Nutrients in Belgian Continental Shelf Waters : A Ten Years' Survey (1978 - 1987)

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NUTRIENTS IN BELGIAN CONTINENTAL SHELF WATERS : A TEN YEARS'SURVEY (1978-1987).

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ABSTRACT

Concentrations of nitrate/nitrite, ammonium, dissolved orthophosphate and silicate were determined in four areas off the Belgian coast (two sand extraction zones, one dumping site for industrial wastes and a coastal area as reference). Other parameters of importance were also measured : salinity, pH, oxygen content and turbidity. No significant trends neither for nutrients nor for the related parameters could be observed, indicating that the content of nutrients did not increase from 1978 to 1987.

RESUME

Les concentrations de nitrate/nitrite, ammonium, orthophosphate dissous et silicate on été déterminées dans quatre zones au large de la côte belge (deux zones d'extraction de sable, un site de déversement de déchets industriels et une zone côtière comme référence). D'autres paramètres d'importance ont aussi été mesurés : salinité, pH, teneur en oxygène dissous et turbidité. Aucune tendance significative n'a pu être détectée ni pour les nutriments, ni pour les autres paramètres, indiquent que la concentration des nutriments n'a pas augmentée de 1978 à 1987.

1. INTRODUCTION

Since the early seventies the Fisheries Research Station carries out a continuous biological and physico-chemical monitoring programme on sand extraction areas and dumping sites for industrial wastes off the Belgian coast. It was considered useful to take this opportunity to measure also nutrients in the water column.

It should be emphasized that the Belgian continental shelf is characterized by strong tidal currents, prevailing NW-winds and frequent storms. There is a residual NE-current with a speed of 5 cm/sec and a flow of 15-25 m^3/sec (14). This hydrodynamic pattern guarantees a thorough horizontal mixing with water of the Atlantic. Due to the shallowness of the area (20 m on average, with a maximum of 35 m), vertical mixing is quick and almost complete.

Although the industrial activities mentioned were not expected to have an important impact on nutrients, changes in transparancy, pH and oxygen content induced by these activities, could influence primary production and hence nutrients content, be it on a scale limited in time and in space.

For the purpose of monitoring the Belgian part of the continental shelf was divided into four areas.

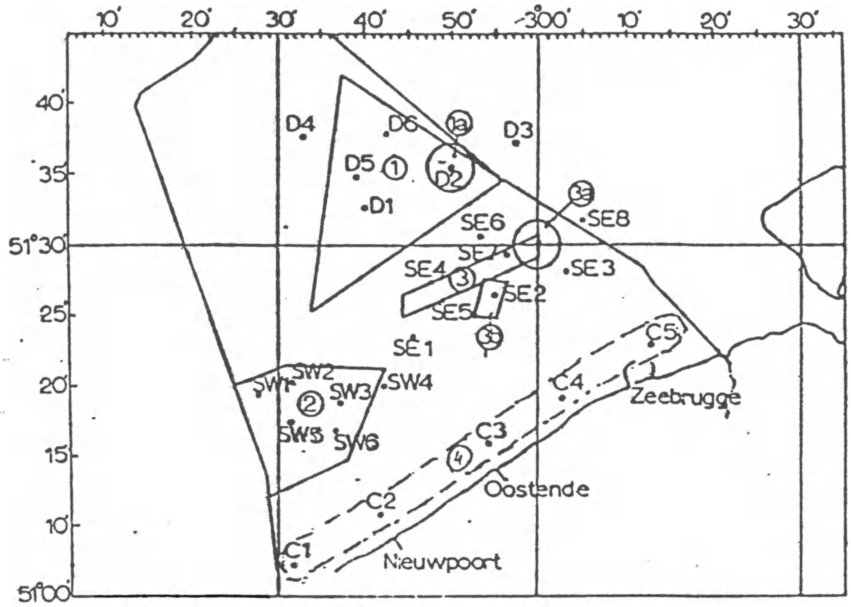

Fig. 1. Sampling points.

Area 1 is a dumping site where acid wastes from the production of titanium dioxide are discharged since 1985. Waste brines from the production of thiocarbomates and of alkylated compounds were dumped in sub-area 1a since 1977; from 1985 on, this is allowed in the whole area 1. Stations D1-3 were sampled from 1978 till 1984; stations D4-6 were added in 1985. Area 2 is the Western sand extraction zone. Area 3 is the Eastern sand extraction zone, with two temporary dumping sites. In area 3a, TiO_2- waste was discharged until 1984. In area 3b, wastes from the production of proteolytic enzymes and from phenolic compounds were dumped until 1983 and 1986 respectively. Stations SE1-3 were monitored only until 1985, the other points throughout the whole period. Area 4 is a coastal zone with five stations where there is a direct influence of land based pollution sources. The limited changes in sampling stations in areas 1 and 3 were not expected to influence comparability of data in time due to the rather small distances between the "old" and the "new" points.

This paper describes the evolution of nutrients over a ten years-period (1978-1987). Determinations were limited to nitrate/nitrite, ammonium, dissolved orthophosphate and silicate. Salinity, pH, dissolved oxygen content and transparency, which influence nutrients concentrations, were also reported.

Other parameters related more directly to the extraction and dumping activities such as sediment and biota analyses were already published (5) or will be reported separately.

2. MATERIALS AND METHODS

With some exceptions sampling was carried out four times a year. The sampling stations are mentioned in fig.1. Water was taken at about 1 m from the bottom of the sea by a Nansen or Niskin sampler.

- Dissolved oxygen : by the Winkler method (4)
- pH : directly with pH-meter
- Salinity : by titration with silver nitrate (4)
- Transparency with Secchi disc
- Nitrates/nitrites : by the cadmium reduction method according to Grasshoff (12)
- Ammonium : with Nessler reagent after accelerated microdiffusion (20)
- Dissolved orthophosphate : by the ascorbic acid method (4)
- Silicates : by the silicomolybdate procedure ; for concentrations below 1000 ug Si/l the heteropolyblue method was applied (4).

When possible, all samples were analysed immediately according to the methods described by Grasshoff (12).

When immediate analyses was not possible, samples were filtered and preserved for analysis later on in the laboratory.

3. RESULTS AND DISCUSSION

The evolution of the mean values of the different parameters is shown in figures 2 to 10.

- Salinity was as to be expected lower in the coastal area 4 due to river inputs; near the coast the percentage of river water is 10-15% (calculated from the difference in salinity) decreasing to a few ercentages in area 1, which leads to a seaward increasing gradient. No clear seasonal influence was noted. Due to the shallowness of the area there is no remarkable stratification of salinity in depth.

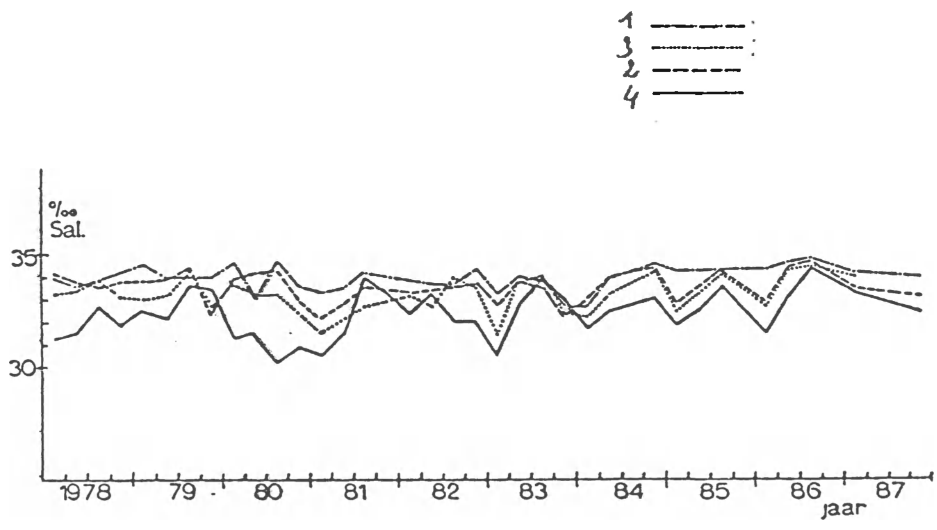

Fig. 2. Evolution of the mean values of salinity (‰)in the four areas.

- No marked difference neither in space nor in time were observed for the dissolved oxygen content. The percentage saturation was always high, indicating well aerated waters throughout the year and no expected negative effects of biochemical processes requiring oxygen e.g. nitrification of ammonium and nitrite. In absolute values, dissolved oxygen content was most of the time in the 8-10 mg O_2/l range, which is also the case over the North Sea as a whole (3).

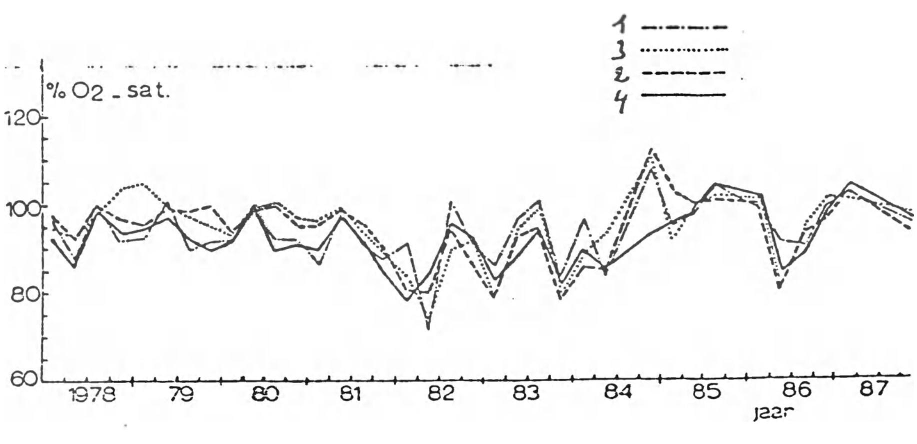

Fig. 3. Evolution of the mean values of dissolved oxygen (as saturation percentage) in the four areas.

- A very pronounced seaward increasing gradient in transparancy was observed (fig.4). Seasonal influences could not be detected. It should be stressed that transparancy is greatly influenced by the weather conditions (turbulence of the water) which can strongly vary.

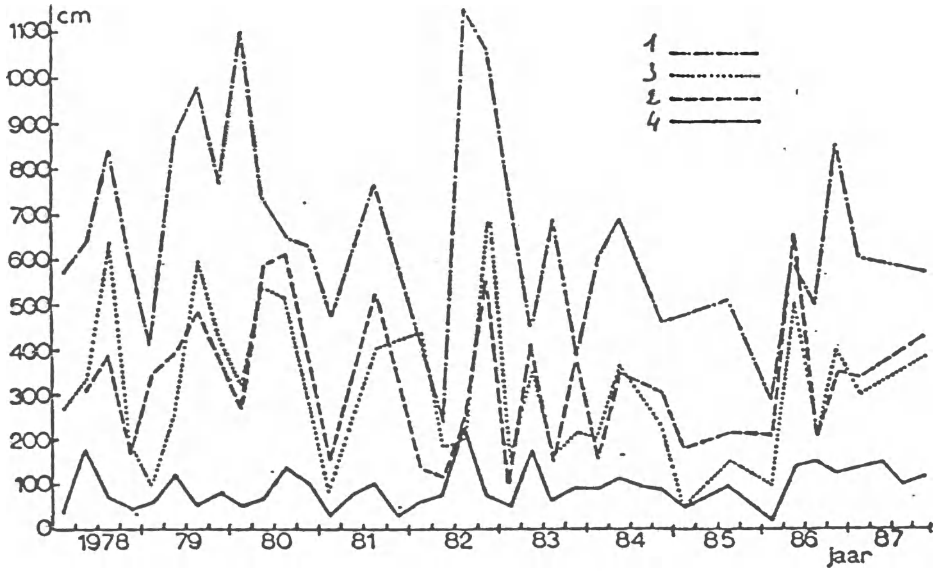

Fig. 4. Evolution of the mean transparency (Secchi) values in the four areas.

With a few exceptions, pH-values were also subject to a seaward increasing trend, due to deminishing influence of incoming water from telluric origin; this observation was also made in the neighbouring Dutch coastal waters (2). In most cases pH-values were higher in summer than in winter, partly due to the activity of algae which absorb CO_2 from the water, hence increasing the pH. This was also observed off the Dutch coast (2).

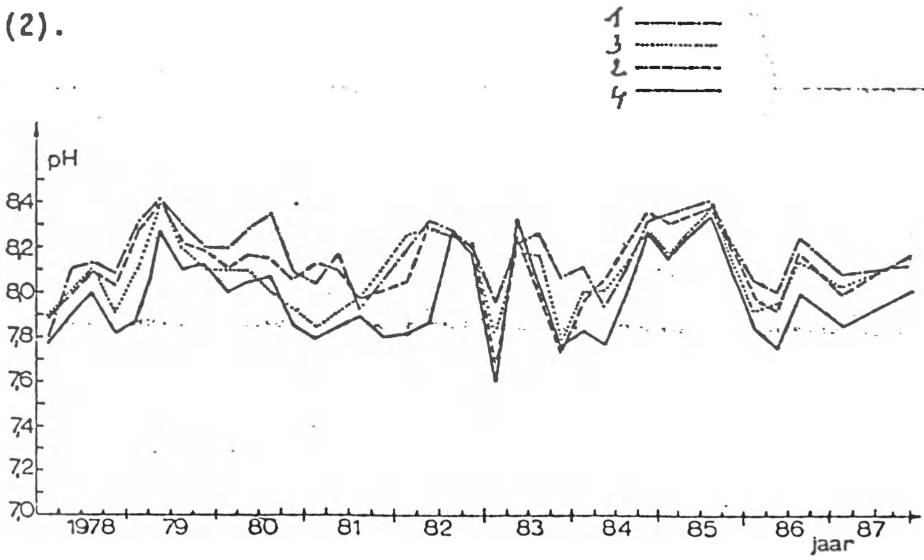

Fig. 5. Evolution of the mean pH-values in the four areas.

- Nitrates-N (the sum of NO_3^-/NO_2^-) showed typical annual peaks which occurred with a few exceptions in the first quarter of the year (winter). This pattern has been reported repeatedly in other areas of the North Sea (2)(3)(6). The data also indicated a seaward decreasing gradient in concentrations due to higher solubility of N in freshwater than in salt water and to inputs from anthropogenic origin near the coast. This was also reported off the Dutch and British coasts (2)(9). It is striking that values of areas 3 and 4 with the highest concentrations on the one hand and of areas 1 and 2 with the lowest concentrations on the other hand were quite similar. The lower concentrations in area 2 can be explained by an increasing dilution with the incoming Channel water which contains lower amounts of nitrogen and which follows the main NE-current passing about North of area 1. For area 3, which is situated even at a longer distance from the coast than area 2, the higher concentrations can be explained by the influence of the river Scheldt, the estuary mixing zone (gyre) still reaching this area (15).

In this respect, it should also be remarked that in coastal stations C4 and C5 concentrations were 30-50 % higher than in C1-C3. This is also due to the proximity of the river Scheldt. For reasons of comparison with the other areas and moreover because the other nutrients did not show this difference, they were included in area 4.

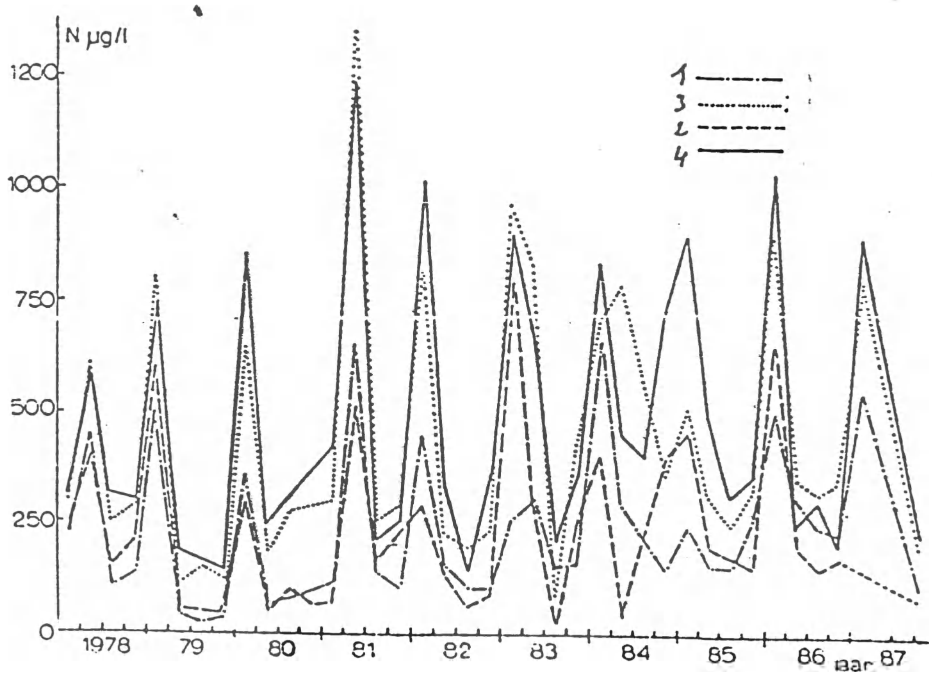

Fig. 6. Evolution of the mean nitrogen content from the sum of NO_3^- and NO_2^- in the four areas.

- Ammonium-N presented a less regular pattern and the differences between the four areas were not striking, although certainly from 1982 on, the coastal area 4 showed persistently the highest average values. This nutrient however is less stable than nitrate (10) and the formation and degradation processes are more complex. On the whole, a decrease in nitrate (spring) corresponded to an increase in ammonium-N, with peaks occurring generally 1 or 2 quarters later than for NO_3^-. This was also observed along the Dutch (22) and Danish coasts (1).

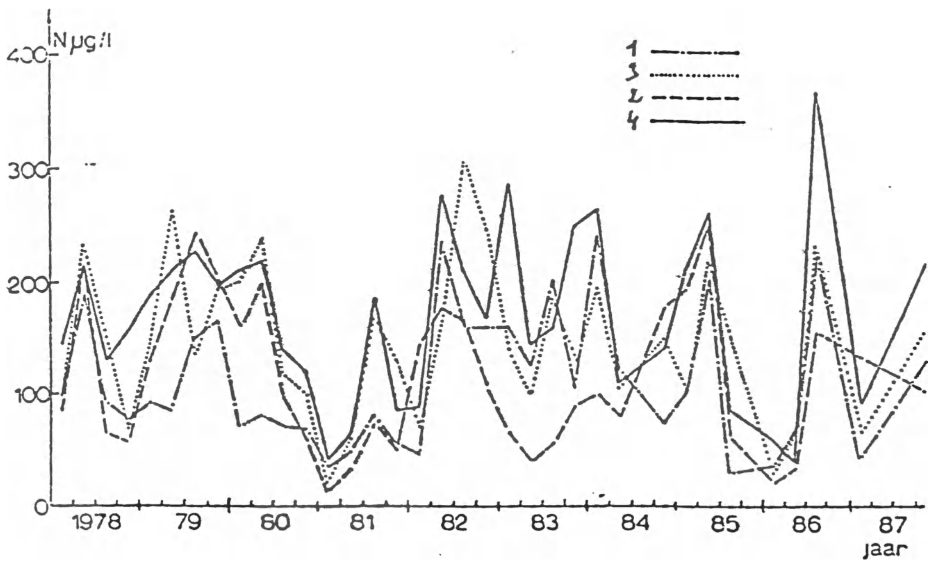

Fig. 7. Evolution of the mean nitrogen content as NH_4^+ in the four areas.

- Dissolved orthophosphate presented the same typical pattern as nitrate. For this nutrient there was also a seaward decreasing gradient with the highest concentrations occurring in areas 3 and 4.

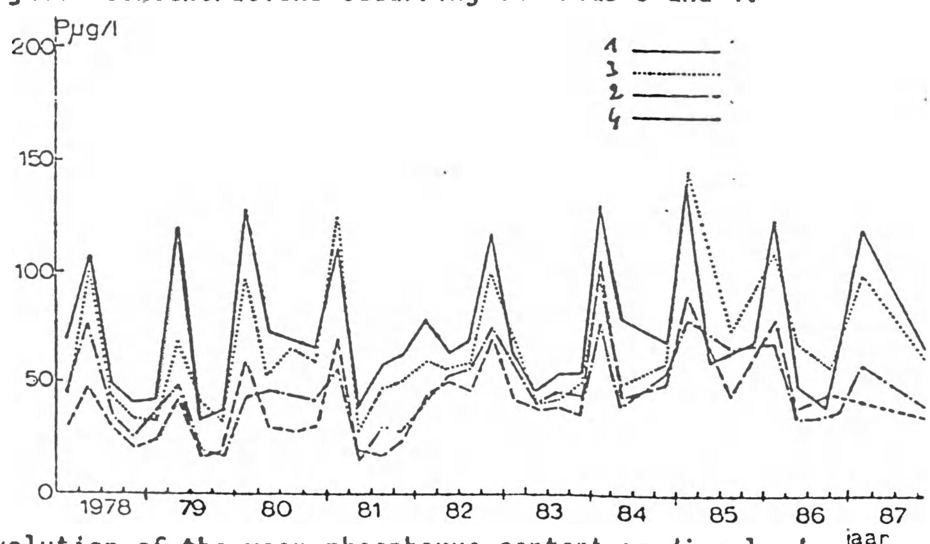

Fig. 8. Evolution of the mean phosphorus content as dissolved orthophosphate in the four areas.

- The N/P molar ratios were low in the periods of intense phytoplancton activity (mostly < 7) confirming the finding of other authors that nitrogen is the limiting factor in Belgian coastal waters and very often in other coastal zones (11)(13)(17), the theoretical optimum ratio being 16/1 (7)(18)(19). Clear differences between the four areas however were not shown.

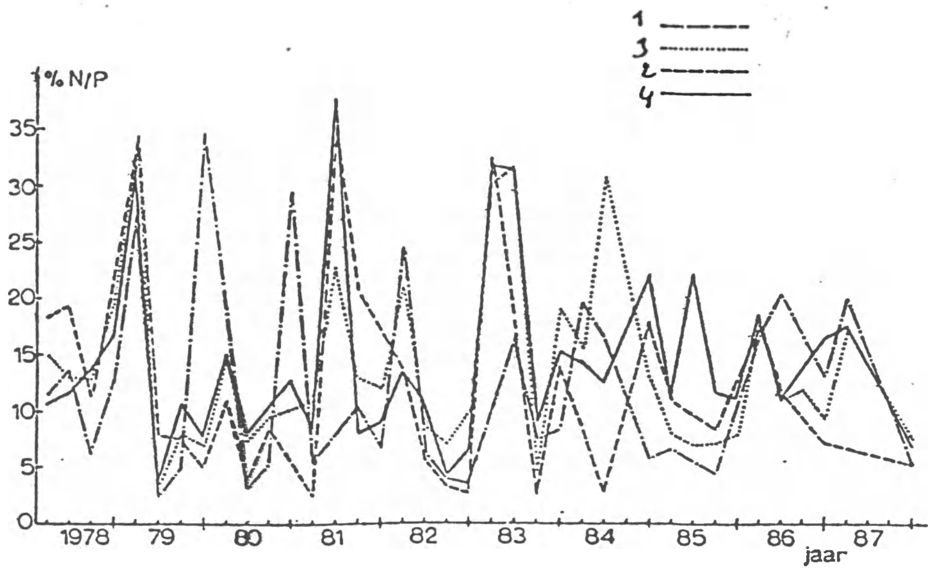

Fig. 9. The N/P molar ratios in the four areas.

- Silicate also showed the "winter peaks pattern" with a seaward decreasing gradient which is also reported off the Dutch coast (2). In this case however the concentration in the coastal area 4 was clearly higher than in the other areas, contrasting with the nitrate and phosphate contents.

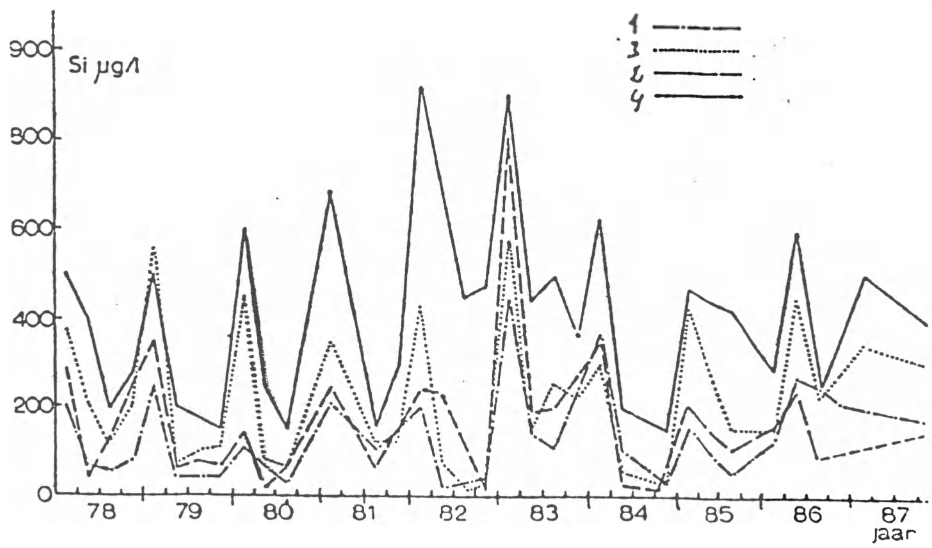

Fig. 10. Evolution of the silicate content in the four areas.

4. CONCLUSIONS

Linear regression on the peak values showed no significant trends, neither for nutrients nor for related parameters such as salinity, dissolved oxygen, transparency and pH.

On the other hand, there are strong indications that the nitrogen and phosphorus contents of the North Sea as a whole increased especially in the sixties and seventies (3)(9)(21) to reach a steady state in the eighties. Earlier observations in the Belgian coastal waters tend to confirm this. In 1970-72 peaks up to 350 ug NO_3^- - N/l were recorded in coastal waters off Nieuwpoort (8). In 1974-75 concentrations in winter reached 600 ug NO_3^-- N/l in Belgian coastal waters (16) while these values are markedly lower than the winter peaks recorded in the period 1978-87 (750-1250 ug NO_3^- - N/l for areas 3 and 4).

The main conclusion of the present survey is that the content of nutrients did not appear to have increased from 1978 to 1987. This was also observed in most parts of the North Sea as a whole (3)(21). In some coastal areas (Netherlands, Germany, Denmark) however a significant increase in N and especially P was observed due to the inputs from the rivers Scheldt and especially Rhine/Meuse and Elbe (1)(3)(22)(23). Silicates on the other hand remained at the same level (3)(21).

The second conclusion is that there was a seaward decreasing gradient with the highest values recorded in the coastal zone and in the estuary mixing zone of the river Scheldt.

Finally, no influence of the industrial activities (waste dumping and sand extractions) on the nutrient levels could be assessed.

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