12-21-82

Bear Lake Water Quality

INTRODUCTION:

Lakes are complex living systems providing home for a large variety of plants and animals. The living component works with physical and chemical components to determine lake use. Recreation and more vital lake use such as water supply, depend on the quality of the water or pollution level. Biologists and other resource scientists classify lakes according to their trohpic or productivity level. Clear, deep lakes with few plants and animals are called oligotrophic lakes. More productive lakes that support a healthy balance of plants and animals are mesotrophic. Lakes with excess vegetation, usually shallow, that limit recreation and other use are eutrophic.

WATER QUALITY DATA

Water chemistry samples were taken from Bear Lake on a quarterly basis in 1975. Samples were also taken from the 1980 summer quarter thru the spring 1982. Results are tabulated, see table____________.

The prupose of the monitoring program was to determine in-lake nutrient levels, nitrogen and phosphorus, and relate them to the productivity of the lake. Nutrient loadings from land practices in the watershed, failing septic systems, and atmospheric fallout were extimated with lake mathematical models.

Interpretation of the data is based on:

1. Sayyer's (1947) nutrient levels.
2. Inorganic nitrogen/dissolved phosphorus ration
3. Secchi disc transparency.
4. Chlorophyll a concentrations.
5. Oxygen depletion in the hypolimnion.

Sawyer's concentrations of inorganic nitrogen and dissolved phosphorus indicate the potential for increases in primary producers, algae and/or rooted aquatic vegetation. A concentration of $NH_4 + NO_3 + NO_2$ as N of o.3 mg/l and dissolved phosphorus of 0.015 mg/l during spring turnover will in-

Sample Date	3/18/75	4/21/75	7/30/75	11/14/75	8/7/80		11/3/80		2/11/81		4/13/81		7/27/81		10/29/81		3/11/82		3/4/82	
Depth					1M	17M	1M	10M	1M	16M	1M	14M	1M	16M	1M	12M	1M	13M	1M	
Parameter																				
BOD-5 Tot.																				
pH	7.5		8.4	8.1	8.7		7.9	7.9	8.3	8.0	8.3	8.1	8.6	7.4	8.2	8.1				
Tot-P	.04	.05	.028	.05	<.02	.15	.05	.05	.02	.08	.05	.04	.02	.16	.05	.05	.04	.10	.06	.04
Sol-P	.025	.013	.010	.003	<.004	.122	.008	.009	<.004	.064	<.004	.004	<.004	.112	.008	.011	<.004	.095	<.004	<.004
Tot. Org-N	.19	.49	.93	.51	0.8	0.8	.8	.8	.8	.7										
Kjel-N											1.0	1.5	0.8	2.3	1.1	1.2	1.1	1.6	1.1	0.9
NH_3-N	.51	.16	.05	.21	<.02	1.4	.42	.42	.31	.88	.08	.19	.02	1.1	.41	.41	.30	.93	.02	.12
NO_2-N + NO_3-N	.15	.51	.01	.02	<.02	<.02	.03	.03	.08	.12	.26	.27	.02	<.02	.03	.04	.16	.06	<.02	.37
Tot. Alkalinity	201	64	162	176	168	194	191	191	207	215	192	192	176	202	190	190	206	212		
Chlorophyll a					7		17						7		17				22	
Chlorophyll a corrected															16				19	
Hardness	216	70	172	192																
Secchi			1.4	2.4	1.5		2.4				1.7		1.8		2.1				1.2	
Other Inorganic N/P	26	52	4.6	7.7		8.2	56	50	-	15	-	115		10	55	41		10		

crease the number of primary producers. Dissolved nitrogen did exceed Sawyer's limit on occassion. Phosphorus levels were low during spring turnover. Concentrations of phosphorus were high in the hypolimnion during periods of stratification due to anaerobic conditions releasing phosphorus.

Nitrogen/phosphorus ratios identify the limiting nutrient affecting increases in primary producers. Combining Sawyer's nutrient levels with the ratio identifies immediate as well as long term lake problems. Ratios less than eleven indicate the biomass at that time is limited by nitrogen. Greater than eleven it would be phosphorus limited. When biomass is abundant, the nutrient present in large quantities is not limiting growth; rather the depleted nutrient is the one controlling or limiting growth. N/P ratios for Bear Lake show nitrogen in excess and phosphorus limited.

The eight inch in diameter black and white secchi disc is used to measure water transparency. While water clarity is caused by a combination of suspended matter as well as water color, the secchi disc reading along with chlorophyll a concentrations indicate the presence of algae ~~abundance~~. A secchi disc reading less than 1.5 meters and chlorophyll a greater than 14 ug/l ~~indicates~~ demonstrates algae abundance. Five chlorophyll a readings the past two years ranged from 7 ug/l to 22 ug/l. The average was 14 ug/l. Bear Lake does not suffer from an excess or persistent algae problem. The average secchi reading was 1.8 meters indicating moderate levels of turbidity.

Dissolved oxygen depletion was significant in the hypolimnion during the winter and summer periods of stratification. The August 7, 1980 sample had the most critical oxygen profile. Below a depth of 5 meters dissolved oxygen was less than 2 mg/l, and anaerobic donditions existed at 7 meters in an 18 meter profile.

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AQUATIC VEGETATION

Oxygen depletion in a lake is caused by bacteria decomposing organic matter and using dissolved oxygen in the process. Organic matter in Bear Lake exists as a nuisance in certain areas in the form of aquatic vegetation. Figure_______ is a map indicating areas of excess vegetation based on surveys the summers of 1980-81. The kinds of vegetation observed and relative abundances are listed on table_____. Decomposing organic matter did cause significant oxygen depletion during periods of stratification in Bear Lake.

PHYSICAL OR MORPHOLOGICAL FEATURES

Maximum depth	79 feet
Surface acerage	193.7 acres
Volume	4,620 acre/feet
Average depth	23.85 feet
Size of Watershed	2,321 acres, 3.6 mi^2

PHOSPHORUS FROM AGRICULTURE

The phosphorus transport from agriculture practices in the watershed was arrived at using information gathered on soil types, slopes, annual precipitation, and specific land practices. The annual phosphorus load was estimated to be 1,025 lbs/year.

PHOSPHORUS FROM SEPTIC SYSTEMS

Phosphorus from septic systems was estimated. Assuming 62 dwellings adjacent to the lake, 80% seasonal and four persons per household we arrive at 61 pounds of phosphorus/year. (US Forest Service March 1977)

PHOSPHORUS FROM ATMOSPHERIC DEPOSITION

Phosphorus from atmospheric deposition is arrived at using the National Oceanic and Atmospheric Administration climatological data for this area. Estimated loadings are 89 lbs/year based upon annual precipitation and surface acerage of the lake.

MATHEMATICAL MODELING

Bear Lake is a drainage lake with a continuous inlet and outlet. The water that enters the lake from the inlet carries nutrients that effect the water quality. A better understanding of the long term effect of the inlet on the lake is gained through mathematical models. Based upon the size of the drainage area and physical features of the outlet stream, it was estimated that the average daily outflow was 3 ft^3/sec. Combining this information along with previous mentioned chemical, biological and physical data into the Dillon and Rigler 1974B mathematical model, we arrive at the following phosphorus budget for Bear Lake.

Hydraulic residence time	2.127 years
Phosphorus areal load	1.19 grams/M^2/year
Phosphorus volumetric load	163.14 mg/M^3/year
Phosphorus equilibrium factor	0.59 years
Half life of the change in concentration	0.41 years
Current total areal load	0.59 grans/M^2/year
Acceptable total areal load	0.12 grams/M^2/year
Excessive total areal load	0.23 grams/M^2/year
Phosphorus steady state concentration	47.82 mg/M^3
Chlorophyll <u>a</u>	19.74 mg/M^3

The predictive values are close to actual values using the total phosphorus annual load of 1175 lbs/year. Average ~~cholo~~ chlorophyll a was 14 mg/M^3, close to the estimated. The total phosphorus steady state condentration went from 20 to 160 mg/M^3, averaging 57.4 mg/M^3; again, colse to predicted. Breakdown of the three prime sources of phosphorus:

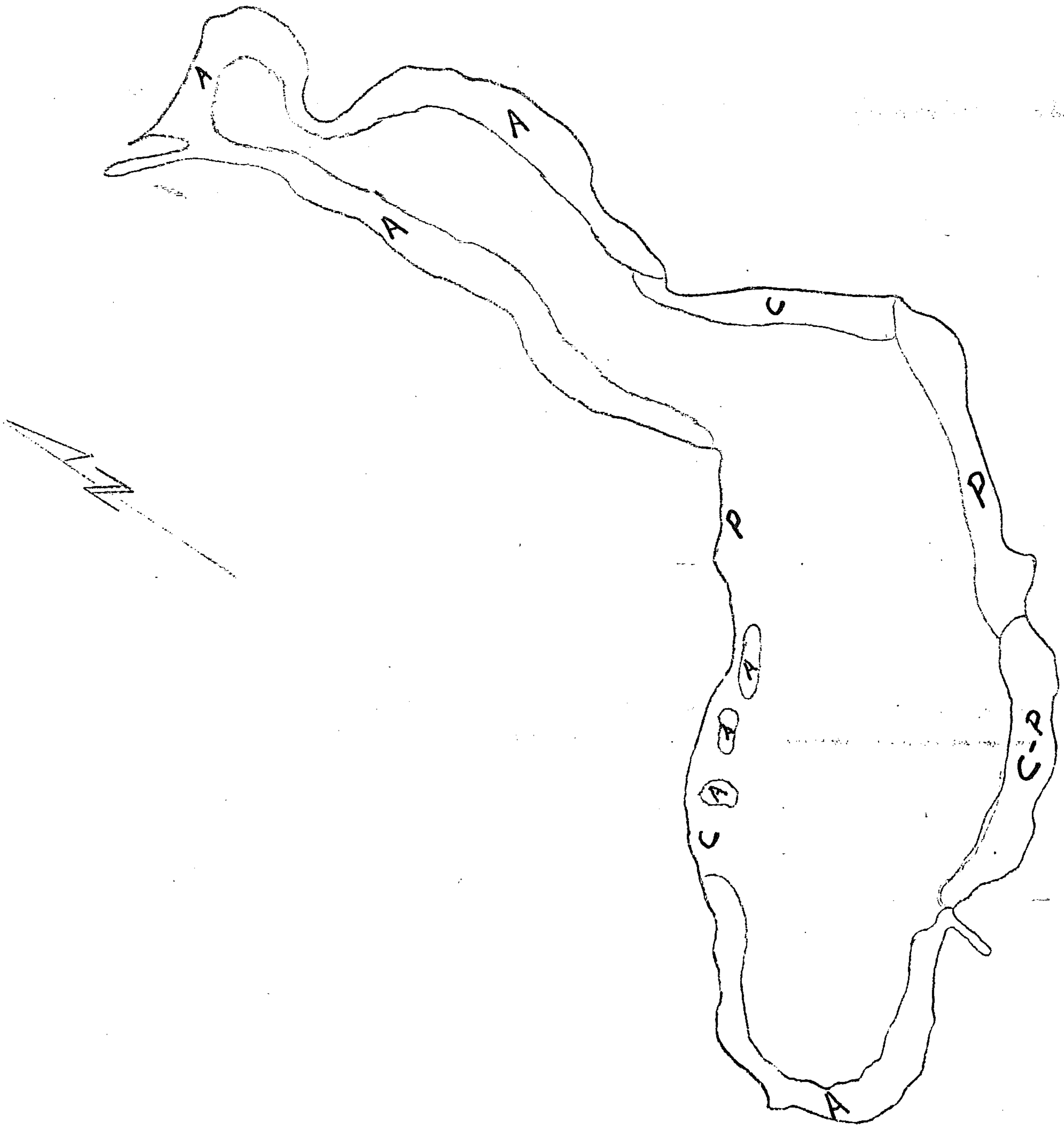
Sources	lbs/yr	%
Agriculture in watershed	1025	87.2%
Septic systems	61	5.2%
Atmospheric deposition	89	7.6%
Totals	1175	100%

CONCLUSION

Bear Lake is a mesotrophic lake with moderate levels of production in the form of aquatic vegetation. The ~~estim~~ estimated phosphorus input to Bear Lake appears to be quite accurate. Actual in lake chemistry samples confirm this. Phosphorus is essential for aquatic vegetation. The more phosphorus the more vegetation; a case of supply and demand. A management plan that reduces phosphorus input to Bear Lake is necessary to protect and enhance the resource. The extensive amount of poor agriculture practices that drain to the lake should be controlled. Farmers can volunteer to work with county resosrce agency personnel to implement best land mamagement practices and prevent nutrient input to Bear Lake.

Figure______________ Aquatic Vegetation

A - Abundant
C - Common
P - Present



Table________________

Shoreline aquatic vegetation surveys were conducted the summers of 1980-81. The following is a list of vegetation and their relative abundanae.

A - Abundant
C - Common
P - Present

EMERGENT VEGETATION

Common Name	Scientific Name	Relative Abundance
Bulrush	*Scirpus spp.*	C
Pickerelweed	*Pontederia cordata*	P
Cattail	*Typha latifolia*	P
FLOATING VEGETATION		
Duckweed	*Lemna spp.*	A
White pond lilly	*Nymphae spp.*	A
Yellow pond lilly	*Nuphar spp.*	A
SUBMERGENT VEGETATION		
Coontail	*Ceratophyllum spp*	A
Bushy Pondweed	*Najas flexilis*	P
Waterstar grass	*Heteranthera dubia*	C
Milfoil	*Myriophyllum exalbescens*	A
Eel grass	*Vallisneria spp*	C
~~Chara~~ Musk grass	*Chara*	A
Whitestem pondweed	*Potamogeton praelongus*	A
Floating leaf	*P. natans*	C
Big leaf	*P. amplifolius*	C
Clasping leaf	*P. richardsonii*	C

LAKE MANAGEMENT DISTRICT STATUS

Since 1975 lake property owners in Wisconsin have had the unique opportunity to form Lake Management Districts, or local units of government. There are approximately 130 districts in the State. Once formed, a district holds annual meetings to elect commissioners, adopt a budget, and vote a tax for the cost of operation for the coming year. The district board of commissioners is authorized to plan, adopt, and carry out lake protection and rehabilitation projects. Under certain conditions, the district may also provide sanitary services to the lake community. The district has the power to issue contracts, hold property, and do other things to carry out a program of lake protection and rehabilitation. It may raise money through taxation, special assessment, user charges, bonds, or loans. Lake Districts can seek technical and financial assistance from the Wisconsin Department of Natural Resources Inland Lake program.