Lake
Simcoe
Environmental
Management
Strategy

DICHOTOMOSIPHON TUBEROSUS, A BENTHIC ALGAL SPECIES WIDESPREAD IN LAKE SIMCOE

TECHNICAL REPORT B.2

1985

Ontario

LAKE SIMCOE ENVIRONMENTAL MANAGEMENT STRATEGY

DICHOTOMOSIPHON TUBEROSUS
A BENTHIC ALGAL SPECIES WIDE-SPREAD IN LAKE SIMCOE

Prepared for the Steering Committee of the Lake Simcoe
Environmental Management Strategy

by
J.H. Neil [1]
G.W. Robinson [2]

[1] Limnos Limited
22 Roe Avenue
Toronto, Ont.

[2] Ontario Ministry of the Environment
Water Resources Branch
Aquatic Ecosystems Section
Box 213, Rexdale, Ontario M9W 5L1

Technical Report B2
Field Study August - September 1983

LAKE SIMCOE ENVIRONMENTAL MANAGEMENT STRATEGY

FOREWORD

This report is one of a series of technical reports prepared in the course of the Lake Simcoe Environmental Management Strategy (LSEMS) studies. These studies were initiated in 1981, as directed by the Cabinet Committee on Resources Development, to investigate methods of reducing phosphorus loadings from the Holland Marsh.

The studies are under the direction of the LSEMS Steering Committee, which is comprised of representatives of the following agencies:

- Ministry of Agriculture and Food
- Ministry of the Environment
- Ministry of Natural Resources and
- South Lake Simcoe Conservation Authority

This Committee expanded the SCOPE of these studies to include the total Lake Simcoe basin. This change in study mandate was made to place all sources of phosphorus loadings to Lake Simcoe into perspective. Thus the following sources were investigated:

- agricultural and rural runoff
- urban runoff
- streambank erosion and
- sewage treatment facilities.

In order to develop practical abatement measures to minimize such inputs, studies were initiated to inventory, quantify and target areas with respect to soil loss, livestock and farming operations, streambank erosion and urban runoff.

The Committee also approved Lake Simcoe studies to establish current information on lake water quality and aquatic plant growth. Such studies were required to establish baseline conditions to compare future water quality conditions. These are expected to improve, because of the following:

- municipal and provincial efforts to reduce phosphorus loadings from sewage treatment facilities and

- because of expected changes to more environmentally acceptable land use practices by developers and farmers to reduce inputs from non-point sources.

Questions with respect to the contents of this report should be directed to:

Regional Director, Central Region
Ministry of the Environment
7 Overlea Boulevard, Toronto, Ontario, M4H 1A8

or

General Manager
South Lake Simcoe Conservation Authority
120 Bayview Avenue, Box 282
Newmarket, Ontario, L3Y 4X1

DISCLAIMER

The material presented in these reports is analytical support information and does not necessarily constitute policy or approved management priorities of the Province and/or the South Lake Simcoe Conservation Authority. Interpretation and evaluation of the data and findings, should not be based solely on this specific report. Instead they should be analysed in light of other reports produced within the comprehensive framework of this environmental management strategy.

Reference to equipment, brand names or suppliers in this publication is not to be interpreted as an endorsement of that product or supplier by the authors, the Ministry of the Environment or the South Lake Simcoe Conservation Authority.

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EXECUTIVE SUMMARY

Two field collections from Lake Simcoe of a hitherto unreported species of green algae, *Dichotomosiphon tuberosus*, suggested that a new biological influence on the lake ecosystem may have developed in recent years. As strategies were being developed for the control of evident eutrophication, a contract was issued to develop preliminary information on the areal distribution of the species, algal biomass and an assessment of potential effects on the chemical and biological environment of the lake.

Surveys to assess algal distribution were conducted using a towed diver over 28 km of bottom. As growth appeared to be restricted to depths of 3 to 10 m, most of the survey work was confined to the east shore where the principal area of suitable depth was present. *Dichotomosiphon* distribution as predicted from diver surveys and subsequent dredge sampling was identified on a chart and estimated to cover 56 km^2, and a total of 8% of the lake bottom. Where good growth was present, it formed a continuous dark green mat 3 to 10 cm in depth.

Biomass sampling using three replicate 522.6 cm^2 (9" x 9") Ekman dredge samples at each of 42 locations, indicated growth ranging from 0 to 410 g/m^2 dry weight (d.w.) and a mean of 104 g/m^2 d.w. for stations where the alga was present.

Eleven tissue samples analyzed by the Ontario Ministry of the Environment laboratory reported a relatively low organic fraction of 22.0%, indicating some sediments remained in the washed samples. Mean tissue nutrient content calculated on an ash-free basis was 0.5% phosphorus, and 5.9% nitrogen. Total organic carbon content was 51.0% (ash-free).

Observed environmental conditions supporting growth indicated that the species grew under minimal light conditions (4.3 x Secchi depth). It appeared to favour sand/silt sediments and maximum bottom water temperatures of 22°C were recorded during the summer survey. A core sample survey conducted through the ice in February indicated no active growth and that fragments had been distributed into the lake to at least 20 m depths.

A calculation to assess whether the biomass documented could affect the summer oxygen levels in the hypolimnion indicated that the total crop of 1,280 tonnes (ash-free d.w.) if decomposed in the hypolimnion could account for a loss of 0.79 mg O_2/L or 10% of the oxygen resource. A similar calculation estimated the algal crop to contain 6.7 t of P and 75.9 t of N during the late summer survey period.

This study demonstrates that an extensive growth of *Dichotomosiphon* occurs over the important sublittoral lake bottom and that this may cause important physical, chemical and biological changes in the lake ecosystem. Reduced phosphorus loadings to Lake Simcoe will lower phytoplankton levels and thereby improve water clarity. However, this may extend the range of *Dichotomosiphon* and thereby diminish the benefit of the reduced phytoplankton biomass to the dissolved oxygen regime. It could ultimately increase the phytoplankton community again.

In order to define the effects of this new influence better, general recommendations for future areas of research, as determined from this study, are identified.

INTRODUCTION

In September 1978, a bottom dredge sample which contained a thick mass of apparently healthy green algae, was collected by the Ontario Ministry of the Environment (MOE) staff from a 30 m depth in north central Lake Simcoe (Figures 1 and 2). The alga was later identified by ministry staff to be *Dichotomosiphon tuberosus* (A. Br.) Ernst (1902). A second sample was subsequently collected in shallower water (12 m) from a location 5 km north of Thorah Island. These isolated collections of a hitherto unreported algal species from widely separated locations, suggest that a significant biomass might have become established in the lake.

Lake Simcoe is mesotrophic in character, but has shown a classical trend towards eutrophy. Blue-green algal blooms have become more frequent and severe; an increasing pool of low dissolved oxygen has developed in the hypolimnion; and populations of important cold water species including lake trout *(Salvelinus namaycush*) and whitefish (*Coregonus clupeaformis*) have decreased and are now sustained largely by stocking. Species better adapted to more eutrophic conditions including yellow perch (*Perca flavescens*) and smelt (*Osmerus mordax*) have increased in abundance.

The recognition of a trend to lowering water quality has led to a comprehensive evaluation of the lake by staff of the Ministries of the Environment and Natural Resources, and the South Lake Simcoe Conservation Authority. Their studies have identified phosphorus to be the principal factor in enrichment and have defined and implemented strategies to reduce loading rates.

The identification of *Dichotomosiphon* as a new source of primary production to the lake suggests that if present in significant quantities, it could modify the physical nature of the bottom, contribute to the oxygen demand of sediments during periods of decomposition and possibly depreciate conditions for spawning of important game fish species. In order to obtain preliminary information on *Dichotomosiphon* in Lake Simcoe, a contract was issued by the MOE in July, 1983 for the collection of data relating to distribution, standing crop biomass and an evaluation of the potential effect of the alga on the aquatic environment. This report has been prepared to document the findings of this contract.

DICHOTOMOSIPHON TUBEROSUS

Description

The species was originally described by Ernst in 1902 from a collection made in Switzerland. It is classified in the Order Siphonales, Family Vauchariaceae. *Tuberosus* is the only freshwater species of *Dichotomosiphon*.

In its natural environment, it grows as a felt or rug-like mass on the surface of bottom sediments. The alga is quite distinctive in morphology (Figure 3). The thallus is composed of siphonous tubes with constrictions at points of dichotomous branching but divided only at locations of sexual or asexual reproductive bodies. Plant material collected during the course of this study was dark green in colour (Fig. 4). Microscopic examination indicated it to be well branched and to have produced liberal quantities of the asexual reproductive akinetes. All cells of the thallus contained green chloroplasts, and light amber coloured rhizoids were common throughout the plant mass. Accumulations presumed to be iron (Nicholls 1982) were present at the location of branching and on the cell wall of thallus material.

Descriptions of classification morphology and reproduction are published in the works of Ernst (1902), Collins (1909), Prescott (1962), Smith (1950) and Taft (1971).

Distribution

Dichotomosiphon tuberosus is worldwide in distribution having been reported from Switzerland, France, U.S.A., Canada, Asia, Burma and Northern India. While widely distributed, it is considered rare, probably being more common in North America than elsewhere. Moestrup and Hoffman (1973) indicate that it has been observed in nine states of the United States east of the Rocky Mountains. To our knowledge, Nicholls (1982) publication on the Lake Simcoe collection is the first reference to its occurrence in Canada.

Environmental Requirements

Little information is published on growth requirements but it has been collected from a number of very diverse habitats. All authors appear to agree that it is found only in hard-water environments. Taft (1971) noted its presence in Pelee East Harbour on Lake Erie, but also growing barely submerged along shorelines. Stoermer (1980) recorded diver observations in Lake Michigan where the presence of occasional large and luxuriant beds of *Dichotomosiphon* were noted 10 to 20 cm thick growing on silty sand substrate at depths of 10 to 20 m. There were also occasional problems caused by the alga blinding bar screens at the Chicago water filtration plant after fall storms.

Prescott (1962) reported that ‘the plant seems to grow only in lakes with a rich organic silt bottom' and had been collected in Michigan and Wisconsin to depths of 16 m. Mention is also made of growth being ‘rarely subareal on damp soil'. Smith (1950) noted that it had been found in the United States at the surface in shallow pools and 20 to 50 feet below the surface in deep water lakes. Davis and Gworek (1972), collected *Dichotomosiphon* from five springs in north central Florida. It is of interest to note that in one spring, the alga was found to be growing abundantly in a cavern, 37 ft. from a 3 x 3 ft. opening of the spring boil which admitted the only light. Two records of collections from northern India (Rao and Valvigi 1973) report growth occurring on the side of channels carrying cool water.

The record indicates conditions suitable for growth to vary from profundal sediments in lakes to subareal habitats. The alga has been found in both lentic and lotic conditions. No information on temperature, nutrient or light requirements was found.

Prescott (1962) noted that '*Dichotomosiphon* forms a habitat for an association of *Rotifera, Cladocera* and many protozoa'. Davis *et al.* (1972), noted the epiphytes *Cocconeis* and *Gomphonema* and that *Clostridium, Scenedesmus* and *Cymbella* were common within the alga mat.

PROJECT OBJECTIVES

In order to determine the environmental significance of *Dichotomosiphon* to Lake Simcoe, the following broad objectives were established:

1. To determine the areal extent of bottom coverage of the alga.

2. To estimate total biomass.

3. To determine the gross chemical structure of the species and from this information estimate its significance to the oxygen and phosphorus regime of the lake.

METHODS AND MATERIALS

Areal Distribution

Distribution was determined using a towed diver to observe presence or absence, percent cover, thickness of the algal mat and bottom type. These observations were supplemented subsequently by Ekman dredge collections made at single locations during the biomass collections.

The towed diver survey commenced August 17, 1983 and was completed September 1, 1983. A 21 ft. inboard/outboard boat was used to carry equipment and tow the diver. At each transect selected, the diver took the sled to the bottom and signalled to proceed when ready. The sled was equipped with an electric door bell and pre-arranged signals allowed communication for purposes of stop, start, faster, slower or emergency. Towing speed was approximately 3 km/hr and most runs covered a 1 km distance in approximately twenty minutes.

Upon completing each run, the diver recorded his observations with respect to bottom type, percent cover, appearance and thickness of the algal mat, and any comments or general observations of note.

On each occasion during the survey and biomass sampling, general conditions including surface and bottom temperatures, Secchi depth, air temperature, wind speed and direction, and cloud cover were recorded.

Biomass Sampling

Biomass sampling was accomplished using a 522.6 cm^2 (9" x 9") Ekman dredge. At each sample location, three replicates were taken and added together to represent the algal biomass in 0.1568 m^2. These data were recalculated to indicate biomass/m^2. Ekman samples upon retrieval were screened through 2.0 mm mesh to remove sand

and sediments and rinsed until the wash water was clear of turbidity. Obvious clams, snails and shell material and large insects or debris were removed, but no attempt was made to clear all extraneous matter. Water was removed in the field by hand squeezing, packaged in plastic bags and iced. Each day upon return to the laboratory, the algal samples were removed from the bags, the wet weights determined, the volume measured in a graduated cylinder and the sample frozen. At the conclusion of the field work, 11 samples were oven-dried at 60°C and weighed to determine dry weight. A total of eleven dried samples of appropriate size for analyses were ground in a Wylie Mill and submitted to the MOE laboratory for analyses.

Winter Core Sample Collections

One series of core samples was collected through the ice in February to obtain qualitative information on the distribution of *Dichotomosiphon* during the winter period. A snowmobile was used for transportation; holes were bored using an ice auger and a WILDCO KB core sampler employed to obtain sediment plugs. A sample of the surface layer was removed from the core using a coarse pipette.

Navigation

To establish positions for the beginning and end of runs and the locations of individual sample stations, locations were determined and plotted (Figure 5). Transects normally began off a known shore point and proceeded on a compass bearing. Offshore transects employed bearings on shore and on ranges to establish positions (Figure 5).

Sample Analyses

Analyses of plant material for total phosphorus, total nitrogen, loss on ignition (LOI) and total organic carbon (TOC) followed standard MOE practices for biological materials. Winter *Dichotomosiphon* distribution from the surface of sediment cores was evaluated using a binocular microscope at 45x.

RESULTS

Chemical and Physical Conditions

Table 1 reports the physical conditions of the lake during the two sampling periods from mid to late August, and late September to early October. Representative values for water quality are shown in Table 2.

Distribution

A total of 28 km of bottom was examined by the towed diver over transects run on the easterly side of the lake from Jackson's Point in the south to McGinnis Point in the north. Most transects were oriented perpendicular to the shore of the mainland or islands with additional runs offshore where suitable depths appeared to be indicated (Figure 5).

Of the total 25 transects, *Dichotomosiphon* growths were observed over some or all of 13 runs. In addition, diver observations were made at ten separate locations around the north segment of the lake from McGinnis Point to Moon Shoal. Of these spot dives, the alga was found in two locations (Stations 34 and 35) (Figure 5).

Diver reports indicated the alga to be growing between 3 and 10 m. In most locations, there was a significant reduction in the observed thickness of the mat and continuity of coverage at 7-8 m, although one of the heaviest collections was made at 10 m (Station 26) (Table 3).

Where good growth occurred, the alga had a dark green, rug-like appearance and covered 90 to 100% of the bottom. The depth of the mat was 3 to 6 cm with thicknesses to 10 cm in the heaviest areas. As water depth or other factors limited growth, the mat became thinner and growth more patchy until only a few strands were evident on the surface.

Bottom type in the areas surveyed varied from rocky bottoms (bedrock, boulders, gravel) through sand, sand-silt to "plastic" muds. No growth occurred on rocky bottoms except where gravel was interspersed with sediments. The prevalence of rocky substrates along much of the shoreline served to limit growth in the area surveyed that would otherwise afford a suitable habitat. At the times of our survey, no *Cladophora* was found to be growing on these rocky substrates.

The alga appeared to colonize all bottom sediment types from sand-silt mixtures to mud-sand types. Subsequent dredge samples indicated that considerable shell material was incorporated into most of the bottom sampled.

A preliminary map of *Dichotomosiphon* in the easterly portion of the lake has been prepared based on diver observations and subsequent dredge sampling (Figure 6). In preparing the distribution map, *Dichotomosiphon* was presumed to be growing where suitable depths (3 to 8 m) and bottom type occurred. The discontinuity of distribution indicated in the north east quadrant of the lake is a result of the extensive rocky bottom observed in that area.

Additional but apparently less suitable areas having depths of 8 to 10 m can be expected to sustain some growth, although observations at these depths indicated *Dichotomosiphon* to be present in some cases and not in others, i.e. Station 26 and Transect 6. Using the area of presumed growth indicated on Figure 6, the total area of growth along the easterly shore has been estimated to be 56 km^2.

The shoreline along the westerly side of the lake drops quickly to more than 10 m and much of the littoral area has a rocky substrate. For this reason, no extensive areas suitable for growth appear to exist. A series of ten dredge samples was taken from Cook Bay on October 11 over a range west from the Maskinonge River and a return run 1 km to the north. The bottom was soft and contained aquatic macrophytes and/or plant debris. A microscopic examination of the washed residue indicated decomposed *Dichotomosiphon* to be present only in the sample collected on the west shore of the northerly transect.

Biomass and Tissue Analyses

Quantitative biomass samples were collected from forty-two locations along the west and north shore of the lake (Table 3). While there was some variability in the wet weight and volume measurements, they would be expected to be about equal and the overall mean suggested this to be the case (mean volume 294 ml/m^2). The mean dry weight of the forty-two samples collected was 104 g/m^2 and the average dry weight was 36.9% of the wet weight.

It is of interest to note that the dry weight of the forty-two replicate samples measured varied from 1 to 410 g/m^2. Eighteen were in excess of 100 g and 5 greater than 200 g. When washed, the Ekman composite of the larger samples made a fist-sized ball.

Analysis of the plant tissue indicates a high and variable inorganic (LOI) content (Table 4). While the samples were washed in the field to the extent that visible turbidity no longer remained in the wash water, it is evident that a more vigorous rinsing to reduce the inorganic content as much as possible would have benefited the results. The high ash content rendered the interpretation of tissue nutrient, iron and total organic carbon content somewhat difficult when the percent organic or algal fraction was calculated.

Table 4 summarizes the results of eleven tissue samples selected for analysis. The organic content (LOI) was found to range from 8.5 to 35% with a mean of 22.0%.

Tissue nutrients are of particular interest as a major biomass will take up and hold a portion of the lake nutrient resources and release them to the ecosystem upon decomposition. Future studies may also use tissue nutrient levels to determine whether available nitrogen and phosphorus resources exist in marginal or abundant supply and therefore whether control of input may affect algal production. Tissue phosphorus values while showing some variability (range 0.26 - 1.29% by weight, mean 0.52%, Table 4) are in a range expected when compared to a mean of 0.40% reported for samples of *Cladophora* from Lake Ontario (Limnos 1982). Tissue nitrogen values again show some scatter and a mean of 5.93%. The mean value for *Cladophora* from Lake Ontario was 5.19% (Limnos 1982).

In *Dichotomosiphon tuberosus*, iron is deposited externally and internally on the cell wall and internally in the rhizoids (Nicholls 1982). The function or reason for the association of iron with the alga is unknown. Because a high level of iron was anticipated, an analysis was requested to establish a tissue level. Values determined ranged from 0.23 to 0.58% with a mean of 0.37%. Iron was analyzed from a few *Cladophora* samples collected from Lake Simcoe in 1980 (M. Jackson, personal communication). Values ranged from 0.05 to 0.4% with a mean in the 0.2 - 0.3% range. This suggests that unique levels of iron are not a feature of *Dichotomosiphon* biomass.

Total organic analyses (TOC) were reported by MOE. The results were transposed to ash-free dry weight (afdw) and reported as percent organic in Table 4. Values ranged from 32.3% to 70.0% with a mean of 50.97%.

DISCUSSION

Growth Requirements

Substrate, light, temperature and available nutrients combine to determine the areal distribution and biomass that will develop in the lake. Our observations indicated sediments in the growth zone vary from sandy material at the nearshore limit of growth to soft "plastic" muds in profundal waters. The nearshore limit is probably determined by the depth at which wave action will dislodge growth. The offshore limit was presumed to be determined by light, however, heavy growths were found at 10 m in some locations where other locations indicated it to have diminished by that depth. Likewise, MOE found healthy *Dichotomosiphon* present at depths greater than our survey indicated growth to take place. It would seem possible that bottom type may play a role with the plant favouring coarser sediments found on more exposed shores or those having higher nutrient characteristics.

The alga is better adapted to utilization of minimal light conditions than any other commonly distributed aquatic species. Stoermer (1980) recorded luxuriant growths on sand-silt bottom in depths of 10-20 m in Lake Michigan. In our survey we found *Dichotomosiphon* growth at 4.3x Secchi depth, which is about half the light required for *Cladophora* growth. Kaseyama *et al.* (1978) indicated that the alga contained siphonein, 'a green light absorbing pigment which is important for deep water green algae living under green illuminations in deep coastal waters'.

Temperature requirements for growth are not known. Algal growth occurred in the areas surveyed at temperatures typical of the epilimnion, which exceeded 23°C in August. Temperatures of 16°C or less would be present earlier in the summer as the metalimnion would encompass the deeper growth areas (MOE 1982). Our general observations suggested declining biomass between late August and late September during the time when water temperatures decreased 5°C. At the time of the February core sample collections, algal mat growth did not appear to be present although cells containing green pigment were in evidence.

Nutrient requirements did not appear to have been evaluated. Prescott (1962) noted that the 'plant seems to grow only in lakes with a rich organic silt bottom'. The presence of rhizoids penetrating the sediment and the close association of the plant with the bottom suggest the possibility that some or all required nutrients may be derived from these sources. The unique presence of iron within and externally on the plant also raise the interesting possibility that iron-bound phosphorus is being used. If this is the case, a mechanism for mobilizing phosphorus reserves from the sediments may be in place with recirculation back to the lake waters when the alga decomposes.

MOE (1982) reported data for tissue nitrogen and phosphorus values for *Cladophora* in Lake Simcoe. The results do not include data for the organic fraction so that while comparisons are not precise, the concentrations noted in *Dichotomosiphon* appear to be about double the reported values for *Cladophora*.

Biological, Physical and Chemical Effects

No positive evidence can be offered on whether *Dichotomosiphon tuberosus* is a new species to Lake Simcoe. The lake has been the subject of a number of biological investigations over the last half century, and one would have to surmise that if it was established at current abundance, its presence would have been documented before 1978.

Studies of periphyton growths were reported by MOE in 1975. The report concluded that periphyton constituted only a minor portion of the overall production.

Of the 15 genera identified, *Cladophora* was reported to be most common and *Dichotomosiphon* was not listed.

The eight percent of the lake bottom utilized for growth encompasses the most productive environment and could therefore exert an important influence on the overall lake condition. Qualitative observations of sediment samples collected by Ekman dredge indicated abundant benthic organisms including gammarids, may fly larvae, snails, fingernail clams, midge larvae, tubificid worms and large clams to be present in the algal mat. Quantitative information is not available that would indicate whether equivalent areas of open and covered bottom contained differing numbers or species of benthic organisms.

An important environmental quality effect could be a role played in the depletion of summer oxygen reserves in the hypolimnion. *Dichotomosiphon* appears to be released from the growth beds in the fall. While its fate at that time is unknown, it may decompose in situ or be carried by the fetch of fall storms into deeper quiescent waters occupied by the hypolimnion in summer. The February qualitative core sampling indicated it to be present from nearshore areas to at least a depth of 20 m, suggesting movement to deep water.

Benthic oxygen demand has been studied by a number of authors because of its importance in oxygen depletion (Hargrave 1972, Welch, Dillon and Sreedharan 1976, Mathias and Barica 1980, Sain 1983). Hargrave reported that sediment respiration is the major factor in oxygen depletion of the hypolimnion. MOE (1975) reported benthic respiration rates in the central basin of Lake Simcoe to be 0.65 g O_2/m^2/day, with maxima off Trout Shoal and The Narrows of 1 .8 and 3.1 g O_2/m^2/day respectively. The report commented that these values were 'not greatly out of line with the normal benthic respiration rate range'.

In order to assess whether *Dichotomosiphon* may play a role in the depletion of summer hypolimnion oxygen reserves, a calculation based on Sain's (Sain 1983) procedure of carbon to CO_2 conversion has been made by estimating the effect of the total crop on the lake's hypolimnion volume.

In developing the estimate, the following data were used:

-	estimated dry weight of *Dichotomosiphon* crop:	5,820 tonnes
-	mean total organic carbon (afdw):	50.97%
-	total volume of water below thermocline (17 m):	2.2×10^9 m^3
-	initial concentration of O_2 in hypolimnion:	8.0 mg $O_{2/}$L

Mass of Algae

10^4 g/m^2 x 56 km^2 x 10^6 m^2 = 5.82×10^9 g
(average density) x (area of coverage) x (conversion factor) = (algal mass) or
5.82×10^6 kg = 5.82×10^3 tonnes

Organic (ash-free) mass of algae

5.82×10^6 kg x 0.22 = 1.28×10^6 kg
(total algal mass) x (organic fraction) = (algal organic mass)

Total organic carbon mass

1.28×10^6 kg x 0.5097 = 6.52×10^5 kg C
(algal organic mass) x (TOC on afdw basis) = (algal organic carbon)

Oxygen demand

converting all carbon to CO_2
6.52×10^5 kg x 32/12 = 1.74×10^6 kg
(algal organic carbon) x (stoichiometric conversion factor) = (total oxygen demand).

Calculating oxygen reduction in hypolimnion

$$2.2 \times 10^{9}\ m^3 \quad \times 1000\ kg/m^3 \quad = \ 2.2 \times 10^{12}\ kg$$

(hypolimnion volume) x (density of H_2O) = (mass of H_2O in hypolimnion)

$$1.74 \times 10^6\ kg\ /\ 4.\ 2.2 \times 10^{12}\ kg \times 10^6 \quad = \quad 0.79\ mg\ O_2/L$$

(total oxygen demand) / (total lake mass) x (conversion constant to mg/L) =

(oxygen demand in mg/L)

Therefore if the total algal crop decomposed in the hypolimnion, it would account for a 0.79 mg O_2/L reduction in oxygen or about 10% of the summer oxygen resource.

A new influence adding a potential 10% of the respiration requirement of the hydrosol would represent a serious loading to a system already exhibiting periods of stress. The values derived should not be considered definitive for several reasons. The calculation does not include the oxidation of nitrogenous materials, sulfur or iron, factors that would increase oxygen demand. The calculation is based on the total crop undergoing decomposition in the hypolimnion in a fresh state. Undoubtedly only a portion of the biomass will reach the area below the thermocline and thus will have lost a portion of its oxygen demand through decomposition before the onset of thermal stratification.

It is evident that while a more sophisticated approach is required to develop a meaningful value of the influence of *Dichotomosiphon* in the summer oxygen regimes, this crude approach suggests cause for concern.

A gross approach can also be taken to evaluate the impact of the alga on the phosphorus and nitrogen resources of the lake. As both the total tonnes or organic weight (afdw) of the alga and the tissue concentration of these elements are known, the following calculations may be made:

afdw x concentration (% organic P) = total tissue content.

Phosphorus - 1.28×10^6 kg x 0.52% = 6656 kg P

Nitrogen - 1.28×10^6 kg x 5.93% = 75,904 kg N

If the phosphorus utilized by the *Dichotomosiphon* is derived from ambient lake resources, it will represent a reduction in the available supply to the phytoplankton community. If on the other hand the alga is mobilizing sediment resources which would not otherwise be exchanged, it may pump an additional 6.7 tonnes of phosphorus a year back into the ecosystem until this resource has been depleted.

CONCLUSIONS AND RECOMMENDATIONS

The current study defines the extent of *Dichotomosiphon* growth in Lake Simcoe at the present time (1983), and estimates the potential impact of this alga, when it has completed its annual growth cycle, on the dissolved oxygen regime of the lake. An estimate of the phosphorus and nitrogen content of the plant was also made, and the possible effect of recycling this material on the lake ecosystem (depending on whether *Dichotomosiphon* obtains its nutrient supply from the sediment, the water, or both) was discussed.

However, a note of caution must be introduced when relating the findings of the *Dichotomosiphon* survey to the phosphorus loading dissolved oxygen relationship in Lake Simcoe (a major goal of LSEMS).

As stated earlier, the goal of LSEMS is to reduce phosphorus loading to Lake Simcoe. A reduction in phosphorus supply can be expected to reduce phytoplankton densities and thereby improve water clarity conditions. This improved light penetration could extend the area of habitat suitable for *Dichotomosiphon* (and possibly macrophyte) growth. *Dichotomosiphon* would not likely be affected by the decreased phosphorus supply in the water since it probably obtains most of its nutritional requirements from the sediment. The subsequent decomposition of this larger biomass of *Dichotomosiphon* could negate the gain in dissolved oxygen achieved by the reduced phytoplankton biomass. The following spring, those nutrients drawn from the sediments by the *Dichotomosiphon*, which would have subsequently decomposed under winter ice cover, would become available for new plant growth, including phytoplankton.

It is evident that while a significant body of information has been collected. Further work will be required to quantify the potentially serious effects that this newly discovered influence will have on the immediate areas of growth and the areas to which it may be carried at the end of its growth cycle.

Future studies should:

- develop more precise information on possible growth areas below 10 m,
- provide a larger number of cleaner algal samples from which to derive more precise information on tissue nutrients and organic biomass,
- develop detailed biological information on sediment organisms and relationships to fish production,
- provide general life history information including seasonal production and requirements with respect to nutrients, light, sediment type, and temperature.

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Table 1: Representative temperature and light conditions at selected stations in Lake Simcoe.

Date		Station	Depth(m)	Temperature (°C)		Secchi Depth (m)
				Top	Bottom	
Aug.	17	3	15.0	22.0	12.0	2.0
"	18	5	6.5	22.0	21.5	2.9
"	22	8	7.0	23.0	-	1.9
"	23	10	3.0	23.0	22.0	2.1
"	23	12	7.0	23.0	22.6	1.8
"	24	13	5.0	22.5	-	2.1
"	25	19	7.0	22.0	-	2.3
"	25	23	8.0	23.0	21.0	2.0
	Mean			22.5	21.8	2.3
Sept.	28	15	6.0	17.5	-	2.5
"	29	13	5.0	17.5	-	2.2
"	29	29	5.0	17.5	-	2.9
"	29	5	7.0	18.0	-	3.9
"	29	28	8.5	17.3	-	3.5
Oct.	5	2	4.0	17.0	-	2.6
	Mean			17.5	-	3.0

Table 2: Summary of Lake Simcoe chemical and physical data (MOE 1982).

	Total P µg/L	DRP µg/L	Total Kjeldahl mg/L	NH_3 mg/L	NO_3 mg/L	Chloro. a µg/L	Secchi m
Station E50							
Mean	17	3.0	0.37	0.016	0.006	2.0	2.8
Range	13-26	1-7	0.35-0.39	0.006-0.038	0.005-0.010	1.1-3.1	1.5-4.5
Station E51							
Mean	16	3.0	0.38	0.017		2.0	4.4
Range	12-29	1.14	0.32-0.45	0.008-0.044	0.004-0.010	1.1-3.0	1.8-7.5
Lake Mean							
Conductivity:	330 µmho/cm^3						
Fe:	20-70 µg/L						
Thermocline:	10-12 m						

Table 3: Summary of *Dichotomosiphon* (wet weight and dry weight) biomass samples collected from Lake Simcoe.

Location	Date	Depth (m)	Volume (mL/m^2)	Wet Wt.(g/m^3)	Dry Wt. (g/m^3)	Bottom/Type
Transect 2	Aug.17	4.0	102	126	39	sand/silt
		5.0	128	99	27	" “
" 3	Sept.29	6.5	102	108	29	sand
		7.2	140	172	63	sand/gravel
		7.1	115	131	37	sand/silt
" 8	Oct.5	4.0	300	271	49	silt/debris
		6.0	166	177	33	mud/shell
		7.0	-	22	3	" “
” 13	Sept.29	4.0	414	449	113	“plastic"/mud
		5.0	153	153	31	mud/shell
		6.0	230	246	53	mud/shell
" 14	Sept.29	4.2	-	182	85	sand/shell
		6.5	115	115	53	
" 15	Sept.28	5.5	383	447	102	mud/sand
		6.0	225	291	81	" “
		6.0	225	295	54	" “
" 17	Sept.28	6.0	414	419	125	
		9.0	-	16	8	
		10.0	-	8	1	
" 19	Sept.28	6.0	319	368	121	sand/silt
		7.0	204	256	124	" “
		7.0	134	167	125	" “
" 22	Aug.31	7.0	96	96	52	sand/silt
		8.0	287	274	202	" “
		8.0	223	204	165	" “
" 23	Aug.31	7.0	479	587	329	
		8.0	351	459	251	
		9.0	223	287	161	
" 24	Aug. 25	7.0	893	727	410	sand/silt
" 29	Sept.29	4.0	102	110	26	
		4.5	128	163	52	
		5.0	319	341	95	
Station 26	Aug.31	10.0	351	482	291	mud
" 28	Sept.29	9.0	-	8	-	mud/sand
" 34	Sept. 1	8.0	446	506	148	
" 35	Sept. 1	6.5	510	618	199	sand/silt
" 36	Oct. 5	3.0	561	597	140	mud/sand
		4.0	606	678	165	mud/shell
		5.0	638	678	112	" “
		6.0	-	22	3	" “
" 37	Oct. 5	4.0	140	149	49	silt/sand
		5.0	287	340	116	" “
MEAN			294	282	104	

Mean dry weight/wet weight - 0.369

Transect: Denotes samples taken over course where diver observations made.

Station: Denotes Ekman dredge samples only.

Table 4: Summary of chemical analyses from *Dichotomosiphon* tissues; eleven Lake Simcoe samples analyzed.

Sample No.	Location	Date	%Org. (LOI)	% Total N	% Org. N	%Total P	% Org. P	% Fe	% Org. TOC
D1	Trans. 22	Aug.31	35	2.39	6.83	0.18	0.51	0.37	32.3
D2	Trans. 22	Aug.31	31	1.13	3.65	0.08	0.26	0.34	45.2
D3	Trans. 22	Aug.31	8.5	0.45	5.29	0.11	1.29	0.58	45.9
D4	Trans. 22	Aug.31	18	1.05	5.83	0.11	0.61	0.46	45.0
D5	Trans. 12	Aug.31	29	1.12	3.86	0.08	0.28	0.23	41.4
D6	Trans. 12	Aug.23	29	1.42	4.89	0.13	0.45	0.46	48.3
D7	Station 23	Aug.31	24	1.33	5.54	0.11	0.46	0.23	50.0
D8	Station 23	Aug.31	20	1.18	5.90	0.10	0.50	0.24	70.0
D9	Trans. 24	Aug.31	13	0.99	7.60	0.10	0.77	0.42	56.9
D10	Station 34	Sept.1	14	0.76	5.43	0.10	0.71	0.41	60.7
D11	Station 35	Sept.1	20	2.09	10.45	0.19	0.95	0.43	65.0
	Mean		22.0	1.26	5.93	0.11	0.52	0.37	50.97

Transect: Denotes samples taken over course where diver observations made.
Station: Denotes Ekman dredge samples only

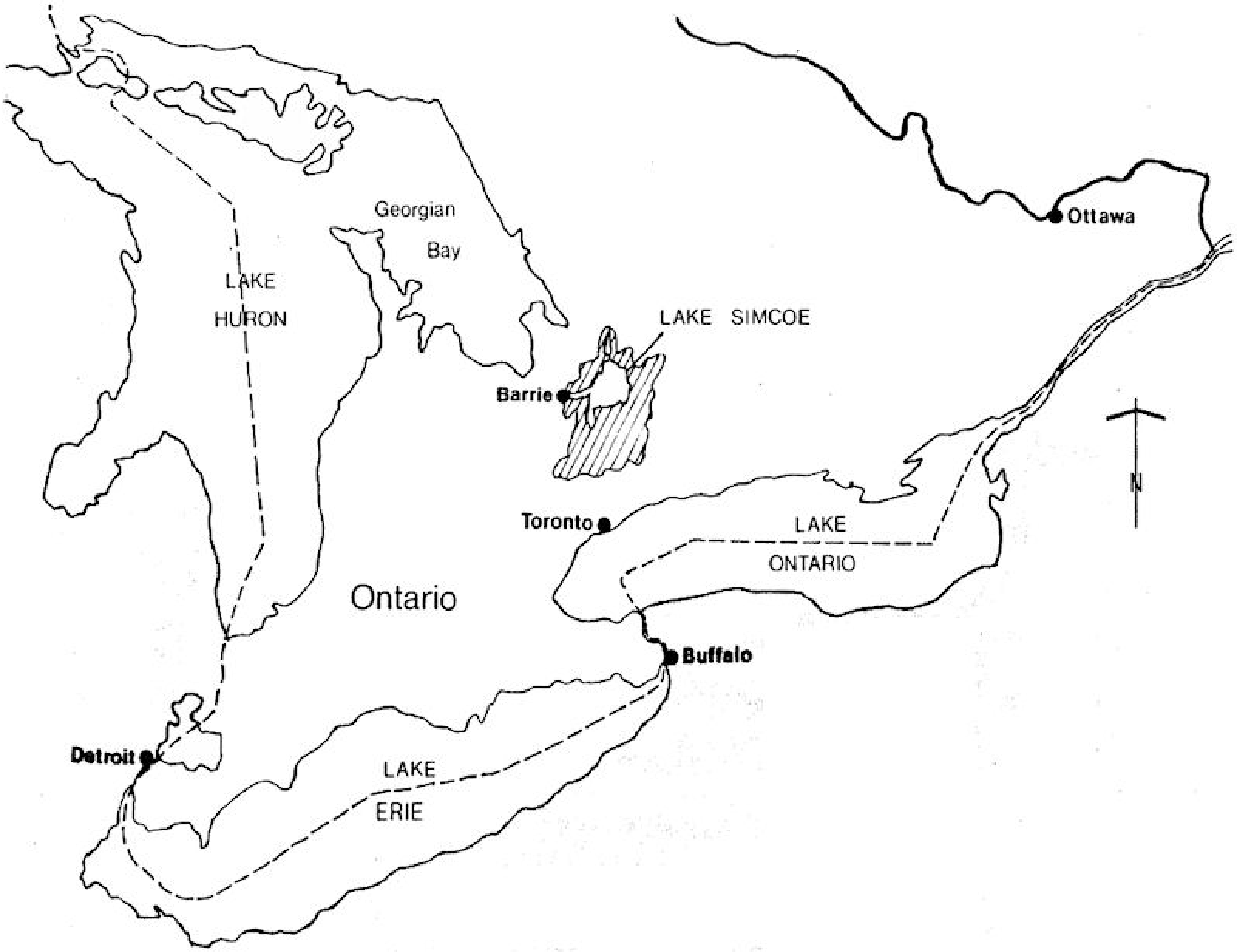


Figure 1: Location of Lake Simcoe and its drainage basin (diagonal lines) relative to the Great Lakes.

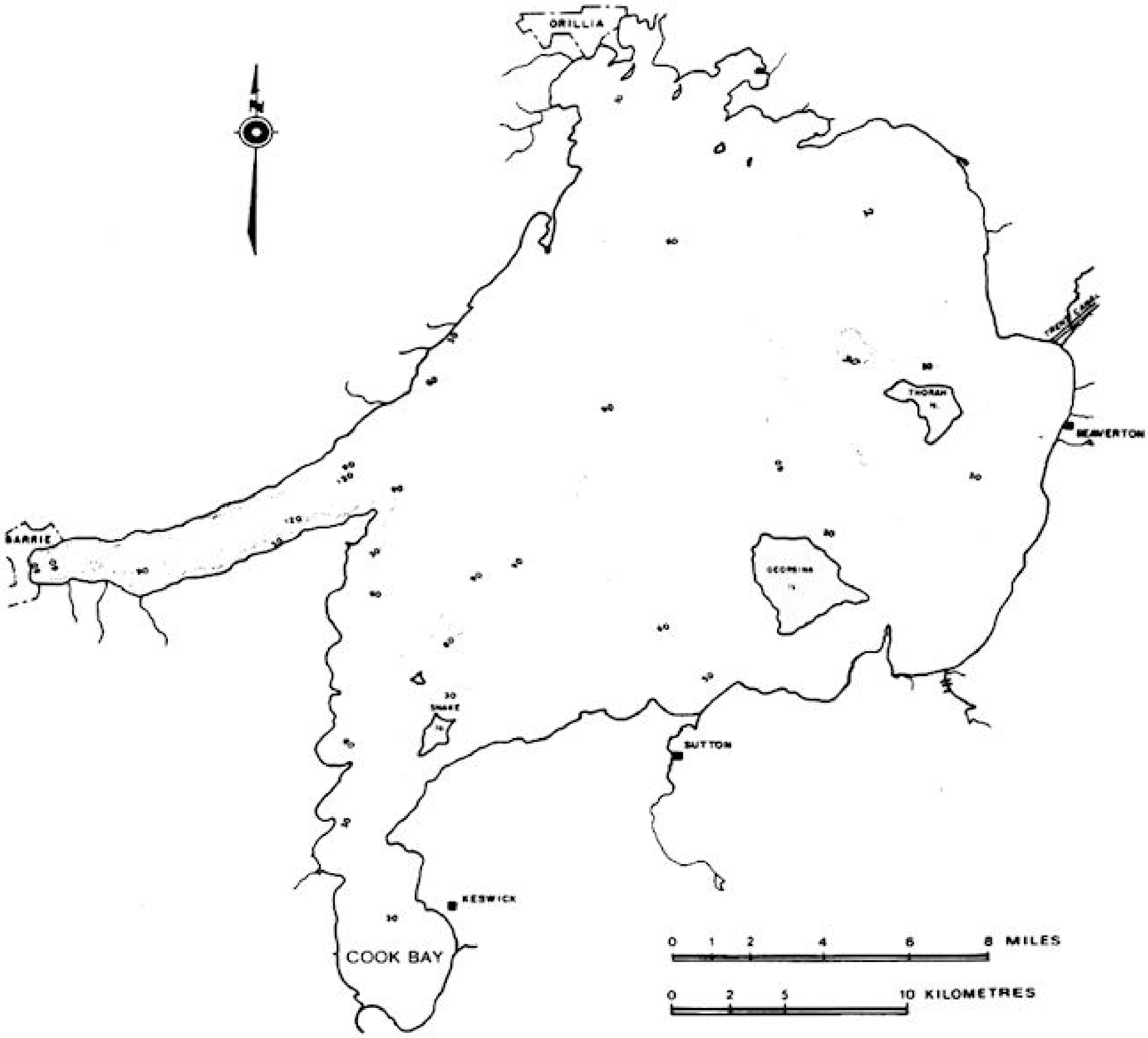


Figure 2: Morphometry of Lake Simcoe (soundings in feet).

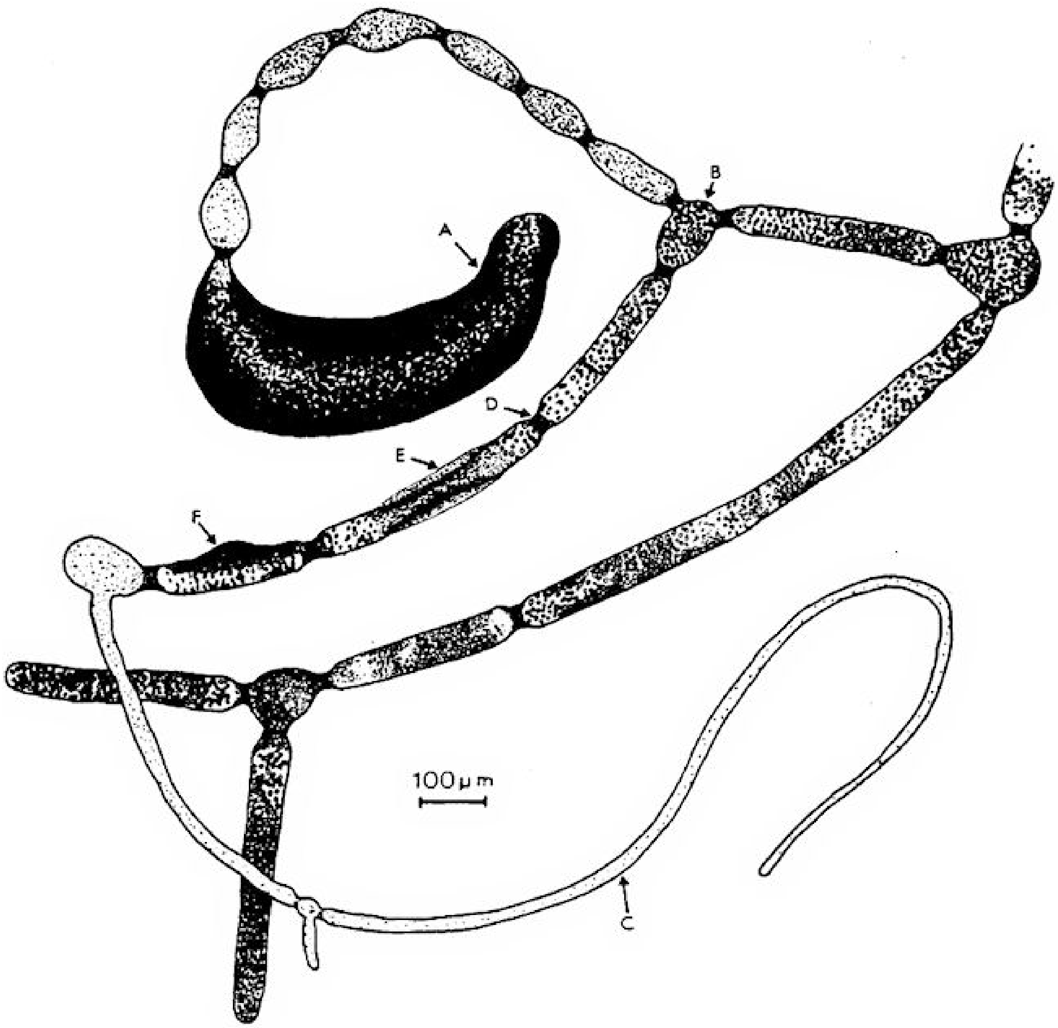
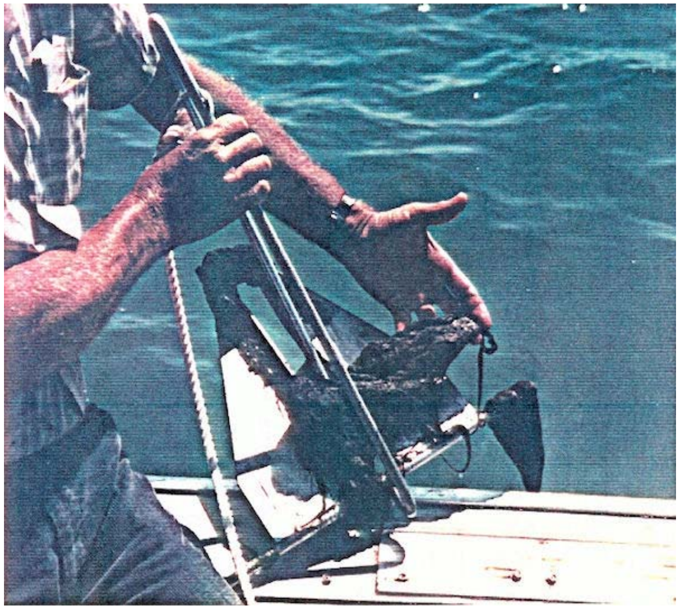


Figure 3: Portion of a thallus of *Dichotomosiphon tuberosus* from Lake Simcoe, Ontario showing a large akinete (A). the dichotomously branched filament with constrictions at the nodes (B) and at points along the length of the filament (D). The rhizoid (C), which is lacking in plastids, anchors the plant in the bottom mud of the lake. Three types of iron accumulation are illustrated at D, E and F (Nicholls and Fung 1982).



⇦ Algae collected on Anchor

A Small Dredge Sample

⇦ Algae on Sediment Surface

Fig. 4: *Dichotomosiphon tuberosus* from Lake Simcoe.

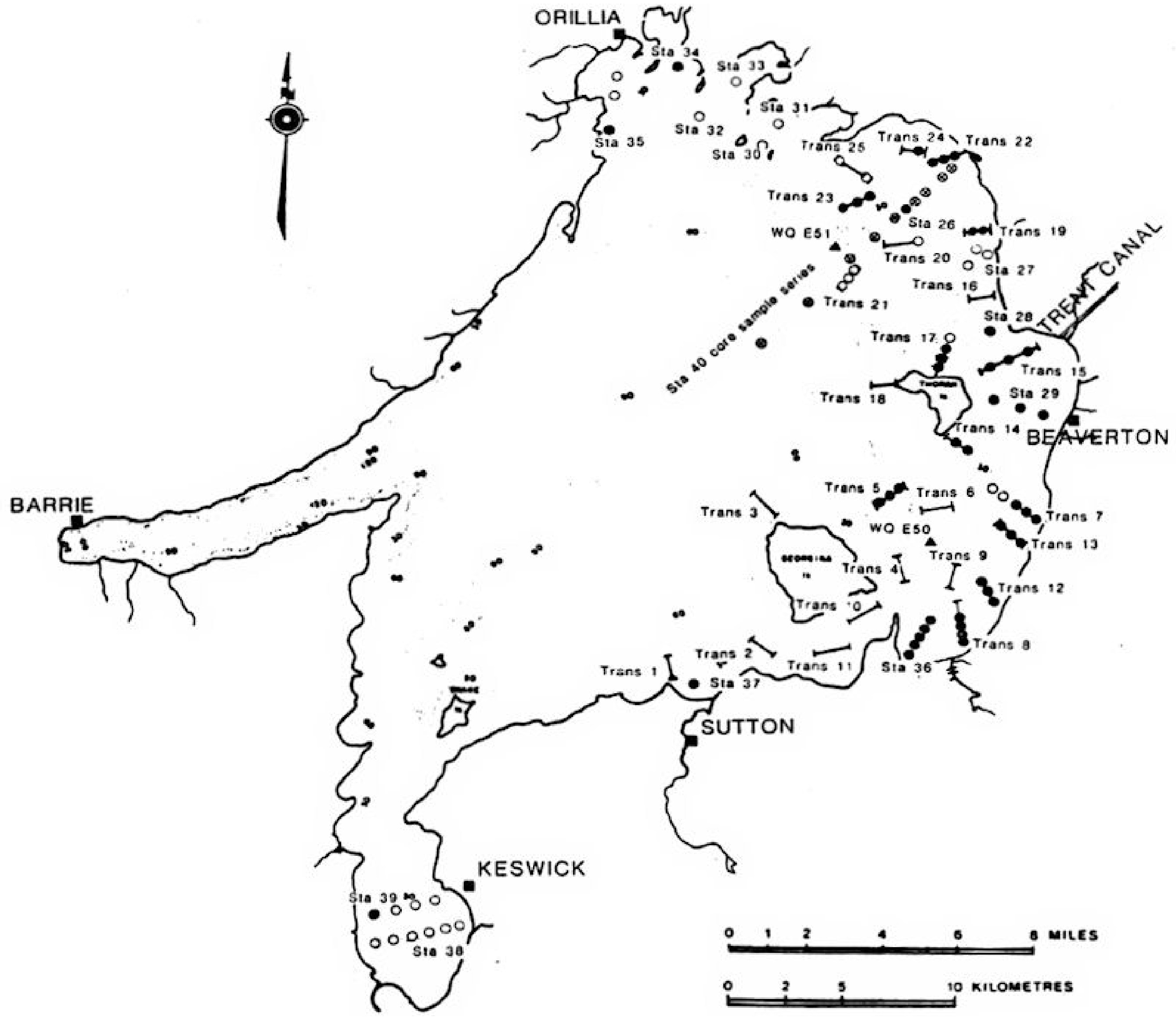


Figure 5: *Dichotomosiphon* survey locations — 1983.

Legend:	Diver bottom survey.	├─┤
	Sample collected *Dichotomosiphon* present.	●
	Sample collected no Dichotomosiphon.	○
	Winter core sample *Dichotomosiphon* cells present.	⊗
	Water quality stations.	▲

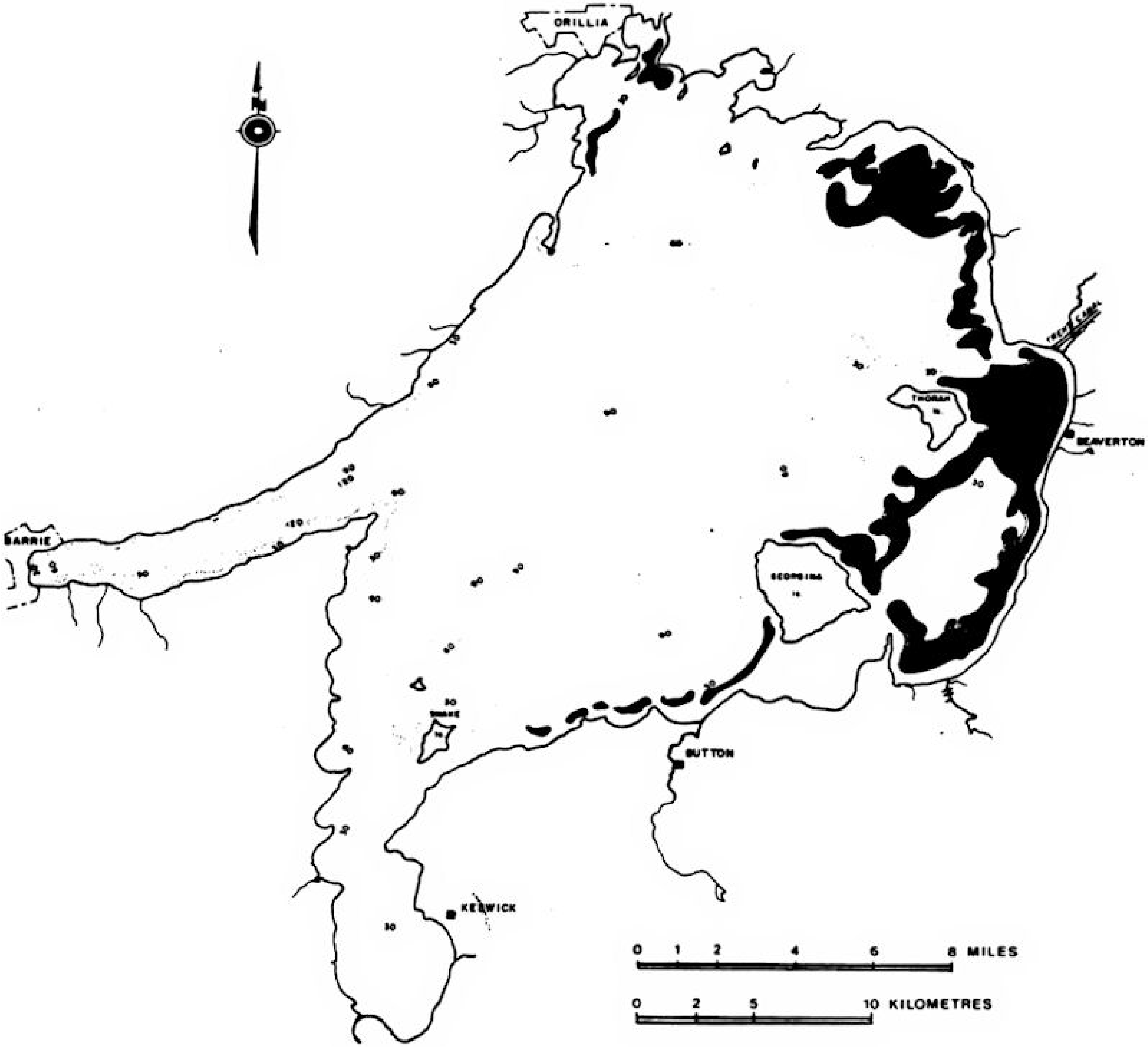


Figure 6: *Dichotomosiphon* January 28, 2013 areal distribution — 1983 (Shaded areas represent areas of growth).

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W. Lammers, Central Region, Ministry of the Environment
(Chairman and Co—ordinator)

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D. Draper, Water Resources Branch, Ministry of the Environment

R.L. Des Jardine, Maple District, Ministry of the Natural Resources

H. Gault, South Lake Simcoe Conservation Authority

R. Gregg, retired, Ministry of Agriculture and Food (past member)

D. Henry, South Lake Simcoe Conservation Authority

K. Nicholls, Water Resources Branch, Ministry of the Environment

B. Noels, South Lake Simcoe Conservation Authority

G. Robinson, Water Resources Branch, Ministry of the Environment

R. Shaw, Central Region, Ministry of the Environment

S. So, South Lake Simcoe Conservation Authority (past member)

S. Singer, Soil and Water Management Branch, Ministry of Agriculture and Food

D. Weatherbe, Water Resources Branch, Ministry of the Environment

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