Stream testing

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State of the Lake Report

Cossayuna Lake Water Quality Study 1984 - 1987

Report to the Cossayuna Lake Improvement Association Committee on Water Quality

Prepared by:

David L. Smith, Ph.D.
Lecturer in Biology
Department of Biology
Skidmore College
Saratoga Springs, NY 12866

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Cossayuna Lake is a relatively small (314 ha, 117 acres), shallow, nutrient enriched lake located in Washington County, New York. The lake basin is of probable glacial origin, with a dam on the southern end which is used to control the lake level. Studies done in the past (Northern Fisheries Report 1949, Greater ARCD Report 1976) all speak to the fact that macrophytes are a problem in the lake but in the mid 1970's *Myriophyllum spicatum* (Eurasian milfoil) was introduced into the lake and has since become a major nuisance, covering perhaps 50% of the lake.

Several characteristics of the lake are likely to contribute to the expansive growth illustrated by this exotic macrophyte, including relatively clear, shallow water which allows for light penetration to the bottom of the lake in many areas, nutrient loads within the lake basin which are more than adequate to support luxurious plant growth, stream inflows which contribute to the nutrient load of the lake, a predominance of soft, silty substrate built up by years of partial macrophyte decomposition, and unregulated onshore development (including the effects of marsh and wetlands drainage, erosion, and old or non-functioning septic systems).

A major emphasis of the Cossayuna Lake Improvement Association since 1984 has been to seek methods of control over *M. spicatum* . There are several ways to approach this problem including harvesting and removal of the macrophyte, and the application of a herbicide to kill the plant. A third approach, addressed here, is the determination of the lake water quality and its relationship to the macrophyte problem.

The objectives of this study remain as they were stated in 1984: to determine the baseline water quality of the lake and its major inflows, to determine whether seasonal changes occur in the water quality parameters, to determine whether there are significant inputs of the test parameters entering the lake via stream inflows, and lastly to determine whether correlations exist between lake water quality and the resident population of Cossayuna Lake.

Methods and Materials

Five sampling locations (Sites 1-5) were initially selected for the determination of overall water quality of the lake (Figure 1). At the beginning of the 1985 sampling season this number was reduced to three lake sites (Sites 1,3 and 5) with an additional

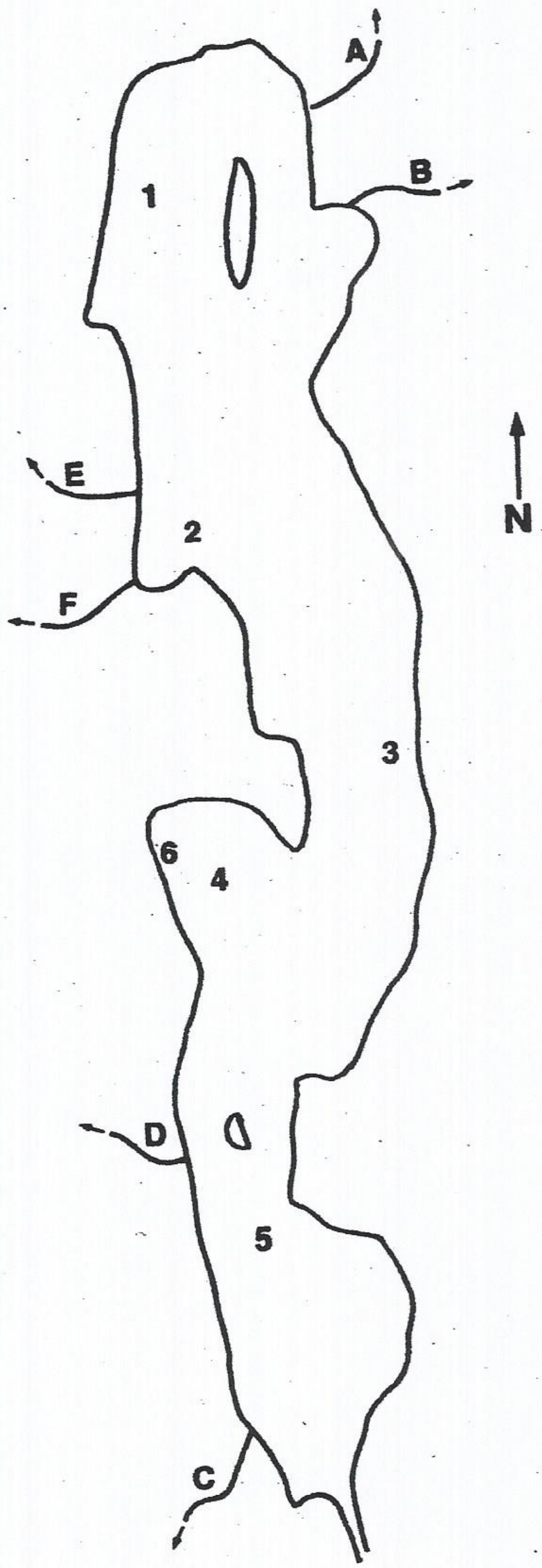

Figure 1. Map of Cossayuna Lake showing lake and stream sampling sites 1984 - 1987.

inshore site within one of the herbicide test sites (Site 6). The following criteria were observed when the sites were selected.

1) Locations were selected to avoid any obvious bias such as stream inflows or known point sources of pollution.
2) Locations were selected away from the weed treatment areas. The resultant decomposing plant material could create conditions of lower dissolved oxygen, decreased water clarity, and increased nitrate and ortho-phosphate concentrations. Site 6 was later established to monitor these potential effects.
3) Sites were located in water that was approximately 2-3 meters deep and which were approximately 15 meters offshore. Water samples at each site were taken as grab samples beneath the surface to minimize the problem of surface contamination (unless otherwise stated). The inshore sample at Site 6 is an exception; here the water depth is approximately one meter and the sample is taken approximately 5 meters from shore.

Samples were taken at approximately the same time each day to minimize bias from normal daily fluctuations.

Five streams flowing into Cossayuna Lake (Figure 1, A - E) were sampled at the same time as the lake sites. These streams were selected because they were known to flow year around and were therefore suspected to be contributors to the water quality conditions. Sites within the streams were selected upstream from roads and lake front homes and for ease of sampling. In 1986 another stream (F) was added to the list as it was found to fit the above criteria as well as being a New York State DEC classified stream.

Water samples were taken at intervals ranging between four to eight weeks apart during the ice-free season. Once ice began to form on the lake, sampling was suspended until the ice was thick enough to traverse safely. One sample set was then taken at approximately mid-winter. The following parameters were examined at each of the sampling locations.

Depth
Cross-sectional area and current velocity (streams only, 1986-1987)
Water temperature (vertical series, except streams)
Dissolved oxygen (vertical series, except streams)
Nitrate-nitrogen
Ortho-phosphate
Fecal coliform counts
Fecal streptococcus counts

Water temperature and dissolved oxygen measurements were taken on site with a YSI Oxygen Meter. Samples were returned to the laboratory where nitrate, ortho-phosphate and bacterial analyses were performed. When immediate chemical analysis was not possible, samples were frozen at -10°C (Standard Methods 1981). Nitrate-nitrogen and ortho-phosphate (soluble reactive phosphorous) determinations were made colorimetically using the cadmium reduction and ascorbic acid techniques (respectively) as described in the Hach Company Water Analysis Handbook (1981).

Both the fecal coliform and the fecal streptococcus coliform analyses (Standard Methods 1981) involved filtering 25 ml of sample through 0.45 µm membrane filters which were then placed on pads containing M-FC broth (fecal coliform) or KF Streptococcus agar (fecal streptococcus coliform). The fecal coliform plates were incubated in a water bath for 24 hours at 44.5°C while the fecal streptococcus plates were held at 35°C for 48 hours. Colonies were counted within 30 minutes from the time the plates were removed from the incubator and bacterial density expressed as colonies per 100 ml of water. Fecal coliform/fecal streptococcus ratios were analyzed in an attempt to determine whether coliform bacteria in the lake and feeder streams are of human origin. This is possible through a relationship based on consistent differences in the relative proportion of these bacteria in the feces of humans and other warm-blooded animals (Geldreich 1967). A fecal coliform/fecal streptococcus ratio greater than 4.0 is typical of human fecal material, while a ratio less than 1.0 is typical of other warm-blooded animals. A ratio betwen 1.0 and 4.0 allows no interpretation but requires further investigation.

Spearman correlation coefficients were calculated to examine relationships between stream discharge and nutrient concentration.

Results

Monthly discharge of the six streams flowing into Cossayuna Lake are shown in Figure 2. Flow measurements were started in mid 1985 and have been continued to the present. The irregular sampling makes it difficult to predict the yearly hydrological regime but some patterns are apparent. High spring discharges would be expected following snow melt, and they were observed in 1987 (April). This spring flush was not observed in 1986 because little precipitation fell during the winter of 1985 and the spring of 1986. In 1985 and 1986 there was increased discharge during October and November, following low summer discharges.

Figures 3 and 4 show the mean concentrations of ortho-phosphate in the lake and stream samples (1984-1987). During this time, the streams flowing into Cossayuna

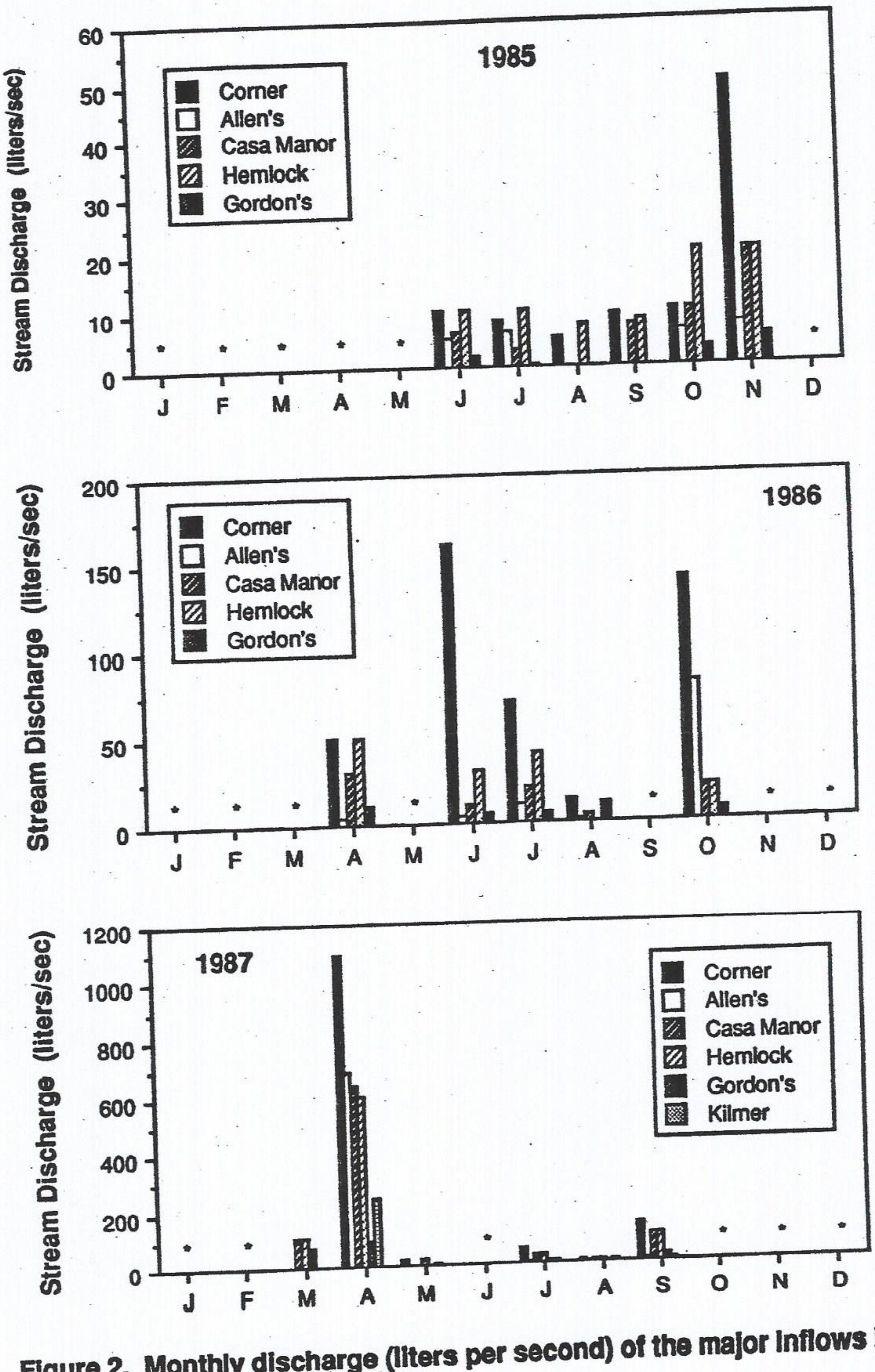

Figure 2. Monthly discharge (liters per second) of the major inflows into Cossayuna Lake 1984 - 1987.

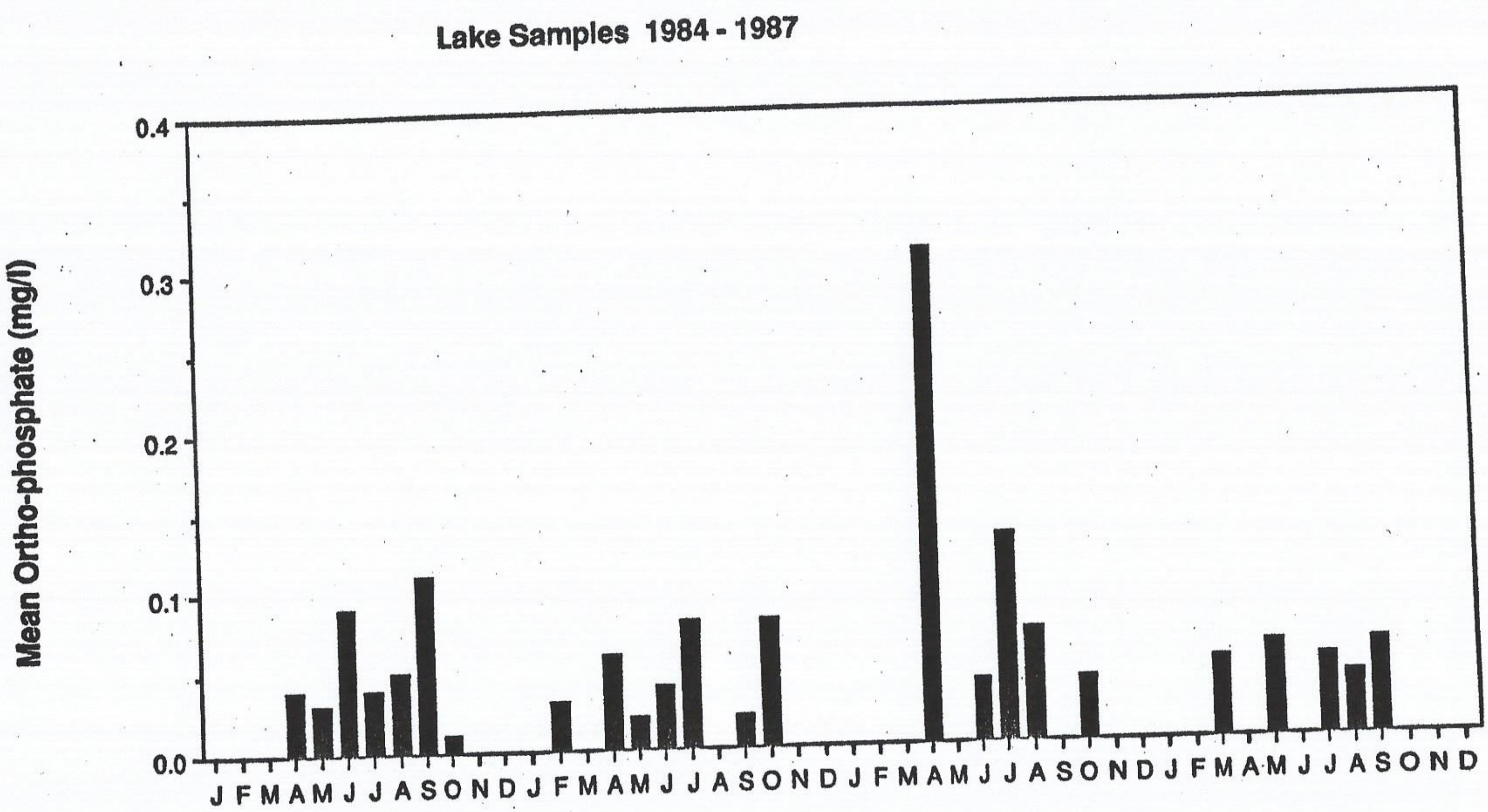

Figure 3. Mean ortho-phosphate conentrations (mg/l) for lake sites 1984 - 1987.

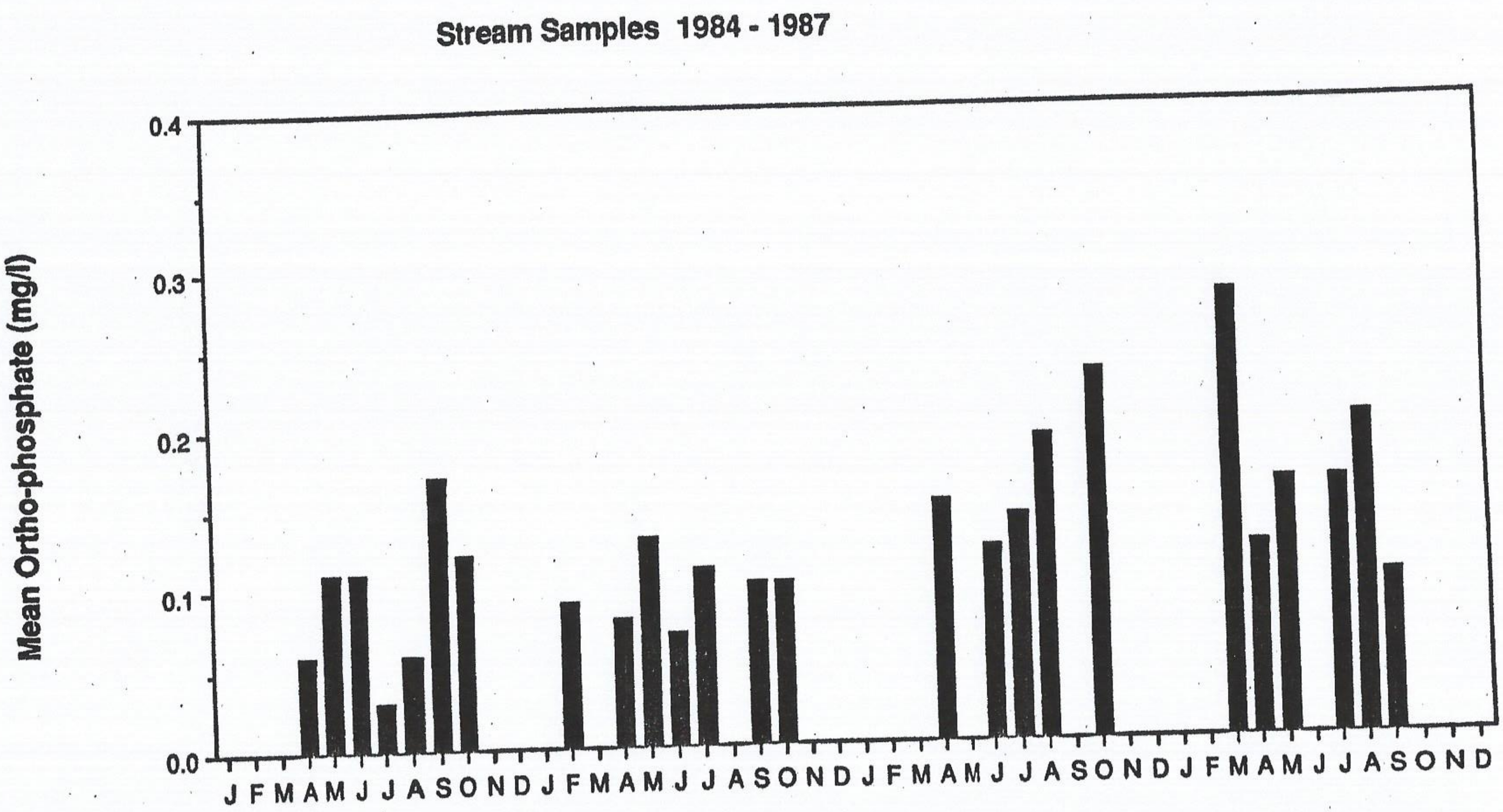

Figure 4. Mean ortho-phosphate concentrations (mg/l) for streams 1984 -1987.

Lake exhibited ortho-phosphate concentrations at least twice those found in the lake. Stream samples also show a bi-modal distribution in ortho-phosphate with peaks in the late spring and early fall. Ortho-phosphate levels in the lake however were variable, both seasonally and during the sampling period. Nitrate concentrations for lake and stream samples can be seen in Figures 5 and 6. There are no discernible patterns in stream nitrate levels either seasonally or for the sampling period. The lake samples however, show a bi-modal distribution for nitrate, again with late spring and early fall peaks. Both ortho-phosphate and nitrate concentrations were generally lower and less variable during the 1987 sampling season.

Correlation analyses show the concentrations of nitrates and ortho-phosphates in the streams to be highly correlated with stream discharge ($r = 0.92$ and 0.85 respectively with $P < 0.001$).

During the four sampling seasons that coliform data have been collected some patterns have appeared (Table 1). Stream samples generally contain higher numbers of bacterial colonies than do lake samples. The samples with the highest number of bacteria are those from streams A and C, followed by D, E, F and B (see Figure 1 for locations). The coliform counts in 1984 and 1985 appear to be higher than those observed in 1986 and 1987 although fewer samples were taken in 1986 and 1987 than during the first two years.

Fecal coliform/fecal streptococcus ratios were tested on one occasion during 1987 and for lake site 3 and streams B and C, the ratios fell within the range of 1.0 - 4.0. Not only do these values fall within the range requiring further investigation, but it must be noted that the colony counts were also low enough to interfere with the interpretation.

Discussion

The streams flowing into Cossayuna Lake seem to be regulated by the amount of precipitation that has fallen prior to a sampling event. During the dry summer and fall of 1985, only streams B and C were able to maintain flow; the others dried up for a period of one to two months (August - September). Streams B and C typically had larger discharges than the other streams and collectively they drain a large percentage of the watershed.

The concentrations of nitrates and ortho-phosphates both in the streams and the lake suggest that a considerable amount of nutrients move into and are found within the lake at any given point in time. Earlier studies performed by various local and state agencies do not describe nutrient levels so it is difficult to categorize the present

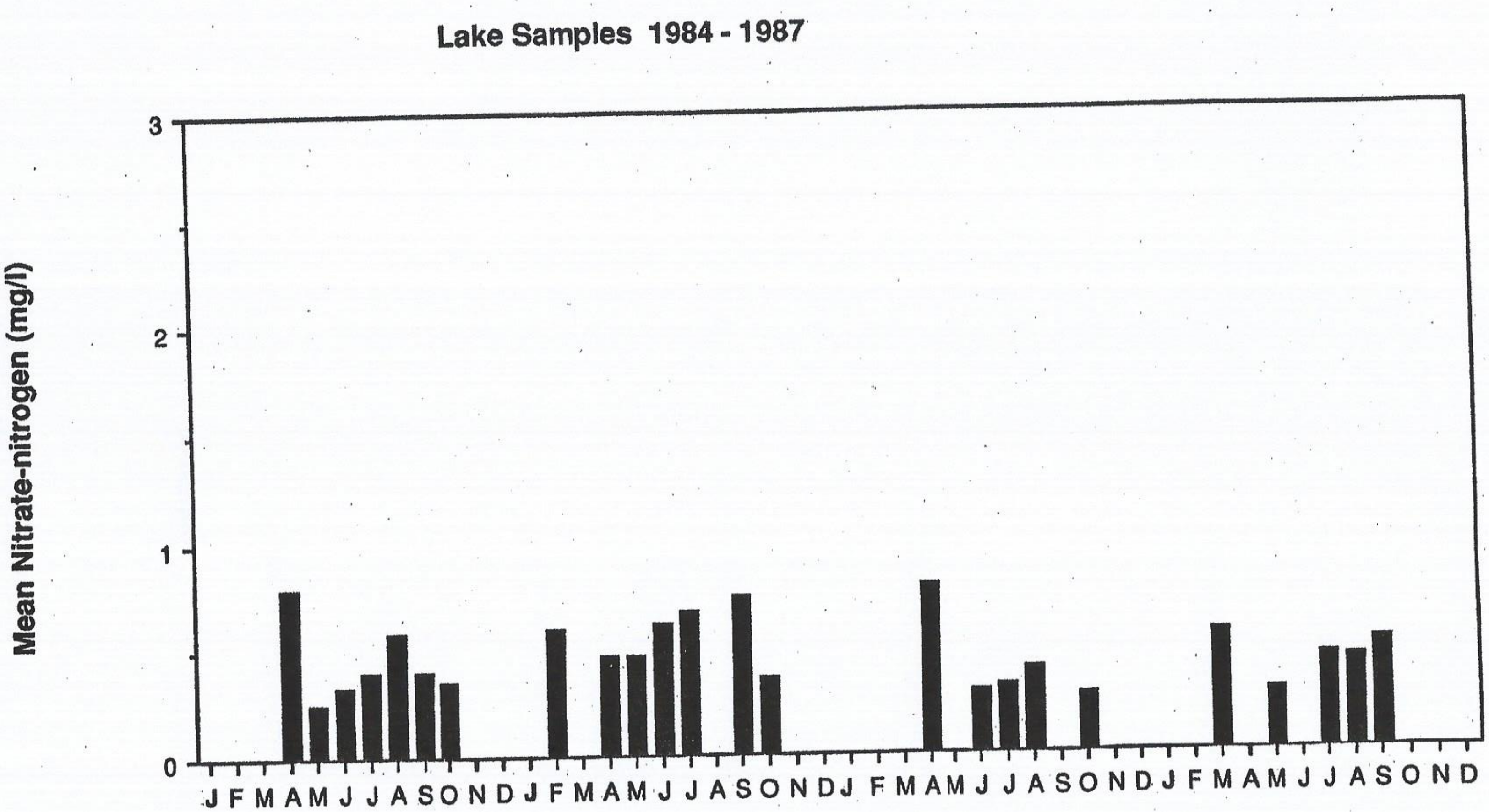

Figure 5. Mean nitrate conentrations (mg/l) for lake sites 1984 - 1987.

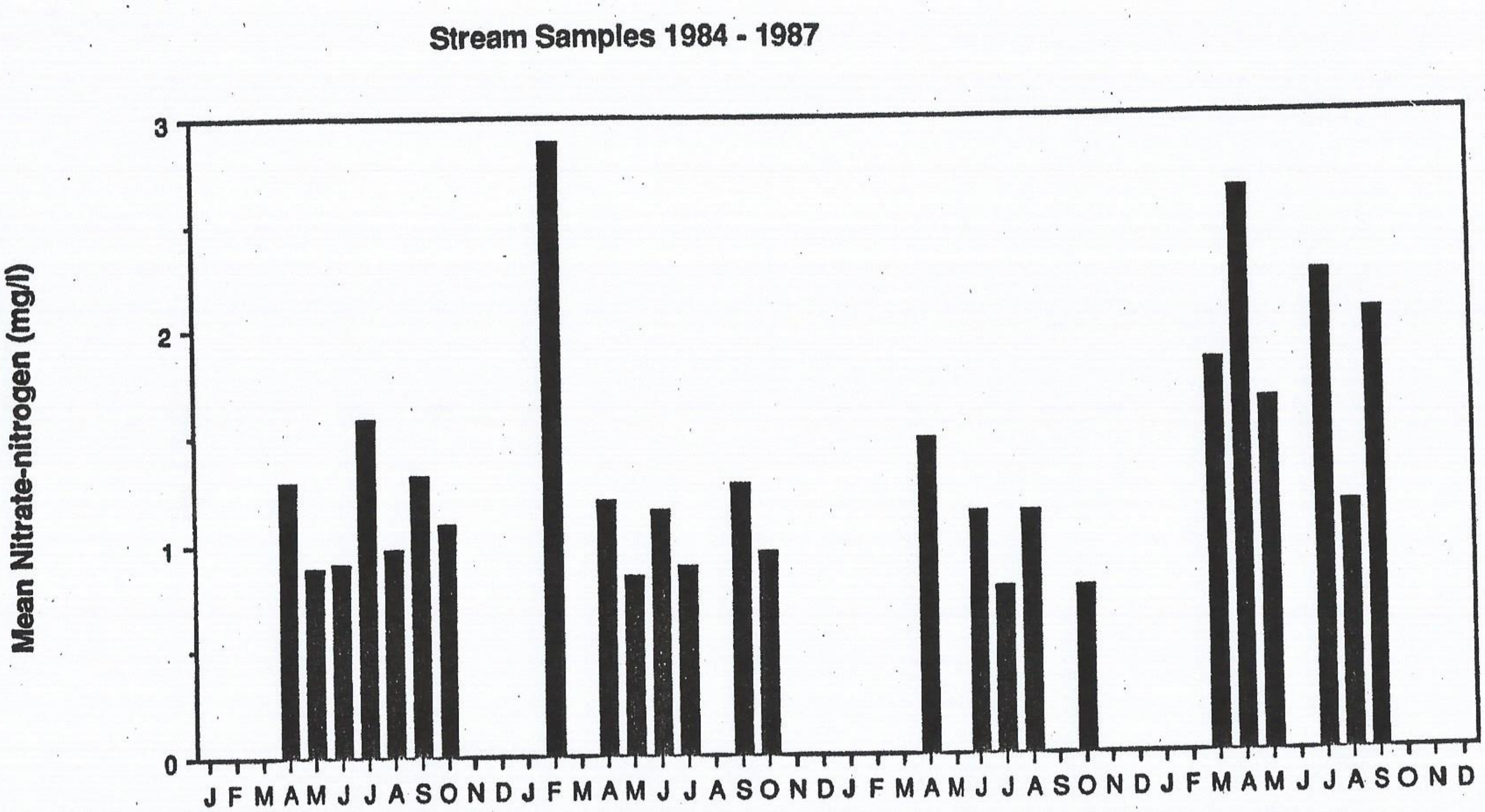

Figure 6. Mean nitrate concentrations (mg/l) for streams 1984 - 1987.

Table 1. Fecal coliform colony counts per 100 ml water from Cossayuna Lake and its inflows 1984 - 1987.

	Lake Site						Stream					
	1	2	3	4	5	6	A	B	C	D	E	F
1984												
28 Apr	4	2	2	0	-	-	-	-	-	-	-	-
26 May	0	0	2	22	0	-	25	84	254	90	2	-
30 Jun	28	0	0	0	0	-	194	63	0	6000	110	-
21 Jul	0	2	8	0	0	-	304	166	100	782	68	-
11 Aug	0	0	0	0	12	-	*	2400	*	1200	3200	-
30 Sept	0	0	0	4	4	-	20	116	20	0	4	-
28 Oct	0	4	0	0	0	-	24	12	24	100	0	-
1985												
3 Feb	0	-	0	-	0	0	0	20	4	0	4	-
21 Apr	0	-	0	-	0	0	705	270	80	20	20	-
18 May	0	-	0	-	0	2	5	5	3720	664	2240	-
22 Jun	0	-	0	-	0	4	16	48	384	234	64	-
13 Jul	8	-	4	-	0	0	0	100	2060	216	204	-
10 Aug	0	-	0	-	0	8	-	20	0	20	-	-
21 Sept	0	-	4	-	0	0	-	28	28	256	-	-
12 Oct	0	-	4	-	0	0	80	8	32	12	4	-
1986												
27 Apr	0	-	0	-	0	0	20	0	0	0	0	-
15 Jun	0	-	0	-	4	0	52	80	612	80	116	-
31 Aug	0	-	0	-	0	0	48	24	8	404	4	-
5 Oct	0	-	4	-	20	4	*	140	112	112	65	-
1987												
3 Mar	0	-	4	-	4	0	2304	100	28	60	16	-
4 Apr	-	-	-	-	-	-	700	160	0	0	20	30
11 Jul	0	-	0	-	0	0	212	52	8	172	48	152
23 Aug	36	-	8	-	0	12	*	276	556	408	188	644

* indicates solid coliform growth on filters
- indicates no sample analyzed

condition of the lake. However in his book, Limnology in North America, Frey (1966) lists nitrate levels from several New York lakes which range from 0.08 to 0.57 mg/l. In Saratoga Lake, Hardt *et al.* (1983) found lake surface ortho-phosphate levels remaining constant at 0.005 mg/l and nitrate concentrations that ranged from 0.05 to 0.54 mg/l. Kayaderosseras Creek, which flows into Saratoga Lake had ortho-phosphate concentrations which ranged from 0.005 to 0.022 mg/l and nitrate levels which ran from 0.01 to 0.57 mg/l, both of which peaked in the spring. These values from the literature suggest that Cossayuna Lake receives and maintains levels of nutrients somewhat higher than those observed in other New York lakes. Considering the lakeside development and agricultural land use in the Cossayuna Lake watershed these discrepencies are not unexpected. One interesting point is the apparent lowering and decrease in variation in the lake concentrations of nitrate and ortho-phosphate during 1987. This may be an artifact of the sampling program or a chance occurrence, but it could be a consequence of the management techniques used on Cossayuna Lake since 1984. A combination of the harvesting, herbicide treatments and opportunistic flushings of the lake during algal blooms should result in a decrease in lake nutrients. Only continued sampling will document whether this decrease is real or only a normal part of the nutrient fluctuation in Cossayuna Lake.

Because the concentrations of nutrients flowing into Cossayuna Lake from the watershed are highly correlated with discharge, it can be assumed that the source of these nutrients is constantly leaching nitrates and ortho-phosphates into the streams. Whether this is from anthropogenic sources or from the natural dissolution of nitrates and phosphates from the rocks or soil is as yet unclear.

Lake bacteria counts were generally low. Except for a few occasions they were below levels established by the U. S. Environmental Protection Agency for drinking water (1 colony/100 ml of water) and on only one or two occasions a year was the EPA action limit exceeded (4 colonies/100 ml of water). These occurrences seem to be random and at this point there are not enough data to establish patterns of bacterial pollution. At all times the bacterial counts were well below the water quality criterion established by the EPA for primary contact recreation (200 colonies/100 ml of water). Bacterial counts for the inflows were high, particularly so during times of runoff from spring thaws or storm events. Generally the counts exceeded the drinking water standards and frequently they exceeded the recreation standards. Since water samples were not taken where the streams enter the lake, no comments can be made about the quality of the lake water in areas where the streams and lake meet.

Fecal coliform/fecal streptococcus ratios calculated for August 1987 suggest that lake sites 3 and 6 and streams B and E contained coliforms which may from human sources. These data are very preliminary however and are certainly not strong enough to warrant any action other than further testing. The other lake sites and streams, during this testing period contained coliforms that are most likely from non-human sources.

Conclusions

The nitrate and ortho-phosphate levels in Cossayuna Lake are characteristic of a moderately eutrophic lake; the concentrations are not exceptionally high but they are higher that they could or should be. Having extensive macrophyte beds in the lake should not be considered unusual; however having one plant dominate the community probably represents a deviation from normal plant community structure. When the dominant plant is Eurasian milfoil, an introduced species whose presence and excessive growth is indicative of less than ideal water quality conditions, the situation becomes somewhat more problematic. The state of the lake at the present time could be considered analogous to a person who is still generally healthy but who has been feeling unwell for some time as a result of some as yet unspecified terminal disease.

It is crucial at this time to realize that the above characteristics of Cossayuna Lake are not the problems themselves; they are merely the symptoms of the disease, which is the over-development and non-management of the watershed. As with an illness, the symptoms must be treated, but no cure is possible until the disease itself is addressed.

A lake watershed consists of any land surface which causes falling precipitation to move into the lake, and the condition of the lake at any given time is the direct result of past and present activities within the watershed. For Cossayuna Lake this watershed consists of approximately 3023 ha (7467 acres) of land used for a variety of purposes, ranging from agricultural to light commercial. This diversity in land use complicates matters even more, because many different interests and goals for the lake must be considered if lake improvement is attempted. Therefore a coordinated attack on the eutrophication of Cossayuna Lake (nutrient load reduction, aquatic plant harvesting, flushing , chemical treatment) along with addressing the roots of the problem (soil conservation practices, zoning, land use management) is the only way that lake restoration can be achieved.

Acknowledgements

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Literature Cited

Frey, D. G. (ed). 1966. Limnology in North America. Univ. of Wisconsin Press. Madison, Wisconsin. 734 pgs.

Geldreich, E.E. 1967 Origins of microbial pollution in streams. In G. Berg, ed. Transmission of Viruses by the Water Route. J. Wiley and Sons. New York.

Greenberg A., J. Connors and D. Jenkins (eds). 1981. Standard Methods for the Examination of Water and Wastewater. American Public Health Association. Washington D.C. 1134 pgs.

Hach Company. 1981. Hach Company Water Analysis Manual. Hach Company. Loveland, Colorado.

Hardt, F. W.; Hodgson, G. and G. F. Mikol. 1983. Saratoga Lake Diagnostic-Feasibility Study and Management Plan. 474 pgs.

Northern Fisheries District. 1949. Cossayuna Lake Report. NYS Conservation Department. 6 pgs.

Project Area Water Study Commission. 1976. Cossayuna Lake Technical Report. Greater ARCD. Chestertown , NY. 100 pgs.