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The distribution of nutrient salts in the southern North Sea during early 1974

by

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INTRODUCTION

During recent years, evidence has accumulated, mainly from unpublished reports, that the level of nutrient salts is increasing in the southern North Sea and concern has been expressed that eutrophic conditions may become established, with deleterious side effects. In 1961 and 1962 extensive surveys of the distribution of nutrient salts in the southern North Sea were made by the Fisheries Laboratory, Lowestoft to provide baseline values for subsequent studies. The results of the 1962 surveys have been presented in an atlas of nutrient salts in the North Sea (Johnston and Jones 1965). Similar observations were made during early 1974, and in this paper the distributions of phosphate, nitrate, nitrite, silicate and salinity are compared with the earlier observations of 1961 and 1962. Only data collected between January and March are used in this comparison, since these observations will probably not be influenced to any great extent by plankton growth.

METHODS

All observations refer to surface samples. Water for the analysis of nutrient salts was filtered through Whatman GF/C papers.

The 1961-62 series were analysed by manual techniques and the 1974 samples were determined on a Technicon Autoanalyser II system. There is no reason to believe that the results from the two techniques are not comparable and it seems most unlikely that the differences reported below between the two sets of observations can be attributed to differences in the method of analysis.

RESULTS

Continental coastal region

An area between Zeebrugge and Texel, extending to the central part of the southern North Sea, was surveyed between 14 and 16 January 1974. The results of this investigation are compared with a survey of the same

locality made between 4 and 10 January 1962. Observations made during the same period of 1961 (not reproduced) showed similar results to those of 1962.

Salinity (Figure 1): During January 1962 a broad band of water of salinity below 30°/oo lay parallel to the coast off the Schelde-Rhine complex. On the 1974 survey inshore values were somewhat higher and a westerly protrusion of low-salinity water was evident north of the Hook of Holland. Values above 35°/oo occurred offshore during 1974, whereas during the 1962 investigation the 35°/oo isohaline did not enter the southern North Sea (P. G. W. Jones, unpublished data).

Phosphate (Figure 2): During the 1974 survey, phosphate values were significantly higher than in 1962. This feature was most marked in the region off the Hook of Holland, where the level of phosphate was approximately three times higher. The offshore configuration of this parameter showed features common to both surveys, with an area of relatively low values to the north of the region probably indicative of phytoplankton growth.

Nitrate (Figure 3): The distribution of this constituent was similar on both surveys. The inshore level of nitrate was mainly at 25 µg atoms NO_3-N/l. However, a small area of values up to 40 µg atoms/l occurred north of Zeebrugge during the earlier investigation. Conditions at inshore localities such as this are often subject to short-term variation, depending on the state of tide at the time of observation. This high level of nitrate should therefore not be considered as significant in relation to the survey area as a whole.

Nitrite (Figure 4): Inshore nitrite values during 1974 were approximately two to three times higher than on the 1962 investigation. It is interesting to note that during both surveys an offshore area of values up to 1 µg atom NO_2-N/l was evident. This particular feature probably reflected natural biological activity rather than the result of terrestrial discharge, since it showed no obvious connection with any terrestrial source.

Silicate (Figure 5): During both surveys the level of silicate was very similar. Low values to the north of the area coincided with the low levels of phosphate and nitrate and were therefore probably indicative of diatom growth.

Thames Estuary

Phosphate and salinity only were measured during 1974, and these results are compared with observations made during the first part of 1961 and 1962. The stations, which were near lightvessels, were too few to allow us to prepare contoured figures. The data are therefore tabulated

in Table 1. Most observations were made at random states of tide, except for the 1974 Oaze Deep station which spanned a complete tidal cycle. It is apparent that the level of phosphate at each station in 1974 was higher than that for 1961-62. The salinity values for 1974 were within the 1961-62 range, except that the salinity at the Shipwash and Barrow Deep Lightvessels was somewhat higher in 1974 compared with 1961-62. The percentage increase in phosphate in the Thames Estuary, when comparing the 1974 values with the earlier observations, was lower than that recorded off the Continental coast. However, the 1974 values were made during March, when spring plankton growth may have started to diminish the winter nutrient levels.

DISCUSSION

Comparing the values of 1974 with observations made some 12 years earlier, the results indicate a marked increase in the winter level of phosphate in the coastal regions of the southern North Sea. Off the Continental coast nitrite levels were also elevated in 1974. The offshore values of these constituents remained relatively unchanged. One may thus infer that the observed increase had originated from terrestrial sources. The distributions of salinity did not indicate any major variation in the inshore flow pattern sufficient to account for the differences in phosphate and nitrite between the two sets of observations; hence one may assume that an increase in these constituents per unit volume of fresh water discharged had occurred.

Although observations from the present study show nitrate and silicate levels to have remained relatively unchanged, other unpublished reports have indicated that nitrate, like phosphate, has increased during recent years but to a lesser extent.

From the published literature Tijssen (1969, 1970) has shown phosphate values off the continental coast during 1968 and 1969 to be approximately midway between the range of values reported here for 1962 and 1974, thus providing evidence for a progressive increase over the period in question.

The increased levels of phosphate and nitrite observed during the period of the present investigation may be indicative of an increase in the sewage content of the water. It is strange, however, that this feature was not reflected in an increase in nitrate. It is possible that a nitrogen load of such an origin may be in a form other than nitrate, such as ammonia. The relatively high nitrite values observed during the 1974 survey (Figure 4) suggest a source of inorganic nitrogen other than nitrate. Ammonia was measured during the 1974 investigation only, by a

method new to us, and hence the results are not reproduced here. There were indications, however, of relatively high values of up to 20 µg atoms NH_4-N/l in inshore waters.

On the other hand, the high phosphate levels may well have been derived, at least in part, from detergent effluent. Although one may expect the phosphate fraction of detergent to be mainly in the form of polyphosphate at the time of discharge, a form which the method of analysis used in this investigation does not measure, nevertheless, biological and chemical degradation processes may have converted polyphosphate to measurable orthophosphate by the time such effluent reached the sea.

If these trends continue and eutrophic conditions become established, harmful side effects on both the natural biological balance of the region and the recreational amenities of the coastal resorts may become more evident. With this problem in mind, the ICES Working Group on the International Study of the Pollution of the North Sea and its Effects on Living Resources and their Exploitation recently convened a meeting at the Rijkswaterstaat in the Hague (2-3 April 1974) to discuss the problem of eutrophication in the southern North Sea. One of the recommendations of this group was that phosphorus, nitrogen and silicon should be regularly monitored in the North Sea. Thus future trends in the distribution of these constituents should be well documented.

SUMMARY

Nutrient salt surveys in the southern North Sea have shown that the level of phosphate and nitrite off the continental coast during January 1974 was two to three times higher than during the same period in 1962. The level of phosphate has also increased in the Thames Estuary but to a lesser degree. It is suggested that these increases are related to the discharge of waste material from terrestrial sources and that such changes must be considered in the context of eutrophication in the southern North Sea.

REFERENCES

JOHNSTON, R. and JONES, P. G. W., 1965. Inorganic nutrients in the North Sea. Serial Atlas of the Marine Environment, Folio 11, American Geographical Society.

TIJSSEN, S. B., 1969. Hydrographical and chemical observations in the Southern Bight, February, May, August and November 1968. Annls biol., Copenh., 25, 51-59.

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Table 1 Dissolved surface phosphate and salinity in the Thames Estuary during the first parts of 1961, 1962 and 1974

Approximate location	Date	Salinity (°/oo)	µg atoms PO_4-P/l
Shipwash Lightvessel (52°00'N 01°40'E)	13 Jan 1961	34.14	0.65
	7 Jan 1962	34.43	0.72
	30 Mar 1962	33.93	0.69
	13 Mar 1974	35.00	1.1
Kentish Knock Lightvessel (51°40'N 01°40'E)	9 Jan 1962	34.84	0.67
	30 Mar 1962	34.12	0.73
	13 Mar 1974	34.69	0.9
Barrow Deep Lightvessel (51°42'N 01°20'E)	9 Jan 1962	34.56	0.82
	30 Mar 1962	34.04	0.71
	16 Mar 1974	34.64	1.0
Tongue Lightvessel (51°31'N 01°21'E)	13 Jan 1961	34.10	0.62
	9 Jan 1962	34.75	0.77
	30 Mar 1962	33.91	0.78
	14 Mar 1974	34.52	1.0
Oaze Deep (51°30'N 01°01'E)	9 Jan 1962	33.52	1.39
	30 Mar 1962	33.37	1.03
	15-16 Mar 1974*	31.25-33.88*	1.50-3.60*

*Range of values over 13-hour tidal cycle.

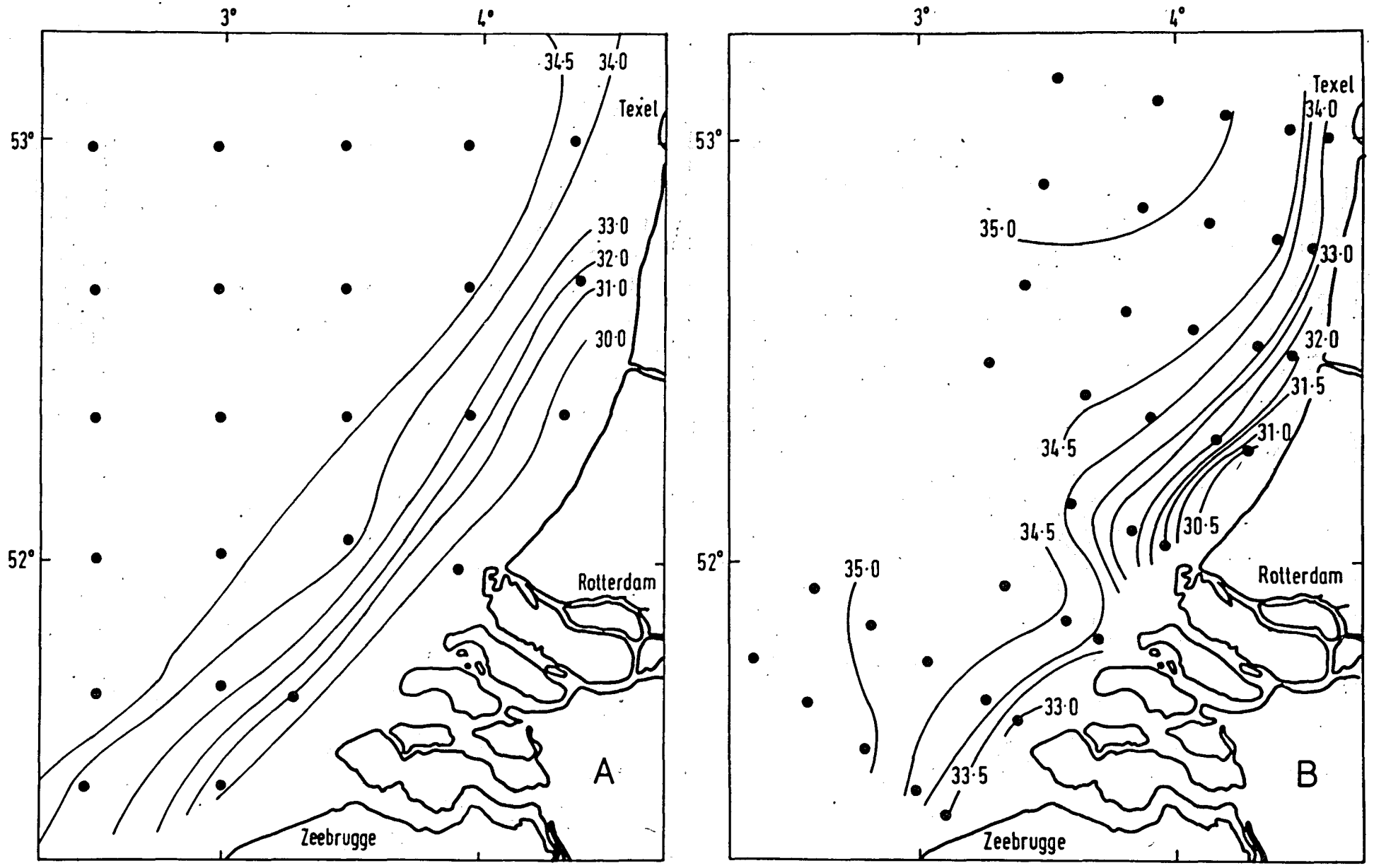

Figure 1 The distribution of surface salinity (S^{o}/oo) in the eastern part of the southern North Sea during (A) 4-10 January 1962 and (B) 14-16 January 1974. Solid circles represent station positions.

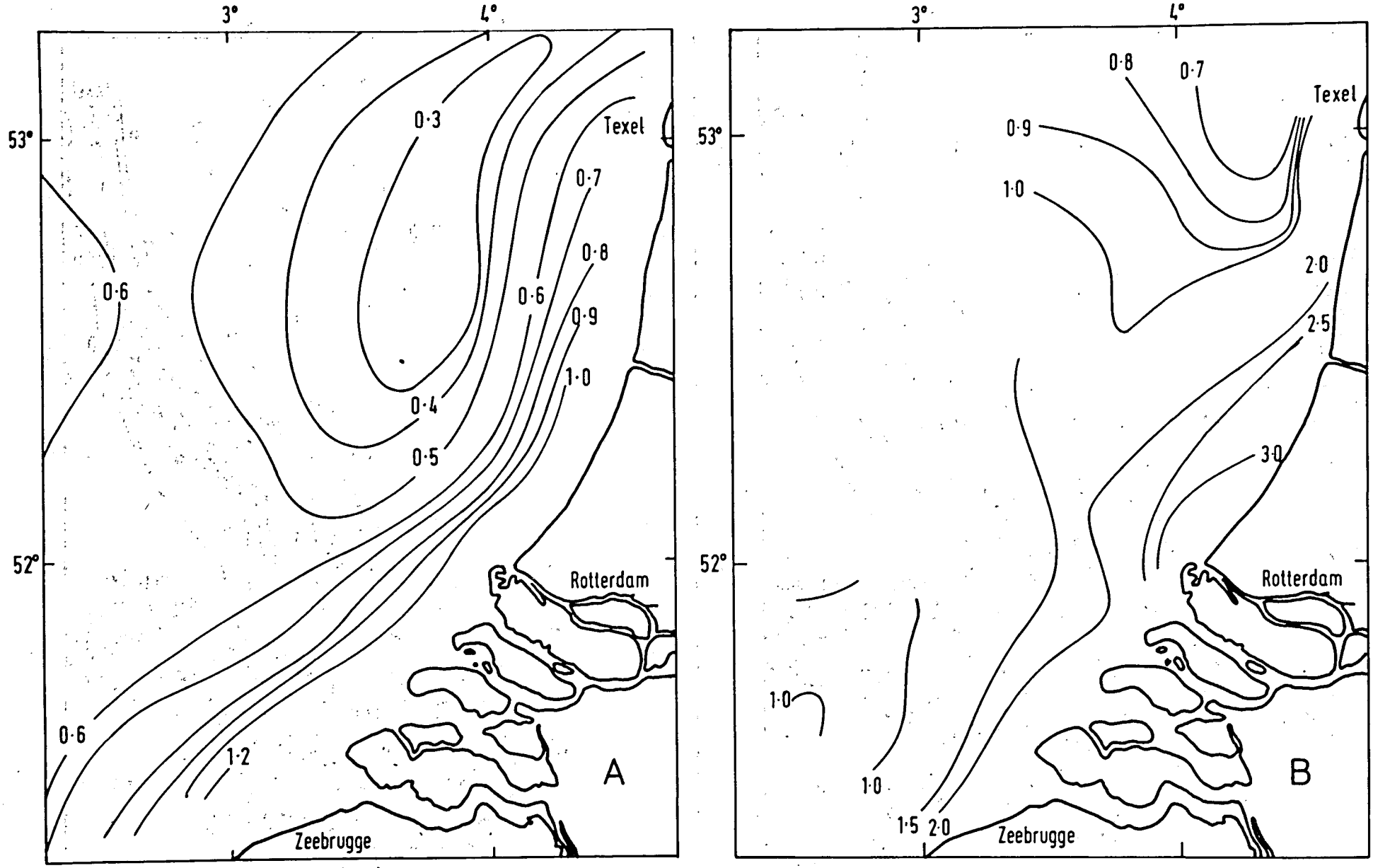

Figure 2 The distribution of surface phosphate (μg. atoms PO_4-P/l) in the eastern part of the southern North Sea during (A) 4-10 January 1962 and (B) 14-16 January 1974.

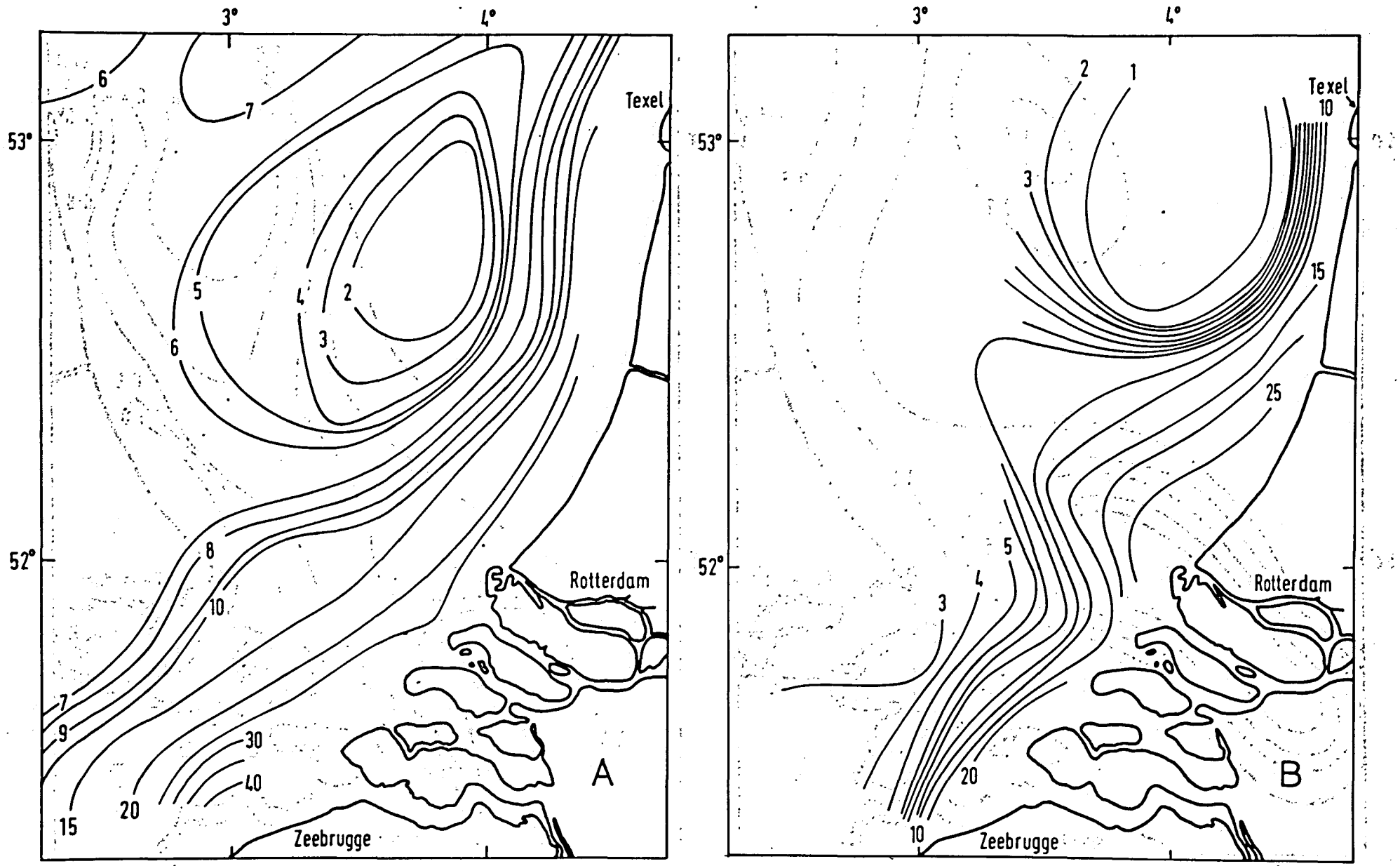

Figure 3 The distribution of surface nitrate (μg. atoms NO_3-N/l) in the eastern part of the southern North Sea during (A) 4-10 January 1962 and (B) 14-[redacted] January 1974.

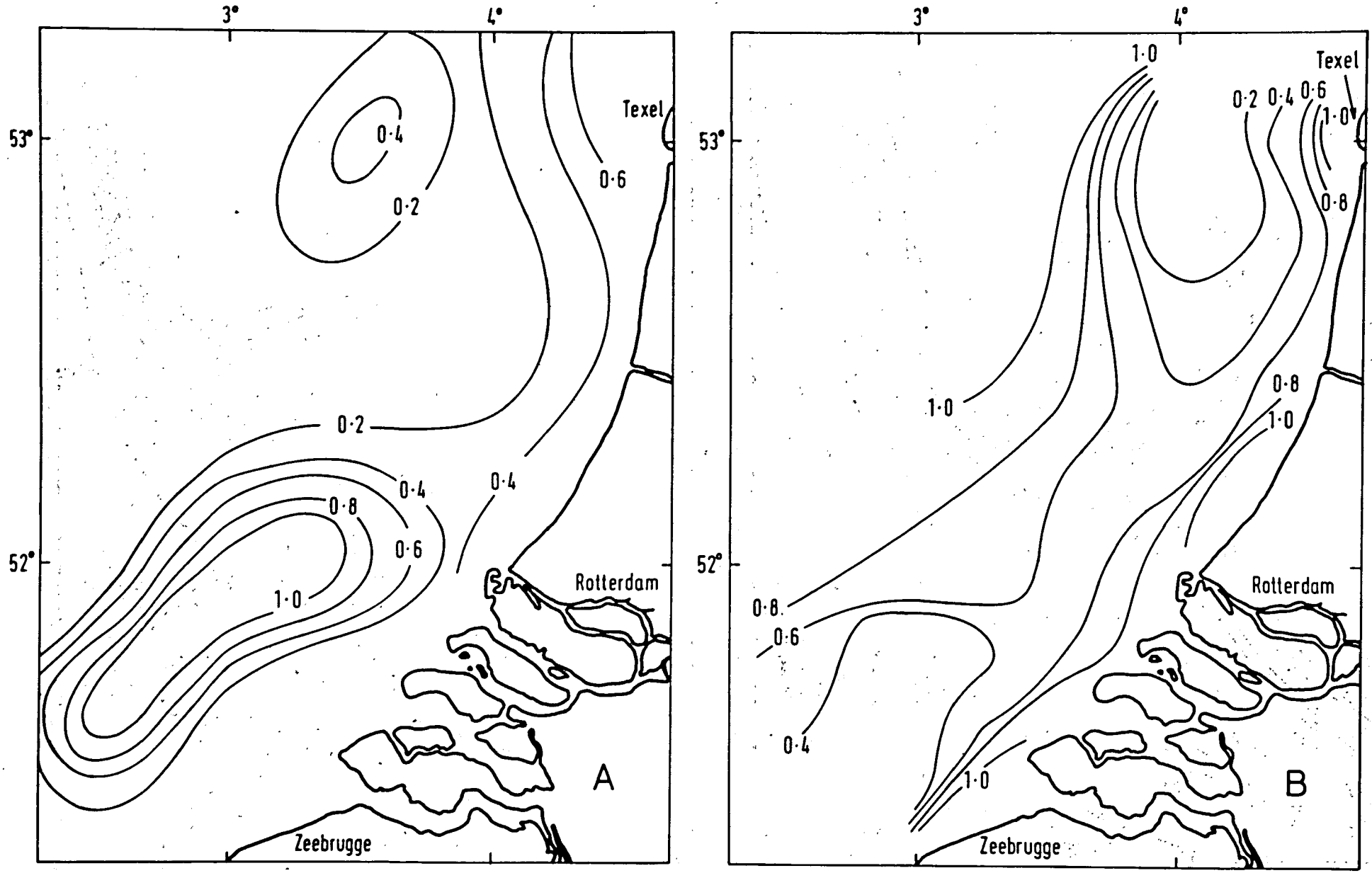

Figure 4 The distribution of surface nitrite (μg. atoms NO_2-N/l) in the eastern part of the southern North Sea during (A) 4-10 January 1962 and (B) 14–16 January 1974.

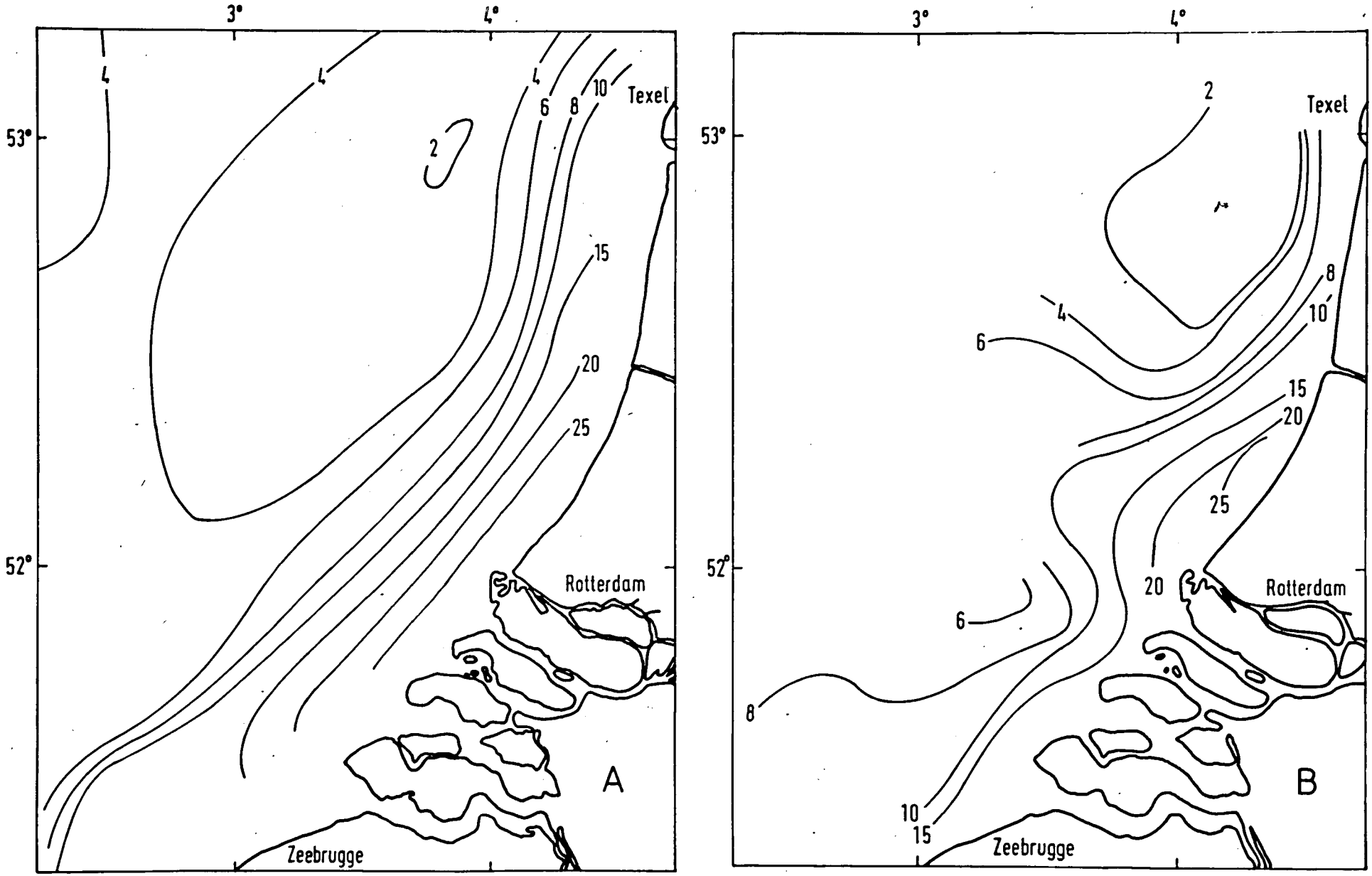

Figure 5 The distribution of surface silicate (µg. atoms SiO_3-Si/l) in the eastern part of the southern North Sea during (A) 4-10 January 1962 and (B) 14-16 January 1974.