

## PHYTOPLANKTON (Plant Plankton) Nutrient Status

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### INTRODUCTION

The primary task of this research was to measure *nitrogen fixation*, the direct capture of nitrogen from the atmosphere by certain species of blue-green algae that annually dominate the summer algal community. In essence, it is a measure of the extent to which algal growth in Lake Winnipeg becomes independent of nitrogen inputs from rivers, drawing instead on the infinite supply from the atmosphere.

**Until now, the amount of nitrogen that was being imported into the lake by nitrogen fixation had not been quantified.** Preliminary findings show that during the summer period, significant amounts of atmospheric nitrogen are being used (fixed) by algae and, therefore, added to the lakes nitrogen supply. **Algal nitrogen fixation (based on areal fixation estimates) accounted for up to 100 tonnes of nitrogen being drawn into the North basin directly from the atmosphere per 24h.**

**These measurements and findings are very important, especially from a management perspective, because the intentional reduction of nitrogen to the lake, as proposed by government, could actually promote the growth of blue-green algal blooms, thus aggravating the current problem.**

### OBJECTIVES

- To gain a better understanding of where and when algae blooms develop on Lake Winnipeg as the open water season progresses. Also, of particular interest is the way in which algae cycle the nutrients nitrogen and phosphorus.
- To quantify the direct uptake of phosphorus and nitrogen from the lake by the algae.

### METHODS

- Nitrogen fixation (the direct capture of nitrogen from the atmosphere by certain species of blue-green algae that annually dominate the summer algal community) was determined by using the acetylene reduction method. Nitrogen fixation was measured at more than 60 stations during both the summer and fall cruises but not during the spring cruise.
- The direct uptake of phosphorus and nitrogen by algae was determined by measuring alkaline phosphatase activity (APA) and nitrogen debt (N Debt), respectively. APA and N Debt were measured at approximately 40 stations during each of the spring, summer and fall cruises.

## RESULTS

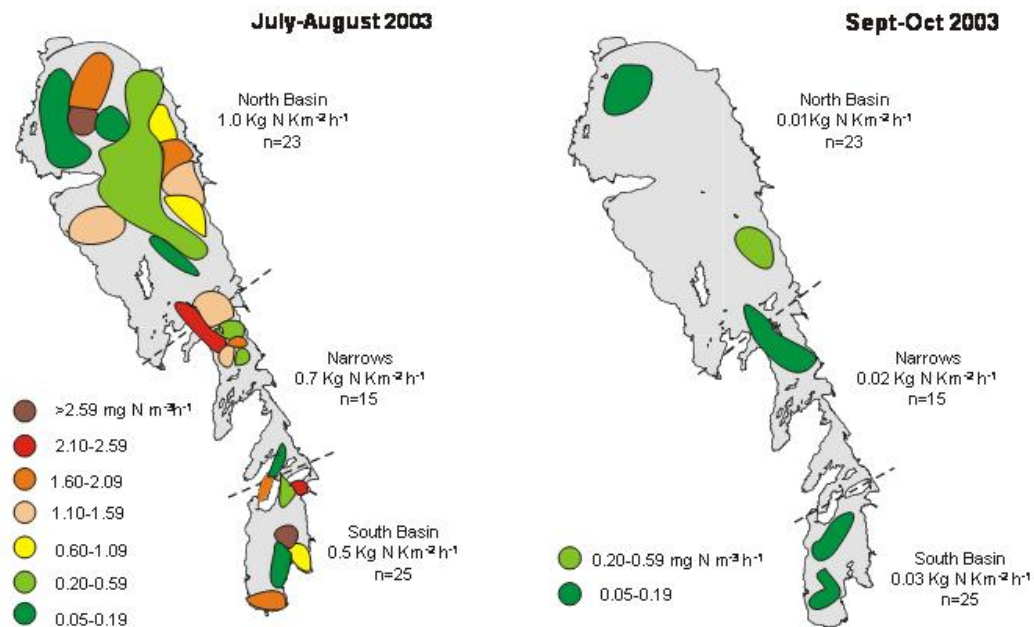
This table summarizes the Lake Winnipeg seasonal mean volumetric alkaline phosphatase (APA) activity, nitrogen debt (N Debt) and nitrogen fixation activity for 2003.

		APA $\mu\text{M P L}^{-1} \text{ h}^{-1}$	N Debt $\mu\text{M N L}^{-1} 24\text{h}^{-1}$	N fixation $\text{mg N m}^{-2}\text{h}^{-1}$
<b>North Basin</b>	Spring	0.005	0.309	
	Summer	0.119	0.019	1.008
	Fall	0.173	0.007	0.020
<b>Narrows</b>	Spring	0.003	0.176	
	Summer	0.353	0.006	0.732
	Fall	0.467	0.023	0.024
<b>South Basin</b>	Spring	0.002	0.075	
	Summer	0.225	0.030	0.488
	Fall	0.439	0.019	0.033

**Spring** - The APA and N Debt data from spring 2003 (see table) suggest that the phytoplankton community was *phosphorus sufficient* in all basins while being strongly *nitrogen deficient* in the Narrows and North basin. The South basin was *nitrogen sufficient* during this time.

**Summer** - In general, nitrogen fixing blue-green algal blooms covered a large area of the North basin, with isolated blooms in the Narrows and South basin during the summer of 2003. The figure below shows that summer nitrogen fixation was significant in all three basins of the lake during 2003 with the highest surface volumetric rates being measured in the extensive North basin.

### Nitrogen Fixation by *Blue-green algal blooms* Summer and Fall 2003



Balancing these high rates of nitrogen fixation was a high seasonal need for phosphorus with demand exceeding availability as indicated by the very high APA activity (*highly phosphorus deficient*) (see table above). Nitrogen Debt measurements showed that nitrogen deficiency was low in the areas where nitrogen fixation was high, i.e. both the Narrows and North basins. This

summer period saw significant amounts of atmospheric nitrogen being fixed and added to the lakes nitrogen supply. **On a good day in the summer of 2003, algal nitrogen fixation based on areal fixation estimates accounted for up to 100 tonnes of nitrogen being drawn into the North basin directly from the atmosphere per 24h.**

**Fall** - During the fall of 2003, nitrogen fixation was only measured in a few isolated areas of the lake and activity was low. APA indicated that *phosphorus deficiency* was still considered as *severe* during this time while N Debt showed that both the North and South basins were *nitrogen sufficient*. The Narrows was deemed to be only moderately nitrogen deficient during this time.

## **CONCLUSIONS**

Spring nitrogen deficiency, reflecting low dissolved N:P ratios in the lake, was followed by nitrogen fixation and induced phosphorus deficiency in the summer blue-green algae blooms followed by variable nitrogen and phosphorus deficiency in the fall algal populations.

Summer nitrogen fixation was significant in the three basins; algal nitrogen deficiency is reduced as a consequence of nitrogen fixation and phosphorus deficiency increased. Summer nitrogen fixing blue-green algal blooms covered a large area of the North basin, with isolated blooms in the Narrows and South basin.

By the fall, there remained little evidence of any nitrogen fixation, nitrogen deficiency rebounded in the Narrows and the South basin and phosphorus deficiency remained significant in the Narrows and the South basin.

## **FURTHER RESEARCH**

Continue this research to expand on a model predicting in-lake nitrogen fixation directly from the frequency of heterocysts, the specialized cells responsible for nitrogen fixation.

Continue to examine the relationship between nutrient status (nitrogen and phosphorus deficiency) and nitrogen fixation on a spatial and temporal scale (i.e. nutrient modeling data).