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RESEARCH ARTICLE

Value and structure of fish catches and stocking intensity in lake enterprises before and after fisheries ownership transfer in Poland

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Abstract. The current report was written using data from the 1973-2004 period regarding fisheries catches and stocking. These data come from management logs for 300 lakes with a total surface area of 116,736 ha. In the 1973-1982 period, the mean annual value of catches for all species of fish was 226.33 PLN ha^{-1}, and this was twice as high as that in the 1995-2004 period (113.77 PLN ha^{-1}). Of stocked species, eel, *Anguilla anguilla* (L.) (46%), and vendace, *Coregonus albula* (L.) (17%), dominated the value structure of catches in the first decade, while eel (35%), vendace (15%), pike, *Esox lucius* L., (11%), and pikeperch, *Sander lucioperca* (L.) (9%) dominated in the second decade. The mean annual value of stocking material of all species in the 1973-1982 period, which was 385.91 PLN ha^{-1}, was more than 7.5 times higher than that in the 1995-2004 period (50.40 PLN ha^{-1}). This difference was determined by the value of eel stocking. With a share of more than 95%, the value of eel stocking dominated decisively in the first decade. In the second decade analyzed, the value of stocked eel (57%), vendace (15%), and pike (14%) dominated. After eliminating the value of eel catches and stocking, the value of stocking in comparison with the value of catches in the first decade analyzed was barely 15%, while in the second decade analyzed it was almost twice as high at 29%.

Keywords: fisheries management, lake stocking, ownership transformation

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Introduction

Lake stocking management is shaped by many factors in Poland, among which one of the most important is water eutrophication leading to the deterioration of aquatic ecosystems (Zdanowski 1996). Stocking is also necessary to manage lake fisheries in accordance with criteria for eco-development (Leopold and Bnińska 1992). In the early 1990s another very significant factor came into play – the ownership transformation in lake fisheries requiring fisheries management be conducted under free-market conditions. Presently, public inland surface waters, including lakes, rivers, and dam reservoirs, are the property of the Polish State Treasury, and they are supervised by Regional Water Management Boards. Inland fisheries in lakes, rivers, and dam reservoirs are exploited mainly by legal persons – primarily limited liability companies that were formed by the former employees of state fisheries enterprises and local branches of the Polish Angling Association, and physical persons usually represented by individual fishers or farmers. Enterprises exploiting public inland flowing surface waters were required by lease terms and feasibility studies to earmark a designated portion of their financial resources to perform stocking with suitable material of a declared value that obliged these enterprises to implement planned stocking policy.

The political and economic transformation in Poland in the early 1990s and the corresponding ownership transformation in fisheries resulted in changes in the system for and management of lake fisheries, which caused changes in the intensity of lake exploitation and stocking. Investigations of changes were performed previously, but they focused on a smaller group of lakes than that in the present report (Mickiewicz 2001, 2006). The aim of this work was to identify the intensity of stocking of different species as part of lake fisheries management, and also to determine the intensity of their exploitation following the ownership transformation in fisheries based on a selected group of lakes and long-term data from fisheries logs pertaining to catches and stocking in these lakes. The aim of the current report is to determine if the ownership transformation in Polish fisheries had a positive impact on lake fisheries stocking management. This work is an economic analysis that comprises as much information as is feasible regarding lake fisheries stocking management, as well as its effects on commercial fisheries catches.

Materials and methods

This report was developed based on data from the 1973-2004 period regarding fisheries catches and stocking that were collected from fisheries logs for 300 lakes with a total surface area of 116,736 ha. These lakes are located in the largest lake regions in Poland (Mazury, Pomerania, Wielkopolska), and the fisheries are exploited by 31 enterprises. These data have been collected successively over approximately the past fifteen years directly from the headquarters of these enterprises, and they have been compiled into a uniform digital data base. Additionally, the wholesale prices for commercial lake fish and the most important forms of stocking material used in fisheries management were drawn from 2005 (Mickiewicz 2010). This information was collected in fall 2005 by surveying 31 lake fisheries enterprises exploiting 153,685 ha of lakes located in the largest regional lake districts in Poland (Mazury, Pomerania, Wielkopolska). The value of glass eel, *Anguilla anguilla* (L.), stocking material was determined based on the price for 1 kg of this material in 2005, which was 4,000 PLN, according to information obtained from the importer (in spring 2005 the price for glass eel on the western European market was about 1000 EUR per kg, in 2005, the mean annual exchange rate of PLN to USD was 3.2348 PLN, while for EUR it was 4.0254 PLN.

The analysis of the fisheries management data was based on the monetary value (in PLN) of catches and stocking calculated using the wholesale price of various species of commercial fish and the mean prices of various types of stocking material used by lake fisheries management in 2005 (Mickiewicz 2010). The monetary values obtained were analyzed with regard to the surface area of the lakes analyzed as the indicator PLN ha^{-1}. The species that were included in stocking management programs during the 1973-2004 period were analyzed and included the following: eel; whitefish, *Coregonus lavaretus* (L.); vendace, *Coregonus albula* (L.); pike, *Esox lucius* L.; pikeperch, *Sander lucioperca* (L.); wels catfish, *Silurus glanis* (L.) (stocking only since catches of this species in the analyzed lakes and periods were not noted and were recorded in lake management logs under the heading "other species"); tench, *Tinca tinca* (L.); crucian carp, *Carassius carassius* (L.), and Prussian carp, *Carassius gibelio* Bloch, together; carp, *Cyprinus carpio* L.; grass carp, *Ctenopharyngodon idella* Val.; bighead carp, *Aristichthys nobilis* Rich., and silver carp, *Hypophthalmichthys molitrix* Val., together.

In order to present and compare exploitation and stocking intensity in the analyzed lakes prior to and following the fisheries ownership transformation period, two ten-year management periods were designated. The 1973-1982 period was selected as it was the final time during which state fisheries enterprises was responsible for managing this sector. The 1995-2004 period includes the time following ownership transformation when most state fisheries enterprises had been divided into smaller units – usually limited liability companies. Data regarding

fish catches and stocking from fisheries logs were recalculated into monetary value (in PLN) using the mean wholesale prices for individual commercial fish species, and with regard to bream and roach, these calculations were also done for size variety. The mean prices paid for different forms of stocking material released by lake fisheries enterprises in 2005 were also calculated (Mickiewicz 2010). Next, the weighted averages of the annual values for both of these periods per ha of lake surface analyzed were calculated and compared. In order to preserve the comparative precision of these data for the two periods analyzed, identical prices from 2005 for commercial fish and stocking material were used and identical lake surface areas were analyzed. The mean annual share (%) of the catch values of individual fish species and size varieties and of various forms of stocking materials of the total mean annual values of these parameters were compared as were their mutual relationships (the share of the mean annual value of stocking in the mean annual value of catches in %) in both of the periods analyzed. The data analysis methodology used in the present report is identical to that used previously with regard to a smaller group of lakes (Mickiewicz 2001, 2006).

Results and Discussion

In the 1973-1982 period, the mean annual value of catches of all fish species and size varieties, at 226.33 PLN ha^{-1}, was two-fold higher than that in the 1995-2004 period, when it was 113.77 PLN ha^{-1} (Table 1). The value of catches was lower in the first period analyzed only with regard to pikeperch, crucian carp, small non-commercial size bream, bighead and silver carps, and species of "small, non-commercial fish". In the case of medium-sized bream the value of the catches in both of the periods analyzed was identical at 2.24 PLN ha^{-1}. The value of catches of the other species and size varieties was higher in the first period analyzed than in the second.

The values of the species stocked in the first decade analyzed were higher by the following amounts: eel – 63.65 PLN ha^{-1}; vendace – 19.88 PLN ha^{-1}; whitefish – 6.19 PLN ha^{-1}; tench – 2.12 PLN ha^{-1}; pike – 1.48 PLN ha^{-1}; carp – 0.35 PLN ha^{-1}; grass carp – 0.03 PLN ha^{-1}. The total value for all of the species mentioned above in the first decade analyzed was 93.70 PLN ha^{-1} higher than in the second decade. Thus, the value of these species in the second decade analyzed was barely 28% of the value in the first decade. The increased value of catches of pikeperch, crucian carp, and silver and bighead carps (i.e., species that are stocked) in the second decade as compared to the first decade by 2.05 PLN ha^{-1} certainly did not compensate for the decreased value of catches of the other species that were stocked since the decreases noted for all of the species stocked were of approximately 92 PLN ha^{-1}.

The structure of the catch value (Table 1) in the first decade of stocked species was dominated by eel at a share of 46%, vendace – 17%, pike – 6%, pikeperch – 4%, whitefish – 3%, and tench – 2%. The share of the other species stocked, i.e., crucian carp, carp, grass carp, silver and bighead carps, of the overall value of catches in the first decade analyzed was inconsequential and did not exceed 0.4%. The structure of the catch value of stocked species in the second decade analyzed was as follows: eel continued to dominate, but at a much lower share of 35%; vendace was also at a lower share of 15%; the share of pike was higher at 11%. The share of pikeperch at 9% and of tench at 3% remained stable, while the share of crucian carp at 0.7%, and silver and bighead carps at 1% increased. Although the share of the catch value of whitefish at 1.4% was higher than that of the latter two species, it was lower in comparison to its share in comparison to the first decade. The values of the share of carp and grass carp catches were similar to those of these species in the first period analyzed. Together, the share of the value of stocked species in the overall value of fish catches in the first decade analyzed was nearly 79%, while in the second period analyzed it was 77%, which was comparable.

In the 1973-1982 period the mean annual value of stocking material of all fish species, which was 385.91 PLN ha^{-1}, was in excess of 7.5 times higher than that in the 1995-2004 period when it 50.40

Table 1
Mean annual value (PLN ha^{-1}) of catches by species and classes of fish and their share (%) during the analyzed periods of 1973-1982 and 1995-2004

	Value of catches (PLN ha^{-1})		Share (%) of the overall value of catches	
Species/size-class	1973-1982	1995-2004	1973-1982	1995-2004
Eel	103.63	39.98	45.78	35.17
Vendace	37.37	17.49	16.51	15.38
Whitefish	7.79	1.60	3.44	1.41
Pikeperch	9.92	10.10	4.38	8.88
Pike	13.61	12.13	6.01	10.67
Tench	5.49	3.37	2.42	2.97
Crucian carp	0.11	0.80	0.05	0.70
Perch	5.39	4.69	2.38	4.12
Smelt	1.42	0.64	0.63	0.56
Large-sized bream	8.94	4.46	3.95	3.92
Medium-sized bream	8.44	6.13	3.73	5.39
Small-sized bream	2.24	2.24	0.99	1.97
Small non-commercial bream	0.00	0.06	0.00	0.06
Silver bream	2.10	1.33	0.93	1.17
Medium-sized roach	6.74	2.56	2.98	2.25
Small-sized roach	10.10	3.71	4.46	3.27
Carp	0.77	0.42	0.34	0.37
Bighead and silver carp	0.06	1.24	0.03	1.09
Grass carp	0.04	0.01	0.02	0.01
Bleak	0.13	0.03	0.06	0.0
Small non-commercial fishes	0.14	0.35	0.06	0.31
Other	1.89	0.36	0.84	0.32
Total	226.33	113.77	100% = 226.33 PLN ha^{-1}	100% = 113.77 PLN ha^{-1}

PLN ha^{-1} (Table 2). This significant difference depended mainly only on the value of eel stocking which was higher in the first decade by nearly 339 PLN ha^{-1} than it was in the second period analyzed. The mean annual values of the stocking of the following species were also higher: whitefish by 4.38 PLN ha^{-1}; vendace by 1.32 PLN ha^{-1}; grass carp by 0.05 PLN ha^{-1}. The values of stocking in the first decade analyzed were lower than in the second decade analyzed with regard to the following species: pike by 6.34 PLN ha^{-1}; pikeperch by 1.10 PLN ha^{-1}; carp by 0.91 PLN ha^{-1}; crucian carp by 0.33 PLN ha^{-1}; tench by 0.16 PLN ha^{-1}; silver and bighead carp by 0.09 PLN ha^{-1}; wels catfish, which was not stocked in the first decade analyzed.

The structure of the value of stocking in the first decade was dominated decidedly by eel with a share of more than 95%, while the value of vendace and whitefish stocking was approximately 2% (Table 2). The other species combined accounted for less than 1% (0.64%). During the second decade analyzed (Table 2), eel dominated (57%), followed by vendace (15%), pike (14%), whitefish (4%), and carp and pikeperch (at 3% each). The value of the shares of stocking material of tench, crucian carp, silver and bighead carps, and grass carp also increased in comparison to that in the first decade. The mean annual share of the value of stocking

Table 2
Mean annual values (PLN ha^{-1}) of stocking material of fish species and stocking material by fish species and their share (%) in the analyzed periods of 1973-1982 and 1995-2004

	Value of stocking material (PLN ha^{-1})		Share (%) of the overall value of stocking material	
Species	1973-1982	1995-2004	1973-1982	1995-2004
Eel	367.92	29.00	95.32	57.54
Vendace	9.09	7.77	2.36	15.41
Whitefish	6.48	2.10	1.68	4.17
Pikeperch	0.29	1.39	0.07	2.76
Pike	0.80	7.14	0.21	14.17
Wels	0.00	0.22	0.00	0.44
Tench	0.53	0.69	0.14	1.37
Crucian carp	0.06	0.39	0.02	0.77
Carp	0.53	1.44	0.14	2.86
Bighead and silver carp	0.14	0.23	0.04	0.46
Grass carp	0.07	0.02	0.02	0.05
Total	385.91	50.40	100 % = 385.91 PLN ha^{-1}	100 % = 50.40 PLN ha^{-1}

material of wels catfish, which was not stocked in the analyzed lakes in the first decade analyzed, was 0.44%. When comparing the two analyzed decades of 1973-1982 and 1995-2004, it is noteworthy that the decrease in the mean annual share of the value of eel stocking material was compensated for by the increased share of the other species including pike, vendace, pikeperch, carp, and crucian carp, *Carassius carassius* (L.).

When analyzing the total annual mean value of fish caught to the total annual mean value of stocking material in the two decades analyzed (Table 3), it is of particular note that, if the value of eel stocking is subtracted from the value of catches of this species, the value of stocking to the value of catches in the first decade analyzed is barely 15%, while in the second decade it was 29%, which was nearly two-fold higher.

The methodological approach used in this study, which was based on using 2005 prices to calculate the value of catches and stocking for the periods analyzed, especially that of 1973-1982, deserves comment. This approach ensured that the results obtained from various periods were comparable, but with certain reservations. The comparison is based on prices in 2005, and not on prices or the mutual price relations among different fish species or forms of stocking material from the different years of the periods analyzed. This permitted omitting calculations required by a strictly economic methodological approach that takes into consideration the long-term volatility in the price indexes of consumer goods and services (i.e., inflation), which, under the Polish economic conditions of the periods from which long-term data was analyzed including such difficult economic realities as the serious economic crisis of the 1980s or the currency denomination of 1995, both of which are difficult to quantify.

Applying unified prices from 2005 for the two periods analyzed was particularly important with regard to the value of eel catches and even more importantly with regard to the value of the stocking material of this species. Calculations of the value of catches and of the stocking material were based on prices from 2005 (wholesale price of commercial eel – 33.80 PLN kg^{-1}, price of cultured eel stocking material – 349.28 PLN kg^{-1}, price of glass eel – 4000 PLN kg^{-1}), as was done with the calculations for all the other species analyzed. However, the mutual

Table 3
Mean annual values of fish caught and stocking material in the analyzed periods of 1973-1982 and 1995-2004 and their mutual relationship of the share of the value of stocking in the value of catches

1973-1982			1995-2004		
Value of catches (PLN ha^{-1})	Value of stocking (PLN ha^{-1})	Value of stocking to value of catches (%)	Value of catches (PLN ha^{-1})	Value of stocking (PLN ha^{-1})	Value of stocking to value of catches (%)
226.33	385.91	170.51	113.77	50.40	44.30
122.70[1]	17.99[2]	14.66	73.79[1]	21.40[2]	29.00

[1]without the value of eel catches
[2]without the value of eel stocking

relations between the prices of commercial eel, and the prices of eel stocking material varied significantly, and especially so in the 1973-1982 and 1995-2004 periods. Although this fact probably applied to all the species, it was most evident in the case of eel. According to data from the Freshwater Fish Price List (No. 402-Z/76) and the Freshwater Fish Stocking Material Price List (No. 404-Z/76) from the Ministry of Agriculture in 1976, live commercial eel cost 134 PLN kg^{-1}, cultured eel cost 425 PLN kg^{-1}, and glass eel cost 800 PLN kg^{-1}. As can be calculated, in 2005 a kg of cultured eel cost the same as over 10 kg of commercial eel, while a kg of glass eel cost more than 118 kg of commercial eel. In 1976 the value of a kg of cultured eel was worth more than 3 kg of commercial eel, while a kg of glass eel was worth just under 6 kg of commercial eel. These proportions varied significantly, which was the impact of the crisis suffered in the glass eel market, the collapse in its supply, and the consequent very high prices in recent years for this stocking material, which was once so commonly released (Moriarty et al. 1990, Moriarty 1997, Leopold and Wołos 2001).

Because of the methodological approach discussed above and the disproportions in the mutual relationships between the value of eel catches and stocking, the intensity of stocking management data compared distorts the picture in the first of the analyzed periods from 1973-1982. This is because the calculations performed in accordance with the methodology applied, in excess of 170% of the value of mean annual catches was spent on stocking in this period. During the second period analyzed from 1995 to 2004, the value of this was in excess of 44%, thus, it appears that a significantly larger sum was spent on stocking in the 1973-1982 period than the catches were worth. This situation changes dramatically, however, when the value of eel stocking is subtracted from both of the 1973-1982 and 1995-2004 periods analyzed. It appears that in the 1973-1982 period this was nearly 15% of the mean annual catch value, while in 1995-2004 it was 29%. Obviously, the near two-fold difference in favor of the 1995-2004 period, can be declared *de facto* as a very important measure of the differences in the manner in which lake fisheries management was operated both before and after the ownership transformation.

The conclusions drawn from the results of a study on a different group of lakes in a different period and that employed exactly the same methodology to that in the present study were identical. In the first instance, 230 lakes located throughout all of the Polish lake regions with a total surface area of 96.3 thousand ha were compared for the periods of 1973-1977 and 1995-1999 (Mickiewicz 2001), while in the second, 35 lakes with a total surface area of 36.5 thousand ha that comprise the Great Mazurian Lakes System were compared for the periods of 1973-1982 and 1995-2004 (Mickiewicz 2006). Both of these studies confirmed unequivocally that the quality of stocking management in terms of species diversity and the value of stocking in relation to that of catches was higher after the ownership transformation period in lake fisheries than it had been before it. One might wonder whether this difference was caused only by

the crisis in the supply of eel stocking material, or if the overall changes in the management system also had an impact. Recreational fisheries have assumed a vast role in the new management system (Wołos 1992, 2000), and the significance of maintaining ichthyofauna biodiversity in lakes has also been recognized (Bnińska 1994), as has the overall value of lakes, which, the larger they are, the more valuable they are as natural, minimally undisturbed aquatic ecosystems (Leopold and Bnińska 1992, Leopold et al. 1994, Leopold et al. 1998, Turkowski 2006).

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