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RESEARCH ARTICLE

Management of fish populations in lobelia lakes in the vicinity of Bytów (northern Poland)

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Abstract. The aim of the studies was to describe the fisheries management of five lobelia lakes and one non-lobelia reference lake. Data from commercial catches was used to estimate the size of the catches, and to determine the species and ecologial structure of the catches, and to describe stocking. During the period from 1968 to 2006, eleven fish species belonging to five families were noted in the catches. The species structure of the commercial catches of the analyzed lobelia lakes corresponded to that of either vendace or eutrophic lakes. Catches made in lobelia lakes were from 2.5 to 5-fold smaller in comparison to the reference lake. The dominant species in commercial catches made in basins with lobelia vegetation were roach, *Rutilus rutilus* (L.), and pike, *Esox lucius* L., but bream, *Abramis brama* (L.), vendace, *Coregonus albula* (L.), and carp, *Cyprinus carpio* L., also occurred in some lakes. Pike was caught most frequently, followed by bream, roach, and perch. The largest catches were made in either March or November. During the period from 1968 to 2006, the lakes were stocked with ten fish species, nine of which were noted in the official statistics. Only six species occurred naturally in these lakes. Peled, *Coregonus peled* (Gmelin), is an alien species, and its occurrence was certainly connected with stocking. Pikeperch, *Sander lucioperca* (L.), was translocated outside of its area of natural occurrence, while carp and Prussian carp, *Carassius gibelio* (Bloch), were alien species.

Keywords: Commercial fisheries, management, effects of fishing, stocking

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Introduction

Among all of the natural European post-glacial lakes, lobelia lakes are a particularly interesting group (Szańkowski and Kłosowski 2006). Lobelia lakes differ from other aquatic basins as they are inhabited by rare, relict aquatic vegetation, their water is soft, and contents of calcium and nutrients are small (Kraska 2004, Free et al. 2009). The geographic range of lobelia lakes includes Scandinavia, Denmark, Iceland, the British Isles, the northern regions of North America, and New Zealand. In the Baltic region, numerous lobelia lakes are located in Lithuania, Latvia, and Estonia. There are from 150 to 170 lobelia lakes in Poland (Kraska et al. 1996, Szmeja 1997), which are located primarily in Pomerania, with single lakes occurring in Masuria and the Sudetes. Lobelia lakes usually have no outlet, are shallow, and do not exceed 15 ha in surface area (Kraska 2004).

Most lakes in Poland are managed by commercial fisheries (Bnińska and Wołos 2001), through net catches and stocking, which is considered to compensate for the losses fish populations suffer as a result of exploitation. The main fish species that caught in recent years are pike, *Esox lucius* L., bream, *Abramis brama* (L.), roach, *Rutilus rutilus* (L.), pikeperch, *Sander lucioperca* (L.), vendace, *Coregonus albula* (L.), and eel, *Anguilla anguilla* (L.) (Wołos et al. 2009). The species that are stocked most frequently are pike, vendace, and tench, *Tinca tinca* (L.) (Mickiewicz 2009). Lobelia lakes are

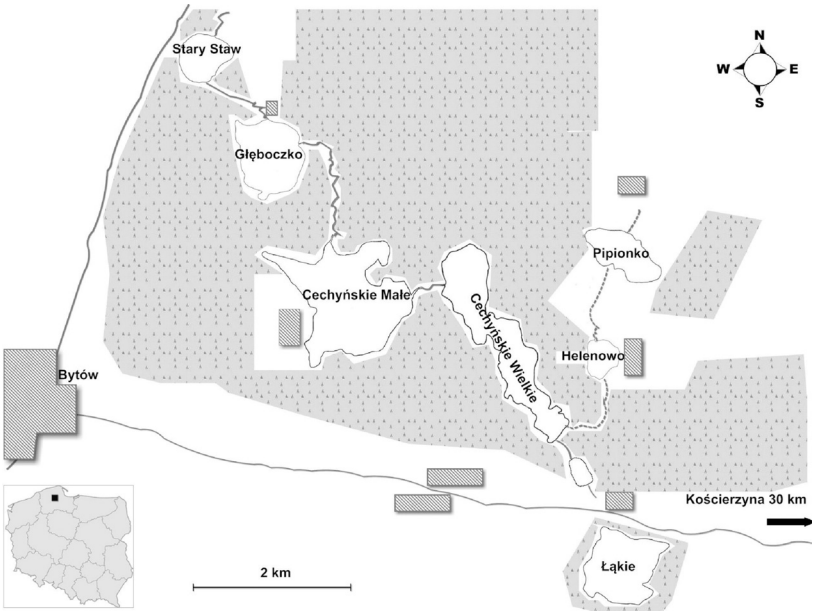

Figure 1. Location analyzed lakes on a map of Poland.

considered to be unsuitable for fishing because of their low productivity (Kraska et al. 1996, Hesse 2000, Kapusta et al. 2007). Commercial fishing in lobelia lakes relies on catches of several species and catch yield seldom exceeds 10 kg ha^{-1}. Based on analyses of the composition of the ichthyofauna and the commercial fisheries, Heese (2000) identified four fish assemblages that inhabit lobelia lakes of varied trophic status.

The literature available on the subject of fisheries exploitation in lobelia lakes indicates that, since its inception, fisheries management has had a substantial impact on the trophic and ecological states of these lakes. The aim of the current study was to describe the fisheries management in lobelia lakes and in one non-lobelia reference lake. The current work analyzed the size, species structure, fish assemblages fished by ecological group, and stocking in these lakes.

Materials and methods

Study area

The lakes studied are all in the upper reaches of the Słupia and Łupawa catchments in the Pomeranian Lakeland in northern Poland (Fig. 1). Most of the lakes studied were connected by small streams that dried up periodically, but Lake Łąkie has neither inlets nor outlets. The lakes are located in various types of terrain. The catchment areas of the lakes comprise primarily forests and some meadows and arable land. The morphometrics and trophic statuses of the lakes differ (Table 1). Lake Cechyńskie Małe has the largest surface area at 48.8 ha, while Lake Helenowo has the smallest at 8.8 ha. Lake Głęboczko is the deepest of the lakes and also has the deepest mean depth, while the shallowest is Lake Helenowo. Lake Łąkie is an oligotrophic, and lakes Pipionko and Helenow are eutrophic. Thermal and oxygen stratification occurs in the waters of all the lakes. Lakes Cechyńskie Małe, Cechyńskie Wielkie, Głęboczko, Łąkie, and Pipionko are all lobelia lakes while Lake Helenowo is not.

Analysis of the fisheries exploitation of the lakes

Fisheries were conducted in these lakes from 1968 to 1994 by the State Fisheries Enterprise in Bytów, which was privatized in 1995. Data regarding catches taken from the fisheries management logs

Table 1
Selected morphological and environmental characteristics of the lakes analyzed (data from IFI Olsztyn). Those marked with an asterisk are Lobelia lakes

Parameter	Cechyńskie Małe*	Cechyńskie Wielkie*	Głęboczko*	Łąkie*	Pipionko*	Helenowo
Area (ha)	48.4	45.6	22.0	23.4	22.8	8.8
Max depth (m)	19.7	13.3	29.6	23.0	10.7	10.7
Mean depth (m)	8.5	4.5	11.1	9.7	5.7	5.1
Volume (m^3)	4148.2	2044.3	2437.9	2275.4	1294.7	446.9
pH	7.35	7.61	7.10	6.60	7.35	-
Conductivity ($\mu S\ cm^{-1}$)	99	115	107	74	172	-
Trophy	mesotrophic	mesotrophic	mesotrophic	oligotrophic	eutrophic	eutrophic

from the period from 1968 to 2006 were used in the analysis. All fishing enterprises operating in all lakes are required to keep lake logs. These contain monthly reports regarding how many fish were caught by species, and information about stocking. Analyzing lakes menagement logs permitted determining which species were stocked and at what frequency, the dominant and mean stocking intensity in respective time periods, and the variety of the fish stocked. The aim of analyzing commercial catches was to designate the species dominance of the fish stocked and the frequency at which individual species were stocked. The fish assemblages were identified in each lake and presented by ecological reproductive groups. The mean annual yield and catch share was also determined by ecological fish groups, as follows: coregonids (whitefish, vendace, *Coregonus lavaretus* (L.) peled, *Coregonus peled* (Gmelin)); eel; predatory (pike, perch, *Perca fluviatilis* L., pikeperch); cyprinids (roach, bream, carp, *Cyprinus carpio* L., tench).

Statistical analysis

Statistical analysis was based on comparing the catch yield and the share of individual ecological groups in the lakes analyzed using variance analysis (ANOVA). When statistically significant differences of the F test were detected, post-hoc analysis was performed. Tukey's test was applied to identify statistically significant differences among the variables tested. Agglomeration analysis of assemblages was applied to classify the lakes and the species that occurred in the commercial catches. This method is based on organizing the variables and detecting sensible structures with defined algorithms. The data was agglomerated using Ward's method with Euclidean distances as the measure of similarity. The statistical calculations were done using the Statistica 8.0 package (StatSoft, Inc., USA).

Results

Catch characteristics

Eleven species of fish belonging to five families were noted in the commercial catches of the lakes analyzed during the period from 1968 to 2006 (Table 2). Four species represented the cyprinid family (*Cyprynidae*), three – the coregonid sub-family (*Coregoninae*), and two species from the percid family (*Percidae*). Fish from the Esocidae (pike) and Angullidae families were represented by single species among those of the commercially exploited fish assemblage.

Fish catches made in the lakes analyzed were highly irregular. The highest catch frequency was noted in Lake Cechyńskie Wielkie, while the lowest was in Lake Cechyńskie Małe (Table 2). The number of species exploited commercially differed in the different lakes ($P < 0.01$). The highest total number of

Table 2
Characteristics of the fish catches in the lakes analyzed. Cyprinids were represented by roach, bream, tench, and carp; corregonids by vendace, whitefish, peled; and predatory fish by pike, perch, and pikeperch. Values in the same row with different letter indexes differ statistically significantly ($P < 0.05$)

	Cechyńskie Małe	Cechyńskie Wielkie	Głęboczko	Łąkie	Pipionko	Helenowo
Fishing years	23	24	21	24	21	22
Total no. of fish species	8	10	6	9	8	9
Mean no. of fish species	$4.1^{b}\pm1.60$	$4.2^{b}\pm1.18$	$2.9^{a}\pm1.14$	$4.6^{b}\pm1.53$	$4.3^{b}\pm1.52$	$3.5^{b}\pm1.79$
Mean catch (kg year^{-1})	203.1	153.6	85.2	173	163.3	152.3
Max. catch (kg year^{-1})	611	458	286	465	275	417
Mean fish yield (kg ha^{-1})	$4.2^{a}\pm3.79$	$3.4^{a}\pm2.55$	$3.7^{a}\pm2.53$	$7.4^{ab}\pm5.34$	$7.1^{a}\pm5.69$	$17.3^{b}\pm14.63$
htMax. fish yield (kg ha^{-1})	12.2	10	11.8	18.5	12.1	47.3
Cyprinid yield (kg ha^{-1})	$1.6^{a}\pm2.66$	$2.2^{ab}\pm2.58$	$0.9^{a}\pm1.20$	$3.0^{ab}\pm3.76$	$5.3^{bc}\pm4.88$	$14.2^{c}\pm13.53$
Coregonid yield (kg ha^{-1})	$1.7^{b}\pm1.87$	$0.2^{a}\pm0.55$	$2.3^{b}\pm2.52$	$3.8^{b}\pm3.54$	$0.2^{a}\pm0.49$	$0.1^{a}\pm0.44$
Predator yield (kg ha^{-1})	$0.7^{ab}\pm0.92$	$0.7^{ab}\pm0.58$	$0.5^{a}\pm0.66$	$1.0^{ab}\pm0.70$	$1.1^{ab}\pm1.38$	$2.3^{b}\pm2.85$
Eel yield (kg ha^{-1})	$0.2^{ab}\pm0.36$	$0.3^{ab}\pm0.36$	0.0	$0.0^{a}\pm0.04$	$0.5^{b}\pm0.70$	$0.7^{ab}\pm1.72$
Catch frequency (%)	60.5	100	91.3	95.8	87	83.3

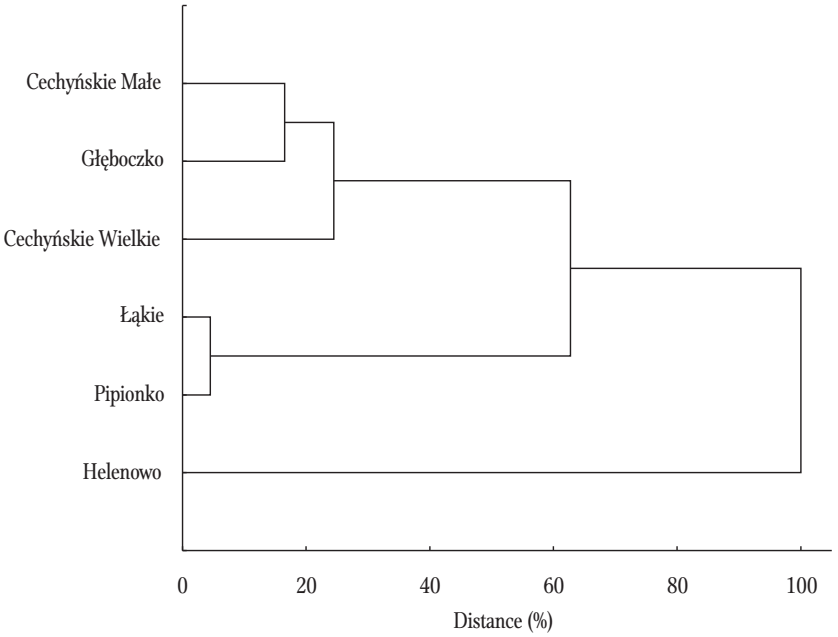

Figure 2. Dendrogram of lake similarity based on fishing efficiency and the number of species fished commercially. Data agglomeration was performed with Ward's method using Euclidean distance as the measure of similarity. All the basins are lobelia lakes with the exception of Lake Helenowo.

species fished commercially was noted in Lake Cechyńskie Wielkie, while the lowest was in Lake Głęboczko. There was a statistically significant difference in the mean annual catches among the lakes ($P < 0.001$). The highest mean annual catch yield was noted in Lake Helenowo, while the lowest was noted in Lake Cechyńskie Wielkie at 17.3 and 3.4 kg ha^{-1}, respectively. The analysis of the classification permitted identifying three groups of lakes that differed in yield and the quantity of fish species caught (Fig. 2). The most numerous group of lakes were those with the lowest yield that ranged from 3.4 to 4.2 kg ha^{-1} (Cechyńskie Wielkie, Głęboczko, Cechyńskie Małe) and in which from six to eight species were caught.

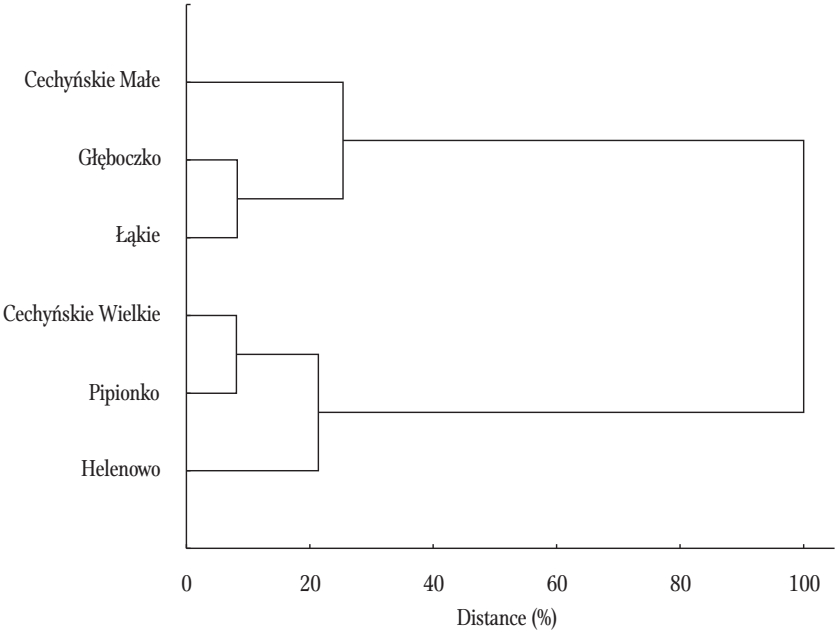

Figure 3. Dendrogram of lake similarity based on the frequency of species in commercial catches. Data agglomeration performed with Ward's method using Euclidean distance as the measure of similarity. All the basins are lobelia lakes with the exception of Lake Helenowo.

However, eight to nine species occurred in the catches made in lakes Łąkie and Pipionko where the mean fishing yield was from 7.1 to 7.4 kg ha^{-1}). Lake Helenowo was the only lake that was categorized with the highest yield. The mean yield in the period from 1982 to 2006 was from four to five fold higher than that of the lakes categorized in the first group and 2.5-fold higher than that of either Lake Łąkie or Lake Pipionko. Nine species of fish occurred in the commercial catches of Lake Helenowo.

Significantly differences were confirmed among the catches that were divided by ecological group (Table 2). Cyprinids were the largest group of fish caught in lakes Helenowo and Pipionko at 14.2 and 5.3 kg ha^{-1}, respectively, while the smallest quantities of cyprinids were caught in lakes Głęboczko and Cechyńskie Małe at 0.9 and 1.6 kg ha^{-1}. The mean yield of corregonid catches was from 0.1 to 3.8 kg ha^{-1} and differed statistically significantly among all of the lakes analyzed ($P < 0.001$). The mean yield of predatory fish catches was from 0.5 to 2.3 kg ha^{-1}, and of eel from 0 to 0.7 kg ha^{-1}. The analysis of commercial catch results permitted identifying two groups of lakes (Fig. 3). Cechyńskie Małe, Głęboczko, and Łąkie are lakes in which vendace dominated (40-60%), with a cyprinid share of less than 40%. However, lakes Cechyńskie Wielkie, Pipionko, and Helenowo were dominated by cyprinids (40-60%) with a share of coregonids that was lower than 5%.

Species structure of the catches

The domination and frequency of species in the catches from the individual lakes varied. The dominant groups included the following species: roach, bream, pike, and in some lakes vendace or carp, but the species that occurred the least frequently in the catches included tench, perch, pikeperch, whitefish, peled, and eel (Table 3). Pike was noted the most frequently in the catches, followed by bream, roach, and perch (Table 4). Vendace occurred in five of the six lakes analyzed. In the lakes in which large quantities of vendace were caught (from 36.1 to 59.5% of the total fish biomass), its frequency was high (87.5-82.6%). However, its percentage in other catches ranged from 0.1 to 5.4%, at a frequency that did not exceed 15%.

Table 3
Species structure (%) of the commercial catches made in the lakes analyzed. Species origin: r – native, i – introduced

Scientific name	Fish species	Species origin	Cechyńskie Małe	Cechyńskie Wielkie	Głęboczko	Łąkie	Pipionko	Helenowo
Coregonus lavaretus	Whitefish	r	3.6	0.1	-	0.6	3.1	-
Coregonus albula	Vendace	r	36.1	5.4	59.5	45.1	-	0.1
Coregonus peled	Peled	i	-	-	-	-	0.1	0.6
Sander lucioperca	Pikeperch	i	-	2.4	-	0.2	-	-
Perca fluviatilis	Perch	r	5.9	4.7	3.6	5.9	3.1	1.9
Esox lucius	Pike	r	11.7	14.5	10.4	7.4	12.7	11.5
Anguilla anguilla	Europen eel	r	3.6	8.5	-	0.2	6.5	3.8
Rutillus rutillus	Roach	r	20.8	13.6	16.9	29.2	41.8	43.2
Abramis brama	Common bream	r	17.5	29.0	7.2	7.8	30.4	4.1
Tinca tinca	Tench	r	0.8	0.4	2.4	3.6	2.3	1.6
Cyprinus carpio	Common carp	i	-	21.4	-	-	-	33.2

Table 4
Species frequency (%) in commercial catches from the lakes analyzed

Fish species	Cechyńskie Małe	Cechyńskie Wielkie	Głęboczko	Łąkie	Pipionko	Helenowo
Whitefish	4.3	16.7	-	20.8	28.6	-
Vendace	82.6	12.5	86.4	87.5	-	4.5
Peled	-	-	-	-	4.8	9.1
Pikeperch	-	20.8	-	4.2	-	-
Perch	56.5	54.2	27.3	75.0	52.4	31.8
Pike	78.3	91.7	68.2	91.7	95.2	77.3
Europen eel	43.5	58.3		16.7	66.7	36.4
Roach	47.8	54.2	45.5	58.3	66.7	72.7
Common bream	69.6	70.8	50.0	41.7	71.4	45.5
Tench	26.1	16.7	27.3	66.7	42.9	27.3
Common carp	-	25.0	-	-	-	50.0

Long-term changes in catches

Catches of fish in the lakes analyzed underwent substantial variation in species structure and the overall biomass of the fish caught. Catches in Lake Cechyńskie Małe were highly irregular and highly variable, and the total annual catch ranged from 3 to 611 kg year^{-1}. In the 1968-1973 period, catches were nearly 4.5-fold higher than they were in the 1995-2006 period (Fig. 4). In the latter period, the primary species caught were vendace, pike, and perch. In Lake Cechyńskie Wielkie catches ranged from 30 to 458 kg fish. In the 1983-1994 period, catches were nearly twice as large as those from the 1995-2006 period. The catches were dominated by cyprinids until the end of the 1990s, but following the ownership transformation predatory species became dominant (Fig. 4). During the overall period analyzed, catches in Lake Głęboczko ranged from 9 to 286 kg, and the dominant species in the catch was

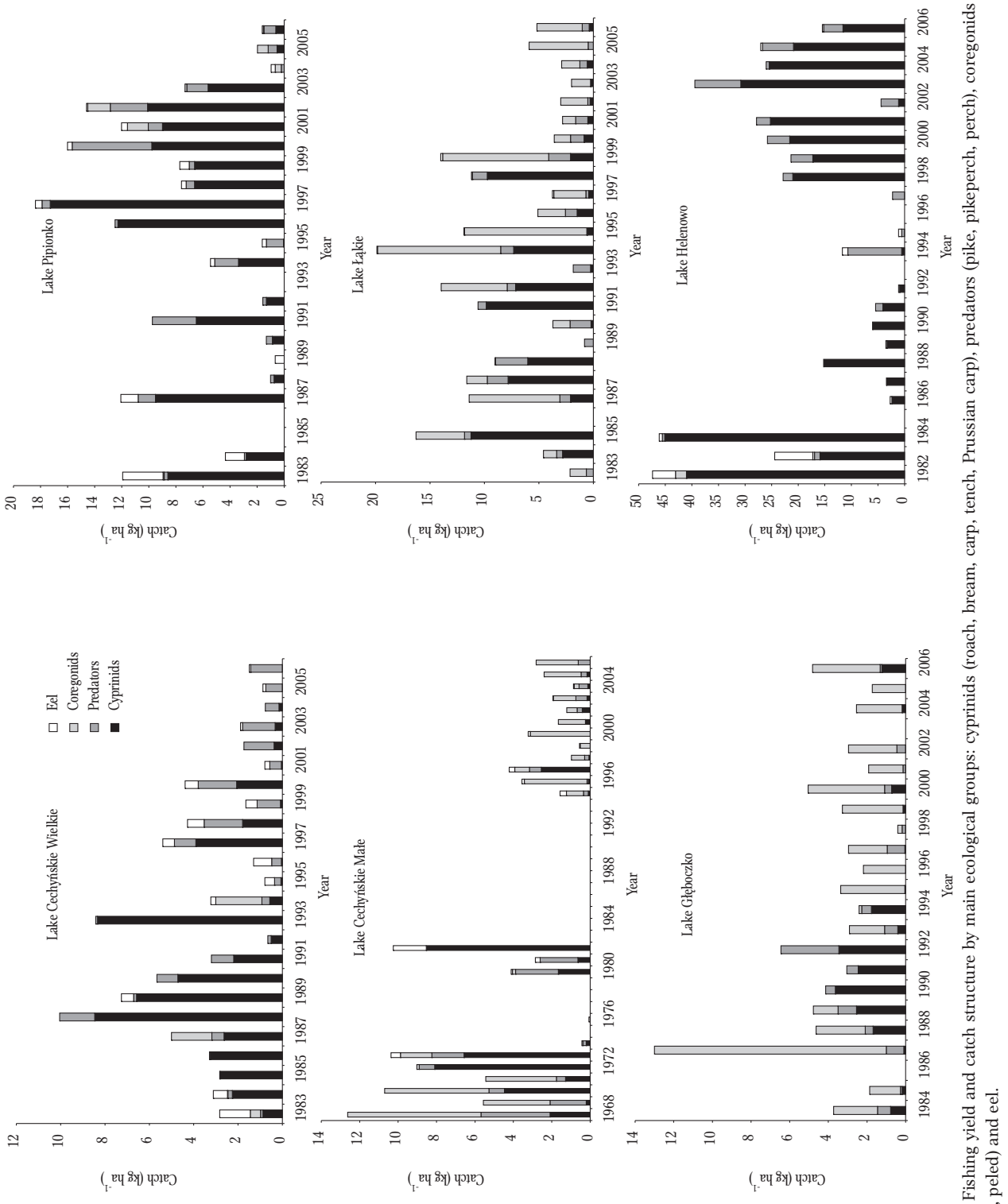

Figure 4. Fishing yield and catch structure by main ecological groups: cyprinids (roach, bream, carp, tench, Prussian carp), predators (pike, pikeperch, perch), coregonids (vendace, whitefish, peled) and eel.

Table 5
Mean commercial stocking operations in the period of 1968- 2006. Stocking events are given in parentheses

Species	Size-groups	Cechyńskie Małe	Cechyńskie Wielkie	Głęboczko	Łąkie	Pipionko	Helenowo	Total
Whitefish	newly hatched	-	-	-	2750 (2)	100000 (1)	-	105500 (3)
Whitefish	fry	-	1500 (1)	-	700 (2)	1517 (3)	-	7450 (6)
Vendace	newly hatched	100000 (2)	-	100000 (1)	102812 (8)	-	-	1122500 (11)
Pike	fingerling	-	1100 (7)	-	608 (6)	775 (2)	700 (2)	14150 (17)
Pikeperch	fingerling	-	500 (2)	-		350 (1)	400 (1)	1750 (4)
Tench	yearling	-	200 (2)	-	200 (3)	500 (1)	850 (2)	3200 (8)
Europen ell	montee	25000 (1)	-	-	-	-	-	25000 (1)
Crucian carp	yearling	-	15000 (1)	-	-	-	-	15000 (1)
Common carp	yearling	-	-	-	-	-	354 (3)	1060 (3)
Roach	adults	-	-	-	100 kg (1)	-	-	100 kg (1)

vendace, the biomass of which in 1987 was 264 kg (92% of the maximum catches). In the period from 1983 to 2006, catches exceed the mean yield only eight times. Fish catches in Lake Łąkie were also characterized by significant fluctuations; during the period analyzed catches ranged from 19 to 465 kg of fish. From 1982 to 1999, catches that exceeded the mean were separated by one to two years in which decidedly smaller quantities of fish were caught. Until the end of the 1990s, a large share of the fish caught were cyprinids, but after 2000 the share of these in the overall biomass of fish caught declined. In the 2000-2006 period, catch yield remained below the mean. The mean annual catch in Lake Pipionko ranged from 15 to 275 kg of fish. In the 1995-2003 period, increases in the catch yield were noted, and the dominant group of fish was the cyprinids. In the later period of 2004-2006, the fisheries yield remained below the mean. Catches of fish from Lake Helenowo were irregular and characterized by substantial variability with catch yield ranging from 10 to 417 kg of fish. In the 1982-1993 period, the share of pike in the catches was low, but after 1993 there was an increase in the share of predatory fish, especially of pike, in the biomass of fish caught. This trend was maintained until 2006.

Seasonal variability of catches

The results of commercial catches in the lakes analyzed were characterized by seasonal variation. The most abundant mean monthly catches in five of the six lakes analyzed were noted in November, and they ranged from 25.5 to 41.8% of the mean annual catches (Fig. 5). In lakes Cechyńskie Małe, Głęboczko, and Łąkie, the catches were dominated by vendace, while in Lake Pipionko bream and roach dominated and in Lake Helenowo the dominants were roach and carp. The seasonal variability of the fish catches in Lake Cechyńskie Wielkie differed with the most fish caught in March at 16.4% of the mean annual catch. These catches were dominated by pike and roach. A long period during which greater quantities of fish were caught in this lake extended from October to December when primarily bream were caught.

Stocking

Ten species of fish were stocked into these lakes during the period from 1968 to 2006, of these nine species were recorded in the official statistics (Table 5). Only six species occurred in these waters naturally. Peled is an alien species, and its occurrence in lakes Pipionko and Helenowo was the result of stocking.

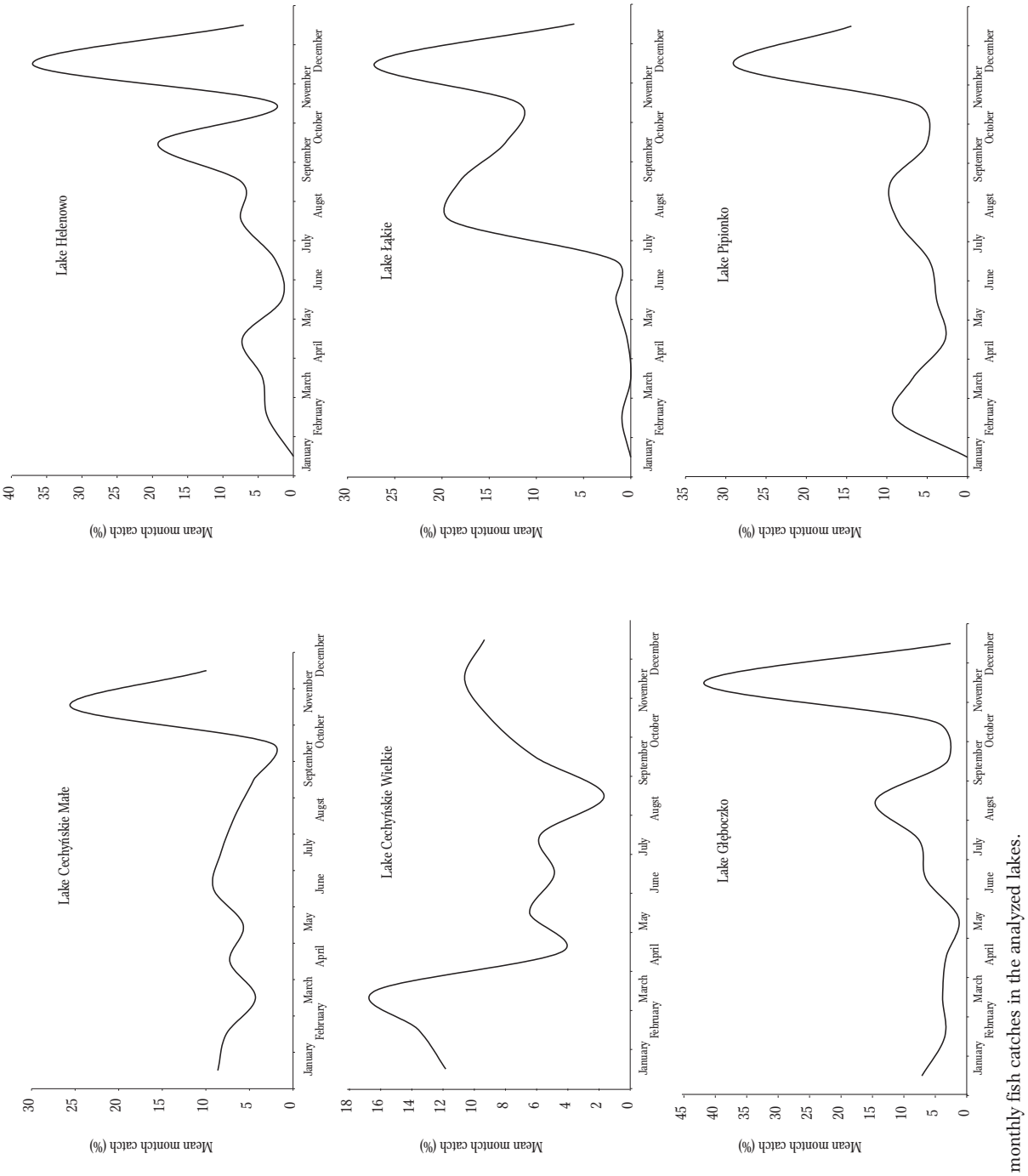

Figure 5. Mean monthly fish catches in the analyzed lakes.

Pikeperch was translocated outside of its natural range of occurrence, while carp and Prussian carp, *Carassius gibelio* (Bloch), are both alien species. Pike was the most frequently stocked species; pike fry measuring 5-10 cm in length were released 17 times in three of the six lakes analyzed. The mean quantity of fish stocked ranged from 600 to 1100 indiv. year^{-1}. The lobelia lakes were stocked with a substantially fewer number of pike fry (from 24 to 33 indiv. ha^{-1}) than was the reference Lake Helenowo (80 indiv. ha^{-1}). Vendace hatch were released eleven times in three of the lobelia lakes. The mean number of fish stocked ranged from 2000 to 4500 indiv. ha^{-1}. Lake Łąkie was stocked most regularly. Whitefish were stocked in three of the lakes; hatch was released three times and fry six times. Tench fry were stocked in three of the lobelia lakes and the reference lake. The lobelia lakes were stocked with quantities ranging from 200 to 500 indiv. year^{-1} (4-22 indiv. ha^{-1}), on average, while the eutrophic Lake Helenowo was stocked with 96 indiv. ha^{-1}.

Discussion

Management of fish populations in lobelia lakes

Commercial fisheries have long been considered to be one of the main factors causing changes in the species composition and abundance of fish assemblages in lakes (Bronte et al. 2003). Simultaneously, the results of commercial fishing have been used to identify the trophic status of lakes (Leopold et al. 1986). Lobelia lakes, with their small surface areas and specific water parameters, were considered to be especially susceptible to degradation, and fisheries management was identified as one of the leading factors causing changes in the ecological status of these lakes (Kraska et al. 1996). The cause of this was the desire to catch the maximum quantity of commercially valuable fish in lobelia lakes. Despite the declining numbers of catches made in Polish lakes, they have been the subject of detailed studies for many years (see Bnińska and Wołos 2001, Mickiewicz 2009, Wołos et al. 2009). However, lobelia lakes, which are of particular ecological value, have only been the subject of a few more or less detailed studies addressing the management of fish populations (Kraska et al. 1996, Hesse 2000, Kapusta and Bogacka 2003). This provided the impetus for the current attempt to characterize the fisheries management of lobelia lakes through the inclusion of an analysis of commercial catches of fish in lakes devoid of the vegetation that is characteristic for this group of aquatic basins.

Specific elements of the fisheries exploitation of lobelia lakes in Poland are the irregular catches and low yield. In a study of the fisheries in lobelia lakes with surface areas ranging from 14.7 to 550 ha in the Pomerania Lakeland, Heese (2000) concluded that there is substantial variability in the biomass of the fish caught. The mean yield ranged from 3.6 to 10.4 kg ha^{-1}. However, in another study of the fisheries exploitation of twelve lobelia lakes, Kraska et al. (1996) reported the catch yield to range from 1.7 to 13.4 kg ha^{-1}. Both papers include lakes with substantially larger surface areas, and in these lakes the fishing yield was the highest. Taking this into consideration, it can be concluded that the size of the catches made in the lobelia lakes near Bytów are similar. The commercial catches in lobelia lakes located in the upper catchment area of the Słupia River ranged from 3.4 to 7.1 kg ha^{-1}, while those in the eutrophic Lake Helenowo were as high as 17.3 kg ha^{-1}. In comparison to the commercial catches made in the eutrophic reference Lake Helenowo, those made in the lobelia lakes were from 2.5 to 5-fold smaller. For the sake of comparison, the mean fisheries yield in Polish lakes in recent years is 9-11 kg ha^{-1}, which is several-fold smaller in comparison to that from the 1970s or 1980s (Wołos et al. 2007, 2009).

The species structure of fish catches in lobelia lakes assume highly varied patterns ranging from the domination of coregonids to that of fish from the cyprinid family. In an analysis of the fisheries management of lobelia lakes, Hesse (2000) categorized the basins according to the share of the various ecological groups in the catches. There were four types

of lobelia lakes with regard to the ichthyofauna species structure. In the current study, the species assemblages identified allowed categorizing the lakes as coregonid (Cechyńskie Małe, Głęboczko, Łąkie) and eutrophic (Cechyńskie Wielkie, Pipionko). The first group included the deepest lakes, while the latter included the shallowest lakes. In turn, none of the lakes was noted to be a single-species basin or a typically lobelia lake (Hesse 2000). According to the polish fisheries typology, the first corresponds to Prussian carp lakes, in which this species or perch occurs, and the second to tench-pike lakes.

The results of the present analysis indicate that the way lakes are exploited has a substantial impact on the results of commercial fishing in them. Changes in fisheries exploitation were reflected in fish catches. The long-term analysis of the fish catches indicated there were changes in the structure of commercial catches in the lobelia lakes that were undergoing eutrophication. Catches of cyprinids declined while catches of predatory fish increased. Since predatory fish have a cascade impact on the lower trophic levels in lakes (Jeppesen et al. 1990, Lammens 1999), this can have disadvantageous consequences for the ecological states of these lakes. Kraska et al. (1996) reported that fisheries exploitation made possible by stocking leads to transformations in the ichthyofauna structure of lobelia lakes. The current paper demonstrates that changes in how the lakes are fished commercially has an impact on the species structure of the fish that are caught commercially.

Stocking is one of the ways to counteract disadvantageous changes in fish assemblages in lakes. One of the general characteristics of the stocking performed in the lakes analyzed was its irregularity. The lakes were stocked most frequently with pike, vendace, and tench, which are all species that are also stocked into non-lobelia lakes. Pike stocking in lobelia lakes was three to four times smaller than it was in the reference non-lobelia lake. In the past, alien species of commercial importance were stocked, but this practice has not been permitted for many years. Carp do not reproduce in most inland waters in Poland (Brylińska 2000), but Prussian carp is an alien species that flourishes in most types of waters (Witkowski 1996). However, introducing pikeperch into waters in which it had not previously occurred is not permissible either economically or ecologically. Peled has been introduced into many Polish lakes so it can crossbreed with whitefish (Brzuzan and Luczynski 1999, Kirtiklis and Jankun 2006). To date no appropriate studies have been performed that would shed light on the cross breeding of peled with native coregonid species in lobelia lakes; thus, it is difficult to evaluate what significance the small, irregular stocking of peled has had in Lake Pipionko. Another management tool that has a disadvantageous effect on the ecological status of lobelia lakes is stocking fish species that feed on macro-invertebrates. Stocking benthophageous fish such as carp, Prussian carp, tench, or bream, leads to the increased trophic status of waters, and the consequent loss of some of the characteristic features of the lakes (Kraska et al. 1996).

Summation and pointers for fisheries management

The functioning of lobelia lake ecosystems and preserving their unique properties depends not only on ensuring that their water parameters remain appropriate, but also that the structure of their biocenoses remains intact. Fish populations are especially important for the functioning of basins with lobelia vegetation (Hesse 2000). The specific environmental conditions in lobelia lakes impact the modest species diversity and the biomass of the fish caught. Fisheries management in lobelia lakes leads to changes in the ichthyofauna species structure and disadvantageous environmental changes (Kraska et al. 1996, Heese 2000). The profitability of commercial fisheries in lobelia lakes is marginal partly because of the substantially smaller catches made in them in comparison to those made in non-lobelia lakes. Only in large, deep lakes (with surface areas in excess of 50 ha) can commercial catches (mainly of vendace) be conducted without having significant consequences for

these ecosystems (Kraska et al. 1996). Heese (2000) postulates that there should be a total ban on fishing in lakes with surface areas of less than 20 ha.

The current analysis indicates that commercial fish catches in lobelia lakes are substantially lower than those made in other types of lakes in Poland. These are based primarily on species that reproduce in lakes, and stocking is only done sporadically. One of the negative aspects of fisheries management was the stocking of alien species. The species structure of the commercial catches made in lobelia lakes corresponds to the fish assemblages that are found in either vendace lakes or eutrophic basins. Increasing anthropogenic stress that results from commercial fisheries can lead to disadvantageous environmental changes, which can lead to the loss of the characteristic features of lobelia lakes. The shallowest lakes are most susceptible to this. To protect the ichthyofauna of lobelia lakes, the continuity of the occurrence of characteristic fish assemblages must be guaranteed. It is recommended to undertake measures to eliminate and prevent the occurrence of alien species in these lakes.

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Streszczenie

Gospodarowanie populacjami ryb w jeziorach lobeliowych w okolicy Bytowa (północna Polska)

Celem przeprowadzonych badań była charakterystyka gospodarki rybackiej prowadzonej na pięciu jeziorach lobeliowych i referencyjnym jeziorze nielobeliowym. Na podstawie danych o odłowach gospodarczych dokonano oceny wielkości odłowów, struktury gatunkowej oraz ekologicznej poławianych zespołów ryb oraz charakterystyki zarybień. W latach 1968-2006 w połowach notowano występowanie 11 gatunków ryb należących do 5 rodzin. Struktura gatunkowa odłowów gospodarczych analizowanych jezior lobeliowych odpowiadała zespołom ryb typu sielawowego lub eutroficznego. Odłowy ryb w jeziorach lobeliowych były od 2,5 do 5-krotnie mniejsze w porównaniu do referencyjnego jeziora. W zbiornikach z roślinnością lobeliową do grupy dominantów w połowach gospodarczych należały płoć i szczupak, a w niektórych jeziorach również leszcz, sielawa lub karp. Największą frekwencją w odłowach wyróżniał się szczupak, a w dalszej kolejności leszcz, płoć i okoń. Najintensywniejsze odłowy ryb miały miejsce w listopadzie lub marcu. W latach 1968-2006 jeziora zarybiano 10 gatunkami ryb, z czego 9 gatunków wykazano w oficjalnych statystykach. Jedynie 6 gatunków występowała naturalnie w tych zbiornikach. Peluga jest obcym gatunkiem ryb i na pewno jej występowanie w jeziorach Pipionko i Helenowo było związane z zarybieniami. W przypadku sandacza dokonano translokacji poza naturalną granicę jego występowania, a karp oraz karaś srebrzysty to obce gatunki ryb.