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Heavy Metals, Σ DDT and Σ PCB in the Gonads of Pikeperch Females Spawning in Southern Baltic Sea Lagoons

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Abstract

This paper presents the results of studies of the levels of heavy metals, organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) in the gonads of pikeperch females from the Szczecin, Vistula and Curonian lagoons.

This study determined that the levels of heavy metals such as Zn, Cu, Pb and Cd and those of organochlorine pesticides and polychlorinated biphenyls occur in pikeperch gonads in different quantities depending on the region studied. The highest level of zinc was recorded in pikeperch gonads from the Szczecin Lagoon, and the highest levels of copper were noted in those from the Vistula Lagoon. The highest levels of S HCH occurred in the gonads of Vistula Szczecin pikeperch.

Keywords: Szczecin Lagoon, Vistula Lagoon, Curonian Lagoon, pikeperch, female gonads, heavy metals, DDT, PCB, HCH.

Introduction

The progressive degradation of the aquatic environment is evidenced by many factors; two of them are elevated levels of heavy metals and the occurrence of agricultural chemicals. Heavy metals, those metabolic elements with an atomic weight over 20 [10, 18], play a role in the balanced cycle of elements in nature. The rapid development of industry and other areas of the economy have disrupted this balance. Agricultural chemicals reach water basins in the form of organochlorine pesticides, and industry is the source of polychlorinated biphenyls contamination.

The heavy metals which are recognized as especially dangerous are: cadmium, copper, zinc and lead. If there is an excess of these elements in the aquatic environment, then fish, one of the more important links in the food chain, are forced to take part in the cycle of these metals.

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The occurrence of heavy metals and agricultural chemicals in the aquatic environment and their bioaccumulation in organisms at various trophic levels has been the subject of numerous publications. For example, Aoyama *et al.* [2] reported that the size of the food ration determines the level of metals in the fish. Chodyniecki *et al.* [4] addressed the dependence between heavy metal contamination in the environment and the levels of their accumulation in a study on mercury levels, and Protasowicki [17] did so with a study on copper and zinc levels.

Protasowicki [18] studied the heavy metal levels in the muscles, liver, and stomach contents of herring, cod and flounder. He also studied the influence of fish sex on the level of heavy metals in the muscles, liver, and gonads. When a sex-related difference was detected, the higher heavy metal level was observed most frequently in male livers. He stated that the sex of fish had a significant influence on the levels of microelements in the livers and gonads.

Some authors addressed the physiological differences

between males and females and focused their studies on the impact that sex has on heavy metal levels. According to Deb and Santry [5], who conducted studies in sewage-polluted areas in India, the levels of heavy metals in fish tissues are the highest in the liver, followed by the brain, the muscles, ovaries and bones. Marqez *et al.* [13] studied the levels of zinc, magnesium and copper in the muscles, livers and gonads of *Notothenia coriiceps* from the southern Shetland region. They reported that the concentration of these metals was the highest in the livers and gonads, and they noted a sex-dependent difference of heavy metal levels. The highest levels occurred in the livers of males and the gonads of females.

A review of literature indicated that many papers have been published which are devoted to testing the levels of toxins such as petroleum-based compounds, ΣPCBs and ΣDDT in fish and their negative influence on development and reproduction processes.

In their studies of aquatic environments polluted with petroleum-based compounds, Jacobsson *et al.* [9] and Jacobsson and Neuman [8] reported that the number of dead embryos in the ovaries of female eel might be an indicator of the pollution level.

Mac and Schwartz [11] studied PCB levels in the ovaries of sea trout from Lake Michigan and the survival of embryos. They reported that as the levels of PCBs rose, so did the percentage of anomalous hatch.

Mac *et al.* [12] also reported that there was a link between PCB levels in spawn and adult specimens and the mortality of sea trout eggs from the Great Lakes region. The embryos died in the period between fertilization and hatching.

In the available literature, no papers were found that focused on levels of heavy metals and pesticides in the gonads and internal organs of female and male pikeperch and the influence the accumulation of these elements has on the fecundity of females from the lagoons of the southern Baltic Sea.

The aim of this work was to determine the levels of heavy metals, organochlorine pesticides and polychlorinated biphenyls in the female gonads of pikeperch from the lagoons of the southern Baltic Sea and to compare the contamination levels found in different regions.

Materials and Methods

During the pre-spawning season in March and April 2000 material was collected for a study on the absolute fecundity of female pikeperch which spawn in the lagoons of the southern Baltic. Of the 882 pairs of ovaries collected, 46 pairs of gonads were selected for the current study. They were slightly damaged and thus inappropriate for use in the fecundity study (Tab. 1). These gonads were used to determine the levels of heavy metals and pesticides.

Female specimens were selected from commercial catches, and those chosen had gonads in maturity stage IV according to the Maier scale. The total length of the studied females was 61-65 cm for the Szczecin and Vistula lagoon specimens and 51-67 cm for the Curonian Lagoon specimens. The fish were measured to the nearest 1 cm. Total fish weight was determined to the nearest 10 g; its weight following gutting was also recorded. The ovaries were weighed to the nearest 1 g. The age of the specimens was determined from the scales. Directly after the analyses, the gonads were frozen and then stored at a temperature of -20°C.

Table 1. Material collected in 2000.

Lagoon	Length l.t. [cm]	Age Class	Fish weight [g]	Gutted fish weight [g]	Gonad weight [g]
Szczecin	61	5	2540	2030	253
	61	6	2285	1855	194
	61	6	2710	2145	323
	61	6	2595	1985	356
	61	7	2795	2200	274
	62	6	2400	2025	146
	62	6	2680	2155	314
	62	6	2470	2000	293
	62	6	2380	1920	227
	62	6	2775	2250	315
	62	6	2885	2280	314
	62	6	2470	2010	191
	62	7	2710	2230	263
	62	6	2695	2150	268
	62	6	2740	2090	305
	64	6	3100	2180	369
	64	8	3345	2770	269
	65	7	3490	2560	438
	65	7	3110	2425	352
Vistula	55	5	2050	1580	256
	56	5	1890	1570	178
	56	5	1950	1550	211
	59	6	2190	1820	167
	59	6	1970	1640	210
	59	7	2180	1670	259
	59	7	2300	1880	190
	60	7	2290	1810	177
	60	6	2350	1990	208
	61	8	2170	1780	170
	61	7	2490	1960	234
	61	7	2230	1850	202
	61	6	2460	1980	209
	61	6	2380	2000	248
	61	7	2690	2180	232
	61	7	2410	2030	261
	61	6	2210	1910	208
	65	8	2640	2140	216
	65	8	2690	2200	238
	65	7	2820	2410	280
Curonian	51	7	1600	1200	245
	51	7	1590	1300	150
	51	7	1350	1140	115
	53	7	1600	1340	159
	53	7	1670	1320	212
	55	7	1900	1490	219
	67	8	3000	2450	313

Table 2. Heavy metals in the gonads of pikeperch females.

Lagoon	Number of samples	Length [cm]	Metal levels [µg/g w.w.]			
			Zn	Cu	Pb	Cd
Szczecin	5	61	107.71	2.47	0.081	0.013
	10	62	93.8	3.13	0.276	0.033
	2	64	100.74	2.08	0.179	0.008
	2	65	104.61	1.91	0.061	0.003
Vistula	3	55-56	70.93	3.83	0.196	0.026
	6	59-60	72.22	4.04	0.116	0.022
	8	61	71.82	4.53	0.076	0.024
	3	65	78.74	4.78	0.064	0.032
Curonian	3	51	76.12	3.96	0.072	0.023
	2	53	68.49	4.81	0.096	0.019
	1	55	106.04	1.95	0.064	0.01
	1	67	110.52	2.37	0.094	0.006

Atomic absorption spectrometry (AAS) was used to determine the levels of heavy metals, while pesticides and PCBs levels were determined using gas chromatography.

The samples were mineralized before determining the levels of heavy metals. This procedure was carried out in a Microwave Digestion System Model MDS-81D with concentrated nitric acid. Concentration measurements were taken using a Perkin-Elmer 1100B atomic absorption spectrometer and an HGA graphite oven. Zinc and copper concentrations were determined directly from the mineralized sample solutions using the ionizing flame method in an air- acetylene flame [1]. Cadmium and lead levels were determined with the flameless method in a graphite oven [1].

The accuracy and precision of the applied analytic methods were verified against certified reference material CRM 422 that contained certified amounts of metals: Cd 0.017 ± 0.002 µg/g; Cu 1.05 ± 0.07 µg/g; Pb 0.085 ± 0.015 µg/g; Zn 19.6 + 0.5 µg/g. The authors' results on the certified material were as follows: Cd 0.019 ± 0.0033 µg/g; Cu 0.99 ± 0.033 µg/g; Pb 0.075 ± 0.009 µg/g; Zn 20.1 ± 0.2 µg/g.

Identifying organochlorine pesticides (α-HCH, β-HCH, γ-HCH, HCB, p,p'-DDE, p,p'-DDD, p,p'-DDT) and polychlorinated biphenyls (PCB congeners: 28, 52, 101,151,118,138,153 and 180) was conducted according to Sea Fisheries Institute (SFI) Research Laboratory procedure PB-10. This procedure was developed at the SFI based on recommendations from the United Nations Environment Program (1984), Reference Methods for Marine Pollution Studies No. 14 (1982) and No. 4 (1988) and on European Norm EN 1526 1-4:1996. This method was accredited by the Polish Center for Research and Certification in 1999 (accreditation certificate no. L 17/4/99).

The above mentioned toxic compounds were identified using capillary gas chromatography with electron capture detection. The gonad samples were ground and then freeze-dried and the lipids were extracted with hexane. These extracts were chemically cleaned-up with a mixture of sulfuric acid and 30% oleum. Blank samples were prepared and taken into account during calculation of final results in the case of OCPs and PCBs as well as toxic metals. This method is verified annually in inter-laboratory calibrations; in Poland they are supervised by the Polish Department of Health and those of international scope - by the International Atomic Energy Agency in Monaco.

Comparison of heavy metals, Σ DDT and Σ PCBs in the gonads of female pikeperch from chosen lagoons was carried out by means of ANOVA. The "post-hoc" test of least significant differences (LSD) was used to find out which average values calculated for studied lagoons were significantly different.

Results

Metals

The levels of the heavy metals zinc, copper, lead and cadmium in the gonads of female pikeperch that spawn in the three southern Baltic Sea lagoons were studied. The results obtained varied depending on the study region (Tab. 2). The females studied measured between 5 land 67 cm, and belonged to the V to VIII year classes. The gonads were collected during the same period of March to May, so that they were all in maturity stage IV. The range of the results from the few Curonian Lagoon samples is very wide; this was caused by the small number of samples.

Zinc

The data presented indicate that the highest level of this element was found in the gonads of females from the Szczecin Lagoon. The values ranged from 93.80 to 107.70 µg/g w.w., with an average of 101.76 µg/g w.w. In the Vistula Lagoon, the gonads contained only from 70.93 to 78.74 µg/g w.w., with an average of 73.92 µg/g w.w. The lowest zinc levels (after disregarding the two extreme levels) were found in the gonads of females from the

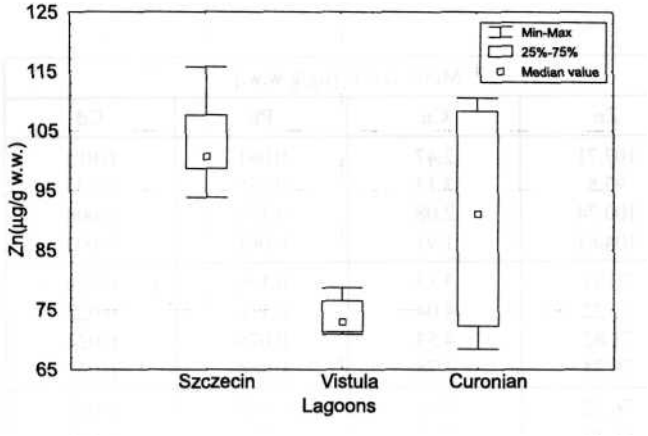

Fig. 1. Content of Zn in the gonads of pikeperch females in studied Lagoons.

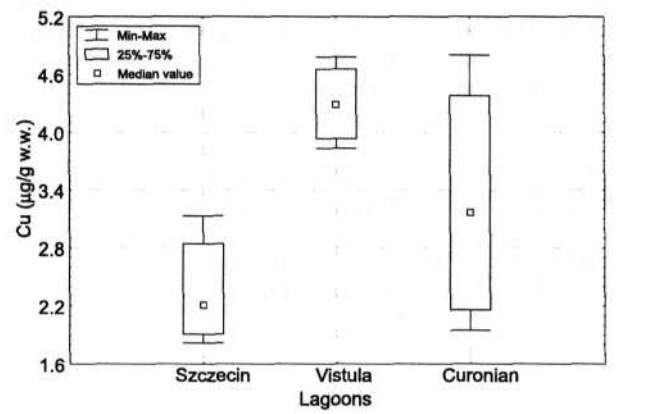

Fig. 2. Content of Cu in the gonads of pikeperch females in studied Lagoons.

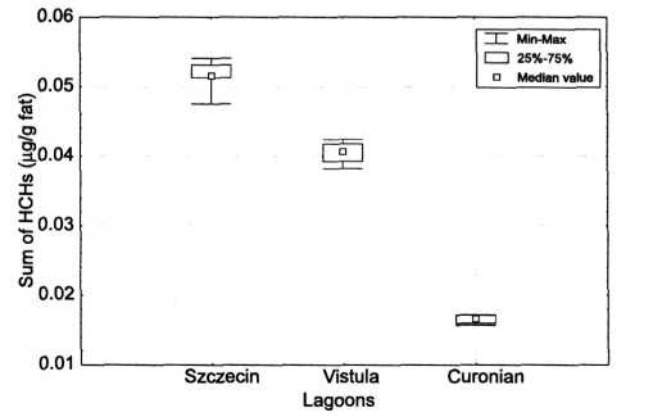

Fig. 3. Content of Σ HCH in the gonads of pikeperch females in studied Lagoons.

Curonian Lagoon, with an average of 72.30 µg/g w.w. Analysis of variance proved that differences between the average content of zinc in the gonads of pikeperch from studied lagoons were significant ($p < 0.01$). Multiple comparison tests confirmed that results obtained for the samples from the Szczecin Lagoon were significantly higher than those of the Vistula Lagoon ($p < 0.01$) (Fig- 1).

Copper

The highest concentration of this element was found in the gonads of females from the Curonian Lagoon, at an average of 4.38 µg/g w.w. The average level of copper in the gonads of females from the Vistula Lagoon was 4.29 µg/g w.w., while in those of females from the Szczecin Lagoon the average copper level was the lowest at 2.39 µg/g w.w.

Significant statistical differences were observed for the Szczecin and Vistula Lagoons ($p < 0.01$), reaching higher values for the latter one (Fig. 2).

Lead

It was determined that the average amount of lead in the gonads of females from the Szczecin Lagoon was 0.149 µg/g w.w. The lower level was found in the gonads of females from the Vistula Lagoon - 0.113 µg/g w.w., while the gonads of females from the Curonian Lagoon had an average lead content - 0.084 µg/g w.w.

However, statistical analysis showed that these differences were not significant.

Cadmium

The average cadmium content in the gonads of females from the Szczecin Lagoon was 0.0145 µg/g w.w. It reached 0.0260 µg/g w.w. in samples from the Vistula Lagoon, and 0.0210 µ/g w.w. in those from the Curonian Lagoon.

However, same as it was in the case of lead, statistical analysis showed that these differences were not significant.

Organochlorine pesticides

Analyzing results presented in Table 3, it can be observed that the highest level of Σ DDT was found in the gonads of females from the Vistula Lagoon. It ranged from 115.13 to 147.61 µg/kg w.w., with an average of 128.03 µg/kg w.w. The least varied results were obtained from the Szczecin Lagoon samples - from 92.53 to 102.99 µg/kg w.w., with an average of 98.42 µg/kg w.w. The average from the Curonian Lagoon was 64.45 µg/kg w.w. This was the lowest result obtained in the study of Σ DDT levels.

However, it should be stated that statistical analysis of obtained Σ DDT results proved that the differences be-

Table 3. Organochlorine pesticides in female pikeperch gonads.

Lagoon	Number of samples	Length [cm]	Fat [%]	Organochlorine pesticides [mg/kg fat]							Σ HCH	Σ DDT	Σ HCH	Σ DDT
				α-HCH	HCB	β-HCH	γ-HCH	DDE	DDD	DDT	[mg/kg fat]		[µg/kg w.w.]	
Szczecin	5	61	8.26	0.0106	0.0302	0.0247	0.0153	0.8735	0.1966	0.1546	0.0506	1.2247	4.18	101.16
	10	62	7.91	0.0108	0.0300	0.0251	0.0167	0.8791	0.1947	0.1524	0.0526	1.2262	4.16	96.99
	2	64	8.07	0.0118	0.0265	0.0258	0.0165	0.8652	0.1823	0.0991	0.0541	1.1466	4.37	92.53
	2	65	8.15	0.0105	0.0306	0.0249	0.0161	0.8933	0.1921	0.1783	0.0515	1.2637	4.20	102.99
Vistula	3	55-56	9.09	0.0079	0.0268	0.0202	0.0101	0.7559	0.3909	0.1198	0.0382	1.2666	3.47	115.13
	6	59-60	9.01	0.0083	0.0292	0.0215	0.0126	0.7468	0.4072	0.1342	0.0424	1.2882	3.82	116.07
	8	61	8.91	0.0090	0.0316	0.0180	0.0133	1.0008	0.4965	0.1594	0.0403	1.6567	3.59	147.61
	3	65	9.38	0.0080	0.0237	0.0194	0.0137	0.9310	0.3851	0.1053	0.0411	1.4214	3.86	133.33
Curonian	3	51	8.77	0.0044	0.0195	0.0074	0.0045	0.6312	0.1324	0.0308	0.0163	0.7944	1.43	69.67
	2	53	9.02	0.0041	0.0199	0.0083	0.0046	0.5575	0.1160	0.0276	0.0170	0.7011	1.53	63.24
	1	55	7.78	0.0037	0.0124	0.0080	0.0040	0.3455	0.0602	0.0154	0.0157	0.4211	1.22	32.76
	1	67	7.71	0.0045	0.0301	0.0082	0.0045	1.6817	0.4033	0.2072	0.0172	2.2922	1.33	176.73

Notes:

1. Each result is the arithmetic average of two parallel determinations
2. Organochlorine pesticide contents are expressed in mg/kg fat [ppm]; sum total of HCH and DDT is also presented in µg/kg wet weight [ppb].
3. Heptachlor levels were confirmed to be at the limit of detection at 0.0001 mg/kg fat.

tween studied lagoons were not significant. In the case of 2 HCH the highest average value (4.23 µg/kg w.w.) was found in the samples from the Szczecin Lagoon, lower (3.69 µg/kg w.w.) in these from the Vistula Lagoon, and the lowest (1.38 µg/kg w.w.) in the case of the Curonian Lagoon. Differences were statistically significant ($p < 0.0001$) for all the lagoons. It was observed that Σ HCH values were lower for eastern lagoons (Fig. 3).

Polychlorinated Biphenyls

The highest Σ PCB content was found in the gonads of females from the Vistula Lagoon, with an average of 92.67 ug/kg w.w. The Σ PCBs level was lower for the Szczecin Lagoon - from 61.65 µg/kg w.w. to 76.29 µg/kg w.w., with an average of 67.24 µg/kg w.w. The lowest average value of 42.60 µg/kg w.w. was obtained for the

Table 4. Polychlorinated biphenyl levels in female pikeperch gonads.

Lagoon	Number of samples	Length [cm]	Fat [%]	Polychlorinated biphenyls [mg/kg fat]								Σ PCB mg/kg fa	Σ PCB [µg/kg w.w.]
				28	52	101	151	118	153	138	180		
Szczecin	5	61	8.26	0.0044	0.0496	0.1049	0.0388	0.0735	0.2277	0.2211	0.0264	0.7464	61.65
	10	62	7.91	0.0039	0.0393	0.114	0.0441	0.0733	0.2633	0.2515	0.0341	0.8235	65.14
	2	64	8.07	0.0025	0.0536	0.1168	0.0471	0.0797	0.3129	0.2932	0.0396	0.9454	76.29
	2	65	8.15	0.0019	0.0568	0.1099	0.0403	0.0826	0.2434	0.2443	0.0291	0.8083	65.88
Vistula	3	55-56	9.09	0.0073	0.0333	0.1453	0.0473	0.1762	0.2151	0.2513	0.0223	0.8981	81.64
	6	59-60	9.01	0.0083	0.0370	0.1430	0.0433	0.1461	0.2027	0.2382	0.0204	0.8390	75.59
	8	61	8.91	0.0094	0.0396	0.1910	0.0539	0.2270	0.2910	0.3360	0.0311	1.1790	105.05
	3	65	9.38	0.0084	0.0292	0.1757	0.0502	0.2208	0.2967	0.3423	0.0325	1.1558	108.41
Curonian	3	51	8.77	0.0134	0.0226	0.0574	0.0212	0.0719	0.1361	0.1501	0.0155	0.4882	42.82
	2	53	9.02	0.0092	0.0209	0.0556	0.0219	0.0698	0.1318	0.1454	0.0154	0.4700	42.39
	1	55	7.78	0.0054	0.0177	0.0341	0.0133	0.0414	0.0871	0.0995	0.0107	0.3092	24.06
	1	67	7.71	0.0136	0.0543	0.2439	0.0672	0.3074	0.4777	0.5144	0.0559	1.7344	133.72

Notes:

1. Each result is the arithmetic average of two parallel determinations
2. Results of PCBs content are expressed in mg/kg fat [ppm]; sum total is also given in mg/kg wet weight [ppb].

Curonian Lagoon (Tab. 4). However, it should be emphasized that statistical analysis of obtained 2 PCBs results proved that the differences between studied lagoons were not significant.

Discussion

The comparison of the levels of heavy metals (Zn, Cu) and toxic substances Σ HCH in the gonads of pikeperch females from the three regions indicates that the amounts of heavy metals and pesticides differ according to region.

The contents of zinc in the gonads of pikeperch females from the Szczecin Lagoon are the highest, while the samples from the Vistula Lagoon had the highest content of copper. However, the gonads of females from the Curonian Lagoon had similar levels of zinc as those from the females from the Vistula Lagoon did. The specimens from the Curonian Lagoon were in second position with regards to levels of copper.

With regard to levels of Σ HCH, the first position was taken by the female gonads from the Szczecin Lagoon, followed by those from the Vistula Lagoon, and the Curonian Lagoon.

No publications in the literature were found which contained data regarding the levels of heavy metals in the gonads of female pikeperch. However, there are data, published by Polak-Juszczak [15], regarding the levels of heavy metals in the muscle tissues of pikeperch from the Vistula Lagoon. When these data were compared to the average values of heavy metals in the gonads of female pikeperch from the same lagoon, it was revealed that the zinc content in the gonads was almost 18-fold higher than in the muscle tissue. For the purpose of comparison, Table 5 presents the results of the study by Protasowicki [18] regarding the levels of heavy metals in the muscle tissues and in the female gonads of cod and flounder. Admittedly, this is a comparison between marine and diadromous fishes; however, the authors wanted to compare the proportions of heavy metals in muscle tissue and gonads. It was revealed that zinc levels in the female cod gonads are almost ten-fold higher than those in muscle tissues, while in flounder this level was only four-fold higher. This most probably results from inter-species differences.

As Protasowicki [18] reported, in the case of essential elements such as copper and zinc, significant accumulation of these elements takes place in internal organs which perform important life functions, such as the gonads. According to Protasowicki, female gonads from cod contained higher levels of copper and zinc, while those of the males had higher cadmium levels. This was also the case with common bream; the female gonads had high levels of copper and zinc, while the male gonads contained more cadmium and lead - elements recognized as highly toxic.

Data on the content of Σ DDT and Σ PCBs in the muscle tissue of different species of fish from the Vistula Lagoon (Tab. 6) were chosen from the Baltic resources monitoring program conducted in the year 2000 [3]. This data were compared with those obtained from the study of the gonads of pikeperch females from the same lagoon. It was revealed that the content of toxic substances in the pikeperch gonads was several-fold higher than those found in the fish muscle tissues. It must be emphasized that the high values of Σ PCBs in food and environmental samples are linked with the occurrence in these samples of dioxins and furans [14]. During the study on dioxins, a dependence

Table 5. Heavy metal levels in the muscle tissue of different fish species [μg/g w.w.].

Metal	Vistula Lagoon		Southern Baltic***			
	Pikeperch		Cod		Flounder	
	Muscles*	Gonads**	Muscles	Gonads	Muscles	Gonads
Zn	4.11	73.92	3.84	31.23	5.54	21.91
Cu	0.16	4.29	0.25	1.16	0.35	1.19
Pb	0.012	0.113	0.68	0.85	0.66	0.98
Cd	0.006	0.26	0.072	0.087	0.098	0.067

*[15]
** Authors' own data, 2000
*** [17]

Table 6. Content of Σ DDT and Σ PCBs in muscle tissues of Vistula Lagoon fish.

Fish	Σ DDT		Σ PCB	
	μg/g fat	μg/kg w.w.	μg/g fat	μg/kg w.w.
Eel	0.213	39.02	0.269	49.28
	0.183	31.83	0.282	49.22
	0.356	25.40	0.342	24.32
	0.263	74.19	0.344	97.02
	0.258	61.31	0.277	65.78
	0.161	36.77	0.226	51.46
Sichel	2.212	30.31	3.650	49.93
	1.175	17.86	2.070	31.47
	0.639	15.07	0.690	16.29
	0.735	15.58	1.160	24.63
	0.696	16.62	1.120	26.85
	0.935	20.86	1.510	33.68
	0.374	5.46	0.495	7.22
	1.371	19.19	2.200	30.81
Common bream	0.335	7.51	0.461	10.32
	0.284	10.08	0.468	16.60
	0.345	10.03	0.548	15.94
	0.237	5.92	0.363	9.07
	0.331	8.71	0.237	6.24
	0.304	12.14	0.383	15.33
	0.409	1.79	0.378	1.66
	0.216	10.62	0.388	19.01
	0.283	7.55	0.403	10.75
	0.228	7.27	0.265	8.44
Perch	0.493	1.28	0.683	1.77
	0.356	25.34	0.342	24.32
	0.605	4.17	0.450	3.10
	0.656	1.44	0.930	2.04
	0.56	1.23	1.220	2.68
	0.646	2.32	0.685	2.47
Pikeperch	0.575	1.15	0.825	1.65
	0.646	1.09	0.784	1.33
	0.642	1.22	0.615	1.17
	0.739	1.48	0.906	1.81
	0.505	0.81	0.740	1.19
	0.584	1.05	1.040	1.89
	0.261	0.37	0.450	0.63

was noted between the total content of seven indicative PCB congeners (28, 52, 101, 118, 153, 138 and 180) (Tab. 4) and the content of dioxins and furans. Based on these results, the European Union Commission of Experts accepted the theory that by knowing the value of Σ PCBs in food and their chromatographic profile, the level of dioxins contamination can be evaluated with a certain degree of probability. A so-called "intervention level" was established, according to which testing of dioxins and diox-in-like substances should be conducted in all food samples in which the total content of all seven indicative congeners is higher than 0.1 mg/kg fat. The samples of female pikeperch gonads tested in the current study showed a Σ PCBs content ranging from 0.309 to 1.73 mg/kg fat. This means that all the samples should be qualified for testing the levels of dioxins and furans.

It is well known that organochlorine compounds, especially PCBs and dioxins, disrupt the reproductive systems of both humans and animals and result in a lesser ability to procreate by damaging newly forming cells, lowering immunological responses, and negatively impacting developing fetuses [6, 7]. It follows that accumulated organochlorine compounds in the gonads of pikeperch could have a negative impact on the reproduction of this species as well as on the condition of its young. The data given in Table 4 (after disregarding the two extreme values of Σ PCBs from the Curonian Lagoon) indicate that the highest average level of Σ PCBs was observed in the gonads of females from the Vistula Lagoon (1.017 mg/kg fat), followed by those from the Szczecin Lagoon (0.8306 mg/kg fat). In the Curonian Lagoon, the average level was only 0.4791 mg/kg fat; this was still, however, almost five-fold higher that the proposed "intervention level". It is not known to what extent exceeding this limit is harmful to fish.

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