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Trends in Submersed Macrophyte Communities of the Currituck Sound: 1909-1979

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ABSTRACT

The biomass and diversity of submersed macrophyte communities in Currituck Sound have undergone large changes over the past 70 years. Biomass reductions are related to increases in turbidity, whether stemming from storm activity or serious pollution. Quick recovery of a diverse flora follows when storms are the source of turbidity. However, after a storm in 1962, Eurasian watermilfoil dominated recovery and has been present ever since. Recent studies show that biomass of this species varies from year to year in response to light penetration during critical phases of growth in the spring.

Key words: macrophyte decline, turbidity, Eurasian watermilfoil, biomass, salinity.

INTRODUCTION

There are few published accounts of changes in submersed macrophyte communities that are based on observations of more than 10 years. Stevenson and Confer (18) have summarized the known history of submersed macrophyte changes in the Chesapeake Bay area; Bayley et al. (1) described changes in submersed macrophyte populations occurring in Susquehanna Flats at the head of Chesapeake Bay from 1958-1975; and Carpenter (5) discussed changes in submersed macrophyte communities in Lake Wingra from 1968-1978. Elsewhere (8) we summarized long term changes in freshwater submersed macrophyte systems from data that included Iowa Great Lakes, 1894-1972 (7); Put-in-Bay, Ohio, 1898-1967 (19); University Bay, Wisconsin, 1912-1965 (13); Green Lake, Wisconsin, 1921-1974 (4); and Lake Wingra, Wisconsin, 1929-1969 (15).

In this paper we report observations that have been made sporadically in the Currituck Sound over a 70 year period.

THE CURRITUCK SOUND

The Currituck Sound is a northern arm of Albemarle-Pamlico Sound system of North Carolina and is separated form the Atlantic Ocean by a narrow spit which is the northern extension of the barrier island system of the North Carolina coast (Figure 1). The Sound is connected to Back Bay on the northeast by shallow waters between marsh islands. There are numerous marsh islands along the eastern shore and in the middle reach (Figure 1, No. 6). The Currituck system has about 40,000 ha of open water while the open water of Back Bay covers around 9,000 ha. The entire system is shallow with a mean depth of 1.6 m with over 80 percent of the area less than 2.1 m deep (6). The record is incomplete but it appears that since the New Currituck Inlet through the spit closed around 1830 (reviewed in 16) the salinity has normally varied from less than one to a few parts per thousand ($^{o}/_{oo}$).

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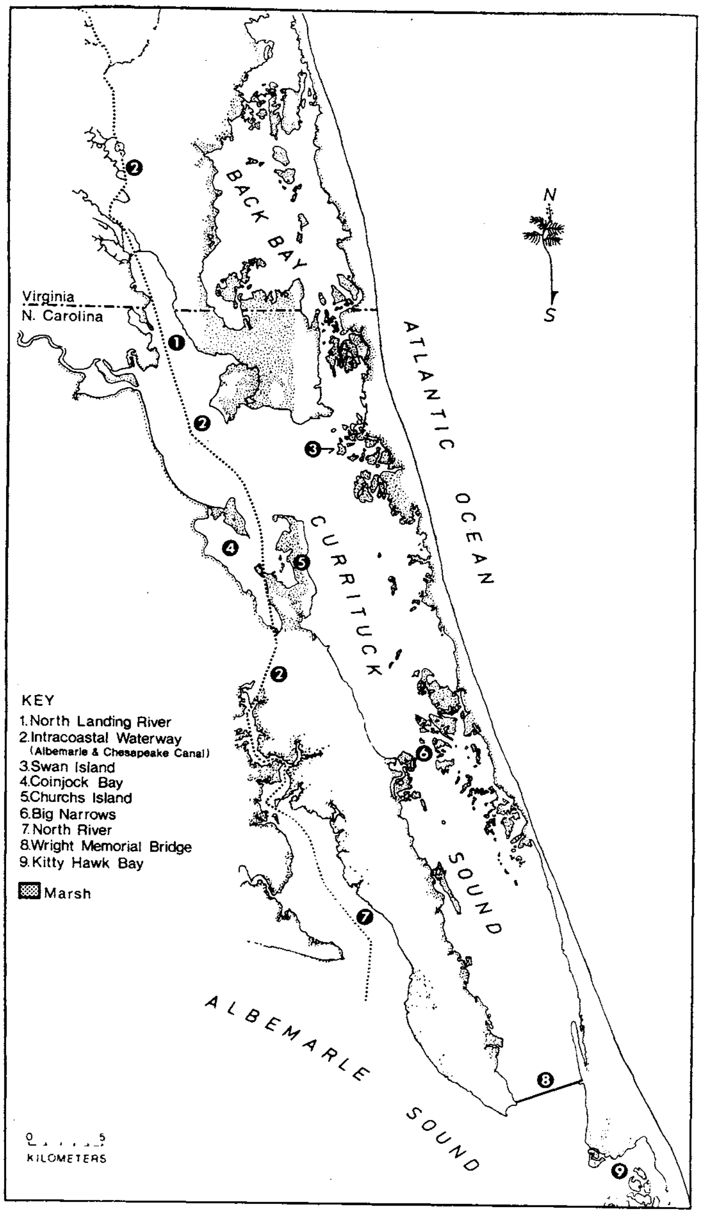

Figure 1. Regional map of Currituck Sound, North Carolina and Back Bay, Virginia.

No hydrologic studies have been reported, but it is likely that the system is essentially wind driven with water levels rising and falling as water is exchanged with the Albermarle Sound. Numerous creeks and farm ditches enter along the western shore and three small rivers arising in or near the Great Dismal Swamp drain into the northwestern part of the Sound.

EARLY OBSERVATIONS

After a review of the sketchy literature, Sincock (16) concluded that from the mid-1800's to around 1918, Currituck Sound and Back Bay must have been a principal wintering ground of waterfowl on the East Coast. This implies the presence of lush submersed vegetation. In 1918 environmental deterioration of the Currituck Sound-Back Bay system began, which was to last for many years (3). About that time the locks of the Albemarle and Chesapeake Canal, which connect the Norfolk Harbor at the mouth of the Chesapeake Bay with Currituck Sound by way of the North Landing River were opened. From 1914 through 1918 the canal was deepened and widened and North Landing River was dredged extensively. Bourn (3) observed that plant cover in northern Currituck Sound and Back Bay began to decrease in 1918, vast areas were almost denuded by 1926, and plants in deeper areas disappeared completely.

Bourn made extensive studies of submersed macrophytes in the area between 1926 and 1930, and encountered most of the species reported by McAtee (14) for the Churchs Island area in 1909. Sago pondweed (*Potamogeton pectinatus* L.) was the dominant species in both cases. Other species reported by Bourn (1) in order of abundance were bushy pondweed (*Najas gudalupensis* (Spreng.) *Magnus*), wild celery (*Vallisneria americana* Michx.), redhead grass (*Potamogeton perfoliatus* var *bupleuroides* (Fern.) Farwell), widgeon grass (*Ruppia maritima* L.), coontail (*Ceratophyllum demersum* L.), and leafy pondweed (*Potamogeton foliosus* Raf.). Little zonation was noted but sago pondweed was always in the deeper areas though not always in pure stands. Maximum depth of plant growth was around 1.8 m. The primary difference between 1909 and 1918 appears to be related to total biomass observed. Bourn's (3) description of conditions during the study period implies a deteriorated ecosystem with low oxygen, turbid water, higher salinity than normal, and a foul odor. There was a "deep layer of sludge" on the bottom which was kept in partial suspension by waves. Sludge accumulated at rates as high as 5 cm per year. The mean 1 percent level of light transmission for the center of northern Currituck Sound for the summer of 1929 was between 0.9 and 1.2 m. Based on these observations and extensive laboratory experiments, Bourn (3) concluded that turbidity was the principal cause of the demise of the submersed macrophytes. Before the locks to the Albemarle and Chesapeake Canal were opened, the northern sound water was used routinely by fisherman for drinking.

Bourn attributed the poor water quality to raw sewage outfalls for Norfolk and Portsmouth near the mouth of the Albemarle and Chesapeake Canal. Along with industrial wastes, these effluents moved down the Canal into the Currituck-Back Bay system. In 1932 new tide locks were installed at Bourn's suggestion and have been in operation since then. His memorandum in 1952 (cited in 16) stated that periodic checks of the Currituck-Back Bay system had been made and that the system had gradually improved since the closing of the locks in 1932. Annual surpluses of waterfowl food were found since 1943 with the maximum production of submersed aquatic plants in 1951.

During 1954 and 1955 four hurricanes buffeted the North Carolina coast. Dickson (10) found that by 1956 plants were restricted to shallow and protected areas of the Sound. He concluded that widespread destruction of plant beds by hurricanes in the fall of 1955 resulted in increased turbidities. Recovery was rapid since growth of plants in most parts of the Currituck Sound was described as good in 1957. Secchi disc depths were taken in spring of 1957 and averaged 0.3 to 0.5 m in the northern part and 0.3 to 0.8 m in the southern part of the Sound.

COOPERATIVE BACK BAY-CURRITUCK SOUND STUDIES

From 1958 through 1964 a study of the Currituck Sound-Back Bay system was made through cooperative efforts by the U.S. Fish and Wildlife Service, the Virginia Commission of Game and Inland Fisheries and the North Carolina Wildlife Resources Commission (16). The results of this extensive and intensive research have not been published.

This research included seasonal sampling of biomass in transects and in a grid pattern, using methods similar to those of Kerwin et al. (12). During the study over 9,000 samples of biomass were taken with modified oyster tongs along transects and over 15,000 samples were taken in a grid to determine species distribution. Species not previously reported for the area were found in small amounts but those listed for 1909 remained dominant. Bushy pondweed predominated throughout the study period with wildcelery generally the subdominant. Differences between the species for depths of greatest frequency were small, but bushy pondweed occurred most frequently at the greater depths (0.9-1.5 m). This species also had the greatest depth penetration with one occurrence at 4.2 m. Depth distribution of all species for the grid surveys of August 1959 and 1960 have been summarized. Mean Secchi depths during the early growing season were 0.7 and 0.6 m respectively.

Between August, 1958 and August, 1961, biomass (not including charophytes) in the Sound increased by a factor of 2.2. Including charophytes the increase was only 1.7, illustrating the decreasing biomass of this group over the 4 years. Turbidity remained high, but there were no major hurricane disturbances.

On March 7, 1962, an especially severe storm (a "northeastener") resulted in several breaks in the barrier spit with seawater intrusion. Although the breaks were soon closed, salinities for the growing season for the system in 1962 were high, averaging 4.4 $^{o}/_{oo}$. Salinities decreased the following year, but remained higher than normal through August, 1963, the month of maximal biomass and the last time for which data were reported. It seems likely that drastic and extended environmental changes occurred in the Currituck Sound-Back Bay system as a result of the 1962 storm. November biomass of bushy pondweed in 1964 was about twice that of 1962 and 1963 as this species remained dominant in the Sound. In the summer of 1964 fisherman in the Currituck Sound occasionally observed the presence of a "strange" plant in the vicinity of Swan Island (Figure 1) later assumed to be Eurasian watermilfoil (6). By 1965, 40 ha in the northern sound were covered with an intertwining mat of Eurasian watermilfoil while lower densities extended over 200 to 400 ha. By 1966 high density infestations covered around 3200 ha and overall the plant had spread to around 27,000 ha. The species extended into Back Bay and into some embayments of the Albemarle Sound system to the south, such as Kitty Hawk Bay. However, during 1977 and 1978, biomass in the Sound decreased dramatically and the thickest remaining stands were restricted to the upper northern part (9). Factors associated with this decline will be mentioned later.

We believe that changes following the 1962 storm, especially decreased turbidity as affected by increased flocculation of suspended sediments by increased salinity in the northern part of the Sound, resulted in the irruption of Eurasian watermilfoil. This species was widespread in the Chesapeake Bay in the early 1960's (1) so that vegetative material on or in boats from that area could have resulted in initial colonization in Currituck Sound.

The mean mid-sound Secchi depths for the earlier part of the growing season for three transects in the northern part of the sound (not including North Landing River, which is essentially barren) for 1959 through 1963 were: 1959—0.7 m, 1960—0.6 m, 1969—0.6m, 1962—0.9 m (16). March or April through June or July data were used, depending on the time the readings were made.

There was no overall reduction in turbidity with the increase in biomass of native species in the northern, Currituck Sound from 1959 through 1961. The decreases in turbidity from 1962 through 1963 appear to be related to increases in salinity from the storm of March 1962, which may have enhanced flocculation of suspended sediments or their export. The initial invasion of Eurasian watermilfoil occurred in a system of native vegetation that had been subjected to natural ecosystem perturbations. We suggest that decreased turbidity, which increased Secchi transparency from 0.6 to 0.9 m, was the principal factor leading to a drastic long-lasting change in the submersed macrophyte composition of the Currituck Sound-Back system.

Another possible adverse effect on submersed plants is dredging. In his review of the literature, Sincock (16) mentioned several cases where dredging was said to result in decreased abundance of plants in the system. The information is essentially anecdotal with no research cited. Sincock (16) estimated that 7,600,000 m^3 of sediment were dredged in the Albermarle and Chesapeake Canal and North Landing River between 1914 and 1919. He was convinced that major dredging activities in North Landing River and Back Bay led to the accumulation of silty semiliquid sediments that he documented for the North Landing River, western Back Bay and northern Currituck Sound in 1962. Sincock considered the North Landing River and western Back Bay to be a source of fine sediments. The extent of resuspension and dispersion were related to hydrographic and meterological conditions. Perhaps the suspended sediments contributing to turbidity changes described by Bourn (3) were more associated with dredging than urban wastewaters moving down from the Norfolk area.

Sincock (16) attributed a collapse of macrophytes in Back Bay in 1963 to extensive dredging and filling which began in the northern part of the bay in 1963. Seechi depth means in the middle (deeper) stations in Back Bay for March through August for 1961 through 1963 were: 1961—0.6 m, 1962 0.7 m, 1963—0.5 m.

FURTHER STUDIES

In August of 1973, Kearson (11), using methods of Sincock (16), repeated the Back Bay-Currituck Sound study transects for Currituck Sound to determine the impact of Eurasian watermilfoil on the submersed macrophyte stands (see Davis and Carey (9) for summary). Eurasian watermilfoil was dominant and bushy pondweed was subdominant. Most of the submersed plant biomass was north of the Big

Narrows (Figure 1) as has been true for all studies. Total biomass was similar to that of August 1963 but 45 percent of this was Eurasian watermilfoil. Davis and Carey (9) correlated changes in seasonal growth of Eurasian watermilfoil in Coinjock Bay (Figure 1) with changes in turbidity. Secchi transparencies remained at 0.2 m through April, 1978 in association with excessive rain and wind during the early growing season. By mid May the standing crop (shoot biomass) of Eurasian watermilfoil in the study area was only about 13 percent of that of 1977 when Secchi transparencies were greater (0.6 to 1.1 m). Standing crop in 1978 increased through July but did not approach the 1977 standing crop which peaked in June. During 1979, Secchi transparencies were between 0.4 and 0.5 m through April as standing crop in June approached that of June 1977. Although Secchi depths were still rather low, this recovery of biomass in 1979 suggests that biomass responses were at least in part related to light availability.

A comparison of 1978 submersed macrophyte biomasses in Currituck Sound with those on the same transects in 1973 shows important differences. The total macrophyte biomass in 1978 was only 42 percent of that of 1973. Biomass of Eurasian watermilfoil was reduced by more than half and bushy pondweed, a strong subdominant to Eurasian watermilfoil in 1973, had been virtually eliminated. We attribute these changes to turbidity and turbulence associated with the weather during the early growing season of 1978. Informal observations in the northern Sound in 1979 and 1981 suggested that, unlike for Coinjock Bay, Eurasian watermilfoil did not recover even though limited Secchi depth data in 1979 indicated that turbidities were similar in the two areas.

CONCLUSIONS

Major changes in biomass and species composition of submersed macrophytes in the Currituck Sound have usually been correlated with changes in suspended sediment turbidity. The demise of the communities in the 1920s was attributed by Bourn (3) to increased turbidity. We suggest that decreased turbidities were probably important in the spread of Eurasian watermilfoil in the Sound in the mid-sixties and that the subsequent reduction of this plant in the late seventies was associated at least in part with increased turbidities.

Negative relationships between high turbidity and submersed macrophyte presence and biomass are strongly supported in the literature reviewed by Davis and Brinson (8). All changes in plant communities that are documented for the Currituck Sound system cannot be explained by turbidity alone. For example, the submersed macrophytes in Back Bay nearly disappeared in 1963 (16) even though Secchi depths were similar to those in Coinjock Bay in 1979 when Eurasian watermilfoil came back strongly.

Although we believe the turbidity, and in some cases turbulence, have often been important forces leading to both long- and short-term changes in submersed macrophyte communities in the Currituck Sound, there are many other factors which can effect changes in these communities. Carpenter (5) suggested that decreased biomass of Eurasian watermil foil in a Wisconsin lake may have been due to synergic interactions between nutrients, epiphytes, competitors, and parasites or pathogens. There are few data to indicate the relative importance of these factors in the Currituck Sound. Abundant growth of epiphytic diatoms were noted on plants near Swan Island during 1978 (Davis and Carey, unpublished), during a period when biomass was generally depressed throughout the Sound as compared with that found in 1973 by Kearson (11).

Scouring by ice formed on the Sound in 1977, 1978, and 1979 could have disrupted plant beds. However the highest plant biomass in Coinjock Bay was in 1977, the year of the greatest ice prevalence (9). The only direct evidence of ice damage to Eurasian watermilfoil was in a small area in the northern Sound following ice breakups in 1977. The upper portion (0.3 m) of milfoil stems was brown and dead but the rest of the plant seemed unaffected. Summer biomass here was also heavy (Davis and Carey, unpublished).

Bayley et al. (1) suggested that increased turbidity associated with hurricanes of 1954 and 1955 may have contributed to the establishment and spread of Eurasian watermilfoil in the late fifties and early sixties in the Susquehanna Flats of the Chesapeake Bay, but turbidity was not estimated. Observations in the northern Chesapeake Bay area (17) indicated that Eurasian watermilfoil was often among the first species to decline in areas where turbidity increased. Bean et al. (2) suggested that disease enhanced by low light penetration may have contributed to the decline of Eurasian watermilfoil in the Chesapeake Bay area beginning in the sixties.

The relatively high salinity of 2.34 $^{0}/_{00}$ measured in Susquehanna Flats in October 1957 was suggested by Bayley et al. (1) as another ecosystem change which could have been associated with Eurasian watermilfoil establishment. Since this was a very dry year (1) and since higher salinities would have been conducive to suspended sediment flocculation, water transparency should have been relatively high at that time. A possible increase in pH and calcium ions associated with flow from the Susquehanna River during years of excess rain were also mentioned as factors which may have contributed to the establishment and growth of Eurasian watermilfoil in the Flats.

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