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Trends in Submersed Macrophyte Communities of the Currituck Sound: 1977-1979

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ABSTRACT

The biomass and distribution of submersed macrophytes in the Currituck Sound, N. C. were determined in July, 1978 and compared with that of August, 1973. Eurasian watermilfoil (*Myriophyllum spicatum* L.) was dominant in 1973 and bushy pondweed (*Najas guadalupensis* (Spreng.) Mangus) was a strong subdominant. Plant biomass in 1978 was 42 percent of that of 1973. Eurasian watermilfoil biomass was reduced by 54 percent in 1978 and bushy pondweed was found in only trace amounts. Biomass of sago pondweed (*Potamogeton pectinatus* L.) in 1978 was greater than that measured in 1973. The changes in biomass and, to some extent, distribution, are attributed primarily to increased turbidity and turbulence resulting from unusual weather during the early growing season of 1978. These conclusions are supported by seasonal studies of an Eurasian watermilfoil community in Coinjock Bay which is contiguous with Currituck Sound.

INTRODUCTION

Currituck Sound (40,000 ha) North Carolina (Figure 1) is a large, shallow (mean depth 1.6 m) system which, as reviewed by Sincock (13), has supported submersed macrophyte communities for many years. There are no published studies of the submersed macrophyte communities of Currituck Sound before the observations of McAtee (9) during 1909 in the northern sound (north of the Big Narrows). Sago pondweed (*Potamogeton pectinatus* L.) was dominant, bushy pondweed (*Najas guadalupensis* (Spreng.) Mangus) and wild celery (*Vallisneria americana* Michx.) abundant, redhead grass (*Potamogeton perfoliatus* var *bupleuroides* (Fern.) Farw.) common, widgeon grass (*Ruppia maritima* L.) scattered, and leafy pondweed (*Potamogeton foliosus* Raf.) scarce. Subsequent observations by Bourn (2) and others suggest that sago pondweed remained dominant until the 1950's. From 1958 through 1965 quantitative studies showed bushy pondweed to be dominant and wild celery was generally the subdominant (13). By 1966, Eurasian watermilfoil (*Myriophyllum spicatum* L.) had spread throughout most of the Currituck Sound system including Coinjock Bay (personal communication, John Stennis). In 1973, Kearson (7) found that Eurasian watermilfoil was dominant with bushy pondweed a strong subdominant.

Changes observed in the submersed macrophyte communities in Currituck Sound and Coinjock Bay from 1977-1979 are reported. These changes are discussed in relation to changing environmental conditions during the study period and historical changes in the submersed macrophyte communities of the system.

METHODS AND MATERIALS

Coinjock Bay Studies

Coinjock Bay (9,000 ha) is a shallow embayment contiguous with Currituck Sound. Two random 0.2 ha plots were established in 1977 in a 16 ha Coinjock Bay study site. (Figure 1) as control plots for mowing and regrowth studies. Biomass data for 1977 are based on random sampling of these plots. Seasonal biomass data for 1978 and the 9, 10 June 1979 study were based on random sampling of the 16 ha study site.

Except for samples taken by modified oyster tongs (0.5 m^2 sample area) on 12 March 1977, all plant samples were obtained by skin diving. Square quadrat frames (0.35 m^2) were used for all but one sampling date when a 0.25 m^2 frame was used. Biomass is reported on a m^2 basis.

All plants within the quadrat frames were dug by hand, washed, separated into shoot and root-rhizome fractions, placed in fine mesh bags, and spun 7-8 minutes in a clothes washer. Subsamples were dried in an oven at 85 C and weighed. The dried samples were ground in a Wiley mill and ashed at 550 C. These data were extrapolated to calculate organic (ash free) dry weight for all plants. Biomass data are reported as ± one standard deviation.

As a part of a hydrographic study of the Currituck Sound system, the Coinjock Bay study area was visited approximately once a month from 3 March 1977 through 20 August 1978. A second hydrographic study with limited data collection was conducted from March through June 1979. Only Secchi depth data are reported in detail here. Wind, air temperature, and precipitation data are from the National Weather Service Station at the Norfolk, Virginia Airport which is 60 km north of the Coinjock Bay study area.

Currituck Sound Transects

During July 1978, 12 of 13 transects were sampled that had been originally established in the Currituck Sound system and studied during the period 1958 through 1963 in the Cooperative Back Bay-Currituck Sound Studies (13) and studied again in 1973 (Figure 1). Transect designations

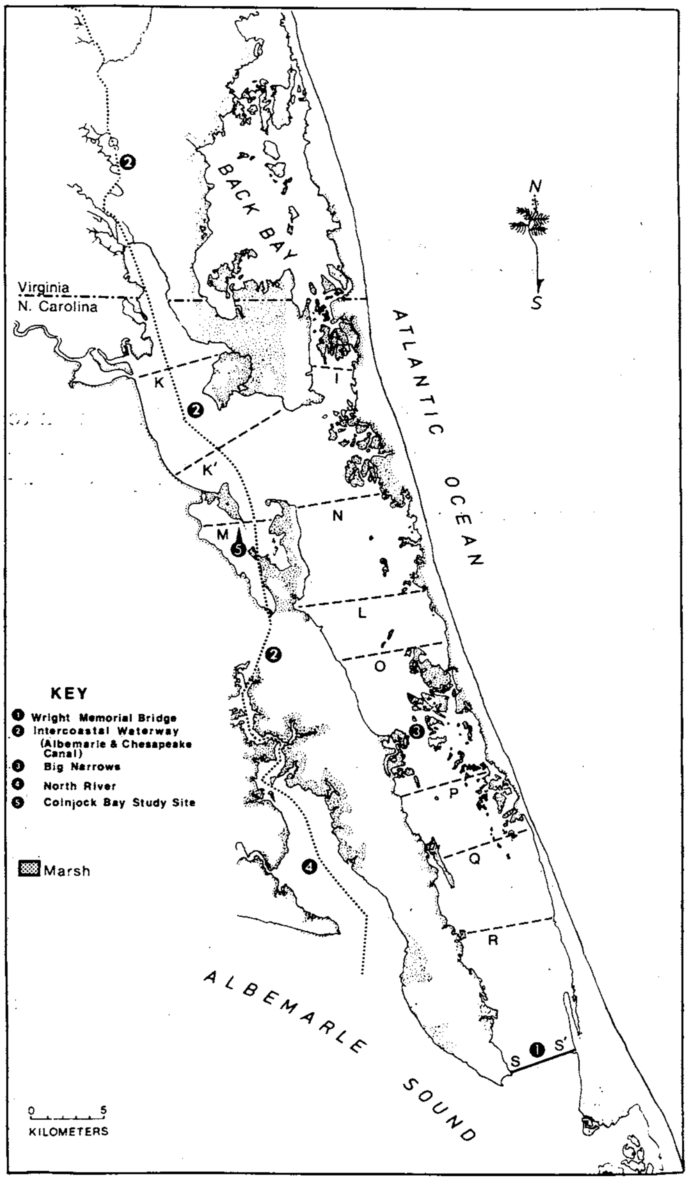

Figure 1. Currituck Sound and contiguous waters showing the Coinjock Bay study site, transects, and sampling stations.

are those used in these studies. Two 0.25 m^2 samples were dug by hand every 500 m along each transect with a random starting point.

Dry weight conversion factors for the 1978 studies were used to convert the 1973 data (7) to organic weight. Transect data (g/m^2) were used to extrapolate total biomass to the areal coverage of the sound represented by each transect and the percent biomass remaining in 1978 was calculated. Likewise, the percent of biomass of each species remaining in 1978 was calculated for the sound.

RESULTS AND DISCUSSION

Coinjock Bay

Eurasian watermilfoil predominated in the Coinjock Bay study site (Figure 2) and bushy pondweed made up most of the remaining submersed macrophyte biomass. Other species found in trace amounts were musk grasses (*Chara fibrosa* Ag. ex Burz. *Chara braunii* G., *Nitella hyalina* (DC.) Ag. and *Nitella flexilis* (L.) Ag.), leafy pondweed, redhead grass, waterweed (*Elodea nutallii* (Planch.) H. St. John), wild celery, dwarf spikerush *Eleocharis* sp., and coontail (*Ceratophyllum demersum* L.). We were unable to positively identify the plant listed as dwarf spikerush since flowers and fruits were not found. Both this species and water arrowhead (*Sagittaria subulata* (L.) Buckl.), another small rosulate plant, were found on the Coinjock Bay transect during the Back Bay-Currituck Sound Studies (13). Of the species found in the present study, *Elodea nuttallii* has not been previously reported for the Currituck Sound system but *Elodea canadensis* Michx. was found on occasions in the Back Bay-Currituck Sound Studies (13).

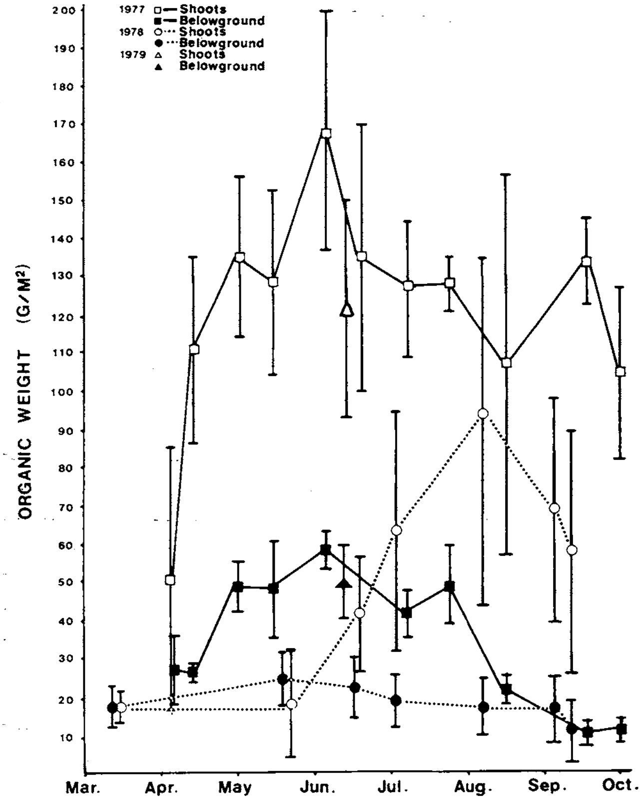

Figure 2. Biomass of Eurasian watermilfoil in the Coinjock Bay study site:1977-1979. Vertical bars represent one standard deviation. The points represent 3 to 18 quadrat samples with a mean of 8.

Eurasian watermilfoil grew rapidly in early 1977 (Figure 2). Biomass on 2 April would have been greater, except that significant plant material was broken and uprooted in some parts of the study area due to a wind storm on that date. Shoots had reached the surface (around 1.2 to 1.4 m depth) by 12 April. The maximum mean biomass for the growing season occurred on 4 June; 167.9 ± 31.3 g/m^2 for shoots and 58.6 ± 4.9 g/m^2 for belowground biomass. Toward the end of the study period, belowground biomass decreased more rapidly than shoot biomass.

Accelerated growth of Eurasian watermilfoil shoots began in 1978 in phase with decreasing turbidity (Figure 2 and Figure 3). Maximum biomass occurred in August, and approached that of the same month for 1977; however, the

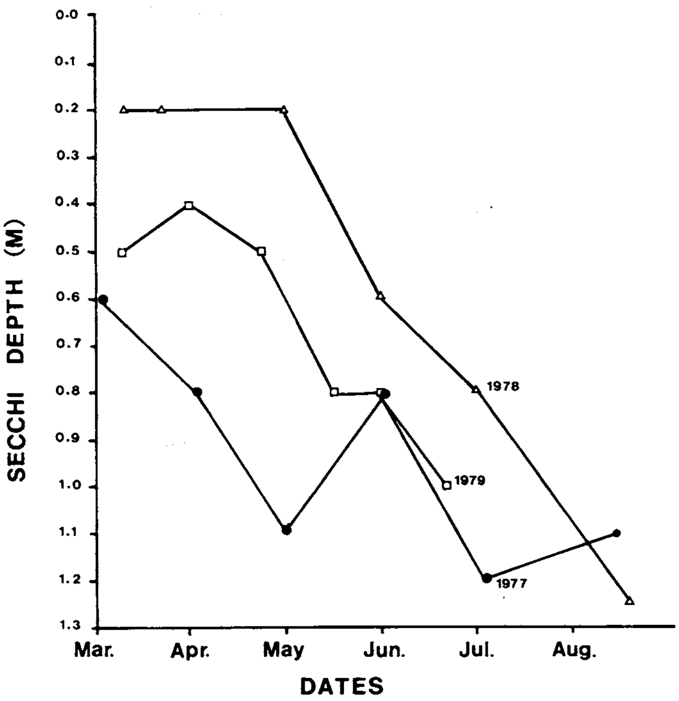

Figure 3. Coinjock Bay Secchi depths:1977-1979.

average biomass for the year was well below that of 1977. Belowground biomass remained low, even during the growth phase. At the end of the study periods for both years, the belowground biomass was uniformly low even though there were pronounced differences in both shoot and belowground production during the growing season. Belowground biomass of March 1978, as compared with October 1977, suggests that most of this biomass was carried over to the 1978 growing season.

A final survey of the study area on 9-10 June 1979 showed that Eurasian watermilfoil biomass (shoots = 121.4 ± 28.0 g/m^2; belowground = 49.5 ± 9.1 g/m^2) approached that of the comparable date for June 1977. The community had, then, recovered from the low biomass state prevailing in 1978.

The seasonal maximal standing crop at the Coinjock Bay study site for 1977 is in the middle range reported for Eurasian watermilfoil (6) while that for 1978 is in the lower range. As compared with northern areas (1, 6, 20) where significant seasonal growth begins in May and June, rapid growth occurred in Coinjock Bay in April and May in 1977 and there was no secondary growth period in late summer.

The depressed growth of Eurasian watermilfoil during 1978 is attributed to excessively turbid waters, especially during the early growing season (Figure 3). Secchi transparencies during February, March, and April 1978 were at or near 0.2 m throughout the Currituck Sound system. This high turbidity was related to unusual weather conditions. During March and especially April, wind duration and force had a strong northeastern component even for this area with a history of wintertime northeasters. Such winds roil the silty semiliquid sediments common on Coinjock Bay and the northern sound. Rainfall in March 1978 was the highest for the 78 years recorded for this month. This contributed to the suspended sediment turbidity through land runoff as well causing decreased salinities. Salinity gradually dropped from 1.3 0/00 in December 1977 to 0.1 0/00 in March 1978 and remained near this level through July. Laboratory research conducted during the Back Bay-Currituck Sound Studies (13) indicates that the minimum salinity range for rapid flocculation and sedimentation of clay and silt is between 0.7 and 1.8 0/00.

Secchi depths for the three years (Figure 3) suggest that the critical transparency for normal early season growth is between around 0.5 to 0.2 m at the study plot depths of around 1.2-1.4 m. June biomass in 1979 was similar to that of 1977 even though Secchi transparencies were decidedly greater in 1977.

Observations in the northern tributaries of the Chesapeake Bay indicate that Eurasian watermilfoil is sensitive to suspended sediment turbidity (8, 16, 17, 18). Stevenson and Confer (18) suggest that the general decline in abundance of Eurasian watermilfoil and other submersed species in the Chesapeake Bay area over the past 15 years cannot be attributed solely to turbidity since turbidity has decreased in some subestuaries where submersed macrophyte communities have disappeared. However, Steenis (16) attributed decimation of some Eurasian watermilfoil communities following heavy spring rains primarily to reduced light penetration due to high turbidities, suggesting that short-term turbidity changes can be more important than long term trends. High turbidity was suggested as one possible factor contributing to a low standing crop of Eurasian watermilfoil in a cove of a subestuary of the Hudson River (10).

What appears to be a normal low seasonal carryover of belowground biomass of Eurasian watermilfoil in the study area helps to explain the poor growth observed in 1978 when the turbidity was high. With renewed photosynthetic production inhibited due to decreased light penetration in the spring, reserve food in the root-rhizome system would be rapidly depleted. A large belowground carryover biomass was probably the primary reason for high standing crops of Eurasian watermilfoil observed by Young (21) in a highly turbid reservoir in Tennessee.

With no observed seasonal carryover of roots of Eurasian watermilfoil at cool, warm, and hot stations in a reactor cooling reservoir (5), there was significant summer biomass at 3.25 to 4.00 m only at the cool and warm stations. Turbidity in the reservoir was comparatively low (Secchi depth 2.5 m). Lack of growth in deep water at the hot station might have been associated with a low photosynthetic-respiratory ratio as affected by reduced light and high temperatures during the spring growth period.

Mean temperatures in January and February were lower than normal for all three years. Ice formed in the bay each year, but the problem was most severe in 1977, a year of high biomass.

Factors other than turbidity and temperature which could have contributed to the lower biomass observed in 1978 include variations in salinity and inorganic nutrients, epiphytic growth and siltation on plants, breakage and uprooting of plants in storms, and disease. There is no evidence that any of these significantly effected the changes observed.

Currituck Sound Transects

Biomass for the July 1978 transects is compared with that of the August 1973 transects in Table 1. Differences between the two years are striking with the total macrophyte biomass in 1978 only 42 percent of that of 1973. The decrease in biomass was associated mainly with the demise of Eurasian watermilfoil and bushy pondweed throughout their range. The increase in biomass in sago pondweed is associated with the high biomass found in Knotts Island Bay (Transect I) even though this transect represents only a small portion of the sound. The difference is more apparent than real since sago pondweed was observed on this transect in 1973 but was not found at the sampling stations (7). Although wild celery biomass was lower in 1978, there was wider distribution of this species south of the Big Narrows. Biomass of redhead grass was low in 1973 and found in essentially trace amounts in 1978. There was no change in charophyte (*Chara* spp. and some *Nitella* spp.) biomass for the sound while widgeon grass was a minor component both years. Dwarf spikerush was reported in 1973 for the northern sound with the greatest biomass on Transect L. This species and/or water arrowhead is still present in the sound and traces of one or both of these species were probably included in the wild celery collected in 1978.

The changes in the macrophyte communities of the sound were apparently due to increased turbidity and wind stress. A survey of the northern sound by boat and two flights over the entire sound in the summer of 1976 indicated that most of the northern sound was covered with Eurasian watermilfoil. In the deeper water of the central area north of Transect L there were circular patches several meters across and closely spaced. Scattered large strands of Eurasian watermilfoil were observed in the shallower waters of the southern sound. L. C. Barrow, a local resident, has observed the vagaries of macrophyte communities in the northern sound since before the spread of Eurasian watermilfoil in 1966. He notes that, although there was some localized flux in Eurasian watermilfoil over the years, biomass remained high through 1976.

On the monthly hydrographic runs it was observed that Eurasian watermilfoil during the summer of 1977 had decreased in the lower section of the northern sound (up to around Transect N) as compared with 1976. The lower section of the northern sound was more turbid than the upper section in 1977 (Figure 4). The dramatic increase in turbidity in the northern sound in 1978 was observed throughout the system. As for Coinjock Bay, we consider increasing turbidity to be of primary importance in causing

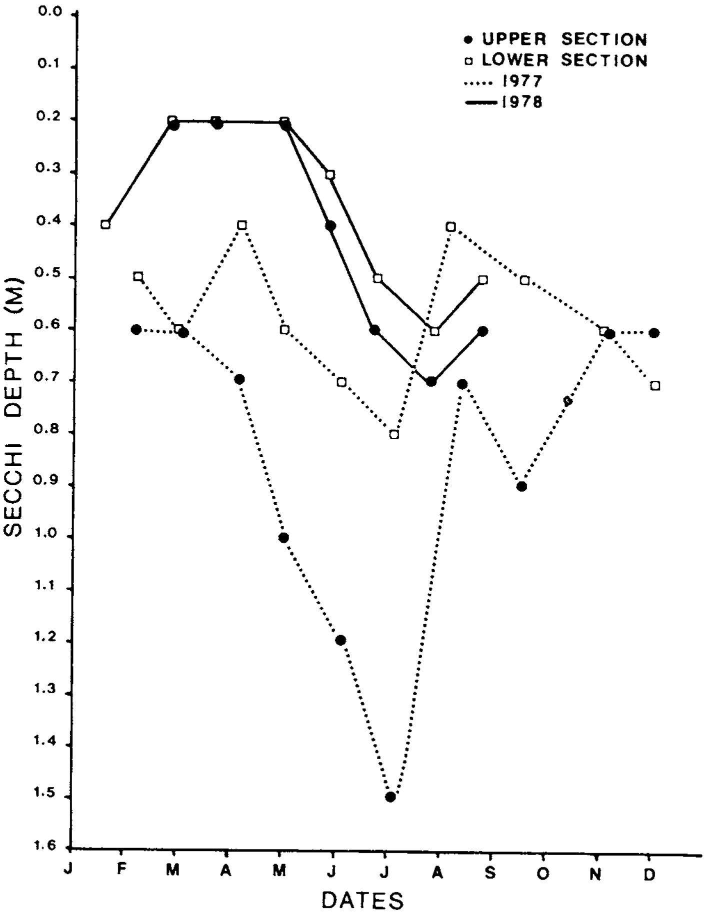

Figure 4. Secchi depths in the upper and lower sections of the northern Currituck Sound:1977-1978.

TABLE 2. PLANT FREQUENCY-DEPTH RELATIONSHIPS FOR THE CURRITUCK SOUND TRANSECT STATIONS IN JULY, 1978.

Depth (m)	No. of Stations	Charophytes	% freq.	Sago pwd.	% freq.	Red-head gr.	% freq.	Widgeon gr.	% freq.	Bushy pwd.	% freq.	Wild celery	% freq.	Eurasian water-milfoil	% freq.	any species	% freq.
0.6-0.8	4	3	75.00	3	75.00	0	0	2	50.00	0	0	3	75.00	2	50.00	4	100.00
0.8-1.0	13	12	92.31	11	84.62	3	23.08	8	61.54	1	7.69	11	84.62	6	46.15	13	100.00
1.0-1.2	16	10	62.50	8	50.00	3	18.75	1	6.25	2	12.50	7	43.75	13	81.25	15	93.75
1.2-1.4	5	0	0	1	20.00	0	0	2	40.00	1	20.00	3	60.00	2	40.00	4	80.00
1.4-1.6	14	8	57.14	8	57.14	2	14.29	4	28.57	0	0	9	64.29	7	50.00	12	85.71
1.6-1.8	16	9	56.25	6	37.50	1	6.25	5	31.25	0	0	4	25.00	7	43.75	12	75.00
1.8-2.0	14	4	28.57	4	28.57	0	0	3	21.43	0	0	5	35.71	5	35.71	7	50.00
2.0-2.2	7	0	0	0	0	0	0	0	0	1	14.29	1	14.29	3	42.86	3	42.86
2.2-2.4	8	0	0	0	0	0	0	0	0	0	0	0	0	1	12.50	1	12.50
2.4-2.6	25	0	0	0	0	0	0	0	0	0	0	1	4.00	0	0	1	4.00
2.6-2.8	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.8-3.0	3	0	0	0	0	0	0	0	0	0	0	1	33.33	0	0	1	33.33
3.0-3.2	6	0	0	0	0	0	0	0	0	0	0	1	16.67	0	0	1	16.67

changes in the submersed macrophyte biomass and distribution observed.

Sago pondweed was less affected by factors which diminished Eurasian watermilfoil and bushy pondweed stands. Perhaps this species was more resistant to turbulence under the conditions here. Since at least 1909 this species has apparently been present in the sound at a relatively high biomass.

The tendency of wild celery to become established in the lower sound under conditions prevailing in 1978 suggests that the species may spread with pertubations that increase turbulence. In 1957, following the hurricanes of 1955, Dickson (4) found that wild celery was spreading southward in the Currituck Sound.

The relationships between depth and plant frequency are shown in Table 2. The maximum frequency-depth relationships for plants in the sound in 1978 were similar to those found in surveys in 1959-1960 (13). However, the maximum depths at which plants were found were greater in 1959-1960. This is probably a reflection of less turbid waters and, to some extent, greater sampling intensities during the earlier studies.

It is apparent that drastic changes occurred in the submersed macrophyte populations in the main body of Currituck Sound in 1977 and especially 1978. Pronounced changes in submersed macrophyte communities associated with short-term environmental pertubations have been observed in other studies. Steenis (15) found that the submersed macrophyte community in Reelfoot Lake, Tennessee was decimated following June rains which caused increased suspended sediment turbidity along with increased fetch due to a rise in water level. Accelerated recovery occurred the following year. Sago pondweed was not as adversely affected as most species. With increased water and turbidity in a lake in New York, sago pondweed disappeared, milfoil became more prevalent, and wild celery was unaffected; the following year milfoil remained dominant and sago pondweed reappeared (12). The varying response observed for sago pondweed during the two studies suggests that it is hard to predict responses of a given species to pertubations in different systems. Sago pondweed is, however, often tolerant of highly turbid waters (3). Other areas for which turbidity has been correlated with changes in short-term responses of submersed macrophyte communities are a small subestuary of Chesapeake Bay (14), a small pond (19), and a reservoir (11).

Most of the studies cited indicate that aquatic macrophyte communities recover quickly from short-term dis-

TABLE 1. SUBMERSED MACROPHYTE BIOMASS IN CURRITUCK SOUND IN 1973 AND 1978 (G ORGANIC WEIGHT/M^2).

					Species					
Transect	Year	Charophytes	Sago pdw.	Redhead gr.	Widgeon gr.	Bushy pdw.	Wild celery	Eurasian watermilfoil	Transect Total	Remaining Total (%)
I	1973	5.6	0.0	1.4	0.0	68.3	4.9	30.4	110.6	
	1978	Trace	131.2	0.0	0.0	0.0	0.0	9.7	140.9	127.4
J		3.4	21.4	0.5	0.0	72.0	5.0	73.0	175.3	
		3.2	19.7	0.3	Trace	0.0	0.7	57.2	81.1	46.3
K′		0.0	0.0	0.0	0.0	Trace	3.3	4.1	7.4	
		Trace	0.0	0.0	0.0	0.0	0.0	5.2	5.2	70.3
K		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		Trace	0.0	0.0	0.0	0.2	0.4	13.3	13.9	—
L		2.0	0.0	0.9	0.0	26.8	6.2	48.6	84.5	
		4.1	2.4	0.4	1.2	0.0	1.6	10.5	20.2	23.9
M		Trace	0.0	0.2	0.0	20.1	2.4	82.2	104.9	
		0.5	0.0	0.5	0.0	0.0	1.6	53.6	56.2	53.6
N		1.2	12.8	21.1	0.0	29.6	9.2	51.3	125.2	
		Trace	13.6	0.0	0.0	0.0	0.0	1.2	14.8	11.8
O		2.9	24.0	Trace	0.7	12.1	4.2	8.3	52.2	
		1.0	17.6	0.0	0.4	0.0	0.4	Trace	19.4	37.2
P		0.4	7.1	0.8	0.4	15.8	2.7	3.7	30.9	
		Trace	0.5	0.0	0.1	0.0	0.4	0.5	1.5	4.9
Q		0.0	1.5	0.2	Trace	Trace	0.6	24.9	27.2	
		1.0	2.5	Trace	2.3	Trace	2.3	Trace	8.1	29.8
R		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		0.0	2.1	0.0	Trace	Trace	0.4	8.0	10.5	—
S		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		0.0	0.0	0.0	0.0	0.0	Trace	0.0	Trace	—
Sound (weighed mean)		0.9	4.2	1.6	0.1	13.2	3.0	21.3	44.3	
		0.9	6.6	0.1	0.4	Trace	0.6	9.9	18.5	41.8
Remaining in 1978 (%)		100	157	6	400	Trace	20	46	41	

turbances. This was true, at least for the Coinjock Bay study plot, where the June 1979 biomass approached that of June 1977. The future of the aquatic macrophyte communities in the Currituck Sound is problematical. Due to environmental changes which are not well defined, most of the submersed macrophyte communities in the upper Chesapeake Bay subestuaries have either disappeared or been greatly reduced in size and vigor over the past 15 years (18). This has adversely affected the normal productivity of the estuaries. The same fate can be expected for the Currituck Sound if submersed macrophyte communities are not soon reestablished.

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