

Results of Back Bay Nutrient  
Sampling, April 1986 - March 1987

by

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December, 1987

## INTRODUCTION

To determine nutrient levels in Back Bay, water samples were collected monthly from April, 1986 through March, 1987. Surface water samples were collected at six stations (Figure 1) and sent to the Virginia Consolidated Laboratory for analyses. Parameters monitored by the State Lab were suspended solids (total, volatile and fixed), ammonia, nitrite, nitrate, total Kjeldalh nitrogen and phosphorus (total and ortho). Other parameters which were monitored in the field at the time of the collection were salinity, conductivity, water temperature, Secchi disc transparency, pH and turbidity. These results were reported by Norman and Southwick (1987).

Overall, the nutrient levels in Back Bay were not excessively high. Only suspended solids and total Kjeldalh nitrogen surpassed or violated the EPA reference levels. Levels for the basic nutrients (nitrate and phosphate) were well below the EPA reference levels. Furthermore, the 1986 Virginia Water Quality Assessment (S.W.C.B., 1986) reported the water quality in Back Bay to be "good". Nutrient levels in Back Bay have changed little since the early 1970's. Water samples collected by the State Water Control Board from 1972 to 1975 showed that Total Kjeldalh nitrogen and pH were the only parameters which violated the EPA reference levels. However, levels for suspended solids were not determined during that survey.

## RESULTS

### Suspended Solids (Total, Volatile and Fixed)

Total suspended solids include 1) "Fixed" matter which is inorganic colloidal clay and coarse suspensions of soil particles, and 2) "Volatile" matter which is made up of living and dead organic matter.

Total suspended solids in Back Bay were very high during the study period. The mean level/station ranged from 57.3 mg/l (Sta. 22) to 94.8 mg/l (Sta. 5 and 20). Suspended solids were highest from January through March when the level routinely exceeded 100 mg/l and frequently exceeded 200 mg/l (Figures 9-14). Values as high as 294 mg/l were detected (March, Sta. 20). The high level of suspended solids during the Winter months was due to strong wind induced wave action which kept the sediment in suspension.

The EPA reference level for suspended solids is 80 mg/l (Table 7). By comparison, the mean level of suspended solids/station in Back Bay exceeded the EPA reference level at two stations (# 5 and 20) (Figure 2). Individual station readings for suspended solids were generally below the EPA reference level from April through December. However, during the January-March period the individual readings for suspended solids exceeded the EPA reference level considerably - sometimes by a factor of three.

The cause for this high level of suspended solids (turbidity) in Back Bay is two fold; 1) an abundance of inorganic material in suspension and 2) an abundant phytoplankton population (unpublished report, H.G. Marshall, 1987). Both of these factors keep water clarity poor year around. Average Secchi disc transparencies ranged from less than 5 inches to a maximum of only 14 inches during the same period.

Volatile suspended solids ranged from a mean of 25.8 mg/l (Sta. 22) to 34.6 mg/l (Sta. 20). The value for volatile suspended solids was highest in February at each station except #22 (Figures 15-20).

Fixed suspended solids ranged from a mean of 31.5 mg/l (Sta. 22) to 60.3 mg/l at (Sta. 20). Monthly values were consistently higher during March (Figures 21-26).

#### Nitrite as Nitrogen

Nitrite does not appear to be a problem in Back Bay. Mean nitrite level for each station ranged from 0.01 to 0.03 mg/l. Many of the individual station readings were below the minimum detectable level (0.01 mg/l) and are indicated with a "K" in Tables 1-6. The EPA reference level for nitrite in natural waters is 0.9 mg/l. Therefore, the nitrite levels in Back Bay are well below the EPA standards (Figure 3). Nitrite levels of natural waters are generally very low (Wetzel, 1983). Generally

nitrite levels in Back Bay were lowest during the Spring and highest during the Winter (Figures 27-32).

#### Nitrate as Nitrogen

Nitrate occurs in relatively small concentrations in unpolluted waters (Reid, 1961). This nutrient is rapidly taken up by plants (including phytoplankton). There is concern by some that excessive nitrate from agricultural sources around Back Bay is posing a problem in the bay. However, the data from this survey indicate differently. Nitrate levels in Back Bay were well below the EPA reference level of 0.9 mg/l (Figure 4). Average nitrate readings/station ranged from 0.18 mg/l (Sta. 5) to 0.24 mg/l (Sta. 20). Apparently the marsh vegetation and phytoplankton in Back Bay utilize much of the nitrates entering the system. This would account for the decrease in nitrate levels from May through December, e.g. a period of increase phytoplankton activity. Nitrates were very low ( $<0.05$  mg/l) at each station from May through January but increased appreciably in February and March (Figures 33-38). This increase was probably due to increased run-off from agricultural fields with heavy rainfall during those months.

#### Total Kjeldahl Nitrogen (TKN)

This form of nitrogen is present in soluble organic compounds and as a constituent of living and dead particulate organic matter. According to Boyd (1979), concentrations of

organic nitrogen are usually well below 1.0 mg/l in unpolluted natural waters. The EPA reference level for TKN is 0.9 mg/l (Table 7). Average TKN/station in Back Bay ranged from 2.3 to 2.8 mg/l with three of the six stations having the same high value. Levels of TKN in Back Bay violated the reference level in all of the samples (Figure 5). This is a substantial increase from the results of the 1972-75 SWCB study when TKN levels exceeded the EPA reference level in only 11.4% of the samples. These high values in Back Bay are indicative of the high level of biological productivity from the marsh vegetation and the abundant phytoplankton in the bay. As a general rule, TKN was relatively low in April; then increased progressively through the Summer to peak in August or September; then declined through January; and then increase again through March (Figures 39-44).

#### Ammonia as Nitrogen

Ammonia is an end product of the bacterial decomposition of organic matter and an excretory product of aquatic animals. At high levels, ammonia can be detrimental to aquatic life. The EPA reference level for ammonia is 0.89 mg/l (Table 7). The mean ammonia level/station in Back Bay ranged from 0.32 mg/l (Sta. 14) to 0.41 mg/l (Sta. 3) and was, therefore, well below the EPA reference level (Figure 6). Ammonia was generally low April through November, then increased progressively each month to peak in January-February, and then "crashed" to low values again by

March (Figures 45-50). High concentrations of ammonia occur following phytoplankton die-offs (Boyd, et al., 1975). This could be an explanation for the increase in ammonia in Back Bay from December through February.

#### Phosphorus (Total and Ortho)

Phosphorus is a key metabolic nutrient, and the supply of this element often regulates the productivity of natural waters. Concentrations of total phosphorus seldom exceed 1.0 mg/l (Boyd, 1979). The EPA reference level for total phosphorus is 0.3 mg/l (Table 7). The average level/station for total phosphorus in Back Bay ranged from 0.12 mg/l (Sta. 22) to 0.15 mg/l (Sta. 5 and 20) (Figure 7). At most stations, total phosphorus showed two distinct peaks in a seasonal cycle (Figures 51-56). One peak was in March-April; the other was in August.

Ortho phosphorus is the soluble and simplest form of phosphorus found in natural waters, making it readily available to plants. Concentrations of ortho phosphate are quite low and usually no greater than 0.0005 to 0.02 mg/l and seldom exceed 0.1 mg/l even in highly eutrophic waters (Boyd, 1979). The EPA reference level for ortho phosphate is 0.1 mg/l (Table 7). Average values/station for ortho phosphorus in Back Bay ranged from 0.04 to 0.06 mg/l (Figure 8). Although mean phosphorus levels in Back Bay did not surpass the EPA reference level, some sample values approached or equalled the reference level. At most stations, ortho phosphorus was highest July through September (Figures 57-62).

#### LITERATURE CITED

- Boyd, C.E., E.E. Prather, and R. W. Parks. 1975. Sudden mortality of a massive phytoplankton bloom. *Weed Sci.*, 23:61-67
- Boyd, Claude E. 1979. Water quality in warm water fish ponds. Auburn University, Agri. Exp. Sta., 359 pg.
- Marshall, H. G. 1987. Back Bay Phytoplankton Study. Va-DJ-F-58 (in preparation).
- Norman, M. D. and Ron Southwick, 1987. Back Bay: Report on salinity and Water Clarity in 1986. Department of Game and Inland Fisheries. 30 pp
- Reid, George K. 1961. Ecology of Inland waters and Estuaries. ed. Van Nostrand Reinhold Company, New York, 375 pp.
- State Water Control Board. 1976. Water Quality Inventory (305(b) Report). S.W.C.B. Info. Bull. 526. 361 pp.
- Wetzel, Robert G. 1983. Limnology. ed. Saunders College Publishing Philadelphia. 767 pp.



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	TOT.SOLIDS TOT.(mg/l)	TOT.SOLIDS VOL.(mg/l)	TOT.SOLIDS FIX.(mg/l)	SUS.SOLIDS TOT.(mg/l)	SUS.SOLIDS VOL.(mg/l)	SUS.SOLIDS FIX.(mg/l)	AMMONIA (mg/l as N)	NITRITE (mg/l as N)	NITRATE (mg/l as N)	TOT.K.NIT (mg/l)	TOT.PHOS. (mg/l as P)	ORTHO.PHOS. (mg/l as P)	TOT.ORG.C. (mg/l)
APRIL86	3438	629	2809	15	5	9	0.1	0.01	0.12	1.3	0.2	0.05	15
MAY	3597	532	3065	37	17	20	.10K	.01K	.05K	1.5	.10K	0.02	17
JUNE	4155	891	3424	60	24	36	.10K	.01K	.05K	2.1	0.1	0.02	20
JULY	4616	847	3769	46	30	16	.10K	.01K	.05K	3	0.1	0	22
AUG	4618	941	3677	46	38	8	0.2	0.01	.05K	3.8	0.2	0.08	24
SEPT	4839	924	3905	36	30	6	0.1	0.02	.05K	3.3	0.1	0.09	22
OCT	4809	841	3968	40	31	9	.10K	0.02	.05K	3.5	0.1	0	24
NOV	4861	821	4040	70	34	36	0.1	0.02	.05K	3.1	0.1	0	24
DEC	4614	711	3603	50	24	26	0.4	0.01	.05K	3	0.1	0.08	21
JAN87	3924	665	3259	83	32	56	0.3	0.04	0.09	2.4	0.1	0	18
FEB	2840	496	2344	81	23	58	0.9	0.02	0.31	2.6	0.1	0.06	12
MAR	2659	393	2266	188	44	144	0.7	0.03	0.23	2.9	0.2	0	21
MEANS	4079.2	725.1	3344.1	63.1	27.8	35.3	0.41	0.02	0.19	2.8	0.13	0.06	20

Table 1. Nutrient levels (mg/l) determined from water samples collected at Station 3, Back Bay from April, 1986 to March, 1987.

	TOT.SOLIDS TOT.(mg/l)	TOT.SOLIDS VOL.(mg/l)	TOT.SOLIDS FIL.(mg/l)	SUS.SOLIDS TOT.(mg/l)	SUS.SOLIDS VOL.(mg/l)	SUS.SOLIDS FIL.(mg/l)	AMMONIA (mg/l as N)	NITRITE (mg/l as N)	NITRATE (mg/l as N)	TOT.K.NIT. (mg/l)	TOT.PHOS. (mg/l as P)	ORTHO.PHOS. (mg/l as P)	TOT.ORG.C. (mg/l)
APRIL86	3361	559	2802	49	17	26	0.1	0.01	0.1	1.8	0.3	0.04	15
MAY	3549	509	3035	33	17	16	.10K	.01K	.95K	1.7	0.1	0.03	18
JUNE	4252	874	3419	57	25	31	.10K	.01K	.05K	2	0.1	0.02	20
JULY	4565	906	3759	34	34	20	0.1	0.01	.05K	3.1	0.1	0	22
AUG	4039	865	3176	30	36	14	0.1	0.02	.05K	3.6	0.2	0	22
SEPT	4475	904	3571	30	30	20	0.2	0.02	.05K	3	0.1	0	21
OCT	4792	849	3943	77	36	41	0.1	0.02	.05K	3.2	0.1	0	25
NOV	4722	763	3959	76	32	44	0.1	0.03	.05K	2.7	0.1	0	22
DEC	4361	699	3662	21	14	7	0.5	0.01	0.05	2.8	0.1	0.07	19
JAN87	3676	696	2980	144	40	104	0.8	0.04	0.14	2.4	0.1	0	19
FEB	2452	435	2027	184	40	144	0.8	0.02	0.35	3.2	0.2	0	16
MAR	2452	386	2066	264	56	208	0.6	0.02	0.24	3.4	0.3	0	23
MEANS	3895	695.2	3199.8	87.9	31.5	55.3	0.34	0.02	0.16	2.8	0.15	0.04	20.2

Table 2. Nutrient levels (mg/l) determined from water samples collected at Station 5, Back Bay from April, 1986 to March, 1987.

	TOT.SOLIDS TOT.(mg/l)	TOT.SOLIDS VOL.(mg/l)	TOT.SOLIDS FIX.(mg/l)	SUS.SOLIDS TOT.(mg/l)	SUS.SOLIDS VOL.(mg/l)	SUS.SOLIDS FIX.(mg/l)	AMMONIA (mg/l as N)	NITRITE (mg/l as N)	NITRATE (mg/l as N)	TOT.K.NIT. (mg/l)	TOT.PHOS. (mg/l as P)	ORTHO.PHOS. (mg/l as P)	TOT.ORG.C. (mg/l)
APRIL86	3020	500	2520	40	14	26	0.1	0.01	0.19	1.1	0.1	0.06	15
MAY	3406	486	2920	32	13	19	.10K	.01K	.05K	1.7	0.1	0.02	19
JUNE	4405	1065	3320	48	14	34	.10K	.01K	.05K	2	0.1	0.02	20
JULY	4405	784	3621	42	28	14	0.1	0.01	.05K	3.4	0.1	0	23
AUG	2435	507	1928	40	24	16	0.2	0.01	.05K	2.5	0.2	0.07	18
SEPT	3457	702	2755	62	22	40	0.1	0.02	.05K	2.7	0.2	0.09	22
OCT	4634	991	3743	68	27	41	0.5	0.03	.05K	3.3	0.1	0	21
NOV	4609	743	3866	104	44	60	0.4	0.04	.05K	2.9	0.2	0	23
DEC	4445	715	3730	47	23	24	0.5	0.02	0.05	2.7	0.1	0.08	20
JAN87	3335	640	2745	66	28	38	0.7	0.04	0.16	2.2	0.1	0	16
FEB	1719	304	1415	74	22	52	0.6	0.02	0.46	2.2	0.1	0.06	12
MAR	1974	309	1665	208	36	172	0.5	0.03	0.26	2.8	0.2	0	23
MEANS	3491.2	638.8	2852.3	69.3	24.6	44.7	0.37	0.03	0.22	2.5	0.13	0.06	19.3

Table 3. Nutrient levels (mg/l) determined from water samples collected at Station 9, Back Bay from April, 1986 to March, 1987.



	TOT.SOLIDS	TOT.SOLIDS	TOT.SOLIDS	SUS.SOLIDS	SUS.SOLIDS	SUS.SOLIDS	AMMONIA	NITRITE	NITRATE	TOT.K.NIT.	TOT.PHOS.	ORTHOPHOS.	TOT.ORG.C
	TOT.(mg/l)	VOL.(mg/l)	FIX.(mg/l)	TOT.(mg/l)	VOL.(mg/l)	FIX.(mg/l)	(mg/l as N)	(mg/l as N)	(mg/l as N)	(mg/l)	(mg/l as P)	(mg/l as P)	(mg/l)
APRIL86	3384	558	2925	56	20	35	0.1	0.01	0.13	1.1	0.1	0.06	15
MAY	3570	474	3026	41	16	25	.10K	.01K	.05K	1.8	0.1	0.03	17
JUNE	4252	856	3396	66	22	44	0.1	0.01	0.05	2.1	0.1	0.02	22
JULY	4511	837	3674	38	28	10	0.1	0.01	.05K	2.9	0.1	0	21
AUG	4556	958	3598	62	42	20	0.2	0.01	.05K	3.3	0.2	0.08	21
SEPT	4674	976	3698	36	32	6	0.1	0.02	.05K	3.4	0.1	0.1	22
OCT	4847	901	3946	53	35	18	0.1	0.02	.05K	3.7	0.1	0	24
NOV	4802	838	3964	69	44	24	0.1	0.02	.05K	2.8	0.1	0	24
DEC	4641	735	3906	44	24	20	0.2	0.01	.05K	2.7	0.1	0.08	21
JAN87	4416	824	3592	62	30	32	0.7	0.03	0.07	2.4	0.1	0	17
FEB	2755	561	2374	133	33	100	1	0.03	0.47	3.5	0.2	0	16
MAR	2775	418	2357	248	56	192	0.7	0.03	0.29	3.5	0.2	0	25
MEANS	4109.6	744.7	3364.9	75.8	31.8	43.7	0.32	0.02	0.2	2.8	0.13	0.05	20.4

Table 4. Nutrient levels (mg/l) determined from water samples collected at Station 14, Back Bay from April, 1986 to March, 1987.

	TOT.SOLIDS TOT.(mg/l)	TOT.SOLIDS VOL.(mg/l)	TOT.SOLIDS FIX.(mg/l)	SUS.SOLIDS TOT.(mg/l)	SUS.SOLIDS VOL.(mg/l)	SUS.SOLIDS FIX.(mg/l)	AMMONIA (mg/l as N)	NITRITE (mg/l as N)	NITRATE (mg/l as N)	TOT.K.NIT. (mg/l)	TOT.PHOS. (mg/l as P)	ORTHO.PHOS. (mg/l as P)	TOT.ORG.C. (mg/l)
APRIL86	2957	480	2477	33	11	22	.10K	.01K	0.13	0.9	0.1	0.04	13
MAY	3451	487	2964	32	16	16	.10K	.01K	.05K	1.6	0.1	0.03	16
JUNE	4207	866	3341	58	28	30	.10K	0.01	.05K	2	0.1	0.03	13
JULY	4469	803	3666	40	28	12	0.1	0.01	.05K	2.9	0.1	0	21
AUG	4595	950	3645	56	42	14	0.2	0.01	.05K	3.3	0.2	0.08	24
SEPT	4800	967	3833	36	34	4	0.1	0.02	.05K	3.4	0.1	0.1	25
OCT	4234	935	3299	52	34	18	0.1	0.02	.05K	3.3	0.1	0	23
NOV	5051	965	4086	136	52	104	0.1	0.02	.05K	3.1	0.2	0	29
DEC	4752	772	4180	50	26	24	0.2	0.01	.05K	2.4	0.1	0.07	21
JAN87	4525	781	3744	100	38	62	0.7	0.03	0.05	2.5	0.2	0	18
FEB	2738	557	2181	229	52	177	0.8	0.02	0.45	3.9	0.3	0	19
MAR	2798	414	2374	274	54	240	0.7	0.04	0.32	3.6	0.2	0	23
MEANS	4131.4	748.1	3383.3	94.8	34.6	60.3	0.33	0.02	0.24	2.7	0.15	0.06	20.8

Total 5. Nutrient levels (mg/l) determined from water samples collected at Station 20, Back Bay from April, 1986 to March, 1987.

	TOT.SOLIDS TOT.(mg/l)	TOT.SOLIDS VOL.(mg/l)	TOT.SOLIDS FIX.(mg/l)	SUS.SOLIDS TOT.(mg/l)	SUS.SOLIDS VOL.(mg/l)	SUS.SOLIDS FIX.(mg/l)	AMMONIA (mg/l as N)	NITRITE (mg/l as N)	NITRATE (mg/l as N)	TOT.K.NIT. (mg/l)	TOT.PHOS. (mg/l as P)	Ortho.Phos. (mg/l as P)	TOT.ORGANIC (mg/l)
APRIL86	3503	584	2919	34	18	16	.10K	0.01	.05K	1.5	0.2	0.04	15
MAY	3529	492	3037	41	17	24	.10K	.01K	.05K	1.5	.10K	0.03	16
JUNE	4190	364	3326	66	22	44	.10K	.01K	.05K	1.9	0.1	0.02	20
JULY	4536	803	3733	39	25	10	0.1	0.01	.05K	2.9	.10K	0	21
AUG	4808	996	3812	51	42	9	0.2	0.01	.05K	3.2	0.2	0.08	25
SEPT	4738	929	3809	32	30	2	0.1	0.02	.05K	2.8	0.1	0.09	24
OCT	5157	267	4290	34	24	10	.10K	0.01	.05K	2.4	0.1	0.03	19
NOV	5548	854	4494	52	26	26	.10K	0.01	.05K	1.9	.10K	0.04	19
DEC	5109	747	4362	31	19	12	0.4	0.01	.05K	2.4	0.1	0.05	19
JAN87	4776	573	3896	82	30	52	0.6	0.02	0.06	2.3	0.1	0	17
FEB	2838	495	2343	134	33	101	0.8	0.02	0.27	2.6	0.1	0.04	14
MAR	2579	379	2200	92	20	72	0.1	0.02	0.3	1.8	0.1	0	18
MEANS	4259.3	740.7	3518.6	57.3	25.8	31.5	0.33	0.01	0.21	2.3	0.12	0.05	18.9

Table 6. Nutrient levels (mg/l) determined from water samples collected at Station 22, Back Bay from April, 1986 to March, 1987.

<u>PARAMETER</u>	<u>REFERENCE LEVEL AND SOURCE</u>
Orthophosphate (as P)	0.1 mg/l -Nutrient*
Total Phosphorus	0.3 mg/l -Nutrient*
Ammonia (as N)	0.89 mg/l -Aquatic Life **
Nitrite (as N)	0.9 mg/l -Nutrient***
Nitrate (as N)	0.9 mg/l -Nutrient***
Total Kjeldalh Nitrogen	0.9 mg/l -Nutrient***

\* Guidelines for Developing or Revising Water Quality Standards, EPA Water Planning Division, April 1973

\*\* Criteria for Water Quality, EPA, 1973 (Section 304(a)(1) Guidelines)

\*\*\*Biological Associated Problems in Freshwater Environments, FWPCA, 1966, pp 132-3

Source: Virginia State Water Control Board

Table 7. Reference levels and source for selected water quality parameters.

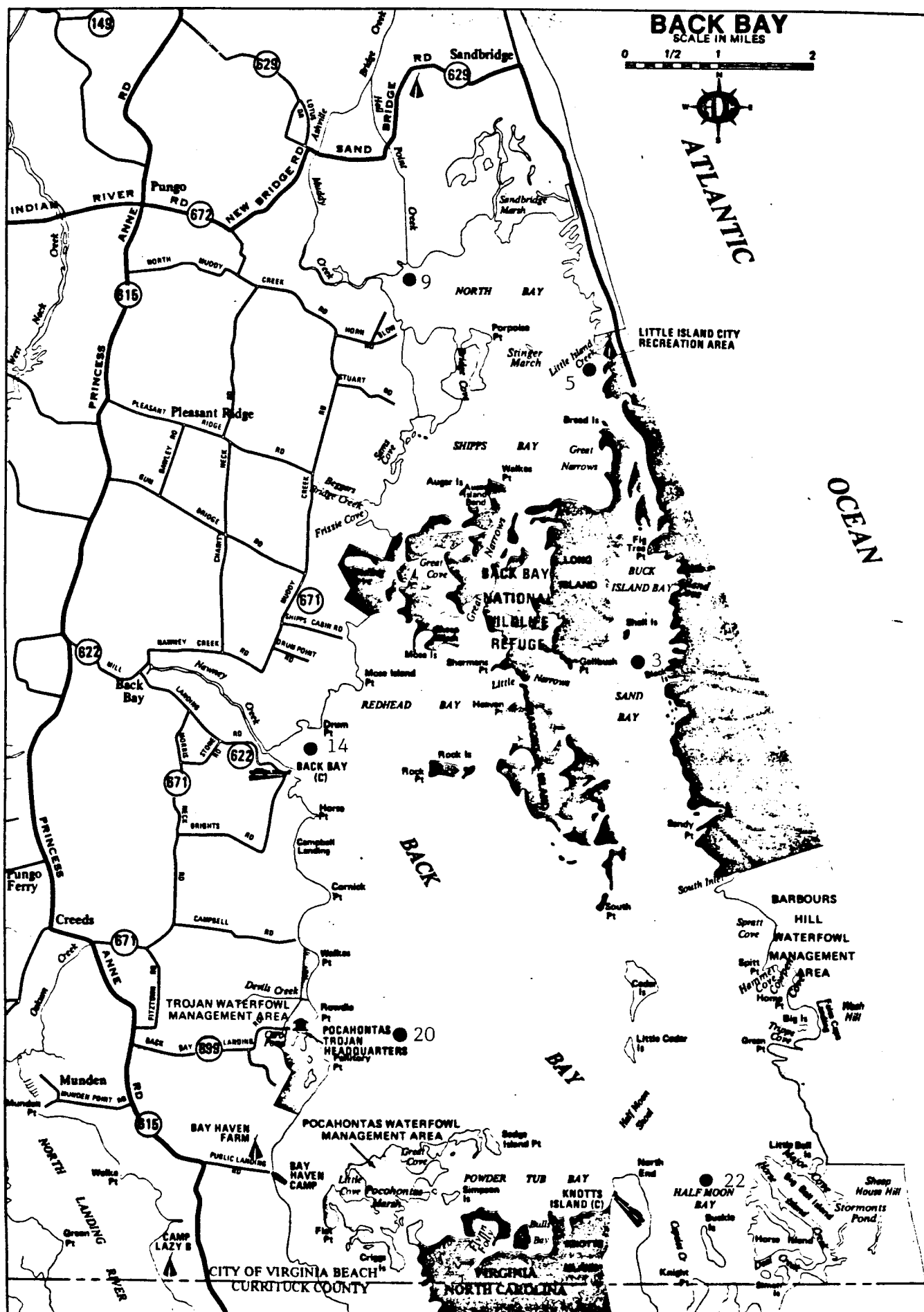


Figure 1. Map of Back Bay, Virginia showing the location of stations for nutrient analysis.

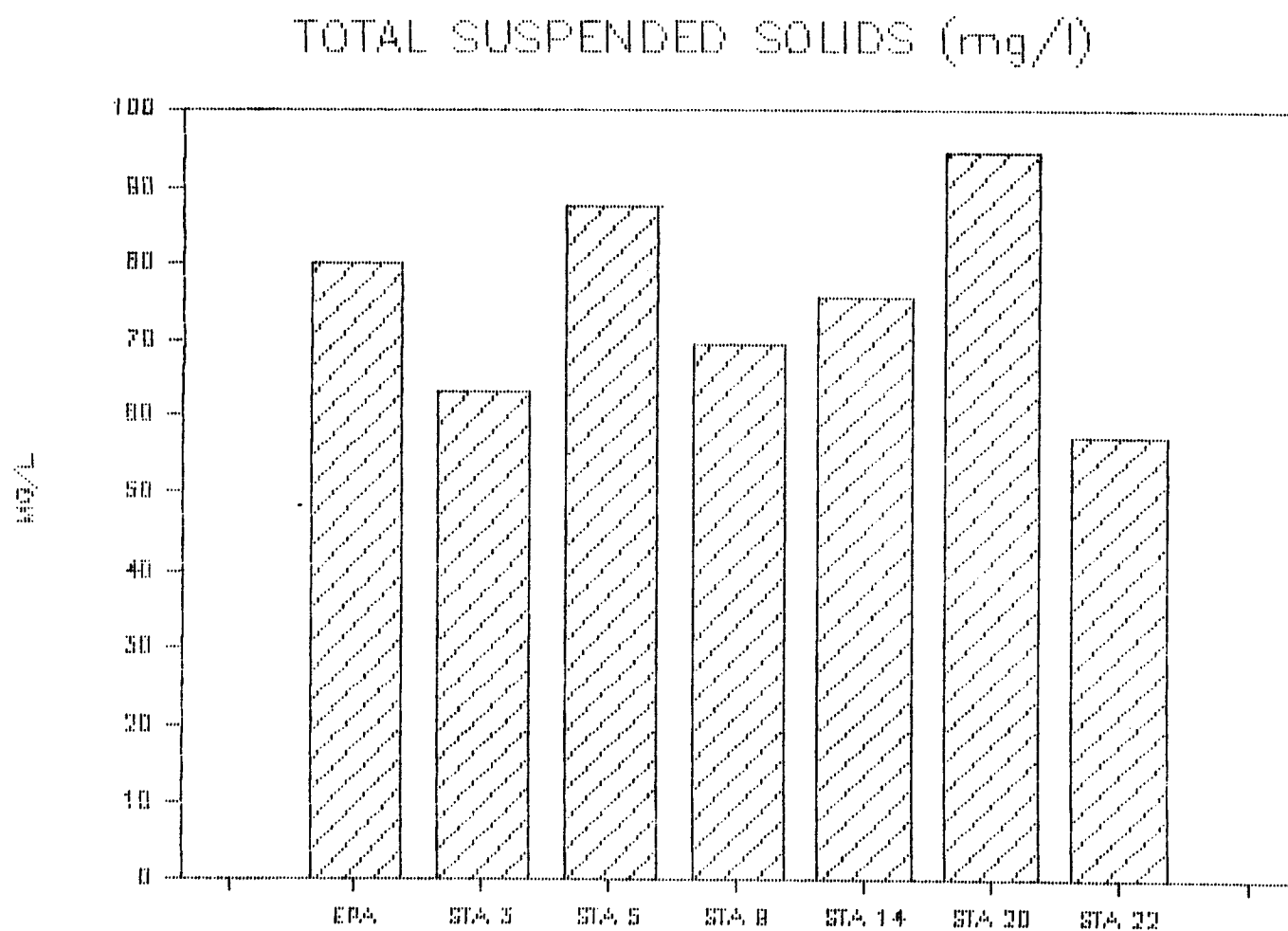


Figure 2. Comparison of Total Suspended Solids (mg/l) in Back Bay (as mean of each station for period April, 1986 to March, 1987) with EPA "Reference Level".

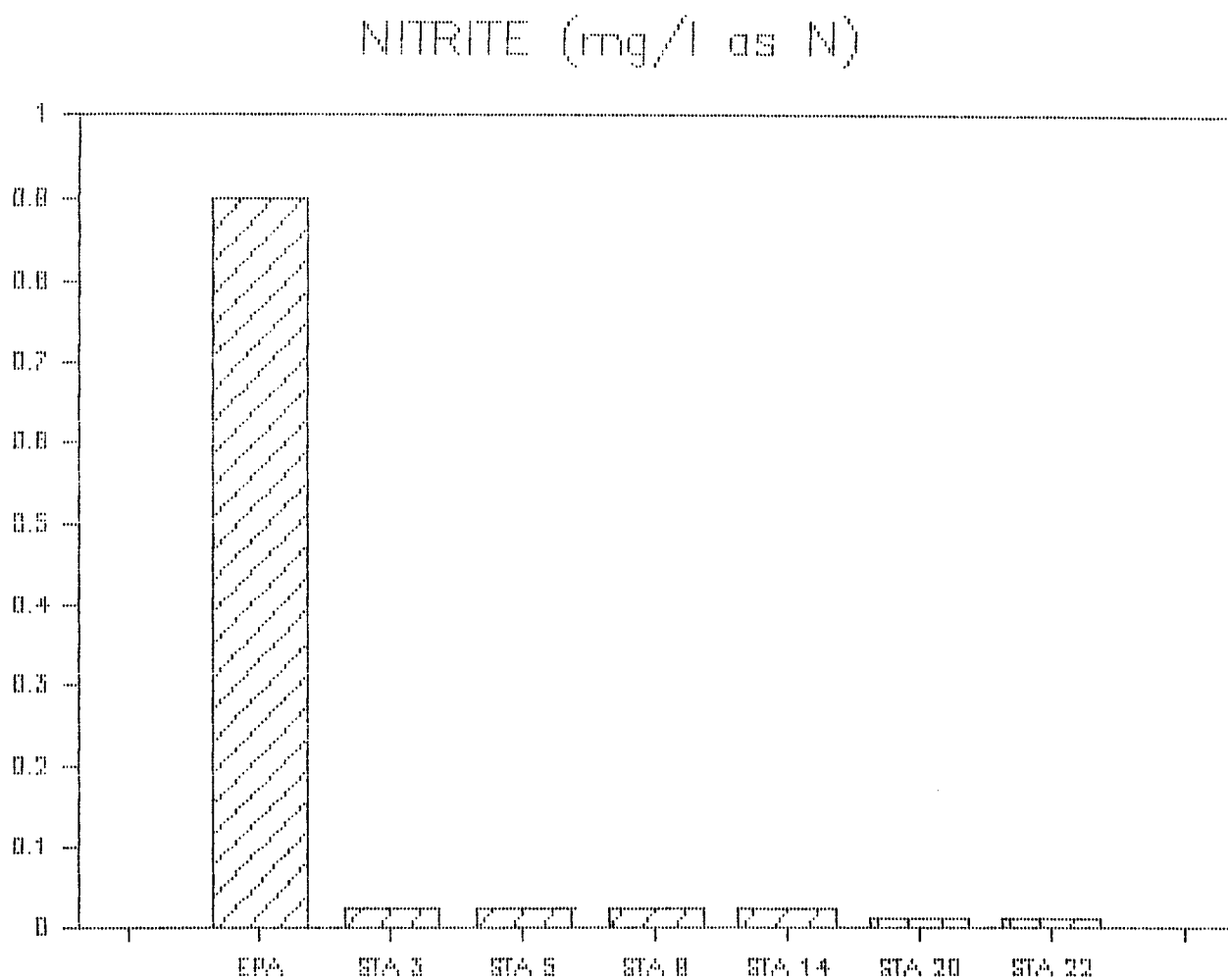


Figure 3. Comparison of Total Nitrite level (mg/l) in Back Bay (as mean of each station for period April, 1986 to March, 1987) with EPA "Reference level.

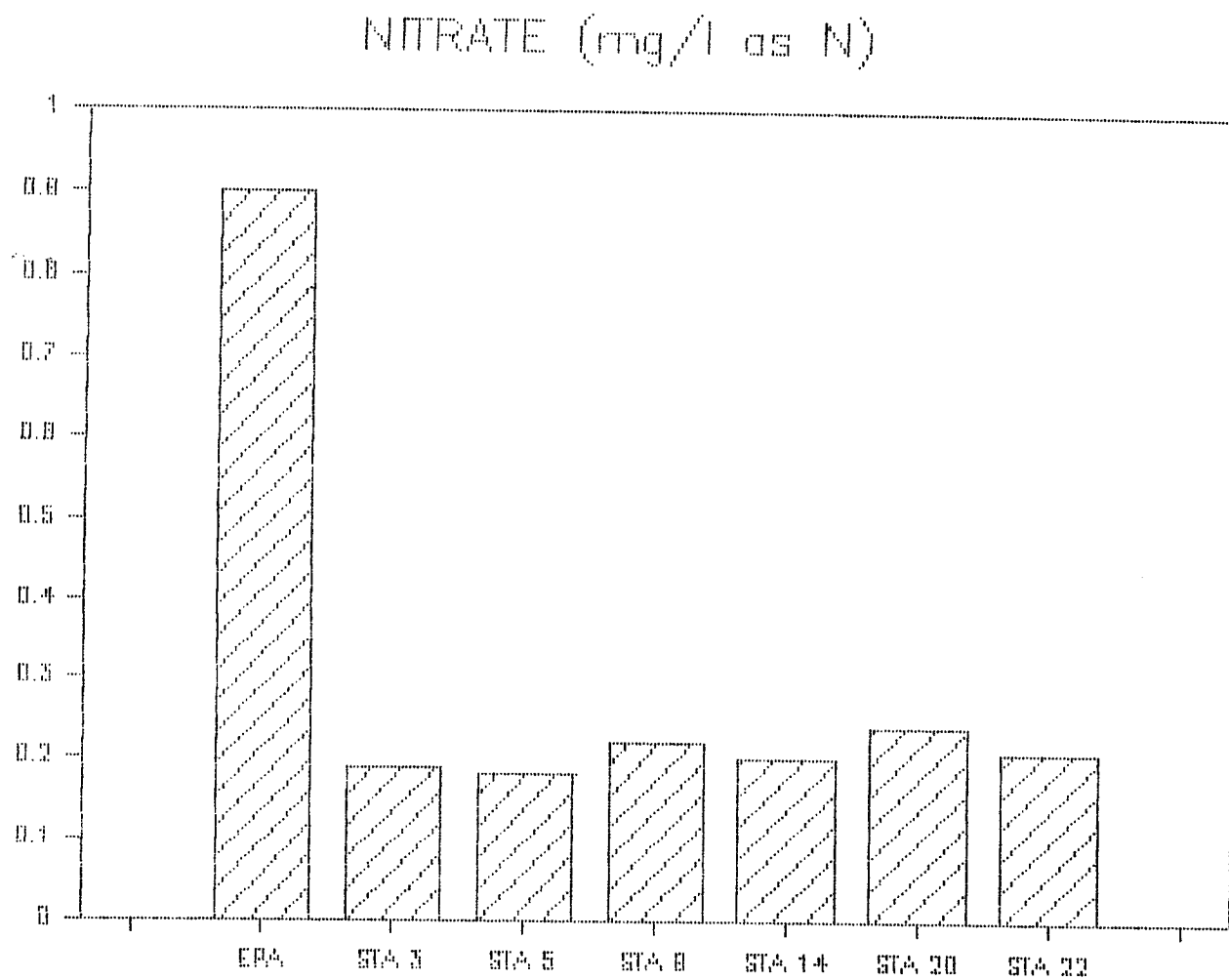


Figure 4. Comparison of Total Nitrate (mg/l) in Back Bay (as mean of each station for period April, 1986 to March, 1987) with EPA "Reference Level".



# NITROGEN, Tot. Kjeldahl (mg/l)

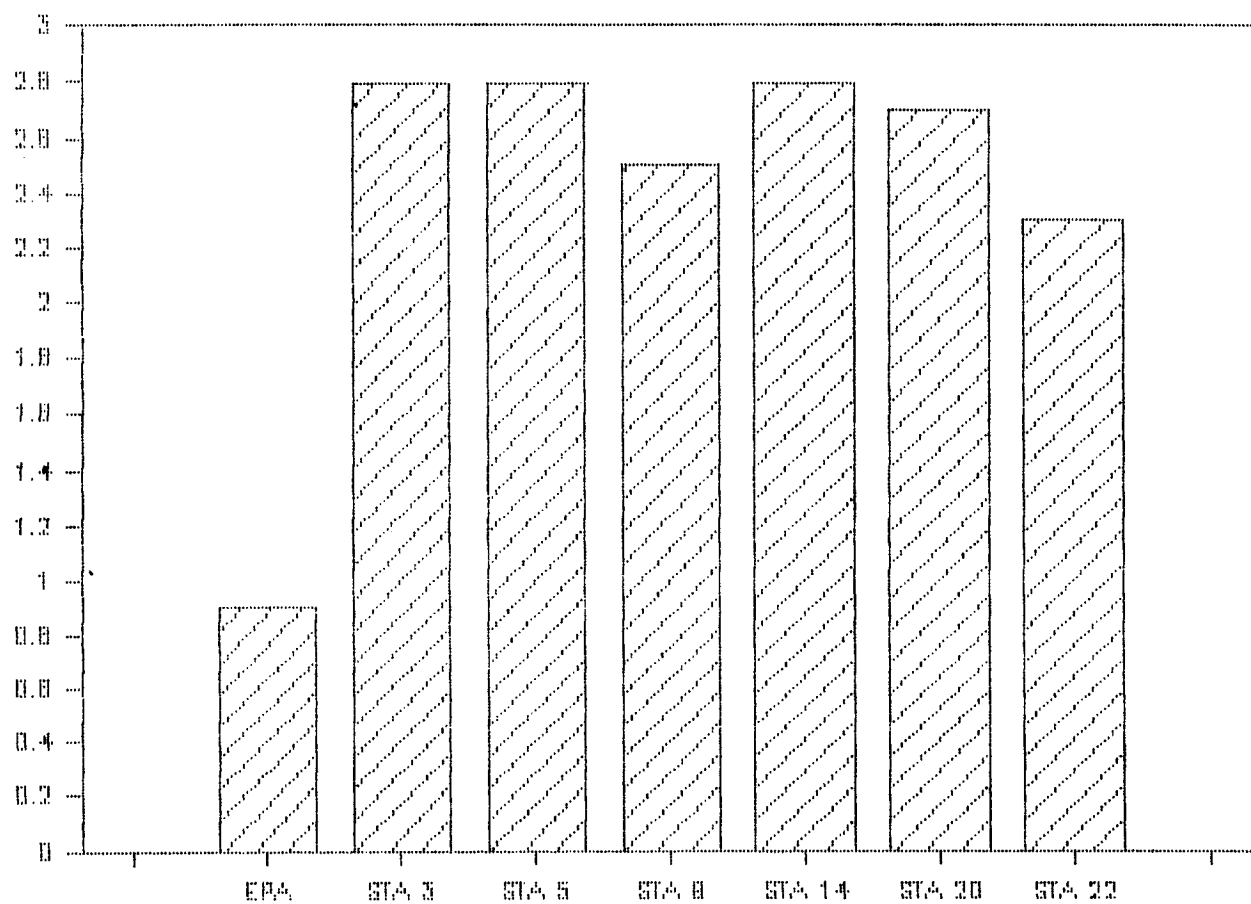


Figure 5. Comparison of Total Kjeldahl Nitrogen (mg/l) in Back Bay (as mean of each station for period April, 1986 to March, 1987) with EPA "Reference Level".

# AMMONIA (mg/l as N)

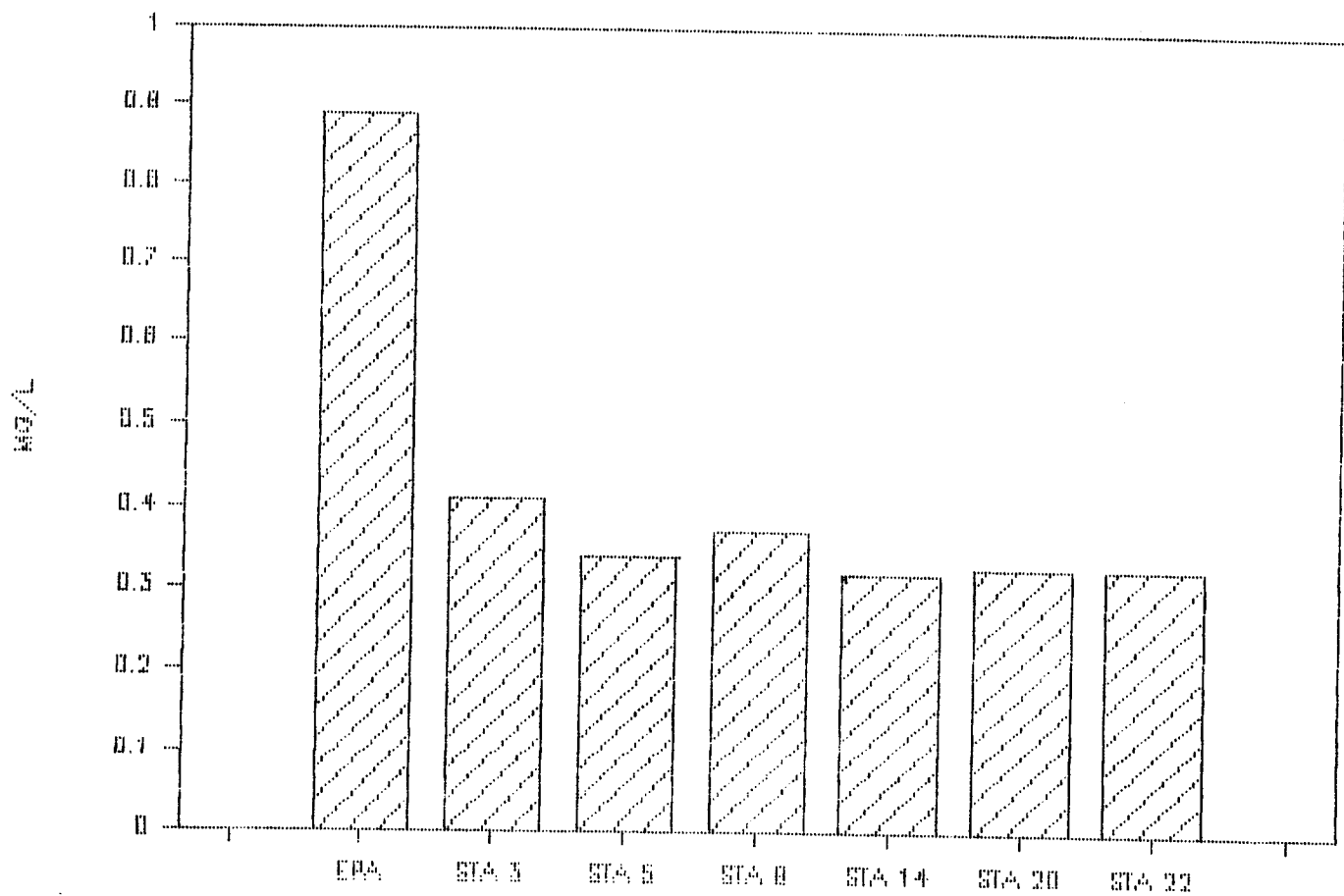


Figure 6. Comparison of Total Ammonia (mg/l) in Back Bay (as mean of each station for period April, 1986 to March, 1987) with EPA "Reference Level".

## TOTAL PHOSPHORUS (mg/l)

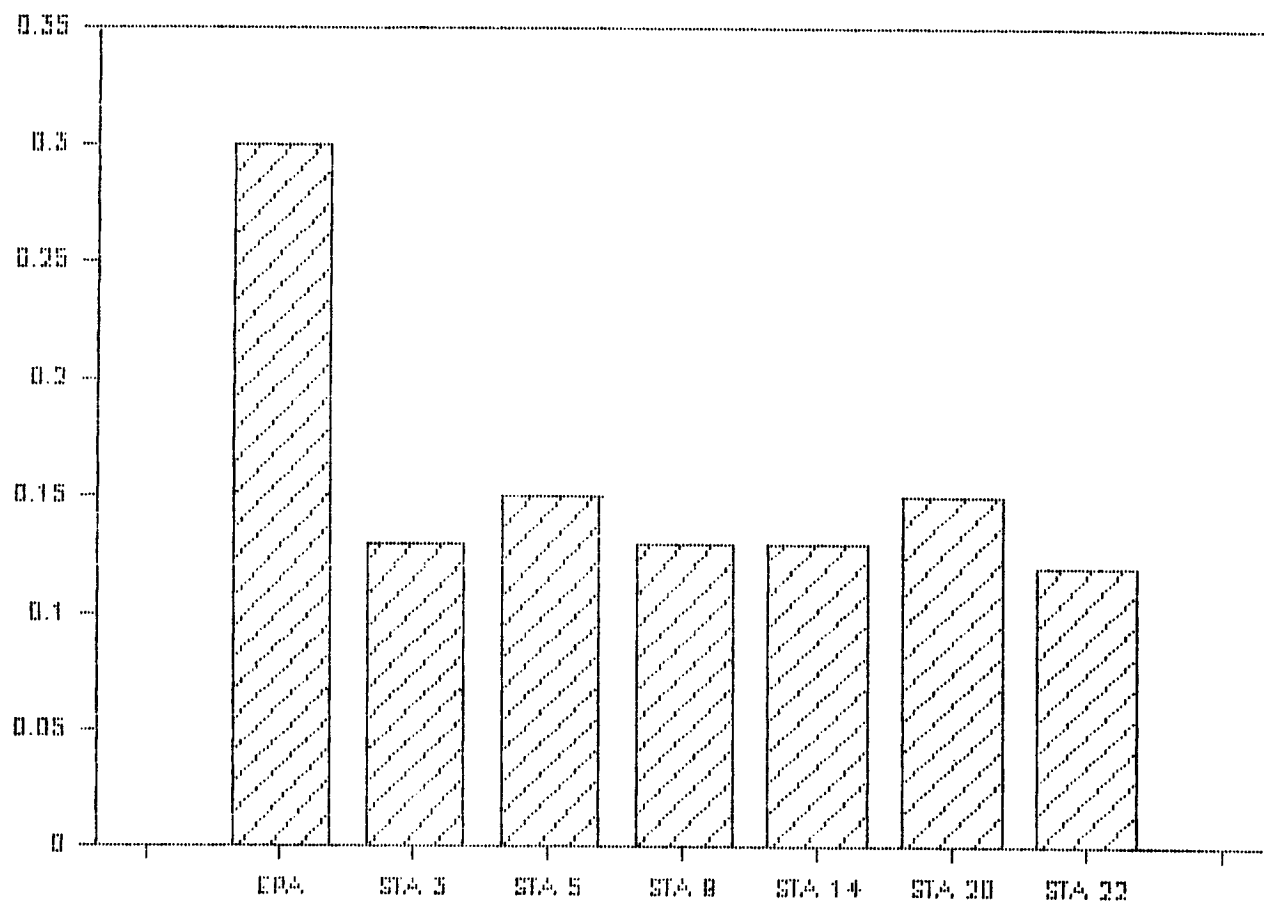


Figure 7. Comparison of Total Phosphorus (mg/l) in Back Bay (as mean of each station for period April, 1986 to March, 1987) with EPA "Reference Level".

# PHOSPHORUS, ORTHO (mg/l) as P

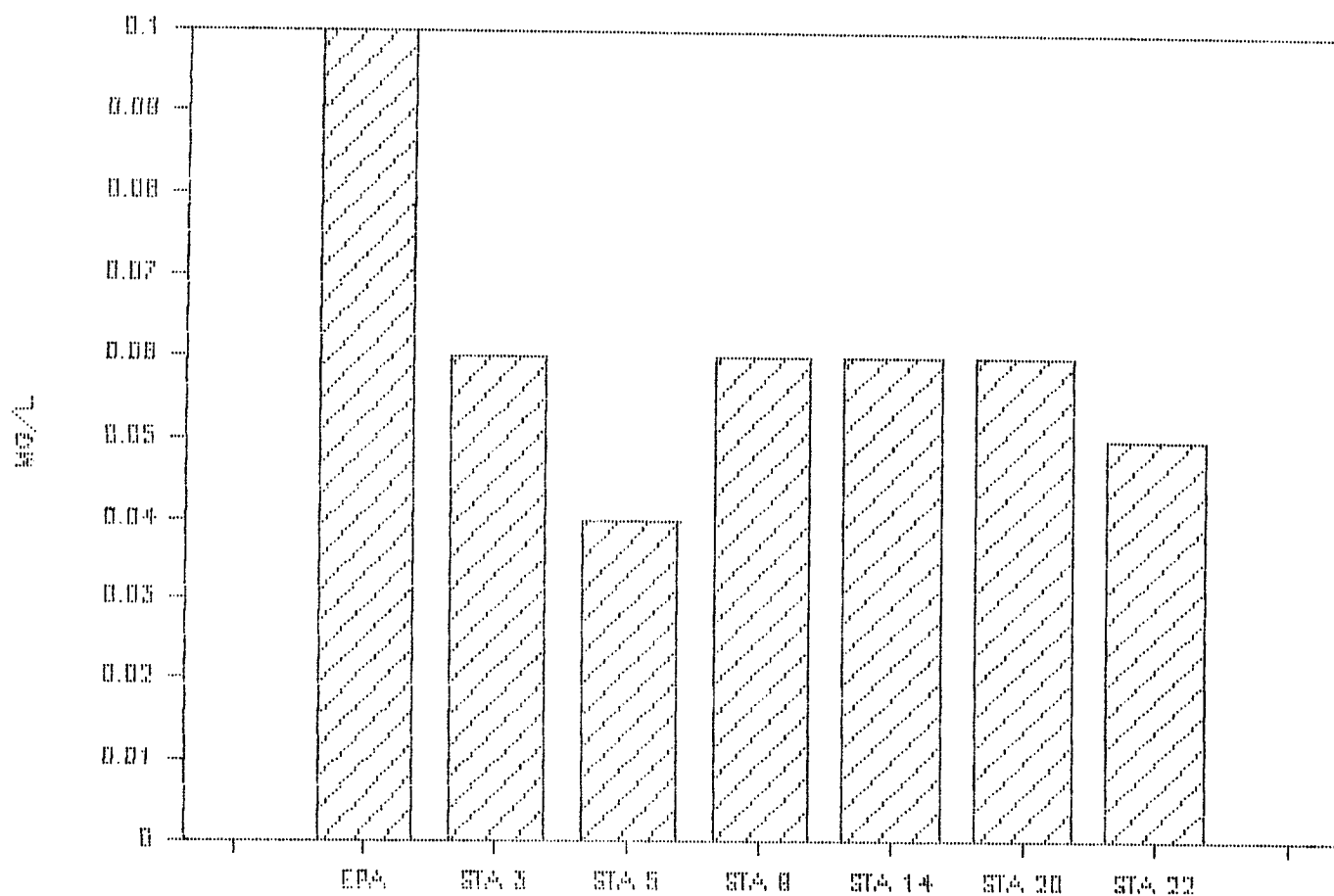


Figure 8. Comparison of Total Ortho Phosphorus (mg/l) in Back Bay (as mean of each station for period April, 1986 to March, 1987) with EPA "Reference Level".

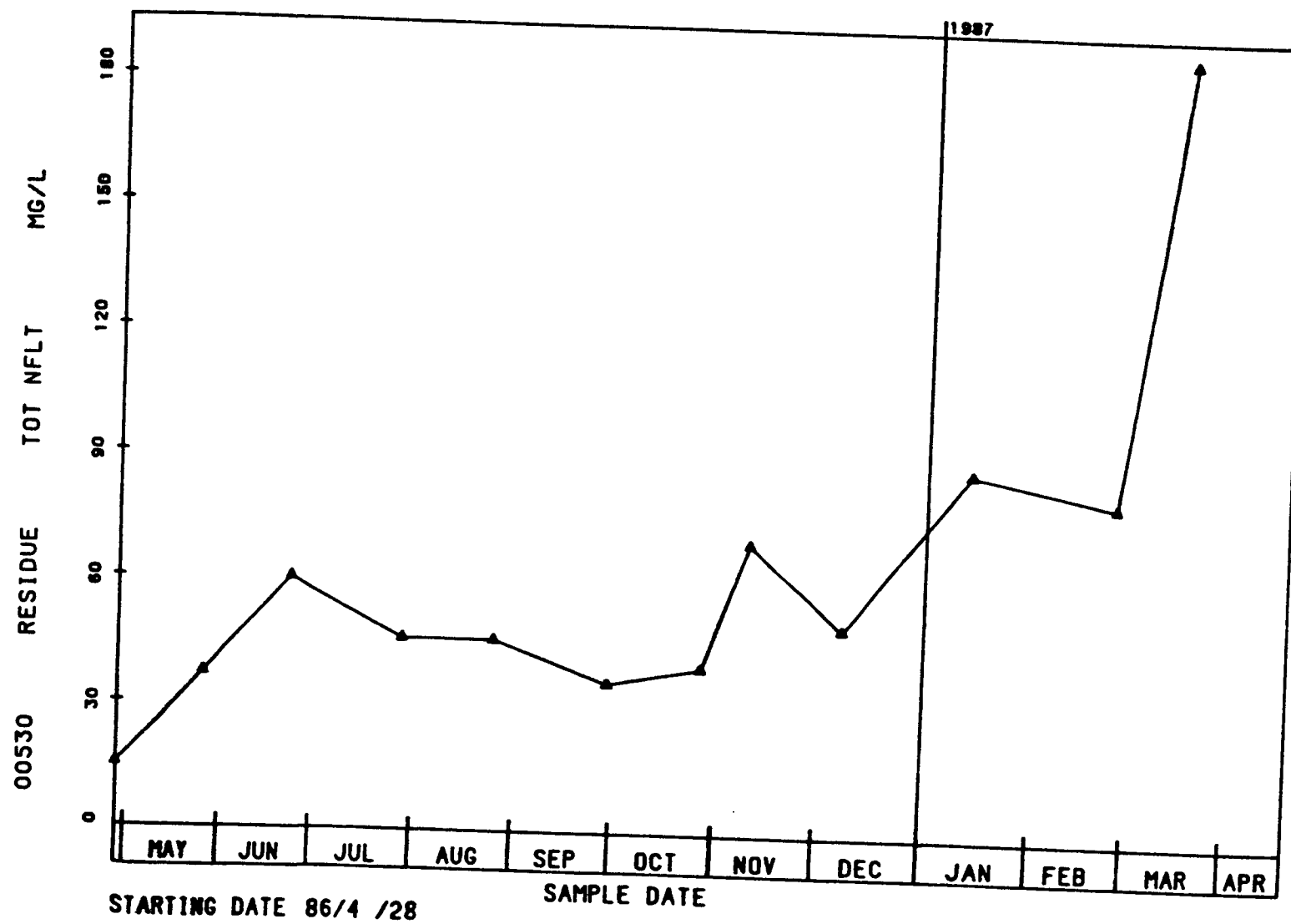


Figure 9. Monthly level of Total Suspended Solids (mg/l) at Station 3, Back Bay from April, 1986 to March, 1987.

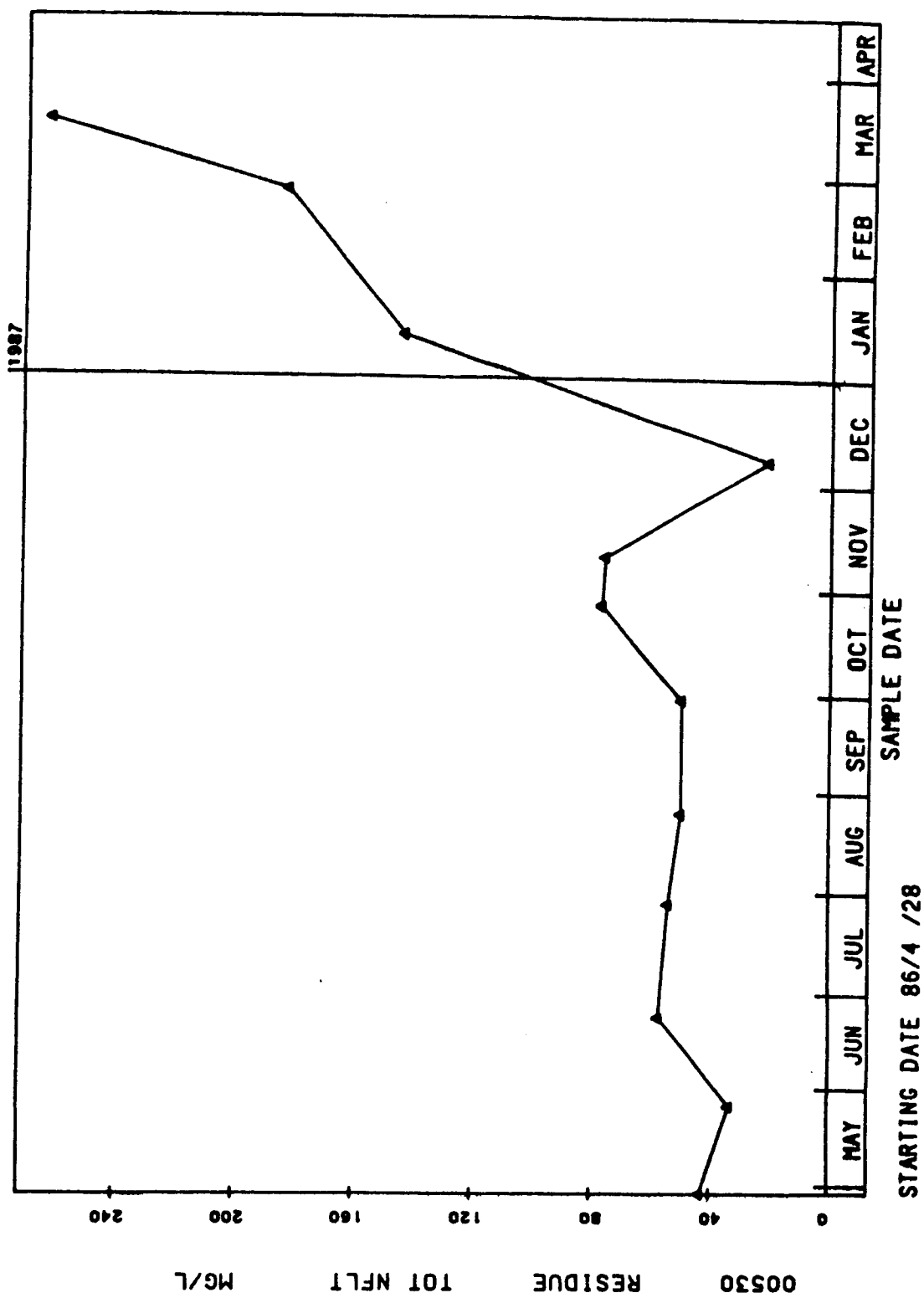


Figure 10: Monthly level of Total Suspended Solids (mg/l) at Station 5, Back Bay from April, 1986 to March, 1987.

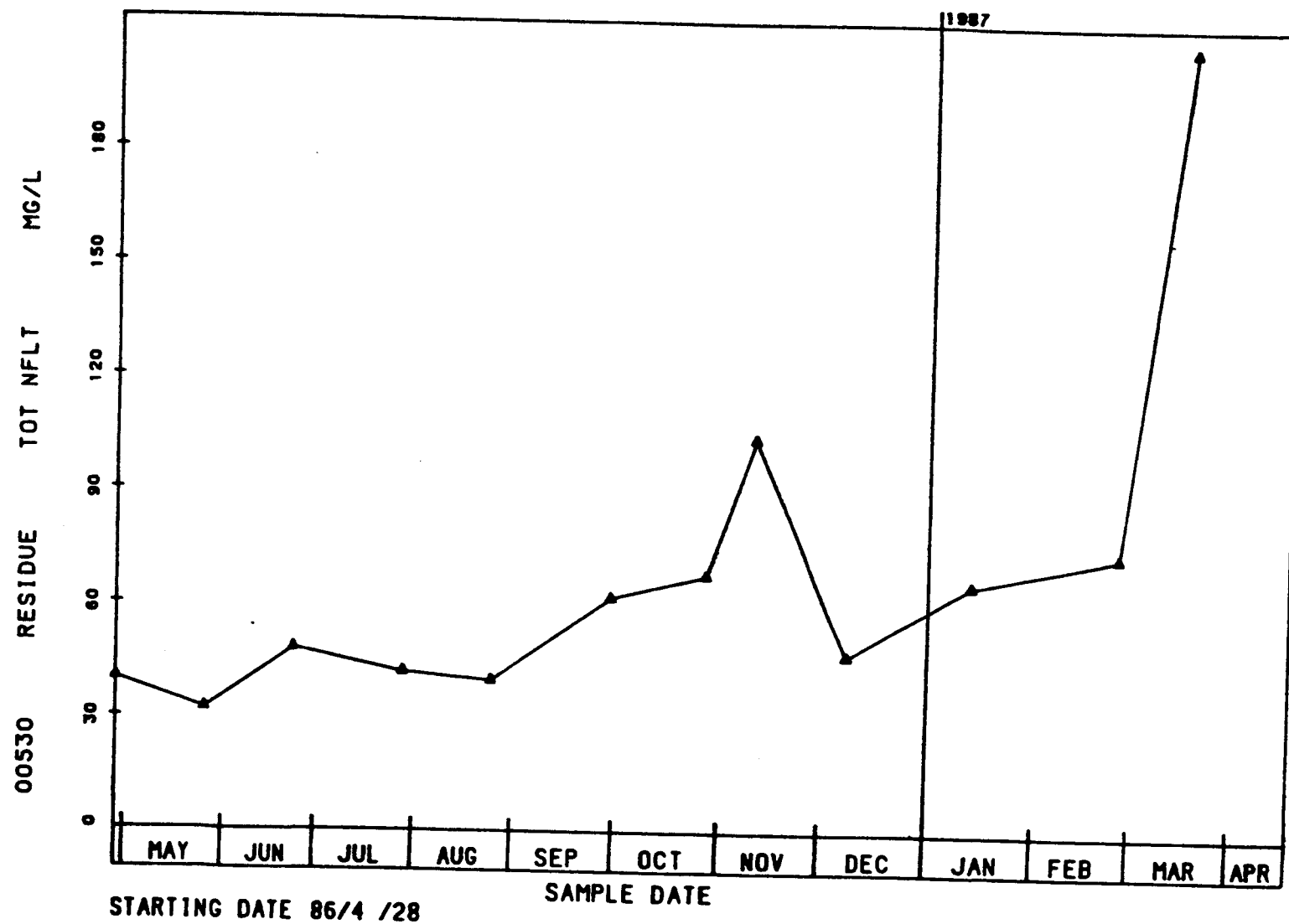


Figure 11. Monthly level of Total Suspended Solids (mg/l) at Station 9, Back Bay from April, 1986 to March, 1987.

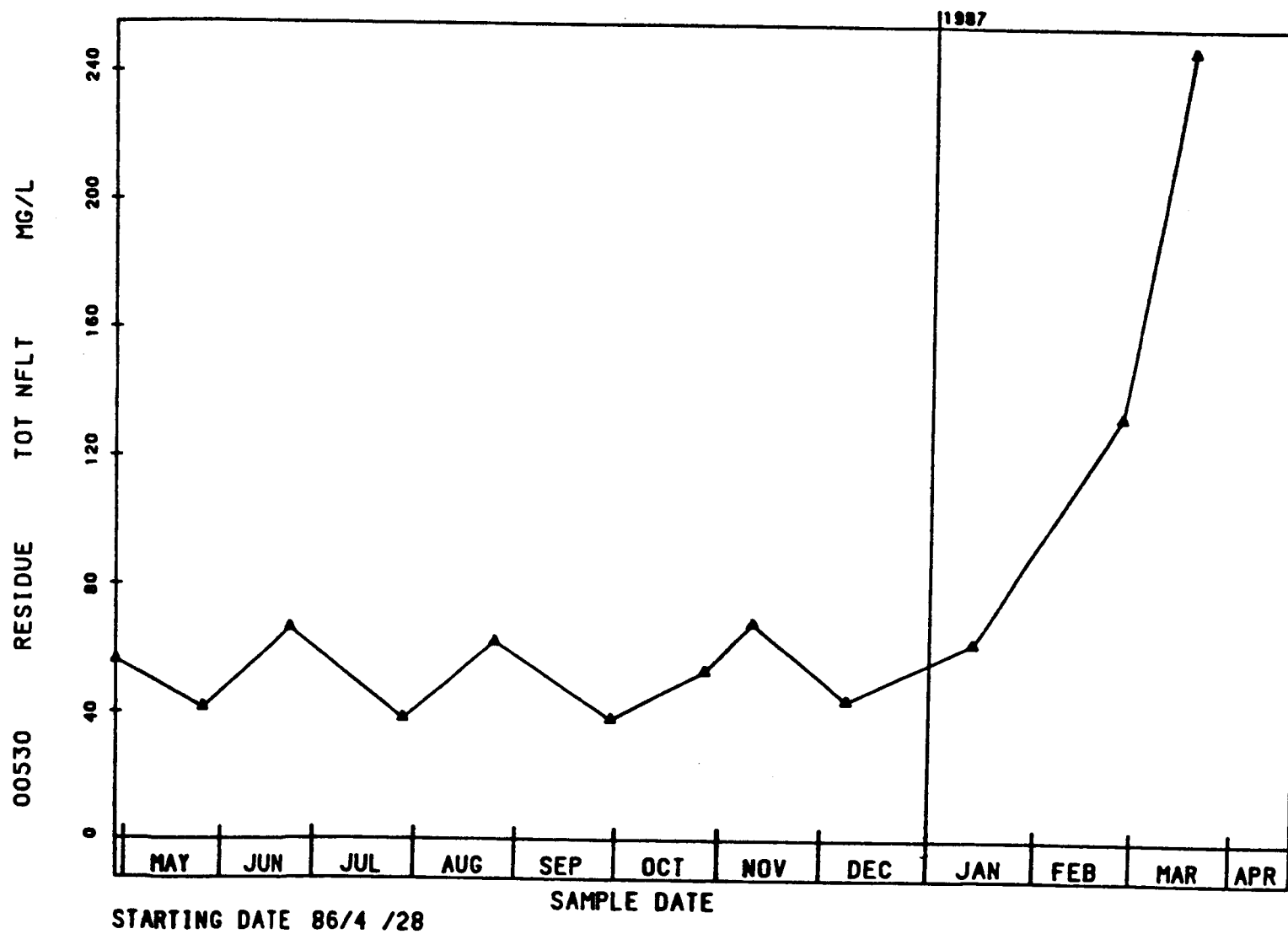


Figure 12. Monthly level of Total Suspended Solids (mg/l) at Station 14, Back Bay from April, 1986 to March, 1987.



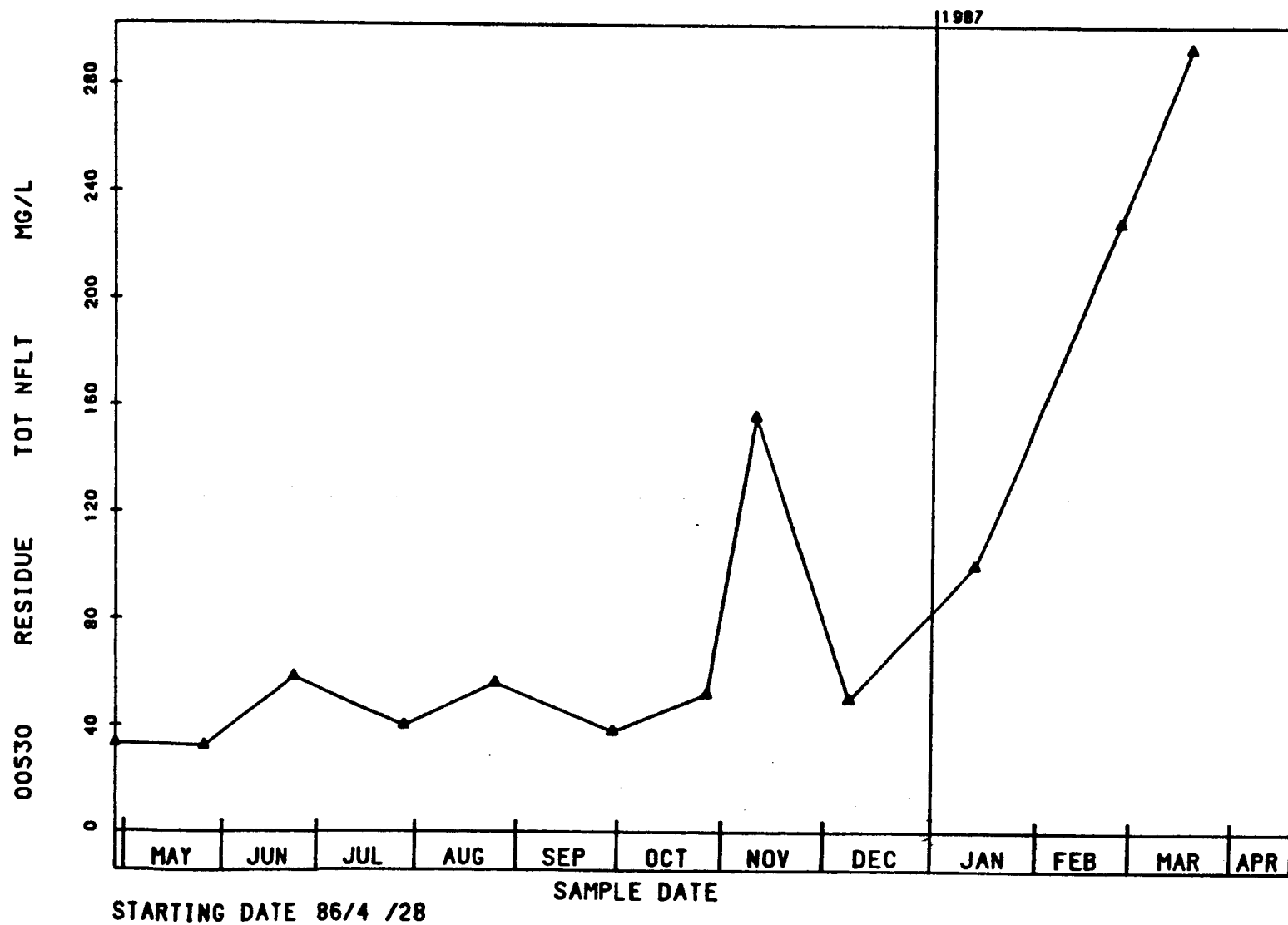


Figure 13. Monthly level of Total Suspended Solids (mg/l) at Station 20, Back Bay from April, 1986 to March, 1987.

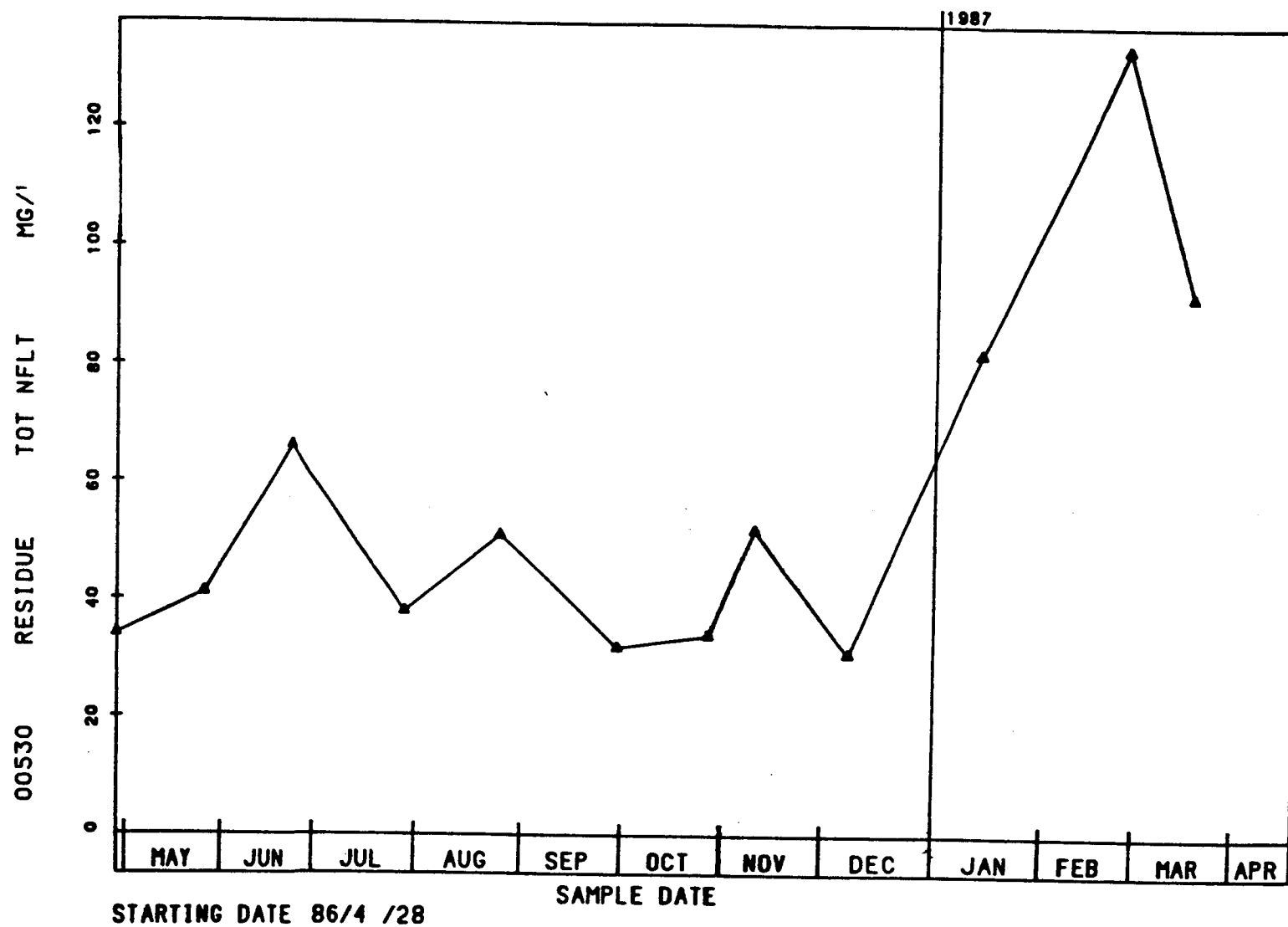


Figure 14. Monthly level of Total Suspended Solids (mg/l) at Station 22, Back Bay from April, 1986 to March, 1987.

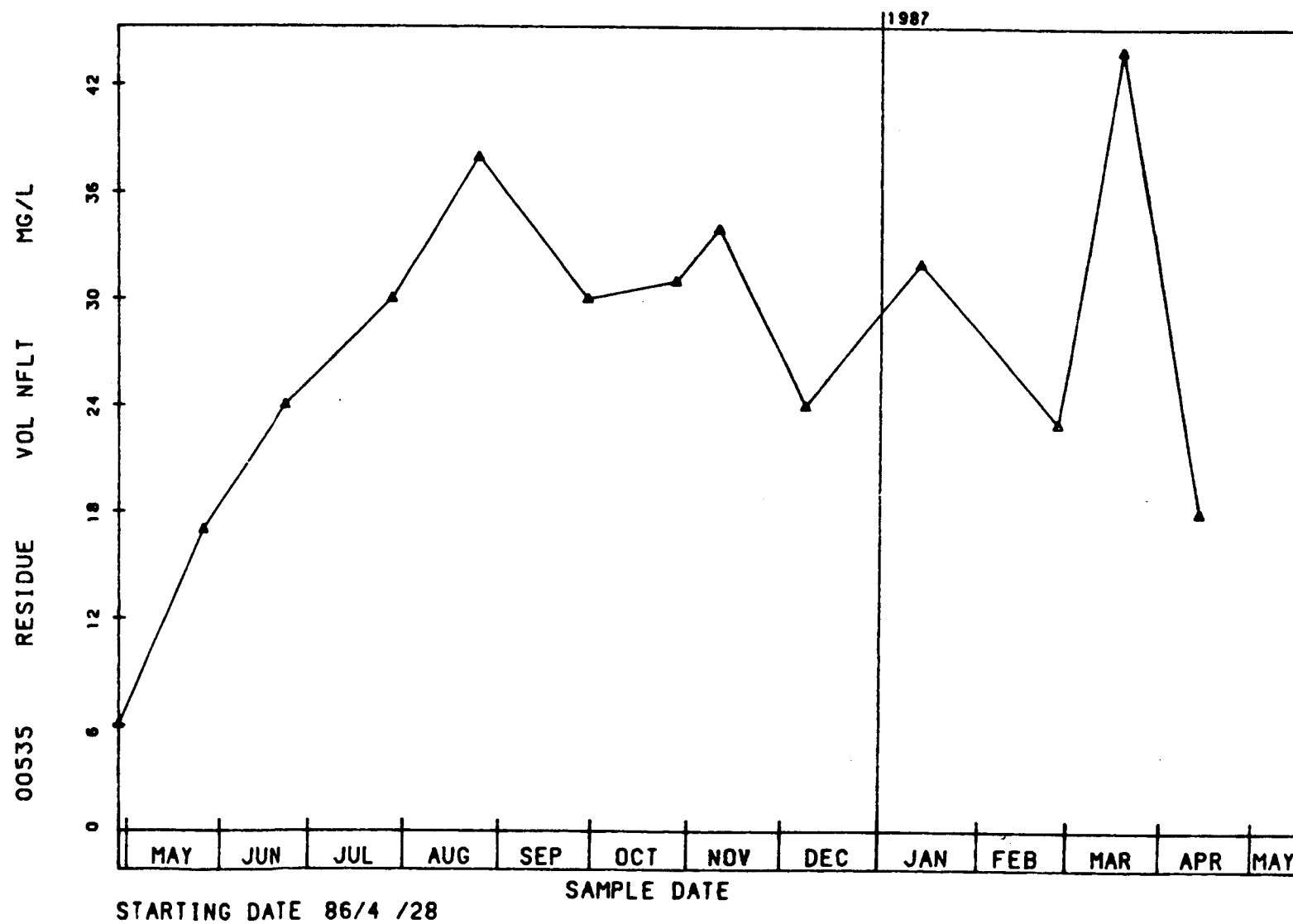


Figure 15. Monthly level of Volatile Suspended Solids (mg/l) at Station 3, Back Bay from April, 1986 to March, 1987.

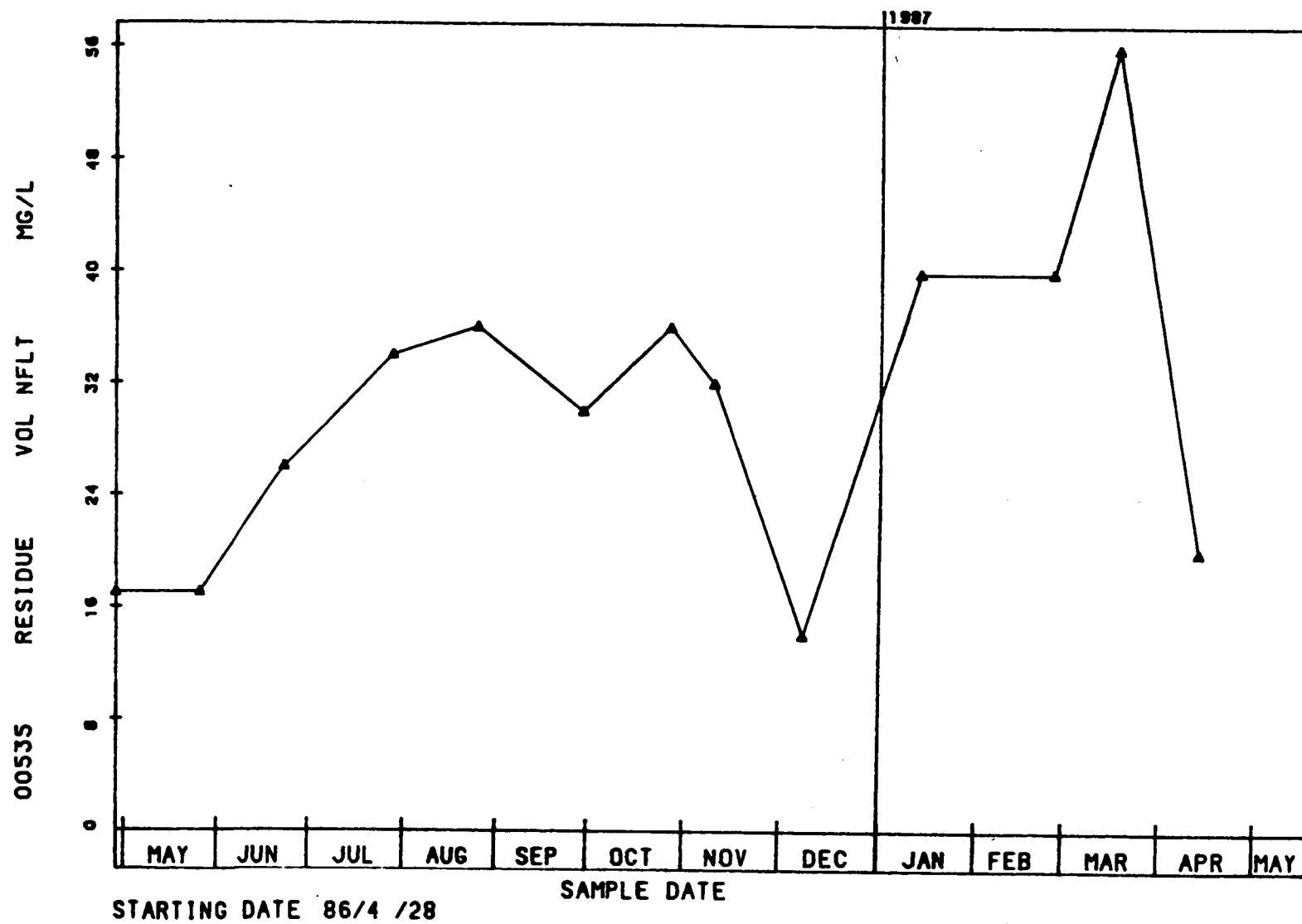


Figure 16. Monthly level of Volatile Suspended Solids (mg/l) at Station 5, Back Bay from April, 1986 to March, 1987.

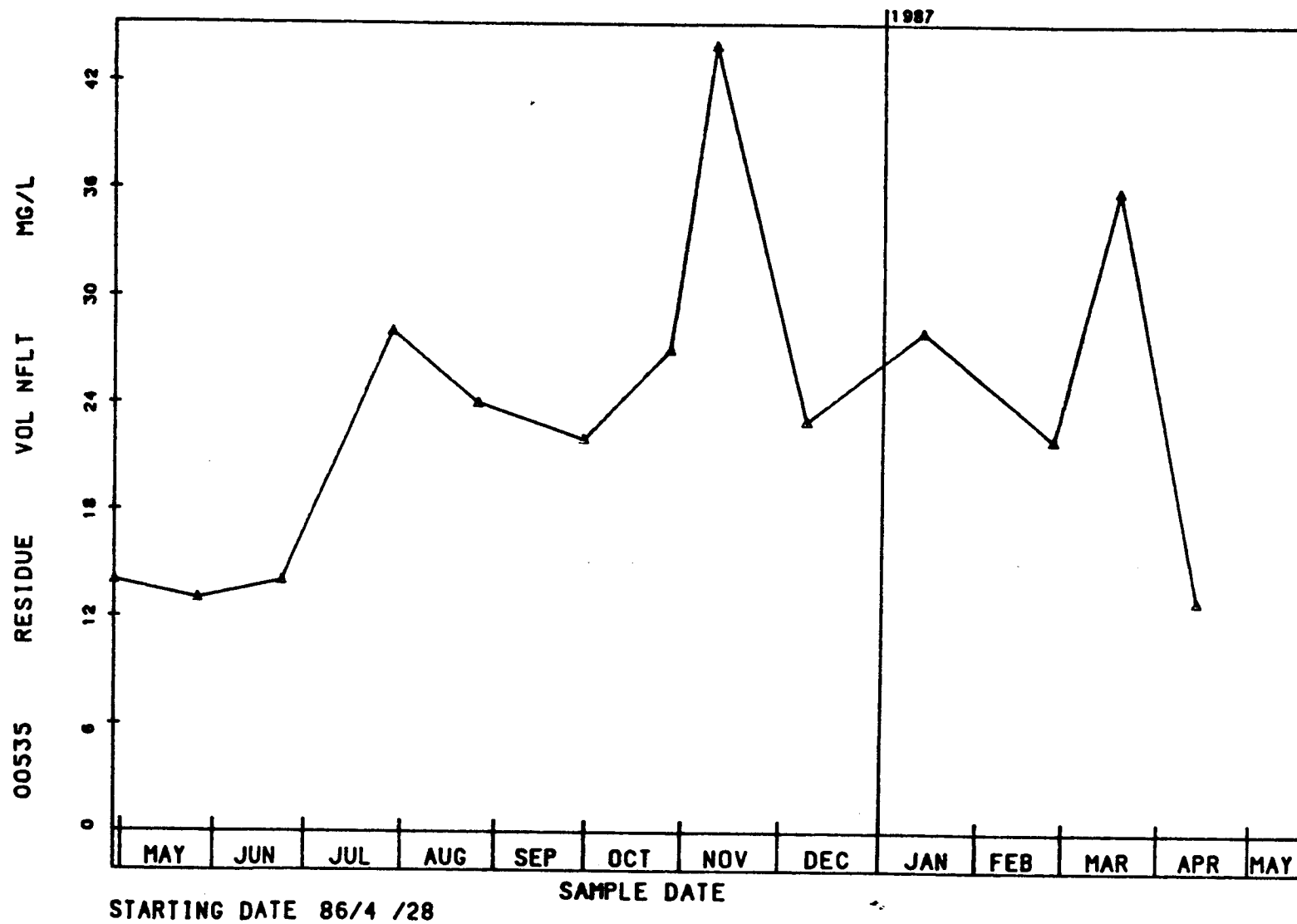


Figure 17. Monthly level of Volatile Suspended Solids (mg/l) at Station 9, Back Bay from April, 1986 to March, 1987.

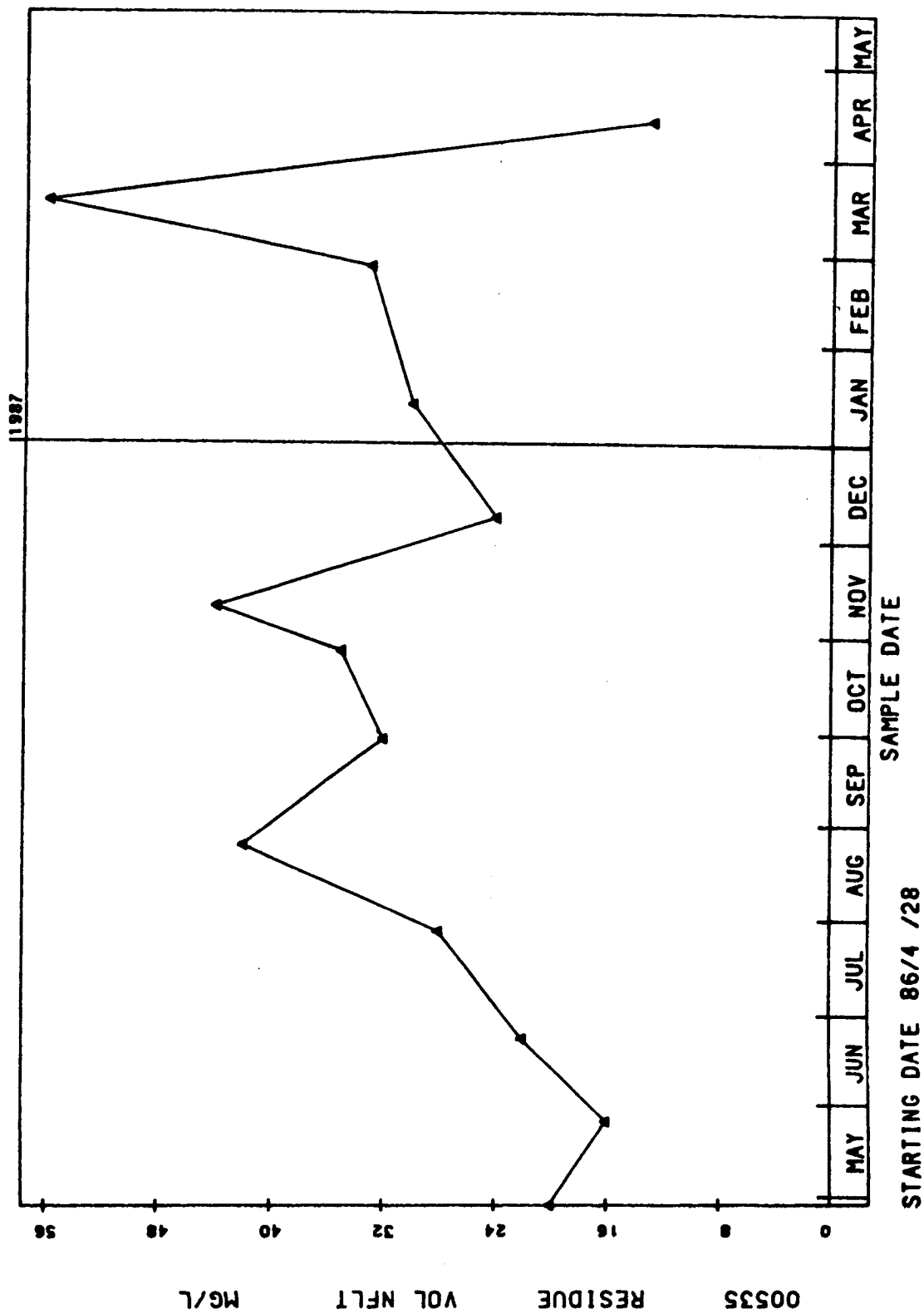


Figure 18. Monthly level of Volatile Suspended Solids (mg/l) at Station 14, Back Bay from April, 1986 to March, 1987.

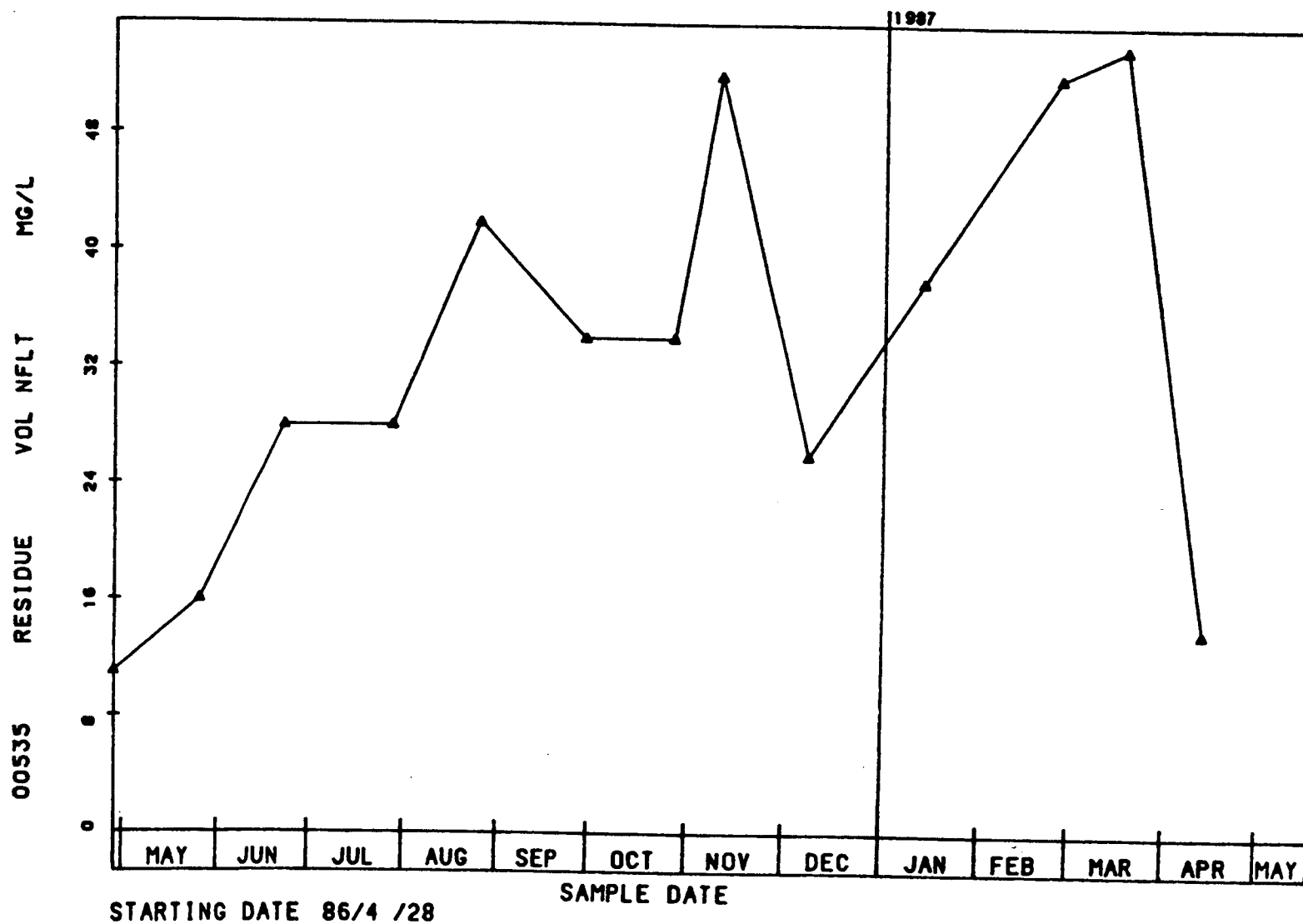


Figure 19. Monthly level of Volatile Suspended Solids (mg/l) at Station 20, Back Bay from April, 1986 to March, 1987.

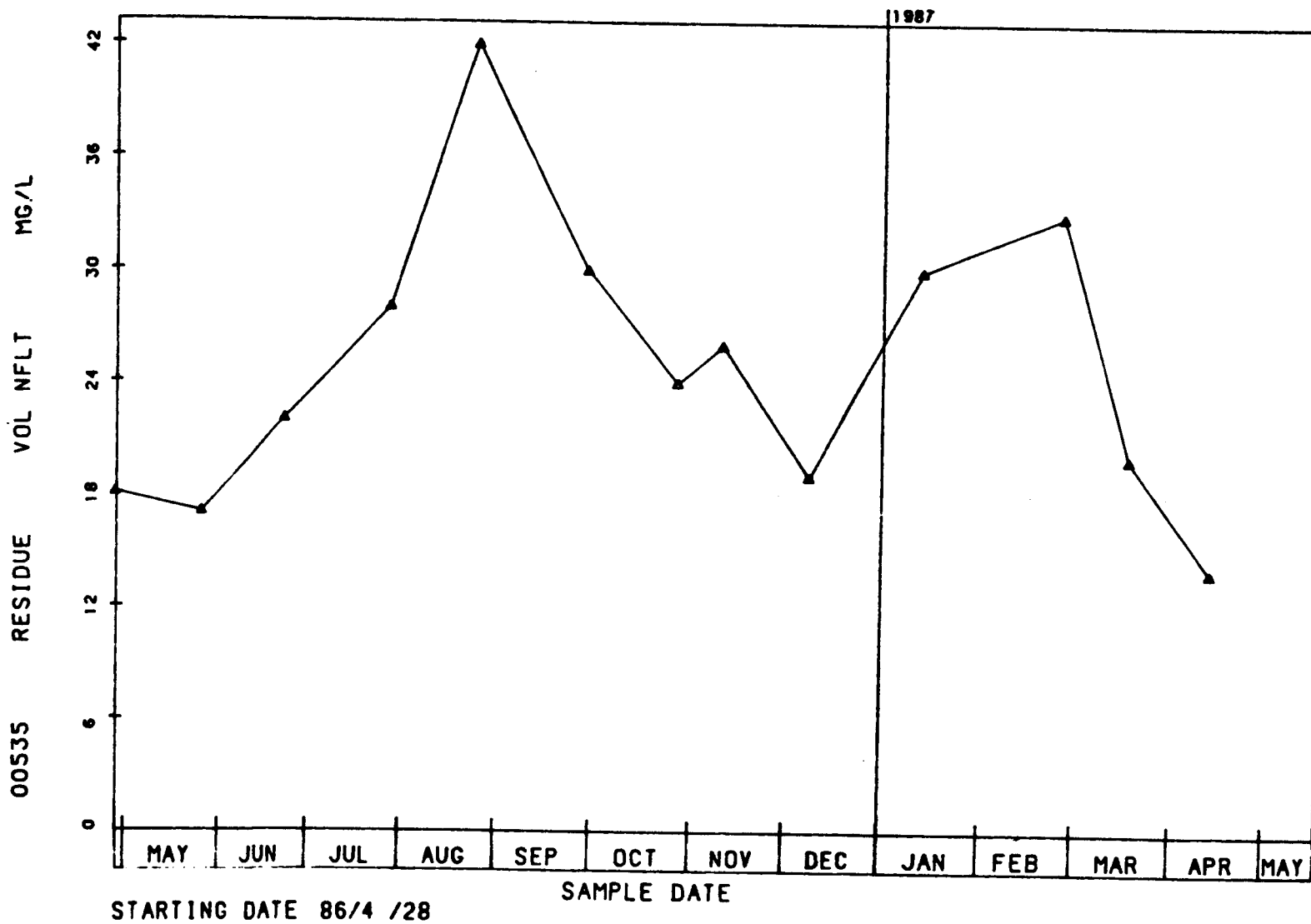


Figure 20. Monthly level of Volatile Suspended Solids (mg/l) at Station 22, Back Bay from April, 1986 to March, 1987.



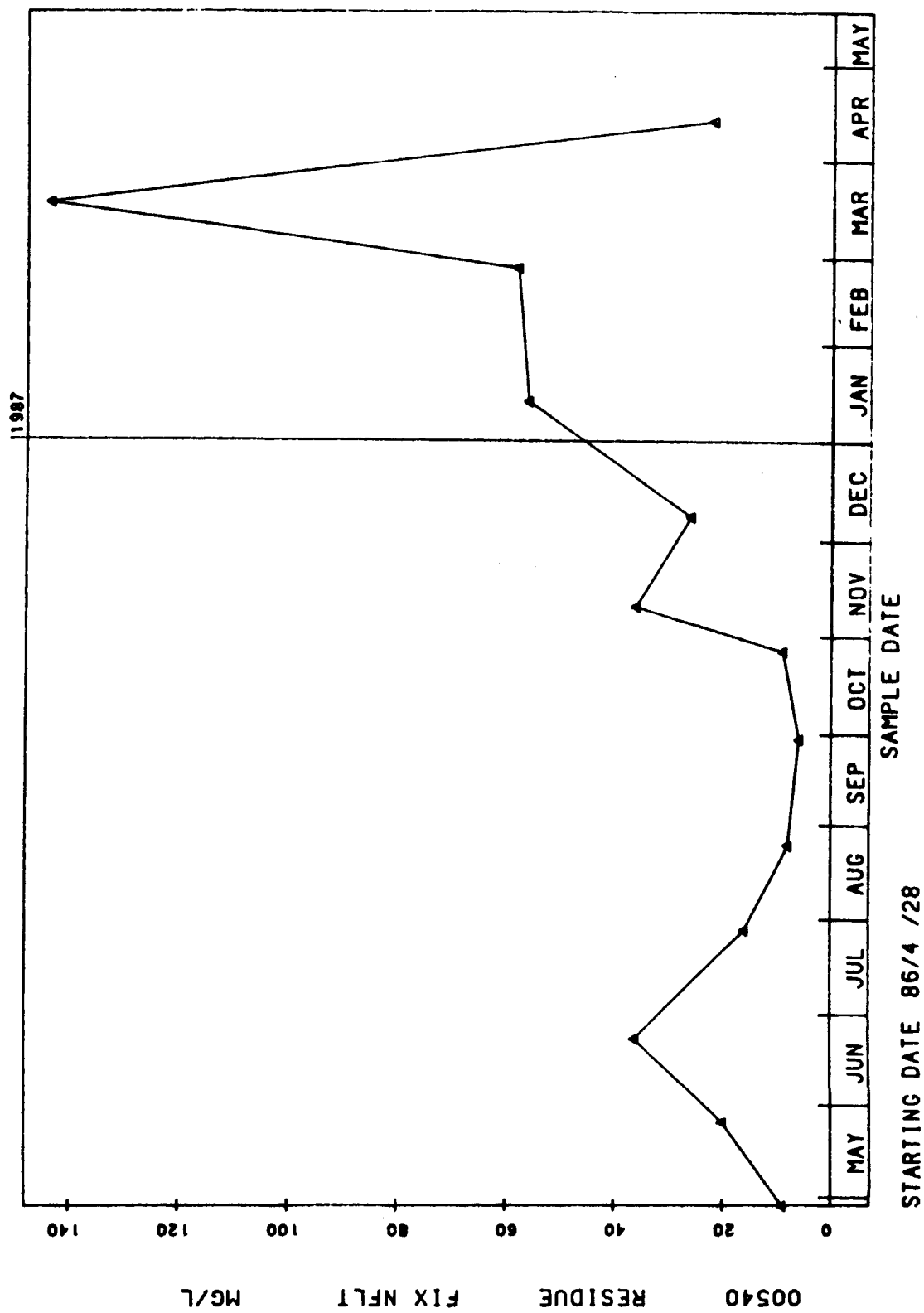


Figure 21. Monthly level of Fixed Suspended Solids (mg/l) at Station 3, Back Bay from April, 1986 to March, 1987.

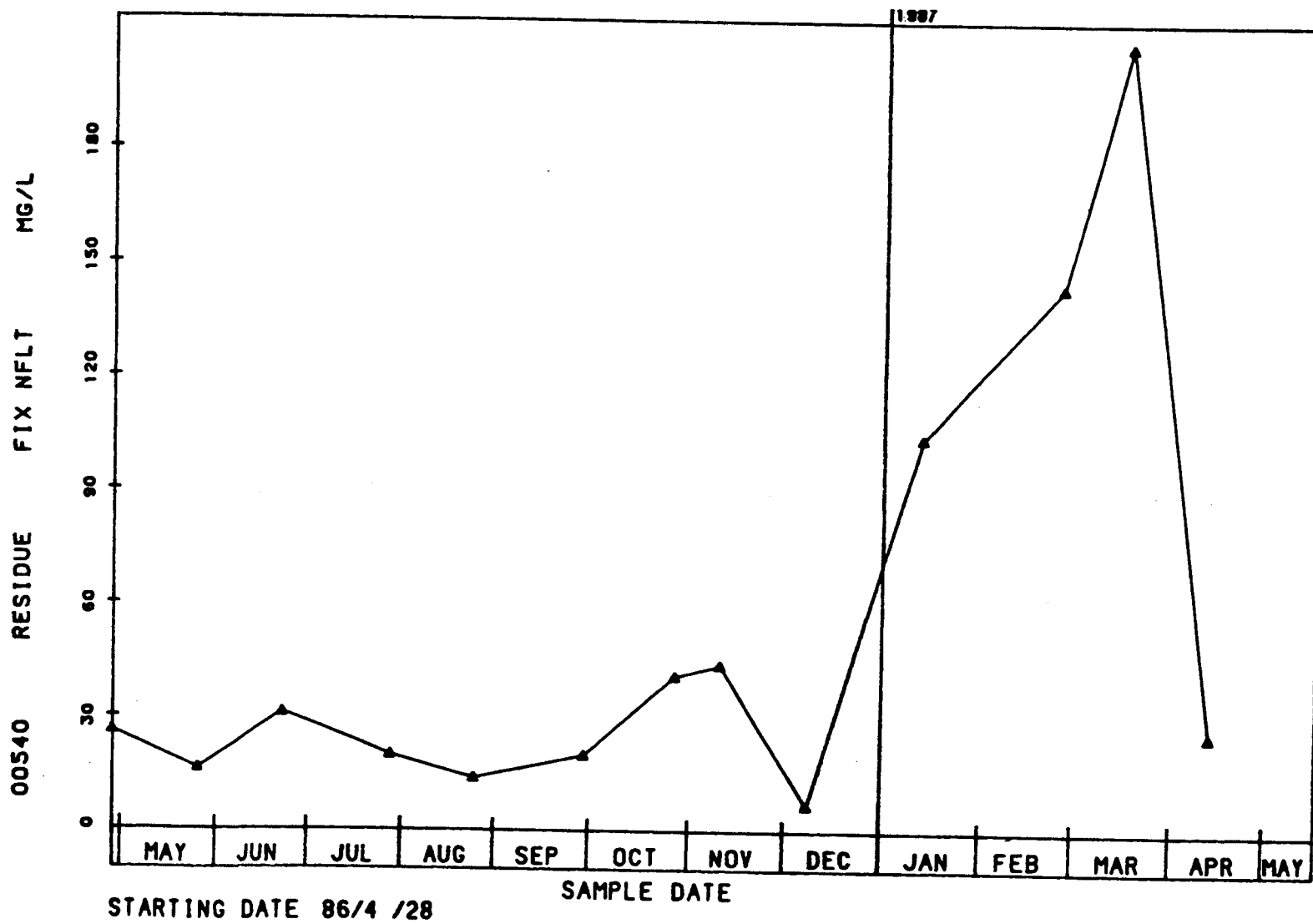


Figure 22. Monthly level of Fixed Suspended Solids (mg/l) at Station 5, Back Bay from April, 1986 to March, 1987.

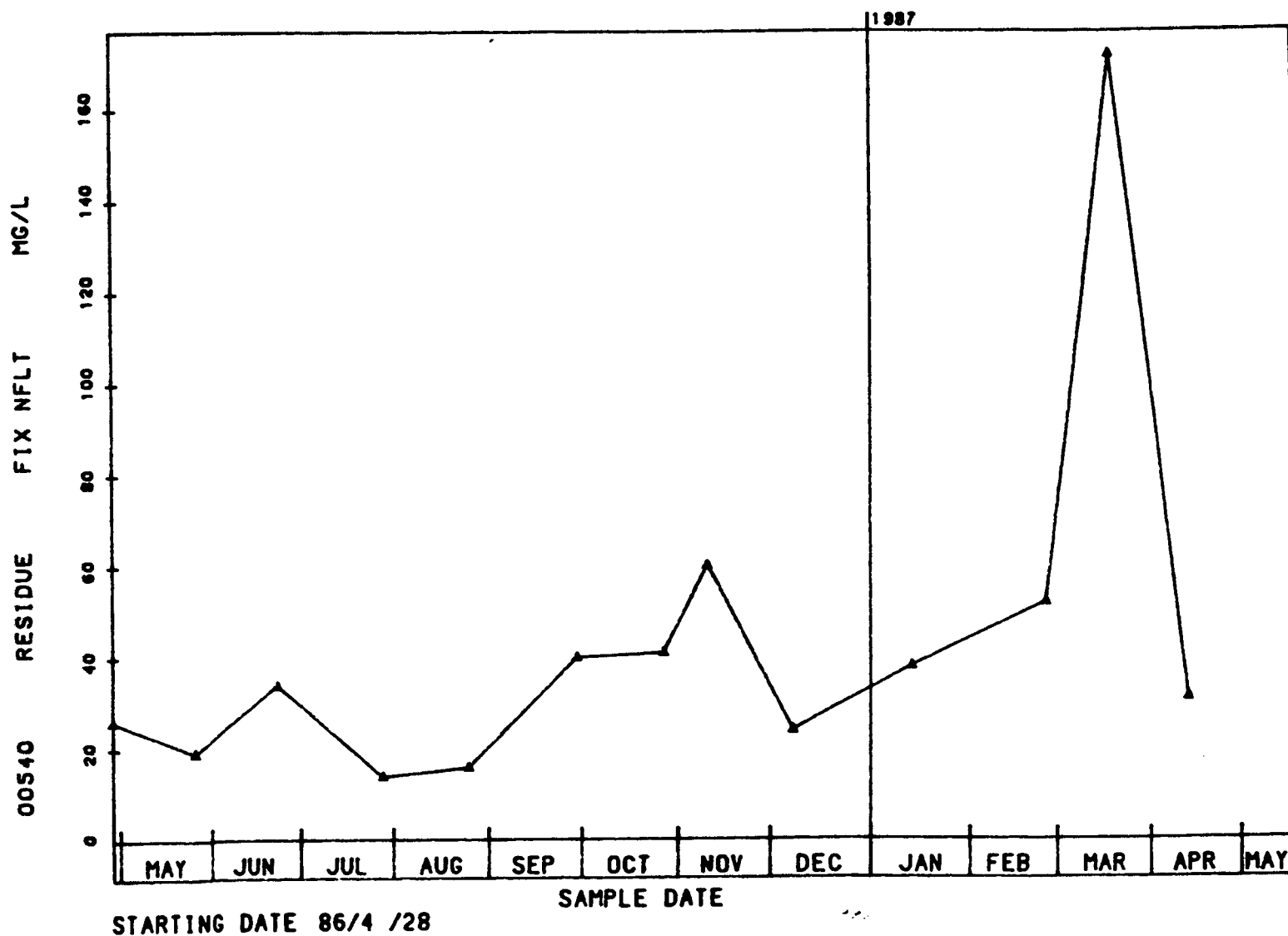


Figure 23. Monthly level of Fixed Suspended Solids (mg/l) at Station 9, Back Bay from April, 1986 to March, 1987.

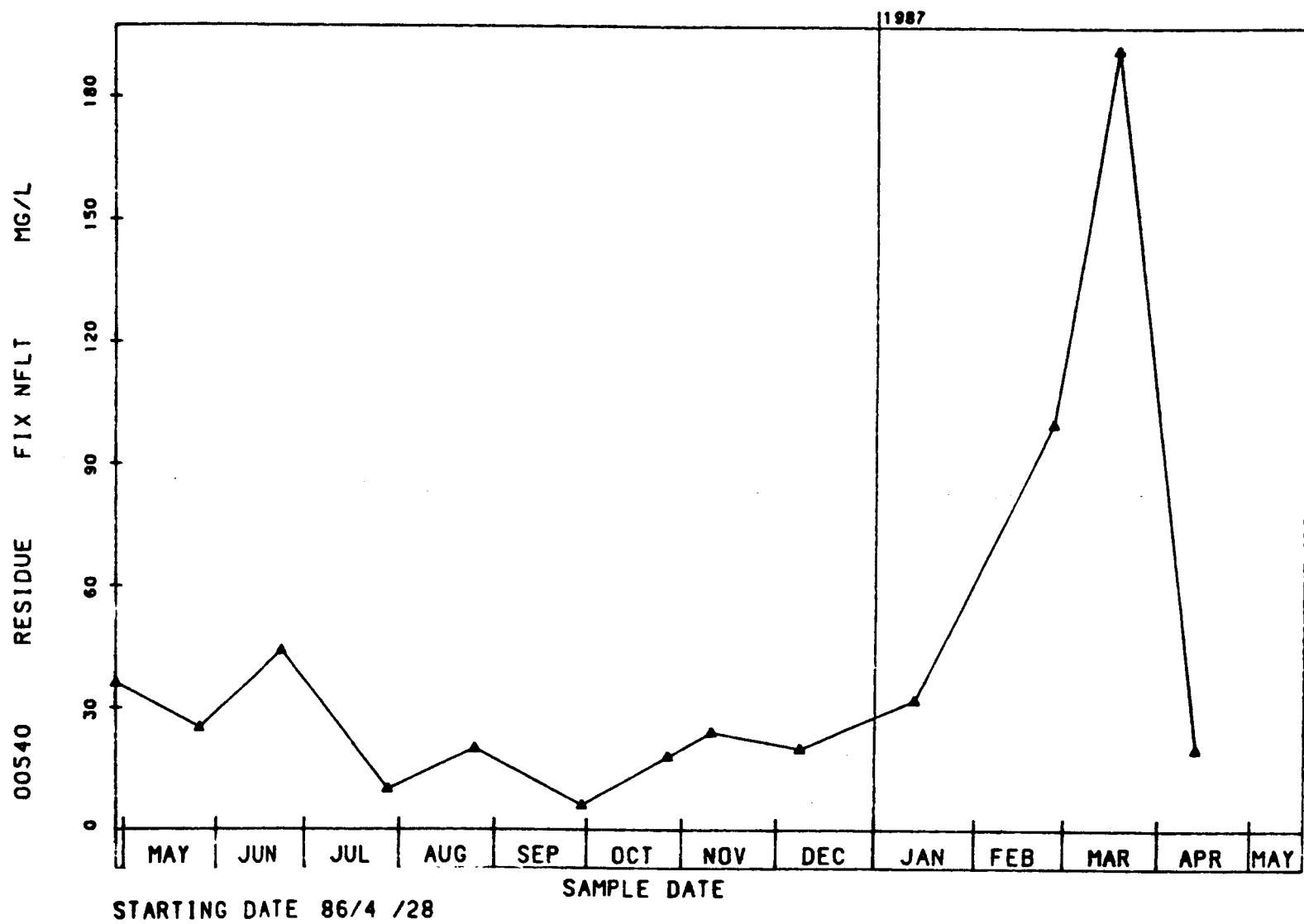


Figure 24. Monthly level of Fixed Suspended Solids (mg/l) at Station 14, Back Bay from April, 1986 to March, 1987.

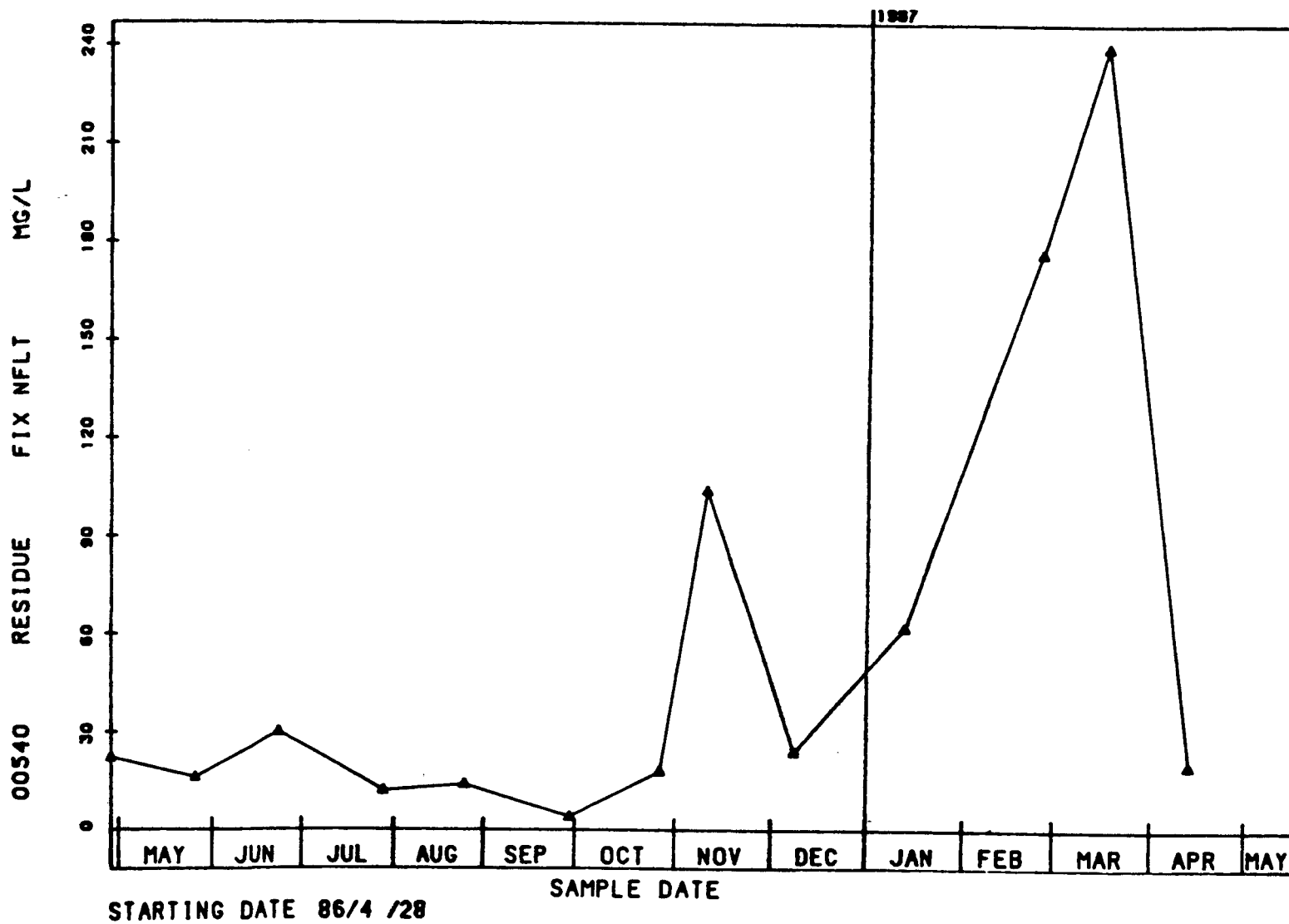


Figure 25. Monthly level of Fixed Suspended Solids (mg/l) at Station 20, Back Bay from April, 1986 to March, 1987.

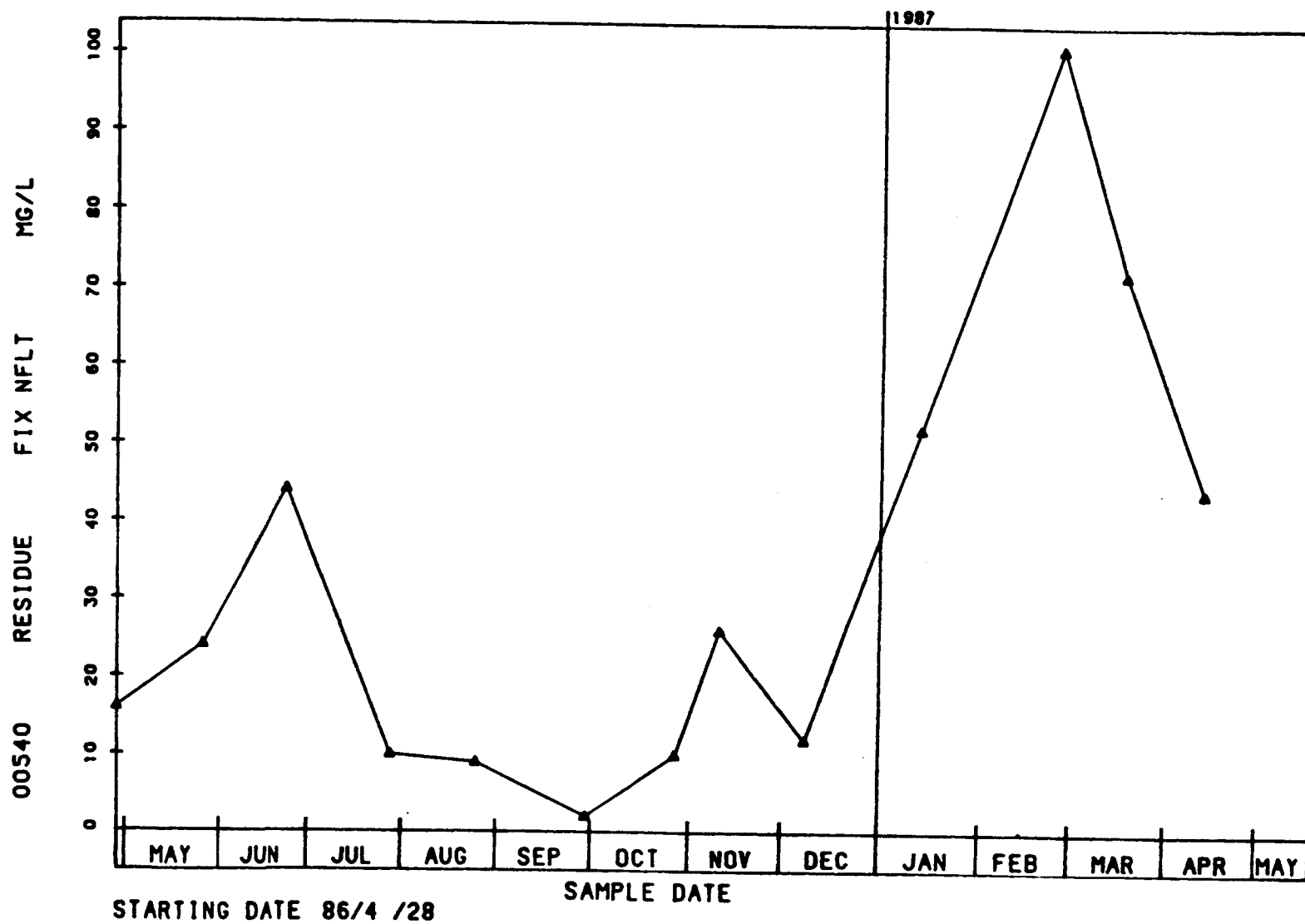


Figure 26. Monthly level of Fixed Suspended Solids (mg/l) at Station 22, Back Bay from April, 1986 to March, 1987.

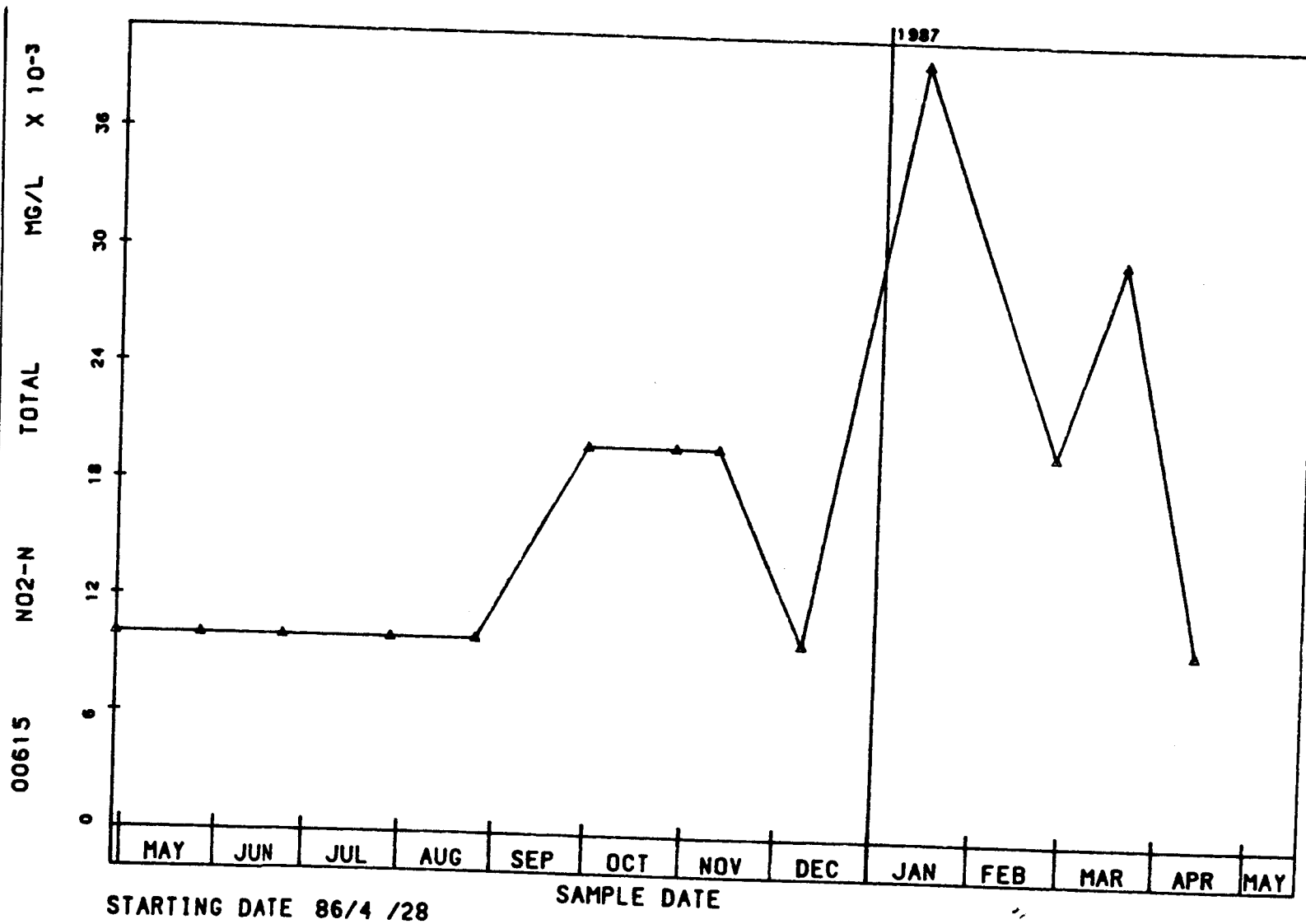


Figure 27. Monthly level of Nitrite as Nitrogen (mg/l) at Station 3, Back Bay from April, 1986 to March, 1987.

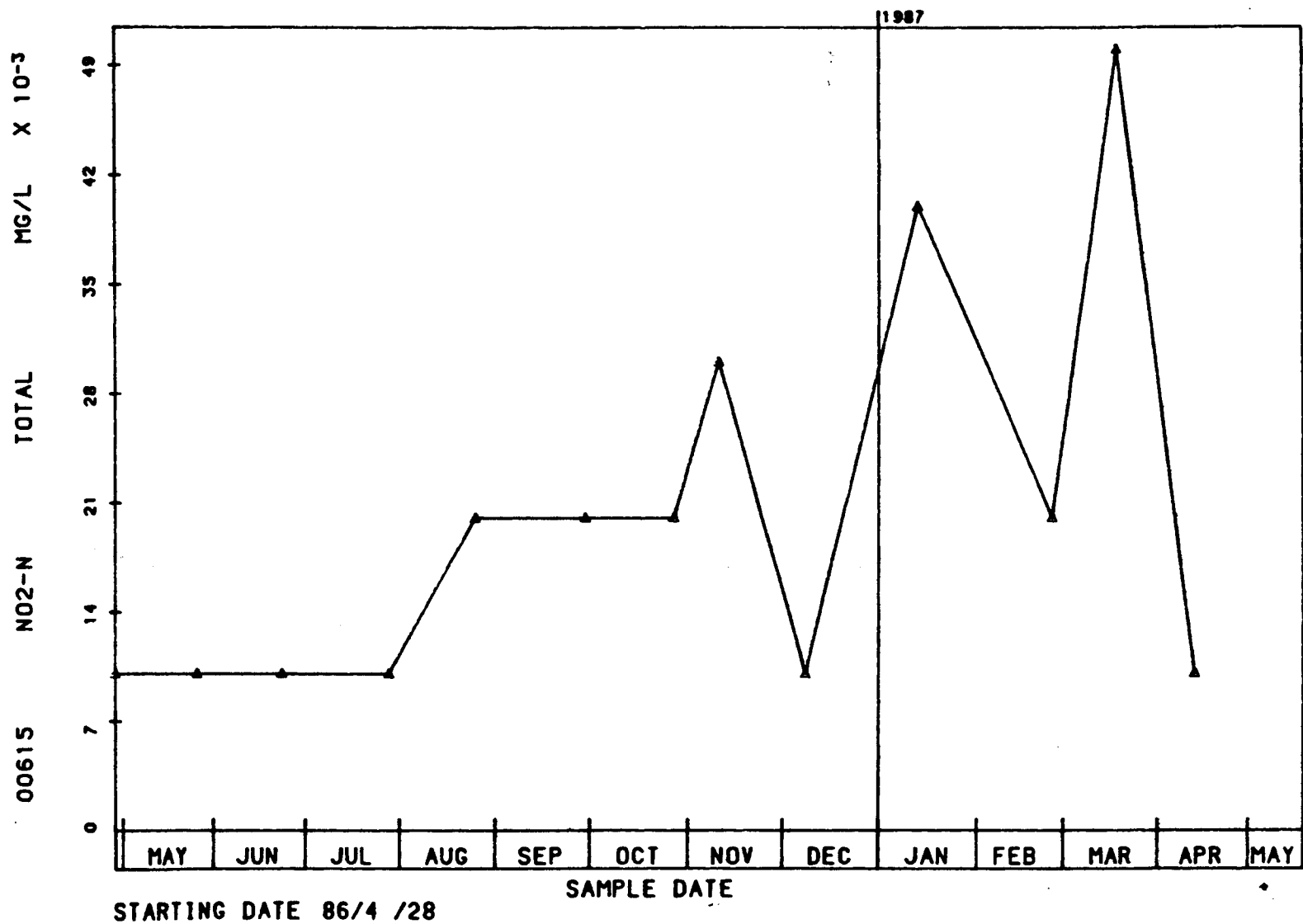


Figure 28. Monthly level of Nitrite as Nitrogen (mg/l) at Station 5, Back Bay from April, 1986 to March, 1987.



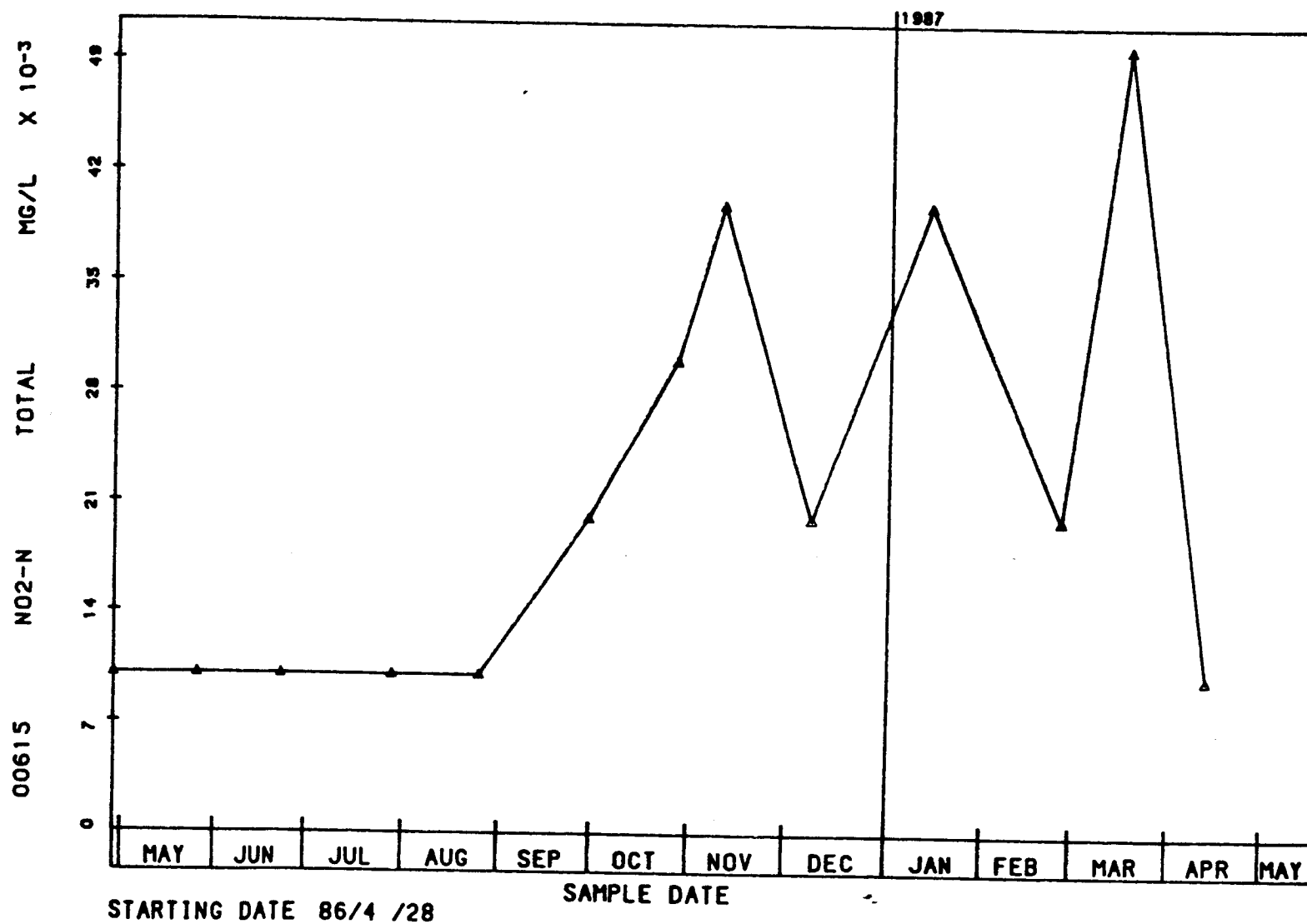


Figure 29. Monthly level of Nitrite as Nitrogen (mg/l) at Station 9, Back Bay from April, 1986 to March, 1987.

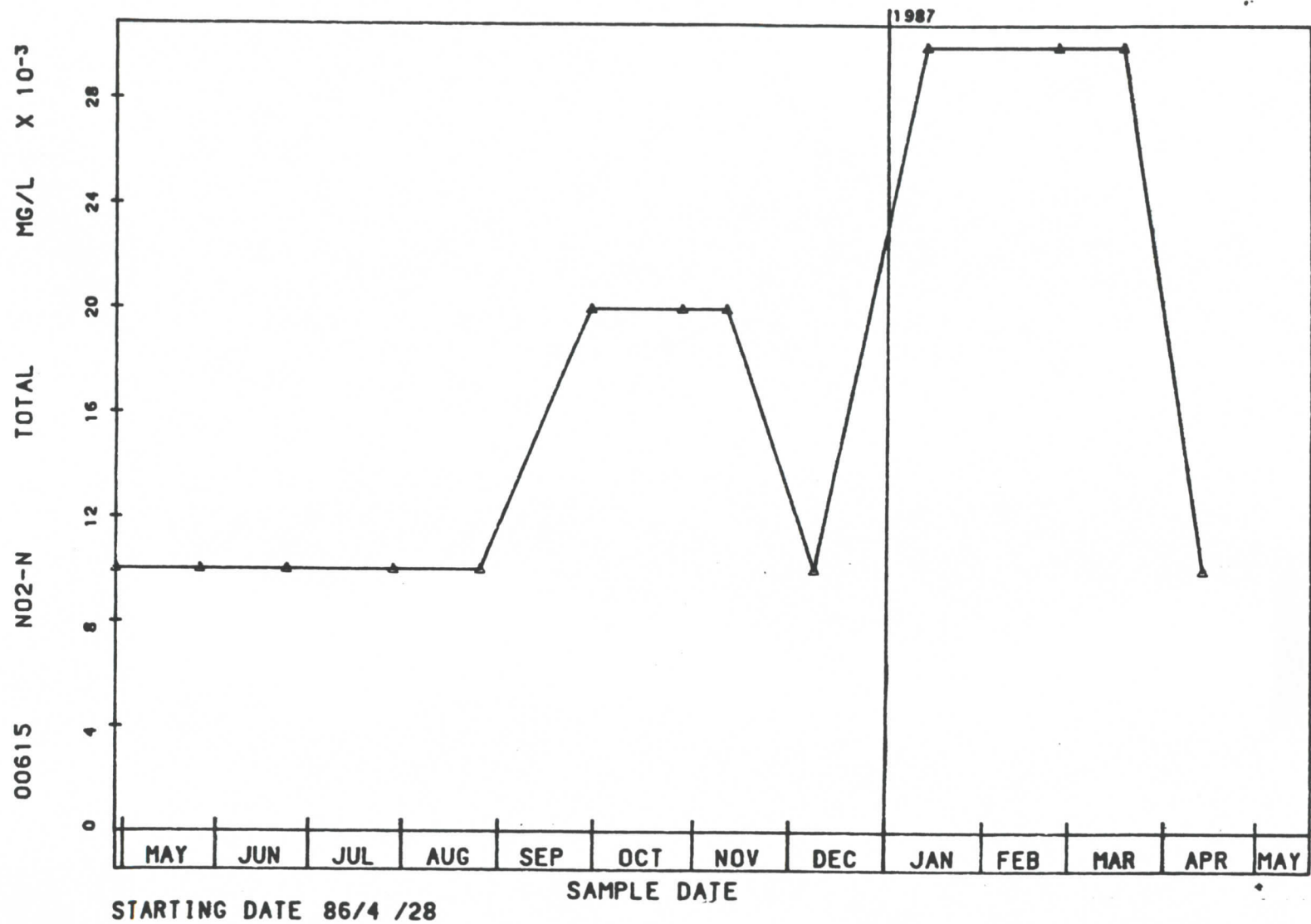


Figure 30. Monthly level of Nitrite as Nitrogen (mg/l) at Station 14, Back Bay from April, 1986 to March, 1987.

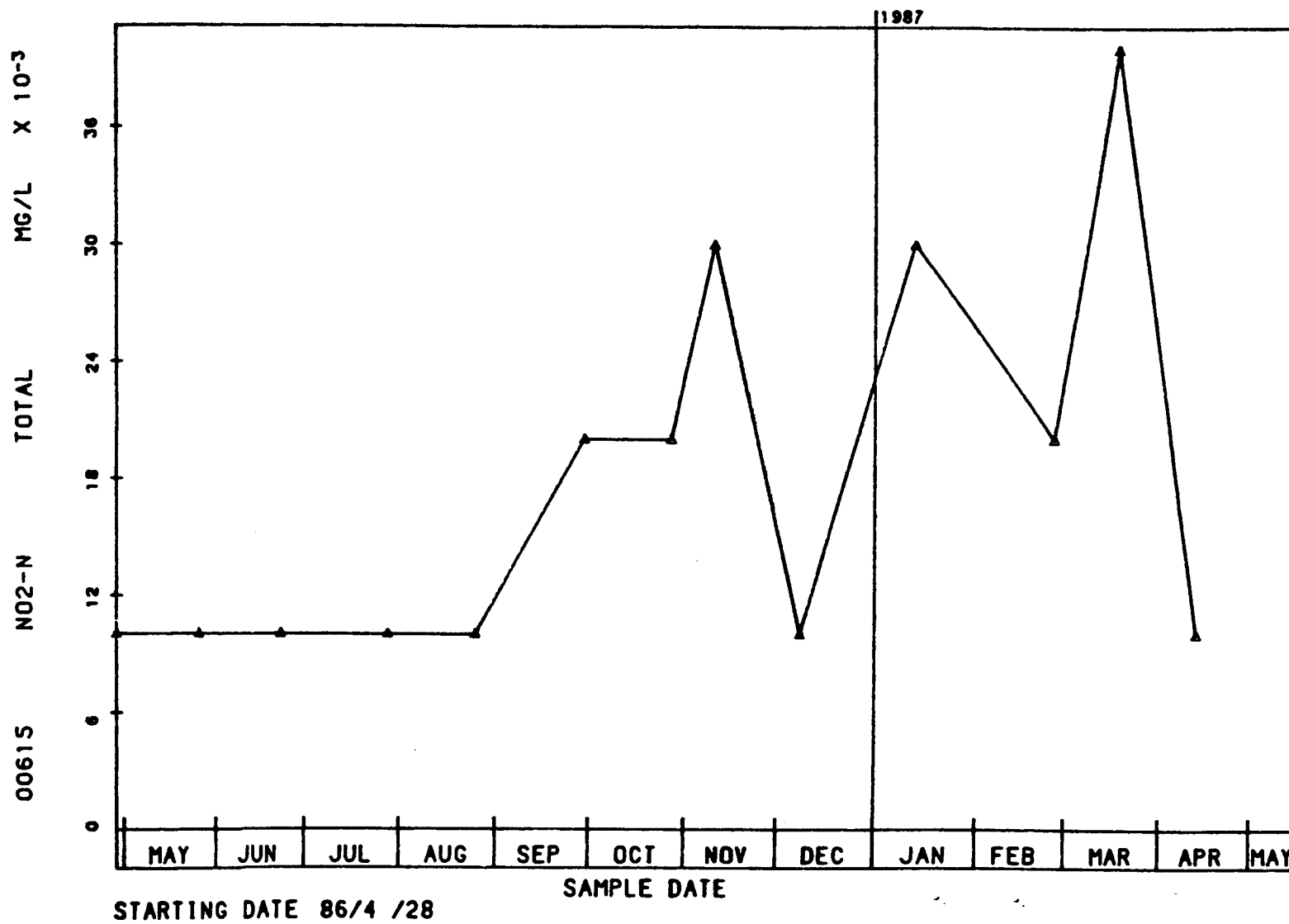


Figure 31. Monthly level of Nitrite as Nitrogen (mg/l) at Station 20, Back Bay fro April, 1986 to March, 1987.

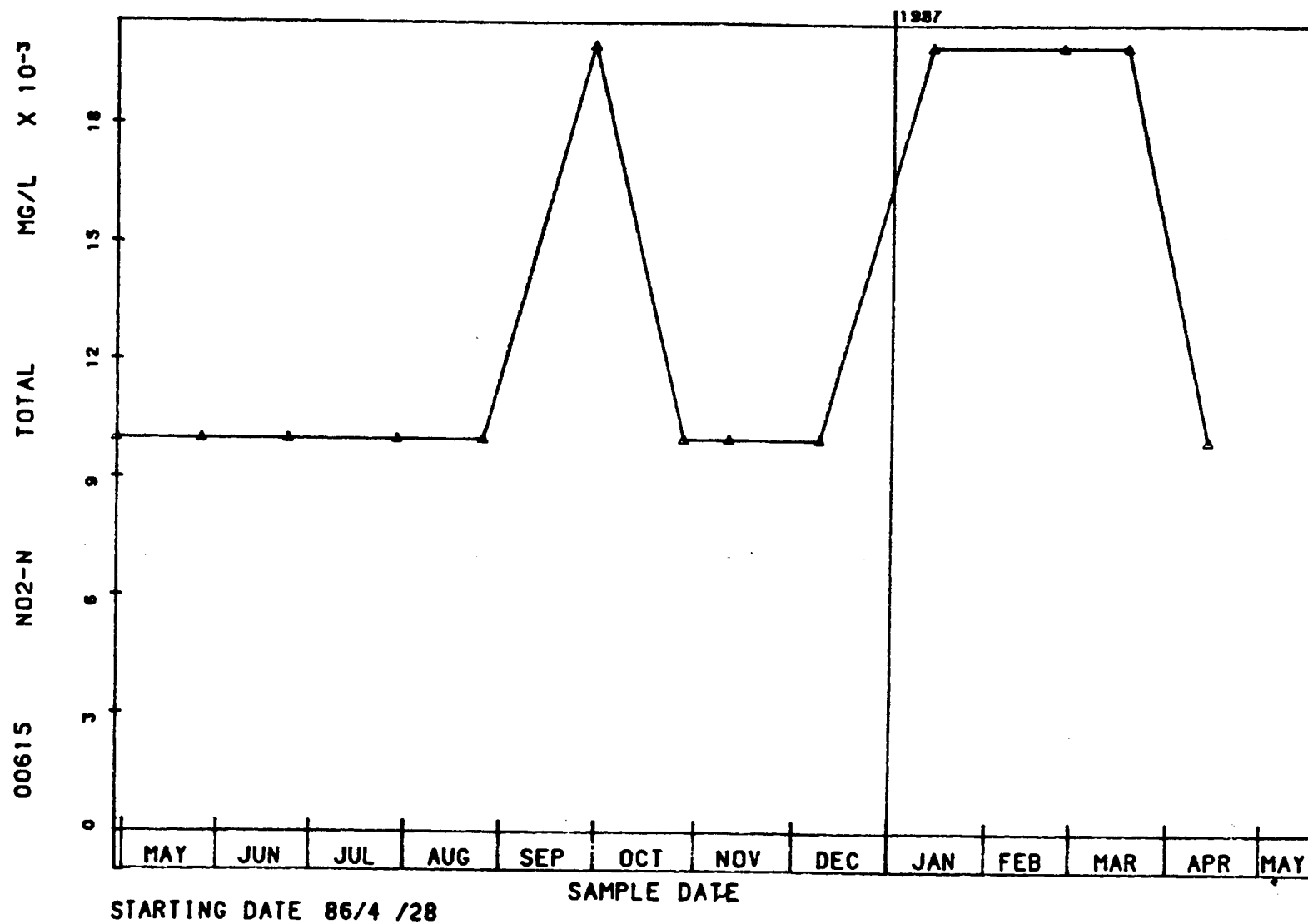


Figure 32. Monthly level of Nitrite as Nitrogen (mg/l) at Station 22, Back Bay from April, 1986 to March, 1987.

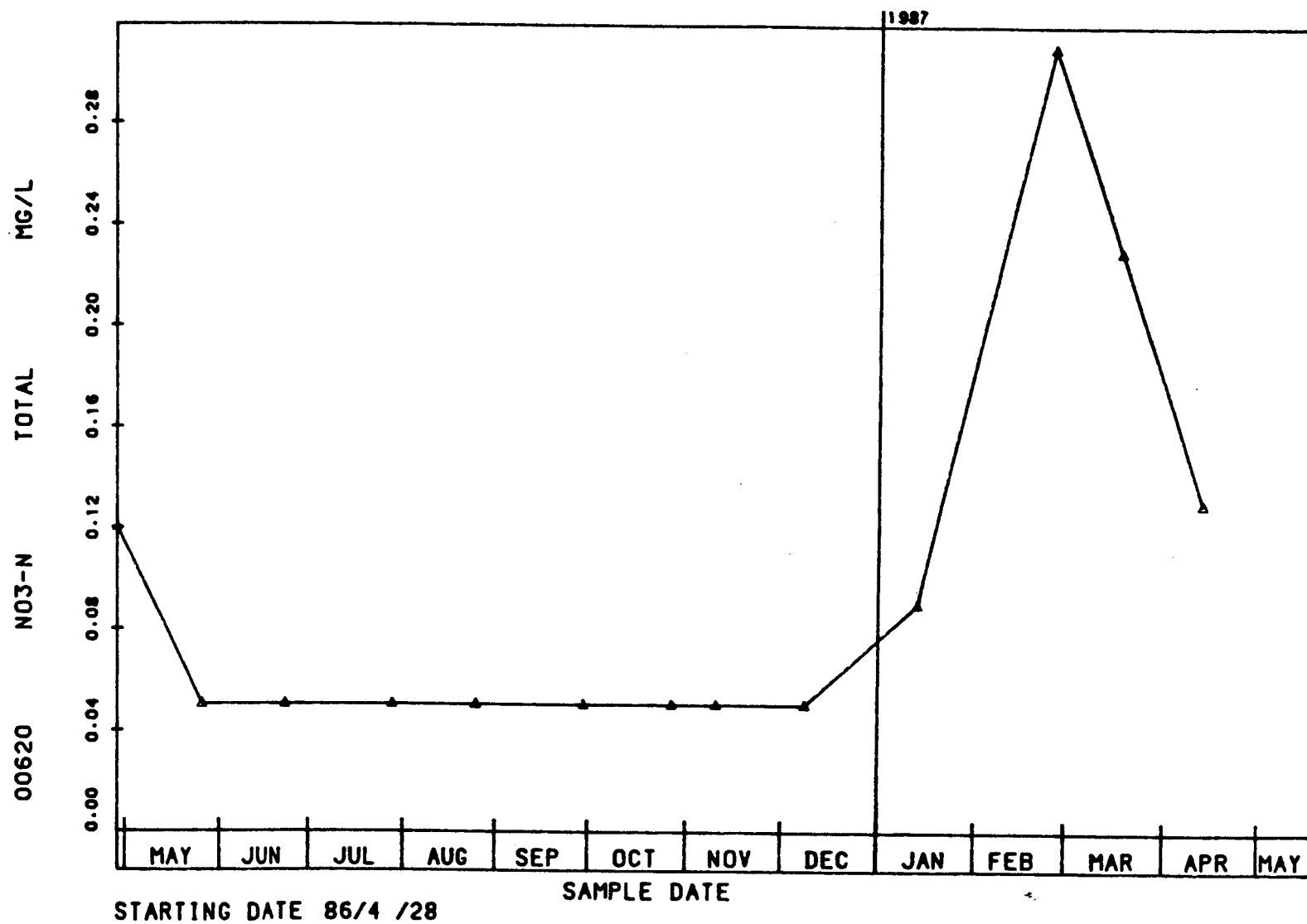


Figure 33. Monthly level of Nitrate as Nitrogen (mg/l) at Station 3, Back Bay from April, 1986 to March, 1987.

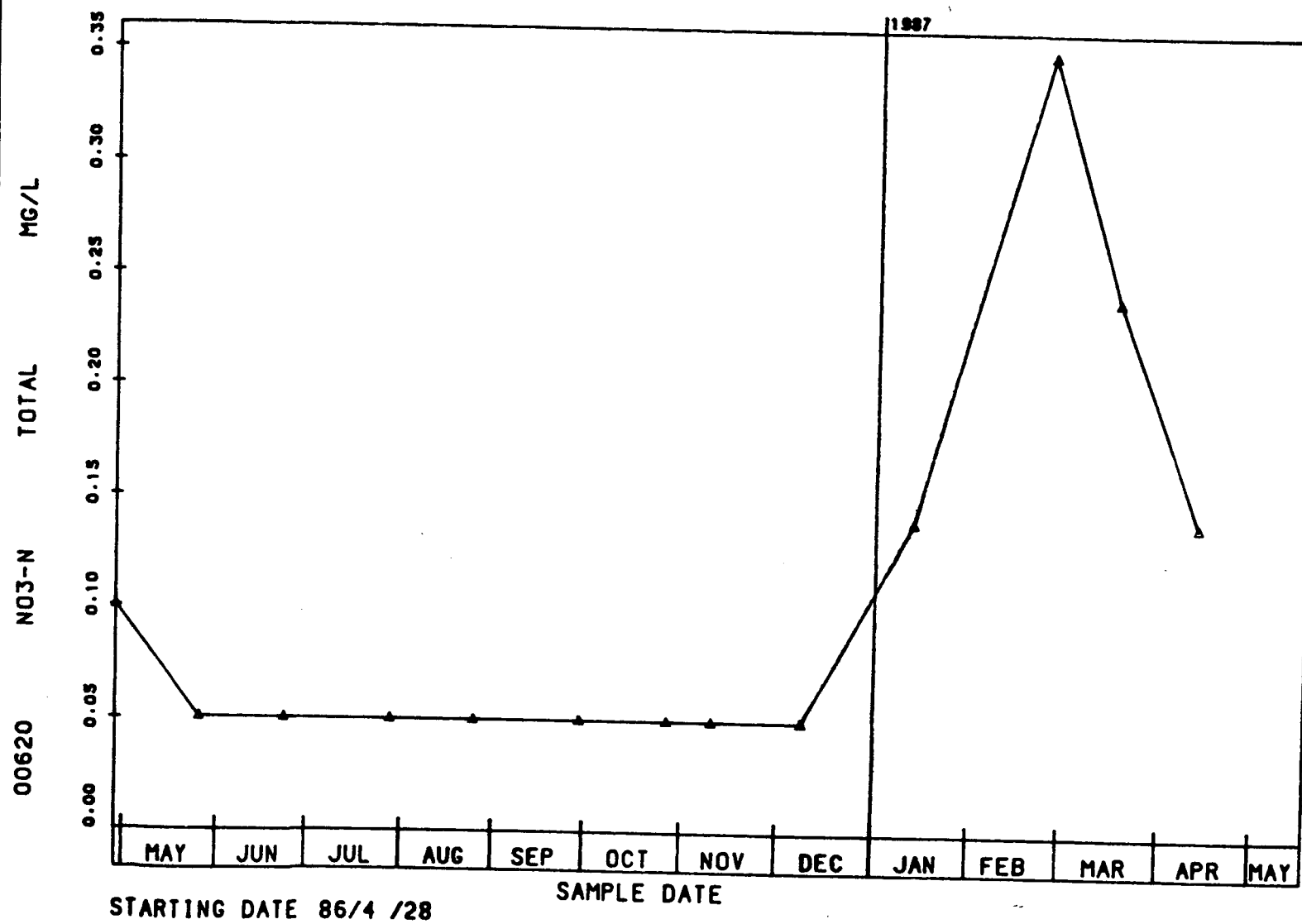


Figure 34. Monthly level of Nitrate as Nitrogen (mg/l) at Station 5, Back Bay from April, 1986 to March 1987.

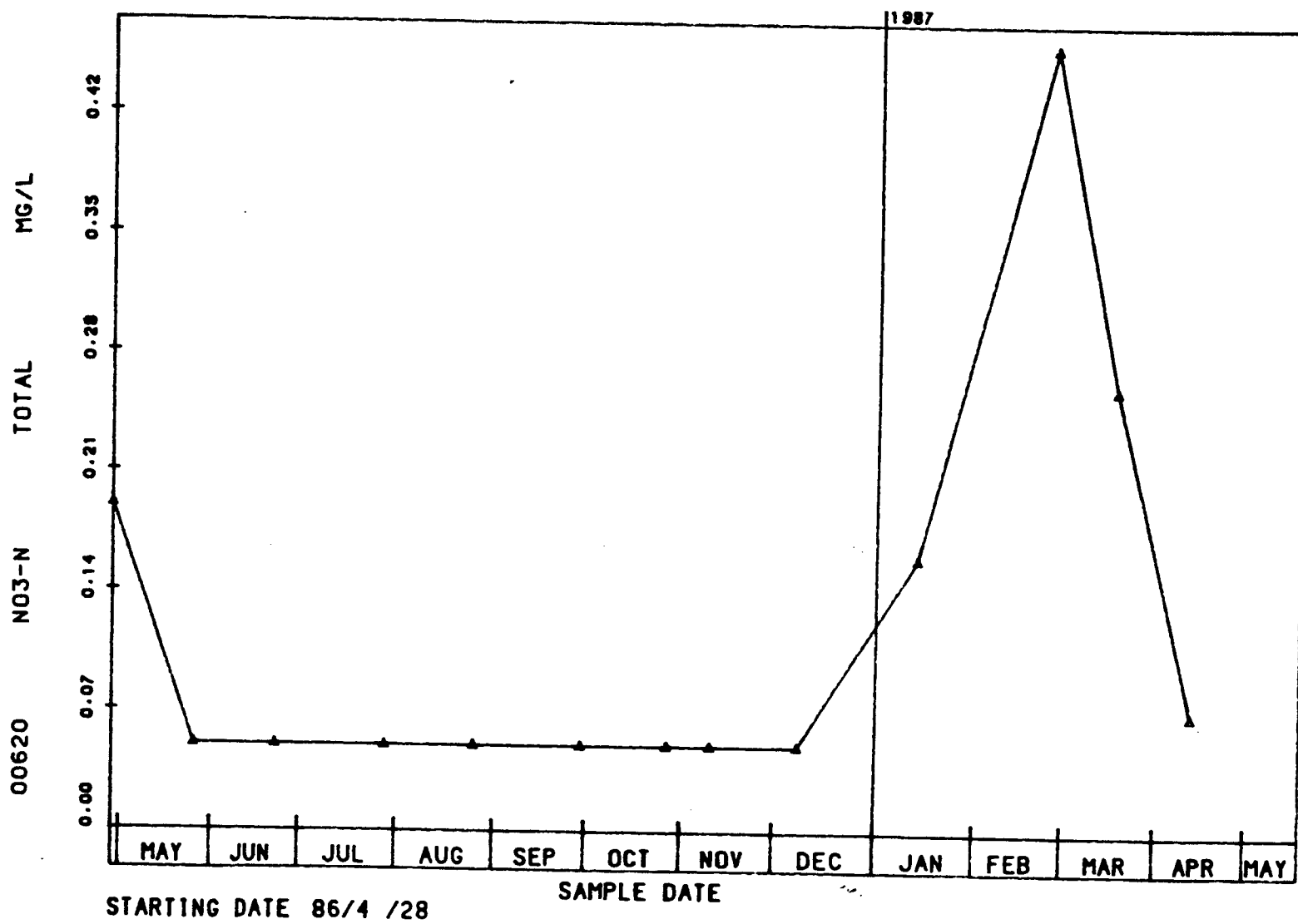


Figure 35. Monthly level of Nitrate as Nitrogen (mg/l) at Station 9, Back Bay from April, 1986 to March, 1987

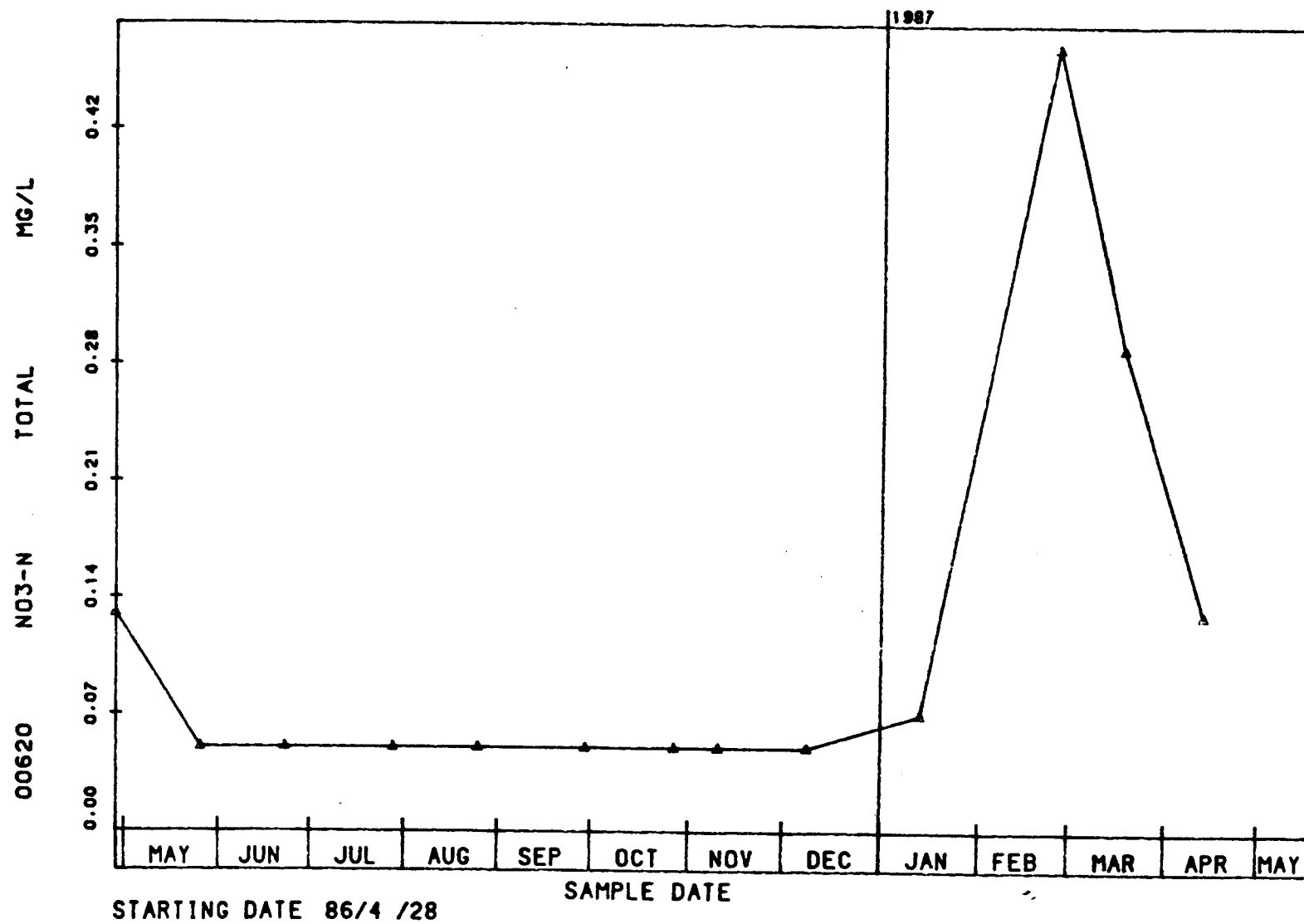


Figure 36. Monthly level of Nitrate as Nitrogen (mg/l) at Station 14, Back Bay from April, 1986 to March, 1987.



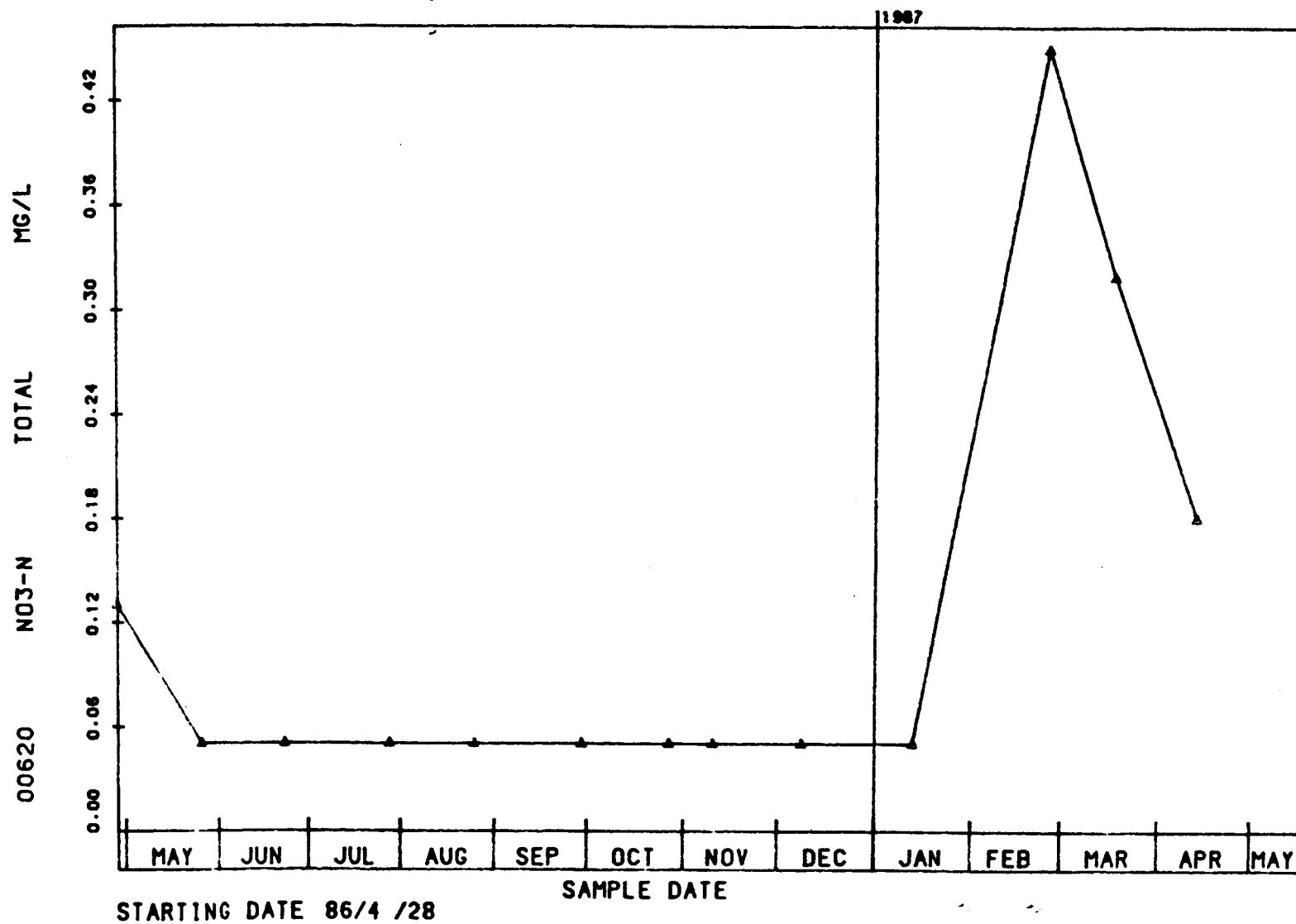


Figure 37. Monthly level of Nitrate as Nitrogen (mg/l) at Station 20, Back Bay from April, 1986 to March, 1987.

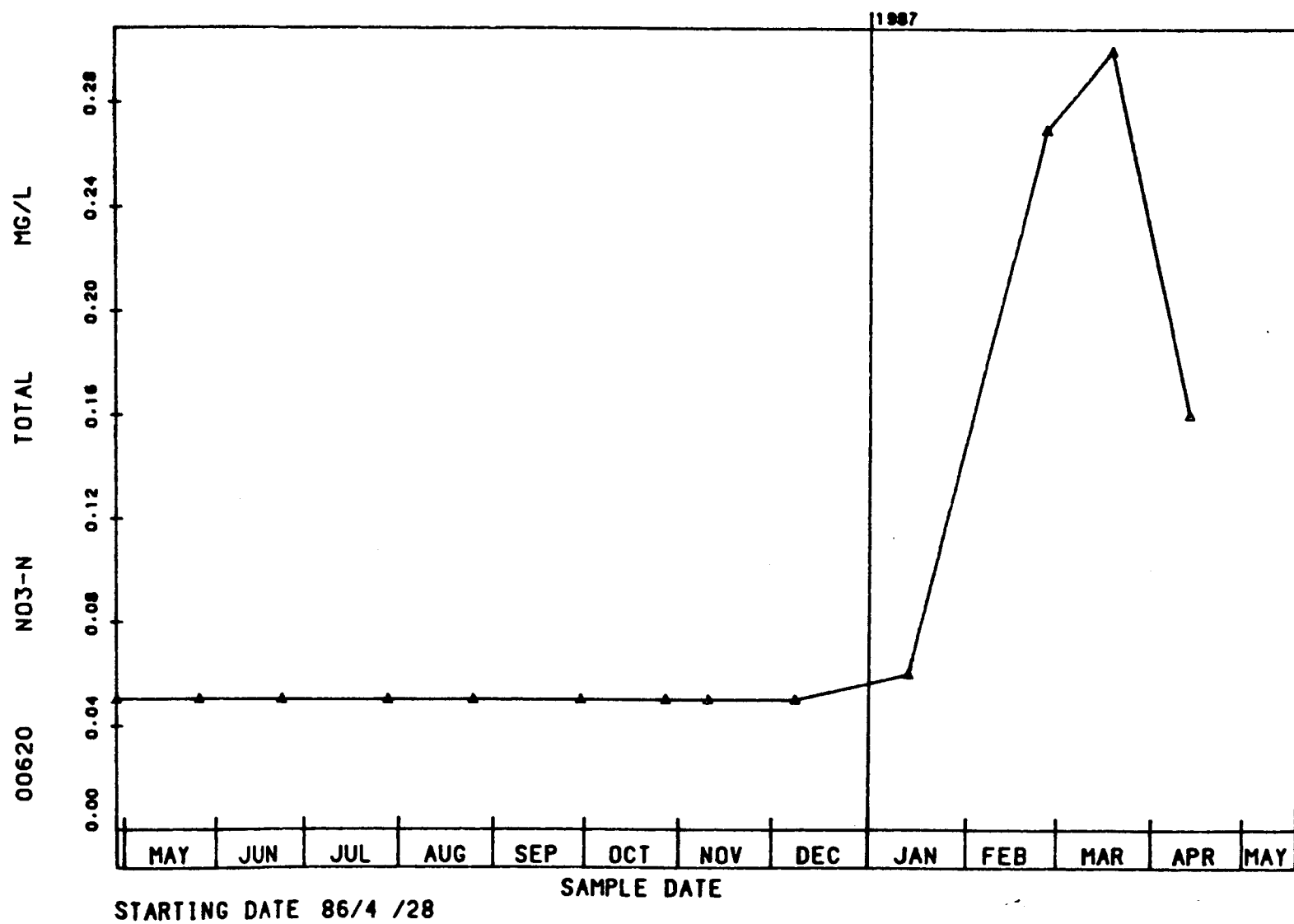


Figure 38. Monthly level of Nitrite as Nitrogen (mg/l) at Station 22, Back Bay from April, 1986 to March, 1987.

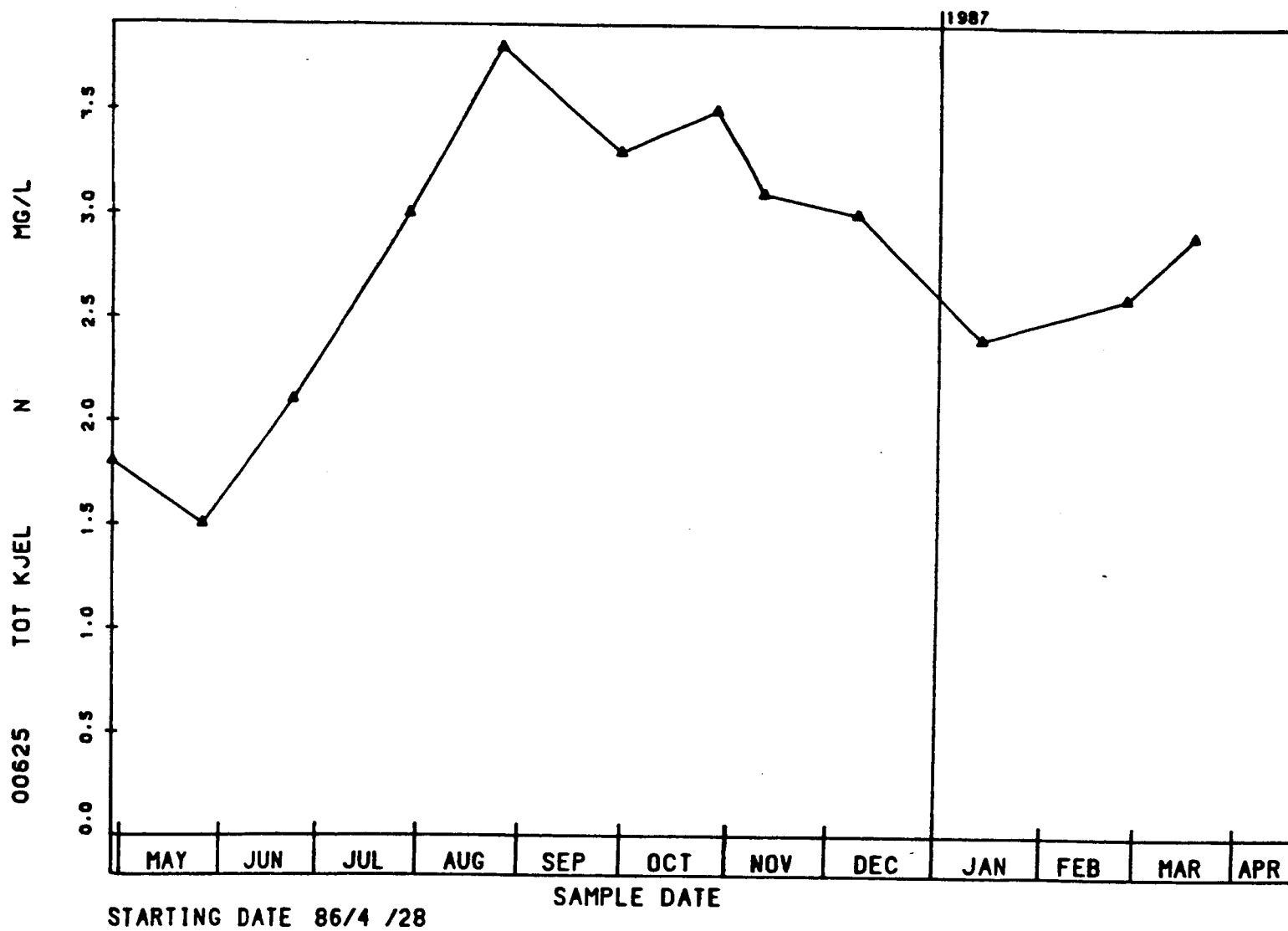


Figure 39. Monthly level of TKN (mg/l) at Station 3, Back Bay from April, 1986 to march, 1987.

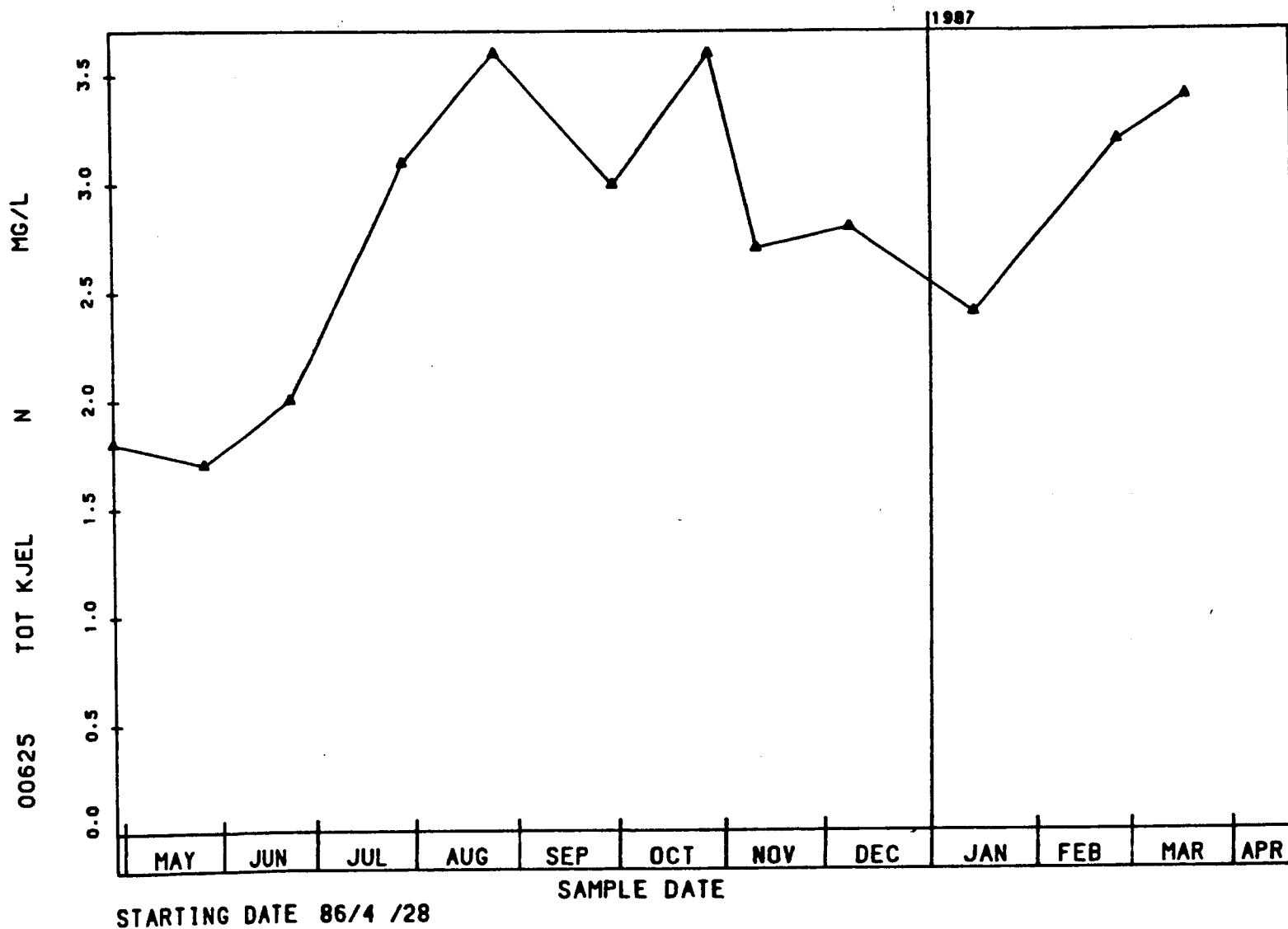


Figure 40. Monthly level of TKN (mg/l) at Station 5, Back Bay from April, 1986 to March, 1987.

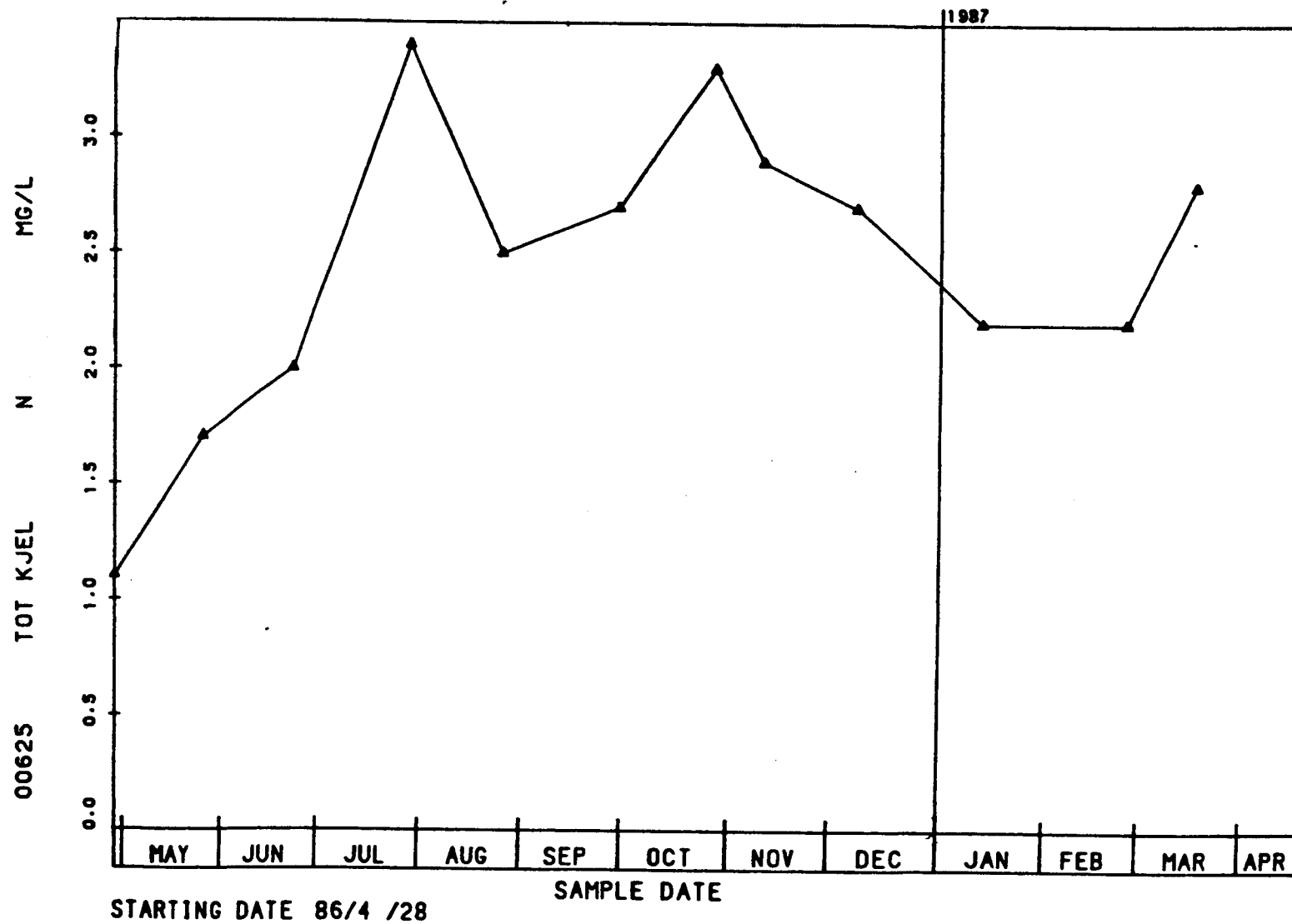


Figure 41. Monthly level of TKN (mg/l) at Station 9, Back Bay from April, 1986 to March, 1987.

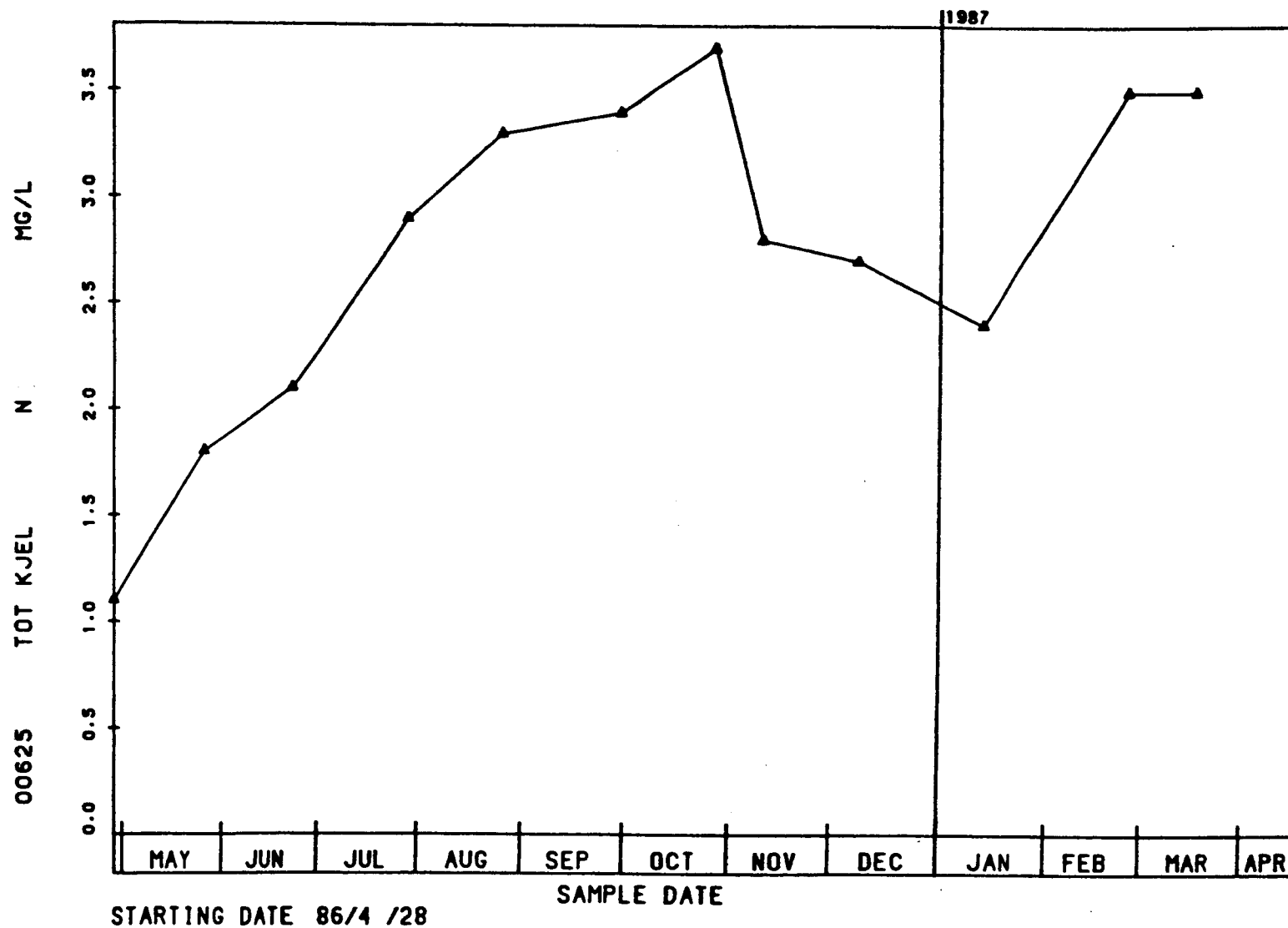


Figure 42. Monthly level of TKN (mg/l) at Station 14, Back Bay from April, 1986 to March, 1987.

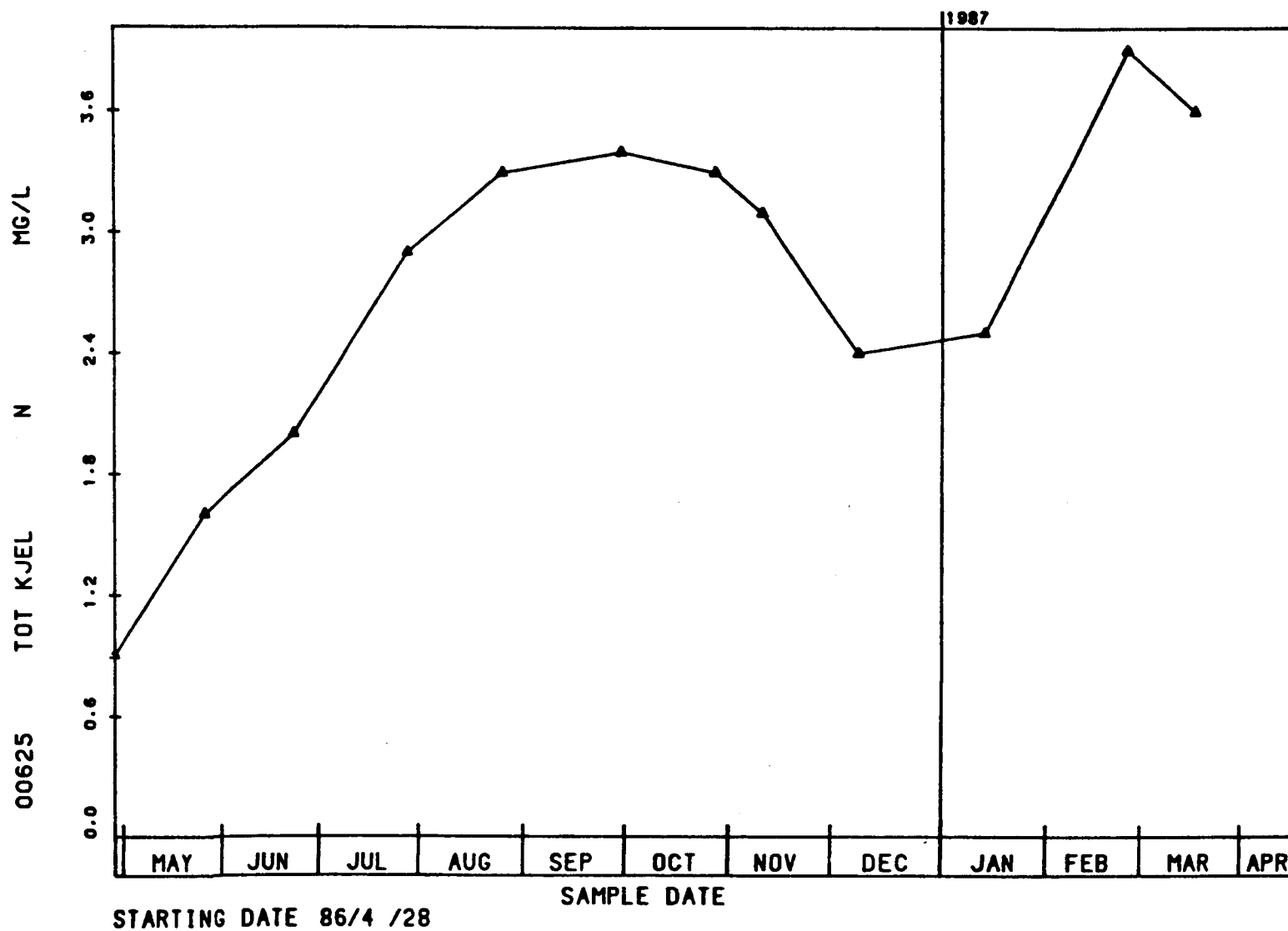


Figure 43. Monthly level of TKN (mg/l) at Station 20, Back Bay from April, 1986 to March, 1987.

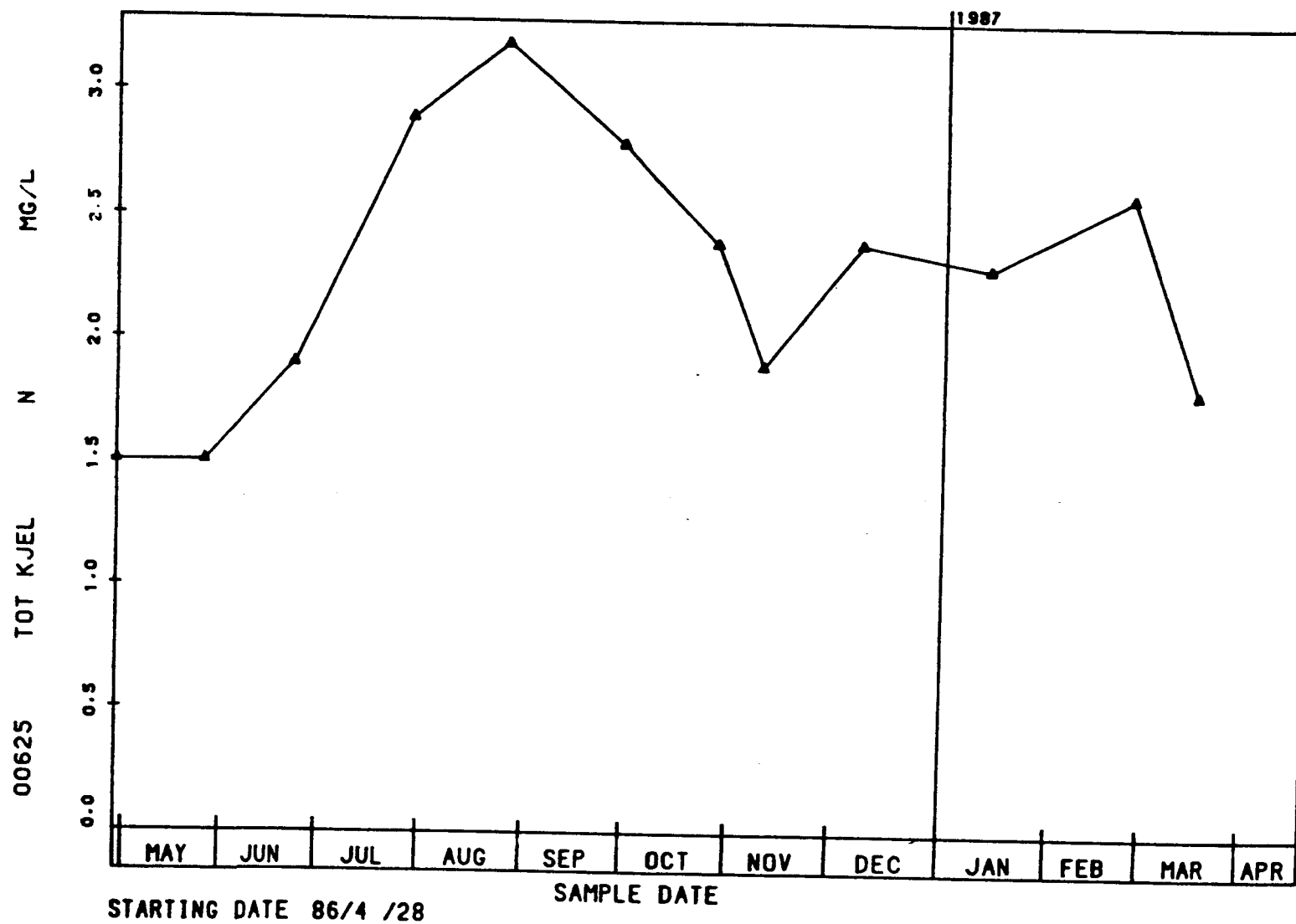


Figure 44. Monthly level of TKN (mg/l) at Station 22, Back Bay from April, 1986 to March, 1987.



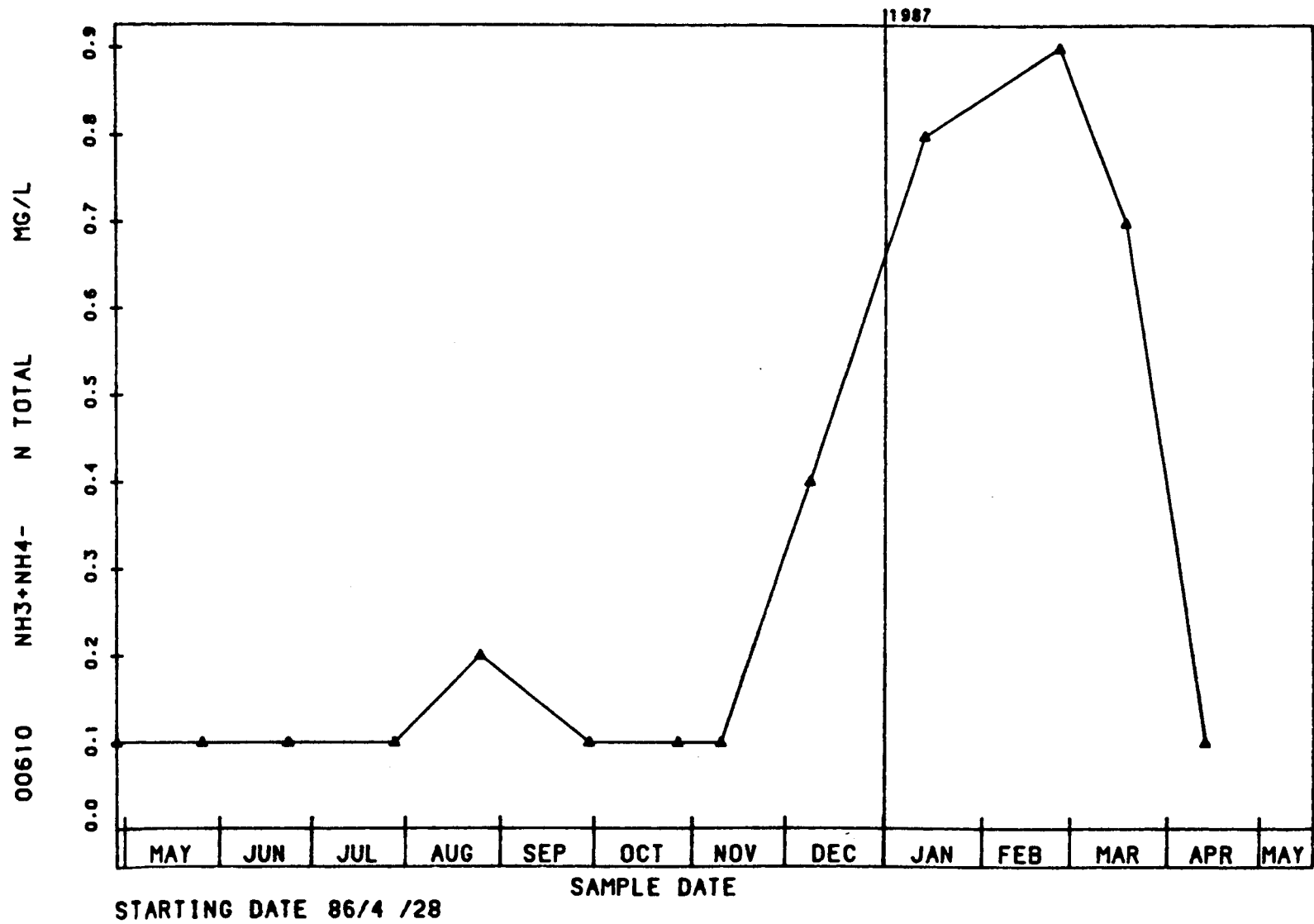


Figure 45. Monthly level of Ammonia as Nitrogen (mg/l) at Station 3, Back Bay from April, 1986 to March 1987.

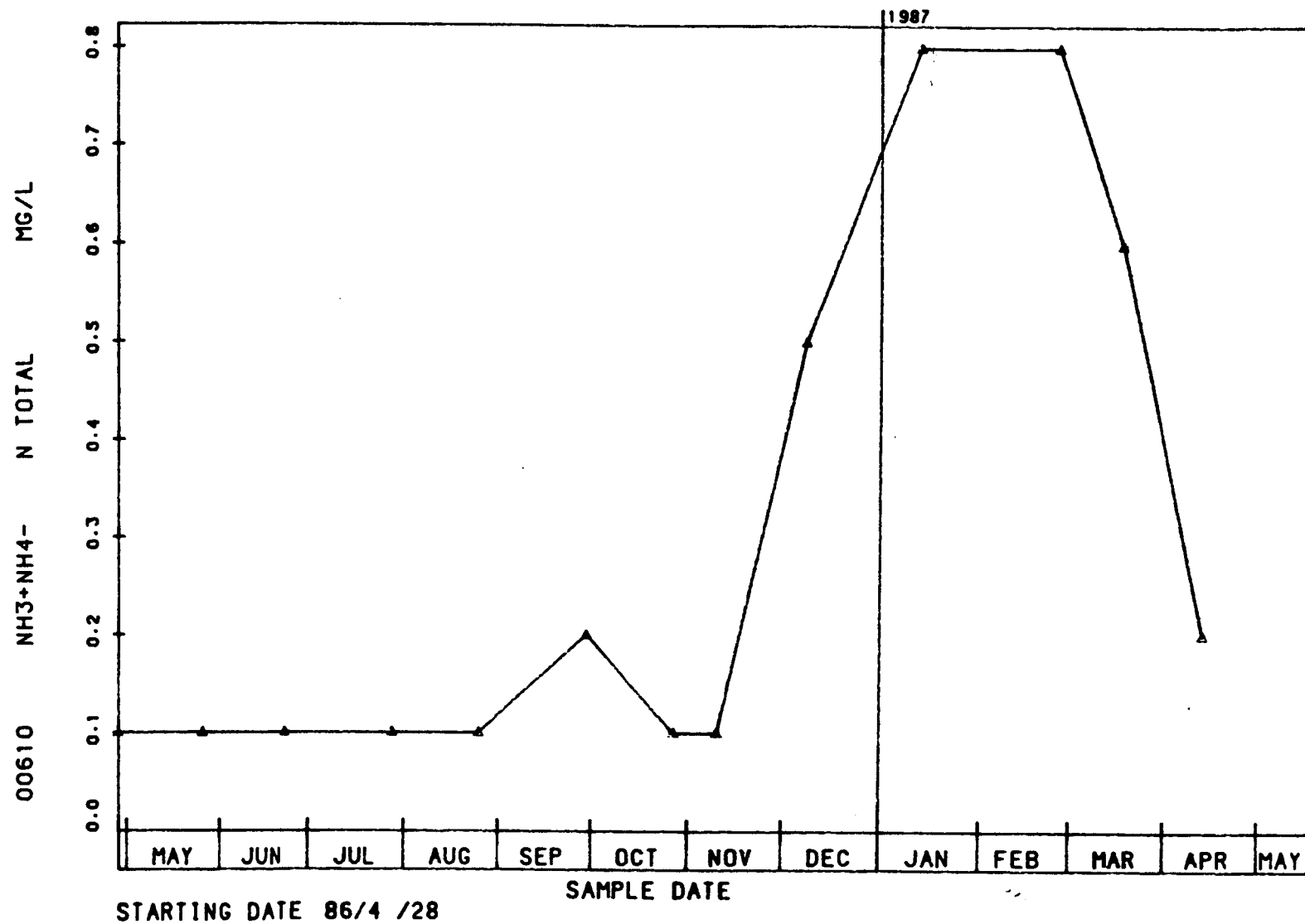


Figure 46. Monthly level of Ammonia as Nitrogen (mg/l) at Station 5, Back Bay from April, 1986 to March, 1987.

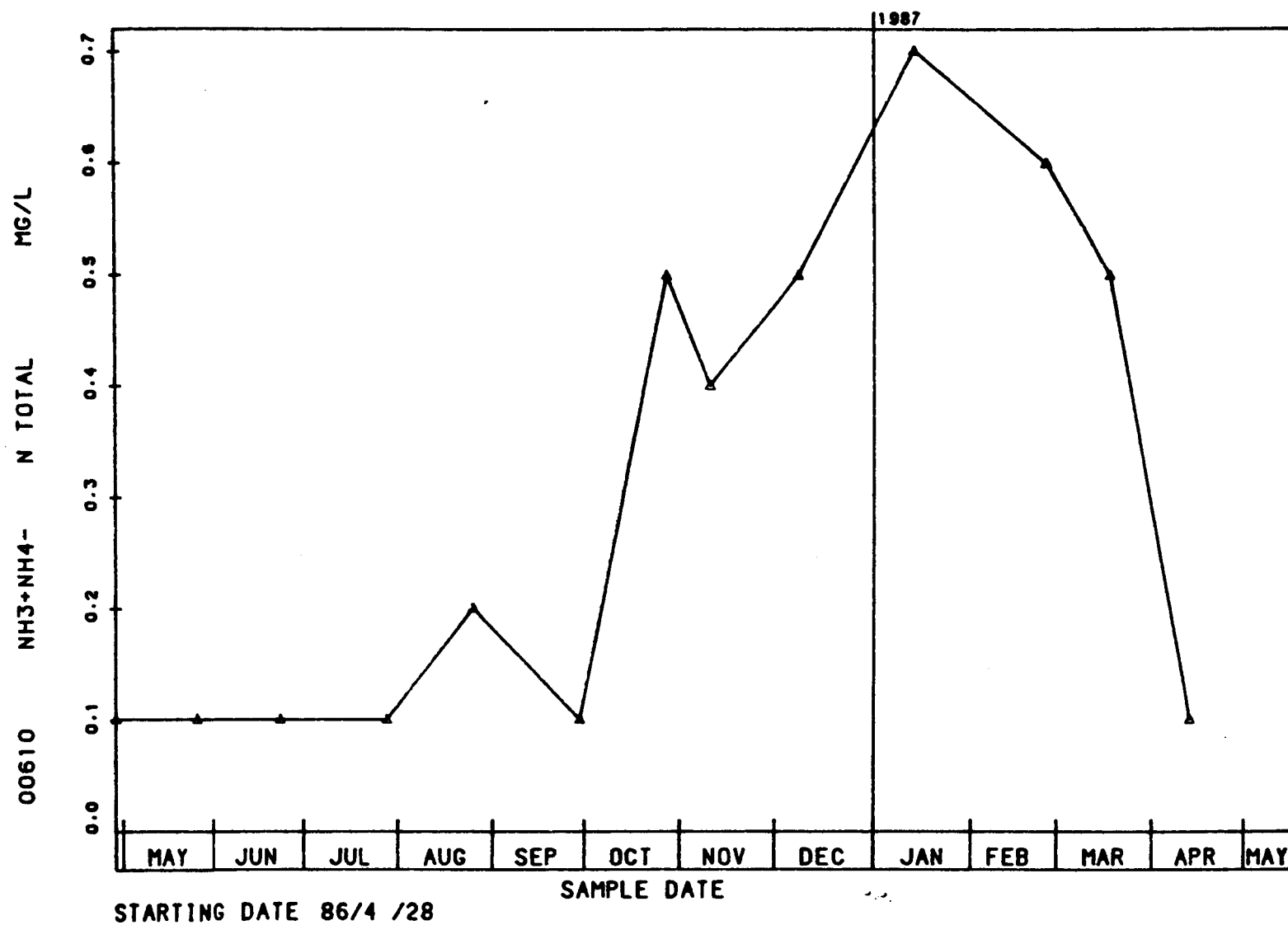


Figure 47. Monthly level of Ammonia as Nitrogen (mg/l) at Station 9, Back Bay from April, 1986 to March, 1987.

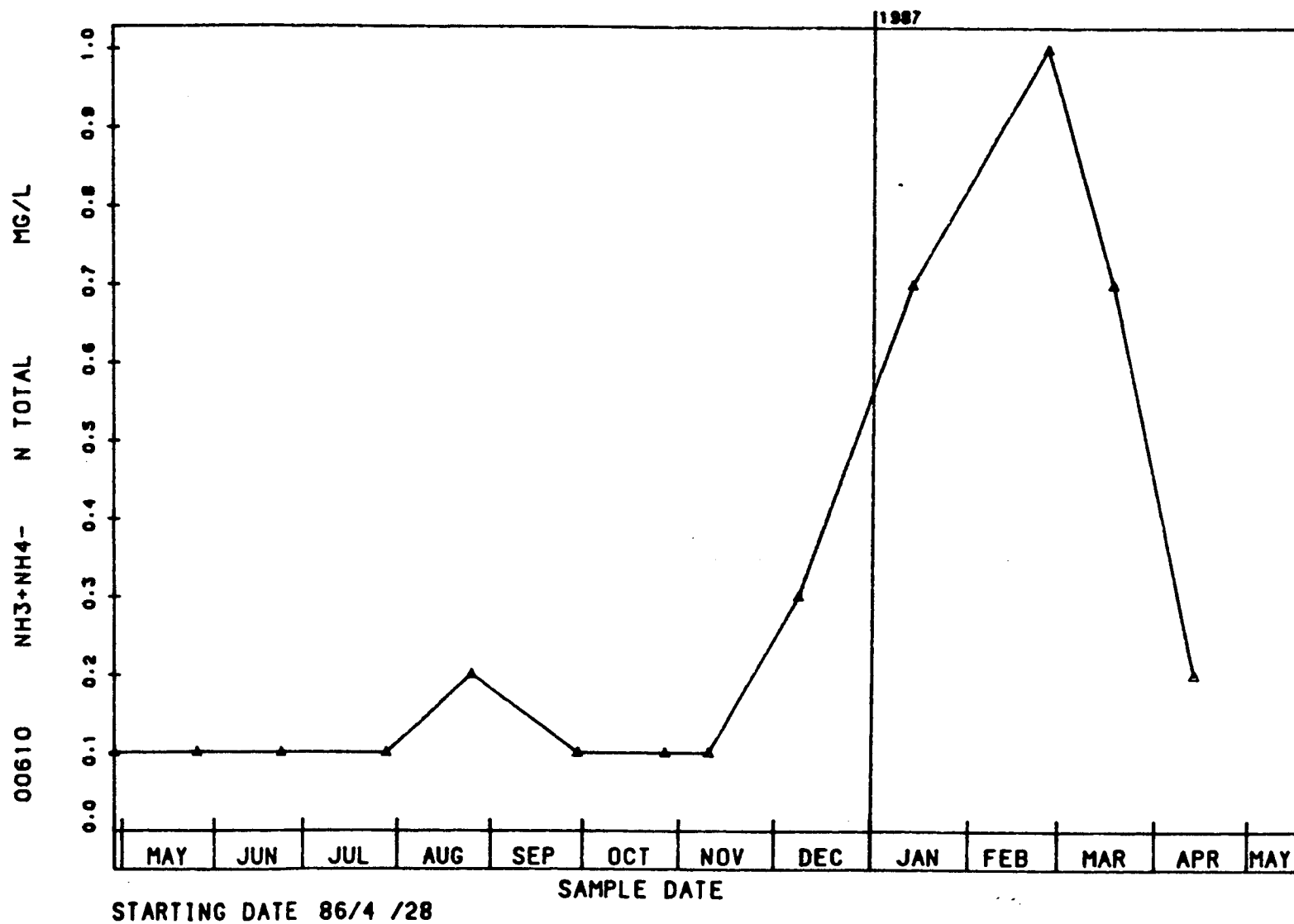


Figure 48. Monthly level of Ammonia as Nitrogen (mg/l) at Station 14, Back Bay from April, 1986 to March, 1987.

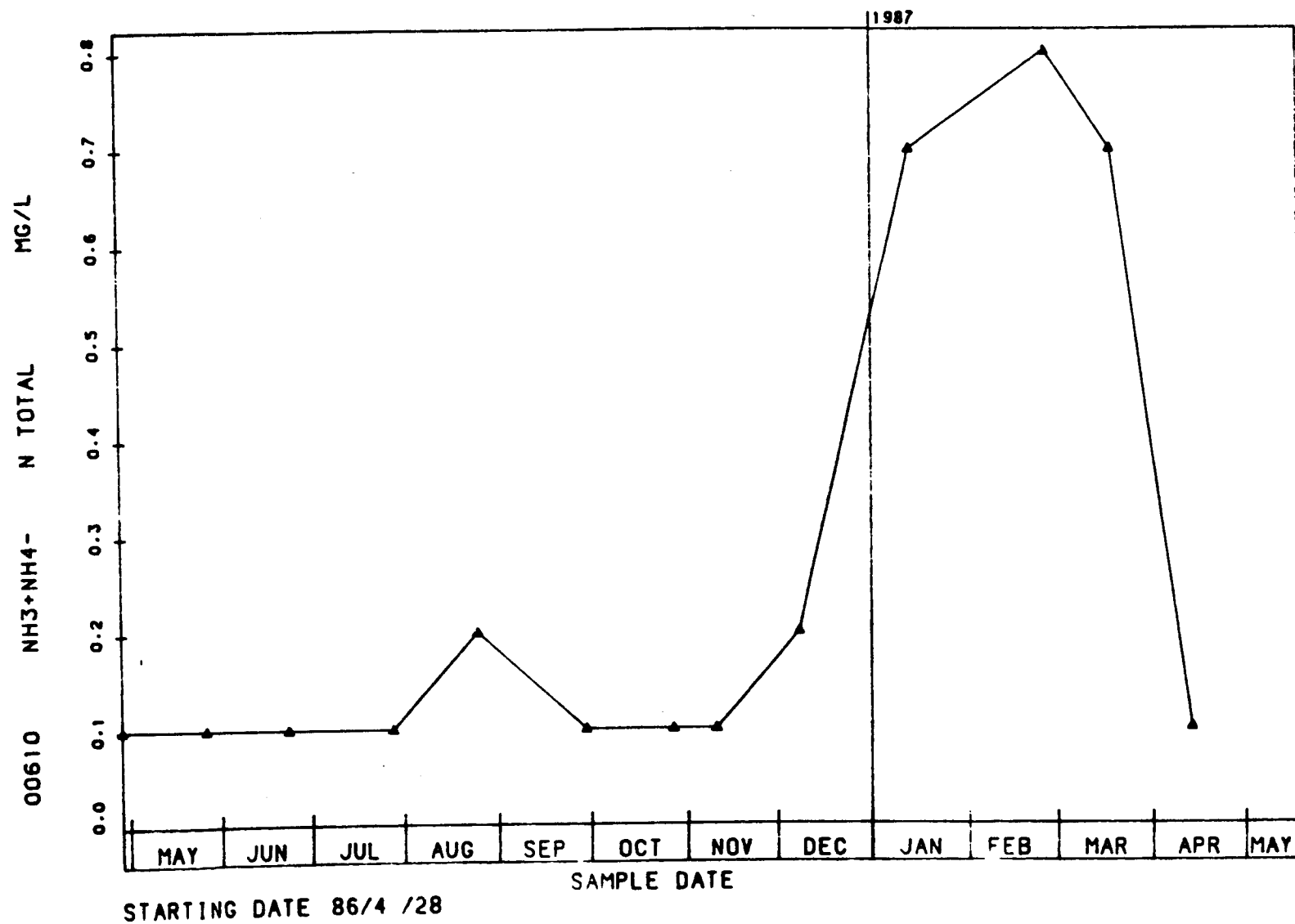


Figure 49. Monthly level of Ammonia as Nitrogen (mg/l) at Station 20, Back Bay from April, 1986 to March, 1987.

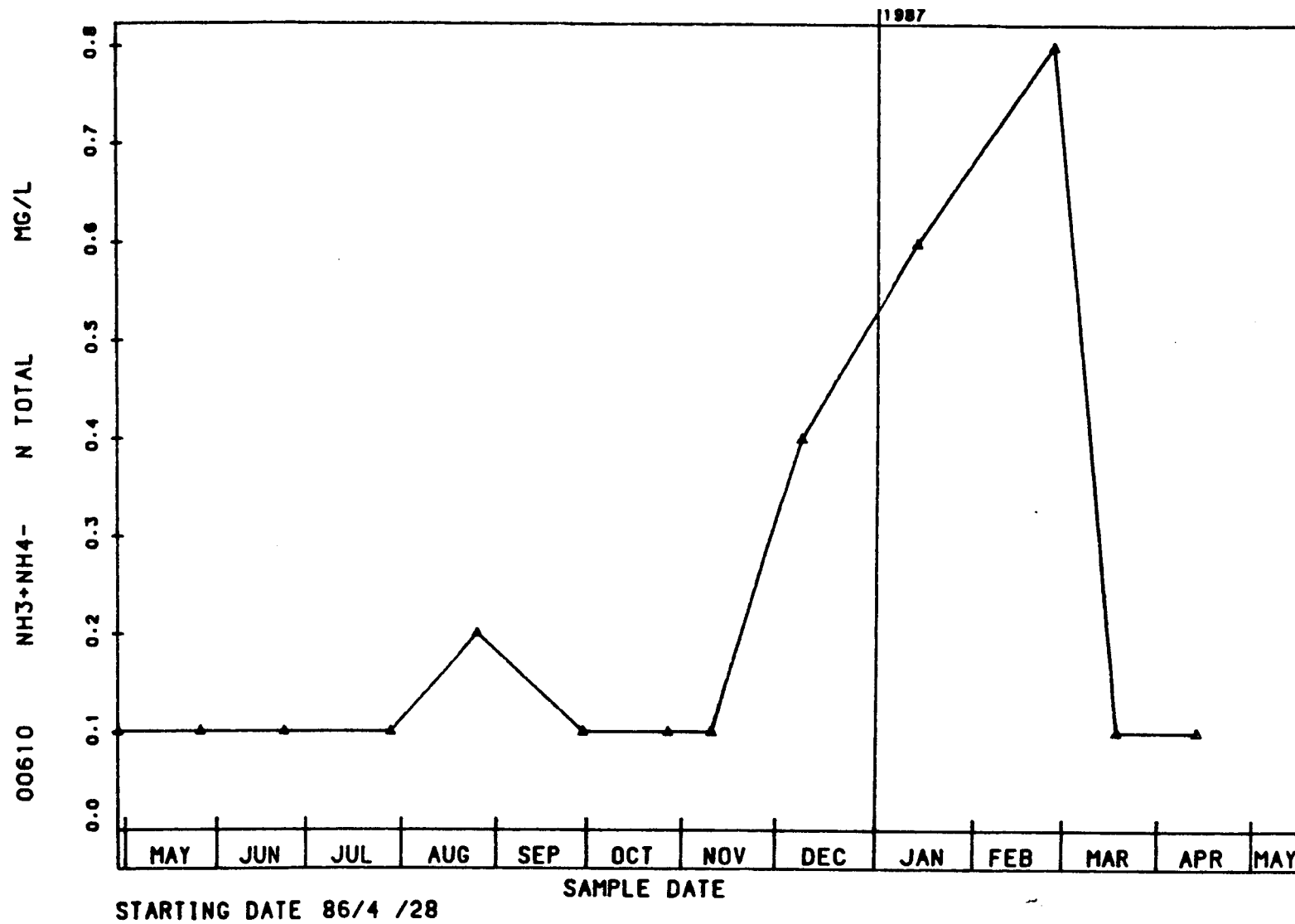


Figure 50. Monthly level of Ammonia as Nitrogen (mg/l) at Station 22, Back Bay from April, 1986 to March 1987.

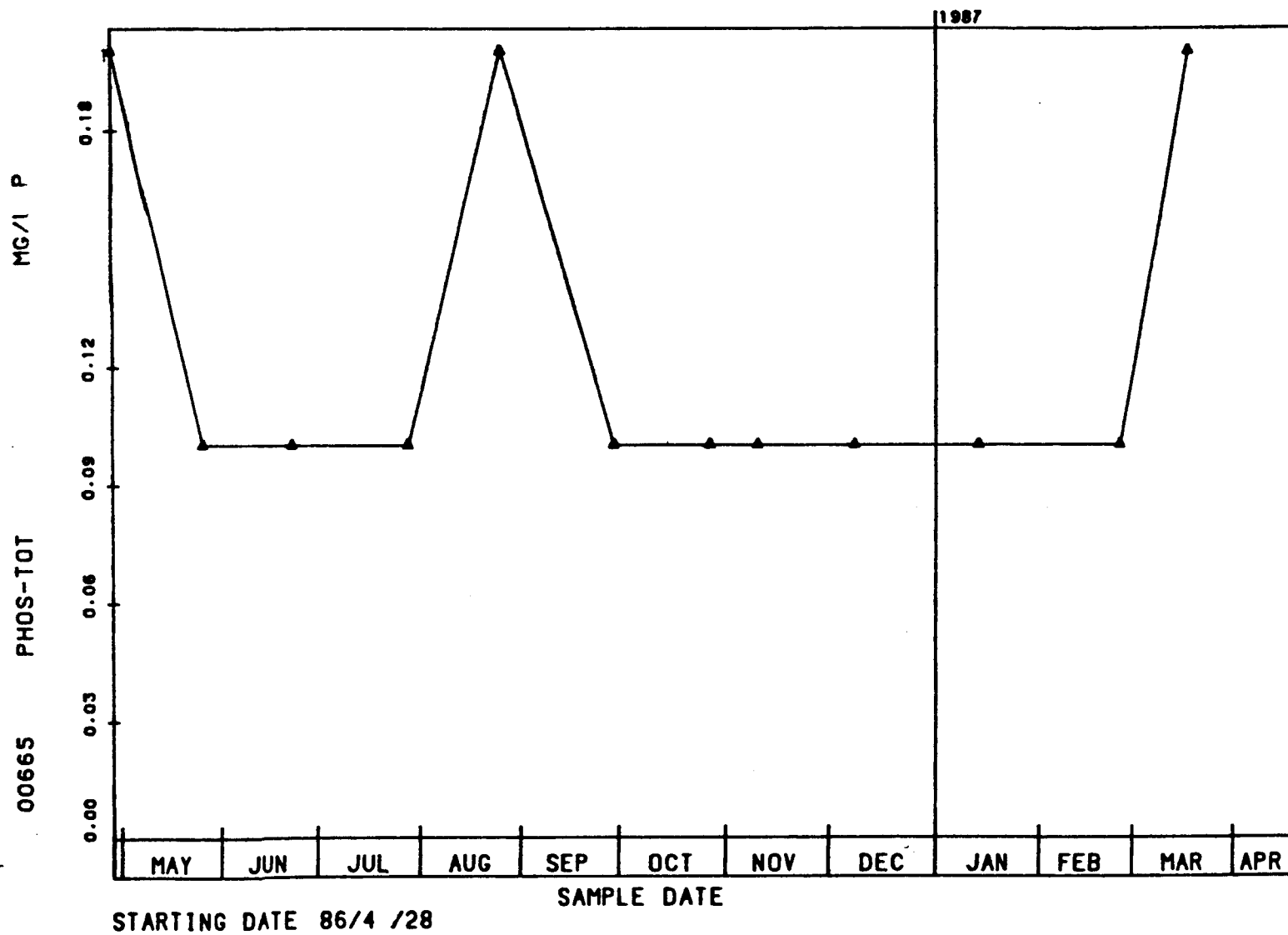


Figure 51. Monthly level of Total Phosphorus as P (mg/l) at Station 3, Back Bay from April, 1986 to March, 1987.

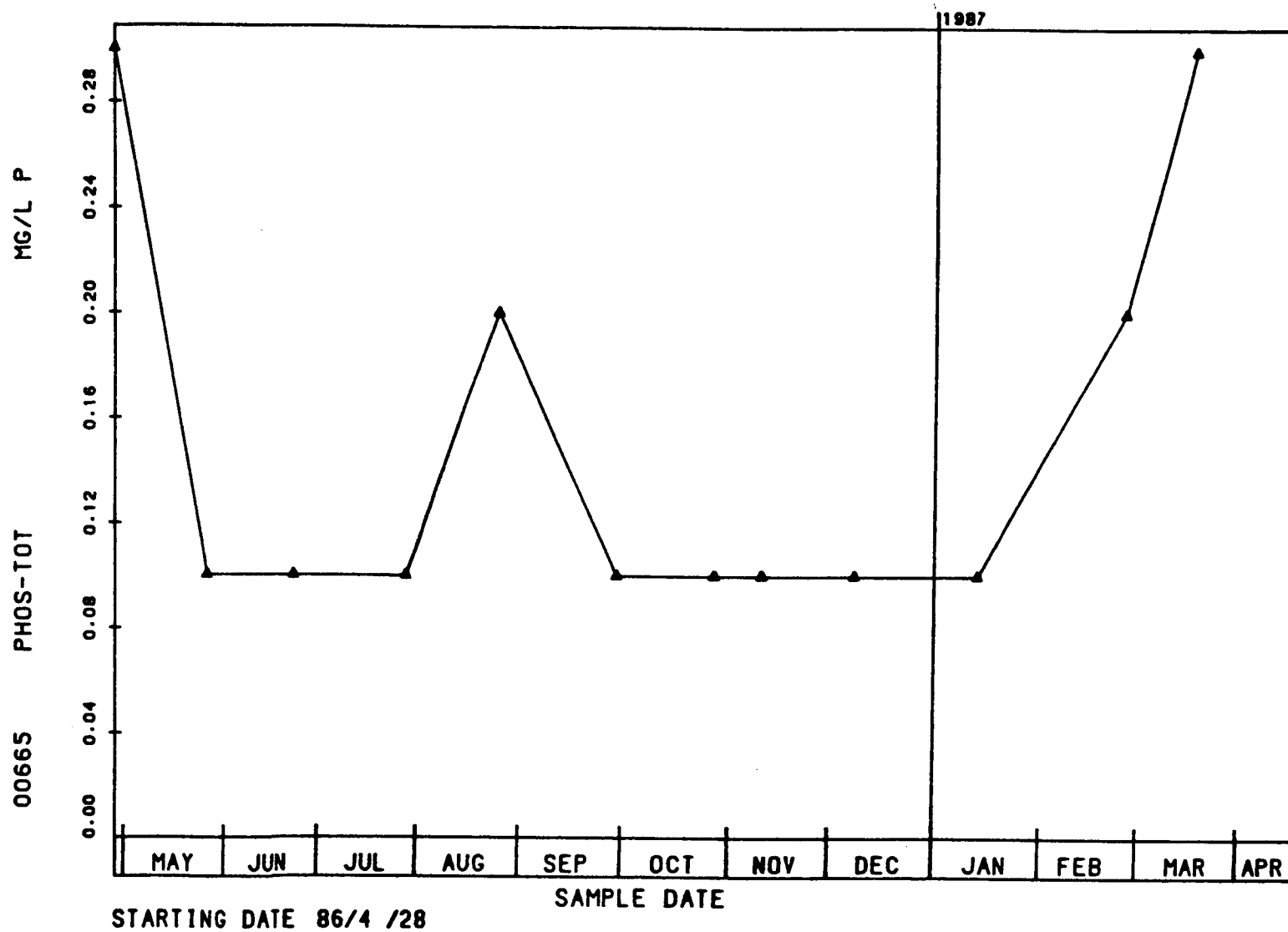


Figure 52. Monthly level of Total Phosphorus as P (mg/l) at Station 5, Back Bay from April, 1986 to March, 1987.



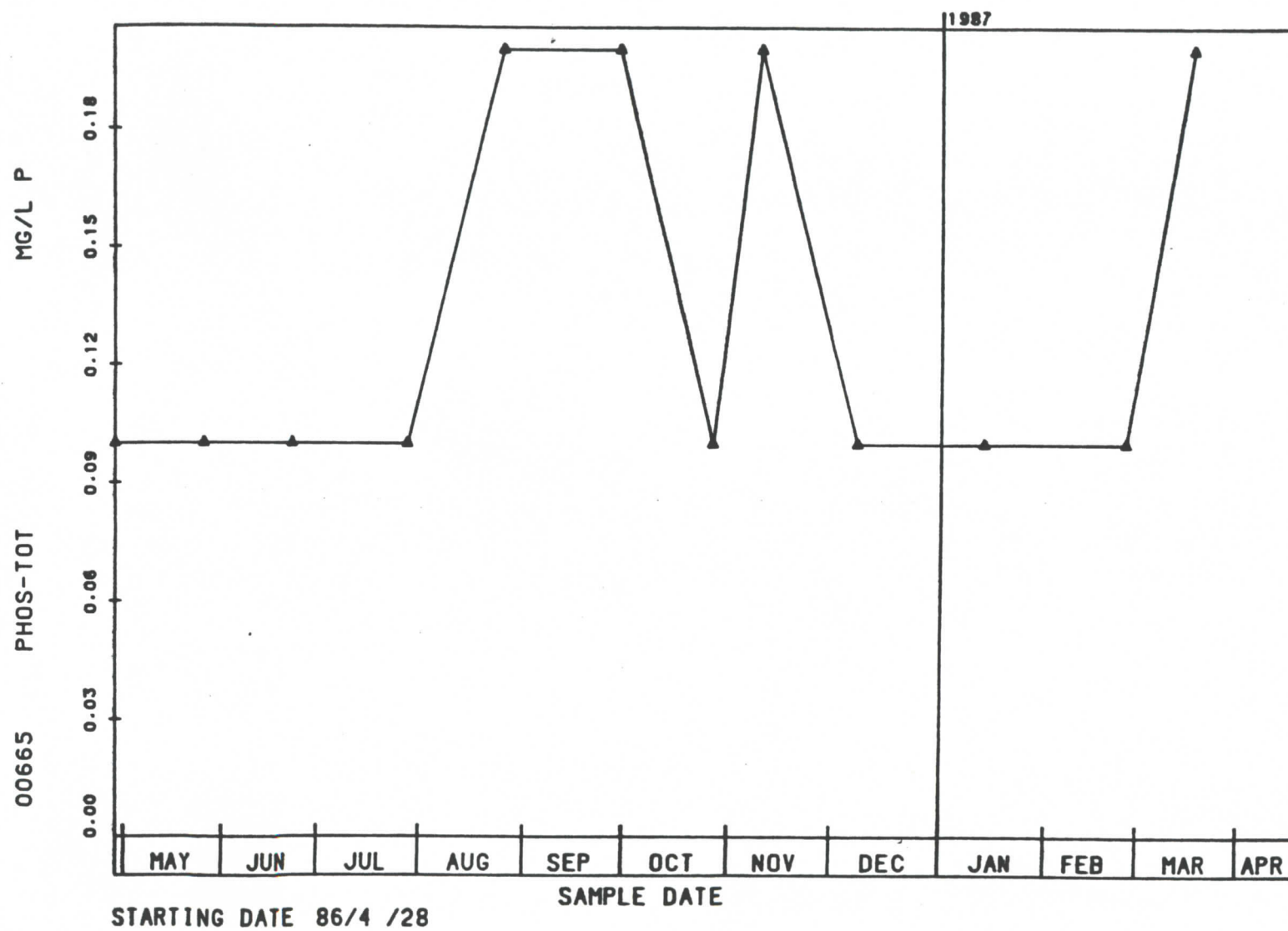


Figure 53. Monthly level of Total Phosphorus as P (mg/l) at Station 9, Back Bay from April, 1986 to March, 1987.

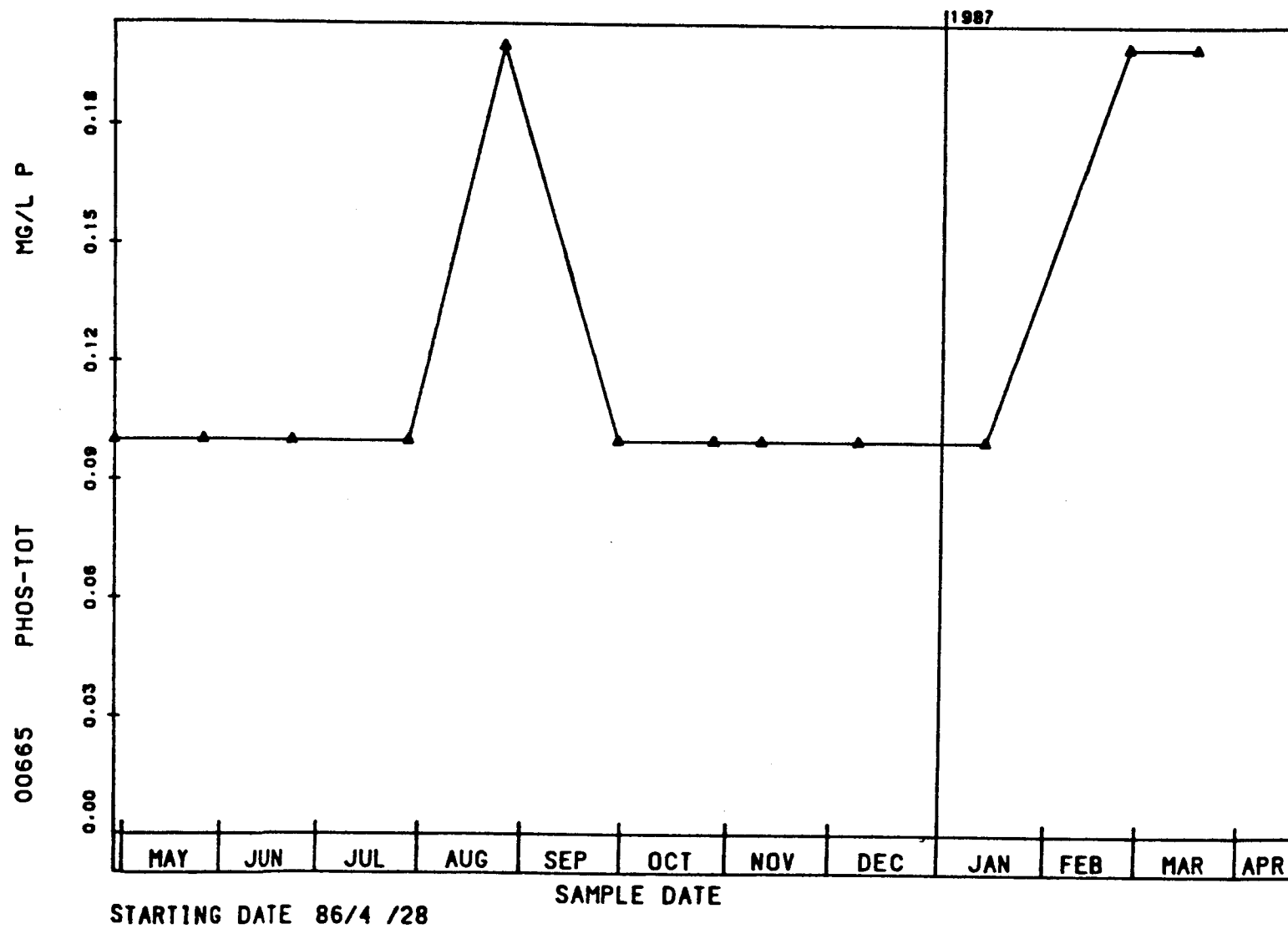


Figure 54. Monthly level of Total Phosphorus as P (mg/l) at Station 14, Back Bay from April, 1986 to March, 1987.

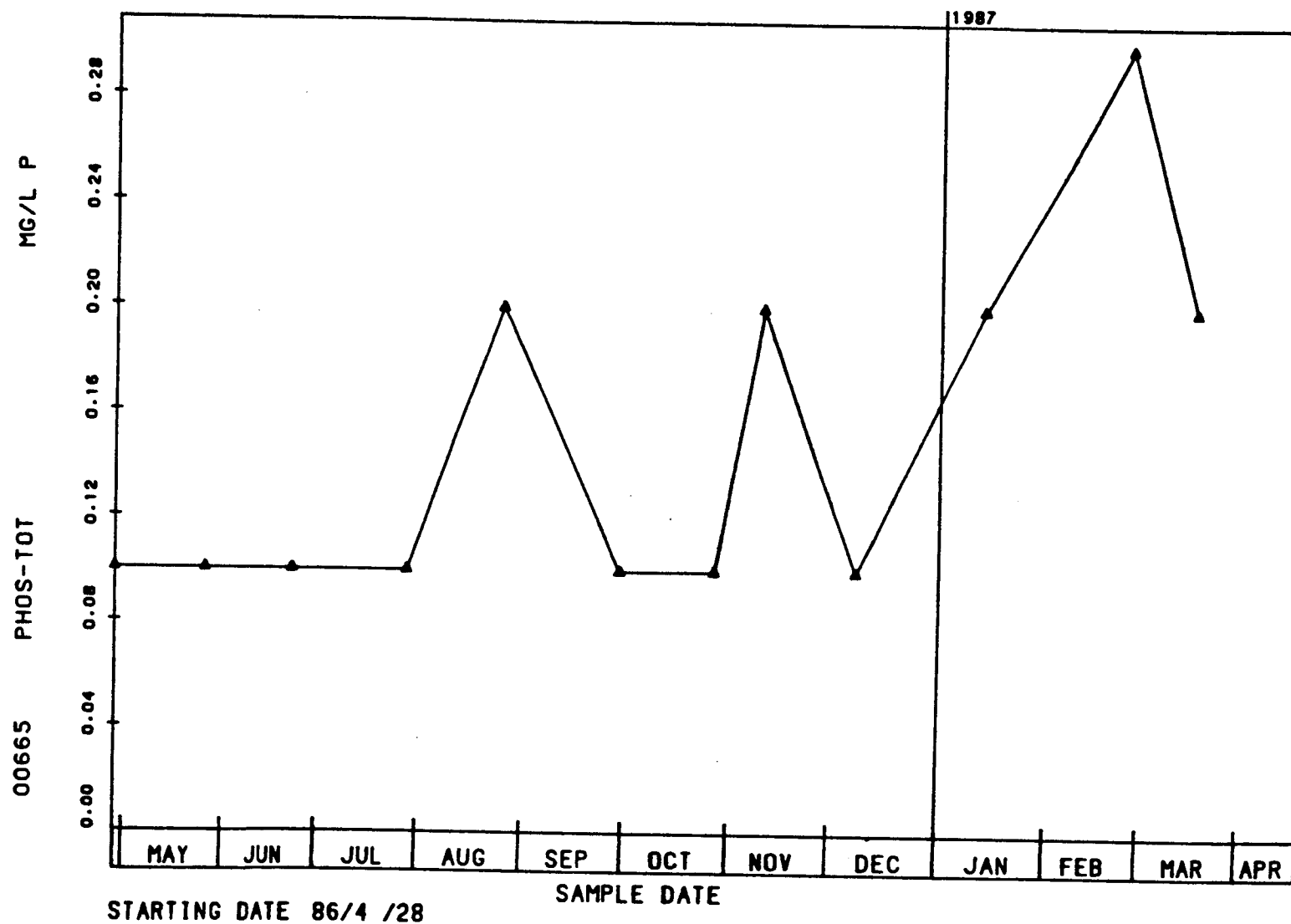


Figure 55. Monthly level of Total Phosphorus as P (mg/l) at Station 20, Back Bay from April, 1986 to March, 1987.

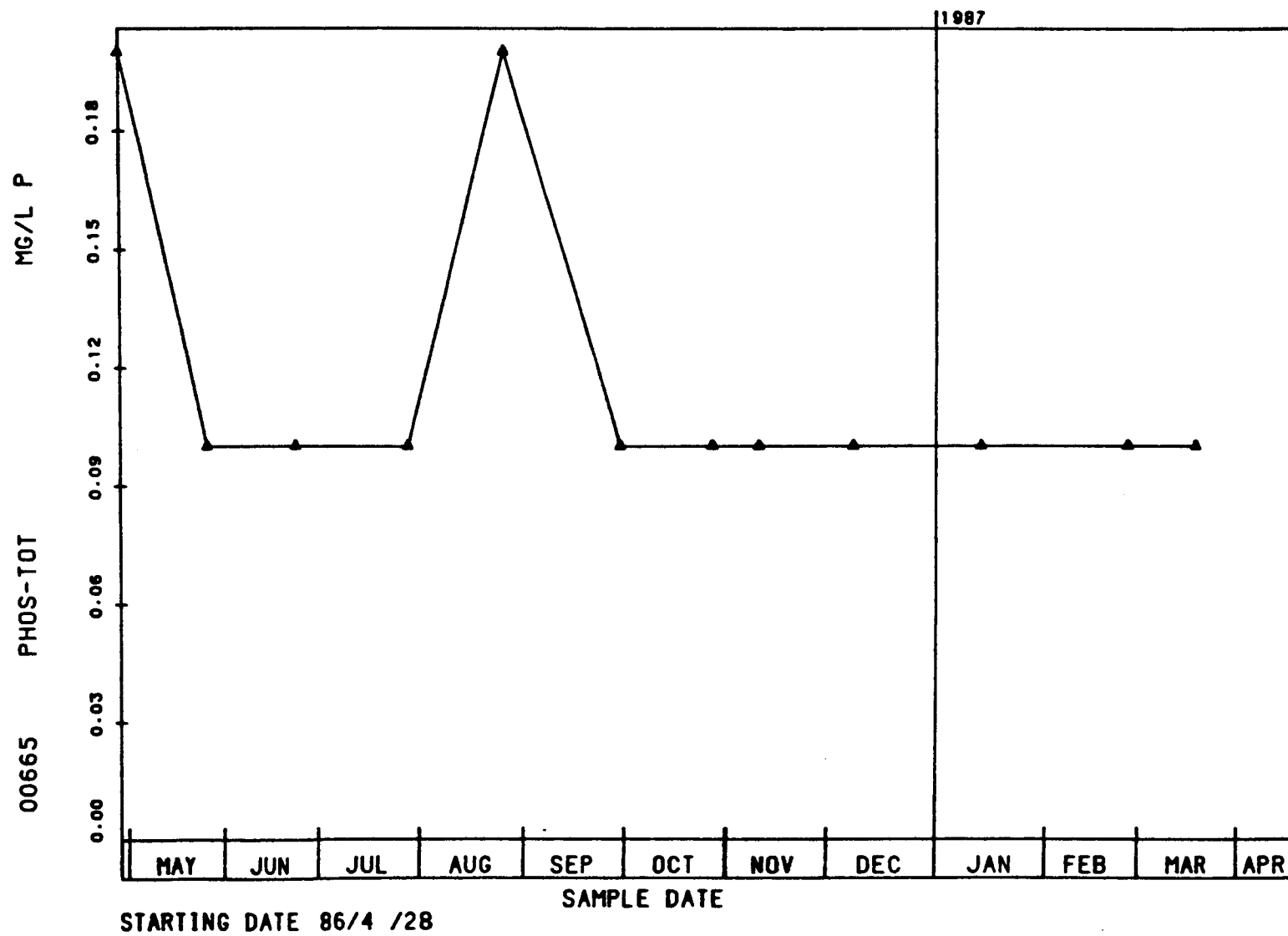


Figure 56. Monthly level of Total Phosphorus as P (mg/l) at Station 22, Back Bay from April, 1986 to March 1987.

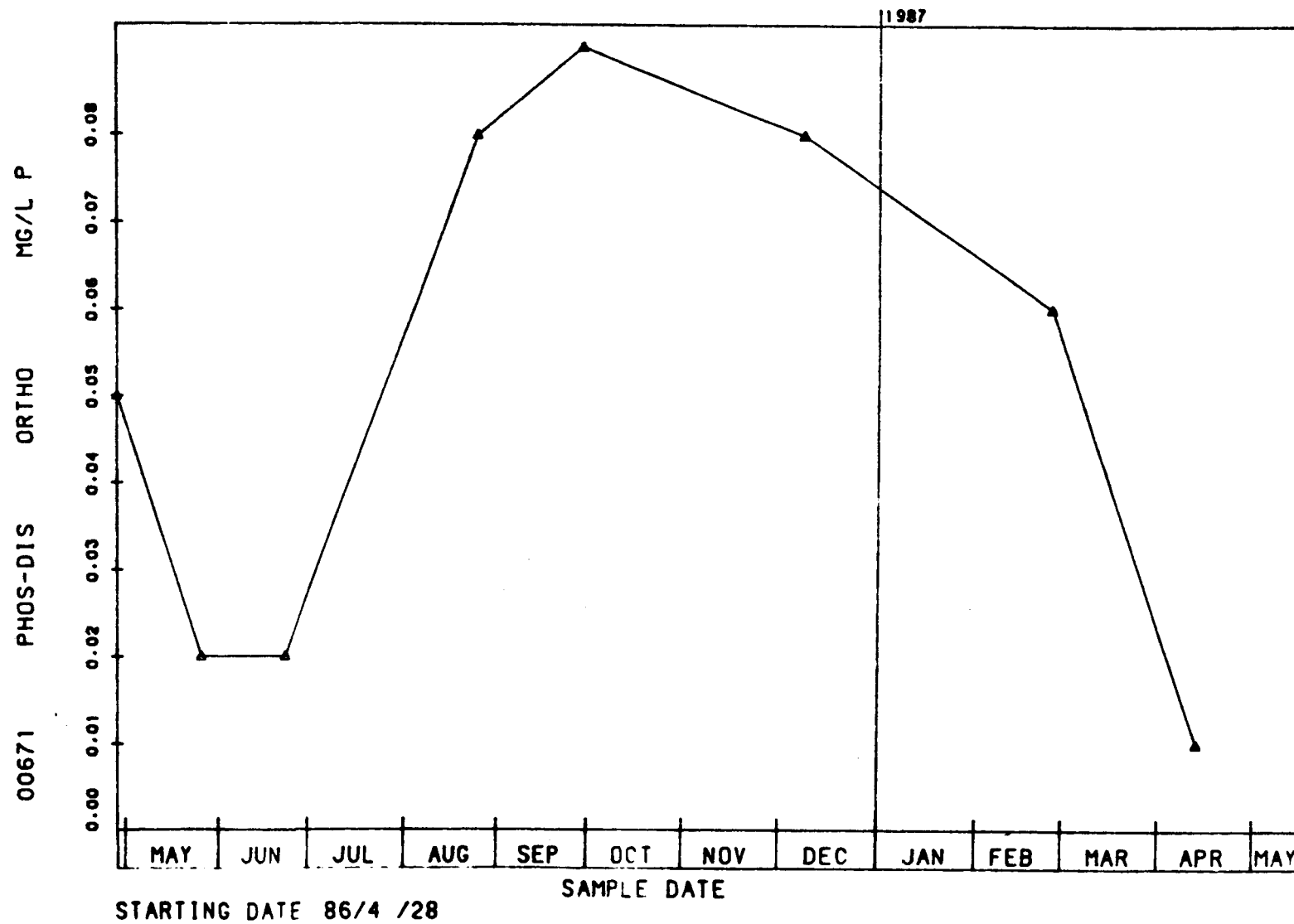


Figure 57. Monthly level of Ortho Phosphorus as P (mg/l) at Station 3, Back Bay from April, 1986 to March, 1987.

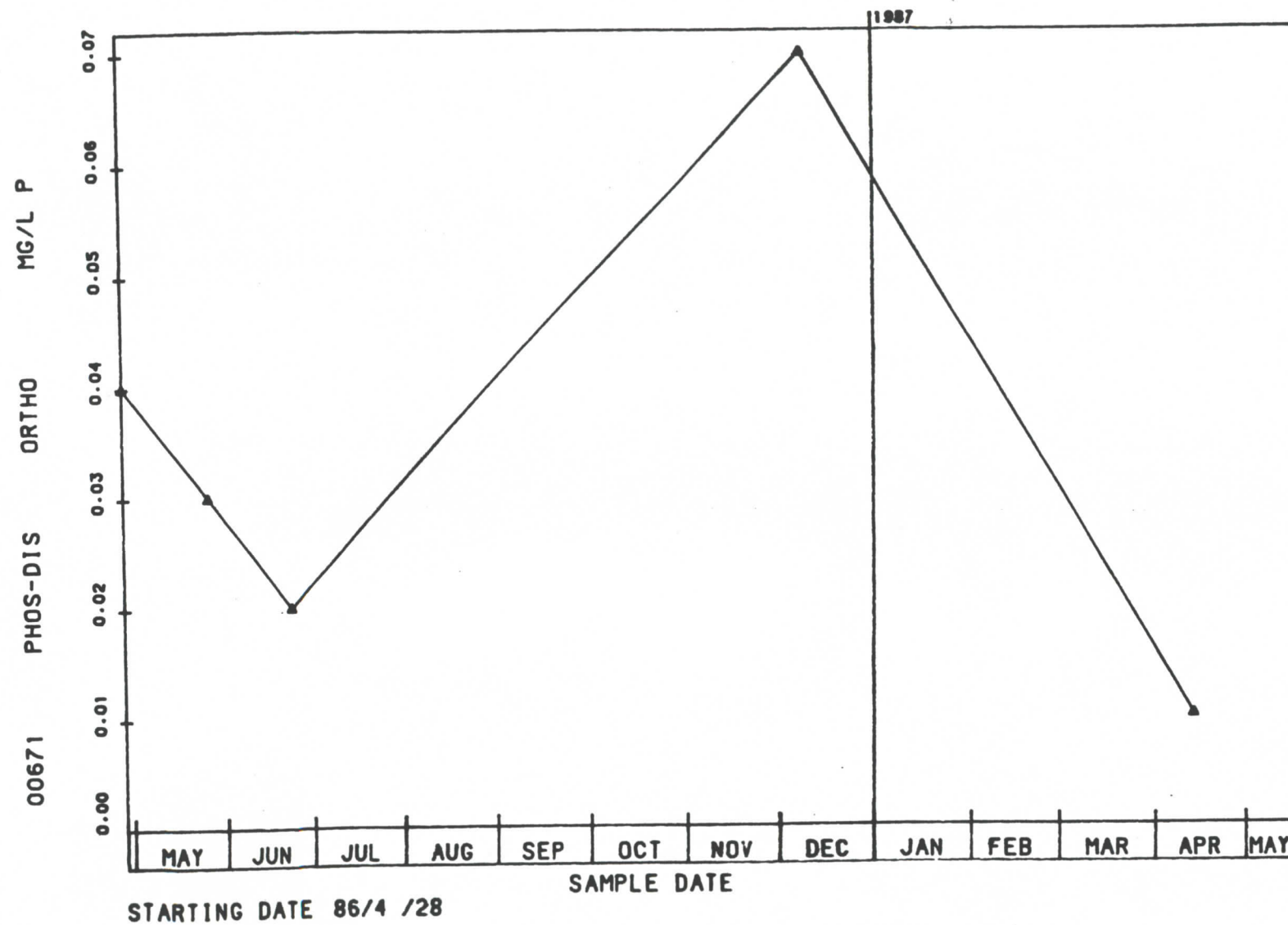


Figure 58. Monthly level of Ortho Phosphorus as P (mg/l) at Station 5, Back Bay from April, 1986 to March, 1987.

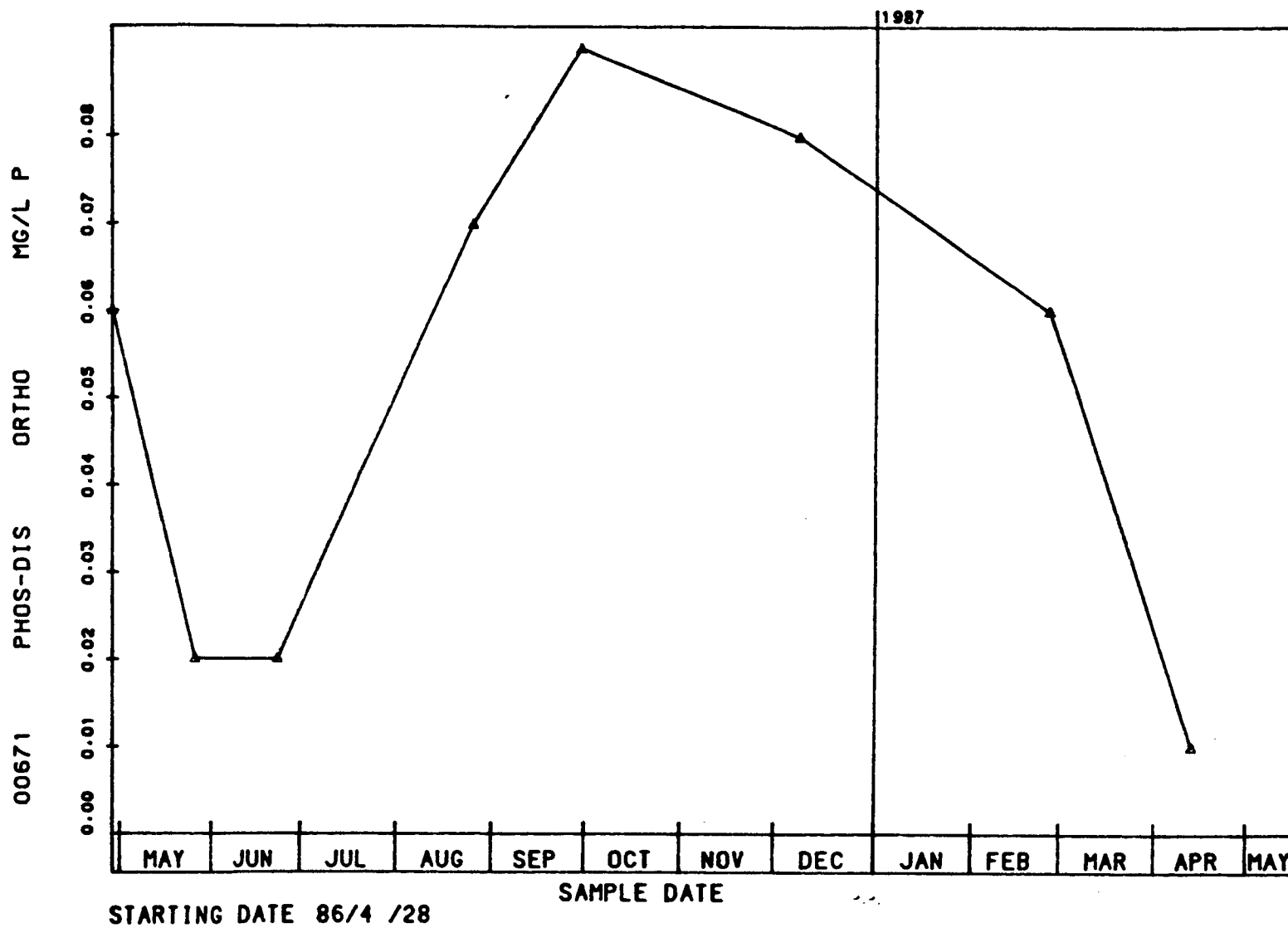


Figure 59. Monthly level of Ortho Phosphorus as P (mg/l) at Station 9, Back Bay from April, 1986 to March, 1987.

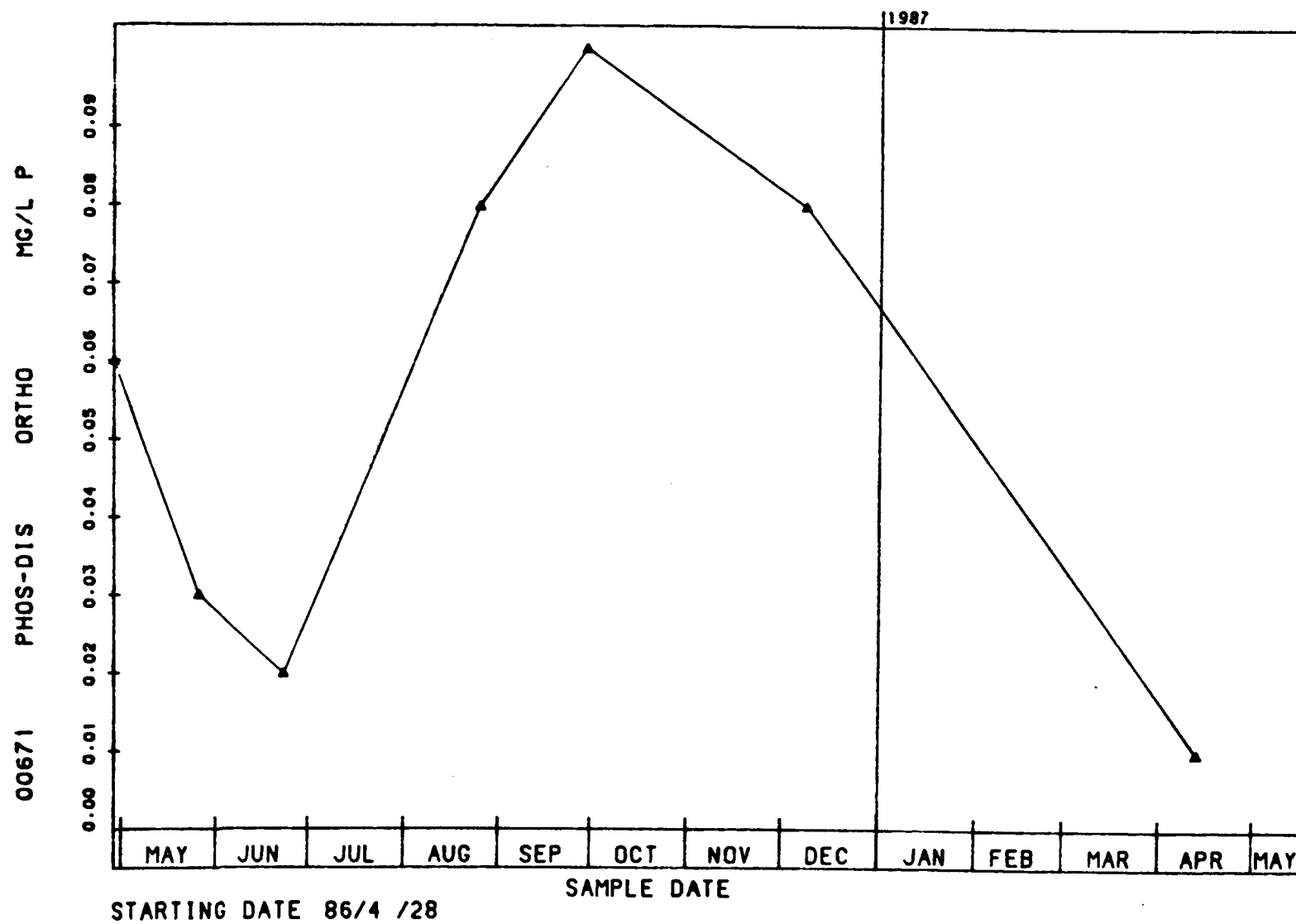


Figure 60. Monthly level of Ortho Phosphorus as P (mg/l) at Station 14, Back Bay from April, 1986 to March, 1987.



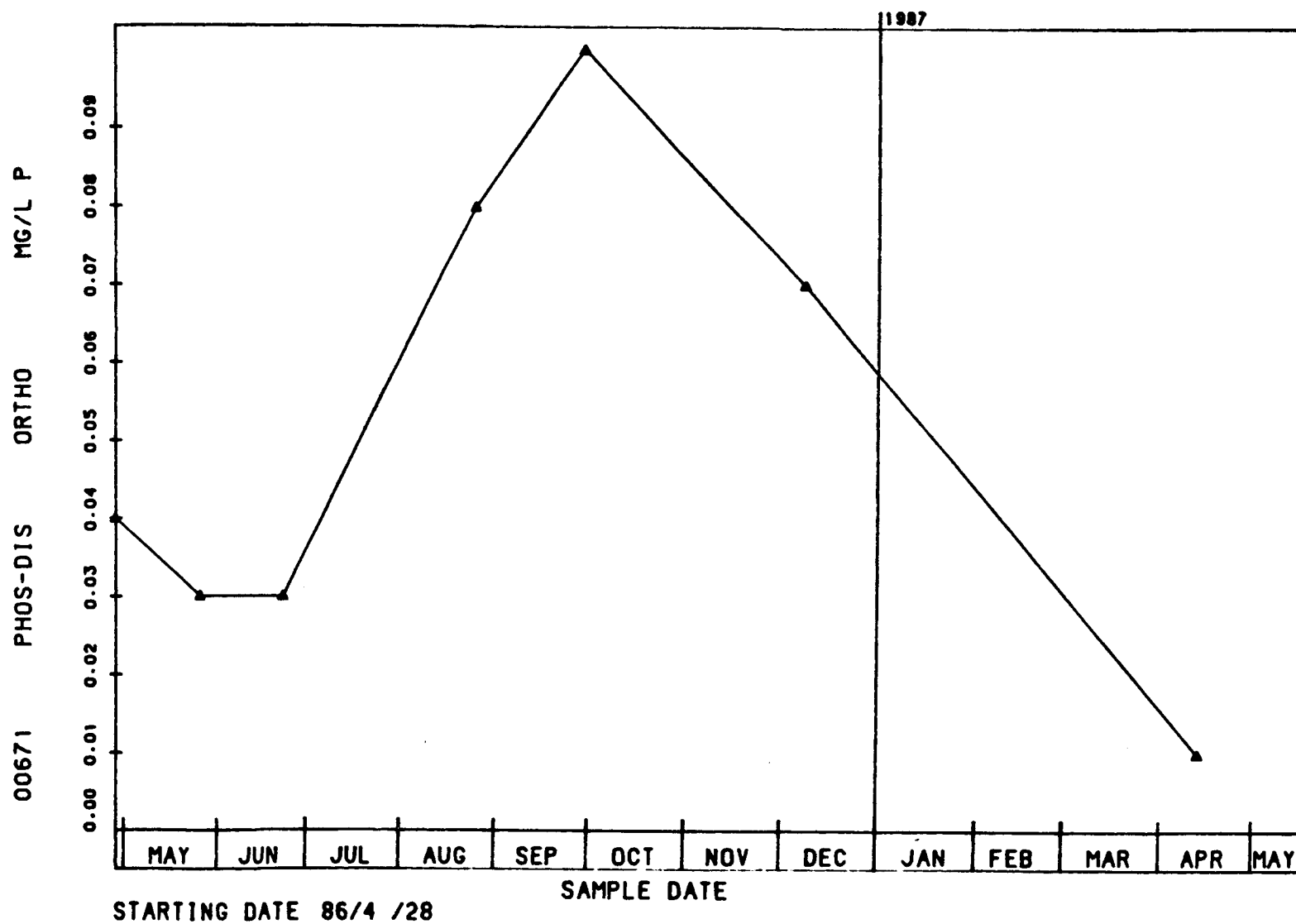


Figure 61. Monthly level of Ortho Phosphorus as P (mg/l) at Station 20, Back Bay from April, 1986 to March 1987.

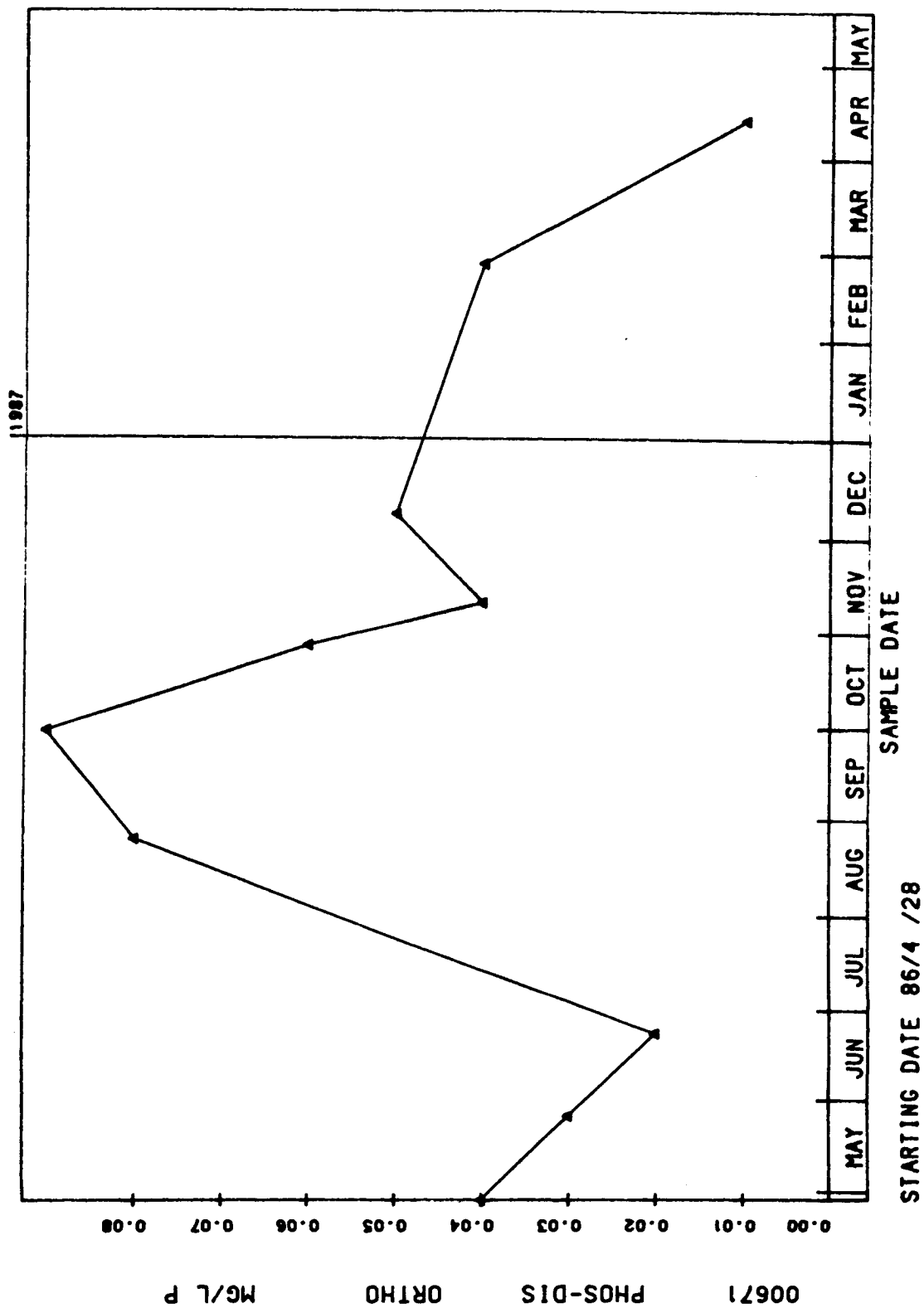


Figure 62. Monthly level of Ortho Phosphorus as P (mg/l) at Station 22, Back Bay from April, 1986 to March, 1987.