

ECOLOGICAL ANALYSIS OF FISHING IN ESTUARY LAKES, GARDNO AND WICKO, IN THE YEARS 1952–1991

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Key words: catchment area, mass dominance, pike-perch *Stizostedion lucio-perca* L., spawning-time

Abstract

The aim of this study is to present a retrospective and comparative evaluation of the trends in the biomass dynamism for 9 species of fishes. The course of fish exploitation during a yearly period and the size of fishing at the time of spawning have been critically stressed in the study. Position and degree of mass dominance for separate species of fishes in fishing have been established in consecutive decades and for the whole 40 years' time. Pairs of super-dominants and eudominants with the greatest quantitative participation have been distinguished in the fishing from Gardno and Wicko lakes.

INTRODUCTION

A break down in fishing in the lakes Gardno and Wicko in the 80's resulting from greater and greater eutrophication of waters (Ciepielewski 1992, Leopold and Wołos 1994) was the main reason to conduct studies in both lakes on the basis of the existing exploitative data. The retrospective analysis of the fishing materials enables to state an objective evaluation of the speed of the ecological degradation of the waters and taking remedial measures by the fishery management. These activities serve to restore and keep fishing at a desirable level with preserving ecological equilibrium (Ciepielewski 1995).

The aim of the study was to know the trends of the biomass dynamism of fishing, the course of their exploitation during a years time and the change of dominance relations for a biomass fishing in consecutive decades during 40 years time of exploitation in both reservoirs.

AREA, MATERIAL AND METHODS

The estuary lakes Gardno and Wicko are situated on a territory close to the sea of the Southern Baltic (Fig. 1). Both reservoirs are old sea lagoons separated from the Baltic Sea with narrow and sandy sand-bar formed by sea currents. The preserved connections with the sea let the fresh waters coming to the lake mix with the salty waters penetrating from the Baltic Sea. A precise morphometric and bathymetric characteristic has been shown in Tab. 1.



Fig. 1. Location of the investigated lakes

Table 1

A Morphometric and Bathymetric Characteristics of the Studied Lakes

Parameters		GARDNO	WICKO
Geographic situation	Northern latitude	54°39,4'	54°32,2'
	Eastern longitude	17°07,1'	16°37,1'
Area in km ²		25.0	11.0
Area of acquired reality in km ²		24.6	10.5
Maximum depth in meters		2.6	6.1
Mean depth in meters		2.0	3.5
Volume of lake in thousands of m ³		30950.5	28495.0
Height above sea level in meters		0.3	0.2
Genesis		- Littoral Estuarine -	
Total catchment area in km ²		922.3	102.2

Elaborated on the basis of materials of Inland Fish. Inst.
(1959, 1962) Olsztyn, Poland

The subject matter of the present research was only 9 species of fishes intensely exploited from among above 40 species of the rich and various ichtiocenosis living in both reservoirs. In Gardno lake there can also be found a few species of fishes which are typically sea-like. The connection of Wicko with the sea, one-way at present, enables the sea fish to make their trip toward the lake.

The following species have been examined: bream *Abramis brama* L., the roach *Rutilus rutilus* L., the eel *Anquilla anquilla* L., the white bream *Blicca björkna* L., the perch *Perca fluviatilis* L., the pike *Esox lucius* L., the pike-perch *Stizostedion lucioperca* L., the tench *Tinca tinca* L., the crucian carp *Carassius carassius* L.

The evidence analysis of the fishing used in this study is a modification of indirect methods used in ecology for a long time for an estimation of quantitative states, that is of an abundance, density, biomass or production of animal population (Allee and others 1958). The method, in the case of fish gives strict and precise reflection of the abundance or biomass dynamism in many years' cycle (Ciepielewski 1992, Leopold and Wołos 1994, Pyka 1993).

Data of the present research have been taken from economy books of the Fishery Department in Siemianice near Słupsk, to which belongs the exploitation of both reservoirs during the studied period. The registry of fishing for the years: 1952–1991 refers mainly to older and the oldest individuals of the analysed population.

The weight value of the caught fish in separate months and years has been considered altogether. That is why various commodity assortments of the fish weighing up to 1 kg, from 1 to 3 kgs and above 3 kgs, for each species have been summed up contrary to economy requirements.

The errors of not precise data records in the fishery documentation for both lakes have been reduced by long-term, that is 40 years' period of systematic, not expeditional fishing (Leopold and Wołos 1994, Pyka 1993).

The estimation of the trends in every year's fishing has been made thanks to the five years mean. The mass dominance (Dm) of fish at the dynamism of fishing for consecutive decades has been presented by numbers directly from 1 to 9 Dm and for the 40 years' period in the form of analytic ratios of the dominance Balogha (1995).

RESULTS

The data about the size of fishing taken from the fishery economy records, processed into graphic charts (Fig. 2, 3) have a definitely fluctuative character for the majority of species. The greatest changeability of separate phases for the biomass dynamism in the 40 years' fishing refers to the bream and the crucian carp in Gardno. For Wicko lake the fluctuative character of fishing is characteristic especially for the biomass of the white bream and the pike-perch during the 40 years' time, and the bream only for the 70's. The states of relative equilibrium in the dynamism of fishing are characteristic in longer periods for the eel in Gardno and the bream, the perch and the roach in Wicko. For the dynamism of the biomass for the bream, the perch and mainly the roach from Wicko, the state of relative equilibrium may be noticed more often from the half of the 70's. The fishing of these species have been maintained at a particularly low level.

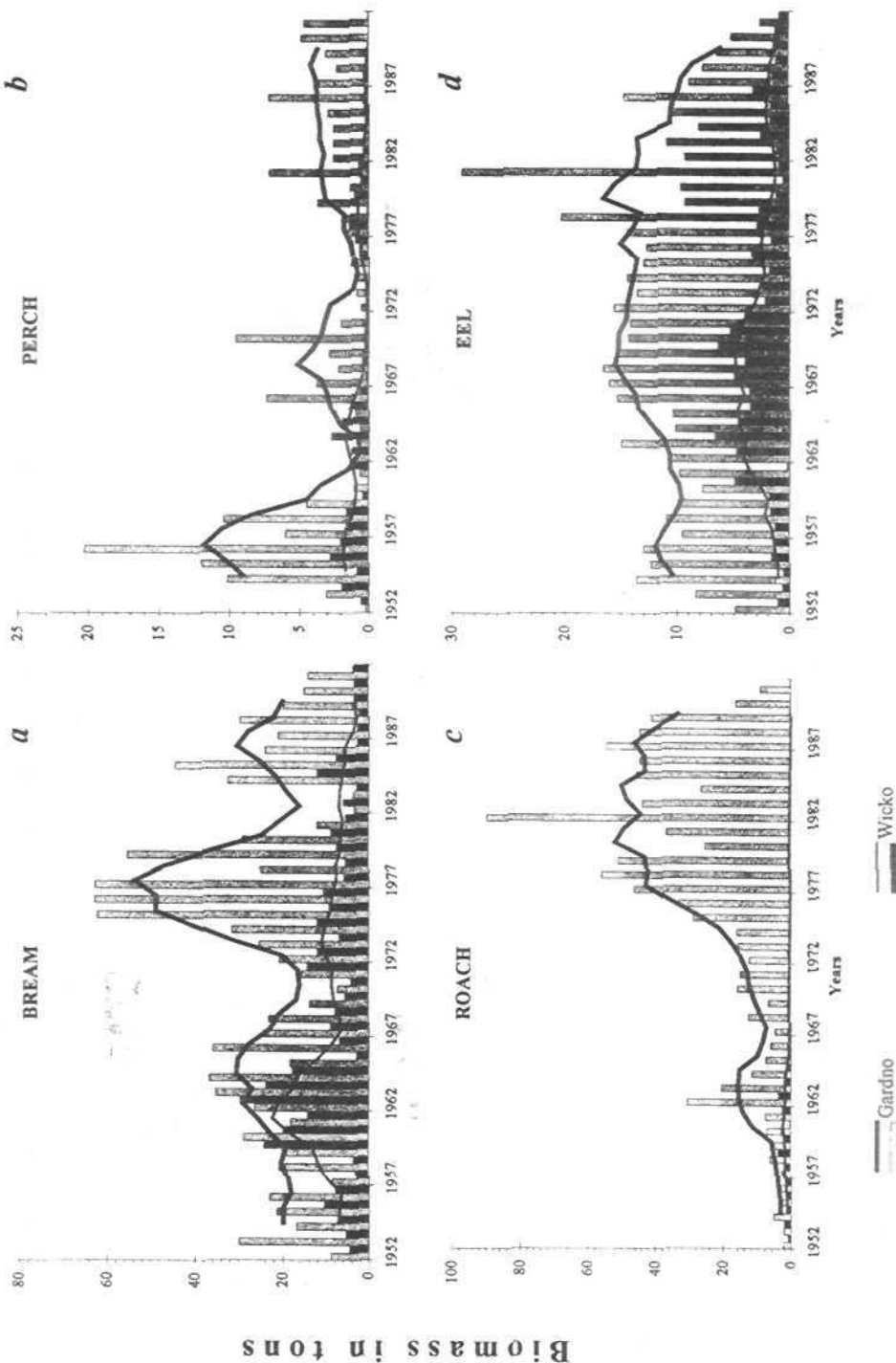


Fig. 2. Fish biomass fluctuations at fishing for the studied lakes during the 40 years' time

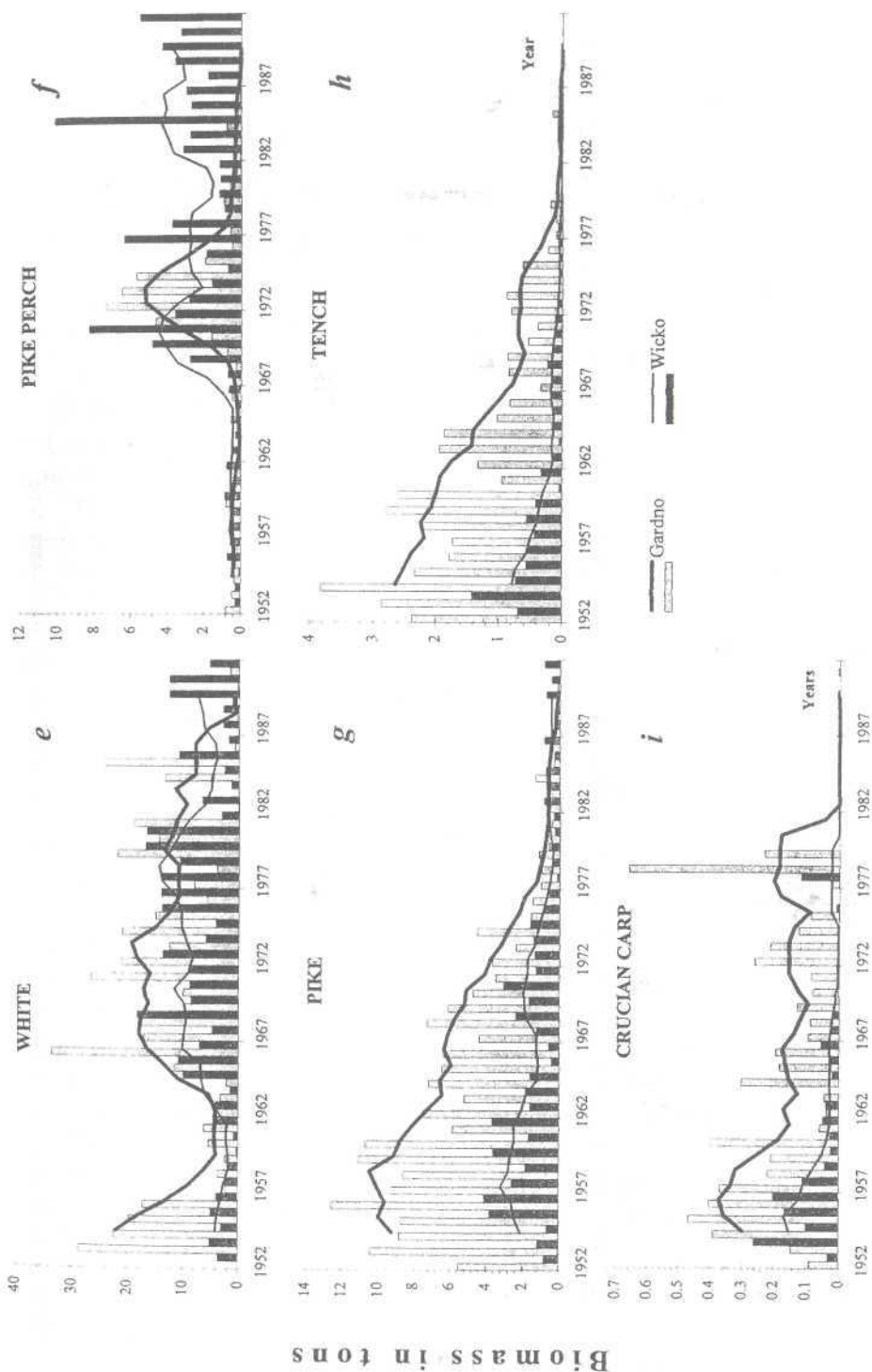


Fig. 3. Fish biomass fluctuations at fishing for the studied lakes during the 40 years' time

The decrease trends of the biomass dynamism of the typically littoral species, such as the pike, the tench, and the crucian carp, have been noted at both lakes from the half of the 50's in the fishing of the pike-perch in Gardno similar tendencies were noted only at the beginning of the 70's. The decrease of the phytophil littoral fishes in Gardno was more intensive in comparison with Wicko (Fig. 3).

The fishing of the pike, the crucian carp and the tench in Wicko were 3, 4 and 5 times smaller, respectively. Anyhow, the smallest fishing in 12 out of 18 cases took place in decade IV in the years 1952–1991 (Tab. 2). The systematically diminishing fishing of the crucian carp, the tench, and the pike in both lakes, the perch and the roach only in Wicko show distinctively that those species were caught in too big amounts in consecutive decades. As the table 2 shows the resources of the crucian carp and the tench in Wicko were violated in the first decade of the 40 years' time exploitation for about 74%, and in the case of the pike, the perch and the roach about 45%. About 63% of the tench, 53% of the pike and 49% of the crucian carp were caught in Gardno in the first decade. That is why the greatest difference in fishing for the mentioned species were noted between the first and the second decade. For the goldfish and the tench from Wicko the differences between the first and the second decade are 58% and 54% respectively, and in Gardno 27% and 36% (Tab. 2). The fishing of the crucian carp in Wicko has lost its practical significance since 1969 and in Gardno since 1980. The crisis in the tench fishing goes back as far as 1980 and in Gardno as far as 1986 (Fig. 3). For the species of greater significance in fishing i. e. the bream, the eel, the roach and the white bream (Fig. 2) the disproportions between the decades were much smaller, which has been shown in table 2.

The increasing tendencies in fishing, with the maximum level in decade IV, were noted only for the roach in Gardno and for the pike-perch in Wicko. In comparison with decade III, there has been increase in the fishing of the perch in Gardno. However, the fishing of other species of fish has decreased in both lakes (Tab. 2). The reason of the decreasing tendencies in the dynamism of biomass must be identified with the greatest intensity of fishing during the spawning (Fig. 4). The exception was the pike-perch and the not appreciated white bream. The eel as a double-habitat fish and a catadromus one is a controversial species. Anyhow, the highest level of the eel fishing in Gardno and Wicko appears during its spring and autumn trip for spawning toward the sea. But fishing of the eel is completely explicable while taking into consideration the costs of artificial stocking. Completely destructive character concerned the fishing of phytophil littoral fishes from both lakes during their spawning period. And so, the fishing of the crucian carp from Wicko were extremely high, that is 86% and from Gardno 68% of their annual value during the 40 years' time. The fishing of the bream, the roach, the eel and the

Table 2

The total fishing and the average yearly fishing of the 40-years, the relative quantity of the fishing in sequent decades and the fishery efficiency of the analyzed lakes in years 1952-1991

Species	GARDNO				WICKO			
	Tons	Decades	%	kgs/ha	Tons	Decades	%	kgs/ha
Bream	1029.041 25.726	I	29.09	10.56	351.889 8.797	I	28.42	8.38
		II	23.04			II	34.58	
		III	37.62			III	23.76	
		IV	20.25			IV	13.24	
Perch	175.120 4.378	I	43.90	1.90	26.920 0.673	I	44.86	0.64
		II	19.75			II	30.98	
		III	12.87			III	18.36	
		IV	23.48			IV	5.80	
Roach	914.860 22.872	I	5.03	9.30	33.927 0.848	I	47.69	0.81
		II	14.38			II	30.13	
		III	35.09			III	13.80	
		IV	45.50			IV	6.38	
Eel	473.364 11.834	I	21.12	4.81	99.726 2.493	I	15.65	2.37
		II	29.09			II	47.82	
		III	32.10			III	20.00	
		IV	17.68			IV	16.52	
White bream	428.672 10.717	I	25.20	4.36	283.078 7.077	I	10.33	6.74
		II	31.64			II	29.06	
		III	33.30			III	39.73	
		IV	9.85			IV	20.88	
Pikeperch	39.145 0.979	I	11.05	0.40	88.614 2.215	I	5.30	2.11
		II	21.49			II	25.25	
		III	63.65			III	24.24	
		IV	3.80			IV	45.21	
Pike	172.571 4.314	I	53.15	1.75	53.832 1.346	I	44.63	1.28
		II	34.13			II	29.37	
		III	10.48			III	14.50	
		IV	2.24			IV	11.50	
Tench	37.506 0.938	I	62.73	0.38	7.722 0.193	I	74.19	0.18
		II	26.68			II	19.49	
		III	9.83			III	5.44	
		IV	0.76			IV	0.88	
Crucian Carp	5.616 0.140	I	49.07	0.06	1.385 0.035	I	73.72	0.03
		II	22.17			II	15.67	
		III	28.60			III	9.67	
		IV	0.05			IV	0.94	
General	3275.875			33.52	947.101			22.54

Decades of the smallest fishing

Permanent decrease of fishing

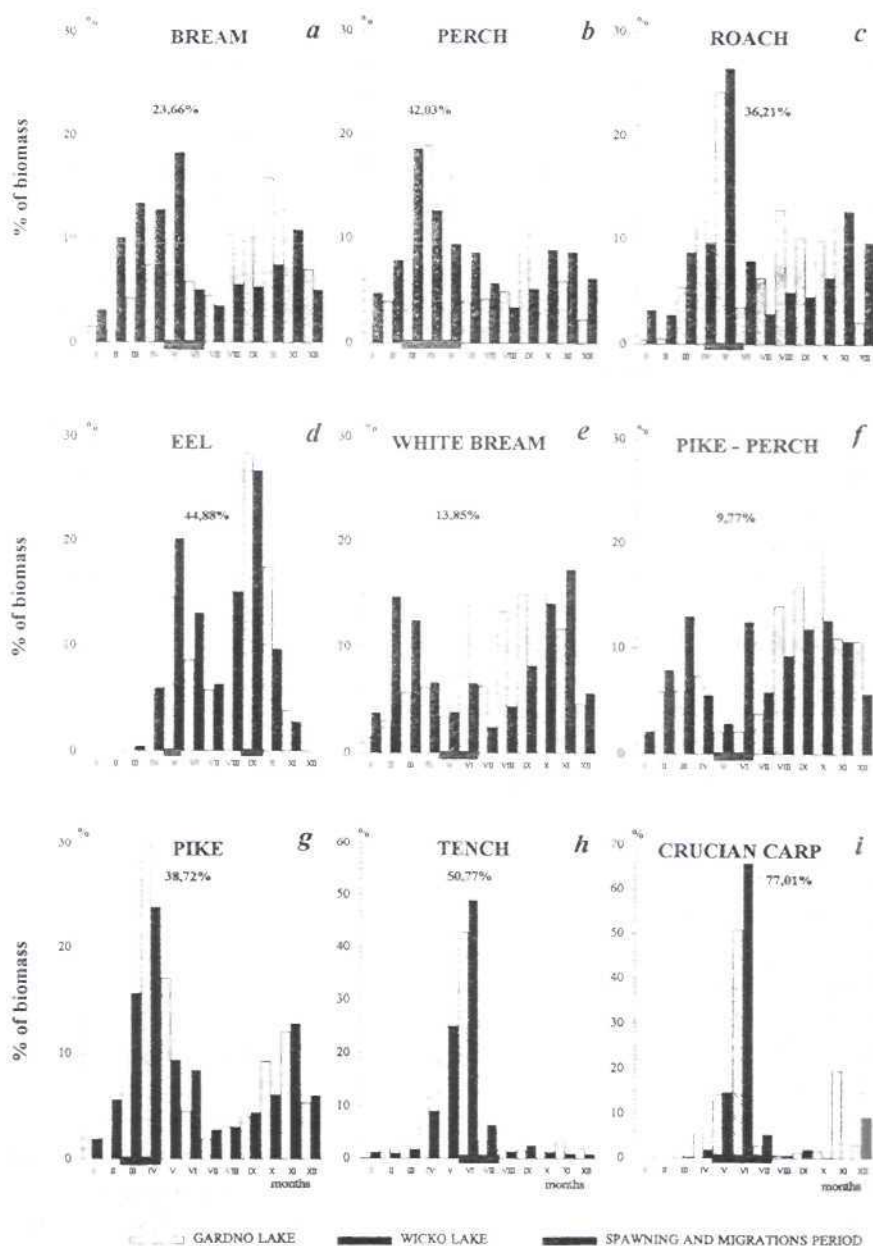


Fig. 4. Fishing of the studied lakes in the yearly cycle in the years 1952–1991

Remarks: The relative data from 9.77–77.01% were received by enumerating the mean for the sum of fishings periods or migrations to the spawning. Therefore this data have value higher than the one marked out on the axis „Y”

white bream at a critical period of their spawning did not overcome 24%, 37%, 45% and 14%. It is most probable that for this reason those species take the supreme position in fishing. Generally, the high fishery efficiency from Gardno in decade IV has been maintained on a similar level to mean yearly ratio thanks to the roach. In Wicko 86% increase of fishing of the small pike-perch in decade IV, with the biomass decrease of the other species in fishing did not compensate 26% of the decrease in the general fishery efficiency on the lake.

Finally, the fishing from Wicko, which is about 57% smaller, was lower than fishing from Gardno at about 71% in the studied 40 years. The differences concerning the fishery efficiency between those two lakes were also big, as far as 33%.

The analysis of the dominance relations in Gardno (Tab. 3) presents a drastic decrease of biomass for 7 species of the fish and an increase of biomass of the perch and the roach at fishing during decade IV. In Wicko in decade IV there was a biomass decrease of 8 species of fish (Tab. 4) and a significant increase of the pike-perch biomass.

The dominant of the decade IV was the roach which was ahead of the bream. In Wicko the dominant was the white bream, which overhauled the bream in the third decade. The second place belonged to the bream in both lakes. The third place belonged to the eel in Gardno and the pike-perch in Wicko. The last place belonged to the tench and the goldfish in both reservoirs in the 4th decade during the 40 years' fishing exploitation. The participation of the dominants in the fishing biomass of the decade IV was over 78% for a combination of the roach and the bream in Gardno and 67% for a combination of the white bream and the bream in Wicko. The participation of the dominants in previous decades in fishings from Gardno for a combination of the bream and the white bream, for the bream and the eel, the bream and the roach was lower, so more advantageous (Tab. 3, Fig. 5). In Wicko in all decades there was a disadvantageous and exclusive dominance of the bream and the white bream, the highest in the third decade, reaching its value to over 76% (Tab. 4, Fig. 5). The disadvantageous change in the qualitative stock of fishing from Gardno was only partially compensated with the absolute quantitative dominance of the small roach. The highest degree of dominance in biomass of the 40 years' fishing in Gardno belonged to the bream and the roach — 59%, and in Wicko to the bream and the white bream — 67%. The bream in both lakes with its over 30% participation in a general biomass of fishing was a superdominant. The eudominants in Gardno were the roach, the eel and the white bream, and in Wicko: the white bream and the eel. The dominants in Gardno were the perch and the pike, and in Wicko: the pike-perch and the pike. Gardno was lacking its subdominants, while the subdominants of Wicko were the perch and the pike. The recedents in Gardno were the pike-perch and the tench. Wicko was lacking its recedents. The

Table 3

The changes of the positions and the mass dominance of the fishes in the fishing in Gardno lake in years 1952-1991

Species	I		II		III		IV		General in 40 years			
	Tons	P.	Tons	P.	Tons	P.	Tons	P.	Tons	P.		
Bream	196.4	1	237.0	1	387.2	1	208.4	2	1029.0	1	31.41	D ₁
Roach	46.0	6	131.6	4	321.1	2	416.2	1	914.9	2	27.93	D ₁
Eel	100.0	3	137.7	2	152.0	3	83.7	3	473.4	3	14.45	D ₁
White bream	108.0	2	135.6	3	142.8	4	42.2	4	428.7	4	13.08	D ₁
Perch	76.9	5	34.6	6	22.5	6	41.1	5	175.1	5	5.35	D ₁
Pike	91.7	4	58.9	5	18.1	7	3.9	6	172.6	6	5.27	D ₁
Pikeperch	4.3	8	8.4	8	24.9	5	1.5	7	39.1	7	1.19	D ₂
Tench	23.5	7	10.0	7	3.7	8	0.3	8	37.5	8	1.14	D ₂
Crucian carp	2.8	9	1.2	9	1.6	9	0.0	9	5.6	9	0.17	D ₂
In decades	649.6	*	755.0	*	1073.9	*	797.3	*	3275.9	*	100.00	
% of biomass	19.83		23.05		32.78		24.34		100.0			
Biomass of dominants (%)	46.86		49.63		65.06		78.34		59.1			
Kgs/ha	26.4		30.1		43.6		32.4		33.3			

P₁₋₉ - the position of species in sequent decades and during 40 yearsD_{m1-6} - the analytic ratios of the mass dominance in 40 years

Table 4

The changes of the positions and the mass dominance of the fishes in the fishing in Wicko lake in years 1952-1991

Species	I		II		III		IV		General in 40 years			
	Tons	P.	Tons	P.	Tons	P.	Tons	P.	Tons	P.	%	D ₀
Bream	99.9	1	121.8	1	83.6	2	46.6	2	351.9	1	37.16	D ₀
White bream	29.2	2	82.4	2	112.5	1	59.0	1	283.1	2	29.89	D ₁
Eel	15.6	5	47.7	3	19.9	4	16.5	4	99.7	3	10.53	D ₁
Pikeperch	4.7	8	22.4	4	21.5	3	40.0	3	88.6	4	9.35	D ₂
Pike	24.0	3	15.8	5	7.8	5	6.2	5	53.8	5	5.68	D ₃
Roach	16.2	4	10.2	6	4.7	7	2.8	6	33.9	6	3.58	D ₄
Perch	12.1	6	8.3	7	4.9	6	1.6	7	26.9	7	2.84	D ₅
Tench	5.7	7	1.5	8	0.4	8	0.1	8	7.7	8	0.81	D ₅
Crucian carp	1.1	9	0.2	9	0.1	9	0.0	9	1.4	9	0.15	D ₅
In decades	208.5	-	310.3	-	255.4	-	172.8	-	947.0	-	100.00	
% of biomass	22.02		32.77		26.97		18.25		100.0			
Biomass of dominants (%)	61.92		65.81		76.78		61.11		67.05			
Kgs/ha	19.9		29.5		24.3		16.5		22.5			

P_{1...9} the position of species in sequent decades and during 40-yearsD_{0...5} the analytic ratios of the mass dominance in 40-years

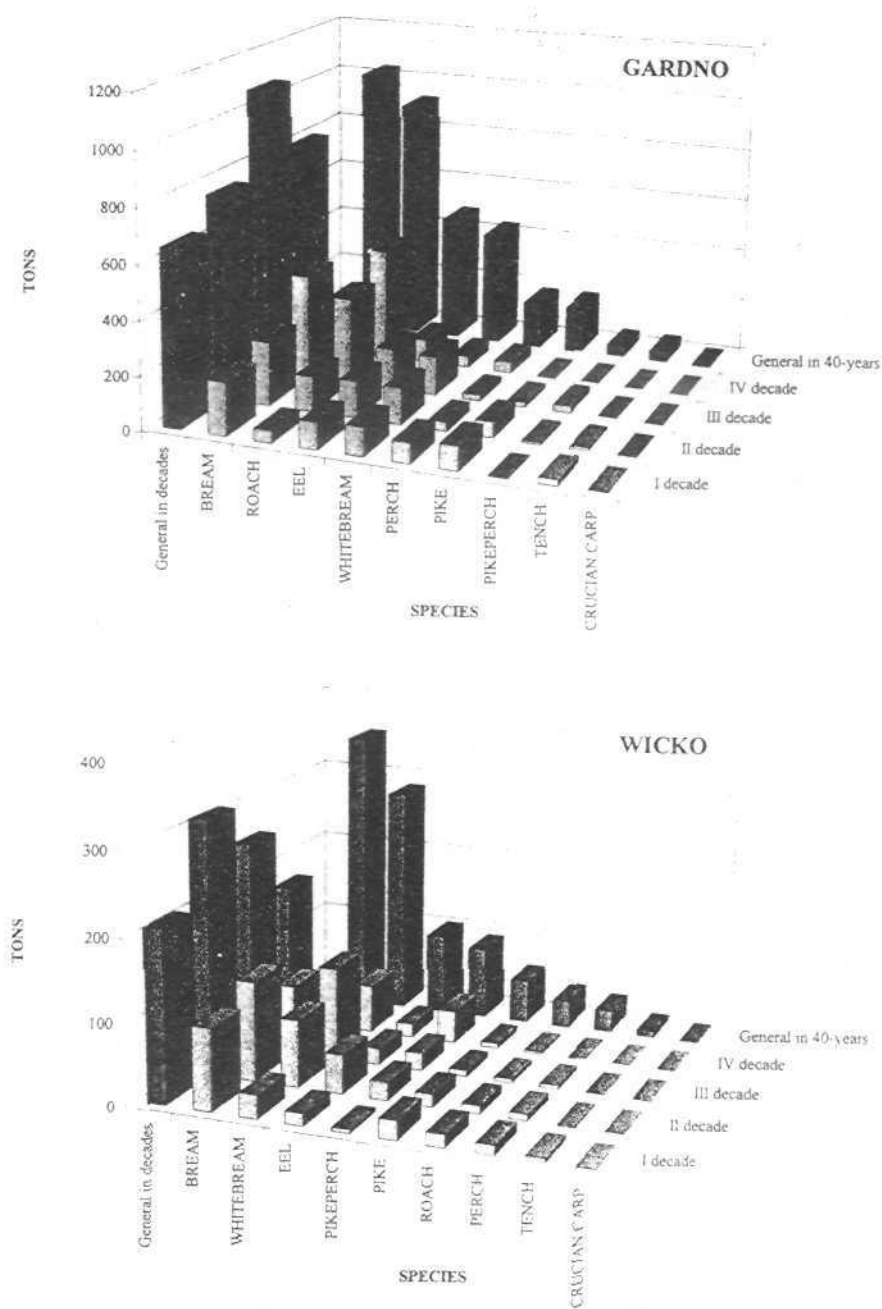


Fig. 5. The analytic and the synthetic picture of the fishing in the exploited lakes in years 1952–1991

subprecedent in Gardno was only the crucian carp, and in Wicko: the tench and the goldfish. In conclusion, the dominance of the bream and the roach in Gardno as well as the bream with the white bream in Wicko is negatively correlated with the small variety of species in the exploited community of fishes.

DISCUSSION

The alarming signals about the increasing pollution of waters having influence on fishing in certain estuarine lakes, i. e. in Gardno (Ciepielewski 1992, Leopold and Wofos 1994) should be, however, considered with careful interpretation. The fact of permanent or growth biomass of particular species as well as its decrease in comparison with other species in Gardno and Wicko, reflect a phenomena of relatively balanced ecological conditions in both lakes. The limnological type and the size of the studied reservoirs exclude, however, the possibility of a sudden breakdown of environmental conditions prevailing in the lakes. The most polluted among the estuarine lakes, Jamno (Zdanowski and others 1979) had the greatest fishery efficiency in the analysed period of the 40 years — 60 kg/ha/per year (Ciepielewski 1992). The reasons of the negative phenomena in fishing should be found rather in a notorious exploitation for the purpose of getting more precious species of fish as well as violating the structures of the habitats and the places of spawning. The suspicions that prove the exploitation in too big amounts are presented in Pykas studies (1993) in the years 1952–1991 concerning the fishing of the tench in 33 different lakes of the Brodnica Lake District. A destructive influence of the bream exploitation in too great scale has been shown in the research of Ciepielewski (1992). The maximum reduction of the fish biomass in their population, for the sake of permanent and possibly the highest fishing according to Ricker's model (1958) is used without any criticism in fishery practices. According to Gulland (1962, 1969) the theoretical claims of the model may be fulfilled only in simplified paratrophic structures or in fish farms. It denotes a poor feeding competition for other species or a complete lack of them. In natural ecosystems the maximum reduction, without taking into consideration the biological and the ecological peculiarities of the exploited species, leads directly to their exploitation in too big scale (Garrod 1967, citation by Opuszyński 1983). No theoretical model presents the maximum reduction of the most productive individuals from a population during their spawning, which has been stated by the author in case of the crucian carp, the tench and the pike from Gardno and Wicko (Fig. 4). The theoretical principles, therefore, refer to rational fishery exploitation in an annual cycle (Ricker 1958). They may not be bent to technological possibilities or to

short-term economy plans in fishery. The accepted in labour methods way of expressing the fish mass dominance in fishings in a direct way seem to be more legible than the five Balogh's analytic significant of dominance (1958) to which the value of dominance has been brought in the final phase of the analysis (Tab. 3, 4).

CONCLUSIONS

On the basis of the 40 years' analysis of the fishing from the estuarine lakes, Gardno and Wicko, there has been stated:

- A superiority of fluctuative trends of the biomass dynamism in the majority of the caught species of fish and the shortage of the littoral fish biomass in fishing.
- A notorious and extremally high exploitation of fish during spawning.
- The dominant structure of the fish mass in fishing typical to structures extremely simplified being subject to permanent antropopression, negatively correlated with a small variety of the fish exploited in this group of fishes.

For the sake of restauration of the ecological equilibrium in both lakes and for making the fishery economy more optimal the following activity is necessary:

- Reduction of the roach and the white bream in Gardno by effective stock with the pike in the lake.
- Reduction of the bream and the white bream in Wicko by effective stock with the pike-perch in the lake.
- Protection of spawning places, obeying the protective periods and the dimensions for the exploited fishes.

SUMMARY

The research has shown a superiority of fluctuative trends in the biomass dynamism for a majority of the caught species of fishes and the dying out of the phytophil littoral fishes (Fig. 2, 3). The main reason of the fishery breakdown of the pike, the tench and the crucian carp in both reservoirs as well as the roach and the perch in Wicko was exploitation in too big scale. The resources of the mentioned fish populations was drastically violated in the first decade of the 40 years' exploitation, that is in the years: 1952–1961 (Tab. 2). However, the highest level of fishings of the majority of fishes in a yearly cycle was achieved notoriously at spawning periods during the whole 40 years'time (Fig. 4). It just goes to show a complete ignorance of valid periods

and the protective dimensions in fishery practice. In consecutive decades and for all 40 years, the position and the degree of mass dominance for separate species of fish in fishing have been established. Pairs of superdominants and eudominants with the greatest quantitative participation in fishing have been distinguished for each of the lakes (Tab. 3 and 4, Fig. 5). For the regeneration of the pike's population, of the tench and the crucian carp, fishing of those species should be banned for the time of their generation. Reduction to small *Cyprynidae* species should be conducted by intensive stock in Gardno with the pike and in Wicko with the pike-perch.

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