Bear Lake District has sponsored numerous projects funded entirely by the District and also in conjunction with the WDNR. The objectives of the previous studies and projects have been to evaluate existing conditions and to improve problems areas associated with stunted sunfish, low walleye population, sedimentation concerns, and watershed development and pollution inputs. This report summaries past projects, evaluates existing conditions and makes recommendations for future lake projects.

Watershed Lands

The watershed is the land around the lake that sheds water to the lake. The Bear Lake watershed encompasses 840 acres. The watershed land breakdown is 26% wetlands (219 acres), 69% forests (580 acres), and 5% residential (41 acres). The original landscape of this area 150 years ago was pine forest. Today most of the watershed is still forest. Residential land use is found primarily by the lakes edge and is seasonal in nature.

Springs and Septic System Status

Areas of groundwater inflow were characterized in 1977 and in our 1992 study. We found that the conductivity reading described inflow areas delineated from a groundwater using wells. There are a number of springs in Bear Lake. We conclude that conductivity surveys are as good as extensive groundwater studies using wells for finding areas of groundwater. A septic leachate survey designed to locate potential septic system inputs to Bear Lake was conducted almost 10 years to the day of the last septic leachate survey. Results from 1992 did not indicate any septic system problems.

Lake Sediments:

10,000 Years of Sedimentation in Bear Lake: In 1978 a soft sediment survey was conducted on Bear Lake. Thirteen different transects were followed, to determine of the sediment depth. It was determined at that time that the soft sediment depth was from a few feet to over 23 feet (the length of the pole) in depth. Based on the water clarity, it is expected that sedimentation rates are low.

Rate of build up: The rate of buildup is low. Sets of sediment traps were recovered in Bear Lake over the summer of 1992. Sediment traps were set in bays because these are the areas that have the greatest accumulation of organic sediment. Sediment traps were left in place for 108 days. When recovered we found a sediment accumulation in the traps of 3 inches. This equates to a sedimentation rate of 9 inches per year. However, this is not a new sediment deposition, but rather a resuspended deposition rate. Phosphorus content in the resuspended sediment was low. We concluded our method of evaluating sedimentation rates in shallow bays was not valid, but it did characterize resuspension.

Lake Sediment Fertility: Phosphorus fertility is low in the sediments of Bear Lake. However the iron is very high and the sediments have an acidic pH. Ten samples were collected from Bear Lake and were analyzed at Eco-Agri Laboratory in Willmar, Minnesota.

Lake Water Quality:

Secchi Disc: Is a black and white disc that is lowered into the water to determine the water transparency. Bear Lake resident, Dale Jalinski, has been collecting monthly secchi disc readings (April through November) continuously since 1985. Water clarity in Bear Lake is good.

Dissolved Oxygen and Temperature: Summer dissolved oxygen (DO) and temperature profiles, compiled from the information collected during the summer of 1991, indicate that the deeper water (greater than 20 feet) is nearly depleted of dissolved oxygen. The temperature remained basically the same from top to bottom indicating the lake frequently mixes (polymictic conditions). The average summer secchi disc for 1991 was 3.2 meters (10.4 feet).

Nutrients: Most of the total phosphorus readings for Bear Lake were below 25 ppb. Bear Lake would be considered to have moderate fertility. Phosphorus levels have not drastically changed since 1977. Orthophosphorus levels are moderate.

Lake Biology:

Algae: Samples collected in June 1986 did not support any algae. This could be explained by either our preservative was inadequate or algae densities were too low. Phytoplankton identification was conducted in June and July 1993 and bluegreens were dominant algae in Bear Lake.

Lake Plants: The aquatic vascular plant study conducted in 1991 was compared to one done in 1977. Plant coverage in 1977 was 81% of the lake, and in 1991 it was 89% of the lake. In the 1991 study plants were noted to be rooted in deeper water.

Zooplankton: The zooplankton results from August 1984 and from August 1991 indicate that numbers have remained about the same. The zooplankton results from June 1985, 1986, and 1991 appear to have more animals per liter than the August sampling. The potential impacts of biomanipulation from the removal of the stunted sunfish are inconclusive. However, water clarity has improved slightly in 1991 compared to 1984.

Bottom Living (Benthic) Animals (including rusty crayfish): Chironmids (nonbiting midges) were the most abundant (21 different genera) bottom living animals in Bear Lake. The samples taken in the aquatic plant locations had the highest species richness.

Fish: Stunted sunfish have been collected and removed from the lake since 1985 in hopes of removing some pressure on the food source so gamefish may have better recruitment. From 1985-1988 sunfish were removed and 1989 and 1991 were used as sampling years. Conclusions were that walleyes have not changed, white suckers are declining, but perch and northern pike are increasing. It appears that the fish community is adjusting to stunted panfish removal efforts conducted in 1985, 86, 87, 88, 89 and 1991. Scat netting found fertilized walleye eggs in spawning areas, but fyke netting found no evidence of natural walleye reproduction. The number of bluegills and pumpkinseeds over 6 inches has increased compared to 1985 data.

Wildlife: The Bear Lake District is actively working to attract additional wildlife to the area. Some of the projects that have been conducted are: installation of osprey nesting platforms and wood duck boxes around the watershed.

Lake Status: The Trophic State Index (Carlson's Index) indicates that Bear Lake is a mesotrophic lake, having a value of 41 for water transparency and 48 for total phosphorus. Something in Bear Lake is inhibiting the algae to grow because the water transparency is better then what would be expected in mesotrophic conditions found in Bear Lake.

Management Actions

1. How close is Bear Lake to experiencing nuisance algae blooms?

It's close but the lake is stable at this time. Bear Lake is approaching a phosphorus threshold, where if the threshold is exceeded nuisance algae blooms could occur in July and August. Basically, the turbid water/algae phase is undesirable and should be avoided. It is important to keep excess phosphorus from washing into Bear Lake.

2. What are impacts of backlot development?

Additional development in the watershed will add more nutrients to the lake. Protection projects can minimize impacts. Vegetation should be left in place where possible to reduce erosion and nutrient runoff into Bear Lake.

3. Should Bear Lake abandon the idea of improving the walleye community?

No. Bear Lake has the structural habitat for a good walleye population. However the odds are low of reestablishing a walleye population similar to the 1950s, due to changes in the whole fish community. Walleye stocking on alternative years is worth a try, but more expensive efforts are not cost effective at this time because of a low probability of success.

4. Does the Bear Lake District need to conduct panfish removal every two or three years or can gamefish handle it?

Panfish removal by the Lake District can be put aside for now. Gamefish may be able to take over. Future fish surveys and angler success will help determine if Lake District netting is needed.

5. Is aquatic plant management needed?

Not at this time. The plant community does not produce recreational nuisance conditions so it is best to minimize plant removal. Conventional plant harvesting is not needed. Actions should be ongoing to ensure that a vigorous plant community is maintained.

6. Is dredging necessary?

No. Benefits from dredging muck out of the outlet bay would not justify the cost at this time. Lake levels in normal years will allow the current types of activities to continue.

1. INTRODUCTION

Bear lake is located in a region pock-marked with lakes and lies on the Oneida and Vilas County border. A list of watershed and lake characteristics is shown in Table 1. Land use and lake depths are shown in Figure 1.

A watershed is the land area around the lake that captures rainfall and where all the drainage and runoff goes into the lake.

About one hundred years ago the area and the watershed of Bear Lake was dominated by pine forests. Many of the original pines that the first loggers saw were well over 400 years old. Most of the pine forest was cut in the late 1800's. Today we are looking at second and third growth forest for the most part.

The fish community in these northern Wisconsin lakes prior to settlement and prior to the onslaught of resorters was very different then found today. Gamefish species were dominated by large members and they probably exerted important control over prey species such as sunfish, minnows, and other slender body fish. Examples of some of the lake monsters are pictured in the early photographs and old newspaper articles from the area. A newspaper article from the Centennial Edition of the Cities of Minocqua and Woodruff (1988) describes some of the giant muskies that were caught in the early 1900's. Today much of Bear Lake and its watershed is still relatively undeveloped except for tier one development around part of the shoreline and some backlot development. The total number of residences is about 100, otherwise much of the watershed is a combination of forested land (second and third growth) and wetlands.

Table 1. Watershed and lake characteristics for Bear Lake.

Watershed		
Watershed acreage:		840
Land use:	Forests:	580
	Wetlands:	219
	Residential:	41
Lake		
size:	312 acres	
mean depth:	8.4 feet	
maximum depth:	23 feet	
shoreline length:		

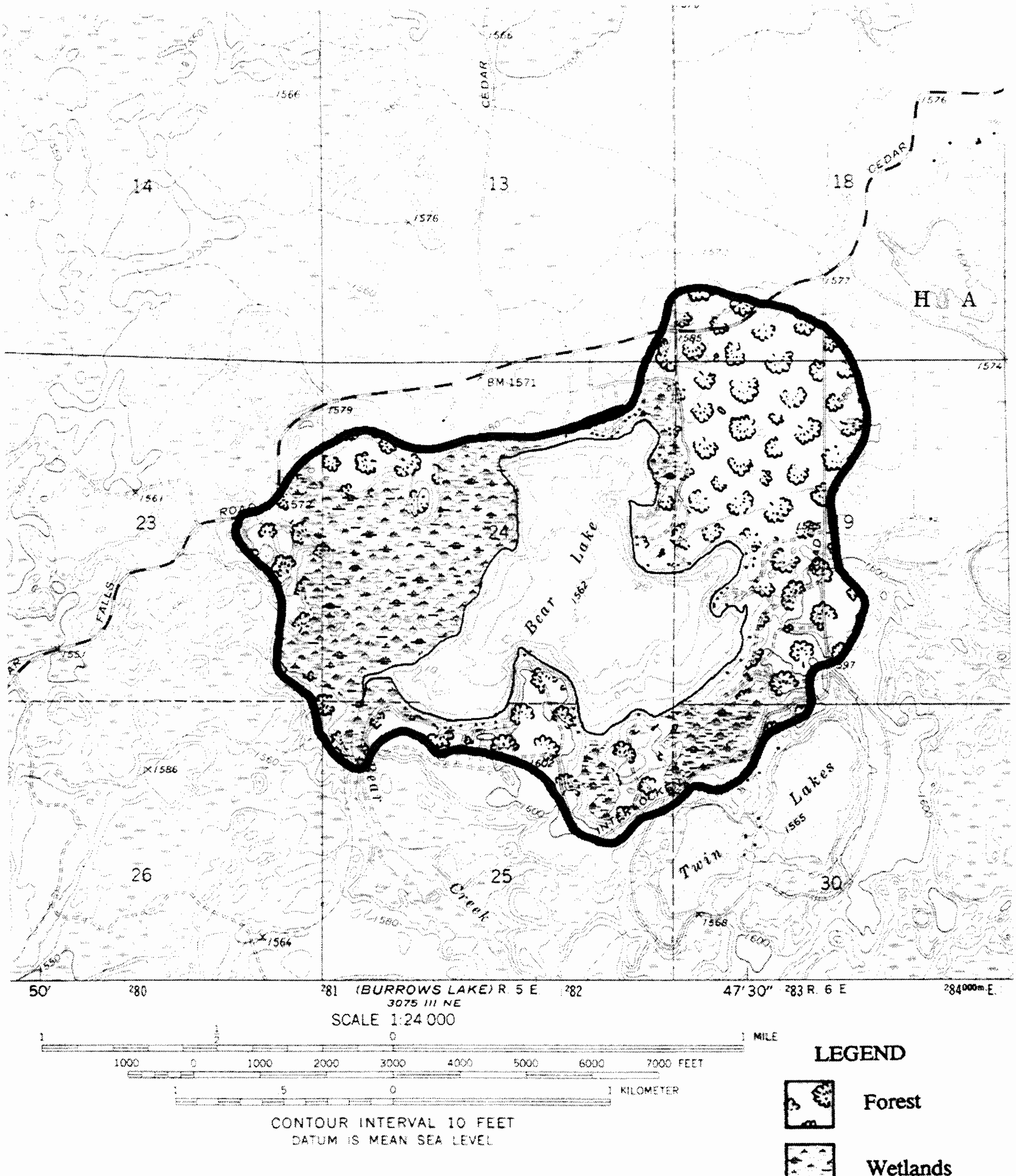


Figure 1. Bear Lake and the watershed.

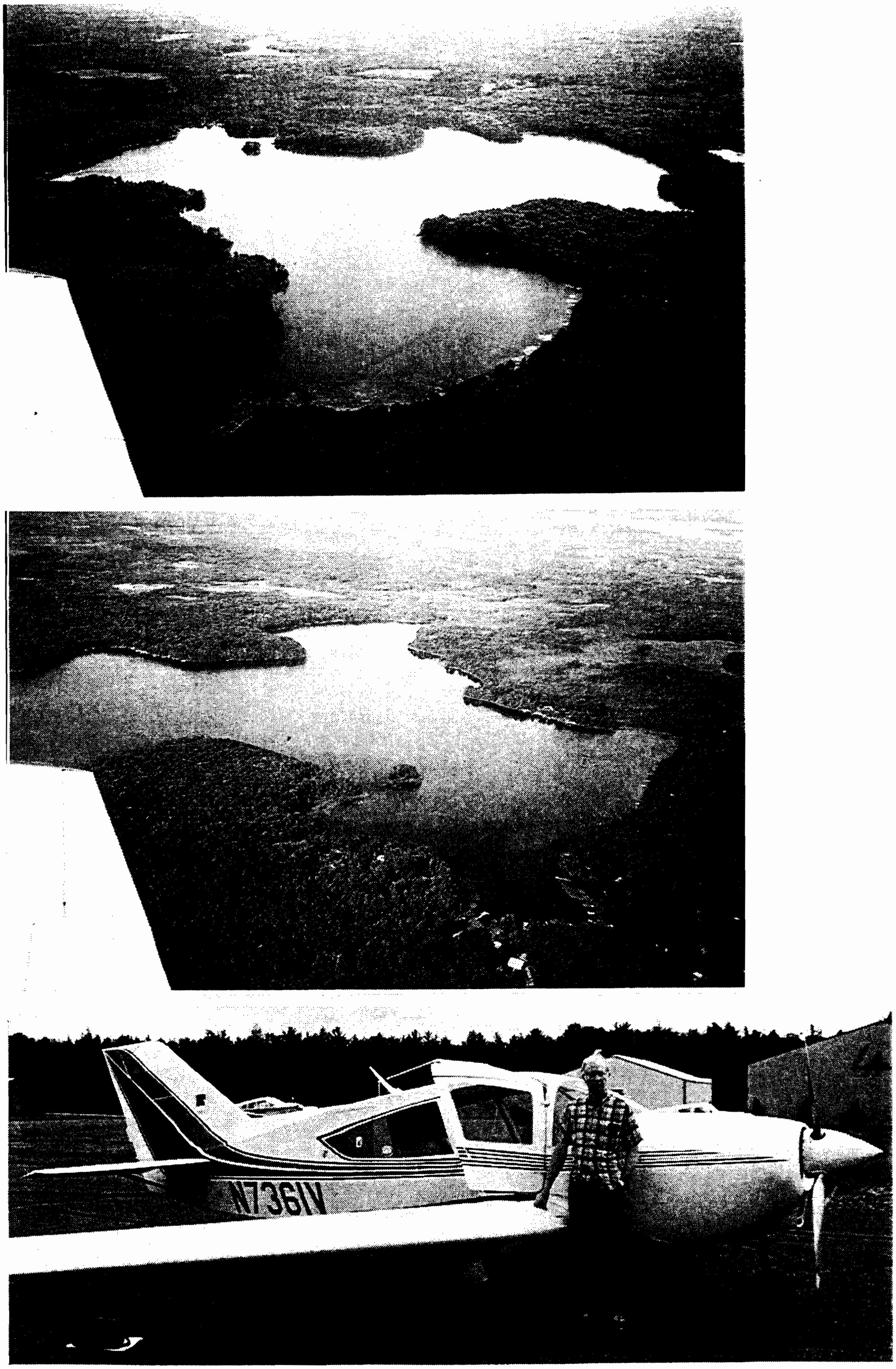


Figure 3. top and middle: An aerial view of Bear Lake (top and middle photo). bottom: We would like to thank Dr. VanProoien for the use the airplane and for taking the photos.

2. PAST PROJECTS

The Bear Lake Protection and Rehabilitation District was formed in 1977. Fish stocking and lake and fish surveys had been conducted prior to 1977 by WDNR, but detailed studies began after 1977. A summary of Bear Lake Studies and projects over the years is shown in Table 2.

Table 2. List of projects that have occurred on Bear Lake over the years. Specific stocking records are at WDNR-Woodruff.

Year	Project	Sponsoring Group/Contractor
1930s-present	Walleye stocking	WDNR
1964	Fish cribs	WDNR
1977	Formation of Lake District	Bear Lake Dist (BLD), WDNR
1977	Bear Lake Limnological Study	Northern Lake Service
1978	Bear Lake Feasibility Study	WDNR
1982	Septic leachate survey	Swanson Environmental
1982	Gamefish survey, Bear Lake	WDNR
1984	Summary of existing conditions and implementation manual	BLD, Blue Water Science
1985-present	Water Quality monitoring (twice a year)	BLD, UW-Stevens Point
1985-89 1991, 93, 96	Sunfish and bullhead removal using fyke nets	Bear Lake District and Blue Water Science (nets loaned by WDNR)
1987	Walleye stocking	WDNR
1988	Autumn shocking survey	WDNR
1989	Walleye stocking	WDNR
1989	Autumn shocking survey	WDNR
1989-present	Septic tank maintenance program	BLD
1989-present	Walleye spawning bed rejuvenation	BLD and Blue Water Science
1991	Nutrient budget, aquatic plant survey, zooplankton evaluation, panfish evaluation	BLD, WDNR, Blue Water Science
1992	Walleye stocking	BLD
1992	Fish survey, septic leachate survey, and sedimentation study	BLD, WDNR, Blue Water Science
1993	Fish survey	BLD, Blue Water Science
1994	Macroinvertebrate study	BLD, WDNR, Blue Water Science
1995	Lake soil study	Blue Water Science
1996	Panfish Survey	BLD, Blue Water Science
1996	Comprehensive study, lake magazine (this study)	BLD, WDNR, Blue Water Science

3. WATERSHED EVALUATION

3.1. Land use, streams, and nutrient inputs

Introduction: To help protect the water quality of Bear Lake, the amount of fertilizing nutrients going into Bear Lake need to characterized.

Methods: We used a U.S. Geological Survey map to delineate the Bear Lake watershed. Based on traveling around the area, and using aerial photos taken by Blue Water Science (and flown by Dr. Van Prooien) we made a map of land use in the watershed. We put this on the U.S.G.S. map and then used a planimeter to estimate acreages.

The Bear Lake watershed is approximately 840 acres and is dominated by forest (580 acres).

Results: General land use in the watershed is listed in Table 3. The Bear Lake Watershed encompasses approximately 840 acres. Of that 840 acres, forest lands dominate with 580 acres, followed by 219 acres of wetlands area and 41 acres of residential lands . A good part of the wetlands and forested area is papermill land and is currently undeveloped on the northwest areas of Bear Lake. Residential land use is composed of about 100 tier one cabins that are predominately seasonal in nature with about 9 to 13 homes being permanent.

Table 3 Land use in the Bear Lake watershed.

Wetlands	219 acres
Forest	580 acres
Residential	41 acres
TOTAL	840 acres

No permanent streams flow into Bear Lake. During rainstorms and snowmelt runoff, water goes down drainage ways. No serious erosional sources have been detected. Stream inflows have not been monitored.

Nutrient sources to Bear Lake have been estimated based on land use. A discussion of nutrient sources is presented in Section 5, the **Lake Status** section.

3.2. Groundwater Inputs and Septic System Status

Introduction: Septic tank/soil absorption systems are the main type of wastewater treatment around Bear Lake. We wanted to know if they were an important nutrient source to Bear Lake. At the time we were able to evaluate possible areas of groundwater inflow.

Methods: A septic leachate survey and groundwater inflow study was conducted on Bear Lake on August 15, 1992. For the survey we used a YSI (Yellow Springs Instruments) Conductivity Meter with the probe attached to an 8-foot pole. We proceeded around the shoreline in a boat and measured conductivity. The objective was to detect either an increase or decrease in conductivity as we went around the lake. We assumed an increase in conductivity could be an indicator of septic tank effluent entering the lake. We assumed a decrease in conductivity reflected groundwater inputs from groundwater that had a relatively short contact time with the soil.

On-site systems do not appear to be a major source of nutrients to Bear Lake. But they should still be check periodically.

Results: Septic tank systems do not appear to be a major nutrient source to Bear Lake. Open water conductivity was 56 umhos/cm and nearshore background was 59 umhos/cm. Several areas around the lake had below background conductivity readings. These may be areas of groundwater inflow (Figure 2). Several areas showed a conductivity reading of 1 or 3 umhos/cm above background. These maybe areas of septic tank effluent inputs. We did not perform any water testing. Typically, phosphorus measurements taken from suspected plumes are inconclusive.

Discussion: Impact of Onsite Systems on Bear Lake and Groundwater Inflow

In 1977 Northern Lake Service conducted a groundwater survey on Bear Lake. Their results indicated that at the time of the survey groundwater was not a big influence on the water quality of the lake. Northern Lake Service also concluded that of the eight sites that were studied, four flowed into the lake and four flowed away for the lake. All four that flow toward the lake had higher conductivity values and higher concentrations of chlorides than the values that were found in the lake. They concluded that this meant that humans had influenced the groundwater.

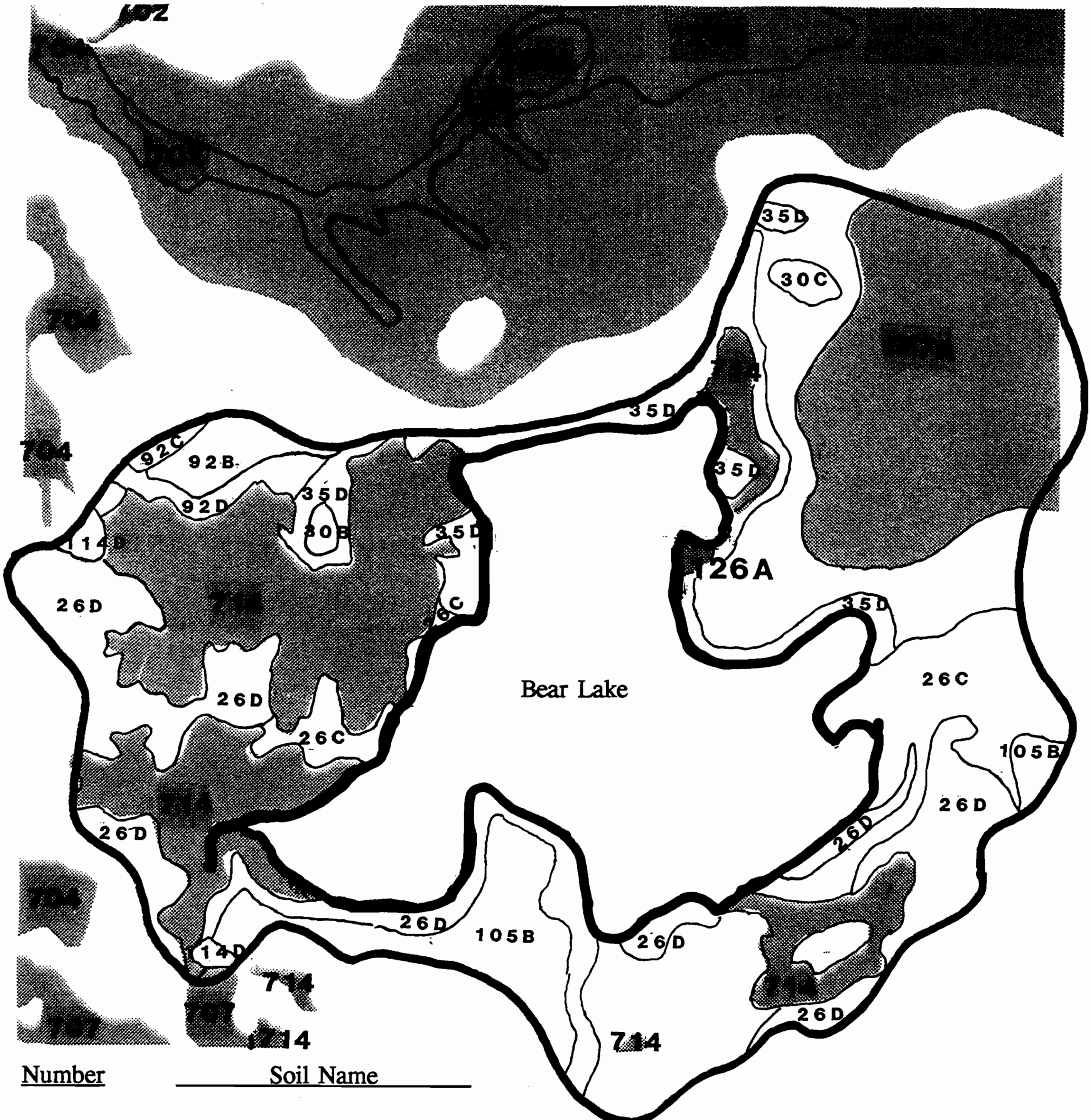
There are four incoming springs and four outgoing springs in Bear Lake. They don't appear to be very influential on the water quality of Bear Lake.

The methods that they followed were to collect water samples monthly from the 15 wells that were placed around the lake. The wells were placed, one near the lake, and one away from the lake. There was no off site location of wells at A and B because of the rocky terrain. Only one well was placed at the outflow. Three deep wells were placed next to sample sites A, E and G. These deep wells were used to determine vertical groundwater flow.

In the following year, Wisconsin Department of Natural Resources (WDNR) interpreted the results from the Northern Lake Service to show that there were five sources of groundwater entering the lake and four spots where water was leaving the lake (Figure 2). The groundwater that was entering the lake was very good and the lake's nutrient concentration was low. It was stated that because of the long water residence time, any major changes in the groundwater quality could have a longterm effect on the lake water quality.

When the Blue Water Science conductivity survey is compared to the WDNR groundwater survey, the conductivity survey's results are very close to what was found with an extensive well installation and monitoring program.

We conclude that with cautiously interpreting conductivity surveys, that general areas of groundwater inflow can be determined. When looking at WDNR input arrows and comparing with conductivity readings, there is some overlap of areas of predicted inflows. Conductivity readings show broad areas of inflow (by looking at elevated or depressed conductivity compared to open water (background) readings. I believe in many cases, groundwater enters a lake as a diffuse front, so WDNR arrows probably indicate a diffuse inflow area and not a point source inflow. In this respect a conductivity survey is very inexpensive and quick and probably can be used as a lake management tool. One component that is missing from these types of groundwater studies is the magnitude of groundwater inflow. Inexpensive techniques for determining the volume of groundwater inflow is not available (seepage meters generally are not satisfactory). However, some promising techniques that Blue Water Science is developing may soon be mainstream (flow velocity measurements, etc).



Number	Soil Name
26	Padus-Pence sandy loams
30	Vilas loamy sand
35	Vilas loamy sand
92	Keweenaw-Vilas loamy sands
105	Padus sandy loam
114	Sayner-Vilas loamy sands
126A*	Au Gres loamy sand
127A*	Croswell loamy sand
714*	Greenwood & Loxley soils

*soil with an asterisk have severe soil limitations for on-site systems due to seasonal high water table. They are also organic soils.

Figure 3. Soil map of Bear Lake watershed. Problem soils are indicated with gray shading.

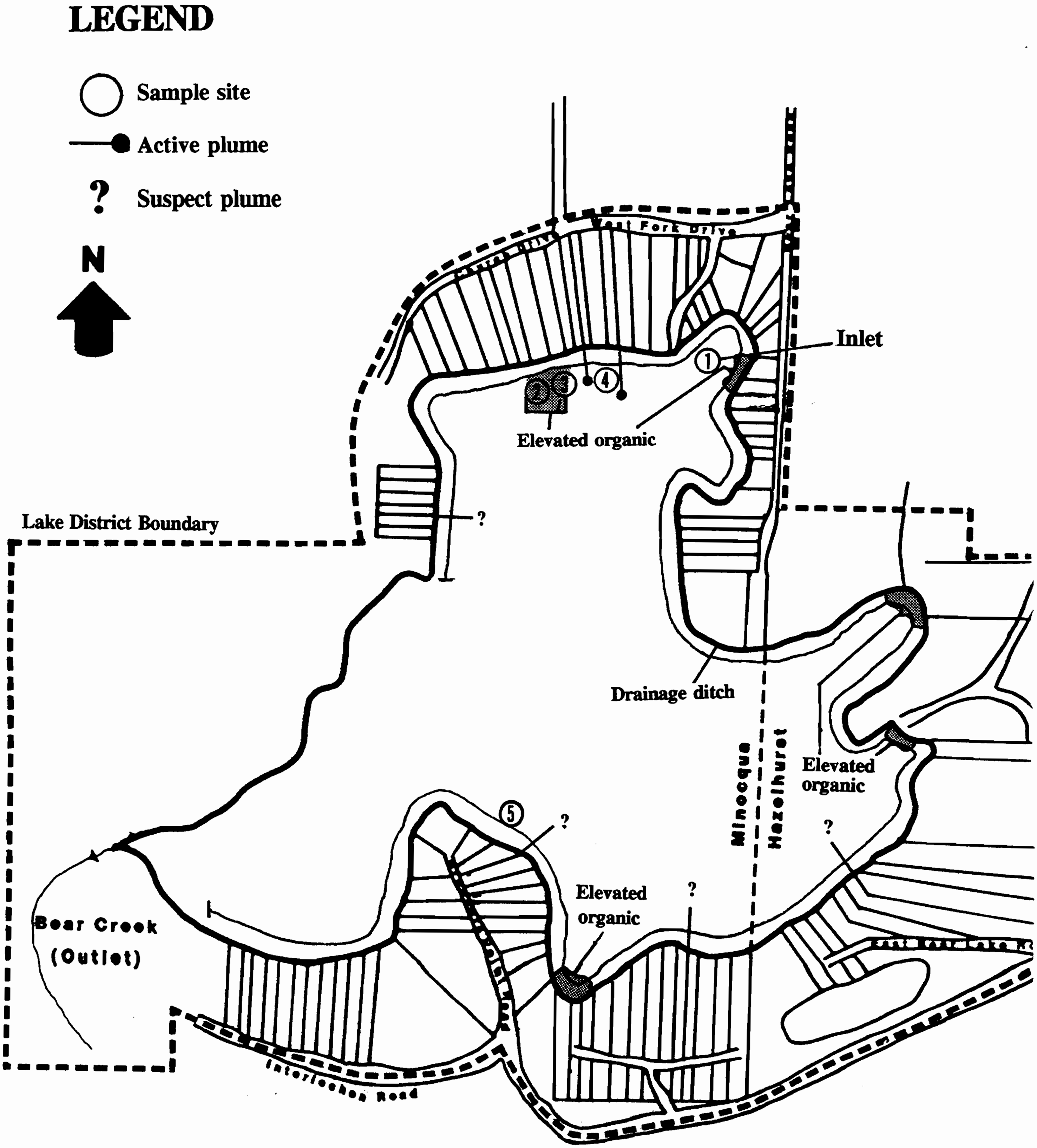


Figure 4. Septic leachate survey from August 17-19, 1982 using the fancy septic leachate rig an ENDECO Septic Snooper™ Model 2100 (Fluorometer and conductivity meters). Survey was conducted by Swanson Environmental, Inc.

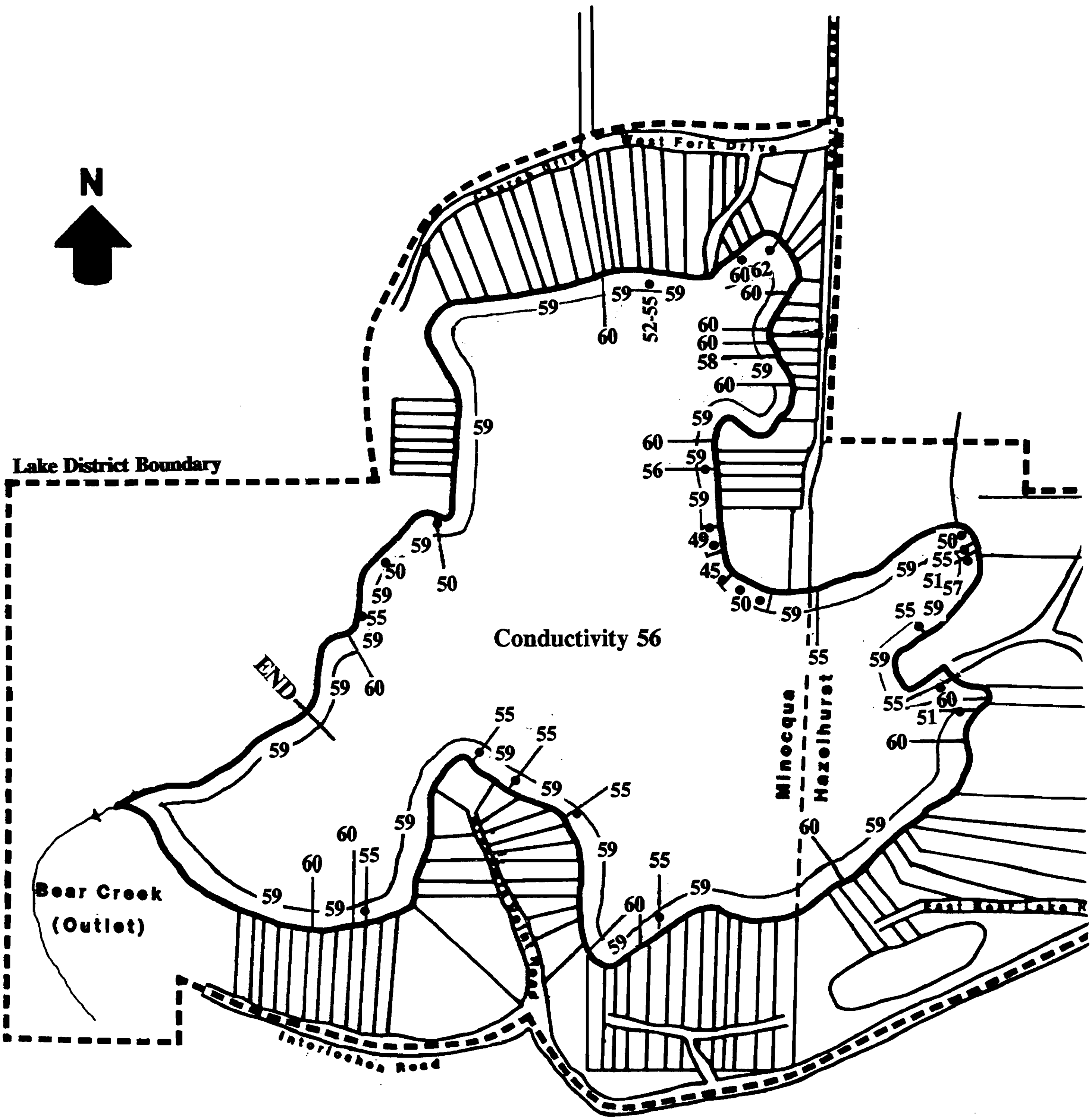


Figure 5. Results of septic leachate for Bear Lake, August 15, 1992.

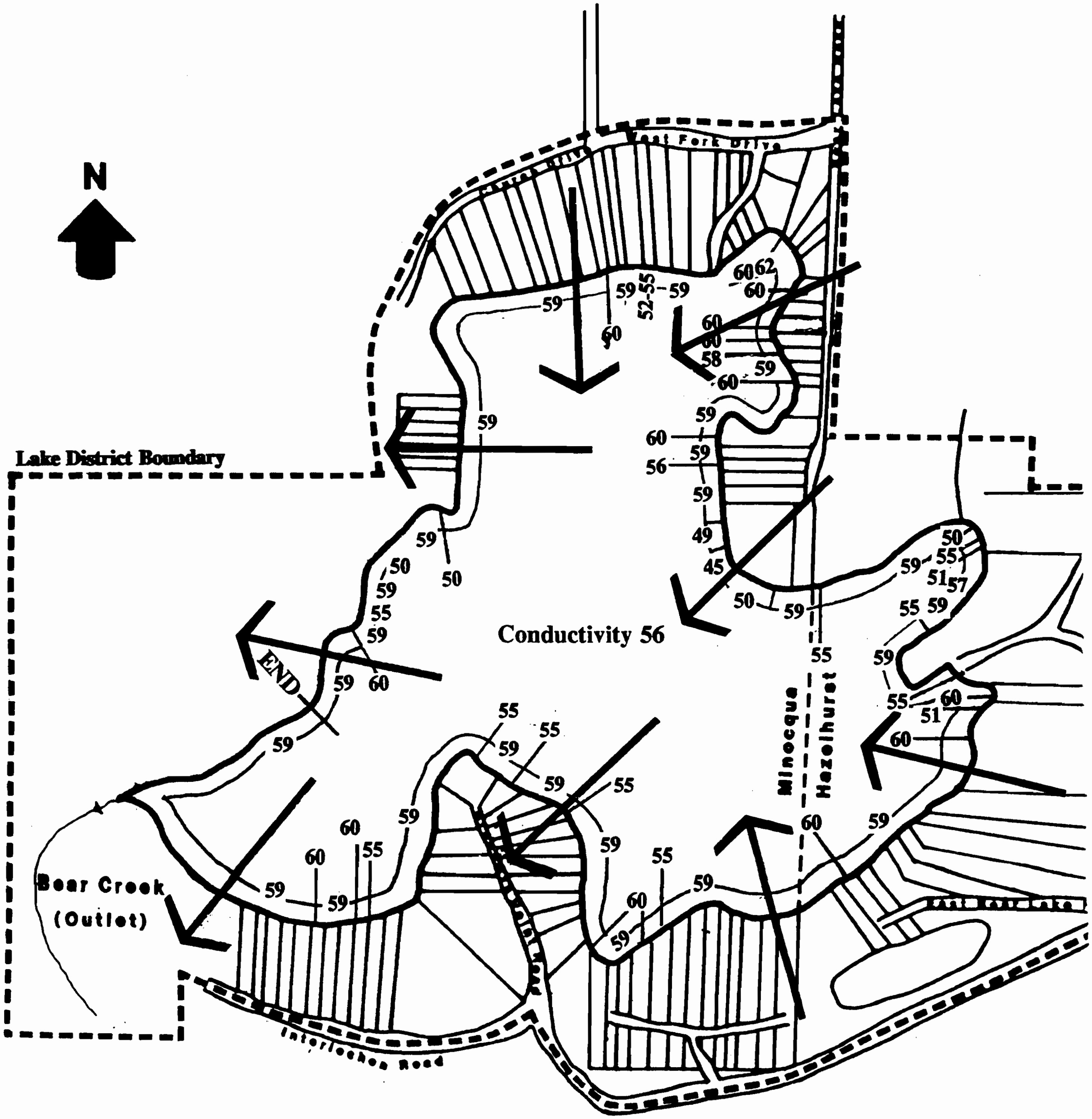


Figure 6. Areas of inflow and outflow as determined by the WDNR 1978 are shown with large arrows. These roughly correspond to areas of changes in conductivity indicating areas of groundwater inflow.

3.3. Watershed Rules and Regulations Pertaining to Zoning, etc

Introduction: Increased development around lakes acre lead to a degradation of lake water quality. State, county, and township rules and regulations have been formulated to protect natural resources. The intent of this section was to highlight the pertinent rules and regs and is not, by any means, all encompassing.

Methods: We called Oneida County Zoning to get the latest information.

Results: Excerpts from County information is shown in Appendix A. Rules and ordinances change from time to time, so we put the latest ordinance in the Appendix so it can be updated.

Rules and regulations are designed to protect property rights of the owner and to protect the natural resources of the north woods setting. Enforcement of the regulations is the key to accomplishing the ordinance objectives.

4. LAKE CHARACTERISTICS

Bear Lake is a 312 acre mesotrophic lake in Oneida County, Wisconsin. General Lake characteristics are shown in Table 4.

Table 4. Bear Lake Characteristics

Area (Lake): 312 acres (126 ha)
Mean depth: 8.4 feet (2.6 m)
Maximum depth: 23 feet (7 m)
Volume: 2,620.8 acre-feet (327.6 Ha-M)
Fetch: 1.2 mile (1.9 km)
Watershed area: 840 acres (340 ha)
Watershed: Lake surface ratio 2.6:1
Estimated average
water residence time 2.98 years
Public accesses (#): 1
Inlets: 1 Outlets: 1

Land Use (percentage/area):

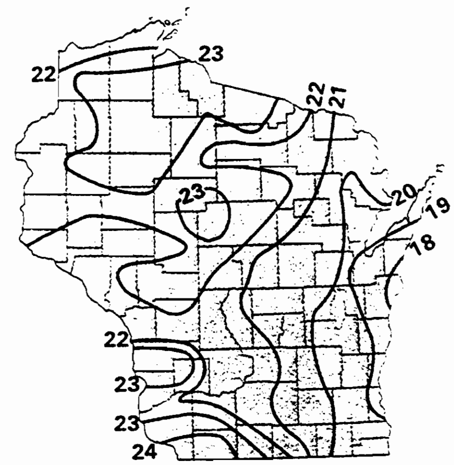
	Forest	Wetlands	Urban-Res
Percentage	69	26	5
Acres	580	219	41

Development (Homes):	Seasonal	Permanent	Total
	85	11	96

Land use is dominated by forest crop and a large percentage is owned by paper mills. Wetland areas are significant and residential acreage represents only 5% of the watershed. With good stewardship of watershed acreage, Bear Lake has a good chance of maintaining good water quality.

4.1. Ice Out and Rainfall Data

Introduction: Dale Jalinski, Bear Lake resident, has been tracking ice out since 1978 and rainfall since 1985 at Bear Lake. Ice out dates sometimes may influence fish spawning dates, because spawning is temperature dependent. Rainfall amounts are helpful to have because they can give insights into possible nutrient loads associated with runoff. In wet years, sometimes more nutrients are washed into the lake than in dry years.



AVERAGE PRECIPITATION
(April to September, inclusive)

Methods: Dale Jalinski has kept a rain gage on his deck since 1985 and checks it weekly. His cabin is on the south side of Bear Lake. He has either observed or got first had accounts of ice out dates since 1978.

Results: Ice out dates and growing season rainfall amounts are shown in Table 5. Since 1978, the earliest ice out date was April 5 and the latest was April 30.

There does not seem to be a correlation between rainfall and average summer seechi disc measurements.

Table 5. Bear Lake records for ice out and rainfall, as well as summer average secchi disc. (Source: Dale Jalinski, Bear Lake property owner)

Year	Ice out Date	Rainfall (May1-Nov1)	Secchi Disc (ft) (Avg. May-Sept)
1977		22.0	9.4
1978	April 23	--	--
1979	April 29	--	--
1980	April 19	--	--
1981	April 13	--	--
1982	April 30	--	--
1983	April 27	--	--
1984	April 15	--	--
1985	April 19	32.4	9.2
1986	April 9	24.0	10.0
1987	April 8	19.4	10.6
1988	April 11	19.3	11.4
1989	April 22	16.8	10.8
1990	April 5	30.5	11.3
1991	April 13	28.3	10.7
1992	April 28	21.6	11.2
1993	April 27	26.0	9.6
1994	April 15	33.3	11.6
1995	April 18	25.6	10.9
1996	May 8	20.1	9.9

4.2. Lake Sediments

10,000 Years of Sedimentation in Bear Lake

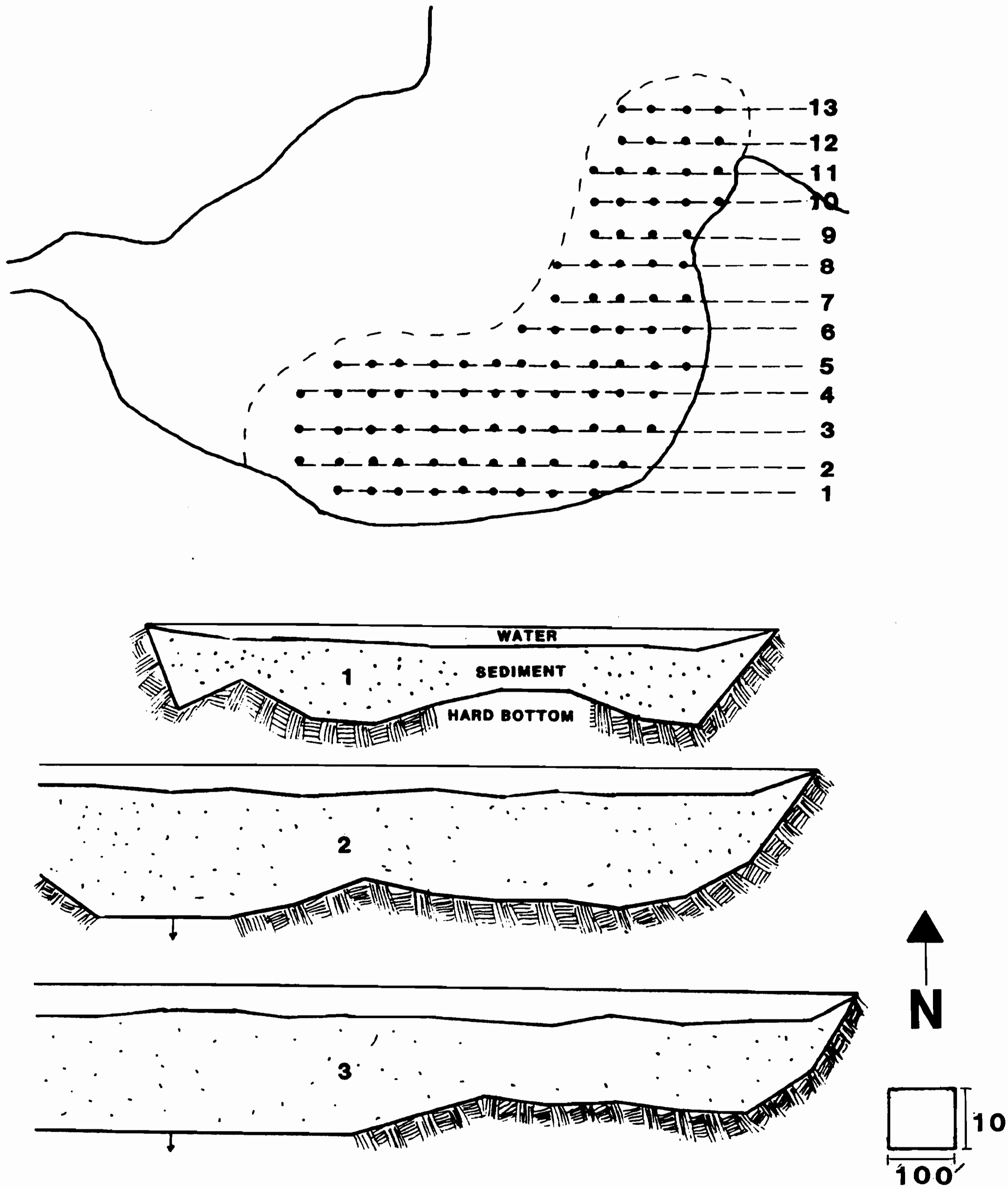
Introduction: Sedimentation is the build-up of material, usually gravel, plants, and other organic matter, in a lake or river basin. This build up has been happening on Bear Lake for about the last 10,000 years, since the last glacier receded.

Results: In 1978 a soft sediment survey was conducted in the southern bay of Bear Lake to determine the depths of the soft sediments. It was determined at the time that the depths of the sediments ranged from several feet to greater than 23 feet (the length of the probe was 23 feet). It was not, nor could it be now, determined the exact rate at which the sediments are being deposited on the bottom of Bear Lake. Of the several methods for determining the general rate of sedimentation one is to use radioactive isotope markers that are found in the sediments. Another approach is to use sediment traps that are placed in the water for a given period of time. When these traps are removed the rate of sedimentation can be determined. Although we tried sediment traps, they did not work. The next try could be radioactive markers.

The sediment depths in Bear Lake currently range from a few feet to over 23 feet.

Transect locations for the Bear Lake soft sediment survey are shown in Figure 7. During each transect the depth of the soft sediments were measured using a steel rod with extensions through the ice. The results are shown in Figure 7 as sediment/water cross-sections.

Because erosion sources are not evident and because water clarity is good (low algae) sedimentation rates are expected to be low.



↓ indicates soft sediments are deeper than 26 feet

Figure 7. Soft sediment in the southwest bay of Bear Lake (modified from Northern Lake Service. 1978. Report to Bear Lake). Transect locations are shown in the top figure.

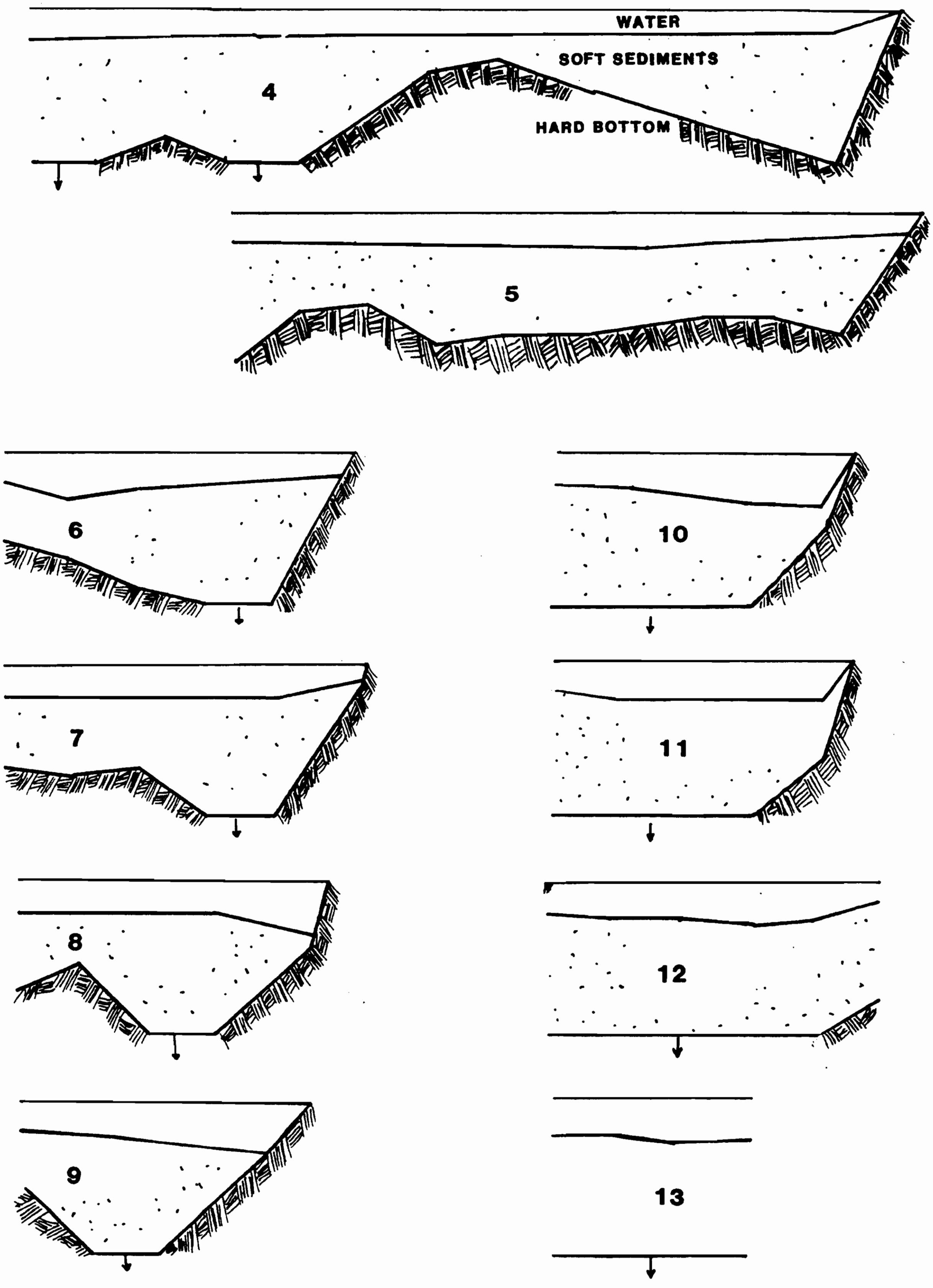


Figure 7. Concluded.

Rate of Sediment Build Up in Bear Lake

Introduction: Bear Lake is relatively shallow and the outlet bay is only 3 to 4 feet deep. The Bear Lake District has wondered for years if they should dredge it or not. Along those lines, they have inquired about sedimentation rates. Also we have wondered about the fertility of the bottom sediments.

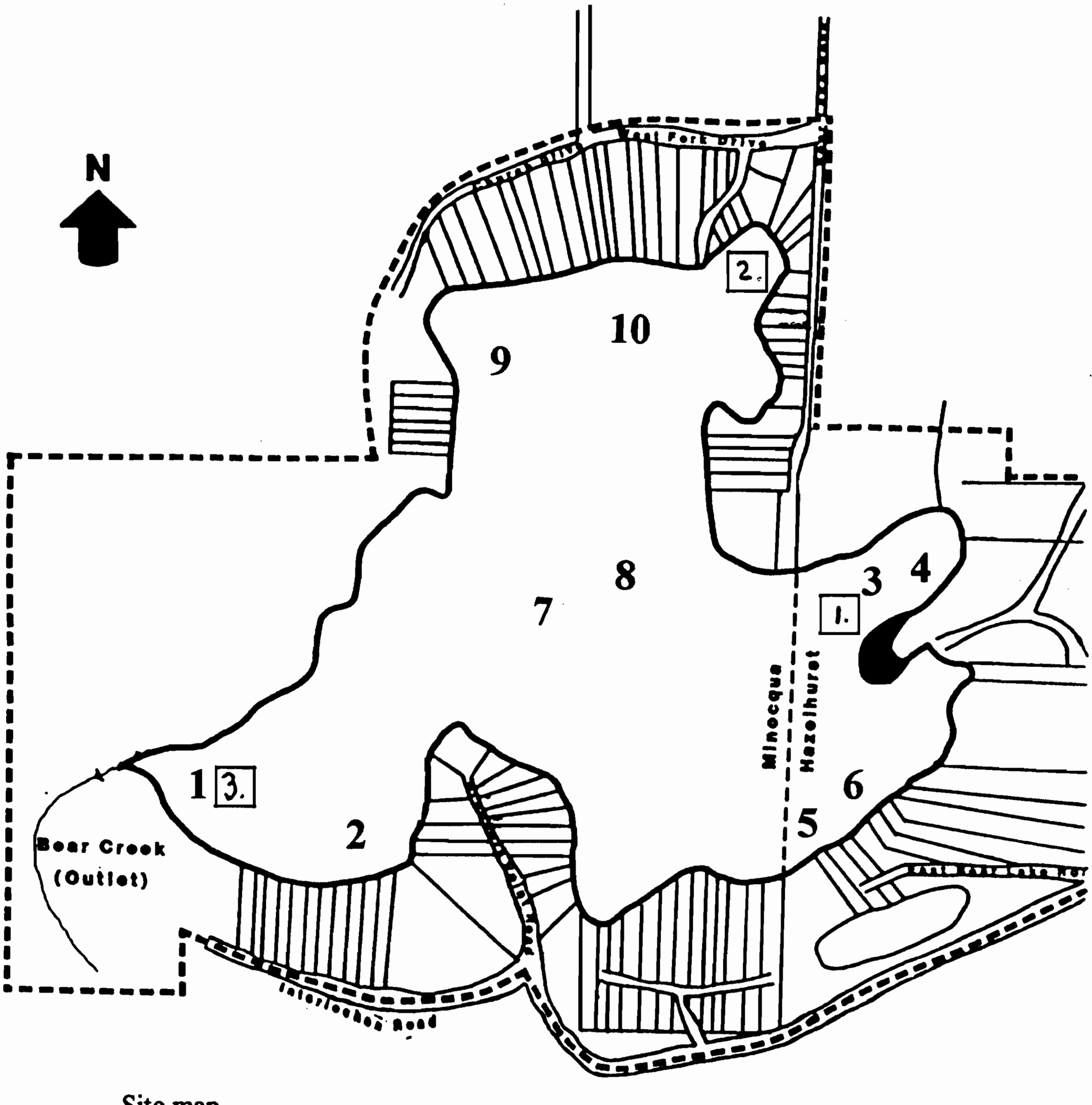
Methods: To evaluate sedimentation in shallow bays, we deployed sediment traps in three locations (shown in Figure 8). The intent was to get a sediment accumulation rate in these shallow bays. The sediment traps consisted of two upright plastic bottles and one inverted plastic bottle taped to a PVC stake. The stake was inserted into the sediments and the top of the bottles were 1-foot off the bottom. Sediment traps were placed on April 29, 1992 and were removed on August 16, 1992. Contents of the bottles were analyzed for total phosphorus, total suspended solids, and total volatile solids. Sediment traps were placed in 5-feet of water (Station 1 and 2) and in 3-feet of water (Station 3).

Results: The amount of the sediment recovered in the traps was unexpectedly high (Figure 9) about three inches in each bottle. Contents of the sediment traps were analyzed for total phosphorus and solids and results are shown in Table 6.

Table 6. Laboratory results of the sediment traps.

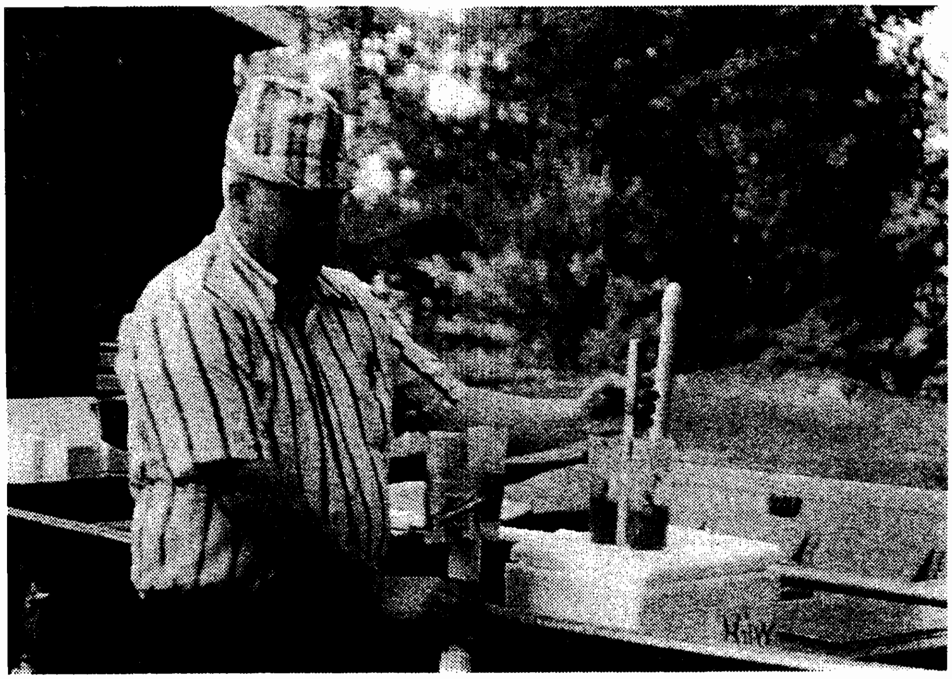
	Sample 2	Sample 3a	Sample 3b
Water depth	5 feet	3 feet	3 feet
Total Phosphorus (mg/L)	17.3	7.02	11.7
Total Solids (mg/L)	12,900	9,460	13,020
Volatile Solids (mg/L)	8,060	6,390	8,910
Percent Volatile Solids	63%	68%	68%
Calculated resuspended phosphorus (mg/m^2/day)	12	5	8

From the laboratory results, total phosphorus that was resuspended and captured in the bottle was calculated on a square meter of lake bottom and results are shown in Table 6. The phosphorus concentrations (17.3 mg/l) was multiplied by the volume of sediments in the bottle (194 ml) to give a mass of 3.4 mg of phosphorus. The bottle opening was 25.4 cm^2. Based on a square meter basis, we get 1,339 mg-P/m^2 over 108 days = 12 mg-P/m^2/day.



Site map
Lake sediment sample sites = numbered sites

Figure 8. Lake sediment study locations. Sediment traps used for sediment buildup test are shown with squares and lake sediment sample sites for fertility testing are numbered.



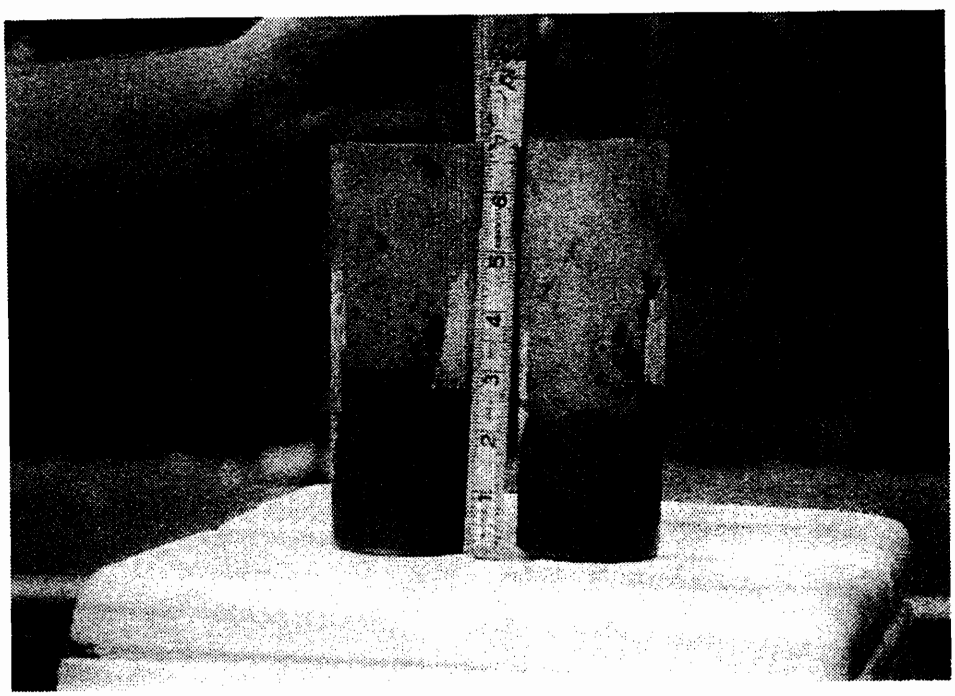


Figure 9. Photographs of sediment traps contents.

Lake Sediment Fertility

Introduction: Lake sediments can have a big influence on algae growth by releasing nutrients into the water column and by serving as a medium for rooted plant growth. To evaluate the fertility of Bear Lake sediments, we collected samples for analysis.

Methods for Lake Sediment Analysis: We collected surficial lake sediments from ten sites around Bear Lake using a modified flap corer (McComas design). Sediment locations were shown in Figure 8. Sediments were stored in sealed plastic bags and sent to Eco Agri Laboratories, Willmar, Minnesota. Sediments were dried, and then tested using standard agricultural soil testing methods.

Results: Overall the phosphorus fertility in Bear Lake sediments is low. This is a good sign. Other findings are that iron is very high and that the sediments have an acidic pH. Individual site results are shown in Table 7 and lake averages are shown in Table 8.

Because using soil testing methods on lake "soils" is a relatively new idea, we do not have a large data base to use for comparison. My experience with interpreting the soil results indicates that overall fertility is low, but adequate to support a diverse aquatic plant community. I do not think internal phosphorus loading would be a big problem in the future.

Table 7. Bear Lake sediment analyses using standard agricultural soil tests. Results are in ppm, except for cation exchange (meg/100 g) and pH.

	1. Outlet Bay	2. Outlet Bay	3. Northern Bay	4. Northern Bay	5. Hazelhurst Line	6. Hazelhurst Line	7. Middle	8. Middle	9. North Shore	10. North Shore
Water Depth (ft)	3	3	7	8	6	8	20	20	6	8
Phosphorus (P2O5) Bray (ppm) Olsen (ppm)	 5.2 4.1	 3.0 4.5	 8.6 5.2	 6.7 4.3	 4.9 1.7	 6.7 5.1	 10.0 6.0	 6.0 5.1	 7.3 3.4	 6.9 2.2
Potassium (K2O)	28	29	41	54	15	20	28	28	20	12
Iron	>150	1746	910	>150	1378	1008	1042	>150	960	888
Manganese	20.8	23.2	9.24	7.14	9.58	7.8	9.32	16.2	20.6	24.9
Zinc	2.08	4.4	2.7	1.72	4.2	2.32	1.3	1.26	4	2.78
Copper	0.18	0.48	0.12	0.06	0.16	0.08	0.02	0.02	0.6	0.24
Calcium	1000	840	720	1920	440	520	760	1120	520	440
Magnesium	20.8	23.2	9.24	7.14	9.58	7.8	9.32	16.2	20.6	24.9
Sodium	10	19	14	20	16	8	15	18	16	12
Sulfur	--	--	--	349	173	227	--	--	102	54.9
Cation Exchange Capacity	--	13.7	--	26.0	11.7	14.2	5.0	7.2	10.6	9.9
pH	--	5.4	--	4.5	4.9	4.9	n/e	n/e	5.1	5
Buffer pH	--	6.3	--	6.3	6.3	6.1	--	--	6.4	6.4

Table 8. Summary and comments for Bear Lake sediment analysis.

	Bear Lake		Comments
	Average	Range (n=10)	
Phosphorus Bray	6.5	3.0-10	Low phosphorus
Olsen	4.2	1.7-6.0	Low phosphorus
Potassium	27.5	12-54	Low
Iron	838.2	150-1746	Fairly high
Manganese	14.9	7.14-24.9	Low
Zinc	2.7	1.3-4.2	Normal
Copper	0.2	0.02-0.48	Normal
Calcium	828	440-1920	Low
Magnesium	14.9	7.14-23.2	Low
Sodium	15	8-20	Normal
Sulfur	181	54.9-349	Normal
Cation Exchange Capacity	12.3	5.0-26.0	Slightly high
pH	5.0	4.5-5.4	Fairly acidic

4.3. Lake Water Quality

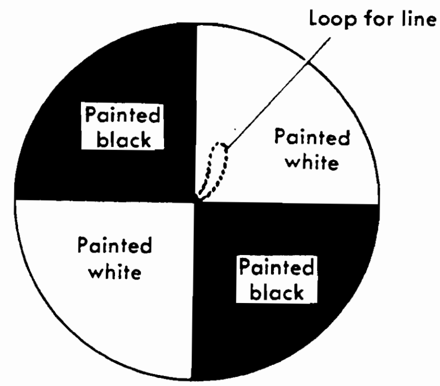
Secchi Disc, Dissolved Oxygen, and Temperature

(text and figure prepared by Dale Jalinski, Bear Lake resident)

Introduction: The secchi disc is a black and white plate that is lowered into the water until you can no longer see it. The depth it disappears is the secchi disc transparency depth.

Methods: The information under the heading of secchi-disc reading contains the recorded secchi-disc reading as recorded in the years of 1977, 1985, through 1996 (Table 9). These readings were made at the deepest hole in Bear Lake.

The information under the Secchi-Reading averages is the information that was used to graph and evaluate the actual reading. 1977 is considered the base year in all graphs.



Picture of secchi disc.

Results: Data shows an overall improvement in the water clarity of the lake in each succeeding year with the exception of the years of 1989, 1990, 1991, and 1995. Data shows that in the years of 1989, 1990, 1991, and 1995 the overall water clarity was lower then the previous year is still better then that of the base year and the five year average of 10.4 feet. It is likely that rain fall was not a major factor in the lack of improvement in the 1989, 1990, and 1991 years. Rain falls from May 1 to November 1 of each of the years was 1985 - 32.35 inch., 1986 - 23.95 inch., 1987 - 19.35 inch., 1988 - 19.30 inch., 1992 - 21.55 inch., 1993 - 25.95 inch., 1994 - 33.30 inch., 1995 - 25.55 inch..

1992 data shows improvement of water clarity to levels of 1988 which was the highest on record. Conditions noted in 1992 were a late ice out (April 28), low rain totals (21.55) and lower level due to removal of Beaver dams on outlet. 1993 data is a complete reversal of 1992, water clarity drop to an average of 10.1 feet which is the lowest readings since 1988 and 1.7 feet lower then the readings of 1992. I am not aware of any factors for this change except that some lakes also reported lower readings. 1993 was the first time that our readings were below the five year average and may be a warning of a change in the lake.

1994 data charts will show clearly the algae blooms of 1993 and 1994. We also are starting to use a ten year average data to help us make better evaluations of water clarity. Rain fall was heavy in August and

September which brought the year total above average. There is no known reason for the algae bloom of late June and along with the bloom of July of 93, the situation will be monitor. The average secchi-disc reading was 11.8 feet in 1994, compare to 10.1 feet in 1993, five years average of 10.4 feet and the ten years average of 10.7 feet.

1995 data charts will show clearly the algae blooms of 1993, 1994, and 1995. What is different about the 1995 bloom is that it occurred shortly after we received a heavy rain the second week of August. The August disc reading were the lowest of the season, but August normally have the lowest reading of the seasons. The rain fall during August was 9.10 inch and was preceded by a 4.50 rain total in July. These two month the rain totals were above normal while all the other month were below normal, but the season total was above normal by several inches. The water clarity for the season average one foot below last year average but was still above the five and ten year averages.

Table 9. Water clarity summary: secchi disc readings for Bear Lake. Data collected by Dale Jalinski, Bear Lake resident.

Year		1977	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Month	wk#	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
April	3	10.9		10.5	12.5	14.2	12.0	12.5						
	4		9.0	8.5					10.5			15.0	11.3	
May	1	11.0	9.0	10.0			10.0	15.3				14.5	12.5	
	2		9.5	10.5	14.0	14.7			12.5	7.5	9.5		11.3	7.0
	3	12.3	10.0	10.5	16.0		14.0	14.0	15.3	10.0		16.0	11.3	7.0
	4		12.0	14.0	15.5	14.7				12.5	11.5	14.5	10.0	7.0
June	1	10.0	11.0	14.0			14.0	15.0	14.0		12.0	15.3	12.0	13.5
	2		9.5	12.0	13.5	15.5		11.5		11.5	13.5	13.3	11.3	14.0
	3	9.0	9.0	10.5			11.5		9.0			11.3	10.0	
	4		8.0	10.5	8.0	8.0		11.0			10.0	7.0	14.5	11.0
July	1	9.0	9.0	10.5	9.0					10.5	9.0	8.0	11.0	11.0
	2		9.0	8.5		8.5	11.0	10.0	10.3	13.5		6.8	9.0	
	3	8.3	8.5		7.5			12.0			8.0	8.5	12.3	10.0
	4		7.5	8.0		10.5	9.0	9.0	7.5	11.8	6.5		13.5	11.3
Aug	1	9.0	8.5	7.5	8.0	9.5	8.0	9.0	9.0	11.3	6.0	10.5	10.8	9.8
	2		8.5	8.0					8.0	11.0	6.5	13.3	9.0	
	3	8.0	8.0	8.0	8.0	9.5	7.8	9.5		11.0	6.8	13.5	7.3	7.5
	4		9.0	8.0			7.8		9.0		6.3	10.5	8.4	7.0
Sept	1	8.5	9.0	9.0	12.0	10.5		8.8	8.8	10.8			9.5	9.0
	2			9.0			9.3	8.0			12.5	12.5	11.3	
	3	8.5	10.0	10.2		13.5			11.5	12.0	10.5	10.8	11.5	
	4		10.5	11.5	11.5		13.0	12.0	10.5				11.3	12.5
Oct	1	8.0	11.0	12.0					12.0	14.0		11.8	11.0	12.0
	2		11.0	12.0	14.0	13.7	15.8	11.0			15.3		11.0	11.3
	3	11.0	9.0	12.5			15.0	15.5		15.0	13.0	13.5	11.0	
	4		9.5		14.5	12.5			11.0	16.0	13.3		9.0	
Nov	1		9.0	12.5			16.8	15.5				14.0		
May-Sept Ave		9.4	9.2	10.0	10.6	11.4	10.8	11.3	10.7	11.2	9.6	11.6	10.9	9.9

Bear Lake Secchi Disc Readings

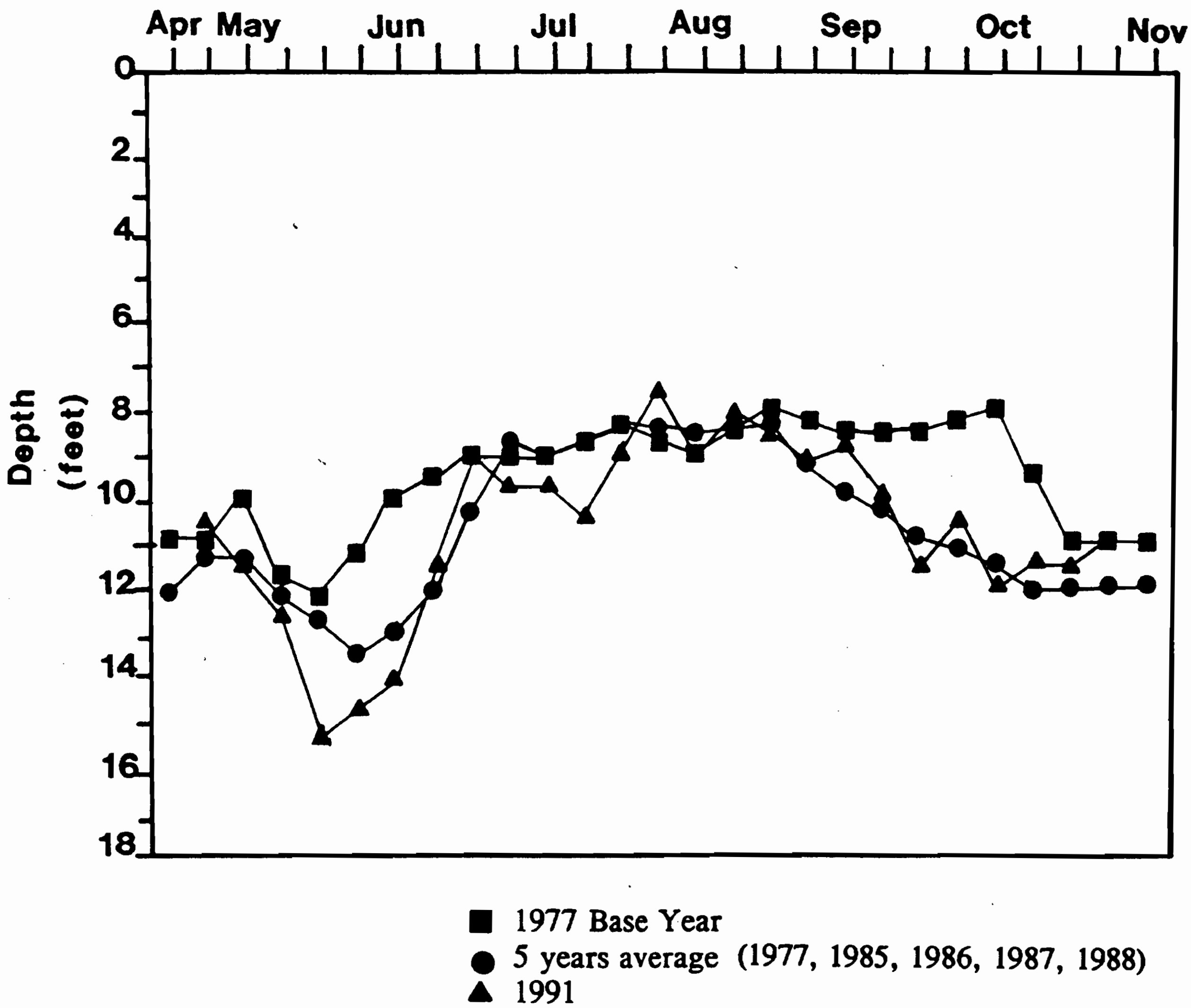


Figure 10. Secchi disc for 1977, 5 year average and 1991 (graph redrawn from D. Jalinski).

Dissolved Oxygen and Temperature: The summer dissolved oxygen (DO) and temperature profiles (Figure 11) indicate that in the deeper waters (20 feet or deeper) the DO is almost gone. This indicates there is a potential for phosphorus release from the bottom sediments. However, our sediment analysis indicates sediments are low in phosphorus.

The temperature throughout the water column is relatively constant, changing only a few degrees, indicating that the lake is polymictic and mixes occasionally through the summer.

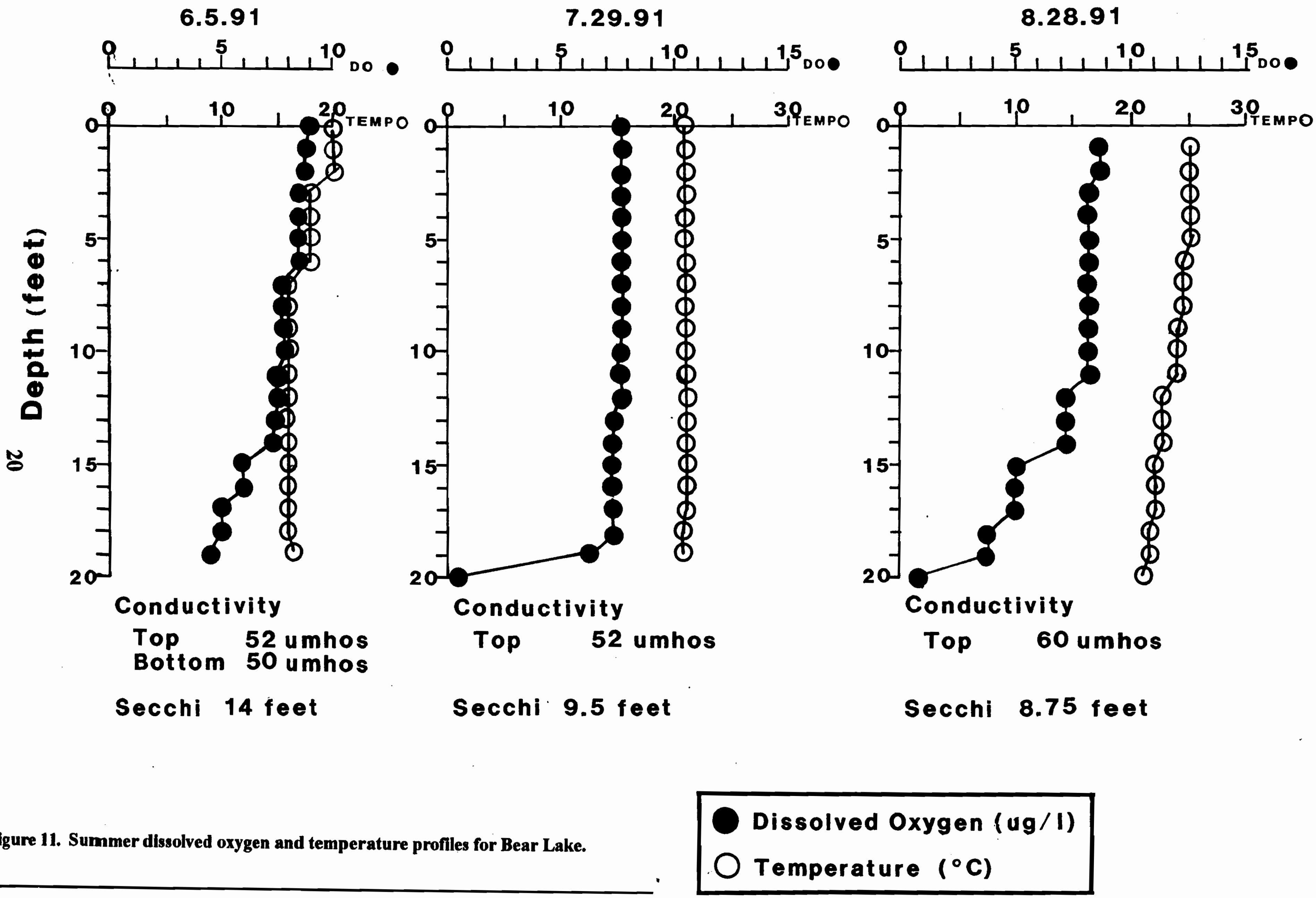


Figure 11. Summer dissolved oxygen and temperature profiles for Bear Lake.

Phosphorus Trends and Other Water Chemistry Parameters

Introduction: Phosphorus is an important fertilizing nutrient that spurs algae growth. The more phosphorus in the water column, greater the algae growth. Phosphorus is measured in parts per billion (ppb) and if concentrations are less than 25 ppb, the water generally is clear.

Methods: Dale Jalinski has faithfully been collecting water samples in May and November since 1985 and sending them to the University of Wisconsin - Stevens Point for analysis. Dale collects the water just below the lake surface at the deepest part of Bear Lake.

Results: A summary of the total phosphorus (TP) and orthophosphorus (OP) results from 1977, and 1985-1996 are shown in Table 10. A majority of the phosphorus readings are less than 25 ppb for TP. Bear Lake would be considered to have moderate fertility in regard to phosphorus. It appears that phosphorus levels have not changed dramatically since 1977. The one high reading in 1995 may be an anomaly. Orthophosphorus levels are moderate.

Table 10. Water quality summary: total phosphorus and orthophosphorus for spring and fall, with 1977 serving as a benchmark.

Year	TP (ppb)		OP (ppb)	
	Spring	Fall	Spring	Fall
1977	17	18	--	--
1985	25	28	22	25
1986	10	8	2	2
1987	8	10	2	2
1988	6	15	2	10
1989	25	35	2	2
1990	15	12	2	8
1991	15	32	10	8
1992	20	15	10	15
1993	15	10	2	5
1994	16	8	3	5
1995	58	21	8	5
1996	14	--	9	--

Phosphorus, Nitrogen, Clarity and Algae:
Summer water chemistry data collected during 1991 included secchi disc, total phosphorus (TP), chlorophyll a (Chl a), total kjeldahl nitrogen (TKN), ammonia (NH_3), nitrate (NO_3), and conductivity (cond)(Table 11). Samples were collected at the surface and two feet off the bottom in the deepest area of Bear Lake. Bottom samples for July 29, 1991 were lost and no results are shown. Total phosphorus was higher in the bottom water than the top water indicating some phosphorus release from the bottom material (sediments or plants) may be occurring and/or reflects the concentrations of settled material "raining" down from the epilimnion. Internal loading is not serious at this time.

Chlorophyll a concentrations were 9 ug/l for July and August which are indicative of mesotrophic lakes. Total kjeldahl nitrogen (TKN) was moderate at 400 to 600 ug/l and nitrate nitrogen was low. Conductivity was recorded at 50-52 umhos/cm which is fairly low for lakes in general, but about average for relatively infertile lakes in northern Wisconsin.

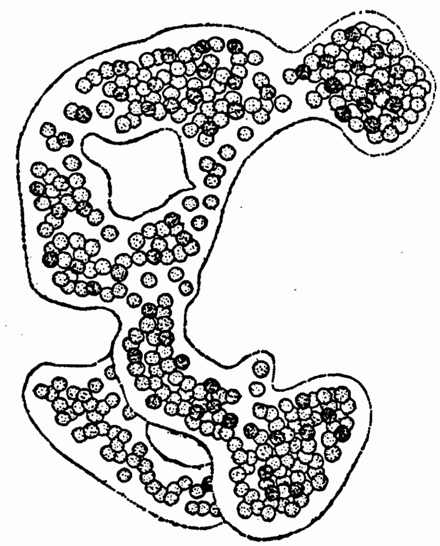
Table 11. Summertime sample results for Bear Lake.

Date	Depth	Secchi (feet)	TP (ug/l)	Chl a (ug/l)	TKN (ug/l)	NH_3 (ug/l)	NO_3 (ug/l)	Cond (umhos)
6.5.91	top	14	14	--	500	<13	<15	52
	bottom	--	38	--	600	14	<15	50
7.29.91	top	9.5	14	9	600	34	ND	52
8.28.91	top	8.75	11	9	400	ND	ND	60
	bottom	--	19	--	--	--	--	--

4.4. Algae

Introduction: Algae are found in all lakes and are a food source for zooplankton. Excessive algae growth produces green, turbid water and is unappealing. At the present time, Bear Lake does not have nuisance algae blooms.

Methods: Two water samples were collected in June 1986, but we did not find any algae. Either our preservative was inadequate (1% formalin) or algae densities were low. We used 5 ml settling tubes and a inverted Nikon microscope at 400x for phytoplankton analysis. Replicate phytoplankton samples were collected for June and July, 1991.



Microcystis, a common bluegreen algae found in Bear Lake.

Results: Information on the algae community for Bear Lake is from chlorophyll readings for 1977 (April - October) and for 1991 (June and July) and for 1994 (Table 12). Phytoplankton identification was conducted in 1993 (June and July)(Table 13). It appears that chlorophyll has remained nearly the same since 1977, allowing for year to year variability. With only two readings for 1991 and one reading in 1994 to compare to 1977, we should be cautious in making comparisons, however because water transparency has remained nearly the same there is probably some support for algae biomass being nearly the same.

Analysis indicate the phytoplankton community was dominated by small unicellular algae. In the July 29, 1991 sample, we found that 1.2 million cells/milliliter of a unicellular algal about 2-3 microns in size. This was by far the dominant phytoplankton by number. The dominant unicellular algal in unidentified at this time. Anabaena was found at 400 filaments/ml and Microcystis was found at 300 colonies/ml.

Bluegreens were dominant by biovolume.

Table 12. Chlorophyll and secchi disc readings for 1977 (Northern Environmental Services) and 1991 and 1994 (secchi = D. Jalinski, chlorophyll = Wisconsin Hygiene Lab).

		1977		1991		1994	
Date Month	wks	Secchi disc (feet)	Chlorophyll (µg/l)	Secchi disc (feet)	Chlorophyll (µg/l)	Secchi disc (feet)	Chlorophyll (µg/l)
Apr	3	10.9	8	10.5	--	15.0	--
May	1	11.0	7	11.5	--	14.5	--
May	3	12.3	2	15.3	--	16.0	--
June	1	10.0	3	14.0	--	15.3	--
June	3	9.0	8	9.0	9	10.2*	7*
July	1	9.0	5	9.7	--	8.0	--
July	3	8.3	3	8.9	9	8.5	--
July	4	9.0	6	7.5	--	8.5	--
Aug	3	8.0	7	8.5	--	13.5	--
Sept	1	8.5	5	8.8	--	11.5	--
Sept	3	8.5	8	11.5	--	10.8	--
Oct	1	8.0	6	12.0	--	11.8	--
Oct	3	11.0	5	11.5	--	13.5	--
		-----	---	-----	---	---	---
Averages		9.5	6	10.7	--	11.6	--

* average of four measurements

Table 13. Phytoplankton counts and biovolumes for Bear Lake.

Date		Anabaena	Microcystis	Tabellaris	Ceratuim	Asterionella	Unicellular Greens
				Counts			
———		**(filaments/ml)**	**(colonies/ml)**	———	**(cells/ml)**	———	**cells/ml)**
6.15.91	1	0	0	0	276	276	552
	2	0	0	0	0	0	552
7.29.91	3	276	276	0	0	0	1,815,923
	4	552	0	276	0	0	712,235
				Biovolumes			
		(1,300µm³)	**(100,000µm³)**	**(3,000µm³)**	**(4,000µm³)**	**350µm³)**	**(10µm³)**
6.15.91	1	0	0	0	1,104,000	96,600	5,520
	2	0	0	0	0	0	5,520
7.29.91	3	1,576	27,600,000	0	0	0	18,159,230
	4	717,600	0	828,000	0	0	7,122,350

Algae distribution: We were interested in how algae could be distributed through Bear Lake. We sampled four locations in 1994 and Figure 12 shows the locations. On the same day, we took aerial photographs of Bear Lake to determine how the algae might be distributed through Bear Lake.

Results show that algae is not uniformly distributed through Bear Lake (Table 14). The north side (site C, Figure 12) had about twice the chlorophyll a as the south side (a) and the west side (d). Aerial photography showed that algae was not uniformly distributed through Bear Lake (Figure 13).

I am not sure why the algae is so "patchy". It may be wind driven or it could be localized nutrient rich pocket fueling algae growth. I think the wind is the primary suspect.

Table 14. Lake sampling on June 21, 1994 to look at distribution of algae around Bear Lake.

	Secchi Disc (ft)	Total Phosphorus (ug/l)	Chl a (ug/l)
a. South side	10.2	14	4
b. Deep hole	10.2	16	8
c. North side	10.2	17	10
d. West side (Dale's Bay)	10.2	15	5

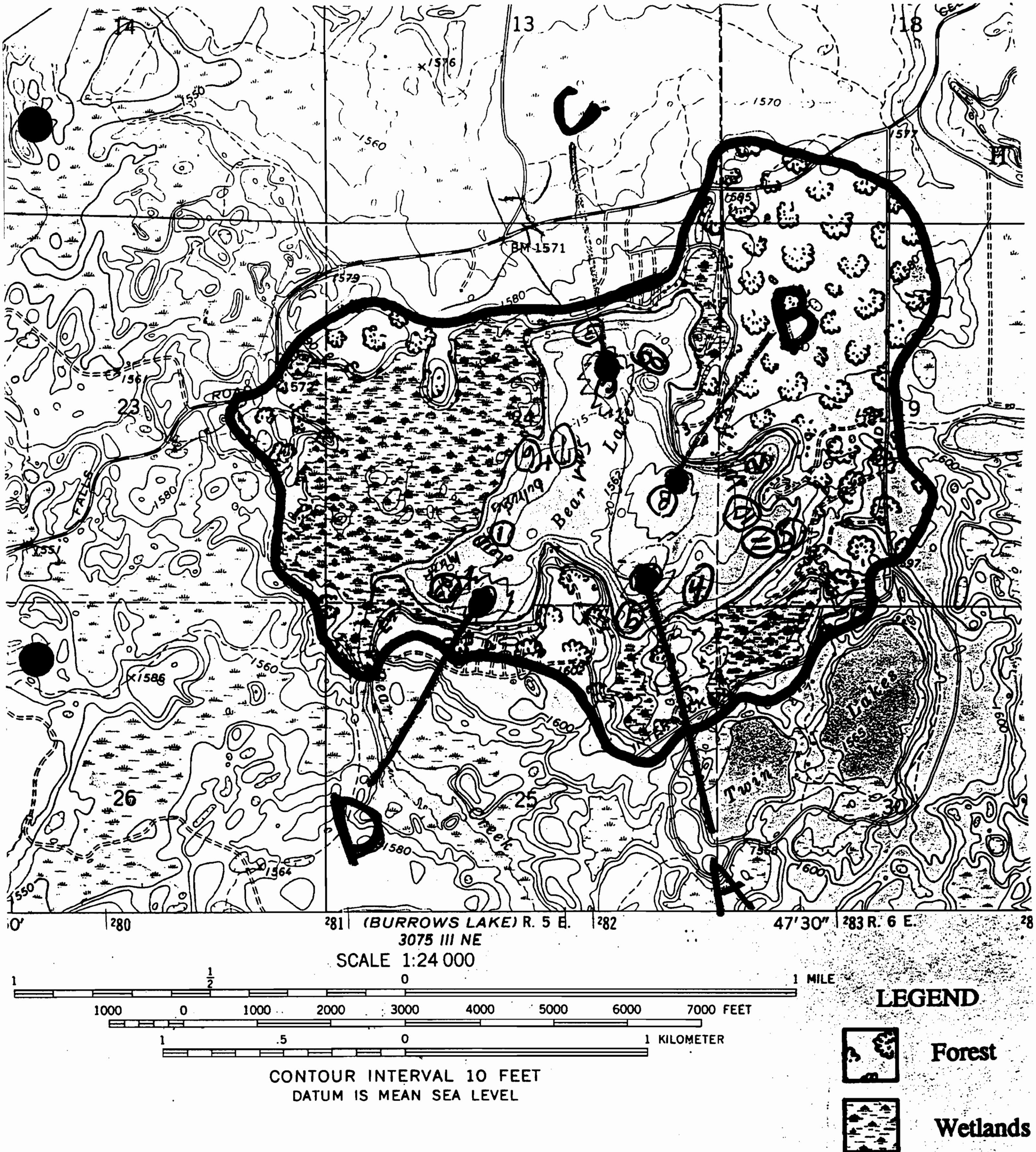


Figure 12. Four Bear Lake sample locations for chlorophyll analysis in 1994.

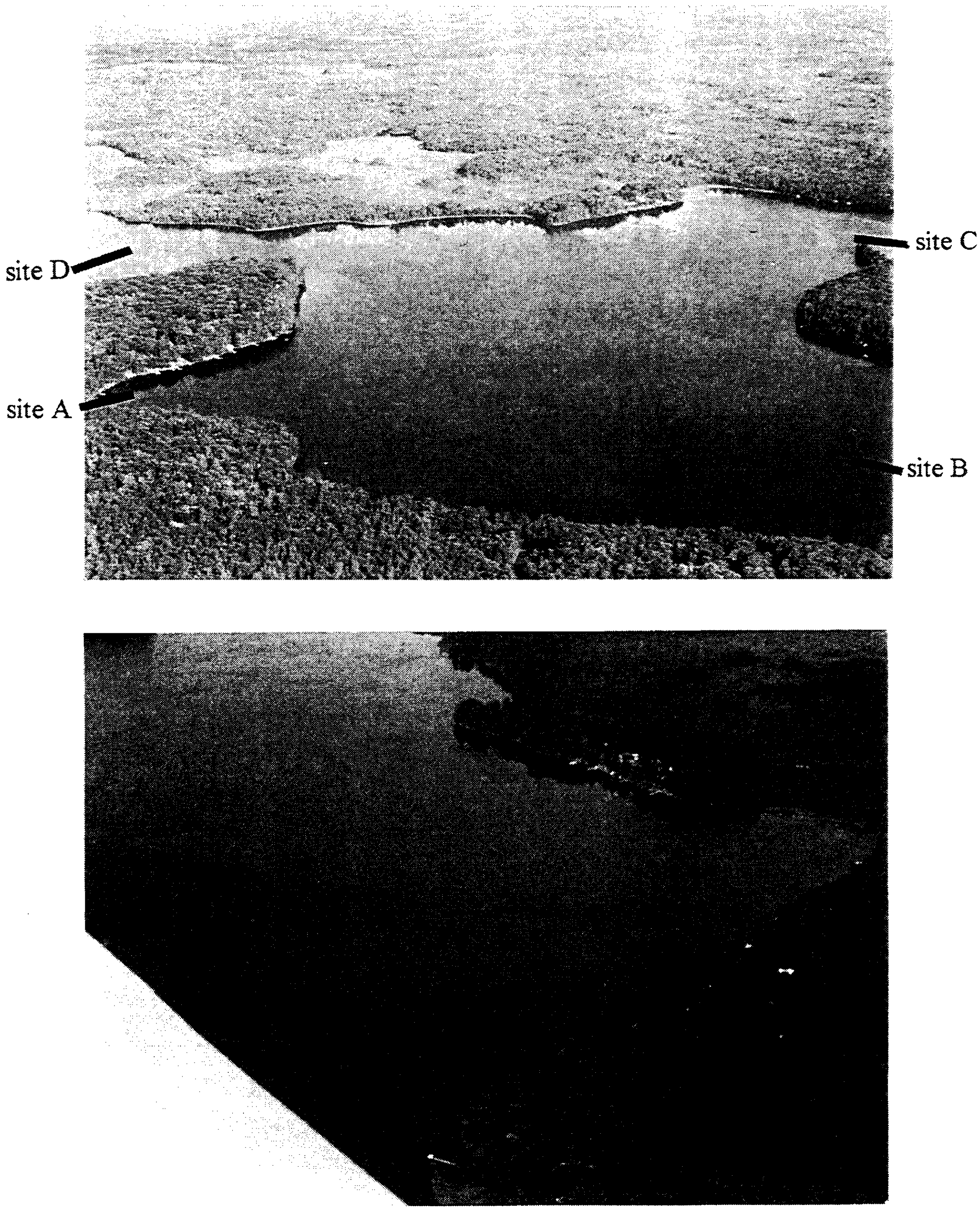


Figure 13. Aerial view of Bear Lake, June 21, 1994. Patches of algae can just barely be seen.

4.5. Lake Plants

Introduction: Aquatic plants are important to maintaining a healthy lake. Bear Lake appears to be healthy and its plant community is healthy. In fact, some residents might think its too healthy. This section reviews aquatic plant data in Bear Lake.

Methods: An aquatic plant survey was conducted on Bear Lake on July 29, 1991. Twenty transects were run with sample points at 0-1.5 feet, 1.5-5 feet, 5-10 feet, and greater than 10 feet (Figure 14).

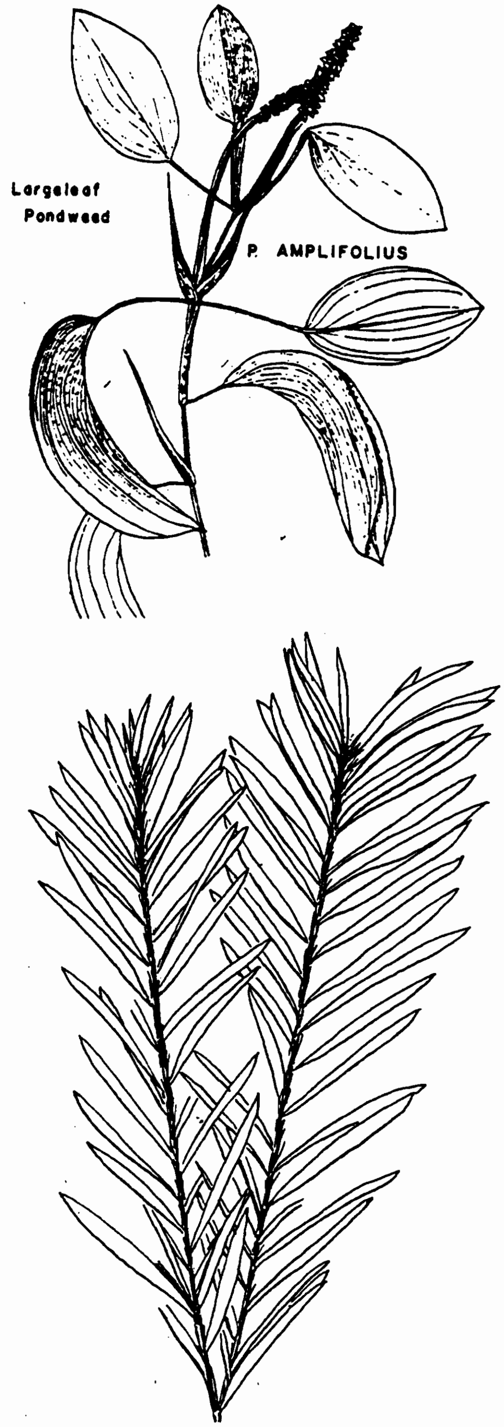
Results: In 1991, rooted plants were found in water to a depth of 17 feet. Plant coverage is shown in Figure 15. Six plant groups are represented, with the group dominated by the fern pondweed (*Potamogeton robbinsii*) being the most abundant. A macrophyte survey was conducted about 14 years prior, on August 1, 1977 (Figure 16). Plant coverage appears to be slightly different compared to 1991. In 1991 *P. amplifolius* and *P. zosterformis* appear to be more abundant than in 1977. Also, plants may have been rooted in slightly deeper water than 1977.

A species list of plants for 1991 and 1977 is shown in Table 15. Percent occurrence is based on number of times plants are present at a sample station. Taking into account that different consultants did the survey, it appears there may have been some changes in the plant community. Comparing 1991 to 1977 the fern pondweed may have decreased and *P. amplifolius* and *P. zosteriformis* may have increased.

The percent of lake that is colonized may have increased slightly from 1977 to 1991 (Table 16). Coverage was about 81% in 1977 and about 89% in 1991. These coverages are pretty close considering that two different firms did the surveys.

Biomass estimates were proposed to be done for Bear Lake using X-16 Lowrance sonar printouts. Estimates have not been made. The sonar printout did not delineate the lake bottom clearly enough to determine where the plants stopped and the sediments began. Scuba diving observations indicated that the extensive fern pondweed beds have several feet of peaty substrate that is partially decomposed fern pondweed. This is why sonar printouts were not able to clearly identify the lake bottom.

The underwater video allowed us to make in-situ observations and to make notes while viewing the aquatic plant community.



Largeleaf pondweed (Potamogeton amplifolius) (top) and fern pondweed (Potamogeton robbinsii) (bottom) are both native aquatic plants and are beneficial to a healthy plants community in Bear Lake.

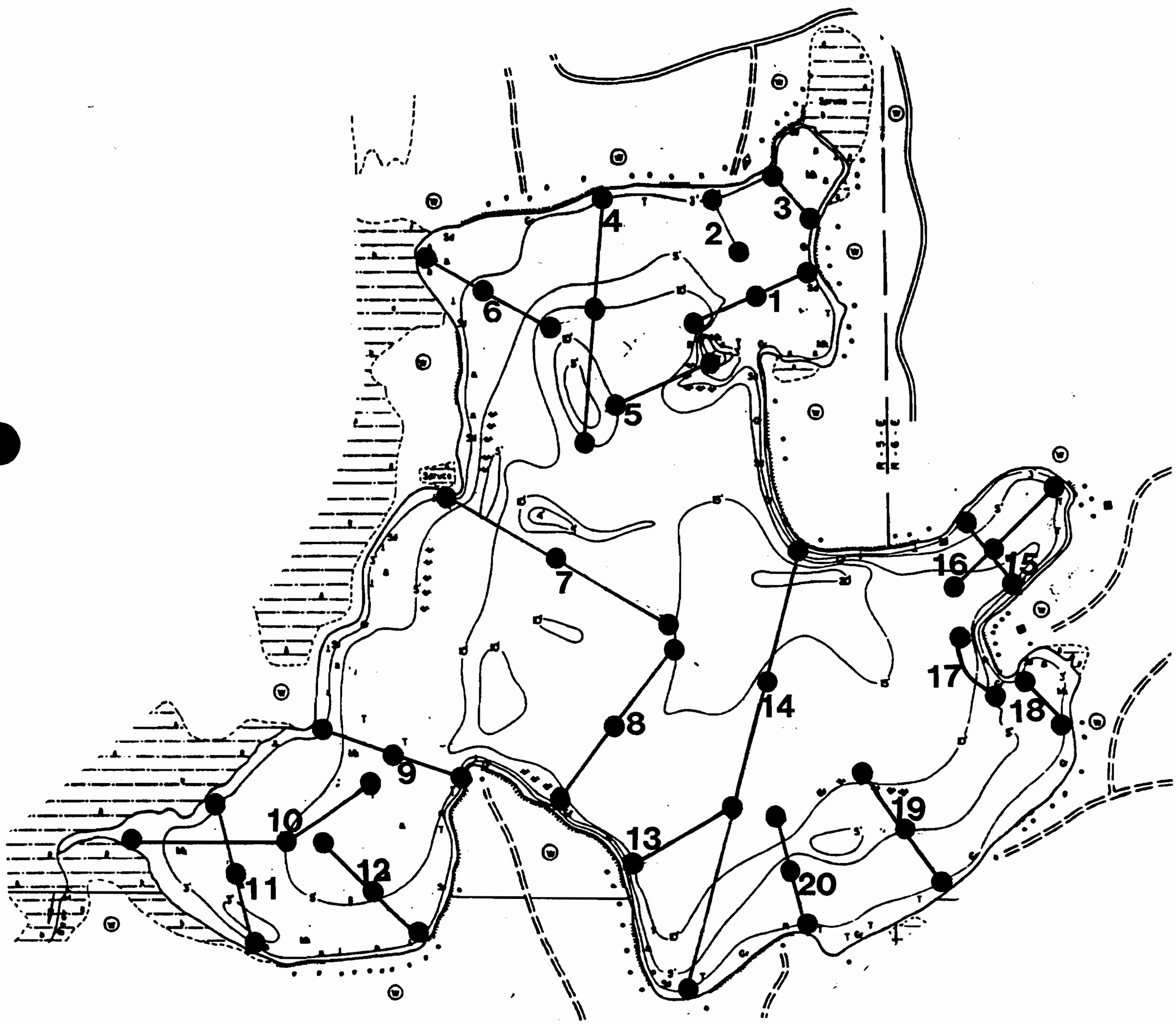


Figure 14. Transects for the aquatic plant survey on Bear Lake, July 29, 1991.

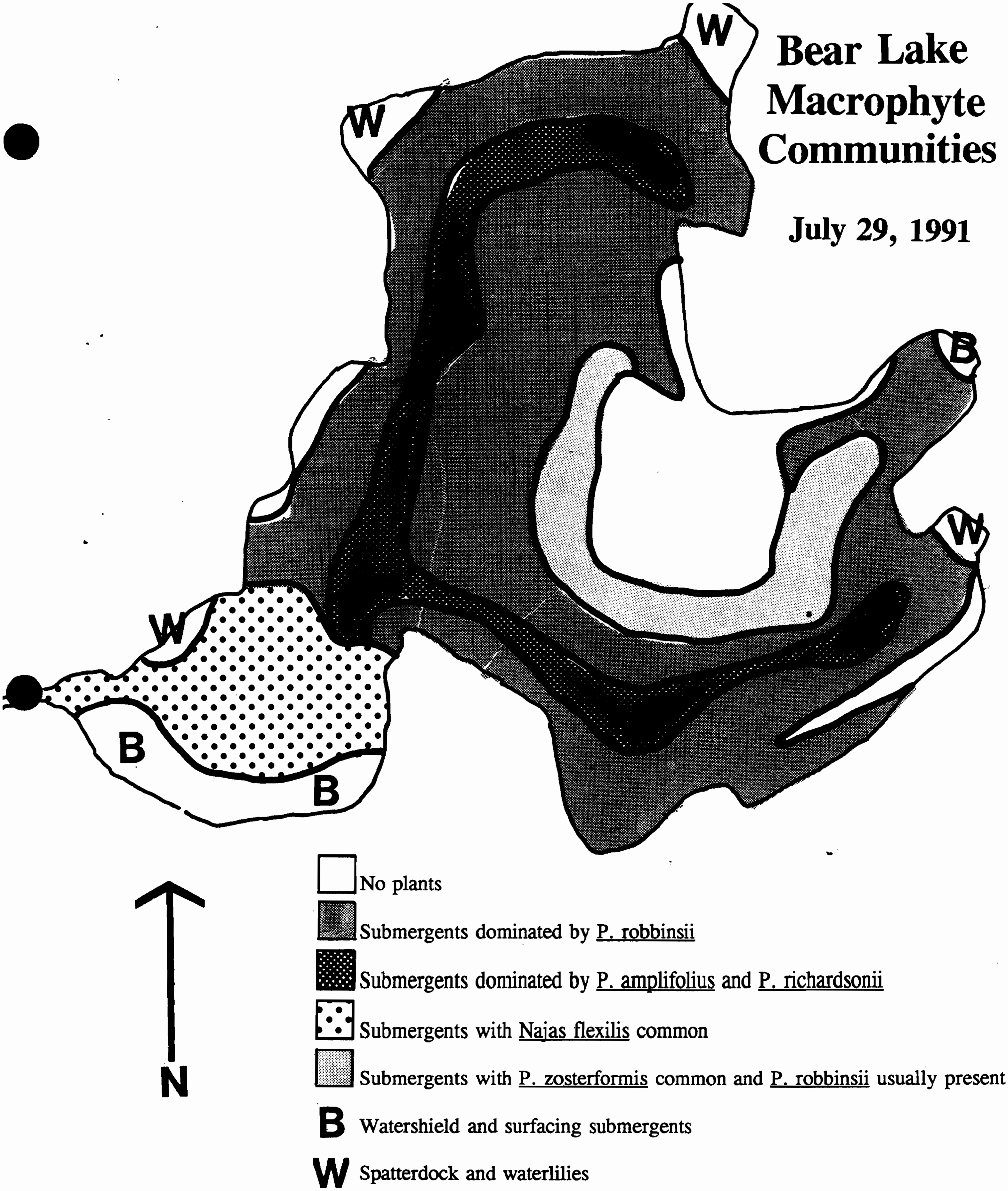


Figure 15. Bear Lake macrophyte survey conducted by Blue Water Science on July 29, 1991.

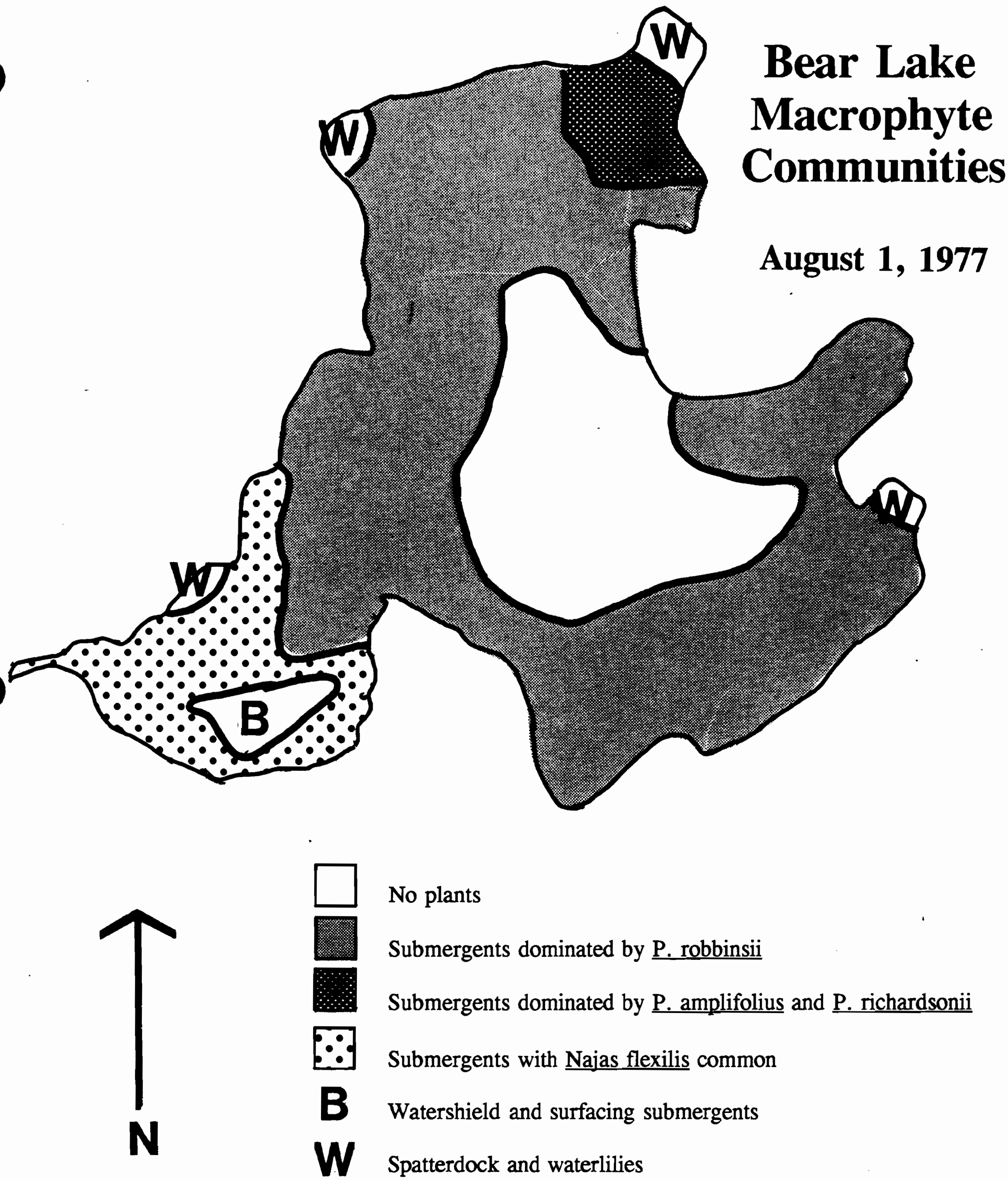


Figure 15. Bear Lake macrophyte survey conducted by Northern Environmental Services on August 1, 1977.

Table 15. Bear Lake macrophyte species list and percent occurrence from August 1, 1977 and July 29, 1991.

Species	Frequency (% occurrence) 1977	1991
Brazenia schreberi (watershield)	1	8
Ceratophyllum demersum (coontail)	1	0
Chara sp. (chara)	1	4
Elodea canadensis (elodea)	15	13
Isoetes sp. (quillwort)	1	3
Lobelia dormtmanna (water lobelia)	0	0
Najas flexilis (slender naiad)	20	21
Nuphar advena (spatterdock)	1	4
Nymphaea odorata (water lily)	1	4
Pontederia cordata (pickerel weed)	0	4
Potamogeton amplifolius (largeleaf pondweed)	23	35
P. epihydrus (ribbonleaf pondweed)	6	0
P. gramineus (variable pondweed)	7	0
P. richardsonii (richardsons pondweed)	4	14
P. robbinsii (fern pondweed)	49	40
P. zosteriformis (flatstem pondweed)	23	36
Sagittaria sp.	0	0
Scirpus (bulrush)	0	3
Typha latifolia (common cattail)	0	4
Valisneria americana (water celery)	17	22

Table 16. Percent of bottom coverage in Bear Lake, August 1, 1977 and July 29, 1991.

Bottom type	1977 Percent of coverage	1991 Percent of coverage
No plants	**19**	**11**
Submergents dominated by *P. robbinsii*	**61**	**52**
Submergents dominated by *P. amplifolius*	**4**	**14**
Submergents *Najas flexilis*	**11**	**6**
Submergents dominated by *P. zosterformis* but with *P. robbinsii* usually present	**0**	**9**
Watershield and surfacing submergents	**2**	**4**
Spatterdock and waterlily	**3**	**3**
	100	**100**

Some of our observations are listed below:

☐ We found light penetration to the deepest parts of Bear lake (around 25 feet) although there was no plant growth.

☐ *P. robbinsii* is not always upright, large expanses of *P. robbinsii* are fallen over. This makes fairly good invertebrate habitat but is not the best fish habitat (in regard to hiding places)

☐ The sediment/water interface is poorly defined over extensive of *P. robbinsii* colonized communities. Poorly decomposed plant material ("proto peat") is often several feet thick. Mucky sediments are below this. For sediment release to be a significant loading factor, it has to come through this organic blanket.

☐ Winter diving observations indicated that much of the aquatic macrophyte community is still "green". It is not growing vigorously, but it is not dead either.

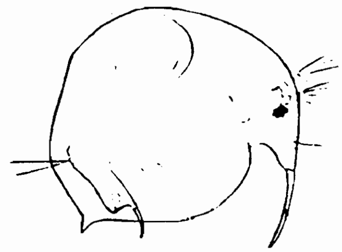
4.6. Small Aquatic Animals

Zooplankton

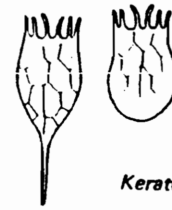
Introduction: Zooplankton are the invisible grazers in the aquatic pasture land. They are only about the size of a dot of an "i". They are important because they feed on algae and keep their numbers down. In turn, they are grazed on by small fish. Bear Lake has good zooplankton.

Methods: Zooplankton samples were taken in 1984, 1985, 1986, and 1987 but not analyzed until 1991. Sunfish removal work started in June, 1985 and continued in 1986 and 1987. We were wondering if sunfish removal would have any impact on the zooplankton community.

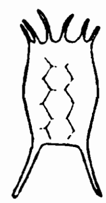
Results: Results are inconclusive, because we do not have enough zooplankton samples. However, examining zooplankton numbers per liter for June of 1985, 1986, and 1991 (Figure 17 and Table 17) there appears to be an increase in the number of zooplankton with a slight increase in daphnids from June 1985 to June 1991. A comparison of August 1984 to August 1991 indicates zooplankton numbers are about the same. It is difficult to say if sunfish removal efforts had a positive biomanipulation affect, meaning due to the reduced number of sunfish (by fyke net removal), predation on zooplankton was reduced, which increased zooplankton numbers and thus grazing pressure on algae which should have improved water clarity. Although water clarity is slightly better in 1991 compared to 1984 and 1985, we cannot attribute this entirely to biomanipulation effects. Unfortunately there is very little information on algae species over this time period.



Bosmina



Keratella



Keratella

Bosmina (a daphnia)(top) and keratella sp (rotifers)(bottom) are examples of some zooplankton found in Bear Lake. Zooplankton are beneficial because they feed on algae and help clear up Bear Lake.

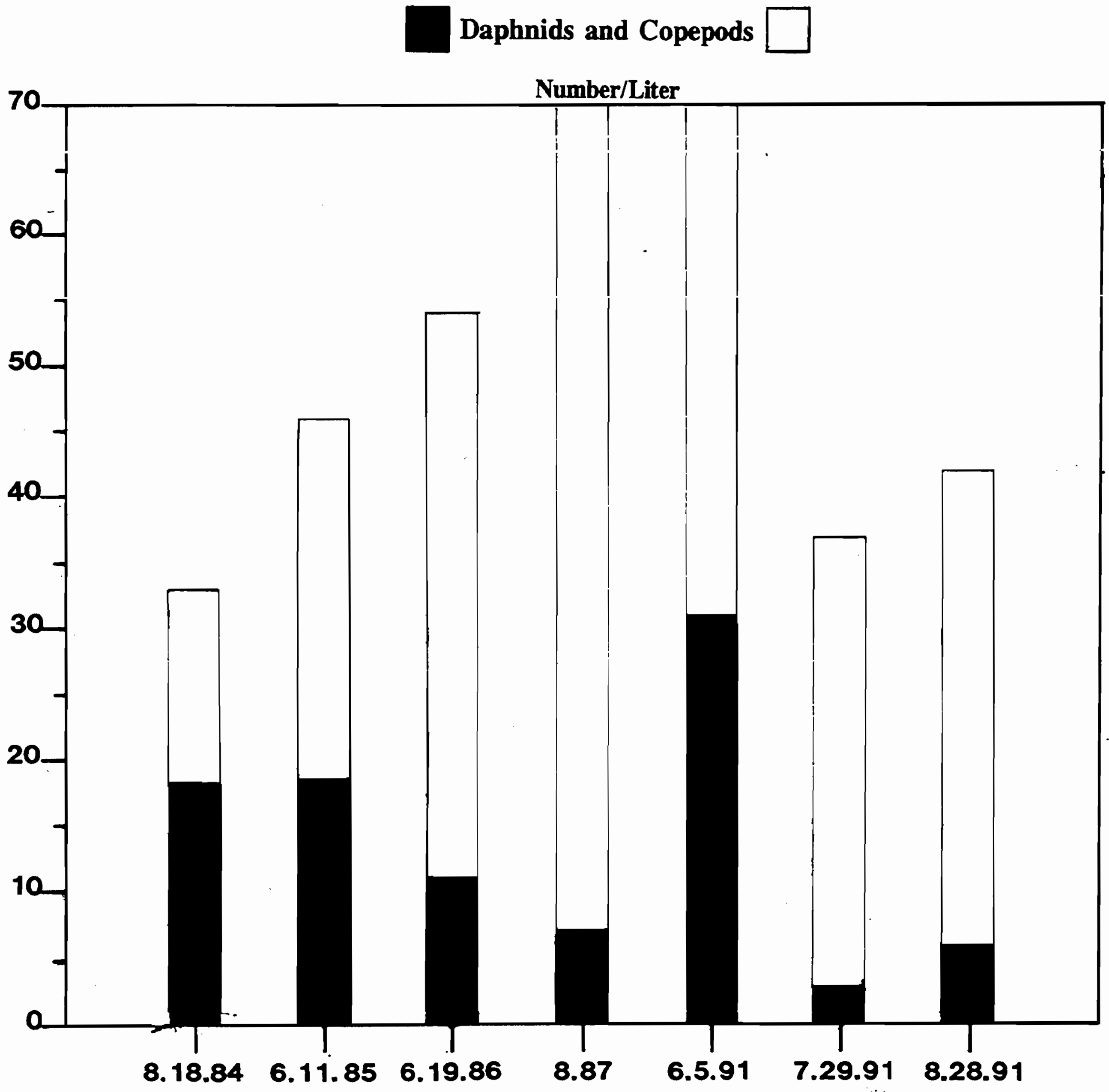
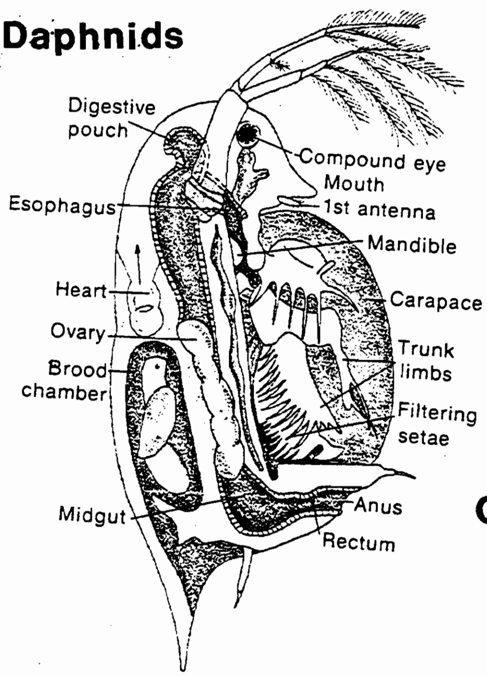


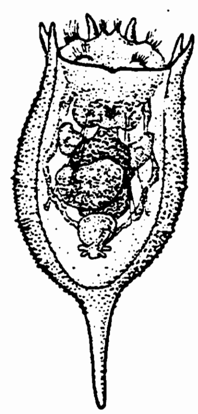
Figure 17. Daphnids and copepods densities for various dates, 1984-1991.

Table 17. Zooplankton counts for Bear Lake, Oneida County, Wisconsin.

Date	Daphnids			Copepods			Rotifers		Total
	Daphnia	Ceriodaphnia	Bosmina	Calonoids	Cyclopoids	Nauplii	Asplanchna	Keratella	
8.18.84	0	0	18.3	3.7	10.8	0.7	0	0	33.5
6.11.85									
Station 1	2.2	0	0.2	18.3	7.2	1.0	0	0	28.9
Station 2	35.0	0	0	3.3	20.4	4.1	0	0	62.8
6.19.86									
Station 1	11.2	0	0.1	17.9	1.1	0	0	0	30.3
Station 2	10.6	0.2	0	1.1	24.1	0	0	0	36.0
8.87									
Station 1	7.4	0	0.4	32.7	54.9	11.8	1.7	22.2	131.1
Station 2	5.0	0	0.7	5.4	16.2	11.1	2.4	17.9	58.7
6.5.91									
Station 1	29.8	0	0	26.0	6.6	3.5	0.5	3.3	69.7
Station 2	31.3	0	0	26.7	13.2	5.8	0.8	3.3	81.1
7.29.91	2.5	0	0	18.9	2.8	11.8	0.5	7.0	43.5
8.28.91	6.0	0	0	17.7	9.2	8.8	0.3	4.2	46.2

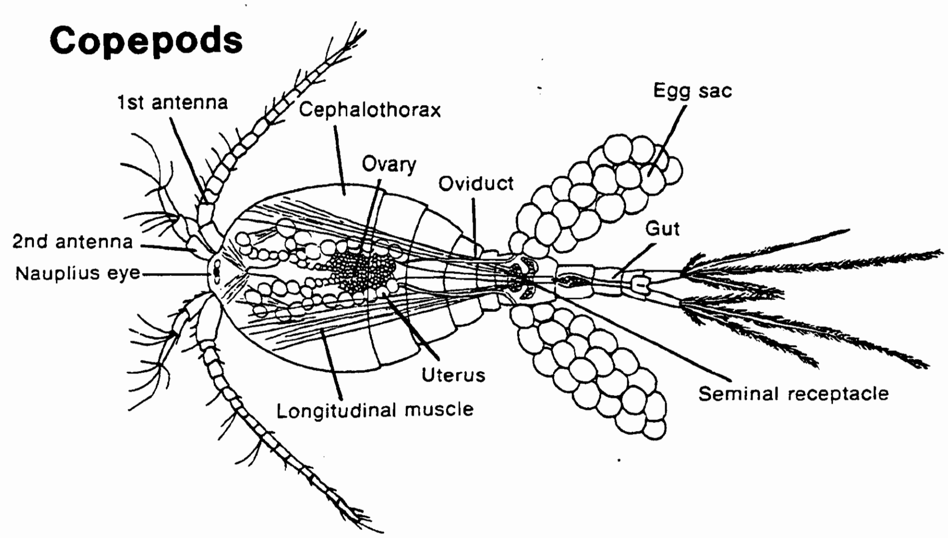
Daphnids





Rotifers

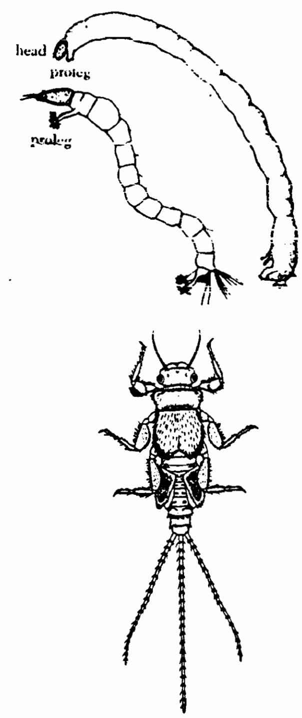
Copepods



Bottom Living Animals

Introduction: Macroinverbrates is a fancy name for big aquatic insects in the larval form plus some beetles and various types of worms. Bear Lake has a nice variety. Macroinvertebrate communities were investigated on a variety of substrates from Bear Lake. These substrates included different types of aquatic plants, as well as different sediment types. The aim of this investigation was to determine what types of invertebrates colonized the different substrates, as well as exploring which substrates supported the greatest diversity of fauna.

Invertebrates living in submerged macrophyte beds are very abundant and productive (Cooper & Knight 1985). They make up a major food source for fish and waterfowl and are likely an important link in the transfer of energy between trophic levels in lakes (Dall et al. 1984). Freshwater macrophytes serve as substrates for plant-dwelling invertebrates and provide an added structural dimension for colonization beyond that provided by the lake bottom. McDermid and Naiman (1983) have described macrophytes as the "forests of lakes and rivers".



Non-biting midges (Chironomidae) and mayflies (ephemeroptera) are a food source for young fish.

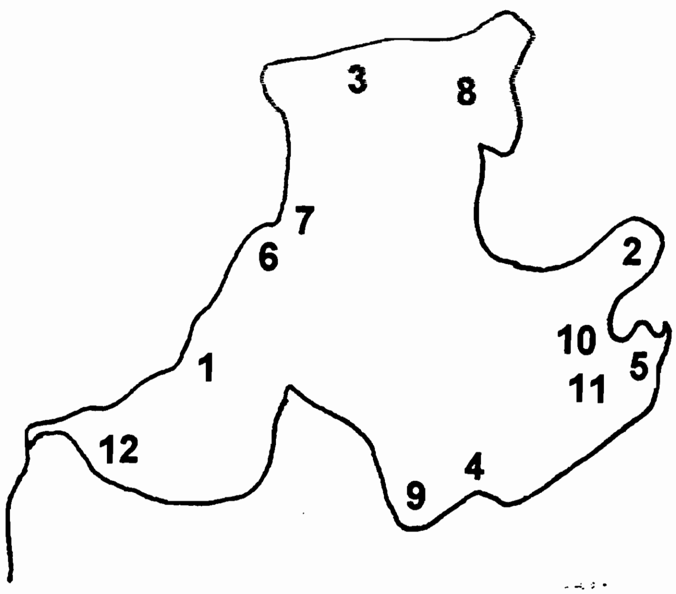
The plants sampled in this study included a pondweed, a largeleaf plant, a water lily, and a reed. It is believed that the physical structure of the plant is the major factor determining the number and diversity of invertebrates inhabiting a particular plant. Krecker (1939) suggested that plants with progressively more dissected leaves should harbor more invertebrates per unit biomass. The logic behind this is that an increase in surface area allows more room for periphyton growth, and thus more potential food for invertebrates. The plants sampled in this study provide a fair array of structural diversity for exploring this theory. Others (Cyr & Downing 1988) found that this idea did not hold true in all cases. They found that some plants with very finely dissected leaves such as coontail (*Ceratophyllum demersum*) and watermilfoil (*Myriophyllum sp.*) did not support as many invertebrates as some of the plant with broader leaves. One possible reason is that these plants are too fragile to support some of the heavier invertebrates like snails which make up a major component of most phytophillic macroinvertebrate communities.

Methods:

Sampling: The sample locations are shown on page 49. Twelve sites were visited. Sites 1-6 were exclusively vegetation and sites 7-12 were either sand, gravel, or muck.

Sample site characteristics

1. Fern pondweed bed, 12' of water, outlet bay area (north of D. Jalinski)
2. Fern pondweed bed, 12' of water, northern bay
3. Cabbage bed, 7' of water, north end
4. Cabbage bed, 7' of water, south end
5. Water lily bed, 6' of eater, Ruth's Bay
6. Bulrush stand, 2' of water, Papermill property, NW shore
7. Sand
8. Gravel - cobble, 1' of water, by island
9. Sand
10. Gravel - cobble (rocks at Ruth's)
11. Peaty muck (Muck at Ruth's)
12. Peaty muck (Dale's place)



Midge Larvae Procedures: Midges (Chironomidae), because they are superficially non-descript require a more intensive identification process. Examination of their mouthparts is the primary means of identification of this taxonomic group. Slides were made of the midge's head capsules (Figure 18) and identified under a microscope. The methods for slide preparation are as follows (Zischke et al 1993):

1. Place specimen on slide.
2. Wash with a few drops of 95% ethanol.
3. Gently pull off head capsule.
4. Blot up excess ethanol with tissue.
5. Add 2-3 drops of xylene to each capsule until clear (if necessary).
6. Position head capsule so that dark ring on ventral side is facing up.
7. Add one drop of mounting medium.
8. Add coverglass and press down until mandibles flare out.

Data Analysis: Data from the samples were used to calculate different metrics. These metrics can be useful for assessing the relative health of the macroinvertebrate communities at a particular site. The metrics include:

Species Richness - The total number of taxa in a community. Healthy communities have larger numbers than impacted communities.

Chironomids most abundant and diverse found in Bear Lake.

Diversity Index - The Shannon-Weaver species diversity index (d) can be calculated with the following expression: d= C/N (N log 10 N - Sum ni log 10 ni)
C = 3.321923 (converts base 10 to base 2 bits)
N = total number of taxa
ni = total number of individuals of the ith species

The Shannon-Weaver index indicates the relative importance of each species collected, not merely the relationship between total numbers of species and individuals. The index ranges from 0-4, with the higher values indicating a more healthy community.

Results: Chironomids were generally the most abundant, as well as the most diverse group of invertebrates recovered from the samples. Twenty-one different genera of chironomids were identified. Leeches (Hirudinea), aquatic worms (Oligochaeta), and snails (Gastropoda) were also quite common.

The pondweed samples had the highest species richness as well as the highest ratings from the Shannon-Weaver Diversity Index (Table 18). The largeleaf vegetation, waterlily, and reeds all had lower species richness and diversity.

Of the sediment types, the rocky-gravel substrate had the greatest richness and diversity, followed by the sandy substrate and then the mucky substrate. All of the sediment samples had less richness and lower diversity than the plant samples.

Discussion: The results of this study suggest several things:

1) Aquatic plants are important for a lake's ecosystem because they provide a tremendous amount of substrate heterogeneity for invertebrates to colonize. This heterogeneity is important because it allows a diverse community of invertebrates to inhabit the lake, which has positive effects up the food chain for fish and waterfowl.

2) These results also lend support to Krecker's theory about more invertebrates inhabiting plants with more finely-dissected leaves. Our results showed that the pondweed, which had the most finely dissected leaves of the plants sampled, harbored the greatest diversity of invertebrates, whereas the waterlily, the plant with the most uniform leaves, had the lowest species diversity of the plants sampled.

Of the substrates, the rocky-gravel substrate supported the greatest richness and diversity of invertebrates

3) Bare lake bottom supports significantly less invertebrate diversity than the plants do. There was some variation between bottom substrate types, but all had poorer diversity than the plant samples.

Aquatic plant are often viewed simply as "weeds" to be eradicated. It should be noted that they provide many benefits to a lake as well. These include stabilizing bottom sediments and reducing turbidity, taking up nutrients which reduces algal densities, providing fish habitat, and food for waterfowl. This study suggests that another benefit be added to the list. That being their role in allowing for a rich and diverse invertebrate community which helps to transfer energy from the periphyton (algae attached to plants) and provides a variety of food for animals further up the food chain such as fish and waterfowl.

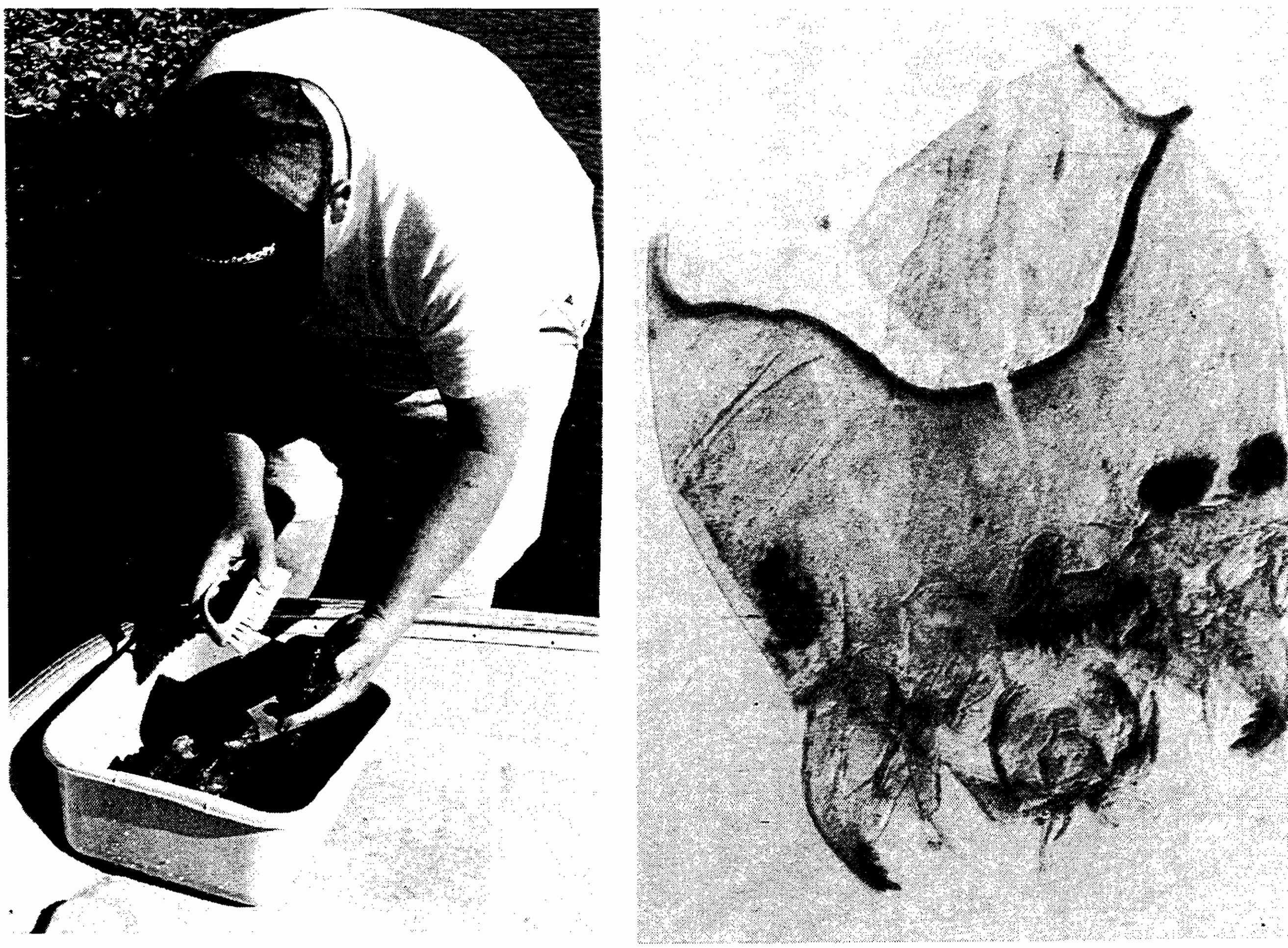


Figure 18. Dale Jalinski collecting of invertebrates from a rock substrate and a photograph of a Bear Lake chironomid (magnified 60 times).

Table 18. Macroinvertebrate taxa, abundances, and indices.

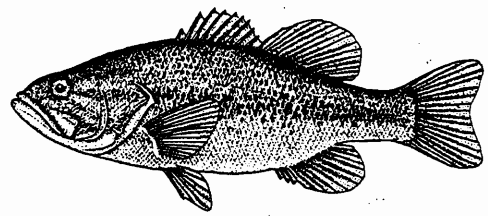
Taxa	BL#1	BL#2	BL#3	BL#4	BL#5	BL#6	BL#7	BL#8	BL#9	BL#10	BL#11	BL#12
GASTROPODA												
Amnicola				1								1
Gyraulus								1				
Helisoma		1	5									
Stagnicola					1					1		
Viviparus				1								
PELECYPODA												
Pisidium	1											
HIRUDINEA	2	6	17	4	2			1				
OLIGOCHAETA	20		5	1	3							
AMPHIPODA												
Gammarus	3				5	1	1				1	
COLEOPTERA												
Stenelmis	1											
CHIRONOMIDAE												
Chironomus	7	3						3				1
Cricotopus	3	7	2	11		2						
Dicrotendipes	20	3						1				
Einfeldia						1						
Eukiefferiella				8	2	8						
Glyptotendipes	27	10			2							
Heterotrissocladius								5				
Lauterborniella	10	7										
Micropsectra										2		
Microtendipes			1						1			
Omisus		3										
Parachironomus		13	4	6				7				
Paralauterborniella			1			3						
Paratendipes									1			
Polypedilum					2	3						
Pseudochironomus										7		
Robackia									1			
Stictochironomus		13	1	34	26	2	8					
Tanytarsus	7	20										
Thienemannimyia	7	3	10	8		3	1	1		1	1	
Xenochironomus					3		1					
EPHEMEROPTERA												
Caenis	1	2										
TRICHOPTERA												
Goera							1					1
Species Richness	13	13	9	9	9	8	5	7	3	4	2	3
S-W Diversity Index	3.1	3.3	2.6	2.4	2.2	2.7	1.6	2.3	1.5	1.5	1	1.5
Species unidentified		25	5	4								
Number of Individuals	109	116	51	78	42	23	12	19	3	11	2	3

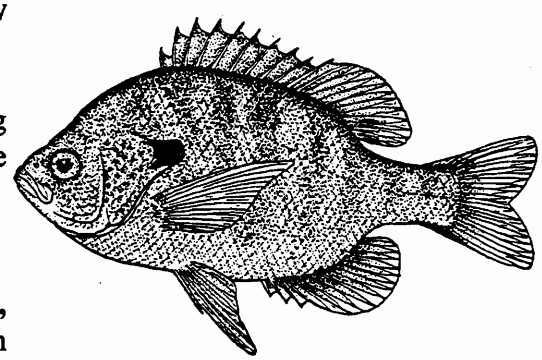
4.7. Fish

Introduction: Fish projects have been an important part of Bear Lake management going back to 1985.

The objective of the original panfish removal effort was to reduce fish predation pressure in the littoral zone to allow young walleye access to a food source that would allow them to reach a piscivorous stage. We hypothesized (we meaning Blue Water Science and the Bear Lake Board of Directors) that walleyes were encountering a bottleneck at 2-3 inches in size and that if they could reach piscivorous size, there would be enough food to allow recruitment into harvestable fish. A secondary objective was to increase the average size of bluegill and pumpkinseed. By removing sunfish at spawning time, we were hoping to disrupt spawning as well as remove fish, with the remaining fish then having more food available, allowing members of this slow growing community to get larger.

In addition, the Bear Lake District has been supplementally stocking walleyes in Bear Lake. We would like to see if these projects have had positive impacts on the fish community.





Largemouth bass (top) and bluegill sunfish (bottom) are both important fish in the Bear Lake fishery. Largemouth bass surprisingly has increased in number and size since the fish removal project was started. The bluegill sunfish populations has decreased in number and has increased in size. This was one of the objectives to the fish removal project.

Methods – Summer Fish Surveys and Fish Removal: 1985, 1986, 1987, 1988, 1989, 1991, 1993, 1996: June panfish surveys have been conducted on Bear Lake using fyke nets for 5 to 10 days on eight occasions since 1985. Incidental with panfish, gamefish were surveyed at this time as well (Figures 19 and 20).

Besides serving as summer fish surveys, panfish removal was also undertaken. All gamefish caught in the fyke nets were counted and released, and all sunfish and bullheads were removed from Bear Lake. Since 1985, Bear Lake volunteers have subsampled every net to get length measurements on bluegills and pumpkinseeds. Measurements were taken to the closest quarter-inch. All the fish were counted. Since 1986, bluegills and pumkinseeds were weighed in bulk, but separately. A summary of sample dates, number of nets and number of lifts, for each survey is shown in Table 19.

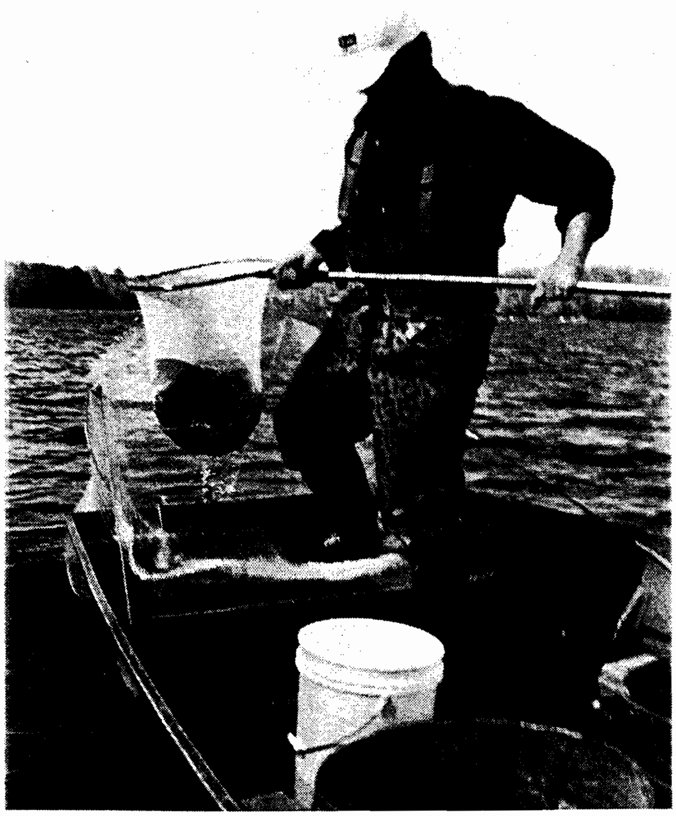


Figure 19. top: an empty fyke net sits on the front of the boat, ready to be deployed. bottom: emptying of a set fyke net.

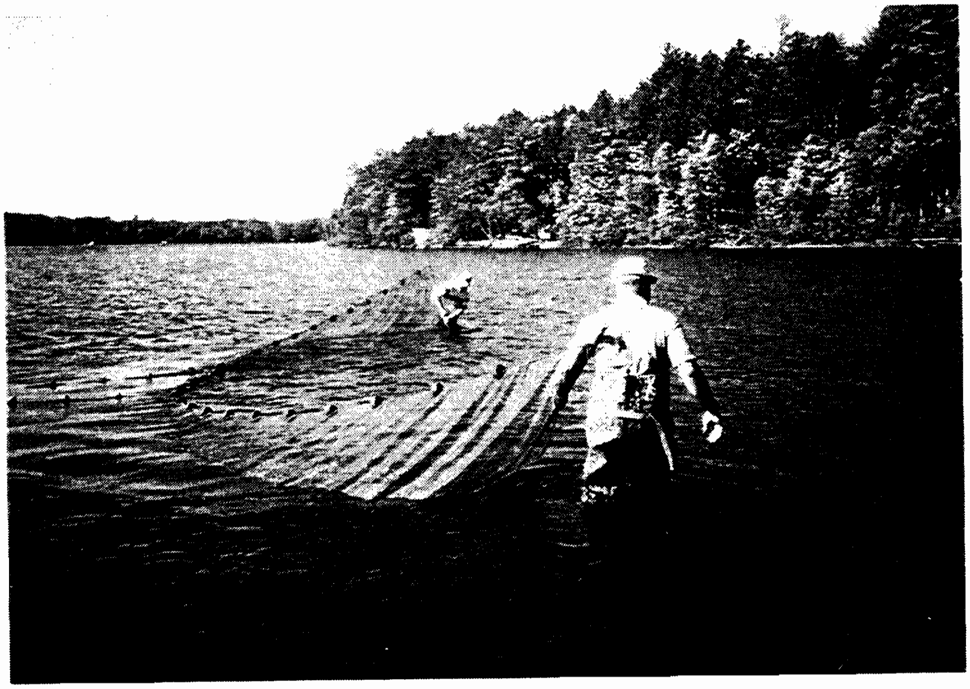


Figure 20. top: shoreline seining in 1988 supplemented fyke net removal. We average 50 lbs of fish/day using this net. Caution, do not purchase a 300 feet seine with a 1 inch mesh. Sunfish swim right through it. bottom: sorting of the days catch. Healthy sunfish were transported to Big Bearskin Lake and bullheads were taken out to woods for Bear treats.

Table 19. Summary of sample dates and net lifts.

Year	June Dates	Number of Nets	Days	Number of Lifts
1985	11	6	4	24
1986	10	10	10	100
1987	8	10	10	100
1988	6	10	10	100
1989	6	6	6	36
1991	3	10	5	50
1993	7-11	4, 10	4	44
1996	3	10	4	40

Spring Gamefish Fish Survey and Related Tasks - Methods:
The 1992 Bear Lake spring gamefish project had several tasks:

1. Preform scat netting on walleye spawning beds to see if fertilized eggs are present
2. Sample dissolved oxygen in the pore water of spawning beds to see if eggs can survive
3. Deploy fyke nets for spring gamefish survey
4. Collect scale samples from walleye for age determination

Scat netting Methods: Scat netting is a method to sample walleye eggs or other fish eggs deposited in sand, cobble, or even muck and vegetation. The scat net is a flat net with a mesh of about 2 millimeters (we used window screen) stretched over a rectangle frame measuring about 18 inches wide by 10 inches deep (we used a dip net that was bent into the shape of a rectangle and replaced the net with the screen material). The scat net is used like a sweep net. The net is swept over walleye spawning habitat and eggs are collected on the net. All eggs observed in the Bear Lake study were counted and returned to the lake.

Spawning Bed Pore Water Dissolved Oxygen Methods: At several walleye spawning sites, interstitial water (pore water) was analyzed for dissolved oxygen and conductivity. A 1.5-inch inside-diameter PVC pipe was driven 6-inches into the gravel-cobble substrate at several locations at a spawning site. Pipes were left in place for 5 to 30 minutes, then a YSI oxygen/temperature meter and a YSI Conductivity meter probe were lowered into the pipe, below the surface of the substrate to make temperature, oxygen, and conductivity measurements.

Fyke Net Deployment Methods: For the gamefish survey, six Wisconsin DNR style fyke nets were deployed from April 28 to April 31, 1992 on Bear Lake. WDNR style fyke nets consist of a square frame followed by four hoops with 2 throats. A 0.75 inch mesh (bar length) was used. Two of the nets were dipcoated, the other four were untreated.

We intended to fish for four days, but ice was still on Bear Lake on April 27. When we first set the nets on April 28, ice was still present on shaded shorelines. Because the state Walleye opener was May 2, nets were removed May 1. Fyke net locations were similar to sets in 1980.

All fish were measured except bluegill and perch which were subsampled and measured. Any fin clipped walleyes were noted.

Scales Samples from Walleyes Methods: Scale samples were collected from all walleyes. Scales were read under a Nikon stereoscope. Edges of scales were counted as a ring, the center was not counted.

Walleye Spawning Area Improvements Methods: In the 1990s, Dale Jalinski and Steve McComas had experimented using the discharge from a 3-inch centrifugal pump to remove silt from cobble-sized rocks in walleye spawning areas. In June, 1995, we did a new strip, approximately 100 feet long, along the point on an eastern shoreline (Ruth Van Prooien's property). The idea was to remove a thin deposit of silt and attached algae growth.

Panfish Fishing Survey 1995 Methods: On June 5, 1995, Dale Jalinski and Steve McComas visited seven stations around Bear Lake and fished with hook and line. We used meal worms and small poppers. We fished in shallow water (less than five feet) and within 30 feet of shore. Panfish had made spawning beds and were in spawning conditions. Fish were counted and measured from each station.

Walleye Stocking by the Lake District Methods: Since 1992, the Bear Lake District has been stocking walleyes in the fall. Fish have come from private fish hatcheries either from Phillips or nearby.

Results: Panfish Dynamics from 1985 through 1996: The 1996 panfish survey and panfish removal project capped an effort that was first started in 1985. The Bear Lake Protection and Rehabilitation District, with assistance from the WDNR - Woodruff and from WDNR - Rhinelander committed itself to a long term fish improvement program that relied heavily on lake district volunteer labor. In 1985, the lake improvement objectives were two-fold: to increase the average size of the sunfish from four inches to over six inches and to increase the number of walleyes to levels found in Bear Lake in the 1950s (over 40 walleyes per trapnet lift, April, 1959).

The approach was to use fyke nets to trap and remove bluegill sunfish, pumpkinseed sunfish, and yellow bullheads. We wanted to sustain the effort for at least three straight years. The idea was that if we reduced the number of panfish, there would be reduced competition with young walleyes, which would allow more walleyes to reach a fish-eating size. Also by reducing sunfish numbers, the remaining sunfish would have more food and grow larger.

A summary of panfish removed from Bear Lake from 1985 through 1996 is shown in Table 20.

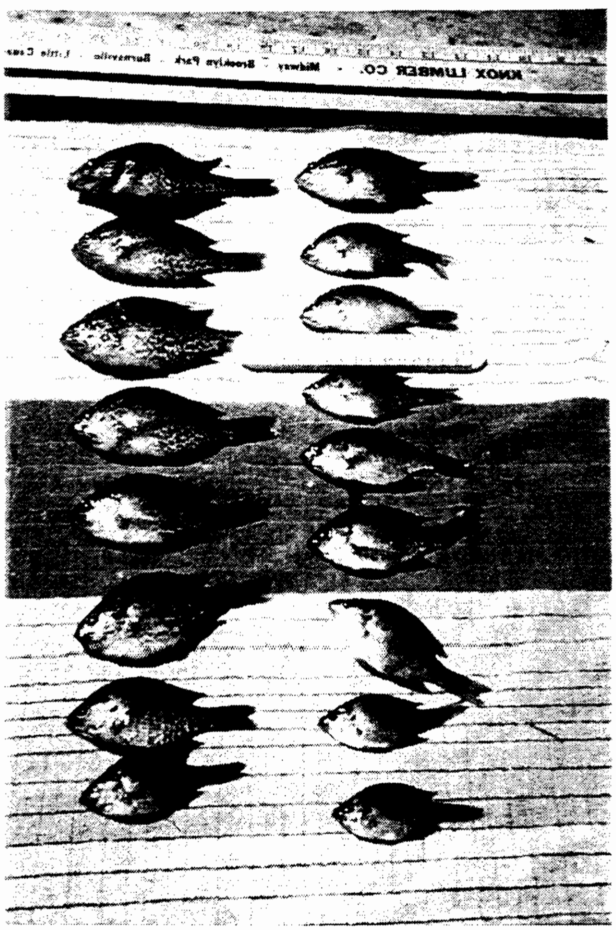
Sunfish and bullhead removal projects has been going on since 1985.

The first year, 1985, we used six fyke nets for four days. It turned out to be somewhat of a practice year in that we found good net locations, and also found that the net mesh size should be ½ inch or less. We removed 7,600 sunfish, but figured we needed to do better than that in the future, if we were to have an impact on the panfish. For the next three years we used 10 nets for a two week period in June (1986, 1987, and 1988). This was our major removal effort, and we removed over 100,000 sunfish.

The next four net-setting years (1989, 91, 93 and 96) were a combination of panfish and gamefish evaluation, as well as what we regarded as maintenance panfish removal.

The 1993 evaluation/removal was the first year we saw significant increases in the size of bluegills (Tables 21 and 22). In 1985 only 4% of the bluegills were six inches or larger. In 1993, 49% registered six inches or larger and in 1996, 45% were in that category. We have had large bluegills for at least four years running (1993-1996). Pumpkinseed size increases may have started before the bluegills. In 1985, 14% of the pumpkinseeds were six inches or larger. In 1989, 45% were in that category. Results in 1996 indicate there are still big pumpkinseed in the lake with over 60% registering six inches or larger. For both species of sunfish, the number of fish per lift has declined since 1985. Bullheads appear to have remained at about the same level but they are slightly larger in 1996 compared to 1986.

A picture showing panfish in 1985 and in 1986 is shown below in Figures 21 and 22.



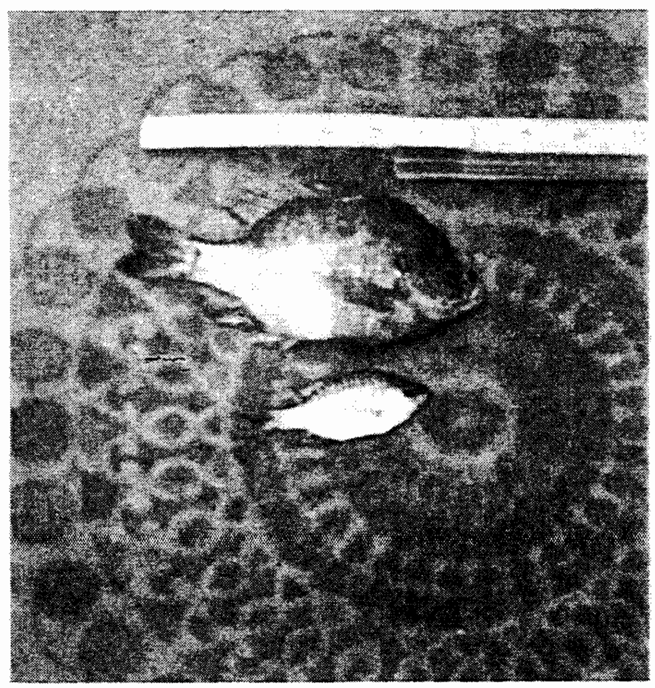


Figure 21. Stunted panfish in 1985 (left).
Figure 22. Bluegill sunfish (over 7 inches) are now much more common in 1996 in Bear Lake (right).

Table 20. Pounds and numbers of bluegills, pumpkinseeds, and bullheads removed from Bear Lake since 1985.

	Pound						Number					
	Bluegill	Pumpkinseed	Total sunfish	Bullhead	Total pounds	Total pounds	Bluegill	Pumpkinseed	Total sunfish	Bullhead	Total fish	Fish per acre
1985[b]	?	?	688	0	688[a]	2.2	3,135	4,485	7,620	--	7,620	24
1986[c]	1,397	1,471	2,868	483	3,351	10.7	24,571	14,508	39,079	1,931	41,010	131
1987[c]	1,148	1,146	2,294	376	2,670	8.6	23,978	11,559	35,537	1,656	37,193	119
1988[c]	939	947	1,886	767	2,653	8.5	18,839	9,117	27,956	3,948	31,904	102
1989[d]	443	571	1,014	321	1,335	4.3	6,087	3,945	10,032	1,274	11,306	36
1991[e]	995	545	1,540	391	1,931	6.2	17,157	4,072	21,229	1,392	22,621	73
1993[f]	149	438	587	391	978	3.1	1,025	2,754	3,779	1,374	5,153	17
1996[g]	144	455	599	296	895	2.9	1,169	2,677	3,846	618	4,464	14
Total	**5,215**	**5,573**	**11,476**	**3,025**	**14,501**	**46.5**	**95,961**	**53,117**	**149,078**	**12,193**	**161,271**	**517**

[a] estimate of bluegill and pumpkinseed pounds removed
[b] 4 days, 6 nets, bullheads were not removed (24 lifts)
[c] 10 days, 10 nets, major removal effort (100 lifts)
[d] 6 days, 6 nets, this was intended as a sampling year not a full-blown fish removal year (36 lifts)
[e] 5 days, 10 nets (50 lifts)
[f] 5 days, 10 nets (44 lifts)
[g] 4 days, 10 nets (40 lifts)

Table 21. Percent of bluegills and pumpkinseed sunfish six inches or bigger based on June fyke net data.

Date	Bluegill	Sunfish	Temperature
1985	4	14	66
1986	7	18	62-70
1987	5	21	67-75
1988	2	17	67-74
1989	7	45	58-65
1991	10	30	70-74
1993	49	59	58-69
1996	45	60	62-64

Table 22. Frequency distribution of bluegill and pumpkinseed sunfish for June fyke net data for Bear Lake 1985-1996.

Total length	*Percent Occurrence*							
(inches)	*1985*	*1986*	*1987*	*1988*	*1989*	*1991*	*1993*	*1996*
BLUEGILL								
2.5	3	0	0	0	0	0	0	0
3.0	4	3	0	0.3	1	0	0	0
3.5	4	6	5	2	1	12	1	2
4.0	34	22	55	45	7	43	1	1
4.5	11	25	18	32	19	18	4	4
5.0	26	28	13	15	30	8	9	20
5.5	14	9	6	4	35	9	36	27
6.0	0	1	0.1	0.4	0	2	30	36
6.5	0	1	0.1	0.4	0	2	13	9
7.0	0	0	0	0	0	1	5	1
7.5	0	0	0	0	0	0	1	0
PUMPKINSEED								
2.5	0	0	0	0	0	0	0	0
3.0	0	0	0	0.3	0	0	1	0
3.5	2	2	0.8	0.8	1	1	0	0
4.0	11	8	12	7	3	14	1	0
4.5	12	12	19	17	3	17	3	1
5.0	36	32	27	33	14	16	5	11
5.5	25	30	21	23	34	22	32	28
6.0	12	15	17	12	36	21	31	36
6.5	2	2	3	4	8	6	21	16
7.0	0	1	0.6	0.8	1	2	4	8
7.5	0	0	0	0	0	1	2	0

The gamefish community has thrown us a couple surprises. First, the walleye community does not appear to have been enhanced by panfish removal (Table 23). Numbers of walleye per lift have been similar for the last 11 years. Although, our walleye objective apparently was not achieved, we did see dramatic increase in the number of largemouth bass. This is somewhat unexpected but not unwelcomed. The bass fishery is about as good as it has ever been.

Table 23. Number of gamefish and panfish caught for every fyke net set.

Date	Walleye	Northern Pike	Largemouth Bass	Yellow Perch	Bluegill	Pumpkinseed	Bullhead
1985*	0.3	0.2	1.9	3.4	131	187	18
1986	0.3	0.4	2.1	1.2	246	145	19
1987	0.5	0.6	0.9	1.0	240	116	17
1988	0.1	0.5	1.7	0.4	188	91	40
1986*	0.2	0.6	4.0	0.4	169	110	35
1991*	0.2	1.4	3.5	0.4	343	81	28
1993*	0.2	0.4	2.0	0.3	23	63	31
1996*	0.2	0.6	6.4	1.2	29	67	16

* netting conducted for one week period. Other years netting was conducted for 2 weeks.

In conclusion, the panfish removal efforts beginning in 1985 coincide with several changes in the fish community. The following was observed:

Species	**Observations (comparing 1985 to 1996 fish status)**
bluegill	**fewer, bigger**
pumpkinseed	**fewer, bigger**
bullheads	**numbers are the same, bigger**
largemouth bass	**increased numbers, bigger**
walleye	**no change**
northern pike	**no change**
yellow perch	**no change**

We would like to think that netting alone could account for positive changes in the fish community. However, length limits have been set by the WDNR for bass, walleye, and northern pike in 1994 and this may have had an influence on the fish community as well.

Results: Gamefish Population Based on Spring Surveys: The total number of fish captured in the 1992 April fyke net survey is shown in Table 24. A summary of fish length distribution for major species that were captured is shown in Figure 23.

The main objective of this study was to evaluate the walleye population. Results showing individual walleye lengths and weights is shown in Table 25. Length distribution for other fish species are shown in Table 26.

Walleye age determination based on scale readings, and total lengths for an age class is shown in Table 27. Few walleyes were found in I-II year class. Growth rates were similar to what was found in 1980.

Table 24. Total number of fish captured and the fish per net for the April 28-31, 1992 Bear Lake fish survey.

Species	Total Number of Fish	Fish/Net (18 nets)
Bluegill	271	15.1
Pumpinseeds	128	7.1
Yellow bullheads	343	19.1
Largemouth bass	6	0.3
Northern pike	75	4.2
Walleye	64*	3.6
Black crappie	165	9.2
Rock bass	15	0.8
Yellow perch	1531	85
White sucker	136	7.6

*average weight = 1.7 lbs based on 64 fish

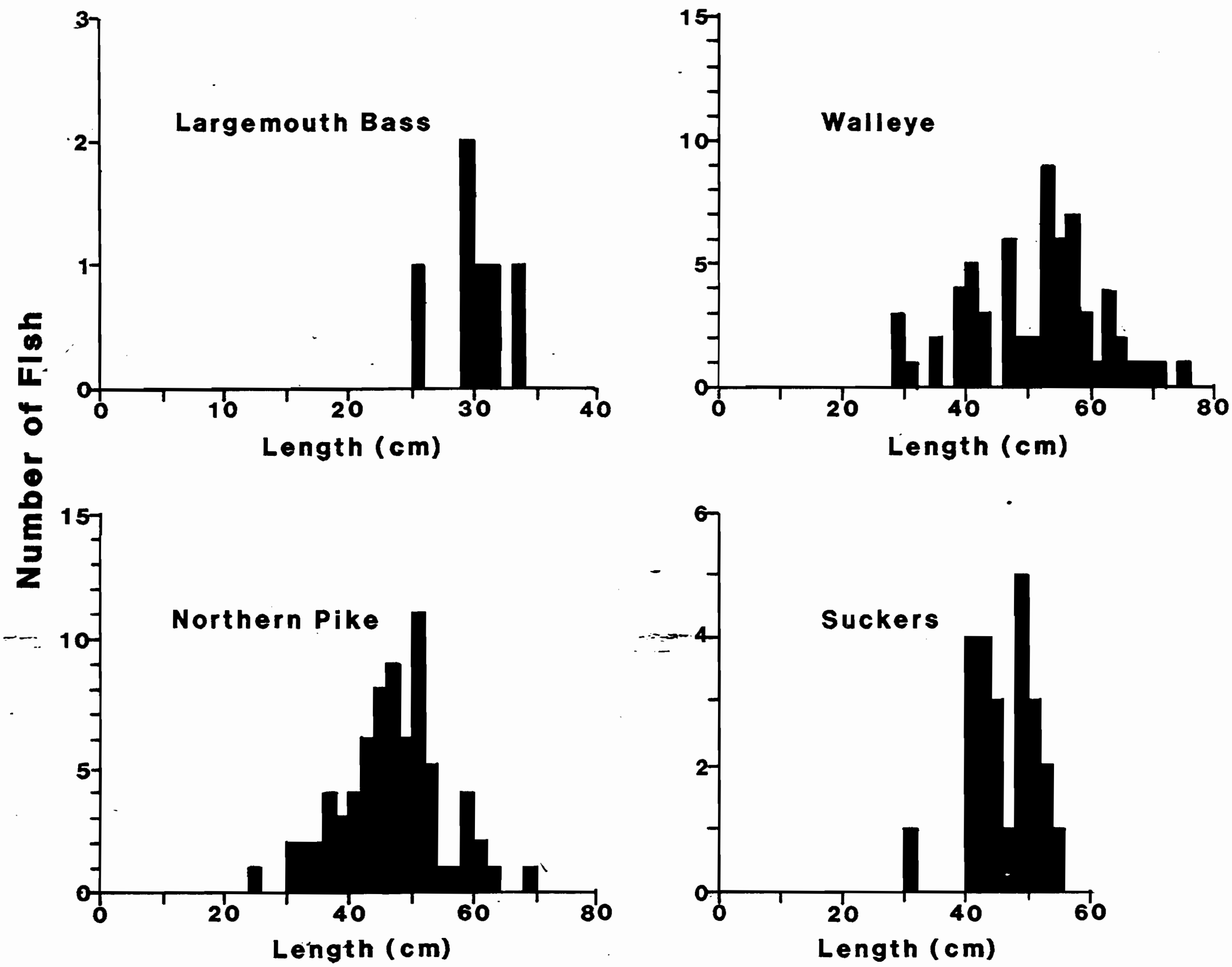


Figure 23. Fish length distribution for April 28-May 1, 1992. Bear Lake fish fyke net survey.

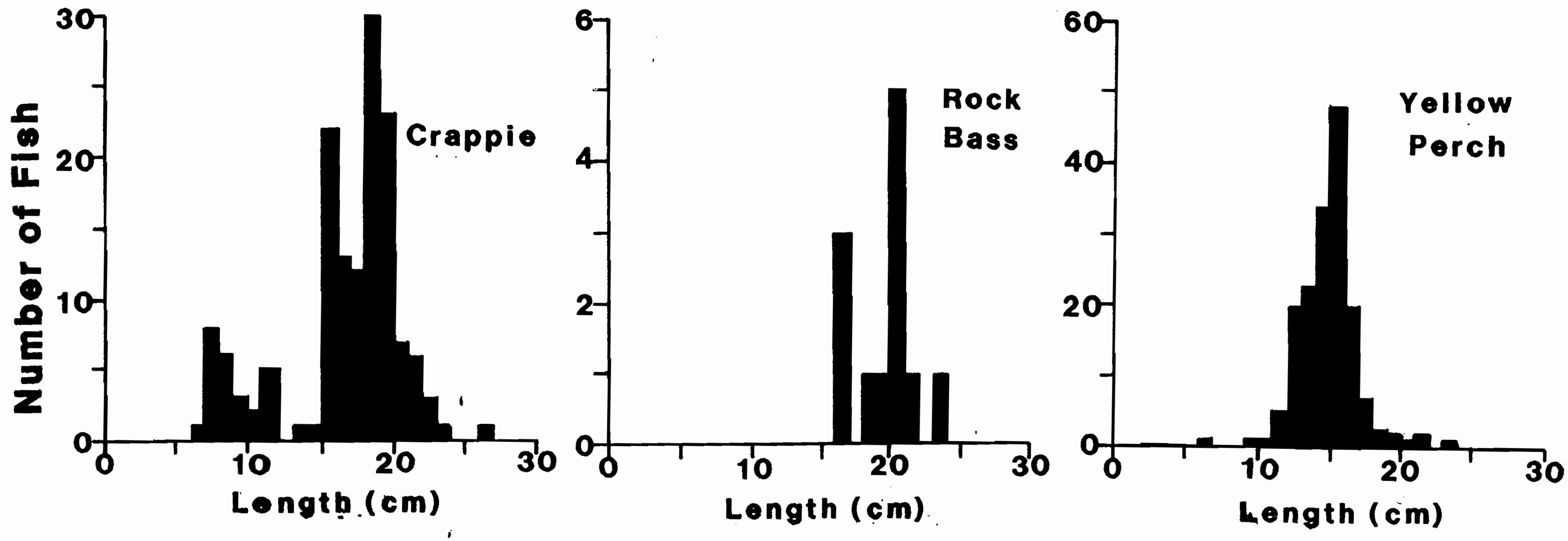


Figure 23. Concluded.

Table 25. Walleye length distribution on Bear Lake, April 28-May 1, 1992 fyke net survey.

	Males		Females		Undetermined	
Length (cm)	Number	Average Weight (lbs)	Number	Average Weight (lbs)	Number	Average Weight (lbs)
0.0-1.9						
2.0-3.9						
4.0-5.9						
6.0-7.9						
8.0-9.9						
10.0-11.9						
12.0-13.9						
14.0-15.9						
16.0-17.9						
18.0-19.9						
20.0-21.9						
22.0-23.9						
24.0-25.9						
26.0-27.9						
28.0-29.9	2	0.5			1^a	0.5
30.0-31.9						
32.0-33.9	1	0.7				
34.0-35.9	1^b	1			1^b	1
36.0-37.9						
38.0-39.9	4^c	1.3				
40.0-41.9	5	1.8				
42.0-43.9	2	2			1	1.7
44.0-45.9						
46.0-47.9	5	2			1	2.2
48.0-49.9	1	2.1	1	3.3		
50.0-51.9	1	3	1	3.6		
52.0-53.9	6	3.2	3	3.7		
54.0-55.9	4^d	3.6	2	3.9		
56.0-57.9	4	3.7	3^e	3		
58.0-59.9	1	3.9	1	5.5		
60.0-61.9					1	4.4
62.0-63.9	2	5.6	1	6	1	4.6
64.0-65.9			2^g	5.5		
66.0-67.9			1	6.9		
68.0-69.9			1	7.6		
70.0-71.9			1^f	6.5		
72.0-73.9						
74.0-75.9			1	8.7		
TOTALS	39		18		6	

Total weight captured:

Males	99.0 lbs
Female	81.3 lbs
Undetermined	14.4 lbs

a = 1 undetermined 0.5 lbs clipped fin
b = clipped fin
c = 1 male 1.5 clipped fin
d = 1 male 3.5 lbs clipped fin
e = 1 female no weight clipped fin
f = 1 female 6.5 lbs clipped fin
g = 1 fish no weight

Table 26. Species length distribution for Bear Lake spring survey 1992*.

Length (cm)	Northern Pike	Largemouth Bass	Crappie	Rock Bass	Yellow Perch	White Sucker
not measured			13		1359	109
4.0-5.9						
6.0-7.9			9		1	
8.0-9.9			11		1	
10.0-11.9			8		6	
12.0-13.9			1		43	
14.0-15.9			23		82	
16.0-17.9			29	3	27	
18.0-19.9			53	2	5	
20.0-21.9			13	6	3	
22.0-23.9			4	1	1	
24.0-25.9	1	1				
26.0-27.9			1			
28.0-29.9		2		1		
30.0-31.9	2	2				1
32.0-33.9	2	1				
34.0-35.9	2					
36.0-37.9	4					
38.0-39.9	3					
40.0-41.9	4					4
42.0-43.9	6					4
44.0-45.9	8					3
46.0-47.9	9					1
48.0-49.9	6					5
50.0-51.9	11					3
52.0-53.9	5					2
54.0-55.9	1					1
56.0-57.9	1					
58.0-59.9	5					
60.0-61.9	2					
62.0-63.9	1					
64.0-65.9						
66.0-67.9						
68.0-69.9	1					
70.0-71.9						
72.0-73.9						
74.0-75.9						
TOTALS	74	6	165	13	1528	133

* 271 bluegills and 128 pumpkinsedd sunfish were trapped but not measured.

Table 27. Age and average walleye total lengths for an age class from 1992 spring fyke net survey are compared to age and average walleye total lengths for an age class from 1980 spring fyke net survey. Length is in inches. Number of fish for each age class is in parentheses.

Age	1980 Walleye(M)	1980 Walleye(F)	1980 Walleye (Combined)	1992 Walleye(M)	1992 Walleye(F)	1992 Walleye (Combined)
I	--	--	--	--	--	--
II	--	--	--	9.1(1)	--	9.1(1)
III	11.4(3)	--	11.4(3)	11.4(3)	--	11.4(3)
IV	14.3(6)	--	14.3(6)	14.5(7)	--	14.5(7)
V	16.1(37)	--	16.1(37)	16.5(8)	--	16.5(8)
VI	18.0(42)	18.4(17)	18.1(59)	18.2(3)	--	18.2(3)
VII	19.8(23)	20.1(12)	19.9(35)	20.1(3)	20.3(2)	20.2(5)
VIII	21.3(3)	21.3(5)	21.3(8)	21.2(3)	21.3(1)	21.2(4)
IX	22.1(3)	23.0(11)	22.8(14)	22.4(2)	22.4(3)	22.4(5)
X	--	24.3(5)	24.3(5)	--	25.2(2)	25.2(2)
XI	--	26.2(4)	26.2(4)	--	26.0(1)	26.0(1)
XII	--	--	--	--	27.6(1)	27.6(1)
XIII	--	28.4(4)	28.4(4)	--	--	
Total Number of Fish Captured			175			40*

* 2 fish were not added into age determination. Their lengths were 53 cm and 75 cm, also.

White suckers seem to have declined in the last 30 years. As with walleyes, few young suckers were found. The three suckers that we made age determinations for were four and five years old (Table 28).

Table 28. Age and length of three white suckers that were captured in 1992. Length is in cm.

Age	Length
IV	45(1);46(1)
V	49(1)

Another project that was conducted along with fyke netting was walleye spawning bed investigation. We used scat netting to look for fertilized walleye eggs and we performed some water quality monitoring of the interstitial pore water at spawning locations. Results are summarized in Table 29.

Table 29. Scat netting results, and spawning bed pore water quality results for spring 1992.

Location	Water Depth	Number of Eggs	Water Temp ©	Cond. (uS)	Open Water DO (mg/l)	Pore Water DO (mg/l)	Pore Water Cond (uS)
April 29							
Island Stat	18-24"	10	9	40	9.4	7.0	--
Island Stat.	6"	100	9	40	9.4	7.0	--
Ruth's Point	6-24"	0	9	43	9.2	7.4	--
Webers	6-24"	2?	9	--	--	--	
April 30							
Island Stat.	6-12"	50-60	11	45	10.6	6.0	60
Shaefers	6-18"	10-20	--	--	--	--	--
Ruth's	6-18"	2	10.5	40	9.2	6.0	90
Bremer's	6-12"	20-40	--	--	--	--	--

Results indicated that the island shoreline produces the most walleye eggs. Ruth's point, which is the shoreline along Sunset Resort, has excellent rock rubble substrate but low eggs counts. We don't know why. In the 1950's and 1960's walleyes were frequently seen on these beds (R. Van Prooien, personal communication). Pore water is different than open-lake water but should not inhibit egg hatching. Reasons for a lack of walleye spawning success do not appear to be to poor water quality or a lack of suitable spawning substrate.

Some changes in the fish community appear to have taken place since 1959 (Table 30). Since 1959, walleyes have decreased as have white suckers, whereas bluegill, yellow perch, crappie, and bullheads have increased. Northern pike may have increased also. However, this table may not show the whole picture. Summer fyke netting results indicate largemouth bass are increasing. And the startling increase in perch appears to be recent (1992). The 1991 summer fyke panfish survey did not show an increase in perch.

I think the Bear Lake fish community is still changing. With the recent increase in yellow perch, it may be possible that walleye recruitment will increase in the future. This is something to watch.

Table 30. Number of each species per lift found in Bear Lake during 1959, 1980, and 1992 surveys.

	1959[1]	1980[2]	1992[3]
Walleye (total)	46	9.6	3.6
(males)	--	7.1	2.3
(females)	--	2.5	1.3
Northern Pike	present	1.3	4.2
White Sucker	143	29.2	7.7
Bluegill	0	A	15.1
Yellow Perch	0.5	B	85
Crappie	?	B	9.2
Bullhead	1.5	B	19.1[c]
Rock Bass	0.1	B	0.8
Muskie	present	0	0
Smallmouth Bass	present	B	0

[A]numerous 3.0-inch bluegills
[B]not mentioned
[C]Yellow bullhead

[1]1959: April 27-30, 1959; 20 lifts (WDNR)
[2]1980: April 23-26, 1980; 24 lifts (WDNR)
[3]1992: April 28-May 1, 1992; 18 lifts (Blue Water Science)

Sunfish Fishing Survey: The panfish were biting the day we sampled (Table 31). Bluegills were more numerous than pumpkinseed, but pumpkinseeds were slightly larger. The catch per unit effort averaged 33 fish per hour (Table 32), with nearly half of those fish being keepers (6 inches or larger). We caught fish at every station, although we purposely selected stations we thought would produce. Only Station G (D. Lemanski's place) was a little slow.

Although bluegills and sunfish were on beds, only a handful of female bluegills were in spawning condition.

Table 31. Bluegill and pumpkinseed sampling with hook and line, June 5, 1995.

Bluegills (size in inches)									
Station	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	Total
A	0	0	11	11	1	0	0	0	23
B	0	0	1	6	16	13	2	0	38
C	0	3	6	11	7	0	0	0	27
D	4	0	11	8	11	1	0	0	35
E	0	2	4	2	5	3	1	0	17
F	3	3	7	17	4	1	0	0	35
G	0	0	5	3	3	0	0	0	11
Total	7	8	45	58	47	18	3	0	186
% Fish over 6 inches: 68/186 = 37%									
Pumpkinseed (size in inches)									
Station	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	Total
A	0	0	1	4	1	1	0	0	7
B	0	0	0	1	0	0	0	0	1
C	0	0	0	4	2	1	0	0	7
D	0	0	0	0	1	0	1	0	2
E	0	0	1	4	3	3	0	1	12
F	1	0	0	1	4	0	0	0	6
G	0	0	0	3	3	1	0	0	7
Total	1	0	2	17	14	6	1	1	42
% Fish over 6 inches: 22/42 = 52%									

Table 32. Catch per unit effort for Bear Lake panfish on June 5, 1995.

Station	Bluegill	Pumpkinseed	Total	Fish/hour
A - Beaver Lodge	23	7	30	30
B - Paper Company Beach	38	1	39	39
C - F. Harris	27	7	34	34
D - Bremers Point	35	2	37	37
E - Ruths Bay	17	12	39	39
F - Island	35	6	41	41
G - D. Lemanski	11	7	18	18
Total	186	42	228	33

Walleye Spawning Area Desilting: From work on Bear Lake in 1991 and 1993, we knew that walleyes were dropping eggs on gravel/cobble substrate in nearshore areas. We found eggs using scat nets. However, natural walleye reproduction has been lacking in Bear Lake. We thought if we desilted spawning sites, that eggs survival might increase.

We worked off of Ruth's point. In the 1995 effort we found an interesting result. We held the discharge tube too close to the rock substrate. By doing this we fluidized the bed and the cobble-sized rocks sunk faster than the sand and gravel. The result was we ended up with about two inches of sand over the cobble (Figure 24). In the future we will not use such a forceful discharge.

Figure 24. Whoops! Walleye spawning site is shown above, and after cleaning it is shown below. We "over" cleaned it.

Walleye Stocking by the Lake District: The Bear Lake District has been buying walleyes for stocking on an annual basis since 1992 to supplementally add to the WDNR stocking. The number of walleyes stocked is shown in Table 33. At the end of 1996, there has not been a noticeable increase in walleye numbers based on angler comments. One of the District's goals is to improve walleye fishing success (Figure 25).

Table 33. Bear Lake District walleye planting.

Year	Number of Walleye	Length (inches)
1992	420	5-8
1993	500	6-9
1994	800	6-10
1995	1,000	6-10
1996	1,000	6-10

Figure 25. One of the Bear Lake District's fish program goals is to improve the walleye population.

Conclusions

Panfish and bullhead removal as a fish manipulation project started in 1985. Have our efforts had an impact? With all the data that as been collected over the years the feeling of the lake users is that we are effecting the lake positively, and one of the strong indicators is the increase in the size of the panfish (based on our records). Another good indicator is the fishermen's creel. More sunfish are being kept in 1996 then in 1985 (based on fishermen's remarks). Another positive indicator from the panfish survey results is the bass population. Fishermen has commented that more bass and bigger bass are being caught with most of them being released. This is good for long term control of the stunted sunfish situation.

Volunteer help has made the sunfish/bullhead removal project feasible for Bear Lake.

However, the walleye population does not appear to be increasing in number. This was one of our objectives of the fish manipulation projects. Although walleyes have not increased yet, there is a chance they still could. I think the lake community is still adjusting to the manipulation. Hopefully walleyes will be able to get strong year classes going again.

One last question is: "is this a viable technique for addressing stunted panfish conditions?" I think the answer is yes under the right circumstances. The technique of panfish removal with fyke nets if time consuming and labor intensive. Unless there is a volunteer group willing to do the work, this will be too expensive. Also, our level of effort was 1 fyke net for every 30 acres of lake surface (10 nets for 300 ac) fished for 2 weeks per summer for 3 years. I would not recommend anything less.

4.8. Wildlife

The Bear Lake watershed and lake has a wide variety of wildlife. Some examples are shown in Figures 26, 27, and 28.

Members of the Bear Lake District have played an active role in supporting and helping wildlife in the area. They set out an array of feeders that attract a number of species of wildlife including:

- deer
- bear
- racoons
- flying squirrels
- fisher
- muskrat
- gold finches
- red breasted grosbeak
- wood ducks

In addition sightings of other animals include:

- beavers
- porcupines
- grouse
- ducks
- loons
- otter
- eagles
- osprey
- turtles

The Bear Lake District has installed two osprey nesting platforms in the last several years as well as wood duck boxes. Wildlife enhancement project are ongoing with many lake residents.

Figure 26. (Top) A pitcher plant found in a peaty area near the Bear Lake outlet. This plant "eats" insects. Figure 27. (Bottom): A rare colonial bryozoan (small flagellated animal) living in Bear Lake. The filter lake water and feed on algae.

Figure 28. Turtles: big (top) -- a snapper and small (bottom) -- a mud turtle.

5. LAKE STATUS

Phosphorus Model

Lake modeling is a tool that aids in predicting what phosphorus concentrations should be in a lake based on the amount of nutrients that comes into a lake on an annual basis. A lake model can also be used to predict what future conditions could be if changes occur in the watershed that bring in more phosphorus.

The Wisconsin Lake Model Spreadsheet phosphorus model was used in this study. The model format is shown in Table 34. Before the models could be run, nutrient and water budgets for Bear Lake were needed. To estimate the nutrient budget, phosphorus concentrations were assigned for various land use delineations and then assuming a certain amount of runoff per year we estimated phosphorus inputs from various land uses. A summary of phosphorus export coefficients for each land use and then the total estimated phosphorus input to Bear Lake is shown in Table 34. Rainfall is the major nutrient contributor to Bear Lake followed by forested areas and then followed by residential areas, and lastly the wetlands systems (Figure 29). The variables with high uncertainty are groundwater inputs as well as septic tank inputs. Our estimates are that septic tanks inputs are low.

The phosphorus model estimates show that the major nutrient contributor to Bear Lake is rain water, followed closely by the forested areas, residential areas, and lastly the wetlands.

The phosphorus model predictions and the actual observed phosphorus load are shown on the second page of Table 34. For Bear Lake, the Reckhow and Simpson model prediction was 6 parts per billion (ppb) and the Canfield and Bachmann model prediction was 32 ppb, while the average found for Bear Lake was 33 ppb.

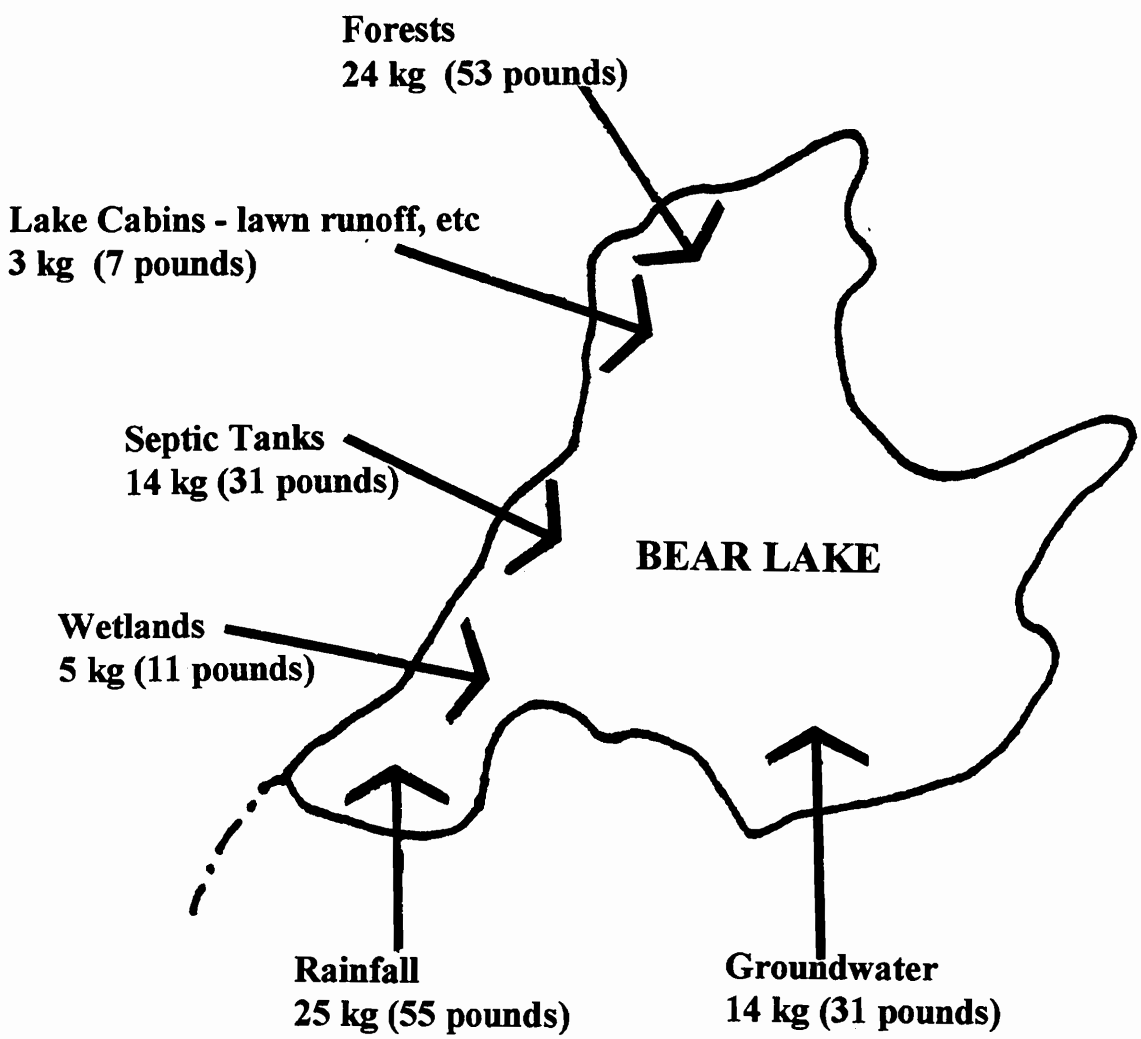


Figure 29. Diagram of estimated nutrient inputs to Bear Lake on an annual basis.

Table 34. Phosphorus model.

```
********* ********* ********* ********* ********* ********* ********* * **
*                    WISCONSIN LAKE MODEL SPREADSHEET                    *
*                       VERSION 1.01 - JULY 1994                         *
*               WISCONSIN DEPARTMENT OF NATURAL RESOURCES                *
* Although this model has been tested by WDNR, no warranty is            *
* expressed or implied.  See users manual prior to using model.          *
********* ********* ********* ********* ********* ********* ********* * **
* LAKE ID  Bear Lake                                                     *
* TO AUTO LOAD WTRSHD.  DATA ENTER COUNTY ID, HOLD ALT & TYPE  L          *
* WATERSHED COUNTY IDENT. NUMBER            44  CO. NAM  Oneida          *
********* ********* ********* ********* ********* ********* ********* * **
*               HYDROLOGIC AND MORPHOMETRIC MODULE                       *
* ===================================================                    *
*                              ENGLISH           METRIC                  *
* TRIB. DRAINAGE AREA   =        840.0  Ac.       3.40E+06  m^2          *
* TOTAL UNIT RUNOFF     =         12.2  In.          0.310  m            *
* ANNUAL RUNOFF VOLUME           854.0  Ac-Ft.    1.05E+06  m^3          *
* LAKE SURFACE AREA <As>         312.0  Ac.       1.26E+06  m^2          *
* L. VOLUME <V>         =       2620.8  Ac-ft.    3.23E+06  m^3          *
* L. MEAN DEPTH <z>     =         8.40  Ft.           2.56  m            *
* L. NET ANNUAL PRECIP. =            0  In.           0.00  m            *
* HYDRAULIC LOADING     =        854.0  Ac-Ft/Yr  1.05E+06  m^3/Yr       *
* AREAL WATER LOAD <qs>       2.74E+00  Ft/Yr.    8.34E-01  m/Yr         *
* L. FLUSHING RATE <p>  =         0.33  /Yr  Tw =     3.07  Yr           *
********* ********* ********* ********* ********* ********* ********* * **
*                    PHOSPHORUS LOADING MODULE                           *
* ===================================================                    *
*                              --LOADING (Kg/Ha-Yr)--                    *
* LAND USE           AREA               MOST                 LOADIN      *
*                    (Ac)       LOW    LIKELY  HIGH          PERCENT     *
* AGRICULTURE          0.0      0.30     0.50      2.00          0.0     *
* FOREST             580.0      0.05     0.10      0.20         25.8     *
* URBAN               41.0      0.50     1.00      1.50         18.3     *
* OPEN GRASSLAN        0.0      0.10     0.30      0.50          0.0     *
* WETLAND            219.0      0.10     0.10      0.10          9.8     *
* PRECIPITATION      312.0      0.10     0.30      1.00         41.7     *
* --------------------------------------------                           *
* POINT SOURCE WATER LOADING (m^3/Yr)          0.00E+00                  *
* POINT SOURCE PHOS.(Kg/Yr)     0.00     0.00      0.00          0.0     *
* SEP.TANK OUTPUT(kg/cp-yr)     0.70     0.80      2.10     ----         *
* # capita-years     50.00   ---  ----   ---  ---                        *
* % P. RETAINED BY SOIL           98       90        80     ----         *
* SEP. TANK LOADING (Kg/Yr)     0.70     4.00     21.00          4.4     *
* --------------------------------------------                           *
* TOTAL LOADINGS (Lb)       9.31E+01 2.00E+02 5.03E+02       100.0       *
* TOTAL LOADINGS (Kg)       4.22E+01 9.08E+01 2.28E+02       100.0       *
* --------------------------------------------                           *
* AREAL LOADING(Lb/Ac-Yr) =  2.98E-01  6.42E-01 1.61E+00                 *
* AREAL LOADING(mg/m^2-yr) 3.34E+01 7.19E+01 1.81E+02                    *
*  % TOTAL PHOSPHORUS REDUCTION          0                               *
********* ********* ********* ********* ********* ********* ********* * **
```

Table 34. Continued.

PHOSPHORUS PREDICTION MODULE

OBSERVED SPRING TOTAL PHOSPHORUS = 33 mg/m^3

LAKE PHOSPHORUS MODELS				PREDICTED TOTAL PHOSPHORU (mg/m^3)
1. WALKER, 1987 RESERVOIR MODEL				39
	18	39	98	
2. CANFIELD-BACHMANN, 1981, NATURAL LAKE MODEL				32
3. CANFIELD-BACHMANN, 1981, ARTIFICAL LAKE MODEL				28
4. RECKHOW, 1979, NATURAL LAKE MODEL				6
	0.003	0.006	0.014	
5. RECKHOW, 1977, ANOXIC LAKE MODEL				52
	24	52	131	
6. RECKHOW, 1977 OXIC LAKES qs < 50 m/yr				32
	15	32	79	
7. RECKHOW, 1977 OXIC LAKES qs > 50 m/yr				9
	4	9	23	
8. WALKER 1977, GENERAL LAKE MODEL				34
	34	34	34	
9. VOLLENWEIDER, 1975 LAKE MODEL				7
10. DILLON-RIGLER-KIRCHNER, 1975 LAKE MODEL				8
P. RETENTION COEFFICIENT <R>		0.91		

UNCERTAINTY ANALYSIS MODULE

LAKE RESPONSE MODEL	PREDICTED MINUS OBSERVED (mg/m^3)	PERCENT DIFF.	90 PERCENT CONFIDENCE LIMITS(mg/m^3)	
1.WALKER, 1987 RESERVOIR	6	18	10	106
2.CANFIELD-BACHMANN, 198	-1	-3	10	91
3.CANFIELD-BACHMANN, 198	-5	-15	9	80
4.RECKHOW, 1979 GENERAL	-27	-82	0	16
5.RECKHOW, 1977 ANOXIC	19	58	52	141
6.RECKHOW, 1977 qs<50 m/y	-1	-3	0	87
7.RECKHOW, 1977 qs>50 m/y	-24	-73	0	23
8.WALKER, 1977 GENERAL	1	3	23	69
9.VOLLENWEIDER, 1975	-26	-79	--	--
10.DILLON-RIGLER-KIRCHNE	-25	-76	--	--

< = Range within which 95% of the observations should fall.

See users manual discussion on the use of these models.

Table 34. Continued.

```
********* ********* ********* ********* ********* ********* ********* * **
*             PARAMETER RANGE MODULE                                     *
*   Model input values MUST be within the range listed below.            *
* ====================================================================== *
*                          PARAMETERS                                    *
********* ********* ********* ********* ********* ********* ********* * **
* AREAL WATER LOADING <qs=z/Tw> =   8.34E-01  m/yr                        *
* INFLOW PHOSPHORUS CONC.<LTw/z>    8.62E-02  mg/l                        *
* MEAN DEPTH <z>          =         2.56E+00  m                           *
* FLUSHING RATE <p>       =             0.33  /yr                         *
* HYDRAULIC RETENTION TIME <Tw> =       3.07  yr                          *
* AREAL PHOSPHORUS LOADING <L>         71.92  mg/m^2-yr                   *
* P = PREDICTED IN-LAKE PHOSPHORUS CONC.  mg/m^3                          *
* ====================================================================== *
*                                          Lakes in data base             *
* 1. WALKER, 1985 RESERVOIR MODEL                          (41)           *
*  1.5 < z < 58 m   0.13 < Tw < 1.91 yr                                   *
*  0.014 < LTw/z < 1.047 mg/l                     P=        39            *
* ----------------------------------------------                          *
* 2. CANFIELD-BACHMANN, 1981 NATURAL LAKE MODEL            (704)          *
*  4< P < 2600 mg/m^3  30< L < 7600 mg/m^2-yr                             *
*  0.2< z <307 m      0.001< p <183/yr            P=        32            *
* ----------------------------------------------                          *
* 3. CANFIELD-BACHMANN, 1981 ARTIFICIAL LAKE MODEL         (704)          *
*  6< P <1500 mg/m^3  40< L <820,000 mg/m^2/yr                            *
*  0.6< z <59 m      0.019< p <1800/Yr            P=        28            *
* ----------------------------------------------                          *
* 4. RECKHOW, 1979 NATURAL LAKE MODEL                      (47)           *
*  4 < P < 135 mg/m^3   70 < L <31,400 mg/m^2-yr                          *
*  0.75< qs <187 m/yr                             P=         6            *
* ----------------------------------------------                          *
* 5. RECKHOW, 1977 ANOXIC LAKE MODEL                       (21)           *
*  17< P < 610 mg/m^3 0.024< LTw/z< 0.621mg/l     P=        52            *
* ----------------------------------------------                          *
* 6. RECKHOW, 1977 OXIC LAKES  qs < 50 m/yr                (33)           *
*  P < 60 mg/m^3   LTw/z < .298 mg/l              P=        32            *
* ----------------------------------------------                          *
* 7. RECKHOW, 1977 LAKES WITH  qs > 50 m/yr                (28)           *
*  P < 135 mg/m^3   LTw/z < 0.178 mg/l                                    *
*  Tw < 0.25 yr    z < 13 m                       P=         9            *
* ----------------------------------------------                          *
* 8. WALKER, 1977 GENERAL LAKE MODEL                       (105)          *
*  P< 900 mg/m^3   LTw/z < 1.0 mg/l               P=        34            *
* ----------------------------------------------                          *
* 9. VOLLENWEIDER, 1975  GENERAL LAKE MODEL                               *
*   NOT AVAILABLE                                 P=         7            *
* ----------------------------------------------                          *
* 10. DILLON, RIGLER, KIRCHNER, 1975 GENERAL LAKE MODEL     (15)           *
*  P < 15 mg/m^3    107 < L < 2210 mg/m^2-yr      P=         8            *
*  1.5< qs <223 m/yr  0.21<  p < 63/yr                                    *
********* ********* ********* ********* ********* ********* ********* * **
```

Table 34. Concluded.

```
********* ********* ********* ********* ********* ********* ********* * **
*                   LAKE CONDITION MODULE                                *
*                                                                        *
* ===========================================                            *
* ENTER THE AVE. SPRING MIXED T. PHOSPHORUS          33     mg/m^3       *
* ---------------------------------------------------                    *
* THE GROWING SEASON CHLOROPHYLL          13  mg/m^3                     *
* ---------------------------------------------------                    *
* ENTER THE AVE. GROWING SEASON CHLOROPHY            6  mg/m^3           *
* ---------------------------------------------------                    *
* THE MIXED NATURAL LAKE SECCHI DEPTH    =        2.01  m                *
* THE STRATIFIED NATURAL LAKE SECCHI DEPTH =      2.53  m                *
* ---------------------------------------------------                    *
* THE MIXED IMPOUNDMENT SECCHI DEPTH     =        1.50  m                *
* THE STRATIFIED IMPOUNDMENT SECCHI DEPTH         2.07  m                *
* ---------------------------------------------------                    *
* Regressions from:  (Lillie, Graham and Rasmussen, 1993)                *
* ---------------------------------------------------                    *
*                   TROPHIC STATE INDICIES                               *
* ---------------------------------------------------                    *
* ENTER TOTAL PHOSPHORUS          33  mg/m^3   T.S.I =        55         *
* ENTER CHLOROPHYLL a    =         6  mg/m^3   T.S.I =        48         *
* ENTER SECCHI DISC DEPTH        3.3  meters   T.S.I =        43         *
********* ********* ********* ********* ********* ********* ********* * **
*              WATER AND NUTRIENT OUTFLOW MODULE                         *
*                                                                        *
* ===========================================                            *
* THE AVE. ANNUAL INLAKE TOTAL PHOSPHORUS            25  mg/m^3          *
*                                                                        *
* ANNUAL DISCHARGE     =    8.54E+02 AF        1.05E+06 m^3              *
*                                                                        *
* ANNUAL OUTFLOW LOADING       11.4  LB            25.2  Kg              *
********* ********* ********* ********* ********* ********* ********* * **
```

How can one model underestimate the phosphorus concentration, while another model over estimate the phosphorus? It is quite rare that two models predict the same value. Each model is set up differently and is more sensitive to different aspects of the lake. The Reckhow model does not seem to account very well for internal loading, and often underestimates lake phosphorus concentrations. The Canfield model is sensitive to the mean depth of the lake, and is better at predicting phosphorus concentrations in lakes with internal loading. Both models use the same nutrient budget and water budget but have a different equation that sometimes results in different phosphorus concentrations. I interpret the model results to indicate that Bear Lake has very little internal loading with an annual average total phosphorus concentration of ranging from 20 to 30 parts per billion.

The status of Bear Lake appears to be good in terms of phosphorus concentrations.

6. MANAGEMENT ACTIONS

1. How close is Bear Lake to experiencing nuisance algae blooms?

It's close but the lake is stable at this time. Bear Lake is approaching a phosphorus threshold, where if the threshold is exceeded nuisance algae blooms could occur in July and August. The threshold idea id explained below. Basically, the turbid water/algae phase is undesirable and should be avoided. It is important to keep excess phosphorus from washing into Bear Lake.

Clear Water/Plant Condition is Generally More Desirable Than a Turbid Water/Algae Condition.

Clear Water/Plant Phase: Lakes without excessive nutrients generally have clear water and aquatic plants. The watershed's nutrient input is low. Oxygen is found even in deep water throughout the year. Sediments accumulate phosphorus, but release very little. Clear water allows gamefish to control undesirable bottom feeding fish such as carp.

Turbid Water/Algae Phase: Nonpoint sources of pollution in the watershed can increase nutrient inputs to a lake making it eutrophic. Increased nutrient inputs cause spring algae blooms and when the algae die and settle to the lake bottom, bacteria use oxygen to decompose the algae. If oxygen is depleted, iron dissolves in the lake sediment, and phosphorus that was formerly tied up with the iron, is now released. The phosphorus greatly enhances summertime algae growth, increasing water turbidity. Rooted plants can no longer grow in deep water because of reduced light penetration.

Fewer plants also mean reduced surface area for attached algae growth so more algae are now free-living. Bottom feeding fish also recycle phosphorus from the lake sediment. The algae blooms that die at the end of the summer represent an organic phosphorus source that will be available for algae growth in the spring. Sometimes, even if watershed phosphorus inputs decrease, the lake sediment phosphorus will be sufficient to fuel spring growth.

Currently Bear Lake is in the Clear Water/Plant Phase.

2. What are impacts of backlot development?

Additional development in the watershed will add more nutrients to the lake. Protection projects can minimize impacts. Vegetation should be left in place where possible to reduce erosion and nutrient runoff into Bear Lake.

3. Should Bear Lake abandon the idea of improving the walleye community?

No. Bear Lake has the structural habitat for a good walleye population. However the odds are low of reestablishing a walleye population similar to the 1950s, due to changes in the whole fish community. Walleye stocking on alternative years is worth a try, but more expensive efforts are not cost effective at this time because of a low probability of success.

4. Does the Bear Lake District need to conduct panfish removal every two or three years or can gamefish handle it?

Panfish removal by the Lake District can be put aside for now. Gamefish may be able to take over. Future fish surveys and angler success will help determine if Lake District netting is needed.

5. Is aquatic plant management needed?

Not at this time. The plant community does not produce recreational nuisance conditions so it is best to minimize plant removal. Conventional plant harvesting is not needed. Actions should be ongoing to ensure that a vigorous plant community is maintained.

6. Is dredging necessary?

No. Benefits from dredging muck out of the outlet bay would not justify the cost at this time. Lake levels in normal years will allow the current types of activities to continue.

BEAR LAKE DISTRICT PROTECTION & REHABILITATION ONEIDA COUNTY, WISCONSIN

DATE:____________________

I have had my septic tank cleaned after August 16, 1986, and am applying for the BLPRD $25 cost-sharing.

NAME____

HOME ADDRESS____

____

PHONE NUMBER____

ADDRESS OF BEAR LAKE PROPERTY SERVICED:

____

____

PHONE NUMBER____

COMPANY PROVIDING SERVICE___________________________

==

VERIFICATION OF WORK PERFORMED:

I certify that ______________________________(company name) cleaned the septic tank at the above named Bear Lake address, on the above stated date.

____
(authorized company signature)

MAIL TO:
Dick Lemanski
1412 No. 2nd Street
Watertown, Wisconsin 53094

7. BEAR LAKE REPORTS

1977. Krueger, R. And R. Martens. Limnological study of Bear Lake, Oneida County, Wisconsin October 1976 through October 1977. Pages 70.

1978. Office of Inland Lake Renewal - Wisconsin Department of Natural Resources. Bear Lake, Oneida County Feasibility Study Results: Management Alternatives. Pages 26.

1982. Swanson Environmental Inc. Investigation of septic leachate discharges into Bear Lake Oneida County, Wisconsin. Pages 32.

1984. Applied Research & Technology, S. McComas. Summary of existing conditions and management recommendations for Bear Lake, Oneida County, Wisconsin. Pages 36.

1984. Applied Research & Technology, S. McComas. Things to do, things to consider, an implementation manual for Bear Lake. Pages 17.

1985. Applied Research & Technology, S. McComas. The Bear Lake sunfish removal project, Oneida County, Wisconsin, 1985: the 1st year. Pages 10.

1986. Applied Research & Technology, S. McComas. The Bear Lake fish removal project, Oneida County, Wisconsin, 1986: the 2nd year. Pages 14.

1987. Blue Water Science. The Bear Lake fish removal project, Oneida County, Wisconsin, 1987: the 3rd year. Pages 2.

1987. R. Lemanski. Community focus: Bear Lake District. Lake Tides, Autumn 1987, vol. 12 no. 4.

1988. Blue Water Science. The Bear Lake fish removal project, Oneida County, Wisconsin, 1988: the 4th year. Pages 6.

1989. Blue Water Science. The Bear Lake fish removal project, Oneida County, Wisconsin, 1989: the final year. Pages 4.

1993. Blue Water Science. Bear Lake, Oneida County, Wisconsin, lake and watershed characterization 1977-1991. Pages 58.

1993. Blue Water Science. Bear Lake, Oneida County, Wisconsin, fish survey, septic leachate survey, and sedimentation study, 1992. Pages 43.

1993. Blue Water Science. Bear Lake, Oneida County, Wisconsin, fish survey, 1993. Pages 11.

1993. Blue Water Science. Bear Lake, Oneida County, Wisconsin 1993 project results. Poster, pages 4.

1995. Bear Lake Protection and Rehabilitation District & Bear lake Property Owner's Association. Bear Lake Property Owners information packet.

1996. Blue Water Science. Bear Lake sunfish fishing survey, walleye habitat improvement, and lake sediment analysis, June, 1995. Pages 8.

1996. Bear Lake, Oneida County, Wisconsin, panfish survey results for 1996 and evaluation of panfish removal impacts from 1985 to 1996. Pages 19.

8. REFERENCES

Boisclair, D. and W.C. Leggett. 1985. Rates of food exploitation by littoral fishes in a mesotrophic north temperate lake. Can. J. Fish. Aquat. Sci. 42:556-566.

Cooper, C.M. & Knight L.A., Jr. 1985. Macrobenthos-sediment relationships in Ross Barnett Reservoir, Mississippi. *Hydrobiologica*, **126**, 193-197.

Cyr, H. & J.A. Downing. 1988. The abundance of phytophilous invertebrates on different species of submerged macrophytes. *Freshwater Biology*, **20**, 365-374.

Dall, P.C., C. Lindegaard, E. Jonsson, & P.M. Jonasson. 1984. Invertebrate communities and their environment in the exposed littoral zone of Lake Esrom, Denmark. *Archiv fur Hydrobiolgie Supplementband*, **69**, 477-524.

Drenner, R.W., M.L. LaGrone, C.A. Cahill, S.R. McComas, and S.W. Brush. In prep. Forage fish availability to largemouth bass in a fishing club lake.

Eddy, S. and A.C. Hodson. 1982. Taxonomic Keys to the common animals of the north central states. Fourth Edition. Burgess Publishing Company, Minneapolis.

Grice, F. 1957. Effect of removal of panfish and trashfish by fyke nets upon fish populations of some Massachusetts' ponds. Trans. Amer. Fish. Soc. 87:108-115.

Gutreuter, S.J. and R.O. Anderson. 1985. Importance of body size to the recruitment process in largemouth bass populations. Trans. Amer. Fish. Soc. 114:317-327.

Hanson, D.A., B.J. Belonger, and D.L. Schoenike. 1983. Evaluation of a mechanical population reduction of black crappie and black bullheads in a small Wisconsin lake. North Amer. J. Fish. Man. 3:41-47

Hanson, J.M. and W.C. Leggett. 1985. Experimental and field evidence for inter- and intraspecific competition in two freshwater fishes. Can. J. Fish. Aquat. Sci. 42:280-286.

Hilsenhoff, W.L. 1991. Aquatic Insects of Wisconsin. Number 2. Natural History Council, University of Wisconsin-Madison.

Inskip, P.D. and J.J. Magnuson. 1983. Changes in fish populations over an 80-year period: Big Pine Lake, Wisconsin. Trans. Amer. Fish. Soc. 112:378-389.

Johnson, F.H. 1977. Responses of walleye (Stizostedion vitreum vitreum) and yellow perch (Perca flavescens) to removal of white sucker (Catostomus commersoni) from a Minnesota lake, 1966. J. Fish. Res. Board Can. 34:1633-1642.

Kempinger, J.J. and R.F. Carline. 1977. Dynamics of the walleye (Stizostedion vitreum vitreum) population in Escanaba Lake, Wisconsin, 1955-72. J. Fish. Res. Board Can. 34:1800-1811.

Krecker, F. H. 1939. A comparative study of the animal population of certain submerged aquatic plants. *Ecology*, **20**, 553-562.

Lawrence, J.M. 1958. Estimated sizes of various forage fishes largemouth bass can swallow. Proc. 11th Annual Conf. Southwest Assoc. Game Fish Comm. 220-225.

Lehmkuhl, D.M. 1979. How to know the aquatic insects. Wm. C. Brown Company Publishers. Dubuque, Iowa.

Lindner, A. and others. 1983. Pike, a handbook of strategies. Al Lindner's Outdoors, Inc. Brainerd, Minn.

McDermid, K.J., and Naiman, R.J. 1983. Macrophytes: freshwater forests of lakes and rivers. *Am. Biol. Teach.* **45**, 144-150.

Minnesota DNR. 1982. Lake management planning guide. Minnesota Department of Natural Resources Special Publ. 132.

Oliver, D.R. and M.E. Roussel. 1983. The Insects and Arachnids of Canada. Part 11: The Genera of Larval Midges of Canada. Canadian Government Publishing Centre. Ottawa, Canada.

Pennak, R. W., 1978. Freshwater Invertebrates of the United States. Second Edition. John Wiley & Sons, New York.

Zischke, J.A., G. Ericksen, D. Waller, R. Bellig. 1993. Analysis of Benthic Macroinvertebrate Communities in the Minnesota River Watershed. St. Olaf College, Northfield, Minnesota.