Baltic Coastal Zone No. 12	
(53-67) 2008	Institute of Biology and Environmental Protection Pomeranian Academy Słupsk

BIOMASS DYNAMICS OF FISHING IN ESTUARINE LAKES ŁEBSKO AND SARBSKO

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Abstract

The research has shown the domination of fluctuative trends in the biomass dynamics for a majority of the caught fish species and decrease in the stocks of littoral phytophil fish. The main reason of the fishery breakdown of the pike perch in Łebsko and perch in Sarbsko was exploitation at a too big scale. The resources of the mentioned fish populations were drastically violated in the first decade of the 47 years of exploitation, that is in the years: 1952-1999. However, the highest fishing level of most of the fish species in annual cycles was achieved notoriously at spawning periods during the whole 47 years. It just goes to show a complete ignorance of valid periods and the protective dimensions in the fishery practice. In the consecutive decades and for all the 47 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 lake. For the regeneration of the pike's, the tench' and the crucian carp' population 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 Łebsko with the pike and in Sarbsko with the pike-perch.

Key words: catchment area, mass dominance, estuary lakes

INTRODUCTION

A break down in fishing in the lakes Łebsko and Sarbsko in the 80's of the 20th century 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. Up to now the detailed analysis was performed for two estuary lakes Gardno and Wicko (Orzechowski 1997). In the remaining lakes of the coastal zone the level of fishing exploitation was analysed in Jamno, Resko Przymorskie, Wicko only for some fish species by Grzelak (1990), Krauze and Wiczkowska (1998).
The aim of the study was to reveal the trends of the biomass dynamics of fishing, the course of their exploitation during years and the change of dominance relations for

a biomass fishing in the consecutive decades during 50 years of exploitation of the Łebsko Lake lying in grounds of the Słowiński National Park and joint with it lake Sarbsko. The retrospective analysis of the fishing materials enables an objective evaluation of the speed of the waters ecological degradation 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

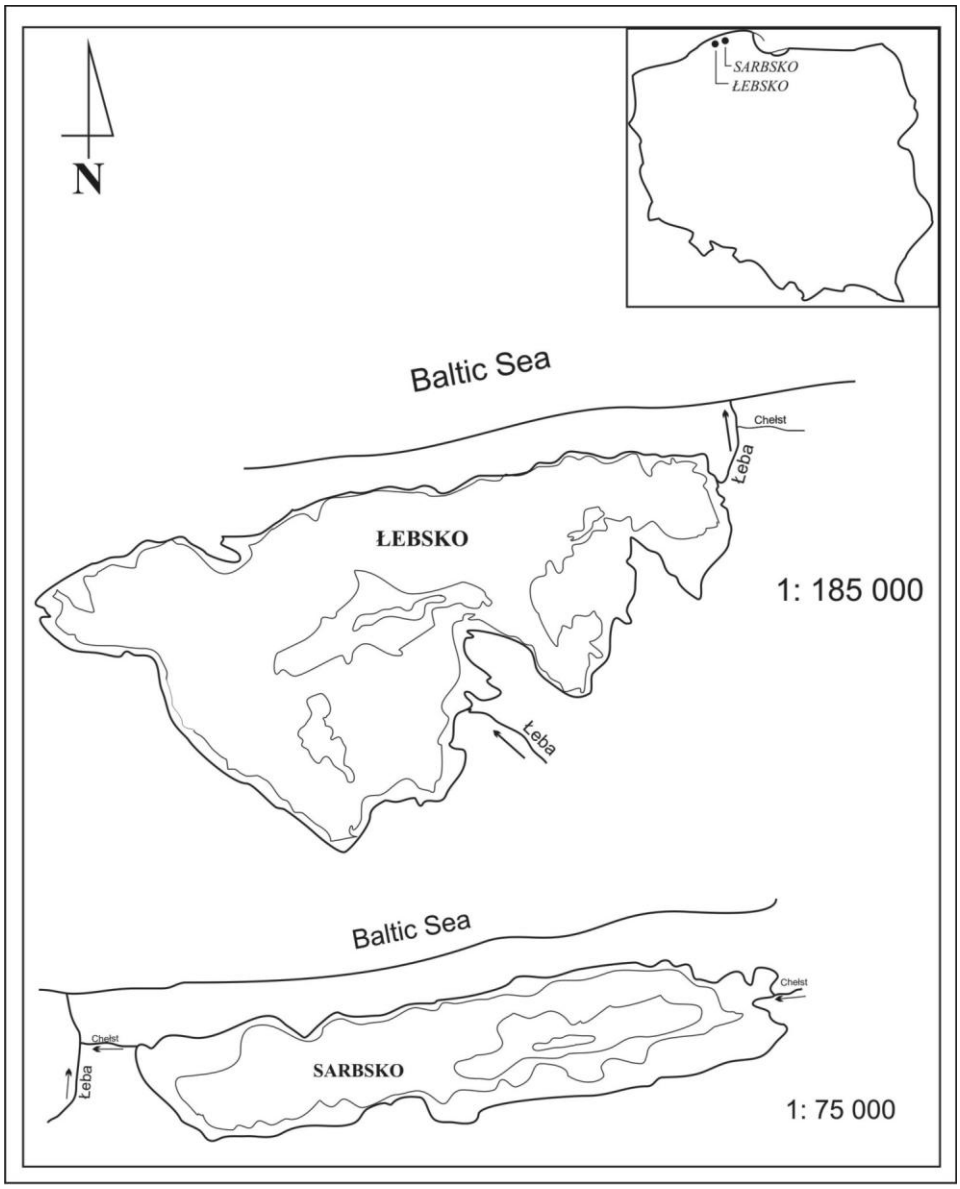

Fig. 1. Location of the investigated lakes

1995), what will let qualify the ways of the reconstruction of this food economy branch, which since the 80's has suffered from a clear crisis. The size of lake fishings in Poland in 2000 is assessed at 3.4 thousand tones, which consists 6.5% of the overall gain of the freshwater fish (MRiRW 2004).

MATERIALS AND METHODS

The estuarine Łebsko and Sarbsko lakes are situated in the coastal zone of the southern Baltic Sea (Fig. 1). Both reservoirs are old sea lagoons separated from the Baltic Sea with narrow and sandy sand-bars formed by sea currents. The preserved connections with the sea let the freshwaters coming to the lake mix with the salty waters penetrating from the Baltic Sea. Both lakes have the same connection with the sea through the estuary of the Łeba River, which flows through the Łebsko Lake, to which estuary has the channel Chełst flowing by the Sarbsko Lake. A precise morphometric and bathymetric characteristics is shown in table 1.

The subject of the present research was only 9 species of fish intensely exploited from among above 40 species of the rich and various ichtiocenosis living in both reservoirs. The following species have been examined: bream *Abramis brama* L., roach *Rutilus rutilus* L., eel *Anquilla anquilla* L., white bream *Blicca bjorkna* L., perch *Perca fluviatilis* L., pike *Esox lucius* L., pike perch *Stizostedion lucioperca* L., tench *Tinea tinea* L. and crucian carp *Carassius carassius* L. The anadromic fish like salmon *Salmo salar* L. appears because of the connection of these reservoirs with the sea, but only in the Łebsko Lake.

Table 1

A morphometric and bathymetric characteristics of the studied lakes elaborated on the basis of materials of Inland Fish. Inst. in Olsztyn (1962, 1966)

Parameters		Łebsko	Sarbsko
Geographic situation	Northern latitude	54°42′8″	54°45′9″
	Eastern longitude	17°24′7″	17°37′6″
Area in ha		7 443	652
Area of acquired reality in ha		7 140	641
Volume of lake in thousands of m^3		117 521	8 074
Max. longitude in meters		13 360	6 580
Max. latitude in meters		7 600	1 240
Max. depth in meters		6.30	3.20
Mean depth in meters		1.60	1.20
Height above sea level in meters		0.30	0.50
Genesis		Littoral Estuarine	Littoral Estuarine

Data of the present research have been taken from the economy books of the Fishery Department in Łeba and from individual fishermen exploiting both reservoirs during the studied period. The registry of fishing for the years 1952-1999 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 weigthing up to 1 kg, from 1 to 3 kgs and above 3 kgs, for each species have been summed up on the contrary to the economy requirements. The errors of not precise data records in the fishery documentation for both lakes have been reduced by long-term, that is fifty-years period of systematic, not expeditional fishing (Leopold and Wołos 1994, Pyka 1993). The record analysis of the fishing used in this study is a modification of indirect methods used in ecology for a long time for quantitative estimation, that is estimation of abundance, density, biomass or production of animal population (Allee et al. 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, Orzechowski 1997, 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 and the dynamics of fishing for the consecutive decades has been presented by numbers directly from 1 to 9 Dm and for the fifty-years period in the form of analytic ratios of the dominance (Balogh 1958).

RESULTS

The data on 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 fourty seven years of fishing refers to the perch and the eel in Łebsko. For the Sarbsko Lake the fluctuative character of fishing is characteristic especially for the biomass of the white crucian carp during the fourty seven years time, and the white bream only for the 70's. The states of relative equilibrium in the dynamism of fishing are characteristic in longer periods for the pike in Łebsko and the eel, pike perch, roach and bream in Sarbsko. The condition of relative equilibrium appears just from the half of the 60's in the dynamics of the tench biomass more often, however the perch fishing stabilized in Sarbsko from the end of the 50's. In both cases the equilibrium maintained at a particularly low level.
Downward trends in the dynamics of biomass of littoral species like pike, tench, and crucian carp showed in the studied lakes already in the 50's and 60's and the decrease was more intensive in the Łebsko Lake than in the Sarbsko Lake (Fig. 3). Similar tendency was observed in the pike perch fishing in the Łebsko Lake in the second half of the 80's, while in Sarbsko the discussed fish stock was slight (Fig. 3). The pike and tench fishing in the Sarbsko Lake were respectively 2- and 6-fold lower than in the Łebsko Lake while for crucian carp they were the same (Tab. 2). However, the lowest fishing in 50% of cases occurred in the 5^{th} decade of the years 1952--1999 (Tab. 2). Then, systematically decreasing fishing of pike and eel in both lakes,

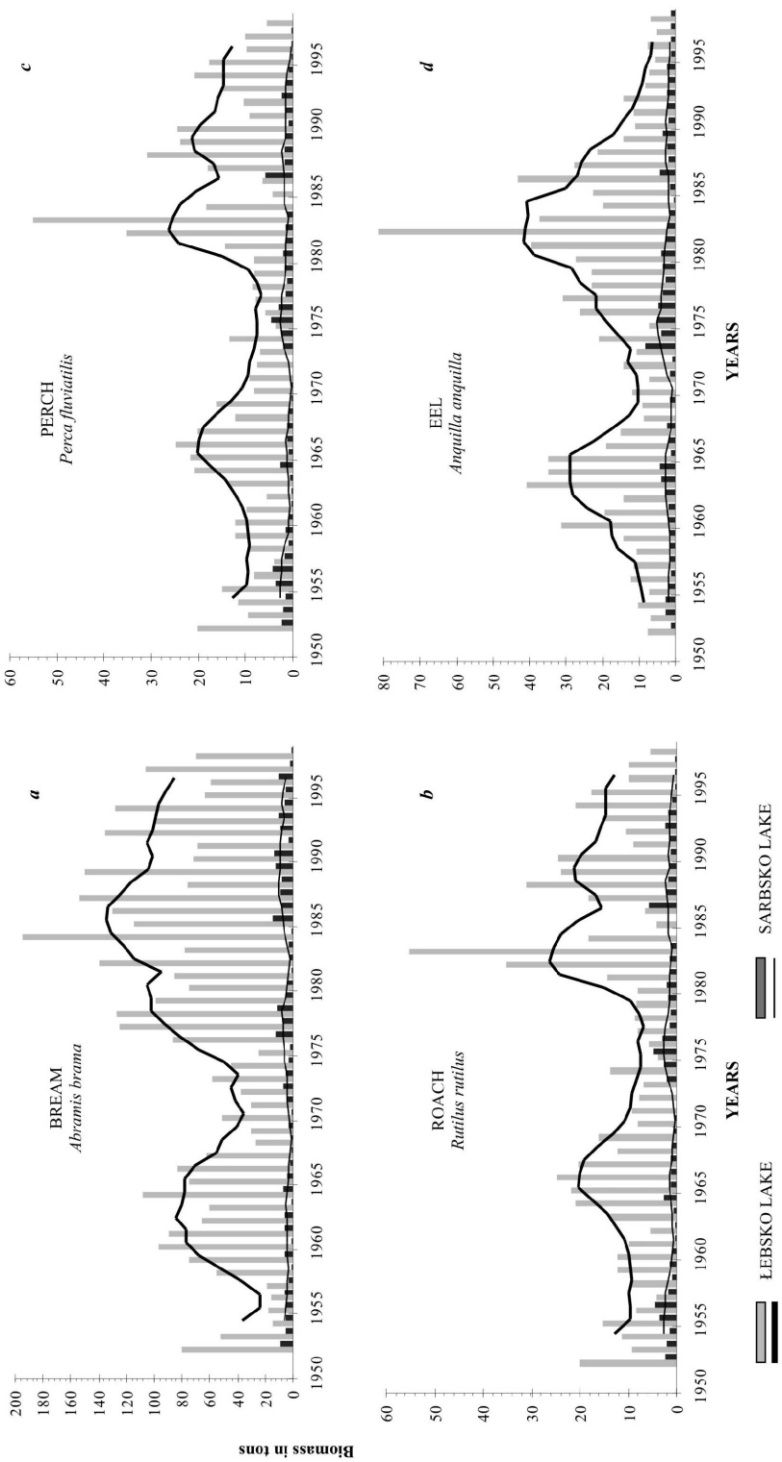

Fig. 2. Fish biomass fluctuations at fishing for the studied lakes in years 1952-1999

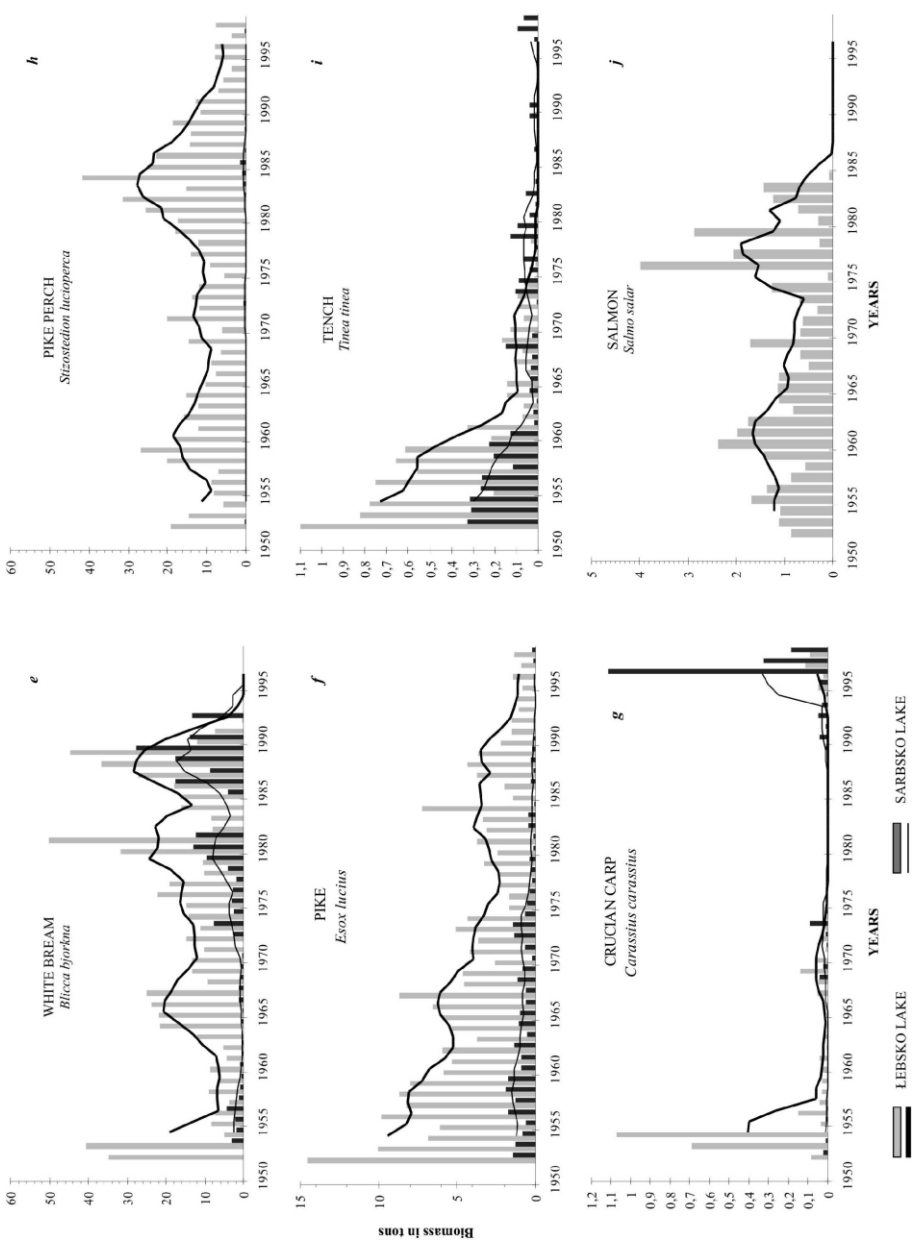

Fig. 3. Fish biomass fluctuations at fishing for the studied lakes in years 1952-1999

Table 2

The total fishing and the average yearly fishing of the fourty seven-years period, the relative quantity of the fishing in sequent decades and the fishery efficiency of the analyzed lakes in years 1952-1999

Species	ŁEBSKO				SARBSKO			
	Tons	Decades	%	kg ha^{-1}	Tons	Decades	%	kg ha^{-1}
1	2	3	4	5	6	7	8	9
BREAM *Abramis brama*	**3 722.93** 79.22	I	19.942	**11.09**	**258.04** 5.49	I	18.879	**8.57**
		II	15.144			II	11.644	
		III	21.721			III	22.967	
		IV	33.889			IV	29.406	
		V	25.581			V	17.105	
EEL *Anquilla anquilla*	**894.45** 19.03	I	23.154	**2.66**	**112.04** 2.38	I	16.380	**3.72**
		II	21.091			II	17.193	
		III	25.176			III	35.814	
		IV	36.884			IV	20.136	
		V	9.623			V	10.459	
PERCH *Perca fluviatilis*	**623.66** 13.27	I	27.919	**1.86**	**57.44** 1.22	I	67.138	**1.91**
		II	18.179			II	9.422	
		III	11.846			III	10.449	
		IV	34.261			IV	9.102	
		V	19.098			V	3.888	
ROACH *Rutilus rutilus*	**664.36** 14.13	I	23.950	**1.98**	**70.68** 1.50	I	27.394	**2.35**
		II	21.560			II	11.932	
		III	14.594			III	28.734	
		IV	36.137			IV	22.845	
		V	19.127			V	9.093	
PIKE PERCH *Stizostedion lucioperca*	**648.09** 13.79	I	32.441	**1.93**	**6.08** 0.13	I	6.429	**0.2**
		II	14.984			II	1.792	
		III	23.548			III	20.190	
		IV	35.871			IV	64.485	
		V	10.018			V	7.103	
WHITE BREAM *Blicca bjorkna*	**625.03** 13.30	I	35.274	**1.86**	**183.36** 3.90	I	8.595	**2.11**
		II	23.159			II	3.117	
		III	30.514			III	32.075	
		IV	31.029			IV	48.974	
		V	0.175			V	7.240	

1	2	3	4	5	6	7	8	9
		I	59.846			I	44.342	
		II	23.203			II	27.471	
PIKE	**206.87**	III	18.184	**0.62**	**29.09**	III	19.335	**0.97**
Esox lucius	4.40	IV	17.523		0.62	IV	7.249	
		V	5.986			V	1.602	
		I	95.546			I	63.095	
		II	12.346			II	9.832	
TENCH	**7.29**	III	5.422	**0.02**	**3.45**	III	17.256	**0.11**
Tinea tinea	0.16	IV	0.016		0.07	IV	4.756	
		V	0.000			V	5.061	
		I	87.177			I	2.618	
		II	11.945			II	3.950	
CRUCIAN CARP	**2.93**	III	3.065	**0.01**	**2.10**	III	6.140	**0.07**
Carassius carassius	0.06	IV	0.079		0.05	IV	3.665	
		V	11.245			V	83.627	
∑	**6 453.43**			**22.03**	**722.28**			**23.99**

– decades of the smallest fishing

Decades: I – 1950-1959; II – 1960-1969; III – 1970-1979; IV – 1980-1989; V – 1990-1999

tench in Łebsko and perch in Sarbsko reveal a distinct exploitation of the discussed species.

The eudominant species in the fishing from over 50% of the total fish biomass on the Łebsko Lake was bream. A considerable part of the caught ichtiofauna biomass was also eel, being a subdominant. The lowest contribution to the fishing and biocenotic processes had tench and carp. During the fourty seven-years, fishing in the Łebsko Lake, the share of the pike perch and white bream decreased in favour of roach and perch (Tab. 3). The fishing of salmon, a particularly valuable species in the ichtiofauna of the Łebsko Lake, broke down in the middle of the 70's and in late 80's dropped to zero (Fig. 3). Rapid fluctuations of fish biomass occurred in Łebsko between decades. The highest fishing was in the 80's and after each increase at the end of the consecutive decades, a considerable decrease was observed in the following 10 years. The fishing of all the species except for the crucian carp dropped significantly in the last analysed decade (Tab. 3). The overall fishing efficiencies in the Łebsko and Sarbsko lakes during the studied period were at a similar level (Tab. 2 and 4) in spite of considerable differences in the amount of caught consecutive fish species.

The dominant species in Sarbsko in years 1952-1999 were bream and white bream, which consisted slightly over 60% of the fishing biomass (Tab. 4). Eel reached a 15% share. Since the late 50's a continous upward trend was noticed in the

Table 3

The changes of the positions and the mass dominance of the fishes in the fishing in Łebsko Lake in years 1952-1999

Species	DECADES I		II		III		IV		V		General in fourty seven-years		
	Tons	P.	Tons	P.	Tons	P.	Tons	P.	Tons	P.	Tons	P.	%
Bream – *Abramis brama*	516.43	1	563.82	1	718.57	1	1 261.68	1	662.44	1	3722.93	1	50.08
Eel – *Anquilla anquilla*	131.02	4	188.65	2	190.40	2	329.91	2	54.46	4	894.45	2	12.03
Roach – *Rutilus rutilus*	111.90	6	143.24	4	79.81	5	240.08	3	89.33	3	664.36	3	8.94
Pike perch – *Stizostedion lucioperca*	141.03	2	97.11	6	133.91	4	232.48	4	43.55	5	648.09	4	8.72
White bream – *Blicca bjorkna*	127.27	5	144.75	3	158.44	3	193.94	6	0.63	7	625.03	5	8.41
Perch – *Perca fluviatilis*	136.98	3	113.38	5	65.93	6	213.67	5	93.70	2	623.66	6	8.39
Pike – *Esox lucius*	83.34	7	48.00	7	30.95	7	36.25	7	8.33	6	206.87	7	2.78
Salmon – *Salmo salar*	8.95	8	13.16	8	12.82	8	3.78	8	0.00	9	38.71	8	0.52
Tench – *Tinea tinea*	6.03	9	0.90	9	0.36	9	0.00	9	0.00	9	7.29	9	0.10
Crucian carp – *Carassius carassius*	2.21	10	0.35	10	0.08	10	0.00	9	0.28	8	2.93	10	0.04
In decades	**1 265.16**	**-**	**1 313.36**	**-**	**1 391.27**	**-**	**2 511.79**	**-**	**952.72**	**-**	**7 434.32**	**-**	**100.00**
% of biomass	17.02		17.67		18.71		33.79		12.82		100.00		
Biomass of dominations (%)	51.97		57.29		65.33		63.36		79.36		62.11		
Kgs ha^{-1}	**17.59**		**18.39**		**19.48**		**35.18**		**19.06**		**22.04**		

$P_{1 \ldots 10}$ the position of species in sequent decades and during fourty seven-years

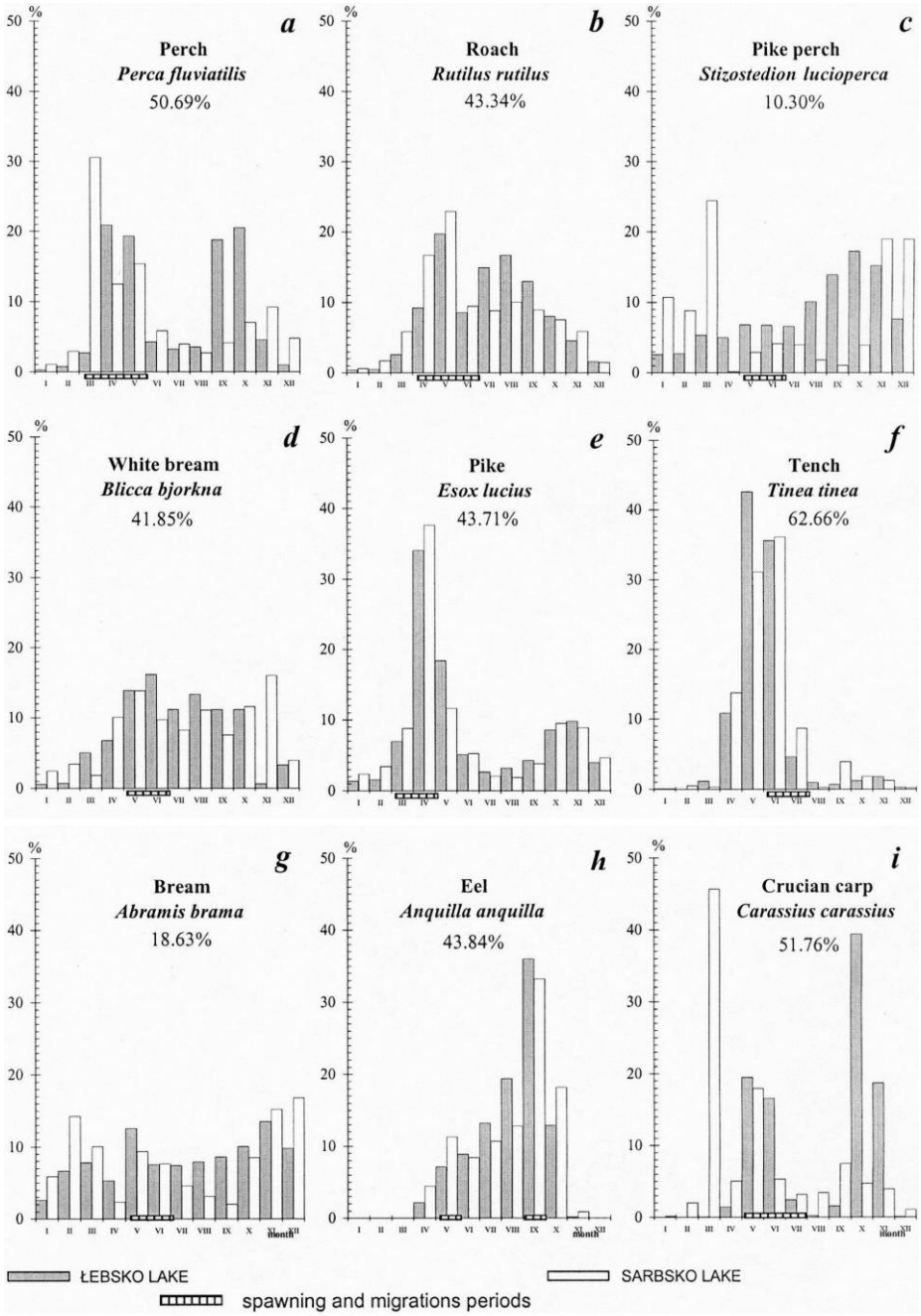

Fig. 4. Fishing on the studied lakes in the yearly cycle in the years 1952-1999
Remarks: The relative data from 10.30 to 62.66% were received by enumerating the mean for

the biomass of fishings periods or migrations to the spawning. Therefore this data have value higher than the one marked out on the axis "Y"
fishing of white bream, which in the 4th decade took the first place among the economically important species (Tab. 4). The lowest contribution in the biomass had pike perch, tench and crucian carp (Tab. 4). In the studied 47 years systematicaly decreased the importance of perch which was particularly distinct in the 50's and 60's (Tab. 4). The overall fishing biomass in the Sarbsko Lake revealed large fluctuations between the consecutive decades (Tab. 4).
The overall fishing efficiency in Łebsko was stable for most of the time (1st, 2nd, 3rd and 5th decade) at the level of approximately 20 kg ha^{-1} and reached the highest values in the 80's (Table 3). In the Sarbsko Lake the efficiency was most varied and in the 1st, 3rd and 4th decade ranged from 24.38 to 33.68 kg ha^{-1} while in the remaining two decades did not exceed 18 kg ha^{-1} (Tab. 4).
A systematic decrease in the biomass of the caught fish in both lakes seems to be correlated with fishing during spawning of most of the species except for pike perch and bream (Fig. 4). This was mostly destructive for phytophilic littoral fish. The highest fishing of the crucian carp during its spawning in both lakes reached 52% of the annual value taking into account the whole analysed period. Fishing of the bream, roach, eel and white bream in the critical spawning period did not exceed 19, 43, 45 and 42% respectively, therefore those species had the main share in the fishing from both lakes.

DISCUSSION

Changes in the aquatic environment influence the supplies of freshwater fish. Eutrophication of inland waters contributes to deep changes in the species composition and structure of the fish populations. It is a common knowledge, that generally in the contaminated lakes the cyprinids fish of a small economic value predominate (MRiRW 2004).
The alarming signals about the increasing pollution of waters having influence on fishing in some of the estuarine lakes, i.e. Gardno (Ciepielewski 1992, Leopold and Wołos 1994, Orzechowski 1997) should be, however, considered with careful interpretation. The fact of permanent growth in biomass of particular species as well as its decrease in comparison with other species in Łebsko and Sarbsko, 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 varied kind of pollution has the very large influence on the spawning-grounds, setting on them rubbed, incubation, the larvae growth and the individuals maturity (Wawrzyniak and Grawiński 1985). The bad condition of lakes Łebsko and Sarbsko is caused by the inflow of waters rich in biogens into their basin. The influence of these waters is so large that the caused changes in the bottom settlings' structure are the result of the accumulation of organic pollution brought into these reservoirs (PIOŚ 1999). The most polluted among the estuarine lakes, Jamno (Zdanowski et al. 1979), had the

greatest fishery efficiency in the analysed period of the 40 years – 60 kg/ha/year (Ciepielewski 1992). In the lake Gardno being in the direct contact with the lake Łebsko (the channel Łebsko of length 10.2 km) in the period of 40 years, the fishing efficiency was higher and reached 33 kg ha^{-1} $year^{-1}$ comparing to 22 kg ha^{-1} $year^{-1}$ in Łebsko (Orzechowski 1997). The reasons of the negative phenomena in fishing should be found rather in a notorious exploitation for the purpose of getting more precious fish species 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 a too great scale has been shown in the Jamno Lake by Ciepielewski (1992), in the Gardno and Wicko Lakes by Orzechowski (1997)**,** and in reference to the majority of species on the area of the Puck Bay (Wawrzyniak and Grawiński 1985, Skóra 1997).

The biomass changes of the economically valuable fish species in lakes Wicko and Gardno (Orzechowski 1997) both with the present study in Łebsko and Sarbsko show stable, similar downward tendencies in the fish stock of for example tench, pike and eel. The exception was pike perch which stock underwent the essential reconstruction in Gardno and Wicko lakes, while in the 90's its fishing share decreased in Łebsko Lake, and became a very rare species in Sarbsko.

The maximum reduction of the fish biomass in their population, for the sake of permanent and the highest fishing according to Ricker's model (1958) is used without any criticism in fishery practice. According to Gulland (1962, 1969), the theoretical assumptions of the model may be fulfilled only in simplified trophic structures or in fish farms. It denotes a poor feeding competition from 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 a 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 Łebsko and Sarbsko (Fig. 4). The theoretical principles, therefore, refer to rational fishery exploitation in an annual cycle (Ricker 1958). They may not be adjusted 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 significants of dominance (1958) to which the value of dominance has been brought in the final phase of the analysis (Tab. 3 and 4).

CONCLUSIONS

On the basis of the fifty years analysis of the fishing from the estuarine lakes Łebsko and Sarbsko, 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 extremely high exploitation of fish during spawning.
- The dominant structure of the fish mass in fishing typical for structures extremely simplified being subject to permanent anthropopression, negatively correlated with a small variety of the fish exploited in this group of fishes.

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

- Reduction of the white bream in Sarbsko by effective stock with the pike and the pike perch in the lake.
- Reduction of the bream in Łebsko and Sarbsko 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.

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DYNAMIKA BIOMASY RYB W POŁOWACH RYBACKICH Z ESTUARIOWYCH JEZIOR ŁEBSKO I SARBSKO

Streszczenie

W pracy wykazano przewagę trendów fluktuacyjnych w dynamice biomasy większości poławianych gatunków ryb i wygasanie połowów fitofilnych ryb litoralowych. Główną przyczyną załamania się połowów sandacza w Łebsku oraz okonia w Sarbsku był brak prawidłowej gospodarki rybackiej. Zasoby wymienionych populacji ryb naruszano drastycznie już od pierwszej dekady blisko 50-letniej eksploatacji. Szczytowe połowy większości ryb w cyklu rocznym były osiągane głównie w okresie tarła przez cały analizowany okres.

Dla odrodzenia się populacji szczupaka, lina oraz karasia należy całkowicie zaniechać ich połowów na czas trwania generacji i zredukować drobne karpiowate poprzez przeprowadzenie intensywnego zarybiania jezior szczupakiem i sandaczem.