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CHANGES IN THE ENVIRONMENTAL CONDITIONS OF MESOTROPHIC LAKES IN THE RIVER-LAKE SYSTEM OF THE MARÓZKA AND UPPER ŁYNA RIVERS (MAZURIAN LAKELAND, POLAND)

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ABSTRACT. This study focused on the environmental conditions in four mesotrophic lakes, Mielno, Maróz, Święte, and Łańskie, located in the catchment basin of the Marózka and upper Łyna rivers. Changes in the thermal and oxygen conditions and the trophic status of the water of these lakes were evaluated based on the results of measurements conducted in 2004-2005 and archival materials. The highest oxygen content was noted in Lake Łańskie. The oxygen concentration in the waters of the hypolimnion of this basin was two orders of magnitude higher than in those of the epilimnion. The lowest oxygen concentration was noted in Lake Święte. The waters of the investigated lakes were of the calcium – hydrogen – carbonate type, which is typical for harmonic lakes. The contents of phosphorous and nitrogen in the lakes was similar and indicated that eutrophication in the basins was moderately advanced. The organic fractions of phosphorous and nitrogen were the dominant forms in the epilimnia. The near-bottom water layers were dominated by phosphates and ammonia nitrogen, the contents of which increased during the spring-summer period as oxygen deficits increased at the bottom. The values of parameters TSI_{SD} and TSI_{Chl} indicated that lakes Mielno, Maróz, and Łańskie were mesoeutrophic, while Lake Święte was eutrophic. The phosphorous index (TSI_{Ptot}) indicated that the degree of eutrophication in the lakes was slightly higher. The deteriorating oxygen conditions in the metalimnion and hypolimnion of Lake Łańskie could lead to the rapid rise in the eutrophication of this basin.

Key words: LAKE, EUTROPHICATION, THERMAL AND OXYGEN CONDITIONS, WATER CHEMISTRY, PHOSPHOROUS, NITROGEN

INTRODUCTION

Coregonid fish assemblages occur in oligo-mesotrophic lakes. Their occurrence and distribution in and among the various lake zones and particularly the effectiveness of their natural reproduction depends on the state of the aquatic environment. This is determined foremost by the oxygen conditions in the waters of the metalimnion, the

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hypolimnion, as well as in the water-sediment contact layer (Hartmann 1977, Müller 1992, Wilkońska 1992).

The eutrophication of waters, in which the contents of nutrients (N, P) increase, leads to the intense development of phytoplankton and diminishing lake water visibility. A consequence of this is increased sedimentation and the decomposition of organic matter, which leads to increasing deficits in oxygen content in the metalimnion and hypolimnion (Zdanowski 1982, Kajak 1983, Bajkiewicz-Grabowska 2002). The disappearance of coregonids in deep mesotrophic lakes can occur as early as in the initial stages of eutrophication.

The aim of the current work was to identify changes occurring in the environment of four mesotrophic lakes that are a natural habitat for coregonids.

MATERIALS AND METHODS

Four deep lakes located in the catchment basin of the Marózka River were chosen for the study (Mielno, Maróz, Święte and Łańskie; Fig. 1, Table 1). This river is the main tributary of

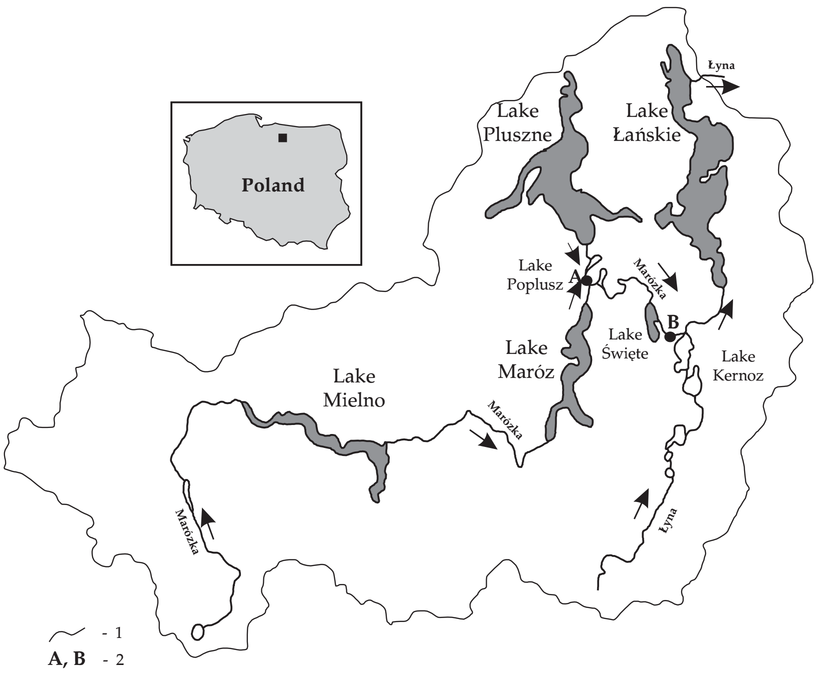

Fig. 1. Drainage basin of the river-lake system of the Marózka and the upper Łyna rivers: 1 – borderlines of the drainage basin; A, B – location of trout farms (according to Lossow et. al. 2006).

the Łyna River and drains an area of 305 km^2. The uppermost portion of it is exploited mainly for agriculture while the remainder is largely forested (Lossow et al. 2006).

TABLE 1

Limnological parameters of the studied lakes

Parameter		Lake: Mielno	Maróz	Święte	Łańskie
Surface area (ha)		362.8	332.5	59.4	1042.3
Volume (mln m^3)		43.9	39.6	4.3	168.0
Maximum depth (m)		39.9	41.0	40.8	53.0
Mean depth (m)		12.1	11.9	6.8	16.0
Maximum length (km)		8.2	5.6	1.6	10.0
Maximum width (km)		0.8	1.2	0.5	2.2
Degree of lake stability[1]		III	III	IV	III
Active lake bottom (%)[2]		21.6	23.1	38.2	20.0
Mean water outflow from lake (m^3 s^{-1})[3]		0.8	1.5	1.2	2.3
Lake hydraulic index (qs)[4]		7.1	14.6	64.4	7.0
Annual lake water exchange (%)[3]		59	122	891	43
Phosphorous load on lakes according to depth	p	0.11 (0.16)	0.11 (0.28)	0.08 (0.85)	0.13 (0.23)
criteria (hydraulic)[5] (g P_{tot} m^{-2} $year^{-1}$)	d	0.22 (0.33)	0.22 (0.56)	0.16 (1.70)	0.26 (0.46)
Phosphorous load delivered to lakes by the river (g P_{tot} m^{-2} $year^{-1}$)[6]		0.72	1.37	9.6	0.81
Nitrogen load on lakes according to depth	p	1.1	1.1	0.8	1.3
criteria[5] (g N_{tot} m^{-2} $year^{-1}$)	d	2.2	2.2	1.6	2.6
Nitrogen load delivered to the lakes by the river (g N_{tot} m^{-2} $year^{-1}$)[6]		7.6	11.8	104.4	7.2
Limnological/ fisheries type[7]		mesotrophic vendace	mesotrophic vendace	mesotrophic vendace	mesotrophic vendace

[1] According to the typology by Patalas (1960b); [2] Share of lake bottom within the reach of the epilimnion; [3] according to Lossow et al. 2006; [4] annual relationship of the outflow of water from the lake to its surface area; [5] according to the criteria of Vollenweider (1968. 1976) (p – permissible; d – dangerous); [6] according to Lossow et al. 2006, Teodorowicza et al. 2006; [7] According to Olszewski and Paschalski 1959, Korycka 1991, Zdanowski 2003

The lakes under investigation are dimictic. In Lake Święte there was significant water exchange in the epilimnion that comprised 55.2% of its volume. The hypolimnion, which comprised barely 18.1% of this lake's volume, was relatively stable and not susceptible to mixing (IV degree equilibrium), with a tendency for the occurrence of periodic meromixing.

The primary source of eutrophication in the lakes was the matter load delivered to the individual basins by the Marózka River. The immediate drainage basin (pollen precipitation, local run-off) increased the total nutrient load in the studied lakes as follows: Mielno – 25%; Maróz – 12%; Łańskie – 8% (Lossow et al. 2006). Lake Święte received the largest load.

The annual load of nitrogen and phosphorous delivered by the Marózka River exceeded critical levels (Table 1). Lake Mielno receives the highest amount of the total load from the agricultural drainage basin (Lossow et al. 2006). The overall load of nutrients delivered to lakes Święte and Łańskie can increase by as much as 26% if trout farm post-production waters are drained into the river (Teodorowicz et al. 2006).

In the 2003-2004 hydrological season Lake Mielno retained not more than 7.7% of the phosphorous load, while in the other lakes the figures were as follows: Maróz – 9.1%; Łańskie – 17.4%; Święte – 19.4%. Nitrogen load retention was the highest in Lake Mielno (40.5%), significant in Lake Łańskie (23.8%), and the lowest in Lake Maróz (11.1%) (Lossow et al. 2006). The magnitude of phosphorous retention exceeded the critical value in Lake Święte, while that of nitrogen did so in Lake Mielno.

The lakes were investigated five times in two vegetation seasons which included the spring circulation, summer stagnation, and fall circulation from April 5 to November 17, 2004 and from April 12 to November 15, 2005. The temperature and oxygen contents in the lakes were measured with a YSI model 58 oxygen meter at intervals of 1 m from the water surface to the bottom. Visibility measurements were performed with a Secchi disc. Water samples for physico-chemical analyses were collected with a Toń-2 sampler from the surface (0.5 m) and near-bottom (0.5 m from the bottom) water layers.

The physico-chemical analyses were performed according to standard methods (Standard Methods 1980, Hermanowicz et al. 1999), pH was measured with a HI 22 pH meter by Hanna Instruments, and electrolytic conductivity was determined with a Digitalmeter DIGI 610. The content of free carbon dioxide and the contents of carbon, hydrogen carbonate, calcium, and magnesium ions were determined with titration methods. The concentrations of sodium and potassium ions were determined with a Zeiss flame photometer. The concentrations of chloride, sulfate, and nitrate ions were determined with Metrohm 690 ion chromatography. Concentrations of phosphates and total phosphorous (following mineralization) and ammonium nitrate where determined colormetrically on a Shimadzu UV1601 spectrophotometer, while total nitrogen was determined with an Epoll ECO 20 spectrophotometer. The contents of chlorophyll and pheopigments in the epilimnia were determined according to the Lorenzen method

(1967). The amount of particulate matter in the epilimnia was determined by weight after water samples had been passed through glass filters (45 μm), and they were dried to a constant mass at a temperature of 105°C.

The trophic state of the lakes was determined based on the results of measurements of Secchi disc visibility (SD), concentrations of total phosphorous (P_{tot}), and chlorophyll contents (Chl) that were performed during the summer period (June to August). The Carlson formula (1977) was used to transform the results of these measurements into the trophic state index. The oligo-mesotrophic state is determined by values of TSI (TSI_{SD}, TSI_{Ptot}, and TSI_{Chl}) of less than 40, mesoeutrophic – 40-60, and eutrophic – exceeding 60.

RESULTS AND DISCUSSION

The thermal regime of the studied lakes was similar during the summer stagnation period (Fig. 2a, b). The temperature of the surface water layers did not exceed 21.2°C, while that in the near-bottom layer did not exceed 6°C during this period. The reach of the epilimnia did not exceed 7 m and occupied just 27% of the volume of Lake Łańskie, 36% of lakes Mielno and Maróz, and 55% of Lake Święte. The share of the hypolimnion of the entire water volume was the highest in Lake Łańskie (51%), less in lakes Mielno and Maróz (36%), and the lowest in Lake Święte (18%). The surface area of the active bottom of Lake Święte was substantial at 38%. The thermocline, with a volume of several meters, was generally located in the lakes studied at a depth that did not exceed 12 m (Fig. 2a, b).

The highest oxygen contents were noted in Lake Łańskie. The oxygen content in the waters of the hypolimnion (H) in this lake were two orders of magnitude higher than that in the waters of the epilimnion (E) (O_2 H/E = 0.007). These values were lower in lakes Mielno and Maróz (1.102 and 1.036, respectively) and were the lowest in Lake Święte (3.526).

One measure of lake eutrophication is the areal hypolimnetic oxygen deficit (Hutchinson 1957, Patalas 1960a). When thermal stratification was forming during the spring-summer period, the oxygen deficit was an average of 0.069 mg O_2 cm^{-2} d^{-1} in Lake Mielno, 0.081 mg O_2 cm^{-2} d^{-1} in Lake Święte, and 0.060 mg O_2 cm^{-2} d^{-1} in Lake Maróz (Fig. 3) and was characteristic of eutrophic waters. Deficits below 0.033

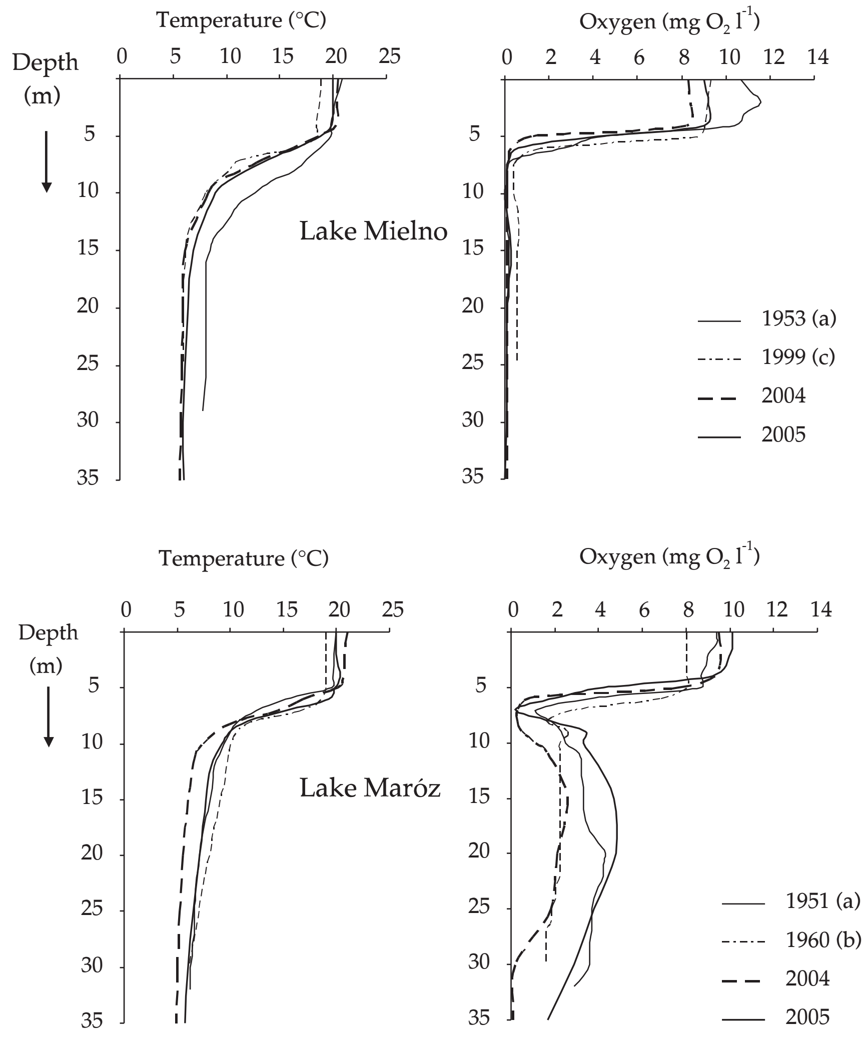

Fig. 2a. Summer thermal-oxygen stratification in lakes Mielno and Maróz in the 1951-2005 period. Data according to (a) Olszewski and Paschalski 1959, (b) Korycka 1991 (c) Zdanowski 2003b.

mg O_2 cm^{-2} d^{-1} indicate oligotrophy, those from 0.033 mg O_2 cm^{-2} d^{-1} to 0.050 mg O_2 cm^{-2} d^{-1} mesotrophy, and from 0.050 mg O_2 cm^{-2} d^{-1} to 0.140 mg O_2 cm^{-2} d^{-1} eutrophy (Hutchinson 1957). However, the tempo of oxygen deficit was more intense in Lake Łańskie at an average of 0.100 mg O_2 cm^{-2} d^{-1}. The total lack of oxygen in the hypolimnion of this lake was not noted due to the substantial oxygen concentrations and the large volume of this layer. As eutrophication progresses in a lake the increasing

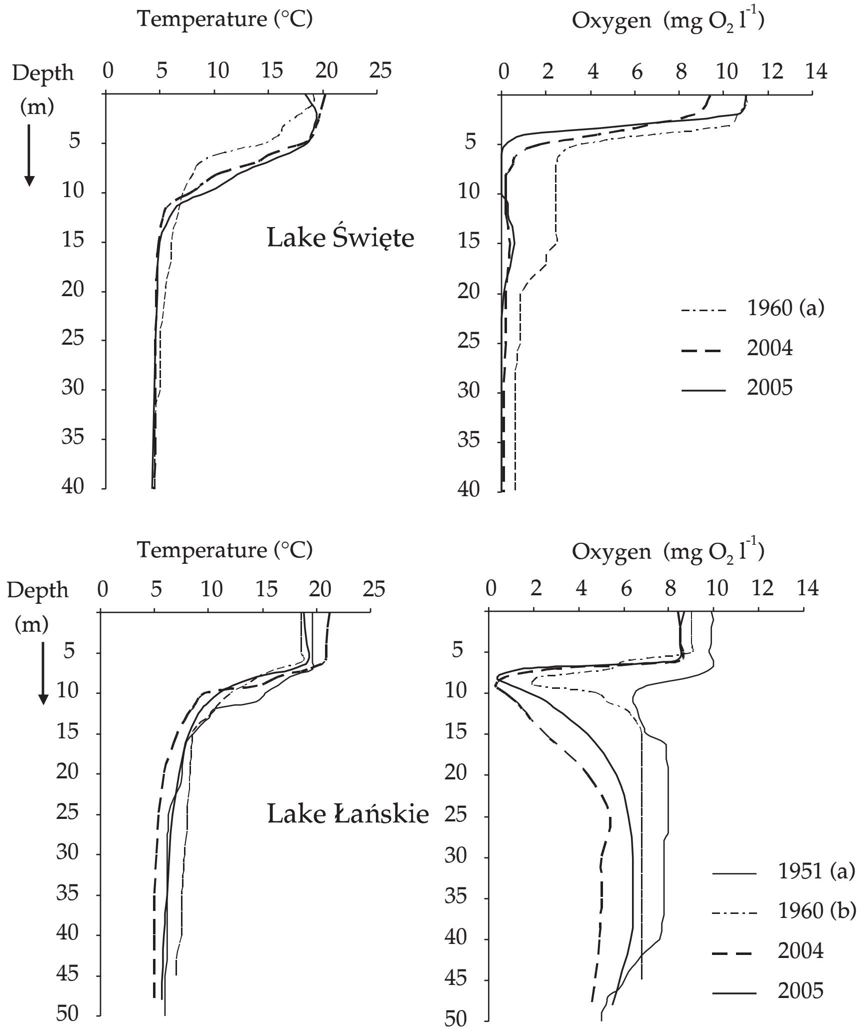

Fig. 2b. Summer thermal-oxygen stratification in lakes Święte and Łańskie in the 1951-2005 period. Data according to (a) Olszewski and Paschalski 1959, (b) Korycka 1991, (c) Zdanowski 2003b.

sedimentation of organic matter and its decomposition can disrupt the prevailing trophic conditions and lead to the depletion of oxygen resources in the hypolimnion. A consequence of an oxygen deficit at the bottom is nutrient loading from within the lake as their release from the bottom sediments intensifies. This phenomenon has been observed in many lakes that are undergoing this stage of eutrophication (Patalas 1960a, Zdanowski et al. 1992, Gawrońska et al. 2005).

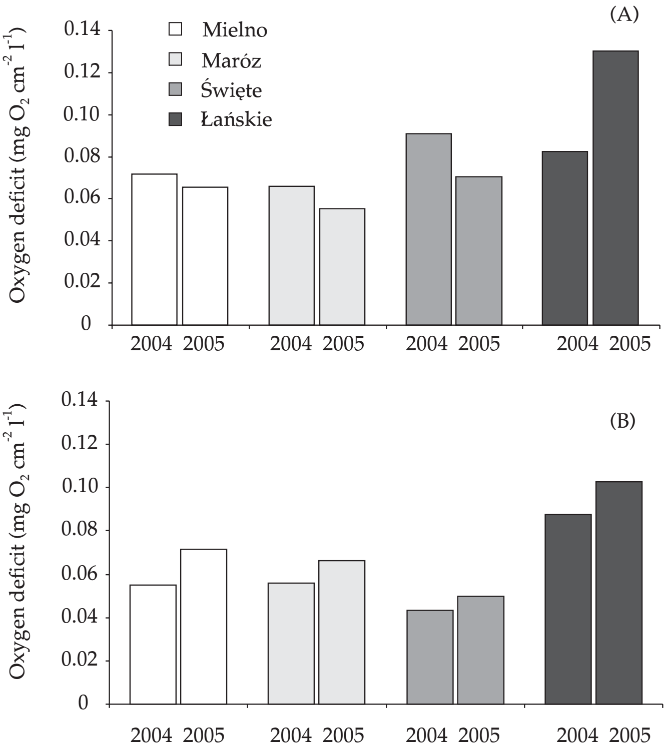

Fig. 3. Areal hypolimnetic oxygen deficit in the spring period (A – April-June) and spring-summer (B – June-August) in lakes Mielno, Maróz, Święte, and Łańskie in 2004 and 2005.

The highest oxygen content in the water layer from the surface to the bottom was noted in the lakes during the spring diatom bloom (lower than 14.4 mg O_2 l^{-1}, 115% saturation). In summer, the oxygen content in the surface layer did not exceed 11.0 mg O_2 l^{-1} (116% saturation). As a result of photosynthesis the water CO_2 concentration fell to trace levels and the pH increased to 8.7. In summer, the oxygen concentration in the near-bottom layers was at trace levels in lakes Mielno, Maróz, and Święte, while in Lake Łańskie it fell to 4 mg O_2 l^{-1} (36% saturation). The CO_2 content in the near-bottom layers of the lakes ranged in summer from 5.1 to 7.9 mg l^{-1}, while the water pH ranged from 7.3 to 8.0.

The greatest oxygen deficits were noted in the summer in the metalimnia and hypolimnia in lakes Mielno and Święte (Fig. 2a, b). Changes in the oxygen contents in the vertical profile of these two lakes were described by clinograde curves, which are usually noted in eutrophic lakes (Prusik et al. 1989, Marszelewski 2005). The severity of the increase in oxygen deficit in the metalimnion and hypolimnion in Lake Święte was slightly higher than that in the 1960s, probably as a result of eutrophication that was already in progress in this basin. A negative heterograde oxygen curve (Fig. 2a, b) described the changes in the oxygen content of the vertical profile of lakes Maróz and Łańskie, which, in the opinion of Stangenberg (1936), is characteristic of b-mesotrophic lakes. This type of curve was noted as early as the 1950s and 1960s in lakes Maróz and Łańskie (Olszewski and Paschalski 1959, Korycka 1991) (Fig. 2a, b). The studies of Teodorowicz (2002) indicate that in Lake Łańskie the oxygen contents in the metalimnion as well as in the near-bottom water layer dropped to trace levels over the past decade during the summer period.

The waters of the studied lakes were of the calcium – hydrogen – carbonate type. This type of salinity is typical of European lowland harmonic lakes (Korycka 1991, Marszelewski 2005). The electrolytic conductivity of the studied lakes ranged, on aver-

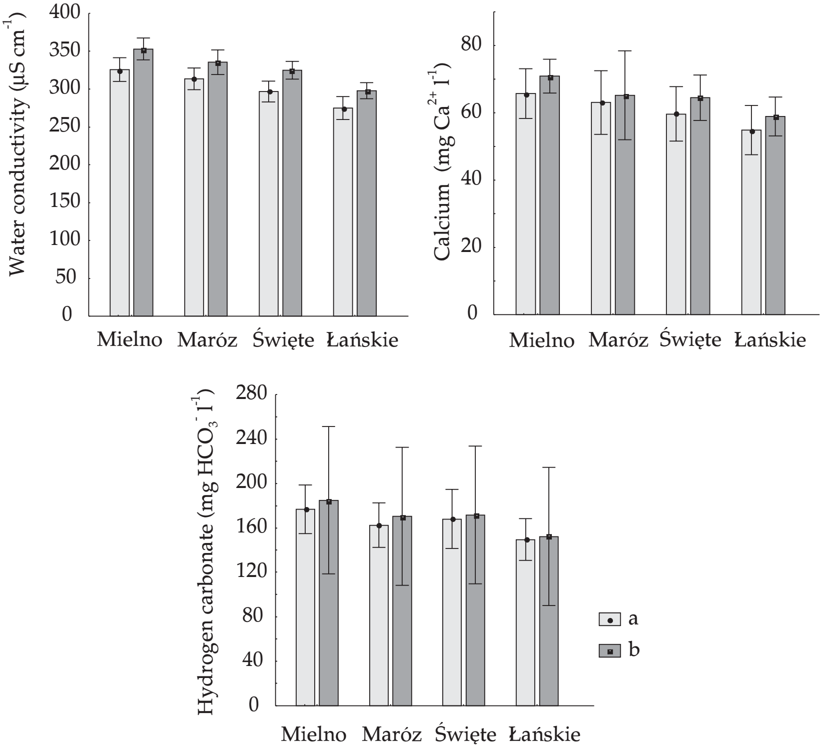

Fig. 4. Variability in the electrolytic conductivity of water and the contents of calcium and hydrogen carbonate (mean ± SD) in surface (a) and near-bottom (b) water layers in lakes Mielno, Maróz, Święte, and Łańskie in the 2004-2005 period.

age, from 275 to 326 μS cm^{-1} in the water surface layers and from 298 to 353 μS cm^{-1} in the near-bottom layer. The corresponding ranges of calcium content were from 54.9 to 65.8 mg l^{-1} and from 59.9 to 79.0 mg l^{-1} and those of hydrogen carbonate were from 149.6 to 176.9 mg l^{-1} and 152.3 to 184.9 mg l^{-1}.

The degree of salinity in the lake waters decreased along the course of the Marózka River. A similar decrease in the content of microelements was noted in the lakes of the Krutynia River catchment basin (Hillbricht-Ilkowska and Kostrzewska-Szalkowska 1996b). The highest salinity was noted in Lake Mielno, which is in the uppermost location and in an agricultural drainage basin (Fig. 4). A similar tendency was demonstrated by variations in the diatom contents, which decreased, on average, from 6.8 to 4.8 mg l^{-1} in surface water layer and from 12.2 to 8.9 mg l^{-1} in the near-bottom layer. No differences were noted among the lakes regarding the content of other ions dissolved in the water. In the surface water layer the content of Mg^{2+} varied from 7.6 to 8.7 mg l^{-1}, and in the near-bottom layer from 7.7 to 10.6 mg l^{-1}. The concentrations of potassium ions ranged from 1.6 to 1.7 mg l^{-1} and from 1.6 to 1.8 mg l^{-1}, respectively. The concentration of Na^+ remained within a range of 4.6 to 4.9 mg l^{-1} in the surface as well as the bottom layer. The sulfate concentration ranged from 23.9 to 31.3 mg l^{-1} in the surface layers and from 23.4 to 30.9 mg l^{-1} in the near-bottom layers, while chlorides ranged from 8.6 to 12.0 mg l^{-1} and from 8.6 to 11.9 mg l^{-1}, respectively. The precipitation of minerals to the sediments, including the decalcification of waters, is intense in Lake Łańskie. The coprecipitation of phosphates on calcite remains limited by the eutrophication of this basin. This is despite the substantial load of organic matter from Lake Święte. The biochemical oxygen demand of the epilimnion waters of Lake Święte were the highest (average 4.2 mg O_2 l^{-1}), as was $ChZT_{Mn}$ (6.4 mg O_2 l^{-1}) and $ChZT_{Cr}$ (32.9 mg O_2 l^{-1}).

The contents of phosphorous (0.085 mg l^{-1}) and nitrogen (0.78 mg l^{-1}) were similar in all the lakes (Fig. 5) and were characteristic for moderately eutrophic basins (Zdanowski 1982, Kajak 1983, Kufel 2001). The dominant forms of phosphorous and nitrogen in the epilimnia was the organic fraction, which comprised, on average, 56% of the P_{tot} and 83% of the N_{tot} content. The content of ammonia nitrogen and nitrate did not exceed 0.05 mg l^{-1} and 0.07 mg l^{-1}, while phosphates did not exceed 0.034 mg l^{-1}. The low ratio of N/P contents (average 6.4) in the epilimnia of the lakes indicated that there are substantial resources of phosphorous and that nitrogen plays a limiting role in

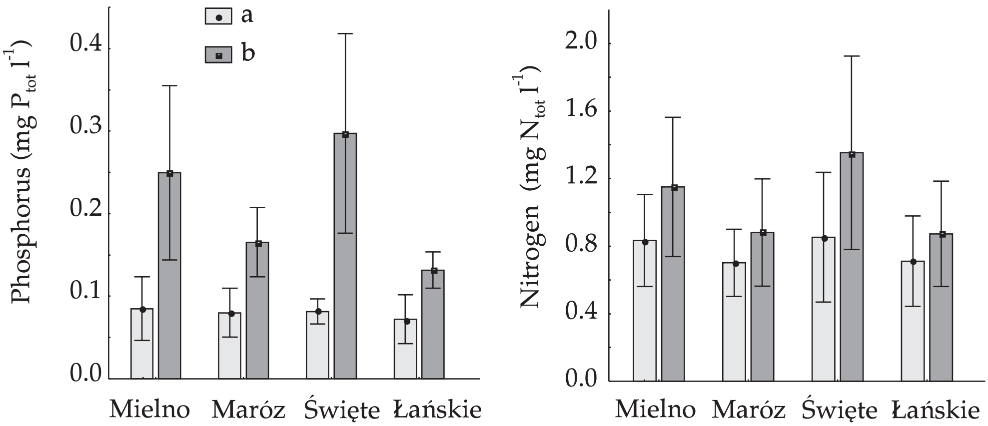

Fig. 5. Variability in the contents of phosphorous and total nitrogen (mean ± SD) in surface (a) and near-bottom (b) water layers in lakes Mielno, Maróz, Święte, and Łańskie in the 2004-2005 period.

the development of phytoplankton during the spring. An increase in the ratio during the summer period (on average to 16.4) indicates that phosphorous increasingly limits primary production.

The highest concentrations of phosphorous and total nitrogen were determined in the near-bottom layers of lakes Mielno and Święte (< 0.30 and < 1.35 mg l^{-1}). The dominant from of phosphorous was phosphates (82%) and of nitrogen – ammonia nitrogen (34%) and organic nitrogen (46%). The content of phosphates and ammonia increased in the spring-summer period along with increasing oxygen deficits in the near-bottom layer (Fig. 6). This phenomenon, which is characteristic for eutrophic lakes (Zdanowski 1982, Korycka 1991, Kubiak 2003, Gawrońska et al. 2005, Marszelewski 2005), was not pronounced in Lake Łańskie, in which the oxygen content near the bottom (exceeding 4 mg l^{-1}) still limited the process of nutrients being released from the bottom sediments. The delivery of nutrients from within lakes is usually most intense when the oxygen content at the bottom falls below 1 mg O_2 l^{-1} (Böstrom et al. 1988, Forsberg 1989, Shaw and Prepas 1990, Höhener and Gächter 1994, Nürberg 1994, Thaler and Tait 1995, Van der Molen et al. 1998).

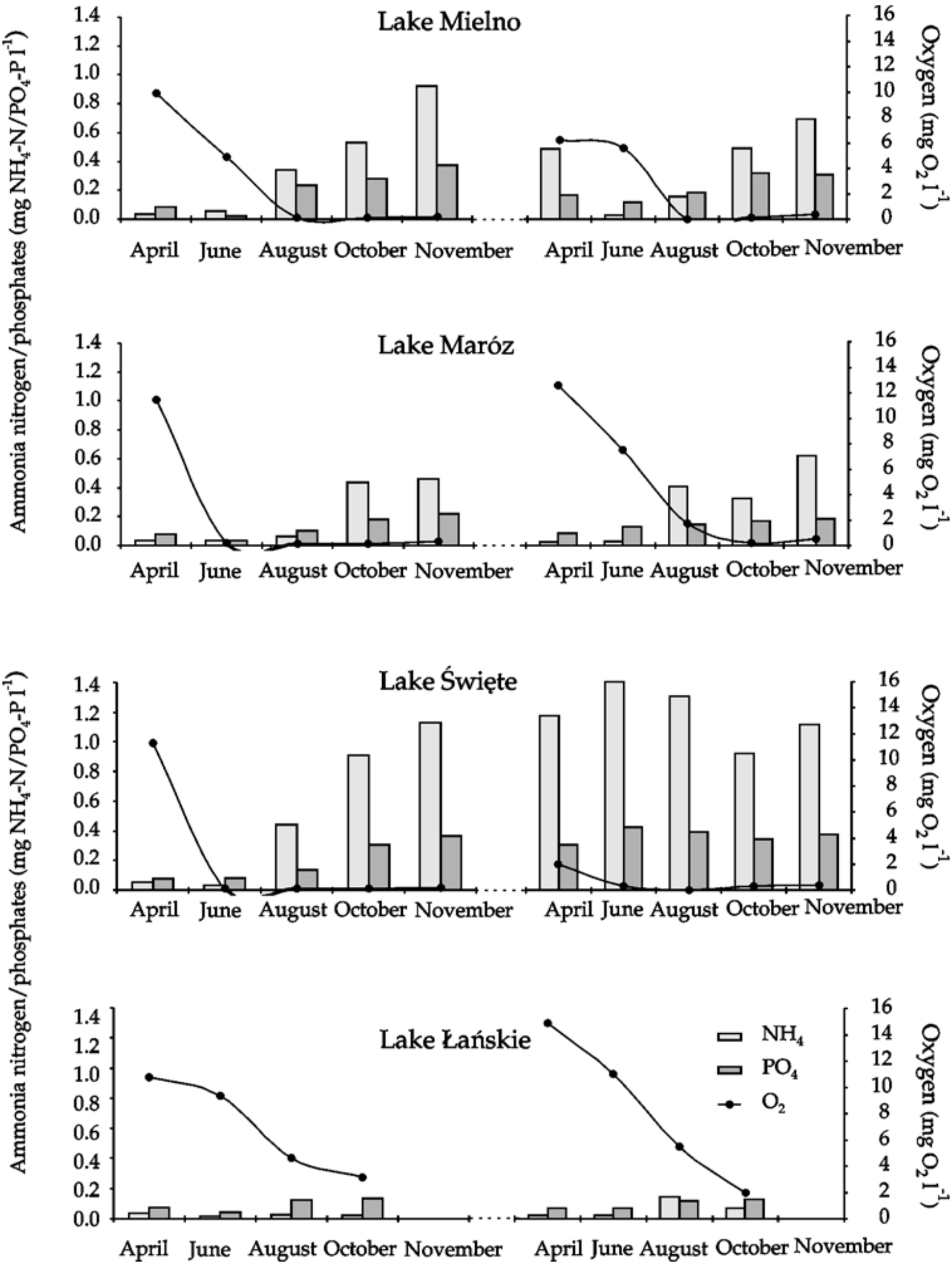

Fig. 6. Seasonal variability in the contents of ammonia nitrogen, phosphates, and oxygen in near-bottom water layers in lakes Mielno, Maróz, Święte, and Łańskie in the 2004-2005 period.

Changes in the contents of chlorophyll and seston, and consequently Secchi disc visibility, are measures of lake eutrophication (Carlson 1977, Kajak 1983, Uchmański and Szeligiewicz 1988, Kufel 2000, 2001). The content of chlorophyll in the epilimnia of lakes Mielno, Maróz, Święte, and Łańskie was similar (average 10 $\mu g\ l^{-1}$), and it did not exceed 15 $\mu g\ l^{-1}$ during periods of phytoplankton blooms. A two-fold higher concentration of chlorophyll was always noted in Lake Święte (maximum 28 $\mu g\ l^{-1}$) (Fig. 7). The least suspended particulate matter was confirmed in the epilimnia of lakes Maróz and Łańskie (average 3.1 and 3.4 mg d.m. l^{-1}, respectively), and the highest water clarity (average 4.0 m) was in Lake Maróz (Fig. 7). The most suspended particulate matter (average 4.2 mg d.m. l^{-1}) and the lowest water visibility (average 1.6 m) were consistently confirmed in the epilimnion of Lake Święte.

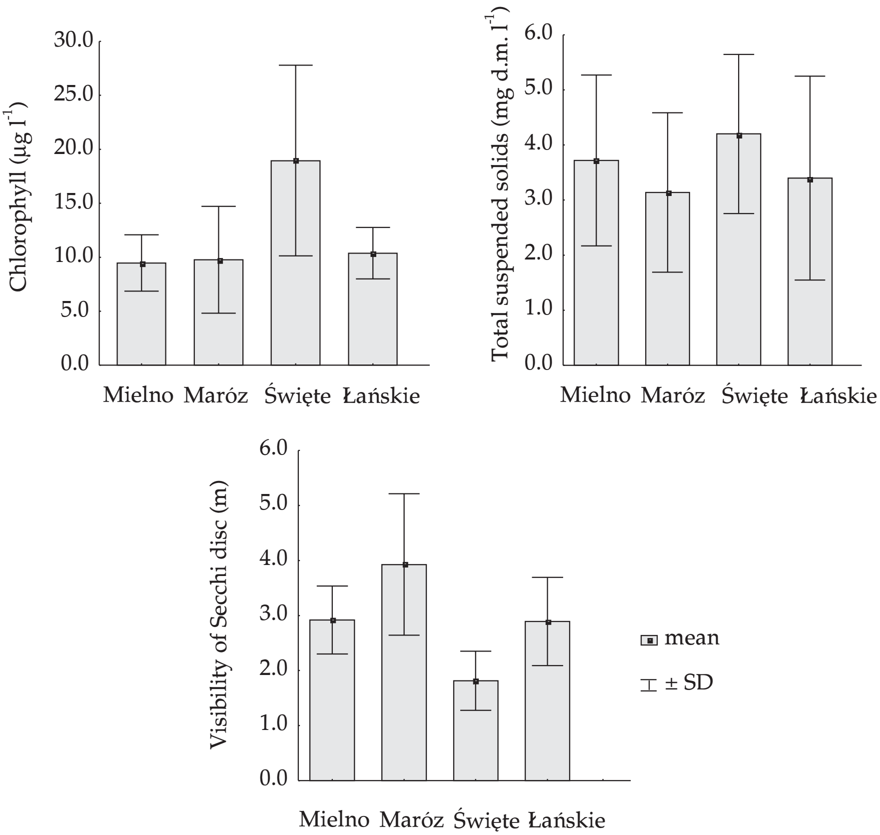

Fig. 7. Variability in the contents of chlorophyll and seston and Secchi disc visibility (mean ± SD) in lakes Mielno, Maróz, Święte, and Łańskie in the 2004-2005 period.

The values of the TSI_{SD} and TSI_{Chl} indices indicate that lakes Mielno, Maróz, and Łańskie are mesotrophic, while Lake Święte is eutrophic (Fig. 8). The phosphorous index (TSI_{Ptot}) indicated that the degree of eutrophication of the lakes was slightly higher. There was a similar lack in coherence with regard to the TSI_{Ptot} index in comparison with the TSI_{SD} and TSI_{Chl} indices in other lake-river systems in Poland (Hillbricht-Ilkowska 1994, Hillbricht-Ilkowska and Wiśniewski 1994, Hillbricht-Ilkowska and Kostrzewska-Szalkowska 1996a, Zdanowski 1999, Kubiak 2003). Phosphorous probably occurred in a form that is inaccessible to phytoplankton; this applies to the lakes studied in the current investigation.

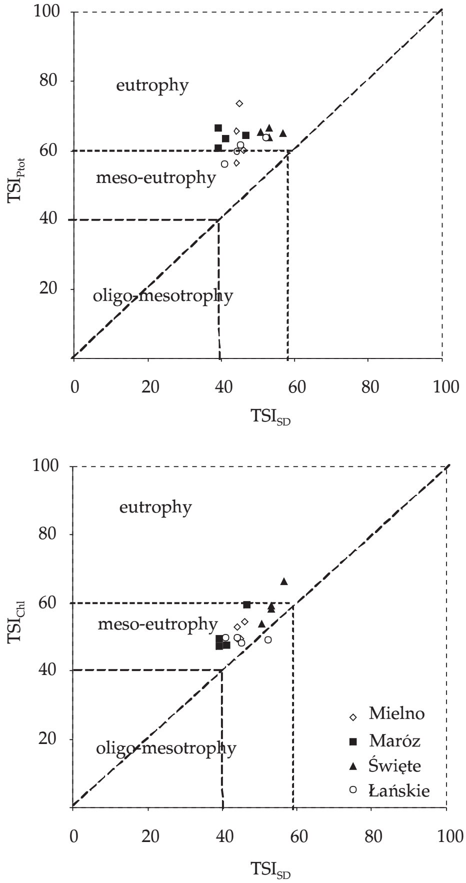

Fig. 8. Trophic state of lakes Mielno, Maróz, Święte, and Łańskie as determined with the Carlson trophic state index (TSI_{SD}, TSI_{Ptot}, TSI_{Chl}) in the summer periods (June-August) of 2004 and 2005.

Generally, Lake Łańskie is the lake most threatened with eutrophication. The substantial amounts of organic matter delivered by the Marózka and Łyna rivers to this basin can contribute to the deterioration of oxygen conditions in the metalimnion and hypolimnion. These, in turn, can lead to rapid increases in the eutrophication of Lake Łańskie. Such conditions can limit the development of the coregonid population.

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STRESZCZENIE

ZMIANY WARUNKÓW ŚRODOWISKA MEZOTROFICZNYCH JEZIOR SYSTEMU RZECZNO-JEZIORNEGO RZEKI MARÓZKI I GÓRNEJ ŁYNY (POJEZIERZE MAZURSKIE, POLSKA)

Zbadano zmiany parametrów chemicznych wody czterech jezior mezotroficznych: Mielno, Maróz, Święte, Łańskie (tab. 1). Oceniono na tej podstawie stan troficzny wód w tych zbiornikach. Największymi zasobami tlenowymi wyróżniało się Jezioro Łańskie. Zasoby tlenowe wód hypolimnionu (H) tego zbiornika były o dwa rzędy wielkości większe niż wód epilimnionu (E) (O_2 H/E = 0,007). Zmiany zawartości tlenu w profilu pionowym podczas stagnacji letniej w jeziorach Maróz i Łańskie opisywała krzywa tlenowa – heterogradowa ujemna, charakterystyczna dla jezior b-mezotroficznych, a w jeziorach Mielno i Święte – klinogradowa, typowa dla zbiorników eutroficznych (rys. 2a, b). Wody badanych jezior cechowało zasolenie wodorowęglanowo-wapienne. Największym zasoleniem wody wyróżniało się szczytowo położone jezioro Mielno usytuowane w zlewni rolniczej (rys. 4). Zasobność jezior w fosfor (0,085 mg l^{-1}) i azot (0,78 mg l^{-1}) była natomiast podobna (rys. 5), charakterystyczna dla zbiorników średnio zeutrofizowanych. Dominującą formą fosforu i azotu w epilimnionie była frakcja organiczna. Największą koncentrację fosforu i azotu całkowitego w warstwach przydennych stwierdzano w jeziorach Mielno i Święte (<0,30 mg l^{-1} i <1,35 mg l^{-1}). Dominującymi formami fosforu były fosforany (82%), a azotu – azot amonowy (34%) i organiczny (46%). Zawartość fosforanów i amoniaku wzrastała przy dnie w okresie wiosenno-letnim w miarę narastania tu deficytów tlenowych (rys. 6). Zawartość chlorofilu, sestonu oraz widzialność krążka Secchi'ego wskazywały na mezo-eutrofię jezior: Mielno, Maróz i Łańskiego, a eutrofię – Jeziora Świętego (rys. 7, 8). Indeks fosforowy (TSI_{Ptot}) wskazywał na nieco wyższy stopień zeutrofizowania zbadanych jezior (rys. 8). Do jezior bardziej zagrożonych eutrofizacją należy Jezioro Łańskie. Wnoszone do tego zbiornika rzeką Marózką znaczące ilości materii organicznej mogą pogarszać warunki tlenowe wód meta- i hypolimnionu, a te z kolei doprowadzać do skokowego wzrostu eutrofizacji jeziora. Takie uwarunkowania mogą ograniczać rozwój populacji koregonidów.