International Council for The Exploration of the Sea

CM 2003/M: 06
Theme session M

DDT and PCB concentrations dependency on the biology and domicile of fish: an example of perch (Perca fluviatilis L.) in Estonian coastal sea

Leili Järv: Estonian Marine Institute, University of Tartu, Mäealuse 10A, 10616 Tallinn, Estonia [ph.: 6529714, e-mail: leili@ness.sea.ee], **Ott Roots**: Estonian Environmental Research Centre Ltd. Marja 4D, 10617 Tallinn, Estonia ph.: 6112964, e-mail: ott @klab.envir.ee] and **Mart Simm**: Estonian Marine Institute, University of Tartu, Marja 4D, 10617 Tallinn, Estonia ph.: 6112949 e-mail: mart @klab.envir.ee]

Abstract

The concentration of DDT and PCB in perch of different areas of Estonian coastal sea has been studied since 1998. The concentration of DDT and PCB of immature perch (L<15cm), feeding mostly on plankton and benthic organisms, has been low. During the maturation of perch (L=15-25cm), when the different fish species started to dominate in the ration of perch, the DDT and PCB concentration increased. After the first spawning the DDT and PCB concentration decreased: probably partially excreted during the spawning process. There were observed also differences in concentrations of toxicants in a perch living in different areas of coastal sea.

At present time the contents of toxic chlororganic compounds, analyzed in the Baltic perch of Estonian coastal sea, remain below standards established by FAO/WHO in food, in which case the content of toxicants in the food does not cause symptoms of illness in case of people.

Keywords: perch, maturity, location, DDT, PCB, Baltic Sea

1. Introduction

By the World Health Organization (WHO), monitoring of persistent organic pollutants in animals-derived food, especially fish, should be carried out in all countries to determine possible sources of this contaminant in the diet.

Perch is one of the most abundant fish species in Estonian waters. The Estonian total annual catch (from the sea) in the years 1994-1997 was from 300 to 600 t and has a decreasing trend. The main coastal fishing areas are Matsalu Bay, the Väinameri (Moonsund) Archipelago, and Pärnu Bay in the Gulf of Riga (Järv, 2000).

Some recent data are available concerning the concentrations of toxic chlororganic compounds in Baltic Sea biota. The polychlorinated biphenyls spatial distribution does not reflect any polarization along the north-south axis, but merely the influence of local sources (Olsson, et al., 2002).

Since 1994, the analyses of hazardous substances from Baltic fish are a part of the Estonian National Environmental Monitoring Program. The content DDT and PCB in the perch, living in different areas of Estonian coastal sea, has been studied since 1998.

There are only a few studies (Blomkvist et al, 1993; Olsson et al., 1999; 2000; Valters et al., 1999a; 1999b; Roots, 2001; Roots and Zitko, 2001) on the DDT and PCB concentrations and trends in the perch of Eastern Baltic Sea and our knowledge's are rather limited.

2. Material and methods

Material has been collected from August to December in 1998-2002 from five different areas of Estonian coastal sea: Narva Bay as one of the most industrially polluted sea areas in Estonia; Dirhami in the mouth of the Gulf of Finland; Kihelkonna Bay as one of the cleanest parts of Estonian coastal sea (a good reference area); Matsalu Bay (Moonsund Archipelago Sea) and Pärnu Bay (Gulf of Riga) as the two best spawning and nursery areas of perch in Estonia (Figure 1.).

Altogether 109 perch were analyzed: 13 male and 96 female specimens of perch, in age 1-11 years. The total length and weight were measured (Table 1.) and the fish was sexed and the maturity stage was also estimated.

Table 1.
The average biological parameters of perch analyzed in 1998-2002

Area / Year	Sex,	n	L, mm	W, g	Age	Fat %
Narva Bay, 2000	F	11	242.3	216.5	5.5 (5-6)	0.15
	M	4	246.3	228.7	5.5 (5-6)	0.14
Dirhami, 2001	F	14	221.2	146.3	4.7 (4-6)	1.27
Kihelkonna Bay, 1998	F	4	241.5	171.8	5.5 (5-6)	0.67
	M	6	218.2	115.1	5.0 (4-7)	0.46
Matsalu Bay, 1998, 1999	F	50	212.9	224.0	4.2 (1-11)	0.80
	M	3	267.0	223.1	6.3 (6-7)	0.61
Pärnu Bay, 2000, 2002	F	17	189.3	112.4	3.2 (1-8)	0.61

All organic chlorine toxicants have been analyzed from the muscle tissue. The samples of fish or muscles were frozen immediately after collection. All perch were analysed individually.

Chemicals

All solvents used were of highest quality commercially available; n-hexane, acetone and diethyl ether were obtained from Riedel-de Haen AG (Seelze, Germany) or Fisons Discol Solvent (UK) and methyl-tert-butyl ether (MTBE) from Rathburn Chemical (Walkerburn, Scotland). 2, 3, 4, 5, 3´, 4´, 5´, - heptachlorobiphenyl (IUPAC No 189), were syntesized at the Department of Environmental Chemistry and the author (O. Roots) has obtained this standard as a gift from the Stockholm University Wallenberg Laboratory. Clophen A-50 from Bayer AG (Germany) was used for the quantification of the total PCB.

Contaminant Analysis

The lateral muscle tissue (approx. 10g) from fish were taken for analyze. The samples were homogenized with an IKA T25 homogenizer (Labassco AB, Pertille, Sweden). The samples were extracted and cleaned up according Jensen et al., 1983; Haraguchi et al., 1992; Roots, 1995; 1996; Roots and Talvari, 1999. Internal standard IUPAC 189 was added. The recovery of organic chlorines from the extraction and clean up procedures was measured. PCB and chlororganic pesticides were analyzed by capillary gas-chromatography (Varian 3400/3300) fitted with an electron capture detector (ECD).

The samples were analyzed in the laboratory of Estonian Environmental Research Centre which is accreditated by German Accreditation Bureau (Reg. No DAP-PO3.131-00-97-01).

3. Results and discussion

Toxic pollutants have had a great impact on animals at the tops of food webs, such as the fishes, sea births and seals. Perch is one of the most important species in Estonian coastal fishery and high demanded article on the European markets. The fish should not contain such high concentrations of toxic pollutants that they are harmful as food for top consumers, including human-beings.

3.1. DDT and PCB concentrations dependency on the biology of perch

Perch is a fish who feeds actively around the year (Järv, 2002). In the first summer, when the perch fry is comparatively small, small-size zooplankton, like *Rotator'*s, is important in perch food. In first autumn and winter the benthic animals: *Chironomidae* larvae, *Gammarus spp.* and *Corophium voluntator,* comprised 40-80% of their total food content (Karås, 1987). About 70% of immatured perch food consists from plankton and benthos (Figure 2).
The concentration of DDT and PCB in the immatured perch (in maturity stage I and II) is low (Figure 3).

In Estonian coastal waters two to four years' old perch becomes to mature. During the maturation of perch the different fish species start to dominate in the ration of perch (Figure 2.) and the DDT and PCB concentration increased in perch muscle (Figure 3.). This increase continues until the first spawning. For this time the concentration of DDT and PCB exceeded over 3 times the concentrations in the immatured perch (Figure 3). During the spawning the content of toxicants rapidly decreased. Probably one part of toxicants has been excreted during the spawning process.
As bigger/older the perch growth as more predatory they becomes, but the plankton and benthos still will be very important (altogether about 30%) in they food (Figure 2.).

After every spawning the perch needs time to rest (maturity level VI and II). It lasts about two months, in most cases in July and August, the period depends on the domicile (Järv, 1997). In resting time plankton and benthos together with different kind of fry's are again dominating in perch food. So, the concentration of chlororganic toxicants stays low, but at the same time the content of toxicants is about two times higher than in immatured perches feeding on food with the same composition (Figure 4.). Degreasing water temperature in autumn releases the new development of gonads (maturity level II-III). In the perch ration started to dominate again different kind of fishes and the concentration of DDT and PCB start to increase (Figure 5.).
While analyzing chlororganic toxicants, it is especially important to determine the maturity stage of fish. Comparing the results, it appears that for summary DDT the content of toxicants in fish with maturity level VI-II (perch's organism rests from spawning) is significantly lower than in case of maturity level III and IV. The differences are not so big for PCB.

3.2. DDT and PCB concentrations dependency on the domicile of fish

The active migration area of perch is relatively small, but in the condition of limited food or spawning grounds, the perch can take rather long migrations up to 20-25 km. So, we can take perch populations, which are located geographically by the long distance, like local populations (Järv, 2000). Here we have compared only matured perch in the length L= 20-30cm, which were represented in all five study areas as well.

The highest content of PCB and DDT has been founded in the perch of Narva Bay and Pärnu Bay (Figure 6). Especially high was the content of PCB in Narva Bay. Rather high was the

concentration of DDT in Pärnu Bay, where the difference with perch living in Narva Bay was not very big. In the Gulf of Finland the concentration of both toxicants have a increasing trend from west to east: comparing the concentration of DDT and PCB in the mouth part of the Gulf of Finland (Dirhami) with concentration in the perch living in the eastern part of the gulf (Narva Bay), the content of DDT increase 2.5 and that of PCB 6.5 times. The lowest concentrations of both toxicants have been founded in Kihelkonna Bay (located in the western coast of Saaremaa Iceland), where the content of DDT was 5.5 and of PCB over 16 times lower, comparing with results from Narva Bay (Figure 6.).
Essentially higher was the DDT and PCB concentration in the small coastal lagoons. So, the content of both toxicants was about 5 times higher in Pärnu Bay (north-eastern part of the Gulf of Riga) as in the Kihelkonna Bay. In Matsalu Bay (eastern part of Moonsund Archipelago Sea) the contents of toxicants were lower than in Pärnu Bay about 1.5 times, but of DDT 3 and PCB 4 times higher as in Kihelkonna Bay (Figure 6).

In the food compositions we did not find principally big differences (except some differences in species composition). So, all founded trends should be caused by the differences in local pollution levels.

For each level of seafood consumption, the health risk from marine pollutants varies according to their concentration. On the basis of ADI (the acceptable daily intake) and NOEL (the highest no-observed-effect) even the maximum levels of organ chlorines found in the perch from the Estonian coastal waters do not represent any human health risk, as they are lower than the standards set by WHO.

4. Conclusions

- The concentration of DDT and PCB of immature perch (L<15cm), feeding mostly on plankton and benthic organisms, has been low.
- During the maturation of perch (L=15-25cm), when the different fish species started to dominate in the ration of perch, the DDT and PCB concentration increased.
- After the first spawning the DDT and PCB concentrations decreased: probably partially excreted during the spawning process.
- The DDT content in the fish, with maturity level VI-II, is significantly lower than in case of maturity level III and IV. The differences are not so big for PCB.
- In the Gulf of Finland the content of DDT and PCB in perch muscle have increasing trend towards the east side.
- The concentration of DDT and PCB in perch from small coastal lagoons (Pärnu Bay, Matsalu Bay) is higher than in reference area (Kihelkonna Bay)
- The content of toxic chlororganic compounds in the perch of Estonian coastal sea, remain below standards established by FAO/WHO in food and does not cause symptoms of illness in case of people.

5. Acknowledgement

The project was financially supported both by the Ministry of Environment and the Estonian Governmental Programme No. 0182578s03.

6. References

Agrell, C., Larsson, P., Okla, L., Bremle, G., Johansson, N., Klavins, M., Roots,O. and

Zelechowska, A. 2001.Atmospheric and river input of PCBs, DDTs and HCHs to the Baltic Sea. In A System Analysis of the Baltic Sea (Eds. F.V. Wulff, L.A. Rahm and P. Larsson), Ecological Studies, Springer Verlag, vol. 148,149-175.

Blomkvist, G., Jensen, S. and Olsson, M. 1993. Concentrations of organochlorines in perch (Perca fluviatilis) sampled in coastal areas of the Baltic Republics. Swedish Museum of Natural History. 10.09.1993, 11p. Mimeorg.

Haraguchi, K., Athanasiadou, M., Bergman, A., Hovander, L. and Jensen, S. 1992. PCB and PCB methyl sulfones groups of seals from the Swedish waters. AMBIO, 21, 546-549.

Jensen, S., Reuthergardh, L. and Jansson, B. 1983. Analytical methods for measuring organochlorines and methyl mercury by gas chromatography. Analysis of metals and organochlorines in fish. FAO Fish Tech. Paper, Rome, vol.212, 21-33.

Järv, L., 2000. Migrations of the perch (*Perca fluviatilis* L.) in the coastal waters of western Estonia.in Proceedings of the Estonian Academy of Sciences. Biology, ecology, vol. 49, 3, 270-276.

Järv, L., 2002. The non-professional fishery as one of the source of unaccounted fishing mortality: an example of perch (Perca fluviatilis L.) fishery in Estonian coastal sea. ICES CM 2002 (Paper). Session code: V09. Mimeorg.

Karås, P., 1987. Food consumption, growth and recruitment in perch (*Perca fluviatilis* L.) Doctoral dissertation, Uppsala, Sweden.

Olsson, A., Vitinsh, M., Plikshs, M. and Bergman, A., 1999.Halogenated environmental contaminants in perch (Perca fluviatilis) from Latvian coastal areas. The Science of the Total Environment 239,19-30.

Olsson, M., Bignert, A., Aune, M., Haarich, M., Harms, U., Korhonen, M., Poutanen, E.L., Roots, O. and Sapota, G. 2002. Organic contaminants. In: Environment of the Baltic Sea area 1994-1998. HELCOM. Balti Sea Env. Proc. No.82B, 133-140.

Olsson, M., Valters, K. and Burreau, S. 2000. Concentrations of organochlorine substances in relation to fish size and trophic position: a study on perch (*Perca fluviatilis* L.). Environmental Science & Technology, vol. 34, 4878 – 4886.

Roots, O.,1995. Organochlorine pesticides and polychlorinated biphenyls in the ecosystem of the Baltic Sea. Chemosphere 31, 4085-4097.

Roots, O., 1996. Toxic chlororganic compounds in the ecosystem of the Baltic Sea, Tallinn, 44p. (ISBN 9985-9072-0-5).

Roots, O. and Talvari, A., 1999. Bioaccumulation of toxic organic compounds and their isomers into the organism of seals in West-Estonian Archipelago Biophere Reserve. Environmental Monitoring and Assessment, Kluwer Academic Publishers, 54, 301-312.

Roots, O. 2001. Halogenated environmental contaminants in fish from Estonian coastal areas. Chemosphere, Elsevier Science Ltd., 43, 4-7, 623-632.

Roots, O. and Zitko, V. 2001. PCB and organochlorine pesticides in perch from Baltic Sea. The Chemistry Preprint Server, CPS:envchem/0105001, 16p. (http://www.chemweb.com).

Valters, K., Olsson, A., Asplund, L. and Bergman, Å. 1999a. Polychlorinated biphenyls and some pesticides in perch (*Perca fluviatilis*) from inland waters of Latvia. Chemosphere, 38, 2053 – 2064.

Valters, K., Olsson, A., Vitinsh, M. and Bergman, Å. 1999b. Contamination sources in Latvia: levels of organochlorines in perch (*Perca fluviatilis*) from rivers Daugava and Lielupe. AMBIO, 28, 335 - 340.

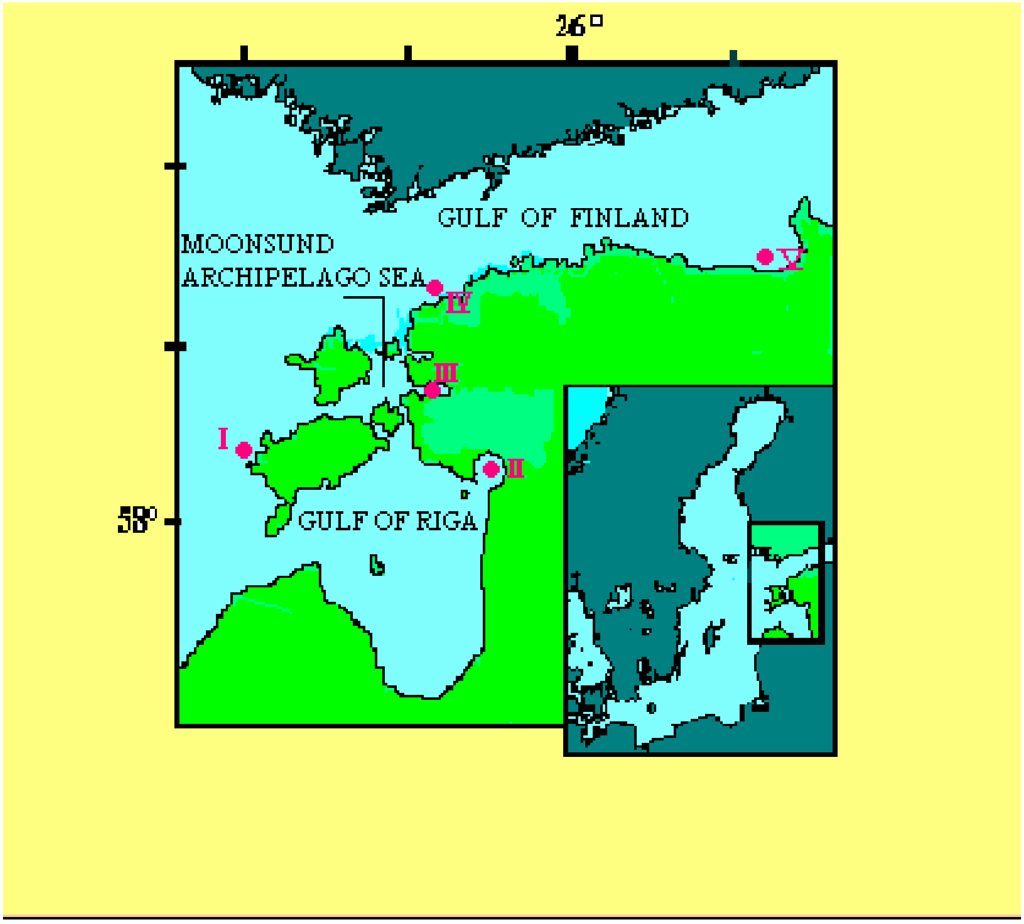

Figure 1. Study area: I Kihelkonna Bay, II Pärnu Bay, III Matsalu Bay, IV Dirhami, V Narva Bay

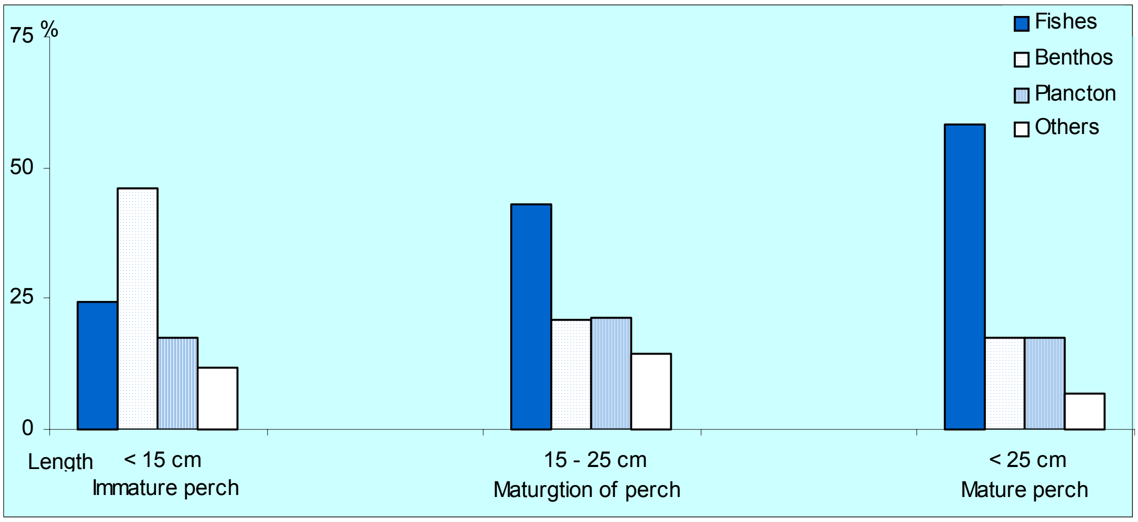

Figure 2. The food composition in different length groups of perch.

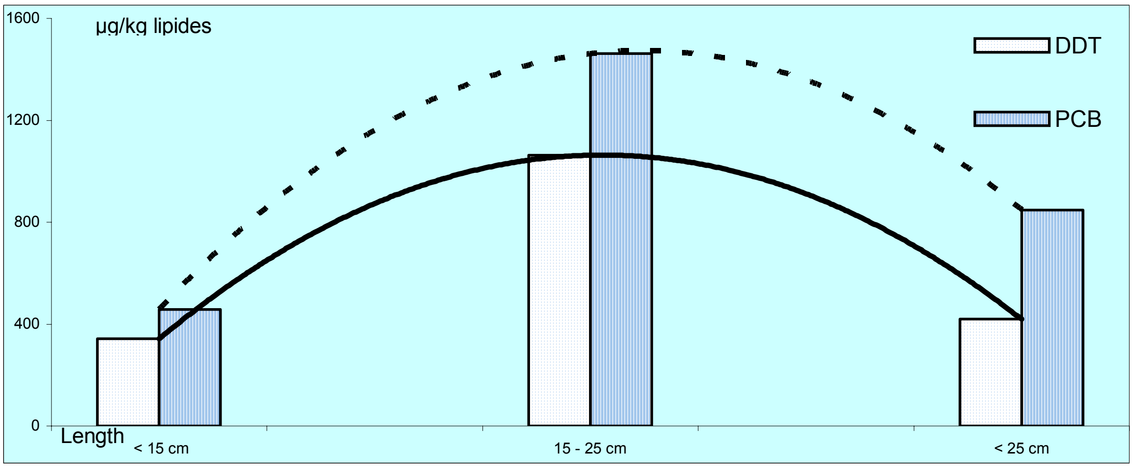

Figure 3. The average concentration of toxicants in different length groups of perch.

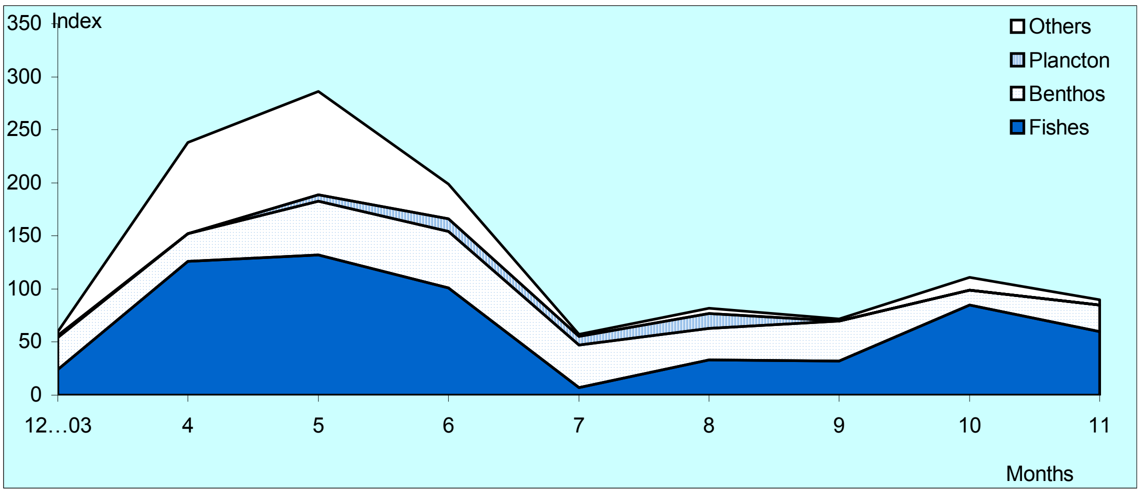

Figure 4. Seasonal changes in the food composition of perch

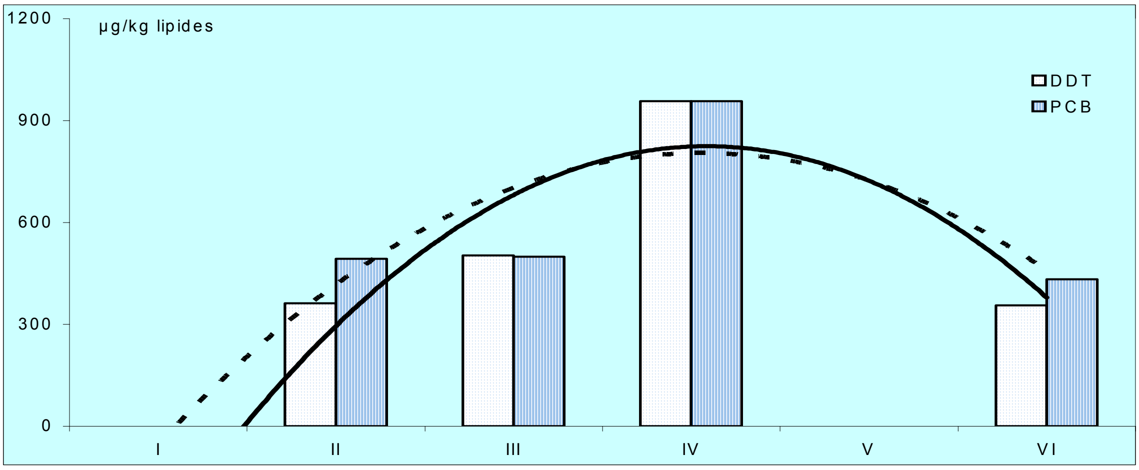

Figure 5. The average content of toxicants in different maturity levels of perch

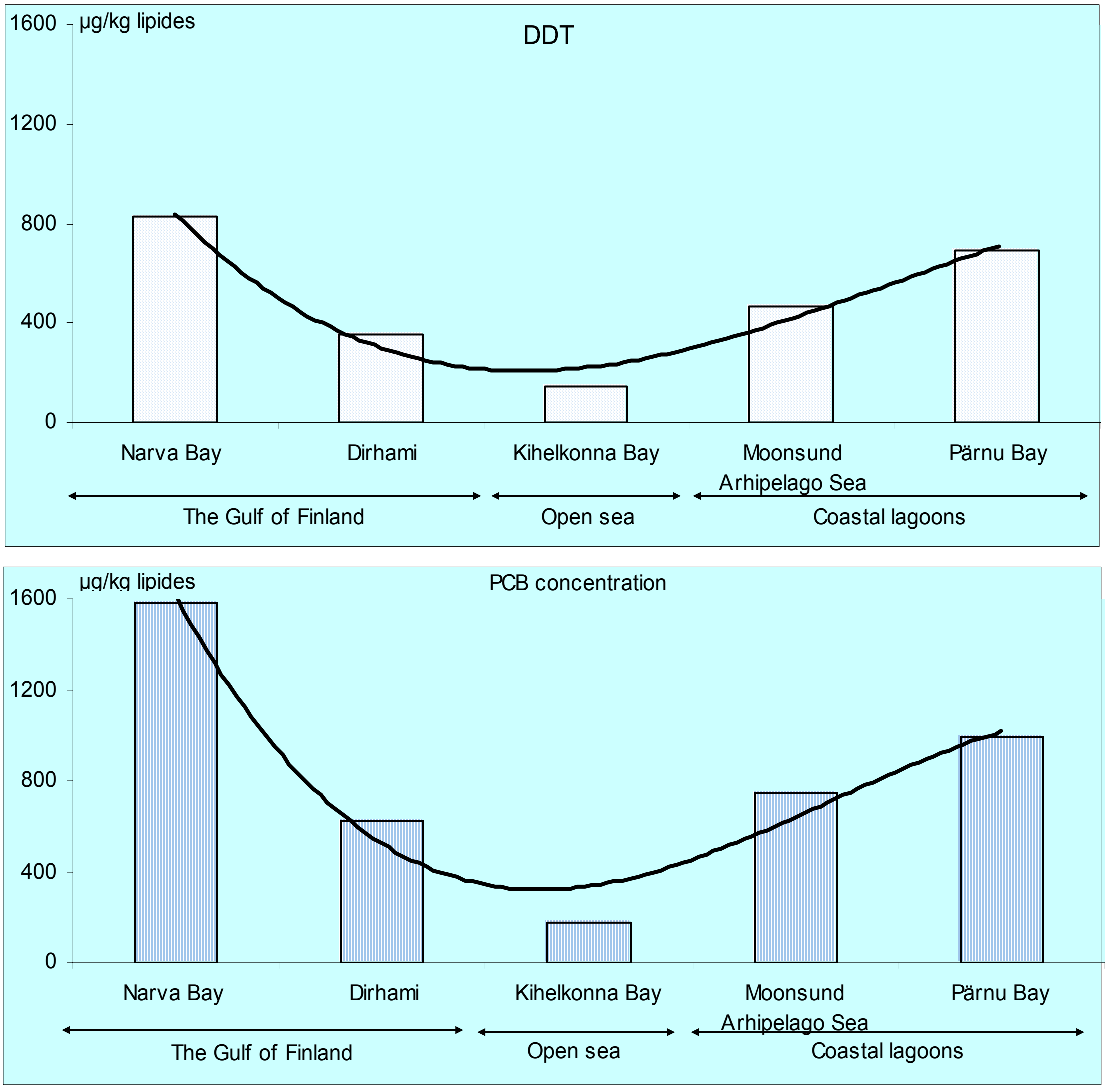

Figure 6. Spatial differences in the content of DDTs and PCBs in the perch