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GENERAL CHARACTERISTICS OF COREGONID MANAGEMENT IN 132 POLISH LAKES

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A B S T R A C T. Analyses were carried out of the data on catches and stockings of vendace and whitefish in 132 lakes used by 21 fishery enterprises. The lakes are located in the following lake districts: Drawskie, Wałeckie, Kaszuby, Mazuria, Varmia and Suwałki. The lakes were divided into classes depending on the morphometry, coregonid yields and stocking rates. A group of several lakes was identified, in which the results of coregonid management were much better than the average. The obtained results systematise the most important parameters of whitefish and vendace management in the lakes of north Poland, and are related to lake morphometry and long-term fishery records.

Key words: LAKE FISHERIES, COREGONID MANAGEMENT, LAKE MORPHOMETRY, YIELDS AND STOCKING RATES, VENDACE, WHITEFISH

INTRODUCTION

Vendace (*Coregonus albula* L.) and whitefish (*Coregonus lavaretus* L.) belong to the most valuable species in Polish lakes subject to fishery management. Their biological, economic and marketing value has been frequently stressed in the relevant literature, just to mention rapid growth, enabling enhancement of the production cycle, mass occurrence, schooling habits, relatively easy production of the stocking material, resistance to parasites, and very tasty meat (Dąbrowski and Leopold 1969a, 1969b, Szczerbowski 1970, Leopold 1972, Falkowski 1991). These characters resulted in the fact that vendace and whitefish landings increased on a national scale notwithstanding deteriorating environmental conditions, from a mean annual level of 356 tons in 1950-1970 (Leopold 1972) to about 600 tons in the next 10 years (Leopold, Bnińska, Nowak 1986), and maximal landings by the end of the seventies, amounting to 570 tons of vendace and 100 tons of whitefish (Szczerbowski et al. 1993). At the beginning of the eighties, however, coregonid production began to decrease, the decreasing trend being even more accentuated by the transformation period (most noticeable in 1991-1993), so that a drop was observed not only of vendace and whitefish landings, but of all inland fish species (Leopold 1994). Regression of coregonid

management is well illustrated by the fact that in 1992 landings of vendace and whitefish were estimated at only 298 and 43 tons respectively, and in 1995 the respective values were 230 and 27 tons (Falkowski and Wołos 1996).

Fishery practice and science are equally interested in coregonids, but vast literature devoted to these fish is dominated by papers dealing with coregonid biology, population dynamics, methods of rearing stocking material, various aspects of exploitation, and - recently - also genetic problems. There are very little papers dealing with the effectiveness of stocking practices, proper allocation of the stocking material, optimisation of whitefish and vendace management etc., viz. with the problems generally related to fishery management and economics. Majority of works dealing with these aspects are found in Finnish literature, but they usually describe single lakes of different environmental conditions and different management methods than in Poland (Salojärvi 1988, 1991, Salojärvi and Ekholm 1990, Salojärvi and Mutenia 1994, Marjomaki, Kirjasniemi, Huolila 1995, Jurvelius et al. 1995). There are some papers dealing with German lakes in Mecklenburg District (Steffens 1995), and some Polish works have delt with selected fishery enterprises (Bnińska 1985, Wołos, Falkowski, Abramczyk 1995) or single lakes (Budych and Mastyński 1978, Mastyński and Wasilewska 1989, Wołos, Falkowski, Czerkies 1998).

In view of this, it became quite important to obtain a complex picture of the effectiveness of coregonid management in Poland, as well as to work out the principles of management policies in relation to the stocking material and vendace and whitefish management in lakes in general. Consequently, a 3-year study project was undertaken, the results of which are presented in the papers published in this volume. This paper systematises the most important parameters of vendace and whitefish management in 132 lakes of north Poland, in relation to lake morphometry and long-term records on the landings and stockings of these species. The other papers deal with particular problems and aspects of coregonid management in a more detailed way.

MATERIAL AND METHODS

This as well as other papers in this volume are based on the analyses of long-term records on coregonid (whitefish and vendace) landings and stockings in 132 lakes of Poland. Total area of these lakes amounts to 65961.5 ha i.e. 27% of all lake area used by inland fisheries and supervised by the Agency of National Agricultural Properties.

The lakes selected for this analysis differ with respect to their morphometric parameters, are characterised by different state of their environments, and are currently used by 21 fishery enterprises located in lake districts: Drawskie, Wałeckie, Kaszuby, Mazuria, Varmia and Suwałki. Consequently, the obtained results will characterise coregonid management in north Poland.

Data on fish landings were collected from the so-called „lake books". Selection of lakes was based on the opinion of the respective fishery managers, who defined these lakes as important (now or in the past) for coregonid management. Consequently, a data base was created, comprising 132 lakes, out of which 131 were at least once stocked with vendace and whitefish (or one of these species), and only 1 has never been stocked with these fish. In several lakes, peled was stocked together with whitefish (mostly in the seventies). However, in view of the fact that peled landings were in most cases recorded as whitefish, data pertaining to the two species were summed up and treated as whitefish.

For 88 lakes the fishery statistics comprise the period of 40 years, for the rest - of 20 years. In view of this, particular papers deal with different number of lakes, depending on the method used, this being stated each time (N - sample size).

Morphometric parameters were obtained from the source materials of the Inland Fisheries Institute. The following characters were selected: water surface area of each lake, average depth, maximal depth, index of shore line development. All production results and management data cited for the given lakes, e.g. yields or stocking rates, have been calculated as long-term weighted means, while the mean parameters for the whole sample represent arithmetical means from particular lakes.

RESULTS

LAKE MORPHOMETRY

The analysed 132 lakes represent classes of different size depending on the analysed parameter.

As regards lakes area, 5 size classes were distinguished (Table 1). The highest number of lakes (30.3 %) belong to size class of 100 to 250 ha, followed by lakes up to

TABLE 1

Frequency distribution of lakes in size classes (N = 132)

Area (ha)	Lake number (%)
0 - 100	30 (22.7)
100 -250	40 (30.3)
250 - 500	26 (19.7)
500 - 1000	23 (17.4)
Ower 1000	13 (9.9)

TABLE 2

Frequency distribution of lakes in average depth classes (N=132)

Average depth (m)	Lake number (%)
do 5	4 (3.0)
5 - 7.5	35 (26.6)
7.5 - 10	41 (31.0)
Ower 10	52 (39.4)

TABLE 3

Frequency distribution of lakes in maximal depth classes (N=132)

Maximal depth (m)	Lake number (%)
do 10	3 (2.3)
10 - 20	25 (18.9)
20 - 30	43 (32.6)
30 - 40	32 (24.2)
40 - 50	18 (13.6)
Ower 50	11 (8.4)

100 ha, 250-500 ha, and 500-1000 ha. Class of lakes of more than 1000 ha contains the lowest numbers.

Taking into account the distinguished average depth classes (Table 2), the most numerous group (39.4% of all lakes) is the one representing very deep lakes, of average depth over 10 m, and moderately deep i.e. 7.5-10 m and 5-7.5 m deep, while the least numerous is the group of lakes having average depth less than 5 m.

Maximal depth ranged considerably (Table 3), classes with depth 20-30 m and 30-40 m being the most numerous. Only 2.3% of the lakes had maximal depth of less

than 10 m, whereas very deep lakes, with maximal depth exceeding 50 m, represented 8.4 %.

As regards development of the shore line (Table 4), 4 classes of the respective index were distinguished (after Szczerbowski et al. 1993). Class 2.0 to 3.0, viz. with fairly well developed shore line, was the most numerous, followed by the class 1.5–2.0 and over 3.0.

TABLE 4

Frequency distribution of lakes in classes of the index of shore-line development (N=132)

Index of shore-line development	Lake number (%)
1.0 - 1.5	20 (15.1)
1.5 - 2.0	31 (23.5)
2.0 - 3.0	52 (39.4)
Ower 3.0	29 (22.0)

CHARACTERISTICS OF FISH LANDINGS

TOTAL FISH LANDINGS

Total fish yield in the analysed 132 lakes was fairly diversified, as illustrated by Table 5. Majority of the lakes were within the yield class of from 20 to 30 kg/ha, followed by the class 10-20 kg/ha. Almost 20 % of lakes were highly productive, with fish yields ranging from 30 to 40 kg/ha, while the least numerous classes were those with the lowest (up to 10 kg/ha) and the highest (over 40 kg/ha) yield. In two lakes, the fish yield exceeded 50 kg/ha.

VENDACE LANDINGS

Vendace was caught in all lakes. Apart from 9 lakes in which these catches were accidental (e.g. lakes Arnowskie and Lubnie Duże, where 1 and 5 kg were caught once), the remaining 123 lakes yielded on the average 241 tons of vendace annually, the mean yield of vendace being 4.1 kg/ha. Taking into account the distinguished classes of fish vendace yields (Table 6), classes with vendace yield 1-3 kg/ha and below 1 kg/ha were the most numerous, followed by 5-10 kg/ha, and 3-5 kg/ha. Eight lakes (6 %) were characterised by very high mean yield of vendace, exceeding 10 kg/ha, in this 4 lakes (3 %) yielded more than 15 kg/ha on the average. Long-term mean vendace yields in these lakes are presented in Table 7. This table presents also

TABLE 5

Frequency distribution of lakes in total fish yield classes (N=132)

Mean fish yield (kg/ha)	Lake number (%)
do 10	11 (8.3)
10 - 20	40 (30.3)
20 - 30	47 (35.6)
30 - 40	26 (19.7)
Ower 40	8 (6.1)

TABLE 6

Frequency distribution of lakes in classes of vendace yield (N=132)

Mean fish yield (kg/ha)	Lake number (%)
do 1	34 (25.8)
1 - 3	39 (29.6)
3 - 5	23 (17.4)
5 - 10	28 (21.2)
10 - 15	4 (3.0)
Ower 15	4 (3.0)

TABLE 7

Lakes with the highest mean yields and catches of vendace

Lake	Mean yield of vendace (kg/ha)	Lake	Mean catch of vendace (kg)
Maróz	17.19	Łańskie	16 331
Rospuda	16.44	Piławskie	15 857
Piławskie	16.18	Narie	14 184
Łańskie	15.67	Mokre	10 420
Kośno	13.51	Wigry	10 093
Mokre	12.39	Lubie	
Narie	11.44	Pluszne	8 306
Bysławskie	11.07	Drawsko	7 665

lakes with the highest annual catches. The highest vendace yields ever recorded were 58.0 and 52.7 kg/ha (Table 8); in 25 lakes they exceeded 25 kg/ha.

In 10 lakes percentage of vendace in total fish landings exceeded 40 %, reaching the highest level of 77.2 % in Lake Piasek (Kaszuby Lake District).

TABLE 8

Lakes with the highest yields of vendace

Lake	Maximal vendace yield (kg/ha)
Jagodzin D.	58.0
Links	52.7
Piławskie	49.8
Maróz	48.7
Szeląg D.	47.5
Rospuda	46.1
Mikołajskie	42.4
Kośno	40.6
Mielno	38.4
Mokre	34.7

WHITEFISH LANDINGS

Catch statistics showed that only in two lakes whitefish was never caught, but in another 10 lakes is landings were negligible and had no economic significance. In the remaining 120 lakes the mean annual catch of whitefish amounted to 36.3 tons. As regards whitefish yields (Table 9), almost half of the lakes had very low yields of this fish (less than 0.25 kg/ha), followed by yield class 0.5-1.0 kg/ha and 0.25 to 0.5 kg/ha. Whitefish yields exceeding 1 kg/ha were attained in only about 20 % of lakes, in this 6 lakes yielded more than 5 kg/ha. Mean long-term yields of whitefish in these lakes are presented in Table 10, which lists also the lakes with the highest recorded yield of whitefish. Maximal values exceeded 10 kg/ha in 22 lakes, the high-

TABLE 9

Frequency distribution of lakes in classes of whitefish yield (N=132)

Mean fish yield (kg/ha)	Lake number (%)
do 0.25	61 (46.2)
0.25 - 0.5	18 (13.6)
0.5 - 1	25 (18.9)
1 - 3	21 (15.9)
3 - 5	1 (0.8)
Ower 5	6 (4.6)

TABLE 10

Lakes with the highest mean yields and catches of whitefish

Lake	Mean whitefish yield (kg/ha)	Lake	Mean whitefish catch (kg)
Ruskowiejskie	6.11	Gołdopiwo	4740
Mielno	5.83	Mamry Płn.	2389
Gołdopiwo	5.50	Mielno	2117
Maróz	5.24	Łańskie	1967
Gąsiorowo	5.23	Pluszne	1841
Czaplino	5.17	Maróz	1808
Rospuda	3.56	Wigry	1564
Żelazne (Isąg)	2.47	Śniardwy	1312

TABLE 11

Lakes with maximal yields of whitefish

Lake	Maximal yield of whitefish (kg/ha)
Ruskowiejskie	77.2
Gąsiorowo	62.1
Rospuda	26.0
Mielno	25.4
Lubno Duże	22.9
Bartąg	20.1
Maróz	18.6
Mołdawskie	18.5
Arnowskie	17.8
Studnica	17.2

est levels being 77.2 and 62.1 kg/ha (Table 11). These values considerably deviate from the maximal yields recorded in consecutive lakes (Rospuda - 26.0 kg/ha, Mielno - 25.4 kg/ha), but in both lakes (Ruskowiejskie and Gąsiorowo) peled was also stocked for quite a long time.

Maximal percentage of whitefish (with peled) in overall fish landings amounted to 22.03 % (Lake Ruskowiejskie), and exceeded 10 % in another 8 lakes.

CHARACTERISTICS OF STOCKINGS

STOCKING WITH VENDACE

From among the 132 lakes under study, 123 were stocked with vendace. Larvae were used in all lakes, and in addition to this, 19 lakes were sporadically stocked with summer fry. Total numbers of released summer fry represented only 0.4% in relation to larvae, pointing to totally marginal role of this form of the stocking material. The mean annual stocking rate with larvae was about 3860 fish/ha. Distribution of stocking rates in the 6 distinguished classes of stocking levels is presented in Table 12. The most numerous group is the one with the lowest stocking rates (less than 2000 larvae/ha), the least numerous - that with high stocking rates (over 10000 larvae/ha).

TABLE 12

Frequency distribution of lakes in classes of stocking rates with vendace (N=123)

Mean stocking rate larvae/ha	Lake number (%)
do 2000	45 (36.6)
2000 - 4000	34 (27.6)
4000 - 6000	18 (14.6)
6000 - 8000	12 (9.8)
8000 - 10000	8 (6.5)
Ower 10000	6 (4.9)

STOCKINGS WITH WHITEFISH

120 lakes out of 132 were stocked with whitefish. Three forms of the stocking material were used: larvae, summer fry and autumn fry. Due to this, it is practically impossible to define the mean stocking rates. Taking into account 7 different variants of possible combinations (Table 13) it is easily seen that the most numerous lakes (over 50%) were those stocked with all three forms of material, followed by those stocked with larvae only (12.5%), those stocked with larvae and autumn fry (12.5%), and stocked with larvae and summer fry (11.7%). The least numerous groups of lakes are those in which only summer fry or only autumn fry were released. It is possible to adopt another approach, viz. to distinguish the prevailing form of the stocking material (Table 14), In that case it appears that in 87.5 % of all lakes larvae were

TABLE 13

Frequency distribution of lakes with respect to the type of whitefish stocking material (N=120)

Form of the stocking material	Lake number (%)
larvae	15 (12.5)
summer fry	2 (1.7)
autumn fry	5 (4.1)
larvae + summer fry	14 (11.7)
larvae + autumn fry	15 (12.5)
summer fry + autumn fry	8 (6.7)
larvae + summer fry + autumn fry	61 (50.8)

TABLE 14

Frequency distribution of lakes with respect to the prevailing forms of whitefish stocking material and stocking rates (N=120)

Prevailing form of the stocking material	Lake number (%)	Mean stocking rate with the prevailing form (fish/ha)
larvae + other forms	105 (87.5)	290.3
summer fry + other forms	85 (70.8)	100.5
autumn fry + other forms	89 (74.2)	7.1

the prevailing material, used together with other forms, followed by autumn fry coupled with other forms, and finally by summer fry together with other forms. Mean stocking rates for the three forms of the stocking material were 290 larvae/ha, 100 summer fry fish/ha and 5 fish in autumn fry stage/ha.

DISCUSSION

It is quite difficult, or even virtually impossible to unequivocally define the state of coregonid management in Polish lakes. All comparisons with 1950-ies, 1960-ies, 1970-ies or 1980-ies (Bernatowicz 1953, Walczak 1956, Radziej 1960, Leopold, Marciak, Backiel 1970, Leopold 1972, Mastyński 1978, Uryn and Falkowski 1979a, b, c, d, Bnińska and Leopold 1990) are definitely in favour of the past years due to the observed decrease of coregonid landings, especially during the transformation period (Leopold 1994, Falkowski 1994). On the other hand, however, some negative tendencies seem to have been overcome, this being reflected in a certain increase of

catches (Leopold and Wołos 1996,1997) and stockings (Wołos 1996, Wołos and Mickiewicz 1997) in 1996 compared to 1995.

Apart from significant constraints imposed on coregonid management by the eutrophication process, it seems that its future prospects are connected more with proper allocation of the stocking material to the lakes that have already been used to produce vendace and whitefish, than with the possibility of looking for new lakes and expanding the lake area used for this production. Results presented in this paper reveal that lakes in which coregonid management has been carried out so far comprise a variety of types, differing as to the area, depth, development of the shore line etc., so that in many cases the manager is able to select the most suitable water bodies, and to disregard those which do not give satisfactory results. Also high diversification of the stocking rates suggests that to some an extent the managers tried to establish the most effective doses. It has also been shown that morphometric parameters of the lakes used to produce coregonids, as well as stocking rates used in these lakes, only partly comply to the recommendations given in the textbooks and manuals. Obviously the fishery managers looked for optimal solutions, and this led to an identification of many lakes in which the results of coregonid production are far better than elsewhere. This is well illustrated by yields exceeding 10 kg/ha in the case of vendace, and 5 kg/ha in the case of whitefish, or - even more - by maximal vendace yields of over 25 kg/ha achieved in 27 lakes, or maximal whitefish yields of more than 10 kg/ha achieved in 22 lakes. Moreover, these data reveal considerable productive potential of these lakes.

In view of the results presented here, a few questions important from both theoretical and practical point of view, can be formulated:

How do the lakes differ in the distinguished classes of the effectiveness of coregonid management ?

Are there any regularities or factors governing the relations between lake morphometry and the effectiveness of coregonid management ?

What management consequences result from high diversification of stocking rates in particular lakes ?

In view of many variants of stocking with whitefish, and a variety of stocking material used, is it possible to work out an adequate method of assessing the effectiveness of stocking with this species ?

What are the characteristics of lakes in which coregonid management gives the best results ?

These questions, significant for the assessment of the effectiveness of coregonid management and for working out some principles of allocating the stocking material, have directed the studies carried out within the research project, the results of which are presented in this volume.

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STRESZCZENIE

OGÓLNA CHARAKTERYSTYKA GOSPODARKI KOREGONIDAMI W 132 JEZIORACH POLSKI

Poddano analizie dane o odłowach i zarybieniach sielawą i sieją w 132 jeziorach Polski, użytkowanych obecnie przez 21 podmiotów gospodarczych z terenów Pojezierzy Drawskiego, Wałeckiego, Kaszubskiego, Mazurskiego i Suwalszczyzny. Dokonano podziału jezior, w których prowadzona jest gospodarka koregonidami na klasy, w zależności od morfometrii, wydajności i wielkości stosowanych dawek zarybieniowych, oraz zidentyfikowano grupę kilkunastu jezior, w których osiągane są wyniki produkcyjne znacznie odbiegające od przeciętnych. Wyniki pracy systematyzują najważniejsze parametry gospodarki sielawą i sieją w jeziorach Polski północnej - w odniesieniu do charakterystyk morfometrycznych jezior i wieloletnich statystyk gospodarczych.

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