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ICHTHYOFAUNA OF SHALLOW MIEJSKIE LAKE ONE YEAR AFTER BIOMANIPULATION

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Summary. Biomanipulation in the Miejskie Lake, consisting in its stocking with piscivorous fish, was conducted in autumn 2006. As a result of gill net control fishing, species composition of ichthyofauna and their structure of domination in the number and biomass of fish before biomanipulation and one year after were defined. Biomanipulation did not change the number of the dominating species – roach, but its participation in the structure of the biomass almost doubled. Besides that, the participation in the structure of the number of other cyprinid fish decreased and, simultaneously, their mean total length increased. One year after the biomanipulation the participation of piscivorous fish in the total number of fish increased from 3.5 to 9.7%.

Key words: biomanipulation, fish, Miejskie Lake

INTRODUCTION

Feasibility of water ecosystem restoration by fish is related mainly to partial or total reduction of fish stock from a reservoir [Barthelmes 1988, Chung 2003] or trophy web manipulation through both bottom-up and top–down control [Carpenter *et al*. 1985, McQueen *et al*. 1986].

Biomanipulation, referring in this context to the removal of planktivorous and benthivorous fish using piscivores, has been proved to be an effective rehabilitation tool to remediate eutrophied lakes [Bergman *et al*. 1999, Drenner Hambright 1999, Lammens 2001].

The available literature reports cases where predatory fish communities were used to regulate the population of planktivorous and benthivorous fish in Poland as well [Gołdyn *et al*. 1997, Prejs *et al*. 1997].

Some effects of the ecosystem rehabilitation may be noticed even two years following the lake improvement procedures implementation, but overall restoration of environmental quality (reduction of phosphorus, water cleanness, and etc.) takes more than 10 years after piscivorous fish stocking [Mehner *et al*. 2002, Olin *et al*. 2006, Søndergaard *et al*. 2007]. Besides, biomanipulation by fish is more likely successful in shallow rather than deep lakes [McQueen *et al*. 1986, Jeppesen *et al*. 1990, Scheffer 1998].

The aim of this study was to determine changes occurring in the ichthyofauna of the shallow Miejskie Lake one year after the biomanipulation measures, i.e. piscivorous fish stocking, were performed.

MATERIAL AND MATHODS

The Miejskie Lake ($51^0$30'N, $22^0$52'E) is a small in area (45.8 ha) and shallow water reservoir (max depth 2.2 m, mean depth 1.3 m) [Harasimiuk *et al*. 1998]. According to fish species distribution, this lake was classified as a tench-pike type, but angling pressure combined with a lack of commercial fishery management enhanced strong development of planktivore fish populations and an increase in the number of benthivorous fish, *Cyprinidae* fish, which consequently resulted in deteriorated water quality (unpublished PAA data).

In summer 2006, in co-operation with the Polish Angling Association in Lublin, there was initiated the lake stocking effort of: pikeperch fry (Lt = 12 cm – 900 ind.; 34 kg; ca. 0.75 kg · ha^{-1}), pike fingerlings (Lt = 12–14 cm – 1000 ind.; ca. 22 ind. · ha^{-1}) and eel (40 kg; ca. 0.9 kg · ha^{-1}), while in autumn, additionally – catfish yearlings (250 kg; ca. 5.5 kg · ha^{-1}) and pike fry (215 kg; ca. 5 kg · ha^{-1}). At the same time, the following catch restrictions were introduced: an increase in the legal size limits and more stringent daily bag limits of piscivorous fish, establishment of no angling zone to provide the fish spawning habitat.

The control fish catches were performed in three terms prior to biomanipulation (spring, summer and autumn 2006) and in two terms a year after its commencement (late summer and autumn 2007). Fish were harvested with Norden S multimesh gillnet (10, 60, 30, 6,25, 43, 22, 50, 33, 12,5, 25, 8, 38, 75, 16,5 mm) with exposure ranging from 8 up to 12 h. All caught fish were measured (with 1 mm accuracy), weighed (to 1 g) and their domination structure and biomass were determined. The obtained catch results were converted into CPUE (catch per unit effort) (ind. or g · 12 h^{-1} per net^{-1}) data and analysed statistically [ANOVA, SAS v. 9.0].

RESULTS

A total of 15 fish species were determined in the Miejskie Lake. Similarly, before and after the biomanipulation, the greatest numbers of fish were obtained in summer (from 385 ind. · 12 h^{-1} · net^{-1} in 2006 year up to 413 ind. · 12 h^{-1} · net^{-1}

a year after the biomanipulation). However, the lowest number of fish was recorded in autumn in both years (Fig. 1). This technique induced a slight reduction in the total number of fish (from 938.0 to 888.2 ind. · 12 h^{-1} · net^{-1}, approx. by 5.1%, R^2 = 0.0665) (Fig. 1).

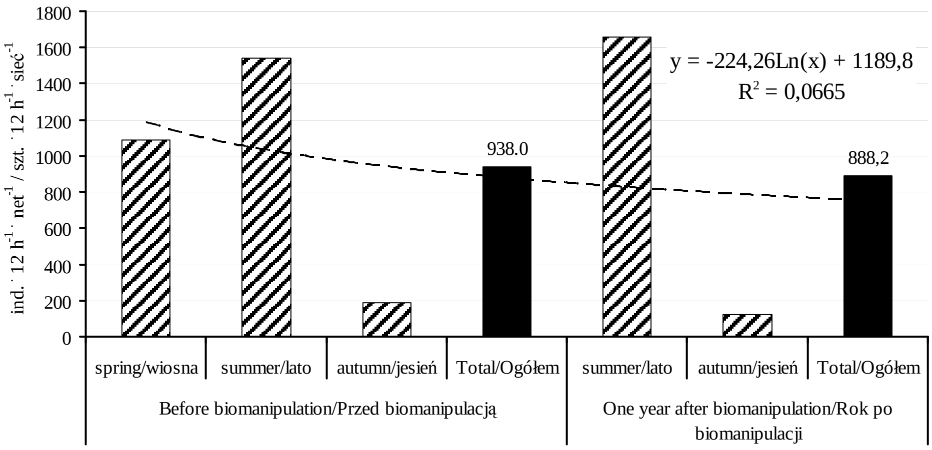

Fig. 1. Total fish number (ind. · 12 h^{-1} · net^{-1}) in the Miejskie Lake prior to and a year after biomanipulation

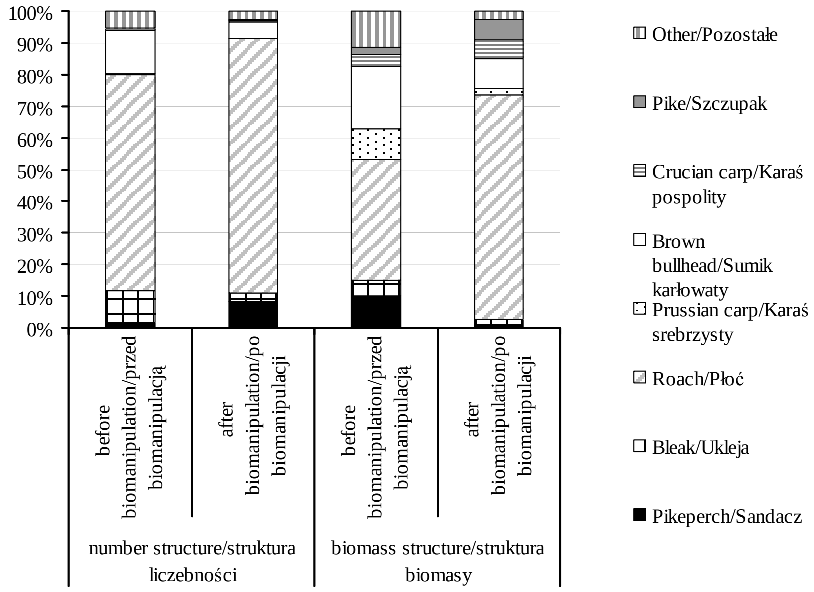

Fig. 2. Domination structure of number and biomass of fish community

Owing to predatory fish stocking, the structure of fish numbers changed, i.e. roach share increased by about 10%, while pikeperch contribution grew over five-fold in total fish numbers (from 1.6 to 10.1%). Additionally, the abundance of bleak decreased four-fold in total fish numbers (Fig. 2). Besides, the predatory fish lake stocking benefited in participation of brown bullhead reduced by more than a half (with 13.7% before up to 5.13% after stocking with predators).

The lake improvement practices were followed by a nearly twofold increase of roach numbers in the biomass structure, but a decreased contribution of other non-piscivorous fish species: bleak and prussian carp as well as of brown bullhead population – an alien species (Fig. 2).

The analysis of abundance and biomass of unpredatory and predatory fish revealed that the biomanipulation produced almost threefold growth of piscivorous fish share in the total number of fish (from 3.46% before the lake stocking with fish, up to 9.66% after). However, in the biomass structure, the share of this fish group declined from 25.66 to 8.54% (Fig. 3).

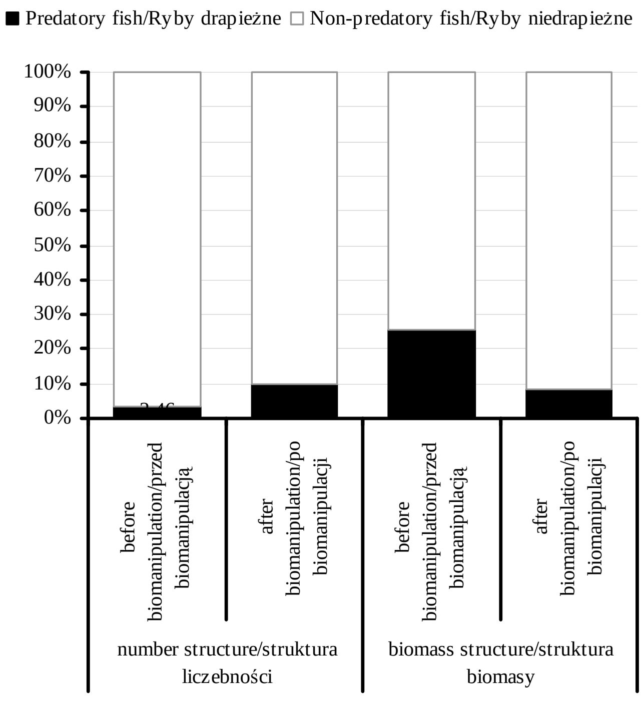

Fig. 3. Contribution of predatory fish to the structure of numbers and biomass

Concurrent with the change of the structure, the abundance of each fish species harvested also changed. One year after stocking with predatory fish, pike-perch (from 3.83 to 18.80 ind. · 12 h^{-1} · net^{-1}) and pike (from 0.17 to 1.00 ind. · 12 h^{-1} · net^{-1})

numbers raised gradually (Tab. 1). Out of non-predatory fish, only the roach numbers remained at a similar high level (160–178 ind. · 12 h^{-1} · net^{-1}), while the abundance of other fish species (rudd and bleak) declined 4–4.5-times (Tab. 1).

Table. 1. Numbers of each fish species in the Miejskie Lake (ind. · 12 h^{-1} · net^{-1}) before and after biomanipulation

	Before biomanipulation (2006)				Year after biomanipulation (2007)		
	Spring	Summer	Autumn	Total	Summer	Autumn	Total
Pikeperch	1.25	9.00	1.25	3.83	37.00	0.60	18.80
Bleak	46.00	22.00	1.75	23.25	10.50	0.90	5.70
Rudd	4.75	5.25	0.00	3.33	1.50	0.00	0.75
Roach	193.25	259.75	28.50	160.50	341.50	14.40	177.95
Prussian carp	1.75	0.25	0.50	0.83	0.00	0.90	0.45
Brown bullhead	17.75	75.00	3.50	32.08	15.00	7.80	11.40
Perch	1.50	6.75	0.25	2.83	0.50	0.60	0.55
Crucian carp	1.00	3.25	0.25	1.50	2.00	0.00	1.00
Rufie	3.25	3.75	10.25	5.75	3.00	5.40	4.20
Tench	0.25	0.00	0.00	0.08	0.00	0.00	0.00
Bream	0.50	0.00	0.00	0.17	0.00	0.00	0.00
Eel	0.25	0.00	0.00	0.08	0.00	0.00	0.00
Asp	0.00	0.25	0.00	0.08	0.00	0.00	0.00
Pike	0.00	0.00	0.50	0.17	2.00	0.00	1.00
Bitterling	0.00	0.00	0.00	0.00	0.50	0.00	0.25

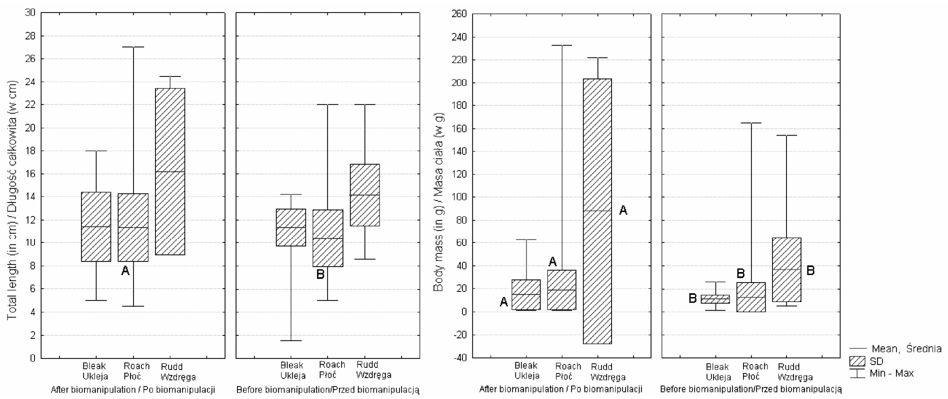

Fig. 4. Total length and body mass of selected species of cyprinids. Means indicate with different letters – statistically significant differences ($p < 0.05$)

The increase of the number of piscivorous fish resulted in higher mean total length and biomass of non-predatory fish. That particularly affected the growth of mean total length of rudd, prussian carp and roach; interestingly, the value characterizing the last one appeared to be statistically significant (N = 2655,

$F = 65.702$; $p = 0.0001$) (Fig. 4). Besides, a year after the biomanipulation, the mean biomass of the mentioned fish species reached significantly higher values (Fig. 4).

DISCUSSION

The study aimed to establish the extent of changes observed in the ichthyofauna of a shallow water lake as an ecosystem response to predatory fish stockings.

The research results showed that the biomanipulation performed did not change the abundance of fish species and that the numbers of collected fish were similar (Fig. 1). However, the domination structure changed slightly. According to Carpenter *et al*. [1985], single enhancement of piscivorous fish stocks favoured the predatory fish species community structure. However, strong manipulations of fish stocks, namely a drastic fish reduction or large-scale removal, seem to be more efficient [Barthelmes 1988, Benndorf 1990]. Still, major effects evident not only in the ichthyofauna structure change but clear-phase water as well, will take more time to appear, i.e. 10 years or longer [Meijer *et al*. 1999, Mehner *et al*. 2002]. A sole 5% reduction of total fish numbers (Fig. 1) promises a further positive pressure of predatory fish species to planktivores and benthivores.

Prior to the biomanipulation measures applied, the lake planktivore dominants proved to be roach and bleak as well as prussian carp, with considerable contribution to fish biomass due to trophy-sized individuals harvested. Piscivorous fish were represented in low numbers by pikeperch and perch. Pike was caught only occasionally (Fig. 2).

The stocking procedure enhanced the predatory fish share from 3.46 up to 9.66%, with decreased length of piscivores and their declined contribution to biomass structure as a consequence of lake stocking with juvenile predatory fish [Søndergaard *et al.* 1997, Dörner *et al*. 1999, Skov *et al*. 2003]. It is noteworthy that too intensive stocking of young piscivores yields the expected results in spring and summer, when the fish feed efficiently on the zooplankton. Besides, the abundance of juvenile piscivores has a detrimental impact on the zooplankton condition, hence strict control of this fish population is recommended to prevent any negative outcomes of excessive predatory fish reproduction [Mehner *et al*. 1996].

The lake restoration techniques resulted in a marked decrease of bleak and rudd species numbers caught, whereas roach harvest maintained at a similar level. It should be noted, however, that both mean total length and mass of this fish species increased significantly, while the other species were characterized by significantly higher body mass (Fig. 4). That gives evidence of enhanced feeding pressure of predatory fish directed to smaller-sized fish (e.g. bleak, rudd) (Fig. 2) and due to the lowered abundance – improved food availability and increased growth rate for the older specimens.

Successful implementation of biomanipulation strategy requires full agreement between the lake managers, anglers and scientists. It should aim at appropriate planning of the manipulation measures, water quality control and monitoring of changes in the ichthyofauna structure [Benndorf 1990, Kitchell 1992, Lathrop *et al*. 2002]. The problem of fishing pressure is of great weight here, as it is usually the selective angling for trophy-sized specimens and quite frequently targets solely piscivorous fish to capture and harvest. But, the objective is to enhance the percentage of specimen-sized cyprinids caught because they stir up the filtrating plankton and, thus, reduce the water clarity in a reservoir [Carpenter *et al*. 1985]. On the other hand, angling strategy may prove beneficial as it may raise some concern about the environmental issues and promote deliberate elimination of alien fish species caught in a lake, such as brown bullhead (Tab. 1, Fig. 2) recognized in the lakes from this region [Kornijów *et al*. 2003].

CONCLUSIONS

1. The biomanipulation restoration program implemented in the Miejskie Lake induced a slight decrease of total fish numbers (by ca. 5.1%).

2. The year following the biomanipulation was marked with declined cyprinid contribution to total fish structure, especially bleak, rudd and prussian carp, along with increased mean total length.

3. The stockings resulted in elevated percentage of piscivores in the total numbers of fish, but decreased contribution to fish biomass as a consequence of juvenile predatory fish stocking.

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ICHTIOFAUNA PŁYTKIEGO JEZIORA MIEJSKIEGO JEDEN ROK PO ZABIEGACH BIOMANIPULACYJNYCH

Streszczenie. Jesienią 2006 r. w Jeziorze Miejskim przeprowadzono zabiegi biomanipulacyjne, polegające na zarybieniu gatunkami ryb drapieżnych. W wyniku odłowów kontrolnych ustalono skład gatunkowy ichtiofauny i strukturę dominacji w liczebności i biomasie ryb przed biomanipulacją i rok po jej przeprowadzeniu. Zabiegi biomanipulacyjne nie wpłynęły na liczebność płoci, ale zwiększył się prawie dwukrotnie jej udział w biomasie. Ponadto zmniejszył się udział innych ryb karpiowatych w liczebności ryb, przy jednoczesnym wzroście ich średnich długości. Rok po zabiegach biomanipulacyjnych zwiększył się udział ryb drapieżnych w ogólnej liczebności ryb z 3,5 do 9,7%.

Słowa kluczowe: biomanipulacja, ryby, Jezioro Miejskie

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