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Report on a survey of the chemistry and hydrography of Great South Bay and Moriches Bay made in June, 1957 for the Town of Islip, New York

By

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I. Introduction.

At the request of the Township of Islip, a chemical and biological survey of Great South Bay and Moriches Bay was conducted by the Woods Hole Oceanographic Institution during the summer of 1957. The survey duplicated to a large extent those which have been made annually by this Institution since 1950. Due to previous commitments of the scientists, the 1957 survey was made during June 24-25 rather than in late August, when the earlier studies were conducted.

Water samples were taken for both direct and subsequent laboratory analyses from the same locations as in the earlier surveys, consisting of a line of 17 stations located approximately along the central channel from Fire Island Inlet, at the western end of Great South Bay, to Westhampton, at the eastern end of Moriches Bay. Eleven additional stations were occupied along the northern side of the embayments in the various coves, creeks and rivers which had earlier been found to contribute to the pollution of the bay waters. Station locations are shown in Figure 1.

The survey was conducted from a boat provided by the New York State Department of Conservation, and the authors wish to acknowledge their generous assistance. Much credit is also due to Mssrs. G. H. Vanderborgh, Sr. and Jr., Mr. Joseph Glancy, Mr. Samuel Cross, and Mr. Kenneth Mockridge for their valuable help before and during the survey, and for making available the seasonal data on salinity, rainfall, and winds which were used in the preparation of this report.

II. The distribution and relative concentrations of salinity, phosphorus and chlorophyll.

In conducting the 1957 survey it was at once obvious that a dramatic change had taken place since the previous August, particularly in Moriches Bay and Bellport Bay. These waters, which had been clear and relatively free from microorganisms were now extremely turbid and reminiscent of the conditions in 1950-53 when Moriches Inlet was closed and the pollution at its peak. In contrast to those times, however, the water in 1957 was rich, chocolate brown color rather than the yellow-green which was characterisitc of the "small form" blooms of earlier years.

To best illustrate the changes which have taken place since 1952, data are presented in Figure 2 showing concentrations of salinity, total phosphorus, and chlorophyll along the central channels of Great South Bay and Moriches Bay in 1952, 1956 and 1957. The salinity, to some extent, illustrates the extent and rapidity of exchange of bay water with the outside ocean water. However, as will be emphasized later in this report, salinity was not a reliable index of water exchange in 1957. Total phosphorus is a convenient tracer of the amount of pollutants in the bay waters, including as it does both the particulate and dissolved components as well as the phosphorus which has been assimilated by microorganisms. Chlorophyll is probably the best single criterion of the total abundance of microscopic plant cells, better for comparative purposes than cell counts which are difficult to interpret without knowledge of the sizes of the different organisms. Unfortunately chlorophyll analyses were not made in 1952.

Salinities in 1957 were generally higher than in 1956 except in Bellport and Narrow Bays. In both of these years the salinity was much higher than in 1952, particularly in Moriches Bay where 1952 salinities fell below 15 ‰. This is also true of the estuaries, not shown in Figure 2, where salinities in both the past two years have been higher than 20 ‰ in contrast to values of 5-10 ‰ in 1952.

The concentration of total phosphorus follows a rather different pattern. In Great South Bay, the level of phosphorus was about the same in 1956 and 1957. However from Bellport Bay eastward and throughout Moriches Bay phosphorus concentrations were much higher in 1957 and approached the high levels found in 1952.

Chlorophyll concentrations in 1957 were some 10 times the 1956 levels. Oddly enough, high concentrations were found near Fire Island Inlet, indicative of a plankton bloom of unknown origin or history in the more saline offshore waters. The chlorophyll concentration decreased in an eastward direction reaching a minimum in central Great South Bay, off Bluepoint, then increased reaching a maximum of 60 mg/m^3 in central Moriches Bay. The highest value found anywhere in the bay waters in 1956 was about 7 mg/m^3. Values for unpolluted coastal waters rarely exceed 5 mg/m^3.

The overall picture in 1957, then, was that of a water mass in the embayments of higher than normal salinity but, at the same time, containing relatively large quantities of pollutants and extremely dense concentrations of microscopic plants. The phytoplankton was comparable in abundance if not in species to the water blooms of the early 1950's at least in the Moriches Bay region, though not extending as far into Great South Bay as in earlier years.

III. The relationship between salinity and total phosphorus.

In 1952, when Moriches Inlet was closed, there was in general an inverse correlation between total phosphorus and salinity. Since the pollutants have their origin at the duck farms located, for the most part, up in the estuaries of Moriches Bay, they were found entrained in and associated with the fresh water runoff from these areas. High salinities in the bay areas, on the other hand, were associated with pollutant free coastal waters entering the bays through tidal exchange. In Figure 3 the open circles show the salinity-phosphorus relationships in 1952, and the solid line has been drawn by eye through these points.

In 1956, both bays were relatively free of pollutants and one question raised was whether the quantity of pollutants entering the bay waters had lessened appreciably or whether the improved situation was due to hydrographic causes. In the report for 1956, it was pointed out that the salinity-phosphorus relationship that year was about the same as in 1952, the points generally falling around the 1952 curve. This was interpreted to mean that the pollution had not materially abated, but that the improved conditions had resulted from the more rapid exchange between Moriches Bay and the outside sea water, presumably through Moriches Inlet.

The 1957 samples from Great South Bay (crossed circles in Figure 3) also appear to fall around the 1952 curve. But the Moriches Bay samples show a radical departure from this relationship. In every case water of a given salinity contained much more phosphorus than in 1952, and there appears to be no recognizable correlation between the two. In other words either the high salinity water found in 1957 was not indicative of the presence of pollution-free sea water in Moriches Bay, or water from the Moriches Bay estuaries contained much greater quantities of pollutants than ever observed before.

IV. The origin of the high salinity water in Moriches Bay.

Figure 2, as mentioned above, illustrates that the salinities in June, 1957, were generally higher throughout the area than at the time of the surveys of either 1952 or 1956. Figure 4, compiled from data provided by Mr. J. B. Glancy, shows that the salinity at West Bay Bridge, at the eastern end of Moriches Bay, was higher throughout the summer of 1957 than in the three previous years, particularly during May and June.

Neither facilities nor funds were available in 1957 for a complete hydrographic survey of the bays and their inlets. However, indirect evidence, strongly supported by conversation with local inhabitants, left little doubt that Moriches Inlet had filled in considerably since its opening in 1954. Both the 1954 and 1956 surveys showed the influence of Moriches Inlet on the two Moriches Bay stations nearest the inlet (Sta. 18 and 35) which were characterized by lower temperature , lower phosphate, less chlorophyll, greater transparency and higher salinity than the other Moriches Bay stations. In 1957 these two stations did not differ appreciably from the others by any of the above mentioned criteria. Apparently, then, much less tidal exchange took place through Moriches Inlet in 1957 than in 1956. Therefore it seems unlikely that the high salinities in Moriches Bay in

1957 could have resulted from the more rapid exchange of water between the bays and the outside ocean water.

Another possible explanation is given in Figure 5 showing the total precipitation for periods of one month (A) and three months (B) prior to the 4 surveys of 1954-57. 1957 was obviously a dry year, particularly during June, the period preceding the survey, when the record showed 0.16 inches of rain at Patchogue. According to persons living near Moriches Bay no rain whatever fell in that area. It seems likely that the lack of rainfall and runoff, and the excess of evaporation over precipitation during that period could have accounted for the higher salinities in the bay.

The high concentrations of pollutants in Moriches Bay supports the theory that the materials had accumulated there as a result of the decreased flushing action. This would result both from the filling in of Moriches Inlet and the reduced amount of fresh water entering the bays as a result of the drought conditions. It seems quite unlikely that more pollution was contributed from the duck farms in 1957, in fact quite the opposite was probably the case since dry weather prevents the leaching of pollutants from the farms into the estuaries.

V. The composition of the phytoplankton.

Table 1 gives a summary of the phytoplankton (microscopic plant) cell counts at 9 selected stations in 1952, '54, '56 and '57. The composition in 1957 was similar to that found in 1956, predominantly a diatom flora with rather large numbers of dinoflagellates and chrysophycean flagellates. The numbers of these organisms in 1957 were some ten to a hundred times as great as were found in 1956. The secondary peak of chlorophyll at Station 2 (Fire Island Inlet) was caused principally by small chrysophycean flagellates (Calcyomonas), other unidentified flagellates, and some small diatoms. These flagellates dominated the phytoplankton throughout Great South Bay, but were less common in Moriches Bay where several species of diatoms, particularly Skeletonema costatum and Thallasiosira nana, were the most abundant forms.

Nannochloris (small forms) were present throughout most of Great South Bay in 1957, but were less common in Moriches Bay. This is in contrast to the situation in 1956, when this species was found only up in the brackish portion of the Forge River. While it appears from the counts to be extremely abundant it should be borne in mind that Nannochloris is perhaps only 1/100th the volume of a small diatom, and that consequently the "small forms" make up an almost negligible fraction of the total quantity of plant cells.

VI. Ecological factors affecting the composition of the phytoplankton.

It is clear from the preceding brief discussion that two rather distinct plankton communities were present in 1957. The one, extending from Fire Island Inlet eastward to Bellport Bay, contained fewer organisms, was dominated by flagellates with relatively fewer diatoms, and contained rather large numbers of Nannochloris. A rather sharp break occurred at Bellport Bay to the east of which the total quantity of phytoplankton increased sharply, the community was dominated by diatoms, and Nannochloris was less common or lacking. The only exception to this pattern was found well up in the creeks (i.e. Sta. 30, Forge River Dock) where flagellates, particularly species of green algae, and some Nannochloris were present.

The ecological factors responsible for the rather distinct difference between these two communities cannot be fully evaluated from the brief survey made in 1957. However, two of these factors are quite apparent. The pollution from the duck farms located in the Moriches Bay area (including those located on the Carman River) appears to penetrate westward as far as Bellport Bay but not appreciably beyond. This is undoubtedly the cause of the greater abundance of phytoplankton comprising the Bellport-Moriches Bay community. The other obvious factor is salinity, which was below 25 ‰ in most of Great South Bay but as high as 30 ‰ in Moriches Bay. There appears to be a tendency for the flagellate-Nannochloris community to be associated with low salinities, the diatom community with higher salinities. Far too little is known about the salinity tolerances and optima of these various organisms to make any positive statement. But some earlier experiments in which both Nannochloris and the diatom, Nitzschia closterium, were grown in different salinities clearly showed that the Nannochloris, while growing at almost any salinity, appeared to do best in about 50% sea water whereas the diatom definitely preferred full sea water and grew much more slowly in brackish water. The results of this study are reproduced in Figure 6.

VII. The relationship between pollutants and the abundance of phytoplankton.

According to Figure 2, the concentration of chlorophyll in Moriches Bay and eastern Great South Bay increased by almost ten-fold in 1957 over that found in 1956. At the same time the quantity of phosphorus in the same area was only twice as high. This would appear to be inconsistent if the abundance of phytoplankton is to be attributed to the quantity of pollutants in the water. The reason for this apparent discrepancy is that phosphorus is present in excess of the plant's requirements relative to the concentrations of available nitrogen compounds. Diatoms contain nitrogen and phosphorus in a ratio of 10-15:1 by atoms, while green algae, such as Nannochloris, have a somewhat lower ratio of 6-8:1. Our analyses of duck feed and duck manure indicate that the N:P ratio in these substances is about 3:1. Thus, when all the nitrogen has become exhausted, as much as 1/2 to 2/3 of the phosphorus is left over in the water. For this reason, phosphorus, though a convenient tracer of pollution, is unreliable as an index of potential plant growth.

It was concluded after the extensive 1952 survey that nitrogen was the factor which limited the growth of phytoplankton in Great South Bay and Moriches Bay at that time. One experiment conducted in 1952 illustrated this point rather conclusively. Water was collected from a group of stations from Fire Island Inlet to central Moriches Bay, including Sta. 30 at the Forge River Dock. This water was filtered and each sample divided into three aliquots which received the following treatment: 1) control (nothing added), 2) phosphorus added, 3) nitrogen added. All were then inoculated with the same concentration of Nannochloris and its growth was followed for 10 days. No significant growth occurred in any of the controls except for a slight increase in the Forge River sample. In no case was growth improved with the addition of phosphorus, but good growth occurred in all of the samples to which nitrogen was added (Table 2). It was concluded from this experiment that nitrogen was utilized in Moriches Bay and its tributaries as quickly as it became available from the duck farms, and that little or no growth of the Nannochloris population occurred in Great South Bay, its presence there in 1952 being the result of its passive transport by tidal flushing.

There is nothing to indicate that conditions have changed appreciably since that time. Analyses for nitrate, nitrite, and ammonia-nitrogen in Moriches Bay in 1957 still showed extremely low concentrations of these compounds and relatively high concentrations of free inorganic phosphorus. The occurrence of a distinct population in Great South Bay is therefore probably indicative of a separate water mass, with its own source of nutrients, perhaps the larger tributaries of Great South Bay itself or the outside ocean water, but not the pollutants originating in Moriches Bay.

VIII. The effect of wind upon the distribution of pollutants and phytoplankton.

In the 1956 report evidence was presented that the force and direction of winds may have a pronounced effect upon the distribution of the polluted Moriches Bay water in Great South Bay. An excess of west wind, which is apparently the normal situation in summer, appeared to hold back Moriches Bay water while an excess of east winds, fairly common in the spring and less common in summer, caused the penetration of polluted water well into Great South Bay. This was held to be the explanation of the presence of waters high in pollutant and phytoplankton concentrations as far west as Bluepoint in 1955, in contrast to conditions in 1954 and 1956. Figure 7 shows the monthly excess miles of east or west winds from May through August for the four years from 1954-1957. There was an excess of west winds throughout the summer of 1957, which is perhaps the reason that the polluted water did not penetrate farther to the west than the Bellport Bay region. The only year in this period in which there was an excess of east wind in the summer was 1955.

Conclusions.

Conditions in Moriches Bay have deteriorated badly since 1956, presumably due to the restriction of Moriches Inlet and the resulting reduction of the tidal exchange between the bay and the outside ocean water. Concentrations of pollutants and the accompanying growth of plankton algae have increased to proportions reminiscent of conditions prior to the opening of the inlet in 1954.

Probably only the circumstance of an unusually dry spring prevented the salinity of Moriches Bay from being reduced to a level which, together with the high concentrations of nutrients, would favor the dense growth of <u>Nannochloris</u> (small forms) over that of the diatoms which occurred in great abundance at the time of the June survey.

Great South Bay, west of Bellport Bay, was still relatively free from the effects of pollution. Apparently there is still sufficient circulation of water through Moriches Inlet to prevent the passage of any appreciable amount of Moriches Bay water through Great South Bay. Thus the two bodies of water exchange with the ocean through their respective inlets and intermix in the Bellport Bay region. This distributional pattern may be upset at any time by a prevalence of easterly winds which appears to force Moriches Bay water westward into Great South Bay.

If the two inlets both fill in at the same rate it is difficult to predict future events. But if Moriches Inlet closes more rapidly than Fire Island Inlet, as appears to have happened within the last year, it is most likely that the two bodies of water will no longer remain distinct, but Moriches Bay will slowly flush westward through Great South Bay. The longer retention time of the polluted waters, in years of normal rainfall, will almost certainly result in the widespread reappearance of dense populations of the small green algae, <u>Nannochloris</u>, to the detriment of the revived shellfish industry.

If the improved conditions in Great South Bay which have existed since 1954 are to continue it is mandatory, in the opinion of this group, that Moriches Inlet be widened, deepened and stabilized as quickly as possible.

Table 1. Phytoplankton cell counts (cells/ml) at selected stations in 1952, '54, '56, and '57.

Sta.	1952 Nannochloris	1952 Diatoms	1952 Flagellates	1954 Nannochloris	1954 Diatoms	1954 Flagellates
2	1,450,000	--	--	1,200	150	320
4	2,550,000	--	--	1,600	15	90
6	2,400,000	--	--	3,900	25	760
10	1,930,000	--	--	4,700	54	890
11	2,490,000	--	--	6,380	80	720
13	7,200,000	--	--	7,400	430	690
18	5,000,000	--	--	1,200	140	509
19	6,000,000	--	--	1,700	35	608
30	2,940,000	--	--	260,000	605	18,000

Sta.	1956 Nannochloris	1956 Diatoms	1956 Flagellates	1957 Nannochloris	1957 Diatoms	1957 Flagellates
2	--	243	20	--	1,909	15,377
3	--	23	39	70,000	2,000	35,600
6	--	206	5	14,000	2,801	1,801
10	--	22	8	11,700	14,153	463
11	--	117	28	--	2,605	156
13	7,300	618	2,850	--	4,261	88
18	--	557	3	Not counted		
19	--	222	8	5,625	10,896	225
30	6,800	165	11,417	144,000	226,800	14,400

Table 2. The growth of Nannochloris sp. in enriched and unenriched water collected from Great South Bay, Moriches Bay and Forge River on September 23-24, 1952. (Figures represent population after 10 days in millions of cells per ml.)

	Station Number							
	2	4	5	11	15	19	21	30
Unenriched	0.71	0.89	0.88	1.25	1.02	0.91	1.04	1.98
P-enriched	0.03	0.42	0.40	0.46	0.38	0.36	0.42	1.08
N-enriched	8.10	10.00	10.20	21.70	20.80	24.20	18.40	19.05

Initial inoculation: 1.00×10^6 cells/ml.

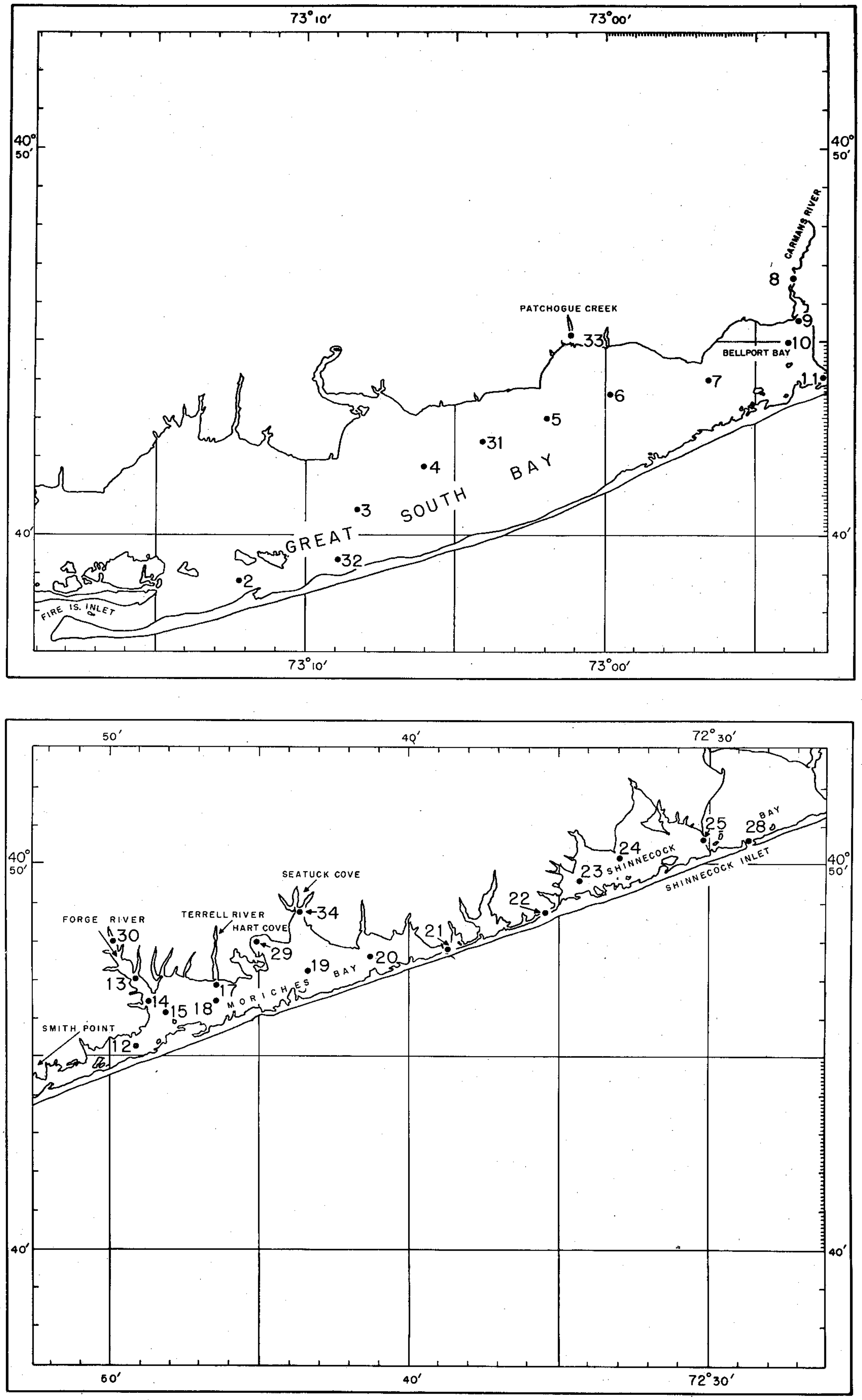

Figure 1. Chart of Great South Bay and Moriches Bay showing station locations.

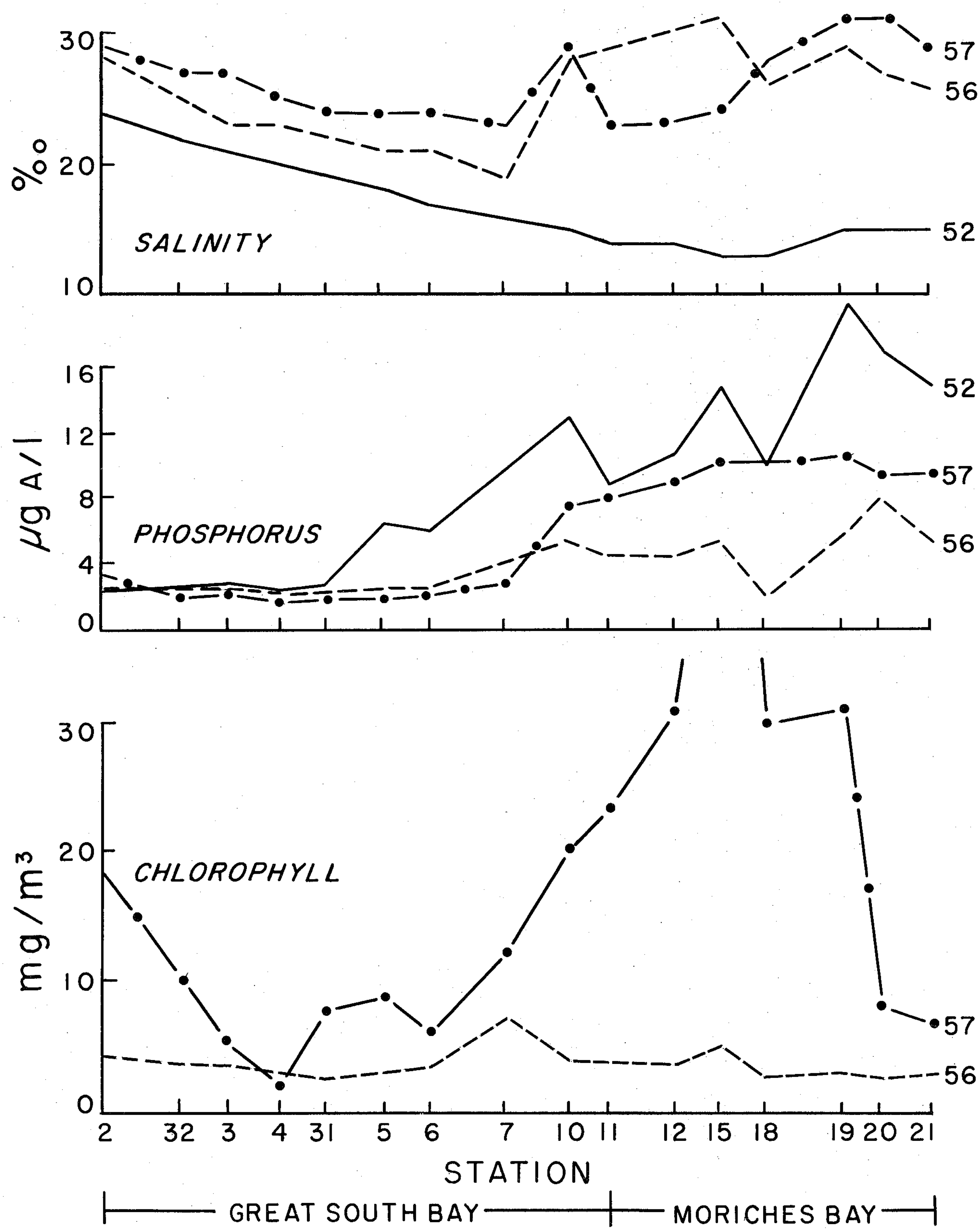

Figure 2. Concentrations of salinity, total phosphorus, and chlorophyll along the central channels of Great South Bay and Moriches Bay in 1952, '56 and '57.

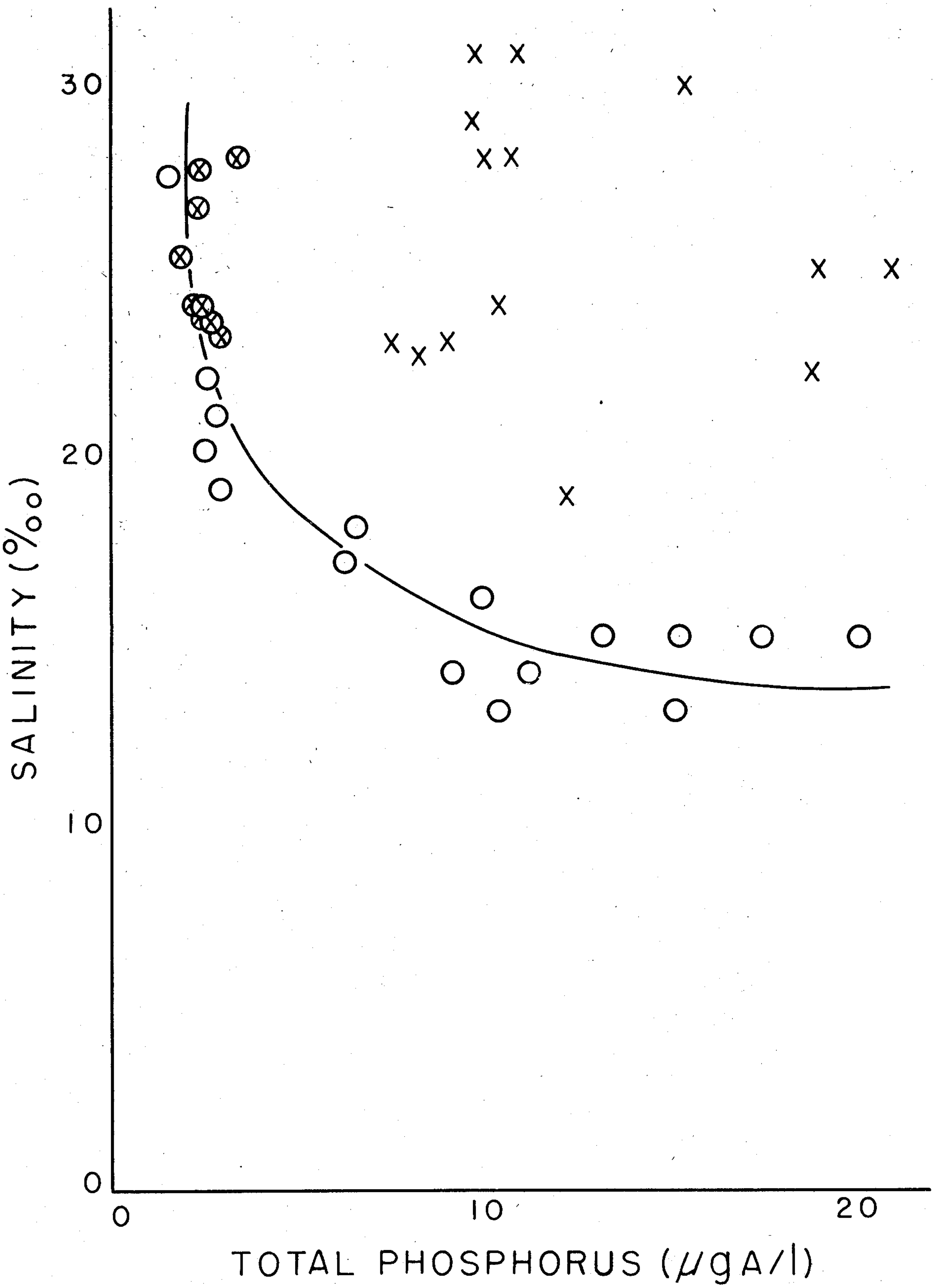

Figure 3. The relation between salinity and total phosphorus. Open circles = both bays, 1952; crossed circles = Great South Bay, 1957; crosses = Moriches Bay, 1957.

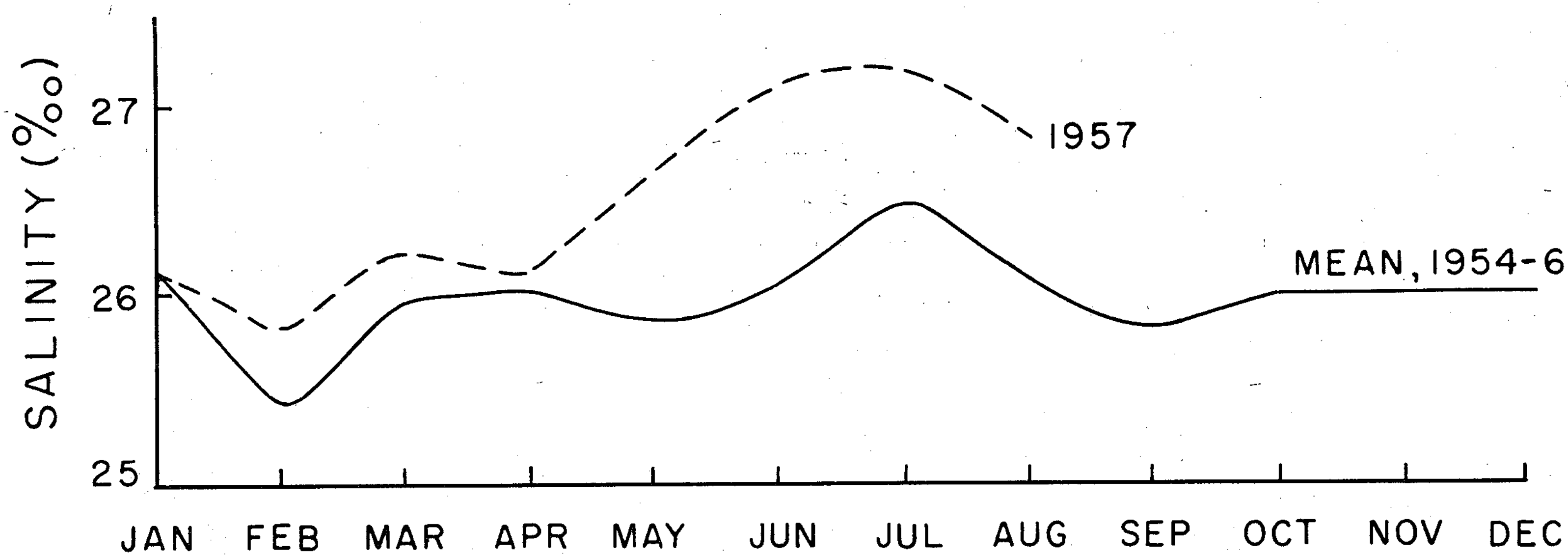

Figure 4. Salinity at West Bay Bridge.

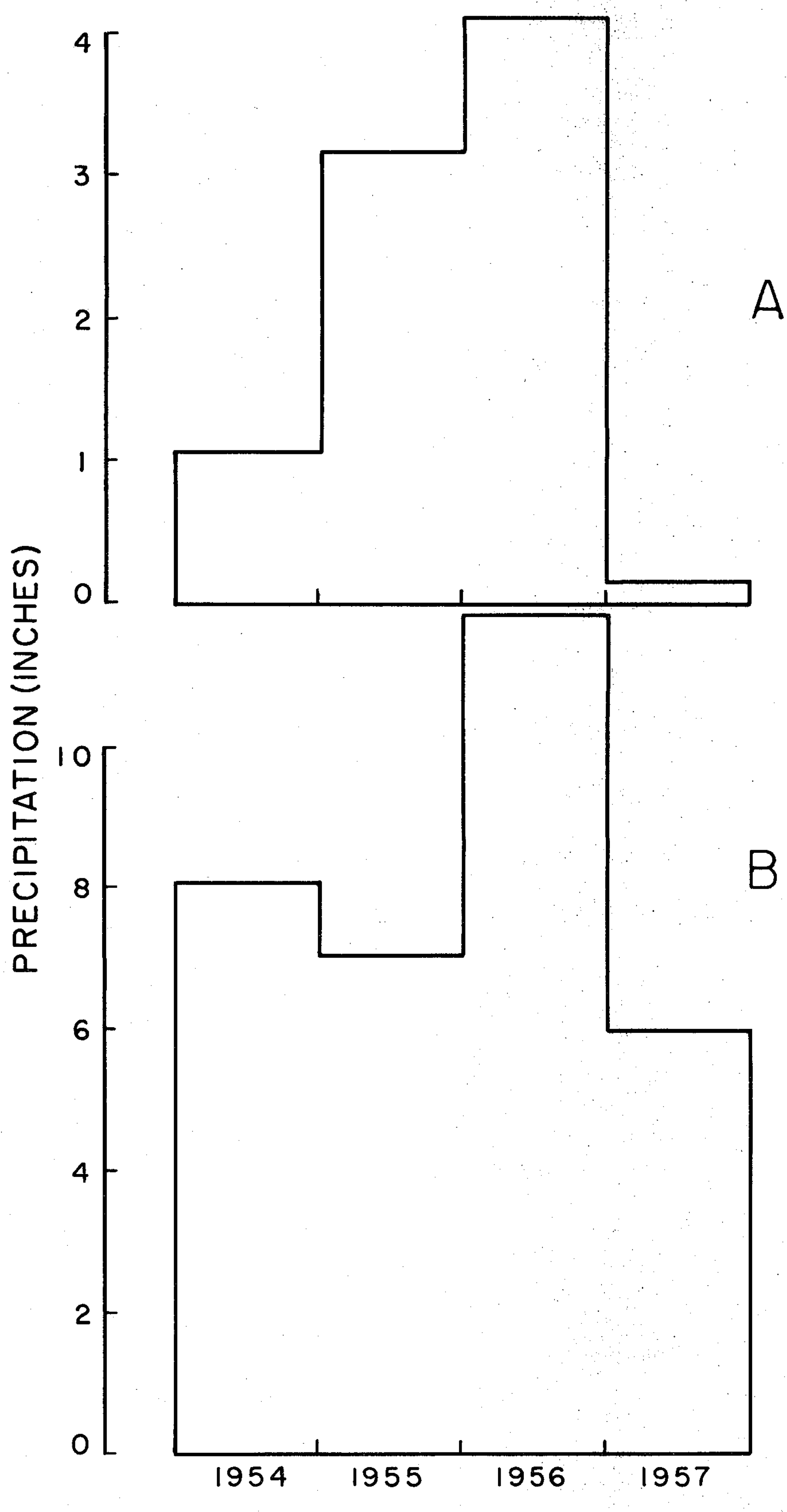

Figure 5. Total precipitation for periods of one month (A) and three months (B) prior to surveys of 1954, '55, '56 and '57.

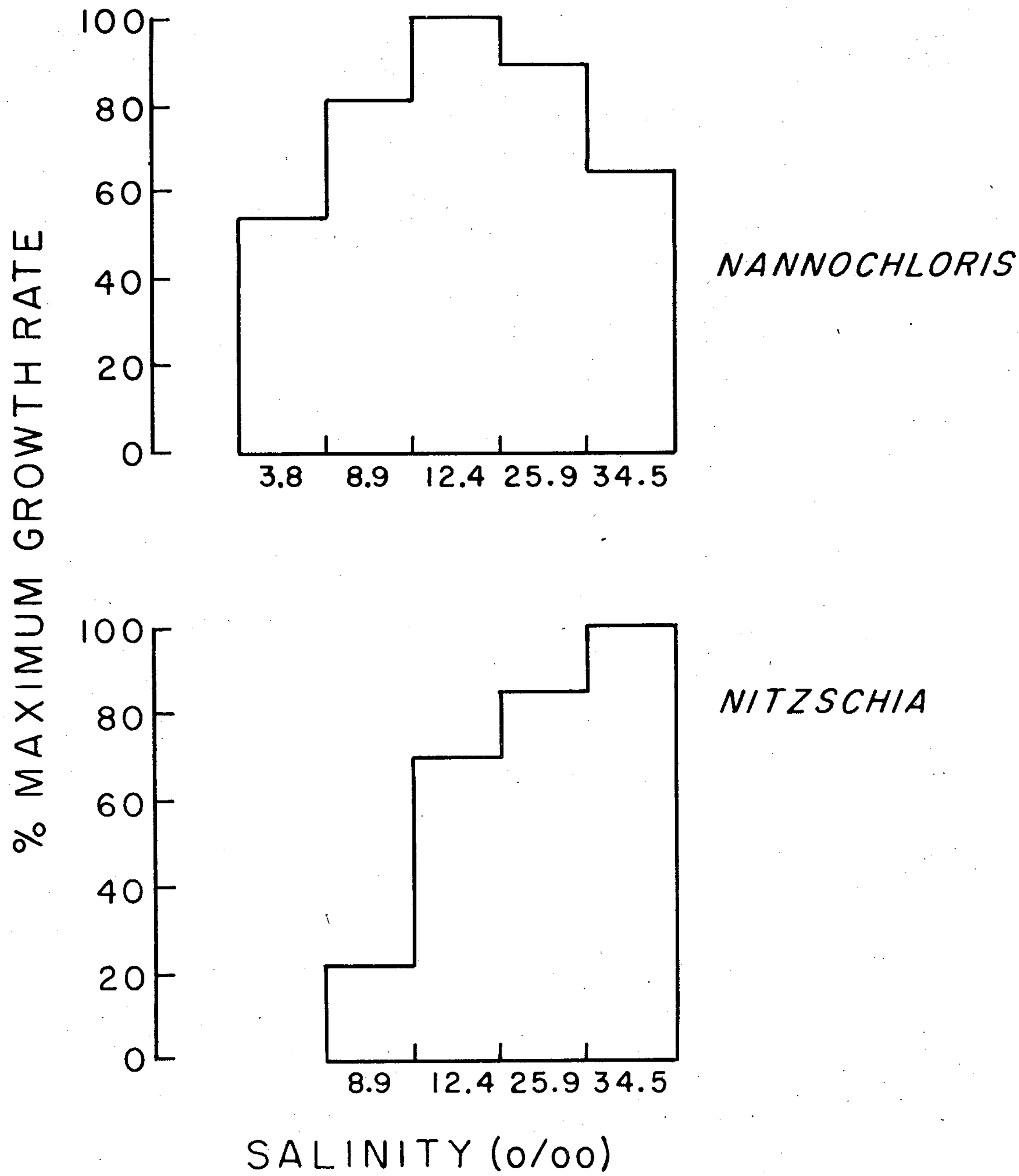

Figure 6. The effect of salinity upon the growth rates of Nannochloris atomus and Nitzschia closterium.

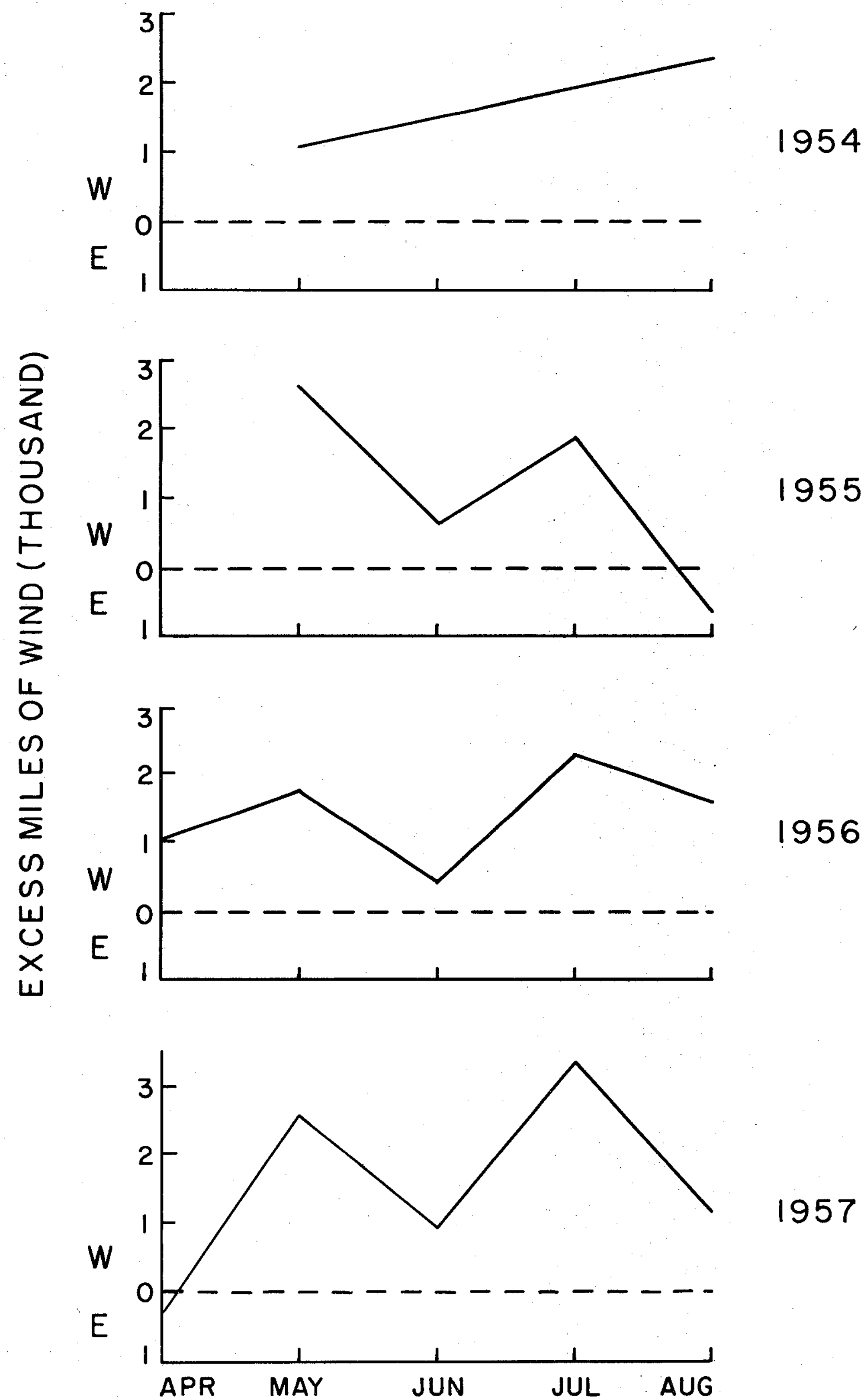

Figure 7. Excess miles of the easterly or westerly component of the wind at Westhampton for April-August, 1954, '55, '56 and '57.