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Nutrient Budget Study

Partitioning of Phosphorus in *Potamogeton crispus*

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PARTITIONING OF PHOSPHORUS IN *POTAMOGETON CRISPUS* (CURLY-LEAF PONDWEED)

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PARTITIONING OF PHOSPHORUS IN *POTAMOGETON CRISPUS* (CURLY-LEAF PONDWEED)

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PREFACE

The Kawartha lakes are a large and economically important system of eight large lakes which are located in central Ontario. Sturgeon Lake and Rice Lake are located near the upper and lower ends of the Kawartha Lakes system respectively and both support significant amounts of urban and recreational development. They were chosen for detailed study because of their importance within the system and because both have shown the symptoms associated with excessive nutrient input for several years.

The Rice and Sturgeon Lakes Nutrient Budget Study was initiated to investigate linkages between point and non-point sources of nutrients, water quality, and aquatic life within the lakes and to estimate the impacts of these processes on in-lake water quality.

The study was supervised by the Rice - Sturgeon Lakes Nutrient Budget Technical Committee which had representatives from the Limnology Section (Water Resources Branch) and Central Region of the Ontario Ministry of the Environment and Energy, the Trent Severn Waterway (Environment Canada) and the Kawartha Lakes Fisheries Assessment Unit of the Ontario Ministry of Natural Resources.

This is one of a series of technical reports. These and the summary report (R/S Tech. Rep. No. 13) will provide a technical basis for the management of the Rice Lake and Sturgeon Lake ecosystems and for the use of land and water resources in the Kawartha Lakes region in general. A list of all reports in the R/S Tech. Rep. series is as follows:

1. Hutchinson N.J., B.J. Clark, J.R. Munro and B.P. Neary 1993. Hydrological data for the watersheds of Rice Lake and Sturgeon Lake. 1986 - 1989, 100 pp.

2. Hutchinson N.J., J.R. Munro, B.J. Clark and B.P. Neary. 1993. Water chemistry data for Rice Lake, Sturgeon Lake and their respective catchments. 1986-1989, 169 pp.

3. Hutchinson N.J., B.P. Neary, B.J. Clark and J.R. Munro 1993. Nutrient Budget data for the watersheds of Rice Lake and Sturgeon Lake. 120 pp.

4. Ryback, M. and I. Rybak. 1993. Sediment pigment stratigraphy as evidence of long term changes in primary productivity of Sturgeon and Rice Lakes (Kawartha Lakes). 24 pp.

5. Nicholls, K.H., M.F.P. Michalski and W. Gibson. 1993. Trophic interactions in Rice Lake I: An experimental demonstration of effects on water quality.

6. Limnos Ltd. 1993. Partitioning of phosphorus in *Potamogeton crispus.* 22 pp

7. Limnos Ltd. 1993. Rice Lake macrophytes: distribution, composition, biomass tissue nutrient content and ecological significance. 123 pp.

8. Beak Consultants Ltd. 1993. Release of phosphorus from Rice Lake sediments. 31 pp.

9. Limnos Ltd., Michael Michalski Associates and D.J. McQueen. 1993. Trophic interactions in Rice Lake II. Young-of-the-year yellow perch - *Daphnia* interactions, preliminary findings. 101 pp.

10. Badgery, J.E., D.J. McQueen, K.H. Nicholls and P.R.H. Schaap. 1993. Trophic interactions in Rice Lake III: Potential for biomanipulation. 1988 and 1989 .

11. Standke, S. 1993. The zooplankton of Rice Lake and Sturgeon Lakes, 19861988, Kawartha Lakes, Ontario.

12. Nicholls, K.H. 1993. The phytoplankton- water quality relationships of the Kawartha Lakes, 1972-1989.

13. Hutchinson, N.J., K.H. Nicholls and S.H. Maude, 1993. Rice and Sturgeon Lake Nutrient Budget Study: Summary and recommendations.

DISCLAIMER

This report was prepared for the Ontario Ministry of Environment and Energy as part of the Rice and Sturgeon Lakes Nutrient Budget Study. The views and ideas expressed in this report are those of the authors and do not necessarily reflect the views and policies of the Ontario Ministry of Environment and Energy. The mention of trade names and products does not constitute endorsement or recommendation of their use.

ABSTRACT

Phosphorus was partitioned among the major structures of *Potamogeton crispus* (roots, turions, leaves and stems) at regular intervals during May and June of 1988 to determine the pathway of phosphorus in the plant matter during growth and die back of the population. Phosphorus concentration in the plants declined from an average of 0.25% of dry weight to 0.13% of dry weight during the period in which biomass doubled and so the total mass of phosphorus in the *P. crispus* population was essentially unchanged. There was no evidence that phosphorus was translocated from stem and leaf tissue to turions and roots during senescence. The development of turions by *P. crispus* and the hypothesized conservation of phosphorus in these reproductive tissues does not explain the lower than expected pulse of phosphorus in the water column coincident with the decomposition of these aquatic plants.

EXECUTIVE SUMMARY

An estimated 12 tonnes of phosphorus is contained in the biomass of *Potamogeton crispus* in Rice Lake at peak growth. Anticipated increases in phosphorus concentrations in the water column following plant senescence have not been observed. Translocation of phosphorus to turions from leaf and stem tissue, prior to senescence, has been suggested as a possible sink to account for lower than expected concentrations of phosphorus in the water column. The following study was developed to address this question.

To determine partitioning of phosphorus in the plant structures (leaf and stems, turions, and roots), samples of twenty plants were collected at four locations in Rice Lake on a regular basis during the main growth phase (May 18 to June 8, 1988) and the period of senescence (June 15 to June 20, 1988). The mass of leaves and stems, turions, and roots were determined individually, and analysed separately for phosphorus, nitrogen and potassium content. The mass of phosphorus in the different structures was determined by multiplying the dry mass of the sample by the phosphorus content for respective samples.

Phosphorus concentrations of stem and leaf samples (vegetative samples) were highest at the beginning of the study period (0.25% on a dry matter basis) and declined steadily until June 8, 1988, when the average phosphorus content was 0.13%. The average concentration of phosphorus increased on the last sampling date for unknown reasons. A similar result was observed for phosphorus content expressed on an ash free, dry matter basis. Average concentrations of nitrogen and potassium in vegetative samples also increased at the end of the sampling period.

During the growth phase, biomass of vegetative samples increased as phosphorus concentrations declined such that the average mass of phosphorus in vegetative samples remained relatively constant until June 8, 1988. Thereafter the total mass of phosphorus declined as the mass of plant samples became smaller due to decomposition. There was no indication that significant amounts of phosphorus was translocated to other structures or lost to the water column prior to senescence.

At peak growth, percent phosphorus content of turions (0.13% to 0.16%) was similar to content of phosphorus in vegetative samples. The mass of turions, and the amount of phosphorus contained in turions, was normally less than 25% of respective vegetative samples. However, the sampling procedure may have resulted in the loss of turions, and subsequently provided conservative estimates of the amount of phosphorus contained in turions. We conclude that formation of turions, and their loss to the sediments, does not explain the lower than expected pulse of phosphorus in the water column coincident with decomposition of *Potamogeton crispus*.

Concentrations of phosphorus, nitrogen, and potassium reported for plant samples at peak growth were similar to values recorded in previous studies which confirms calculations reported on nutrient utilization by *Potamogeton crispus* in Rice Lake.

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INTRODUCTION

Extensive growth of *Potamogeton crispus* develops annually in Rice Lake, Ontario. At peak crop growth, an estimated 12 tonnes of phosphorus is contained in *P. crispus* biomass lakewide (Limnos, 1988). Senescence of the *P. crispus* crop normally occurs in June, and proceeds rapidly once initiated. Expected increases in the concentrations of phosphorus as a result of *P. crispus* senescence have not been recorded, however, and the fate of tissue bound phosphorus is not presently well defined (MOE, 1987).

Translocation of phosphorus to turions during their development represents a potentially significant store, or fate, of tissue bound phosphorus. Turions are vegetative propagules and have been identified as the major method of plant reproduction (Engel, 1985; Sastroutomo, 1981). Initial nutrient analysis of turions indicated that phosphorus concentrations are approximately 50% higher in turions than leaf and stem tissue (Limnos, unpublished data, 1988). Turion density in Rice Lake sediments as determined using an Ekman dredge are in the order of 2,000 turions/m^2 in areas of *P. crispus* growth (Limnos 1988).

Given the large numbers of turions that are produced annually, a large quantity of phosphorus may be stored in the turion biomass. Translocation of phosphorus to the turions from leaf and stem tissues may reduce the amount of phosphorus released to the water column during the senescence period, and account for why the expected increase in phosphorus concentration is not observed following plant dieback. Alternatively, translocation of phosphorus to the root biomass may also reduce the amount of phosphorus released to the water column during senescence. To resolve these uncertainties, a study was initiated with the following objectives.

Objectives

1) To determine whether significant quantities of phosphorus are stored in *P. crispus* turions or root biomass,

2) To determine whether significant phosphorus loss occurs from stem and leaf tissue prior to senescence.

METHODS

Plant samples were collected between May 18 and June 20, 1988, at approximately weekly intervals from two areas in Rice Lake. The sampling dates included the main growth phase of *P. crispus* and continued through the period of senescence. Figure 1 indicates the collection areas, one being southeast of Sheep Island and the other northeast of Gores Landing. Plant samples were collected at 2 m and 3 m depths within each of the two areas.

At each location, twenty whole and intact plants were collected by skin divers. Roots and any turions were removed from the main stems and retained separately. Fresh samples were then centrifugally dewatered using a hand operated salad spinner, and the wet mass recorded. The samples were subsequently air dried and the dry mass determined. Dried plant samples were submitted to Agri-Food Laboratories in Guelph, and the moisture content, organic content, phosphorus, nitrogen and potassium content determined.

Based on analytical results, the mass of phosphorus contained in each sample was determined by multiplying the dry mass of the samples by the phosphorus content result for respective samples. This permitted the authors to document phosphorus partitioning by the plant during the growing season and during the period of senescence, and determine the relative importance of turions as phosphorus stores.

A large sample of fully developed turions was also collected on June 25, 1988, to provide representative information on turion weight and nutrient content. The turions were obtained from plants collected by anchor drags near the sampling sites. Sixty turions from the sample were weighed (wet and dry mass) to determine the average unit weight of individual turions.

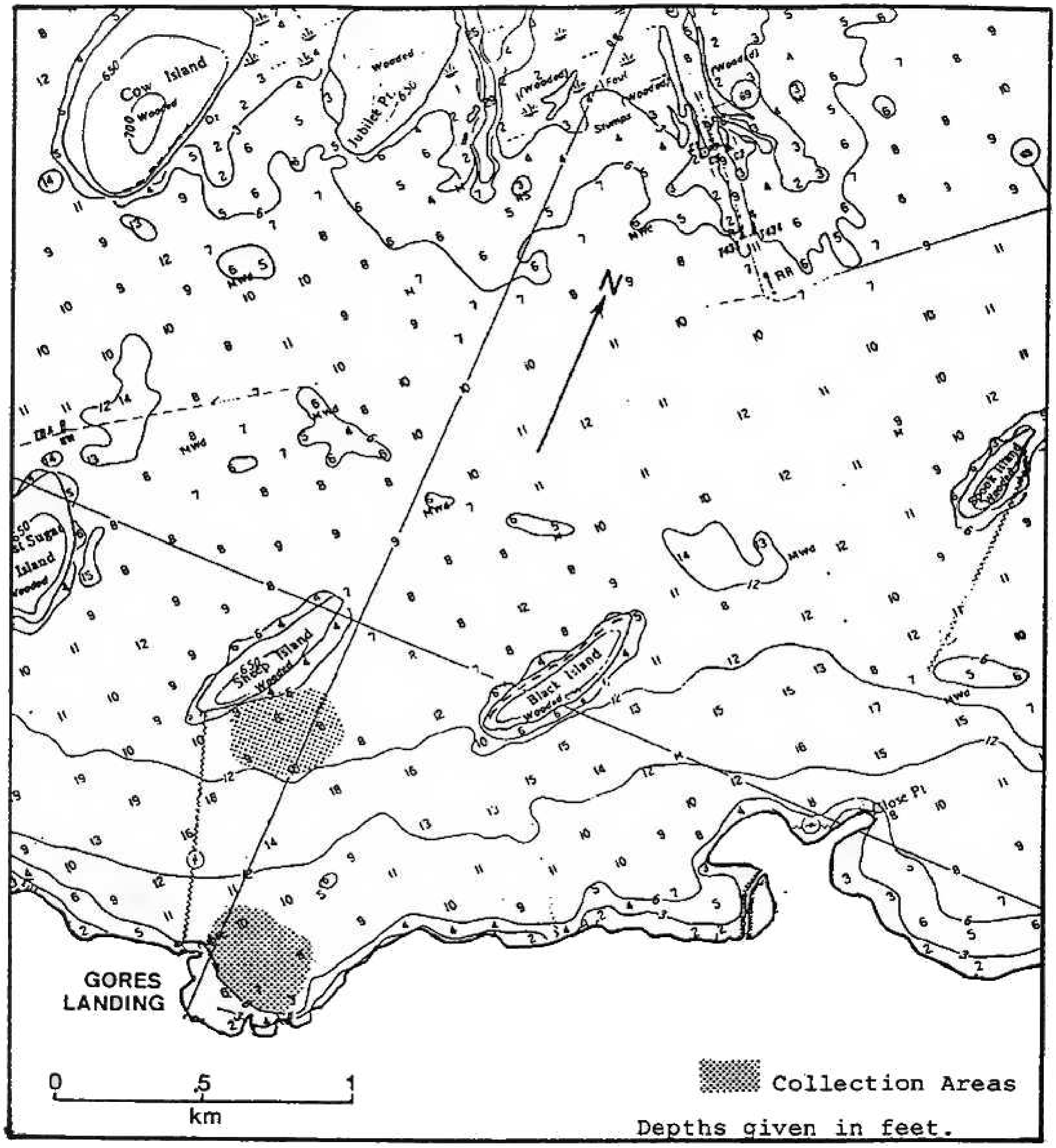

Figure 1. Areas from which *Potamogeton crispus* samples were collected (Gores Landing site and Sheep Island site).

RESULTS

Table 1 presents average dry mass, percent phosphorus content, and mass of phosphorus contained in stem and leaf tissue samples (vegetative samples) and turion samples collected on respective sampling dates. Standard deviations are also presented. The dry mass, percent phosphorus content, and total mass of phosphorus for individual *P. crispus* samples (twenty plants) is given in Appendices A, B, C, and D for the four sampling locations. The appendices also indicate the relative amount of phosphorus contained in the vegetative and turion biomass. Appendix E gives nutrient analysis and organic matter content for all vegetative and turion samples.

Figure 2 indicates the average mass of vegetative and turion samples for respective sampling dates. The maximum biomass of vegetative samples, and the majority of turion samples, occurred on June 8, 1988. The biomass of vegetative material and turions subsequently declined as stems began to lose leaves and vigour, and mature turions detached from stems naturally or when collected by skin divers. The greatest mass of turions relative to vegetative sample mass (15%) also occurred on June 8, 1988. Turions were first collected from plants at the Gores Landing sampling locations on May 25, 1988, and on June 1, 1988 at the Sheep Island locations.

The biomass of plant samples increased through the growing season due to lengthening of stems, enlargement of leaves, and growth of new leaves. The mass of turions collected from plant samples increased until June 8, 1988, as the turions developed and increased in size. Turions develop from modified leaves located in the leaf axils. Development of turions occurs at the top and along the length of the stem where leaves are present.

Table 1. Average Values of Dry Mass, Percent Phosphorus, and Total Mass of Phosphorus of Vegetative and Turion Samples (Twenty Stems) Collected from Four Locations in Rice Lake (1988).

<u>Vegetative Samples</u>

Date	Average Dry Mass (g) (n=4)	Average Percent Phosphorus (n=4)	Average Mass of Phosphorus (g) (n=4)
May 18	5.2 (2.2)*	0.24 (0.04)	15.7 (6.1)
May 25	4.2 (1.6)	0.20 (0.02)	8.6 (3.4)
June 1	7.2 (1.2)	0.16 (0.03)	11.0 (4.7)
June 8	11.6 (1.8)	0.13 (0.03)	15.4 (3.7)
June 15	7.1 (2.3)	0.13 (0.04)	8.6 (0.5)
June 20	4.7 (1.1)	0.16 (0.03)	8.0 (3.1)

<u>Turion Samples</u>

Date	Average Dry Mass (g) (n=4)	Average Percent Phosphorus	Average Mass of Phosphorus (g) n= 4
May 18	0[1]	-	-
May 25	0.3 (0.3)[2]	-[3]	-
June 1	1.1 (0.6)	0.26 (80 stems)	2.8
June 8	1.9 (0.7)	0.15[2] (40 stems)	2.8
June 15	0.8 (0.4)	0.13 (80 stems)	1.1
June 20	0.5 (0.3)	-[3]	-

* - standard deviations in brackets
[1] - no samples collected
[2] - n=2
[3] - samples too small for analysis

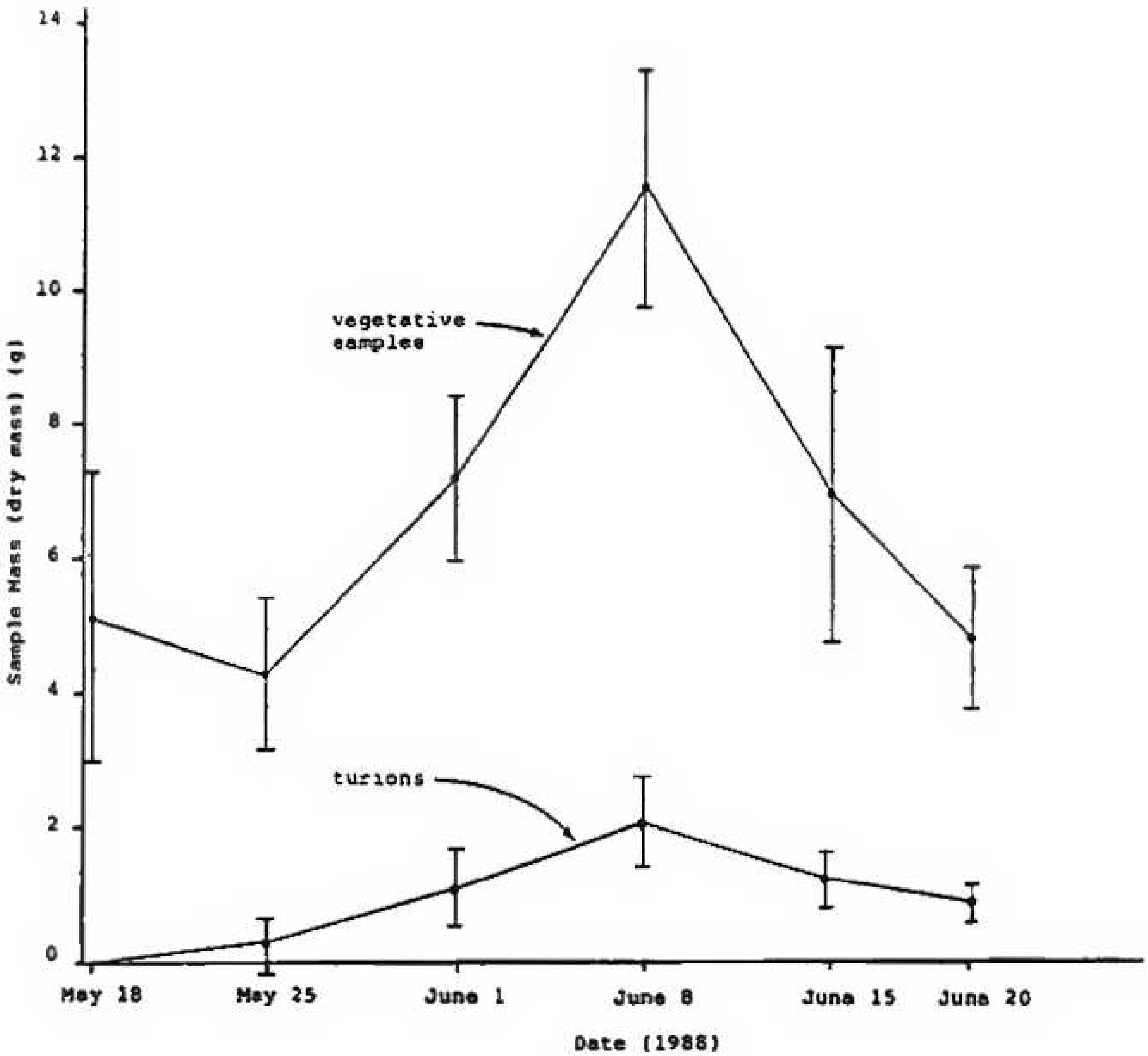

Figure 2. Average Dry Mass of vegetative and Turion Samples (Twenty Stems) Collected from Four Locations in Rice Lake, Ontario.

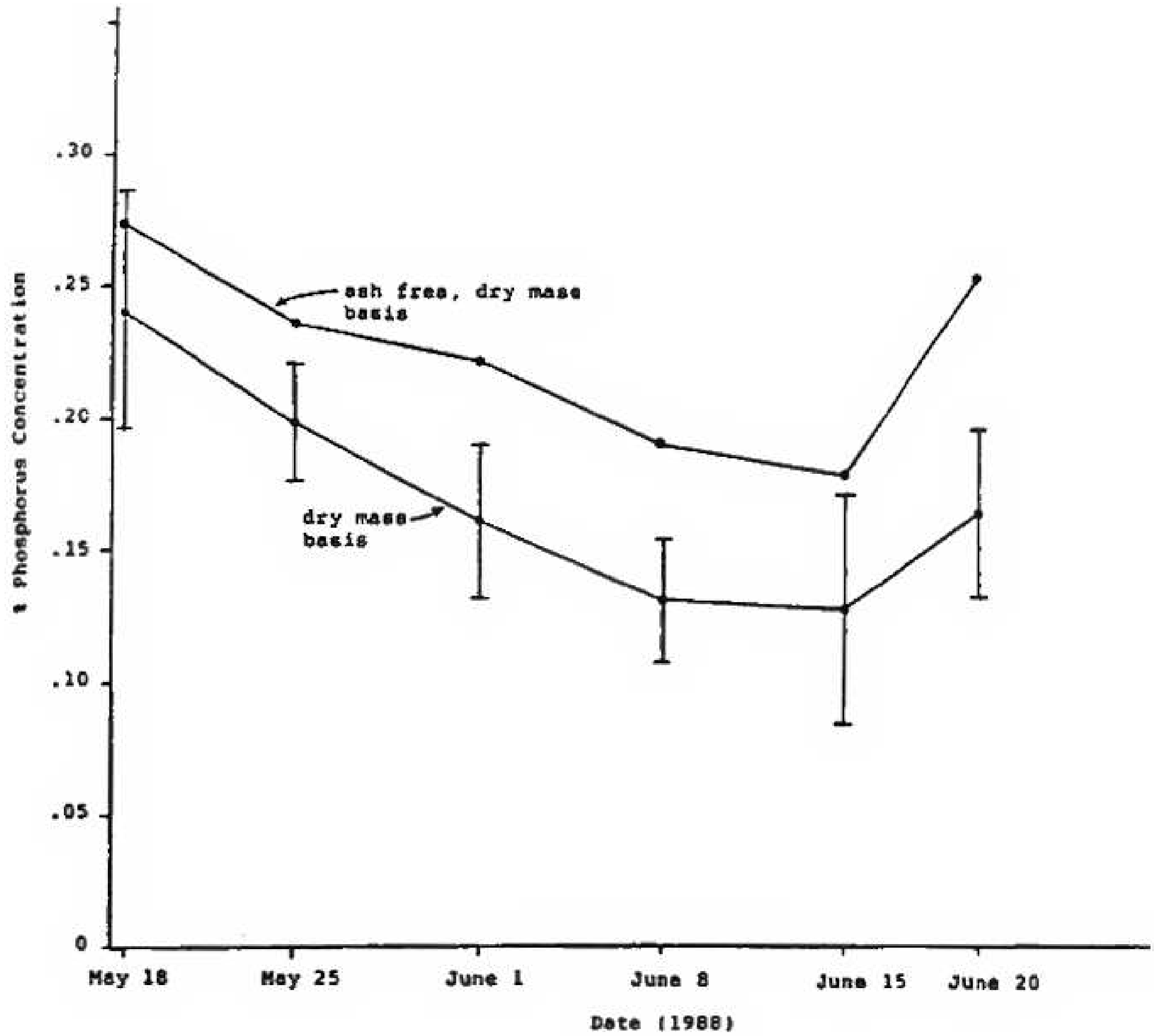

Figure 3. Average Percent Phosphorus Concentration of vegetative and Turion Samples (Twenty Stems) Collected from Four Locations in Rice Lake, Ontario.

Concentrations of phosphorus in vegetative material generally declined from the start to the end of the sampling period. Figure 3 indicates the average phosphorus content and standard deviations for vegetative samples collected on respective sampling dates. Phosphor content averaged between 0.13 and 0.16% (on a dry mass basis) at peak growth and during the period of senescence but exceeded 0.20% on the initial sampling date. On July 25, 1988, an additional sample of decomposing *P. crispus* was collected from the bottom. The phosphorus content of this sample was 0.11%.

On an ash free, dry mass basis, phosphorus concentrations follow the same trend as concentrations plotted on a dry mass basis (Figure 3) though the rate of decline prior to June 8, 1988 of average, ash free, phosphorus concentrations is not as great as for data plotted on a dry mass basis. Average organic content declined from approximately 85% to approximately 65% during the study period (Appendix E). This result indicates that accumulation of calcium carbonate deposits partially accounts for diminishing concentrations of phosphorus until June 8, 1988, though does not account for increases in phosphorus content after June 8, 1988.

Concentrations of nitrogen and potassium on a dry matter basis showed a similar trend of declining concentrations until June 8, 1988 with increasing concentrations thereafter. Concentrations of nitrogen and potassium for respective sampling dates are shown in Figure 4 and Figure 5, respectively. This trend was also observed for data analysed on an ash free, dry matter basis, but to a lesser degree (Figures 4 and 5). Average concentrations of nitrogen and potassium at peak growth (June 1 and June 8, 1988) were 1.41% and 2.57%, respectively.

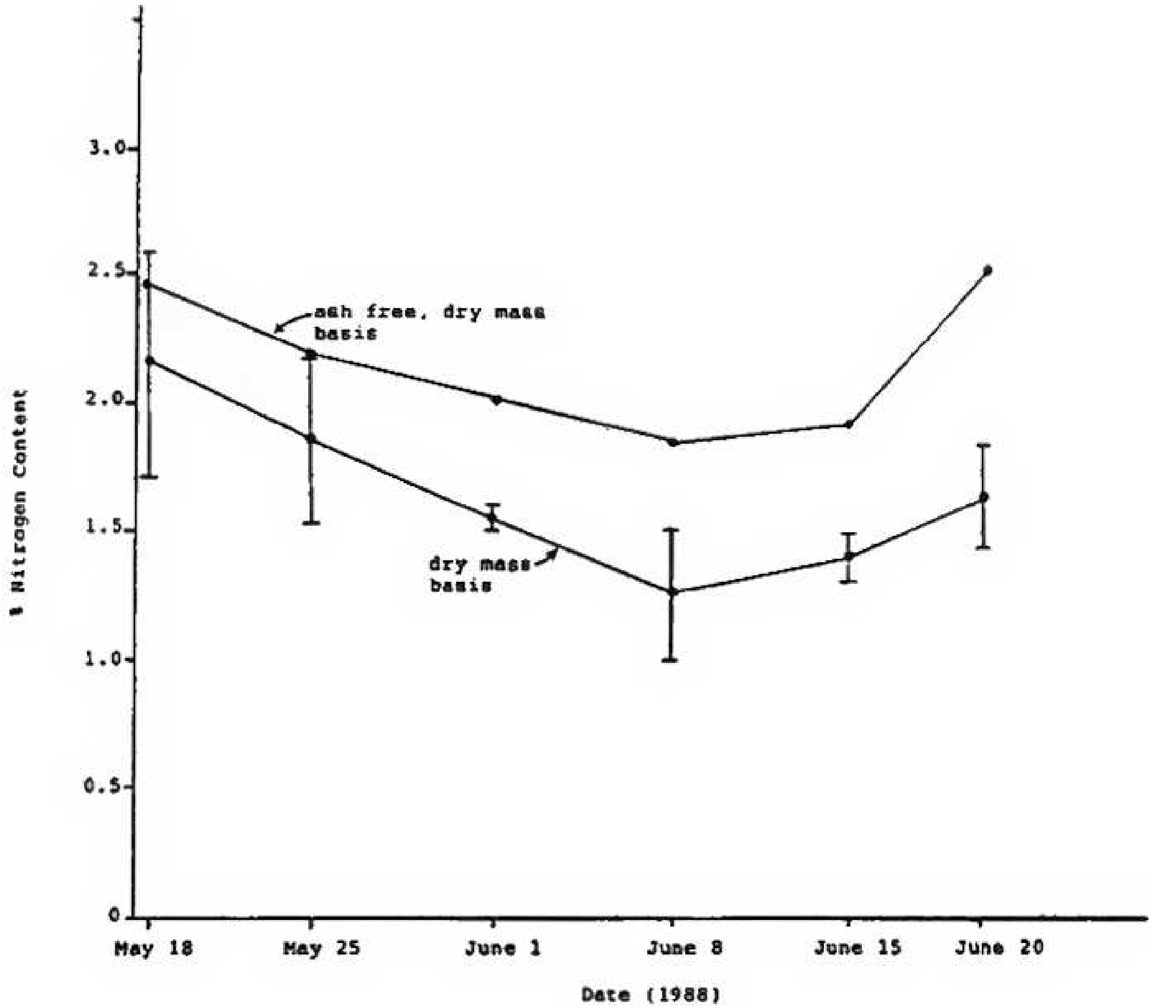

Figure 4. Average Percent Nitrogen Concentration of Vegetative and Turion Samples (Twenty Stems) Collected from Four Locations in Rice Lake, Ontario.

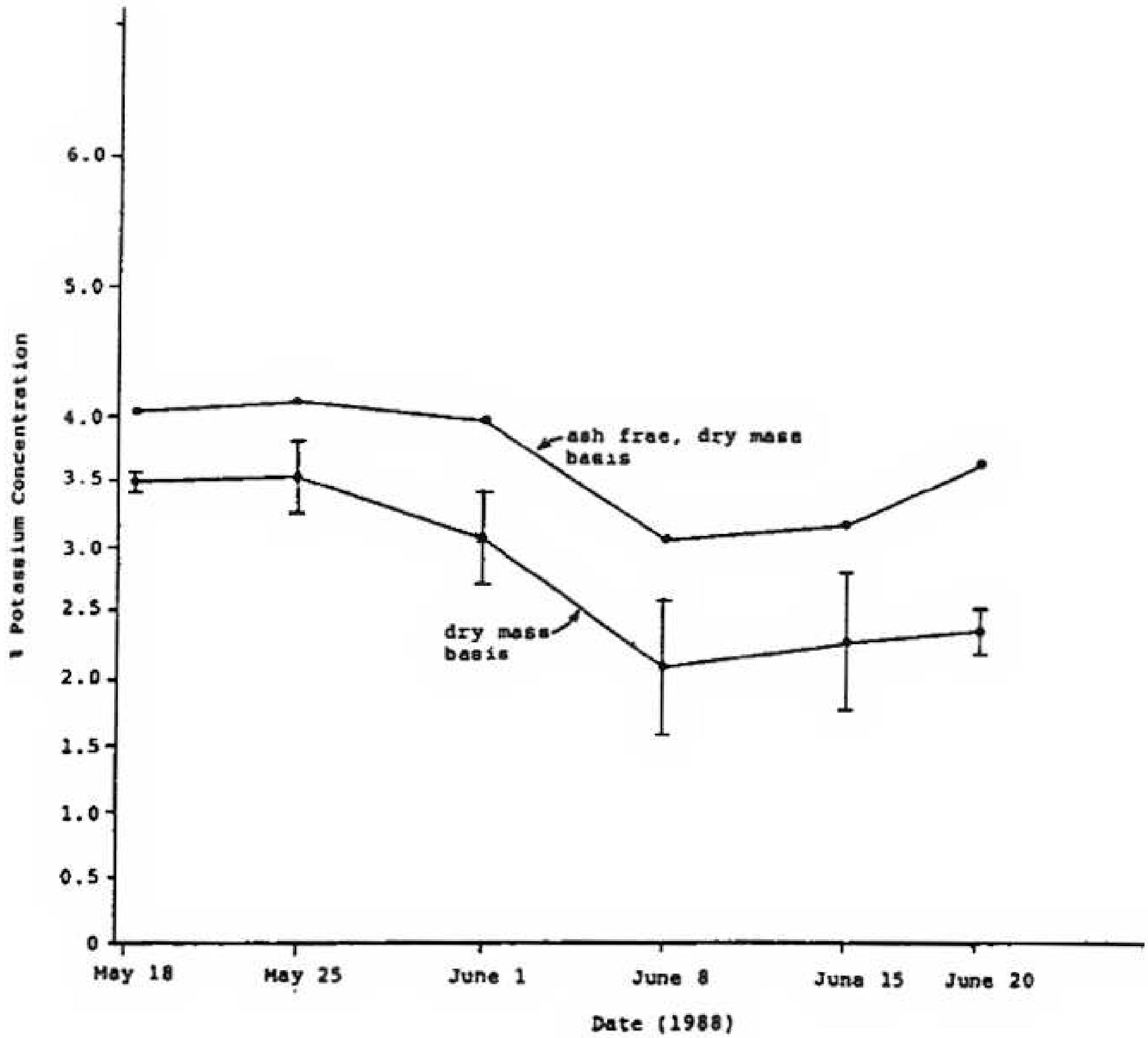

Figure 5. Average Percent Potassium Concentration of Vegetative and Turion Samples (Twenty Stems) Collected from Four Locations in Rice Lake, Ontario.

Concentrations of phosphorus in turions was generally similar to concentrations of phosphorus in vegetative material (Table 1). Phosphorus concentrations of turions collected on June 8, 1988 were 0.14% and 0.15%, on a dry mass basis, for turions collected at Sheep Island and Gores Landing, respectively. The phosphorus concentration of turions collected on June 1, 1988 were 0.26%, and 0.13% on June 15, 1988. The phosphorus content of the additional turion sample collected on June 25, 1988 was 0.11%. Sixty turions randomly selected from the sample weighed on average 0.145 g each (dry mass).

The mass of turions collected from plant samples (twenty plants) was too small in all cases to permit individual nutrient analysis of turion samples. The minimum amount of dried plant material required for analysis was approximately 3 g (S. Sophianopoulous, Agri-Foods Lab., pers. comm.). The mass of turion samples ranged between 0.2 and 2.8 g (dry mass) for samples collected at peak growth (Appendices A, B, C, D). It was necessary to pool turions collected from all four sampling locations on June 1 and June 15, 1988 to provide an acceptably large sample. Turions collected on June 8, 1988 from the two Gores Landing sampling locations were pooled separately, as were turions collected from the Sheep Island sampling locations, to provide samples large enough to permit nutrient analysis. The pooled mass of turions collected on May 25, 1988 from the Gores Landing locations was too small to permit nutrient analysis.

Total phosphorus contained in combined vegetative and turion biomass was greatest on June 8, 1988 for most samples (Appendices A, B, C, D). Figure 6 indicates the average mass and standard deviation of phosphorus contained in vegetative and turion samples collected on respective sampling dates. The total mass of phosphorus

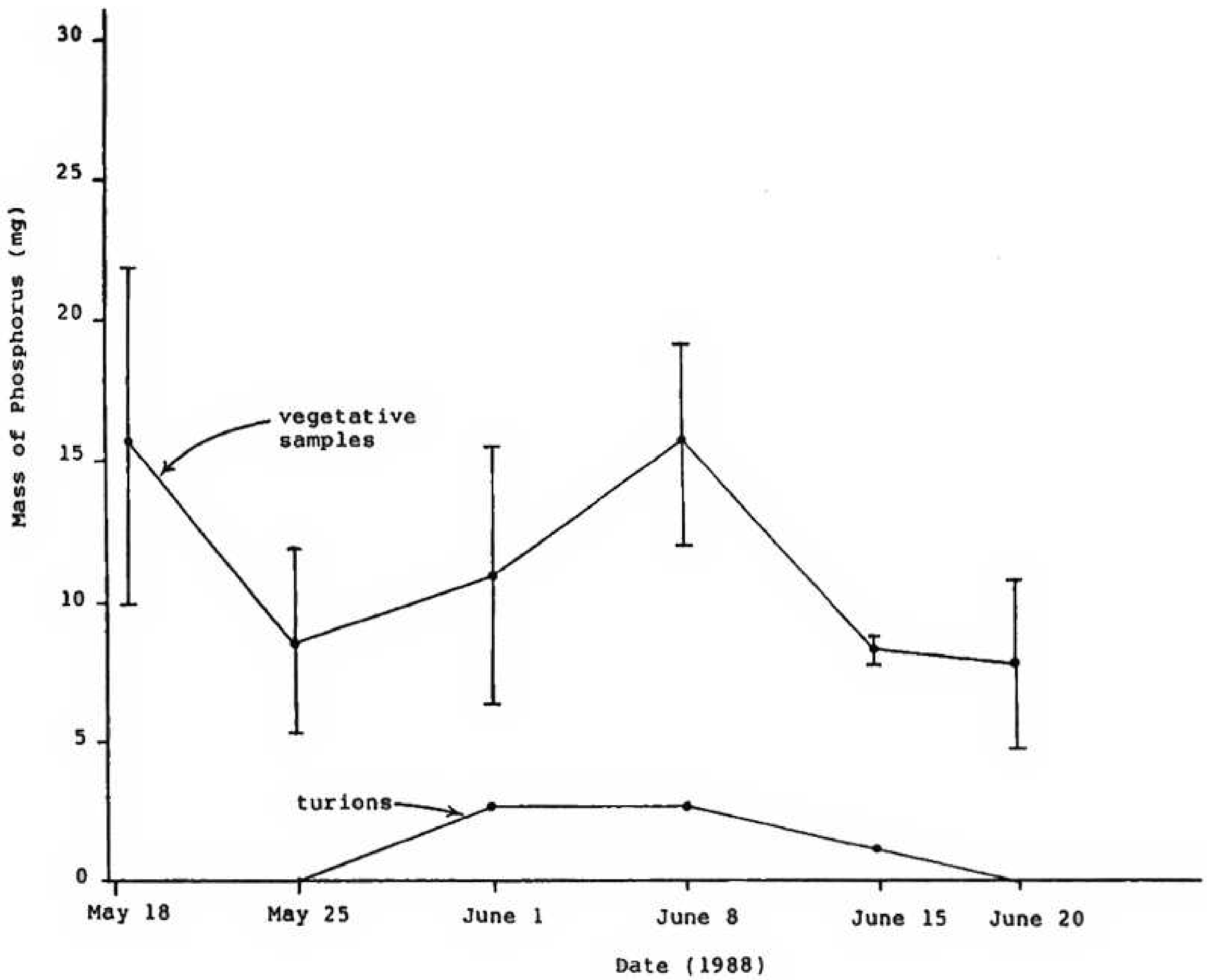

Figure 6. Total Mass of Phosphorus in Vegetative and Turion Samples (Twenty Stems) Collected from Four Locations in Rice Lake, Ontario.

contained in turions was normally less than 25% of the total mass of phosphorus contained in vegetative samples on all sampling days.

Root biomass was sampled on May 18, 1988, and also on June 25, 1988. Root biomass averaged 0.57 mg (dry mass) on May 18, 1988 (n=4) and 0.45 mg on June 25, 1988 (n=2), suggesting that little root biomass develops between mid-May and the period of plant senescence. On May 18, 1988, root mass on a dry mass basis averaged 11% of vegetative biomass. The biomass of vegetative material associated with root samples collected on June 25 was not recorded. In no case was sufficient root material collected to permit nutrient analysis. Appendices A through D provide root biomass information.

DISCUSSION

While a general trend of declining tissue phosphorus concentrations was observed in plant tissues (Figure 3), the majority of recorded phosphorus loss after June 8, 1988 (Figure 6) was associated with diminishing biomass. There is no indication that phosphorus initially contained in plant and stem tissue is translocated to turions and roots. Analysis of the plant sample collected from the sediment surface (0.11% phosphorus content), and in an initial state of decomposition, further indicates that much of the original phosphorus resources in the stem and leaf tissue are retained until degradation is complete.

As the majority of the tissue bound phosphorus is likely retained by the plants until advanced decomposition, a significant amount of phosphorus is probably adsorbed by sediments. Much of the *P. crispus* crop has been observed to collapse to the lake bottom following senescence and partially settle into the unconsolidated sediments that are present in the areas of plant growth (Limnos, 1988).

Phosphorus content of plant samples collected at peak growth in 1988 (0.13% to 0.16%) were similar to concentrations recorded in 1987 for plant samples collected at a similar stage of development (0.14% in 1987). Similar results between years confirm previously developed estimates of the total mass of contained phosphorus (12 tonnes; Limnos, 1988). The average concentration of nitrogen recorded in 1988 at peak growth (1.41%) was also similar to 1988 results (1.45%). However, the average concentration of potassium recorded in 1988 at peak growth (2.57%) was somewhat higher than was recorded in 1987 (1.83%).

The results of the study indicate that the phosphorus concentration of turions is similar to concentrations of phosphorus in stem and leaf tissue (Table 1). The amount of phosphorus contained in turions is generally less than 25% of that contained in vegetative biomass (Figure 6), primarily as the relative biomass of turions recorded in this study was minimal compared to the mass of leaf and stem tissue. However prior observation of developing and mature plants indicate that approximately five turions normally develop on each plant (Limnos, unpublished data). Previous studies (Sastroutomo, 1974) also report that four to six turions normally develop per plant. In comparison, less than twenty turions were normally recovered per sample of twenty stems, whereas approximately 100 turions would be expected if five turions developed per plant. These results would indicate that the majority of turions were not recovered during sampling.

Natural detachment from the stems prior to sampling, or physical agitation during sampling, may have resulted in loss of turions an account for the minimal number of turions collected during the study Given the average mass of a turion (0.145 g), 100 turions normally expected from twenty plants would weigh approximately 14.5 g, as much or more than the dry mass of twenty, mature *P. crispus* plants (Figure 2). The maximum biomass of turions recorded per twenty plants in this study was 2.8 grams (Appendix A). As the mass of turions may be similar the mass of vegetative material, and that phosphorus concentrations o turions and vegetative material is similar, it is probable that the turions contain as much phosphorus as the vegetative material prior t senescence.

Previous estimates of contained phosphorus (Limnos, 1988) were based on the dry mass and percent phosphorus concentration of plant samples collected at peak growth that included a similar number of turions as collected during this study; ie., less than the theoretical five turions per plant. The amount of phosphorus contained in the total biomass of turions has therefore not been established, though it is likely to be approximately 10 tonnes.

While the amount of phosphorus stored in turions may be large, this source of phosphorus may have little influence on growth of planktonic algae. The phosphorus contained in turions that germinate is likely used by the developing plants. Alternatively, turions that do not germinate would normally decompose in the sediments such that liberated phosphorus is not directly available for algal growth.

While samples of roots were not analysed due to the insufficient amount of biomass available, it is unlikely that a significant amount of phosphorus is stored within the root biomass. Previous studies confirm that below sediment biomass is less than 10% of above sediment biomass at peak growth (Sastroutomo, 1974), and that little, additional, root biomass develops during the main growth phase. As *P. crispus* is an annual, and development of new plants is almost exclusively from turions, there would appear to be no ecological requirement for translocation of phosphorus to the roots prior to senescence.

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Appendix A. Biomass Data and Phosphorus Concentrations - Gores Landing (2 m). 1988.

Date	Code	Sample Type	Dry Mass (g)	% P	Mass of P (mg)	Total Mass of P (mg)	% of Total P
May 18	1	Vegetation	6.8	0.31	21.1		100
	43	Roots *	0.7	-		21.1	-
May 25	5	Vegetation	5.8	0.23	13.3		100
	25	Turions *	0.5	-	-	13.3	0
June 1	9	Vegetation	8.7	0.20	17.4		83
	27	Turions [1]	1.4	0.26	3.6	21.0	17
June 8	13	Vegetation	11.7	0.17	19.9		83
	31	Turions [2]	2.8	0.15	4.2	24.1	17
June 15	17	Vegetation	4.9	0.18	8.8		94
	35	Turions [3]	0.5	0.13	0.6	9.4	6
June 20	21	Vegetation	3.7	0.14	5.2		100
	39	Turions *	0.1	-	-	5.2	-

* no analysis (sample too small)
[1] composite sample (all June 1 turions)
[2] composite sample (all June 8 turions from Gores Landing)
[3] composite sample (all June 15 turions)

Appendix B. Biomass Data and Phosphorus Concentrations - Gores Landing (3 m). 1988.

Date	Code	Sample Type	Dry Mass (g)	% P	Mass of P (mg)	Total Mass of P (mg)	% of Total P
May 18	2	Vegetation	7.4	0.23	17.0		100
	44	Roots *	0.3	-	-	17.0	-
May 25	6	Vegetation	4.4	0.20	8.8		
	26	Turions*	0.7	-	-	8.8	-
June 1	10	Vegetation	6.7	0.17	11.4		76
	28	Turions [1]	1.4	0.26	3.6	15.0	24
June 8	14	Vegetation	9.2	0.12	11.0		78
	32	Turions [2]	2.1	0.15	3.1	14.1	22
June 15	18	Vegetation	5.8	0.15	8.7		92
	36	Turions [3]	0.6	0.13	0.78	9.5	8
June 20	22	Vegetation	4.0	0.14	5.6		100
	40	Turions *	0.7	-	-	5.6	-

* no analysis (sample too small)

[1] composite sample (all June 1 turions)

[2] composite sample (all June 8 turions from Gores Landing)

[3] composite sample (all June 15 turions)

Appendix C. Biomass Data and Phosphorus Concentrations - Sheep Island (2 m). 1988.

Date	Code	Sample Type	Dry Mass (g)	% P	Mass of P (mg)	Total Mass of P (mg)	% of Total P
May 18	3	Vegetation	3.3	0.24	7.9		100
	45	Roots *	0.9	-	-	7.9	-
May 25	7	Vegetation	3.1	0.17	5.3	5.3	100
June 1	11	Vegetation	5.8	0.14	8.1		94
	29	Turions [1]	0.2	0.26	0.5	8.6	6
June 8	15	Vegetation	13.5	0.11	14.8		89
	33	Turions [2]	1.3	0.14	1.8	16.6	11
June 15	19	Vegetation	10.0	0.09	9.0		83
	37	Turions [3]	1.4	0.13	1.8	10.8	17
June 20	23	Vegetation	5.9	0.17	10.0		100
	41	Turions*	0.5	-	-	10.0	-

* no analysis (sample too small)

[1] composite sample (all June 1 turions)

[2] composite sample (all June 8 turions from Sheep Island)

[3] composite sample (all June 15 turions)

Appendix D. Biomass Data and Phosphorus Concentrations - Sheep Island (3 m). 1988.

Date	Code	Sample Type	Dry Mass (g)	%P	Mass of P (mg)	Total Mass of P (mg)	% of Total P
May 18	4	Vegetation	3.3	0.21	6.9		100
	46	Roots *	0.4	-	-	6.9	-
May 25	8	Vegetation	3.7	0.19	7.0	7.0	100
June 1	12	Vegetation	7.7	0.14	10.8		75
	30	Turions [1]	1.4	0.26	3.6	14.4	25
June 8	16	Vegetation	12.2	0.13	15.9		88
	34	Turions [2]	1.5	0.14	2.1	18.0	12
June 15	20	Vegetation	7.8	0.10	7.8		87
	38	Turions [3]	0.9	0.13	1.2	9.0	13
June 20	24	Vegetation	5.5	0.21	11.5		100
	42	Turions *	0.7	-	-	11.5	-

* no analysis (sample too small)

[1] composite sample (all June 1 turions)

[2] composite sample (all June 8 turions from Sheep Island

[3] composite sample (all June 15 turions)

Appendix E. Organic Matter and Percent Nutrient Content (dry matter basis) of *P. crispus* Samples Collected at Four Locations in Rice Lake, Ontario between May 18 and June 20, 1988.

Vegetative Samples

Date	Location	Depth (m)	Agri-Foods Code	Organic Content (%)	%P	%N	%K
May 18	G.L.*	2	1	86.6	0.31	1.76	3.50
"	"	3	2	87.4	0.23	2.40	3.46
"	S.I.[1]	2	3	-	0.24	2.70	3.57
"	"	3	4	-	0.21	1.78	3.46
May 25	G.L.	2	5	84.5	0.23	1.61	3.44
"	"	3	6	84.5	0.02	2.30	3.62
"	S.I.	2	7	-	0.17	1.97	3.23
"	"	3	8	-	0.19	1.61	3.87
June 1	G.L.	2	9	78.7	0.20	1.55	2.97
"	"	3	10	80.1	0.26	1.57	3.34
"	S.I.	2	11	68.1	0.14	1.63	2.59
"	"	3	12	81.8	0.14	1.51	3.36
June 8	G.L.	2	13	68.4	0.17	1.54	2.48
"	"	3	14	50.2	0.12	1.14	1.74
"	S.I.	2	15	84.2	0.11	0.97	1.51
"	"	3	16	66.7	0.13	1.41	2.59
June 15	G.L.	2	17	80.6	0.18	1.54	2.43
"	"	3	18	73.3	0.15	1.40	2.80
"	S.I.	2	19	60.4	0.09	1.31	1.55
"	"	3	20	76.2	0.10	1.44	2.45
June 20	G.L.	2	21	-	0.14	1.45	2.32
"	"	3	22	-	0.14	1.58	2.25
"	S.I.	2	23	65.2	0.17	1.63	2.33
"	"	3	24	-	0.21	1.94	2.64
June 25	Veg. Sample		50	-	0.11	1.48	0.62

* - Gores Landing

[1] - Sheep Island

Appendix E (cont'd). Organic Matter and Percent Nutrient Content (dry matter basis) of *P. crispus* Samples Collected at Four Locations in Rice Lake, Ontario between May 18 and June 20, 1988.

Turion Samples

Date	Location	Depth (m)	Agri-Foods Code	Organic Content (%)	%P	%N	%K
May 25	G.L.*	2	25	samples too small for analysis			
"		3	26				
June 1	G.L.	2	A27				
"	"	3	"	-	0.26	2.23	2.35
"	S.I.[1]	2	"				
"	"	3	"				
June 8	G.L.	2	B31	-	0.15	1.12	1.86
"		3	"				
"	S.I.	2	C33	-	0.14	1.36	2.22
"		3	"				
June 15	G.L.,	2	D35				
"		3	"	-	0.13	1.32	1.61
"	S.I.	2	"				
"	"	3	"				
June 20	G.L.	2	39				
"		3	40	samples too small for analysis			
"	S.I.	2	41				
"		3	42				
June 25	Turion Sample		49	-	0.11	0.96	1.60

* - Gores Landing
[1] - Sheep Island