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PCB and pesticide distribution in cod (*Gadus morhua*), sea trout (*Salmo trutta*) and Arctic charr (*Salvelinus alpinus*) from the Norwegian Arctic

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Abstract

Cod (*Gadus morhua*), sea trout (*Salmo trutta*) and Arctic charr (*Salvelinus alpinus*) from the Norwegian Arctic were analyzed for 25 polychlorinated biphenyl (PCB) congeners, hexachlorobenzene (HCB) as well as persistent pesticides. In cod an average sum PCB concentration (PCB 28, 52, 101, 138, 153, 180) of 0.81 ng/g ww (wet weight) and 1.76 ng/g ww were detected for muscle and gonads respectively, whereas the average PCB concentration for cod liver was 240 ng/g ww. However, the differences in sum PCB levels between the tissue types diminished considerably when data were normalized to the extractable organic matter (EOM) content (479 ng/g EOM in muscle, 216 ng/g EOM in gonads and 622 ng/g EOM in liver). The minor differences in the PCB congener distribution between the three organ types analyzed, possibly reflects unlike physiological functions. The results demonstrates the importance of the lipid content as parameter for the comparison of contaminants between unlike tissue types and species.

The PCB concentration in viscera fat and muscle tissue in sea trout were found to be substantially lower compared to cod. An average sum PCB concentrations of 32 ng/g EOM in muscle and 63 ng/g EOM for the viscera samples were found. No evidence for tissue specific differences in congener distribution was observed. Comparable levels were found for Arctic charr from the same area, while charr from Svalbard were slightly more contaminated. The differences in body burden between cod, sea trout and Arctic charr possibly reflects unlike trophic levels, life cycles and feeding habits.

Hexachlorocyclohexanes (HCHs) and *trans-/cis*-chlordane, *trans-/cis*-nonchlor, dieldrin, aldrin and endrin were also analyzed in sea trout and Arctic charr muscle. In general, the pesticide concentrations were far below the PCB levels, and the most abundant one was β-HCH with an average concentration of 844 pg/g EOM in both species.

Introduction

During the last decade several research projects have proven that the Arctic ecosystem is very sensitive towards antropogenic pollutants. Trace analytical investigations in the Arctic environment revealed high concentration levels of persistent organic pollutants (POPs) such as

polychlorinated biphenyls (PCBs), hexachlorocyclohexane isomers (HCHs) and other chlorinated compounds. High POP concentrations in seals, sea birds, polar bears, but also in Canadian Inuits have lead to major concern about the effect of contaminants in pristine areas. Atmospheric long-rang transport is considered as the main sources for the high POP concentrations[1,2] in the Arctic. The bioaccumulation and magnification processes in the Arctic food web lead to concentration levels[5] which are suspected to have toxic effects in polar bears and humans[3,4]. Some aspects of the influences of various parameters on accumulation of selected POPs will be discussed in the following.

Experimental Methods

Samples of cod (*Gadus morhua*) (n=5), sea trout (*Salmo trutta*) (n=2) and anadromous Arctic charr (*Salvelinus alpinus*) (n=4) were collected at different sites in the northern part of the Norwegian mainland and Svalbard, and stored at -30°C until analysis. About 0.5 g of each tissue sample was homogenized with 4-5 fold of sodium sulfate. The homogenate was filled into a glass column (40 cm x 3 cm ID) for extraction and a ^{13}C-marked internal standard was added. The present POPs were extracted by a slow flow of 100 ml cyclohexane (0.5 ml/min). Further clean-up was carried out by gel permeation chromatography using a column (30 cm x 2.5 cm ID) filled with Bio Beads SX-3 and cyclohexane/ethyl acetate (1:1) as mobile phase. All analyzed POPs were collected in one fraction and concentrated to 0.5 ml. Quantification was performed using a capillary gas chromatograph connected either to a high resolution mass spectrometer (GC-HRMS) in electron impact mode (EI) or to a low resolution mass spectrometer in negative ion chemical ionization mode (NICI). The analyses with both instruments were carried out in selected ion mode (SIM). Extractable organic matter (EOM) is based on hexane extraction. The analytical method used for POP analyses is in accordance with the AMAP quality assurance guidelines and accredited according EU-standard EN 45001.

Results and Discussion

PCB and HCB

Also proven by other investigations[6] the liver being the most important storage and detoxification organ in the cod, tend to accumulate persistent pollutants. The PCB-amount (as sum of PCB 28, 52, 101, 138, 153, 180) were found to be 0.81 (+/- 0.57) ng/g ww (wet weight) and 1.76 (+/- 0.48) ng/g ww in muscle and gonads respectively, whereas the average PCB concentration in cod liver was 240 (+/- 53) ng/g ww. These findings are in accordance with the results presented by Hellou *et al.*, 1993[6] for north-west Atlantic cod, except for the muscle data where no PCB was detected. The PCB content based on extractable organic matter (EOM, in average 0.19 +/- 0.05 % in muscle, 1.11 +/- 0.68 % in gonads and 42.9 +/- 21.0 % in liver) reveals a different picture. The differences between the three tissue types diminished considerably (479 ng/g EOM in muscle, 216 ng/g EOM in gonads and 622 ng/g EOM in liver), and demonstrates the importance of the lipid content as parameter for comparison between unlike samples. The values are relatively high and clearly demonstrates the accumulation of PCB in the ecosystem of the so called pristine arctic areas. However, compared to cod from other locations, the found values are low. The minor differences in the PCB congener

distribution between the three organ types analyzed (Fig. 1), possibly reflects the unlike physiological functions.

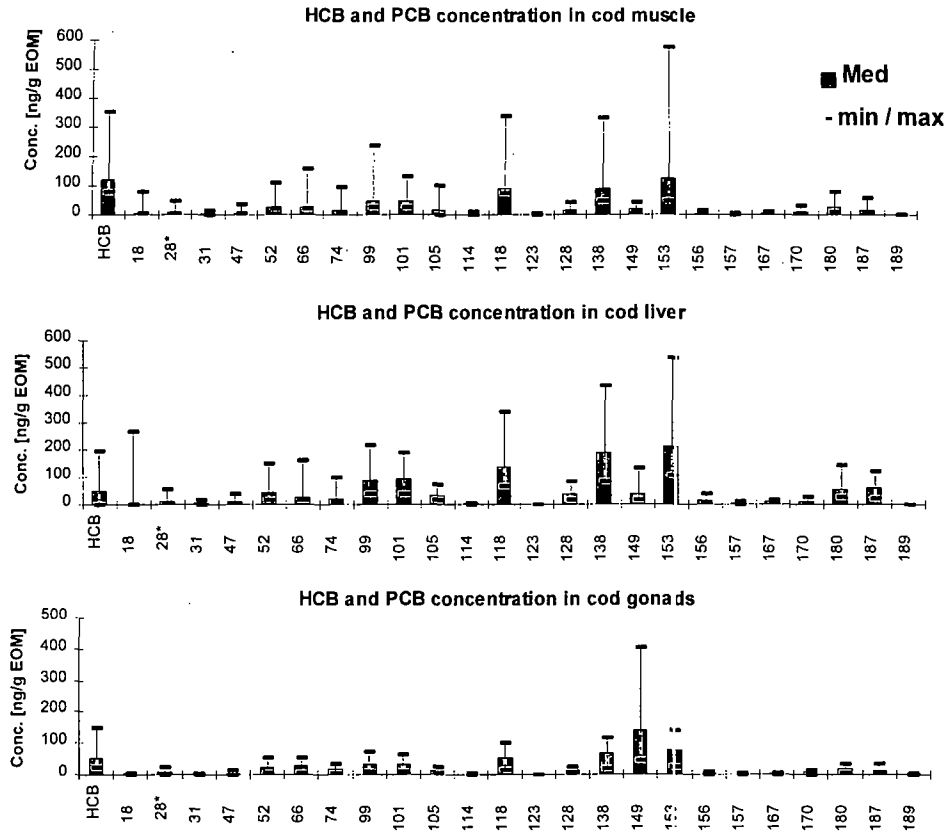

Figure 1: The median distribution of polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB) in different cod tissues (ng/g EOM) (Med = median concentration; Min/max = minimum and maximum concentration).

The PCB concentration in viscera fat and muscle tissue in sea trout were found to be substantially lower compared to cod. An average sum PCB concentrations of 32 ng/g EOM in muscle and 63 ng/g EOM for the viscera samples were found. No evidence for tissue specific differences in congener distribution was observed (Fig. 2). Comparable levels were found for Arctic charr from the same area, with an average sum PCB concentration of 27 ng/g EOM in muscle and 60 ng/g EOM for the viscera samples. Arctic charr from Svalbard were found to be slightly more contaminated. The differences in body burden between cod, sea trout and Arctic charr possibly reflects unlike trophic levels, life cycles and feeding habits.

Hexachlorobenzene (HCB) was present in all samples. As seen for the PCBs, the concentration in cod samples were about 10 times higher than in sea trout and Arctic charr (Fig. 1 and 2). No tissue specific concentration differences were found for HCB.

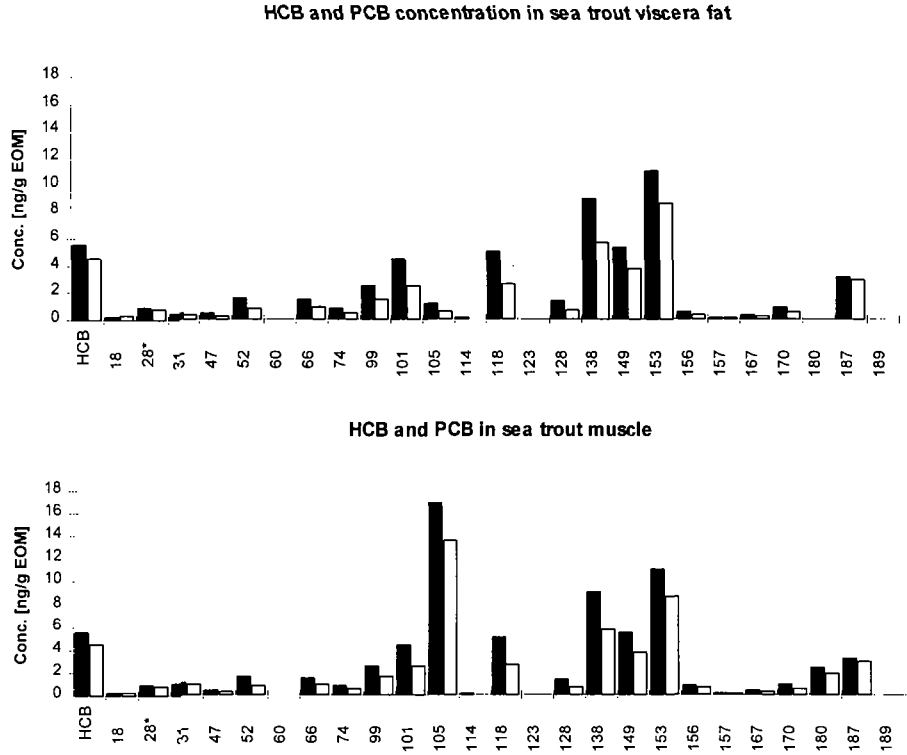

Figure 2: Concentrations (ng/g EOM) of polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB) in muscle and viscera tissues of two selected sea trout.

Chlorinated pesticides

Hexachlorocyclohexanes (HCHs) and *trans-/cis*-chlordane, *trans-/cis*-nonchlor, dieldrin, aldrin, endrin were also analyzed in sea trout and Arctic charr muscle. In general, the pesticide concentrations were comparable in both species analyzed and far below the PCBs levels. The most abundant pesticide was the β-HCH with an average concentration of 844 pg/g EOM (Fig. 3). However, except for the HCH-isomers, no other persistent pesticide exceeds the 100 pg/g EOM median level. The amount of dieldrin and endrin were about 1/10 of the β-HCH concentration. For the chlordane group a dominance of the *trans*-nonachlor isomer was observed (average 49 ng/g EOM). The lowest concentrations were found for chlordene (0.3 pg/g EOM).

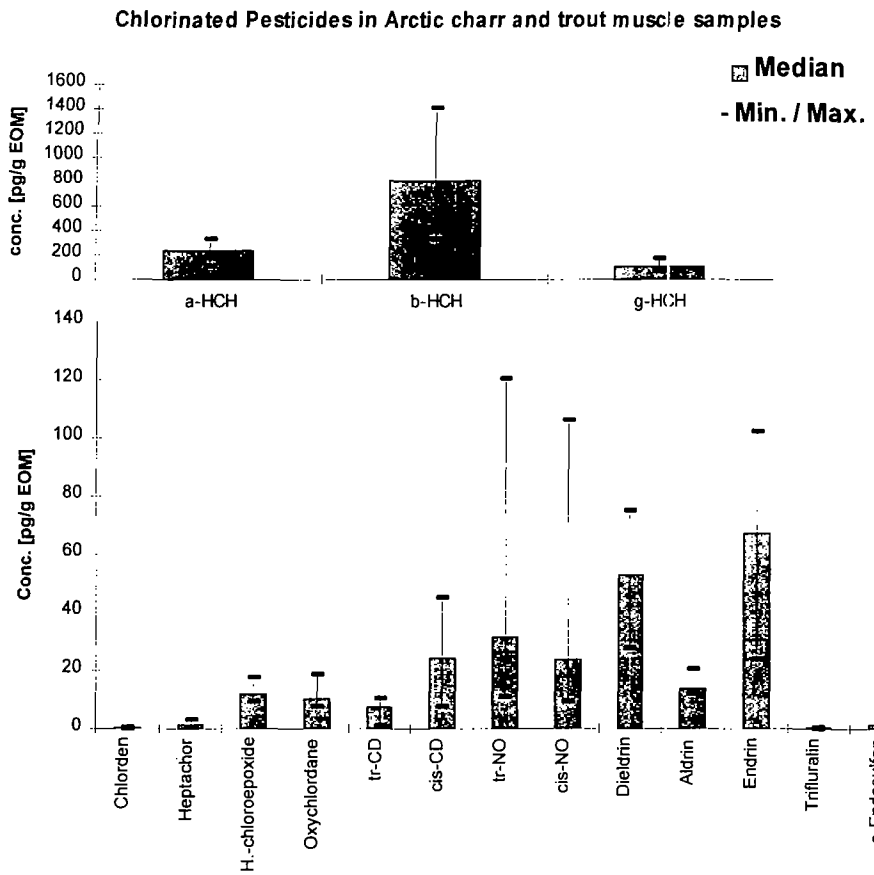

Figure 3: Median distribution (pg/g EOM) of chlorinated pesticides in sea trout and Arctic charr muscle samples (a-, b-, g-HCH = α-, β-, γ-hexachlorocyclohexane; a-Endusulfan = α-Endosulfan; tr-/cis-CD = *trans-/cis*-chlordane; tr-/cis-NO = *trans-/cis-* nonachlor) (Med = median concentration; Min/max = minimum and maximum concentration).

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