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"ARE NUTRIENTS AND NUTRIENT RELATED PARAMETERS SUITABLE IN TREND MONITORING OF ANTROPOGENIC INFLUENCE ?"

By

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ABSTRACT

Examples of observations of nutrients from the North Sea, Skagerrak, Kattegat and some norwegian fjords are presented. The paper discuss the usefullness of such data in trend monitoring and how such data can be used and misused.

INTRODUCTION

Nutrients have, especially during the last years, been in focus as a threat to the marine environment. Politicians and mass media as well, are mentioning nutrients as should they be toxic to marine life. Some restricted areas are known scientifically to be hyperthrophic resulting in oxygen depletion and low diversity of organismes. The reasons for this are well known, a too high load of nutrients from land based sources, mainly domestic sewage and agriculture drain off.

The experience with the *Chrysochromulina polylepis* bloom in may-june this year demonstrated the potential of a plankton bloom as well as the attention of the public to events taking place in the environment. As often recognised when unforseen events take place is the lack of knowledge about the conditions previous to the event.

The availability of nutrients for a plankton bloom may determine the magnitude of the bloom. Knowledge of the dynamical distribution of the nutrients prior to and during the bloom may give a basis for advise of the possible development of the bloom. In the special and rather dramatic plankton bloom this year we do have measurments of nutrients from the whole area a couple of weeks previous to the start of the bloom. However, we do not have a state of readiness or an instrument suitable of digesting and presenting nutrient data on a current day to day advisory manner.

Measurements of nutrients in the sea in an amount necessary to give a picture of both the vertical and horizontal dynamic distribution are a laborious work. We have during the last decade been able to do extensive sampling and analysis of the nutrients in the North Sea area (Føyn, 1986 and 1987). These data, mainly sampled in late autum/winter situations, may serve as a basis for trend analysis.

MATERIALS AND METHODES

Phosphate, nitrite, nitrate and silicate are the main components analysed (Føyn et al. 1981). In addition the oxygen content is analysed onboard, in water samples from standard ICES depths, at selected hydrographical sections and in the fjords. Chlorophyl is measured for control of biological activity, the water samples are filterd onboard and the filters are storde deepfrozen untill analysis at the institute. Preferably the analysis of nutrients are performed onboard or the samples are stored in the cool and preserved by chloroform (Hagebø and Rey, 1984).

In addition to the area covered in the North Sea, the Skagerrak and the Kattegat, 27 fjords from Rogaland in the south to Finnmark in the north of Norway have been monitored regularly once every november/december during the last decade. Unfortunately we stored the watersamples for nutrient determinations, from the fjords, deep-frozen prior to 1981 and consquently these early values are usefull only for a relative understanding of the nutrient load of the fjords.

RESULTS AND DISCUSSION

Nutrients take part in the biological cycles and the concentrations of nutrients in the watercolumn will reflect this. Trends may therefor be hidden whithin the seasonal variations. Even a winter situation without any significant biological activity may not, without reservations, be looked upon as stable and repetitive.

The deep - water of fjords with a pronounced treshold will however be able to reflect an increasing load of nutrients to the fjord. The removal of the deep-water by inflowing more saline water will, however, in some fjords on a regular yearly basis and in others with changeing regularity, disturb the trend picture. Trend analysis must therfore be based on rather long term observation series where these factors are minimized.

The variations in the contens of oxygen in periodical stagnant deep-water of fjords may serve as a good indicator of a changeing situastion. The well known development in the Oslofjord from the introduction of the water closet at the beginning of the century to the first observed severe oxygen depletion in 1949/50 is an example of a long term gradually change in the marine environment. Observations from the mid-thirties of a biological change was assumed to be conected to the use of the fjord as reciepient for untreated domestic sewage and thereby an increase in nutrients in the fjordwater. The increase of nutrients was well documented in the early fifthies and the removal of phosphate from the sewage water was proposed as a suitable solution. Unfortunately this recomandation was about twentyfive years too early to be recognised by the authorities.

The example from the Oslofjord demonstrates that, with the present knowledge and the public concern for the marine environment, a monitoring of the nutrients load in the fjord could have flagged the detrimental development prior to the point when the hyperthrophication became a serious threat to the marine environment of the Oslofjord.

We have, hopefully, by our monitoring in norwegian fjords a possibility to give an early warning should the nutrient load increase. Fig. 1 presents an example from a fjord, Lysefjorden, in the southwest part of Norway. Lysefjorden has a shallow threshold at the inlet, and the fjord is therefore vulnerable as a reciepient for domestic sewage. There is only a scattered population boardring the fjord which at present restricts the discharges.

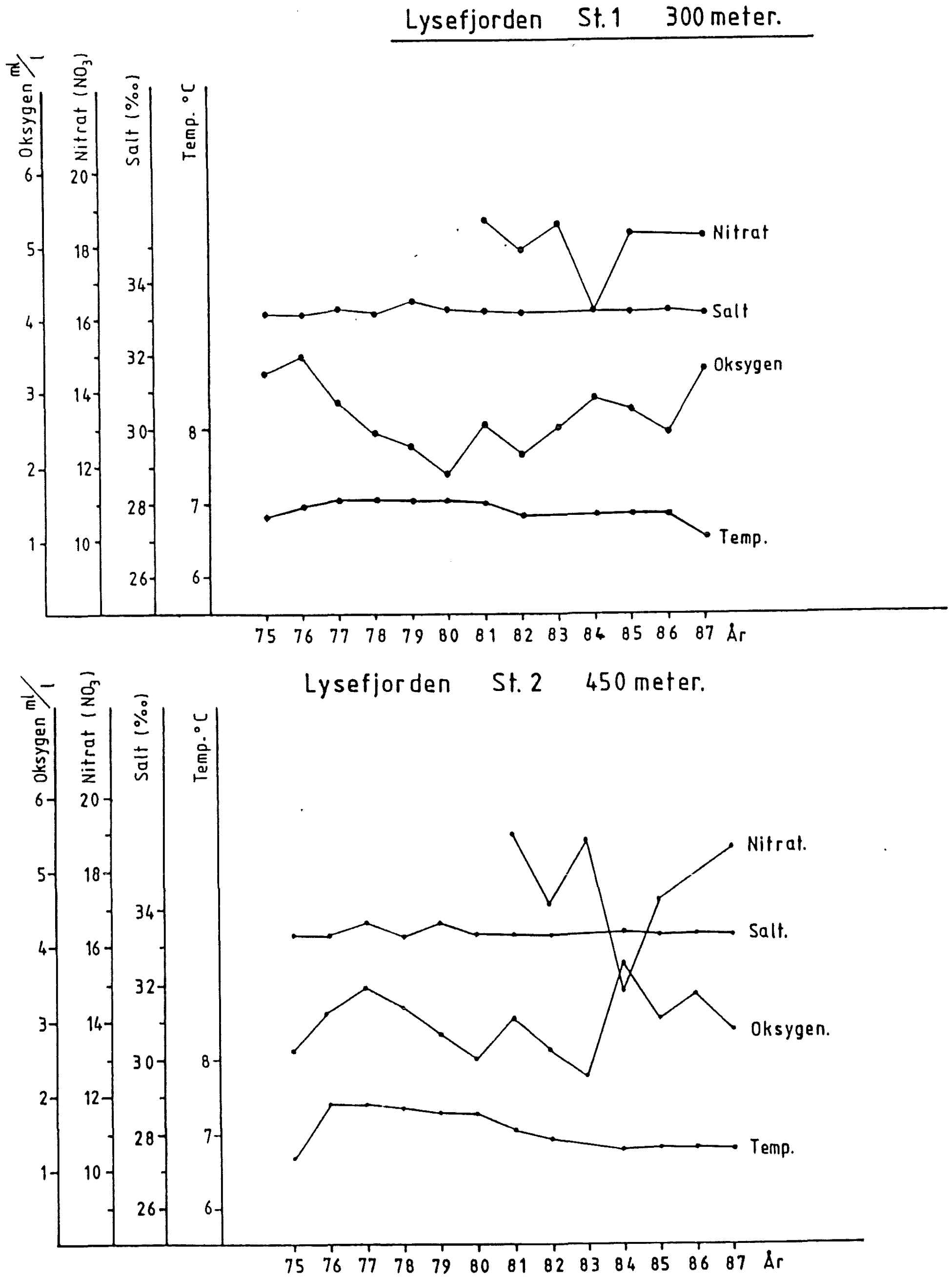

Figure 1. Oxygen(ml/l), nitrate(µM), salinity and temperature observations from november in the inner part of the Lysefjord. St.1 is located at the head of the fjord. St. 2 is located at the deepest part of the fjord.

No particulare trend, i.e. increasing or decreasing, can be seen from the observations. But in desipte of a variability in the nitrate and oxygen values we may charcterise the deep-water of the fjord to be in a steady state situation. The data show however an interesting observation of a slight renewal of the water in the deepest part of the fjord, St.2, 450 m, in 1983/84. Neither the salinity data nor the temperatur data indicates any renewal of the bottom water, but the decrease in the nutrients (nitrate) and the increase in the oxygen content clearly indicate such renewal. Monitoring of nutrients combined with oxygen observations in fjords with a pronounced threshold, provided the time series are adequate for the purpose, may well be suitable in trend analysis.

In the open sea where the antropogenic influence will be relatively limited the time series and the accuracy of the nutrient measurements will be critical. Unforunately there is a serious lack of time series of nutrients data from open sea areas. Weichart,1986, has demonstrated how valuable old nutrient data may become. By comparing data from the German Bight observed by Kalle in the winter of 1935 and 1936 with his own data from the winter of 1978 and 1985 he found an increase in the phosphate values between 2 to 4 from 1935/36 to 1978, but no further increase from 1978 to 1985. This increase in phosphate values was however limitided to near shore waters. In the more open waters of the German Bight there were observed no increase in the phosphate values since 1935. The work of Weichart,1986, clearly shows that trend analysis on nutrients may be done provided the time series or the distance in time are long enough. The observations that the high nutrient load is limited to the near coastal area in the German Bight is confirmed by our own data as fig. 2 may be an example of.

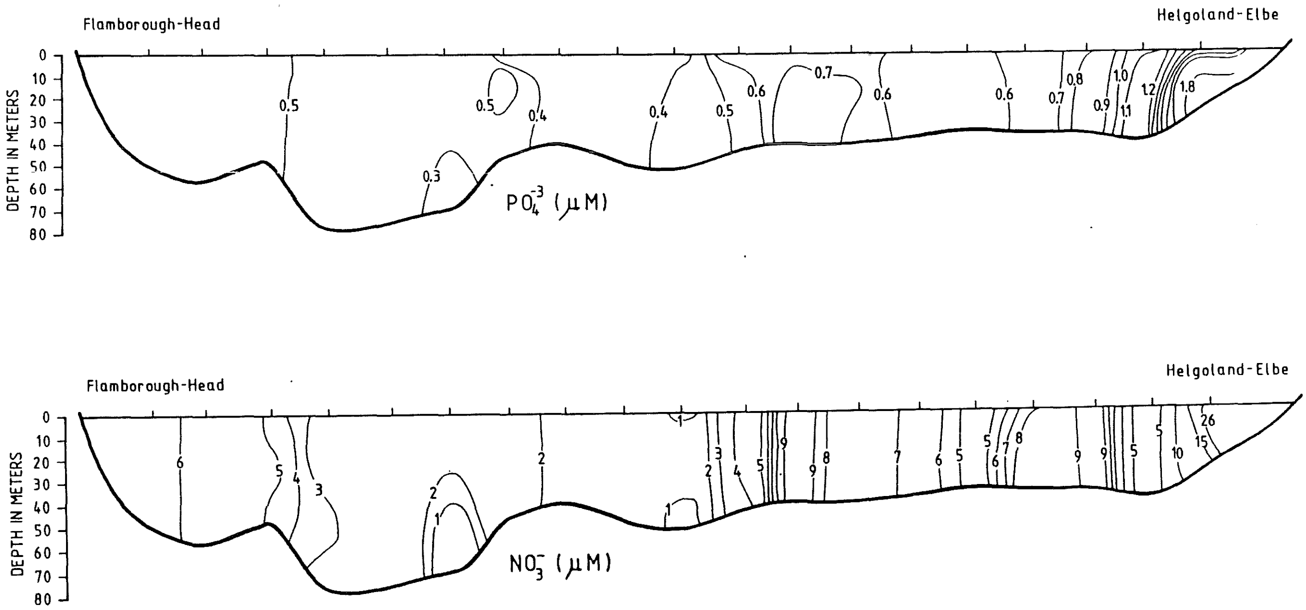

Figure 2. Nitrate and phosphate values from a cross section in the southern part of the North Sea. Data collected on a cruise on R/V G. O. SARS in november 1987.

Our late autum/winter observations from the North Sea have shown an accumulation of nutrients over the northern plateau during the summer and autum (Føyn,1986 and 1987). An example of this is presented in fig. 3 where nitrate data are plotted from the cross section from Feie, just north of Bergen, to the northern point of the Shetland islands, in the beginning of november 1987.

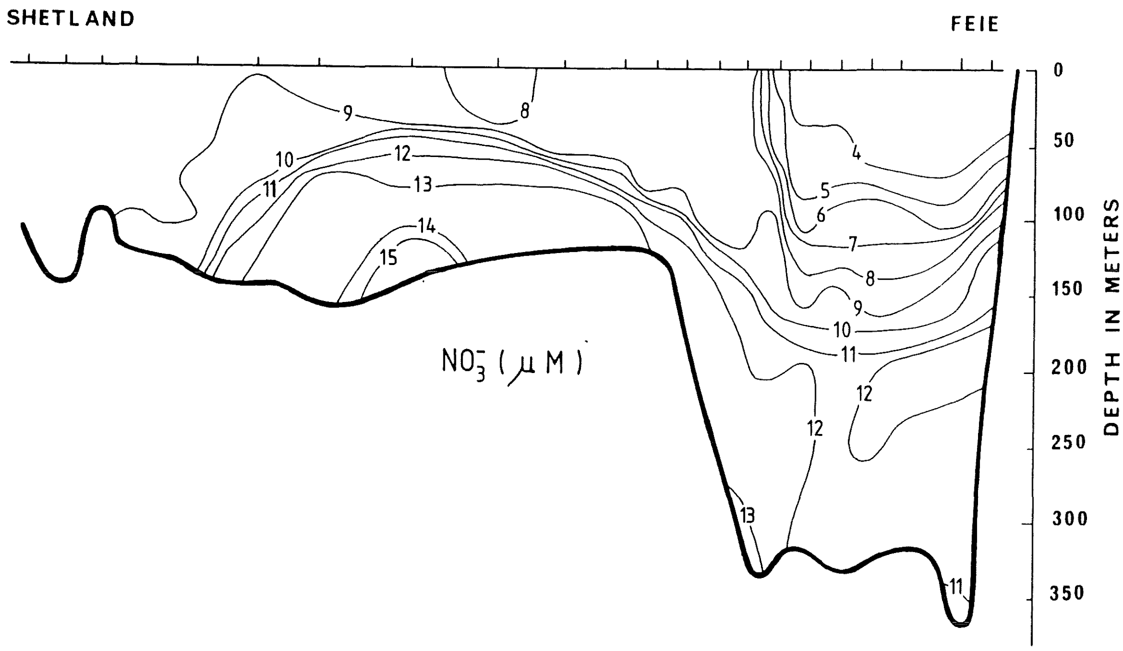

Figure 3. Nitrate values at the cross section, Feie - Shetland, in the northern part of the North Sea. Data collected on a cruise on R/V G. O. SARS in november 1987.

The pronounced accumulation of nutrients over the northern plateau extending from 61^0 N to 58^0 N have been observed by us at this time of the year during the last decade. During the winter the nutrient layers are broken down and the nutrients are probably mixed within the whole watermass. The mechanismes regulateing this accumulation may be that of an eddy extending from the surface to the bottom, trapping organic material in the surface layers for mineralisation in the deeper layers.

The watermasses over the northern North Sea plateau could be reflecting the load of nutrients to the whole North Sea and consequently trends must then be found in the nutrient data. In Fig. 4 all our nitrate data from the november/december cruises are plotted. The two plots represents data from 100 m depth Fig. 4, A, and data from 75m and to the bottom Fig. 4, B.

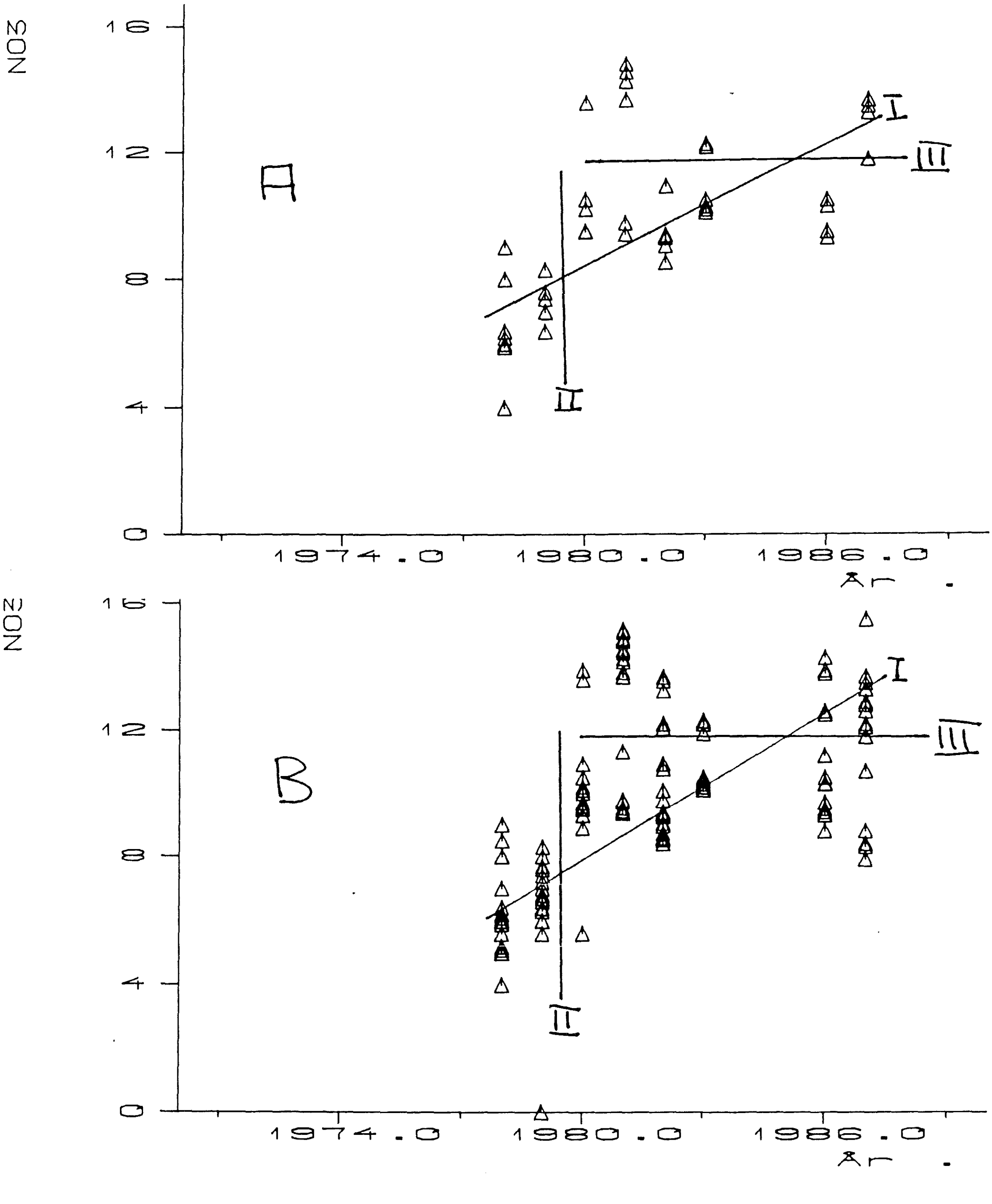

Figure 4. Plots of nitrate (μM) in a time serie from 1978 to 1987, data from the cross section Feie - Shetland. A represents the values from the depth of 100 m. B represents values from the depth of 75 m to the bottom.

The data presented in Fig. 4 may be interpreted in different ways. By just looking at the plots one would easely assume that there is an evident increasing trend in the nutrient values as the line I in both plots indicate. However, by disregarding the data from the years prior to 1980, line II, we may well draw the line III which show no increase in the measured nitrate values. The data from the period prior to 1980 are not correct, our methode of storing samples and analysing them ashore gave too low values. As we have had hand of the data and have performed the analysis as well, we are certanly avare of the fact that our data prior to 1980 have a quality not suitable for other purposes than to give a relative picture of the nutrient distribution in the wattermass. Therefore line I, in both plots, have to be disregarded, and line III stand as the correct ones.

These two plots may be an example of a set of data that may very well be misused to show an increase of nutrients in the area. Beeing aware of the lack of accuracy in the data prior to 1980 the conclusion must be that the data set shows no increase in the nitrate values in this area. The data show however, in my opnion, that long and geographical extended time series of nutrient measurments may be usefull for trend monitoring of anthropogenic influence, provided the area in concern has a stable periode of several months each year.

Monitoring of nutrients may also serve as an early warning for possible plankton blooms. Our measurements just prior to the dramatic bloom of *Chrysochromulina* this year, should have told us that there was a rather unusual nutrient situation in some parts of the Skagerrak/ Kattegat area. This was most pronounced in the cross section between Fredrikshavn in Denmark and Gøteborg in Sweden representing the boarder between Skagerrak and Kattegat. The nitrate values measured here, in 30 m depth, in the last week of april 1988 were almost threefold of the values measured at the same cross section in the first week of december 1987. This should in some way have been alarming. The fact that the ratio between nitrate, phosphate and silicate were quite different from a "normal" situation in that both phophate and silicate were nearly depleted in the water while nitrate was present in more than sufficient amounts. This special conditionts laid the ground for this particular bloom.

The *Chrysochromulina* bloom have learnt us a lesson not to disregard peculiarities in the sea. However, there will be great difficulties in predicting blooms or even to think about the type of bloom. But monitoring of the essential basis, i.e. the nutrients, for phytoplankton production may at least give some "early warning" evidence of the possibility to have an extensive plankton bloom.

AKNOWLEDGEMENT

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