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Salinity and Secchi Disc Records for Back Bay, Virginia (1925-1989)

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Abstract: All available salinity and water clarity data for Back Bay, Virginia were edited for this manuscript. Quantitative salinity records commence in 1925. These are comprehensive and extend to 1989 except for a major interruption in the 1940's and 1950's. Quantitative water clarity records (Secchi disc visibility) commence in 1959 and are continuous to 1989 with only a few years missing.

Since 1925 the water in Back Bay has fluctuated from fresh (less than 0.5 ppt) to brackish (generally oligohaline, 0.5-3.0 ppt). Fresh to slightly brackish (less than 1.0 ppt) conditions existed from the late 1930's to early 1962, from 1975 to late 1978, and in 1989. For the remainder of this 65-year period, the salinity generally ranged from 2.0 to 4.0 ppt. The higher salinity periods were 1933-34, 1936 and 1962. These were caused by voluminous intrusions of ocean water induced by hurricanes or northeastern storms.

Secchi disc visibility was generally 20 to 30 inches from 1959-60 and 1965-80. During most of this period, the frequency of occurrence of submerged aquatic vegetation (SAV) in transect samples was more than 50%. From 1981 to 1989, water clarity greatly deteriorated with Secchi disc readings of only 6 to 12 inches. This increase in turbidity is attributed to the suspension of soil particles by increased wave action following a decline in SAV. Since 1980 the frequency of occurrence of SAV has been less than 5%. Without rooted, aquatic plants to stabilize the substrate, the sediment is kept in suspension by wave action.

Introduction

The scientific literature was thoroughly reviewed for all available salinity and water clarity data for Back Bay. In this search, the literature review by Sincock (1965 and 1966) for the Back Bay-Currituck Sound Study was invaluable. Sincock presented the results of all Back Bay researchers prior to and inclusive of the Back Bay-Currituck Sound Study. The reader is referred to this report for maps of the sampling stations and tables of empirical data of the various researchers. The salinity data in Sincock's report is presented in various units of measurement. For this manuscript, Sincock's salinity data was converted to ppt and averaged for all stations to provide monthly means. Salinity and Secchi disc data collected since 1965 were added to that collected by earlier researchers to provide a long term data base for this report.

The earliest quantitative salinity records for Back Bay commence in March, 1925 when the Game Preservation Association contracted for the Norfolk Testing Laboratory to analyze water samples from nine stations around Knotts Island. Six of these stations were in Back Bay; the remainder were in Currituck Sound. For this manuscript, the data for the six stations in Back Bay were averaged. Water samples were generally collected on a monthly basis from March, 1925 through 1934. Thereafter, the frequency of sampling declined (6 samples in 1935; 4 in 1936; 3 in 1937; and 1 in 1938). The amount of sampling in this survey, especially during the early years, provides a large data base. However, the location of the stations in the extreme southern area of Back Bay limits the merit of the data as representative of the entire bay.

The next quantitative record for salinity in Back Bay was reported by Chamberlain (1948) who studied the submerged aquatic vegetation and monitored salinity at several stations on the Back Bay National Wildlife Refuge in 1946. Chamberlain monitored salinity at nine stations on a weekly basis in June and July and at 15 stations on a weekly basis from August through November and one week in December. This data base can be considered indicative of the entire bay due to the location of the stations and frequency of sampling.

A limited amount of salinity monitoring was done by the US Army Corps of Engineers from 1949 through 1955. The only known record of this is by Robin (1955) who presented salinity as annual means for two stations (north end of Knotts Island and North Bay). Not knowing the frequency of sampling and considering the existence of only two sampling stations widely separated over the bay, this data base is of limited value.

An uncited reference in Sincock (1966) pre-

sented salinity data at Warden's Headquarters (Redhead Bay) on four occasions between August, 1953 and August 1956. The merit of this data is limited and must be used with caution when applied to the entire bay.

The next salinity data base and first Secchi disc records were collected as part of the Back Bay-Currituck Sound Study. Salinity was monitored at three stations along eight transects across the bay. This monitoring was performed from May, 1958 through August, 1963 and generally on a monthly basis.

The US Fish and Wildlife Service (USFWS) monitored salinity and Secchi disc visibility at 22 stations throughout the bay from May, 1965 through 1977 (Figure 1). The data was generally collected on a monthly basis through 1973, after which the frequency of sampling declined. Salinity was monitored for the following number of months in 1974-1977: 5, 4, 1 and 1, respectively. This data was never published.

The Virginia Department of Game and Inland Fisheries commenced salinity and Secchi disc monitoring in March, 1978 and continued through the term of this manuscript. Salinity and Secchi disc visibility were monitored at the same 22 stations used previously by the USFWS. Two additional stations were added in 1986 to better represent the bay (Figure 1). Sampling was conducted almost every month. Results were reported by Norman and Southwick (1987) and Southwick (1989).

Results and Discussion

Salinity records are presented as monthly means from 1925 through 1989 in Figure 2. Secchi disc records are presented as monthly means from 1959 through 1989 in Figure 3.

Salinity

The mean salinity from 1925 through 1930 was generally less than 2.0 ppt and fairly constant (Sincock, 1966 citation of Game Preservation Assoc. records). The mean salinity ranged from 1.2 ppt (December, 1928 and February, 1929) to 3.6 ppt (December, 1925 and November, 1930). Starting in the summer of 1930, the mean salinity increased to approximately 7.0 ppt by the summer of 1931 and then remained between 6-8 ppt through spring, 1933. Presumably this increase was due to ocean water intrusions across the barrier dunes. Sincock (1966) speculated that this freshening of the bay may have been due to the closing of the Great Bridge locks on the Albemarle and Chesapeake Canal. The locks had been open from April, 1917 to August, 1932. During this period salty water from Norfolk Harbor (Elizabeth River) flowed South along the Albemarle and Chesapeake Canal into Currituck Sound. Southerly winds prevalent during the summer months in this area would have pushed this salty water into Back Bay. However, we believe that this freshening was a natural occurrence.

A hurricane in August, 1933 breached the barrier dunes and dumped a vast quantity of ocean water into Back Bay. This increased the mean salinity to approximately 10 ppt where it remained until the following spring. The highest mean salinity found after the hurricane was 11.4 ppt on August 31, 1933. The bay freshened to 3-4 ppt by spring, 1934 and remained relatively constant for the rest of the year.

Salinity records are limited for the last four years of these Game Preservation Association records. However, these records are sufficient to show that the bay freshened further in 1935 and early 1936. By spring, 1936 the mean salinity was less than 1.0 ppt.

Another hurricane breached the barrier dunes in October, 1936. Immediately after the hurricane, the mean salinity was 6.5 ppt. The effect of this 1936 hurricane relative to the 1933 one was probably lessened by the sand fences completed in 1933-35. The salinity in the bay was not increased nearly as high in 1936 as in 1933 and the bay freshened much quicker. The last record in this data set (March, 1938) showed a mean salinity of 1.2 ppt.

Few salinity records exist for Back Bay during the 1940's and 1950's. These records indicate that the bay was fresh to slightly brackish. The most comprehensive and authentic record for this decade is from Chamberlain (1948). He found that salinity in 1946 ranged from 0.6 to 1.0 ppt with little spatial or temporal variation. Another salinity record for the late 1940's - early 1950's is Robin (1955). Robin wrote that from January, 1949 to September 1950 the average salinities at the north end of Knotts Island and North Bay were 0.7 and 0.5 ppt, respectively. This was prior to a storm induced break in the barrier dunes approximately 1.5 miles north of the Currituck Beach Light, which brought in a considerable amount of ocean water. However, this influx of ocean water caused only a slight increase in salinity. According to Robin, the salinities from September, 1950 to August, 1951 averaged 1.2 ppt (north end of Knotts Island) and 1.0 ppt (North Bay). Sincock cited an unpublished reference which gave the salinity at Warden's Headquarters (Redhead Bay) as 0.7 ppt in August, 1953; 1.0 ppt in September, 1953; 1.4 ppt in July, 1956; and 1.6 ppt in August, 1956. Although these records for the 1950's are not extensive, they do indicate that the bay was fresh to slightly brackish during this period.

Salinity data gathered during the Back Bay-Currituck Sound Study showed that the bay remained fresh to slightly brackish until March

7, 1962 when the "Ash Wednesday storm" breached the barrier dunes and washed a voluminous amount of ocean water into the bay. The ocean water did not immediately mix with the fresh water of the bay. Rather, it was stratified in the water column and varied greatly from East to West. Differences as great as 12 ppt were found between surface and bottom samples. Bay salinity near the breaches on March 8, 1962 was as high as 26 ppt. After two weeks of mixing, the salinity averaged 4.7 ppt on March 22, 1962. Following this peak, the salinity gradually declined until spring, 1963 when it tapered off at 1.6 ppt. The salinity remained approximately at this level through summer, 1963 when this data set terminates. The last record in this study was taken on August 21, 1963 and showed a bay average of 1.9 ppt.

The earliest record in the survey conducted by the USFWS was made on May 27, 1965 and showed an average salinity of 0.7 ppt. The salinity rapidly increased following this reading. The explanation for this was the introduction of seawater into Back Bay via a pump located at Little Island. This seawater pumping into Back Bay was initiated and conducted by the City of Virginia Beach. The objective for pumping seawater into Back Bay was to flocculate suspended sediment in the water, thereby allowing sunlight penetration to the bottom for growth of submerged aquatic vegetation. It was locally believed that the principle of soil particles binding to the cations common in seawater and settling out of suspension could be applied to Back Bay. This artificial introduction of seawater raised the salinity from 0.7 ppt in May to 3.9 ppt in August, 1965. Over the next ten years the salinity varied considerably but generally ranged from 2.0 to 3.0 ppt until late 1974 (Norman and Southwick, 1987). Factors influencing the monthly fluctuations included the amount of seawater pumped, rainfall, and salt water blown north from Currituck Sound. There were no storm induced breaches in the barrier dunes during this period. The decline in salinity commencing in late 1974 was due to an extended shutdown of the Little Island pump. Pump operation records are not available after 1972 for this initial pumping period. Apparently any seawater pumped in 1975 and 1976 must have been negligible since the available salinity data showed that the bay was fresh to slightly brackish. The salinity from January to October, 1975 ranged from 0.4 to 0.5 ppt. The salinity did not exceed 0.9 until seawater pumping was resumed. The pump had been destroyed by a fire in May, 1977 and was not replaced until August, 1978. Renewed introduction of seawater had an immediate and pronounced effect on salinity. The salinity increased to 3.0 ppt by September, 1978. The pumping was continued for the next nine years except for pump breakdowns and maintenance shutdowns. The latter were generally done annually during January through March. During this nine year period, the salinity was kept higher than during the previous pumping period. From 1979 through 1987, the salinity was generally between 3.0 and 4.0 ppt. Monthly peaks of 4.0 ppt were common. The highest monthly average was 5.4 ppt in June, 1980. During the periods of maintenance shutdown, the salinity declined to approximately 2.0 ppt. The seawater pump operation was terminated in September, 1987. Following this shutdown, the salinity gradually declined with minor fluctuations due to rainfall and salt water input from Currituck Sound. By December, 1989 the mean salinity had declined to 0.7 ppt.

Secchi disc readings

Secchi disc readings prior to 1965 are limited (only six records from 1959 through 1961). These records are insufficient to draw any conclusion regarding water clarity, except to note that Secchi disc visibility ranged from 8 to 35 inches. Commencing in 1965, the data base for Secchi disc readings is quite extensive and provides a comprehensive record for water clarity. From 1965 through 1980, Secchi disc visibility generally ranged from 20 to 30 inches. Commencing in 1981, water clarity started to deteriorate. From 1981 through 1984, Secchi disc readings averaged about 10 inches. With continued deterioration in water clarity, Secchi disc readings were routinely less than 10 inches during the last four years of this data set. This decline in water clarity is attributed primarily to a decline in the abundance of submerged aquatic vegetation in the bay. With reduced abundance of rooted, aquatic plants to stabilize the substrate in the bay, the wind driven wave action maintained the sediment in suspension. This can be seen very graphically in Figure 4. Other sources of sediment were from land use practices. Residential and commercial development in the watershed intensified in the early 1980's. On a seasonal basis, water clarity was the poorest during the winter and spring. The explanation for this is greater wind activity during these seasons, which resuspended the bottom sediment.

Acknowledgments

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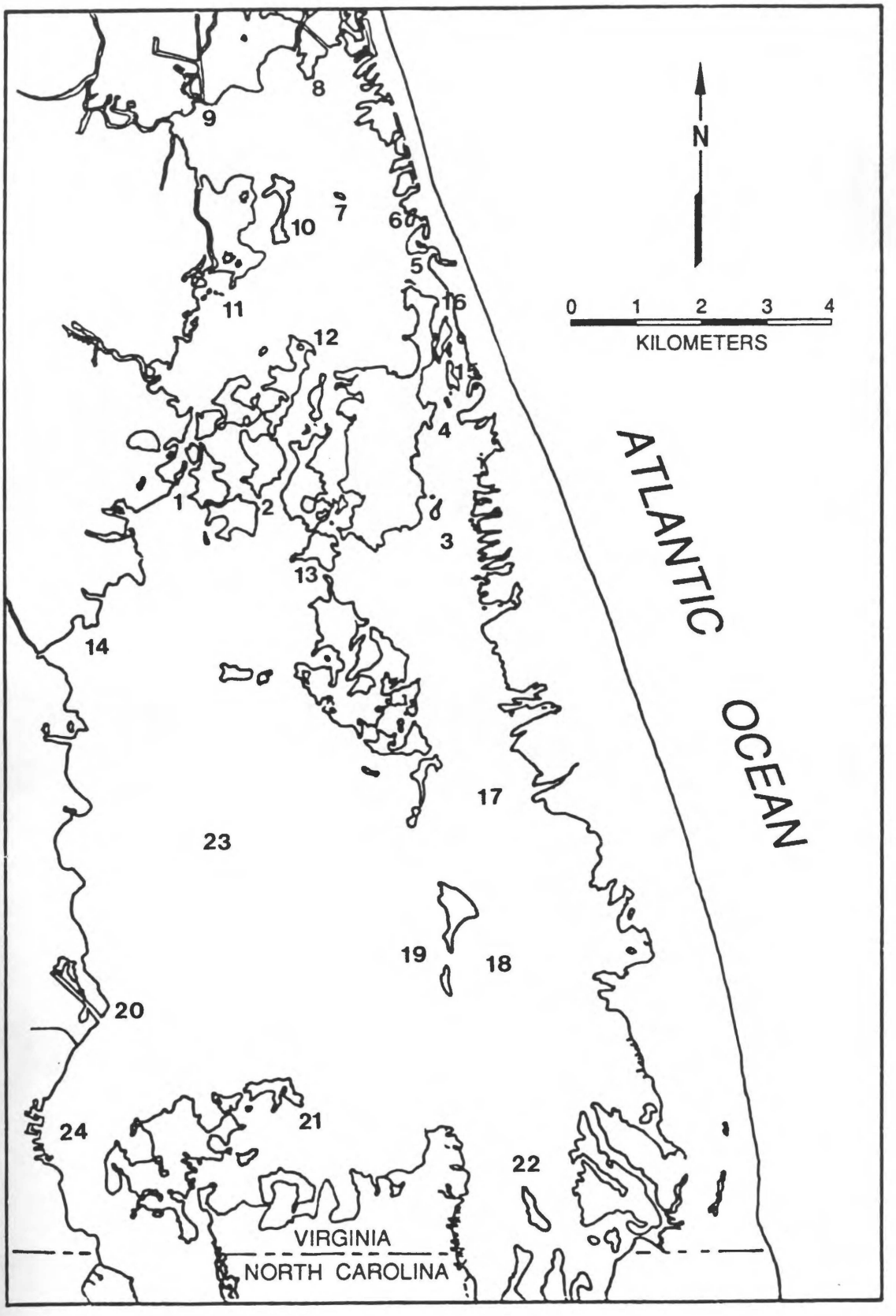

Figure 1. Map of Back Bay showing location of 24 salinity/Secchi disc monitoring stations.

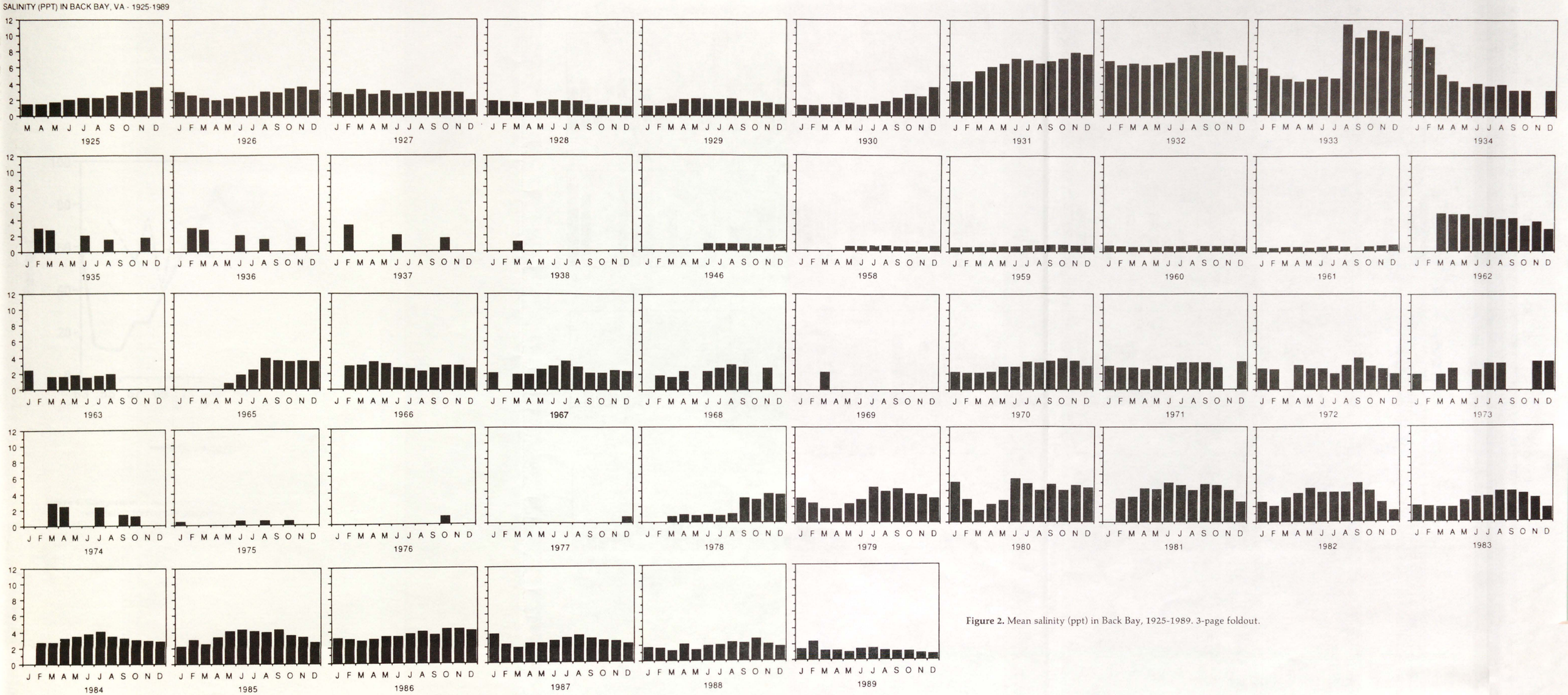

Figure 2. Mean salinity (ppt) in Back Bay, 1925-1989. 3-page foldout.

SECCHI DISC VISIBILITY (INCHES) IN BACK BAY, VIRGINIA (1959-1989)

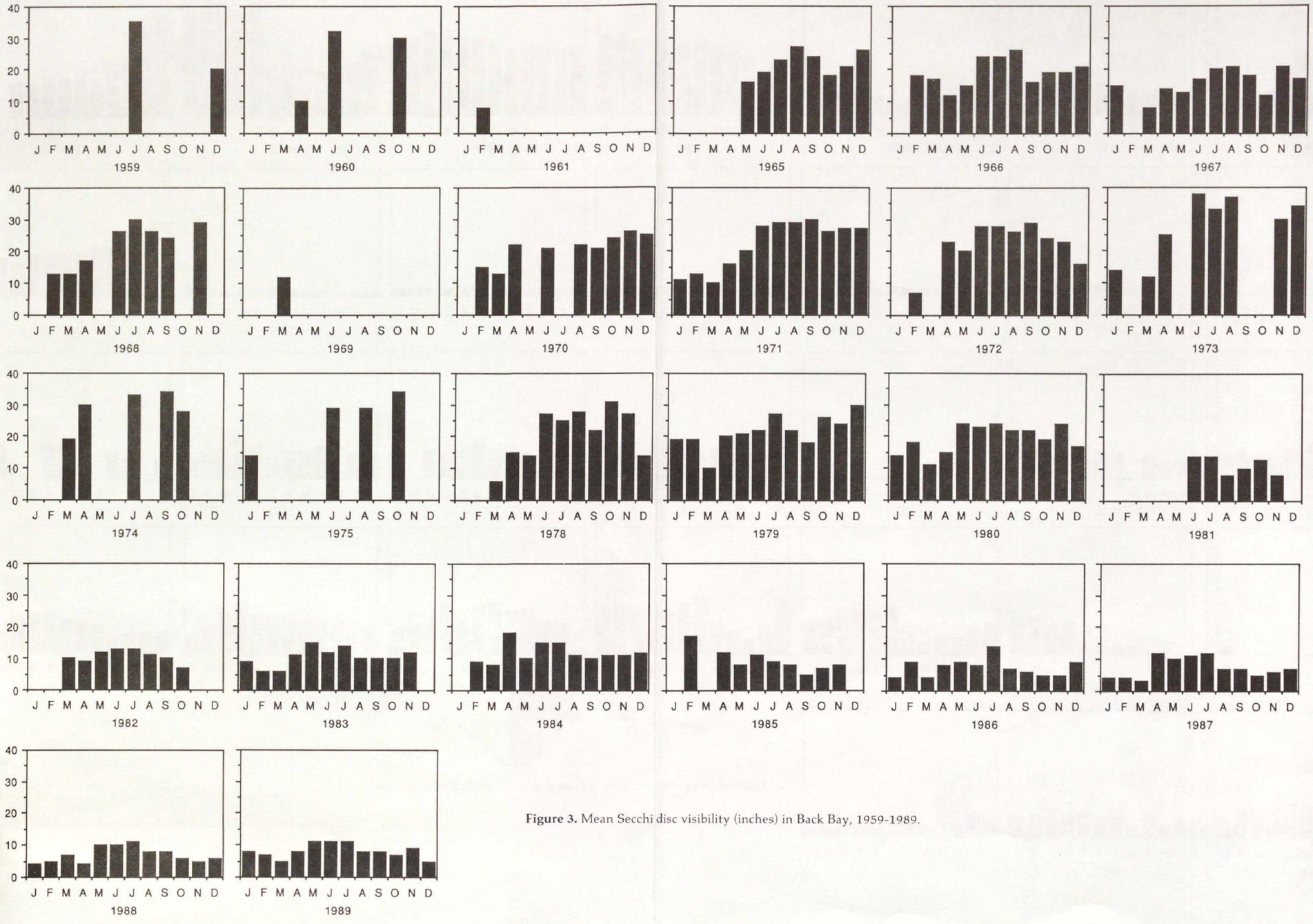

Figure 3. Mean Secchi disc visibility (inches) in Back Bay, 1959-1989.

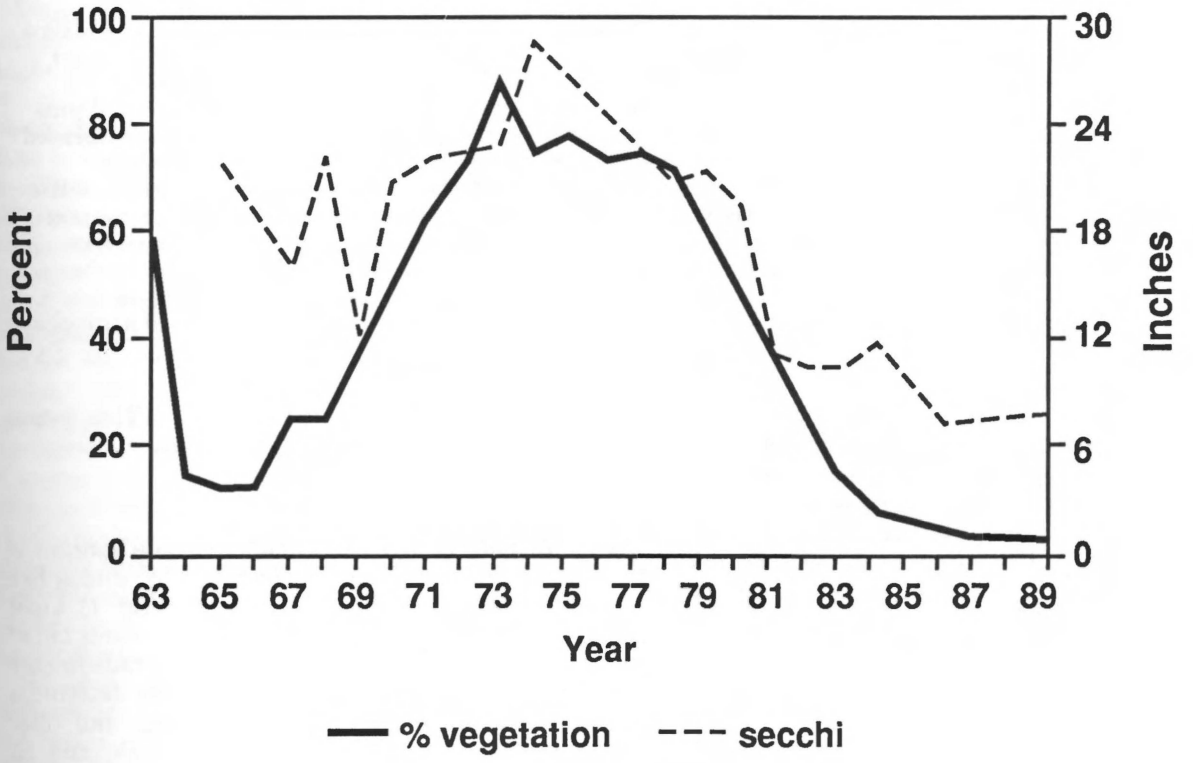

Figure 4. Comparison of mean Secchi disc visibility (inches) with abundance of submerged aquatic vegetation (percent of occurrence at sampling stations).