Interactions of soluble silica and other major nutrients in Lake George

Completed by

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FWI #82-1

INTERACTION OF SOLUBLE SILICA AND OTHER MAJOR NUTRIENTS IN LAKE GEORGE

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ABSTRACT

Soluble silica is necessary for the growth of diatoms, a major component of the phytoplankton community of Lake George. Concentrations of soluble silica have been found to vary spatially, seasonally and with depth in Lake George. These trends and interaction of soluble silica with total phosphorus, total filterable phosphorus will be discussed.

Evidence will be presented suggesting that Lake George diatom growth is limited by more than one nutrient.

INTRODUCTION

The measurement of soluble reactive silica (sometimes referred to as soluble silica) has proven to be an excellent way to monitor the enrichment within oligotrophic lakes (Schelske, 1975). In lakes dominated by diatoms yearly monitoring of soluble reactive silica throughout the total water column allows for the development of a conceptual model of the eutrophication process (Schelske, 1975). The change in soluble silica concentration is determined by the rate of uptake by the diatom community. As a diatom community expands, in response to nutrients, soluble silica will be depleted, since (Schelske, 1971, 1972) the silica is incorporated into the frustula of the diatom and is excluded from analysis during the filtration step of the analytical procedure. The degree of utilization and therefore the decrease in concentration id determined by the number of diatoms present in the system. Soluble silica may therefore become a limiting nutrient but only when it is depleted as a result of uptake or sedimentation (Schelske, 1972, Wetzel, 1975).

Soluble reactive silica was measured previously at Lake George by Fuhs (1972) and Armstrong (unpublished data).

MATERIALS AND METHODS

Samples were collected by one of two methods. At each of the eleven sampling sites (see Long et. al. 1982) and integrated sample was taken by methods previously describe (Dillion and Rigler, 1974, Long et. al. 1980, 1981). A 0-10m integrated sample was collected at the deepwater sites and Northwest Bay while at the shallow water sites; Lake George Village, Warner Bay, and Hearts Bay 0-2m sample was taken. At the remaining sites, Hague and Huletts Landing, 0-5 and 0-3m integrated samples, respectively, were taken. At sites with depths exceeding 20m (Tea Island, Dome Island, French Point, Smith Bay and Rogers Rock deep point samples

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were collected with a Van Dorn bottle at a depth of 20-25m. Samples were filtered in the field immediately upon collection. Samples were stored at 4°C and analyzed with three weeks of collection on refrigerated samples, although samples stored for up to six months were within 10% of their measured concentration found at the time of collection. Samples were analyzed using Technicon Autoanalyzer system equipped with a 50 mm flow cell. The Ascorbic Acid Molybodate method derived from Strickland and Parson (1972) with modifications by Technicon was used.

The data set for 1972-1973 is the result of the work of R. Armstrong. His samples were taken at a depth of five meters using a Van Dorn Sampler and analysis was by a non-automated method also employing the Asorbic-Acid Molybodate reaction.

RESULTS

Even though only one year of soluble reactive silica data has been collection during the present study both temporal and spatial trend are evident.

A comparison of the sites north of the narrows to those south of the narrows and reveals two very different patterns for these sites during 1972 (Armstrong, unpublished) (Figure 1). Soluble silica concentrations were higher at the southern sites than for the northern sites. As the year progressed soluble silica concentration dropped rapidly at sites south of the narrows while a less dramatic decrease was observed for the northern sites. Both groups of sites recover to values about the same as the high spring values following fall overturn.

The differences between the north and south lake found in the early 70's is quite similar to that found during 1980-81 (Figure 2). The sites sampled south of the narrows excluding French Point were found to have a higher spring maximum than those north of the narrows. Again, the south lake fluctuate to a greater degree over short time period than does the north lake.

Soluble reactive silica exhibits seasonal variation at each individual site in the epilimnion (Figure 3). At Lake George Village and Tea Island a 50% reduction in soluble reactive silica was found between spring (April 3 - June 6) and summer. During the same period of time at Dome Island and Northwest Bay a 40% reduction occurred while at French Point and Huletts Landing a 30% reduction took place. Sites north of Huletts Landing had a 15% reduction in soluble silica concentration while at Warner Bay a 20% decrease was measured. During the fall (October 13 - November 4) the sites south of Huletts Landing all showed a noticeable increase in soluble silica while northern sites did not.

At the sites where the water column exceeding 20 meters a significant difference in the concentration of soluble reactive silica between the hypolimnion and the epilimnion was found (Figure 4). The increase in soluble reactive silica concentration in the hypolimnion, as compared with the epilimnion was 60% at Tea Island, 48% at Dome Island, 37% at

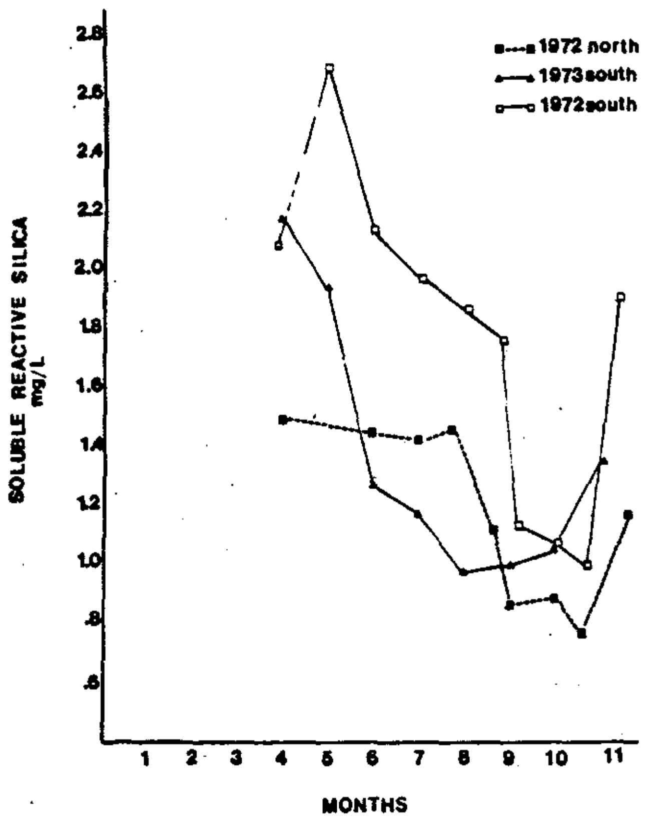

Figure 1. Soluble reactive silica concentration found in Lake George during 1972 - 1973 (R. Armstrong).

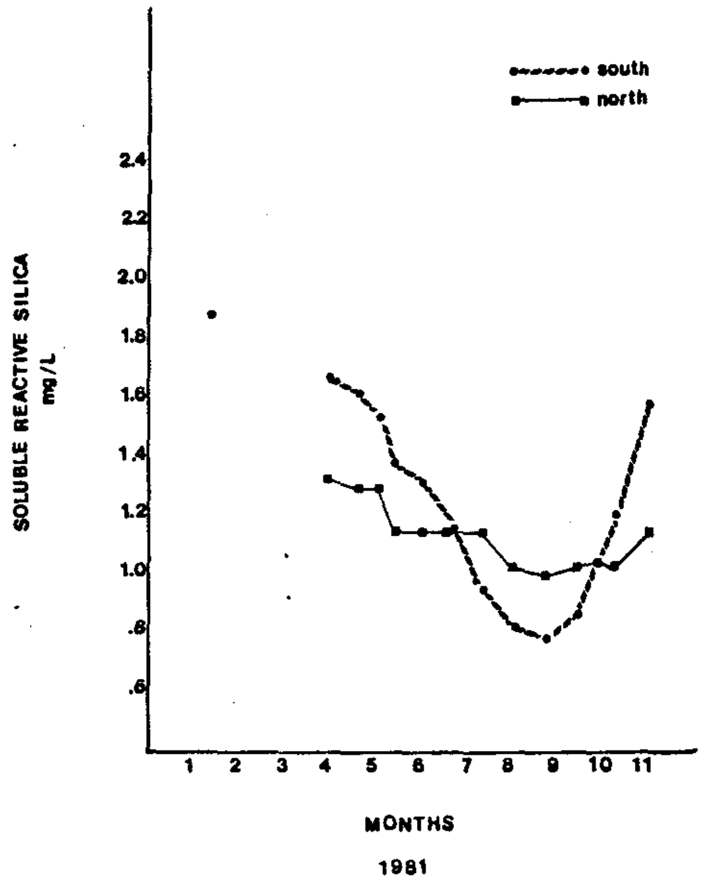

Figure 2. Soluble reactive silica concentration found in Lake George for the period April - November 1981.

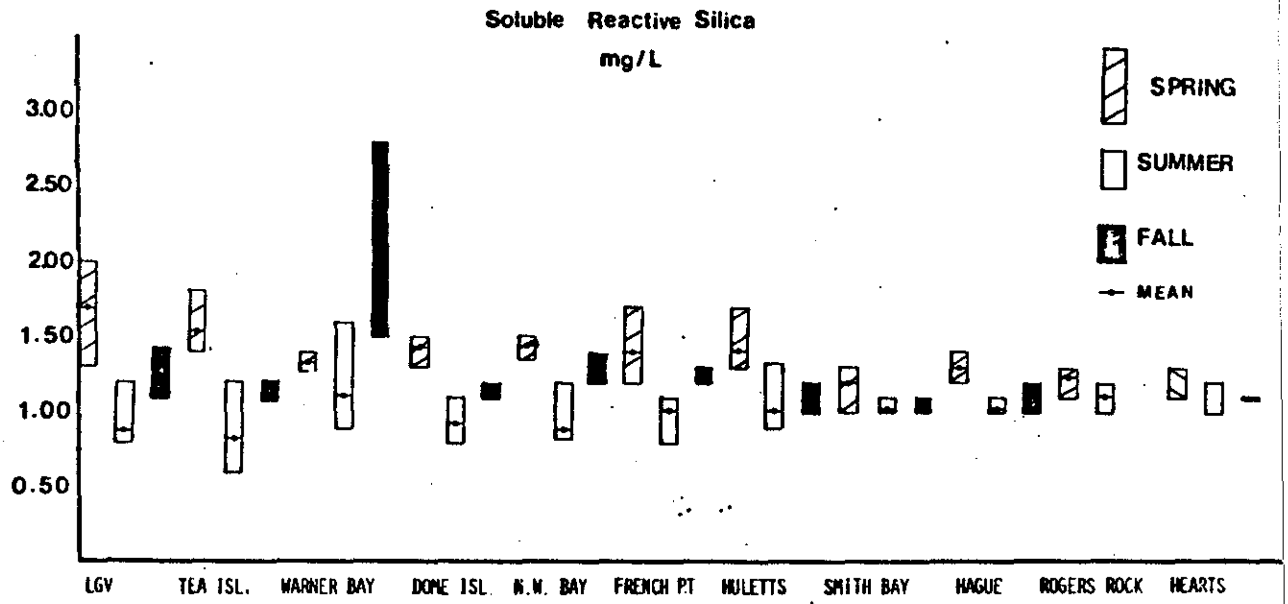

Figure 3. Comparison of soluble reactive silica concentration in the hypolimnion of Lake George during 1981.

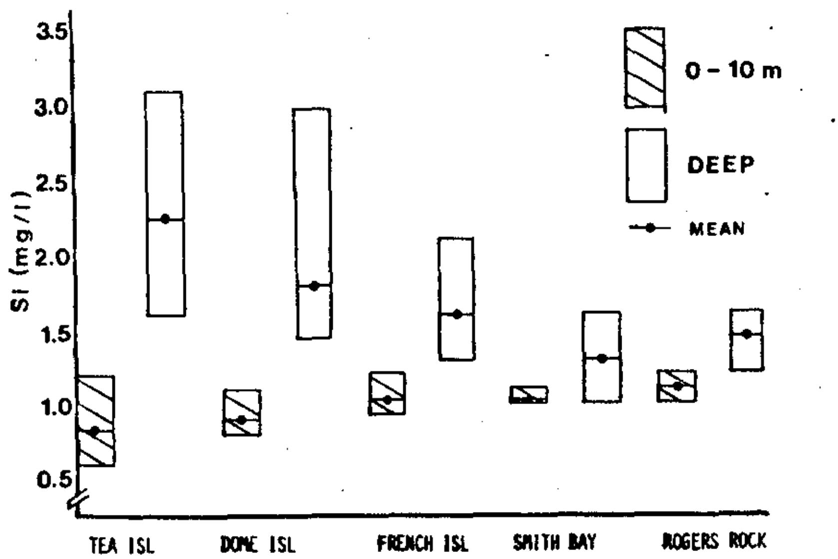

Figure 4. Comparison of hypolimnion and epiliminion soluble reactive silica.

French Point, 25% at Rogers Rock and 20% at Smith Bay. This gradient was only observed during the summer months (June 7 - October 1).

The higher levels of soluble silica in the hypolimnion are due to sedimentation, resuspenion and the lack of viable diatoms that normally take up silica. Diatoms are both structually and physiologically adapted to maintain themselves in the euphotic zone of a lake (Wetzel, 1975).

Nitrate - nitrogen values for the spring months (April 3 - May 20) are listed in Table 1. As can be seen, nitrate values are barely above the detection limit of 0.01 mg/l. After May 20, nitrate concentrations drop to a point below the detection limit and remain at that low level for the rest of the summer (Long et. al. 1982).

The concentration of total filterable phosphorus and total phosphorus in the south lake is slightly greater than that found in the north lake for the same period. No apparent decrease in total phosphorus or, total filterable phosphorus was noted during the spring months (Long et. al, 1982, Tables can be obtained from Lake George Association).

DISCUSSION

Differences in collection techniques used during the 1972-1973 study and those used in 1981 make it inappropriate to make a quantitative comparison of the data. However, several patterns are apparent. These show very little change except that the data from 1972-1973 shows greater amplitude in pre soluble silica concentration. This would indicate that the trophic status of the north and south lakes have not been significantly altered over the last 10 years.

The second figure (Figure 2) demonstrates that significant differences exist in the euphotic zones of the north and south lakes during the summer months. Differences in concentrations are probably caused by differences in the rates of silica uptake by diatoms in these areas. The degree of decrease during May - June in the south lake is more significant when it is realized that the south lake has a much larger watershed and therefore, a greater potential reservior of silica then the north lake (Aulenbach and Clesceri, 1973, Fuhs, 1972). The decrease in soluble silica can be attributed to the rates of growth of diatom populations. Diatom population size is controlled by the availability of nutrients (Schelske, 1972). In the most general sense the seasonal cycle for soluble silica in the north lake is characteristic of a low energy system found in an oligotrophic lake. The south conversely appears to be a higher energy system characteristic of a more nutrient enriched lake. The seasonal variation in epilimnetic soluble silica at each site (Figure 3) is the result of silica uptake by the diatom community, sedimentation, and replenishment by the watershed. Due to the latter in the fall the south lake sites experienced an increase in soluble reactive silica concentration (October 13 - November 2 samplings) while the north lake did not. This can be attributed to the greater size of the watershed for the south lake and the enhanced runoff that occurred as a result of the four or more inches of rain that fell in September (FWI meteriological records).

TABLE 1

NITROGEN (NITRATE) mg/l

CADMIUM REDUCTION METHOD

Site	4/3/81	4/6	4/21	4/22	5/5	5/6	5/19	5/20
Lake George Village 0-2m		0.07	0.04		0.05		0.02	
Tea Isl. 0-10m		0.05	0.04		0.03		0.01	
> 25m		0.05	0.04		0.04		0.03	
Warner Bay 0-2m		0.04	0.01		0.01		0.02	
Dome Isl. 0-10m		0.03	0.02		0.02		<0.01	
> 20m		N.A.	0.02		0.03		0.02	
N.W. Bay 0-10m		0.04	0.03		0.02		0.03	
French Pt. 0-10m		0.02	0.01		<0.01		<0.01	
> 25m		0.02	0.01		0.01		<0.01	
Huletts 0-3m		0.02	0.03		0.02		<0.01	
Smith Bay 0-10m	0.06			0.02		0.02		0.01
> 25m	0.02			0.02		N.A.		0.01
Hague 0-5m	0.03			0.03		0.02		0.01
Rogers Rock 0-10m	0.03			0.02		0.02		0.01
> 25m	0.03			0.03		0.03		0.01
Hearts Bay 0-2m	0.03			0.02		0.02		0.01

N.A. = Not Available

During the summer months the mean soluble silica concentration in the epilimnion of the deepwater site north of the narrows was greater than 1.0 mg/l while south of the narrows it was less than 1.0 mg/l.

The percentage decrease in soluble reactive silica concentration with depth (Figure 4) during the summer months was greatest at Tea Island (60%). This decrease in soluble silica may indicate diatoms are increasing in numbers in response to higher levels of nutrients found in the euphotic zone at Tea Island sampling site. As discussed earlier this situation is typical of higher energy system. At the other sites a smaller decrease in silica concentration was found indicating a lower level of diatom production and a less enriched euphotic zone.

The concentration of soluble silica does not reach a limiting level of between 0.1 mg/l to 0.5 mg/l (Schelske, 1972) during the summer months (range 0.6 - 1.2 mg/l).

During the spring, it was noted that soluble silica concentrations drop rapidly at all sites with a concurrent decrease in nitrate. This relationship was examined statistically and was found not to be significant and at low level of correlation. The relationship of total phosphorus and total filterable phosphorus to soluble reactive silica were also examined and found to be insignificant with an even lower level of correlation than silica to nitrate. We feel however that it is still very interesting that the greatest decrease in soluble silica occurs during the period when nitrate is present in the water column.

CONCLUSION

It is important to monitor soluble reactive silica in Lake George since it can be an indicator of the wide variety of interaction taking place in the lake.

The present study indicated that Tea Island is the most enriched eutrophic deepwater site when compared to other sites on Lake George. The south lake is in general more energetic than the north lake.

Soluble reactive silica, at the present levels, does not represent a constraint on the growth of diatom populations of Lake George. It is not possible at this time to determine whether nitrate or phosphorus is the more critical limiting nutrient for the diatoms of Lake George. It should be noted, however, that soluble silica concentrations alone cannot be used as an indicator of eutrophication. It is best utilized when comparing data from within the lake itself.

ACKNOWLEDGEMENTS

We wish to again thank the Lake George Association Fund for its financial support which made this monitoring program possible. Thanks also go to the Lake George Association and its members and leadership for their moral and financial support of our efforts to monitor and study Lake George. Finally the lay monitors have again given us valuable data which has helped us to better understand Lake George. Many thanks to all of you.

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DISCUSSION

Aulenbach - Is N or P limiting?
Long - Silica is not limiting.

Collins - Have you compared your Si/P ratios to those for algal community succession and competition determined by S. Kilham?
Long - No.