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AQUATIC WEED GROWTHS

in

LAKE SIMCOE

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Some of the information in the following report will be included in a forthcoming comprehensive report dealing with water quality and its preservation in Lake Simcoe.

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INTRODUCTION

During the summer of 1971, a water quality evaluation of Lake Simcoe was carried out by several branches of the Ontario Water Resources Commission. Included in the study was an assessment of the aquatic weed (macrophyte) growths, the results of which are outlined in the following report.

The macrophyte growths were assessed for several reasons. Firstly, a number of complaints about excessive weed growths and shoreline accumulations, especially from residents on Cook Bay and Shingle Bay (Figure 1), had been received by the OWRC. It was felt that a documentation of the locations and extent of macrophyte beds could provide important information on reasons for and possible control measures of these nuisance conditions. Secondly, the management of aquatic resources for maximum public usage and minimum nuisance levels is becoming an important aspect of water-resource agencies. Studies are now being undertaken to determine the most feasible and environmentally safe method of controlling excessive weed growths. It was felt that a report describing the growths of macrophytes in Lake Simcoe could provide useful information for the application of future management techniques. Thirdly, macrophytes play an important ecological role in the production of certain species of fish and other aquatic organisms. Hopefully, the, report will be used to assist the Ontario Department of Lands and Forests in choosing suitable locations for fish stocking and will provide information for other fish-management practices.

The primary objectives of the field investigation were as follows:

1) to determine how extensive weed growth is in Lake Simcoe and outline which areas do have problems resulting from overabundant growth.

2) to determine the species composition of the weeded areas.

3) to indicate some of the factors which may be responsible for distribution and abundance.

Some Ecological Aspects

It is important to understand the significance of macrophytes in the aquatic ecosystem. Being plants, they provide one of the bases of aquatic food chains. Vascular plants serve as attachment surfaces for bacteria, periphyton and aquatic invertebrates. They provide cover and protection for warm-water species of fish and provide food for ducks and other forms of wildlife. Macrophytes also anchor the bottom by their roots and thereby lessen turbidity in stormy weather. Colorful flowering species such as arrowheads, water lilies and pickerel weeds often improve the appearance of barren shores.

Many of the aquatic plant species commonly found in Lake Simcoe have been documented as being ideal for the propagation of fish and wildlife. According to Martin and Uhle (1951), sago pondweed is probably the most important single waterfowl food plant on the continent. Species of *Potamogeton*, as well as Richardson's pondweed are also known to be excellent duck food. Cattail and bulrush are known to provide good cover and nesting areas for ducks.

The abundance and distribution of rooted aquatic plants in a lake is affected by a variety of ecological factors such as light penetration, water depth, substrate type, exposure to wave action and currents, nutrient availability, and the success different species have in extracting nutrition by roots or leaves. Growth is not totally dependent on any one factor but is a product of all the regulating factors. Usually at least one major growth factor is limiting so that a good balance is maintained in the biological community and a nuisance condition does not result. However, when all the requirements for growth are met, over-production usually results.

This normally happens in shallow areas which have a rich supply of nutrients (either naturally or through man's influence), relatively clear water, a soft mud bottom and limited wave and current action. Extensive and dense growth impairs not only the aesthetic quality of a body of water but interferes with the recreational potential for activities such as boating and swimming. Heavily weeded areas are breeding grounds for mosquitoes and are a general nuisance to waterfront and dock owners, particularly in late summer and fall when decomposing plants are washed up on shore creating obnoxious odours and an unsightly mess.

Decaying plant material contributes to the amount of decomposing organic matter present in the water thus consuming dissolved oxygen necessary to other forms of aquatic life. Residues resulting from plant decomposition in areas of luxuriant growth contribute to the gradual filling process of these places, thus enhancing the aging process.

Therefore, while a certain degree of macrophyte production is beneficial in terms of maintaining a balanced aquatic community of plants and animals, excessive growths and detrimental both to the ecological balance and to water users.

Description of Study Area

Lake Simcoe is the fourth largest inland lake in Ontario with an area of 280 square miles and 144 miles of shoreline including the islands (Rawson, 1930). It lies approximately 40 miles north of Toronto and because of this, it is one of the most important recreational sites in southern Ontario.

The shoreline is relatively short considering its area, resulting in extremely exposed shores which do not offer the shelter needed for aquatic plants to become well established. Rawson (1930) states, "It would appear that in large lakes the amount of rooted aquatic vegetation is limited by the shore conditions, since exposed and rapidly shelving shores are unfavourable for plant growth in contrast to shallow, irregular shores which support a heavy growth". He also mentions that of the 144 miles of shoreline 55% is stony. 35% sandy and the remaining 10% can support vegetation. A knowledge of the characteristics would therefore suggest that macrophyte growth should be limited throughout much of the lake.

However, a lake of these proportions does provide a variety of habitat types (including several calm, shallow bays) which provide for a large assortment of species and a great diversity between different locations regarding overall abundance and community structure.

SAMPLING METHODS AND LOCATIONS

Sampling was undertaken from July 12-23 and August 3-12. Sampling locations were established along the shoreline for the most part on a systematic basis. Locations were established along the eastern shore from McGinnis Pt. to Cook Bay as well as along the western shore from Four Mile Pt. to Cook Bay (Kempenfelt Bay excluded) at two mile intervals (see Fig.1). Two mile intervals may appear to be rather large but it was felt that, since time was limited and the shoreline sampled at this interval was much exposed and uniform, an accurate representation of the vegetation could be obtained with this sampling frequency. The sampling interval was reduced where larger amounts of vegetation were expected due to the presence of bays and "sheltered" areas.

In Kempenfelt Bay and Cook Bay, locations were fixed at one mile intervals with the exception of the lower end of Cook Bay where transects were established and sampling stations on each transect were separated by less than a mile. In Shingle Bay transects were pre-selected at regular intervals but the distance between transects was less than a mile. Three other locations in the area where chosen, one between Grape Island and Victoria Point and two near Orchard Point while the remaining locations from the narrows at Atherley to McGinnis Point were at 1 mile intervals. Five locations were established on the perimeter of Georgina Island. the largest island in Lake Simcoe. Limited time prevented the inspection of the other islands, but because all the larger islands (Thorah, Snake and Fox) have mostly sand and rock shorelines, little growth was anticipated.

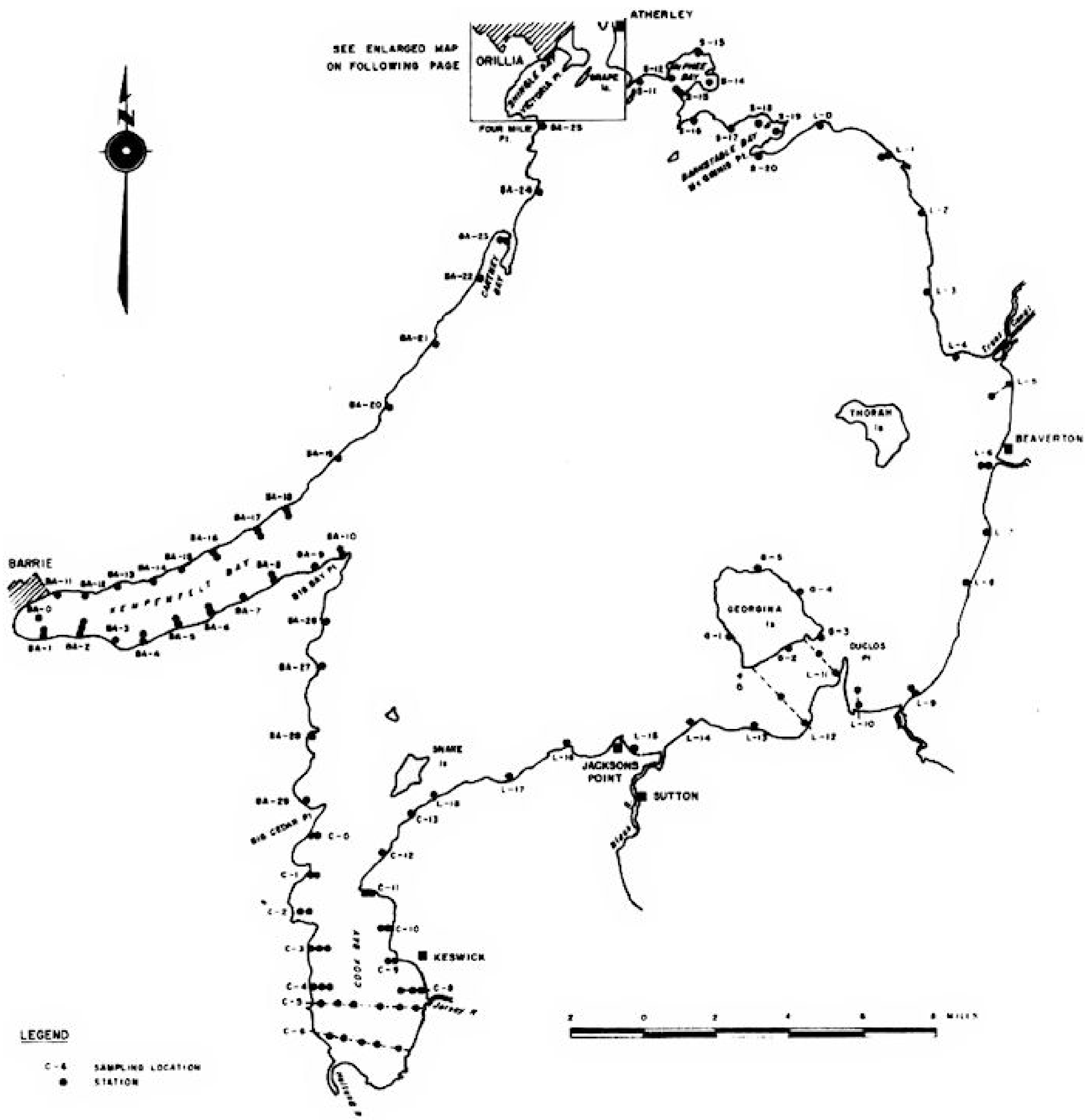

FIGURE : I LAKE SIMCOE SHOWING SAMPLING LOCATIONS AND STATIONS

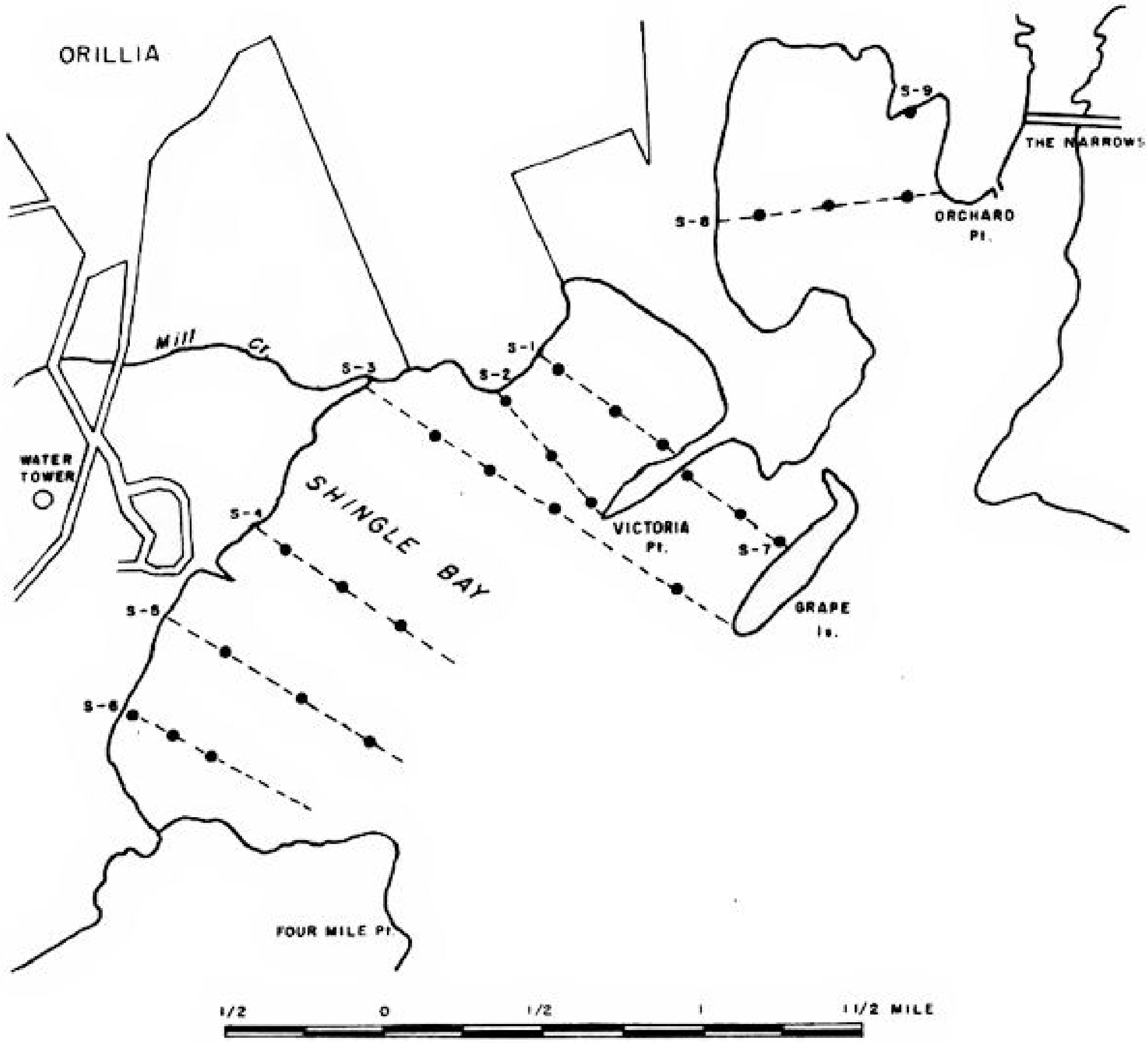

FIGURE 1. Continued

In most cases, plant growth decreased with increasing distance from shore and at each location, at least one sampling was normally undertaken in 4 to 7 feet of water where maximum growth typically occurred; these were the "a" stations. Periodically, additional stations were sampled further away from the shoreline to check variation in abundance and species composition with increased depth; these additional stations were labelled "b", "c" etc.

If growth continued across an entire bay as it did in lower Cook Bay and Shingle Bay, than a transect was made across the area and stations were established along the transect. The minimum sampling depth was sometimes governed by the size of boat (18 foot boat, 60 hp outboard) and as a result the in-shore floating or emergent aquatic plants were largely excluded.

At each station, the boat was anchored and a diver (using either snorkelling or SCUBA gear) swam around the boat at about a 15 foot radius. Specimens of each species of plant were retrieved and identified. If field identification was* not possible, the specimen was fixed in the field and then preserved in 4% formalin and returned to the laboratory for later identification. Specimens were identified according to Fassett (1969), as well as Gleason (1968) and Muenscher (1964); nomenclature is that of Fassett and Muenscher. Each species present within the circle was recorded and the abundance of individual species determined by estimating their respective densities. Density was estimated using a code similar to that used in an aquatic plant survey of the Milwaukee River Watershed Lakes (Modlin, 1970). Each species present at the station was assigned a number which corresponded to the following density code:

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* 120 cc commercial formalin. 260 cc glacial acetic acid, 4000 cc 50% alcohol, saturated with cupric acetate (25 g/L)

I. Heavy Growth - Plants formed a continuous coverage over the sampling area with little space between individuals.

II. Moderate Growth - Plants occurred in dense patches or clumps but the space between individuals could be greater than that encountered in the previous category.

III. Scattered - Plants were highly scattered with varying distances between individuals, yet growth could be abundant.

IV. Occasional occurrence - not common, usually less than 15 individual plants.

An estimate was made at each station of the percent of the bottom covered by macrophytes. Periodical checks were also made on the maximum depth to which growth occurred.

Since estimations of density and percent coverage were a personal choice, the estimates of two divers were compared several times at the beginning of the survey and the reports closely corresponded. With such a basic method, personal bias should not be a prime concern.

RESULTS

Aquatic plants representing thirteen families were found in Lake Simcoe, including sixteen genera from which twenty-four different species were identified. Some of the plants could only be identified to genus because of the lack of fruiting and flowering structures (e.g. milfoil, bladderwort, buttercup). Since different taxonomic levels will be involved throughout the results and discussion, the term plant type will be used collectively when referring to a taxonomic grouping (i.e. genus or species). For simplicity, common names will be used throughout the remainder of the text. A list of the plants encountered including both scientific and common names is presented in Table 1. Included as well in Table 1 is the frequency of occurrence for the most common types found.

Figure 2 illustrates some of the more commonly-found plant types.

The alga chara was the most frequently encountered macrophyte, occurring at stations throughout the entire lake under a wide range of growth factors. Chara was often the only macrophyte found at sampling stations, particularly where an inorganic substrate such as sand or gravel was present. Under these conditions bushy pondweed was often found co-existing with chara although neither plant was ever abundant at these stations. Chara also formed very thick dense mats where there was a soft mud bottom.

Checks on the depth at which macrophyte growth became negligible revealed that chara and coontail were usually the only plants still present in the deeper water and often grew to a depth of 7 or 8 metres in Kempenfelt Bay. It appears that chara and coontail have some different physiological characteristic which allows them to survive under low light levels.

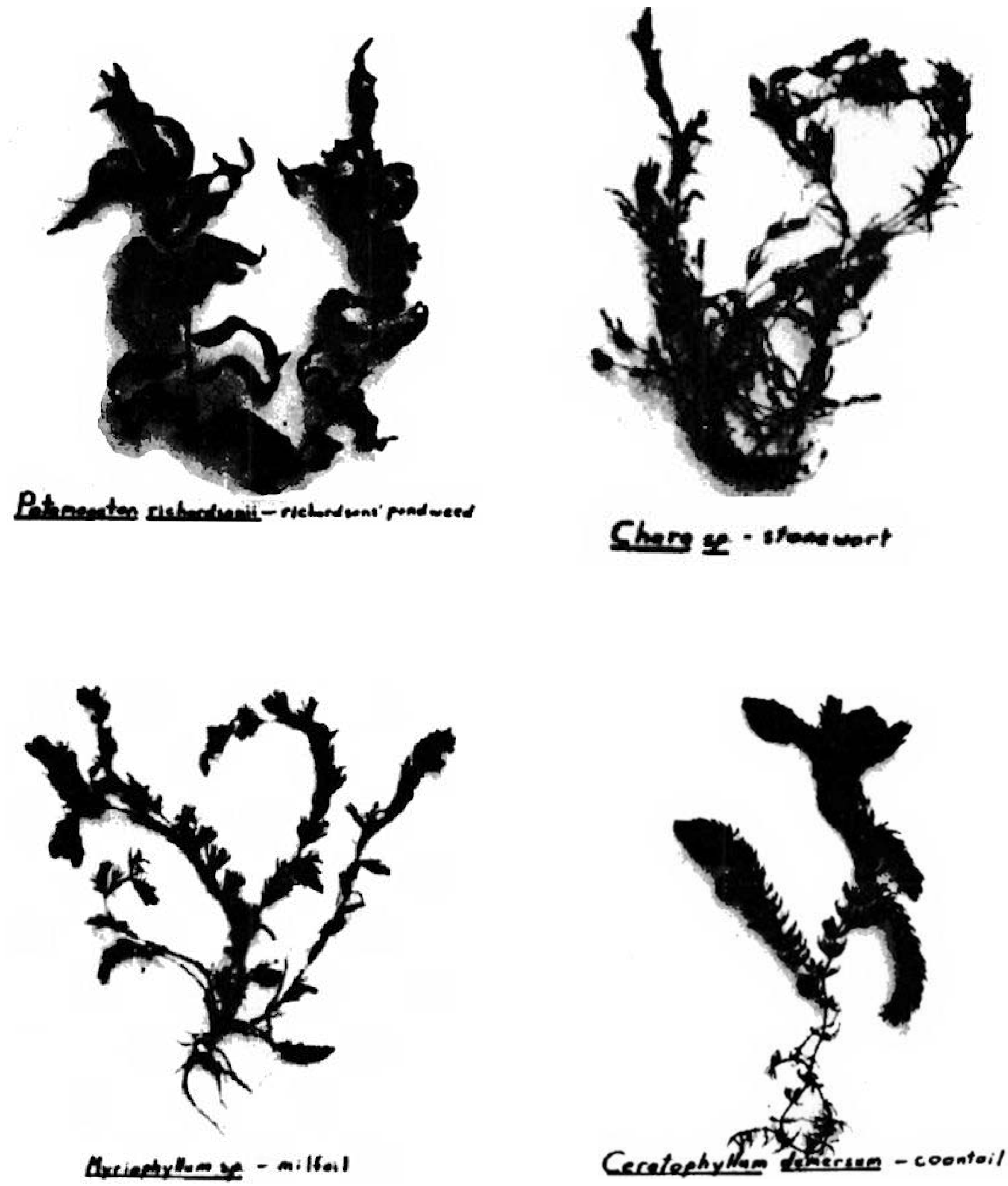

Figure 2. Pictures of some common aquatic weeds found in Lake Simcoe.

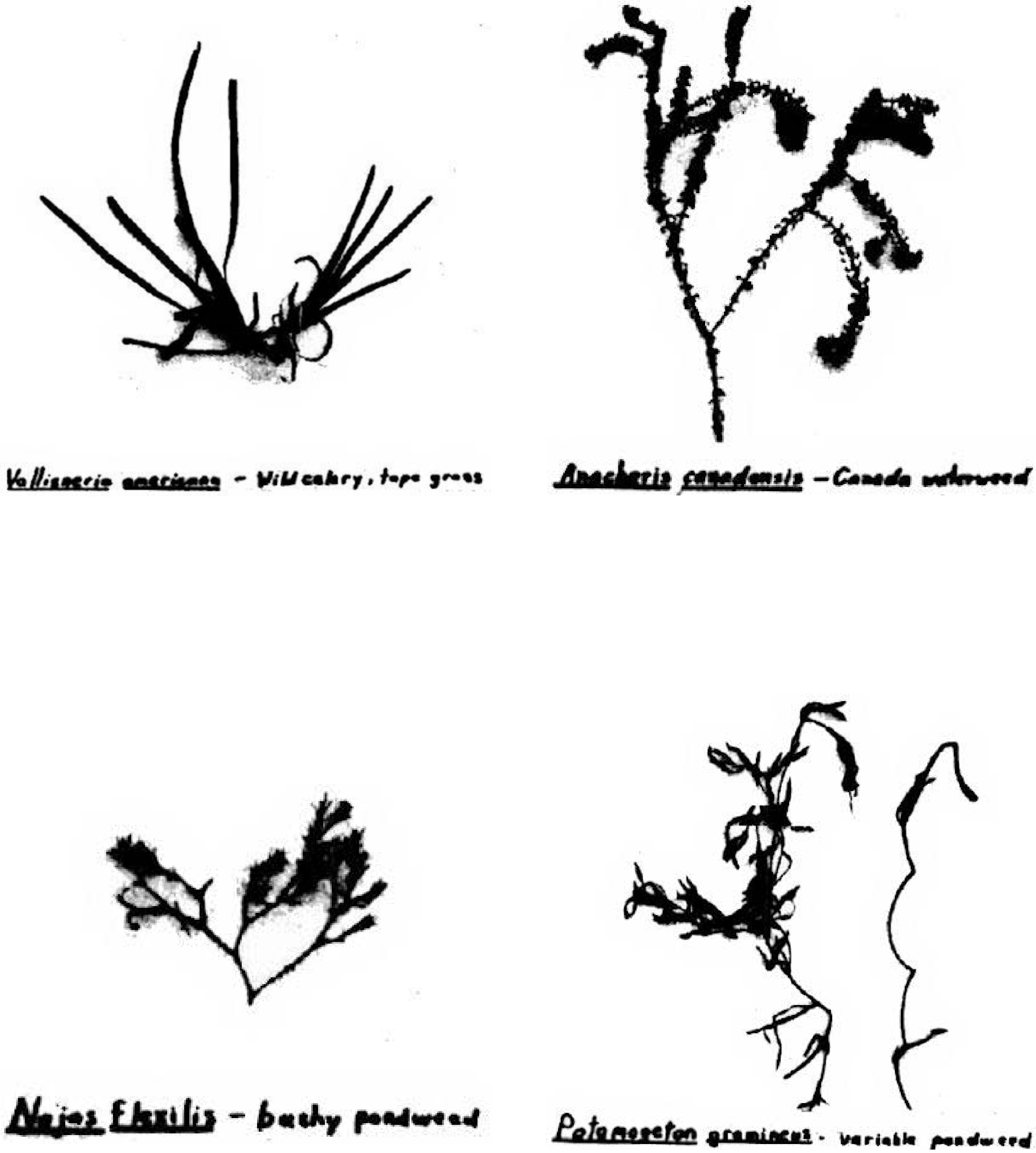

Figure 2. continued.

Figure 2. continued.

Table 1. A list of the aquatic macrophytes found in Lake Simcoe and the frequency* of occurrence of common plant types.

a. Common Species

Scientific Name	Common Name	No. Stations where found	Frequency* of occurrence %
Chara spp.	chara and stonewort	89	61
Myriophyllum sp.	milfoil	63	43
Vallisneria americana (Michx.)	tapegrass and wild celery	47	32
Anacharis canadensis (Michx.) Planchon	canada waterweed	43	30
Potamogeton pectinatus L.	sago pondweed	40	28
P. pusillus L.	slender pondweed	40	28
P. zosteriformis Fernald	flat-stemmed pondweed	40	28
Najas flexilis (Willd.) Rostk & Schmidt	bushy pondweed	37	26
Ceratophyllum demersum L.	coontail	36	25
P. richardsonii (Benn.) Rydb.	richardson's pondweed	32	22
Heteranthera dubia (Jacq.)	water star grass	22	14
P. gramineus L.	variable pondweed	21	14

* frequency of occurrence refers to the percent of the total number of stations (i.e. 145) where the plant type was found.

Table 1. Continued

b. Other Species

Scientific Name	Common Name
Bidens beckii Torr.	water marigold
Eriocaulon septangulare With.	pipewort
Lemna trisulca L.	star duckweed
Neobeckia aquatica (Eaton) Britton	lake cress
Nitella spp.	
Potamogeton americanus C. & S.	american pondweed
P. amplifolius Tuckerm	big leaf pondweed and
P. angustifolius Berchtold & Presl.	bass weed
P. crispus L.	curly-leaf pondweed
P. foliosus Raf.	leafy pondweed
P. natans L.	floating pondweed
P. praelongus Wulf.	whitestem pondweed
P. robbinsii Oakes	robbin's pondweed
P. strictifolius Benn.	
Ranunculus spp.	water buttercup
Scirpus validus Vahl.	softstem bulrush
Utricularia spp.	bladderwort

Milfoil, the second most frequently encountered macrophyte, was not as widely distributed as chara, Milfoil favoured a softer and more fertile type of sediment; the most luxuriant growths were found where the substrate was a soft muck although it was often present but not as abundant on sand-silt compositions. Chara seems to exhibit a greater adaptability to different substrates than does milfoil.

Species diversity was greatest in places where a muck bottom was present which often corresponded to areas of enrichment such as parts of shingle Bay and the south end of Cook Bay. Two stations, one in Kempenfelt Bay. the other in Shingle Bay, had 11 different plant types within the sampling area although the average for the shallow water stations in these as well as the other bays was approximately 5 to 7. Species diversity was very low along the more exposed western shore where one and sometimes two types of plants were present at any one station. Along the eastern shore the situation was similar except at locations L-10, L-11 and L-12 where Georgina Island and Duclos Point produced a sheltering effect from wave action allowing some sediment to be deposited. At these three locations an average of four plant types were found per station.

For a further description of the results. it is convenient to divide the shoreline into several areas. The selection of areas was based on similarities established from the authors general knowledge about substrate types, water quality, shoreline topography, wave action and weed growths in various parts of the lake.

1. Kempenfelt Bay

2. Western shoreline from Four Mile Pt. to Cook Bay excluding Cartney Bay.

3. Upper Cook Bay - locations C-0 to C-3 on the east side and C-10 to C-13 on the west side.

4. Lower Cook Bay - the remaining locations in Cook Bay.

5. Eastern shoreline - from Cook Bay to McGinnis Pt. plus the locations lying on exposed portions of the shoreline from there to the Narrows. (Including S-11, S-16, 517, 5-20)

6. Northern shoreline - locations in the bays from McGinnis Pt. to the Orchard Pt. area and Cartney Bay.

7. Shingle Bay - plus a transect between Victoria Island and Grape Island.

8. Georgina Island

Table 2 outlines the extent of macrophyte growth in the various areas of the lake and Figure 3 illustrates the relative abundance between areas. Averages from only the "a" stations are included in Table 2 and Figure 3 except for areas there transects were used (i.e. Shingle Bay and Lower Cook Bay) in which case information from all the stations was averaged.

The most common species for each area are presented in Table 3 strictly on the basis of highest frequency of occurrence. Some species may occur frequently within the sampling areas but be present in negligible amounts so that the frequency of occurrence does not indicate the most abundant species.

Table 4 illustrates the most abundant plant types found in each area. For each shoreline area, all species which were given density ratings of I and II (explained on page 6) are listed in the table. Normally, each sampling station had only one and sometimes two plant types with a rating I or II - no doubt a result of crowding and competition for growth factors.

Table 2. The extent of macrophyte growth in various shoreline areas in Lake Simcoe ("a" stations only).

Area	% Bottom Coverage	Condition (See scale)
Kempenfelt Bay	17.8	Sparse
Western Shore	1.3	Limited
Upper Cook Bay	34.6	Moderate
Lower Cook Bay	80.0	Very heavy
Eastern Shoreline	10.9	Sparse
Northern Shoreline (sheltered portions) + Cartney Bay	51.4	Abundant
Shingle Bay	54.9	Abundant
Georgina Island	20.0	Sparse

Scale

0-10% - Limited

10-20% - Sparse

20-40% - Moderate

40-60% - Abundant

60-80% - Heavy

80-100% - Very Heavy

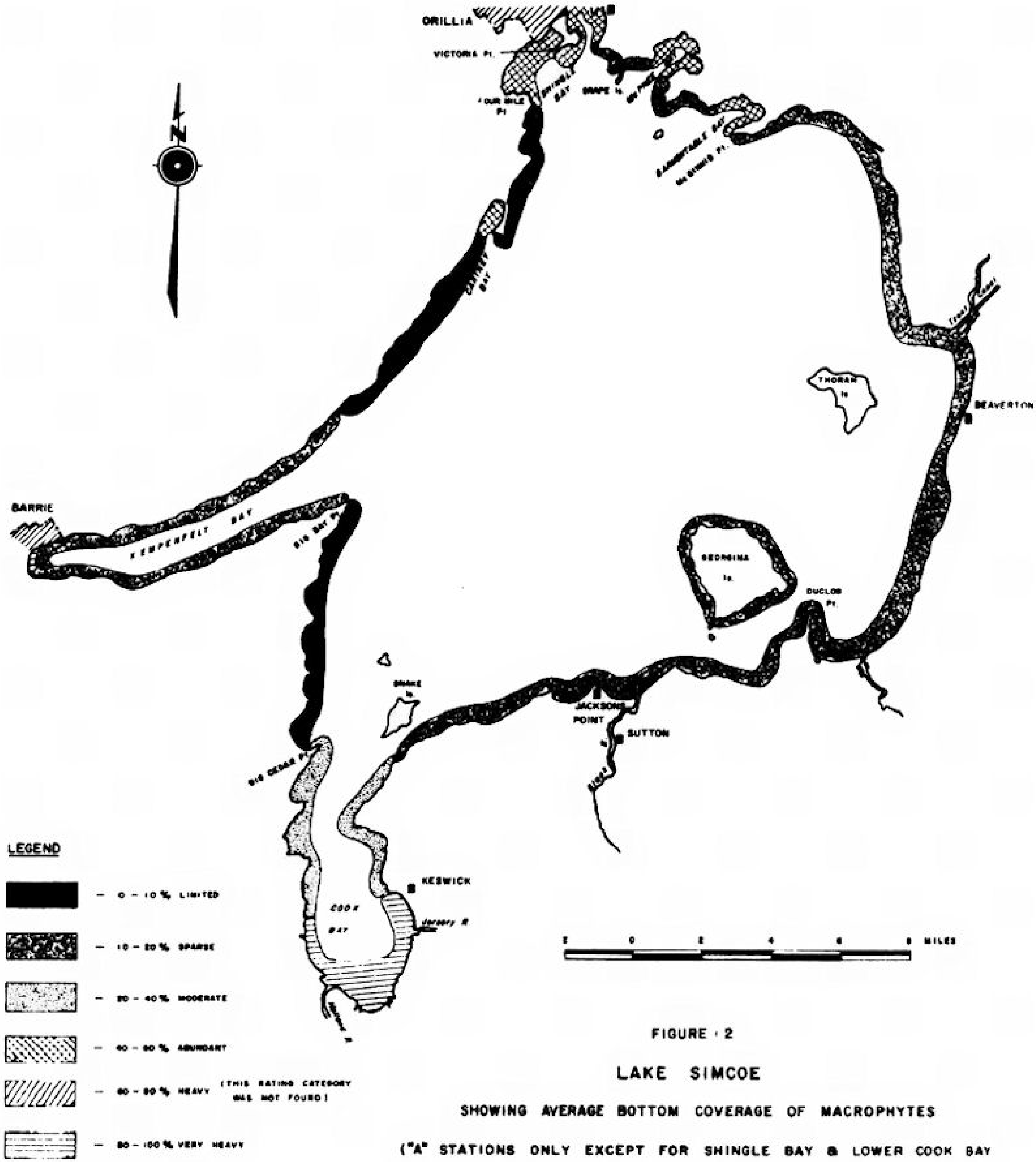

FIGURE 2

LAKE SIMCOE

SHOWING AVERAGE BOTTOM COVERAGE OF MACROPHYTES

("A" STATIONS ONLY EXCEPT FOR SHINGLE BAY & LOWER COOK BAY

Table 3. Most frequently encountered species in each area.

Area	Number of stations in area	Species	Number of stations at which was species present
Kempenfelt Bay	27	chara	22
		milfoil	22
		sago pondweed	17
		variable pondweed	11
Western Shore	10	bushy pondweed	3
		chara	3
		sago pondweed	1
		flat-stemmed pondweed	1
		no plants	5
Upper Cook Bay	15	chara	14
		bushy pondweed	8
		flat-stemmed pondweed	8
		wild celery	8
Lower Cook Bay	19	milfoil	13
		chara	11
		flat-stemmed pondweed	12
		wild celery	10
Eastern Shoreline	30	chara	12
		bushy pondweed	8
		variable pondweed	5
		no plants	14
North Shore	15	chara	11
(sheltered portions)		wild celery	9
+ Cartney Bay		canada waterweed	8
		milfoil	7
Shingle Bay	22	slender pondweed	16
		Canada waterweed	14
		coontail	12
		milfoil	12
		chara	11
		water stargrass	11
Georgina Island	5	chara	2
		no plants	3

Table 4. A listing of the most abundant plant types in each area.

Area	Number of Stations in Area	Species	Number of Stations Where Species Received Density Rating of 1 or 2
Kempenfelt Bay	27	chara	1
		milfoil	2
Western Shore	10	(no species given ratings of 1 or 2)	
Upper cook Bay	15	chara	7
		bushy pondweed	1
		coontail	1
Lower Cook Bay	19	chara	9
		flat-stemmed pondweed	6
		slender pondweed	3
Eastern Shore	30	chara	6
North Shore (sheltered portions + Cartney Bay	15	chara	5
		milfoil	1
Shingle Bay	22	slender pondweed	8
		chara	6
		sago pondweed	3
Georgina Island	5	chara	2

DISCUSSION

The results of this survey revealed that most of Lake Simcoe has a very small crop of aquatic weeds. The eastern and western shorelines which constitute the major portion of the shoreline have the lowest percent coverage 10.9% and 1.3% respectively. Kempenfelt Bay, which has the longest shoreline of the bays, has a relatively low coverage value of 17.3%. The areas where macrophyte growth is substantial - Cook, Shingle, McPhee, Barnstable and Cartney Bays make up a small proportion of the total shoreline.

Western and Eastern Shores

Macrophyte growth along the exposed western and eastern shores of the lake is limited largely by the physical characteristics of the lake. Lake Simcoe is of glacial origin and has a limestone bedrock. On both the east and west sides, much of the inshore area consists of boulders and coarse gravel and vascular aquatics are practically non-existent. Often in these areas there are pockets of sand and silt between the boulders.

In the area from Kempenfelt Bay to Four Mile Point, every station was rocky with some small pockets of silt and sand. From Kempenfelt Bay to Cook Bay the substrate was composed of less rock and more sand.

It is evident that rooted plants cannot anchor properly in a sand or gravel substrate. Also, this type of substrate is basically inorganic and has a very limited supply of plant nutrients. Although there is some controversy whether rooted aquatic plants do in fact fulfil their nutritional requirements by uptake of nutrients from the sediments using their roots or by nutrient diffusion from the surrounding water through their vegetative parts, there is evidence that nutrient uptake by the roots is important for plant growth. Boyd (1967) concluded from a literature review that the roots of hydrophytes absorb nutrients and suggested that nutrient uptake by the roots has an important effect upon plant distribution but that the relative importance probably varies among species and environments. Studies conducted by the Tennessee Valley Authority (Peltier & Welch, 1968) showed that sago pondweed had much higher growth rates in sediment than in sand. Martin and Clements (1968) showed that bushy pondweed did not grow well when rooted in sand regardless of the nutrient concentration of the water. It therefore appears that the accumulation of sediment rich in nutrients may be a prime factor influencing plant growth and distribution.

Another important environmental limitation on the western and eastern shores and one which is largely responsible for the harsh substrate is wave action. No doubt the eastern shore is affected by heavy wave action more so than the western shore because of the prevailing west winds. Waves gouge the shoreline and cause a rock and gravel shelf to be found while the finer particles are deposited in deeper water. This leaves a rocky barren area which can extend out from shore a considerable distance (e.g. the area from Kempenfelt Bay to Four Mile Point).

Often at stations where conditions were similar to those described above a check was made further out from shore to determine whether deposition of sediment had taken place in slightly deeper water which was still shallow enough to allow adequate light penetration. In almost all cases if a barren substrate such as a pure sand or rock area existed, it extended outwards until the water increased rapidly in depth preventing plants from becoming established.

Wave action not only hinders the accumulation of fine sediment and nutritive organic matter but it keeps shifting the coarser sediments and this also inhibits rooting. The eastern shore from Cook Bay to McGinnis Pt. plus the exposed sections of the shore from there to the Narrows presented this type of situation.

The eastern shore has extensive shallow sandy area which were sparsely populated by weeds. Although the average percent cover for the east side of the lake is somewhat higher than for the west side (see Table 2) growth is still negligible.

Several locations in the Georgina Island-Duclos Point region receives shelter from wave action and as a result the deposition of sediment offers a softer and more nutritive substrate than the pure sand and rock bottom typical of most of the east shore. Higher percent coverage values for these locations slightly affected the average for the entire area.

On both the east and west shores, chara and bushy pondweed were the most commonly encountered species. This is probably due to the similarity of conditions in the two areas. No plant types were abundant on the west side of the lake while chara was the only macrophyte reaching densities of any significant degree on the east side of the lake.

Kempenfelt Bay

The small increase in the amount of vegetation compared to the exposed east and west shores is undoubtedly affected by several factors. Kempenfelt Bay, due to its isolated position is not subject to as intense wave action. As a result, sediment has been deposited close to shore so that aquatic weeds can become established. Although for the most part the shoreline is rocky, the substrate in the littoral zone of the bay is a sandy-silt composition. This type of bottom may not be as rich in nutritive material as a substrate composed of organic matter (e.g. mud) but does offer more nutrient value than gravel or pure sand as well as being more easily penetrated by roots.

A biological survey of the bay conducted by the OWRC in 1970 revealed that the western part of Kempenfelt Bay is more enriched than the open lake. This enrichment could be reflected by an increase in productivity and standing crop of aquatic weeds. As no background information is available it is not known where the status of the bay has changed from previous years with regards to weed growth.

Chara, milfoil, sago pondweed and variable pondweed were the most frequently encountered macrophytes. Chara and milfoil were the only plant types which were ever abundant. At most stations in the bay the vegetation was not dominated by any one species. This is illustrated by the fact that chara and milfoil received only a few high density ratings.

Northern Shoreline (sheltered areas plus Cartney Bay)

Cartney Bay has been included in this area as it is typical of the western shoreline where it is found, yet similar to the other bays in the north of the lake. This region contains several bays - Barnstable, McPhee, Cartney and a smaller bay near Orchard Point.

Growth in this area was quite abundant as indicated by the percent coverage value of 51.4%. These bays are not subjected to the forceful water movements found along the more exposed shorelines and as a result, organic matter and sediment has been extensively deposited. At most stations the substrate consisted of a soft mud. The quieter water, soft rich substrate and extensive shallows are major factors in promoting the development of dense stands of rooted weeds.

The common types of weeds encountered differed from the areas previously discussed as might be expected considering the different conditions present. Chara was again the most common macrophyte in the area while wild celery, canada waterweed and milfoil were also prevalent. Wild celery and canada waterweed are common constituents of the communities found on soft organic substrates. Chara and milfoil were the only plant types which were abundant in the area.

COOK BAY

Luxuriant growth of aquatic plants has been a seasonal occurrence in Cook Bay for a considerable length of time. Complaints concerning shoreline accumulations of decomposing weeds have been received in previous years and reports from local residents suggest that it has occurred annually for a number of years. Figure 4 illustrates accumulations of decomposing aquatic weeds along the southeast corner of cook Bay in early September, 1971.

Lower Cook Bay which has a percent bottom coverage of 80% is the most heavily weeded area in the lake. Two transects at the lower end of the bay (Figure 1) revealed that this area had profuse growth from shore to shore.

There are several reasons why macrophyte growth is so heavy in this region. Throughout the southern portion of the bay, the water is shallow - usually not exceeding 10 to 12 feet and averaging less. Although the water is often turbid during periods of stormy weather, which stirs up the soft muck bottom, the growth does not appear to be limited by the lack of light. Also, the Holland-Schomberg River System which is usually quite turbid and rich in nutrients flows into the south end of Cook Bay. This watershed drains a heavily-used agricultural area (i.e. the Holland Marsh) and receives the treated municipal wastes from Newmarket and Aurora. As the Holland River enters the bay, suspended material is discharged and settles to the bottom throughout the lower part of the bay.

Depending on the size of the particles in suspension, sedimentation may be prominent for some distance from the mouth. This sedimentation process has allowed a rich soft substrate to accumulate, thus enhancing conditions for weeds. Each season as weeds die more organic matter is contributed to the substrate and nutrients made available for plant growth. Gessner (1959) found that the buildup of organic sediment may be an important factor for potential weed problems each year. The nuisance situation present in Lower Cook Bay has been a result of a gradual filling and enrichment process. In the future this problem may become amplified as the processes continue unless preventive measures are taken which will be discussed later in the text.

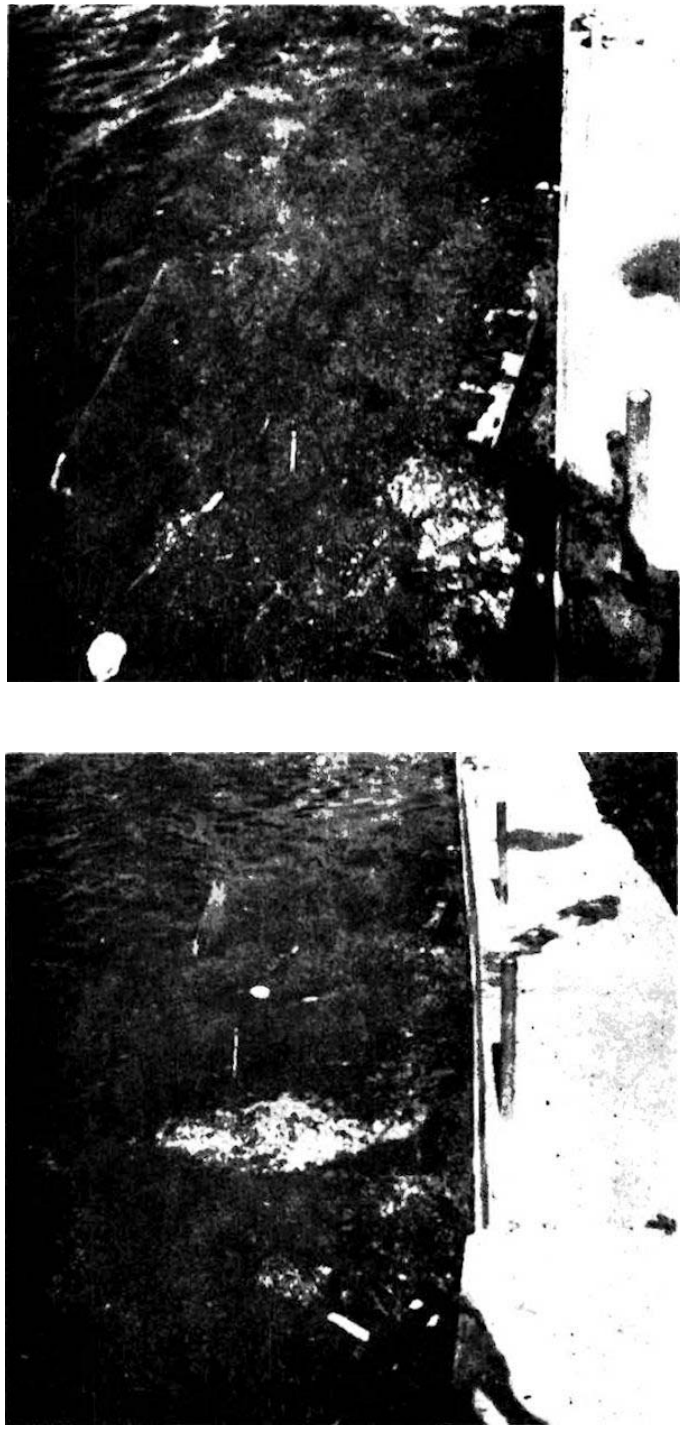

Figure 4. Decomposing accumulations of aquatic weeds in the south-east corner of Cook Bay (September, 1971).

Species distribution and abundance were somewhat different in this area from those already discussed. Milfoil was the most frequently encountered species with flat-stemmed pondweed, chara and wild celery found with almost the same frequency. Chara was also the most abundant species in this area.

It is interesting to note that while chara was often one of the only plant types found in the more barren areas of the lake, it also occurred in dense mats where the substrate was a soft mud. Laboratory studies by Forsberg (1964) showed that charophytes are sensitive to high phosphorus concentrations and that "the sensitivity to phosphorus can explain its absence in very eutrophic waters and its disappearance from polluted localities". The fact that this alga is abundant in Lower Cook Bay suggests that water quality is perhaps not as enriched as the over-all abundance of vegetation may suggest and that the problem may lie in the enriched sediment. Flat-stemmed pondweed and slender pondweed were the other species which were abundant. These two species were two of the more common plants found in the lake, occurring at 28% of the total number of stations. However, these species were only profuse in enriched areas where an organic muck was present as in Lower Cook Bay and Shingle Bay.

The most southern portion of Cook Bay which was very shallow (1-3') was not able to be sampled due to the size of the boat which was used. Visual observation revealed that broad stands of soft stem bulrush and cattail were prevalent.

Upper Cook Bay showed a change in abundance and type of vegetation found. The percent coverage for this area of 34.6% is a great deal lower than that for the southern part of the bay. One reason is no doubt due to heavier wave action which hinders the deposition of fine sediments necessary for a fertile substrate. The bottom type in this area, particularly the eastern shore was usually a sandy-silt with some stations having mixtures of gravel and clay. The western side had several stations with a mud bottom. According to Butcher (1933) "the chief factor governing the quantity and variety of macrophytic vegetation is the deposition of silt and suspended matter from the water and the extent of removal of the substratum by waves or currents". It is likely these factors are instrumental in causing a decrease in macrophytic growth in this area. Due to the distance from the mouth of the Holland River the amount of suspended matter would be much less than in the lower part of the bay. The upper bay receives some of the effect of the nuisance condition in the lower bay when waves wash uprooted and dead vegetation onto the shores in this area to decompose.

SHINGLE BAY

Shingle Bay is the only other large area where aquatic weed growth reaches a nuisance state. Although the average percent coverage is somewhat lower (54.9%) than for Lower Cook Bay, a problem of excessive growths and shoreline accumulations does exist. The figure of 54.9% was lowered by some stations which were located on hard-packed sand or clay, thus making rooting difficult. Also, some stations were in fairly deep water (10-15') as information on the extent of growth in the deeper part of the bay was desired. However, most of the shallow areas of the bay have extremely dense growth of macrophytes, particularly the north-east corner where percent cover averages approximately 90%.

Transect S-3 showed the bottom in the vicinity of Mill Creek to be of hard-packed sand and in deeper water, clay. Stations on this transect showed almost no growth at all compared to stations nearby on transect S-4 which had 80-100% bottom coverage, mainly because of the soft sediment. Mill Creek which receives sewage effluent from the Orillia treatment plant empties into Shingle Bay. It is likely that this material is contributing to the enrichment of the bay and thus facilitates weed growth. The inner part of the bay is very sheltered and escapes the vigorous wave action the shores outside the bay receive so that throughout most of the area a mud bottom has developed. Wave action washing weeds up on the shore may not be as great a problem as in Cook Bay but decomposing weeds remaining in the water may lower dissolved oxygen values and contribute to the enrichment of the near-shore substrate.

Unlike most of the other areas, slender pondweed was the most frequently encountered and most abundant species in Single Bay - especially in the north-east corner where it received a density rating of 2 at 5 out of 6 stations. Chara was also abundant but was not evenly distributed throughout the bay which may reflect a deterioration in water quality. Coontail and canada waterweed were not abundant but were very common and widely distributed throughout the bay. These two species seem to appear regularly in enriched areas and are common problem weeds around docking areas. Coontail which does not root and anchors only weakly is found in quieter waters such as silted bays. Sago pondweed is common on silty substrates and was the other species along with chara and slender pondweed which was most abundant.

GEORGINA ISLAND

Georgina Island has a shoreline which except for the southern side is rock and gravel and supports almost no plants. The southern side being somewhat more sheltered from heavy wave action has a sandy substrate. The near shore area has broad strands of softstem bulrush, while the offshore submergent community supports several different species, chara being the only one in abundance. The remainder of the islands in the lake were not able to be sampled but visual observation revealed that the shorelines were very rocky and therefore supported negligible amounts of rooted vegetation.

REMEDIAL MEASURES

While it is economically unfeasible and ecologically unsound to destroy large areas of aquatic weeds, there are the following methods available to limit the growth in local areas of a lake:

1) mechanical cutting or pulling
2) bottom covers - polyethylene sheeting **and/or** gravel
3) dredging

4) herbicides

1) Mechanical Cutting or Pulling

Many cottagers use hand rakes, chains and hand-pulling techniques to reduce macrophyte growths and improve local shoreline areas for swimming, boating and skiing. Disadvantages of these techniques is that they are time consuming and must be repeated two or three times during the growing season for satisfactory control. Also, the vegetation in only small areas can be controlled. However, such a system involves practically no cost and the removal of small patches of weeds should not significantly damage the ecological balance.

On a larger scale, mechanical weed cutters are now available for hire which can cut a number of acres per day. This method is commonly used to provide weed-free channels for boat traffic.

With any type of mechanical removal of weeds, the plants removed should not be left in the water to wash up and aesthetically ruin other shore front areas.

2) Bottom Covers

Weed growths in small beach areas can also be largely eliminated either by laying polyethylene sheeting on the sediment, or by dumping gravel in the area of concern. These methods are particularly suitable in places where the sediment is reasonably firm so that the covering material does not disappear into the mud.

3) Dredging

Dredging is frequently employed by marine operators to provide a dual function of increasing water depth for boat passage, and temporarily remove weed beds. However, dredging is relatively expensive and can have undesirable effects on water quality. Because the bottom macroinvertebrates are largely restricted to the top few inches of sediment, dredging an area will temporarily eliminate the bottom invertebrates - many of which may be important fish-food organisms. Also, turbidity problems usually result in the areas being dredged as well as at the disposal site if the dredgings are disposed of in deeper water. Floating weeds at the disposal site can also cause aesthetic problems as they are washed ashore. Ideally, dredging spoils should be disposed of on land, but considerable additional expense is involved.

One big advantage of controlling weed growth by dredging is that the aging and eutrophication processes can be reversed. However, if the dredge spoils are deposited in the same basin, the relief from macrophyte growth in one area of the basin may promote problems in another.

4) Herbicides

Many aquatic weeds can effectively be controlled by seasonally applying a herbicide. While the cost of a herbicide treatment varies considerably depending on the type of vegetation, one of the most commonly used herbicide costs approximately sixty dollars per acre (chemical cost only).

The use of aquatic herbicides has several significant disadvantages. Firstly, there is a growing concern and opposition to the use of all pesticides and herbicides because of past experiences (e.g. DDT and 2,4,5-T). While the herbicides recommended by the OWRC are not "hard" and breakdown quite rapidly, controversy exists as to whether any pesticide or herbicide can be tested sufficiently to ensure a complete absence of side effects. Also, there is always the chance that an "over-dose" of chemical will be applied with the resulting unwanted side effects (e.g. fish kill). Another problem with herbicide control is that the weeds remain in the water and as they decompose, dissolved oxygen can be severely depleted and nutrients are released to the sediment and water.

However, it is realized that there are many localized areas where weed growths seriously impair water for recreational purposes and that the use of herbicides is often the most feasible control method. The OWRC therefore operates a permit system* which regulates the use of herbicides.

It should be pointed out, however, that the above mentioned control measures can only provide short-term relief to local areas. Long-term control of macrophyte production will have to become an integral part of an over-all management scheme for Lake Simcoe. The future management of macrophyte production will probably involve the nutrient-production concept. It is generally understood that high nutrient inputs to a lake will stimulate aquatic plant growth. Therefore, controllable inputs will have to be kept to a minimum and the cities of Barrie and Orillia are already taking steps to remove phosphorus from their sanitary sewage. Also, it is possible that plant harvesting techniques can be applied to problem areas (Cook Bay, Shingle Bay) so that repeated harvests provide temporary relief as well as long-term relief by draining nutrients from the water. Perhaps in situations like Lower Cook Bay, the fishery is actually being impaired by an over-abundance of macrophytes in which case a harvesting program would improve the fishery as well as improving recreational values.

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* Permit application forms can be obtained by writing to the Biology Branch, OWRC, P.O. Box 213, Rexdale, Ontario.

SUMMARY

1. The main shoreline of Lake Simcoe is relatively free of weeds due to exposure to wave action hindering the accumulation of sediment.

2. Heavy weed growths occur in several small areas - Lower Cook Bay, Single Bay, Barnstable Bay, McPhee Bay, Cartney Bay and the Narrows.

3. Chara and milfoil were the most common and abundant macrophytes in Lake Simcoe.

4. The most dense and diverse growths of rooted aquatic plants occurred where there was a soft muck bottom which facilitated rooting.

5. Although the aquatic weeds play an important part in the aquatic ecosystem, over-production decreases recreational potential and perhaps hinders the development of a desirable type of fishery. Management policies are now being considered which are aimed at developing water resources for maximum public usage. It is hoped that information in this report will be used as a basis for determining suitable management techniques for Lake Simcoe.

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