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Preliminary study of ichthyofauna in extensively exploited Głębokie Uścimowskie Lake with abnormal fish structure

Wstępne badania ichtiofauny ekstensywnie użytkowanego jeziora Głębokie Uścimowskie o zaburzonej strukturze gatunkowej ryb

Summary. The aim of research was to define the structure of ichthyofauna in a shallow, eutrophic lake where stocking and commercial catches were no conducted for over a dozen of years. In years 2008–2011 control fish catches were made with the use of gill nets. Based on this catches, 10 species of fish were found (in total) in this lake. During entire period of research 3 species of fish: Prussian carp, roach and brown bullhead were dominated in biomass and quality. During four years of research an upward trend in quantity and total biomass in Prussian carp population was observed. Caught fishes were got rather small and because of that they did not show any economic value. The ichthyofauna of Głębokie Uścimowskie Lake had untypical structure, with total absence of predator fish species. This abnormal in trophic structure probably had a significant impact on fish growth parameters such as small size and mass below 0.2 kg.

Key words: eutrophic lake, abnormal trophic structure of ichthyofauna, management of fishing and angling

INTRODUCTION

Nowadays fishery and angling management are conducted in most of lakes and bigger reservoirs in Poland. This management is based on fish stocking and harvesting. Lake resource management is possible when it is on clear rules. These rules must give an opportunity to generate revenue from investment in fish stocking and other agricultural procedures [Mickiewicz 2010]. At the same time according to the polish law of Inland Fishery lake management it should be conducted reasonably in terms of water produc-

tion abilities, utilization and maintaining ichthyofauna structure in biological balance [Wołos 2008]. This is the way of operation in for example lake special fisheries or PZW license fisheries. This way of lake exploitation is associated with many restrictions for anglers according to fish resources utilization in the lake. Law assumptions of reasonable economy do not meet social aspects which may significantly influence the economy and the resource preservation [Wołos and Leopold 2006, Goryczko and Witkowski 2009].

In case when lake is situated in direct neighborhood of a village exploitation of carried out the lake opposite to the rules of reasonable angling and fishery management. Legal users of lakes usually give up fish stocking to avoid conflicts with local commodities, because it does not bring them real economical benefits. Those practices favor species of a low economical value, what in consequence make dwarf population. At the same time angling pressure and net fish caught performed may lead to elimination of economically valuable species, which are responsible for a proper trophic structure in the lake. It especially concerns predatory fish such as pike or pike perch. In small eutrophic lakes with no connection to other reservoirs or streams disturbance of trophic structure may lead to an absolute elimination of fish predators. Similar situation takes place in small eutrophic Głębokie Uścimowskie Lake on Łęczna-Włodawa Lakeland.

The aim of this paper was to describe structure of ichthyofauna in the Głębokie Uścimowskie Lake with an abnormal trophic structure where the basic form of the use angling.

STUDY AREA

Głębokie Uścimowskie Lake (51°28'33"N, 22°55'21"E) is situated on the west part of Łęczna-Włodawa Lakeland, on the territory of Uścimów district on the area of Pojezierze Łęczyńskie Landskape Park (Fig. 1). Lake is without an outflow and its area is about 21 ha, with maximum depth of 7.1 m. The whole basin area is 173.82 ha. [Radwan and Kornijów 1998]. The lake has poorly expanded coastline, (especially at the east side), where fields almost reach the lake. Fields, village homesteads and pastures covered mostly with bushes are a direct neighborhood of the lake. There are few very small watering places with banks covered with grass and few angling piers around the lake. Submerged plants are up to 2.5 m depth. Głębokie Uścimowskie Lake is eutrophic reservoir where partial thermal-oxidative stratification appears in summer. An oxygen deficit at the bottom of the Głębokie Uścimowskie Lake is caused by the presence of toxic cyanide plants, which may influence limit of benthos growth on greater depth as well as fish preying [Kornijów and Halkiewicz 2007].

Water quality in Głębokie Uścimowskie Lake changed significantly in the last 30 years. Even in 90's the lake was described as highly eutrophic reservoir [Kornijów and Halkiewicz 2007]. After 2000 gradual improvement of ecological condition of this lake was observed. Intensity of water blooms significantly decreased and colonization submerged macrophytes began. At the present time, in the summer season water, visibility reach up to 2 m, but as a result of human activities the presence of filamentous algae notably from the side of Głębokie village homesteads was identified improvement. The reason of ecological condition of the lake was probably sewerage the near village and decrease of agriculture pressure [Radwan *et al*. 2002].

The lake is the tench-pike fishery type [Radwan and Kornijów 1998]. Głębokie Uścimowskie Lake was used by several owners, who do not conduct fish stockings for many years.

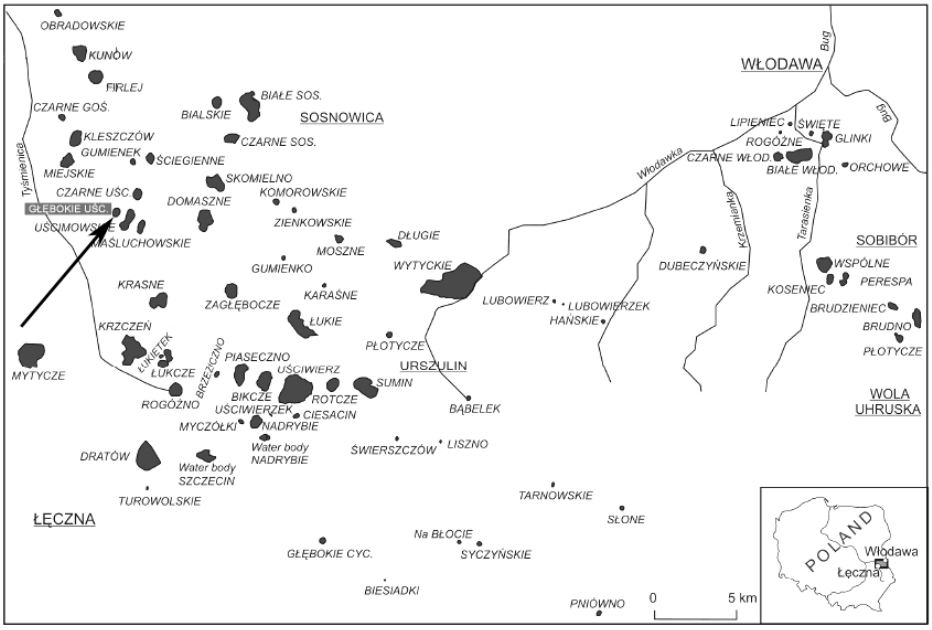

Fig. 1. The location of Głębokie Uścimowskie Lake in Łęczna-Włodawa Lakeland
Rys. 1. Lokalizacja jeziora Głębokie Uścimowskie na Pojezierzu Łęczyńsko-Włodawskim

MATERIAL AND METHODS

Studies of ichthyofauna of Głębokie Uścimowskie Lake were conducted between 2008 and 2011. Control fish catches in the reservoir were performed every year in the summer, using Norden S gillnet, consisting of 14 panels with different mesh size: 10, 60, 30, 6,25, 43, 22, 50, 33, 12,5, 25, 8, 38, 75, 16,5 mm) [Appelberg 2000, CEN document 2005].

The fish caught were identified by the species, their total length (Tl) (±1 mm) and body mass (W) (±1 g). Diversity of fish species was found in the lake and the dominance in the number (D_i) and biomass (W_i) were estimated by the formulas: $D_i = 100 \times n_i/\Sigma n_i$ and $W_i = 100 \times w_i/\Sigma w_i$, where: D_i – share in the number abundance of *i*-species, n_i – number of individuals *i*-species, W_i – share in the biomass of *i*-species, w_i – total biomass of individuals *i*-species.

In addition, the stability of occurrence (C_i) for each species found in the lake was calculated by the formula: $C_i = 100 \times Ns_i/Ns$, where: C_i – stability of occurrence i-species, Ns_i – number of fishing where the *i*-species was found, Ns – total number of fishing conducted in the lake from 2008 to 2011.

Results of fishing each year were converted to catch per unit effort (NPUE for fish number and WPUE for fish biomass). For the abundance, the NPUE, it was the number per unit effort, i.e. number of fish individuals caught in the one net after 12 hours of fishing, and for the fish biomass, WPUE, it was weight per unit effort, i.e. biomass (in grams) of the fish caught in one net after 12 hours of fishing.

To determine the changes in abundance and biomass of dominant fish species in four years of the research, an exponential trend was plotted following to the formula $y = a^{bx}$; where: a and b represent parameters describing the regression curve, y – number (N) or biomass (W) of the dominant fish species, x – year.

Results were statistically analyzed. Differences in the total number of fish and values of NPUE and WPUE in different years were tested using an analysis of variance (one-way ANOVA). Determination of the statistical differences was made using Tuckey post-hoc test. All analysis was performed using Statistica 6.0 program, at the significance level $p \leq 0.05$.

RESULTS

In the Głębokie Uścimowskie Lake 10 fish species of to 3 families such as: *Cyprinidae*, *Percidae* and *Ictaluridae*, were found. The largest number of fish species was observed in 2010 (8 species), while the least in 2009, 3 species (Tab. 1).

Among the fish species occurring in the lake, only one – brown bullhead, *Ictalurus nebulosus* (Lesueur) was an alien, invasive species. Moreover two species: common carp, *Cyprinus carpio* (L.) and Prussian carp, *Carassius auratus gibelio* (Bloch) were classified a non-native fish species.

Fish species detected in all control catches were brown bullhead, Prussian carp and roach, *Rutilus rutilus* (L.) (C_i = 100%). The gudgeon (*Gobio gobio* (L.)) rudd (*Scaridinius erythrophthalmus* (L.)) and sunbleak (*Leucaspius delineatus* (Heckel)) were fish species, which were rarely caught (C_i = 25%) (Tab. 1).

Dominant species in the quantitative structure (Di) were Prussian carp and roach. Their share ranged from 37–38% of the total number of all caught fish. Furthermore, significant abundance of the brown bullhead was characterized (Di = 12.65%). Three mentioned above species were dominant in the structure of fish biomass found in a Głębokie Uścimowskie Lake, but the largest share in the biomass (over 66%) had the Prussian carp. The percentage share of the other two species was similar (around 13–16.5%), but slightly larger in case of brown bullhead (Tab. 1).

Results analysis showed, that the highest average of the total length (Tl) was found in a common carp, which was an only one specimen was caught in 2010. The total average length of the dominant species (Prussian carp, brown bullhead and roach) ranged from 10 to 14 cm. Among these three species, the highest average had a brown bullhead (Tl = 14.04±2.62) (Table 2). The largest individual unit weight had Prussian carp (W = 197 g), while it is average body weight was 46 g, and brown bullhead – 35 g (Tab. 2).

During the study the number of fish individuals caught each year was highly variable (Fig. 2). The largest number of fish, expressed as NPUE, was observed in 2010 (82.25 NPUE), slightly lower in 2008, and over three times less in 2009 and 2011, 27.5 and 25.5 NPUE, respectively (Fig. 2). However, those visible differences were not statistically significant (ANOVA, df = 12; F = 3.328; p = 0.056).

Analysis of the results of weight of fish caught during four years of observation showed that between 2009 and 2011 fish biomass reached a value of just over 900 WPUE. Statistically significantly higher total fish biomass was observed in 2010 – 2262.92 WPUE (ANOVA, df = 12; F = 4.871; p = 0.019). However, despite twice the fish biomass in 2010, than in 2008, differences between these years, were not significant (Fig. 3).

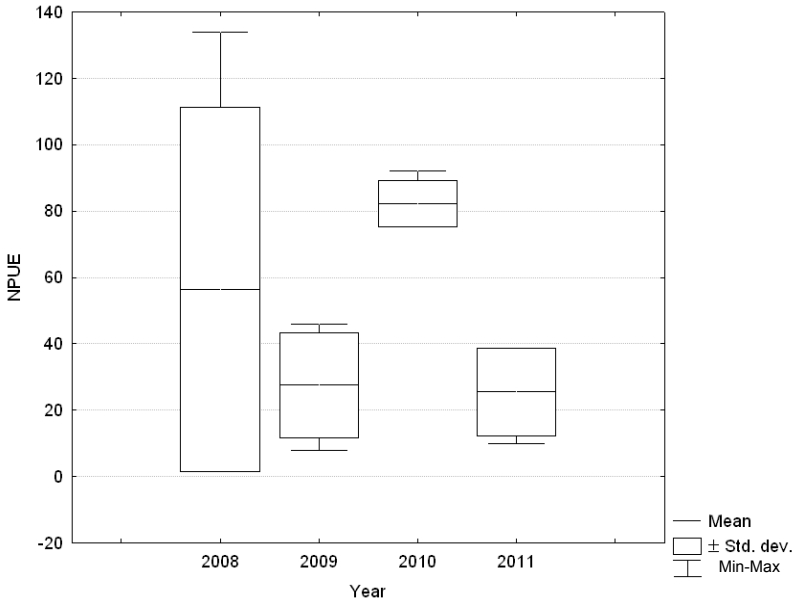

Fig. 2. The number of caught fish (NPUE) in the Głębokie Uścimowskie Lake in the years 2008–2011
Rys. 2. Porównanie wielkości połowów ryb w NPUE w jeziorze Głębokie Uścimowskie w latach 2008–2011

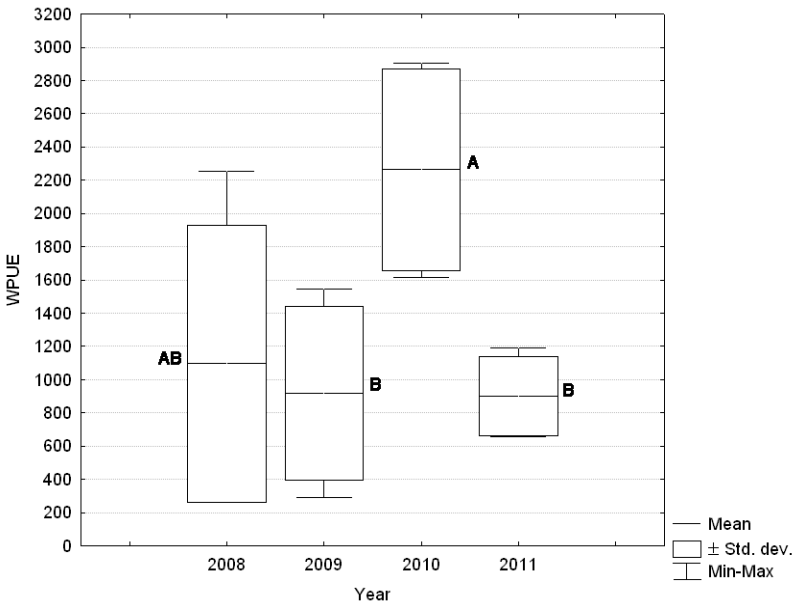

Fig. 3. The biomass of caught fish (WPUE) in Głębokie Uścimowskie Lake between 2008–2011; A, B – means determined with different letter are statistically significant at $p \leq 0.05$.
Rys. 3. Porównanie wielkości połowów ryb w WPUE w jeziorze Głębokie Uścimowskie w latach 2008–2011; A, B – średnie oznaczone różnymi literami różnią się statystycznie istotnie przy $p \leq 0{,}05$

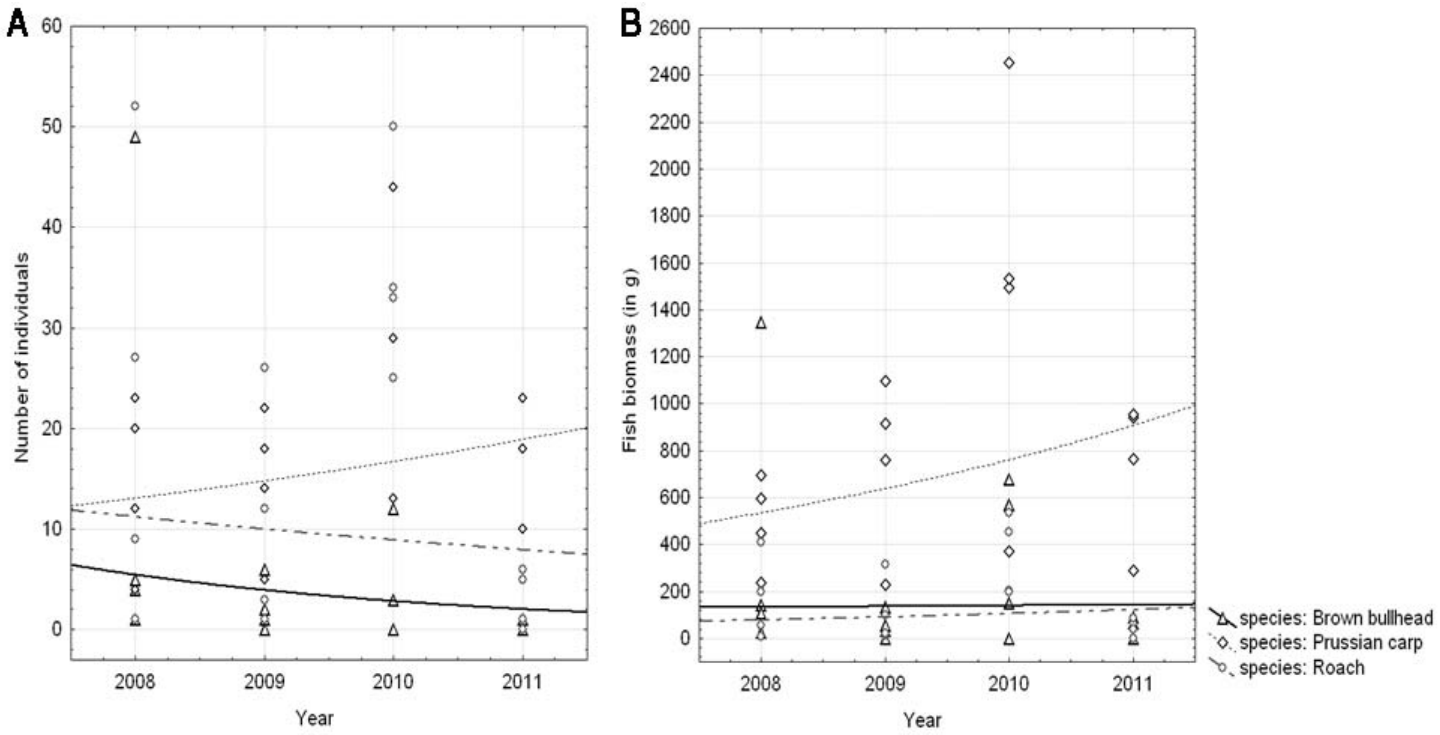

Fig. 4. The changes of number (A) and biomass (B) of the dominant fish species in Głębokie Uścimowskie Lake in years 2008–2011
Rys. 4. Zmiany liczebności (A) i biomasy (B) dominujących gatunków ryb w jeziorze Głębokie Uścimowskie w latach 2008–2011

Table 1. A list of fish species found in Głebokie Uścimowskie Lake. R – classification of species to reproduction guilds (after Balon 1975); A – habitat preferences: E – eurytopic fish, (Schiemer and Waidbacher 1992); K – IUNC categories after Witkowski *et al.* (1999): LC – least concern species, I – introduced species A – alien species; T – affiliation to a trophic group: I – feeding on invertebrates, O – omnivorous, Pl – plankton-eating; D_i – index of dominance in the number, W_i – index of dominance in the biomass, C_i – stability of occurrence

Tabela 1. Lista gatunków ryb stwierdzonych w jeziorze Głębokie Uścimowskie. R – klasyfikacja gatunków do grup rozrodczych (za Balonem 1975); A – preferencje habitatowe: E – ryby eurytopowe (Schiemer i Waidbacher 1992); K – kategorie IUCN za Witkowskim i in. (2009): LC – gatunek najmniejszej troski, I – gatunek introdukowany, A – gatunek obcy; T – przynależność do grupy pokarmowej: I – odżywiający się fauną bezkręgową, O – wszystkożerny, Pl – planktonożerny; D_i – wskaźnik dominacji liczebności, W_i – wskaźnik dominacji w biomasie, C_i – stałość występowania

Species	R	A	K	T	$D_i \pm$ SD	$W_i \pm$ SD	C_i (%)
Brown bullhead – *Ictalurus nebulosus* (Lesueur)	Fitophylis	E	A	O	12.65±10.42	16.39±15.04	100.00
Ruffe – *Gymnocephalus cernuus* (L.)	Fito-lithophylis	E	LC	I	3.13±2.26	0.59±0.40	75.00
Prissian carp – *Carassius auratus gibelio* (Bloch)	Fitophylis	E	I	O	38.98±15.49	66.52±17.49	100.00
White bream – *Blicca bjoerkna* (L.)	Fito-lithophylis	E	LC	O	3.91±2.75	1.16±0.98	75.00
Bleak – *Alburnus alburnus* (L.)	Fito-lithophylis	E	LC	Pl	0.65±0.63	0.14±0.16	50.00
Roach – *Rutilus rutilus* (L.)	Fito-lithophylis	E	LC	O	37.16±14.40	13.01±4.78	100.00
Common carp – *Cyprinus Carpio* (L.)	Fitophylis	E	I	O	0.13±0.15	0.68±0.78	25.00
Gudgeon – *Gobio gobio* (L.)	Psammophilis	E	LC	O	0.13±0.15	0.06±0.07	25.00
Rudd – *Scaridinius erythrophthalmus* (L.)	Fitophylis	E	LC	O	3.00±11.27	1.41±4.05	25.00
Sunbleak – *Leucaspius delineatus* (Heckel)	Pelagophilis	E	LC	Pl	0.26±0.98	0.04±0.12	25.00
Fish species richness – total (range)					10 (3–8)		

Table 2. Total length (in cm) and body mass (in g) of fish species found in Głębokie Uścimowskie Lake, N – number of individuals, SD – standard deviation

Tabela 2. Struktura wielkości (w cm) i masy ciała ryb (w g) z jeziora Głębokie Uścimowskie w okresie 2008–2011, N – liczebność, SD – odchylenie standardowe

Species	N	Total length (Tl)			Body mass (W)		
		Mean	Min – max	SD	Mean	Min – max	SD
Brown bullhead – *Ictalurus nebulosus* (Lesueur)	97	14.04	9.50–23.50	2.62	35.00	10.00–170.00	25.20
Ruffe – *Gymnocephalus cernuus* (L.)	24	7.60	6.50–11.00	1.28	5.06	3.00–12.00	2.78
Prissian carp – *Carassius auratus gibelio* (Bloch)	299	13.04	3.00–23.00	3.55	46.07	1.00–197.00	34.95
White bream – *Blicca bjoerkna* (L.)	30	9.75	7.00–12.00	1.36	8.03	4.00–13.00	3.49
Bleak – *Alburnus alburnus* (L.)	5	8.50	7.00–10.50	1.54	5.80	4.00–9.00	1.92
Roach – *Rutilus rutilus* (L.)	285	10.09	7.00–18.00	1.70	9.45	2.00–58.00	5.97
Common carp – *Cyprinus Carpio* (L.)	1	21.50	21.50	-	141.00	141.00	0.00
Gudgeon – *Gobio gobio* (L.)	1	12.00	12.00	-	12.00	12.00	0.00
Rudd – *Scaridinius erythrophthalmus* (L.)	23	9.22	7.00–11.20	1.19	12.70	5.00–25.00	5.64
Sunbleak – *Leucaspius delineatus* (Heckel)	2	6.90	6.80–7.00	0.14	4.50	4.00–5.00	0.71

Designated exponential regression curves describing the trend of change of population of dominant fish species in Lake Głębokie Uścimowskie showed, that the number of roach and brown bullhead decreased from 2008 to 2011 (b equal -0.11 and -0.33, respectively), while the number of Prussian carp population year by year increased (b = 0.12) (Fig. 4A).

During the observation in the biomass a slight increase in biomass of roach and brown bullhead were observed (b-value from 0.02 to 0.14), simultaneously the Prussian carp showed greater tendency to increase the biomass (Fig. 4B).

DISCUSSION

Fishery management in the Głębokie Uścimowskie Lake is rather extensive and currently limited only to angling. During research any economic catches of fish with the use of net were noticed. Angling utilization was identified as a not significant in terms of lake exploitation. Angler's places are limited to several wooden piers situated on the north side of the lake and several places on the south-east coast of the lake. At the same time no fishing boat was observed on the lake. Anglers report that they mostly catch brown bullhead and Prussian carp. Perch is caught rather occasionally. In the previous years anglers also caught predatory fish (pike) as well as economically valuable fishes (tench, common carp and large individuals of Prussian carp). In Głębokie Uścimowskie Lake angling is the main way of exploitation. This is the real threat for the proper ichthyofauna species proportion especially in the reservoir not stocked from many years. As researchers Wiśniewolski [2002] and Bieniarz et al. [1990a and b] stat anglers caught predatory species first. According to this in case of only angling economy conducted in the reservoir the number of undesirable cyprinids species may increase as well as the trophy and it often takes place in dam reservoirs [Penczak *et al.* 1993, Wiśniewolski 2008]. Due to their character and great type abundance this kind of reservoirs proper exploitation forces users to some additional obligations, requirements and wider consideration of fish economy [Wołos 1994, Wołos *et al*. 2004].

Ichthyofauna of Głębokie Uścimowskie Lake has not been well known so far. In 2000 research of the total biomass of caught ichthyofauna species was conducted by Kornijów *at al.* [2003] and it was 19,82 kg $CPUE^{-1}$ which means it was slightly lower than at the present study.

No large predatory fish specimens were found in the lake, such as the pikes and a low number of small predators as perch. This situation with almost total lack of predatory fish but dominance of benthivorous and planktivorous (especially cyprinids) may cause a serious consequence such as accelerated pressure on zooplankton and zoobenthos. It may have negative influence on water quality [Lammens 1999]. The consequence of predatory fish deficit is uncontrolled fish reproduction, mainly cyprinids – Prussian carp and roach. It causes intensified food and living environment rivalry resulting in dwarfing because of congestion. Predators deficit causes spread of parasitic diseases in fish population because of the lack of natural selection leaded by predatory species. The result of this effect may be generally worse fish condition and a small number of species (10) in comparison to other lakes in the region the where the average number of fish species is from 12 to 16 [Rechulicz 2008, Płaska and Rechulicz 2008, Radwan *et al*. 1992].

Low average specimen mass, low total biomass of caught fish with high quantity and low species diversity as well as the lack of predators indicates existence of those problems in ichthyofauna of Głębokie Uścimowskie Lake.

Reasonably and rationally conducted fish economy with special consideration of predatory species may be a very efficient tool to limit all the negative symptoms of water eutrophysation [Lammens 1999, Zdanowski 2008]. In case of Głębokie Uścimowskie Lake it has a great importance because it may lead to water quality improvement, proper structure of ichthyofauna and right functioning of a lake ecosystem which after all works better and better with time. Moreover rational and well considered fishery and angling management in this lake may bring measurable financial advantages from fishing and angling with no violence against biological balance [Johansson and Pesson 1986, Wołos 1994, Kahl and Radke 2006, Goryczko and Witkowski 2009].

The research conducted by Kornijów et al. [2003] in several lakes of Łęczna-Włodawa Lakeland proves that quantity of brown bullhead population decreases with increase of lake trophy. Brown bullhead was dragged to Europe about 1880. In 1937 it was transferred to Łukie Lake and from there spread out to the lakes of Łęczna-Włodawa Lakeland by many channels. Brown bullhead is classified as a fish pest, undesirable component of fish community [Adamczyk 1975, Kolejko 1998, Kornijów 2001]. This species is very resistant to water pollutions and significant of pH value fluctuations. Moreover it eats eggs and brood of other fish. Brown bullheads colonize reservoir very fast what causes serious changes in fish structure in lakes.

Proper and rational management of anglers and fishing should be conducted in a continuous and consistent. The lack of fishery management and economic activities leads to permanent changes in the structure of fish fauna and as a result to intensive development of valuable fish populations. The costs of restoring the structure of the species and reduction of the occurrence of alien species may be significant.

Conservation efforts in the Głębokie Uścimowskie Lake should rely primarily on carrying out selective fishing to eliminate population of alien fish species (eg brown bullhead). Then lake should be restocked with fish species characteristic for the tench-pike lakes type. Moreover the predatory fish species (eg pike) should be introduced, which could be effectively control the number of planktivorous fish. The proposed reconstruction of the structure of the ichthyofauna of Głębokie Uścimowskie Lake can take place only if the restrictions of catches of predators by anglers will be introduced.

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Streszczenie. Celem badań było ustalenie, jak kształtuje się ichtiofauna płytkiego, eutroficznego jeziora, w którym od kilkunastu lat nie były prowadzone rejestrowane zarybienia i odłowy gospodarcze. W latach 2008–2011 w jeziorze wykonano odłowy kontrolne ryb przy użyciu sieci typu gill net. Ogółem w zbiorniku w wyniku połowów kontrolnych stwierdzono występowanie 10 gatunków ryb. Przez cały okres badań w jeziorze zarówno w biomasie, jak i w liczebności dominowały trzy gatunki: karaś srebrzysty, płoć i sumik karłowaty. W okresie czterech lat badań można było zaobserwować umacnianie się populacji karasia srebrzystego, która wykazuje tendencję wzrostową zarówno w liczebności, jak i całkowitej biomasie. Odławiane ryby charakteryzowały się jednak niewielkimi rozmiarami i przez to nie przedstawiały wartości gospodarczej. Nietypową cechą ichtiofauny badanego jeziora okazał się całkowity brak gatunków drapieżnych. Tak poważne zaburzenie struktury troficznej doprowadziło prawdopodobnie do wykształcenia ichtiofauny o małych rozmiarach i masie nieprzekraczającej 0,2 kg.

Słowa kluczowe: jezioro eutroficzne, zaburzona struktura ichtiofauny, gospodarka rybacko-wędkarska