

Comparison of Ichthyofauna composition in two estuarine lakes: Ptasi Raj and Mikoszewskie located in the Natura 2000 site “Ostoja w Ujściu Wisły”

Porównanie składu gatunkowego ichtiofauny dwóch jezior estuariowych: Ptasi Raj i Mikoszewskiego w obszarze Natura 2000 „Ostoja w Ujściu Wisły”

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Abstract: These studies aimed to obtain knowledge about the composition of the ichthyofauna of two estuarine lakes: Mikoszewskie and Ptasi Raj in the Natura 2000 area “Ostoja w Ujściu Wisły” (PLH220044), located within the delta estuary created by two channels of the Vistula river: Wisła Śmiała and Przekop Wisły, reaching the Gulf of Gdańsk. Despite the research conducted on the existing flora and fauna in both nature reserves, the ichthyofauna of the lakes has not been studied so far. For the most complete determination of the taxonomic composition and quantitative structure of ichthyofauna possible, different fishing gear was used: fyke nets, NORDIC multimash survey gillnets, minnow traps. A total of 774 fish representing 17 species were caught in the Mikoszewskie lake. A higher number of fish in catches, with a comparable effort applied, were recorded on the Ptasi Raj lake, where a total of 2,032 fish representing 16 species was captured. Out of all 26 species found, only 9 were found in both water reservoirs. As it transpires from the above data, both lakes, despite their seemingly similar location, clearly differ in terms of the structure of inhabiting ichthyofauna due to different hydrological conditions. Based on the analysis of results of the conducted fish catches, it can be concluded that the ichthyofauna of the Mikoszewskie Lake is characteristic for freshwater habitats, whereas in the waters of the Ptasi Raj lake, fish populations depend on a permanent connection with the estuary waters of the Wisła Śmiała channel.

Keywords: coastal lakes, estuary, fish community, Natura 2000 habitats, protected areas, Vistula river mouth

Streszczenie: Celem poniższej pracy było poznanie składu ichtiofauny dwóch jezior Mikoszewskiego i Ptasi Raj znajdujących się w obszarze Natura 2000 „Ostoja w Ujściu Wisły” (PLH220044), położonego w obrębie estuarium utworzonego przez ramiona Wisły, Śmiałej i Przekopu Wisły uchodzące do Zatoki Gdańskiej. Pomimo prowadzonych w tym obszarze badań flory i fauny, ichtiofauna znajdujących się w nich jezior nie była do tej pory poznana. W celu jak najbardziej pełnego określenia składu taksonomicznego oraz struktury ilościowej ichtiofauny zastosowano różne narzędzia połowowe: żaki, wielopanelowe sieci typu NORDIC oraz pułapki narybkowe. W jeziorze Mikoszewskim, odłowiono łącznie 774 ryb reprezentujących 17 gatunków. Wyższe liczebności ryb w połowach, przy porównywalnym nakładzie odnotowano na jeziorze Ptasi Raj, gdzie odłowiono łącznie 2032 ryb reprezentujących 16 gatunków. Ze wszystkich 26 stwierdzonych gatunków tylko 9 z nich występowało w obu zbiornikach. Oba jeziora, pomimo wydawałoby się podobnego położenia, na skutek odmiennych uwarunkowań hydrologicznych, wyraźnie się różnią pod względem struktury zamieszkującej je ichtiofauny. Na podstawie analizy wyników przeprowadzonych połowów można stwierdzić, że ichtiofauna jeziora Mikoszewskie jest charakterystyczna dla siedlisk słodkowodnych, natomiast w poddanym wpływowi wód słonawych jeziorze Ptasi Raj, populacje ryb są zależne od stałego połączenia z wodami estuarium Wisły Śmiałej.

Słowa kluczowe: jeziora przybrzeżne, estuarium, zespoły ichtiofauny, siedliska Natura 2000, obszary chronione, ujście Wisły

INTRODUCTION

The purpose of the following studies was to obtain knowledge about the composition of the ichthyofauna of two estuarine lakes: Mikoszewskie and Ptasi Raj located in the Natura 2000 site "Ostoja w Ujściu Wisły" (PLH220044), which includes two Nature Reserves "Ptasi Raj" and "Mewia Łacha". This area is located within the delta estuary created by two channels of the Vistula river: Wisła Śmiała and Przekop Wisły, reaching the Gulf of Gdańsk (RDOŚ 2009 a, Michałek and Kruk-Dowgiałło 2014). There are two lakes in this area: Ptasi Raj (area: 53 ha) and Mikoszewskie (area: 40 ha) as well as several smaller water reservoirs. Despite the research conducted on the existing flora and fauna in both nature reserves, the ichthyofauna of the lakes has not been studied so far. The studies described in this work are therefore the first aimed at learning the species composition of ichthyofauna in these lakes. The conclusions from research were used in the years 2011–2014 to develop a proposal for the protection of the discussed area as the Natura 2000 Conservation Plans "Ostoja w Ujściu Wisły" PLH 220044.

The research analysis and comparative studies of ichthyofauna carried out in this work concern the two largest lakes of these nature reserves. These two shallow (up to 2.5 m deep) lakes are characterized by a poorly developed coastline, hard-to-reach banks with dominant reedbed growth and are separated from the sea by sand spits covered by dunes, which makes them similar to coastal lakes of the central South Baltic shoreline (Nagengast 2004). The lakes were formed relatively recently as a result of overlapping of natural and anthropogenic processes. The Ptasi Raj lake was formed as a result of an ice jam that caused the dammed waters of the Vistula river to break through the coastal dune belt near the village of Górkki. In this way, a new Vistula estuary channel was created in 1840 called Wisła Śmiała, which was probably separated from the Vistula mainstream by the present-day stone dyke in the second half of the 19th century (Ciesliński and Raškiewicz 2007). On the other hand, the origins of the Mikoszewskie lake are related to the opening of another Vistula channel: the Przekop Wisły in 1895. Initially, the material carried by the river waters was deposited directly in front of a new estuary, which resulted, among others, in ice congestion. Thus, until the 1930s, the riverbed was continuously dredged. In 1930 breakwaters were built and extended as the alluvial fan developed. At the end of the 1960s, a lake called Mikoszewskie was formed on the right side of the estuary, due to the closure of the narrow sand spit growing from the north (Stanowicz 2007).

The creation of the Przekop Wisły channel and building locks cutting off the old riverbed (Martwa Wisła channel) have also had an impact on changing the hydrological system in the discussed area. The reduction of freshwater inflow contributed to a greater exchange with sea waters in the Wisła Śmiała area as well as the Ptasi Raj lake through culverts in the dyke and over the dyke during storm surges. This results in maintaining the salinity of the lake waters at a level of 70–80% in the Gulf of Gdańsk waters (Ciesliński and Ogonowski 2008). However, a single

salinity study from July 2012 found a lack of salinity and chlorides in particular in reservoirs located in the immediate vicinity of the Przekop Wisły channel, including the Mikoszewskie lake (Michałek and Kruk-Dowgiałło 2014). Therefore, the Mikoszewskie lake is in fact a freshwater lake into which seawater from the Gulf of Gdańsk cannot penetrate (Szarafin et al., 2012).

STUDY AREA AND METHOD

For the most complete determination of the taxonomic composition and quantitative structure of ichthyofauna possible, the following fishing equipment with different fishing characteristics dependent on the location of their placement was used (Rechulicz 2006):

- ♦ within the waters of open lakes, NORDIC sectoral gillnets were used (costal warm), consisting of 9 panels (sectors), of which each was 5 m long and 1.8 m high with a different mesh size in the sequence of 30 mm, 15 mm, 38 mm, 10 mm, 48 mm, 12 mm, 24 mm, 60 mm and 20 mm. The net panels are made of monofilament (nylon line) with a thickness of 0.15 mm to 0.20 mm. A headrope with a length of 45 m was made of float cord no. 1.5 (7 g · m⁻¹) and a bottom rope of weight rope no. 1.5 (23 g · m⁻¹) with a length of 49.5 m. Multi-panel gillnets are currently used to study ichthyofauna structure for most areas of the coastal zone, lagoons and bays of the Baltic Sea (Neuman et al. 1999, HELCOM 2006)
- ♦ in the direct shallow zone of littoral, minnow traps in the shape of a rectangle with dimensions of 60x60x100 cm and a mesh cross-section of 5 mm were used. Such tools are used in monitoring of small fish species (Kuśnier 2010).
- ♦ fyke nets 60 cm high and 5 m long, made of nylon mesh with a size of 11 mm in the body of the trap.

The research was carried out in August 2011 using fyke nets and in July 2012, with the use of sectoral gillnets and minnow traps. These periods were consulted with ornithologists and allowed to minimize the negative impact of ichthyological research on the avifauna, since the lowest number of water birds in the area is observed in the summer.

THE MIKOSZEWSKIE LAKE (NATURE RESERVE OF MEWIA ŁACHA)

Before the start of the research in August 2011, three measurement stations in the eastern part of the Mikoszewskie lake were designated. Fyke nets were used three times for a period of 8 hours during one day. (Fig. 2):

- ♦ station no. 1. – shallow waters (0.6–0.8 m) strongly overgrown with submerged macrophytes and loosely reed-covered littoral zone,
- ♦ station no. 2. – depth of about 1 m, hard, nonovergrown bottom in the immediate vicinity of a narrow strip of reed,
- ♦ station no. 3. – area between stations 1 and 2 with a depth of about 2 m and a soft muddy bottom.

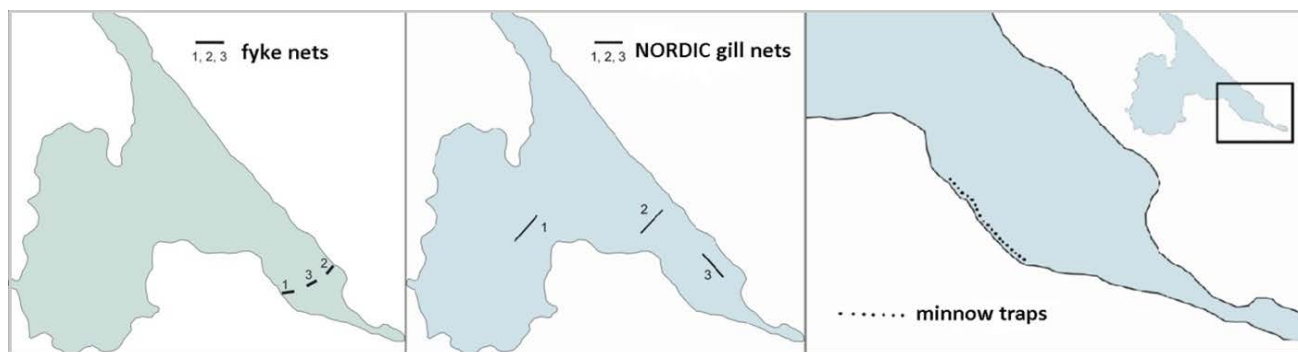


Fig. 1. Location of research stations where catches were made on the Mikoszewskie lake in 2011 and 2012.

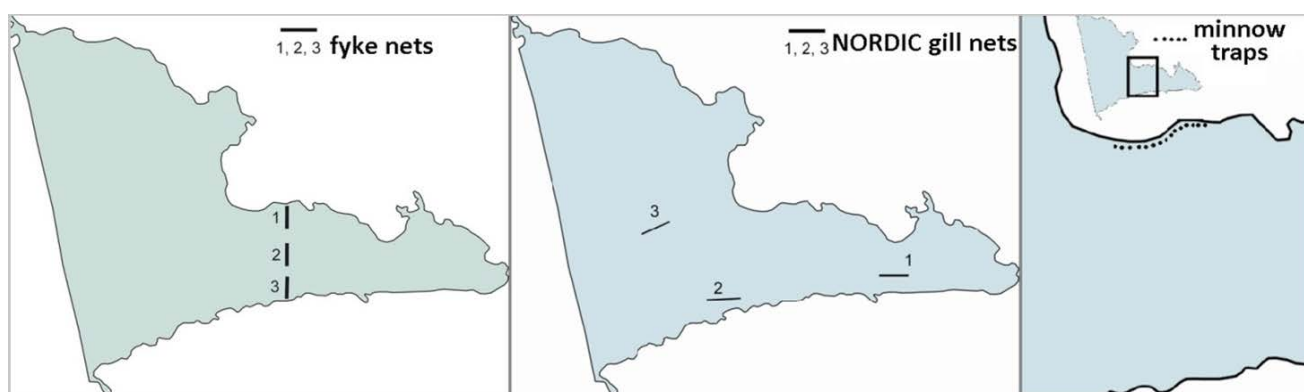


Fig. 2. Location of the research stations where catches on the Ptasi Raj lake were placed in August 2011.

Research with the use of NORDIC survey gillnets and minnow traps was carried out in July 2012. Gillnets were placed at three stations (Fig. 1):

- ♦ station no. 1. – the central part of the lake, about 1.5 m deep with a hard bottom strongly overgrown with submerged macrophytes,
- ♦ station no. 2. – narrow strip of land between the central part of the lake and the eastern bay with a depth of about 1.5 m with a hard, sandy bottom with sparsely submerged macrophytes,
- ♦ station no. 3. – eastern bay of the lake with a depth of about 2 m with a soft muddy bottom.

Sectoral gillnets were placed twice at each station for 12 hours during one day. Minnow traps (20 pcs) were placed at intervals of about 5 m along the shore directly in the littoral zone, between the submerged macrophytes and loosely overgrown reed. The traps were exhibited four times for 6 hours during one day.

THE PTASI RAJ LAKE (NATURE RESERVE OF PTASI RAJ)

During the research in August 2011, fyke nets were placed on the waters of Ptasi Raj lake three times for a period of 8 hours during one day, at three stations in the central part of the lake (Figure 2):

- ♦ station no. 1. – the northern shore in the immediate vicinity of the reedbed, depth 0.6-0.8 m,

- ♦ station no. 2. – shallow waters with a hard bottom in the central part of the lake, depth up to 1 m,
- ♦ station no. 3. – coastal zone in the southern part of the lake near the stripe of dense reeds, depth about 2 m.

Research with the use of NORDIC survey gillnets and minnow traps was carried out in July 2012. Sectoral nets were placed at three stations (Figure 2):

- ♦ station no. 1. – eastern part of the lake, depth about 2 m,
- ♦ station no. 2. – recess along the southern shore of the lake, depth of about 1.5 m,
- ♦ station no. 3. – the main part of the lake from the dyke separating the lake from the Wisła Śmiała channel, depth -1.5 m.

Nets were placed twice on each station for 12 hours during one day. Traps (15 pcs) were placed at intervals of around 5 m along the northern shore of the central part of the lake (Figure 7), which is overgrown with macrophytes immersed in the littoral zone in the immediate vicinity of the reeds. The traps were placed four times for 6 hours during one day. The collected material was subjected to analysis to specify taxonomic affiliation and abundance for each taxon.

RESULTS

In August 2011 and July 2012, a total of 774 fish representing 17 species were caught in the Mikoszewskie lake using all type of

Tab. 1. Fish species recorded in the summer of 2011 and 2012 in research catches in the Mikoszewskie and Ptasi Raj lakes.

NO.	SPECIES	MIKOSZEWSKIE LAKE	PTASI RAJ LAKE
1	<i>Abramis bjoerkna</i> , White bream	x	x
2	<i>Abramis brama</i> , Common bream	x	x
3	<i>Abramis sapa</i> , White-eye bream		x
4	<i>Alburnus alburnus</i> , Common bleak	x	x
5	<i>Anguilla anguilla</i> , European eel		x
6	<i>Aspius aspius</i> , Asp	x	x
7	<i>Carassius carassius</i> , Crucian carp	x	
8	<i>Carassius gibelio</i> , Prussian carp *	x	x
9	<i>Clupea harengus</i> , Atlantic herring		x
10	<i>Cyprinus carpio</i> , Common carp *		x
11	<i>Esox lucius</i> , Northern pike	x	
12	<i>Gasterosteus aculeatus</i> , Three-spined stickleback	x	x
13	<i>Gymnocephalus cernuus</i> , Eurasian ruffe	x	
14	<i>Leuciscus idus</i> , Ide		x
15	<i>Neogobius fluviatilis</i> , Monkey goby *	x	
16	<i>Neogobius gymnotrachelus</i> , Racer goby *	x	
17	<i>Neogobius melanostomus</i> , Round goby *		x
18	<i>Perca fluviatilis</i> , European perch	x	x
19	<i>Percottus glenii</i> , Chinese sleeper *	x	
20	<i>Pungitius pungitius</i> , Ninespine stickleback		x
21	<i>Rhodeus sericeus</i> , Bitterling	x	
22	<i>Rutilus rutilus</i> , Roach	x	x
23	<i>Scardinius erythrophthalmus</i> , Common rudd	x	x
24	<i>Stizostedion lucioperca</i> , Pike perch		x
25	<i>Tinca tinca</i> , Tench	x	
26	<i>Vimba vimba</i> , Vimba bream		x

* alien species

fishing gear. A higher fish number in catches, with a comparable effort applied, were recorded on the Ptasi Raj lake, where a total of 2,032 fish representing 16 species were captured. Out of all 26 species found, only 9 were found in both water reservoirs (Table 1). They were freshwater species, mostly ubiquitous, such as: stickleback, bleak, white bream, roach, common bream or alien silver Prussian carp. Euryhaline species (eel, vimba bream) as well as species characteristic for brackish water (round goby, herring) were recorded only in the Ptasi Raj lake.

Due to a small number of fish caught, catches made in August 2011 on the Mikoszewskie lake using fyke nets can be considered as rather unrepresentative. Only 19 specimens representing 7 taxa were caught. The perch was the most numerous.

In the research conducted in the summer of 2012, during which NORDIC gillnets were used on the Mikoszewskie lake, there was a dominance of perch and bleak among 631 fish, which represented only species typical for freshwater; they accounted for 29% and 25% of all the caught fish at the three stations. Other species included roach (17%) and white bream (12%) (Figure 8). The catches also recorded: rudd, common bream,

Eurasian ruffe, Prussian carp, tench, asp, bitterling, pike, and silver Prussian carp.

In contrast, in catches made with the use of minnow traps placed in the direct littoral zone in the Mikoszewskie lake, 11 species were found ($n = 124$). The most numerous were juvenile fish at different stages from the *Abramis* genus (34%). Next in the rank were roach fry (16%), rudd fry (16%) and an invasive species of Chinese sleeper (14%). The catches also include: three-spined stickleback, bitterling, and fry stages of tench, perch, Prussian carp and two alien species of monkey goby, and racer goby (Figure 9).

In fishing with conducted the use of fyke nets in August 2011 on Ptasi Raj lake, 192 fish were caught; they belonged to 10 species with a dominance of fish from the *Abramis* and round goby genus, accounting for 51% and 36% of fish abundance in the samples (Figure 10). Other species found were: silver Prussian carp, eel, perch, rudd, three-spined stickleback, roach, and herring.

In 2012, 1,476 fish were caught with the use of sectoral gillnets on the Ptasi Raj lake. The dominant species was bleak, which is

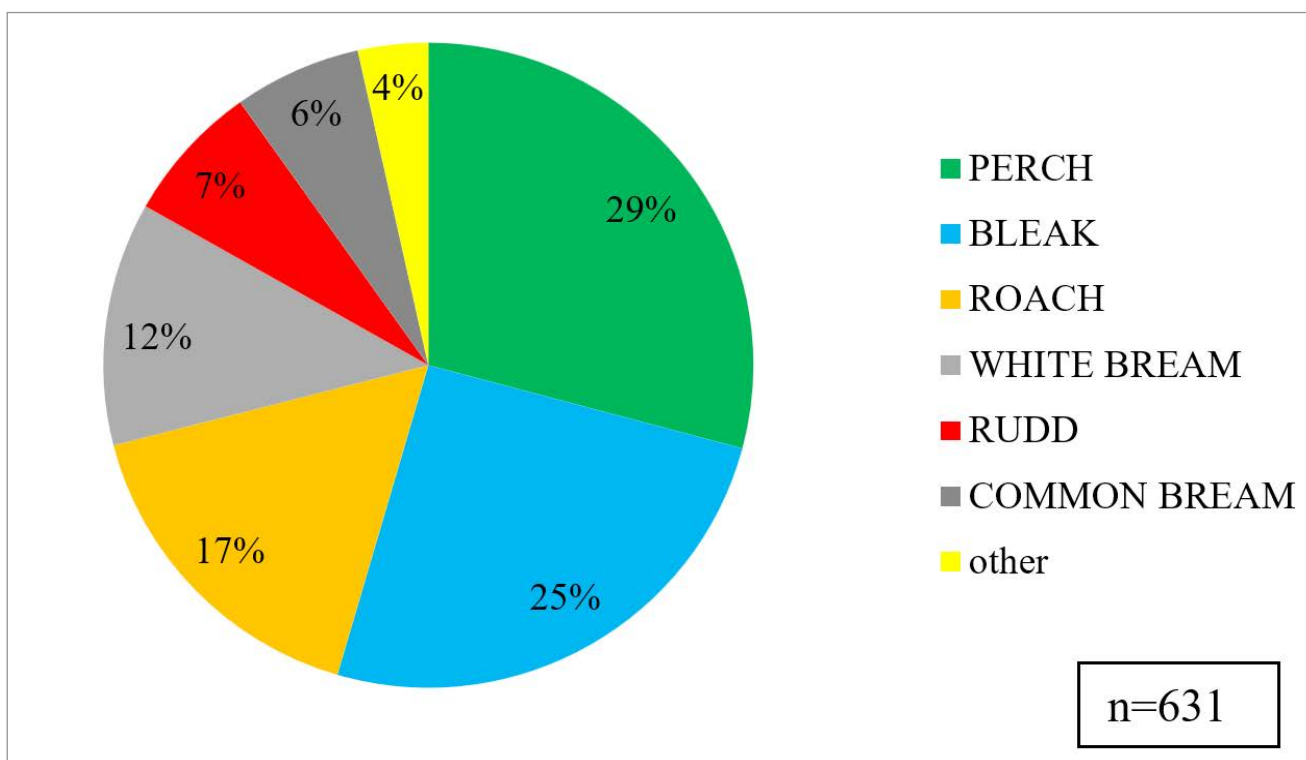


Fig. 3. Share in the abundance of fish species in total catches with NORDIC gillnets on the Mikoszewskie lake (July 2012).

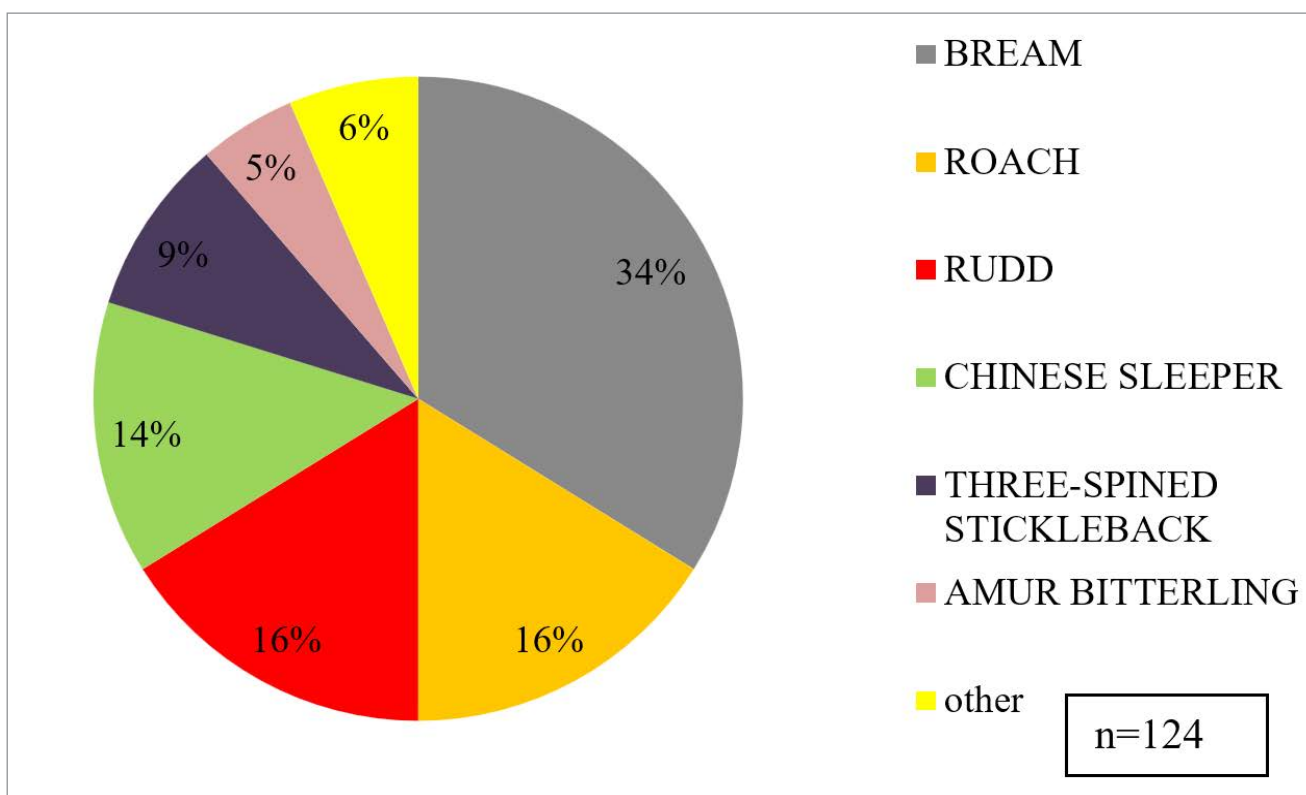


Fig. 4. Share in the abundance of fish species in total catches with minnow traps on Mikoszewskie lake (July 2012).

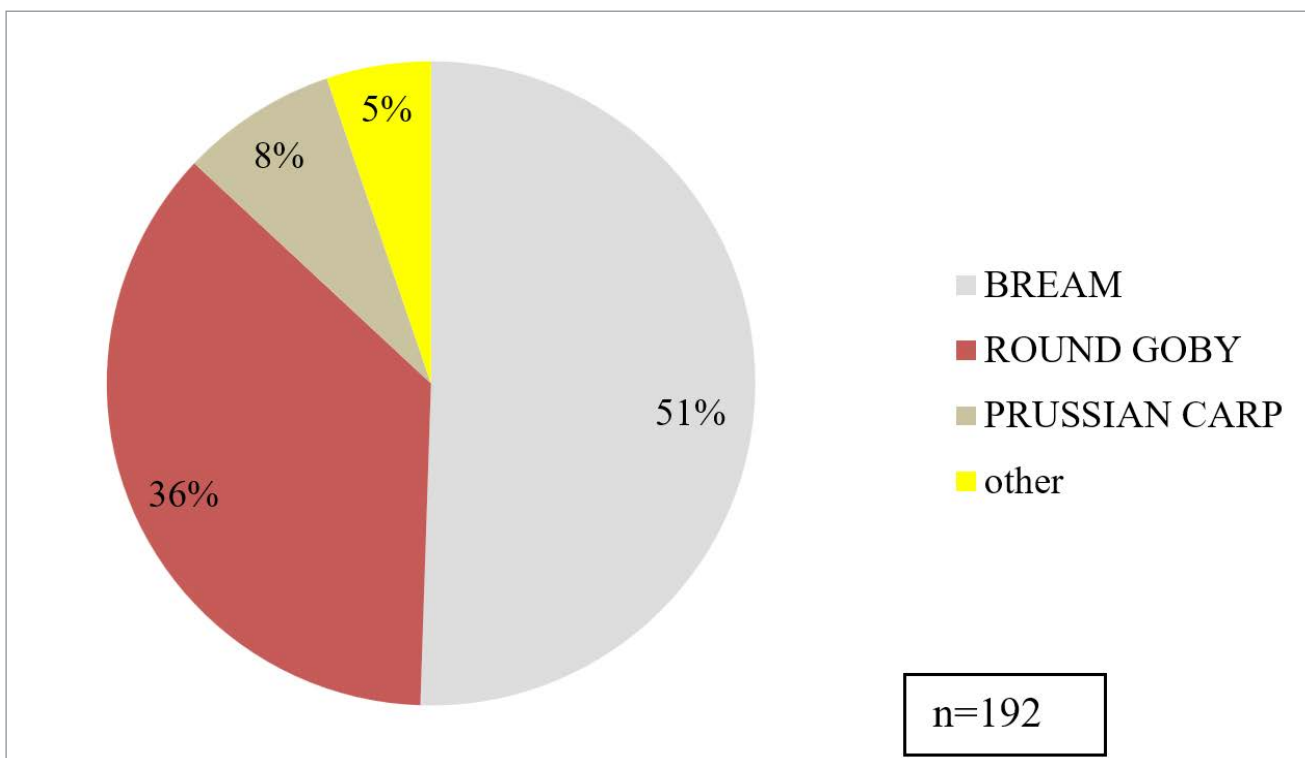


Fig. 5. Participation in the abundance of fish species in the fishing with fyke nets on the Ptasi Raj lake (August 2011).

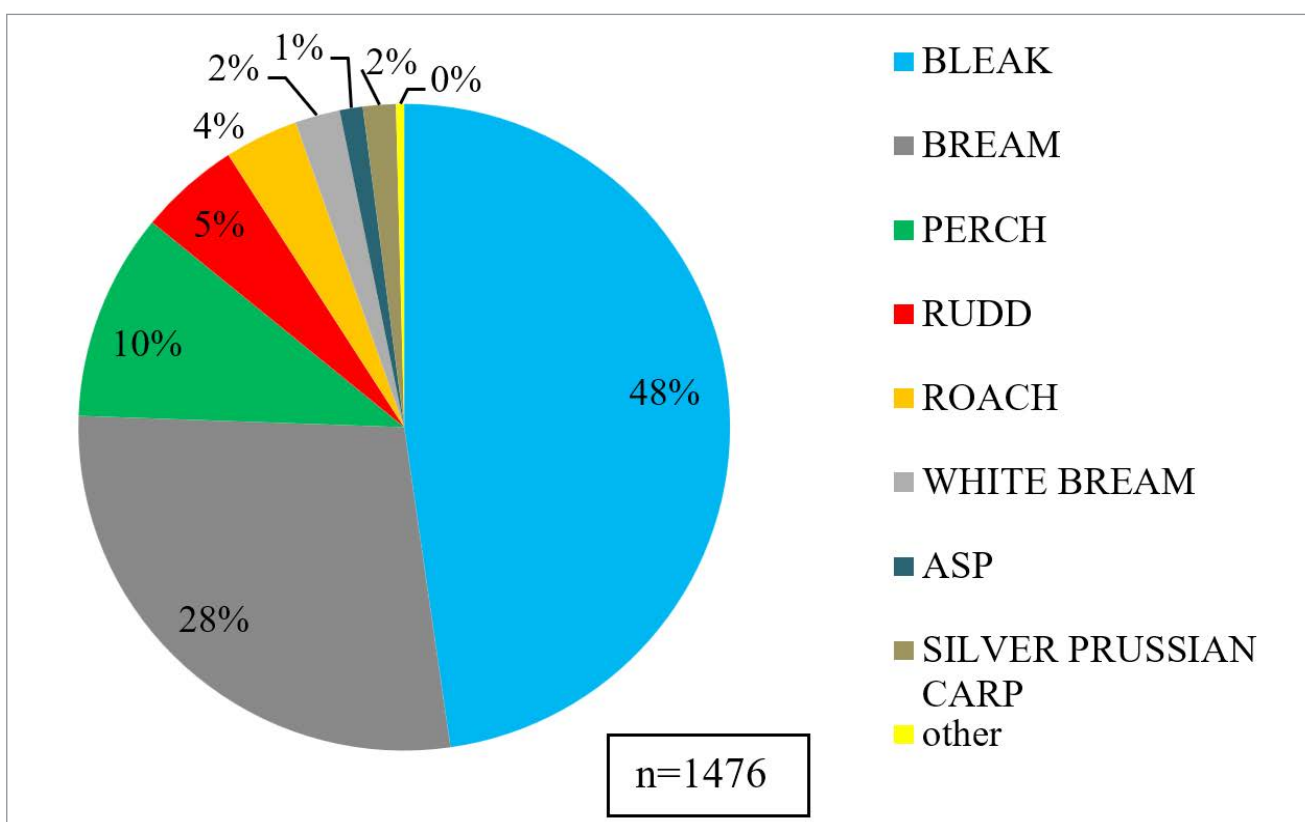


Fig. 6. Share in the abundance of fish species in total catches using NORDIC gillnets on the Ptasi Raj lake (July 2012).

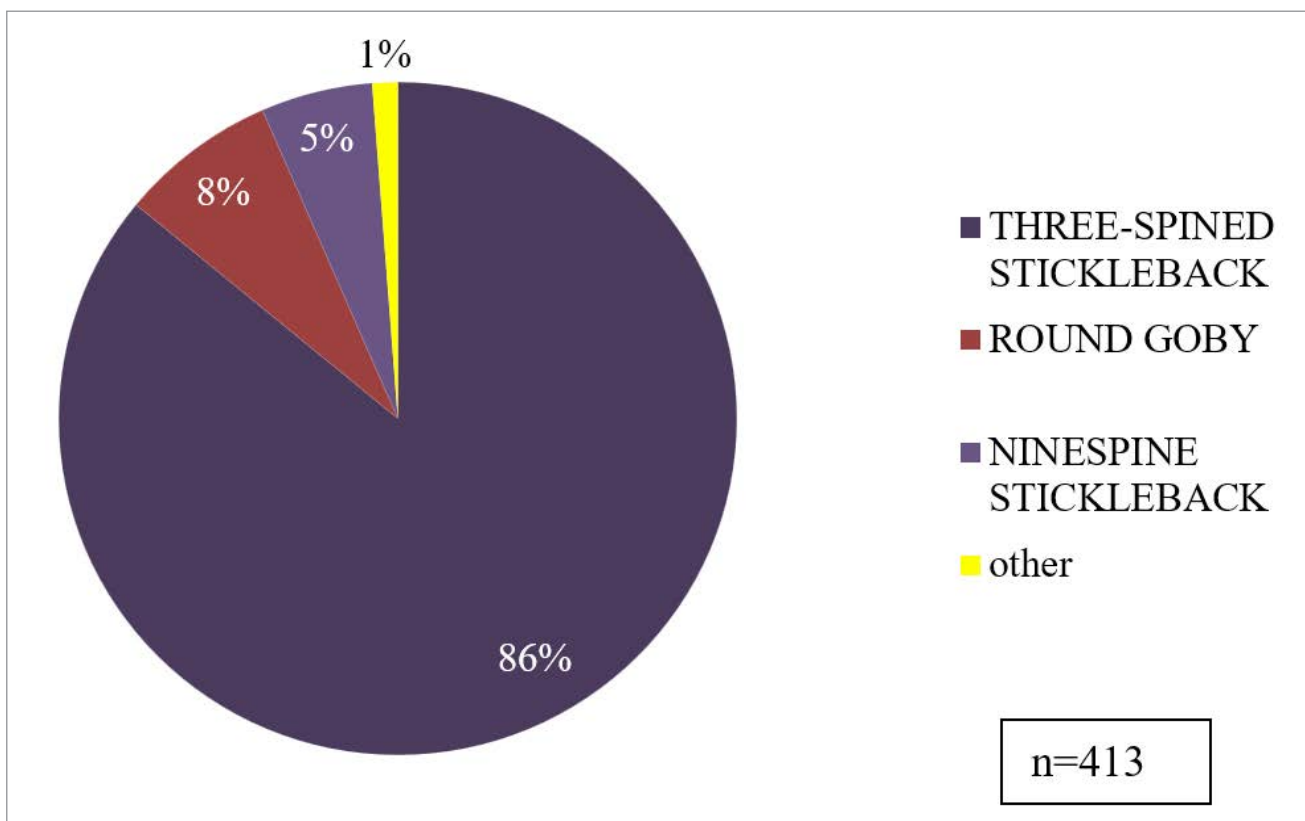


Fig. 7. Share in the abundance of fish species in total catches of minnow traps on the Ptasi Raj lake (July 2012).

DISCUSSION

As it transpires from the above data, both lakes, despite their seemingly similar location, due to different hydrological conditions, clearly differ in terms of the structure of the inhabiting ichthyofauna. In the Mikoszewskie lake, which remains in no connection with the Gulf waters, the potential water exchange could occur during flooding on the Vistula river. This is confirmed by the presence of species typical of freshwater habitats, including fish characteristic for oxbow lakes, such as: crucian carp, pike, Amur bitterling, rudd, and tench (Wisniewolski et al. 2009). In addition, among the representatives of the alien, invasive ichthyofauna, besides the eurytopic species of the silver Prussian carp, species such as Chinese sleeper, round goby, and racer gob were also recorded. These species are most commonly found in the oxbows of the Vistula river waters.

The freshwater character of the lake is also evidenced by the fact that apart from the numerous silver Prussian carp occurring in the Puck Bay, examples of other freshwater species were not recorded in the area of the Gulf of Gdansk at all. This is another proof to the formation of this lake's species composition of the ichthyofauna exclusively by the waters of the Vistula river, despite the close proximity of Gulf waters. Taking the above into account, it can be assumed that the proposed classification of the lake contained in the protection plan for the Mewia Łacha nature reserve (Regional Directorate for Environmental Protection in Gdansk) as a habitat 1150 "Lagoons and coastal lakes" is inappropriate. Despite the lake's origins, seemingly similar to

the typical coastal lake development resulting from the spit cut-off by the gulf, formed from the extension of breakwaters at the mouth of the Przekop Wisły channel, currently the ecosystem of this lake seems to be exclusively of inland character. Quite the opposite situation may be observed in the case of the Ptasi Raj lake; there, the taxonomic composition of the ichthyofauna indicates a significant influence of the Gdansk Gulf waters. This is due to the numerous occurrences of round goby and the presence of herring. In the spring period, the herring enters into a vast number of the neighboring waters of the Wisła Śmiała channel for spawning (Grochowski 2010).

On the other hand, much higher fish catches in the Ptasi Raj lake (more than twice the size) than in the Mikoszewskie lake, as well as the share of cyprinidae reaching almost 90%, including species such as bleak and bream, indicate a much larger eutrophy of these waters (Jezierska-Madziar and Pińskwar 2008). The Ptasi Raj lake also included the euryhaline species such as eel and vimba bream. There were no species that were typical of lake waters such as tench or common crucian carp. The lack of the latter is the more significant, because it creates a large population in the nearby small Karaś lake, which is separated from other waters (Kuczyński et al. 2013). It was formerly the gulf area of the Ptasi Raj lake, from which it was isolated as a result of sedimentation processes at the beginning of the 20th century (Ciesliński 2008). This may indicate that after being cut off from the mainstream of the Vistula river at the end of the 19th century, changes in the environment of the Ptasi Raj lake were not conducive to the development of the common crucian carp

population in contrast to the silver Prussian carp species being the most widespread alien species in Poland due to its high adaptability. (Grabowska et al. 2010). However, the most apparent difference between the described lakes was the qualitative composition of fish in the littoral zone. In this respect, the Mikoszewskie lake was characterized by a relatively balanced structure of domination and the presence of fry forms of seven species, as well as the occurring species of bitterling protected by national and European law, which found a perfect breeding place in the littoral zone. The situation in the Ptasi Raj lake is the opposite, where over 90% of fish stock consists of the stickleback family, with only one specimen of fry forms of the silver Prussian carp found. Despite the similarities in the nature of the both lakes' littoral, the Ptasi Raj has no favorable conditions for spawning and growing of the occurring fry fish, and their numerous populations are dependent on the connection with the waters of the Wisła Śmiała channel. This thesis may also be confirmed by lake salinity, which is too high for the development of freshwater species (Bieniarsz and Epler 1991), as well as by frequent occurrence of the stickleback fish and round goby families in the littoral zone, feeding on fry fish and larvae.

CONCLUSIONS

The research allowed to determine and compare the taxonomic

composition of ichthyofauna inhabiting two lakes located in the estuary of the Vistula river. Due to the high natural value of this area protected both as nature reserves and as Natura 2000 sites, the findings of the research were used while preparing documentation for Protection Plans concerning the habitat protection area PLH "Ostoja w Ujściu Wisły".

At the same time, the obtained results indicated differences in the composition and species structure of fish inhabiting both lakes, which confirms the different existing hydrological conditions. Based on the analysis of results of conducted fish catches, it can be concluded that the ichthyofauna of the Mikoszewskie Lake is characteristic for freshwater habitats, whereas in the waters of the Ptasi Raj lake, fish populations depend on a permanent connection with the estuary waters of the Wisła Śmiała channel. The earlier habitat classification of both these lakes, as habitat 1150 "Lagoons and coastal lakes", therefore seems inappropriate. In the case of the Mikoszewskie lake, in terms of ichthyological characteristics, it corresponds to the type of habitat 3150 "oxbow lakes and natural eutrophic water reservoirs with vegetation community of Nympheion-Potamion." In turn, the Ptasi Raj lake should be treated as an integral part of habitat 1130 "River mouths (estuaries)" covering the waters of the Wisła Śmiała channel. The above example illustrates the necessity to perform ichthyofauna research in the analysis of the classification of aquatic habitats in transitional regions that remain in the bordering areas of freshwater and marine waters.

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