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ANALYSIS OF WHITEFISH (*Coregonus lavaretus* L.) LANDINGS AND STOCKINGS IN 106 LAKES IN 1967-1994

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A B S T R A C T. Based on the fishery records, analyses were performed of the relationships between whitefish landings, stocking rates and effectiveness of stocking in 106 Polish lakes. The lakes were divided into 6 classes based on their individual area. Mean values were calculated for each lake of the level of whitefish landings and of stocking rates (quantity and kind of stocking material) from 1 ha of lake area. Effectiveness of stocking was expressed as level of stocking needed to produce 1 kg of commercial whitefish catch. Using standard prices, the three basic forms of the stocking material used were recalculated into standard autumn fry; reliability of this approach has been discussed. The results suggest that there were several reasons for the observed breakdown of whitefish production in Polish lakes. These embrace quantity and type of the stocking material used and broadly understood effectiveness of the fishery management.

Key words: WHITEFISH, LANDINGS, STOCKINGS, EFFECTIVENESS OF PRODUCTION, STANDARD FRY

INTRODUCTION

Fishery sciences have always been interested in coregonid fish, so that inventories of lakes with whitefish have been made a few times in the past 50 years. The first such an inventory made after the 2nd World War embraced Mazurian and Suwałki Districts. It stated that there were 40 lakes with whitefish stocks, their total area amounting to 30765 ha (Korycki 1953). At that time, whitefish inhabiting waters of Mazurian Lakeland was a totally protected species, so that its catches were limited to the level needed to produce stocking material only (Korycki 1953). Thus, it is not surprising that the average whitefish landings were very low at that time, amounting in 1950-1954 to only 4.1 t annually (Szczerbowski et al. 1973). Lake stocking with whitefish, which had begun by the end of the 40-ies (Kaj 1949, Korycki 1953) and continued for the next few years, resulted in a systematic increase of the number of lakes with whitefish and whitefish landings.

Average annual landings of whitefish in 1956-1965 amounted to 18.3 t and were still too low in relation to the expenditures on stockings. In 1966 whitefish catch

increased by 140 % and reached the level of 44.3 t. This sudden increase was due to abandoning an unrealistic legal size which had been in force till then. That the legal size was too big can be well exemplified by Lake Gołdopiwo, in which 1742 kg of whitefish were caught annually until 1966, corresponding to the yield of some 2.5 kg/ha. Gąsowska (1953) had even suggested that this yield was probably the upper limit of whitefish productive possibilities in this lake. In 1966, when the legal size of 1 kg was abandoned, 11184 kg of whitefish (12.9 kg/ha) were caught (Rożniakowski 1967), contradicting the suggestions on productive capacity of the lake in question. This result also suggested that each lake should be treated individually.

By the end of the sixties, whitefish occurred in about 200 lakes (Szczerbowski 1970), half of which were located in Varmia and Mazuria. Landings in 1966-1973 oscillated around the annual level of 49.3 t.

Subsequent inventory of the lakes with whitefish (used by State Fishery Enterprises), coupled with an analysis of catch and stocking levels, embraced the period 1973-1977 (Uryn and Falkowski 1979). Whitefish was then caught in 242 lakes of total area 94580 ha. Regional differences in the number of „whitefish" lakes became noticeable; whitefish began to disappear from the lakes of Great Poland region, the same being observed also by Mastyński (1978). In Pomerania, whitefish production remained fairly stable, while in Mazuria and Suwałki District it was characterised by considerable development. The highest whitefish landings in Poland were recorded in 1974-1979 (87.5 tons annually); they were related to the introduction of new methods of producing stocking material, changes in proportions of particular forms used to stock the lakes, but most of all to high stocking rates (Falkowski 1994).

In 1980-1985 average whitefish catches decreased to 73.4 t annually. Since then, whitefish landings show a noticeable decreasing trend.

Based on the results obtained in course of the studies as well as taking into account new technologies implemented in the last 25 years, which had to increase whitefish production in lakes (Falkowski 1994), one might conclude that whitefish management should remain in a good condition. However, landings obtained in the recent years (43 t in 1992 and 23 t in 1995) not only confirm the decreasing trend, but even suggest a breakdown of whitefish production (Falkowski and Wołos 1995).

This paper analyses the relationships between whitefish landings, stocking with different forms of the stocking material (larvae, summer fry, autumn fry) and the

effectiveness of production. Discussion is also presented of the reliability of recalculating different forms of stocking material into comparable standard units, and on possible practical implications of such an approach. An attempt has also been made to explain the reasons for this breakdown of whitefish production in Poland.

MATERIAL AND METHODS

Studies were based on fishery records on catches and stockings in 106 lakes of total area 59444.3 ha. 28-year period (1967-1994) was analysed, i.e. beginning from the year when no legal size of 1 kg was in force any more. Data for earlier years were omitted to avoid possible bias of the results.

The lakes were divided into 6 size classes. Mean annual fish yield from 1 ha was calculated for each class, and separately - whitefish yield. Mean stocking rates with whitefish were calculated in the same way, separately for the three forms of the stocking material used. Stocking effectiveness was also determined as the number of released fish needed to yield 1 kg of commercial catch. The latter index was used to discuss the economic effectiveness of whitefish production. In a few cases the fishery records comprised stocking material defined as „reared larvae" or „feeding larvae" - these were treated as larvae.

An attempt to obtain standard stocking units was based on the literature data on the survival of particular forms and on their standard prices. In the first case data presented by Szczerbowski (1977) were used, which resulted in the model: 66.67 larvae = 4 summer fry = 1 autumn fry (66.67 L = 4 SF = 1 AF), while the recalculation based on the current prices (as of 1997) of the stocking material yielded the model: 83 larvae = 5 summer fry = 1 autumn fry (83 L = 5 SF = 1 AF).

Statistical analysis of the data was based on time series approach. Polynomials up to the 4th degree were calculated, accepting the probability level of at least $p = 0.05$. Computer program STATISTICA Version 5 was used, as well as a special programme prepared for the study project 5PO6E 05308.

RESULTS

The obtained trend of whitefish landings in 1967-1994 (Fig. 1) shows that these landings decreased systematically since 1980, reaching the level of only 20 tons in the

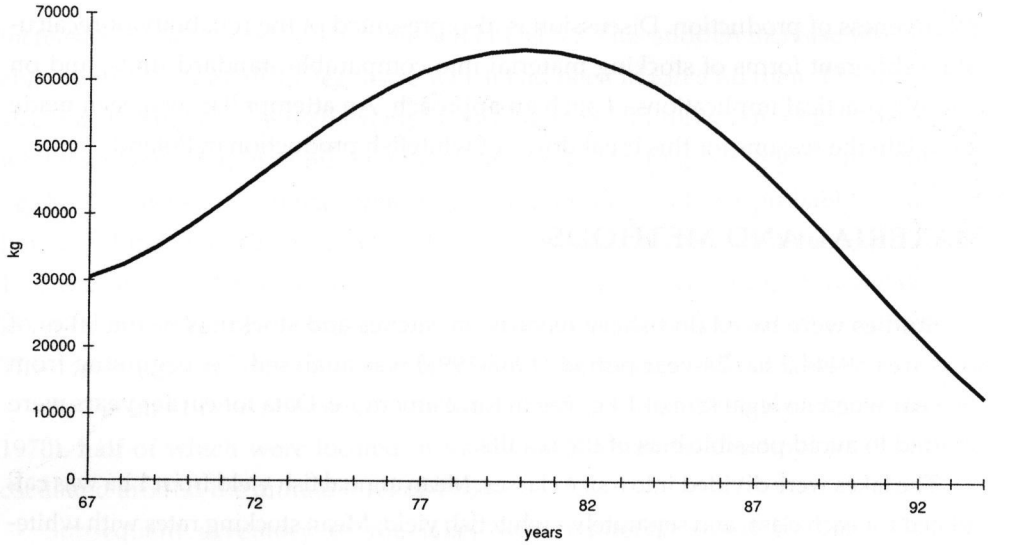

Fig. 1. Trend of whitefish landings in 106 lakes in 1967-1994

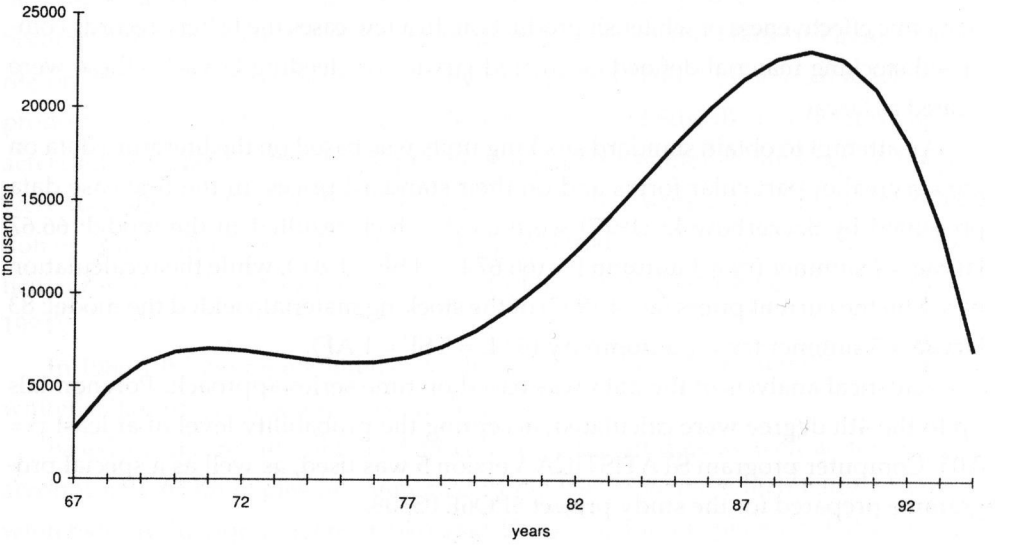

Fig. 2. Trend of stocking with whitefish larvae in 106 lakes

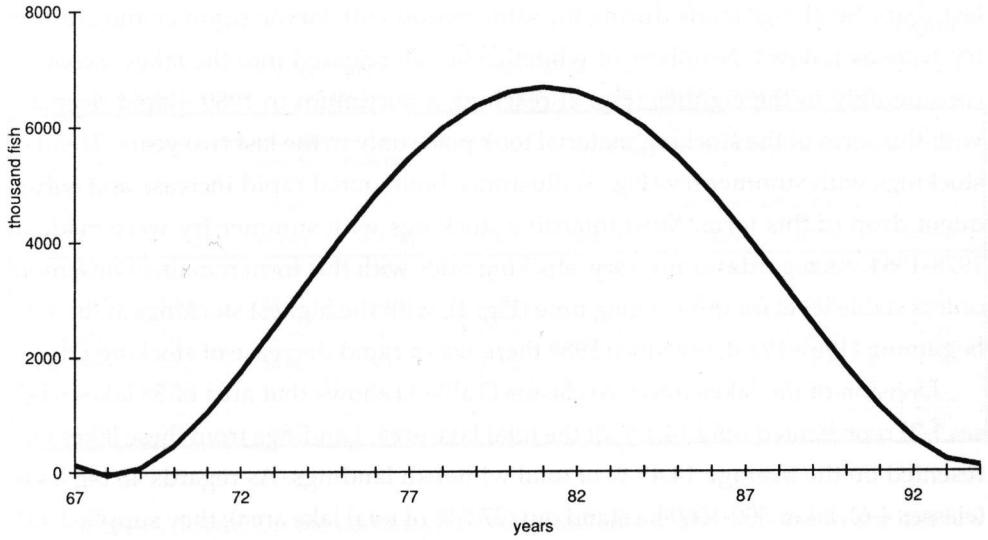

Fig. 3. Trend of stocking with whitefish summer fry in 106 lakes

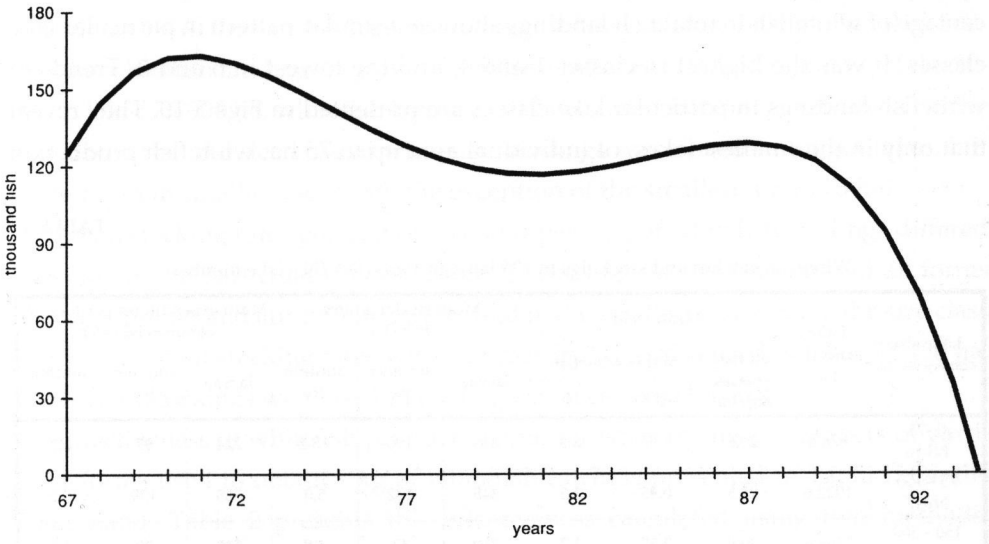

Fig. 4. Trend of stocking with whitefish autumn fry in 106 lakes

last years. Stockings made during the same period with larvae summer and autumn fry were as follows: Numbers of whitefish larvae released into the lakes increased considerably in the eighties (Fig. 2) reaching a maximum in 1989. Rapid decrease with this form of the stocking material took place only in the last two years. Trend of stockings with summer fry (Fig. 3) illustrates both: initial rapid increase and subsequent drop of this form. Most intensive stockings with summer fry were made in 1978-1984. As regards autumn fry, stocking rates with this form remained on a more or less stable level for quite a long time (Fig. 4), with the highest stockings at the very beginning (1969-1973), but since 1989 there was a rapid decrease of stocking rates.

Division of the lakes into size classes (Table 1) shows that area of 58 lakes (classes 1-3) represented only 14.1 % of the total lake area. Landings from these lakes represented on the average 14.45 % of total whitefish landings. As regards 48 big lakes (classes 4-6), lakes 500-1000 ha stand out (27.7 % of total lake area); they supplied 39.2 % of total whitefish landings. The highest average yields of whitefish were obtained in the smallest lakes (1.95 kg/ha) and in lakes 300-500 ha (1.62 kg/ha), and the lowest - in the biggest lakes (0.40 kg/ha) and lakes 150-300 ha (0.57 kg/ha). Also percentage of whitefish in total fish landings showed a similar pattern in particular lake classes. It was the highest in classes 1 and 4, and the lowest in 6 and 3. Trends of whitefish landings in particular lake classes are presented in Figs 5-10. They reveal that only in the smallest lakes, of individual area up to 75 ha, whitefish production

TABLE 1

Whitefish catches and stockings in 106 lakes in 1967-1994 (N - lake number)

Lake size classes in ha	Lake area in ha	Mean yield			Mean stocking rates fish/ha			Mean expenditures per 1 kg of commercial catch		
		all fish species (kg/ha)	in this whitefish		larvae	summer fry	autumn fry	larvae	summer fry	autumn fry
			kg/ha	%						
0 -75 N=16	876.8	23.6	1.95	8.3	436	190	13.2	224	97	6.7
75 - 150 N=17	1922.6	28.5	0.95	3.3	348	132	5.0	365	139	5.2
150 - 300 N=25	5565.6	20.9	0.57	2.7	310	43	1.8	545	79	3.2
300 - 500 N=16	6182.5	29.0	1.62	5.6	381	214	5.4	235	132	3.4
500 - 1000 N= 21	16492.5	30.7	1.10	3.6	255	65	3.1	233	60	2.8
Ponad 1000 N=11	28393.8	26.2	0.40	1.5	90	7	0.2	227	19	0.5

TABLE 2

Stocking rates in 106 lakes recalculated into standard larvae and autumn fry using two different methods, and stocking value according to market prices of whitefish stocking material

Lake size classes in ha	Stocking rates calculated assuming fish survival after Szczerbowski				Stocking rates recalculated using price method			
	standard larvae				standard autumn fry			
	ind./kg	zł/fish	ind./kg	zł/fish	ind./kg	zł/fish	ind./kg	zł/fish
0 - 75	2291	13.75	34.3	17.15	2390	14.34	28.8	14.40
75 - 150	3033	18.20	45.4	22.70	3104	18.62	37.4	18.70
150 - 300	2027	12.16	30.4	15.20	2073	12.44	25.0	12.50
300 - 500	2666	16.00	39.9	19.95	2708	16.25	32.6	16.30
500 - 1000	1422	8.53	21.3	10.65	1461	8.77	17.6	8.80
Ower 1000	578	3.47	8.7	4.35	584	3.50	7.0	3.50

did not break down. On the contrary, it even showed a slight increase in the last few years. In the other 5 classes, whitefish landings show decreasing trends.

Character of the trends presented in Figs 5-10 reveals, that the decrease was not similar in particular classes. In lakes 300-500 ha whitefish catches began to decrease as early as 1978, the same is true of the biggest lakes of over 1000 ha. In lakes 500-1000 ha whitefish landings began to decrease a little later, at the beginning of the 80-ies. In lakes 75-300 ha, whitefish landings still increased until mid-eighties. It can be also noted that the decrease of whitefish landings was slower in bigger lakes, but fairly rapid in smaller ones (with the exception of the smallest, up to 75 ha).

Mean stocking rates per unit of area and per 1 kg of whitefish landings differed considerably in particular classes (Table 1). The highest stocking rates of all forms (larvae, summer and autumn fry) were used in the smallest lakes and in the size class 300-500 ha. High stocking rates with summer fry were also used in lakes 75-150 ha. The lowest stockings were used in the biggest lakes, over 1000 ha.

Effectiveness of whitefish production, measured as the mean numbers of particular forms used to obtain 1 kg of whitefish catch, is presented in Table 1. On the other hand, Table 2 presents this effectiveness calculated using two methods: number of larvae and standard autumn fry per 1 kg of whitefish catch, and value of stocking in comparable prices per 1 kg of the catch.

Levels and value of whitefish stockings, brought down to the form of standard larvae based on the assumed survival and the mean price, did not differ much. On the other hand, when the data were recalculated to standard autumn fry, lower

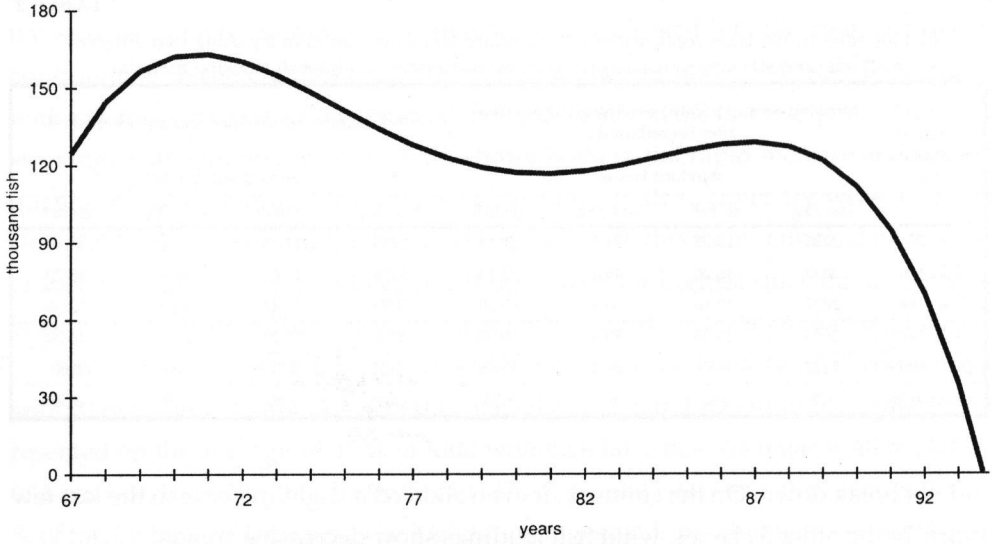

Fig. 4. Trend of stocking with whitefish autumn fry in 106 lakes

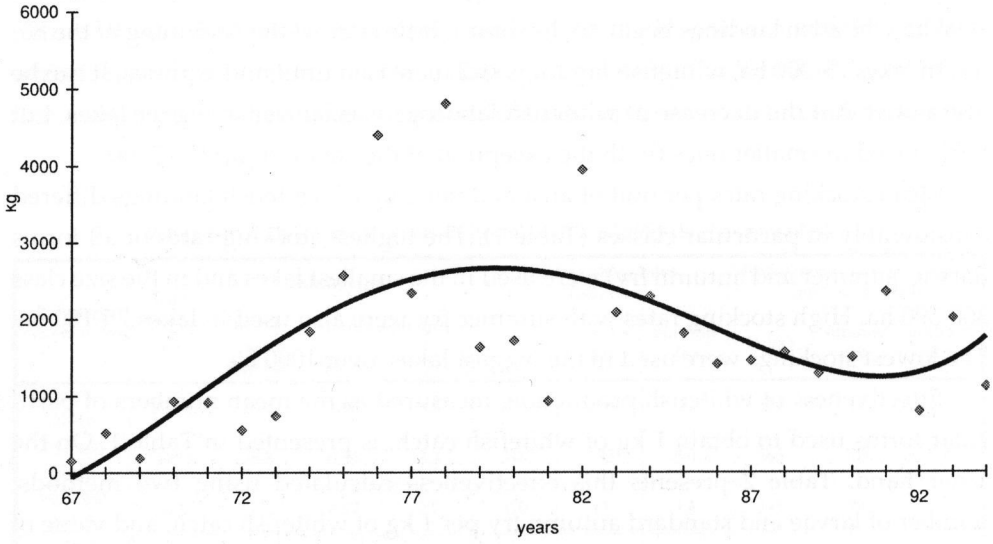

Fig. 5. Trend of whitefish landings in lakes up to 75 ha in 1967-1994

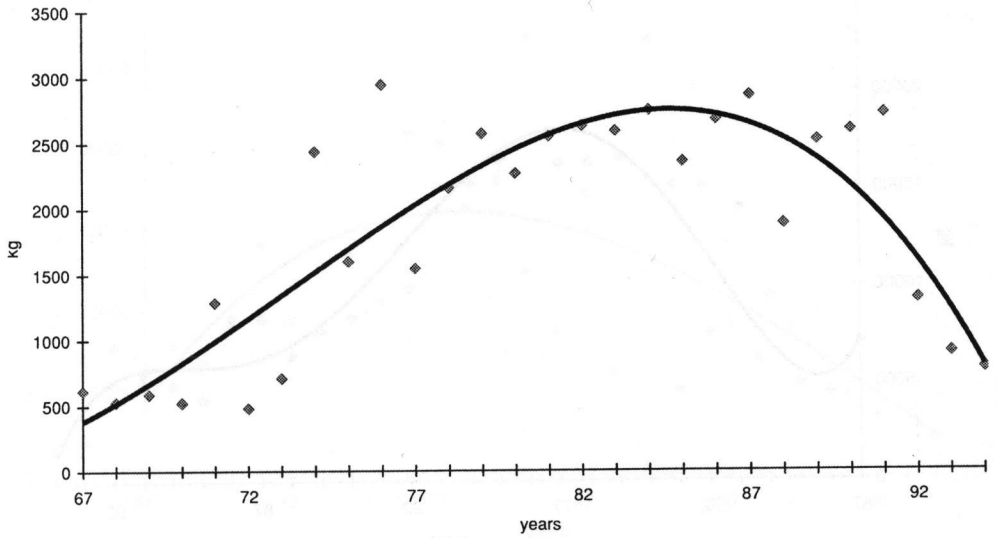

Fig. 6. Trend of whitefish landings in lakes 75-150 ha in 1967-1994

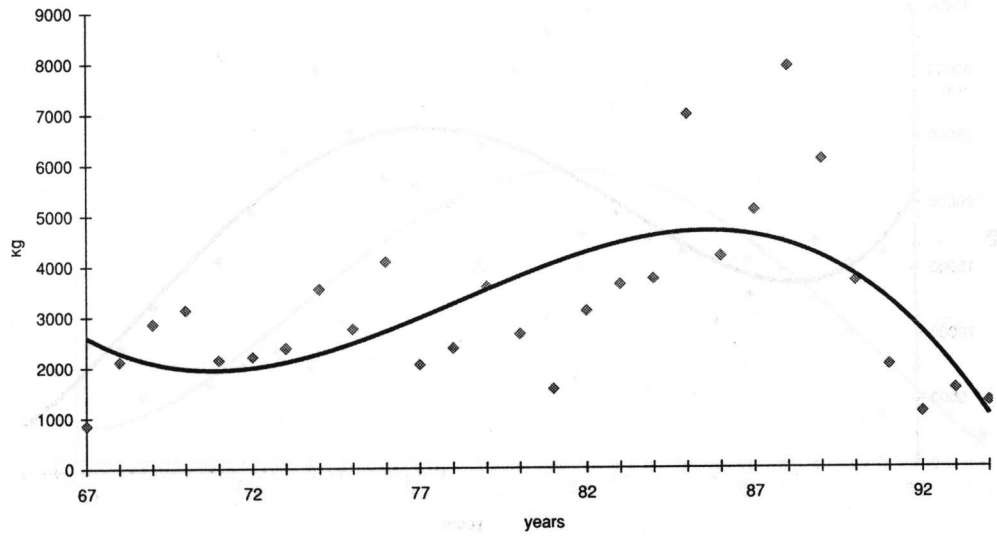

Fig. 7. Trend of whitefish landings in lakes 150-300 ha in 1967-1994

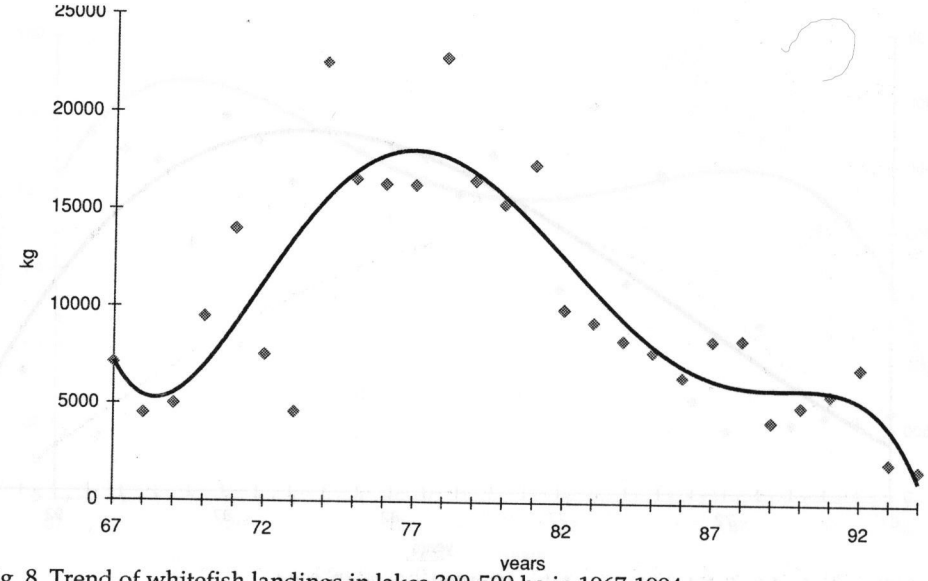

Fig. 8. Trend of whitefish landings in lakes 300-500 ha in 1967-1994

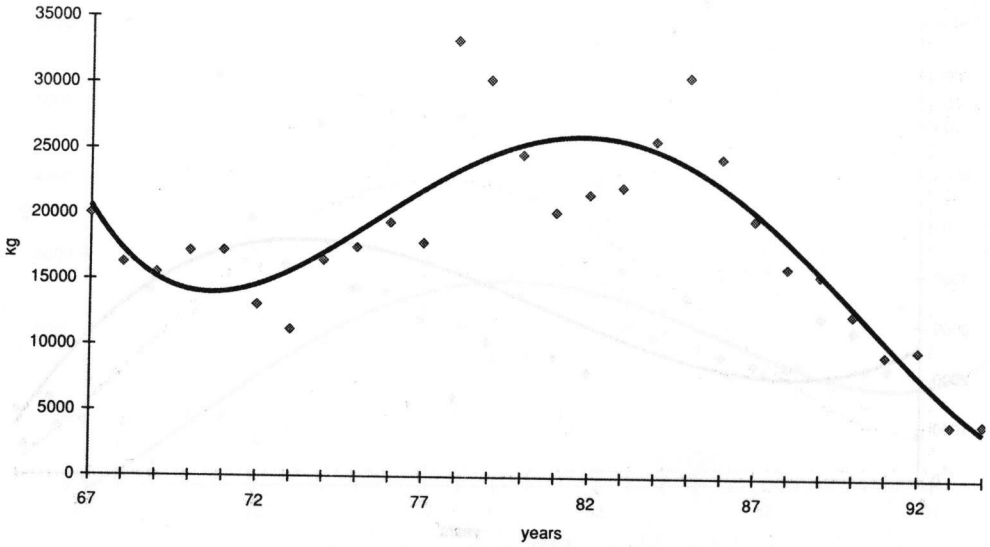

Fig. 9. Trend of whitefish landings in lakes 500-1000 ha in 1967-1994

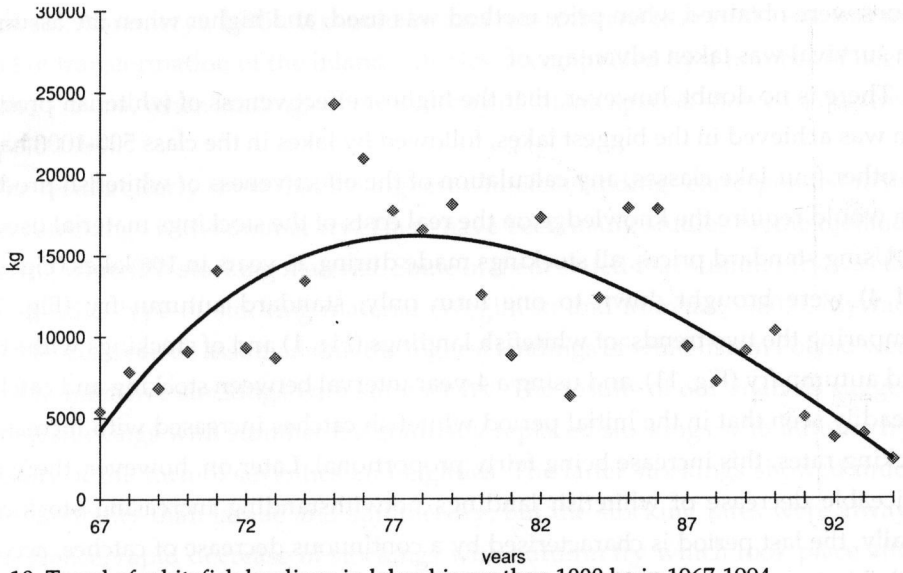

Fig. 10. Trend of whitefish landings in lakes bigger than 1000 ha in 1967-1994

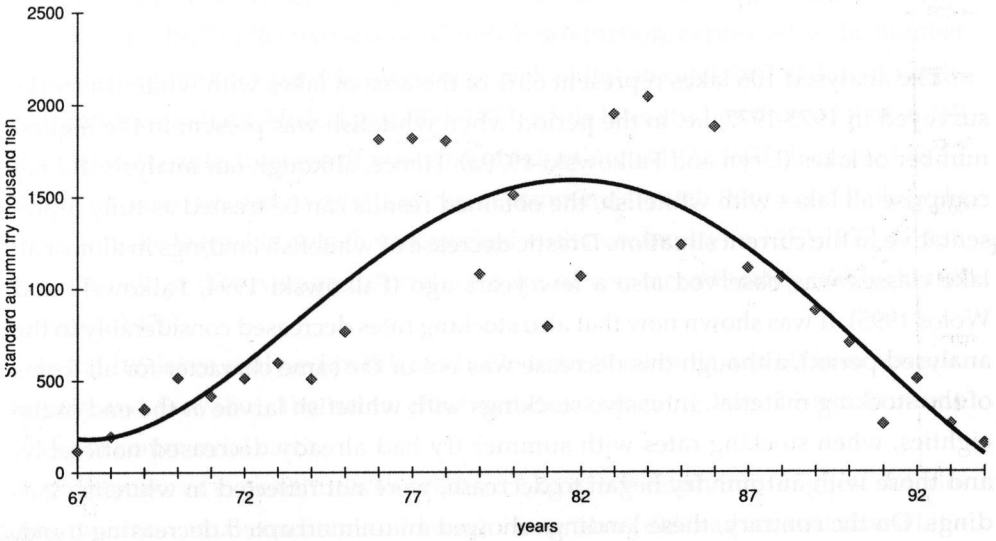

Fig. 11. Trend of whitefish stockings in 106 lakes in 1967-1994 (standard autumn fry)

values were obtained when price method was used, and higher when the assumed fish survival was taken advantage of.

There is no doubt, however, that the highest effectiveness of whitefish production was achieved in the biggest lakes, followed by lakes in the class 500-1000 ha. In the other four lake classes, any calculation of the effectiveness of whitefish production would require the knowledge on the real costs of the stockings material used.

Using standard prices, all stockings made during 26 years in 106 lakes (Figs 2, 3 and 4) were brought down to one form only: standard autumn fry (Fig. 11). Comparing the two trends: of whitefish landings (Fig. 1) and of stockings with standard autumn fry (Fig. 11), and using a 4-year interval between stocking and catch, it is readily seen that in the initial period whitefish catches increased with increasing stocking rates, this increase being fairly proportional. Later on, however, there is a noticeable decrease of whitefish landings notwithstanding increasing stockings. Finally, the last period is characterised by a continuous decrease of catches, accompanied by a gradual decrease of stocking rates.

DISCUSSION

The analysed 106 lakes represent 63% of the area of lakes with whitefish stocks surveyed in 1973-1977, i.e. in the period when whitefish was present in the highest number of lakes (Uryn and Falkowski 1979a). Hence, although our analysis did not comprise all lakes with whitefish, the obtained results can be treated as fully representative in the current situation. Drastic decrease of whitefish landings in almost all lake classes was observed also a few years ago (Falkowski 1994, Falkowski and Wołos 1995). It was shown now that also stocking rates decreased considerably in the analysed period, although this decrease was not of the same character for all forms of the stocking material. Intensive stockings with whitefish larvae at the end of the eighties, when stocking rates with summer fry had already decreased noticeably, and those with autumn fry began to decrease, were not reflected in whitefish landings. On the contrary, these landings showed an uninterrupted decreasing trend. This fact, however, does not imply that stocking with larvae is totally ineffective. Discussion on the suitability of particular forms of the stocking material has been going on for quite a long time now, but no agreement has been reached (Salojärvi 1988, Salojärvi and Ekholm 1990, Salojärvi 1991, Salojärvi and Mutenia 1994, Wołos,

Falkowski, Abramczyk 1995). It should be also remembered that 1990-1994 was the period of transformation of the inland fisheries, accompanied by a number of negative phenomena, when landings of the majority of inland species showed a decrease (Leopold 1994).

The results clearly show that the highest whitefish landings corresponded to the highest stockings with summer fry. There have been many studies on the methods of rearing whitefish stocking material. Some of them stated that summer fry was the most effective type of stocking material (Węgliński and Marciak 1980, Grzywacz 1981). Hence, it can be assumed that the highest landings of whitefish in Poland were related to intensive stockings with summer fry. The results of our analysis suggest also that stockings with summer fry gradually replaced stockings with autumn fry, especially at the turn of seventies and eighties. The latter stockings showed much lower variability than larvae and summer fry, but the stocking rates were always lower. Hence, rapid decrease of stockings with autumn fry which took place after 1989 could not have had a more significant effect on whitefish landings.

It is quite disturbing to note that whitefish landings began to decrease even before the drop of stockings. The same was observed in earlier studies. According to Szczerbowski (1977), effectiveness of whitefish production, expressed as the number of standard autumn fry per 1 kg of commercial whitefish catch in 73 lakes of north-east Poland, was about 9 fish/kg in 1951-1973, while later studies showed that in 169 Polish lakes the effectiveness of whitefish production in 1972-1977 decreased as 13 autumn fry were needed to produce 1 kg of commercial catch (Uryn and Falkowski 1979c). In Lake Śremskie, which was stocked with autumn fry in 1953-1977, 17 fish were needed on the average to produce 1 kg of commercial catch (Budych and Mastyński 1978).

In the 106 lakes analysed in this study (26 from Pomerania and 80 from Varmia, Mazuria and Suwałki), the mean effectiveness of stocking was 20 fish (autumn fry)/kg of commercial catch.

An increase of expenditures to produce 1 kg of whitefish may suggest deteriorating environmental conditions, although Hartmann (1987) advocated that whitefish was not the best indicator of the eutrophication process. In summing up it should be stated that the current status of whitefish management is due most of all to decreasing (since 1982) stocking rates (Fig. 11), but also to a number of other factors, such as e.g. the decrease of exploitation intensity, or macroeconomic factors, as

has been shown also in earlier studies (Falkowski 1994, Wołos, Falkowski, Abramczyk 1995, Wołos, Falkowski, Czerkies in print).

Value of stockings calculated for each lake class based on the current prices of the stocking material (Table 2) should be treated as an illustration only (showing the order of values when recalculation is made), as whitefish stocking material is usually produced by the fishery enterprises for their own use. Hence, it can be assumed that the real costs of production were lower, but proper calculation can be made only by the producers. At present the fishery enterprises are likely to obtain 8-12 zł per 1 kg of whitefish, so if the production is to be based on stocking material bought from other producers, it might happen that the whole process becomes unprofitable (larvae being the only exception as their price is low). In addition to this, stocking rates recommended in earlier papers, such as 100 autumn fry/ha (Bernatowicz 1955), or 100-200 fish/ha (Kempiński and Korycki 1968) should be regarded with considerable caution.

In 1972-1977 whitefish management in Poland was determined by 14 lakes only, of total area 10757 ha (Uryn and Falkowski 1979b). Share of these lakes in total whitefish landings in 1975-1985 reached 60 % (Falkowski 1994). Nine of them, of total area 9435 ha, have been included in the present study. Their share in whitefish landings in 1967-1994 amounted to 54.8 %. These data confirm considerable importance of a few lakes only in the overall status of whitefish management in Poland. Detailed analysis of these very important lakes is presented in an another paper of this volume.

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STRESZCZENIE

ANALIZA ODŁOWÓW I ZARYBIEŃ SIEJĄ (Coregonus lavaretus L.) W 106 JEZIORACH W LATACH 1967-1994

Opierając się na danych gospodarczych przeanalizowano zależności między wysokością odłowów, zarybieniami oraz efektywnością produkcji siei w 106 jeziorach Polski. Badane jeziora podzielono na 6 klas, przyjmując za kryterium wielkość ich powierzchni. Dla każdej klasy obliczono średnią wieloletnią wydajność siei z 1 ha oraz średnie wieloletnie zarybienie (ilość i rodzaj) przypadające na jednostkę powierzchni jezior oraz kilogram odłowionej siei. Stosując przeliczenie cenowe sprowadzono trzy podstawowe formy materiału zarybieniowego do postaci narybku jesiennego przeliczeniowego i przedysku-

towano zasadność takiego postępowania w prowadzonych badaniach. Wyniki pracy wskazują na kilka przyczyn mających bezpośredni wpływ na załamanie się produkcji siei w polskich jeziorach. Między innymi należy do nich zaliczyć wysokość i rodzaj zarybień oraz szeroko pojętą efektywność rybackiego gospodarowania.

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