Productivity of Aquatic Macrophytes and Associated Periphyton in Lake St. Clair: A Data Report

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Abstract

This study was conducted in 1979 and 1980 to define the contribution of aquatic macrophytes to fish production in Anchor Bay, Lake St. Clair. Macrophyte surface area, dry weight, ash-free dry weight, and net productivity were measured. I describe the methods used in the study and summarize the data collected.

Introduction

Aquatic macrophytes are often key elements of the habitat that contribute to fish production in littoral freshwaters. Published information suggests that they provide a stable substrate within the water column for colonization by large numbers of phytomacrofauna (the larger, invertebrate animals on submersed plants), which are eaten by fish. The plants also provide cover for fish, contribute oxygen to the water, and produce organic matter that is incorporated into the aquatic food chain that ultimately supports fish production. No research has been done specifically to define the contribution of aquatic macrophytes to fish production in the Great Lakes, despite the fact that they are prominent features of most of the sheltered, nearshore waters. Man's water-use practices, such as dredge and fill operations and shoreline bulkheading, have destroyed much of the macrophyte habitat in the Great Lakes, and threaten to destroy much of the rest of it.

Concern about the rapid losses of this aquatic habitat in the nearshore waters of the Great Lakes led the Great Lakes Fishery Laboratory (GLFL) to conduct a series of studies in 1979 and 1980 in Lake St. Clair, to evaluate further the contribution of these plants to fish production. Macrophyte studies were conducted concurrently with studies of the distribution, abundance, and productivity of zooplankton, phytomacrofauna, macrozoobenthos, and fish in a variety of fish habitats in Anchor Bay, Lake St. Clair--a productive, ecologically sensitive area that is subject to much development pressure.

The primary objectives of this study were to (1) measure the productivity (rate of organic matter production) of above-ground biomass by the macrophytes and associated periphyton in the nearshore waters and contiguous wetlands in Lake St. Clair, and (2) determine to what extent they provided substrate within the water column for colonization by phytomacrofauna and cover for fish.

Materials and Methods

The study area consisted of three locations in Anchor Bay, Lake St. Clair (Figure 1). These locations were selected to represent habitats that have been physically altered by man's activities to varying degrees: Belvidere Bay, an extensively and permanently modified shoreline and lake bed that contained sparse stands of emergent macrophytes and very dense stands of submersed ones; Muscamoot Bay, an unmodified lake bed and shoreline populated with dense stands of emergent and submersed macrophytes; and Sand Island, a semi-riverine area that has been subject to minor modification and contained moderately dense stands of emergent and submersed macrophytes. At each of these locations, three sampling stations were established (Figure 2) to provide an accurate, comprehensive description of the plant communities and one station was established outside of the plant beds as an experimental control. I collected plants (two duplicate samples per station) 11 times at about 2-week intervals from April through November 1979 with an mKUG sampler (Figure 3), and mapped the distribution of macrophytes at all three locations during August 5-8, 1980, using a grapnel. The mKUG consisted of a hinged stainless steel frame (0.25 cm thick) that supported two jaws to which a cloth bag (U.S. Standard No. 30 mesh;

0.65 mm porosity) was attached. A long pole was attached to the frame and, as the mKUG was pushed toward the lake bottom, the bag billowed and settled over the macrophyte canopy (covering a 0.25-m^2 area of lake bottom). The jaws were then closed by a remote cable system cutting off the macrophytes near the water-sediment interface. Phytomacrofauna and periphyton associated with the macrophytes were also enclosed in the bag. After raising the mKUG to the water surface, macrophytes were removed from the bag and sediment and detritus adhering to them were removed by washing the sample in a #30 mesh sieve (0.65-mm porosity) with a stream of water. Macrophyte samples were then stored in plastic bags in the dark at 4°C until they were sorted.

At the laboratory, the samples were immersed in water in a shallow pan and, after I was certain that no phytomacrofauna were attached to the plants, all macrophytes were removed stem by stem and sorted into taxonomic groups. The plants and associated periphyton were analyzed collectively because they could not be reliably separated, and because both are primary producers in the ecosystem. Subsequent analysis consisted of measuring surface area, dry weight, and ash-free dry weight of each macrophyte taxon.

Surface area measurements were made with a Li-Cor1/ portable area meter that electronically integrates the area. Before the macrophytes passed through the sensing head of the meter, I blotted them dry, and spread the leaves into a single layer within a plastic sheet to avoid overlap of the plant parts. The digital surface area (in square centimeters) of macrophytes that was displayed on the meter was doubled to account for the upper and lower surfaces of the plants. Surface area results were later expressed in terms of square meters of plant surface area per square meter of lake bottom (m^2/m^2). Dry weight and ash-free dry weight determinations of the macrophyte taxa were made after surface area measurements were completed. I placed the macrophytes on tared pieces of aluminum foil, dried them at 105°C for 24 hours, and weighed them to the nearest 0.0001 g on an analytical balance to determine dry weight. I then ashed them at 550°C for 24 hours and reweighed them to obtain ash-free dry weight. The surface area, dry weight, and ash-free dry weight of all taxa combined are summarized by station in Table 1.

I mapped the distribution of macrophyte stands in the three study locations according to a sampling grid that was plotted on charts of each location (Figure 4). In the field, landmarks were used to locate a point from which the boat was piloted along a predetermined compass bearing while buoys were deployed to mark a transect of the sampling grid. From that marked transect, grid stations on axes perpendicular to the transect were located by time-rate-distance measurements. At each station, a grapnel (49 cm long, 27 cm in diameter, lined with hardware cloth of 1-cm^2 porosity) was thrown 5 m from the boat and retrieved along the lake bottom. The taxonomic identity of macrophytes collected with the grapnel was determined and recorded. My subjective visual estimate of macrophyte density was also recorded. Species distribution, as determined by the mapping process, is shown in Figure 5, and the percent of the lake bottom at each location that was covered by macrophytes is summarized in Table 2.

1/ Use of trade names or manufacturer names does not imply Government endorsement of any commercial product.

Net productivity (rate of primary production) values for the macrophytes growing at each location were calculated (in ash-free grams of organic matter produced per square meter of lake bottom per day) by the equation

$$P_n = \frac{\bar{B}_s - \bar{B}_i}{I}$$

where P_n = net productivity ($g/m^2/day$); $\bar{B}_i$ = average biomass of macrophytes on the initial sampling date (g/m^2); $\bar{B}_s$ = average biomass of macrophytes on a subsequent sampling date (g/m^2); and I = time interval between sampling dates (days).

The net production by macrophytes (the net amount of ash-free organic matter produced by macrophytes growing at each location per year) was estimated by the equation

$$\sum P = \frac{(\bar{B}_{max})\ (A)}{10^6}$$

where ΣP = the net production of all macrophytes combined (metric tons/year); $\bar{B}_{max}$ = the maximum seasonal biomass of macrophytes (average of the three stations in macrophyte stands; ash-free g/hectare); A = area of lake bottom covered by macrophytes (hectares); and 10^6 = conversion factor from grams to metric tons.

Net productivity values (Table 3) and net production values (Table 4) were calculated.

This report was prepared to serve as baseline information by which future change in the distribution, abundance, and productivity of aquatic macrophytes in Anchor Bay can be measured. Other reports describing studies done concurrently in Lake St. Clair in conjunction with this one are forthcoming.

Table 1. Summary of macrophyte surface area, ash-free dry weight, and dry weight at Stations 7, 26, and 28 in Belvidere Bay, April to November 1979.

Date	Surface area (m^2/m^2)				Ash-free dry weight (g/m^2)				Dry weight (g/m^2)			
	Sta. 7	Sta. 26	Sta. 28	$\bar{X}$	Sta. 7	Sta. 26	Sta. 28	$\bar{X}$	Sta. 7	Sta. 26	Sta. 28	$\bar{X}$
April 25	a/	0.8	a/	0.8	a/	28.9	a/	28.9	a/	33.4	a/	33.4
May 30	a/	0.3	1.0	0.7	a/	13.6	31.6	22.6	a/	16.4	44.5	30.5
June 21	1.2	0.6	2.2	1.3	29.9	15.4	49.6	31.6	58.0	20.2	74.4	50.9
July 10	1.2	2.0	0.8	1.3	18.6	22.9	17.3	19.6	31.8	30.5	26.3	29.5
July 31	4.2	2.5	2.1	2.9	62.2	34.9	30.7	42.6	108.2	56.2	47.9	70.8
August 21	3.1	4.3	2.1	3.2	64.6	82.1	31.4	59.4	105.2	129.9	54.0	96.4
September 5	2.6	2.9	1.2	2.2	56.6	74.4	25.3	52.1	96.0	108.5	41.6	82.0
September 19	2.5	3.1	1.3	2.3	67.5	71.0	28.4	55.6	116.8	128.2	46.6	97.2
October 10	3.6	1.5	0.6	1.9	118.4	28.3	16.3	54.3	219.1	43.1	32.7	98.3
October 30	1.9	2.3	0.8	1.7	71.7	65.9	26.7	54.8	121.0	112.9	39.2	91.0
November 28	2.5	2.2	1.2	2.0	96.6	82.1	47.6	75.4	181.5	150.0	69.4	133.6
Average	2.5	2.0	1.3	2.0	65.1	47.2	30.5	47.0	115.3	75.4	47.7	78.1

a/ not sampled.

Table 1. (cont'd). Summary of macrophyte surface area, ash-free dry weight, and dry weight at stations 19, 20, and 31 in Little Muscamoot Bay, April to November 1979.

Date	Surface area (m^2/m^2)				Ash-free dry weight (g/m^2)				Dry weight (g/m^2)			
	Sta. 19	Sta. 20	Sta. 31	$\bar{X}$	Sta. 19	Sta. 20	Sta. 31	$\bar{X}$	Sta. 19	Sta. 20	Sta. 31	$\bar{X}$
April 26	0.2	0.0	0.0	0.1	6.7	0.0	0.0	2.2	9.0	0.0	0.0	3.0
May 29	0.7	0.2	0.5	0.5	26.6	5.6	15.5	15.9	38.9	6.5	33.0	26.1
June 19	0.9	0.4	0.4	0.6	21.2	7.6	8.5	12.4	29.2	10.8	10.6	16.9
July 11	1.3	0.8	1.1	1.1	27.0	25.7	25.2	26.0	45.9	29.2	31.4	35.5
August 1	0.8	0.8	1.1	0.9	16.0	23.4	19.1	19.5	23.5	29.3	26.5	26.4
August 22	1.0	0.7	1.7	1.1	26.3	16.5	34.0	25.6	36.3	24.6	52.0	37.6
September 6	2.8	1.2	1.9	2.0	83.2	35.2	44.9	54.4	132.9	52.7	73.6	93.1
September 20	1.2	0.6	1.3	1.0	34.9	33.2	32.5	33.5	57.1	38.6	55.1	50.3
October 11	0.4	0.6	0.8	0.6	8.6	17.6	21.5	15.9	16.1	26.3	54.8	32.4
October 31	0.8	1.4	1.2	1.1	18.0	60.7	31.1	36.6	71.9	71.2	54.6	65.9
November 29	0.4	0.1	0.2	0.2	14.4	1.1	5.1	6.9	31.5	1.3	8.3	13.7
Average	1.0	0.6	0.9	0.8	25.7	20.6	21.6	22.6	44.8	26.4	36.4	39.4

Table 1. (cont'd). Summary of macrophyte surface area, ash-free dry weight, and dry weight at stations 4, 34, and 76 at Sand Island, April to December 1979.

Date	Surface area (m^2/m^2)				Ash-free dry weight (g/m^2)				Dry weight (g/m^2)			
	Sta. 4	Sta. 34	Sta. 76	$\bar{X}$	Sta. 4	Sta. 34	Sta. 76	$\bar{X}$	Sta. 4	Sta. 34	Sta. 76	$\bar{X}$
Aprl 26	0.2	0.0	a/	0.1	6.9	0.0	a/	3.5	9.0	0.0	a/	4.5
May 30	0.2	0.0	a/	0.1	4.1	0.0	a/	2.1	6.3	0.0	a/	3.2
June 19	0.5	0.0	0.0	0.2	13.4	0.0	0.0	4.5	18.7	0.0	0.0	6.2
July 9	1.1	0.1	0.0	0.4	25.0	2.2	0.0	9.1	32.4	6.3	0.0	12.9
July 30	3.6	0.2	0.3	1.4	74.9	5.4	3.5	27.9	93.6	16.5	12.3	40.8
August 20	2.6	0.4	0.4	1.1	55.3	11.9	8.8	25.3	70.0	35.1	25.9	43.7
September 4	3.0	0.3	1.9	1.7	70.2	9.7	45.5	41.8	87.0	27.3	102.8	72.4
September 18	3.5	1.1	2.1	2.2	68.8	26.8	36.0	43.9	85.3	52.4	49.0	62.2
October 9	2.8	0.3	0.1	1.1	55.2	11.9	4.9	24.0	70.2	34.0	13.2	39.1
October 29	1.2	0.3	0.1	0.5	39.9	11.8	4.7	18.8	73.2	30.8	12.0	38.7
December 5	2.5	a/	a/	2.5	60.8	a/	a/	60.8	77.0	a/	a/	77.0
Average	1.9	0.3	0.6	1.0	43.1	8.0	12.9	22.7	56.6	20.2	26.9	35.9

a/ not sampled.

Table 2. Area of the lake bottom colonized by macrophyte stands in Belvidere Bay and Little Muscamoot Bay, and at Sand Island, August 5-8, 1980. Numbers in parentheses indicate the area colonized expressed as a percent of the total area sampled.

Location	Total hectares sampled	Hectares colonized by macrophytes	Hectares of visually estimated categories of macrophyte growth			
			High	Medium	Low	Absent
Belvidere Bay	122	117 (96)	36 (30)	42 (34)	39 (32)	5 (4)
Little Muscamoot Bay	366	231 (63)	20 (5)	78 (21)	133 (36)	135 (37)
Sand Island	88	80 (91)	7 (8)	18 (20)	55 (63)	8 (9)

Table 3. Net macrophyte productivity in Belvidere Bay, April to November 1979.

Sampling date	Average[a/] biomass	Net change[a/]	Sampling interval (days)	Daily net productivity (g/m^2)
April 25	28.9			
		- 6.3	35	-0.18
May 30	22.6			
		+ 9.0	22	+0.41
June 21	31.6			
		-12.0	19	-0.63
July 10	19.6			
		+23.0	21	+1.10
July 31	42.6			
		+16.8	21	+0.80
August 21	59.4			
		- 7.3	15	-0.49
September 5	52.1			
		+ 3.5	14	+0.25
September 19	55.6			
		- 1.3	21	-0.06
October 10	54.3			
		+ 0.5	20	+0.03
October 30	54.8			
		+20.6	29	+0.71
November 28	75.4			
Total				+1.94

a/ Grams ash-free dry weight of macrophytes per square meter of lake bottom at three stations in macrophyte beds.

Table 3. (cont'd). Net macrophyte productivity in Little Muscamoot Bay, April to November 1979.

Sampling date	Average[a]/ biomass	Net change[a]/	Sampling interval (days)	Daily net productivity (g/m^2)
April 26	2.2			
		+13.7	33	+0.42
May 29	15.9			
		- 3.5	21	-0.17
June 19	12.4			
		+13.6	22	+0.62
July 11	26.0			
		- 6.5	21	-0.31
August 1	19.5			
		+ 6.1	21	+0.30
August 22	25.6			
		+28.8	15	+1.92
September 6	54.4			
		-20.9	14	-1.49
September 20	33.5			
		-17.6	21	-0.84
October 11	15.9			
		+20.7	20	+1.04
October 31	36.6			
		-29.7	29	-1.02
November 29	6.9			
Total				+0.47

Table 3. (cont'd). Net macrophyte productivity in Sand Island, April to December 1979.

Sampling date	Average[a] biomass	Net change[a]	Sampling interval (days)	Daily net productivity (g/m^2)
April 26	3.5			
		- 1.4	34	-0.04
May 30	2.1			
		+ 2.4	20	+0.12
June 19	4.5			
		+ 4.6	20	+0.23
July 9	9.1			
		+18.8	21	+0.90
July 30	27.9			
		- 2.6	21	-0.12
August 20	25.3			
		+16.5	15	+1.10
September 4	41.8			
		+ 2.1	14	+0.15
September 18	43.9			
		-19.9	21	-0.95
October 9	24.0			
		- 5.2	20	-0.26
October 29	18.8			
		+42.0	37	+1.14
December 5[b]	60.8			
Total				+2.27

[b] Only one station sampled.

Table 4. Net annual macrophyte production in Belvidere and Little Muscamoot bays, and at Sand Island[a].

Location	Maximum seasonal biomass (g/ha)	Area colonized by macrophytes (ha)	Net production (metric tons per year)
Belvidere Bay	754,000	117	88.2
Little Muscamoot Bay	544,000	231	125.7
Sand Island	439,000	80	35.1

a/ Estimates based on productivity data collected in 1979 and percent cover data collected in 1980.

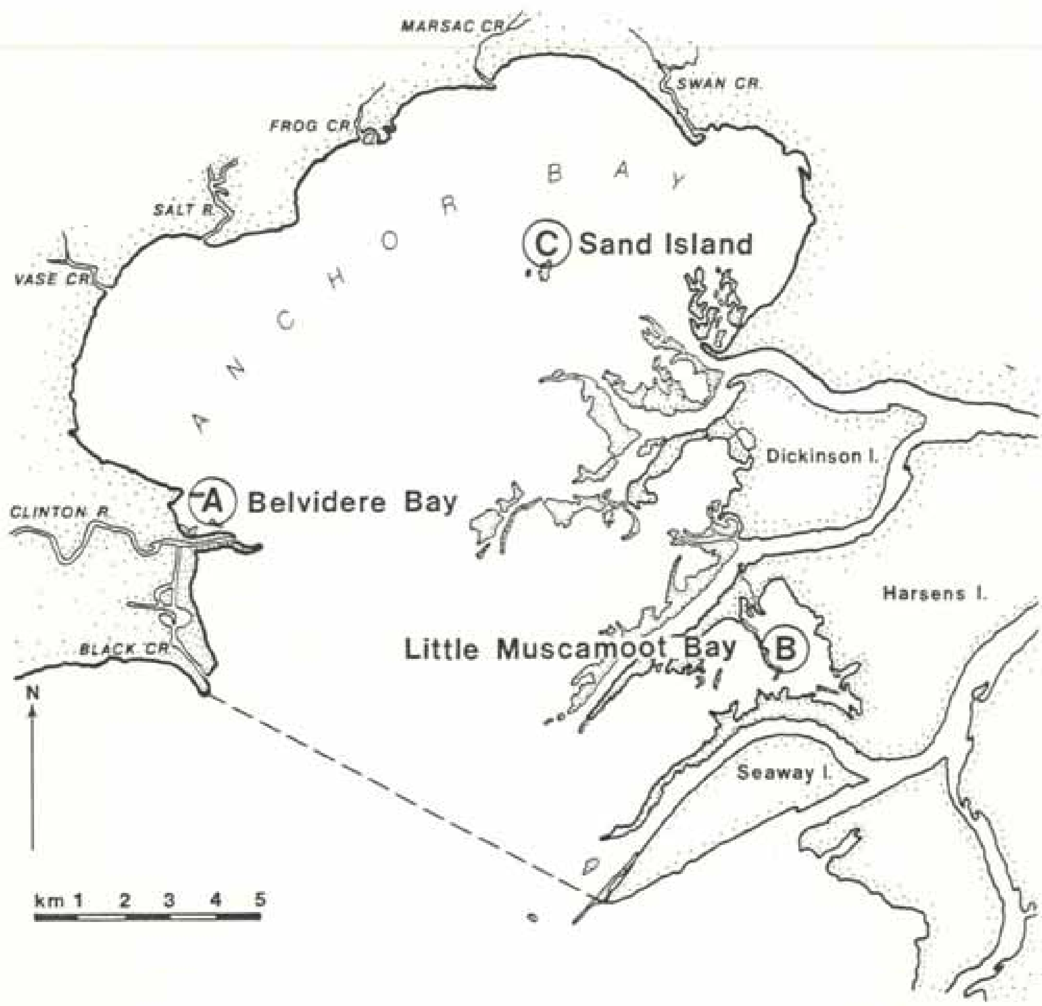

Figure 1. Macrophyte sampling locations in Anchor Bay, Lake St. Clair.

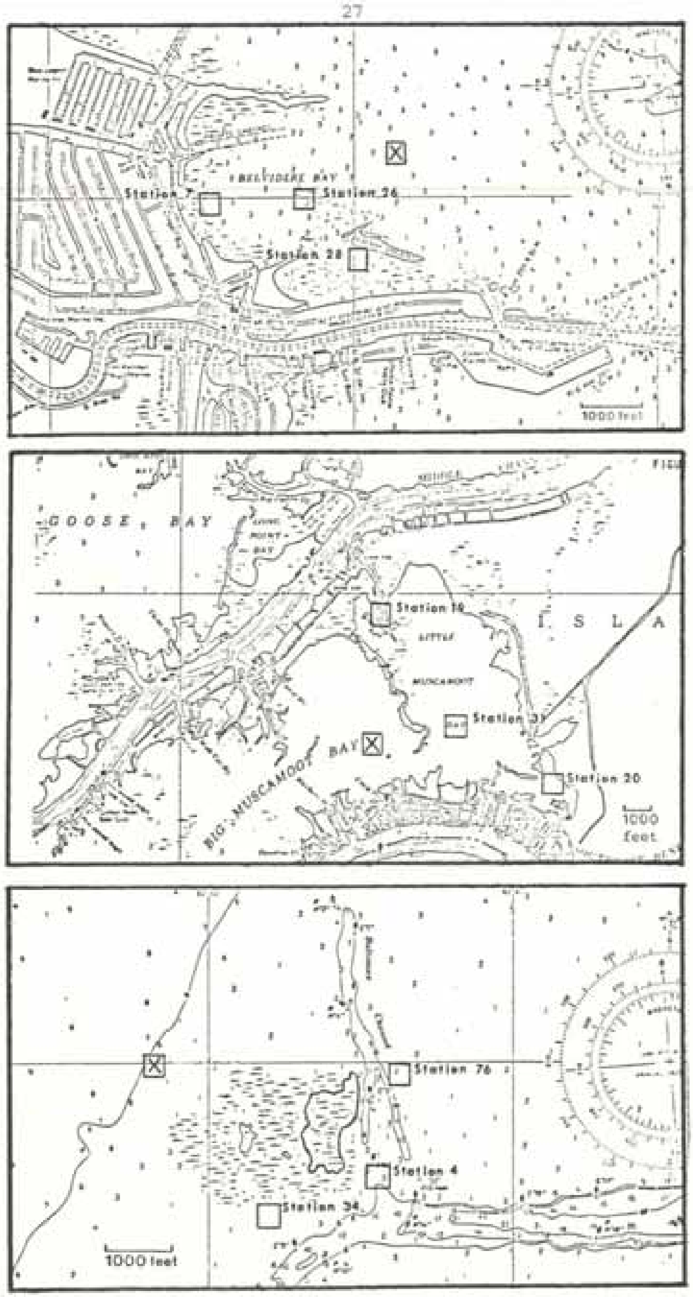

Figure 2. Location of macrophyte sampling stations within Belvidere Bay (top), Little Muscamoot Bay (center), and at Sand Island (bottom), April-November 1979. X marks control station located outside of macrophyte beds.

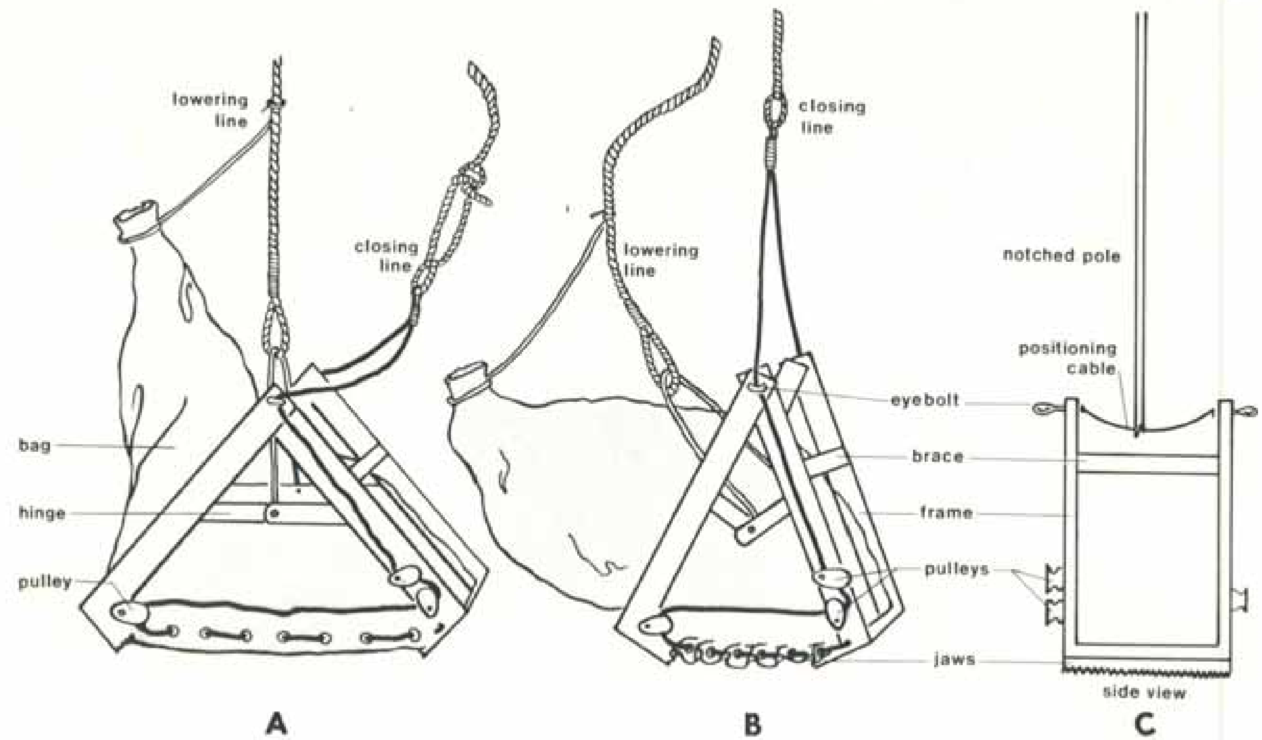

Figure 3. Construction details of mKUG (open, A; closing, B; closed [side view], C). The frame consists of two U-shaped pieces of stainless steel (5 cm wide, 0.25 cm thick). The upright portions are 66 cm and the bases (35 cm long) join to form a pair of jaws. The uprights connect at the top with an eyebolt, and the frame is supported by braces. Hinges 27 cm below the top of the upright allow the jaws to spread 70 cm. A cutting blade is attached to one of the jaws. A nylon lowering line is attached to the hinges. A second nylon cord attaches to the jaw blades, runs through pulleys on the frame alongside the jaws, and through the eyebolt at the top of the frame. This second cord closes the sampler and lifts it to the surface. A cloth bag made of U.S. Standard #30 mesh is bolted to the upper edge of the jaws and encloses the area within the frame. A steel positioning cable extends across the top of the frame. A notched pole is placed on the positioning cable to assist in placement of the sampler.

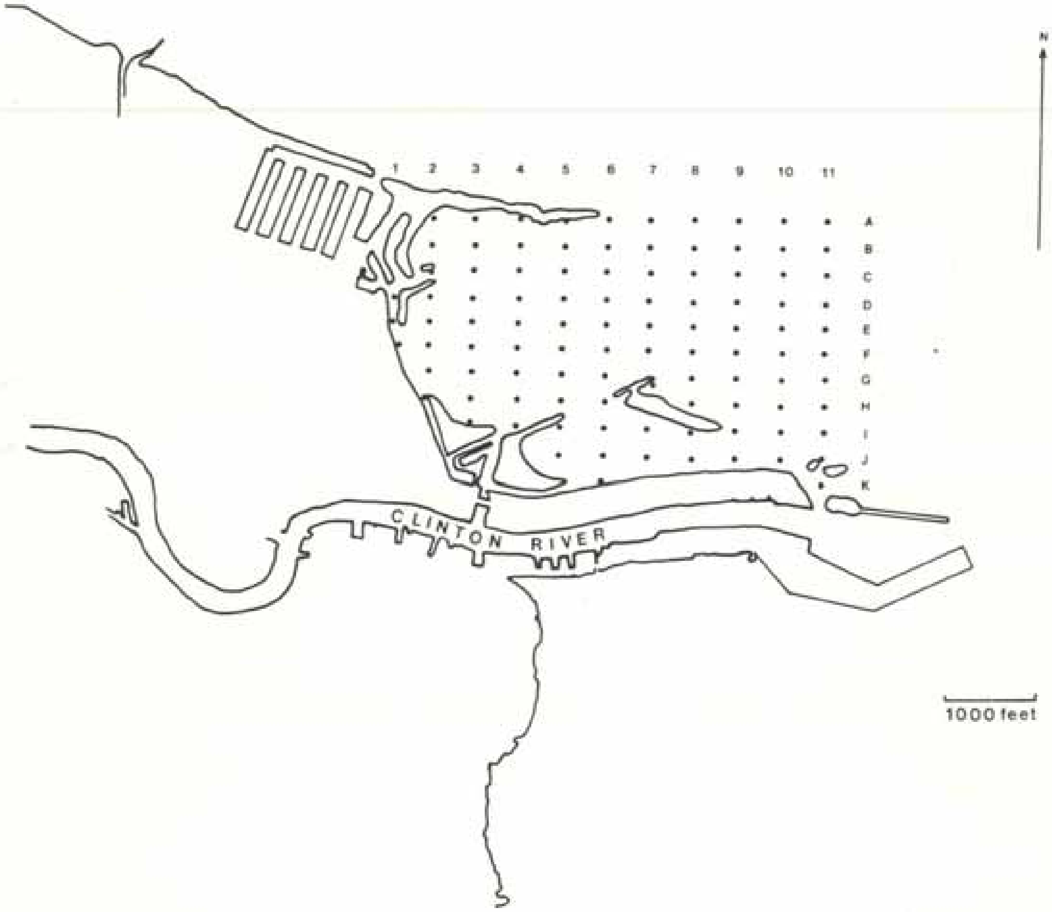

Figure 4. Location of macrophyte mapping grid stations within Belvidere Bay, August 5-8, 1980.

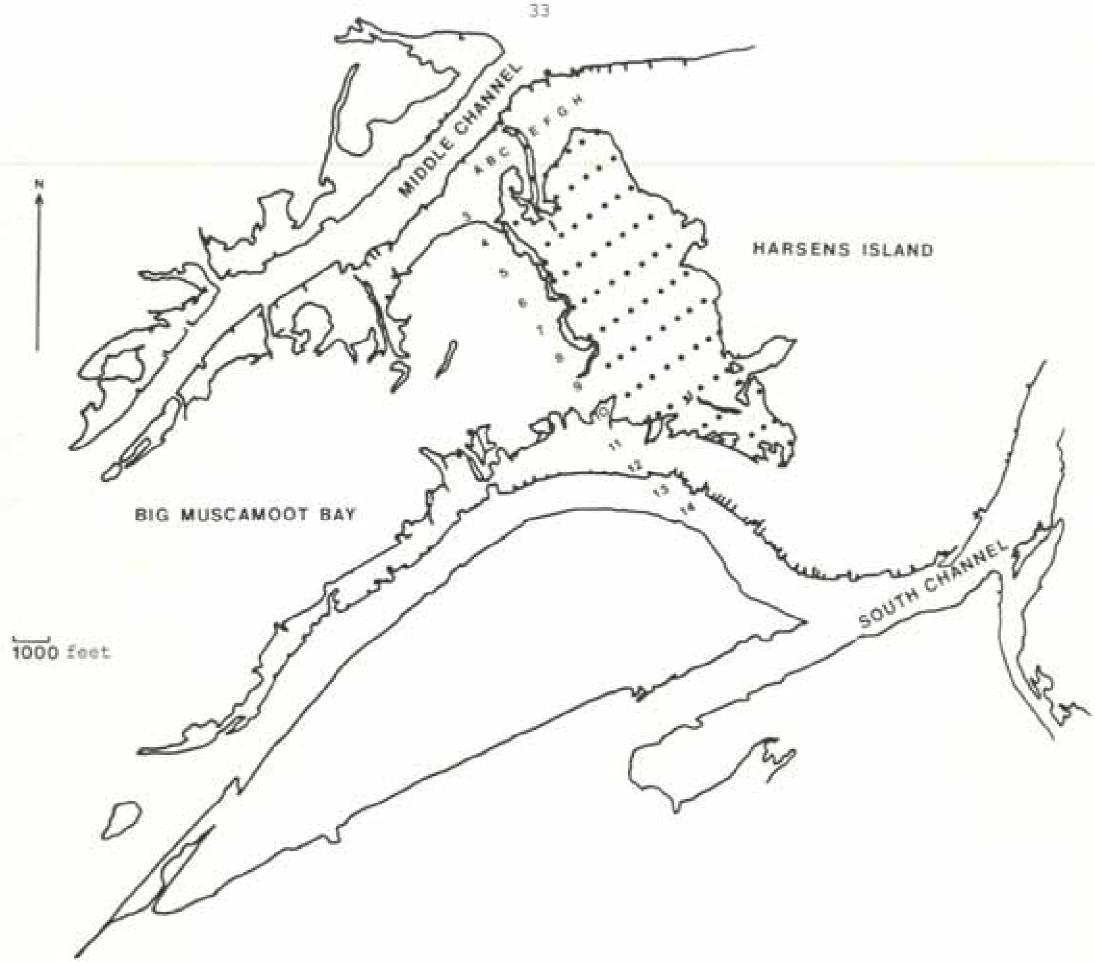

Figure 4 (cont'd). Location of macrophyte mapping grid stations within Little Muscamoot Bay, August 5-8, 1980.

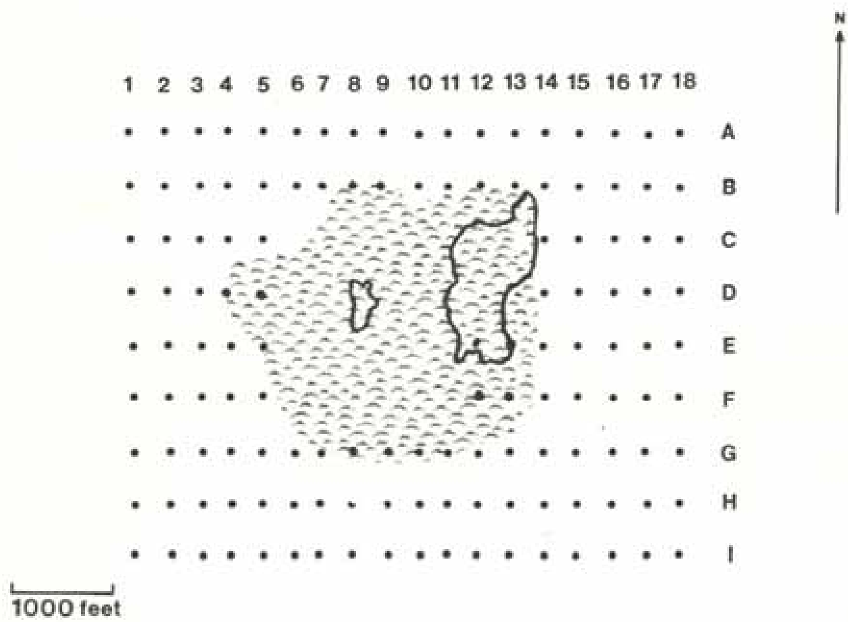

Figure 4 (cont'd). Location of macrophyte mapping grid stations at Sand Island, August 5-8, 1980. Approximate area of emergent vegetation is shown around the island.

Figure 5. Distribution of principal macrophyte taxa within Belvidere Bay, August 1980.

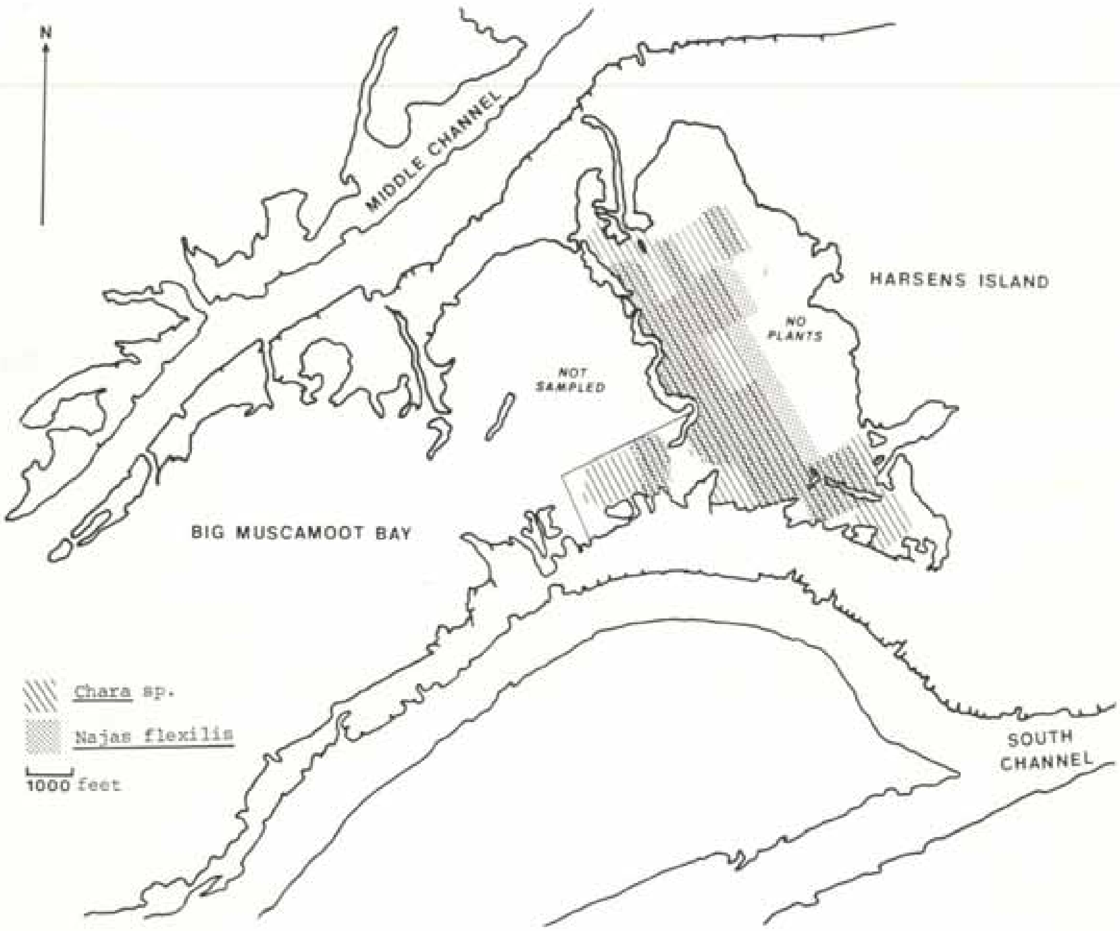

Figure 5 (cont'd). Distribution of principal macrophyte taxa within Little Muscamoot Bay, August 1980.

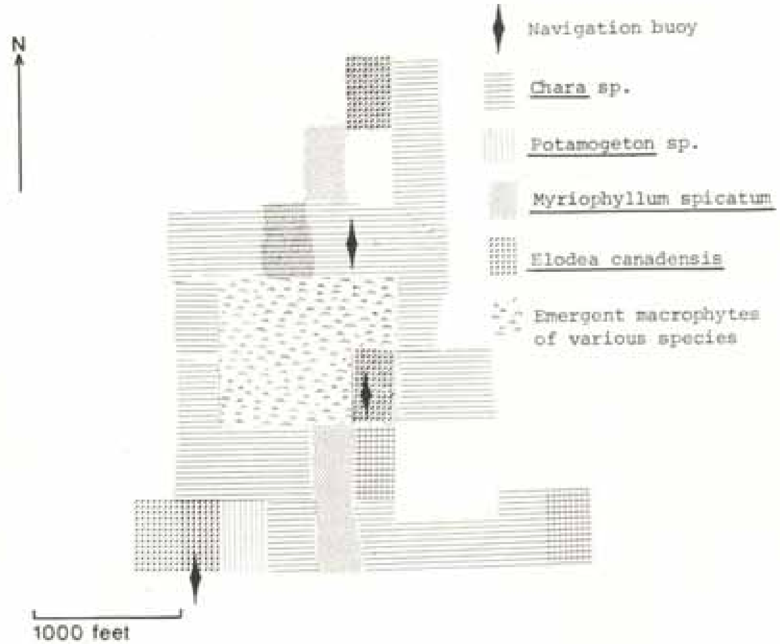

Figure 5 (cont'd). Distribution of principal macrophyte taxa at Sand Island, August 1980.