Persistent organic contaminants in Arctic char (Salvelinus alpinus) on Bear Island

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Introduction

Considerable attention has been focused on atmospheric input and transfer of persistent organic contaminants between trophic levels of marine food chains. Due to different possible pathways in marine areas, freshwater systems are more suitable for identification of the sources and pathways of the contamination. However, information on these pollutants in freshwater systems is more limited.

This paper reports the first data on concentrations of chlorinated organic pesticides and PCBs in Arctic char (Salvelinus alpinus) from the lakes Ellasjøen and Øyangen on Bear Island. Lake Ellasjøen is located in the southern part of Bear Island. Part of the catchment area of Lake Ellasjøen consists of relatively steep mountains where large numbers of seabirds nest. Lake Øyangen is located on the midle part of the island , in a flat and rocky landscape (figure 1).

The Arctic char are top predators in the freshwater systems on the island.

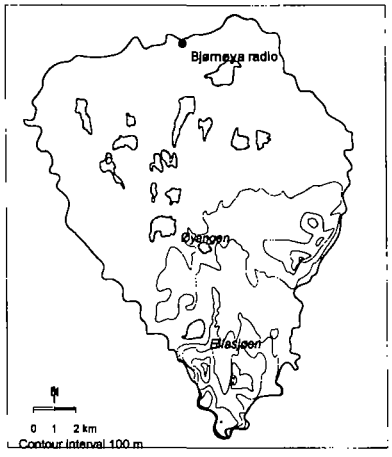

Figure 1: Bear Island with Lake Øyangen and Lake Ellasjøen.

Materials and methods

Sample collection and treatment

Arctic char were collected using gill nets and the following parameters were recorded in the field: fish length (fork length), weight, sex and stage of gonad development. The age of the fish was determined in the laboratory by counting age rings in otoliths. Samples for analysis of PCBs were taken from the dorsal axial muscle (approximately 20 g wet weight). Specially cleaned equipment and vials were used for sample preparation and storage. Samples were frozen (-18 °C) until analysis. Organic contaminants were analyzed in muscle samples from individuals, but samples from some of the smallest fish were pooled to get enough material for analysis. Pooled samples were taken from fish of the same size, sex and stage of maturity.

Analytical methods

About 1 to 15 g of fish sample was homogenized with sodium sulfate. The mixture was filled into a glass column and an internal standard mixture containing ^{13}C-labeled HCB, HCHs, DDE and PCBs was added on top of the column. The lipophilic compounds were eluted by a slow flow of cyclohexane. Lipids were removed by gel permeation chromatography (GPC) on 50 g Biobeads SX-3 with cyclohexane/ethylacetate (50/50). The POP fraction was cleaned additionally on 30 g alumina with the following mobile phase: n-hexane and n-hexane/methyl-t-butyl ether (MTBE) (50/50). Before quantification 1,2,3,4-tetrachloronaphthalene was added as recovery standard.

6 DDT compounds and 33 PCB congeners together with the sum of all tri- to decachlorinated PCBs were determined by HRGC combined with high resolution mass spectrometry (HRMS) using a VG AutoSpec (res > 10000). The separation of the DDT group was performed on a 25 m x 0.2 mm x 0,33 µm HP Ultra 12 GC column (Temperature program, 60 °C, 2 min, 20 °C/min to 270 °C and 4 min isothermal). The separation of the PCB congeners was done on a 50 m x 0.22 mm x 0,15 µm SGE HT8 GC column (Temperature program: 90 °C, 1.3 min, 25 °C/min to 170 °C, and 3 °C/min to 300 °C, 3 min isothermal). Toxaphene Parlar no. 26 and 50 were quantified using HRGC combined with low-resolution negative ion chemical ionization mass spectrometry (MS-NICI) on a HP 5989A GC/MS. The separation was done on a 25 m x 0.2 mm x 0,11 µm HP Ultra 2 GC column (Temperature program: 60 °C, 2 min, 20 °C/min to 150 °C, and 4 °C/min to 280 °C, 10 min isothermal).

A rigorous quality control concept based on the requirements in the European quality norm EN 45001 was applied.

Results and Discussion

The concentrations of ΣPCB (sum of tri- to decachlorinated compounds), ΣDDT (sum of 6 compounds DDT), HCB and toxaphene are listed in table 1. ΣPCB was the major contaminant and was generally present at levels more than 10-fold higher than the other compounds analyzed

Table 1: Concentrations of persistent organic contaminants in Arctic char (Salvelinus alpinus) from Lake Ellasjøen and Lake Øyangen on Bear Island

Lake/ Parameter	Average weight (g)	% lipid	HCB (ng/g w.w.)	SUM PCB (ng/g w.w.)	Sum DDT (ng/g w.w.)	Sum toxafen (ng/g w.w.)
Ellasjøen	560	1,39	0,69	354	28,5	4,83
Ellasjøen	910	2,05	0,85	1 338	97,7	4,79
Ellasjøen	840	1,73	0,83	905	70,2	8,88
Ellasjøen	3 051	4,83	3,29	5 325	429	36,9
Ellasjøen	296	0,55	0,70	218	22,0	16,4
Ellasjøen	172	0,85	0,41	133	10,9	1,45
Ellasjøen	425	0,87	0,52	174	16,9	3,65
Ellasjøen	977	2,14	1,06	795	76,8	14,6
Ellasjøen	622	0,71	0,29	149	12,5	1,53
Ellasjøen	1 030	0,94	0,52	778	53,1	1,00
Ellasjøen	2 410	1,54	0,60	749	64,1	5,51
Ellasjøen	1 226	1,95	0,76	1 010	73,5	8,05
Ellasjøen	855	2,50	0,90	557	43,6	7,40
Ellasjøen	775	3,41	1,38	374	35,8	5,75
Ellasjøen	15,0	2,00	1,31	492	45,6	6,81
Ellasjøen	14,0	3,37	1,63	471	47,7	10,4
Ellasjøen	146	1,41	0,82	322	30,7	8,71
Ellasjøen	71,0	3,46	1,62	435	47,9	8,00
Ellasjøen	86,0	0,82	0,49	109	9,63	2,08
Ellasjøen	99,0	2,33	0,62	233	20,0	4,29
Ellasjøen	105	0,52	0,36	117	10,3	3,82
Ellasjøen	111	0,68	0,40	92,6	8,37	2,41
Ellasjøen	126	1,24	0,60	193	20,4	6,28
Ellasjøen	48,0	5,42	2,25	676	73,0	7,05
Ellasjøen	68,0	5,88	2,49	1 156	119	22,7
Average			1,01	686	58,7	8,13
StDEV			0,55	525	42,7	4,94
Øyangen	853	0,68	0,27	18,7	1,80	0,62
Øyangen	959	0,80	0,20	8,95	0,80	0,27
Øyangen	718	1,09	0,23	10,0	0,82	0,25
Øyangen	832	1,44	0,44	76,2	5,16	1,02
Øyangen	1 600	0,34	0,11	63,4	3,59	0,38
Øyangen	804	1,47	0,25	15,0	1,40	3,13
Øyangen	1 023	1,40	0,40	21,5	1,74	0,45
Øyangen	652	3,76	1,06	119	7,62	3,20
Øyangen	10,0	3,20	0,95	79,4	6,23	2,50
Øyangen	10,0	3,31	1,00	133	9,89	4,24
Øyangen	2 648	2,32	0,68	27,8	2,81	0,82
Øyangen	1 284	2,47	0,96	40,5	2,95	1,23
Average			0,55	51,1	3,73	1,51
StDEV			0,32	35,9	2,33	1,17

Sum PCB: Sum of all tri- to decachlorinated congeners; Sum DDT: Sum of o,p' and p,p'-DDD, DDE and DDT; Sum Tox: Sum of Toxaphene Parlar no 26 and 50.

The results from this study show that Arctic char from Lake Ellasjøen has one of the highest muscle concentrations of PCBs observed so far in remote Arctic areas. The average concentration (±S.D) of ΣPCBs in the Arctic char from Lake Ellasjøen was 686 ± 525 ng/g w.w. A remote Canadian lake which is known for high concentrations of organochlorines is Lake Laberge. The average concentration (± S.D.) of ΣPCB in male lake trout was 1177 ± 1219 ng/g w.w. and 14300 ± 21760 ng/g lipid (1). Arctic char from three remote lakes in the Northwest Territories in Canada had average ΣPCB (90 congeners) concentrations of 7.3 ± 1.8, 71.0 ± 48.6 and 289 ± 118 ng/g w.w. in respectively Buchanan Lake, Amituk Lake and Char Lake (1). These levels are on the same level or higher than the levels found in fish from Lake Øyangen, but far lower than the levels found in Lake Ellasjøen.

Because the lakes Ellasjøen and Øyangen are remote and far from point sources, the presence of organochlorines in the two freshwater systems on the island suggests that the main source of contamination to this area is atmospheric. Long-range atmospheric transport of organochlorines have been documented in a number of studies. (2,3,4,5). Due to temperature differences and specific meteorological conditions between source areas and the Arctic, the Norwegian Arctic is a very important deposition area for semi-volatile persistent organic pollutants. As proven in previous investigations on high-volume ambient air samples in 1982-84, Bear Island belongs to the main deposition areas in the Norwegian Artic, beside the Svalbard region (6).

Explanations for the magnitude of differences between the levels in Arctic char in the two lakes are still to be answered. Dumping of waste containing organochlorines in Lake Ellasjøen can not be excluded but it is not likely. Long range atmospheric transport and locally increased deposition in the catchment area of the lake Ellasjøen, in combination with biological transport via guano from nesting seabirds in the catchment area, are probably the main reasons for the differences between the two lakes.

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