Norman Rockwell: *Boys Fishing (1961)*

BEAR LAKE
Oneida County, Wisconsin
Lake and Watershed Characterization
1977-1991

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Bear Lake, Oneida County, Wisconsin
Lake and Watershed Characterization: 1977-1991

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Dale Jalinski 1985-1992
Phyllis Jalinski 1985-1992
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Bear Lake, Oneida County, Wisconsin
Lake and Watershed Characterization, 1977-1991

Summary

The Bear Lake surface area is 312 acres and its watershed encompasses 840 acres. The watershed land use is 26% wetlands (219 acres), 69% forests (580 acres), and 5% residential (41 acres). The original landscape of this area 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.

Summer dissolved oxygen (DO) and temperature profiles, complied 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 inches).

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 than what would be expected in mesotrophic conditions found in Bear Lake.

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 an increase in the numbers per liter. 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.

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 seemed to be rooted in deeper water.

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. The number of bluegills and pumkinseeds over 6 inches seem to be increasing compared to 1985 data.

A phosphorus model was run for Bear Lake in 1991. Using the Canfield and Bachmann model a concentration of 22 parts per billion (ppb) was predicted. The average total phosphorus concentration found in Bear Lake was 18 ppb.

1. INTRODUCTION AND PROJECT SETTLING

Bear Lake is a glacial seepage lake located in Oneida County, Wisconsin (Figure 1). Bear lake is a mesotrophic lake with moderate phosphorus levels (15-25 ug/l) and relatively good secchi disc transparency (8-9 feet in summer). Bear lake has an active lake protection district that has been working on projects since 1975. Wisconsin Department of Natural Resources (or Department of Conservation) has been working on Bear Lake since the 1930's, conducting fish surveys and stocking gamefish and panfish.

The goals of this project were to examine information collected since the 1970's with one of the primary questions centered around how the fish community has changed since the stunted panfish removal efforts began in 1985 with removal efforts occurring in 1986, 1987, and 1988? The sunfish community was sampled in 1989 and 1991 to monitor results. In addition zooplankton samples were examined from 1985 through 1991 to see if the zooplankton community changed. In 1991 we conducted an aquatic plant survey to see if there were changes in macrophytes compared to survey information from 1977.

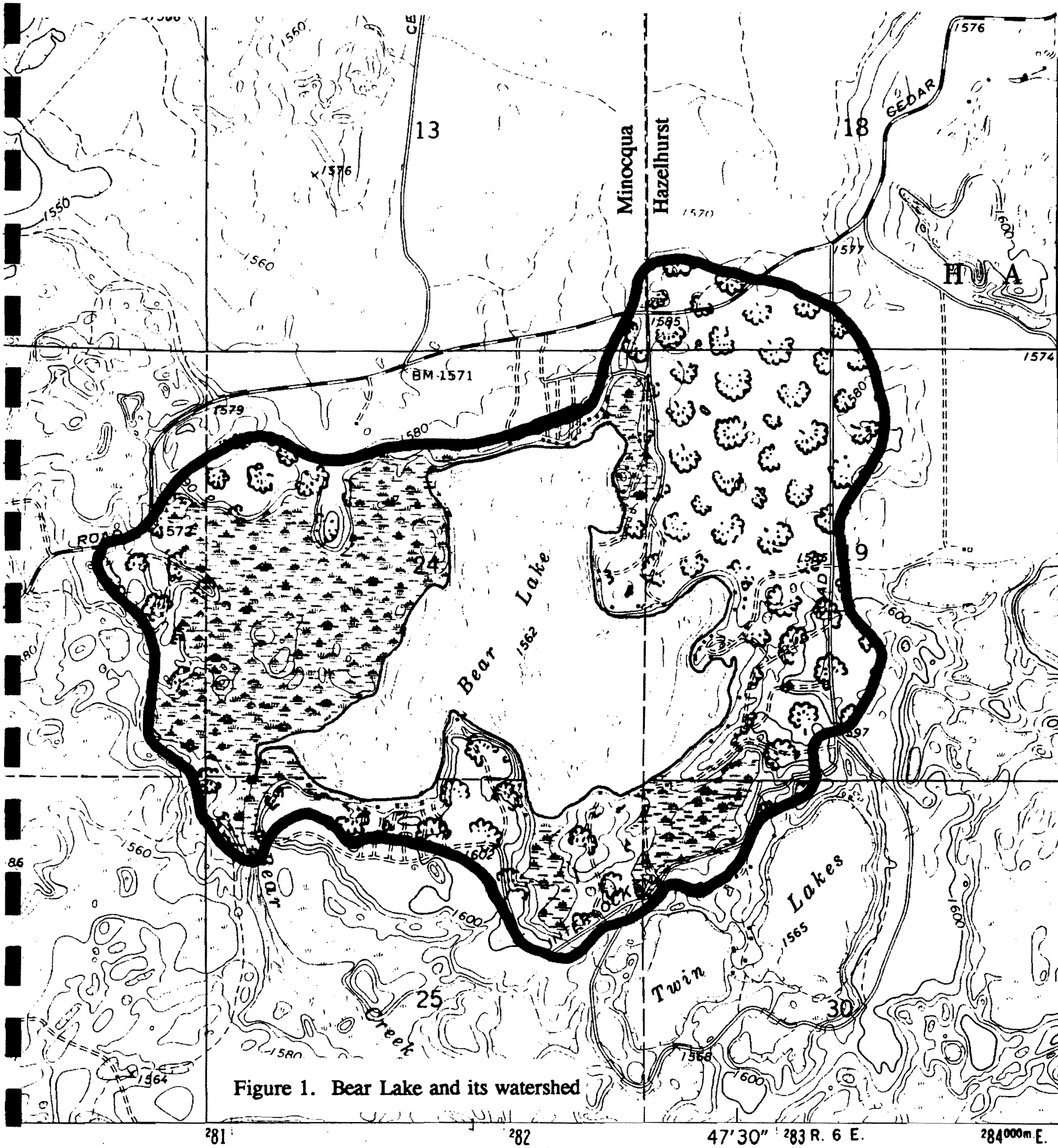


Figure 1. Bear Lake and its watershed

2. LIST OF PROJECTS THAT HAVE BEEN DONE ON BEAR LAKE

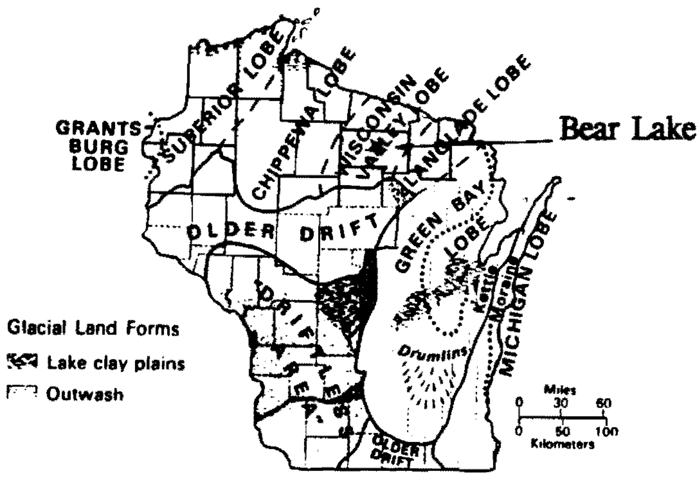
People associated with Bear Lake have conducted a number of projects over the years. A summary of projects is listed in Table 1.

Table 1. List of projects that have occurred on Bear Lake over the years Specific stocking records are at WDNR-Woodruff.

Year	Project	Sponsoring Group
1930s-present	Walleye stocking	WDNR
1964	Fish cribs	WDNR
1977	Formation of Lake District	Bear Lake Dist, WDNR
1977	Bear Lake Limnological Study	Northern Lake Service
1978	Bear Lake Feasibility Study	WDNR
1979	Sedimentation Study	Northern Lake Service
1982	Septic leachate survey	Swanson Environmental
1982	Gamefish survey, Bear Lake	WDNR
1984	Summary of existing conditions and implementation manual	Blue Water Science
1985-present	Water Quality monitoring (twice a year)	UW-Stevens Point
1985,1986, 1987,1988	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	Bear Lake District
1989-present	Walleye spawning bed rejuvenation	Bear Lake District and Blue Water Science
1991 (this study)	Nutrient budget, aquatic plant survey, zooplankton evaluation, panfish evaluation	Blue Water Science, Bear Lake District, WDNR

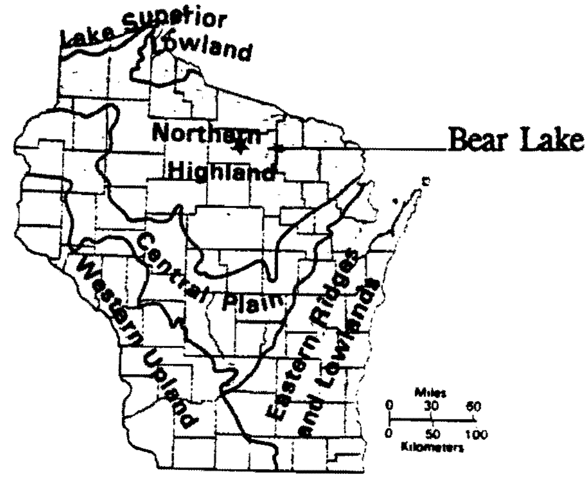
3. GEOLOGIC SETTING

Bear Lake was formed from a depression made by an ice block that was left behind when the glaciers retreated from this area about 16,000 years ago. Bear Lake is located in the Wisconsin Valley Lobe of the last glaciation (Figure 2, Map 6) which is in the Northern Highland geographic provence (Figure 2, Map 8). Bear Lake drains to the Wisconsin River which eventually feeds into the Mississippi River. Bear Lake is very close to the continental divide (Figure 2, Map 9). Most of the land area now is forested (Figure 2, Map 11).



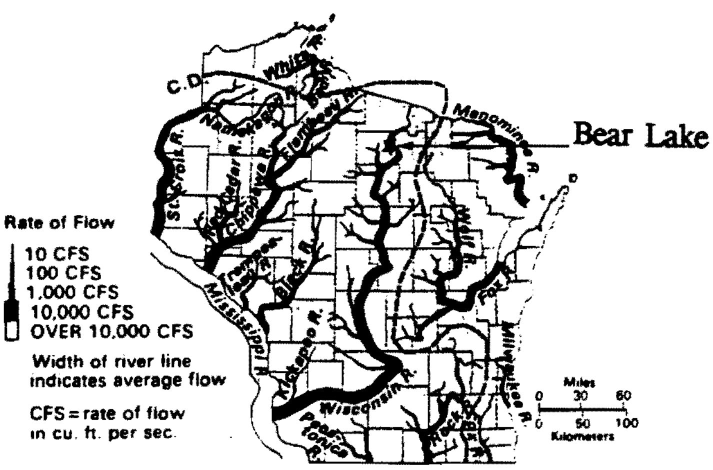
Map 6. GLACIAL GEOLOGY

The last major advance of the ice sheet over Wisconsin was about 16,000 years ago. It covered all but the "driftless" and "older drift" areas. A later ice advanced about 11,000 years ago (dotted boundaries), burying a forest in Manitowoc County. Many land forms were created by the glacial ice and meltwaters: Moraines (solid lines), elongated hills called drumlins, outwash, and lake clay plains. Many peat bogs and lakes occupy glacial pits called kettles.



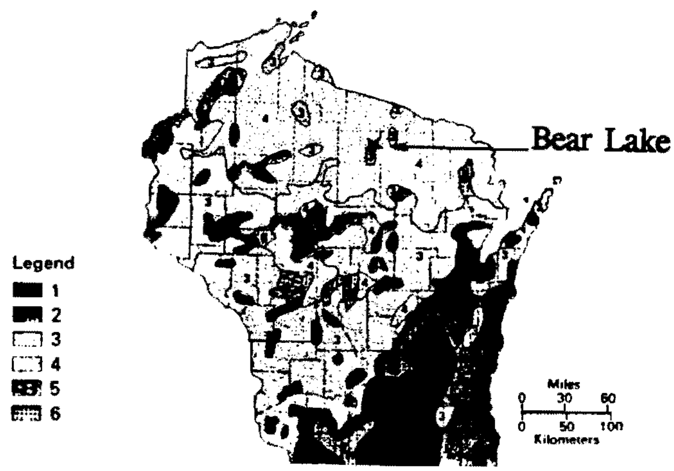
Map 8. GEOGRAPHIC PROVINCES (after Martin, 1932)

The Lake Superior Lowland is an old glacial lake bottom sitting in a much older depression in the bedrock surface. The Northern Highland is a glacial-drift-covered Precambrian "dome," a southern extension of the "Canadian Shield" of igneous and metamorphic rocks. The Central Plain is on an arc of Cambrian sandstones. The drift-covered Eastern Ridges and Lowlands are crossed by dolomite escarpments. The Western Upland is dissected by numerous tributaries to the Mississippi and Wisconsin Rivers.



Map 9. PRINCIPAL RIVERS AND THEIR AVERAGE FLOW

Thirty percent of the state drains to the St. Lawrence River basin, and the remaining 70 percent to the Mississippi River basin. The dashed line represents the continental divide (C.D.) between these two major basins. Peak flows are in March, April and June. The Wisconsin River drains 21 percent of the area of the state; the Chippewa-Flambeau system drains 17 percent; the Fox-Wolf system in northeastern Wisconsin drains 12 percent of the state.



Map 11. AGRICULTURAL AND FORESTRY LAND USE

The map shows land use in terms of proportions of land devoted to agriculture and forestry. Highly productive farm land (1), with less than 15 percent of woodland, is in southern counties. Productive farm land (2), with the same extent of woodland, is prominent in the east, but is also widely scattered. Agricultural land with 15 to 50 percent in woodland (3), occupies about half of the area of the state. Forest lands, not sandy (4), are prominent in the north. Jack pine (5), and scrub oak (6) sandy lands are concentrated in the central plain and northern counties.

Figure 2. Maps of glacial geology, geographic provinces, rivers and land use. Bear Lake is in Oneida County and the location is shown with a star. (Source: Hole, F.D. 1977. Photo-Mosaic soil map of Wisconsin. U-W Extension A2822-1.)

4. HISTORY OF BEAR LAKE AREA

Bear lake is located in a region pock-marked with lakes and lies on the border of the townships of Hazelhurst and Minocqua in Oneida County (Figure 1). About one hundred years ago the area and the watershed of Bear Lake was dominated by pine forests (Figure 3). 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 (Figure 4). Today we are looking at second and third growth forest for the most part. Several cabins at the Sunset Resort on Bear Lake are actually part of the old bunk houses cut in half, that were part of the logging camp. Several pine trees are virgin trees that were not cut down during the Bear Lake logging era.

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 of 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 (Figure 5). 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. Total number of residences is about 100. Otherwise much of the watershed is a combination of forested land (second and third growth) and wetlands.

"The crowns of great white pine and Norways lifted themselves high above the ground and became intertwined to cast a shade like the dusk of a tunnel. Starved for sunlight, the branches below them had given up trying to live, and as the trees swayed in the wind, they jostled each other until they became loosened and fell to the ground, leaving the trunks straight and clear." Isabel Ebert

Figure 3. Example of what the virgin pine forests looked like prior to logging. (Source: Minocqua-Woodruff Centennial Edition, 1988)

Vast acres of logged over, burned over land characterized the lakeland area when E.M. Griffith came to the state.
--Department of Natural Resources photo.

Figure 4. Landscape changed drastically after logging. Much of Bear Lake watershed is now papermill forest. (Source: Minocqua-Woodruff Centennial Edition, 1988)

102-pound muskie

The Loch Ness monster of the North

Fishermen are known for their whoppers. After reading the following article which appeared in the May 2, 1902, issue of "The Minocqua Times," we know how fishermen got their reputations for being long on stories and short on the truth.

As to the validity of the story, Supt. Nevin and E.D. Kennedy took that secret to their grave. The late Jim Kennedy, son of E.D. Kennedy, told "The Lakeland Times" in 1974 that perhaps the story was true, although he added, "the whiskey flowed quite freely in those days."

A lithograph and copy announcing the 1902 catch follows. We hope you enjoy the rest of these fish tales gleaned from the pages of "The Minocqua Times" and "The Lakeland Times."

Supt. Nevin of the State Fish Hatchery Commissioners, who has been taking muskallonge spawn at the Tomahawk and Minocqua lakes the past month, informs us that E.D. Kennedy and himself captured the two largest muskallonge ever taken in these waters.

The largest one was caught in Minocqua lake and weighed 102 pounds, the other being taken in Tomahawk lake and weighed 80 pounds.

After the spawn was taken from these monsters, they were turned back into their native waters, where they await the sportsman to try and land them.

Mr. Nevin has taken muskallonge spawn at this place for the past four years, and says that in seining this season, they have caught more small muskallonge than ever before, which goes to show that they are increasing.

He also informs us that they have about 25,000,000 pike fry ready for distribution and 2,000,000 muskallonge fry, which will be planted in the lakes of Vilas, Oneida and Forest counties. The State Fish Hatchery Commissioners are expected here Saturday to look over the hatchery at this place and to lay out improvements to be done

Figure 5. Prior to heavy fishing pressure, gamefish communities had their share of big ones. Also it is evident that stocking was underway in the early 1900s. (Source: Minocqua-Woodruff Centennial Edition, 1988)

5. WATERSHED CHARACTERISTICS

General land use in the watershed is shown in Figure 6. 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 then 41 acres of residential lands (Table 2). 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 2. Land use in the Bear Lake watershed.

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

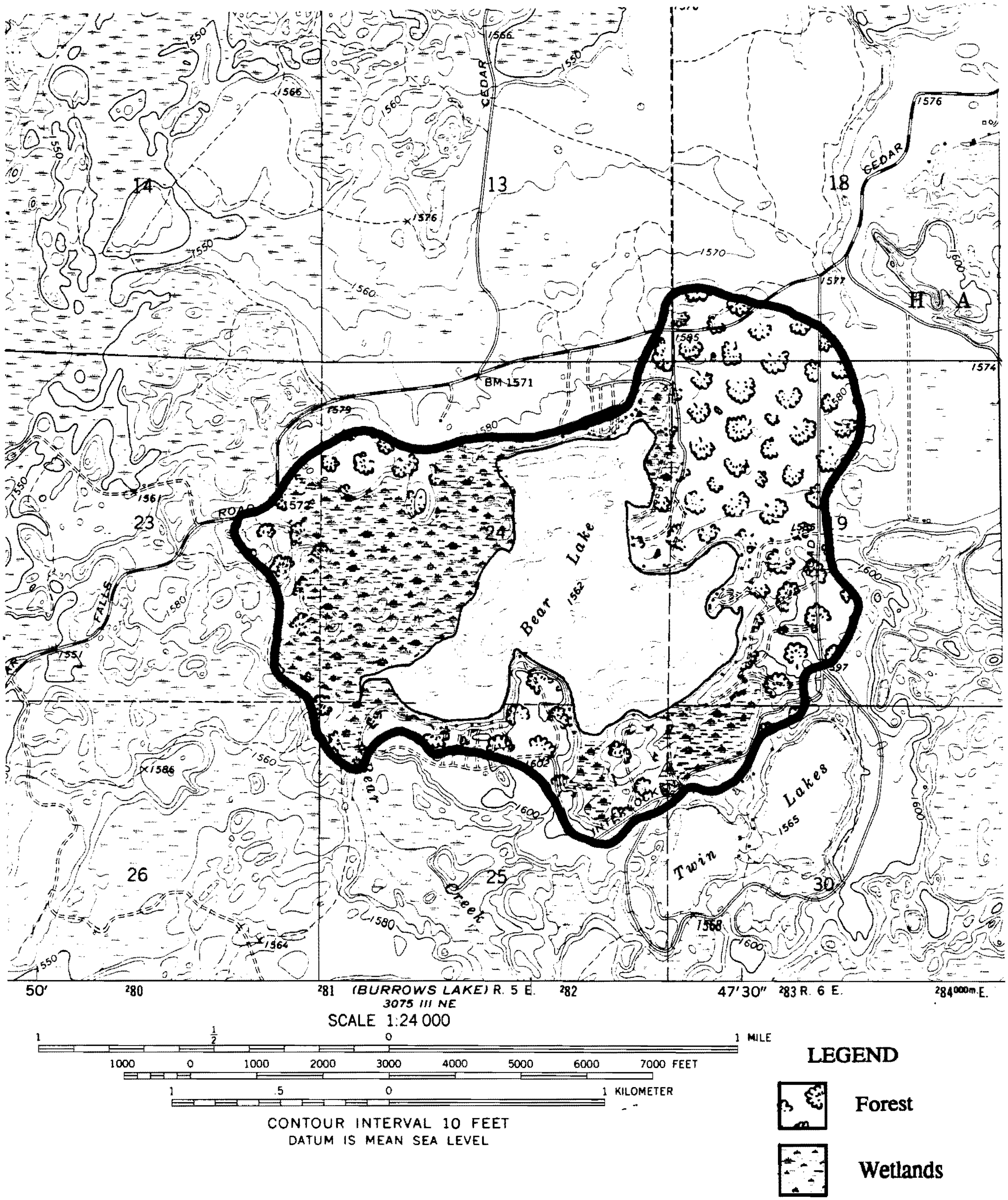
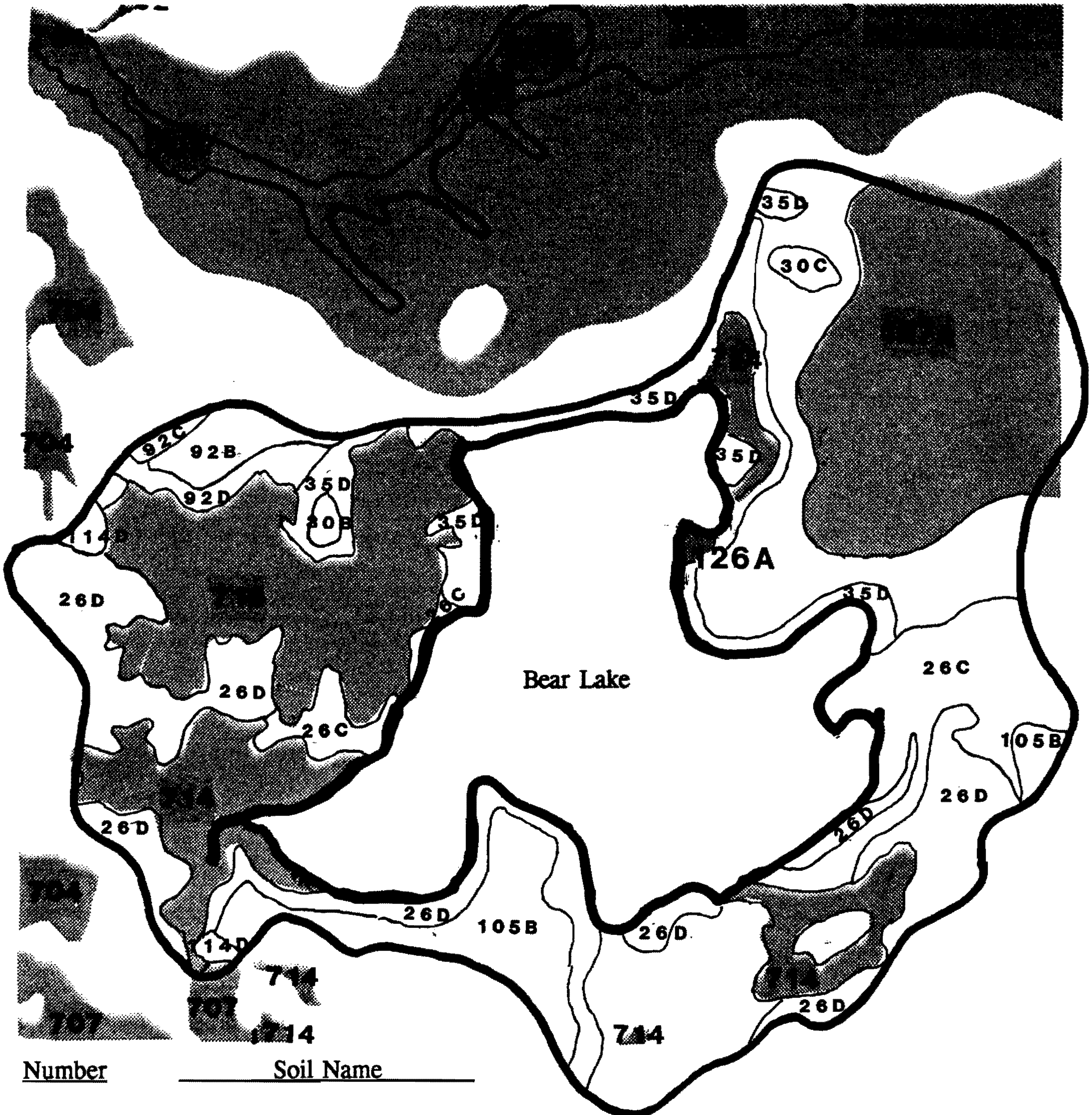


Figure 6. Land use in Bear Lake watershed is dominated by forests and wetlands

Soils in the watershed are dominated by peaty soils in western and eastern parts (Figure 7) or by sandy soils found in between peaty areas and in the high lands. Some of the soils have limitation for septic tanks systems and these areas are shown in Figure 7. Most of the problem soils have high groundwater tables. Otherwise the sandy soils have relatively good drainage characteristics.



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

6. LAKE CHARACTERISTICS

Ice-Out and Rainfall

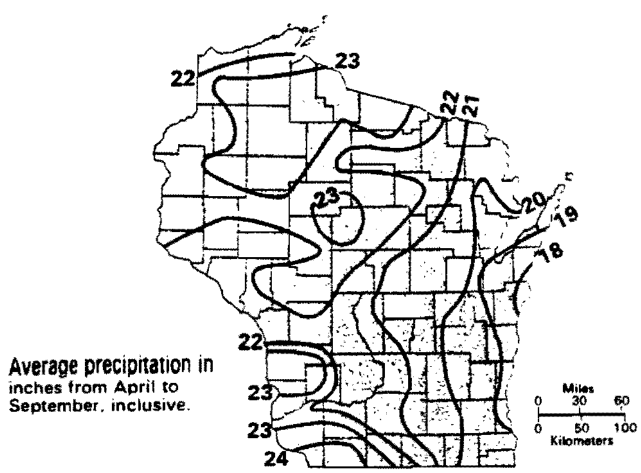
Mr. Dale Jalinski (Bear Lake resident) has been recording ice-out on Bear Lake since 1978. Over the 14 year record, the earliest ice-out was April 5 and the latest was April 30 (Table 3).

Mr. Jalinski has also recorded rainfall from May 1 - Nov 1 from 1986 to present. Rainfall has varied from 16.8 inches to 32.4 inches. The seven year average (1986-1991) is 24 inches. The long-term average from April to September is about 22 inches (Shown on Map 4, under Table 3).

Although there is only a seven year record, average secchi disc transparency from May-September is not correlated to rainfall. Sometimes it appears that years with low runoff result in summers with high transparency. In 1990, there was high rainfall and relatively high transparency in Bear Lake.

Table 3. 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 (Avg. May-Sept)
1978	April 23	--	--
1979	April 29	--	--
1980	April 19	--	--
1981	April 13	--	--
1982	April 30	--	--
1983	April 27	24.2	--
1984	April 15	24.1	--
1985	April 19	32.4	9.2
1986	April 9	24.0	10.0
1987	April 8	19.4	11.2
1988	April 11	19.3	11.5
1989	April 22	16.8	10.5
1990	April 5	30.5	11.2
1991	April 13	28.3	10.4



Map 4. AVERAGE PRECIPITATION (April to September, inclusive)

The April to September rainfall is 23 to 24 inches in the far northern highland and at the southwestern corner of the state; and 18 to 21 inches in east central Wisconsin. Of the 31 inches of annual precipitation, 68 percent falls during these six months when plants are growing. The rainiest month is June; the driest, December. Soils are commonly saturated in April when the snow and ice melt. Soils are commonly driest during August through autumn.

Physical/Chemical Data Emphasizing Dissolved Oxygen, Temperature, and Secchi Disc

Bear Lake is 312 acres in size, with a watershed of 840 acres. The average depth of Bear Lake is 2.6 meters (8.4 feet) with a maximum depth of 7 meters (23 feet)(Table 4). Bear Lake is located in an area of Wisconsin that is dominated by forest. The Bear Lake watershed is 69% forest (580 acres), 26% wetlands (219 acres) and 5% residential (41 acres) (listed in Table 2 and shown again in Table 4).

The summer dissolved oxygen (DO) and temperature profiles (Figure 8) 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. The temperature throughout the water column is relatively constant changing only a few degrees indicating the lake is polymictic and mixes occasionally through the summer.

The secchi disc transparency had an average summer depth of 3.2 meters (10.4 feet) in 1991. Secchi disc readings in 1977 and 1985 are shown in Figure 9. Summertime readings show similar transparency. Additional secchi disc data are shown in Figure 10. Data for 1991 is compared to the 1977 base year and the 5 year average (1977, 1985, 1986, 1987, 1988). It appears that summertime transparency has not changed significantly from 1977 to 1991. Some variability is observed in spring and fall (Figure 10). In 1977, secchi disc transparency was not as great compared to the 5 year average for spring and fall. This is possibly a natural variation based on factors such as temperature, rainfall, sunlight, snowfall, and wind that may affect transparency in spring and fall. Midsummer secchi depths (late June, July, August) appear to be fairly consistent from year-to-year.

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)
Littoral area: 12 %
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

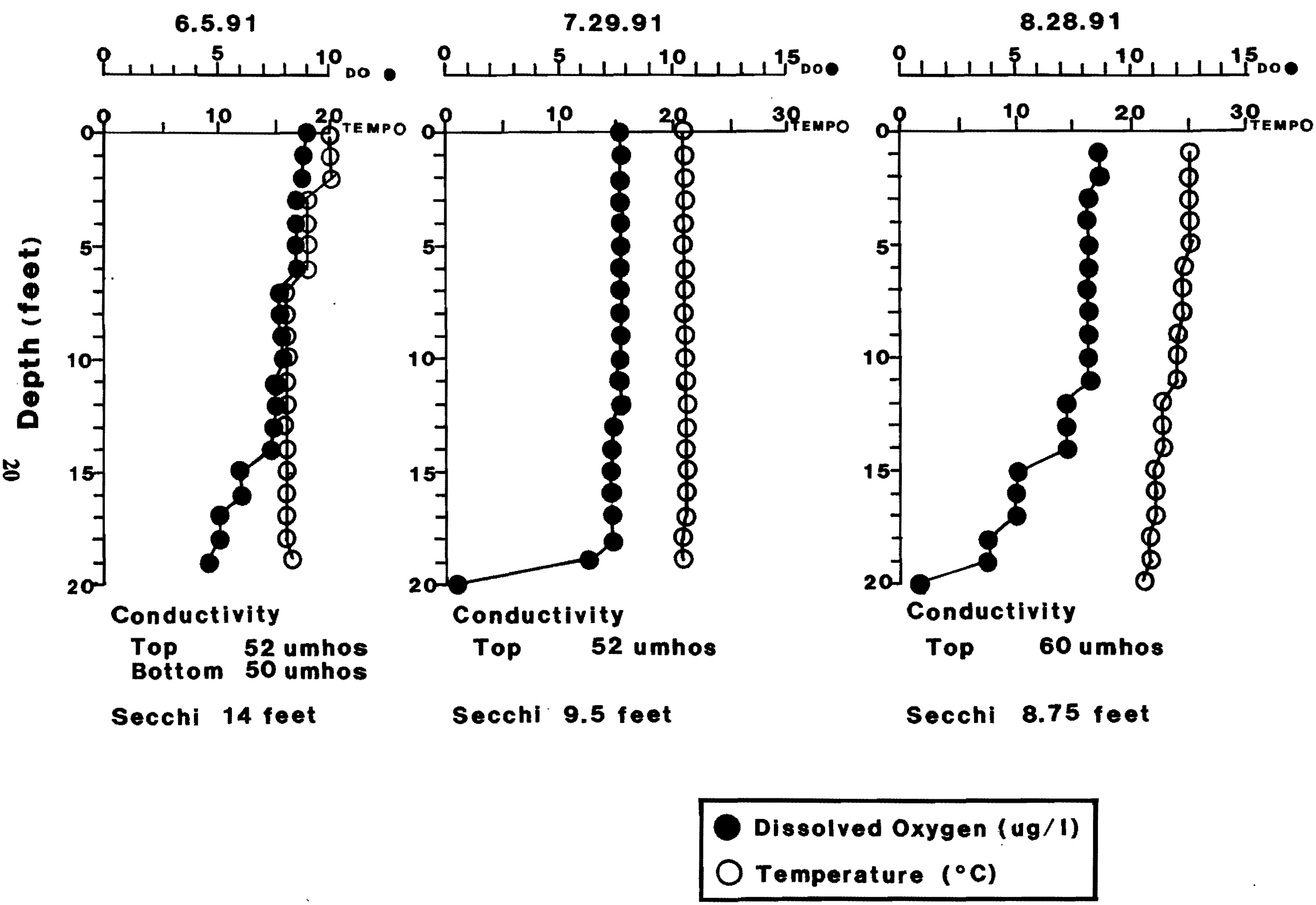


Figure 8. Summer dissolved oxygen and temperature profiles for Bear Lake

Bear Lake Secchi Disc Readings

1977 and 1985

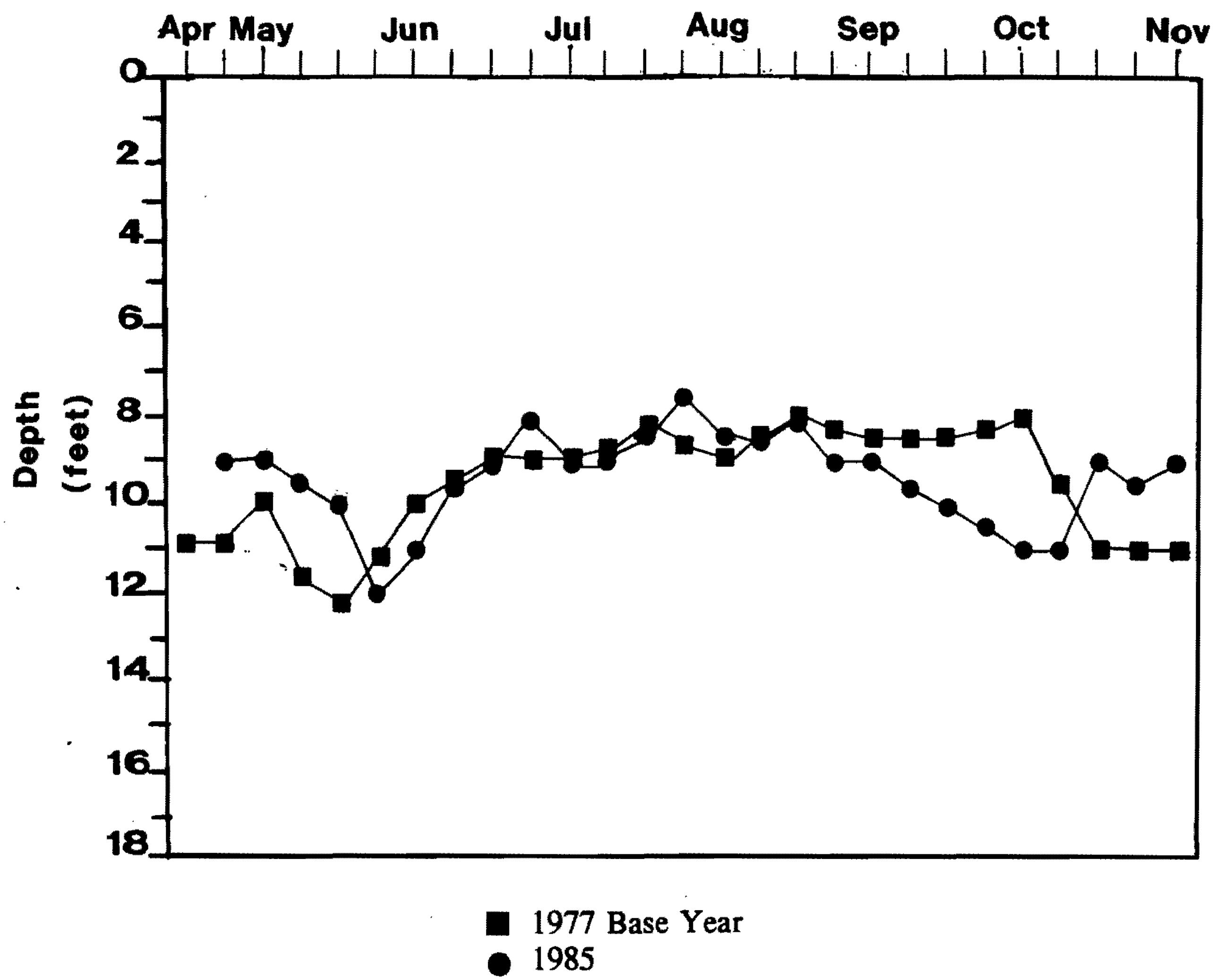


Figure 9. Secchi disc readings for 1977 and 1985. (Graph redrawn from D. Jalinski, Appendix A)

Bear Lake Secchi Disc Readings

1991

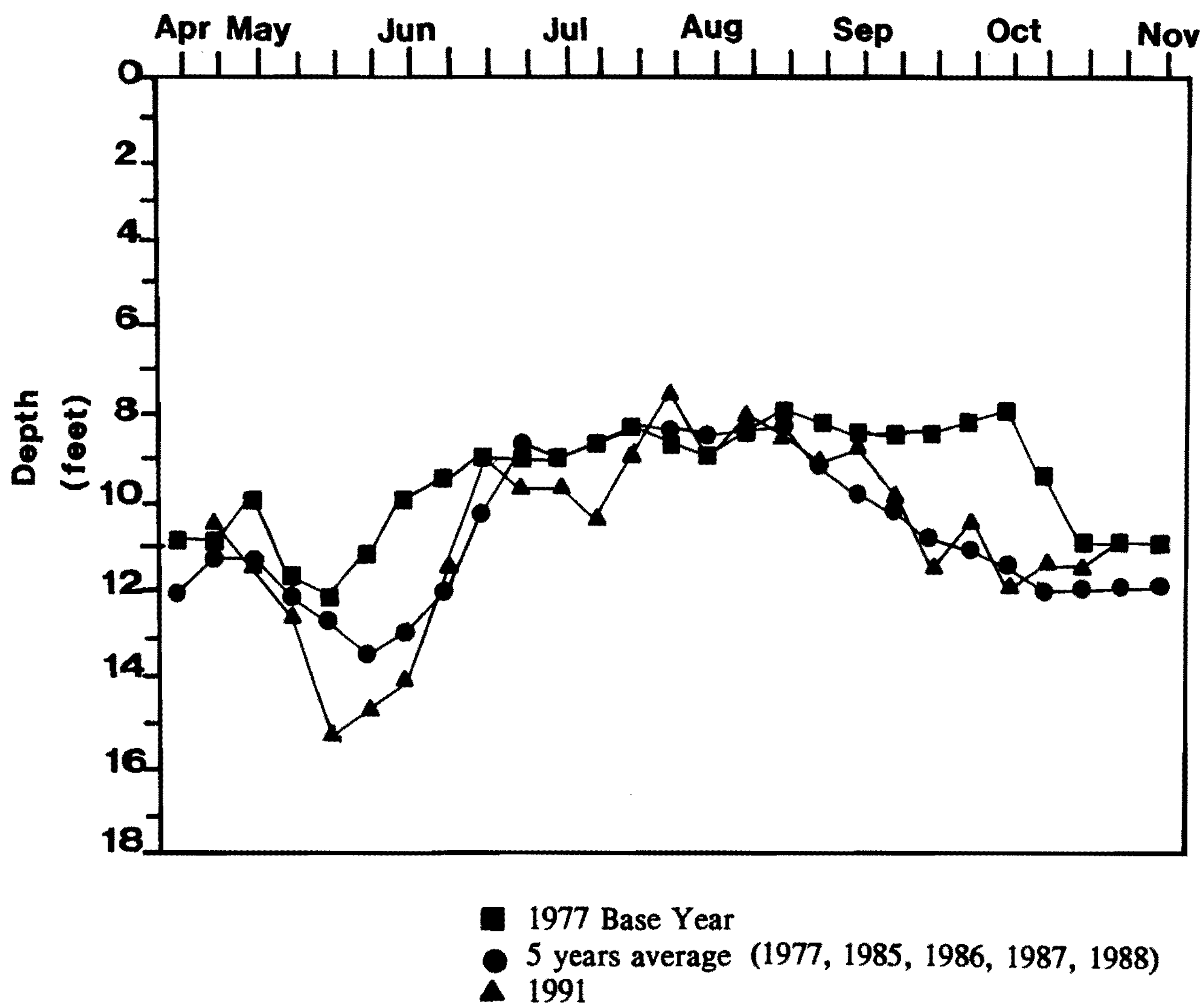


Figure 10. Secchi disc for 1977, 5 year average and 1991. (Graph redrawn from D. Jalinski, Appendix A)

Physical/Chemistry Data Emphasizing Phosphorus and Nitrogen

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 5). 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. Other results are shown in Table 5. 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 it reflects the concentration of settled material "raining" down from the epilimnion.

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 5. Summertime sample results for Bear Lake

Date	Depth	Secchi (feet)	TP (ug/l)	Chl a (ug/l)	TKN (ug/l)	NH3 (ug/l)	NO3 (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	-	-	-	-	-

Other water chemistry data have been collected as well. A summary of collected data from 1985-1991 is shown in Table 6. These are the data collected at spring and fall overturn and analyzed by UW-Stevens Point. Results show that the lake is phosphorus limited (based on a Total Nitrogen:Total Phosphorus ratio of 61:1).

The Trophic State Index (Carlson's Index) was calculated for spring and fall overturn (UW-Stevens Point data) and for the summer (this study). Results indicate Bear Lake is a mesotrophic lake (Table 7). For spring and fall, water transparency had a value of 41 on the Trophic State Index (TSI) while total phosphorus had a reading of 48. Usually the TSI numbers should be nearly the same. Because the secchi disc TSI is lower (meaning the water is more clear) than would be excepted based on the total phosphorus TSI, something in Bear Lake may be inhibiting algae, producing good water transparency.

Summertime TSI values are different than spring and fall values. In this case phosphorus and transparency values are similar, but chlorophyll samples were taken. The average would be slightly lower and come in line with phosphorus and secchi transparency.

Table 6. Epilimnetic Spring and Fall Data for Bear Lake 1985-91.

Parameter	Units	Mean	n	Min	Max
Total phosphorus	ppb	18	15	8	35
Soluble Reactive P	ppb	8	15	2	25
Chlorophyll a*	ppb	9	2		
Secchi disk	m	3.8**	10	2.3	5.1
Total Kjeldahl N	ppm	0.6	15	0.2	2.2
Nitrite + Nitrate-N	ppm	0.5	15	0.01	0.2
Ammonia-N	ppm	0.1	15	0.01	0.2
Alkalinity	ppm	32	15	22	44
Color	Pt-Co Units	18	15	2.3	80
pH	SU	7.5	15	6.8	8.3
Chloride	ppm	1.3	15	1	3
Conductivity	umhos/cm	68	15	54	83

TN:TP ratio 61:1

* summer reading
** 3.8m = 12.5 feet

Table 7. Trophic State Index values for spring and fall turnover (1985-1991) and the summer of 1991. Equations used to calculate TSI are shown below.

Trophic State	Spring and Fall 1985-1991		Summer 1991	
Index Parameter	Avg. Value	TSI Value	Avg. Value	TSI Value
Total phosphorus	(18 ug/L)	48	(13 ug/L)	44
Chlorophyll a	(no data)	--	(9 ug/L)	51
secchi disc	(3.8 m)	41	(3.3 m)	43

TSI = Trophic State Index

TSI(Chl a)(ppb or ug/L) = $36.25 + 15.5 \log_{10}$ [Chl a]
TSI(TP)(ppb or ug/L) = $60 - 33.2 \log_{10} (40.5/TP)$
TSI(Secchi)(meters) = $60-(SD \log_{10} \times 33.2)$

A summary of spring and fall total phosphorus readings for 1985 through 1991 is shown in Figure 11. Readings range from less than 0.01 mg/l to over 0.03 mg/l. Spring and fall readings show variability from year to year. I do not have enough information to correlate total phosphorus with rainfall, but it appears the correlation is weak. Average summer secchi disc transparencies also are weakly correlated to total phosphorus. Typically samples are taken when the lake is well-mixed. Average summer secchi disc readings range from 9.2 feet in 1986 to 11.5 feet in 1988 (a dry year). For a mesotrophic lake like Bear Lake a 2 foot swing in summer average secchi disc transparency may very well be normal.

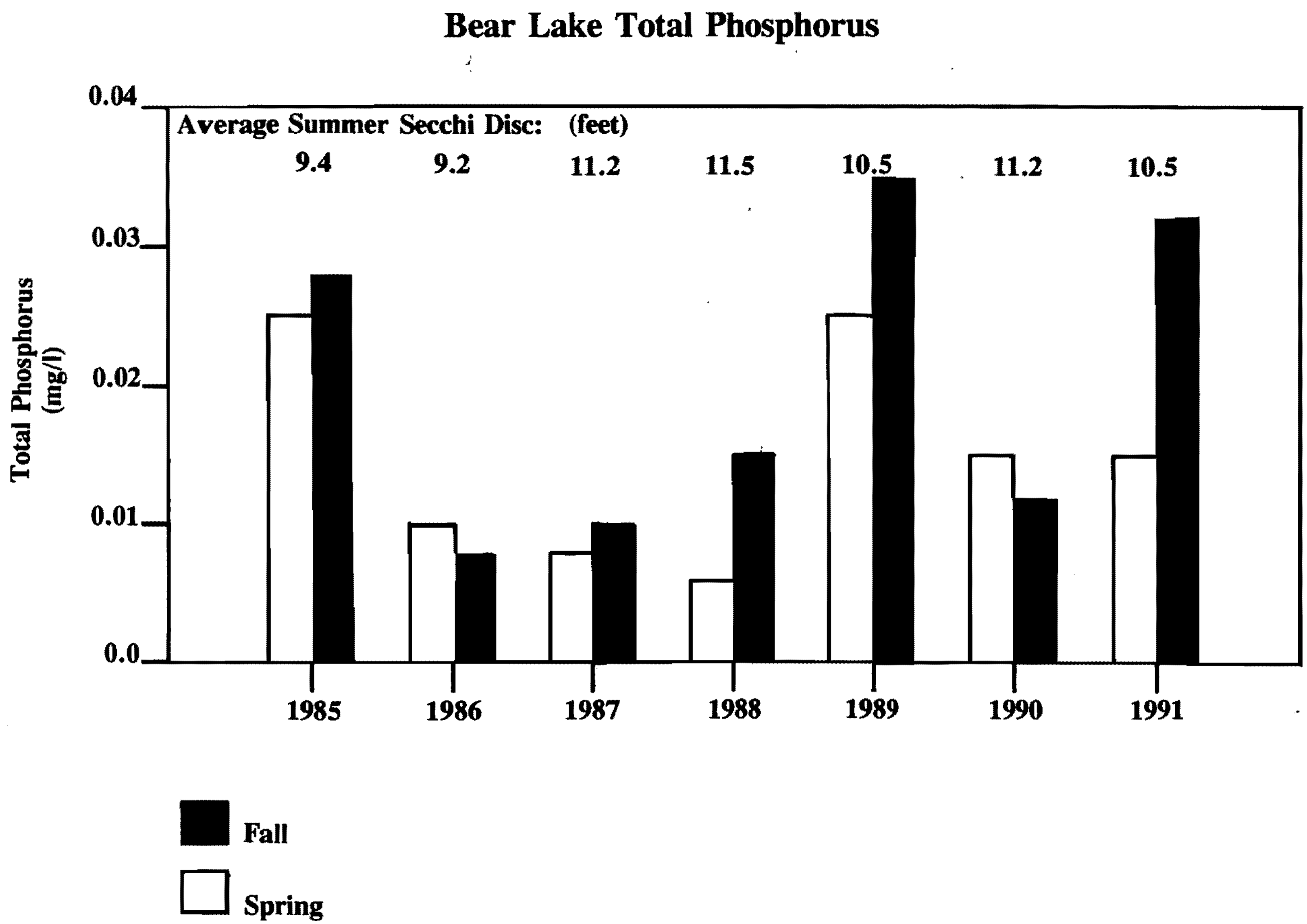


Figure 11. Total phosphorus in spring and fall for Bear Lake. Analysis by UW-Stevens Point

Algae and Zooplankton

Zooplankton samples were taken in 1984, 1985, 1986, and 1987 but never 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. We did some zooplankton sampling in 1991 to see if any drastic changes could be detected. Results did not indicate any drastic changes in zooplankton numbers.

Examining zooplankton numbers per liter for June collections in 1985, 1986, and 1991 (Table 8a, Figure 12) there appears to be an increase in the number of zooplankton with a slight increase in daphnids from June 1985 to June 1991. Comparing 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 little information on algae species over this time period.

Although we proposed to analyze 5 zooplankton samples in 1991, sample collection occurred only in June, July, and August. The April and November samples were not collected because Blue Water Science did not get a zooplankton net to the Bear Lake District.

Table 8a. Zooplankton counts for Bear Lake, Oneida County.

	Daphnids			Copepods			Rotifers		
Date	Daphnia	Ceriodaphnia	Bosmina	Calonoids	Cyclopoids	Nauplii	Asplanchna	Keratella	Total
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

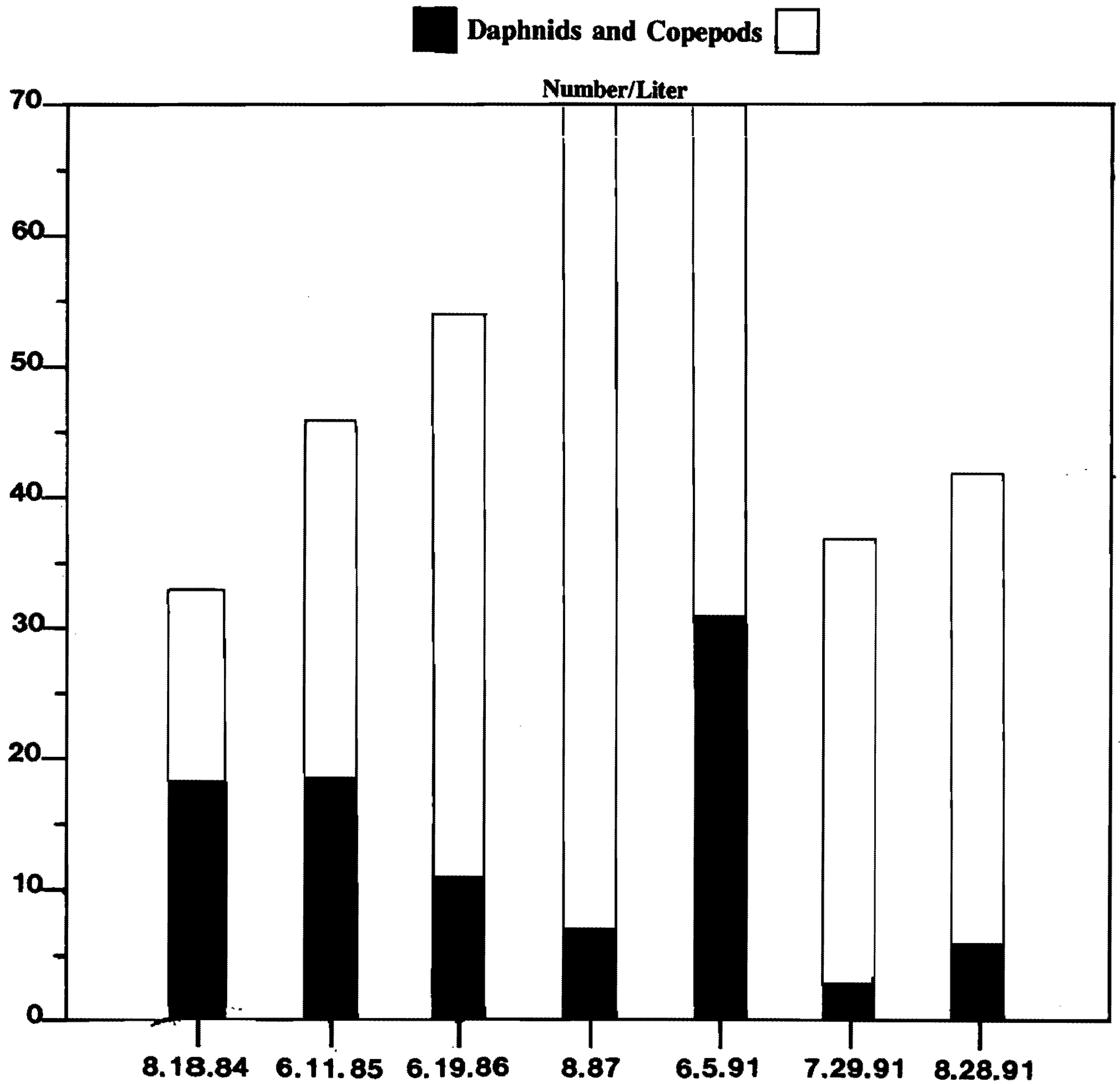


Figure 12. Daphnids and copepods densities for various dates, 1984-1991

Information on the algae community for Bear Lake is from chlorophyll readings for 1977 (April - October) and for 1991 (June and July)(Table 8b) and phytoplankton identification for 1991 (June and July)(Table 8c).

It appears chlorophyll has remained nearly the same since 1977, allowing for year to year variability. With only two readings for 1991 to compare to 1977, and with different labs doing the analysis in 1977 and 1991, conclusions are tentative, but because water transparency has remained nearly the same, there is probably some support for algae biomass being nearly the same.

Replicate Phytoplankton samples were collected for June and July, 1991. Analysis indicated the phytoplankton community was dominated by small unicellular algae.

In the July 29, 1991 sample, we found about 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 is unidentified at this time. Anabaena was found at 400 filaments/ml and microcystis was found at 300 colonies/ml.

Bluegreens were dominant by biovolume.

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 analyses.

Table 8b. Chlorophyll and secchi disc readings for 1977 (Northern Environmental Services) and 1991 (secchi = D. Jalinski, chlorophyll = Wisconsin Hygiene Lab)

Date		1977		1991	
Month	wks	Secchi disc (feet)	Chlorophyll a (ug/l)	Secchi disc (feet)	Chlorophyll a (ug/l)
Apr	3	10.9	8	10.5	--
May	1	11.0	7	11.5	--
May	3	12.3	2	15.3	--
Jun	1	10.0	5	14.0	--
Jun	3	9.0	8	9.0	9
July	1	9.0	5	9.7	--
July	3	8.3	3	8.9	9
July	4	9.0	6	7.5	--
Aug	3	8.0	7	8.5	--
Sept	1	8.5	5	8.8	--
Sept	3	8.5	8	11.5	--
Oct	1	8.0	6	12.0	--
Oct	3	11.0	5	11.5	--
		-------	-----	-------	-----
Average		9.5	6	10.7	--

Table 8c. 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			
		(1,300um³)	(100,000um³)	(3,000um³)	(4,000um³)	(350um³)	(10um³)
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

Macrophytes

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 13). Rooted plants were found in water to a depth of 17 feet. Plant coverage is shown in Figure 14. 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 15). 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.

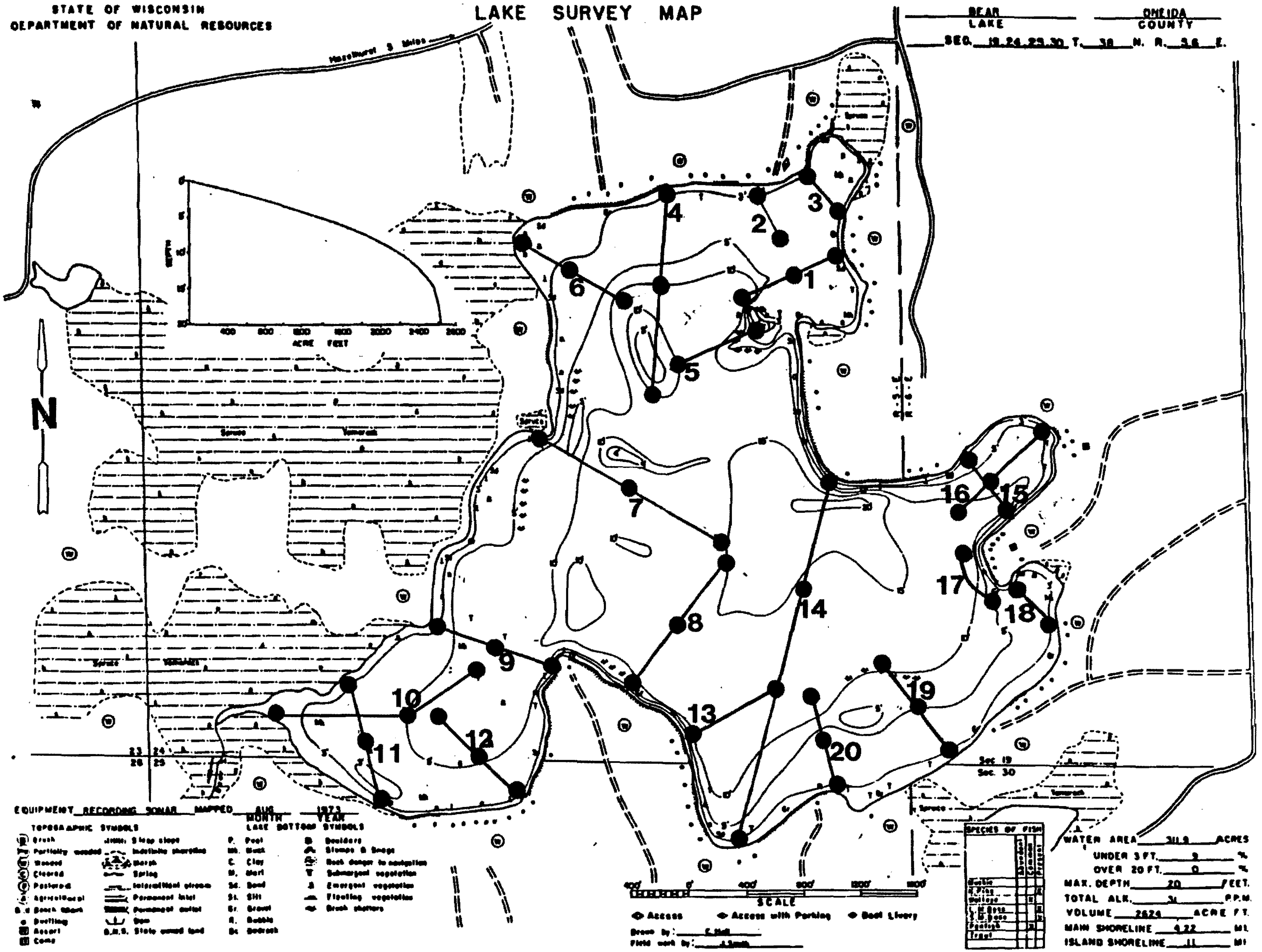


Figure 13. Transects for the aquatic plant survey on Bear Lake, July 29, 1991

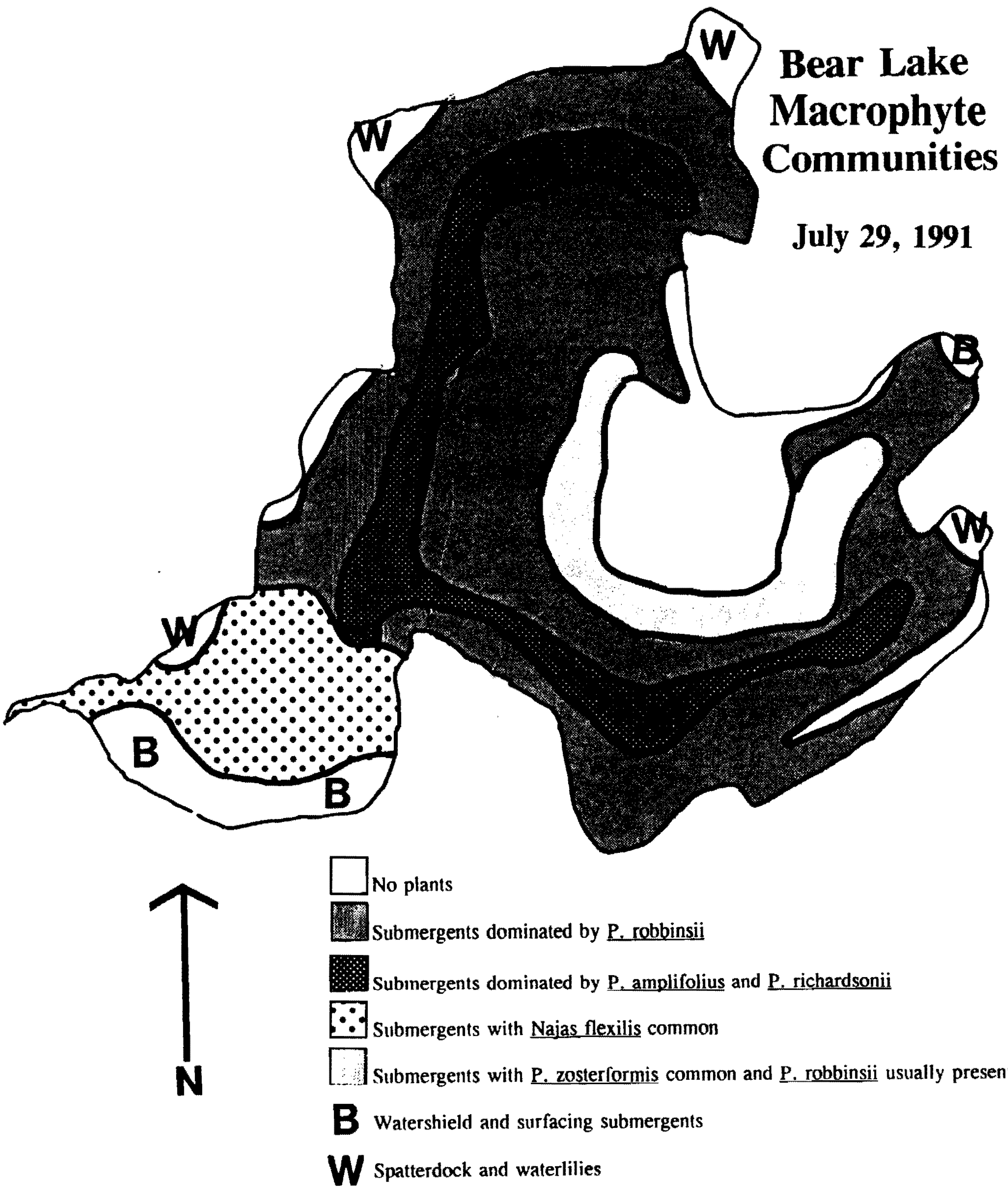


Figure 14. Bear Lake macrophytes survey, July 29, 1991 (Conducted by Blue Water Science)

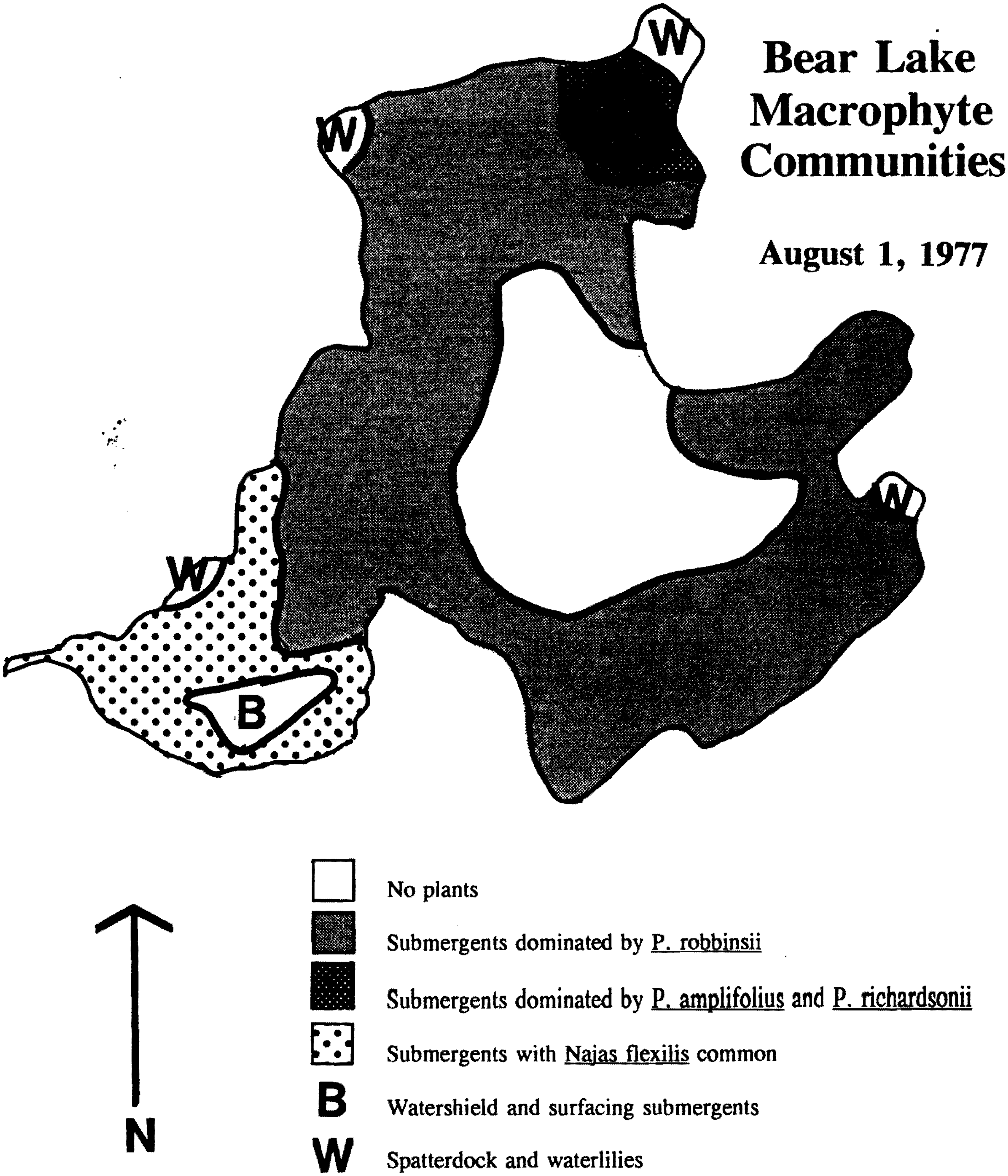


Figure 15. Bear Lake macrophytes survey, August 1, 1977 (conducted by Northern Environmental Services)

A species list of plants for 1991 and 1977 is shown in Table 9. 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 10). 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 take notes while viewing the aquatic plant community. Scuba investigations showed several interesting aspects of aquatic plant community.

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

o *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).

o The sediment/water interface is poorly defined over extensive areas 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.

o 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.

Table 9. 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 10. 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

Fish

In June 1991 a panfish survey was conducted on Bear Lake using 10 fyke nets for 5 days. Incidental with panfish, gamefish were counted as well. The number of fish caught for each species is listed in Table 11. Fish length distributions are shown in Figure 16.

The 1991 survey also included panfish removal. All gamefish caught in the fyke nets were counted and released, and all sunfish and bullheads were removed from Bear Lake. The 1991 effort was the continuation of a panfish removal project that started in 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.

Table 11. Species of fish and number caught in June 1991 using 50 nets.

Species	Total Number of Fish	Fish/Net (50 nets)
Bluegills	17,157	343
Pumpkinseeds	4,072	81
Bullheads	1,392	30
Largemouth Bass	175	3.5
Northern Pike	72	1.4
Walleye	10	0.2
Crappie	43	0.9
Rock Bass	37	0.7
Yellow Perch	18	0.4
Sucker	2	0.04

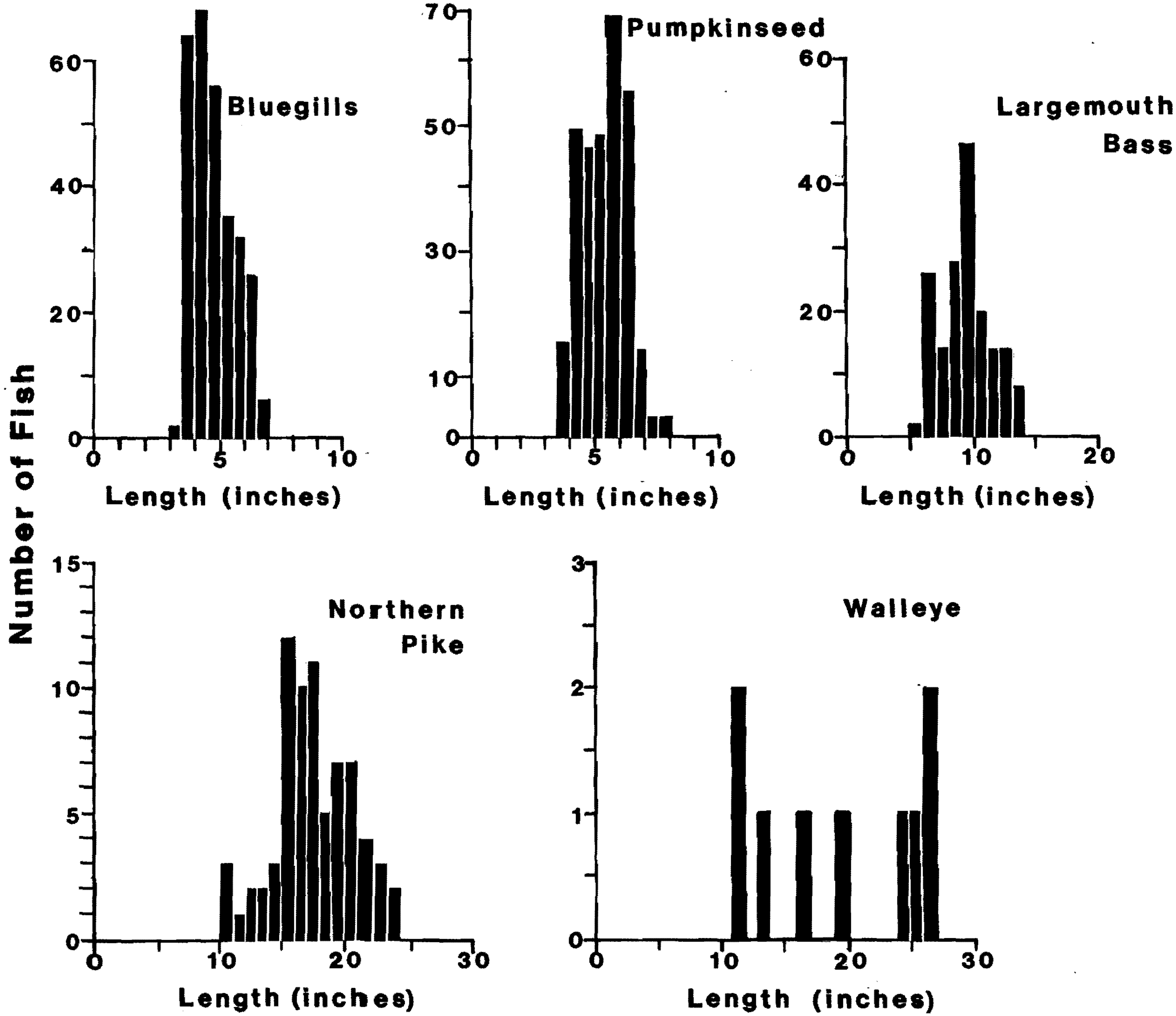


Figure 16. Fish length distributions for June 1991 survey

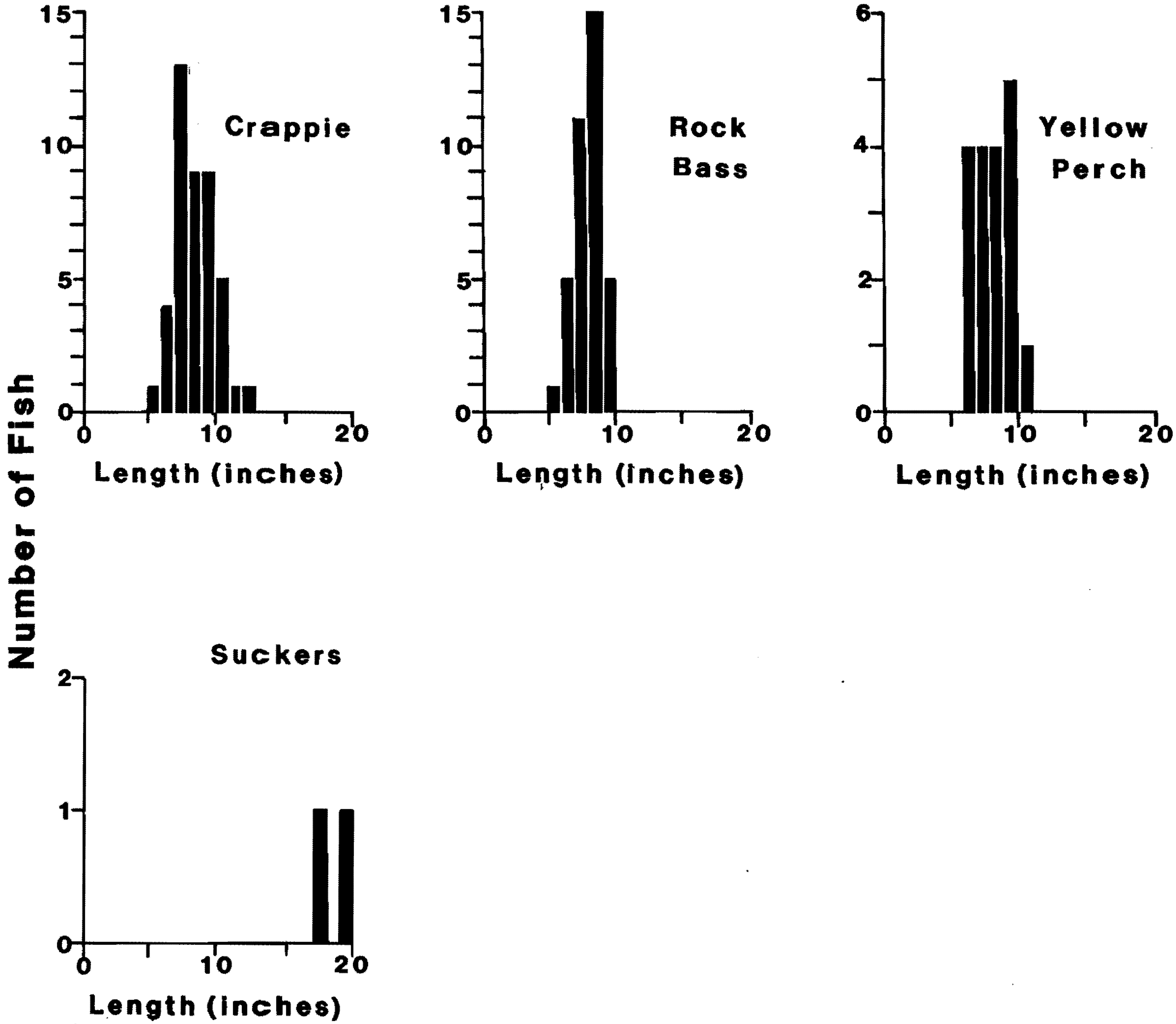


Figure 16. Concluded

Table 12. Total pounds and numbers of fish removed for 1985-1991. The sunfish heading refers to bluegills and pumpkinseed sunfish combined.

	POUNDS			NUMBERS		
Date	Sunfish	Bullheads	TOTAL	Sunfish	Bullheads	TOTAL
1985*	688 est.	-	688	7,620	-	7,620
1986**	2,863	483	3,346	39,079	1,931	41,010
1987**	2,294	376	2,670	35,537	1,656	37,193
1988**	1,886	767	2,653	27,956	3,948	31,904
1989***	1,014	321	1,335	10,032	1,274	11,306
1991****	1,540	391	1,931	21,229	1,392	22,621

*: 4 days, 6 nets, bullheads were not removed
**: 10 days, 10 nets, major removal effort
***: 6 days, 6 nets, this was intended as a sampling year not a fullblown fish removal year
****: 5 days. 10 nets

Table 13. Average weight of Bluegills and pumpkinseeds captured in Bear Lake in June, 1985-1991.

			BLUEGILL			PUMPKINSEED		
Number of days fished	Total lifts	Date (year)	Weight (pounds)	Numbers	Avg. Wt. (ounces)	Weight (pounds)	Numbers	Avg. Wt. (ounces)
4	24	1985	ND	3,135	ND	ND	4,485	ND
10	100	1986	1,397	24,571	0.91	1,471	14,508	1.62
10	100	1987	1,148	23,978	0.77	1,146	11,559	1.59
10	100	1988	939	18,839	0.80	947	9,117	1.66
6	36	1989	443	6,087	1.17	571	3,945	2.32
5	50	1991	995	17,157	0.93	545	4,072	2.14

The first removal effort was conducted in June, 1985. Steve McComas, with Blue Water Science, led a volunteer crew from the Bear Lake District. Six fyke nets were loaned to the Lake District by the WDNR-Woodruff. Dick Wendt and Ron Theis helped get the necessary permits and Ron Theis came out to Bear Lake to instruct us on deploying fyke nets. I wonder what he must have been thinking as he drove back to Woodruff ...*six good fyke nets, in the hands of citizens who had never even seen one before, led by a consultant he had never heard of, all out counting and removing fish, trying to improve a sunfish community on a 300 acre lake with six nets...*

Well, that week in 1985 was interesting. After a quick course on fish identification and how to patch nets, the Bear Lake group rapidly turned into a team. Results for 1985 are shown in Table 12. About 29 pounds of sunfish per lift were removed. The consensus of the team was that to have an impact on the sunfish we would have to hit them harder and longer.

For the next three years we used 10 nets for 10 days in June. Results are shown in Tables 12 and 13. The Bear Lake team was now working like a well-oiled machine. They could set nets, pick them up and move to new locations, and count fish as fast as any one. For all netting years, each sunfish was counted, and weighed in five gallon buckets. Approximately 5% of the fish were subsampled for length measurements.

The question after the 1988 effort was whether we were having an impact. We used 1989 and 1991 as monitoring years although we were still removing sunfish we caught. Average weight of bluegill showed a slight increase in 1989, but the 1991 sample indicated average bluegill weights were similar from 1985 to 1991 (Table 13). Pumpkinseed showed a similar trend, but their average weight was higher in 1991 compared to 1985.

Walleye were the other target fish. Our efforts did not appear to have much impact on walleye numbers (Table 14), however an unexpected change occurred in the largemouth bass. Their numbers appeared to nearly double (Table 14). I can't explain the drop in yellow perch, but they appear to be declining. Alternatively, northern pike seemed to be on the increase.

However, another fish survey was done in 1992 (Please see the Bear Lake 1992 report for details). Results of the 1992 survey indicate the Bear Lake fish community may still be changing. It appears that yellow perch are making a come back. If yellow perch are indeed increasing in number, will walleye numbers increase as well?

My first thoughts when looking at the 1991 data were reduce the emphasis on walleye and emphasize largemouth bass community improvement. However, I think it may be best to wait a couple of years to see what the walleye are going to do.

Table 14. Number of gamefish and panfish caught for every fyke net set.

Date	Walleye	Northern Pike	Largemouth Bass	Yellow Perch	Bluegill	Pumpkin-seed	Bullhead
1985*	0.3	0.2	1.9	3.4	131	187	--
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
1989*	0.2	0.6	4.0	0.4	169	110	35
1991*	0.2	1.4	3.5	0.4	343	81	28

*netting conducted for one week period.

Other years netting was conducted for 2-weeks.

The conclusion from the fyke net removal is that more bluegill and pumpkinseed sunfish are 6 inches or greater compared to the base year of 1985 (Tables 15, 16, and Figure 17). This is positive. Largemouth bass numbers have increased and this is positive. Walleyes did not increase, but they did not decrease either, this in neutral. More information is needed for northern pike and yellow perch.

However, the lake may still be adjusting to the removal and all the impacts may not yet be recorded. A gamefish survey was conducted in 1992 and results will be reported in the next report (preliminary results indicate yellow perch are increasing). It would also be interesting to sample panfish in 1993 to see if they are still adjusting to previous removal efforts.

Are the fish fyke netting data valid? I believe the sunfish numbers are valid and reflect the sunfish community structure. Our sampling was at the same stations and about the same time of the year for all sample years. Thousands of fish were processed. Although water temperatures varied somewhat from year to year at the time of sampling (Table 17) sunfish were in the midst of spawning every sample year.

Table 15. Frequency distribution of bluegill and pumpkinseed sunfish for June fyke net data for Bear Lake 1985-1991.

% OCCURRENCE

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

Table 16. Percent of bluegill and pumpkinseed sunfish 6 inches or bigger based on June fyke net data.

Date	Bluegill	Pumpkinseed
1985	4	14
1986	7	18
1987	5	21
1988	2	17
1989	7	45
1991	10	30

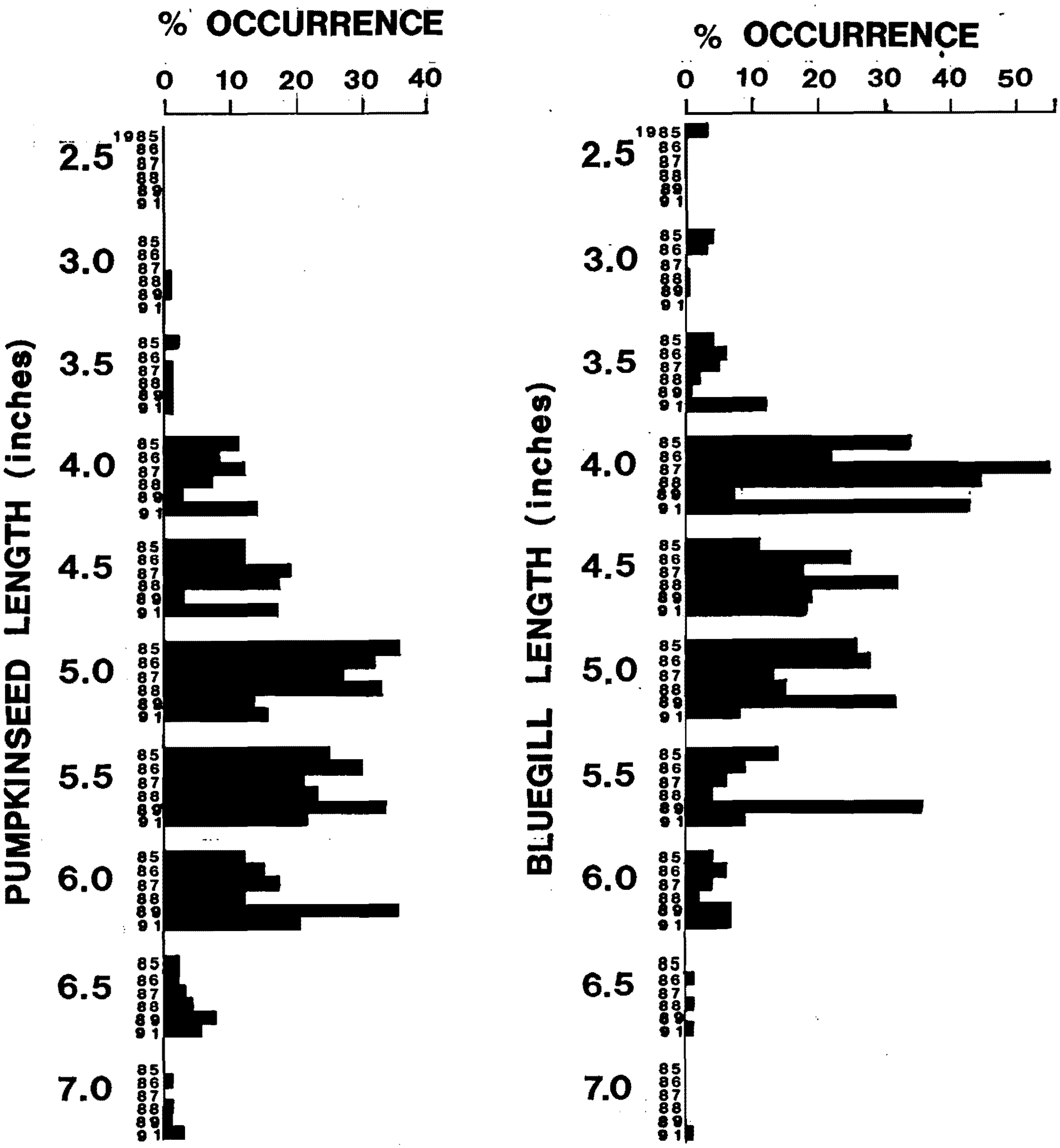


Figure 17. Percent occurrence for Bear Lake sunfish for 1985-1991

Table 17. Morning water temperatures in spawning bed areas (2-3 feet water depths, nearshore area). The dates under the year represents the starting dates.

Netting Days	1985 Jun 11	1986 Jun 10	1987 Jun 8	1988 Jun 6	1989 Jun 6	1991 Jun 3
1	---	---	70	74	65	74
2	66	ND	68	72	64	72
3	ND	62	67	69	64	70
4	ND	64	67	67	---	71
5	ND	64	69	68	---	72
6	---	ND	74	72	63	---
7	---	70	72	71	60	---
8	---	67	74	71	58	---
9	---	70	75	70	---	---
10	---	68	ND	69	---	---

---: no fish removal
ND: not determined

7. BEAR LAKE 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 come 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.

Two phosphorus models were used in this study: the Reckhow and Simpson Model (1980) and Canfield and Bachmann Model (1981). The model formats are shown in Table 18. 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 19. The nutrient input Table (Table 19) shows that rainfall is the major nutrient contributor to Bear Lake followed by forested areas and then followed by residential areas and lastly the wetlands systems. 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 predictions and the actual observed phosphorus concentrations are shown in Table 20. For Bear Lake, the Reckhow and Simpson model prediction was 5 parts per billion (ppb) annual phosphorus concentration and the Canfield and Bachmann model prediction was 22 ppb, while the average found for Bear Lake was 18 ppb annual phosphorus concentration.

Table 18. Phosphorus models used for Bear Lake .

Reckhow and Simpson Phosphorus Model (1979)

Predicted phosphorus concentration (mg/l) $= \dfrac{L \text{ (nutrient budget)}}{11.6 + 1.2\, q_s \text{ (water budget)}}$

where:

$L\ (g/m^2) = \dfrac{\text{Mass of phosphorus loading (g)}}{\text{Lake surface area } (m^2)}$

and:

$q_s\ (m) = \dfrac{\text{Volume of water loaded on the lake surface } (m^3)}{\text{Lake surface area } (m^2)}$

Canfield and Bachmann Phosphorus Model (1981)

Predicted phosphorus concentration (mg/l) $TP = \dfrac{L}{z(0.114\,(L/z)^{0.589} + p)}$

where:

$TP\ (mg/m^3)$ = concentration of total phosphorus in the lake water

$L\ (mg/m^2) = \dfrac{\text{Mass of phosphorus loading (mg)}}{\text{Lake surface area } (m^2)}$

z (m) = mean depth of the lake

$p\ (yr^{-1})$ = hydraulic flushing rate

Table 19. Nutrient input parameters for the Bear Lake phosphorus model. Phosphorus export coefficients were selected from Reckhow 1979 (Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients, EPA, Washington D.C.)

Land use or nutrient source	Area (ha) volume (m^3) or numbers	Export coefficient (kg/ha/yr)	Estimated phosphorus input (kg/yr)
Forest	235 ha	0.1	23.5
Wetland	89 ha	0.05	4.5
Urban	17 ha	0.19	3.2
Septic tank systems			
seasonal	89	0.109*	9.7
permanent	11	0.332*	3.7
Rainfall	126 ha	0.20	25.2
Groundwater	35 ha-m	0.04**	13.9
			83.7

* kg/on-site system/yr was derived from the following assumptions and calculations:
seasonal: 60 gallons/day * 2.5 people/cabin = 150 gallons/day/cabin * 3.785 = 567.75 liters * 120 days = 68,130 liters * 1.6 mg/l* = 109,008 mg/year
permanent: 60 gallons/day * 2.5 people/cabin = 150 gallons/day/cabin * 3.785 = 567.75 liters * 365 days = 207,229 liters * 1.6 mg/l* = 331,566.4 mg/year

** mg/l--based on 1977 Northern Lake Services results.

Table 20. Bear Lake Phosphorus modeling background information and results. Phosphorus concentrations represent spring turnover concentrations.

Lake area (ha)	126 ha
Mean depth (z)	2.6 m
Lake volume	3.2 x 10^6 m^3
Watershed area	340 ha
Inflow from watershed (assumed)	12 inches
Calculated watershed phosphorus load	69.6 kg/yr
Areal TP load (L) (phosphorus load/lake area)	60.0 $mg/m^2/yr$
Hyd. residence time	2.98 years
Hyd. flushing rate (1/years)	0.34 1/years
Overflow rate (qs)	0.82 m/yr
Settling velocity of TP (v)	
Sedimentation coef ($0.162(L/z)^{0.458}$)	0.682
Predicted P conc (model prediction)	
Reckhow and Simpson	**5.0** ppb
Canfield and Bachmann	**22.0** ppb
Observed lake phosphorus concentration (lake sampling results)	**18.0** ppb
Amount of additional P inputs needed to reach nuisance levels of 40-45 ppb	
Annual P load	160-200kg

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 internal loading with an annual average total phosphorus concentration of around 20 parts per billion. I have found the Reckhow model to work the best for oligotrophic systems. A summary of model results is shown in Table 21.

By manipulating the phosphorus model we can estimate the phosphorus loading that would cause nuisance algae problems. Using a phosphorus threshold concentration of 40-45 ppb as producing nuisance algae conditions, it would take an average annual input of between 160kg to 200kg of phosphorus. Current phosphorus inputs are estimated at 70 kg per year. Therefore an increase of 90 to 130kg per year could induce nuisance algae blooms. Conditions to watch for are new home construction which could contribute erosional inputs and in the lake, watch for anoxic hypolimnion, which could contribute to internal P loading.

Table 21. Total phosphorus observed and calculated model predictions based on phosphorus inputs of 69.6 kg/yr

	Total phosphorus
Actual Bear Lake TP	18.0 ppb
Reckhow and Simpson Model	5.0 ppb
Canfield and Bachmann Model	22.0 ppb

8. IMPACT OF SUNFISH REMOVAL ON BEAR LAKE ECOSYSTEM

Some changes appear to have occurred in the Bear Lake fish community since the panfish removal project started in 1985. My interpretation is the changes have been positive. The percent of bluegill and pumpkinseed sunfish six inches and over has increased. The number of largemouth bass apparently has increased, and water clarity may have increased. A lingering question is: have we turned the corner on the stunted sunfish problem. Will they continue to grow into larger size classes? Another panfish survey would help quantify what is happening in the panfish community.

APPENDIX A

Bear Lake Secchi Disc Report

by

Dale M. Jalinski

Bear Lake Resident

Bear Lake Summary of Seechi-Disc Reading

1977-1991

Bear Lake is located in Oneida County within the townships of Minoqua and Haselhurst. Data use in this report was taken by and for the Bear Lake Protection and Rehabilitation District.

The information under the heading of Seechi-Disc Reading contain the recorded seechi-disc reading as recorded in the years of 1977, 1985, 1986,1987, 1988, 1990, and 1991.

The information under the Seechi-Reading Averages is the information that was used to graph and evaluate the actual reading. 1977 is consider the base year in all graphs. The 5yrs. Avg. is the average of the years of 1977, 1985, 1986, 1987, 1988 as found in the Seechi-Disc Reading Averages chart.

Data shows an overall improvement in the water clarity of the lake in each succeeding year with the exception of the years of 1989 and 1991. Data shows that in the years of 1989 and 1991 the overall water clarity thou lower then the previous year is still better then that of the base year and the 5 year average. It is likely that rain fall was not a major factor in the lack of improvement in the 1989 and 1991 years. Rain falls from May 1 to Nov. 1 of each of the years was, 1985-32.35 inch., 1986-23.95 inch., 1987-19.35 inch., 1988-19.30 inch., 1989-16.75 inch., 1990-30.45 inch., 1991-28.30 inch..

Dale M. Jalinski

SEECHI-DISC. READING

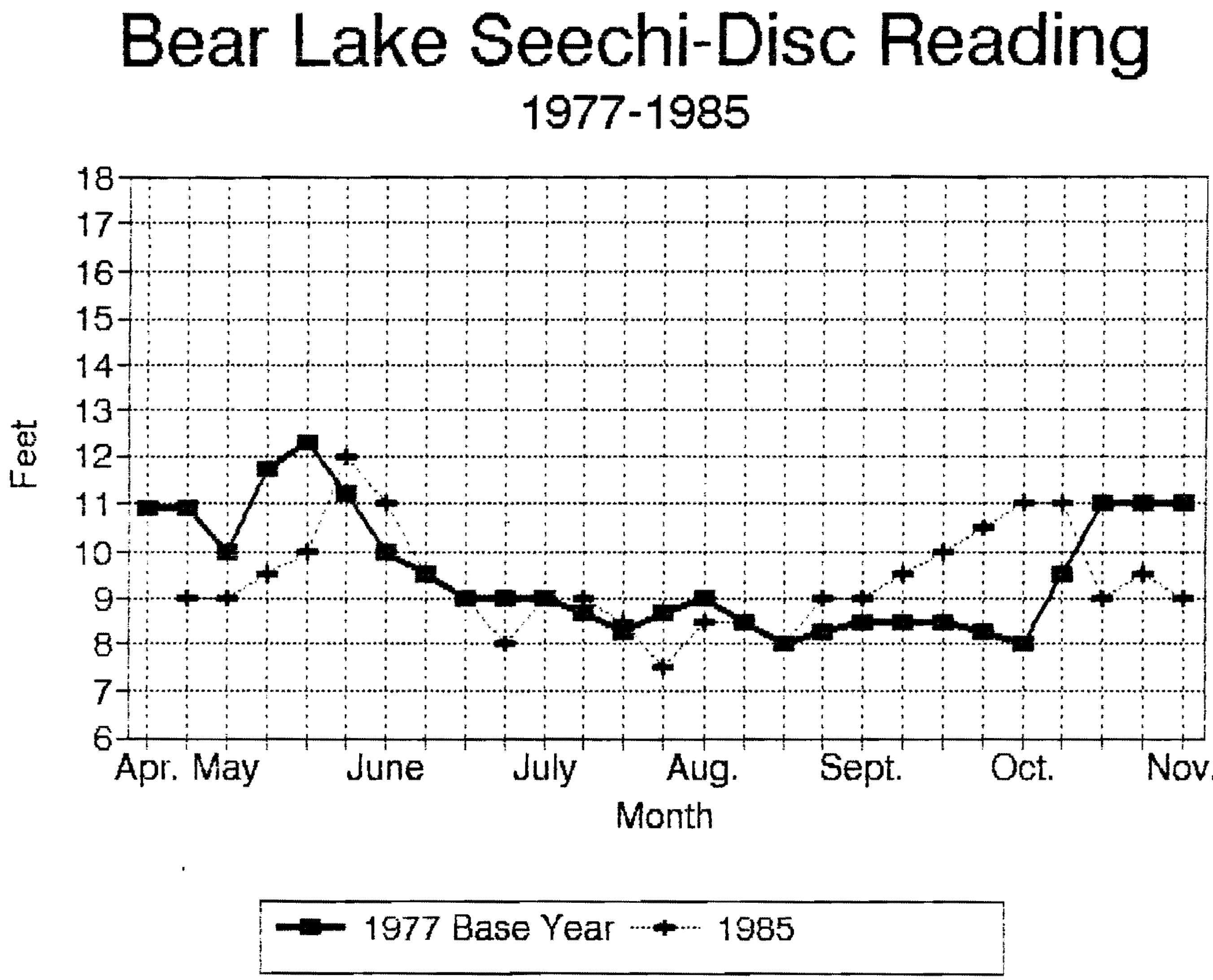
BEAR LAKE

Year:		1977	1985	1986	1987	1988	1989	1990	1991	1992
Month:	wk#	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
Apr.	3	10.9		10.5	12.5	14.2	12.0	12.5		
	4		9.0	8.5					10.5	
May:	1	11.0	9.0	10.0			10.0	15.3		
	2		9.5	10.5	14.0	14.7			12.5	
	3	12.3	10.0	10.5	16.0		14.0	14.0	15.3	
	4		12.0	14.0	15.5	14.7				
June:	1	10.0	11.0	14.0			14.0	15.0	14.0	
	2		9.5	12.0	13.5	15.5		11.5		
	3	9.0	9.0	10.5			11.5		9.0	
	4		8.0	10.5	8.0	8.0		11.0		
July:	1	9.0	9.0	10.0	9.0					
	2		9.0	8.5		8.5	11.0	10.0	10.3	
	3	8.3	8.5		7.5			12.0		
	4		7.5	8.0		10.5	9.0	9.0	7.5	
Aug:	1	9.0	8.5	7.5	8.0	9.5	8.0	9.0	9.0	
	2		8.5	8.0					8.0	
	3	8.0	8.0	8.0	8.0	9.5	7.8	9.5		
	4		9.0	8.0			7.8		9.0	
Sept:	1	8.5	9.0	9.0	12.0	10.5		8.8	8.8	
	2			9.0			9.3	8.0		
	3	8.5	10.0	10.2		13.5			11.5	
	4		10.5	11.5	11.5		13.0	12.0	10.5	
Oct:	1	8.0	11.0	12.0					12.0	
	2		11.0	12.0	14.0	13.7	15.8	11.0		
	3	11.0	9.0	12.5			15.0	15.5		
	4		9.5		14.5	12.5			11.0	
Nov:	1		9.0	12.5			16.8	15.5		

SEECHI-DISC READING AVERAGES

		Base Year					5 yr. Avg.			
		1977	1985	1986	1987	1988		1989	1990	1991
Month	Wks#	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
Apr.	3	10.9		10.5	12.5	14.2	12.0	12.0	12.5	
	4	10.9	9.0	8.5	13.2	14.5	11.2	11.0	14.4	10.5
May	1	10.0	9.0	10.0	13.2	14.5	11.3	10.0	15.3	11.5
	2	11.7	9.5	10.5	14.0	14.7	12.1	12.0	14.7	12.5
	3	12.3	10.0	10.5	16.0	14.7	12.7	14.0	14.0	15.3
	4	11.2	12.0	14.0	15.5	14.7	13.5	14.0	14.5	14.7
June	1	10.0	11.0	14.0	14.5	15.1	12.9	14.0	15.0	14.0
	2	9.5	9.5	12.0	13.5	15.5	12.0	12.7	11.5	11.5
	3	9.0	9.0	10.5	10.8	11.8	10.2	11.5	11.3	9.0
	4	9.0	8.0	10.5	8.0	8.0	8.7	11.3	11.0	9.7
July	1	9.0	9.0	10.0	9.0	8.3	9.1	11.3	10.5	9.7
	2	8.7	9.0	8.5	8.3	8.5	8.6	11.0	10.0	10.3
	3	8.3	8.5	8.3	7.5	9.5	8.4	10.0	12.0	8.9

	4	8.7	7.5	8.0	7.8	10.5	8.5	9.0	9.0	7.5
Aug.	1	9.0	8.5	7.5	8.0	9.5	8.5	8.0	9.0	9.0
	2	8.5	8.5	8.0	8.0	9.5	8.5	7.9	9.3	8.0
	3	8.0	8.0	8.0	8.0	9.5	8.3	7.8	9.5	8.5
	4	8.3	9.0	8.0	10.0	10.0	9.1	7.8	9.3	9.0
Sept.	1	8.5	9.0	9.0	12.0	10.5	9.8	8.6	8.8	8.8
	2	8.5	9.5	9.0	11.8	11.8	10.1	9.3	8.0	9.8
	3	8.5	10.0	10.2	11.8	13.5	10.8	11.2	10.0	11.5
	4	8.3	10.5	11.5	11.5	13.6	11.1	13.0	12.0	10.5
Oct.	1	8.0	11.0	12.0	12.8	13.6	11.5	14.4	11.5	12.0
	2	9.5	11.0	12.0	14.0	13.7	12.0	15.8	11.0	11.5
	3	11.0	9.0	12.5	14.3	13.1	12.0	15.0	15.5	11.5
	4	11.0	9.5	12.5	14.5	12.5	12.0	15.9	15.5	11.0
Nov.	1	11.0	9.0	12.5	14.5	12.5	11.9	16.8	15.5	11.0


Bear Lake Seechi-Disc Reading
1977-1985
18
17
16
15
14
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12
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10
9
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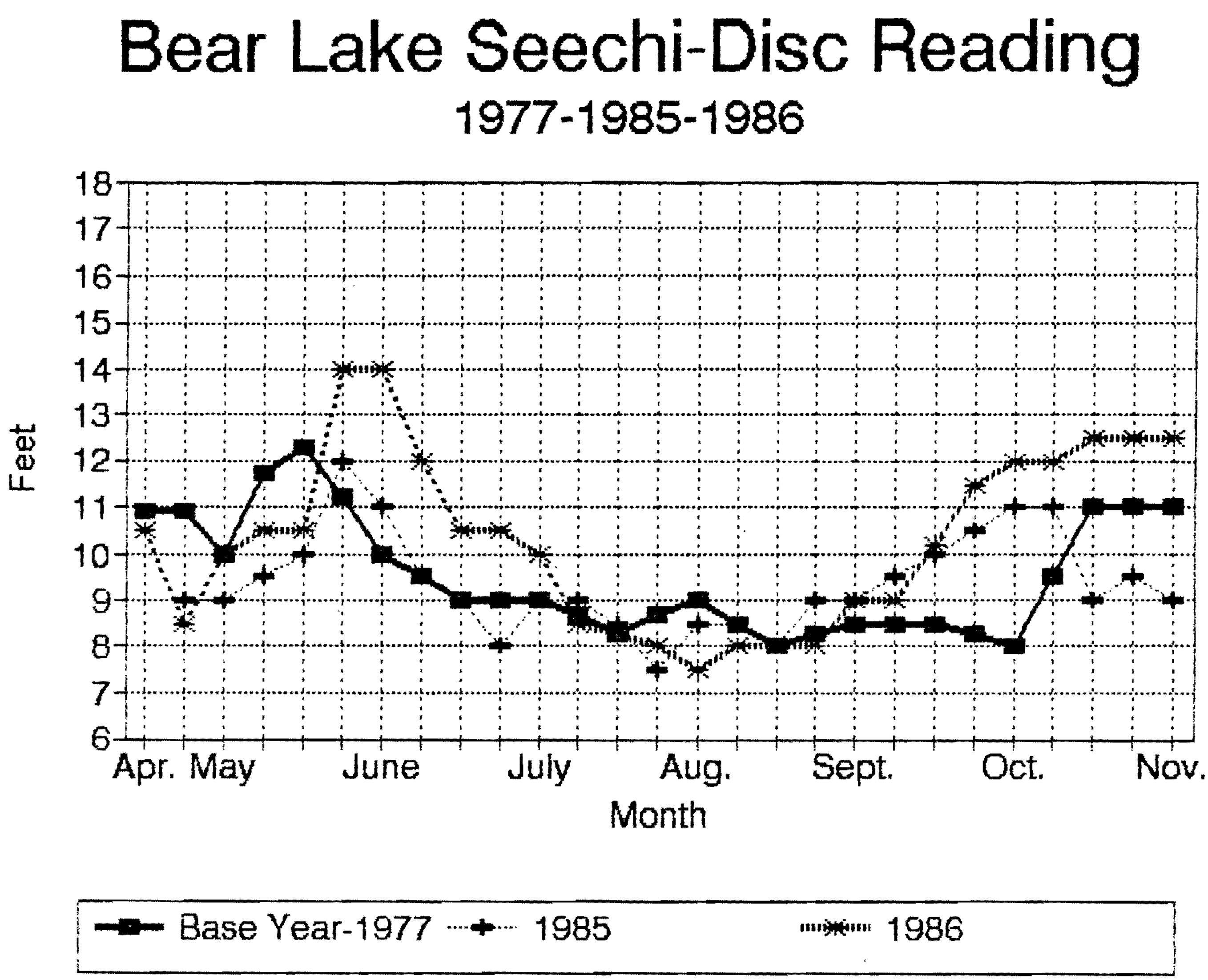
7
6
Feet
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Month
1977 Base Year
1985



Bear Lake Seechi-Disc Reading
1977-1985-1986
18
17
16
15
14
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12
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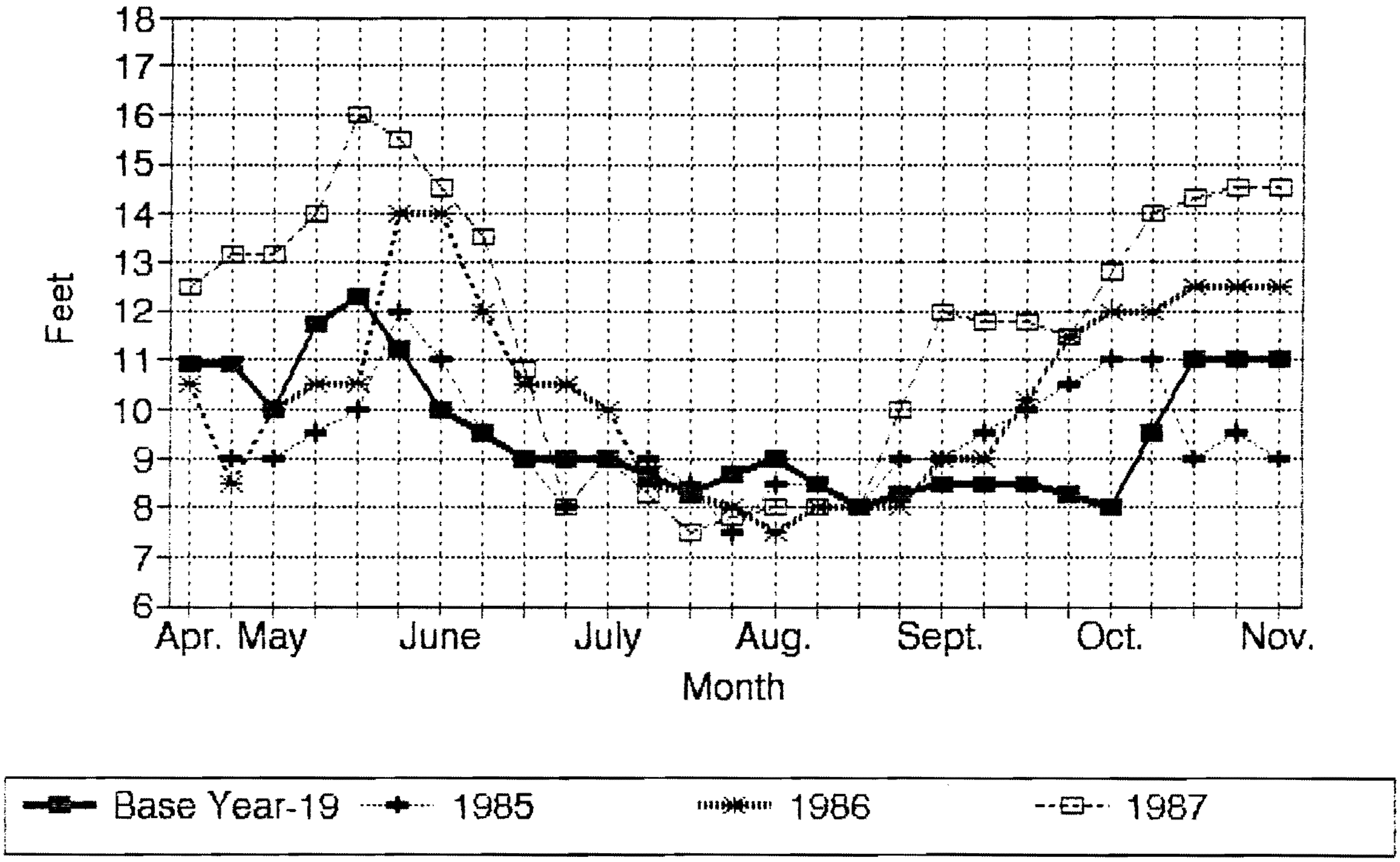
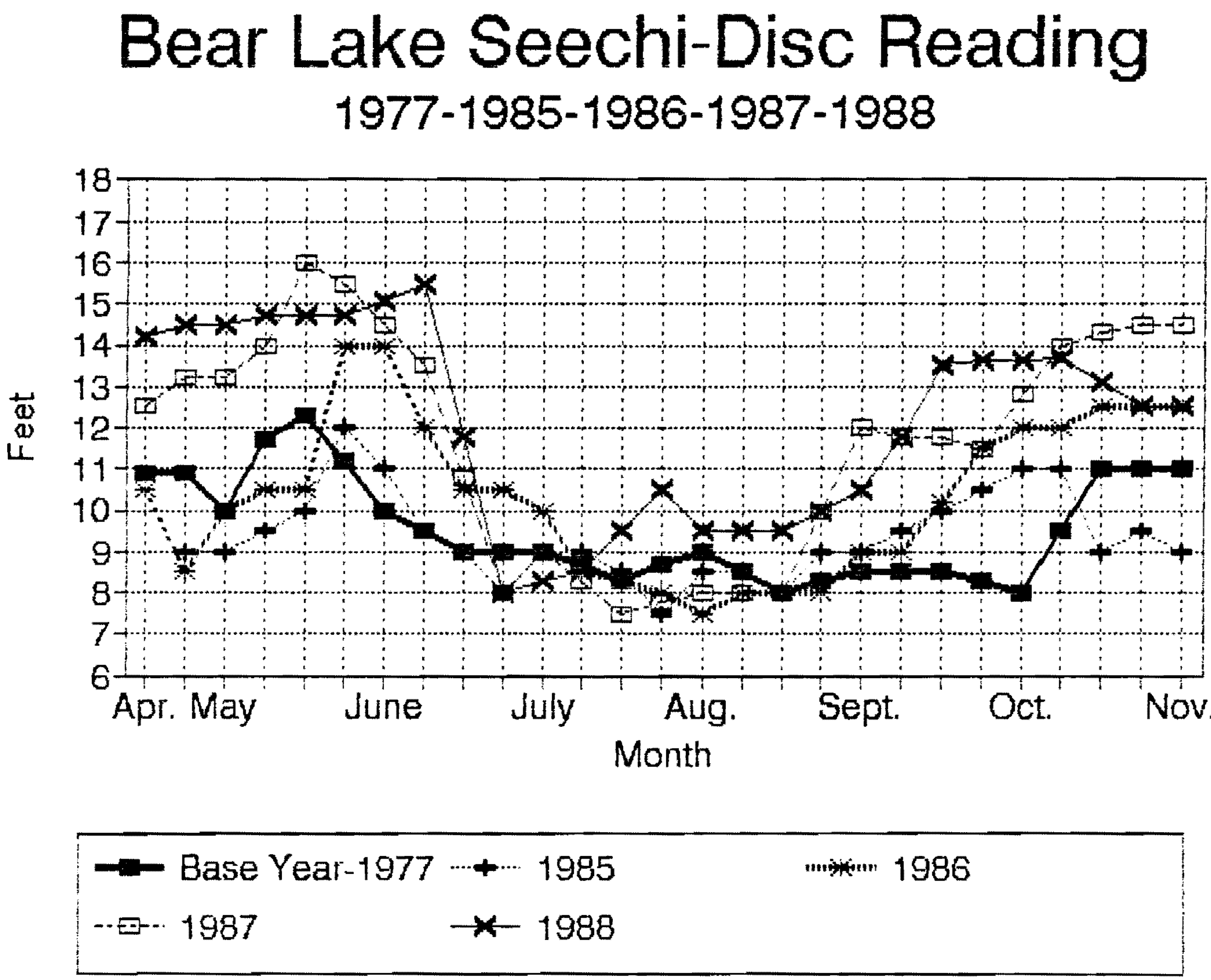
Feet
Apr. May
June
July
Aug.
Sept.
Oct.
Nov.
Month
Base Year-1977
1985
1986

Bear Lake Seechi-Disc Reading

1977-1985-1986-1987





Bear Lake Seechi-Disc Reading
1977-1985-1986-1987-1988
Feet
18
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16
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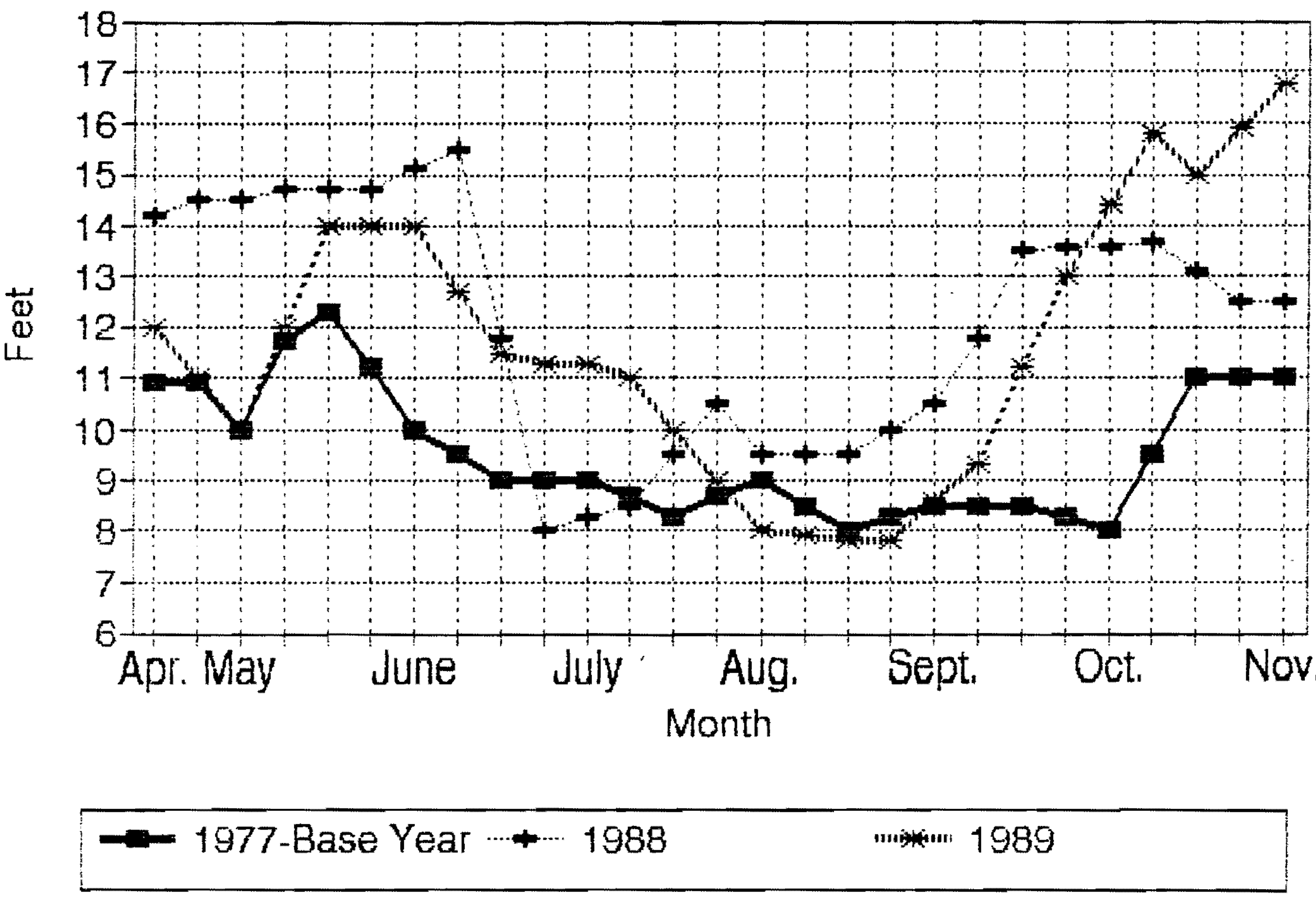
6
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Month
Base Year-1977
1985
1986
1987
1988

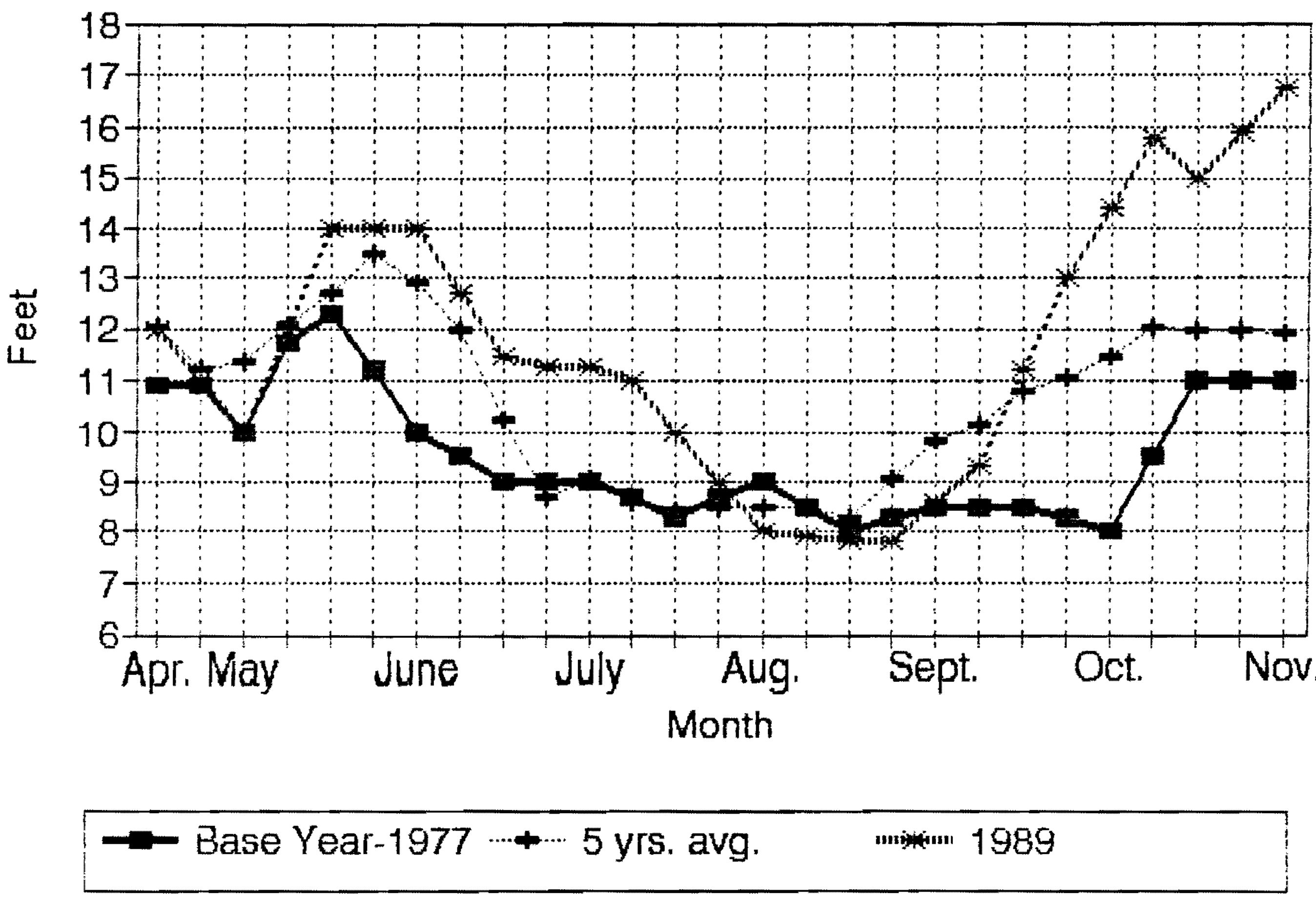
Bear Lake Seechi-Disc Reading

1988-1989



Bear Lake Seechi-Disc Reading

1989



Bear Lake Seechi-Disc Reading

1989-1990