Branch Control No. ECD-167B

This manuscript has been submitted to
NWRI Publication
and the contents are subject to change.
This copy is to provide information
prior to publication.

THE INFLUENCE OF THE GRAND RIVER ON EASTERN LAKE ERIE CLADOPHORA

D.S. Painter and K.J.McCabe

NWRI Contribution No. 87-74

Lakes Research Branch
National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario, Canada L7R 4A6

. Environment Canada

The Influence of the Grand River on Eastern Lake Erie Cladophora

D.S. Painter and K.J. McCabe

National Water Research Institute
Environment Canada
Burlington Ontario

May 26, 1987

Management Perspective

Cladophora problems on the Canadian shoreline of the eastern portion of Lake Erie were insignificant in 1985. Previous studies in the early 60's indicated that this area experienced excessive growths and shoreline accumulations. Internal phosphorus concentrations of the scarce 1985 *Cladophora* biomass were growth-limiting.

The Grand River plume influenced a zone that extended only 2 kilometers from the river mouth. *Cladophora* internal phosphorus was not a function of the Grand River inflow beyond the 2 kilometer zone and *Cladophora* abundance appeared to be influenced by local shoreline inputs and activities.

L'influence de la rivière Grand sur les *Cladophora* dans l'est du lac Érié

D.S. Painter et K.J. McCabe

Institut national de recherche sur les eaux
Environnement Canada
Burlington (Ontario)

26 mai 1987

Perspective-gestion

En 1985, les *Cladophora* n'ont pas vraiment causé de problème dans les eaux littorales canadiennes de l'est du lac Érié. Les études réalisées au début des années soixante avaient révélé que dans ce secteur les algues étaient trop abondantes et qu'il s'en accumulait le long du littoral. En 1985, comme la concentration de phosphore dans la biomasse de *Cladophora* était faible, la croissance a été limitée.

L'influence des eaux de la rivière Grand est limitée à un rayon de 2 kilomètres à partir de l'embouchure. Au-delà de cette zone, la teneur en phosphore des *Cladophora* n'est plus sous l'influence de la rivière Grand; l'abondance des algues semble être liée aux apports et aux activités dans la zone littorale du secteur.

The Influence of the Grand River on Eastern Lake Erie Cladophora

L'influence de la rivière Grand sur les _Cladophora_ dans l'est du lac Érié

D.S. Painter and K.J. McCabe

National Water Research Institute
Environment Canada
Burlington Ontario

May 26, 1987

Abstract

The influence of the Grand River on nearshore water chemistry was confined to a zone of 2 kilometers. Nitrate, total Kjeldahl nitrogen, silica, Secchi disc transparency, soluble reactive phosphorus, and _Cladophora_ internal phosphorus were influenced, but ammonia concentrations were not elevated even within the 2 kilometer zone. _Cladophora_ abundance appeared to be influenced by local shoreline inputs and activities.

Résumé

L'influence de la rivière Grand sur la chimie des eaux littorales est limitée à un rayon de 2 kilomètres. Elle se dénote par la teneur en nitrate, en azote total (méthode de Kjeldahl) et un silice, par la transparence, mesurée avec le disque de Secchi, par la concentration de phosphore réactif soluble et par la teneur en phosphore des _Cladophora_; par contre, la concentration d'ammoniac n'a pas augmenté, même dans la zone de 2 kilomètres. Il semble que l'abondance des _Cladophora_ soit liée aux apports et aux activités dans la zone littorale du secteur.

Introduction

Cladophora glomerata (L.) is a filamentous green alga which grows attached to rocks in nutrient-enriched nearshore zones of the Great Lakes. During storm events, wind and wave action detach the alga's filaments from their rock substrate and nuisance accumulations of decaying algae appear on the shore. Excessive growths of *Cladophora* and subsequent shoreline accumulations can be aesthetically unpleasant for shoreline recreation. The decaying algae can affect the quality of municipal water supplies by imparting tastes and odours to drinking water (Boone, 1984) and frequently clog municipal and industrial water intake screens (Neil and Owen, 1964).

Cladophora growth has been documented as a serious problem along the bedrock shoreline of Lake Erie from Port Maitland to Fort Erie. Using aerial photography, Schenk and Owen (1973) estimated that there were 20 km^2 of *Cladophora* growth along this 72 km shoreline in 1960. Similar prolific growth was also observed by Neil and Owen (1964) in 1963 along the same stretch of shoreline. Accumulations of algae were reported to be 0.75 meters deep and 16 meters wide along 50% of the shoreline.

Excessive growths of *Cladophora* require optimal environmental conditions such as suitable substrate for attachment, water movement, water temperatures less than 21 C, adequate light and sufficient supply of nutrients (Neil and Owen, 1964). The nearshore zone from Fort Erie to Port Dover is ideal for the development of nuisance algae conditions since the substrate is primarily comprised of exposed bedrock that extends lakeward in some areas to a distance of 4-6 km (Rukavina and Jacques, 1971; Jacques and Rukavina, 1973). At locations where the physical conditions are favourable, the amount of Cladophora which will grow in a given area is likely to be limited only by the availability of nutrients (Neil, 1973).

The Grand River, the largest river in southern Ontario, is a major contributor of nutrients and dissolved and suspended solids to Lake Erie (Ross and Hamdy, 1980). It contributes approximately one third of the total Canadian phosphorus input to Lake Erie (Chesters et al., 1978) and about 25% of the total phosphorus input to the eastern basin from all sources (Burns, 1976). In 1984 the loading of phosphorus to Lake Erie from the Grand River was dramatically reduced due to the closing of the Electric Reduction Company of Canada Ltd. (ERCO) which was situated about 1 km up the river mouth in Port Maitland. Between May 1, 1970 and April 30, 1971, ERCO contributed 221 metric tons of phosphorus to Lake Erie via the Grand River which amounted to 37% of the Grand River's annual phosphorus input (581 metric tons). On a water year basis (Oct.1 - Sept.30) at the MOE sampling station upstream from ERCO, the phosphorus loading was estimated to be 455, 550 and 731 metric tons for 1983, 1984 and 1985 respectively. Prior to the closing of ERCO in 1985, phosphorus loading to the Grand River by ERCO alone was 108 and 86.5 metric tons in the calender years of 1983 and 1984 respectively (Dr. J. Clark, IJC, pers. comm.).

Psutka (1974) observed that 22% of the phosphorus input and 100% of the suspended solids from the Grand River was deposited within 5 km. of the river's mouth. Nicholls et al. (1983) suggested that the major influence of the Grand River during the summer was confined to an area within 5-10 km of the river mouth based on phytoplankton species composition. Nutrient data supported this observation.

Since the loading of the Grand River has been significantly reduced due to the implementation of the Great Lakes phosphorus control program and the closing of ERCO, we decided to assess the influence of the Grand River plume on *Cladophora* growth and shoreline nutrient chemistry between Point Abino and Featherstone Point. Other than Neil and Jackson (1982) who studied *Cladophora* growth at Rathfon Point, no studies pertaining to the distribution, environmental requirements or significance of *Cladophora* in the eastern basin of Lake Erie have been reported since 1963.

Methods

Water samples were collected along the northern shoreline in the eastern basin of Lake Erie extending from Point Abino to Featherstone Point and at 20 open water stations within 40 km from the mouth of the Grand River (Figure 1). The complete shoreline in the study area was examined and the shoreline stations were chosen based on the presence of *Cladophora*. Water samples were collected at four periods during the summer of 1985: June 12, June 16,17, July 16,17 and July 30,31. The sampling period was chosen to coincide with the growing season of *Cladophora*. *Cladophora* was collected at the shoreline locations, oven-dried and analyzed for internal phosphorus content. *Cladophora* abundance was estimated as a percentage cover of the bedrock substrate using the following scale: 1-5%, 5-25%, 25-50%, 50-75%, and 75-95%. At each open water station, temperature and Secchi disc transparency were measured. Water samples were analyzed for soluble reactive silicate, soluble reactive phosphorus, nitrate, ammonia, and total Kjeldahl nitrogen (Analytical Methods, NWQL).

Results

Elevated nitrate, soluble reactive silicate, and total Kjeldahl nitrogen concentrations were observed within 2 km to the east and 3 km to the west of the mouth of the Grand River (Figures 2,3, and 4). Soluble reactive phosphorus was only elevated at the mouth of the Grand River (Figure 5). Water clarity, as determined by Secchi disc transparency, was poorer 2 km to the east of the Grand River inflow than the inflow itself

(Figure 6). Two other stations east and west of the inflow by approximately 10 km had reduced water clarity compared to adjacent stations. Ammonia concentrations were not elevated even within the impact zone identified by other water chemistry parameters (Figure 7). Offshore Secchi disc transparencies were improved relative to onshore transparencies as would be expected. Onshore-offshore trends in other water chemistry parameters were not strong but on the two occasions when consistent trends were observed, the onshore stations had lower concentrations of nitrate and silica. Soluble reactive phosphorus and ammonia was usually higher at the middle stations compared to the onshore and offshore stations (Table 1).

The internal phosphorus concentration of Cladophora also showed a trend of enrichment at the river mouth indicating that the impact zone of the Grand River was confined to a distance of less than 2 km to the east. Cladophora internal phosphorus was not affected to the west of the mouth. The internal phosphorus content of Cladophora collected along the 60 km shoreline ranged between 750 and 2000 ugP/g AFDW (ash-free dry weight) with an average internal phosphorus concentration of 1400 ugP/g AFDW (Figure 8). The Cladophora internal phosphorus content at the stations in the river mouth and 1.2 km to the east ranged from 2450 to 5200 ugP/g AFDW. Cladophora growth and abundance was minimal at most shoreline stations (Figure 9). Heavy growth was confined to the mouth of the Grand River and locations where there were point sources of nutrients to enhance algae growth.

Discussion

The predominant pattern of water movement along the north shore in the eastern basin of Lake Erie is from west to east (Simons, 1976). Our water chemistry data does not suggest the existence of a strong Grand River plume influence to the east or at any distance greater than 2 km from the river mouth during the months of June and July, 1985. Soluble reactive phosphorus and ammonia concentrations appeared to be influenced by shoreline processes rather than the Grand River. Secchi disc transparencies also appear to be influenced by shoreline processes.

Nicholls et al. (1983) investigated the phytoplankton community to determine the influence of the Grand River on the phytoplankton of Lake Erie. Based on the distribution of two indicator species which have requirements for high nutrient levels (<u>Skelotonema potamos</u> (Weber) Halse and <u>Stephanodiscus hantzschii</u> (Grun.)), Nicholls et al. (1983) suggested that the major influence of the Grand River during the summer was confined to an area within 5-10 km of the river. Nicholls et al. (1983) presented their observations using a semi-log transformation which visually decreased the pronounced difference between the Grand River stations and their shoreline stations. A plot of their seasonal average phytoplankton biomass data on a linear scale indicated a strong river influence at the two river mouth stations with a smaller river influence at the other stations (Figure 10). The semi-log scale tended to accentuate the small differences in algal biomass to a distance of 20 km from the Grand River. Unfortunately, Nicholls et al. (1983) did not include the standard deviations of the mean algal biovolumes for their 10 stations. Temporal data was presented for 5 of the stations and the mean standard deviation was +/- 22% of the mean. Using the statistical information from the 5 stations, the 5-10 km stations did have significantly higher algal biovolumes than the more remote sites and their conclusion that the Grand River inflow influence was within 5- 10 km of the mouth was correct.

Nicholls et al. (1983) stated that their water chemistry data supported their algal biovolume observations. Figures 11, 12, and 13 illustrate the silica, total phosphorus and total inorganic nitrogen concentrations reported by Nicholls et al. (1983). The seasonal averages and ranges of their water chemistry data are presented in Table 2. Total phosphorus decreased from approximately 20 ug/l at the 5-10 km sites to 13 ug/l at the remote sites. Total inorganic nitrogen dropped from approximately 200-265 ug/l to 160 ug/l which given the ranges of the data probably was not significant but the variability at the 5-10 km sites was higher than the remote sites suggesting that the Grand River was affecting those sites. Dissolved reactive silicate appears not to be affected at the 5-10 km sites. Generally, the water chemistry data would support the conclusion that the influence of the Grand River was extending to 5-10 km but the affect is not as pronounced as the algal biovolume increase.

The internal phosphorus content of *Cladophora* collected along the 60 km shoreline ranged between 750 and 2000 ugP/g AFDW except for the stations at the mouth of the Grand River. According to the Droop formulation which relates the net specific growth rate of *Cladophora* to it's internal phosphorus content (Auer and Canale, 1982), the *Cladophora* we collected was growth-limited. This explains the sparse growth of *Cladophora* observed along the north shore in the eastern basin of Lake Erie in 1985. Difficulty was experienced during the initial site selection trip in locating stations along the shoreline which supported *Cladophora* growth. Local inputs of nutrients appeared to be responsible for the local abundance of the alga. The significant improvement in the *Cladophora* problem from the early 1960's is probably being experienced as a result of the phosphorus loading reduction program in the Great Lakes.

The internal phosphorus content at the river mouth ranged between 2450 and 5200 ugP/g AFDW which is not considered growth-limiting (Auer and Canale, 1982) and supports our finding that the major influence of the Grand River plume during June and July, 1985 is confined to within 2 km of the mouth where prolific *Cladophora* growth occurred. In 1985, the Grand River was not a major influence in the distribution of *Cladophora* of the northern shore of eastern Lake Erie.

Painter and Kamaitus (1985) compared the biomass and internal phosphorus content of *Cladophora* collected from seven sites in Lake Ontario in 1972 to that collected in 1982 and 1983. They wanted to determine what effect the phosphorus loading reduction programs had on the *Cladophora* standing crop and internal phosphorus concentrations in that ten year period. In 1972, lake phosphorus levels were appproaching their maximum and *Cladophora* growth was extensive. By 1983, the phosphorus control programs had achieved the target lake phosphorus levels (Dobson, 1984) and *Cladophora* internal phosphorus concentrations were substantially reduced to the point where they were beginning to limit growth. *Cladophora* biomass in Lake Ontario over the decade had dropped by 58%.

In conclusion, it is evident that *Cladophora* growth has responded to the phosphorus loading reduction programs and that the influence of the Grand River plume on *Cladophora* growth and water chemistry was confined to within 2 km of the river mouth. The recreational impact of *Cladophora* in the eastern basin of Lake Erie was minimal in 1985.

References

Analytical Methods Manual. 1979. National Water Quality Lab. Environment Canada, Burlington, Ontario.

Auer, M.T., and Canale, R.T. 1982. Ecological studies and mathematical modeling of Cladophora in Lake Huron: 3) the dependance of growth rates on internal phosphorus pool size. J. Great Lakes Res. 8(1):93-99.

Boone, R.J. 1984. Analysis of Burlington drinking water for taste and odour compounds. Contract report - Environment Canada

Burns, N.M. 1976. Nutrient budgets for Lake Erie. 1970. J. Fish. Res. Board Can. 33:520-536.

Chesters, G., Stiefel, R., Bahr, T., Robinson, J., Ostry, R., and Coote, D. 1978. Pilot watershed studies, summary report. Report to the IJC from the Internat. Ref. Group on Great Lakes Pollution from Land Use Activities, June 1978.

Dobson, H.F.H. 1984. Lake Ontario water chemistry atlas. Environment Canada, Inland Waters Directorate, Scientific Series #139. 100 pp with 94 figures.

Neil, J.H. 1973. Nature of growth. In: Reports on Cladophora investigations in Ontario 1958 to 1967. Ministry of the Environment.

Neil, J.H., and Jackson, M.B. 1982. Monitoring Cladophora growth conditions and the effect of phosphorus additions at a shoreline site in northeastern Lake Erie. J. Great Lakes Res. 8(1):30-34.

Neil, J.H., and Owen, G.E. 1964. Distribution, environmental requirements and significance of Cladophora in the Great Lakes, pp. 113-121. In: Proc. 7th Conf. Great Lakes Res., Pub. 11, Gt. Lakes Res. Div., University of Michigan.

Nicholls, K.H., Taylor, R., and Hamdy, Y. 1983. The influence of the Grand River on phytoplankton near the northeastern shore of Lake Erie during 1979. Arch. Hydrobiol. 98(2):146-172.

Painter, D.S., and Kamatis, G. 1985. Reduction of Cladophora biomass and tissue phosphorus in Lake Ontario 1972-1983. Environment Canada, National Water Research Institute Report #85-39, 14pp.

Psutka, M.M. 1974. Phosphorus supply and algal production in the lower Grand River, its estuary and adjacent Lake Erie. M.Sc. thesis, University of Guelph.

Ross, D.I., and Hamdy, Y. 1980. Nutrient enrichment status of the Grand River mouth (Ontario), eastern basin Lake Erie. Ontario Min. Environ. Toronto (Manuscript). 71 pp.

Rukavina, N.A., and St. Jacques, D.A. 1971. Lake Erie nearshore sediments Fort Erie to Mohawk Point, Ontario. Proc. 14th Conf. Great Lakes Res., Internat. Assoc. Great Lakes Res., 387-393.

Schenk C.F., and Owen, G.E. 1973. Status report on Cladophora. In: Reports on Cladophora investigations in Ontario 1958 to 1967. Ministry of the Environment.

Simons, T.J. 1976. Continuous dynamical computations of water transports in Lake Erie for 1970. J. Fish. Res. Board Can. 33:371-384.

St. Jacques, D.A., and Rukavina, N.A. 1973. Lake Erie nearshore sediments - Mohawk Point to Port Burnwell, Ontario. Proc. 16th Conf. Great Lakes Res., Internat. Assoc. Great Lakes Res., 454-467.

Figure Legends

Figure 1: Location of 1985 sampling stations (Environment Canada) and 1979 sampling stations of Nicholls et al. 1983.

Figure 2: Nitrate concentrations (ug/l) versus distance from Grand River inflow.

Figure 3: Dissolved reactive silica concentrations (ug/l) versus distance from Grand River inflow

Figure 4: Total Kjeldhal Nitrogen concentrations (ug/l) versus distance from Grand River inflow

Figure 5: Soluble reactive phosphorus concentrations (ug/l) versus distance from Grand River inflow

Figure 6: Secchi disc transparencies (m) versus distance from Grand River inflow

Figure 7: Ammonia concentrations (ug/l) versus distance from Grand River inflow

Figure 8: *Cladophora* internal phosphorus concentrations (ug/g AFDW) versus distance from Grand River inflow

Figure 9: *Cladophora* cover (%) versus distance from Grand River inflow

Figure 10: Algal Biovolume (mm^3/l) versus distance (Nicholls et al. 1983)

Figure 11: Dissolved reactive silicate (ug/l) versus distance (Nicholls et al. 1983)

Figure 12: Total phosphorus (ug/l) versus distance (Nicholls et al. 1983)

Figure 13: Total inorganic Nitrogen (ug/l) versus distance (Nicholls et al. 1983)

Table Legends

Table 1: Onshore-offshore comparisons of water chemistry parameters on July 16-17 and July 30-31, 1985.

Table 2: Summary of seasonal averages and ranges of water chemistry data from Nicholls et al. 1983.

Onshore-Offshore Comparison

July 16-17

Station	Dist.	Depth	SRP	Silica	Ammonia	Nitrate	TKN	Secchi
Evans	0 km	0 m	5.3	20	12	79	201	-
6	2.5	10	16.9	80	15	224	185	2
7	9	22	7.5	85	11	214	176	4
Low	0	0	2.2	69	18	173	201	-
5	1	5	6.4	80	17	229	184	1
4	4	15	1.6	110	14	226	214	1.6
Rock Pt	0	0	2	0	21	10	219	-
10	1	5	3.8	120	24	228	204	1
11	2	12	2.1	170	10	241	193	2
Mohawk	0	0	3	30	7	197	178	-
15	2	10	2.3	30	28	216	198	1
14	3	15	2.2	53	8	208	179	2.3
Morgan	0	0	2.1	64	9	181	169	-
17	1	5	2.3	74	11	221	179	1.8
18	2.5	12	3.2	128	16	210	189	2.1
Rathfon	0	0	6.4	40	17	142	253	-
20	2.5	10	2.9	82	9	218	180	2
19	4	15	8.9	140	12	205	177	3

July 30-31

Station	Dist.	Depth	SRP	Silica	Ammonia	Nitrate	TKN	Secchi
Evans	as above		2.2	49	18	112	219	-
6			12.6	207	25	203	194	4.5
7			0.4	152	10	201	197	7
Low			1.6	256	13	192	186	-
5			2.9	164	11	192	263	2
4			2.7	244	13	202	201	3.5
Rock Pt			0.7	47	11	14	246	-
10			13	231	12	197	216	2
11			1.4	184	11	198	189	2.5
Mohawk			15.2	51	11	166	196	-
15			2.8	206	15	200	188	3.5
14			19.9	263	16	197	181	7
Morgan			1.9	82	11	153	211	-
17			17.2	204	7	172	178	4
18			0.3	123	10	167	201	5.5
Rathfon			0.7	29	36	85	234	-
20			0.3	206	95	203	200	6
19			0.5	211	59	195	194	6

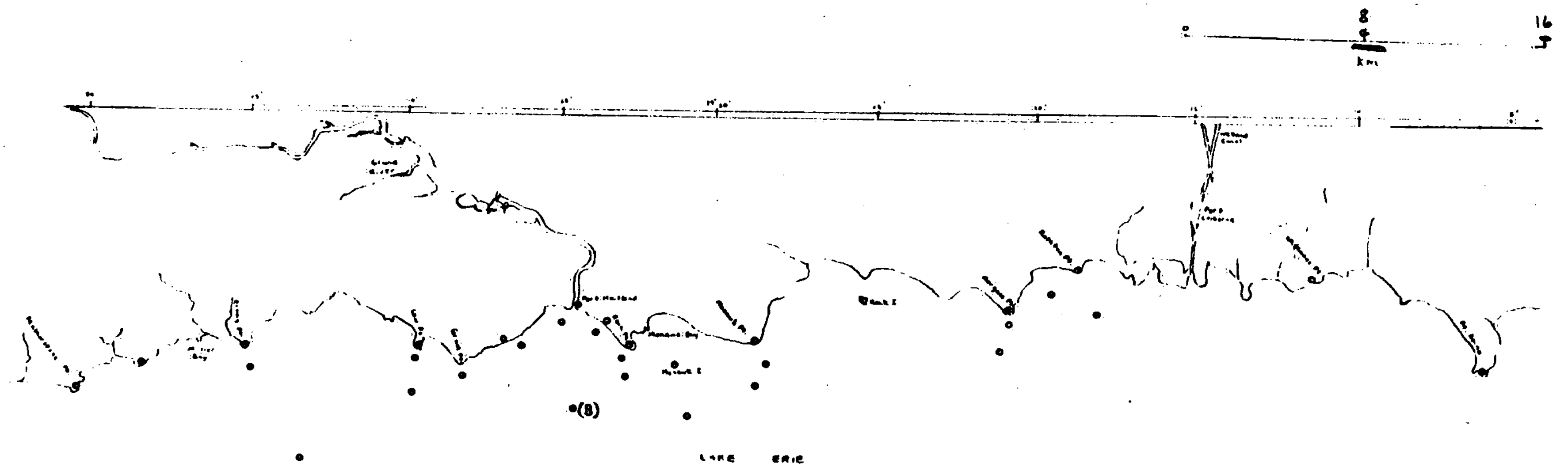
Seasonal water chemistry means and ranges
from Nicholls et al. (1983)

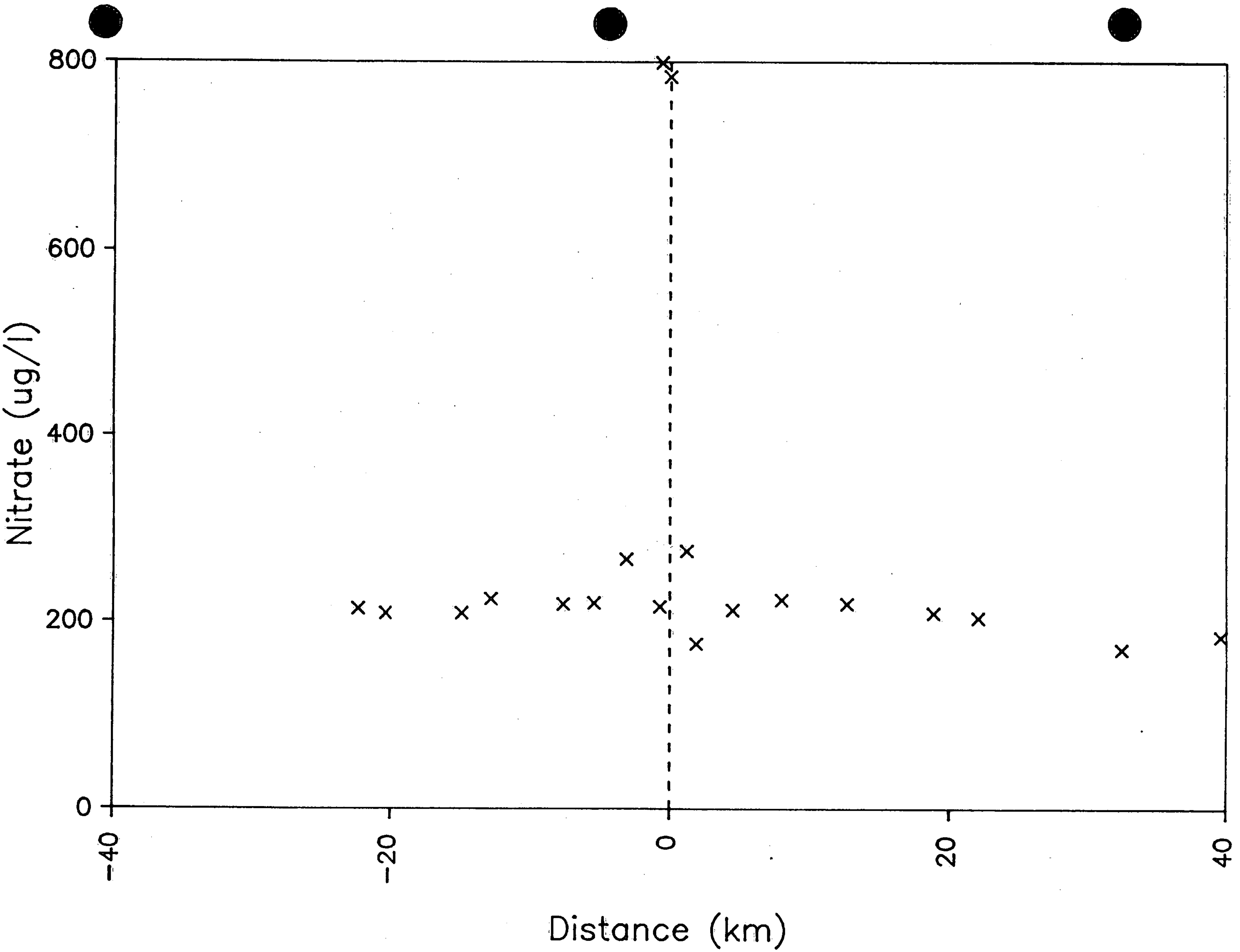
Station West	Total P (ug/l)	TIN (ug/l) mean	TIN (ug/l) range	Silicate (ug/l) mean	Silicate (ug/l) range
1 -40 km	13	162	87	168	217
2 -36 km	13	180	92	145	175
3 -18 km	10	168	130	131	133
4 - 4 km	19	265	750	151	220
5 offshore	13	205	446	119	200
6 river	128	808	2090	700	950
7 river	217	1145	2744	1062	1692
8 10 km	21	200	356	119	125
9 21 km	14	200	358	80	88
10 33 km	13	155	100	81	100
East					

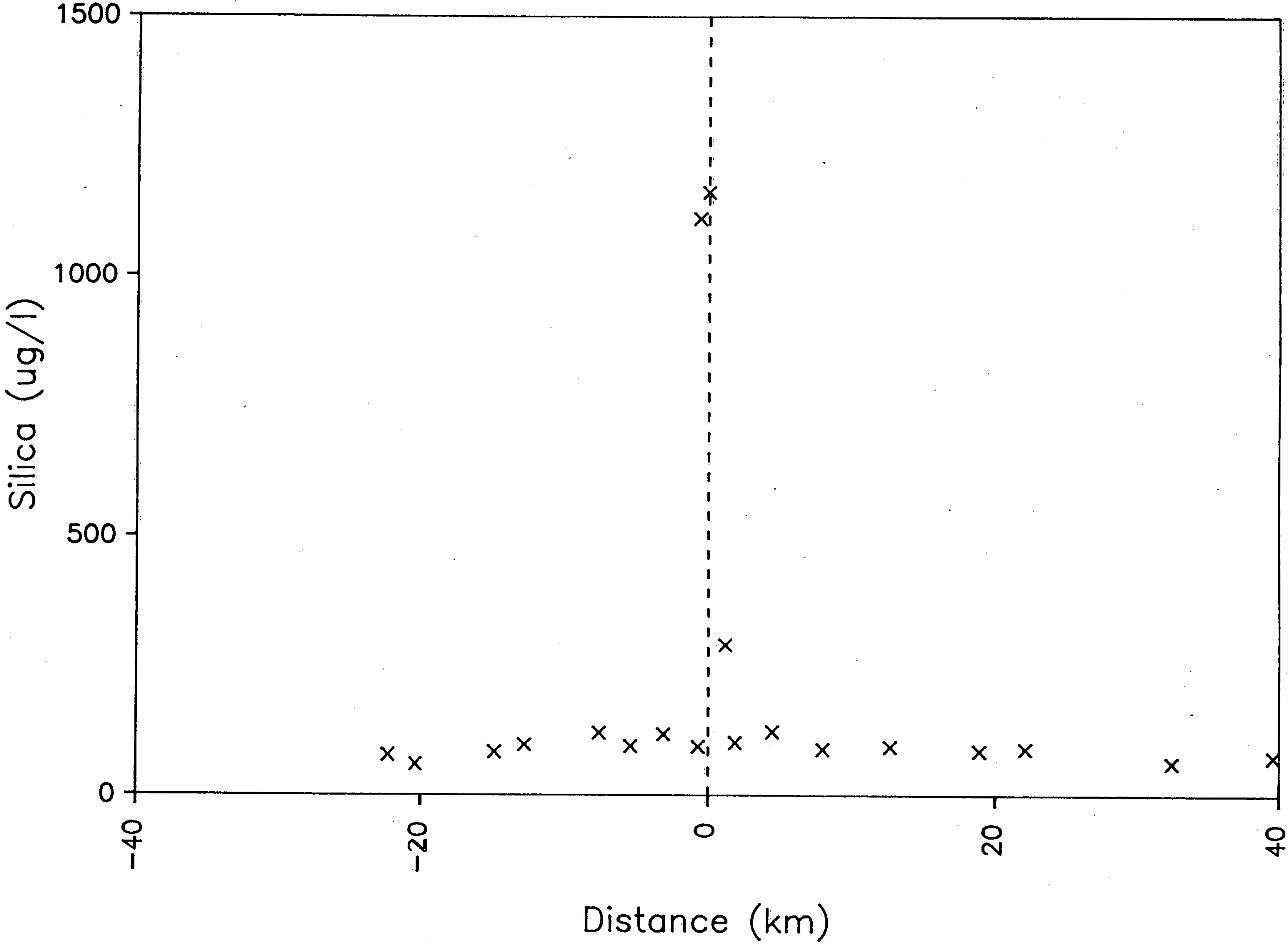
Figure 2 Sampling Stations

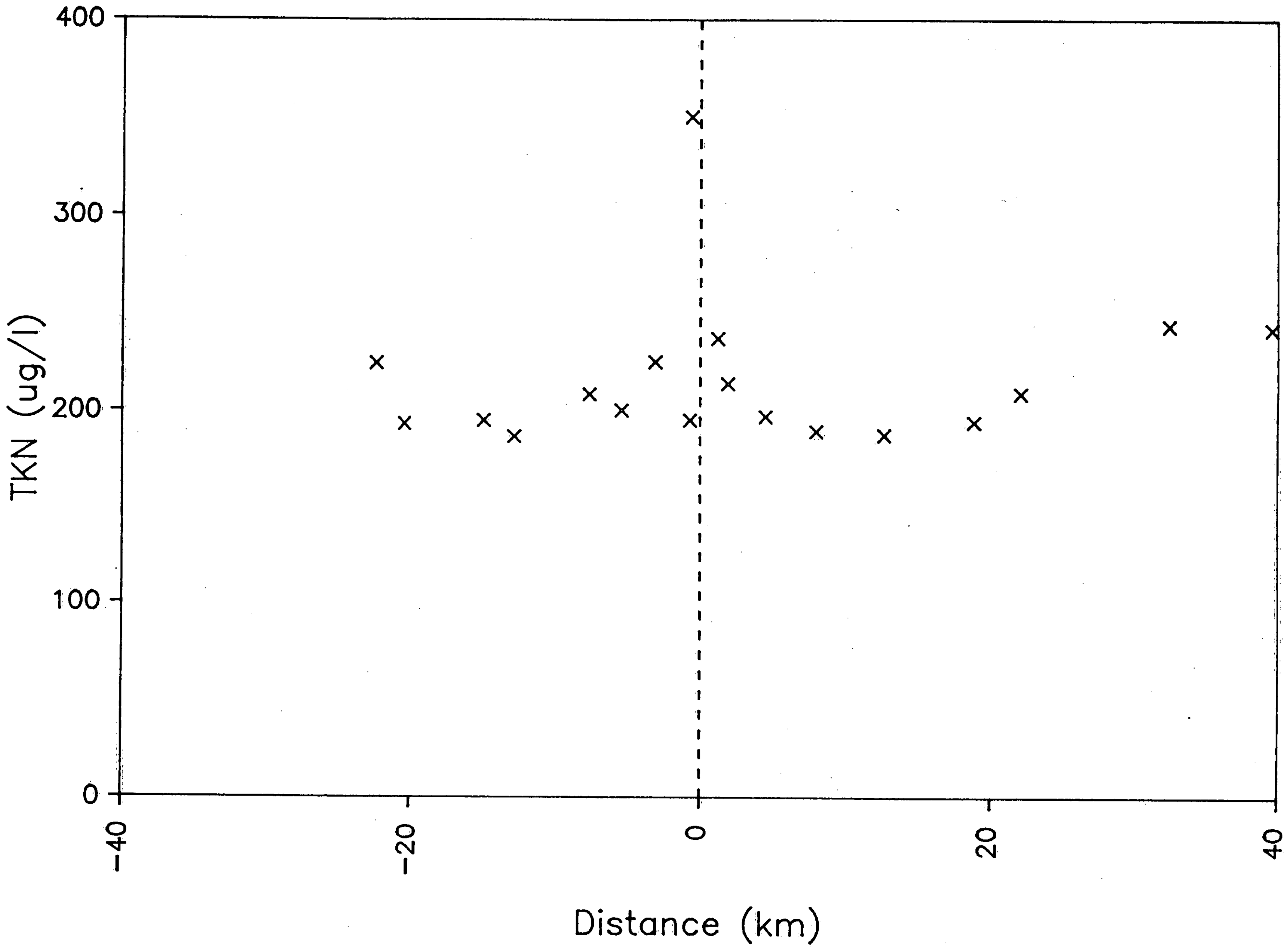
Yours •

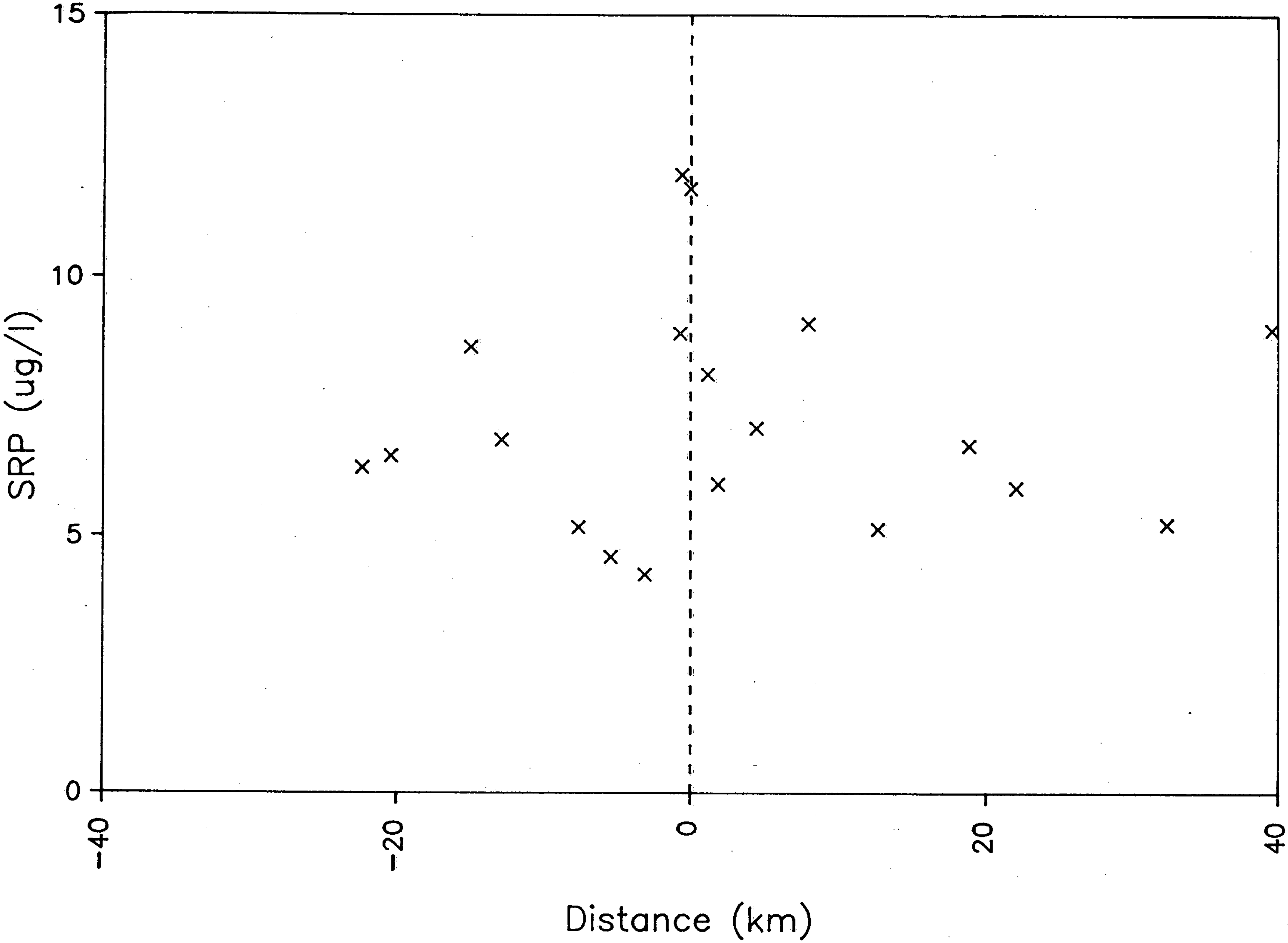
Nichols ?

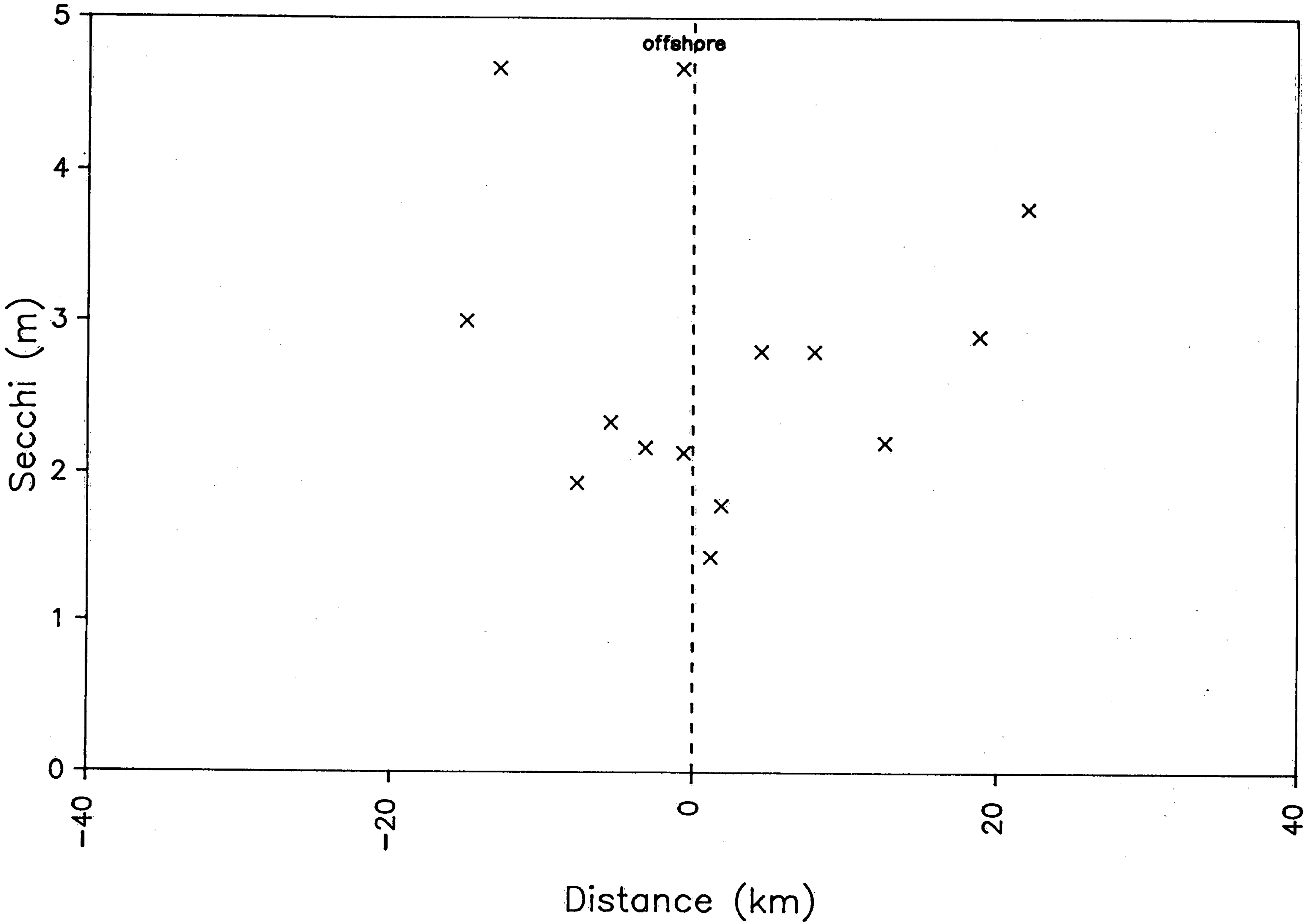


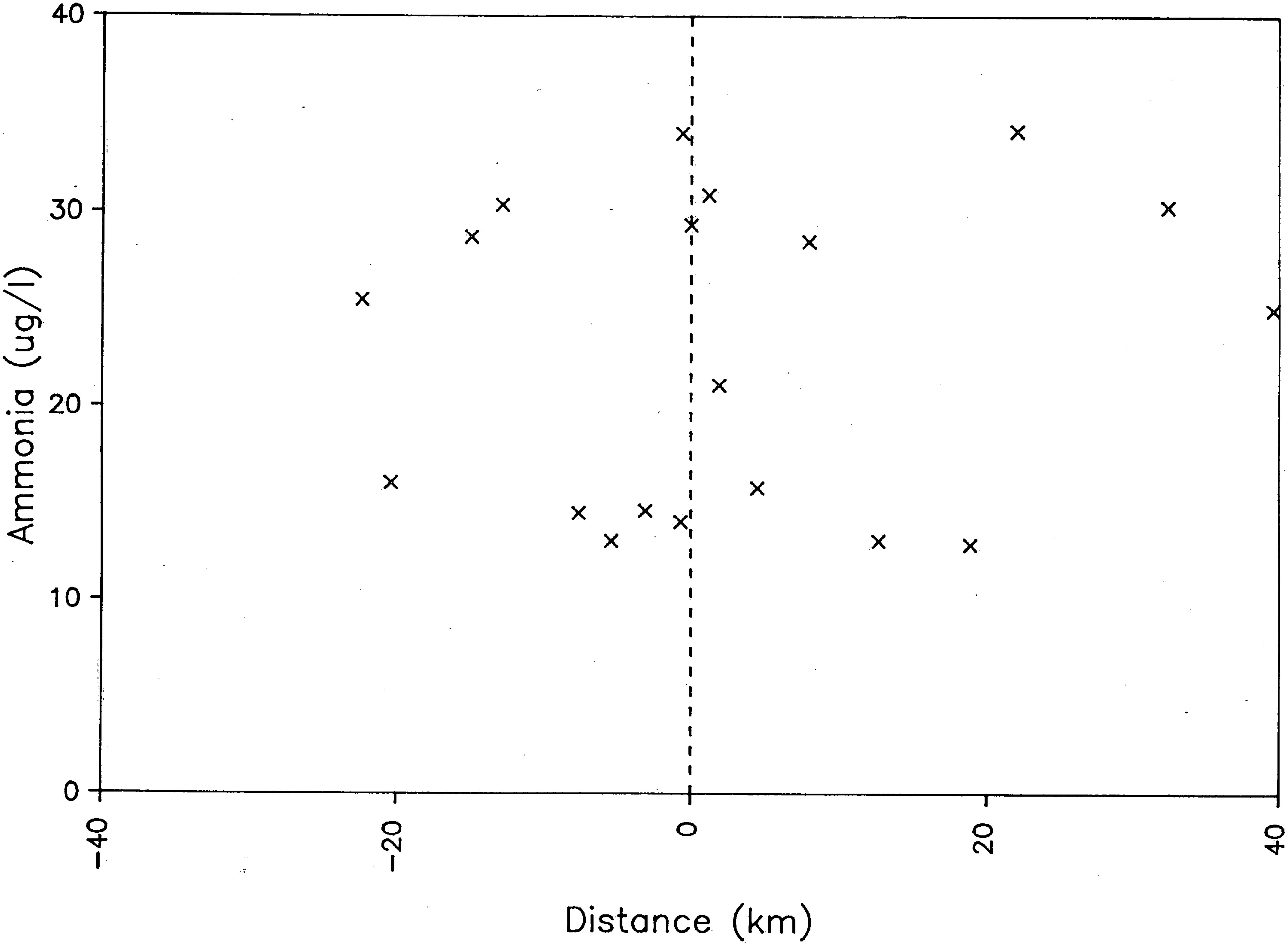

800
600
400
200
0
Nitrate (ug/l)
-40
-20
0
20
40
Distance (km)

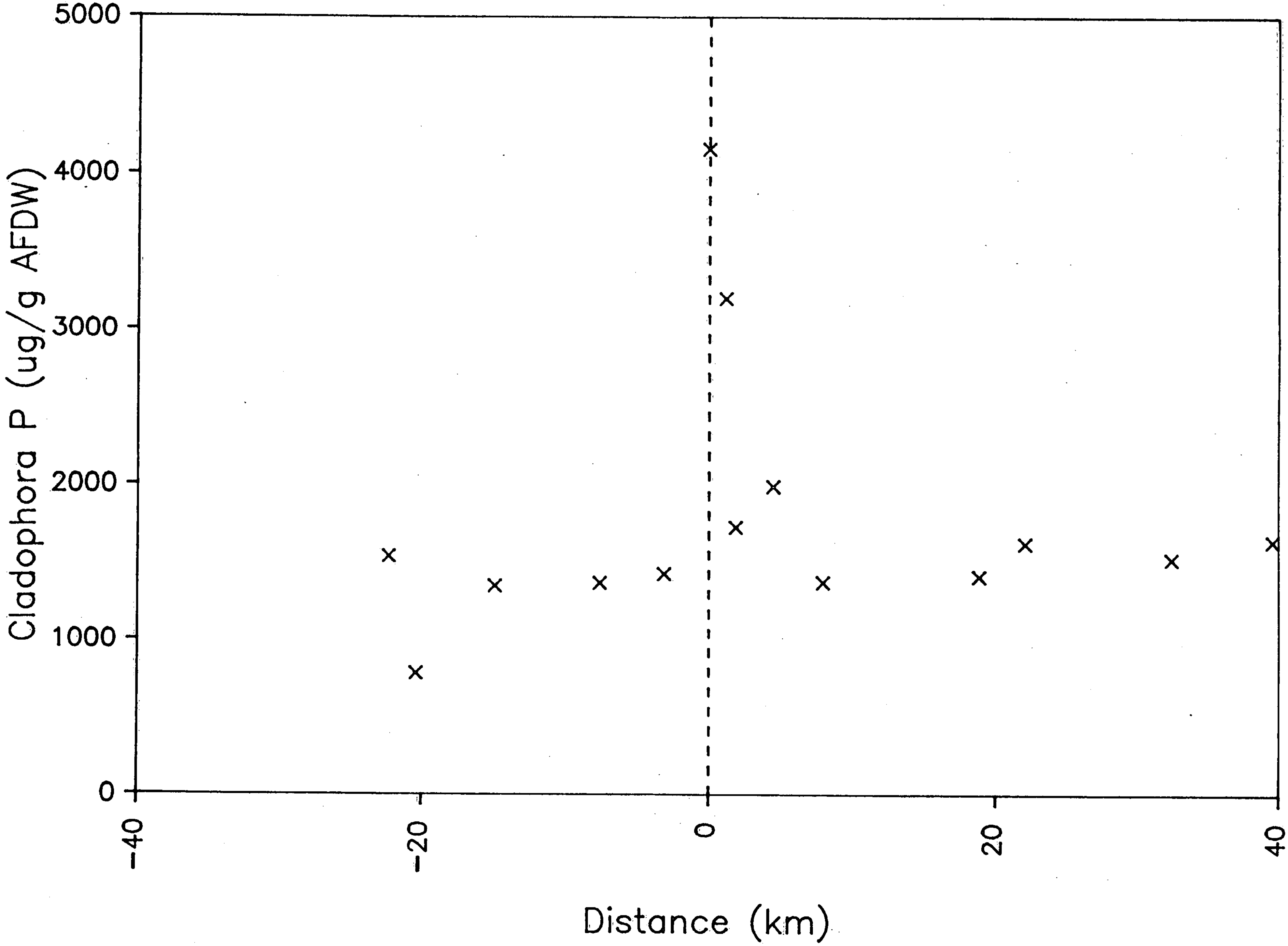

1500
1000
500
0
Silica (ug/l)
-40
-20
0
20
40
Distance (km)


400
300
200
100
0
TKN (ug/l)
-40
-20
0
20
40
Distance (km)

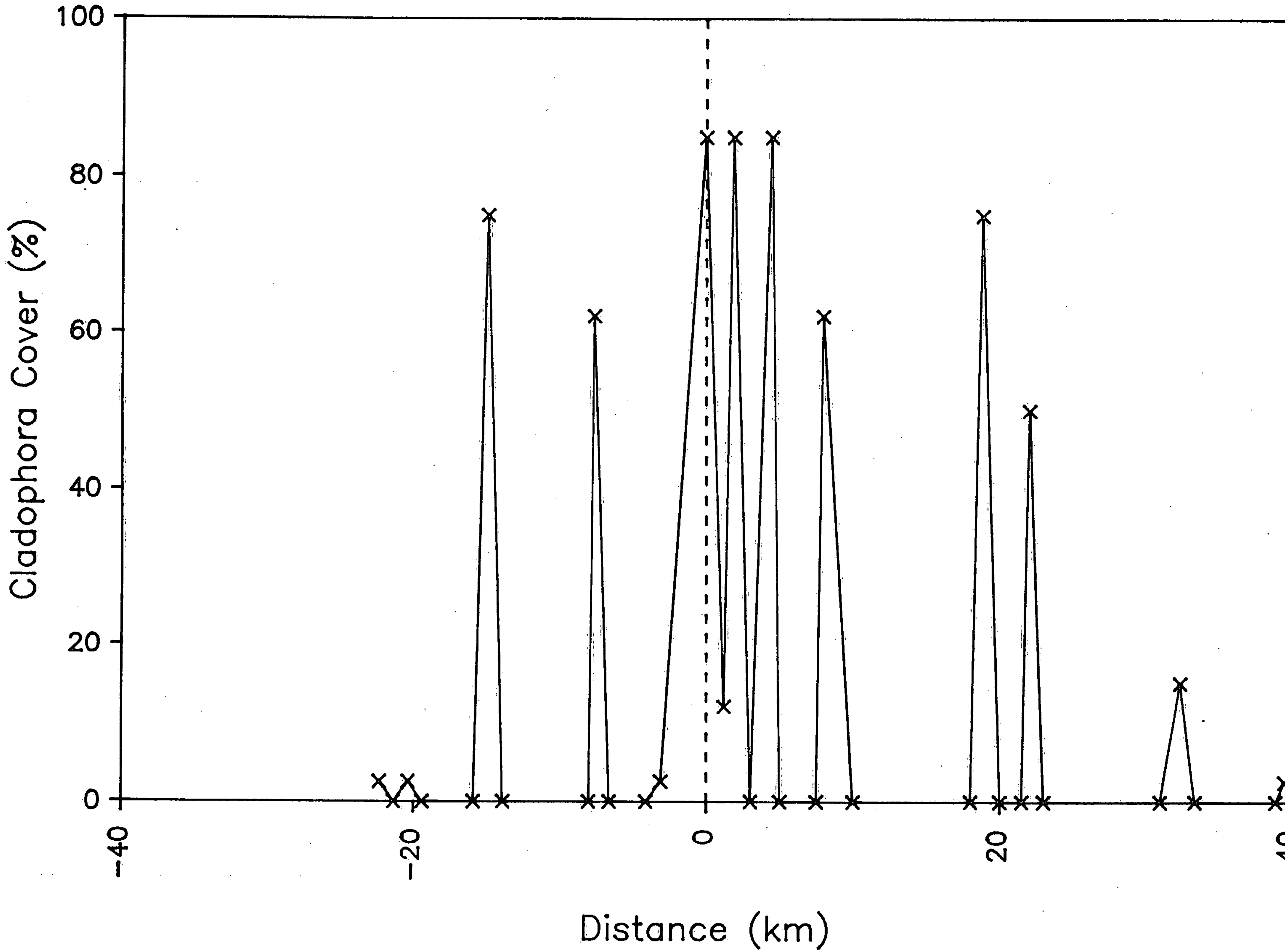

15
10
5
0
SRP (ug/l)
-40
-20
0
20
40
Distance (km)


offshore
Secchi (m)
Distance (km)
0
1
2
3
4
5
-40
-20
0
20
40


Ammonia (ug/l)
40
30
20
10
0
-40
-20
0
20
40
Distance (km)

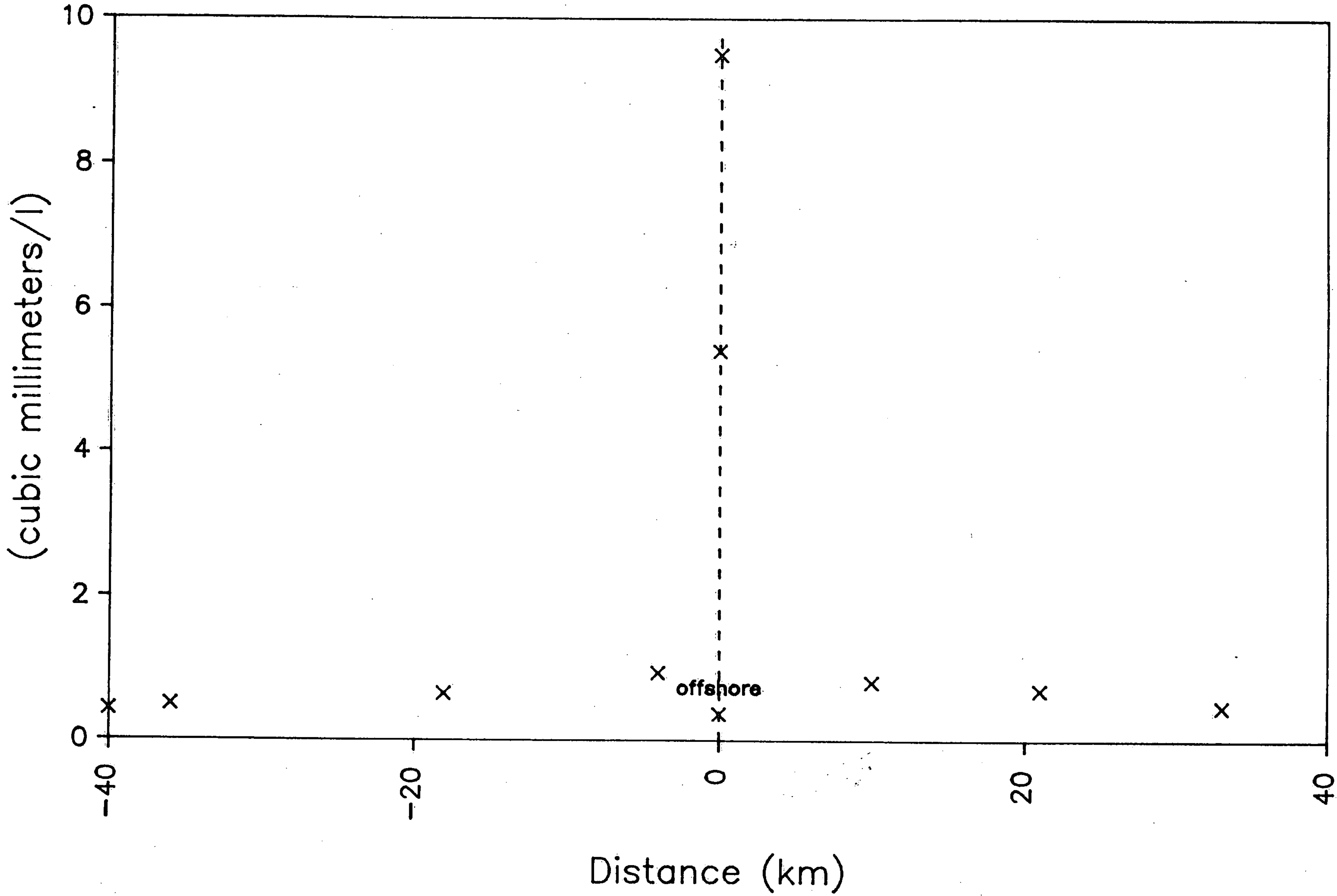


5000
4000
3000
2000
1000
0
Cladophora P (ug/g AFDW)
-40
-20
0
20
40
Distance (km)

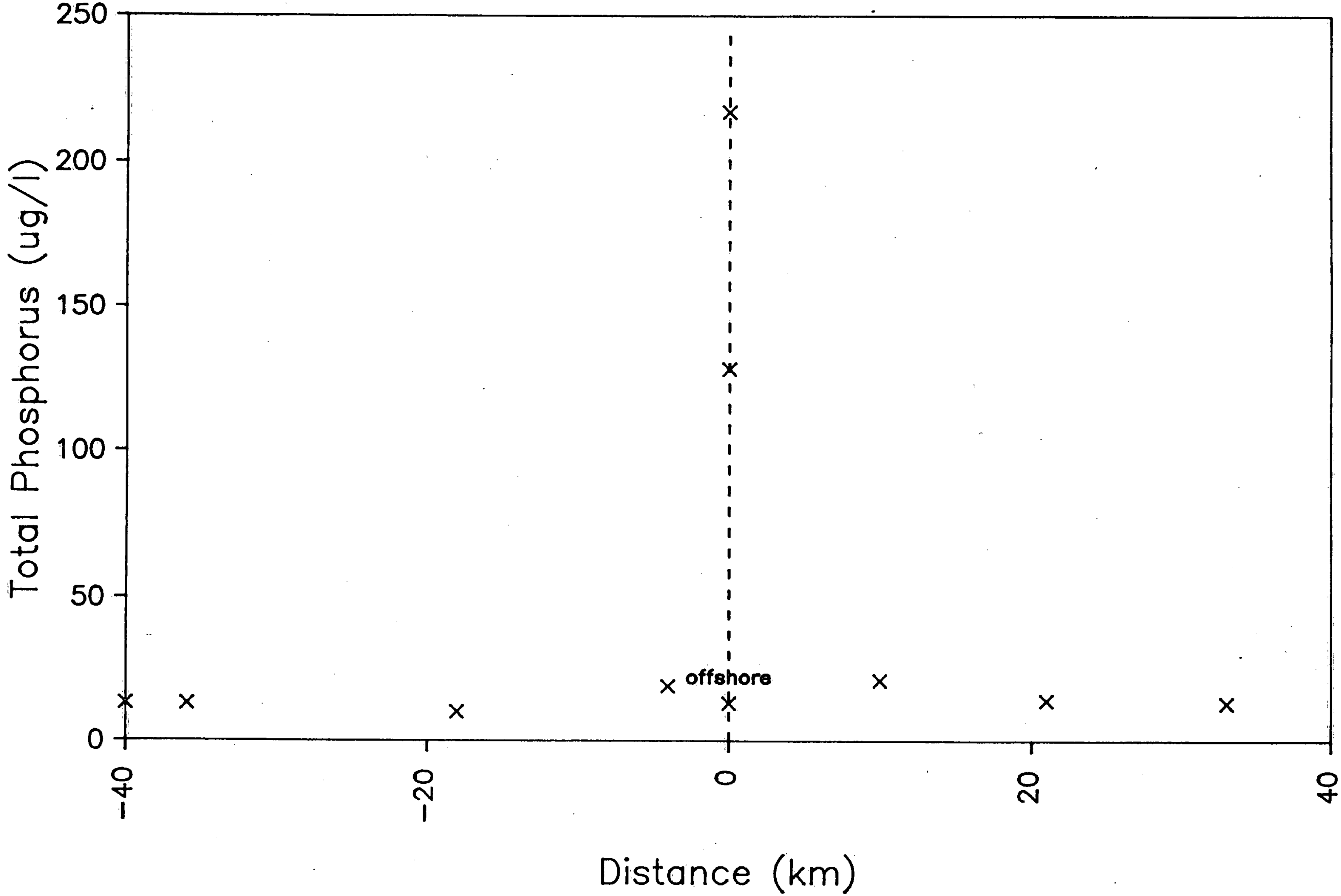


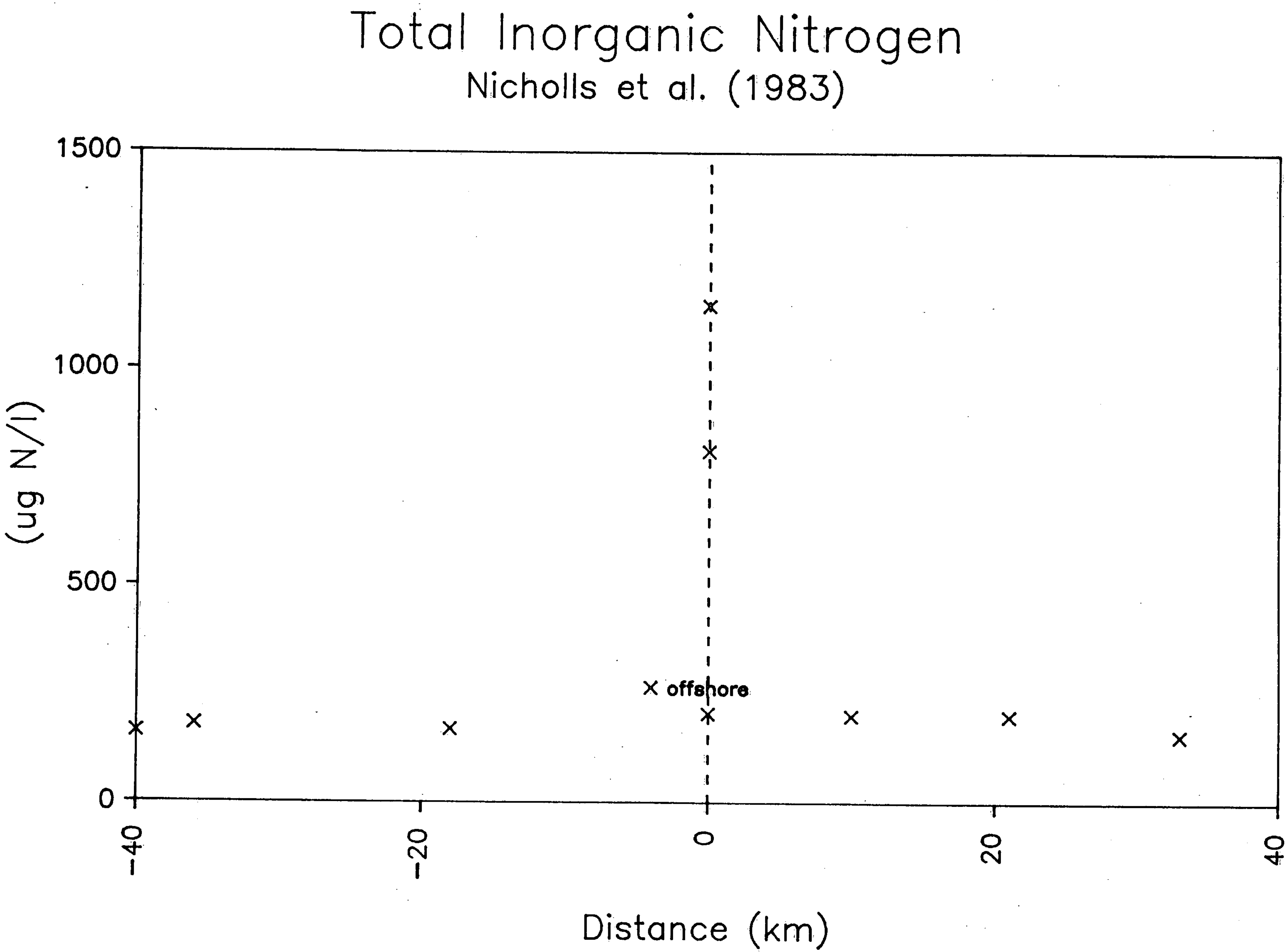
100
80
60
40
20
0
Cladophora Cover (%)
-40
-20
0
20
40
Distance (km)

Algal Biovolume Nicholls et al. (1983)



Total Phosphorus Nicholls et al. (1983)




Total Inorganic Nitrogen
Nicholls et al. (1983)
1500
1000
500
0
(ug N/l)
offshore
-40
-20
0
20
40
Distance (km)

Silica Nicholls et al. (1983)