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PRIMARY PRODUCTION AND CHLOROPHYLL IN THE GULF OF GDAŃSK IN 1987–1988

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The paper presents data on primary production and chlorophyll *a* concentrations at two stations located in the Gulf of Gdańsk (Baltic Sea).

The primary production in 1987 was much higher than the mean values for the region, observed in other years when the production was 125–200 g C/m^2a. Our observations show the primary production in the Puck Bay to be approximately two times that in offshore waters of the Gdańsk Deep. The chlorophyll contents decrease along the Vistula estuary – Gdańsk Deep transect.

INTRODUCTION

Preliminary studies on primary production in the Gulf of Gdańsk began in 1965 (Dera and Bojanowski 1966; Rochon 1968). At first, they were carried out as pilot studies which could barely make it possible to estimate the order of magnitude of the primary production in various seasons, vertical distribution of production, and the thickness of the euphotic layer. During the next years, besides investigating the coastal areas, a preliminary estimation of primary production in the open regions of the Southern Baltic was carried out. Studies on primary production and concentration of chlorophyll *a* in the Gulf of Gdańsk have been gaining momentum since 1970 (Renk 1971, 1973).

In the 1970's, more systematic studies on chlorophyll *a* distribution in the Gulf of Gdańsk were carried out by Renk et al. (1974, 1976), Latała et al. (1980), and Latała (1985). Intensity of photosynthesis and concentrations of chlorophyll were shown to fluctuate significantly, which makes it difficult to estimate the primary production. In 1987, a programme of complex hydrobiological investigations of the Gulf of Gdańsk was commenced by a group of researchers from the Sea Fisheries Institute in Gdynia.

MATERIALS AND METHODS

Primary production and chlorophyll *a* concentrations were measured within February 1987 – end of 1988 (19 cruises in 1987 and 8 cruises in 1988) at two stations located in the Gulf of Gdańsk: G-2 (Gdańsk Deep: 54°50′ N, 19°20′ E; 108 m depth) and 92A (Puck Bay: 54°34.4′N, 18°40′ E; 36 m depth). Primary production and chlorophyll concentration were measured at the depths of 0, 3, 5, 10, 15, and 20 m. Apart from these, sea water samples were taken at the following depths: 0, 5, 10, 15, 20, 25, 30 m and further on every 10m to the bottom. Equal volumes of water were taken at each depth to determine an average chlorophyll concentration in the following layers: 0–15, 15–30, 30–60, and 60–90 m, (depending on the station depth).

Chlorophyll *a* concentration was measured spectrophotometrically. Sea water was filtered through Whatman GF/F glass filters. The filters with plankton collected on them were stored frozen until the end of a cruise. Chlorophyll was extracted with 50% aquaeous acetone solution at room temperature (Anonymus 1984; Edler 1979). The chlorophyll concentration was calculated according to formulae of Jeffrey and Humphrey (1975).

Primary production was estimated using the radioisotope method (Steemann Nielsen 1952, 1965). Water samples with radioactive sodium carbonate (^{14}C) were incubated in situ for 4 hours around noon. Once the incubation was completed, the contents of each bottle were filtered through membrane (Millipore 0.45 μm) filters. Filter activity was determined with a Geiger-Müller counter.

Alkalinity of the sea water was measured with a modified method of Anderson and Robinson (1946).

RESULTS AND DISCUSSION

Chlorophyll *a*

Figs 1 and 2 show seasonal changes in chlorophyll *a* concentrations in different layers at the two stations, G-2 and 92A, in 1987. The highest concentrations occurred in the 0–15 m layer, concentrations of the pigment being much lower at deeper levels. This pattern was observed from April to October. However, during the late autumn and winter, the water in the isohaline Layer became mixed and chlorophyll concentrations were almost uniform throughout the water column. In the deepest layer (60–90 m), chlorophyll concentrations were lower. The peaks of chlorophyll content occurred in early spring, as illustrated in those figures showing seasonal changes in chlorophyll concentrations (Figs 1–4). It can be seen that the periods of maximum chlorophyll concentrations at the offshore station (G-2) are much shorter than those at the inshore station (92A). This results from a rapid exhaustion of nutrients during the spring

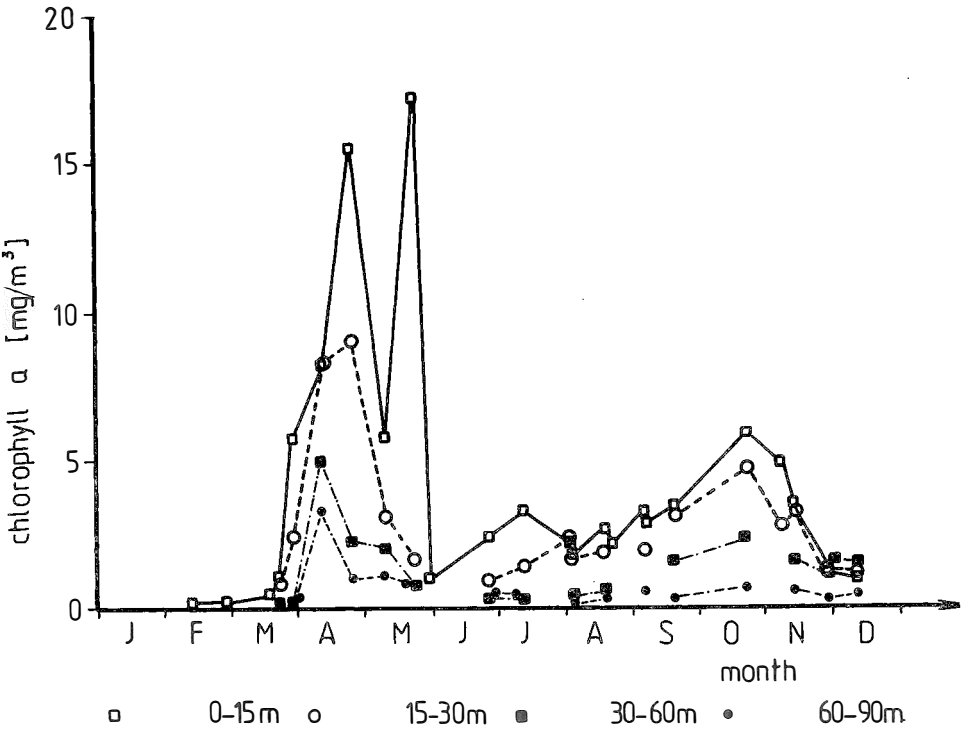

Fig. 1. Seasonal changes of chlorophyll *a* concentration in different water layers at G-2 (Gdańsk Deep) in 1987

phytoplankton bloom in the open sea, whereupon the bloom becomes inhibited. However, in the areas affected by river discharges, the spring bloom is sustained by nutrients brought in by the river.

In 1987, the spring phytoplankton bloom in the Gulf of Gdańsk proceeded in two stages: the first bloom in April was caused by the *Bacillariophyceae* and the second one, in May, by *Gonyaulax catenata* (Bralewska, pers. comm.).

Figs 3 and 4 show changes of chlorophyll concentration within 0–15 m in 1987–1988 against the background of an averaged course of seasonal changes in chlorophyll concentration in the Gdańsk Deep. The averaged course of seasonal changes in chlorophyll at G-2 was derived from a set of long-term (1970–1987) data on chlorophyll (Renk 1987). Fig. 3 shows that seasonal changes of chlorophyll in 1987 approximated the averaged course, while the concentrations in 1987–1988 were higher than the values averaged over the long-term period. Due to a low sampling intensity in 1988, no typical spring bloom could be observed at G-2, the bloom being delayed at 92A. The course of seasonal changes of chlorophyll in the Puck Bay differs from that in the Gdańsk Deep, chlorophyll concentrations being higher in the former. This confirms conclusions of previous investigations (Latała 1985; Renk 1973, 1983).

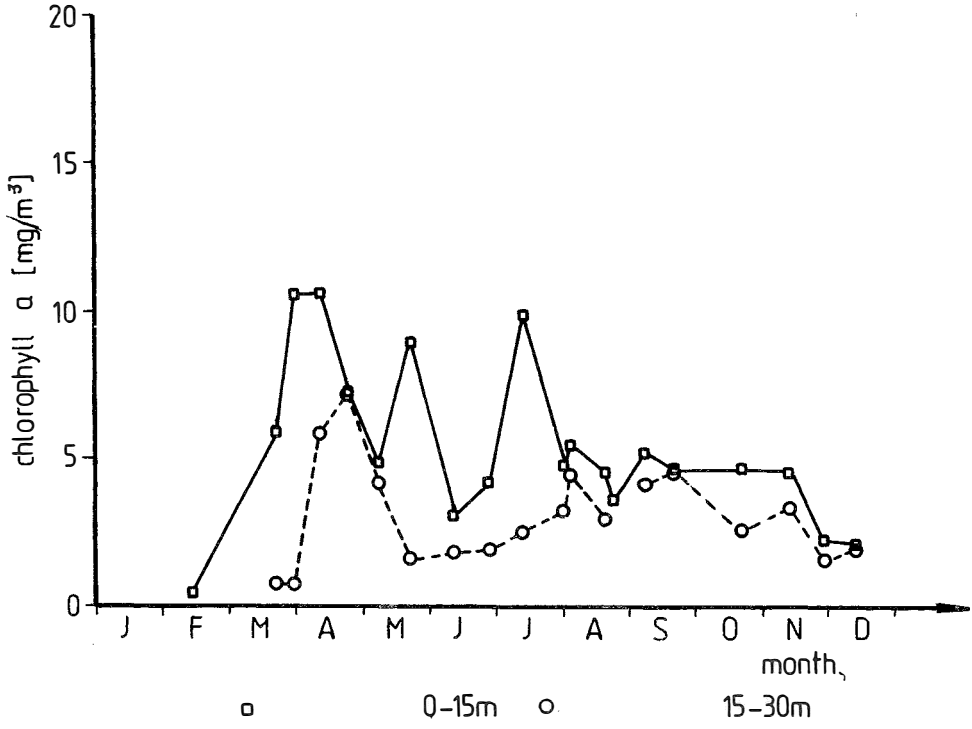

Fig. 2. Seasonal changes of chlorophyll *a* concentration in different water layers at 92A (Puck Bay) in 1987

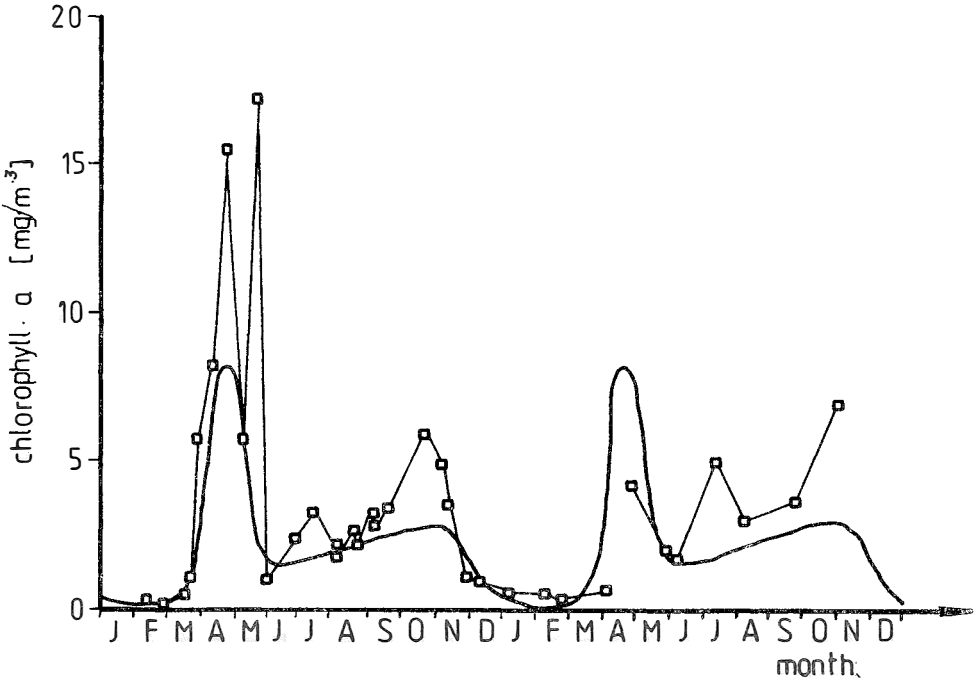

Fig. 3. Seasonal changes of chlorophyll *a* concentration within 0–15 m layer at G-2 (Gdańsk Deep) in 1987–1988 compared with long-term average

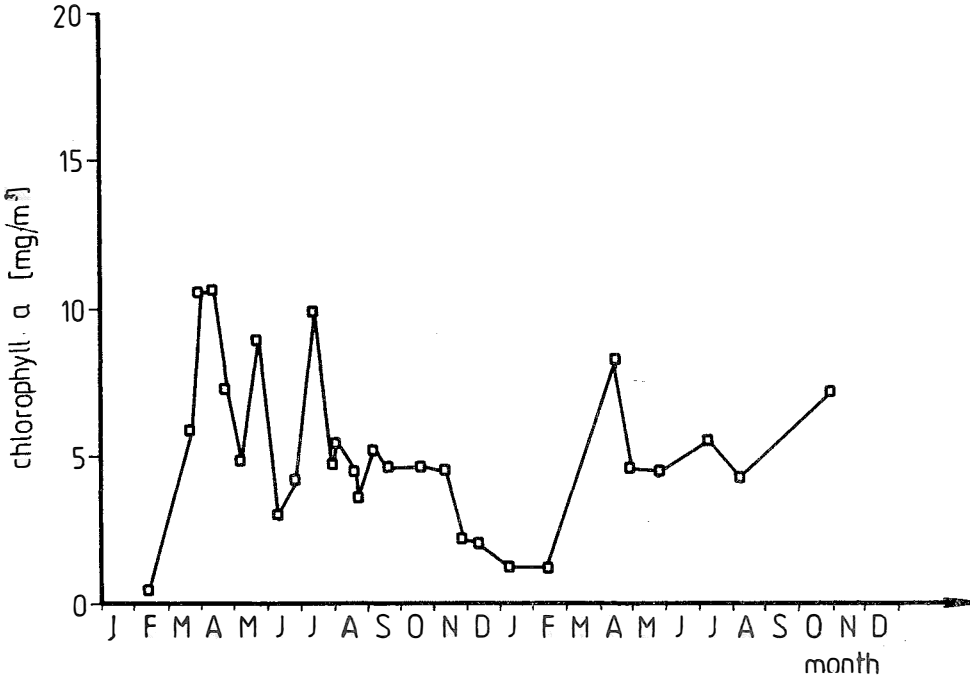

Fig. 4. Seasonal changes of chlorophyll *a* concentration within 0—15 m layer at 92A (Puck Bay) in 1987—1988

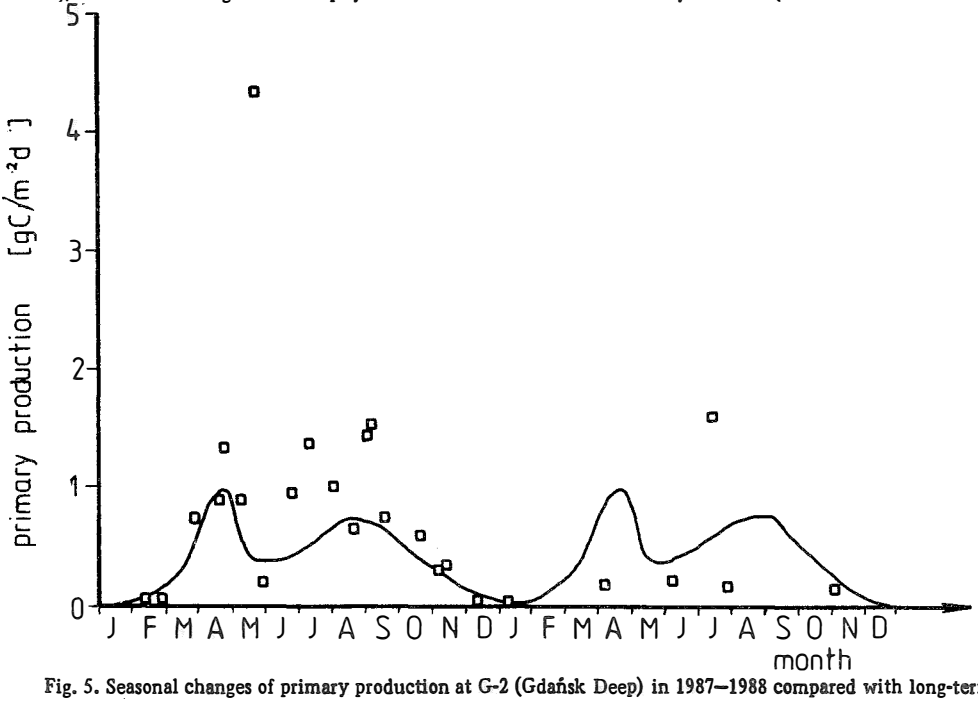

Fig. 5. Seasonal changes of primary production at G-2 (Gdańsk Deep) in 1987—1988 compared with long-term average

Primary production

Fig. 5 illustrates changes in primary production at G-2 and shows an averaged course of seasonal changes in primary production in the Gdańsk Deep as derived from measurements carried out within 1966–1987. In 1987, primary production was considerably higher than the long-term average. The annual mean primary production in the Gdańsk Deep is 124.4 g C/m^2. Table 1 summarizes data on quarterly and annual production at the two stations. In 1987, a record-breaking primary production (220 g C/m^2) was observed in the Gdańsk Deep, a value never recorded before. In 1987, primary production in the Puck Bay (92A) was also very high (303 g C/m^2). Data on primary production at 92A against the background of the averaged course of its seasonal changes in the Puck Bay are illustrated in Fig. 6. The curve includes data collected within 1965–1984 at other stations of the area as well. Figs 5 and 6 show additionally that the 1988 primary production in the entire Gulf of Gdańsk was lower than the long-term average.

Analysis of the graphs shown in the figures allows to conclude that the peak chlorophyll concentrations coincide with the primary production maxima.

It is surprising to observe that in 1987, when a very high primary production was recorded, the water temperature in the euphotic layer of the Gdańsk Deep in spring

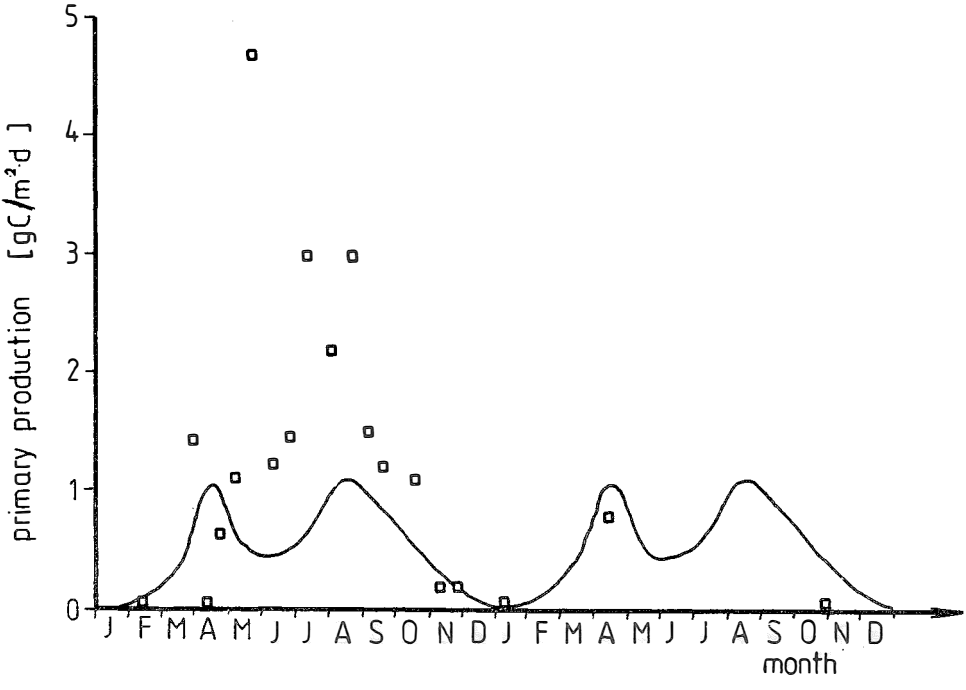

Fig. 6. Seasonal changes of primary production at 92A (Puck Bay) in 1987–1988 compared with long-term average

Table 1

Quarterly and annual primary production (P.P., g C/m^2)

Station	Year(s)	Quarterly primary production				Annual P.P.
		I	II	III	IV	
G-2	1987	5.12	107.85	84.94	22.21	220.12
G-2	1988	6.74	37.58	60.46	13.58	118.36
G-2	1966–1987	6.69	52.49	51.87	13.38	124.43
92A	1987	11.69	116.00	145.92	30.04	303.65
Gulf of Gdańsk	1965–1984	12.32	47.61	60.82	14.21	134.96

and summer was lower than the long-term average, as a lower temperature would be expected to be accompanied by a lower intensity of photosynthesis. On the other hand, it seems obvious that the mesozooplankton biomass is lower at lower temperatures, the grazing intensity being lower, too. This may explain the higher chloropyll concentrations and higher primary production in 1987.

In 1987, primary production was also affected by nutrient concentrations. It is well known that certain nitrogen compounds limit the primary production. As shown by the data obtained from the Institute of Meteorology and Water Management in Gdynia, concentrations of inorganic nitrogen in the euphotic layer in the area were higher in 1987 than the long-term average.

CONCLUSIONS

1. The annual primary production in the Gdańsk Deep and Puck Bay is 220 and 330 g C/m^2, respectively.

2. In 1987, primary production in the Gulf of Gdańsk was almost two times higher than the long-term average.

3. In 1988, primary production in the Gulf of Gdańsk was slightly lower than the long-term average.

4. In 1987–1988, chlorophyll *a* concentrations in the Gulf of Gdańsk were higher than the long-term average.

REFERENCES

Anderson D.R., R.J. Robinson, 1946: Rapid electrometric determination of the alkalinity of sea water using glass electrode. Ind. Eng. Chemistry Ann. Ed., **18**: 767–769.

Anonymus, 1984: Guidelines for the Baltic Monitoring Programme for the second stage. Baltic Sea Environ. Proc. **12**: 249 pp.

Dera J., R. Bojanowski, 1966: Wstępne badania warunków fotosyntezy w wodach Zatoki Gdańskiej. Acta Geophys. Pol., **14**: 23–31.

Edler L., 1979: Recommendations on methods for marine biological studies in the Baltic Sea. Phytoplankton and chlorophyll. BMB Publ. **5**, 38 pp.

Jeffrey S.W., G.F. Humphrey, 1975: New spectrophotometric equations for determining chlorophylls a, b and c in higher plants, algae and natural phytoplankton. Biochem. Physiol. Pflanzen: 167 pp.

Latała A., 1985: Zawartość chlorofilu w wodach powierzchniowych Zatoki Gdańskiej właściwej w roku 1981. Studia Mater. Oceanolog., **46**: 11–22.

Latała A., J. Dąbrowska, M. Pliński, 1980: Koncentracje chlorofilu – a, b, c w wodzie powierzchniowej Zatoki Puckiej w roku 1976 na tle zmian w składzie fitoplanktonu. Zesz. Nauk. Uniw. Gdańsk., Ser. Oceanogr., **7**: 99–109.

Renk H., 1971: Wpływ fosfogipsu na pierwotną produkcję biologiczną. In: Wpływ zrzutu fosfogipsu na biocenozę Zatoki Gdańskiej. Pol. Tow. Geofiz. Sopot: 35–83.

Renk H., 1973: Produkcja pierwotna południowego Bałtyku. Prace MIR Gdyni, **A17**: 157–180.

Renk H., 1983: Light conditions, chlorophyll distribution and primary production in the Southern Baltic. Pol. Ecol. Stud., **9**: 311–329.

Renk H., 1987: Produkcja fitoplanktonu polskiej strefy rybołówstwa (Południowy Bałtyk). Stud. Mat. MIR Gdyni, **A28**: 41–81.

Renk H., H. Torbicki, S. Ochocki, 1974: Influence of river water on the distribution of phytoplankton biomass. Proc. 9th Conf. Baltic Oceanographers, Kiel: 198–210.

Renk H., H. Torbicki, S. Ochocki, 1976: Rozmieszczenie chlorofilu w morzu w rejonach ujściowych rzek. Studia Mat. Oceanolog., **15**: 187–202.

Rochon T., 1968: On primary production in the Southern Baltic (1966–1967). ICES Plankton Cttee, CM/D.

Steemann Nielsen E., 1952: The use of radiocarbon C-14 for measuring organic production in the sea. J. Cons. Int. Explor. Mer, **18**: 117–140.

Steemann Nielsen E., 1965: On the determination of the activity in ^{14}C-ampoules for measuring primary production. Limnol. Oceanogr., **1-Suppl.**: R247–R252.

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