

PHYTOPLANKTON PRODUCTIVITY IN THE PELAGIC ZONE OF LAKE PIASECZNO IN THE EVALUATION OF ITS TROPHIC STATE IN THE SUMMER SEASONS OF 2005–2007

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Summary. The aim of the present study was to determine the rate of eutrophication of Lake Piaseczno (Łęczna-Włodawa Lakeland) in the summer seasons of 2005–2007. In the trophogenic zone of the pelagial, values of gross primary production of phytoplankton and chlorophyll *a* concentration were measured, and values of Carlson's Trophic State Index (TSIChl *a*) were calculated. Increased values of gross primary production of phytoplankton in the study period of 2005–2007 indicated intensified eutrophication of the waters of Lake Piaseczno, however, the values of chlorophyll *a* concentration and TSIChl *a* did not exceed levels typical of mesotrophy.

Key words: lake, phytoplankton, productivity, chlorophyll *a*, eutrophication, TSIChl *a*

INTRODUCTION

Lake Piaseczno, which is considered to be a mesotrophic lake and which is the deepest and one of the most environmentally valuable lakes of the Łęczna-Włodawa Lakeland, has been subjected to a significant impact of dietary minerals intensifying eutrophication as a result of diverse anthropopressure (agriculture, intensified tourist traffic, activities of hard coal mines) from the beginning of the 1970's [Wojciechowski 1976, Wojciechowski *et al.* 1995, Serafin and Czernaś 2003, Czernaś and Serafin 2007]. In spite of specific morphometric and topographic characteristics of Lake Piaseczno, compensating eutrophication pressure, changes are observed, among others, in the species composition and productivity of phytoplankton, determining the specificity of metabolism and the trophic status of the lake [Wojciechowski *et al.* 1995]. The values of the following biological trophic indicators: gross primary production of phytoplankton, chlorophyll *a*

concentration, as well as Carlson's Trophic State Index (TSIChl *a*) calculated on their basis, are competent in the evaluation of the trophic state of the lake waters in the pelagic zone. Therefore, the aim of the present study was to determine water fertility and to analyse the rate of eutrophication of Lake Piaseczno in the summer seasons of 2005–2007 based on the studied indicators.

MATERIALS AND METHODS

Measurements of the values of the biological trophy indicators were made in the trophogenic zone of the pelagial of Lake Piaseczno in the deepest place of the lake (38.8 m) at the following depths: 0.75, 2.5, 5 and 10 m, on 9 sampling dates falling within the full summer season (July) in the years 2005–2007. Gross primary production of phytoplankton was measured using the oxygen method in „light” and „dark” bottles [Vollenweider 1969], with the determination of dissolved oxygen concentration in the water using the Winkler iodometric titration method [Hermanowicz *et al.* 1976]. The amount of oxygen released for the consecutive study periods was converted into the amount of carbon assimilated per 1 m² per hour (mg C_{ass} m⁻² h⁻¹), accepting [after Strickland 1960] that 1 g of oxygen released corresponded to 0.312 g of carbon assimilated. The obtained results, after converting them into mg C_{ass} m⁻² d⁻¹ (accepting that d = 12 h), were referred to the ranges determining lake trophy according to Kajak [1994]. The concentration of chlorophyll *a*, as the most important photosynthetically active pigment for all autotrophic algae, including cyanobacteria [Krupa *et al.* 1991], indirectly indicating primary production of phytoplankton, was analysed using the spectrophotometric method [Nusch 1980] and it was presented in mg Chl.*a*·m⁻² for the consecutive sampling dates. Based on the chlorophyll *a* concentration values expressed in µg Chl *a* dm⁻³, Carlson's Trophic State Index was calculated [Carlson 1977].

RESULTS

Gross primary production of phytoplankton for the trophogenic zone of the pelagial of Lake Piaseczno in the study period had the following range of values: 103.3–372.9 mg C_{ass} m⁻² h⁻¹, with the seasonal mean in the study period: 238.7 mg C_{ass} m⁻² h⁻¹ (see Fig. 1). The obtained values for gross primary production of phytoplankton, after their conversion according to the standards of Kajak [1994], covered the following range: 1239.6–4474.8 mg C_{ass} m⁻² d⁻¹, exceeding the limit values characterising mesotrophy. The chlorophyll *a* concentration took values in the range of 16.8–23.3 mg Chl *a* m⁻², with the seasonal mean in the study period at 19.8 mg Chl *a* m⁻² (see Fig. 1), attesting – after the conversion into mg Chl *a* m⁻³ – to the mesotrophic character of Lake Piaseczno [Kajak 1994].

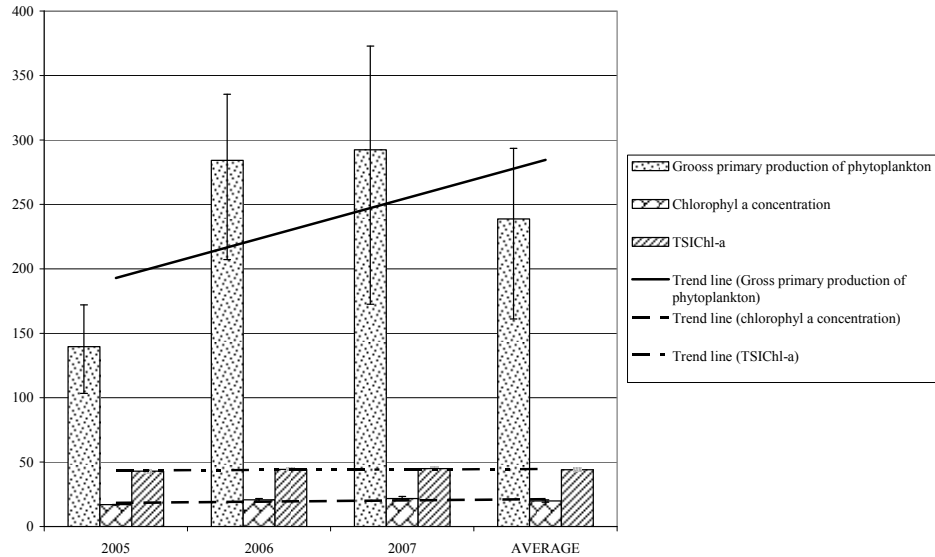


Fig. 1. Mean seasonal (summer) values with fluctuation ranges and exponential trend lines for gross primary production of phytoplankton ($\text{mg C}_{\text{ass}} \text{m}^{-2} \text{h}^{-1}$), chlorophyll *a* concentration ($\text{mg Chl } a \text{m}^{-2}$) and Carlson's Trophic State Index (TSIChl *a*) in the pelagic zone of Lake Piaseczno in the study seasons of 2005–2007

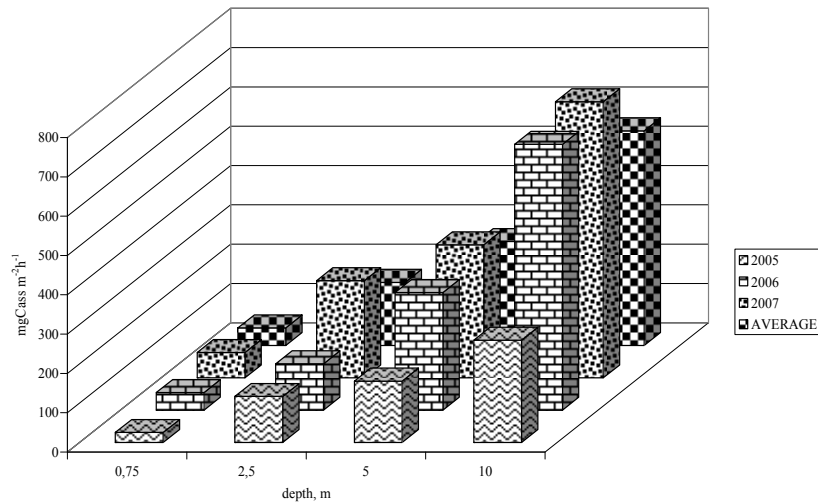


Fig. 2. Mean seasonal (summer) values of gross primary production of phytoplankton in the pelagic zone of Lake Piaseczno for different depths in the study seasons of 2005–2007

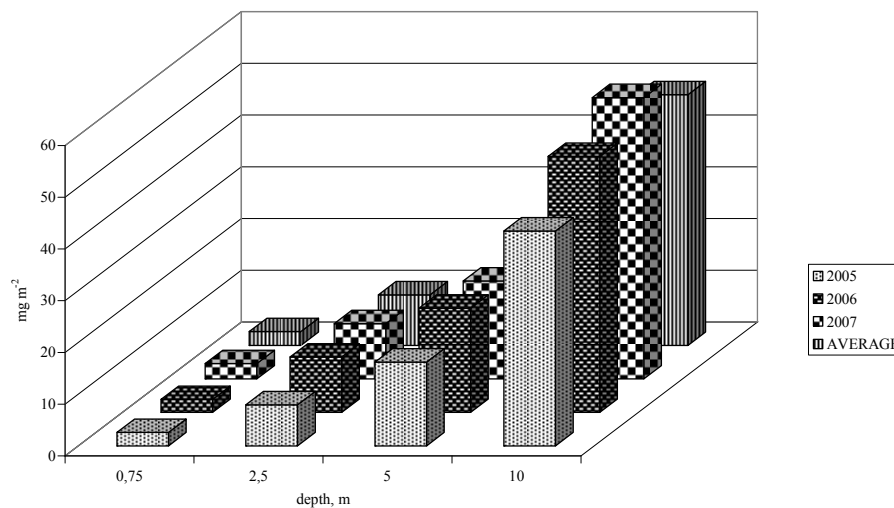


Fig. 3. Mean seasonal (summer) values of chlorophyll *a* concentration in the pelagic zone of Lake Piaseczno for different depths in the study seasons of 2005–2007

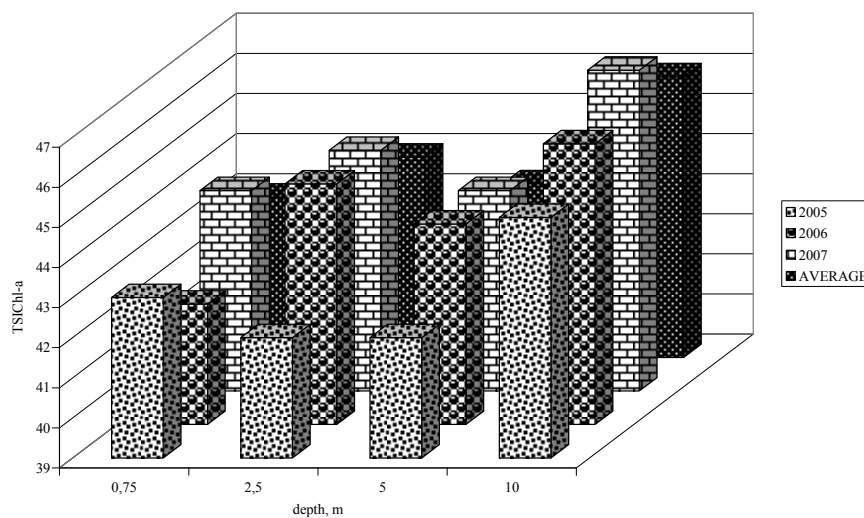


Fig. 4. Mean seasonal (summer) values of Carlson's Trophic State Index (TSIChl *a*) in the pelagic zone of Lake Piaseczno for different depths in the study seasons of 2005–2007

Carlson's Trophic State Index (TSIChl *a*) had values showing small variation in the range of 42–46, with the seasonal mean in the study period standing at 44.1, also attesting to the mesotrophic character of the lake. The lowest values of the investigated biological trophy indicators were noted in 2005, with the sum-

mer season mean for gross primary production of phytoplankton at a level of $139.6 \text{ mg C}_{\text{ass}} \text{ m}^{-2} \text{ h}^{-1}$, for chlorophyll *a* concentration = $17.1 \text{ mg Chl } a \text{ m}^{-2}$, and for TSIChl *a* = 43 (Fig. 1). The highest values of the studied parameters were obtained in 2007 at, respectively, $292.3 \text{ mg C}_{\text{ass}} \text{ m}^{-2} \text{ h}^{-1}$ (gross primary production of phytoplankton), $21.7 \text{ mg Chl } a \text{ m}^{-2}$ (chlorophyll *a* concentration) and 45 (TSIChl *a*) – Fig. 1. Hence, for the consecutive seasons of the study, progression in gross primary production of phytoplankton and relatively constant values of the other parameters studied were found (see Fig. 1). With respect to the depth variation of the trophogenic zone of the pelagial, the highest values of the biological trophy indicators were noted at a depth of 10 m (Figs 2 and 3), whereas the index TSIChl *a* had values showing small variation at all the depths investigated (Fig. 4).

DISCUSSION

Still in the 1950's, Lake Piaseczno was determined to be oligotrophic [Wilgat 1954]. Changes in the use of the catchment area of this water body, oriented towards the intensification of agriculture and stationary recreation, gave rise to the pressure of dietary minerals on the lake waters and to phenomena related to eutrophication [Serafin 2008]. Based on an analysis of the biocenotic structure of the Lake Piaseczno ecosystem and the values of biological trophy indicators, changes in the limnological status of the lake towards mesotrophy, and subsequently eutrophy, were observed [Wojciechowski *et al.* 1995].

Still in the 1970's, the values of gross primary production of phytoplankton were so low that they did not exceed the value of the method error – thus, they were unreliable for this method. From 1985, in the trophogenic zone of the pelagial, an increase in the value of this indicator was noted, up to the level typical of eutrophy [Kajak 1994] = $410 \text{ mg C}_{\text{ass}} \text{ m}^{-2} \text{ h}^{-1}$ in 1993 [Krupa and Czernaś 1997]. In the years 1970–1980 the chlorophyll *a* concentration oscillated around the value of $40 \text{ mg Chl } a \text{ m}^{-2}$ (after conversion – ca. TSIChl *a* = 51), determining the limit value between the mesotrophic and eutrophic character of the lake. At the beginning of the 1990's, the values of this parameter reached $100 \text{ mg Chl } a \text{ m}^{-2}$ (ca. TSIChl *a* = 60), characterizing eutrophic lakes [Krupa and Czernaś 1997].

In the period of 2001–2003 the values of the biological trophy indicators studied were lower than in the 1990's, in the following ranges, respectively: $34.6\text{--}85.5 \text{ mg C}_{\text{ass}} \text{ m}^{-2} \text{ h}^{-1}$ and $3.3\text{--}22.7 \text{ mg Chl } a \text{ m}^{-2}$, and the significant differences between the values of the studied parameters could attest to the biocenotic instability of this water body [Serafin and Czernaś 2003, Czernaś and Serafin 2007].

Similar trends were observed in the summer seasons of 2005–2007 when, with high values of gross primary production of phytoplankton, low values of chlorophyll *a* concentration and TSIChl *a*, determining the mesotrophic character of the waters of Lake Piaseczno, were noted.

Based on significant variations in the biological trophy indicators studied, the existence of biocenotic disorders in Lake Piaseczno can be inferred, and ambiguous signals about its limnological status are an effect of it.

CONCLUSIONS

1. In the summer seasons of 2005–2007, increased values of gross primary production of phytoplankton could indicate intensification of the eutrophication process, determining the above-mesotrophic character of Lake Piaseczno.

2. However, the values of chlorophyll *a* concentration and Carlson's Trophic State Index (TSIChl *a*) in the study period were evidence of the mesotrophic status of this lake.

3. The trend line indicates progression of the values of gross primary production of phytoplankton in the summer seasons of 2005–2007, with a relatively constant run of such lines for chlorophyll *a* concentration and TSIChl *a*.

4. The varying values of the biological trophy indicators, at the same time evidencing different degrees of fertility of the Piaseczno water body, may be evidence of the biocenotic instability of Lake Piaseczno.

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PRODUKTYWNOŚĆ FITOPLANKTONU W STREFIE PELAGIALU
JEZIORA PIASECZNO W OCENIE STANU JEGO TROFII
W SEZONIE LETNIM 2005–2007

Streszczenie. Celem pracy było określenie tempa eutrofizacji jeziora Piaseczno (Pojezierze Łęczyńsko-Włodawskie) w sezonie letnim 2005–2007. W strefie trofogenicznej pelagialu mierzono wartości: produkcji pierwotnej brutto fitoplanktonu, stężenia chlorofilu *a* oraz wyliczono wskaźnik trofii Carlsona (TSIChl *a*). Podwyższone wartości produkcji pierwotnej brutto fitoplanktonu w okresie badań 2005–2007 wskazywały na nasilenie eutrofizacji wód Piaseczna, jednak wartości stężenia chlorofilu *a* i TSIChl *a* nie przekraczały poziomu typowego dla mezotrofii.

Słowa kluczowe: jezioro, fitoplankton, produktywność, chlorofil *a*, eutrofizacja, TSIChl *a*