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LONG-TERM CHANGES IN PRIMARY PRODUCTION AND CHLOROPHYLL CONCENTRATIONS IN THE SOUTHERN BALTIC

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The paper presents results of long-term investigations on primary production and chlorophyll *a* concentrations at two stations in the Southern Baltic (in the Gdańsk Deep and in the Bornholm Deep). The data show increasing trends in the annual primary production and mean chlorophyll *a* contents. A mean increase in the annual primary production within the recent years is estimated at 1–2% per year.

INTRODUCTION

Long-term studies on hydrobiological parameters provide data allowing to estimate changes occurring in the sea water. Sampling frequency in such studies has not always been adequate; however, it is interesting to follow trends of changes in order to predict the course of numerous processes and work out their mathematical models. Long-term changes of different hydrochemical parameters were discussed by Fonselius (1969, 1980), Nehring (1982), and Nehring et al. (1984).

An increase in concentration of nutrients leads to increasing phytoplankton biomass. Increasing trends in primary production were observed in different regions of the Baltic Sea and described by Aertebjerg Nielsen et al. (1981), Gargas et al. (1978), Schulz et al. (1982), Stemann Nielsen (1965a), and Wulff et al. (1986).

Our studies in the Gdańsk Deep have also demonstrated an increasing trend in chlorophyll concentration. Increases in primary production and chlorophyll contents were accompanied by simultaneous increases in zooplankton biomass (Ciszewski 1985; Kurzyk et al. 1983; Mańkowski 1978; Renk et al. 1985).

Increasing trends in chlorophyll concentration and phytoplankton production at two sampling sites situated in the open part of the Baltic Sea are described in the present paper.

MATERIALS AND METHODS

The paper is based on data collected by the authors at two stations: P1 (Gdańsk Deep: 54°50´ N, 19°20´ E) and P5 (Bornholm Deep: 55°15´ N) during long-term studies on primary production and chlorophyll *a* concentration within 1970–1988. Some results of those studies were already published by Renk (1975, 1983) and Nakonieczny et al. (1989).

Primary production was measured by the ^{14}C methods (Anonymus 1981: Gargas 1975; Steemann Nielsen 1952, 1965b). The annual primary production was calculated as in our previous work (Renk et al. 1988).

The chlorophyll *a* concentration was estimated spectrophotometrically. Until 1980, chlorophyll *a* contents were calculated according to the SCOR-UNESCO formulae (Anonymus 1966); later on, the calculations followed Jeffrey and Humphrey (1975).

The mean chlorophyll concentration in the euphotic layer was calculated from three measurements taken at 0, 5, and 10 m. To calculate trends in chlorophyll changes, chlorophyll *a* contents in the summer months (June – September) were used.

RESULTS AND DISCUSSION

Chlorophyll *a* concentration in the euphotic layer were observed to fluctuate considerably in time (Renk et al. 1983, 1985). These fluctuations as well as a low frequency of chlorophyll measurements make it difficult to estimate the mean chlorophyll *a* content in a given year. Estimation of long-term changes in chlorophyll concentrations is not easy either.

As in our previous paper (Nakonieczny et al. 1989), here, too, we disregarded data on chlorophyll *a* content collected during spring phytoplankton blooms.

Figs 1 and 2 show mean chlorophyll contents in the euphotic layer at two stations visited in this study. The plots shown demonstrate significant increasing trends in the chlorophyll concentrations. The relevant trend equations are as follows:

$$\text{chl (P1)} = 1.670 + 0.082\ (t - 1970)$$

$$\text{chl (P5)} = 1.172 + 0.0709\ (t - 1970)$$

The figures show also that the chlorophyll concentrations in the Gdańsk Deep are higher than those in the Bornholm Basin. Phytoplankton biomass in the Gdańsk Deep and in the Bornholm Basin increases annually by 4.9 and 6%, respectively.

Similarly to the increasing trends in chlorophyll *a* concentrations, increasing trends in annual primary production can be observed as well. Figs 3 and 4 illustrate changes in the annual primary production in the Gdańsk and Bornholm Deeps. The regression lines describing the annual primary production trends are expressed by the following equations:

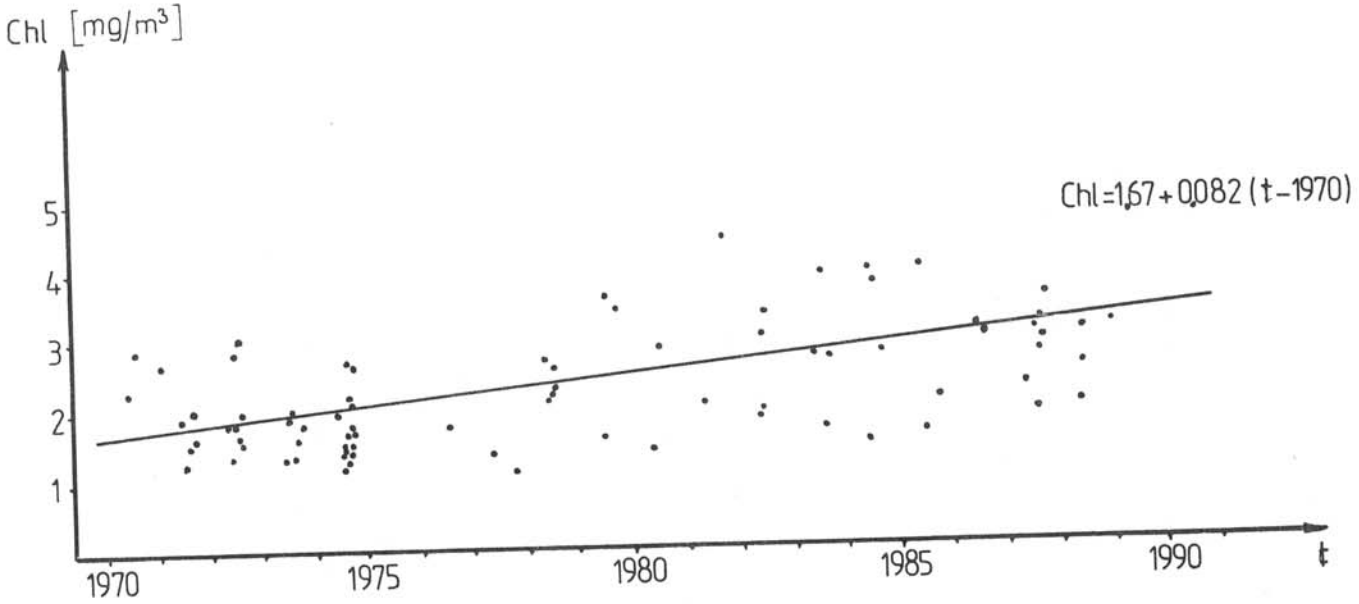

Fig. 1. Mean chlorophyll concentrations in 0—10 m layer in summer (June — September) in the Gdańsk Deep

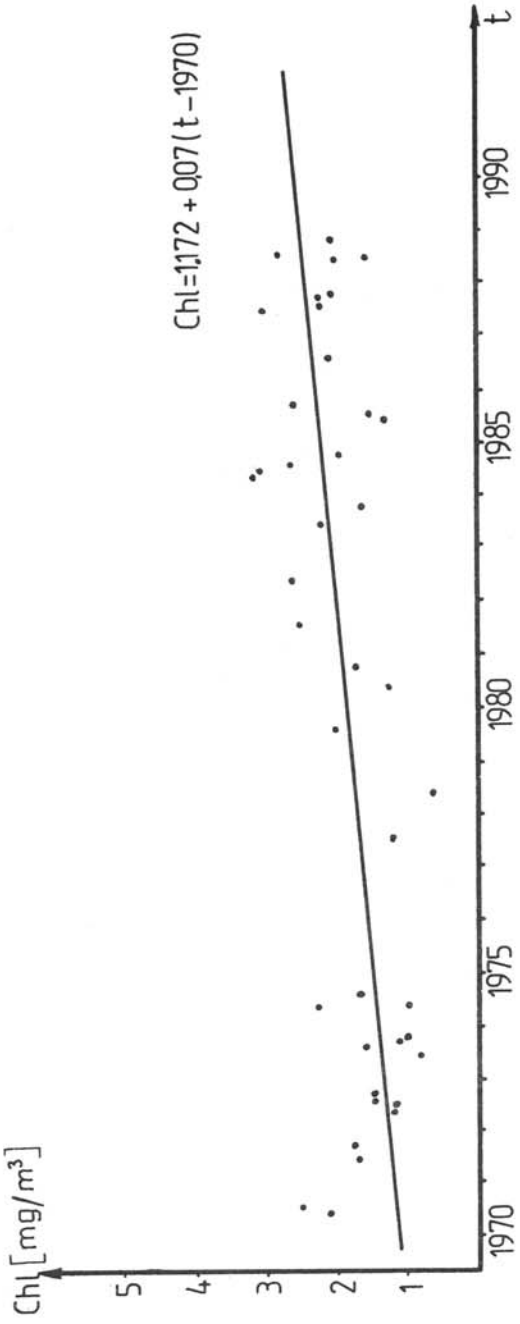

Fig. 2. Mean chlorophyll concentrations in 0–10 m layer in summer (June – September) in the Bornholm Basin

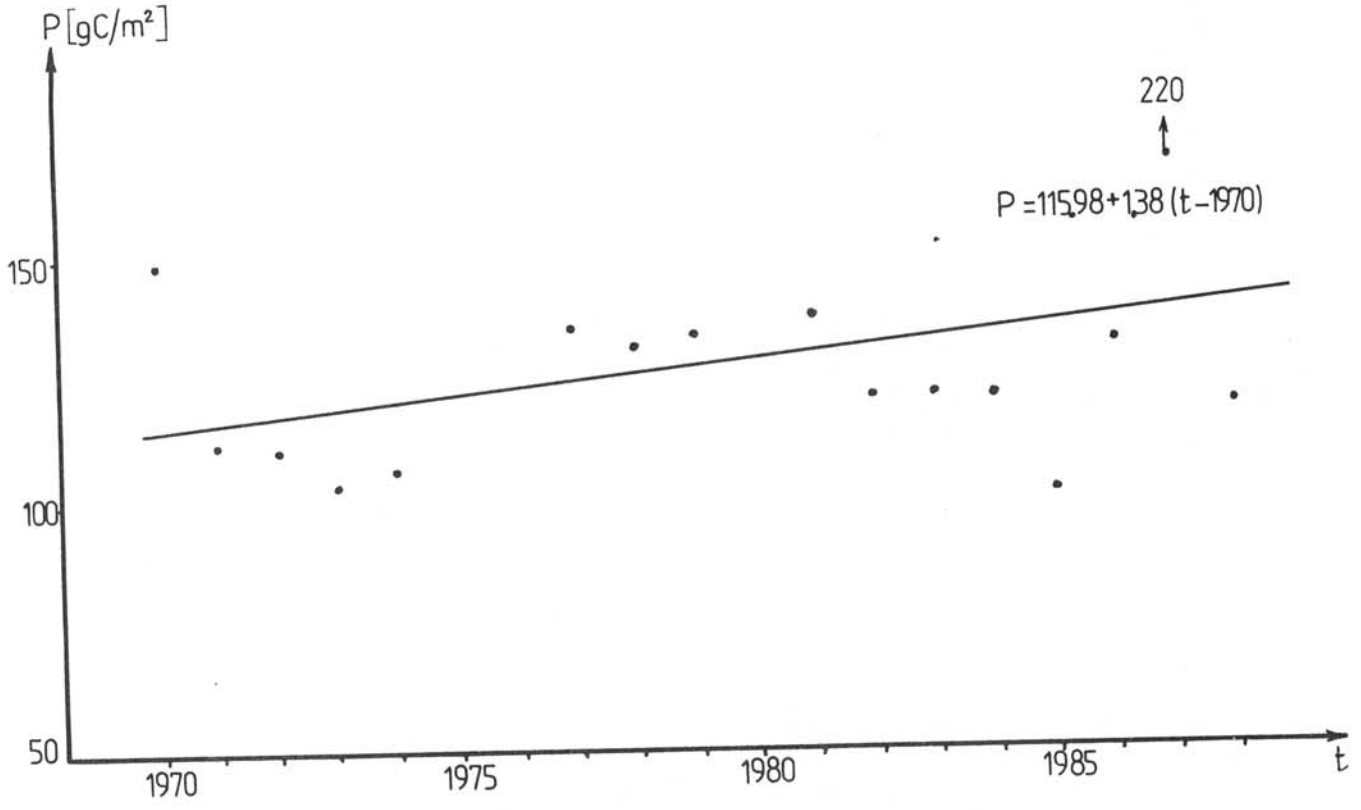

Fig. 3. Annual primary production in the Gdańsk Deep

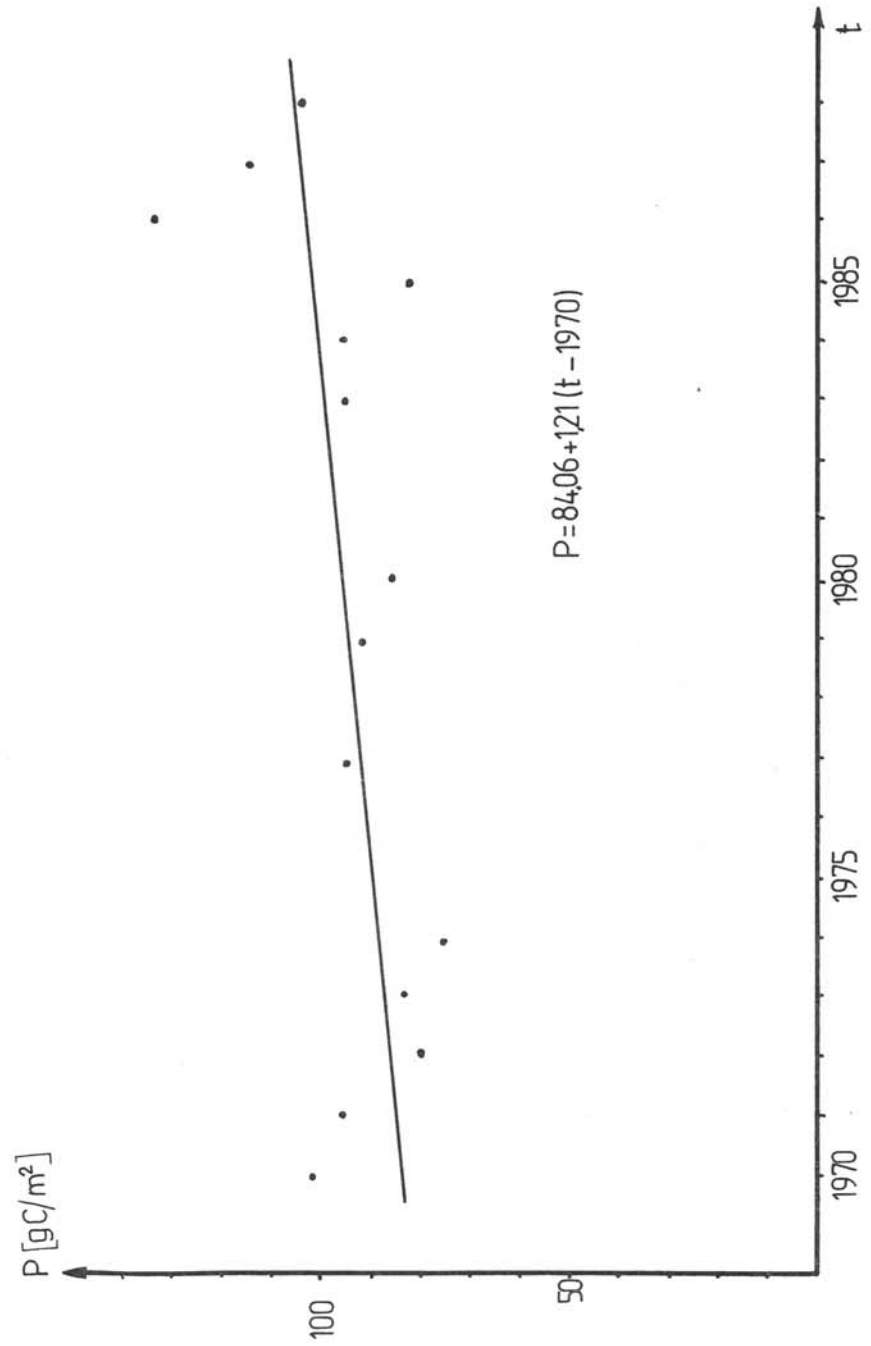

Fig. 4. Annual primary production in the Bornholm Deep

$P(P1) = 115.98 + 1.38\,(t - 1970)$

$P(P5) = 84.06 + 1.21\,(t - 1970)$

As we decided to disregard the years with data obtained less frequently than 6 times a year, mean production values are not shown, in some cases, in Figs 3 and 4, although measurements were taken every year.

Phytoplankton production in the Gdańsk Deep and in the Bornholm Basin increased each year by, on the average, 1.2 and 1.4%, respectively.

Regardless of the considerable variability of the annual primary production in individual years, significant increasing trends in phytoplankton production and chlorophyll concentration are observed. Increasing trends in primary production have also been observed by other authors (Aertebjerg Nielsen et al. 1981; Gargas et al. 1978; Schulz et al. 1982;Steemann Nielsen 1965a; Wulff et al. 1986). A distinct increasing trend in zooplankton biomass was observed in the Baltic as well (Ciszewski 1985).

The increase in summer phytoplankton production coincides with increasing concentrations of inorganic nitrogen within the same period, which was observed by Nehring et al. (1984) and Wulff et al. (1986).

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