



## **Contaminants in fish from potentially polluted sites along the Swedish coast with the national monitoring programme as reference**

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## Summary

In this report, fish from potentially polluted sites along the coast of Sweden were analysed for several contaminants and when possible also compared with concentrations in fish from reference sites used within the national monitoring programme for contaminants in marine biota. However, it is important to have in mind that for the polluted sites, sampling has only been carried one single year and only two pooled samples were analysed from each site, which could have effects on the representativeness and the uncertainty of the results. Generally, perch and herring from Lilla Värtan had the highest concentrations of mercury, lead, nickel, silver, CB-153 and CB-118, DDE, dioxins, brominated flame retardants, perfluorinated chemicals, chlorinated paraffins and organotin compounds compared to the other polluted sites. Among the stations where eelpout and cod were sampled, Rivöfjord had highest concentration of several contaminants. The contaminants include mercury, lead, chromium, CB-153 and CB-118, dioxins, brominated flame retardants, perfluorinated chemicals, chlorinated paraffins and organotin compounds. It is not very surprising that these two areas show the highest concentrations of several of the investigated contaminants in fish. Lilla Värtan is situated in Stockholm and hence is affected by the big city, in addition, heavy boat traffic of different kinds are taking place in this water along with several other harmful environmental activities in this area. SCCP showed the highest concentrations in herring from Lilla Värtan, while perch on the contrary had the lowest concentration of SCCP among all of the perch sites. This is however difficult to explain. Rivö fjord is situated just outside Gothenburg city and is thus affected by activities in the city. Also, the main part of Gothenburg's harbor activities takes place close by Rivö fjord. Moreover, Ryaverken, which is a sewage treatment plant, and two refineries are also affecting the water. Thus, the two largest cities in Sweden contribute with a cocktail of contaminants to its surrounding waters. In addition, fish from Skelleftebukten, herring and/or perch, had elevated concentrations of lead, cadmium, nickel, copper, HCB and BDE-47 and -154. The elevated concentrations of different metals in this area could be caused by Rönnskärsverken, which releases metals. In addition, there are several industries and mining practices in the area that could have contributed with high metal levels. Furthermore, dismantlement activities might contribute with the high levels of brominated flame retardants found in this area. Kungsbackafjorden, on the Swedish west coast, had high concentrations of cadmium and copper in cod and high concentrations of perfluorinated chemicals in both eelpout and cod. There is a sewage treatment plant in the area, which might be one explanation for elevated concentrations of perfluorinated chemicals.

Most of the other selected polluted sites for this study had none or just a few contaminants that differed from the reference sites in the vicinity. Thus it seems that these sites might not be as burdened by local sources of the investigated substances as has been assumed. On the other hand, when comparing the concentrations with their target values, a few of the contaminants at these sites were above the target values, this included mercury, CB-118, PBDEs and TBT. However, the concentrations were not significantly different from reference values, which indicates a more widespread problem concerning these contaminants.

When comparing contaminant concentrations with their respective target value, mercury concentrations exceeded the target value for all species at all sites except for herring from Örnsköldsviksfjärden. Lead was below the target value at all sites and cadmium was also below at all sites except for perch from Skelleftebukten, which exceeded the target value.



CB-153 was in general below the target value, but cod from Rivö fjord and perch from Lilla Värtan exceeded it. In contrast, most polluted sites were above the target value for CB-118 with a few exceptions. Concentrations of DDE were generally below the target value, however perch and herring from Lilla Värtan exceeded it and concentrations of DDE in cod liver were also above, while the concentration in cod muscle were below target value. HCHs, HCB, dioxins, PFOS and HBCDD were below target values for all species at all sites. PBDEs on the other hand exceed the target value for all species at all sites. Concentrations of the priority substances, DEHP (Di-(2-ethylhexyl)-phthalate), HCBd (Hexachlorobutadiene), and PeCB (Pentachlorobenzene) were below the target values, these compounds were even below LOQ at most sites. SCCP (short-chained chlorinated paraffins) were well below the target level for all species at all sites. TBT on the other hand, were in perch above the target value at all sites except at Inre Slätbaken and Skelleftebukten. Yttre fjärden and Lilla Värtan had the highest concentrations of TBT and here the target value was also exceeded in herring. Eelpout and cod had concentrations of TBT below the target value.

In conclusion, Lilla Värtan seems to be the site with the highest concentrations of several contaminants and also where several of these exceed the target values. Rivö fjord and Skelleftebukten also had higher concentrations of several contaminants compared to the other polluted sites.

# 1 Introduction

Within this project metals and organic contaminants in fish from 10 different **potentially polluted** areas around the coast of Sweden were analysed, from here on referred to as **polluted** sites. These areas were identified during a measuring campaign in 2011 and the survey will give basic data for the follow-up of the environmental objectives *A Non-Toxic Environment* and *A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos*. The survey also acts as a complement to the Swedish national marine monitoring of contaminants in biota, where more pristine areas are used (reference sites). The aim of the project was to compare the concentrations at the polluted sites with the concentrations at the reference sites in order to examine if the levels at the polluted sites were significantly higher than at the reference sites.

## 1.1 Sampling sites

Fish was sampled from 10 different areas along the coastline of Sweden identified during a measuring campaign in 2011. The Swedish maritime Administration was required to do a study of contaminant analysis in perch from Bråviken 2011 to monitor the possible impact of dredging activities in the area. This data is also included in the analysis. (Figure 1.1, Table 1.1) The information below of the 10 polluted sites is acquired from a report by the Water Authorities 2012.

**Skelleftebukten (1, Figure 1.1):** This bay is subjected to several types of human activities. Rönnskärsverken contribute with current emissions of dioxins and different kinds of metals and the historical load of contaminants has also been high. Moreover, Skellefteälv, which runs along the city of Skellefteå and several current and disused industries and mines, enters the bay, and can contribute to elevated concentrations of metals and organic contaminants. In addition, other activities, such as fragmentation of scrap metal (emission from flame retardants), harbour activities (TBT pollution), and oil dumping sites are taking place in the area.

**Örnsköldsviksfjärden (2, Figure 1.1):** This area is subjected to eutrophication some part of the year and it is therefore classified as risk 1 according to MIFO (methodology for inventory of polluted areas) classification. In the area, there are also one marina, three industry harbours, conurbations and holiday houses.

**Yttre Fjärden (3, Figure 1.1):** This narrow coastal inlet is situated outside Gävle that has one of Sweden's largest harbours. Also, this area is affected by nutrient input from Gävleån, emissions from Gävle city, Korsnäs (pulp and paper industry) and local sewage treatment plants. High concentrations of cadmium, chromium, copper and lead has been found in the sediment. According to the county administrative board, there might also be a risk of impacts from OTCs (Organotin compounds), PCBs, zink, petroleum products, and solvents.

**Östhammarsfjärden (4, Figure 1.1):** This area has bad ecological status according to the classification by the county administrative board. The area is affected by the Östhammar community, marina, holiday houses, dredging, and small boat traffic.

**Lilla Värtan (5, Figure 1.1):** This area is situated in Stockholm. The water is affected by the largest concentration of people in Sweden but also due to shipping traffic in terms of ferry boats, skerry boats and small boat traffic. There are also several potential environmentally harmful activities in the area.

**Inre Slätbaken (6, Figure 1.1):** This area has bad ecological status according to the classification by the county administrative board. Water circulation in this narrow coastal inlet is bad and hence high nutrient levels (nitrogen and phosphorous), bad secchi depth, and high chlorophyll levels are sometimes measured in the water. Some parts of the area have low oxygen levels in the bottom waters.

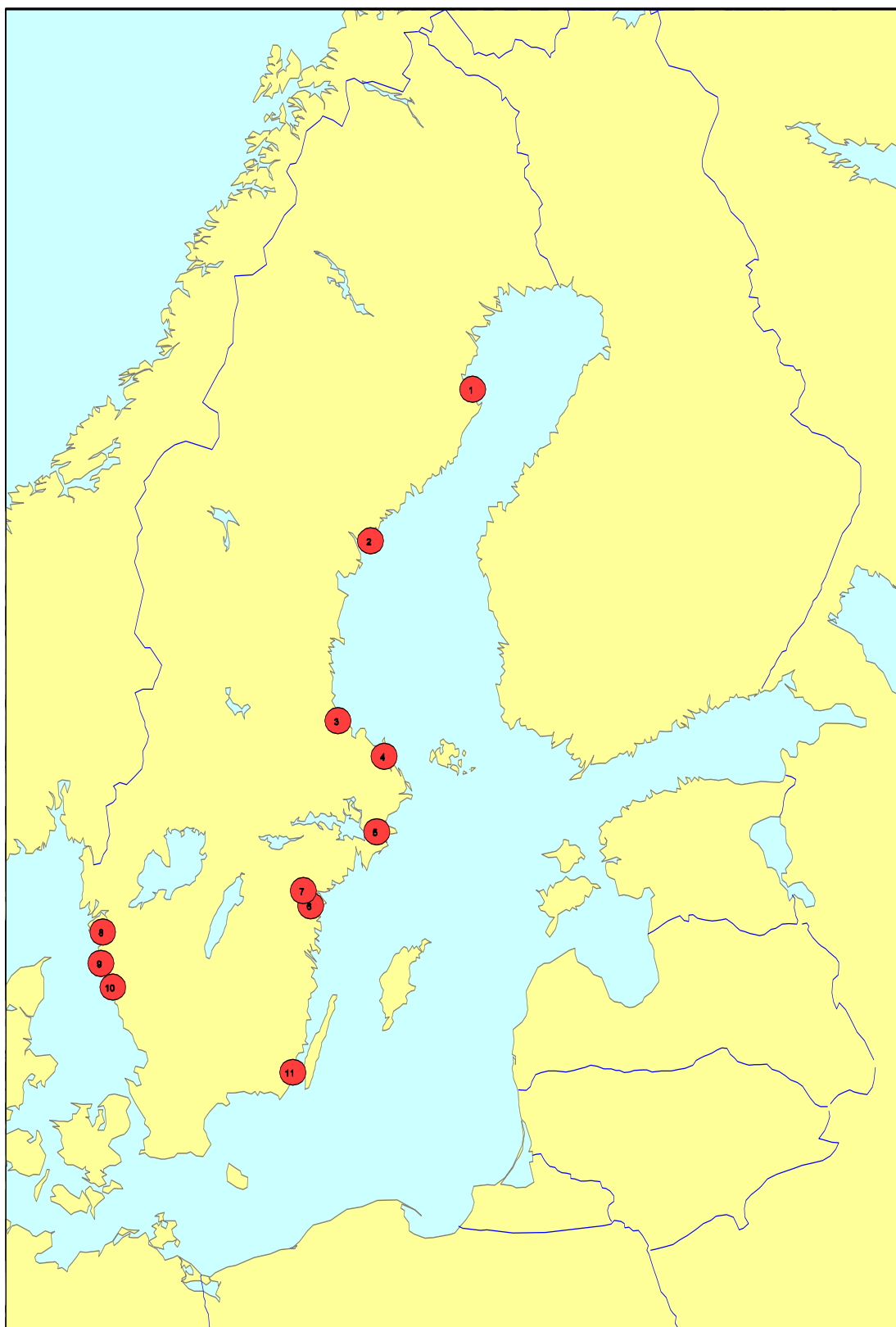
**Bråviken (7, Figure 1.1):** Three stations included in a study made by the Swedish maritime Administration 2011. The stations are located in the inner parts of Bråviken with impact from harbour activities, industries and contaminated land, but also with contribution from stormwater from Norrköping and the rivermouth of Motala river, with a large drainage basin.

**Askeröfjorden and Halsefjorden (8, Figure 1.1):** In this area, two refineries are situated and Stenungssund, which is located close by, is estimated as one of the most affected areas on the Swedish west coast.

**Rivö fjord (9, Figure 1.1):** This is the first water district outside Göta älv. The main part of Gothenburg's harbour activities is taking place in this area, Ryaverket, a large sewage treatment plant, and two refineries are also affecting the water. In addition, this narrow coastal inlet is affected by Gothenburg city.

**Kungsbackafjorden (10, Figure 1.1):** This narrow coastal inlet is mainly affected by eutrophication where Kungsbackaån and Rolfsån are the main contributors, but also the sewage treatment plant in Kungsbacka is affecting the inner parts of the water.

**Torsås (11, Figure 1.1):** This area has been chosen to act as an unpolluted area. This is a part of the coastline that is lacking a continuous monitoring program today.



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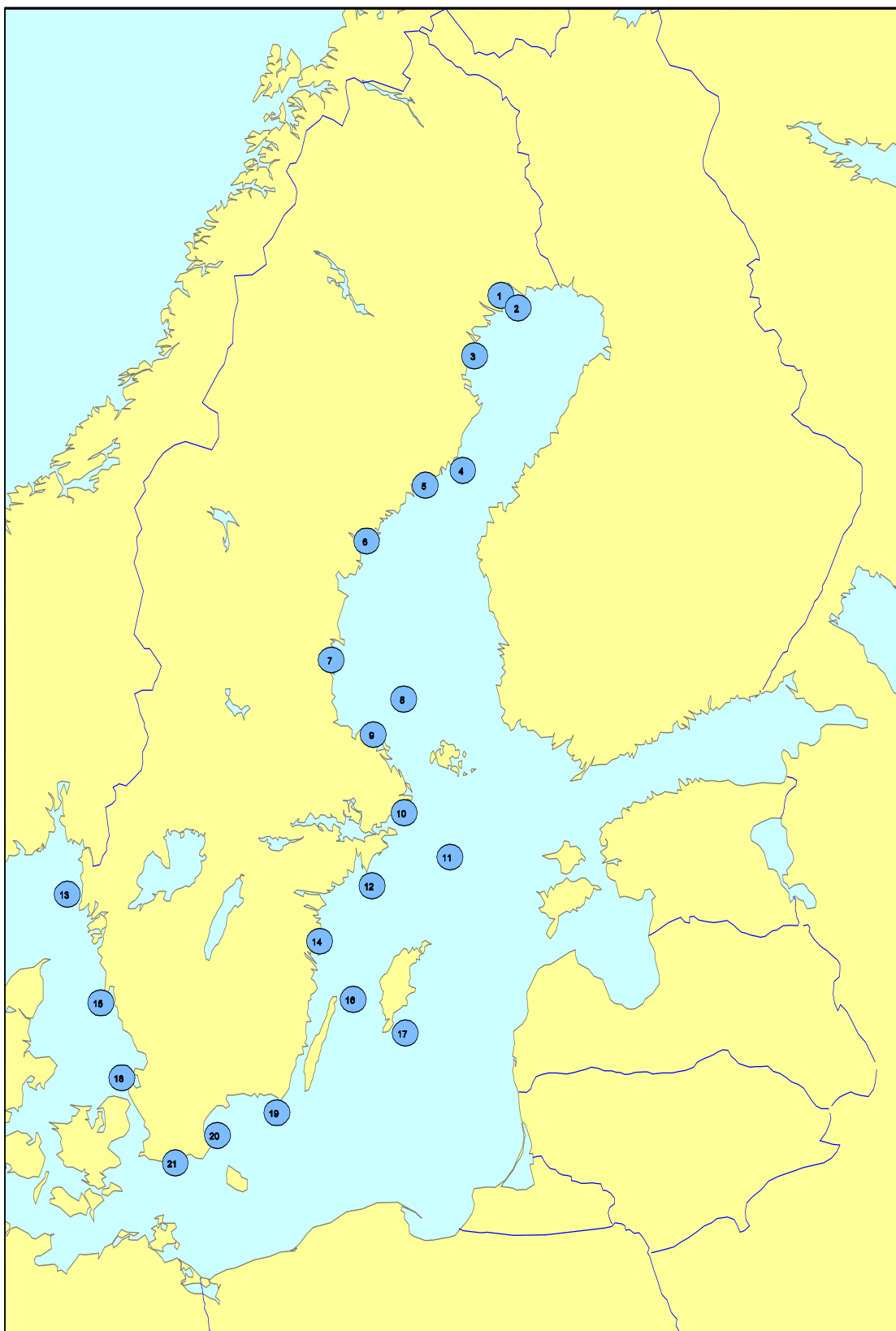
**Figure 1.1.** Potentially polluted sampling sites. Site names, coordinates and species sampled are presented in Table 1.1.

**Table 1.1.** Sampling sites, coordinates and matrices sampled for the polluted sites. The number in the first column refers to the map presented in Figure 1.1.

| Number in Figure 1 | Sampling site                  | Coordinates        | Matrices        |
|--------------------|--------------------------------|--------------------|-----------------|
| 1                  | Skelleftebukten                | 64° 39'N, 21° 15'E | Perch, Herring  |
| 2                  | Örnsköldsviksfjärden           | 62° 53'N, 18° 17'E | Perch, Herring  |
| 3                  | Yttre Fjärden                  | 60° 42'N, 17° 18'E | Perch, Herring, |
| 4                  | Östhammarsfjärden              | 60° 15'N, 18° 15'E | Perch           |
| 5                  | Lilla Värtan                   | 59° 20'N, 18° 10'E | Perch, Herring, |
| 6                  | Inre Slätbaken                 | 58° 27'N, 16° 34'E | Perch           |
| 7                  | Bråviken, s Esterön*           | 58° 28'N, 16° 19'E | Perch           |
| 7                  | Bråviken, n Esterön*           | 58° 28'N, 16° 20'E | Perch           |
| 7                  | Bråviken, n Svindra*           | 58° 38'N, 16° 24'E | Perch           |
| 8                  | Askeröfjorden,<br>Halsefjorden | 58° 04'N, 11° 46'E | Eelpout, Cod    |
| 9                  | Rivö fjorden                   | 57° 41'N, 11° 46'E | Eelpout, Cod    |
| 10                 | Kungsbackafjorden              | 57° 24'N, 12° 04'E | Eelpout, Cod    |
| 11                 | Torsås                         | 56° 25'N, 16° 08'E | Perch, Herring  |

\*Included in a study commissioned by the Swedish maritime Administration 2011

Within the national marine monitoring programme for contaminants in biota, 21 different areas along the Swedish coast is fished and are presented in Figure 1.2 and Table 1.2.



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**Figure 1.2.** Sampling sites within the national Swedish marine monitoring programme for contaminants in biota. Site names, coordinates and species sampled are presented in Table 1.2.

**Table 1.2.** Sampling sites, coordinates and matrices sampled for the reference sites within the national Swedish marine monitoring programme for contaminants in biota. The number in the first column refers to the map presented in Figure 1.2.

| Number in Figure 2 | Sampling site                | Coordinates        | Matrices         |
|--------------------|------------------------------|--------------------|------------------|
| 1                  | Rånefjärden                  | 65° 45'N, 22° 25'E | Herring          |
| 2                  | Harufjärden                  | 65° 35'N, 22° 53'E | Herring          |
| 3                  | Kinnbäcksfjärden             | 65° 03'N, 21° 29'E | Perch, Herring   |
| 4                  | Holmöarna                    | 63° 41'N, 20° 53'E | Perch, Herring   |
| 5                  | Örefjärden                   | 63° 31'N, 19° 50'E | Perch            |
| 6                  | Gaviksfjärden                | 62° 52'N, 18° 14'E | Herring          |
| 7                  | Långvindsfjärden             | 61° 27'N, 17° 10'E | Herring          |
| 8                  | Bothnian Sea, offshore site  | 60° 57'N, 18° 57'E | Herring          |
| 9                  | Ängskärsklubb                | 60° 32'N, 18° 09'E | Perch*, Herring  |
| 10                 | Lagnö                        | 59° 34'N, 18° 50'E | Herring          |
| 11                 | Baltic Proper, offshore site | 58° 60'N, 19° 52'E | Herring          |
| 12                 | Landsort                     | 58° 42'N, 18° 04'E | Herring          |
| 13                 | Väderöarna,                  | 58° 31'N, 10° 54'E | Herring, Eelpout |
| 14                 | Kvädöfjärden                 | 58° 2'N, 16° 46'E  | Perch, Eelpout   |
| 15                 | Fladen                       | 57° 14'N, 11° 50'E | Herring, Cod     |
| 16                 | Byxelkrok                    | 57° 19'N, 17° 30'E | Herring          |
| 17                 | Southeast of Gotland         | 56° 53'N, 18° 38'E | Cod              |
| 18                 | Kullen                       | 56° 19'N, 12° 23'E | Herring          |
| 19                 | Utlängan                     | 55° 57'N, 15° 47'E | Herring          |
| 20                 | Västra Hanöbukten            | 55° 45'N, 14° 17'E | Herring          |
| 21                 | Abbekås                      | 55° 18'N, 13° 36'E | Herring          |

\*One pooled sample of perch was analysed in 2010

## **2 Materials and method**

### **2.1 Sampling**

The samples (herring, perch, cod, and eelpout) were collected by SLU Aqua in the autumn 2011 and shipped frozen to the Environmental Specimen Bank at the Museum of Natural History in Stockholm.

For each fish specimen, total body weight, body length, total length (body length plus the tail fin), sex, age, gonad weight, liver weight and sample weight were recorded. To avoid surface contamination and to obtain a sample consisting of only muscle tissue, the epidermis and subcutaneous fatty tissue were carefully removed before the muscle tissue was excised. Muscle samples were taken from the middle dorsal muscle layer. The sampling and sample preparations were all performed according to the manual for collection, preparation and storage of fish (SMNH, 2012).

The chemical analysis was performed only on pooled samples. The number of fish included in each pooled sample and use of matrices are presented in Table 2.1.



**Table 2.1.** Number of individuals sampled for analysis. The number within the squared brackets show a pooled sample with a specified number of individuals. The tissue/organs sampled are stated below the table.

| Specie  | Sampling site        | Metals <sup>1</sup> | PCB + pesticides <sup>2</sup> | PBDEs+ HBCD <sup>2</sup> | PFAS <sup>3</sup> | Dioxines * dl-PCBs <sup>4</sup> | HCBD <sup>4</sup> | PeCB, HCB <sup>4</sup> | DEHP <sup>4</sup> | Chloroalkanes <sup>5</sup> | OTCs <sup>5</sup> |
|---------|----------------------|---------------------|-------------------------------|--------------------------|-------------------|---------------------------------|-------------------|------------------------|-------------------|----------------------------|-------------------|
| Perch   | Skelleftebukten      | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Örnsköldsviksfjärden | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Yttre fjärden        | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Östhammarsfjärden    | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Lilla Värtan         | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Inre slätbaken       | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Torsås               | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
| Herring | Skelleftebukten      | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Örnsköldsviksfjärden | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Yttre fjärden        | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Lilla Värtan         | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Torsås               | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
| Cod     | Kungsbackafjorden    | 2*[12]              | 2*2*[12]                      | 2*2*[12]                 | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Rivö fjord           | 2*[12]              | 2*2*[12]                      | 2*2*[12]                 | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
| Eelpout | Kungsbackafjorden    | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Rivö fjord           | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Haslefjorden och     | 2*[12]              | 2*[12]                        | 2*[12]                   | 2*2*[12]          | 2*[12]                          | 2*[12]            | 2*[12]                 | 2*[12]            | [24]                       | [24]              |
|         | Askerfjorden         |                     |                               |                          |                   |                                 |                   |                        |                   |                            |                   |

<sup>1</sup>Hg is determined in muscle and the rest of the metals in liver. Apply for all species. <sup>2</sup>PCB+ pesticides and PBDE+HBCDD are determined in muscle. For cod also in liver. <sup>3</sup>PFAS is determined in both liver and muscle for all species. <sup>4</sup>Dioxines+dl-PCBs, HCBD, PeCB, HCB and DEHP are determined in muscle for all species. <sup>5</sup>Chloroalkanes and OTCs are analysed in liver.

## **2.2 Chemical analysis**

The analysis of trace metals, organochlorines, brominated flame retardants and perfluoroalkyl substances was carried out at the Institute of Applied Environmental Science (ITM) at Stockholm University. The analysis of dioxins, dibenzofurans and dl-PCBs was carried out at the Department of Chemistry at Umeå University. The analysis of Organotin compounds (OTCs), Di-(2-ethylhexyl)-phthalate (DEHP), Chloroalkanes, Pentachlorobenzene and Hexachlorobutadiene (HCBD) was carried out by IVL (The Swedish Environmental Research Institute).

### **2.2.1 Trace metals**

Analytical methods for metals in liver were performed according to the Swedish standards SS-EN 13805 (Foodstuffs – Determination of trace elements – Pressure digestion) and SS-EN ISO 17294-2 (Water quality – Application of inductively coupled plasma mass spectrometry (ICP-MS) – Part 2: Determination of 62 elements), and for mercury according to the US EPA Method 7473 (mercury in solids and solutions by thermal decomposition, amalgamation and atomic absorption spectrophotometry). The laboratory participates in the periodic QUASIMEME intercalibration rounds.

### **2.2.2 Organochlorines and brominated flame retardants**

Analysis was carried out on a capillary column (Eriksson et al. 1994). The extraction method originates from the method described by Jensen et al. (1983) where wet tissues were extracted with a mixture of polar and non-polar solvents. The organochlorines were analysed on a gas chromatograph (GC) equipped with a  $\mu$ -electron capture detector (Eriksson et al. 1994). The BFRs were analysed by a GC connected to a mass spectrometer operating in electron capture negative ionization mode (NICI) (Sellström et al. 1998).

### **2.2.3 Dioxins, dibenzofurans and dioxin-like PCBs**

The extraction method was described by Wiberg et al. (1998), the clean-up method by Danielsson et al. (2005), and the instrumental analysis (GC-HRMS) by Liljelind et al. (2003). The laboratory participates in the annual FOOD intercalibration rounds, including laboratory reference material (salmon tissue) with each set of samples.

### **2.2.4 Perfluoroalkyl substances**

A sample aliquot of approximately 1.0 g homogenized tissue in a polypropylene (PP)-centrifuge tube was spiked with 1.0 ng each of a suite of mass-labelled internal standards ( $^{18}\text{O}$ - or  $^{13}\text{C}$ -labelled perfluoroalkyl sulfonates and carboxylic acids). The samples were extracted twice with 5 mL of acetonitrile in an ultrasonic bath. Following centrifugation, the supernatant extract was removed and the combined acetonitrile phases were concentrated to 1 mL under a stream of nitrogen. The concentrated extract underwent dispersive clean-up on graphitised carbon and acetic acid. A volume of 0.5 mL of the cleaned-up extract was added to 0.5 mL of aqueous ammonium acetate. Precipitation occurred and the extract was centrifuged before the clear supernatant was transferred to an autoinjector vial for instrumental analysis and the volume standards M8PFOA and M8PFOS were added.

Aliquots of the final extracts were injected automatically on an ultra performance liquid chromatography (UPLC) system (Acquity, Waters) coupled to a tandem mass spectrometer (MS-MS; Xevo TQS, Waters). Compound separation was achieved on a BEH C18 UPLC column (1.7  $\mu$ m particles, 50  $\times$  2.1 mm, Waters) with a binary gradient of ammonium acetate buffered acetonitrile and water. The mass spectrometer was operated in negative electrospray ionisation mode. Quantification was performed in selected reaction monitoring chromatograms using the internal standard method.

### **2.2.5 Organotin Compounds**

Two freeze dried samples internal standards (monoheptyltin, diheptyltin) and 10 ml hydrobromic acid (50%) were added. The mixture was extracted twice with 20 ml dichloromethane in an ultrasonic bath and on a shaker. The organic extract was reduced in volume by evaporation under a stream of nitrogen and the solvent changed to 2 ml hexane: methanol 1:1. 40  $\mu$ l 25% sodium tetraethylborate in tetrahydrofuran was added and was allowed to react for 2h at 90°C. After cooling, water was added and the hexane phase (together with an additional hexane extract) was reduced in volume and was cleaned up on an alumina column with hexane as solvent.

A six point calibration curve was prepared by diluting Organotin mix 8 stock solution (LGC Promochem) to which fresh solutions of monophenyltin trichloride and diphenyltin dichloride in methanol had been added. After ethylation using sodium tetraethylborate water was added and the ethylates extracted with hexane.

Instrumental analysis was carried out using a 7890A gas chromatograph connected to a 7004A triple quadrupole mass spectrometer (Agilent) used in electron ionization and multiple reaction monitoring (MRM) mode. For most compounds two MRMs were recorded, one as a quantifier and the other as a qualifier to increase specificity. Certified reference materials are used to check the performance of the method.

### **2.2.6 Di-(2-ethylhexyl)-phthalate DEHP**

The samples were spiked with internal standards (d4-DEHP, 13C6-pentachlorobenzene) and extracted with acetonitrile using MAE (Microwave assisted extraction). The extracts were purified on PSA columns and analysed with GC-MS-MS using MRM (multiple reaction monitoring) in EI mode according to TemaNord 2013.

### **2.2.7. Hexachlorobutadiene, pentachlorobenzene, hexachlorobenzene (HCB, PeCB, HCB)**

The extracts used for determination of DEHP were treated with concentrated sulphuric acid and analysed for hexachlorobutadiene, pentachlorobenzene and hexachlorobenzene with GC-MS-MS using MRM in EI mode.

### **2.2.8. Chloroalkanes**

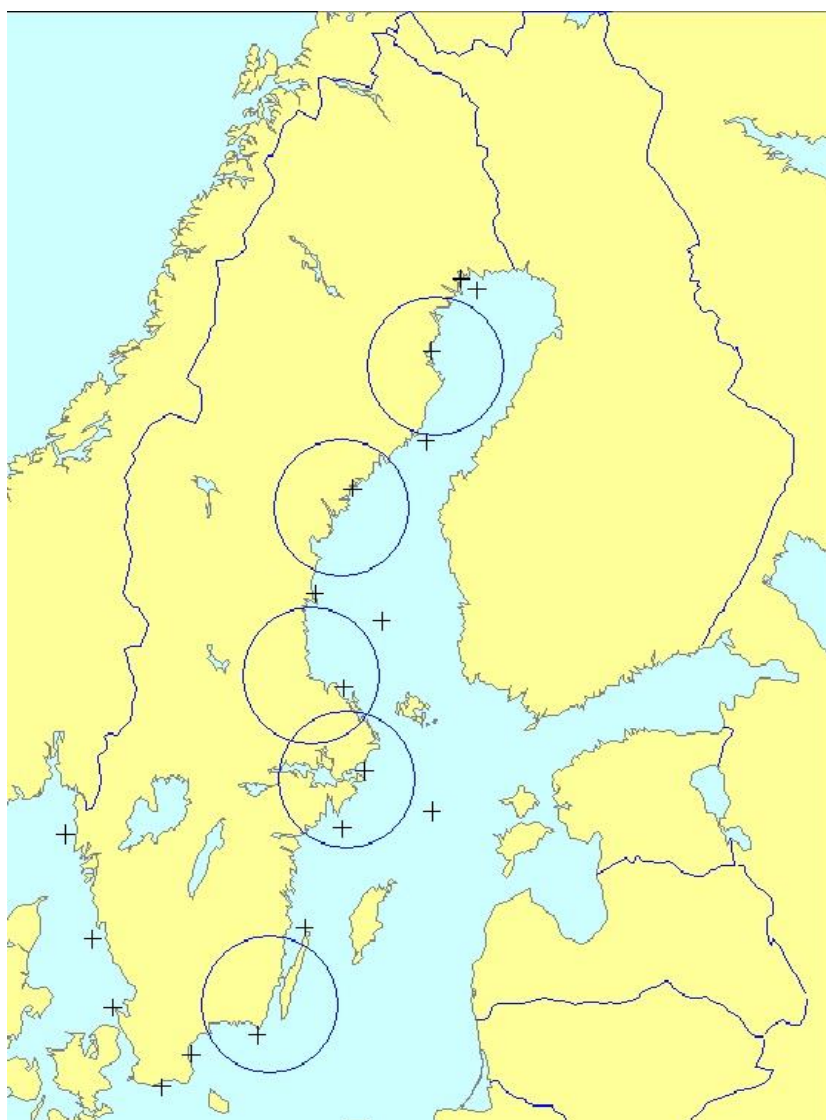
The samples were "cold column" extracted, the extracts treated with sulphuric acid and fractionated on silica gel columns. Analysis was made on a GC-HRMS instrument in NCI mode. Laboratory: NILU, Norwegian Institute for Air Research, Kjeller, Norway.

## 2.3 Statistical analysis and three dimensional maps

### 2.3.1 Comparison between the polluted sites and the reference sites

Differences between each polluted site and the reference sites from the national monitoring program closer than 100 km (for herring and cod) presented in Figure 2.1 and 2.2 and 350 km (for perch) presented in Figure 2.3, where checked by means of one-sample t-tests, assuming that the mean of two pooled samples from each polluted site were representative of the true concentration at the site in question. No analysis was performed for eelpout due to too few samples from the reference sites.

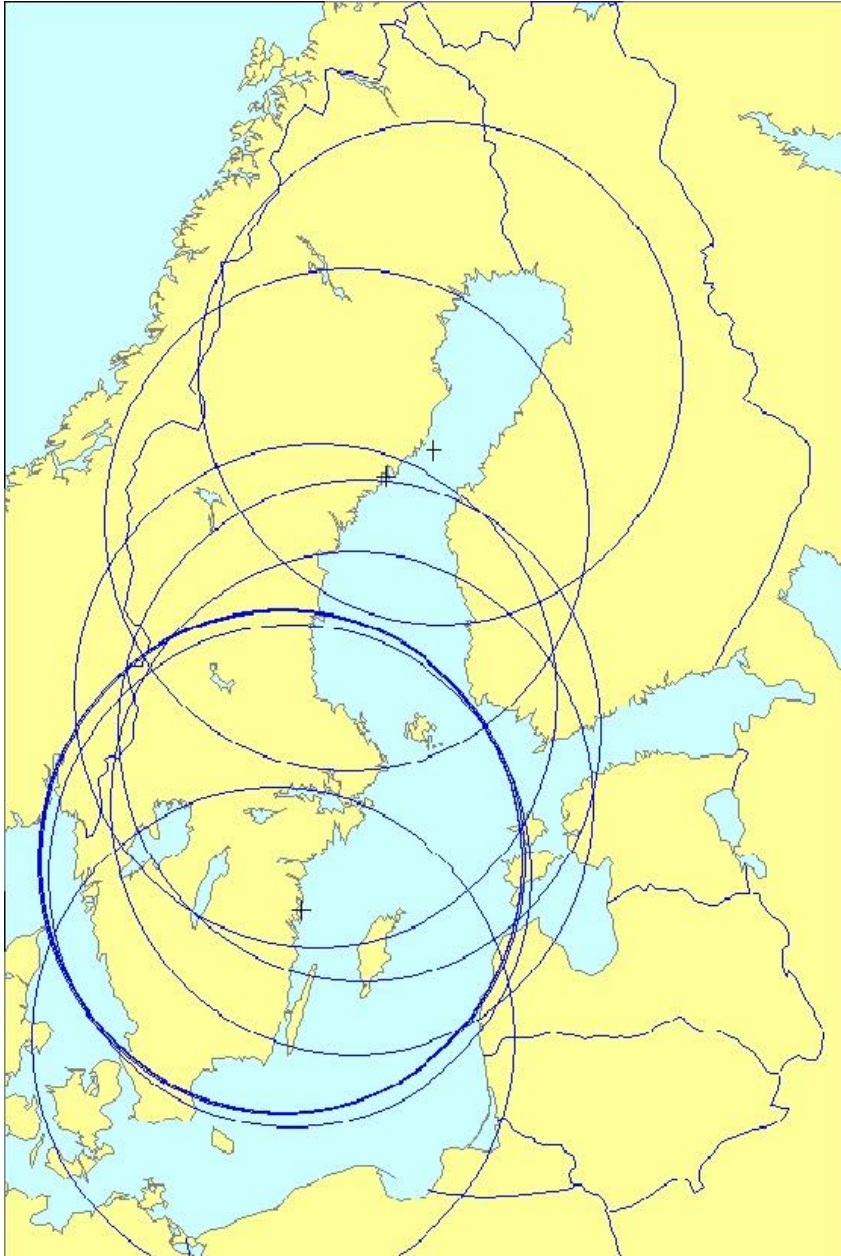
The polluted sites were sampled in year 2011 and for the reference sites measurements from the years 2010-2012 were included. In some tests, a mixture of pooled and individual samples was included from the reference sites implying that the weight from the pooled samples was underestimated. This can be expected to lead to more conservative tests (i.e. lower Type I error rate, lower power to detect differences).



**Figure 2.1.** Map visualizing on what sampling sites the statistical evaluation for herring is performed. The reference sites are presented by a cross in the map and the circle is showing the radius (100 km) around a polluted site.



**Figure 2.2.** Map visualizing on what sampling sites the statistical evaluation for cod is performed. The reference sites are presented by a cross in the map and the circle is showing the radius (100 km) around a polluted site.



**Figure 2.3.** Map visualizing on what sampling sites the statistical evaluation for perch is performed. The reference sites are presented by a cross in the map and the circle is showing the radius (350 km) around a polluted site.

### 2.3.2 Legend for the three dimensional maps

The height of the bars represents the arithmetic mean for 2011 for the polluted sites (red lining) and 2010-2012 for the references sites (black lining). The bars are split into three sections of equal size that each represents the same concentration.

### 3 Target levels

In accordance with the Marine Strategy Framework Directive 2008/56/EC (MSFD), Good Environmental Status (GES) is defined as “concentrations of contaminants at levels not giving rise to pollution effects”. To determine GES, a number of target levels have been established representing a threshold that should not be exceeded. These target levels should protect the most sensitive organisms from the harmful effects of hazardous substances and have been developed within several groups or conventions e.g., Environmental Quality Standards (EQS) developed within the EC to evaluate GES (2008/105/EC), and the Environmental Assessment Criteria (EAC), developed within OSPAR (OSPAR CEMP, 2009).

In addition to EQSs and EACs, chemical status can also be assessed from the point of human consumption. Maximum levels for contaminants in food are set in Commission Regulation (EC, No 1881/2006).

The methodological framework used in deriving these EQSs is described in CIS (2011). Within the OSPAR convention, Environmental Assessment Criteria (EAC) has been developed for interpretation of chemical monitoring data in sediments and biota (OSPAR CEMP 2009). Concentrations below the EACs are considered to present no significant risk to the environment and may be considered as related to the EQSs.

In this report, primarily internationally agreed target levels such as EQS, EAC or EC recommendations for foodstuffs are used. If reliable target levels have been produced with specific regard to Swedish environmental conditions, these are considered (e.g. HCH). Only one type of target level is applied within each substance group.

The target values used in this report are listed in table 3.1. For some contaminants these values have been recalculated to be comparable to the presented results.

**Table 3.1.** Target levels for various environmental pollutants.

| Group of substance |  | Target levels      |                               |
|--------------------|--|--------------------|-------------------------------|
|                    |  | Fish<br>(µg/kg ww) | Background<br>reference       |
| Metals             | Cadmium  | 160                | QS <sub>biota</sub>           |
|                    | Lead   | 1000               | QS <sub>biota</sub>           |
|                    | Mercury  | 20                 | EQS <sub>biota</sub>          |
|                    | Nickel   | 730                | QS <sub>biota</sub>           |
| Pesticides         | DDE (p,p')                                     | 5                  | EAC                           |
|                    | HCH (incl. lindane)                            | 2.6/26             | IVL                           |
| PCBs               | CB-118   | 24 lw              | EAC                           |
|                    | CB-153   | 1600 lw            | EAC                           |
| Other              | BDEs (congeners 28, 47, 99, 100, 153, and 154) | 0.0085             | EQS <sub>biota</sub>          |
|                    | HBCDD  | 167                | EQS <sub>biota</sub>          |
|                    | ΣPCDDs+PCDFs+dl-PCBs                           | 0.0065             | EQS <sub>biota</sub>          |
|                    | HCB  | 10                 | EQS <sub>biota</sub>          |
|                    | PFOS   | 9.1                | EQS <sub>biota</sub>          |
|                    | HCBd   | 55                 | EQS <sub>biota</sub>          |
|                    | DEHP   | 3200               | QS <sub>sec poiss biota</sub> |
|                    | SCCP   | 16600              | QS <sub>sec poiss biota</sub> |
|                    | PeCB   | 367                | QS <sub>sec poiss biota</sub> |
|                    | TBT  | 10.4*              | IVL                           |

\*concentration in fish liver

### 3.1 Metals

#### 3.1.1 Cadmium

There is no EQS or EAC developed for cadmium. The QS<sub>biota</sub> is set at 0.16 mg/kg prey tissue wet weight and evaluates whole fish concentrations in a freshwater system. The QS<sub>hh</sub> is set at 0.1 – 1.0 mg/kg in edible parts of fish. The EC foodstuff regulation sets a maximum level for muscle meat at 0.05 mg/kg wet weight. The directive states that where fish are intended to be eaten whole, the maximum level shall apply to the whole fish.

*Selected target level: QS<sub>biota</sub>*

#### 3.1.2 Lead

There is no EQS or EAC developed for lead. The QS<sub>biota</sub> is set at 1000 µg/kg prey tissue wet weight and evaluates whole fish concentrations. The QS<sub>hh</sub> is set at limit values of 200 – 1000 µg/kg fishery product wet weight. The EC foodstuff regulation sets a maximum level for lead in muscle meat of fish at 0.3 mg/kg wet weight. The directive states that where fish are intended to be eaten whole, the maximum level shall apply to the whole fish.

*Selected target level: QS<sub>biota</sub>*



### 3.1.3 Mercury

The EQS<sub>biota</sub> for mercury is set at 20 µg/kg (methyl-Hg) prey tissue wet weight to protect against secondary poisoning. There is no EAC developed for mercury. The EC foodstuff regulation sets a maximum level for mercury at 0.5 mg/kg wet weight. The directive states that where fish are intended to be eaten whole, the maximum level shall apply to the whole fish.

*Selected target level: EQS<sub>biota</sub>*

### 3.1.4 Nickel

There is no EQS or EAC developed for nickel. The QS<sub>biota</sub> is set at 0.73 mg/kg prey tissue wet weight. The QS<sub>hh</sub> is set at 0.67 mg/kg fishery product wet weight. There is no EC foodstuff regulation developed for nickel.

*Selected target level: QS<sub>biota</sub>*

## 3.2 Organic pollutants

### 3.2.1 DDTs, (DDT, DDE and DDD)

There are no EQS or EC foodstuff regulation developed for any of the DDTs. The EAC developed for DDE is set at 0.005 mg/kg wet weight.

*Selected target level: EAC*

### 3.2.2 HCH

There are no EQS or EC foodstuff regulation developed for HCHs. The EACs developed for γHCH in fish liver is set at 11 µg/kg lipid weight. With regard to Swedish levels of organic carbon in the sediments and factors for bioconcentration (BCF) and biomagnification (BMF), the Swedish Environmental Research Institute (IVL) have performed translations between EQS for surface water to biota (Lilja et al. 2010). The IVL target level is set for the sum of HCH (including lindane) at 26 µg/kg wet weight in a limnic environment and 2.6 µg/kg wet weight in a marine environment.

*Selected target level: IVL*

### 3.2.3 PCBs

The EAC developed for PCBs is expressed as µg/kg lipid weight: CB-28: 64, CB-52: 108, CB-101: 120, CB-118:24, CB-138: 316, CB-153: 1600, CB-180: 480. The EC foodstuff regulation developed for concentrations of PCBs in muscle meat of fish is set for the sum of CB-28, CB-52, CB-101, CB-138, CB-153, CB-180 (ICES - 6) at 75 ng/g wet weight.

*Selected target level: EAC*

### 3.2.4 BDEs

The EQS<sub>biota</sub> for concentrations of sumBDEs is set at 0.0085 µg/kg wet weight. There are no EAC or EC foodstuff regulation developed for BDEs. The EQS<sub>biota</sub> is based on QS set for human health.

*Selected target level: EQS<sub>biota</sub>*

### 3.2.5 HBCDD

The EQSbiota for concentrations of HBCDD is based on secondary poisoning of predators and set at 167 µg/kg fresh weight. There are no EAC or EC foodstuff regulation developed for HBCDD.

*Selected target level: EQSbiota*

### 3.2.6 Dioxins, furans and dioxin-like PCBs.

The EQSbiota for concentrations of dioxins, furans and dioxin like PCBs is based on the EC foodstuff regulation and set at 0.0065 µgWHO05-TEQ /kg ww. The QS set for human health was identified as the critical EQS because of the consensus regarding the value used in existing food legislation and because there is a greater uncertainty regarding the values calculated for QS sec. pois. The EC foodstuff regulation for only dioxins and furans is 0.0035 µgWHO05-TEQ /kg ww.

*Selected target level: EQSbiota*

### 3.2.7 PeCB

The QSbiota for PeCB is based on secondary poisoning of predators and set at 3200 µg/kg wet weight.

*Selected target level: QSbiota*

### 3.2.8 HCB

The EQSbiota for HCB is based on human health and set at 10 µg/kg fishery product wet weight. There is no EC foodstuff regulation developed for HCB.

*Selected target level: EQSbiota*

### 3.2.9 PFOS

The EQSbiota for concentrations of PFOS is based on human health and set at 0.0091 mg/kg wet weight. There are no EAC or EC foodstuff regulation developed for PFOS.

*Selected target level: EQSbiota*

### 3.2.10 HCBd

The EQSbiota for concentrations of HCBd is set to 55 µg/µg/kg ww.

*Selected target level: EQSbiota*

### 3.2.11 DEHP

The QSbiota for DEHP is based on secondary poisoning of predators and set at 3200 µg/kg wet weight.

*Selected target level: QSbiota*

### 3.2.12 TBT

There is no EQS biota or EC foodstuff regulation developed for TBT. The Swedish Environmental Research Institute (IVL) has performed translations between EQS for surface water to biota (fish muscle) (Lilja et al. 2010). In this report the concentrations are analysed in liver, thereby the EQS is instead translated to represent the corresponding value in liver tissue

according to the same method but with the use of BCF (52 000) for liver instead. This results in a target level for TBT in liver of 10.4 µg/kg ww.

*Selected target level: IVL method*

### **3.2.13 SCCP**

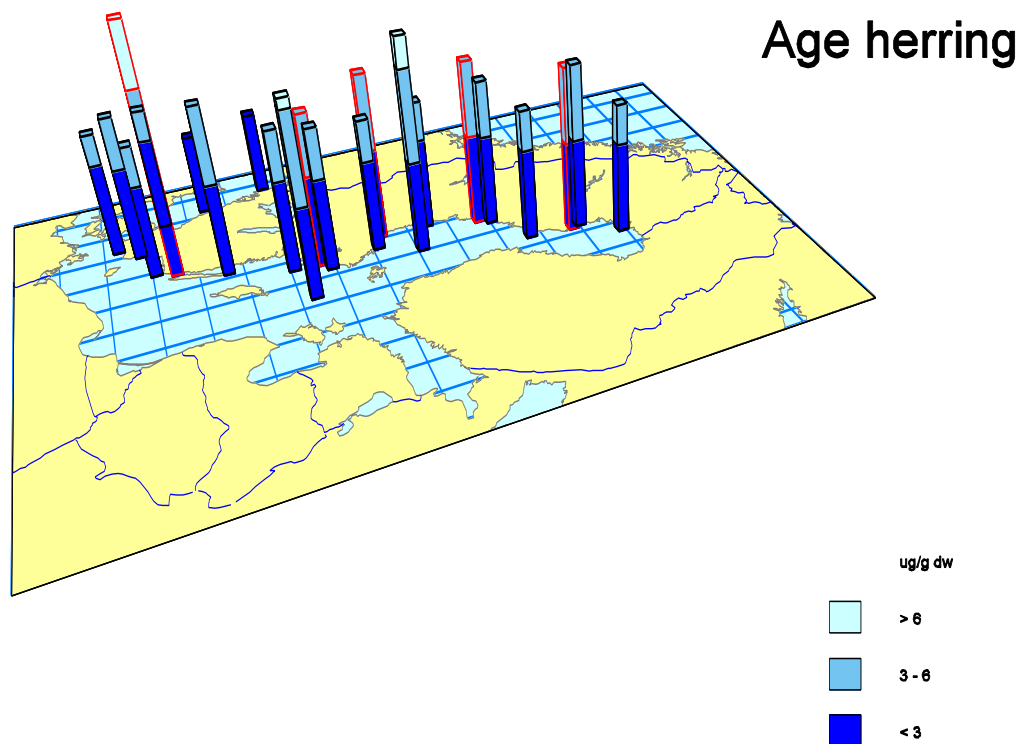
The QSbiota for concentrations of SCCP is set to 16 600 µg/µg/kg ww.

*Selected target level: QSbiota*

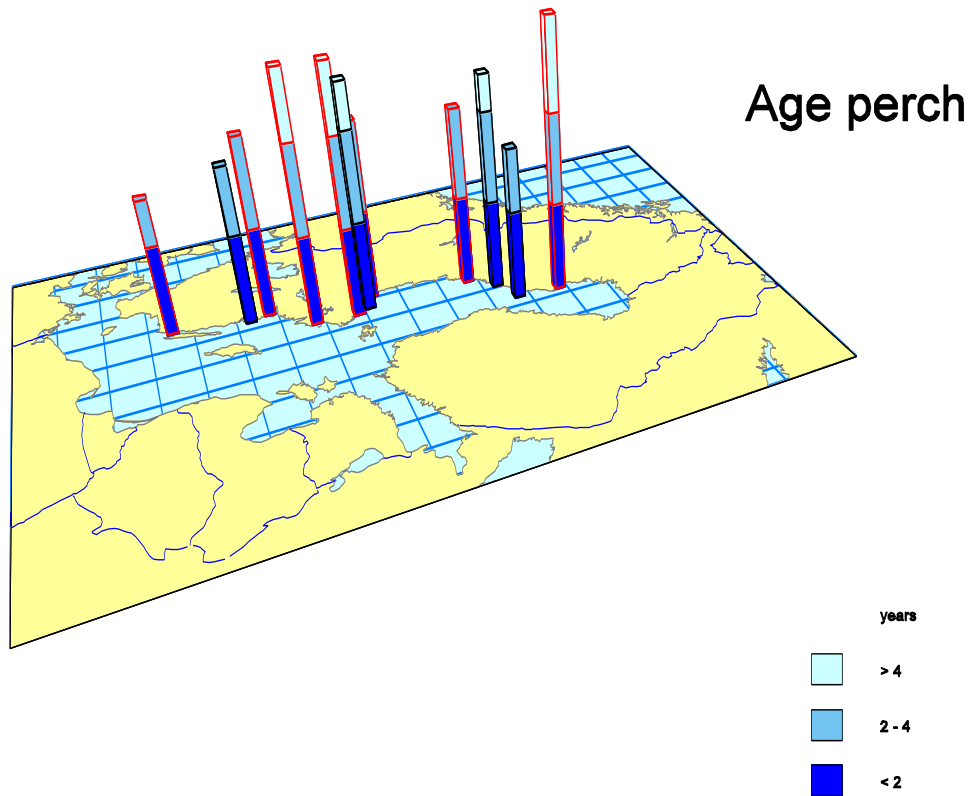
## 4 Results

### 4.1 Biological parameters

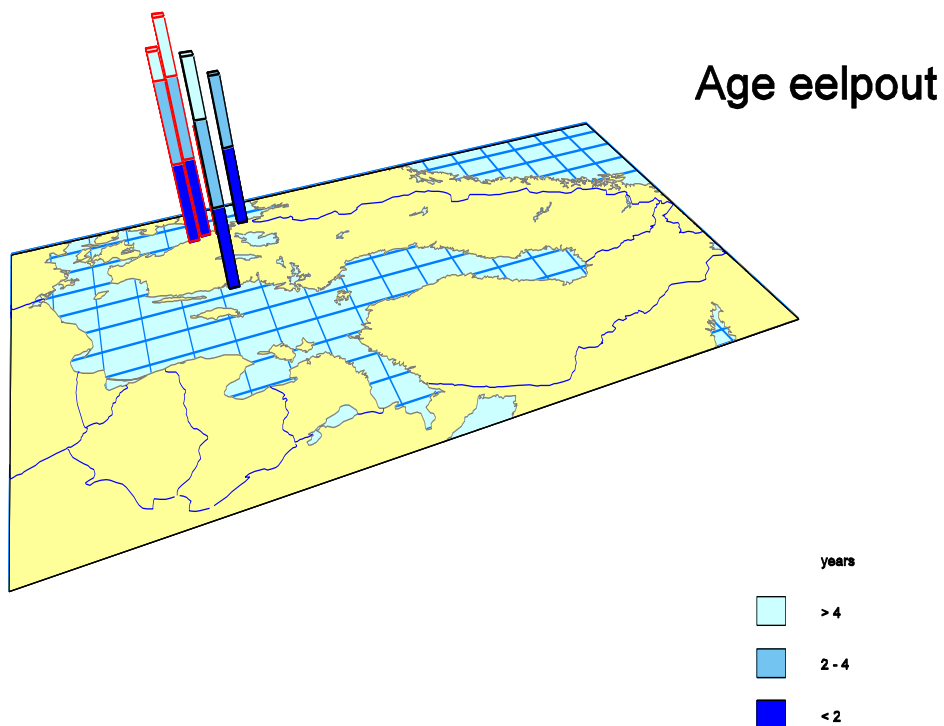
#### 4.1.1 Age



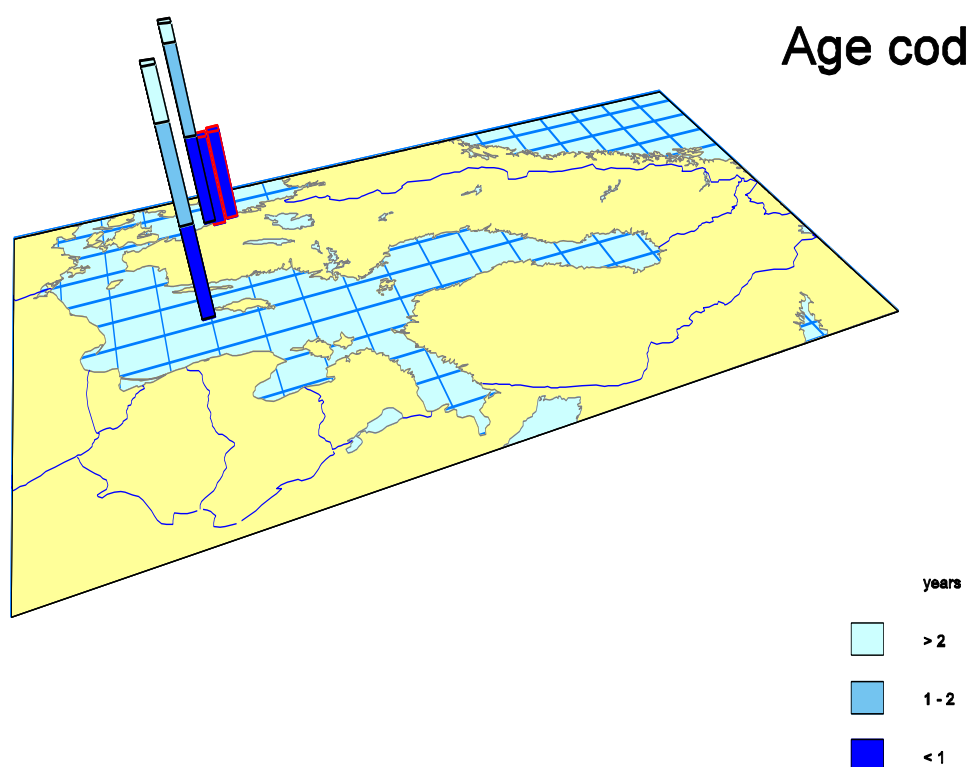
**Figure 4.1.1.** Spatial variation of mean age (year) in herring. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.1.2.** Spatial variation of mean age (year) in perch. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



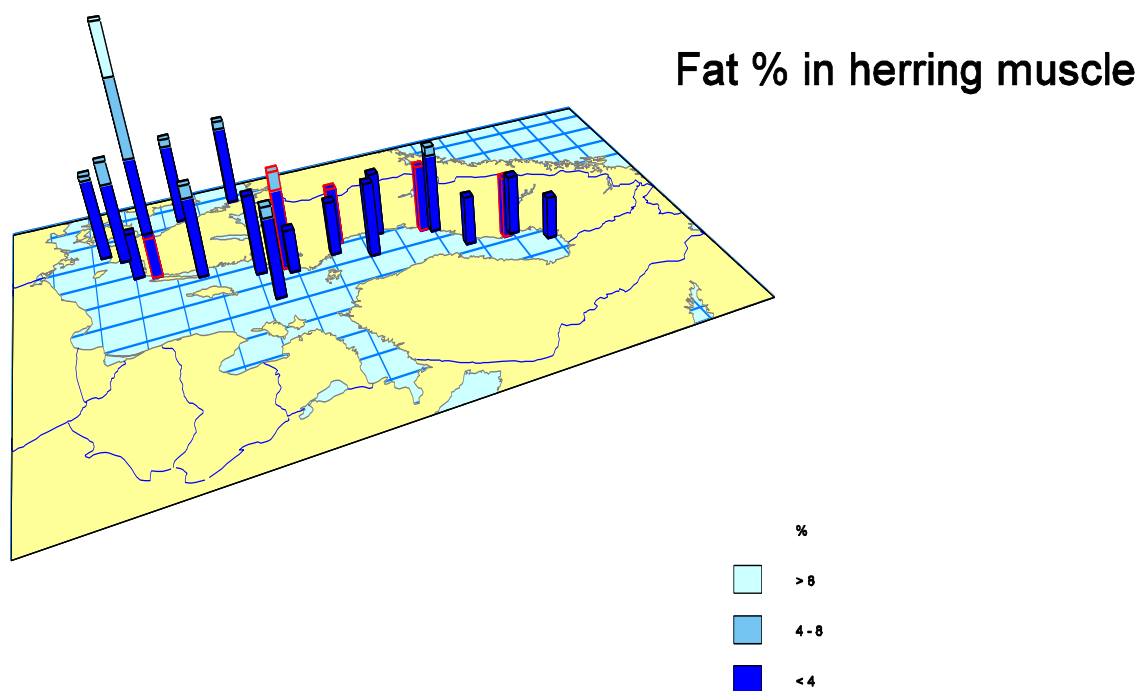
**Figure 4.1.3.** Spatial variation of mean age (year) in eelpout. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



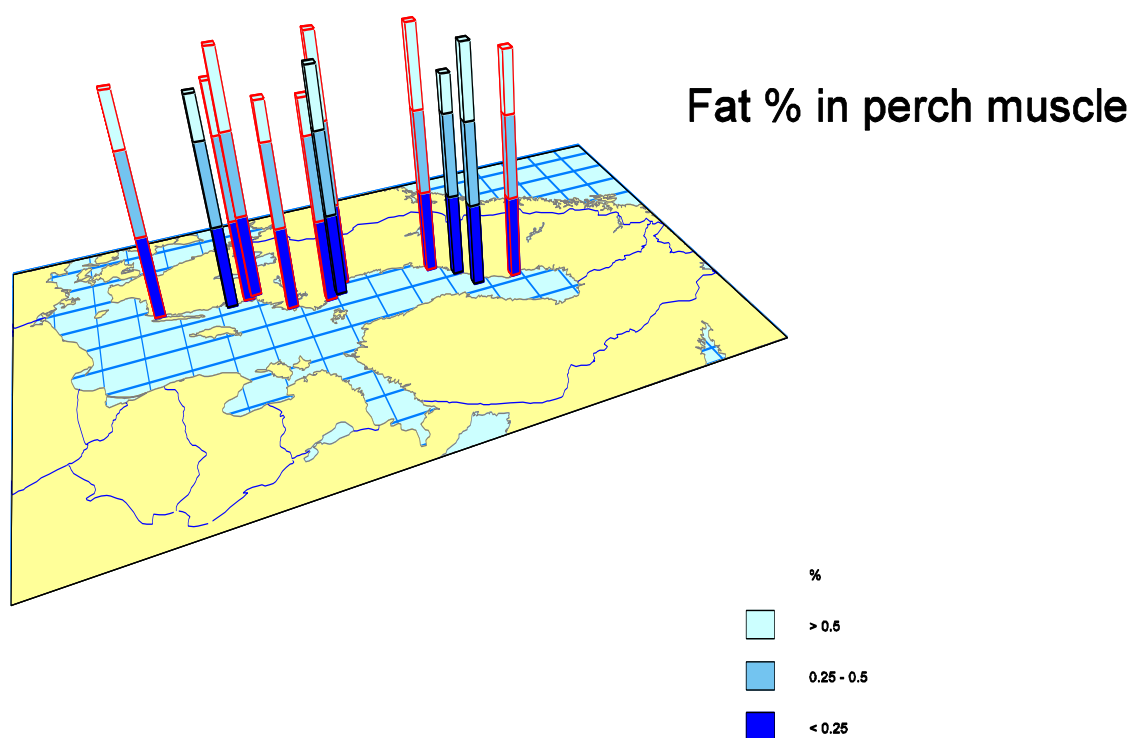
**Figure 4.1.4.** Spatial variation of mean age (year) in cod. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

The age of herring was more or less similar among sites (Fig. 4.1.1). The oldest herring was found in Torsås, with an average age of 8 years and the youngest was found in Lilla Värtan, average age 5. For perch, the age was lower in the southern parts of Sweden compared to the northern parts (Fig. 4.1.2). The oldest perch was found in Skelleftebukten, average 6, and the youngest was found in Torsås, with an average age of 3. The age of eelpout was similar between sites, ranging between 2-4 years (Fig. 4.1.3). The age of cod was similar at the two polluted sites (1 years old), but they were younger compared to the two reference sites (Fig. 4.1.4) implying that for age accumulating substances, elevated exposure in cod at the polluted sites may be more difficult to detect.

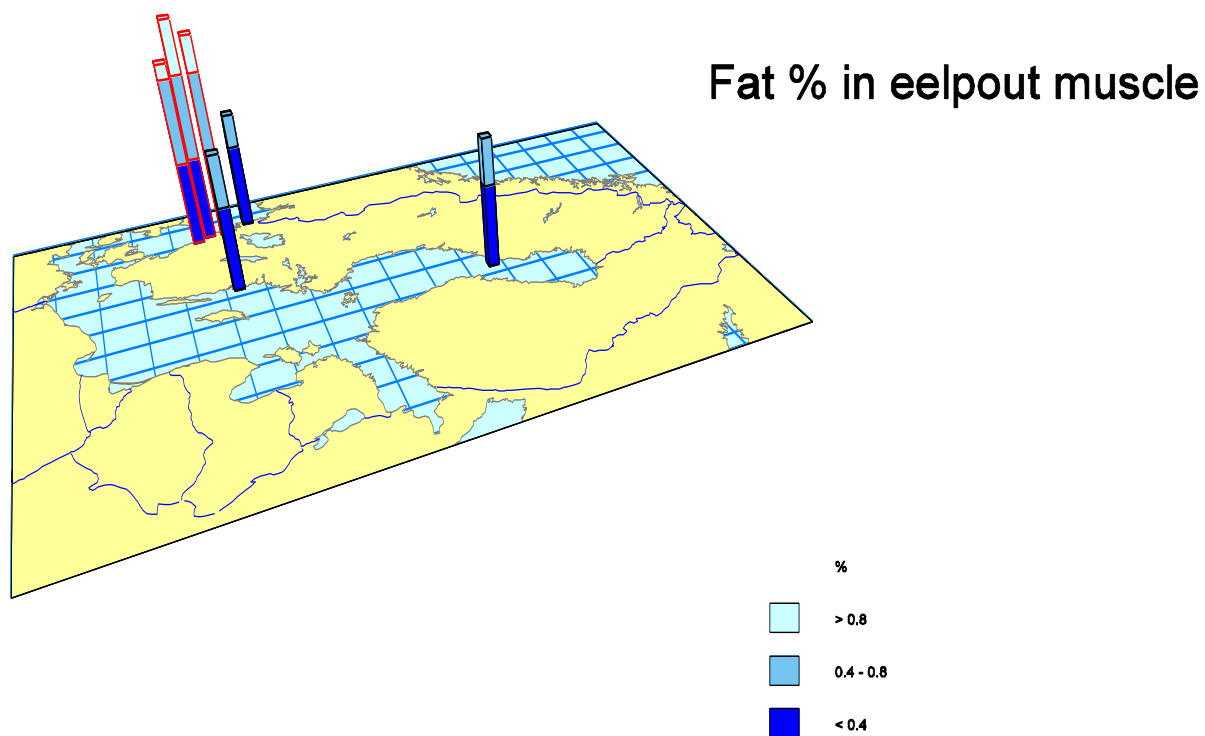
#### 4.1.2 Fat percentage



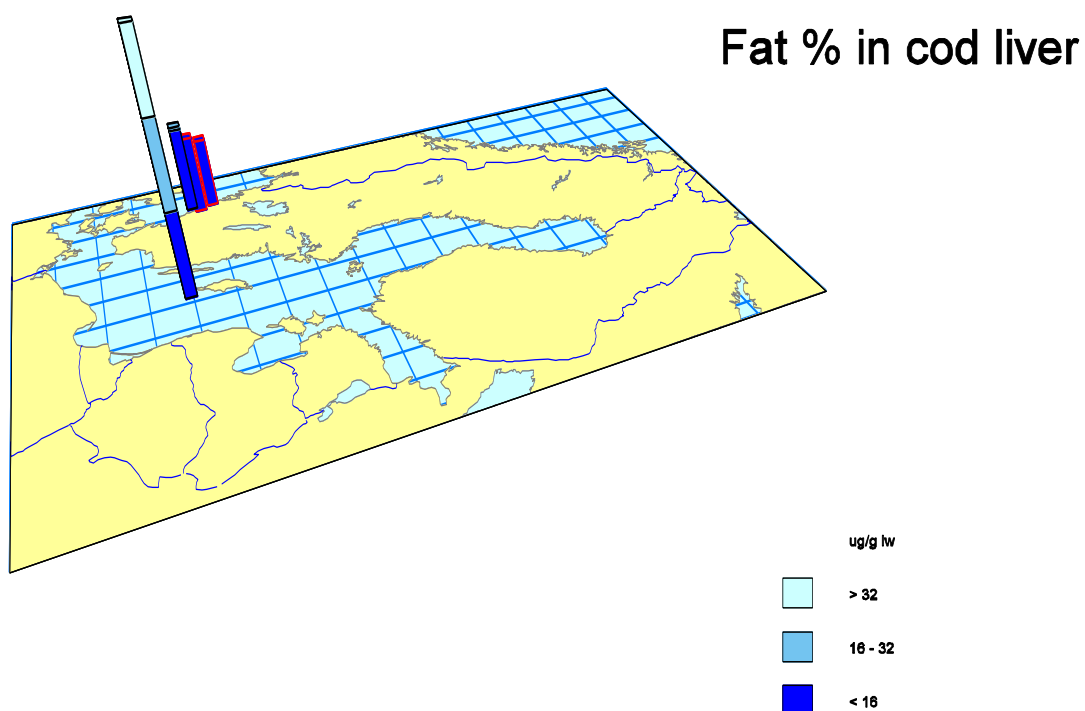
**Figure 4.1.5.** Spatial variation in mean fat percentage in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.1.6.** Spatial variation in mean fat percentage in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.1.7.** Spatial variation in mean fat percentage in eelpout muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

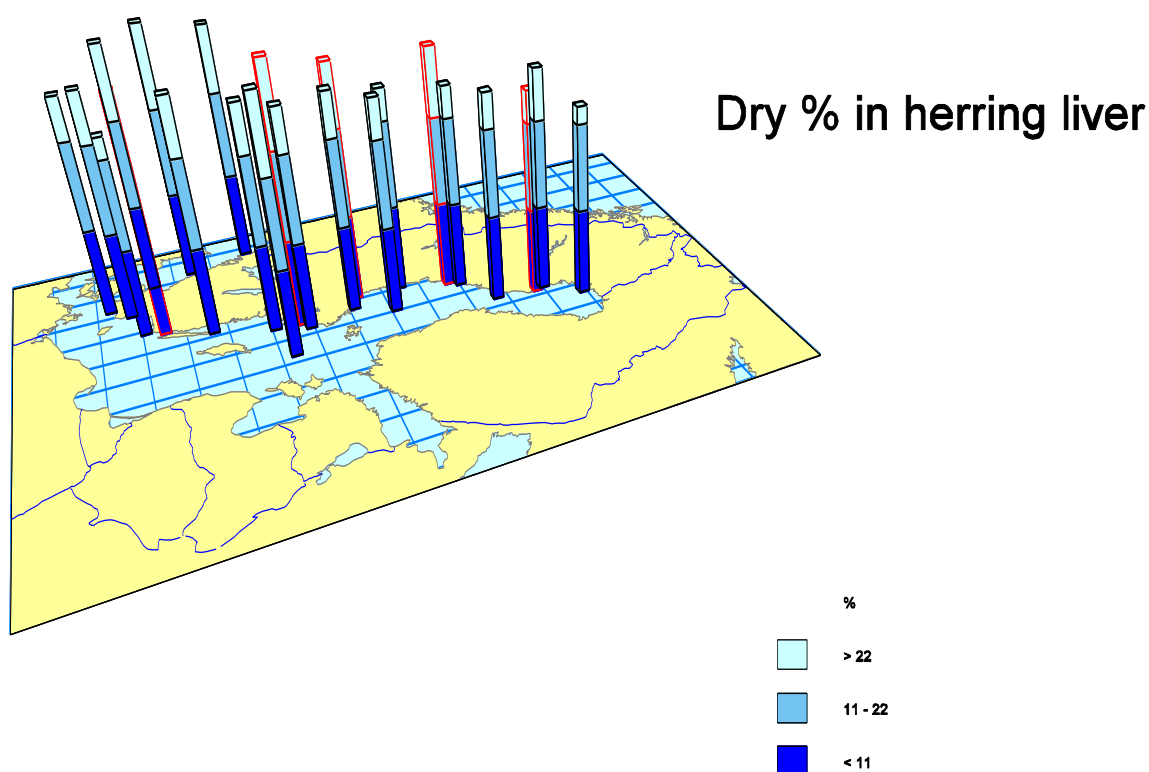


**Figure 4.1.8.** Spatial variation in mean fat percentage in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

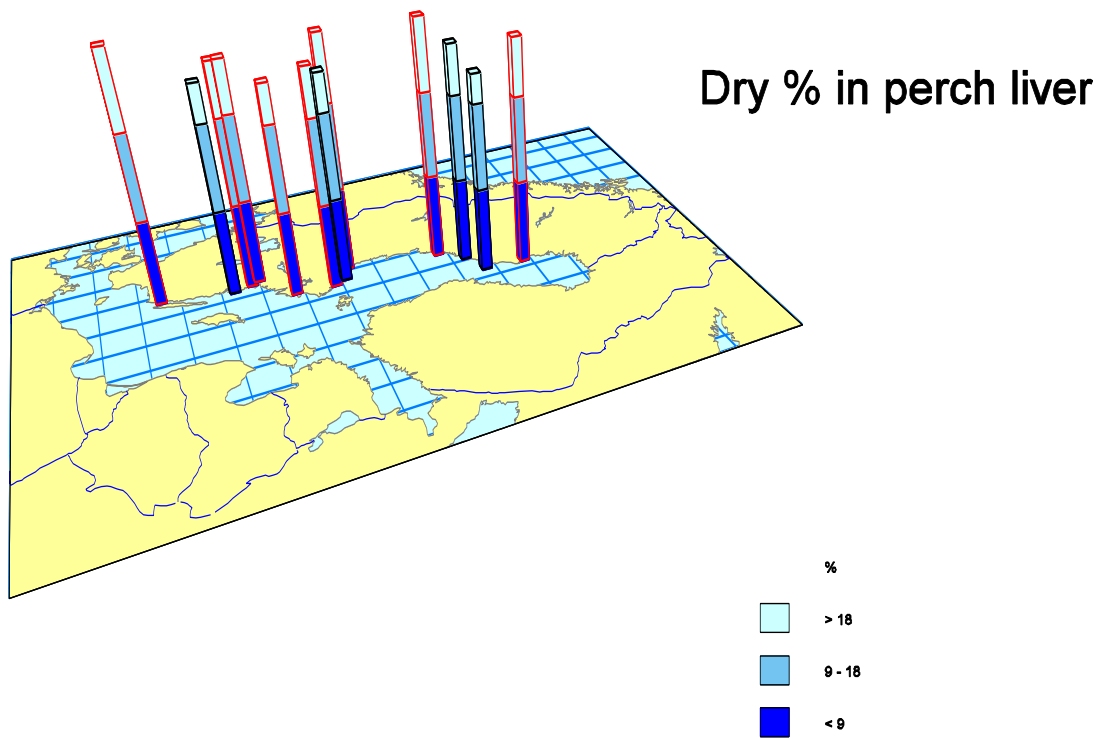


Fat content in herring muscle is relatively similar among sites for the polluted areas, ranging between approximately 2 and 3 %, but herring from Lilla Värtan had somewhat higher fat content, average 4.9% (Fig. 4.1.5). For the reference sites, herring in the southern and western part of Sweden had higher fat content compared to the rest of Sweden. In perch muscle, the fat content was relatively consistent at the different sites (Fig. 4.1.6). In eelpout muscle, the three polluted sites had similar fat content, ranging between 0.9-1.0% while the three reference sites had lower fat percentage, approximately 0.6% (Fig. 4.1.7). In cod liver, the fat content was similar among the polluted sites and the reference site Fladen, 13-14 %. In contrast, in cod from SE of Gotland, one of the reference sites, the fat content was 46 % (Fig. 4.1.8).

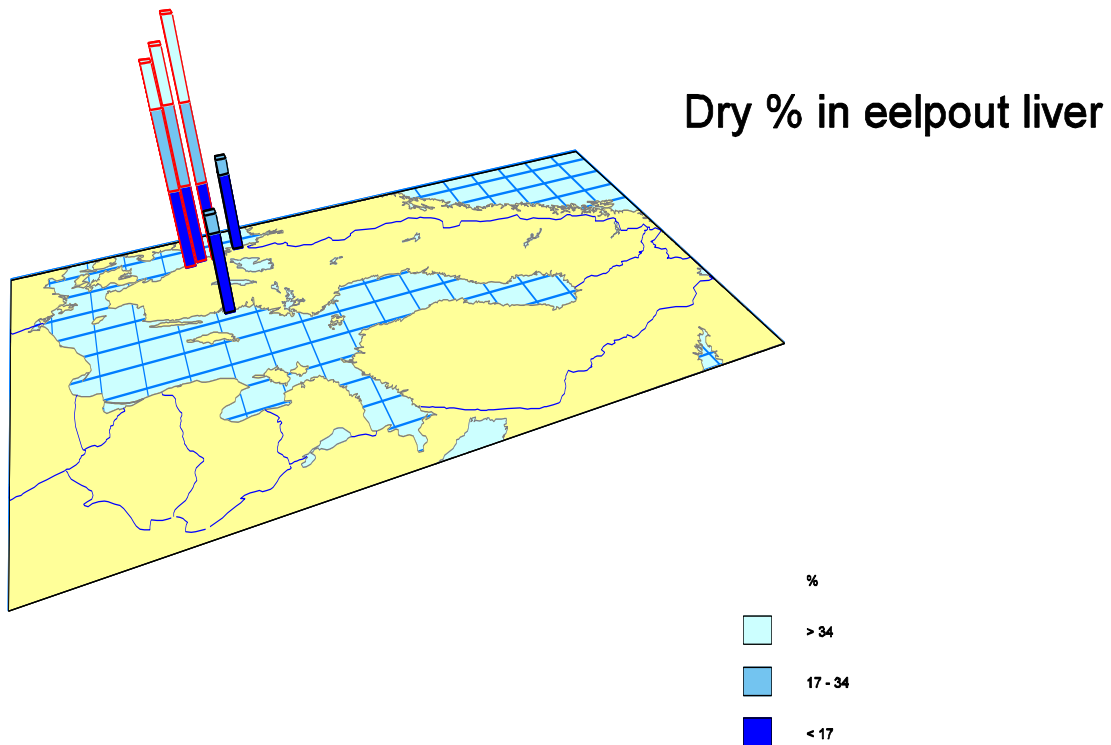
#### 4.1.3 Dry percentage



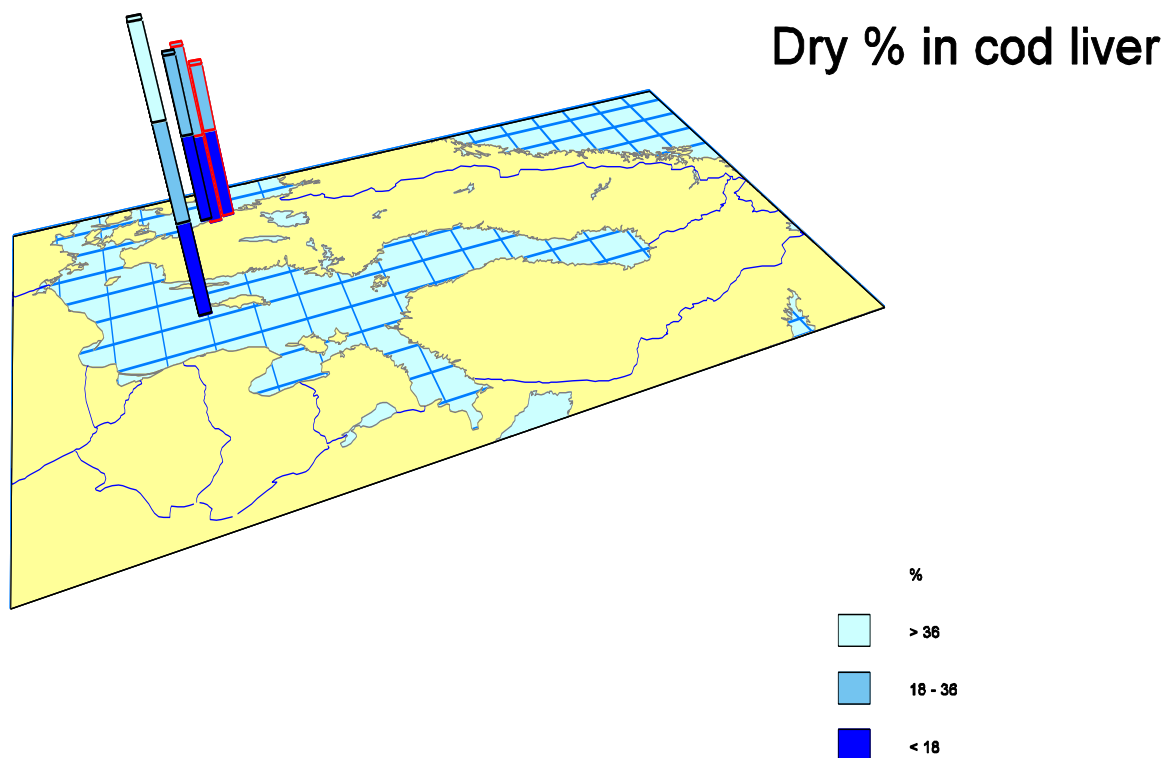
**Figure 4.1.9.** Spatial variation in mean dry percentage in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.1.10.** Spatial variation in mean dry percentage in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



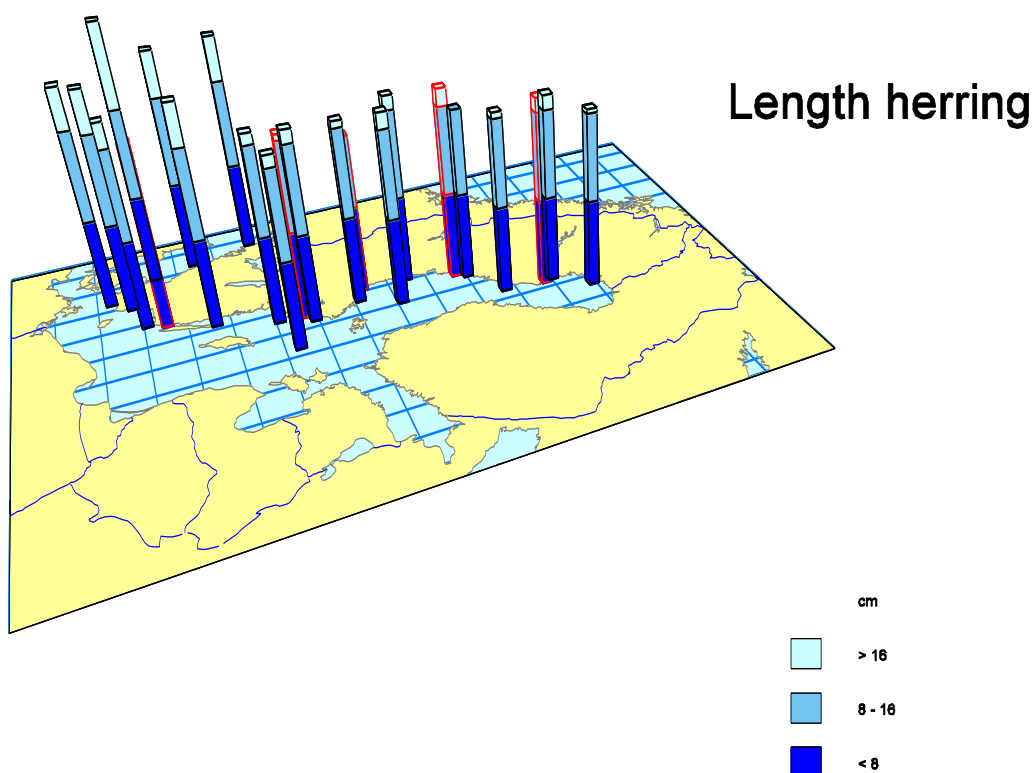
**Figure 4.1.11.** Spatial variation in mean dry percentage in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



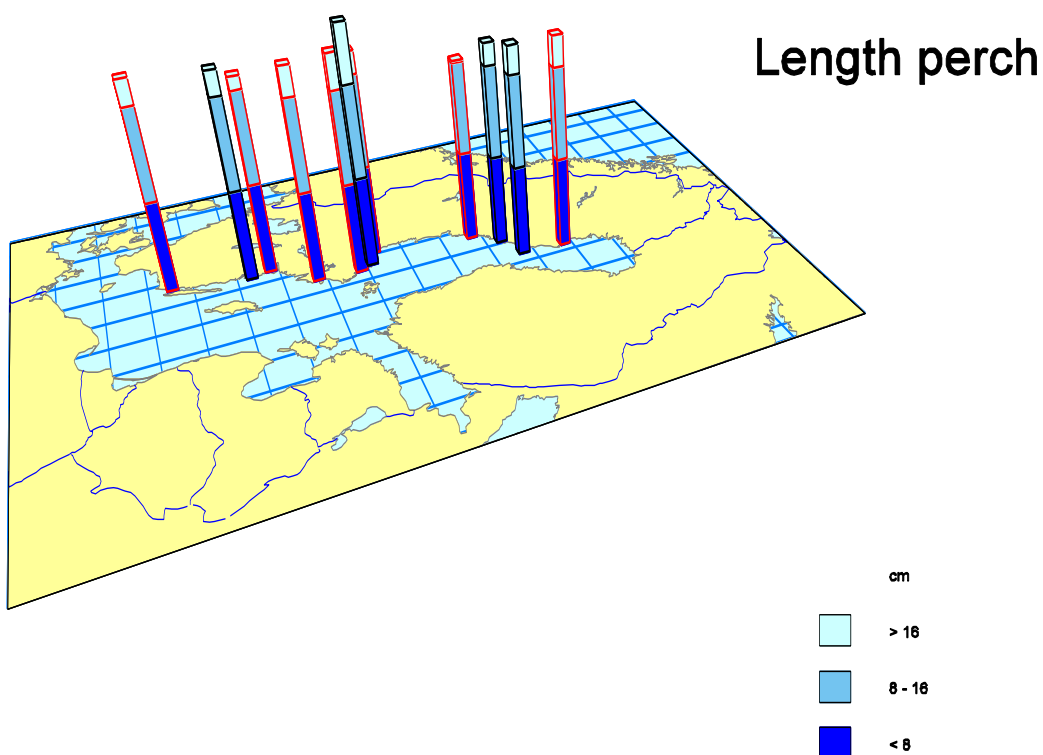
**Figure 4.1.12.** Spatial variation in mean dry percentage in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

The dry percentage in herring liver, 24-32 %, (Fig. 4.1.9) and perch liver, 21-26 %, (Fig. 4.1.10) was similar among sites. For eelpout liver, the three polluted sites had similar dry percentage, ranging between 43-51 %, while the two reference sites had lower, 20 % (Fig. 4.1.11). In cod, the dry percentage was similar for the polluted sites, ranging between 31-25 % and the reference site Fladen while cod from SE Gotland had higher dry percentage, 52 % (Fig. 4.1.12).

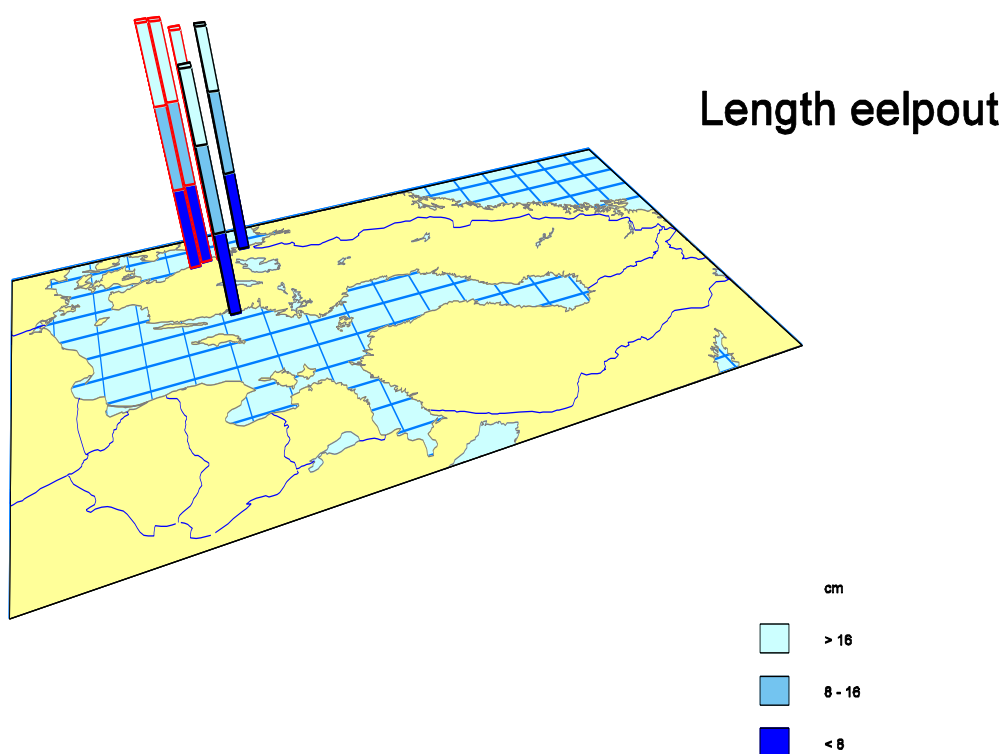
#### 4.1.4 Length



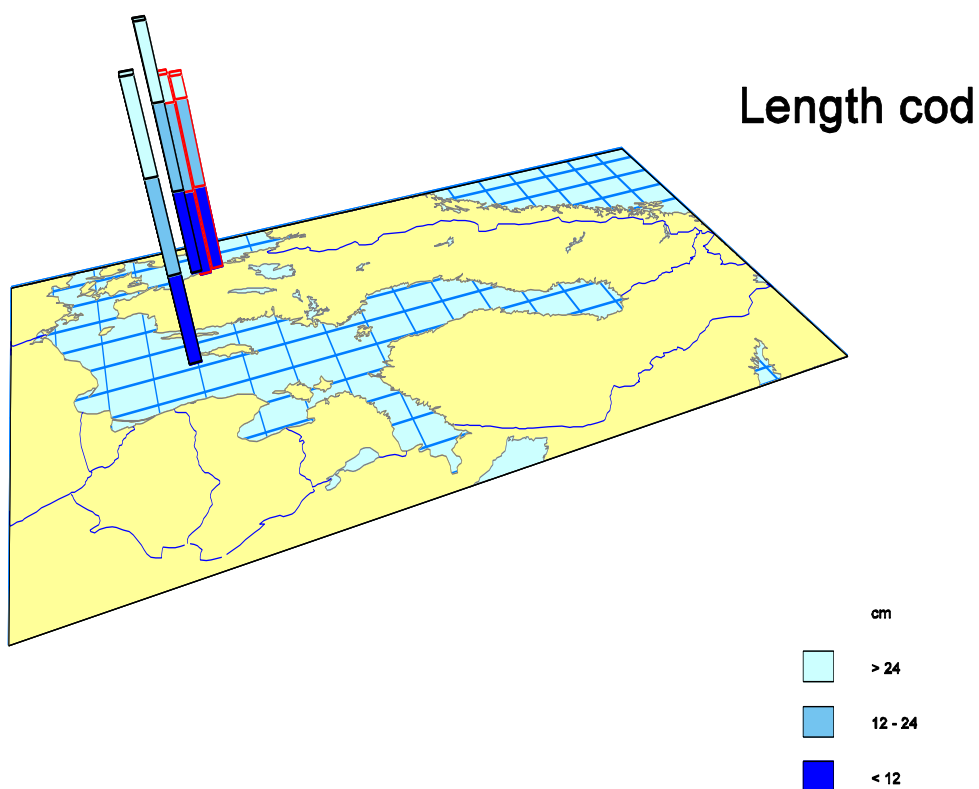
**Figure 4.1.13.** Spatial variation in mean total length (cm) in herring. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.1.14.** Spatial variation in mean total length (cm) in perch. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.1.15.** Spatial variation in mean total length (cm) in eelpout. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.1.16.** Spatial variation in mean total length (cm) in cod. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

The length of herring was similar among sites, ranging between 14.5 and 17.6 cm for the polluted sites (Fig. 4.1.13). Also for perch the length was comparable among the sites, ranging between 16.2 and 19 cm (Fig. 4.1.14). For eelpout the length was also the same among sites, 22-23 cm (Fig. 4.1.15). Cod from the two polluted sites were similar in length, 27 cm, while cod from the two reference sites were somewhat longer, 34-35 cm (Fig. 4.1.16).

## **4.2 Metals**

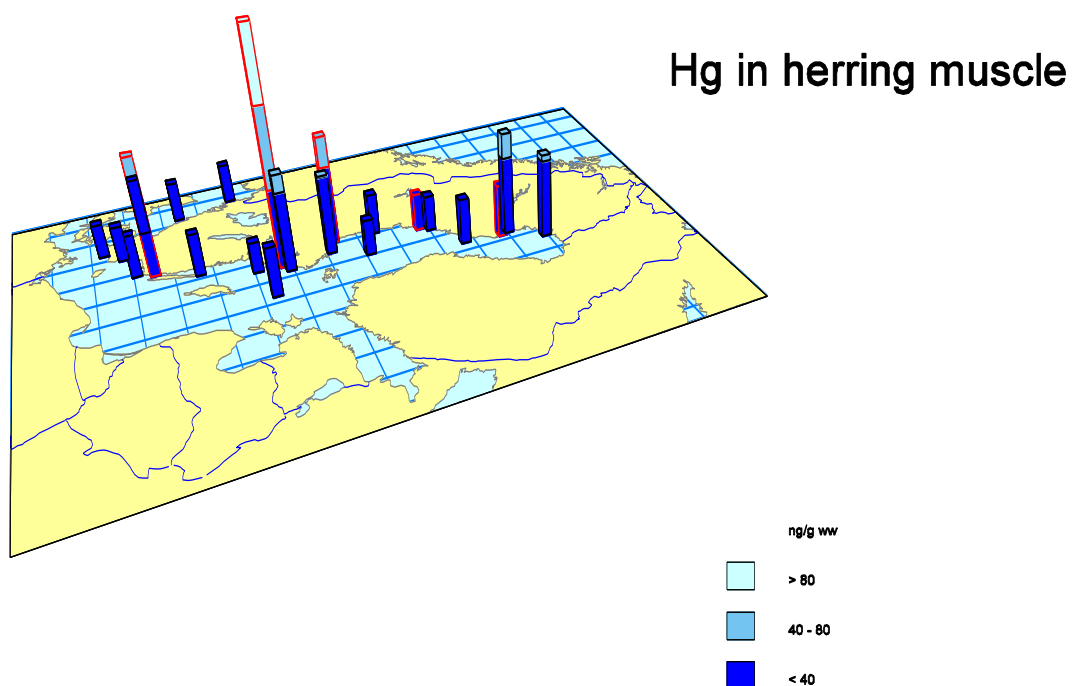
### **4.2.1 Mercury**

#### *Usage*

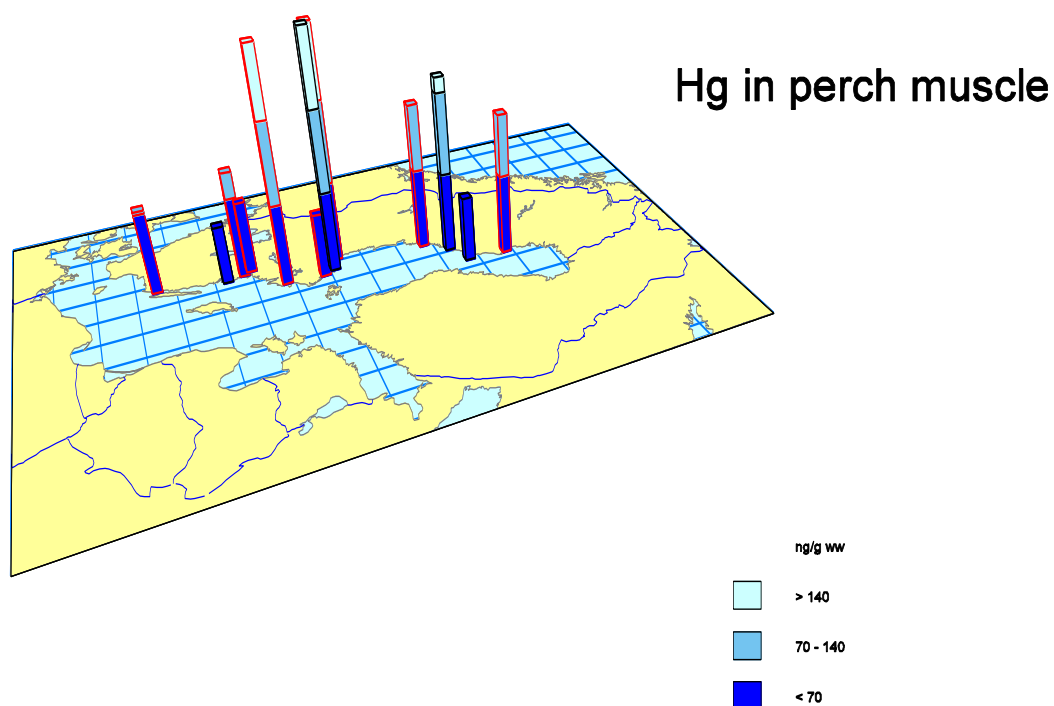
Mercury exists naturally in the environment, e.g. volcanoes, forest fires, fossil fuels, petroleum and cinnabar ore, but it is also used in thermometers, barometers, sphygmomanometers (blood pressure cuffs), float valves, some electrical switches, amalgam for dental restoration, batteries, fluorescent lamps, anti-lock braking systems (ABS) in some 4WD vehicles and airbag sensors in some vehicle models. For a comprehensive list of mercury usage in everyday life, see Huber (1998). Highly toxic and bioaccumulatory methylmercury compounds were previously used as fungicides or were unwanted by-products of the chemical industry (Clarkson 1992).

#### *Restrictions*

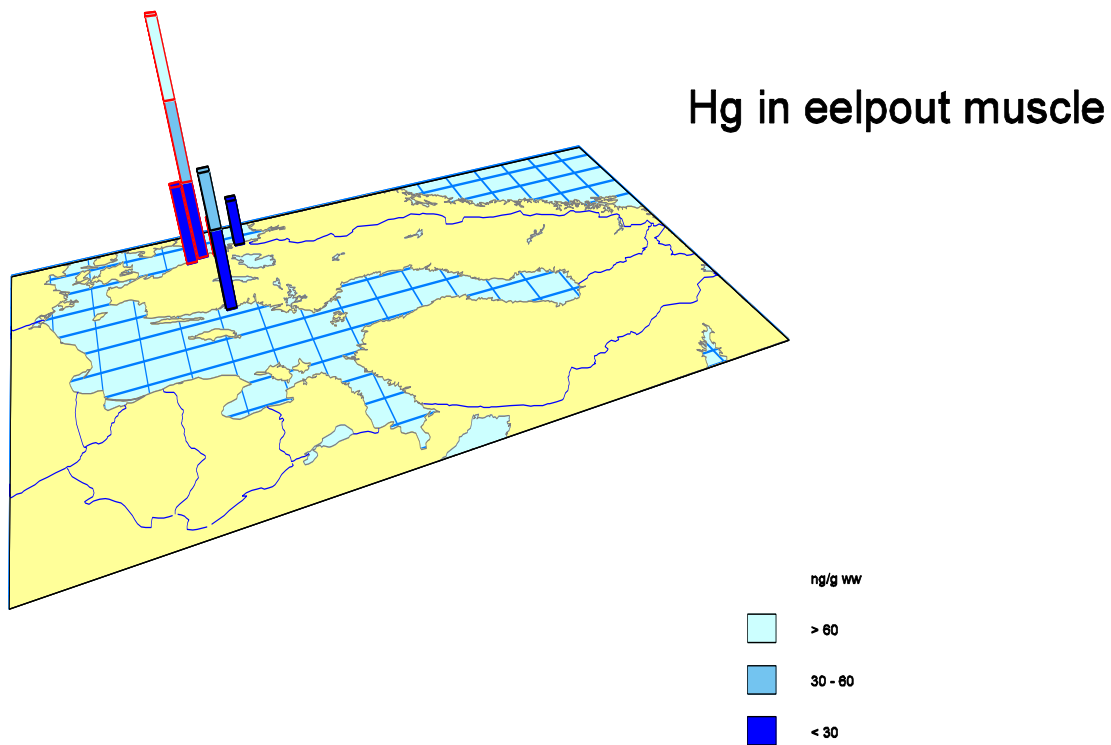
The usage of mercury in paper pulp industries has been banned in Sweden since 1966. According to a governmental proposition (1993/94:163), the aim was that all mercury usage in Sweden should have ceased by 2000.



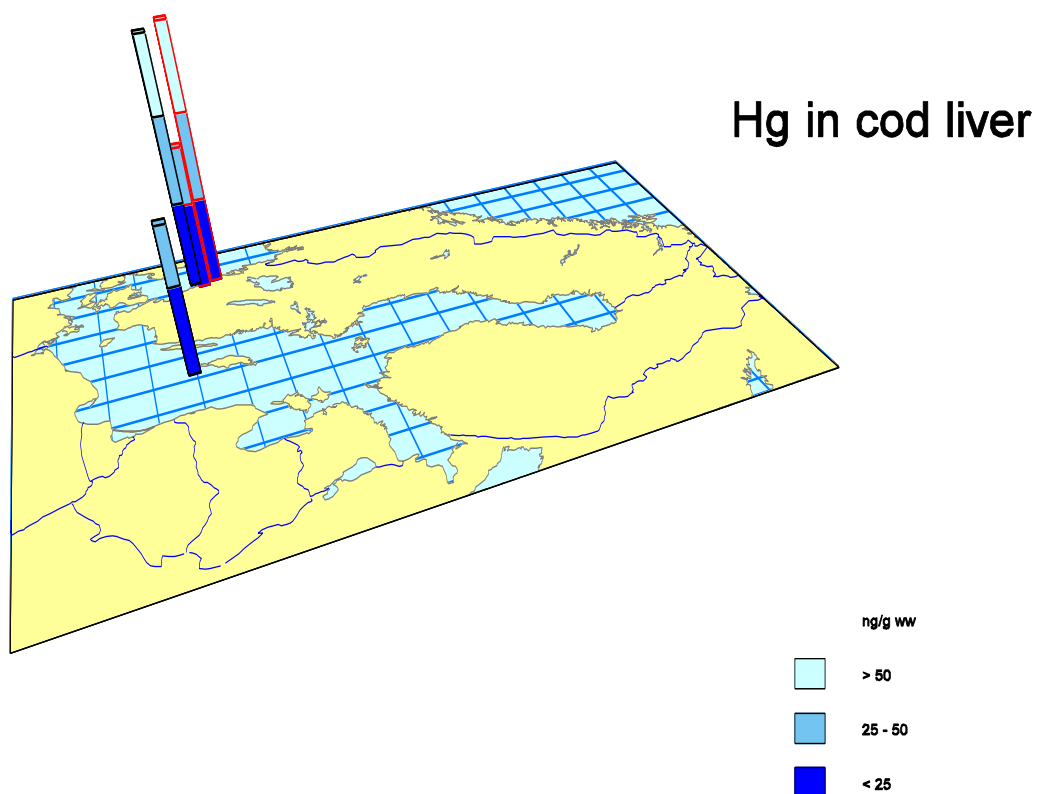
**Figure 4.2.1.** Spatial variation in concentration of mercury (ng/g ww) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.2.** Spatial variation in concentration of mercury (ng/g ww) in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.3.** Spatial variation in concentration of mercury (ng/g ww) in eelpout muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.4.** Spatial variation in concentration of mercury (ng/g ww) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Table 4.2.1.** Differences in Hg concentration in herring muscle (ng/g ww) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | Meanp-Meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | 52.5  | 27.0  | -25.5       | <b>.002</b> |
| Örnsköldsviksfjärden | 6  | 18.2  | 19.0  | .833        | .645        |
| Yttre Fjärden        | 42 | 40.7  | 55.5  | 14.8        | <b>.001</b> |
| Lilla Värtan         | 42 | 20.3  | 116.  | 96.2        | <b>.000</b> |
| Torsås               | 42 | 21.4  | 60.0  | 38.6        | <b>.000</b> |

**Table 4.2.2.** Differences in Hg concentration in perch muscle (ng/g ww) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | Meanp-Meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | 70.6  | 124   | 52.9        | <b>.000</b> |
| Örnsköldsviksfjärden | 36 | 74.3  | 128   | 53.2        | <b>.000</b> |
| Yttre Fjärden        | 36 | 68.8  | 203   | 134         | <b>.000</b> |
| Östhammarsfjärden    | 31 | 55.2  | 55.5  | .274        | .962        |
| Lilla Värtan         | 31 | 55.2  | 200   | 144         | <b>.000</b> |
| Inre Slätbaken       | 31 | 55.2  | 92.5  | 37.3        | <b>.000</b> |
| Bråviken, n Svindra  | 31 | 55.2  | 54.3  | -.938       | .872        |
| Bråviken, s Esterön  | 31 | 55.2  | 61.2  | 5.97        | .307        |
| Bråviken, n Esterön  | 31 | 55.2  | 71.1  | 15.8        | <b>.010</b> |
| Torsås               | 30 | 50.2  | 73.0  | 22.8        | <b>.000</b> |

**Table 4.2.3.** Differences in Hg concentration in cod liver (ng/g wet weight) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | Meanr-meanp | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | 72.0  | 74.5  | 2.53        | .564        |
| Kungsbackafjorden | 30 | 72.0  | 41.5  | -30.5       | <b>.000</b> |

For Hg in herring muscle, the highest concentration was found in Lilla Värtan, 116 ng/g wet weight, while the other polluted sites were in the range 19-60 ng/g wet weight, where the lowest concentration was found in Örnköldsviksfjärden (Fig. 4.2.1). The concentrations at the reference sites ranged between 17 and 52 ng/g wet weight. Yttre fjärden, Lilla Värtan, and Torsås had significantly higher concentrations compared to their respective reference sites (Table 4.2.1). In perch muscle, concentrations of Hg seemed to be elevated in the area around Stockholm, both for the polluted and the reference site, however, the reference site, Ängärsklubb, only consists of one single sample. The highest concentrations were found in Yttre fjärden (202 ng/g ww) and in Lilla Värtan (199 ng/g ww) and the lowest concentration was found in Östhammarsfjärden (55 ng/g ww) (Fig. 4.2.2). Most of the polluted sites were significantly higher compared to their respective reference sites (Table 4.2.2). In eelpout muscle, the highest concentration of Hg was found in Rivö fjord, 88 ng/g wet weight, and the lowest concentration (14 ng/g ww) was found in Halsefjord and Askeröfjord (Fig. 4.2.3). In cod liver the highest concentration was found in Rivö fjord (75 ng/g ww) and the lowest concentration (42 ng/g ww) was found in Kungsbackafjorden (Fig. 4.2.4). None of the polluted cod sites were significantly higher compared to its reference (Table 4.2.3).

#### *Comparison between species*

Generally, concentrations in perch muscle were 2-6 times higher compared to concentrations in herring. Concentrations in cod liver and eelpout muscle were similar and at levels in between herring and perch.

#### *Comparison with target value*

Concentrations of mercury exceed the target value of 20 ng/g ww in all species from all polluted sites except for herring from Örnköldsviksfjärden with concentrations just below.

### **4.2.2 Lead**

#### *Usage, production and sources*

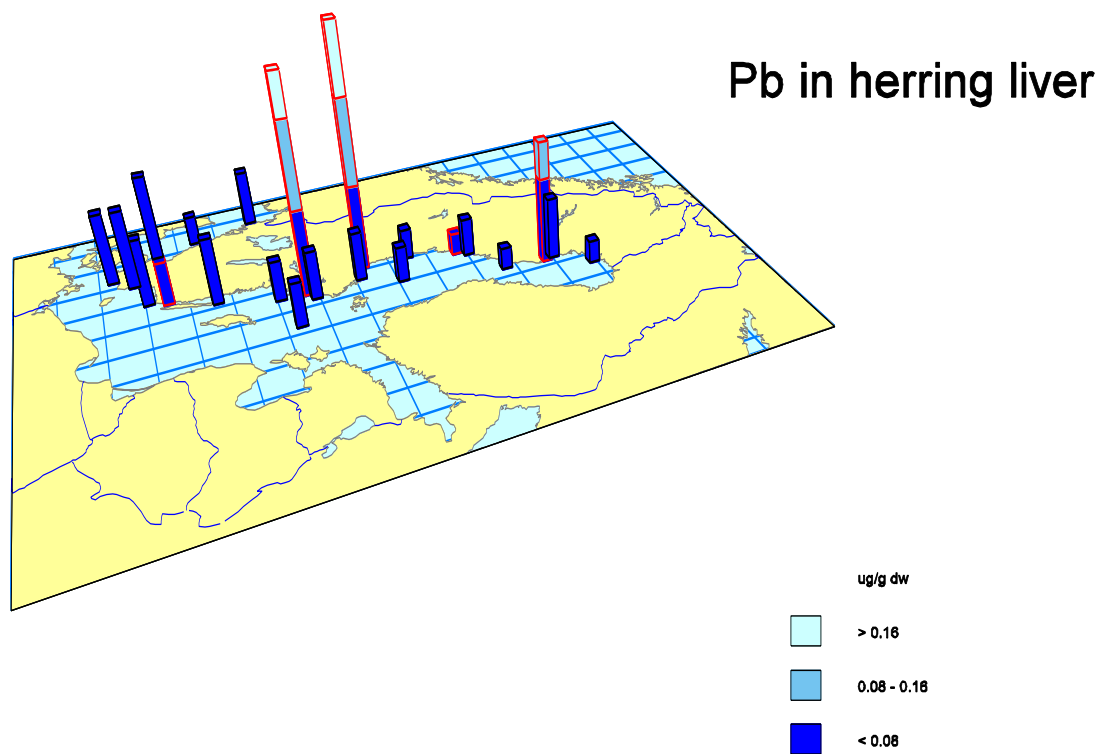
In nature, lead is usually found in ore with zinc, silver or copper. Atmospheric sources of lead in Sweden show a south to north gradient, due to northward atmospheric transport from sources located elsewhere in Europe (Renberg et al. 2000). The main sources of lead pollution in Sweden come from ammunition, lead petrol emissions and associated contamination in road side soils (although leaded gasoline was eliminated in 1994 in Sweden (Faiz et al. 1996)), lead pigments, cables and batteries. There are also point sources (e.g. metal works) that have resulted in high local pollution (Bergbäck et al. 1992), e.g. a secondary lead smelter in Landskrona where lead from car batteries is recycled (Farago et al. 1999).

The lead concentrations in biological samples in Sweden have decreased significantly after the ban of leaded gasoline (Lind et al., 2006).

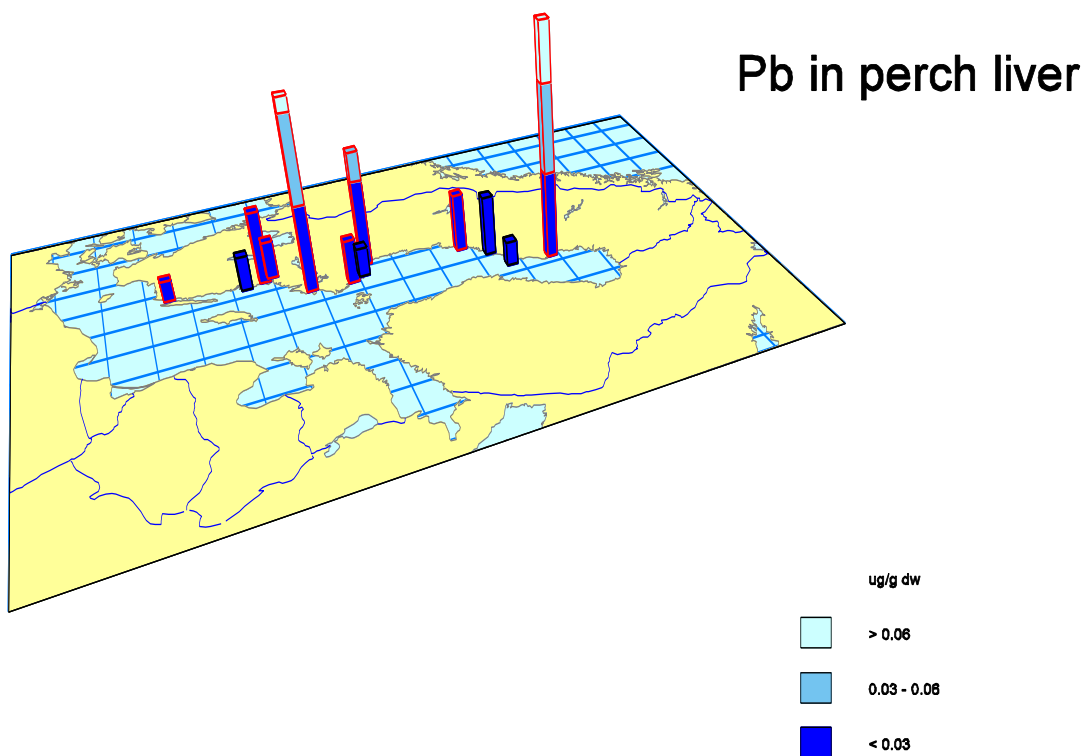
#### *Restrictions*

The usage of lead in gasoline has been banned in Sweden since 1995.

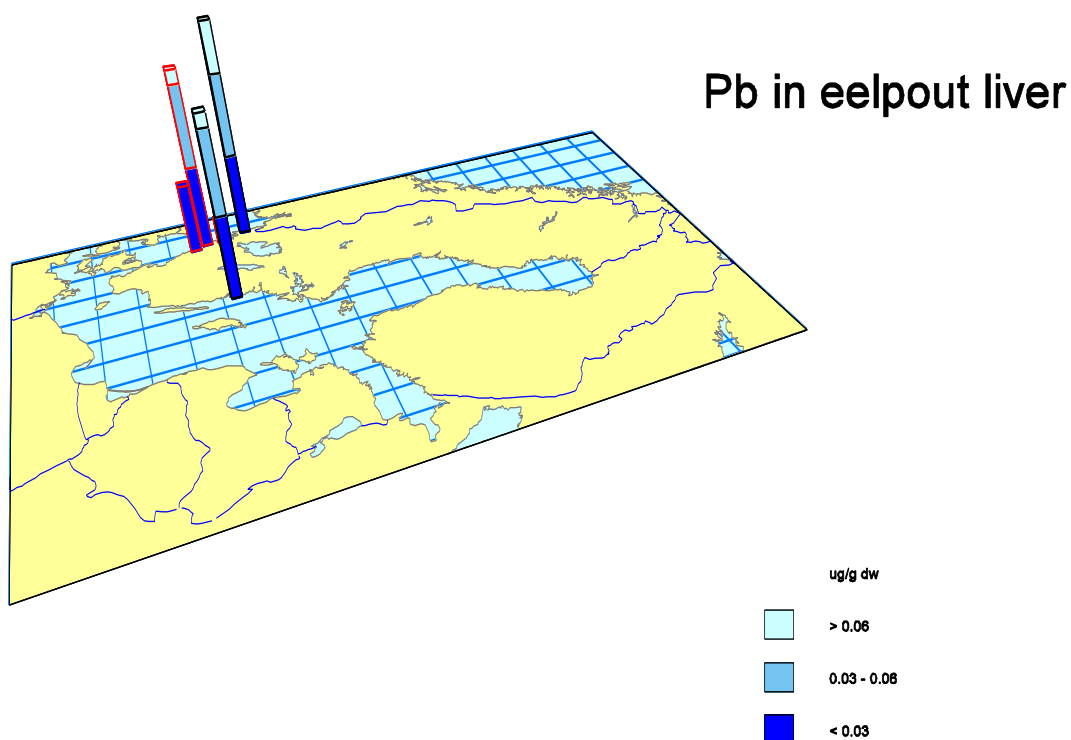
The recommended limit for children's food is set by the Swedish National Food Administration (SNFA) at 50 ng/g fresh weight (SLVFS, 1993).



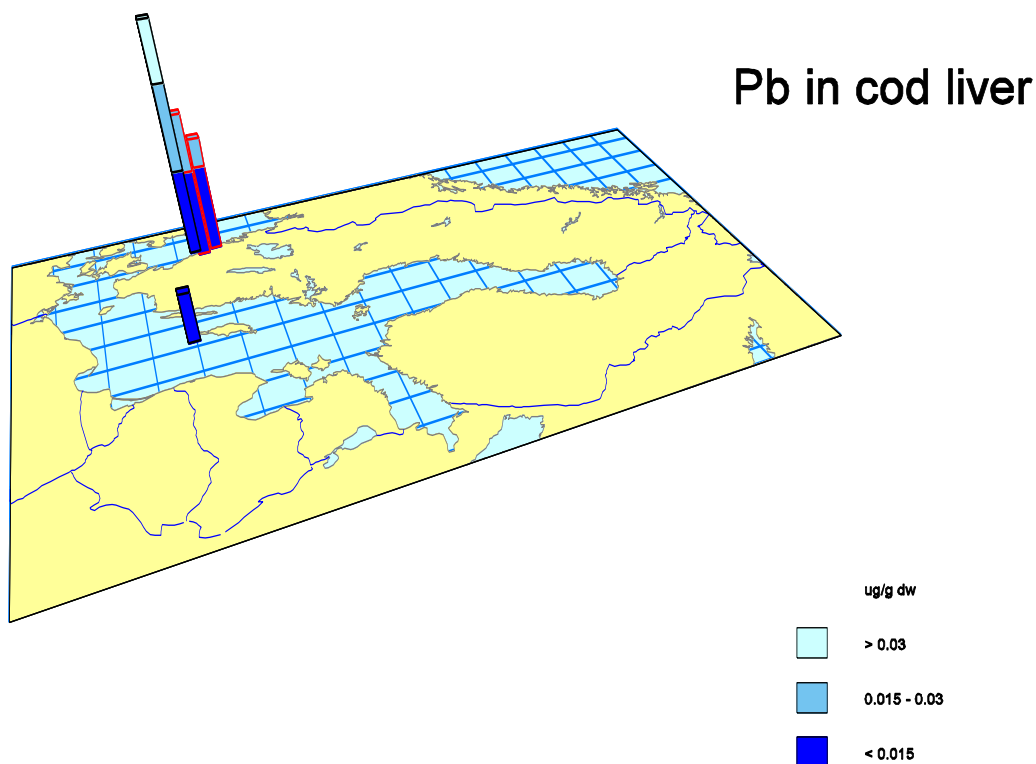
**Figure 4.2.5.** Spatial variation in concentration of lead ( $\mu\text{g}/\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.6.** Spatial variation in concentration of lead ( $\mu\text{g}/\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.7.** Spatial variation in concentration of lead ( $\mu\text{g}/\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.8.** Spatial variation in concentration of lead ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.2.4.** Differences in Pb concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .0583 | .115  | .0567       | .102        |
| Örnsköldsviksfjärden | 6  | .0350 | .020  | -.0150      | .030        |
| Yttre Fjärden        | 42 | .0457 | .225  | .179        | <b>.000</b> |
| Lilla Värtan         | 42 | .0385 | .200  | .162        | <b>.000</b> |
| Torsås               | 42 | .0621 | .040  | -.0221      | <b>.000</b> |

**Table 4.2.5.** Differences in Pb concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | .0101 | .0800 | .0699       | <b>.000</b> |
| Örnsköldsviksfjärden | 36 | .0101 | .0200 | .0099       | <b>.000</b> |
| Yttre Fjärden        | 36 | .0129 | .0400 | .0271       | <b>.000</b> |
| Östhammarsfjärden    | 31 | .0117 | .0150 | .0033       | .072        |
| Lilla Värtan         | 31 | .0117 | .0650 | .0533       | <b>.000</b> |
| Inre Slätbaken       | 31 | .0117 | .0250 | .0133       | <b>.000</b> |
| Bråviken, n Svindra  | 31 | .0117 | .0170 | .0053       | <b>.006</b> |
| Bråviken, s Esterön  | 31 | .0117 | .0210 | .0093       | <b>.000</b> |
| Bråviken, n Esterön  | 31 | .0117 | .0090 | -.0027      | .148        |
| Torsås               | 30 | .0117 | .0071 | -.0046      | <b>.019</b> |

**Table 4.2.6.** Differences in Pb concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | Meanr-meanp | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | .0403 | .0200 | -.0203      | <b>.016</b> |
| Kungsbackafjorden | 30 | .0403 | .0250 | -.0153      | .064        |

The highest concentrations of Pb in herring liver were found in Yttre Fjärden ( $0.22 \mu\text{g/g dw}$ ) and in Lilla Värtan ( $0.2 \mu\text{g/g dw}$ ) and the lowest concentration was found in Örnsköldsviksfjärden ( $0.02 \mu\text{g/g dw}$ ) (Fig. 4.2.5). The concentrations of Pb in herring liver from the reference sites ranged between 0.02 and  $0.08 \mu\text{g/g dw}$ . The concentrations of Pb were significantly higher in Lilla Värtan and Yttre Fjärden compared to their corresponding reference site (Table 4.2.4). The highest concentration of Pb in perch liver was found in Skelleftebukten,  $0.08 \mu\text{g/g dw}$  and the lowest concentration was found in Torsås,  $0.007 \mu\text{g/g dw}$  (Fig. 4.2.6). For the perch from the reference sites, the concentrations ranged between 0.008 and  $0.02 \mu\text{g/g dw}$ . The majority of the perch from the polluted sites were significantly higher compared to their respective reference sites (Table 4.2.5). In eelpout liver the highest concentration was found in Rivö fjord ( $0.065 \mu\text{g/g dw}$ ) and the lowest concentration was found in Halsefjord and Askeröfjord (Fig. 4.2.7). In cod liver, the two polluted sites had almost the same concentration (approximately  $0.02 \mu\text{g/g dw}$ ) (Fig. 4.2.8). For the reference sites the concentrations were rather variable, ranging from 0.008 to  $0.04 \mu\text{g/g dw}$ . None of the cod polluted sites had significantly higher concentration than the reference (Table 4.2.6).

#### *Comparison between species*

In the northern part of Sweden, lead concentrations in herring liver and perch liver were similar, but in the middle and southern part of Sweden herring liver had 5-14 times higher concentration compared to perch liver. For cod liver and eelpout liver, concentrations were comparable in Kungsbackafjorden but in Rivö fjord eelpout liver had three times higher concentrations.

#### *Comparison with target value*

The target value used for Pb is set to 1000 µg/kg wet weight in whole-fish. This value has been recalculated to represent the corresponding value in dry weight in liver for herring and perch that is presented in the maps. No recalculation or comparison to target value is made for cod and eelpout because lack of conversion factors.

The recalculation of the target value for whole-fish is based on a study that compared concentrations of Pb in the liver and whole-fish of herring and perch (Boalt et al., 2011). The whole-fish:liver ratio was 4.58 and 12.18 for herring and perch respectively (Boalt et al., 2011). The recalculation to dry weight is based on the mean liver dry weight of the analysed samples (polluted sites), 29.6% for herring and 24.1% for perch.

The calculated corresponding values for EQS in liver:

EQSbiota (herring liver): 0.74 µg/g dry weight

EQSbiota (perch liver): 0.34 µg/g dry weight

All samples are below the target value. The highest concentrations of Pb in herring and perch liver are 0.22 µg/g dw and 0.08 µg/g dw respectively and thus below the target values.

### **4.2.3 Cadmium**

#### *Usage, production and sources*

Cadmium is an important metal in many industrial applications. It was used extensively until the end of the 1970s in electroplating or galvanising because of its noncorrosive properties. It has also been used (and to some extent is still used) as a cathode material for nickel-cadmium batteries, and as a colour pigment for paints and plastics. However, its industrial use has decreased considerably during recent years. Cadmium can also enter the environment as a by-product of zinc and lead mining and smelting, and as an undesired element in fertilisers.

#### *Restrictions*

The Swedish Parliament has agreed on a general reduction of cadmium discharge, aiming at a reduction of 70% between 1985 and 1995, and further, that all use of cadmium that implies a risk of discharge to the environment, in a longer term perspective, will cease (prop 1990/91:90, JoU 30, rskr.343).

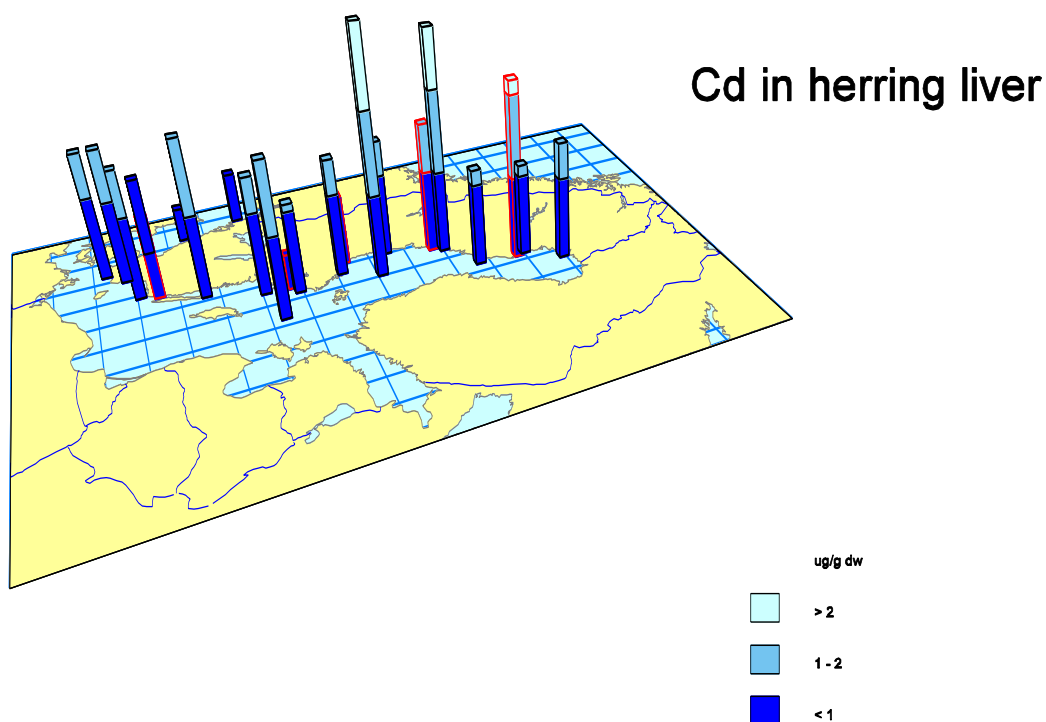
In 1982, the use of cadmium in electroplating and as a thermal stabiliser was banned in Sweden.

In 1987, a fee on batteries containing cadmium was introduced in Sweden. This fee was raised considerably in 1991.

In 1993, the content of cadmium in fertilisers was restricted to 100g/ton of phosphorus in Sweden.

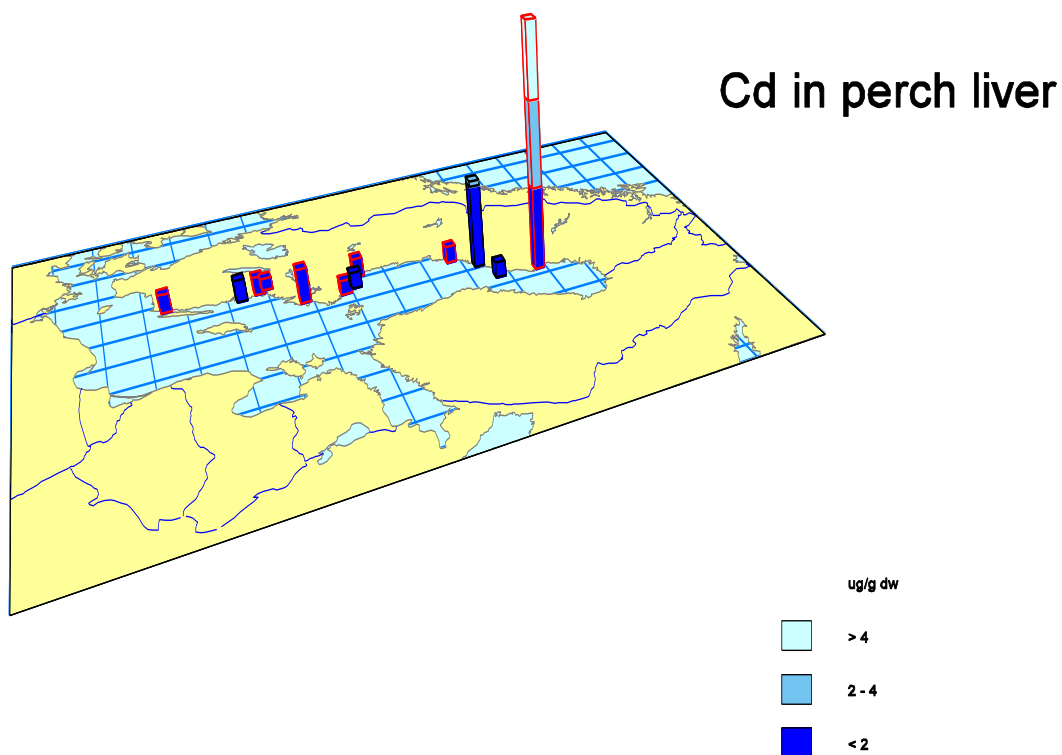
Since 2009, Sweden has followed the cadmium restrictions in fertilizers within REACH.

#### *Spatial variation*

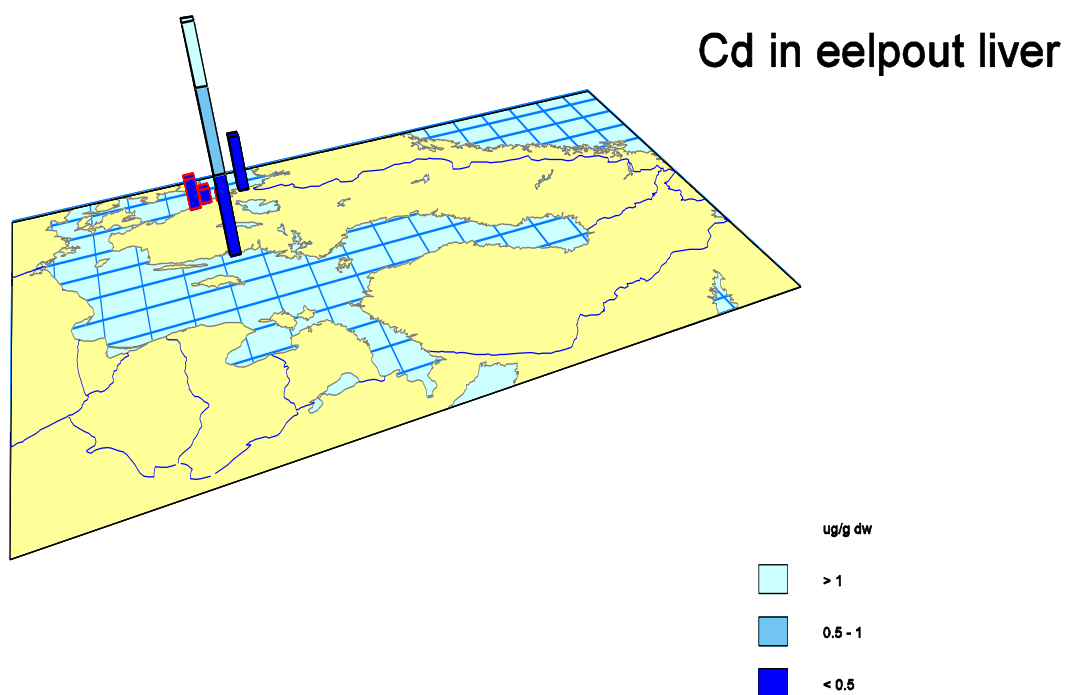


**Figure 4.2.9.** Spatial variation in concentration of cadmium ( $\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

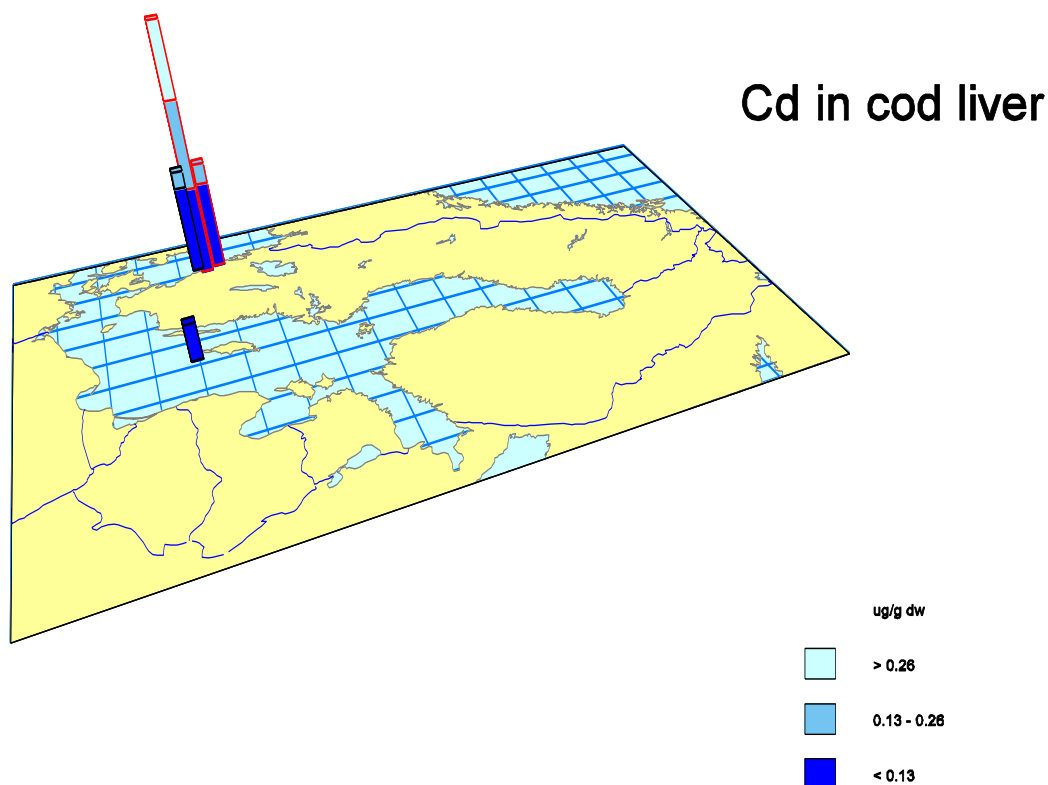




**Figure 4.2.10.** Spatial variation in concentration of cadmium ( $\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.11.** Spatial variation in concentration of cadmium ( $\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.12.** Spatial variation in concentration of cadmium ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.2.7.** Differences in Cd concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | 1.13  | 2.17  | 1.04        | <b>.000</b> |
| Örnsköldsviksfjärden | 6  | 2.71  | 1.60  | -1.11       | .071        |
| Yttre Fjärden        | 42 | 1.43  | .850  | -.579       | <b>.001</b> |
| Lilla Värtan         | 42 | 1.38  | .425  | -.958       | <b>.000</b> |
| Torsås               | 42 | 1.55  | .975  | -.576       | <b>.000</b> |

**Table 4.2.8.** Differences in Cd concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | .627  | 5.71  | 5.08        | <b>.000</b> |
| Örnsköldsviksfjärden | 36 | .621  | .405  | -.216       | .311        |
| Yttre Fjärden        | 36 | .749  | .460  | -.289       | .177        |
| Östhammarsfjärden    | 31 | .527  | .345  | -.182       | <b>.002</b> |
| Lilla Värtan         | 31 | .527  | .830  | .303        | <b>.000</b> |
| Inre Slätbaken       | 31 | .527  | .425  | -.102       | .065        |
| Bråviken, n Svindra  | 31 | .527  | .338  | -.189       | <b>.001</b> |
| Bråviken, s Esterön  | 31 | .527  | .290  | -.237       | <b>.000</b> |
| Bråviken, n Esterön  | 31 | .527  | .245  | -.282       | <b>.000</b> |
| Torsås               | 30 | .532  | .445  | -.0870      | .124        |

**Table 4.2.9.** Differences in Cd concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | Meanr-meanp | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | .154  | .160  | .0057       | .810        |
| Kungsbackafjorden | 30 | .154  | .370  | .216        | <b>.000</b> |

The concentration of Cd in herring liver was highest in Skelleftebukten ( $2.2 \mu\text{g/g dw}$ ) and the lowest concentration was found in Lilla Värtan ( $0.4 \mu\text{g/g dw}$ ) (Fig. 4.2.9). Most reference sites were in the range  $1\text{--}1.5 \mu\text{g/g dw}$ . Herring from Skelleftebukten had significantly higher concentration of Cd compared to the reference sites (Table 4.2.7). In perch liver, Skelleftebukten had very high concentration,  $5.7 \mu\text{g/g dw}$ , compared to all the other sites, which were around  $0.4 \mu\text{g/g dw}$ . The lowest concentration was found in Östhammarsfjärden ( $0.35 \mu\text{g/g dw}$ ) (Fig. 4.2.10). Cd concentrations in perch were significantly higher in Skelleftebukten and Lilla Värtan compared to their respective reference site (Table 4.2.8). The concentration of Cd in eelpout liver was highest in Kungsbackafjorden ( $0.2 \mu\text{g/g dw}$ ) and the lowest concentration was found in Halsefjord and Askeröfjord ( $0.04 \mu\text{g/g dw}$ ) (Fig. 4.2.11). Cod liver from Kungsbackafjorden had the highest concentration of Cd,  $0.37 \mu\text{g/g dw}$ , while Rivö fjord had the lowest concentration,  $0.16 \mu\text{g/g dw}$  (Fig. 4.2.12). The concentration of Cd in cod from Kungsbackafjorden was significantly higher compared to its reference site (Table 4.2.9).

#### *Comparison between species*

Lead concentration in perch liver was twice as high in Skelleftebukten and Lilla Värtan compared to herring liver while at the other sites, concentration in herring was around twice as high than in perch.

Cod liver had twice as high concentrations compared to eelpout liver at the different sites.

#### *Comparison with target value*

The target value used for Cd is set to 160 µg/kg wet weight in whole-fish. This value has been recalculated to represent the corresponding value in dry weight in liver for herring and perch that is presented in the maps. No recalculation or comparison to target value is made for cod and eelpout because lack of conversion factors.

The recalculation of the target value for whole-fish is based on a study that compared concentrations of Cd in the liver and whole-fish of herring and perch (Boalt et al., 2011). The whole-fish:liver ratio was 0.11 and 0.16 for herring and perch respectively (Boalt et al., 2011). The recalculation to dry weight is based on the mean liver dry weight of the analysed samples, 29.6% for herring and 24.1% for perch.

The calculated corresponding values for EQS in liver:

EQSbiota (herring liver): 4.9 µg/g dry weight

EQSbiota (perch liver): 4.1 µg/g dry weight

All herring and perch stations show concentrations below the recalculated target values except for perch from Skellefteåbukten. The concentrations in perch from Skellefteåbukten are clearly elevated and exceed the target value of 4.1 µg/g dry weight with a mean value of 5.7 µg/g dry weight, approximately 10 times higher than the other stations included in the study.

### **4.2.4 Nickel**

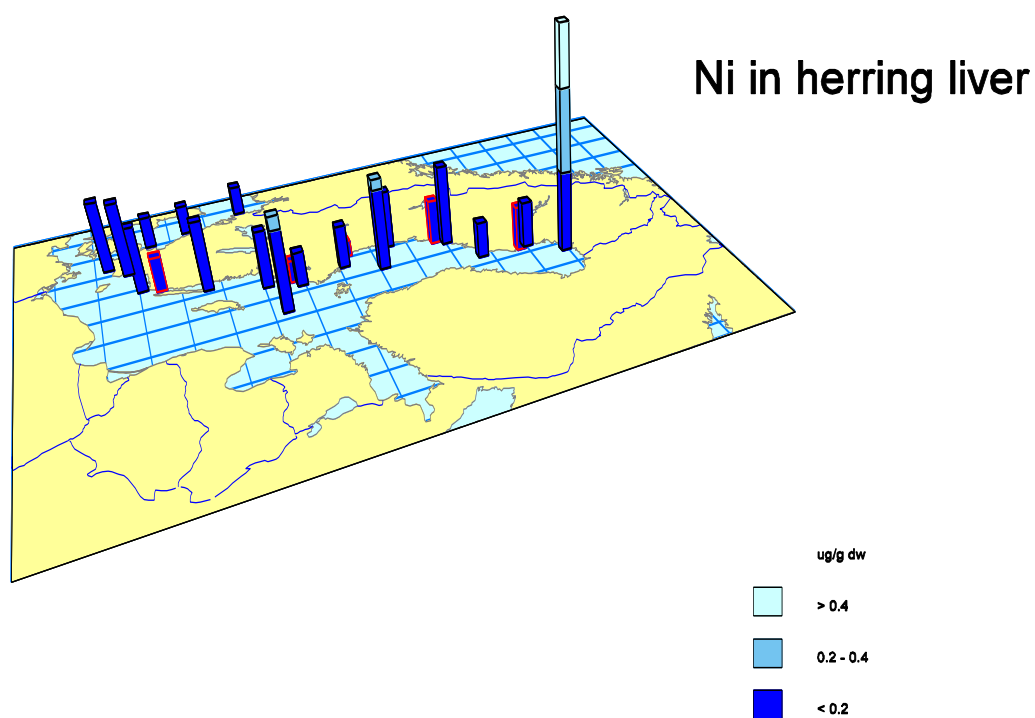
#### *Usage, production and sources*

The most important use of nickel is in manufacturing of a variety of alloys including stainless steel (Cempel and Nikel 2006). Moreover, nickel is also very popular in the battery industry. Nickel-cadmium and nickel-metal hydride batteries are the main line products. Nickel is used in a great variety of appliances, including hand-held power tools, compact disc players, pocket recorders, camcorders, cordless and cellular telephones, scanner radios, and laptop computers. Nickel is also used in electroplating.

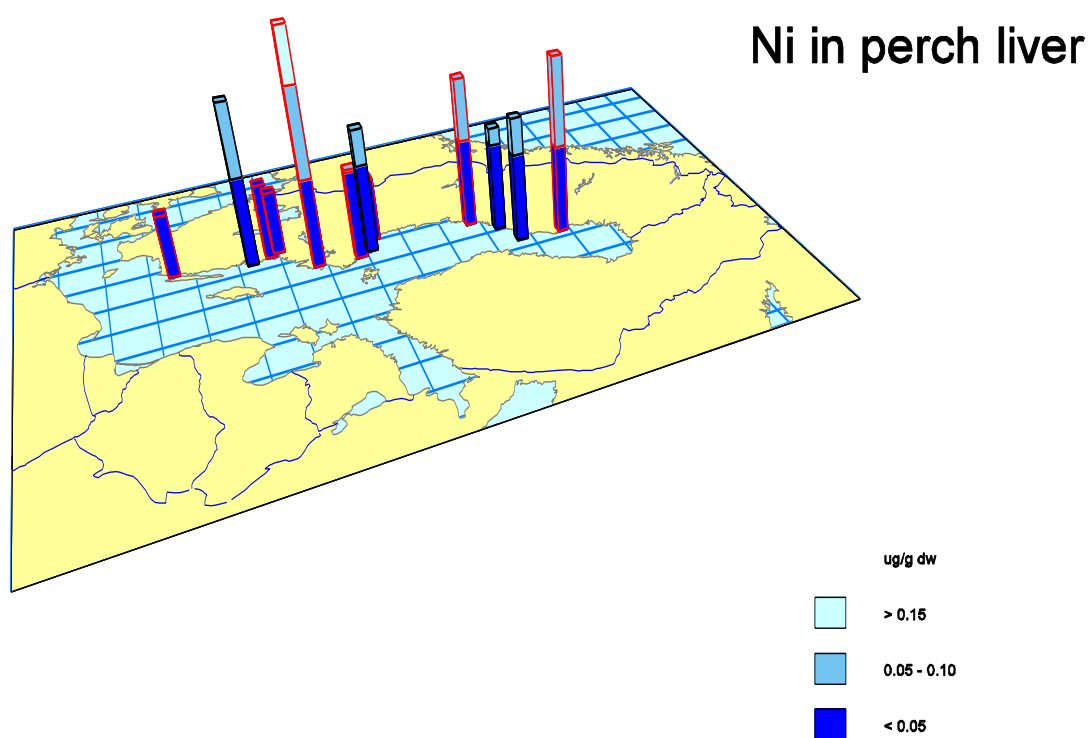
#### *Restrictions*

There are no restrictions against the usage of nickel.

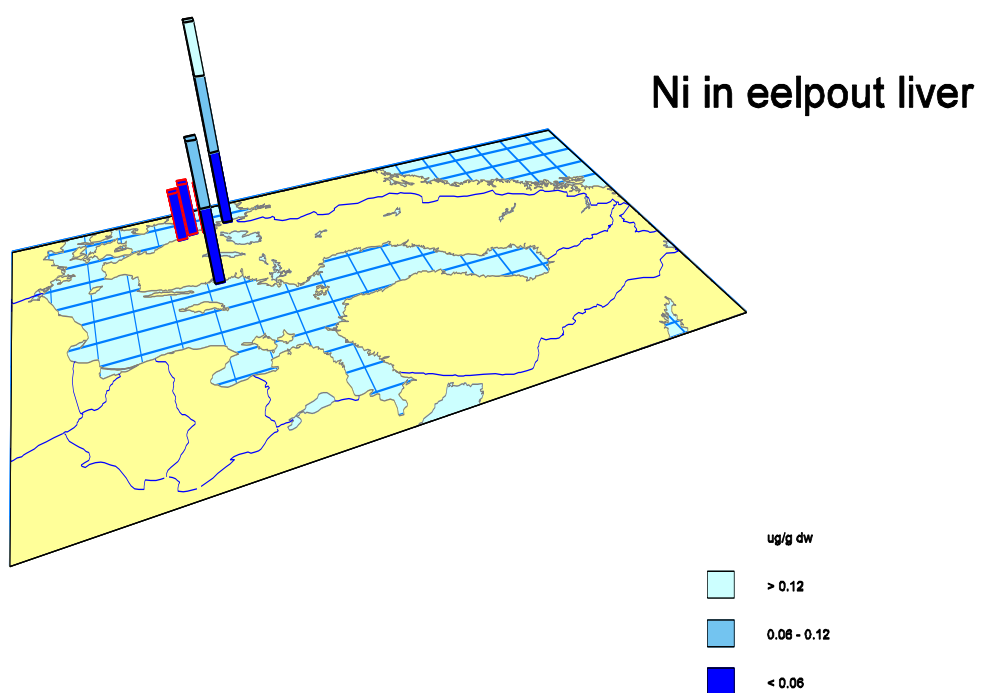
## Spatial variation



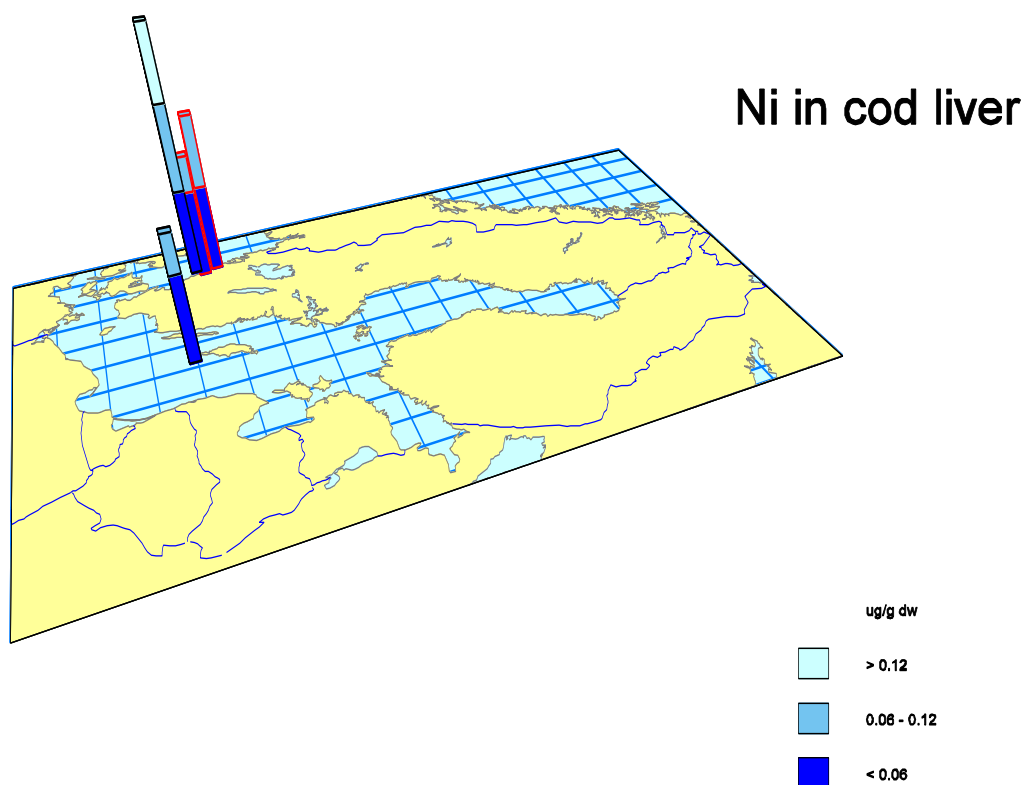
**Figure 4.2.13.** Spatial variation in concentration of nickel ( $\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.14.** Spatial variation in concentration of nickel ( $\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.15.** Spatial variation in concentration of nickel ( $\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.16.** Spatial variation in concentration of nickel ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.2.10.** Differences in Ni concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p    |
|----------------------|----|-------|-------|-------------|------|
| Skelleftebukten      | 6  | .115  | .110  | -.0050      | .656 |
| Örnsköldsviksfjärden | 6  | .198  | .110  | -.0883      | .012 |
| Yttre Fjärden        | 42 | .105  | .0389 | -.0665      | .000 |
| Lilla Värtan         | 42 | .132  | .0527 | -.0797      | .000 |
| Torsås               | 42 | .160  | .0850 | -.0748      | .000 |

**Table 4.2.11.** Differences in Ni concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p    |
|----------------------|----|-------|-------|-------------|------|
| Skelleftebukten      | 35 | .0690 | .100  | .0310       | .000 |
| Örnsköldsviksfjärden | 36 | .0691 | .0850 | .0159       | .041 |
| Yttre Fjärden        | 36 | .0862 | .0354 | -.0508      | .000 |
| Östhammarsfjärden    | 31 | .0905 | .0512 | -.0393      | .012 |
| Lilla Värtan         | 31 | .0905 | .130  | .0395       | .011 |
| Inre Slätbaken       | 31 | .0905 | .0424 | -.0481      | .003 |
| Bråviken, n Svindra  | 31 | .0905 | .0353 | -.1405      | .000 |
| Bråviken, s Esterön  | 31 | .0905 | .0424 | -.1505      | .000 |
| Bråviken, n Esterön  | 31 | .0905 | .0353 | -.1405      | .000 |
| Torsås               | 30 | .0912 | .0354 | -.0558      | .001 |

**Table 4.2.12.** Differences in Ni concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | Meanr-meanp | p    |
|-------------------|----|-------|-------|-------------|------|
| Rivö fjord        | 30 | .172  | .110  | -.0624      | .001 |
| Kungsbackafjorden | 30 | .172  | .0850 | -.0874      | .000 |

Nickel concentrations in herring liver were rather homogenous, except for one of the reference sites, which had higher concentration. The highest Ni concentration for the polluted sites were found in Skelleftebukten and Örnsköldsvik (0.1 µg/g dw) and the lowest concentration was found in Yttre Fjärden (0.04 µg/g dw) (Fig. 4.2.13). None of the polluted sites had higher concentration compared to the reference sites (Table 4.2.10). In perch liver, the highest concentration was found in Lilla Värtan, 0.13 µg/g dw. Three of the other sites, Yttre Fjärden, Torsås, and Bråviken, had the lowest concentration, 0.035 µg/g dw (Fig. 4.2.14). The concentration of Ni was significantly higher in perch from Skelleftebukten, Örnsköldsviksfjärden, and Lilla Värtan (Table 4.2.11). The Concentration of Ni in eelpout liver was similar at the three sites, approximately 0.04 µg/g dw (Fig. 4.2.15). In cod liver, the highest concentration was found in Rivö fjord (0.11 µg/g dw) while Kungsbackafjorden had lower concentration (0.085 µg/g dw) (Fig. 4.2.16). None of the polluted cod sites had significantly higher Ni concentration compared to the reference sites (Table 4.2.12).

#### *Comparison between species*

Generally, the concentration of nickel in herring liver and perch liver were comparable, however, in Lilla Värtan perch liver were more than twice as high and in Torsås herring liver was three times higher compared to perch. Comparing cod liver and eelpout liver, the concentration of nickel in cod was 2-3 times higher.

#### *Comparison with target value*

The target value for nickel is set to 730 µg/kg wet weight for whole-fish. The concentrations of Ni presented in this report are in liver and there are no conversion factors available for recalculation to whole-fish at present, therefore no comparison to target value has been done.

### **4.2.5 Chromium**

#### *Usage, production and sources*

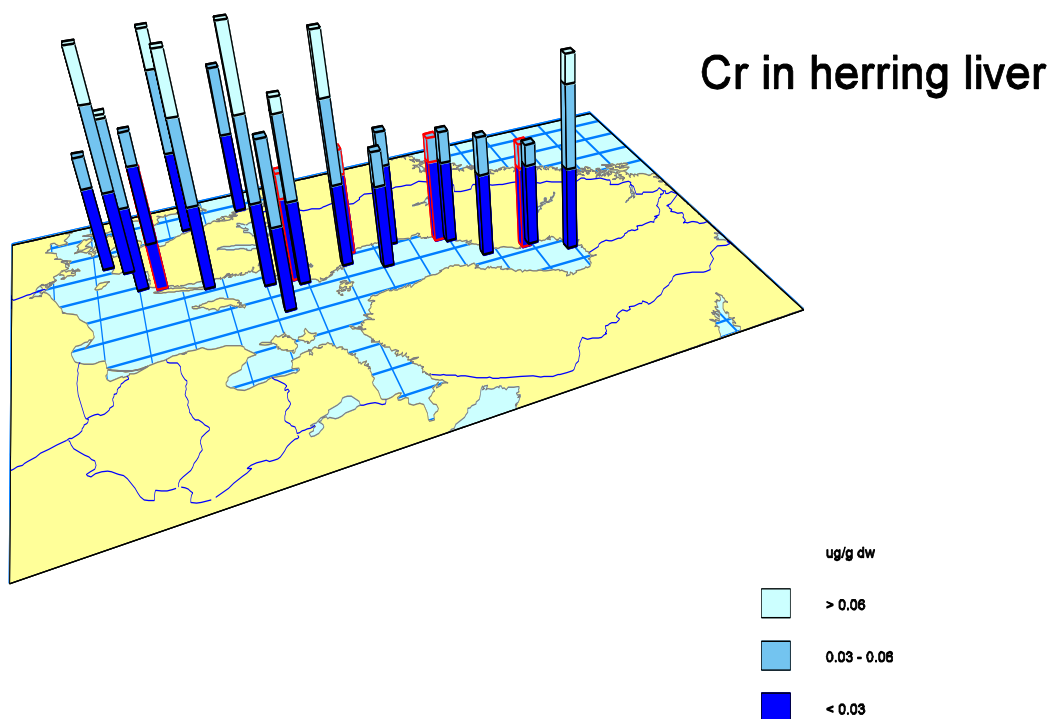
Chromium does not occur as a free element. Rocks or sediments present a wide range of chromium concentration whereas natural water contain quite small amounts (Richard and Bourg, 1991). Most chromium is produced from chromite, or chrome iron ore ( $\text{FeCr}_2\text{O}_4$ ). Chromium is used in the manufacturing of stainless steels, electroplating, leather tanning, pigments for inks and paints.

#### *Restrictions*

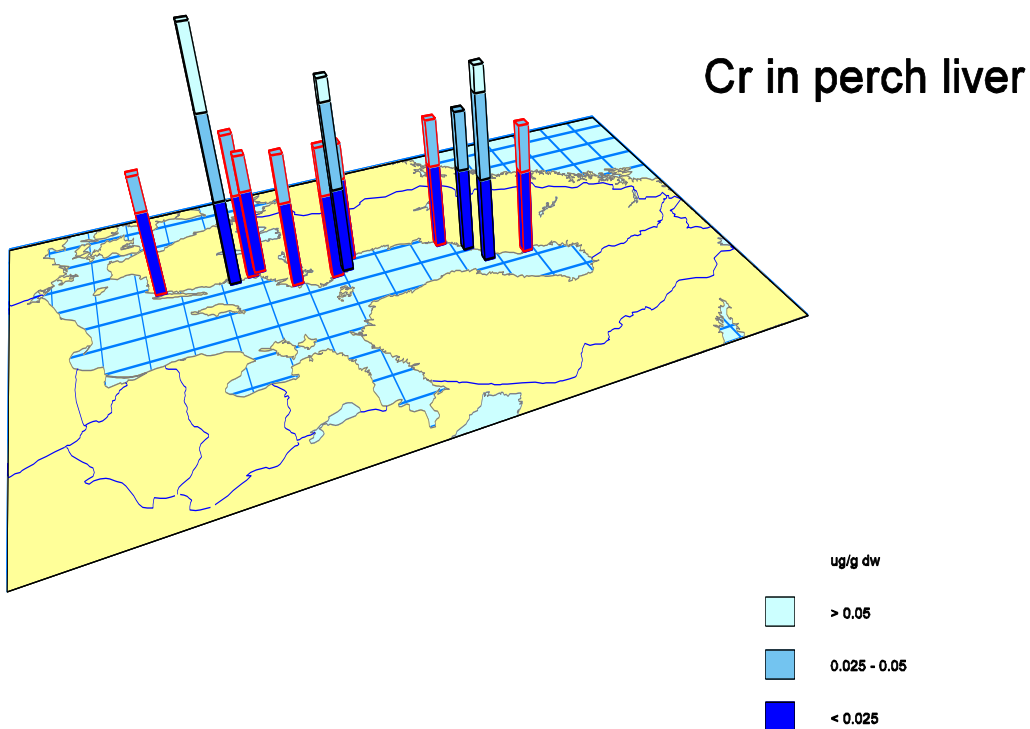
The maximum chromium concentration in drinking water, recommended by the Commission of European Communities, the World Health Organization or the U.S. Environmental Protection Agency, is 50 µg/l (Richard and Bourg, 1991).



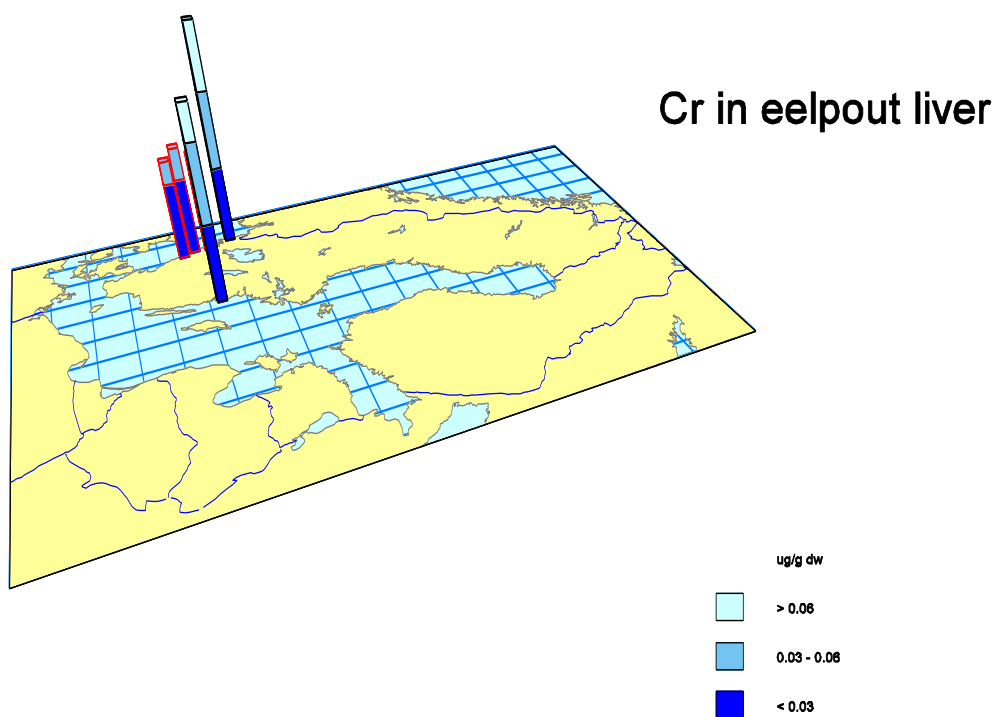
## Spatial variation



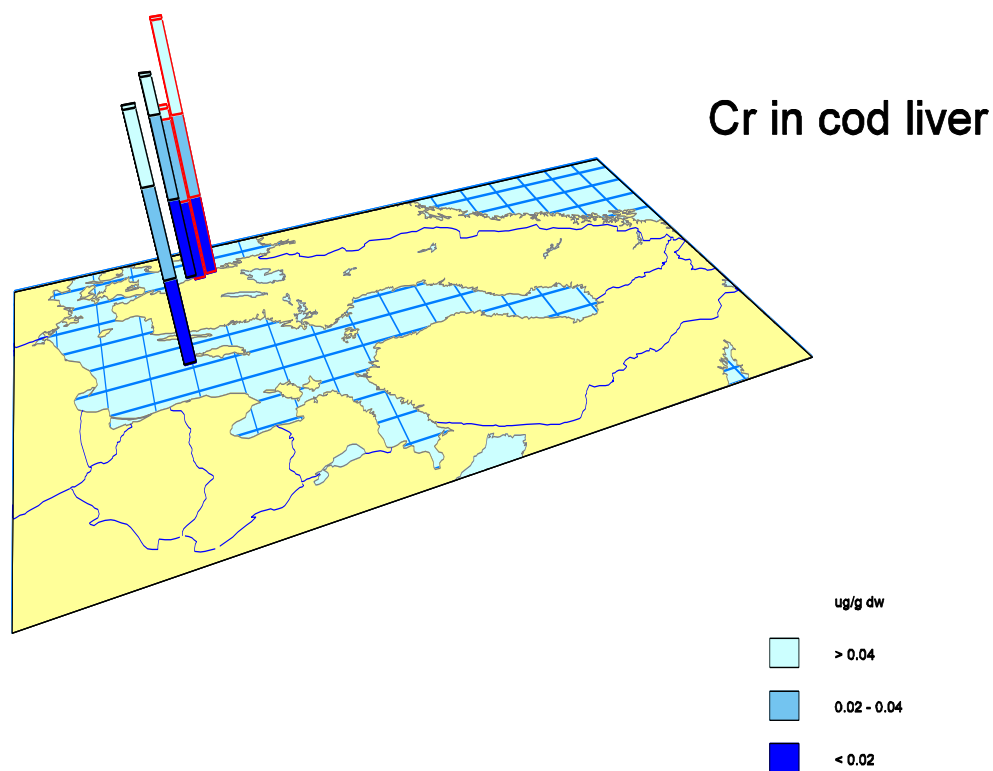
**Figure 4.2.17.** Spatial variation in concentration of chromium ( $\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.18.** Spatial variation in concentration of chromium ( $\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.19.** Spatial variation in concentration of chromium ( $\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.20.** Spatial variation in concentration of chromium ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.2.13.** Differences in Cr concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .0377 | .0389 | .0012       | .462        |
| Örnsköldsviksfjärden | 6  | .0412 | .0389 | -.0023      | .103        |
| Yttre Fjärden        | 42 | .0820 | .0389 | -.0431      | <b>.002</b> |
| Lilla Värtan         | 42 | .0857 | .0389 | -.0468      | <b>.001</b> |
| Torsås               | 42 | .0613 | .0424 | -.0189      | <b>.000</b> |

**Table 4.2.14.** Differences in Cr concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | Meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | .0556 | .0389 | -.0167      | <b>.004</b> |
| Örnsköldsviksfjärden | 36 | .0557 | .0389 | -.0168      | <b>.003</b> |
| Yttre Fjärden        | 36 | .0688 | .0354 | -.0334      | <b>.029</b> |
| Östhammarsfjärden    | 31 | .0730 | .0389 | -.0341      | .053        |
| Lilla Värtan         | 31 | .0730 | .0389 | -.0341      | .053        |
| Inre Slätbaken       | 31 | .0730 | .0424 | -.0306      | .080        |
| Bråviken, n Svindra  | 31 | .0730 | .0353 | -.1230      | <b>.000</b> |
| Bråviken, s Esterön  | 31 | .0730 | .0424 | -.1330      | <b>.000</b> |
| Bråviken, n Esterön  | 31 | .0730 | .0353 | -.1230      | <b>.000</b> |
| Torsås               | 30 | .0736 | .0354 | -.0382      | <b>.037</b> |

**Table 4.2.15.** Differences in Cr concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | Meanr-meanp | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | .0486 | .0612 | .0126       | <b>.000</b> |
| Kungsbackafjorden | 30 | .0486 | .0424 | -.0062      | <b>.003</b> |

In herring liver, concentrations of Cr were similar among all the polluted sites, approximately 0.04 µg/g dw (Fig. 4.2.17). None of the polluted sites were significantly higher than the reference sites for herring (Table 4.2.13). Concentrations of Cr were also in perch liver comparable between sites, and around 0.04 µg/g dw (Fig. 4.2.18). Also here, none of the polluted sites were significantly higher compared to the reference site (Table 4.2.14). For eelpout, the concentrations were likewise comparable among sites, with concentrations around 0.04 µg/g dw (Fig. 4.2.19). For cod liver, the highest concentration was found in Rivö fjord (0.06 µg/g dw) while Kungsbackafjorden had lower concentration (0.04 µg/g dw) (Fig. 4.2.20). The concentration at Rivö fjord was significantly higher compared to the reference site (Table 4.2.15).

#### *Comparison between species*

Concentration of chromium was comparable between herring and perch. In cod liver the concentration was slightly higher compared to eelpout liver.

#### *Comparison with target value*

No national target value for biota is agreed upon for Cr.

### **4.2.6 Copper**

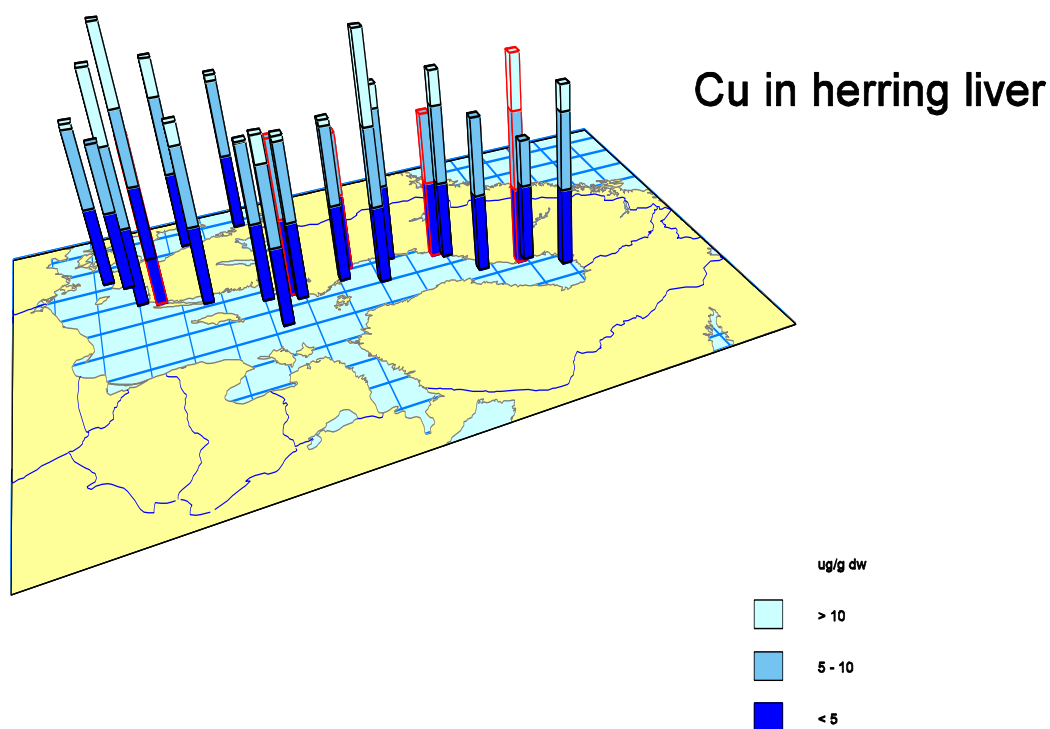
#### *Usage, production and sources*

Copper occurs naturally in rocks, soil, water, sediment, and at low levels in air. In its natural (metallic) form, copper can be found in electrical wiring and some water pipes, for example, plumbing, building wire, telecommunications, automotive electrical wiring and air conditioning systems (Dorsey et al. 2004). Copper compounds can be found in alloys such as brass and bronze. Other anthropogenic sources include road run off (Rice et al. 2002) and mining of copper ore. Copper compounds are commonly used in agriculture as fungicides, in wood, leather and fabric preservative, or for water treatment (Dorsey et al. 2004).

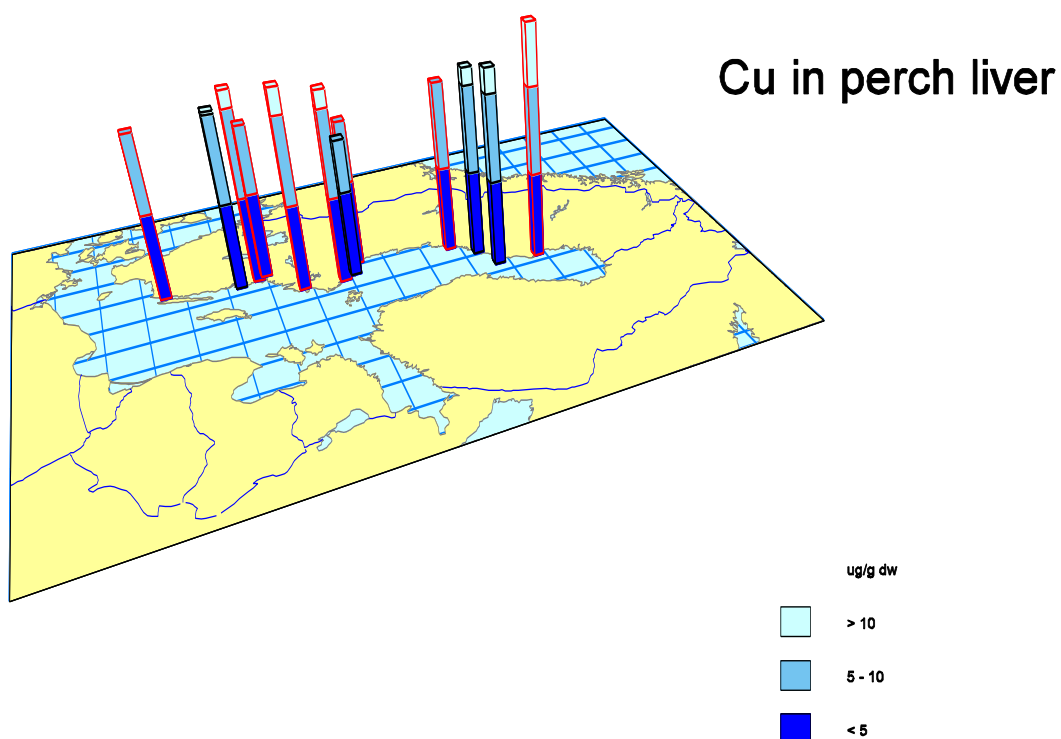
#### *Restrictions*

There are no restrictions against the usage of copper.

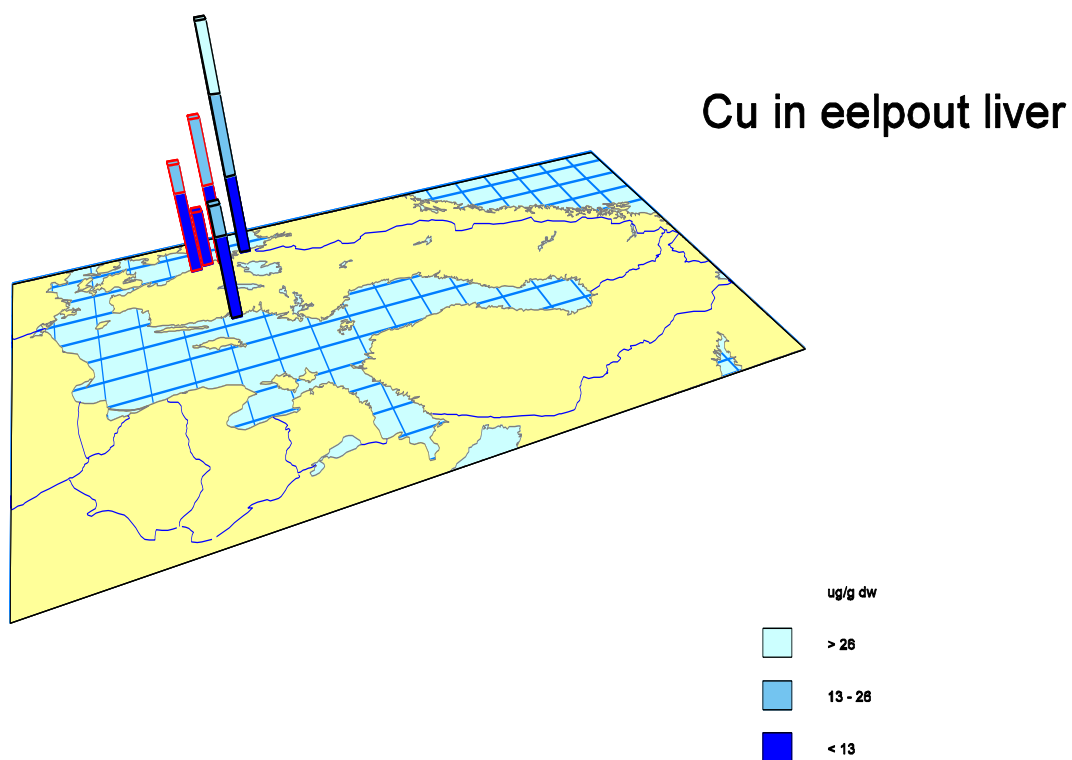
### Spatial variation



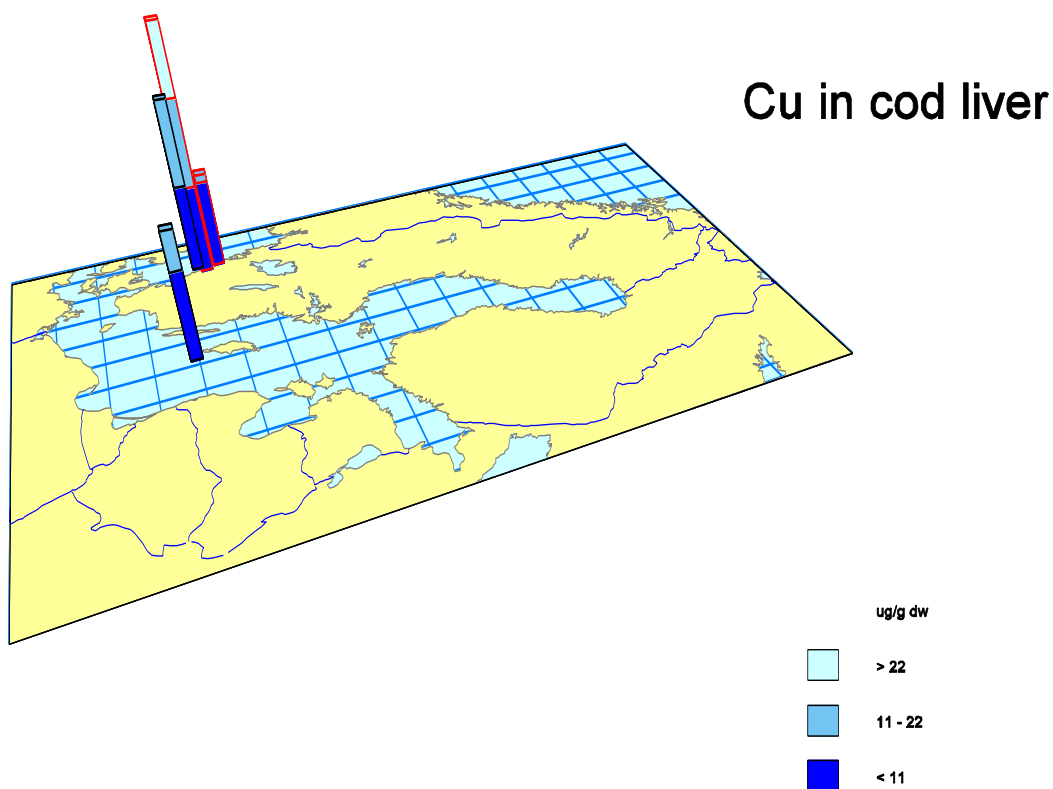
**Figure 4.2.21.** Spatial variation in concentration of copper ( $\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.22.** Spatial variation in concentration of copper ( $\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.23.** Spatial variation in concentration of copper ( $\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.24.** Spatial variation in concentration of copper ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.2.16.** Differences in Cu concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | 8.00  | 13.5  | 5.50        | <b>.000</b> |
| Örnsköldsviksfjärden | 6  | 12.2  | 9.50  | -2.67       | .086        |
| Yttre Fjärden        | 42 | 10.4  | 9.00  | -1.38       | <b>.009</b> |
| Lilla Värtan         | 42 | 10.1  | 10.0  | -.119       | .866        |
| Torsås               | 42 | 14.5  | 10.5  | -3.98       | <b>.000</b> |

**Table 4.2.17.** Differences in Cu concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | 11.4  | 13.5  | 2.13        | <b>.010</b> |
| Örnsköldsviksfjärden | 36 | 11.3  | 10.0  | -1.28       | .102        |
| Yttre Fjärden        | 36 | 10.2  | 8.50  | -1.72       | <b>.003</b> |
| Östhammarsfjärden    | 31 | 10.1  | 11.0  | .903        | .129        |
| Lilla Värtan         | 31 | 10.1  | 11.5  | 1.40        | <b>.021</b> |
| Inre Slätbaken       | 31 | 10.1  | 11.0  | .903        | .129        |
| Bråviken, n Svindra  | 31 | 10.1  | 9.78  | -.317       | .588        |
| Bråviken, s Esterön  | 31 | 10.1  | 11.4  | 1.30        | <b>.032</b> |
| Bråviken, n Esterön  | 31 | 10.1  | 8.01  | -2.09       | <b>.001</b> |
| Torsås               | 30 | 10.2  | 9.50  | -.667       | .270        |

**Table 4.2.18.** Differences in Cu concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value

| Sampling site     | n  | Meanr | Meanp | Meanr-meanp | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | 21.8  | 12.0  | -9.83       | <b>.005</b> |
| Kungsbackafjorden | 30 | 21.8  | 31.0  | 9.17        | <b>.009</b> |

Concentrations of copper in herring liver were rather similar among sites. The highest concentration was found in Skelleftebukten (13.5 µg/g dw) and the lowest concentration was found in Yttre Fjärden (9.0 µg/g dw) (Fig. 4.2.21). In Skelleftebukten, the concentration of Cu was significantly higher compared to the reference site (Table 4.2.16). Also for perch liver, the concentrations were comparable between sites. The highest concentration of Cu was found in Skelleftebukten (13.5 µg/g dw) and the lowest concentration was found in Yttre Fjärden (8.5 µg/g dw) (Fig. 4.2.22). Concentrations of Cu in perch from Skelleftebukten, Lilla Värtan, and Bråviken s Esterön were significantly higher compared to their respective reference site (Table 4.2.17). Concentration of Cu in eelpout was more variable, the highest concentration was found in Halsefjord and Askeröfjord (23.5 µg/g dw) and the lowest concentration, 9.0 µg/g dw, was found in Rivö fjord (Fig. 4.2.23). In cod liver, the concentrations among sites were also variable. Kungsbackafjorden had the highest concentration (31 µg/g dw) and Rivö fjord had the lowest concentration (12 µg/g dw) (Fig. 4.2.24). At Kungsbackafjorden the concentration was significantly higher compared to the reference site (Table 4.2.18).

#### *Comparison between species*

Copper concentrations in herring and perch were comparable. In cod liver copper concentrations were almost twice as high at Kungsbackafjorden but similar in Rivö fjord.

#### *Comparison with target value*

No national target value for biota is agreed upon for Cu.

### **4.2.7 Zinc**

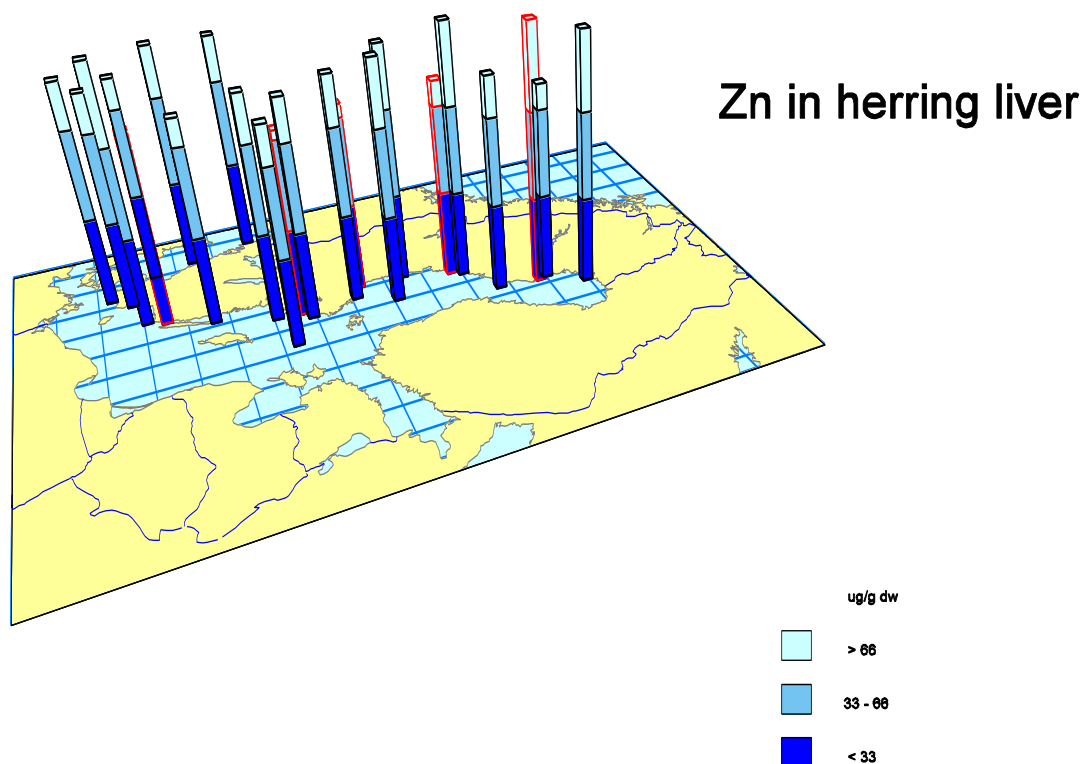
#### *Usage, production and sources*

Zinc occurs naturally in the environment, but most zinc comes from human activities such as mining, steel production and coal burning. In its pure form, anthropogenic sources of zinc can include use in galvanising steel and iron to prevent rust and corrosion; it is mixed with other metals to form alloys such as brass and bronze; and it is used to make dry cell batteries (Draggan 2008). Zinc compounds are used in industry for things such as making white paints and ceramics, producing rubber, preserving wood and dyeing fabrics (Draggan 2008). Tyre tread material contains approximately 1% weight of zinc. Wear of tyres on road surfaces can contribute a small amount of zinc to the environment (Councell et al. 2004). Some sunscreens use zinc oxide nanoparticles (Osmond and McCall 2010); other zinc compounds can be found in, for example, deodorants, nappy rash cream and anti-dandruff shampoo (Draggan 2008).

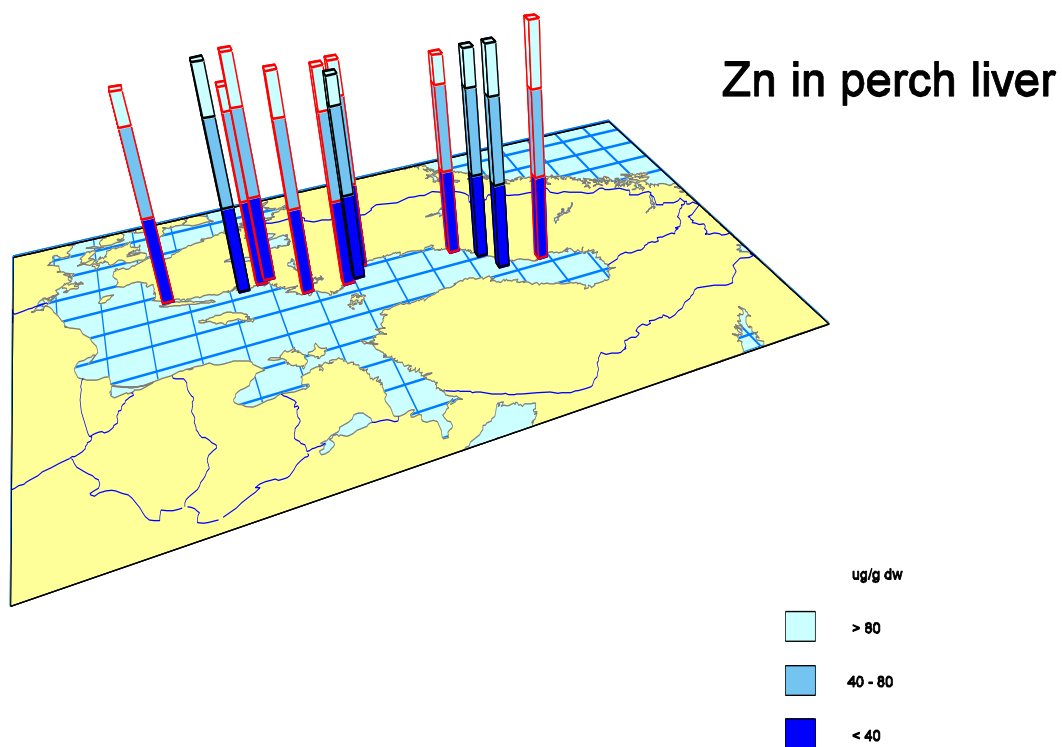
#### *Conventions, aims and restrictions*

There are no restrictions against the usage of zink.

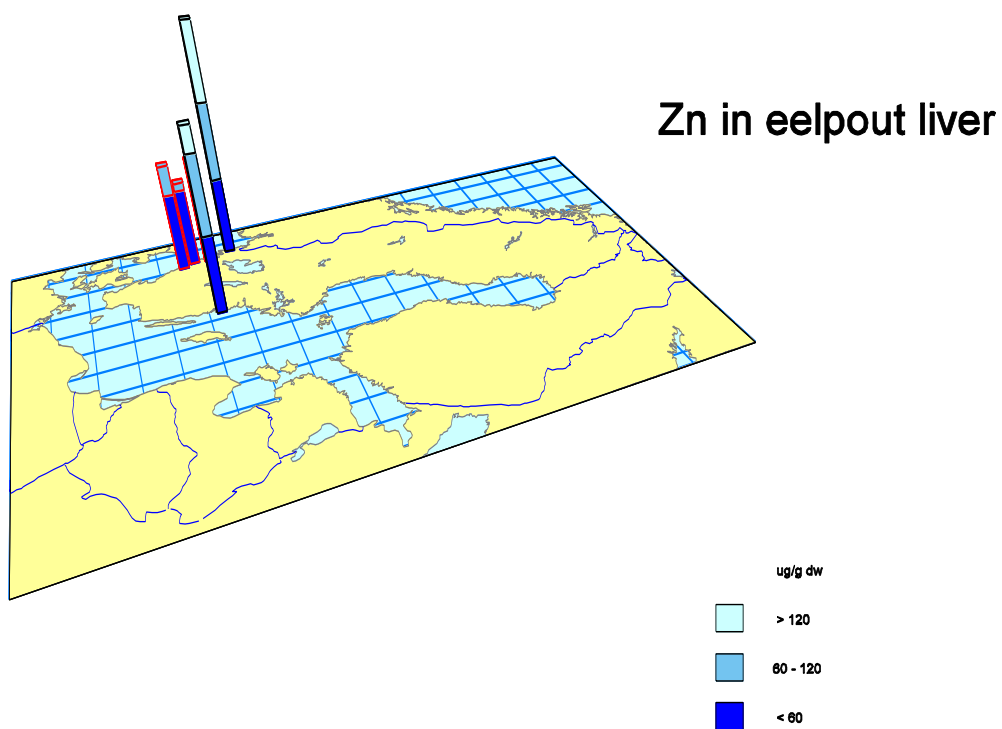




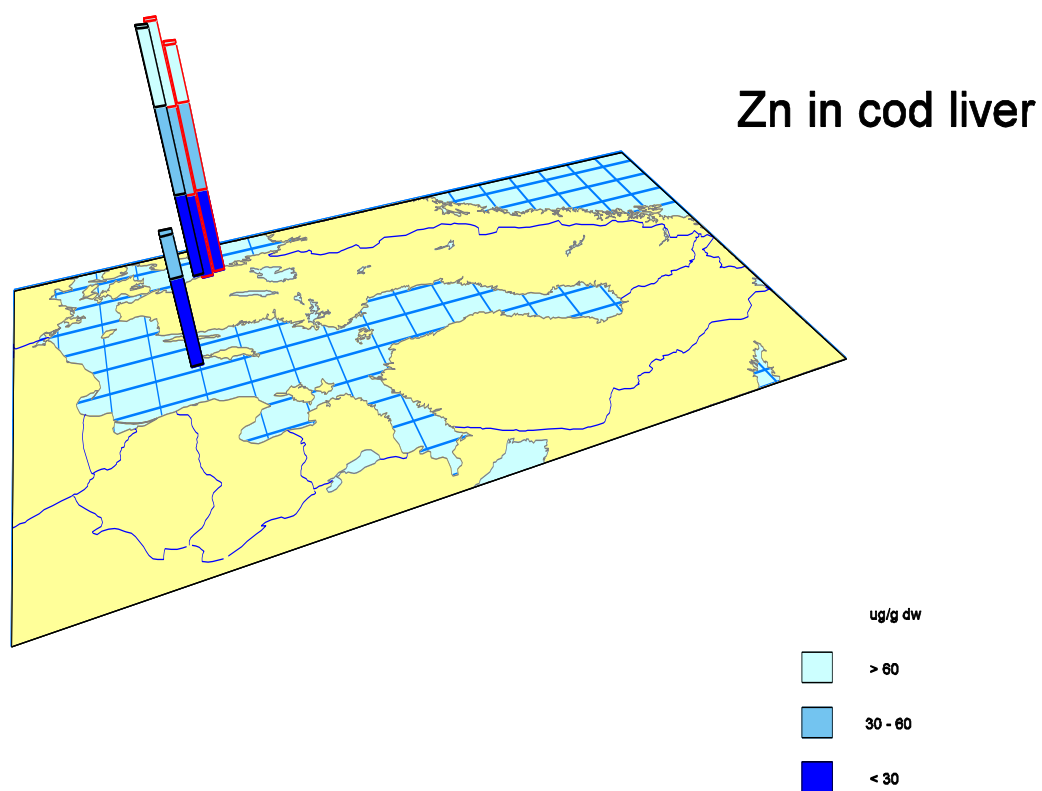
**Figure 4.2.25.** Spatial variation in concentration of zinc ( $\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.26.** Spatial variation in concentration of zinc ( $\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.27.** Spatial variation in concentration of zinc ( $\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 2.2.28.** Spatial variation in concentration of zinc ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.2.19.** Differences in Zn concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | 75.3  | 98.0  | 22.7        | <b>.001</b> |
| Örnsköldsviksfjärden | 6  | 96.3  | 75.5  | -20.8       | <b>.013</b> |
| Yttre Fjärden        | 42 | 84.6  | 71.0  | -13.6       | <b>.000</b> |
| Lilla Värtan         | 42 | 83.3  | 69.5  | -13.8       | <b>.000</b> |
| Torsås               | 42 | 95.0  | 71.5  | -23.5       | <b>.000</b> |

**Table 4.2.20.** Differences in Zn concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | 102   | 110   | 7.67        | <b>.000</b> |
| Örnsköldsviksfjärden | 36 | 102   | 93.0  | -8.58       | <b>.000</b> |
| Yttre Fjärden        | 36 | 102   | 95.5  | -6.25       | <b>.003</b> |
| Östhammarsfjärden    | 31 | 102   | 98.5  | -3.98       | .072        |
| Lilla Värtan         | 31 | 102   | 99.5  | -2.98       | .173        |
| Inre Slätbaken       | 31 | 102   | 90.5  | -12.0       | <b>.000</b> |
| Bråviken, n Svindra  | 31 | 102   | 112   | 9.52        | <b>.000</b> |
| Bråviken, s Esterön  | 31 | 102   | 105   | 2.52        | .248        |
| Bråviken, n Esterön  | 31 | 102   | 94.2  | -8.28       | <b>.001</b> |
| Torsås               | 30 | 103   | 94.5  | -8.30       | <b>.001</b> |

**Table 4.2.21.** Differences in Zn concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | Meanr-meanp | p    |
|-------------------|----|-------|-------|-------------|------|
| Rivö fjord        | 30 | 84.6  | 78.5  | -6.13       | .310 |
| Kungsbackafjorden | 30 | 84.6  | 87.0  | 2.37        | .693 |

Concentrations of zink in herring liver were rather similar among sites. The highest concentration was found in Skelleftebukten (98 µg/g dw) and the lowest concentration was found in Yttre Fjärden and Torsås (71 µg/g dw) (Fig. 4.2.25). In Skelleftebukten, the concentration in herring was significantly higher compared to the reference site (Table 4.2.19). In perch liver, concentrations were also comparable between sites. The highest concentration was found in Skelleftebukten (109 µg/g dw) and the lowest concentration, 90 µg/g dw, was found in Inre Slätbaken (Fig. 4.2.26). The concentration in perch was significantly higher in Skelleftebukten and Bråviken n Svindra compared to their corresponding reference (Table 4.2.20). In eelpout liver, the highest concentrations were found in Kungsbackafjorden and Halsefjord and Askeröfjord, with approximately 83 µg/g dw, while Rivö fjord had lower concentration, 66 µg/g dw (Fig. 4.2.27). The two cod sites had rather similar concentrations, but Kungsbackafjorden had higher concentration (87 µg/g dw) than Rivö fjord (79 µg/g dw) (Fig. 4.2.28). None of these sites had significantly higher concentration compared to the reference sites (Table 4.2.21).

#### *Comparison between species*

Zink concentrations were slightly higher in perch liver compared to herring liver. Cod liver and eelpout liver had similar concentrations of zink.

#### *Comparison with target value*

No national target value for biota is agreed upon for Zn.

### **4.2.8 Arsenic**

#### *Usage, production and sources*

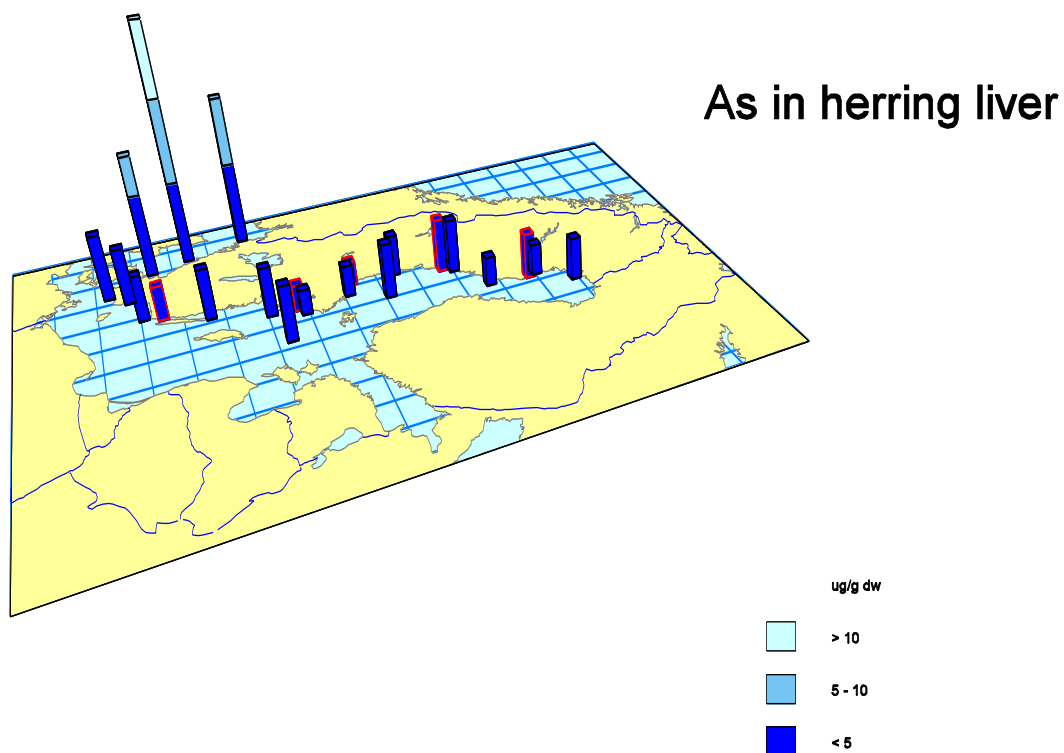
Arsenic is a natural component of the earth's crust, and is found in all environmental media (WHO 2001). Major anthropogenic sources of environmental arsenic contamination are via industrial smelters, coal-fired power plants and production and use of arsenic pesticides and herbicides (Eisler 1994).

#### *Restrictions*

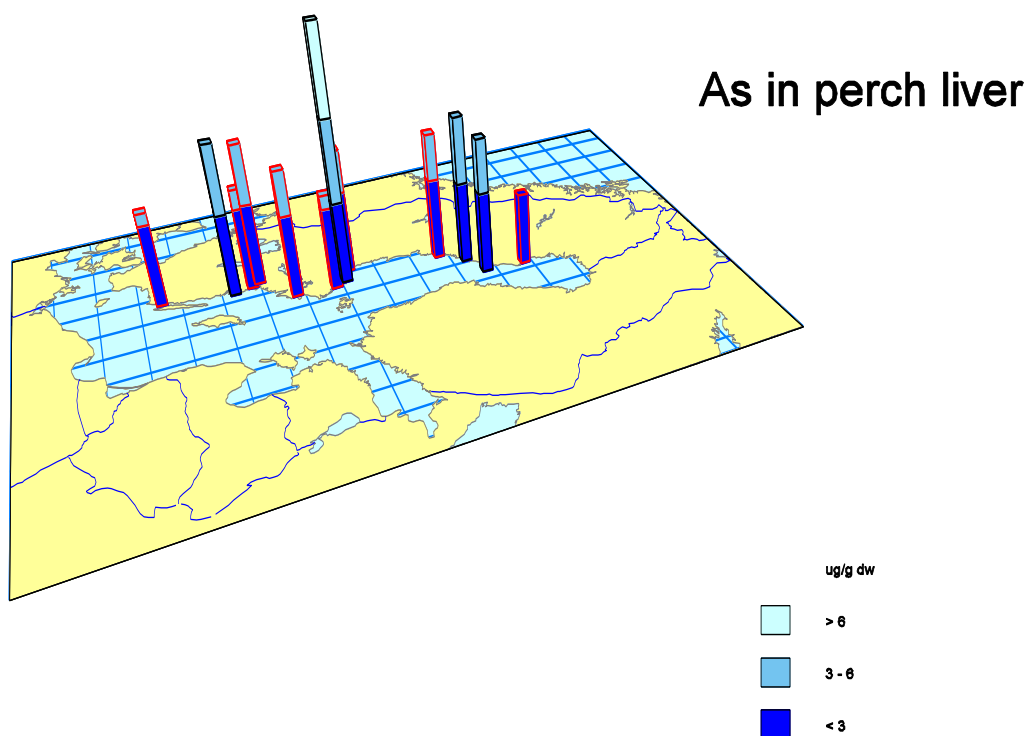
Restrictions on the use of arsenic as a wood preservative are described in Annex XVII of the EU Regulation (EC) 1907/2006 on the Registration, Evaluation and Authorisation of Chemicals (REACH).

COMMISSION DIRECTIVE 2006/139/EC (20<sup>th</sup> December 2006) amending Council Directive 76/769/EEC in regards to restrictions on the marketing and use of arsenic compounds for the purpose of adapting Annex I to technical progress, states that arsenic compounds may not be used in the EU as substances and constituents of preparations intended for, amongst other things, the preservation of wood. Wood treated with arsenic compounds may not be placed on the EU market.

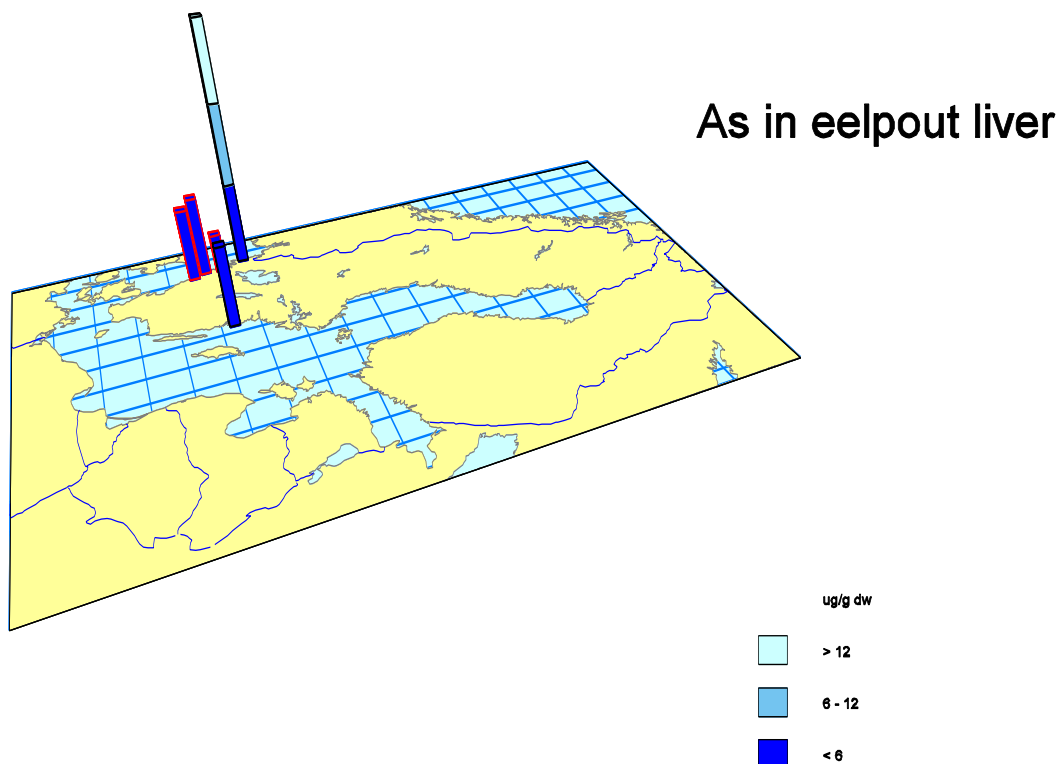
Spatial variation



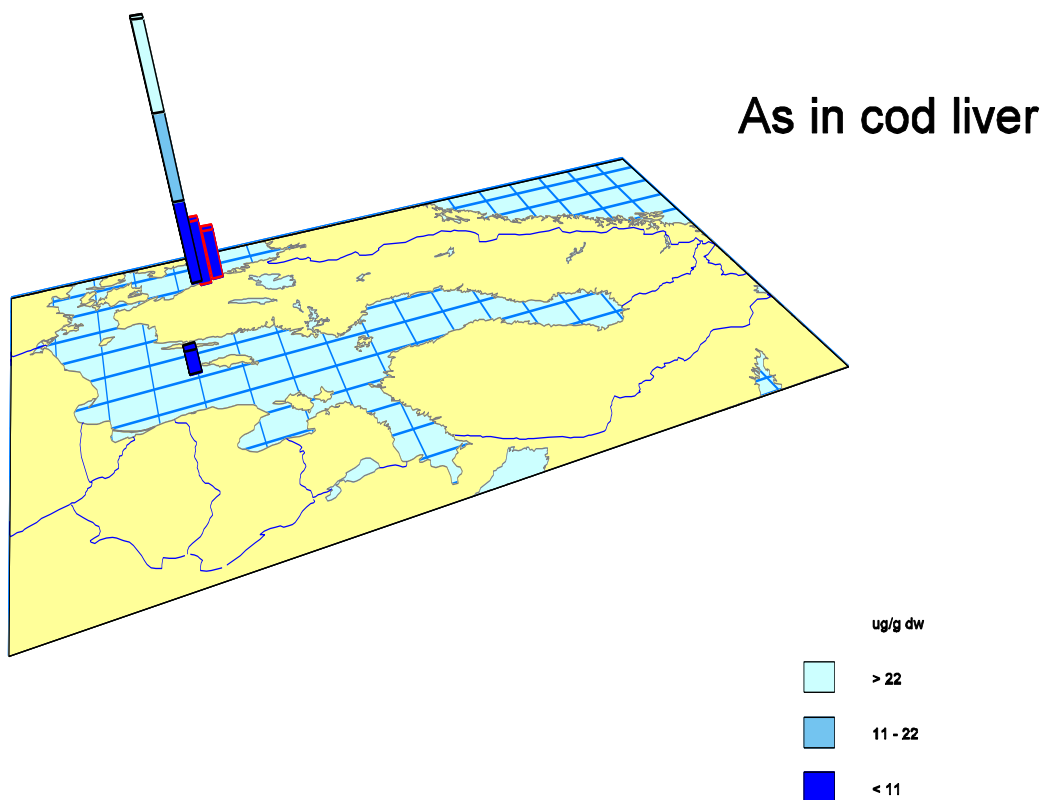
**Figure 4.2.29.** Spatial variation in concentration of arsenic ( $\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.30.** Spatial variation in concentration of arsenic ( $\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.31.** Spatial variation in concentration of arsenic ( $\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.32.** Spatial variation in concentration of arsenic ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.2.22.** Differences in As concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | 1.90  | 2.78  | .880        | <b>.005</b> |
| Örnsköldsviksfjärden | 6  | 3.25  | 3.27  | .0217       | .929        |
| Yttre Fjärden        | 42 | 1.87  | 1.46  | -.410       | <b>.000</b> |
| Lilla Värtan         | 42 | 2.76  | 1.55  | -1.21       | <b>.000</b> |
| Torsås               | 42 | 2.75  | 2.08  | -.677       | <b>.000</b> |

**Table 4.2.23.** Differences in As concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | 5.06  | 2.66  | -2.40       | <b>.000</b> |
| Örnsköldsviksfjärden | 36 | 5.17  | 4.71  | -.465       | .207        |
| Yttre Fjärden        | 36 | 5.62  | 4.56  | -1.07       | <b>.044</b> |
| Östhammarsfjärden    | 31 | 5.65  | 3.50  | -2.15       | <b>.001</b> |
| Lilla Värtan         | 31 | 5.65  | 4.65  | -1.00       | .081        |
| Inre Slätbaken       | 31 | 5.65  | 3.72  | -1.93       | <b>.002</b> |
| Bråviken, n Svindra* | 31 | 5.65  | 4.94  | -.706       | .212        |
| Bråviken, s Esterön* | 31 | 5.65  | 5.28  | -.366       | .514        |
| Bråviken, n Esterön* | 31 | 5.65  | 5.42  | -.226       | .686        |
| Torsås               | 30 | 5.53  | 3.45  | -2.08       | <b>.001</b> |

**Table 4.2.24.** Differences in As concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | meanr-meanp | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | 32.7  | 6.53  | -26.2       | <b>.000</b> |
| Kungsbackafjorden | 30 | 32.7  | 8.47  | -24.2       | <b>.000</b> |

Örnsköldsvikfjärden had the highest concentration of arsenic in herring liver, 3.3 µg/g dw and the lowest concentration was found in Yttre Fjärden, 1.5 µg/g dw (Fig. 4.2.29).

Skelleftebukten had significantly higher concentration of As in herring compared to the reference site (Table 4.2.22). In perch liver, Bråviken had the highest concentration, 5.2 µg/g dw and the lowest concentration was found in Skelleftebukten, 2.7 µg/g dw (Fig. 4.2.30).

None of the polluted sites for perch were significantly higher than their respective reference (Table 4.2.23). Two of the eelpout sites, Kungsbackafjorden and Rivö fjord, had similar concentrations, 5.3 and 5.8 µg/g dw respectively, while Halsefjord and Askeröfjord had lower concentration, 2.8 µg/g dw (Fig. 4.2.31). In cod liver, the concentration was highest in Kungsbackafjorden (8.5 µg/g dw) and lowest in Rivö fjord (6.5 µg/g dw) (Fig. 4.2.32). None of these sites had significantly higher concentration compared to the reference sites (Table 4.2.24).

#### *Comparison between species*

Concentrations of arsenic were almost twice as high in perch liver compared to herring liver, except in Skelleftebukten, where the concentrations were similar. Cod liver had somewhat higher concentration compared to eelpout liver.

#### *Comparison with target value*

No national target value for biota is agreed upon for As.



#### 4.2.9 Silver

##### *Usage, production and sources*

The main source of silver today is as a by-product in copper and lead smelting. In Sweden, silver is extracted in a copper mine near Gällivare, a lead mine at Arjeplog, and mines close to Skellefteå (IVL 2007).

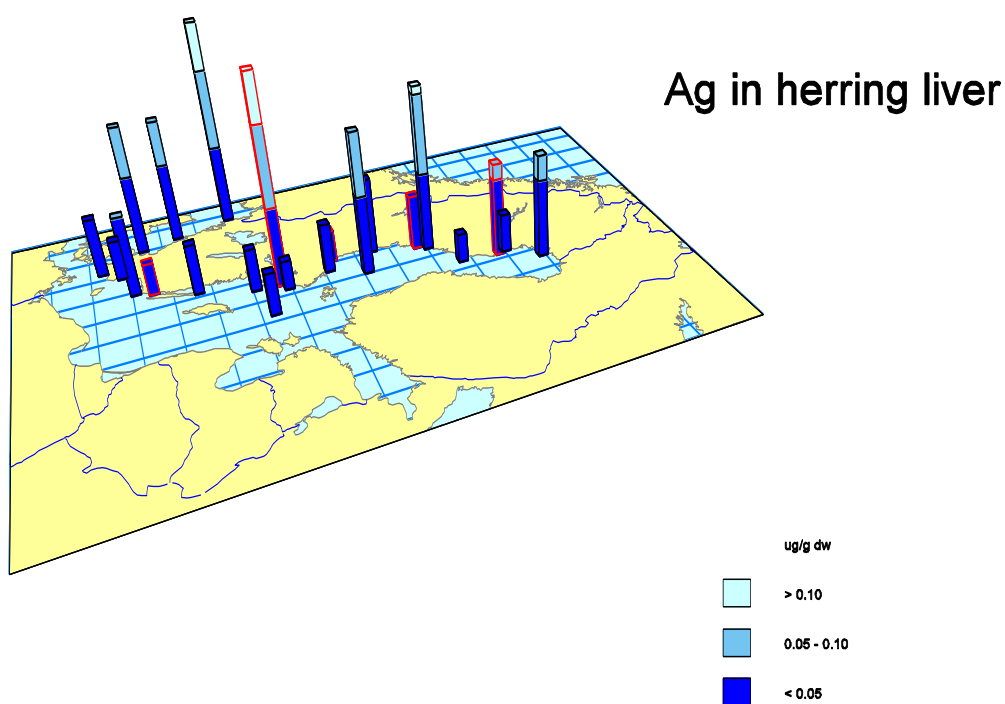
Anthropogenic sources of silver are mainly smelting operations, the manufacture and disposal of certain photographic and electrical supplies, coal combustion and cloud seeding (WHO 2002). Silver is used for jewellery, ornaments, tableware, utensils and currency (Eisler 1996; IVL 2007). Electronics, batteries and solders containing silver may appear as solid waste either deposited in landfills or burnt in waste incinerators. Dispersal of residues in the environment may occur via leakage or emissions to the air (IVL 2007).

Medicinally, silver is used for its bactericidal properties. Soluble silver compounds are used as antiseptic and bacteriostatic agents, as disinfectants (WHO 2004); and as antiseptic and antiodour agents in products such as in washing machines, refrigerators, socks and shoes (IVL 2007). Metallic silver is used in amalgam dental fillings alloyed with mercury and small amounts of other metals (IVL 2007).

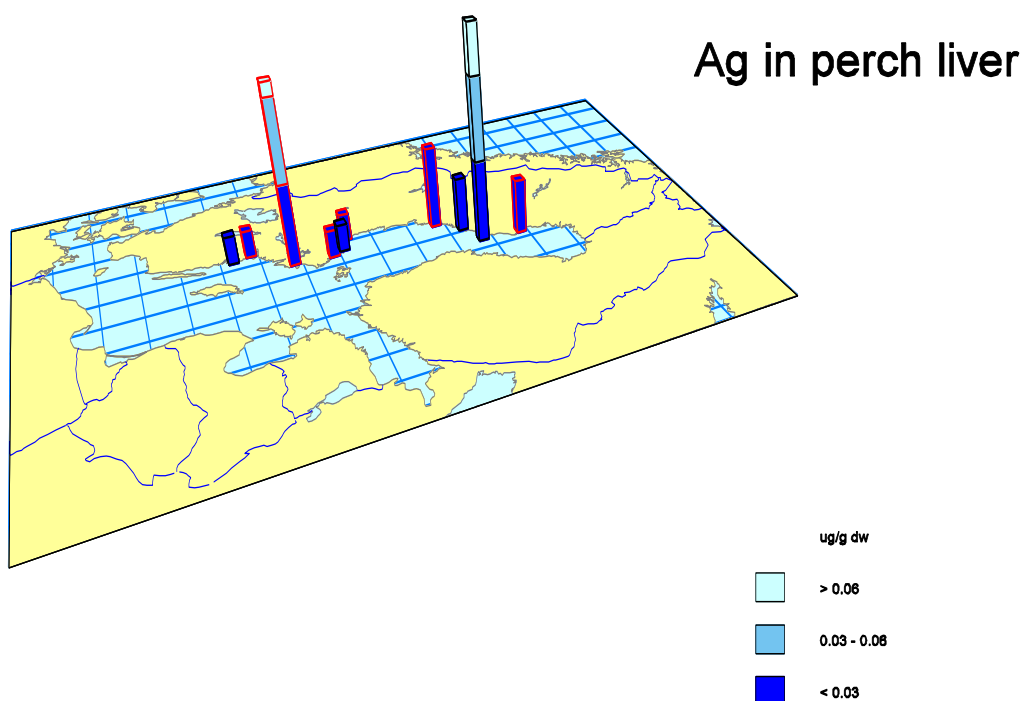
##### *Convention, aims and restrictions*

Silver and all of the chemical compounds that emit silver or silver ions, should be regarded as a biocide product if its purpose is to prevent growth of bacteria. Silver used as a biocide product is restricted by the European directive 98/8/EC concerning the placing of biocidal products on the market.

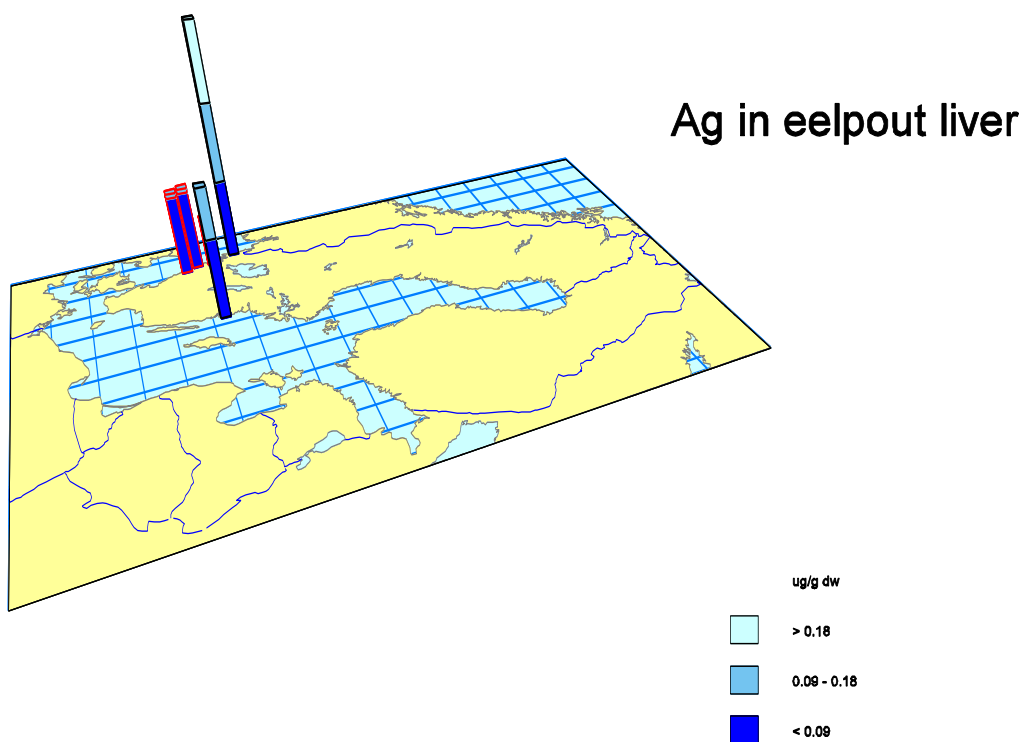
Spatial variation



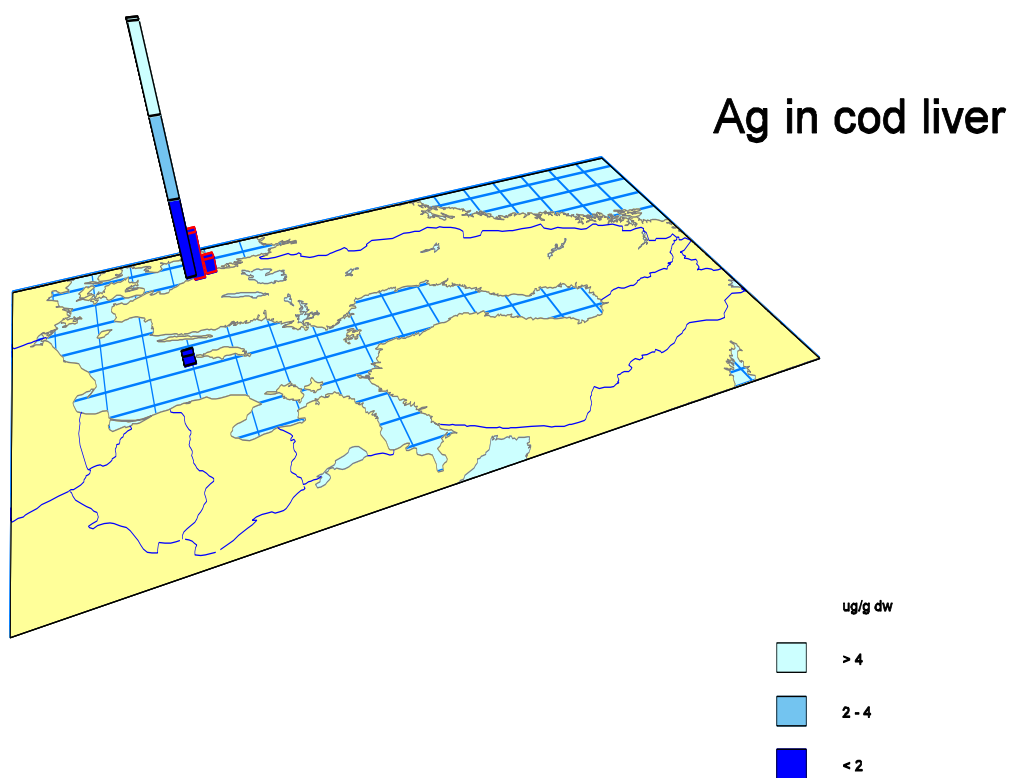
**Figure 4.2.33.** Spatial variation in concentration of silver ( $\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.34.** Spatial variation in concentration of silver ( $\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.35.** Spatial variation in concentration of silver ( $\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.36.** Spatial variation in concentration of silver ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.2.25.** Differences in Ag concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .0250 | .0600 | .0350       | <b>.000</b> |
| Örnsköldsviksfjärden | 6  | .105  | .0350 | -.0700      | <b>.017</b> |
| Yttre Fjärden        | 41 | .0322 | .0200 | -.0122      | .096        |
| Lilla Värtan         | 42 | .0257 | .130  | .104        | <b>.000</b> |
| Torsås               | 42 | .0502 | .0200 | -.0302      | <b>.000</b> |

**Table 4.2.26.** Differences in Ag concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 34 | .0718 | .0200 | -.0518      | .354        |
| Örnsköldsviksfjärden | 35 | .0700 | .0300 | -.0400      | .460        |
| Yttre Fjärden        | 33 | .0128 | .0100 | -.0028      | <b>.007</b> |
| Östhammarsfjärden    | 28 | .0115 | .0100 | -.0015      | .071        |
| Lilla Värtan         | 28 | .0115 | .0650 | .0535       | <b>.000</b> |
| Inre Slätbaken       | 28 | .0115 | .0100 | -.0015      | .071        |
| Torsås               | 27 | .0115 | .0050 | -.0065      | <b>.000</b> |

**Table 4.2.27.** Differences in Ag concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | meanr-meanp | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | 6.06  | .365  | -5.70       | <b>.000</b> |
| Kungsbackafjorden | 30 | 6.06  | 1.18  | -4.89       | <b>.000</b> |

No spatial pattern in Ag concentration in herring liver was seen. The highest concentration was found in Lilla Värtan ( $0.13 \mu\text{g/g dw}$ ) and the lowest concentration was found in Yttre Fjärden and in Torsås ( $0.02 \mu\text{g/g dw}$ ) (Fig. 4.2.33). Herring in Skelleftebukten and Lilla Värtan had significantly higher concentrations compared to their reference sites (Table 4.2.25). Also in perch liver, the highest concentration of Ag was found in Lilla Värtan ( $0.065 \mu\text{g/g dw}$ ). The lowest concentration,  $0.01 \mu\text{g/g dw}$ , was found in Yttre Fjärden,

Östhammarsfjärden, and Inre Slätbaken (Fig. 4.2.34). Perch from Lilla Värtan had significantly higher concentration compared to its reference site (Table 4.2.26). In eelpout liver, Kungsbackafjorden and Rivö fjord had the highest concentrations, 0.095 µg/g dw, while the concentration was lower in Halsefjord and Askeröfjord, 0.055 µg/g dw (Fig. 4.2.35). In cod liver, Kungsbackafjorden had the highest concentration, 1.18 µg/g dw and Rivö fjord had the lowest concentration, 0.37 µg/g dw (Fig. 4.2.36). These concentrations were not significantly higher compared to the reference sites (Table 4.2.27).

#### *Comparison between species*

Generally, herring liver had 2-3 times as high concentration compared to perch liver. Cod liver had 7-13 times higher concentrations compared to eelpout liver.

#### *Comparison with target value*

No national target value for biota is agreed upon for Ag.

### **4.2.10 Selenium**

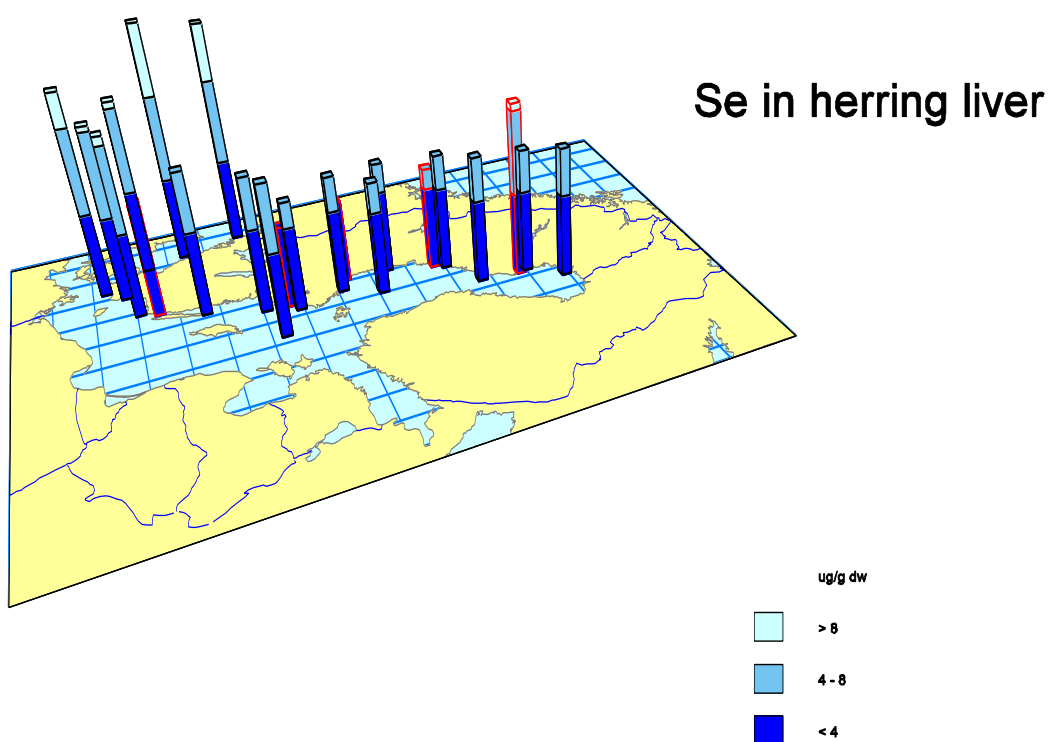
#### *Usage, production and sources*

Selenium is an essential nonmetal which rarely occurs in its elemental state in nature. Selenium is found in metal sulfide ores, where it partially replaces the sulfur. Commercially, selenium is produced as a byproduct in the refining of sulfide ores, most often during copper production. The major commercial uses for selenium today are in glassmaking and in pigments. Selenium is a semiconductor and is used in photocells. In fish and other wildlife, low levels of selenium cause deficiency while high levels cause toxicity. Some studies indicates that Se bioassimilation offset some of the adverse effects of arsenic and mercury poisoning in rodents, and potentially also in humans (Hu et al. 1989; Gailer et al. 2002; Zeng et al. 2005).

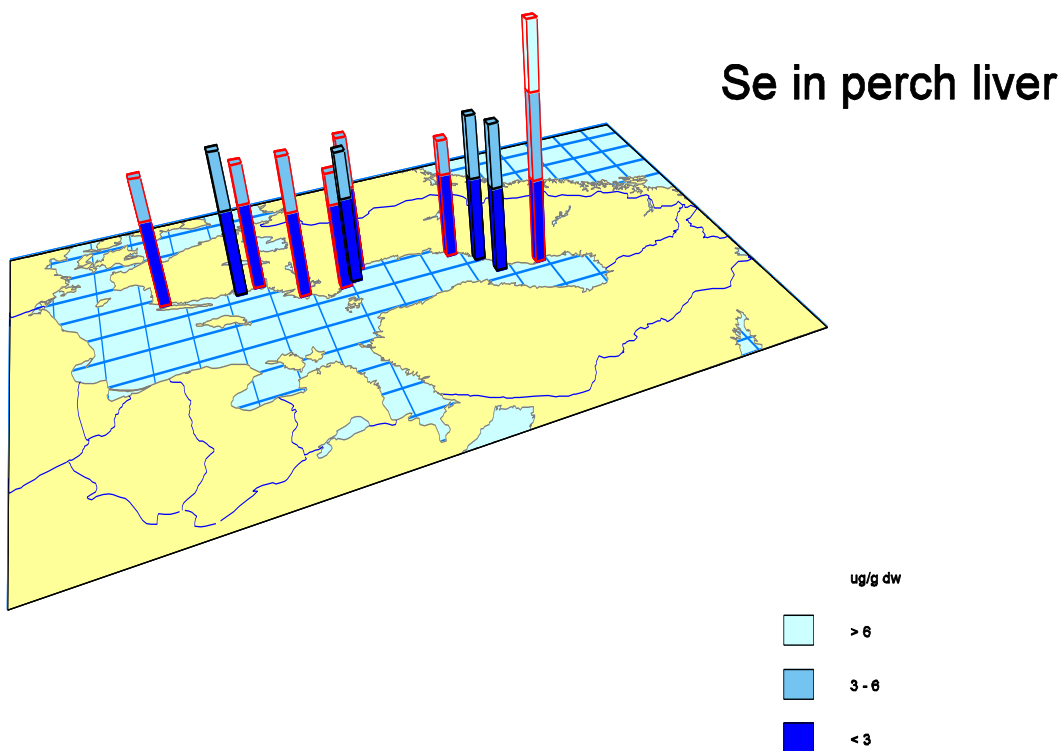
#### *Restrictions*

There are no restrictions against the usage of selenium.

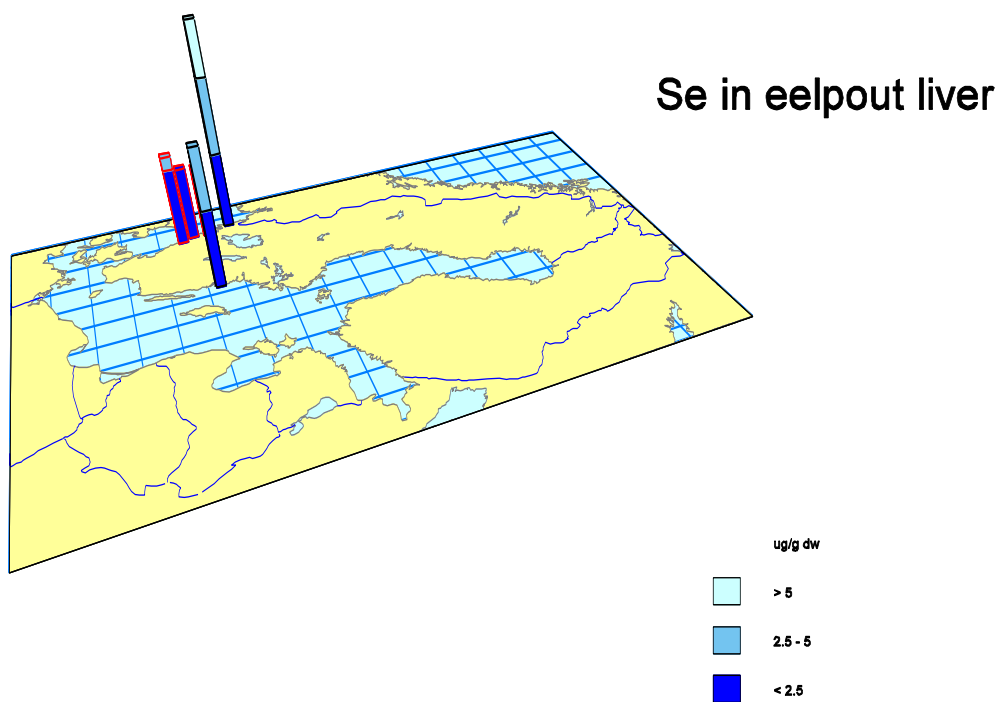
Spatial variation



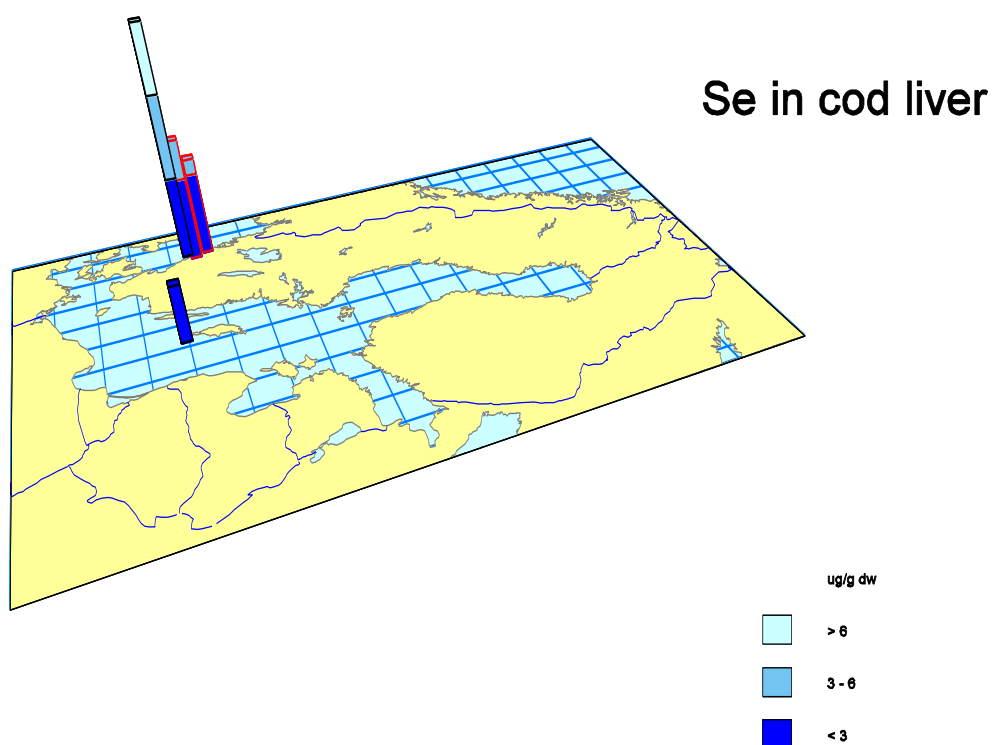
**Figure 4.2.37.** Spatial variation in concentration of selenium ( $\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.38.** Spatial variation in concentration of selenium ( $\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.39.** Spatial variation in concentration of selenium ( $\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.40.** Spatial variation in concentration of selenium ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

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**Table 4.2.28.** Differences in Se concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | 6.04  | 8.34  | 2.30        | <b>.000</b> |
| Örnsköldsviksfjärden | 6  | 5.66  | 4.98  | -.682       | .116        |
| Yttre Fjärden        | 42 | 5.66  | 3.95  | -1.71       | <b>.000</b> |
| Lilla Värtan         | 42 | 6.30  | 3.91  | -2.39       | <b>.000</b> |
| Torsås               | 42 | 8.42  | 5.38  | -3.04       | <b>.000</b> |

**Table 4.2.29.** Differences in Se concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | 5.22  | 8.33  | 3.11        | <b>.000</b> |
| Örnsköldsviksfjärden | 36 | 5.20  | 4.22  | -.978       | <b>.000</b> |
| Yttre Fjärden        | 36 | 5.02  | 4.76  | -.265       | <b>.011</b> |
| Östhammarsfjärden    | 31 | 4.99  | 4.09  | -.908       | <b>.000</b> |
| Lilla Värtan         | 31 | 4.99  | 4.90  | -.0976      | .388        |
| Inre Slätbaken       | 31 | 4.99  | 4.38  | -.613       | <b>.000</b> |
| Torsås               | 30 | 5.01  | 4.45  | -.556       | <b>.000</b> |

**Table 4.2.30.** Differences in Se concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | meanr-meanp | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | 8.43  | 3.57  | -4.86       | <b>.000</b> |
| Kungsbackafjorden | 30 | 8.43  | 4.44  | -3.99       | <b>.000</b> |

There was no spatial pattern for selenium in herring liver. The highest concentration was found in Skelleftebukten ( $8.3 \mu\text{g/g dw}$ ) and the lowest concentration was found in Yttre Fjärden and Lilla Värtan ( $3.9 \mu\text{g/g dw}$ ) (Fig. 4.2.37). Skelleftebukten had significantly higher concentration of Se in herring compared to its reference site (Table 4.2.28). In perch, concentrations were homogenous among sites, with concentrations around  $4 \mu\text{g/g dw}$ , except



in Skelleftebukten, where the concentration was almost twice as high, 8.3 µg/g dw (Fig. 4.2.38). Also in perch, Skelleftebukten had significantly higher concentration compared to its reference site (Table 4.2.29). Selenium concentration in eelpout was comparable between sites, ranging between 2.3 and 2.9 µg/g dw (Fig. 4.2.39). Also in cod, concentrations were similar among sites, 4.4 µg/g dw in Kungsbackafjorden and 3.6 µg/g dw in Rivö fjord (Fig. 4.2.40). None of these were significantly higher compared to the reference (Table 4.2.30).

#### *Comparison between species*

Selenium concentrations were comparable between herring liver and perch liver. Cod liver had slightly higher concentrations than eelpout liver.

#### *Comparison with target value*

No national target value for biota is agreed upon for Se.

### **4.2.11 Tin**

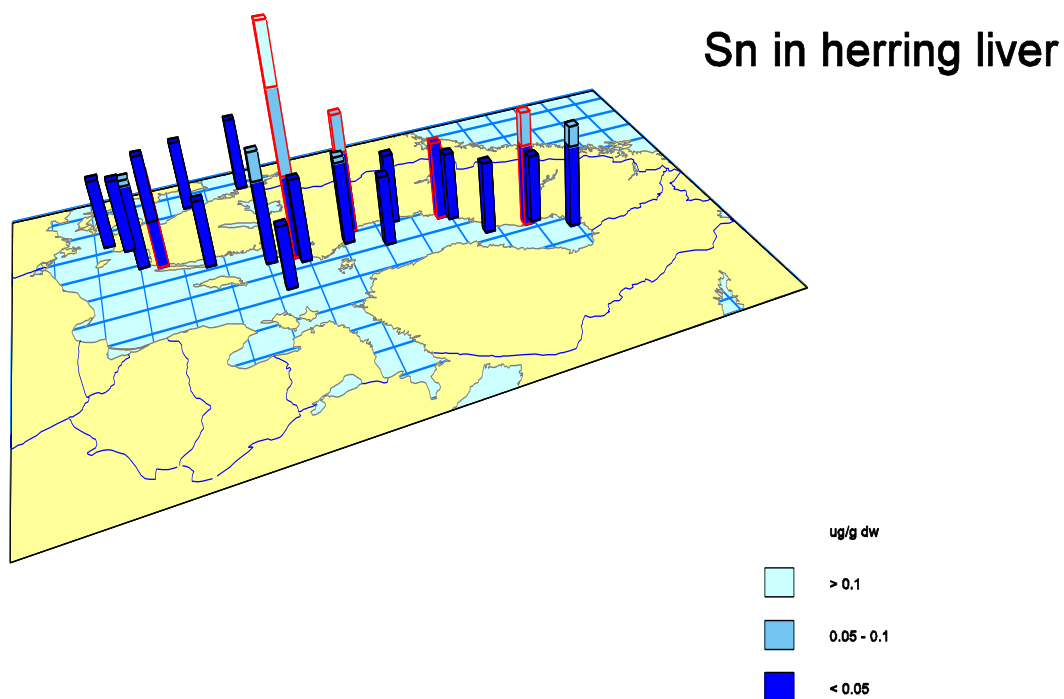
#### *Usage, production and sources*

The most commercially significant inorganic tin compounds include tin (II) chloride, tin (IV) chloride, tin (IV) oxide, potassium and sodium stannates, tin (II) fluoride, tin (II) difluoroborate, and tin (II) pyrophosphate (WHO, 2005). Of these, tin (II) chloride is the most important compound, and it is predominantly used as a reducing agent in organic and inorganic synthesis and in manufacture of metallized glazing, glass, and pigments. Moreover, tin (IV) chloride is also an important compound and it is used in organic synthesis, in plastics, as an intermediate in organotin compound manufacture, and in the production of tin (IV) oxide films on glass (WHO, 2005).

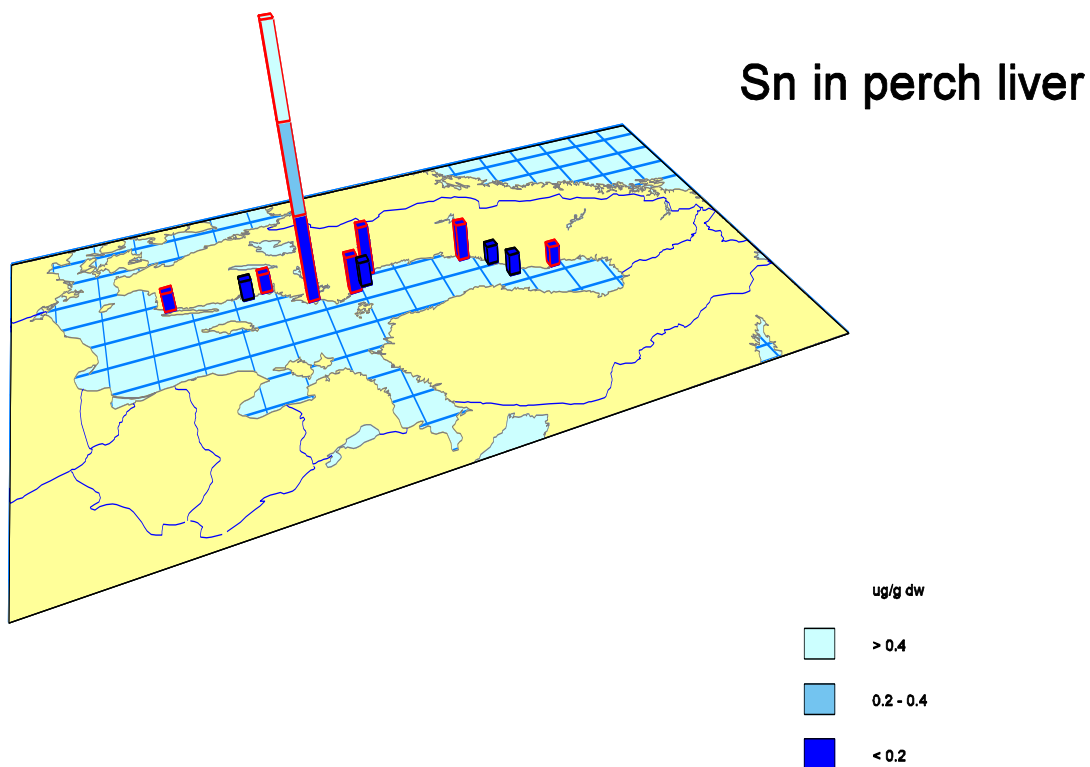
Tin does not oxidize easily in air, and therefore it is used for coating other metals in order to prevent corrosion. Tin is thus used in many alloys, particularly in soft solders, which accounts for about 34% of all tin produced. It is also largely used as corrosion-resistant tin-plating of steel. Another 25-30% of the produced tin is used as a protective coating for other metals, especially food containers, because of its low toxicity. Organic tin compounds have been used in fungicides, bactericides, and slimicides, and it has also been used as stabilizer in plastics (Goyer and Clarkson, 2001).

#### *Restrictions*

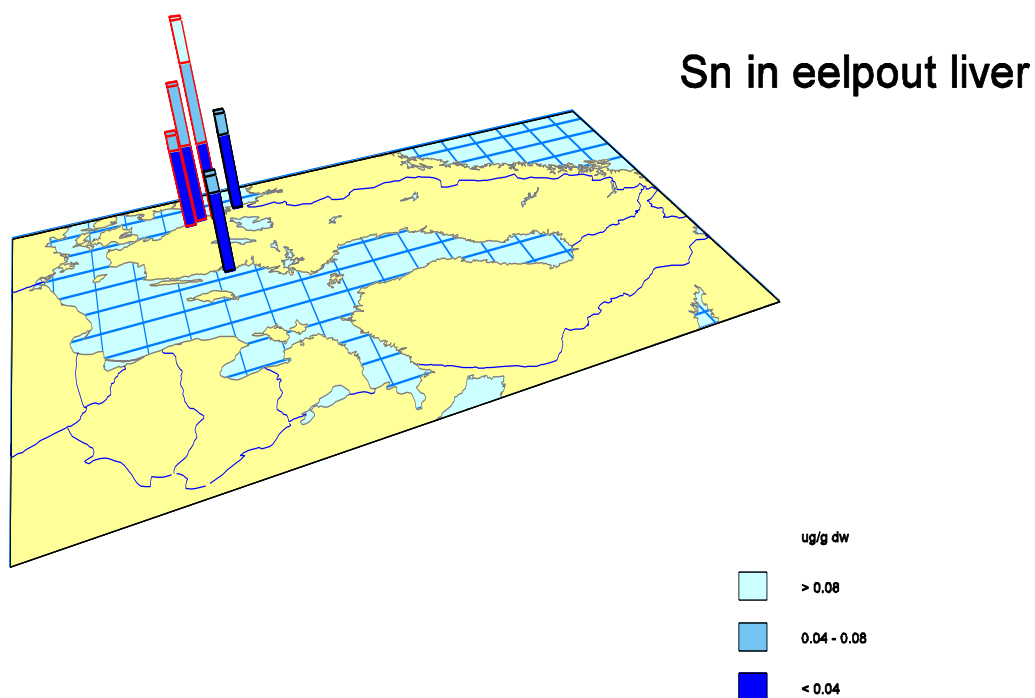
There are no restrictions against the usage of tin.



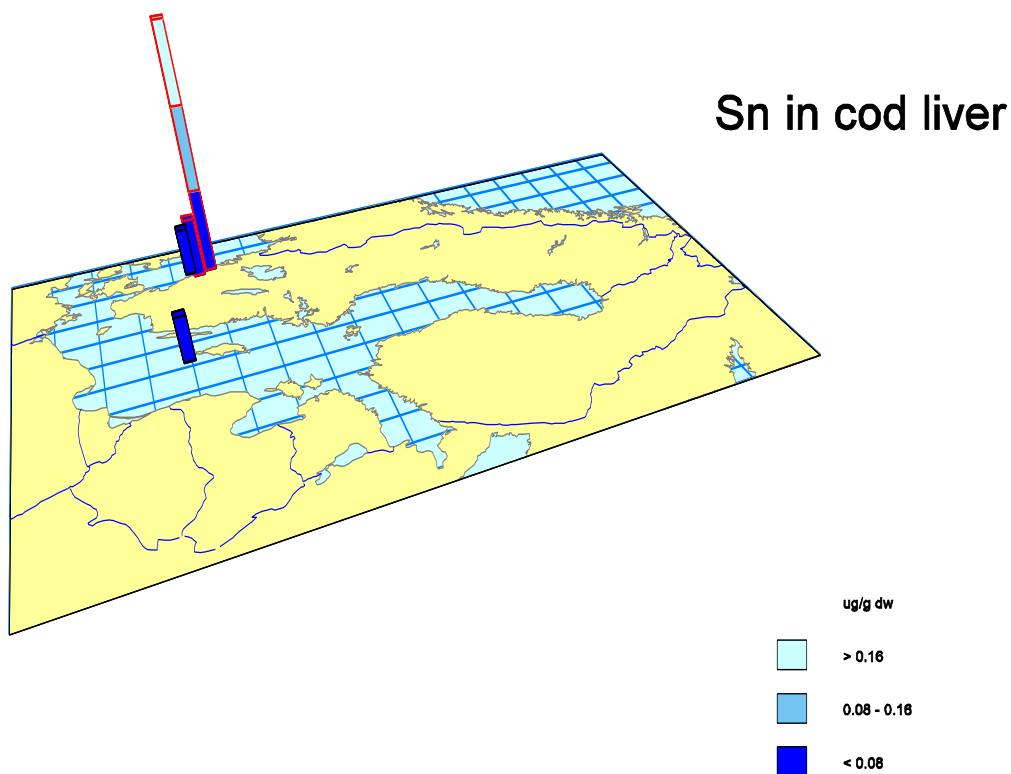
**Figure 4.2.41.** Spatial variation in concentration of tin ( $\mu\text{g/g dw}$ ) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.42.** Spatial variation in concentration of tin ( $\mu\text{g/g dw}$ ) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.43.** Spatial variation in concentration of tin ( $\mu\text{g/g dw}$ ) in eelpout liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.2.44.** Spatial variation in concentration of tin ( $\mu\text{g/g dw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.2.31.** Differences in Sn concentration in herring liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .0418 | .0700 | .0282       | <b>.001</b> |
| Örnsköldsviksfjärden | 6  | .0412 | .0477 | .0065       | <b>.003</b> |
| Yttre Fjärden        | 42 | .0535 | .0727 | .0192       | <b>.000</b> |
| Lilla Värtan         | 42 | .0645 | .135  | .0705       | <b>.000</b> |
| Torsås               | 42 | .0534 | .0562 | .0028       | .471        |

**Table 4.2.32.** Differences in Sn concentration in perch liver ( $\mu\text{g/g dw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | .0475 | .0462 | -.0013      | .483        |
| Örnsköldsviksfjärden | 36 | .0477 | .0850 | .0373       | <b>.000</b> |
| Yttre Fjärden        | 36 | .0448 | .115  | .0702       | <b>.000</b> |
| Östhammarsfjärden    | 31 | .0452 | .0850 | .0398       | <b>.000</b> |
| Lilla Värtan         | 31 | .0452 | .600  | .555        | <b>.000</b> |
| Inre Slätbaken       | 31 | .0452 | .0424 | -.0028      | <b>.042</b> |
| Torsås               | 30 | .0448 | .0427 | -.0021      | .115        |

**Table 4.2.33.** Differences in Sn concentration in cod liver ( $\mu\text{g/g dry weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | meanr-meanp | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | .0450 | .235  | .190        | <b>.000</b> |
| Kungsbackafjorden | 30 | .0450 | .0562 | .0112       | <b>.000</b> |

No clear spatial pattern for tin is seen in herring liver. The highest concentration was found in Lilla Värtan ( $0.14 \mu\text{g/g dw}$ ) and the lowest concentration was seen in Örnsköldsviksfjärden ( $0.048 \mu\text{g/g dw}$ ) (Fig. 4.2.41). All herring sites, except Torsås, had significantly higher concentrations compared to their respective reference site (Table 4.2.31). In perch liver, all sites, except Lilla Värtan, had rather similar concentrations, ranging between 0.04 to  $0.11 \mu\text{g/g dw}$ . In perch from Lilla Värtan however, the concentration was as high as  $0.6 \mu\text{g/g dw}$

(Fig. 4.2.42). The lowest concentration of tin was found in Skelleftebukten, Torsås and Bråviken. Tin concentrations were significantly higher in the majority of the perch sites compared to the respective reference sites (Table 4.2.32). The concentration in eelpout liver increased from south to north, where Kungsbackafjorden had a concentration of 0.05 µg/g dw and Halsefjord and Askeröfjord had a concentration of 0.1 µg/g dw (Fig. 4.2.43). For cod, the highest concentration was found in Rivö fjord (0.24 µg/g dw) and Kungsbackafjorden had the lowest concentration (0.056 µg/g dw) (Fig. 4.2.44). Both of these sites had significantly higher concentrations compared to the reference sites (Table 4.2.33).

#### *Comparison between species*

For tin no clear patterns were seen. Depending on site, either herring or perch had higher concentrations. Cod liver had 3 times as high concentration compared to eelpout, but only in Rivö fjord, the other site had similar concentrations.

#### *Comparison with target value*

No national target value for biota is agreed upon for Sn.

### **4.3 Organic Pollutants**

#### **4.3.1 PCBs, Polychlorinated biphenyls**

##### *Usage, production and sources*

PCBs are synthetic chemicals that have been used in a wide variety of manufacturing processes especially as plasticizers and as insulators and fire retardants. It is widely distributed in the environment through inappropriate handling of waste material or e.g., leakage from large condensers and hydraulic systems.

Temporal trend monitoring show significant decreasing trends of PCBs over time (Bignert et al, 2014)

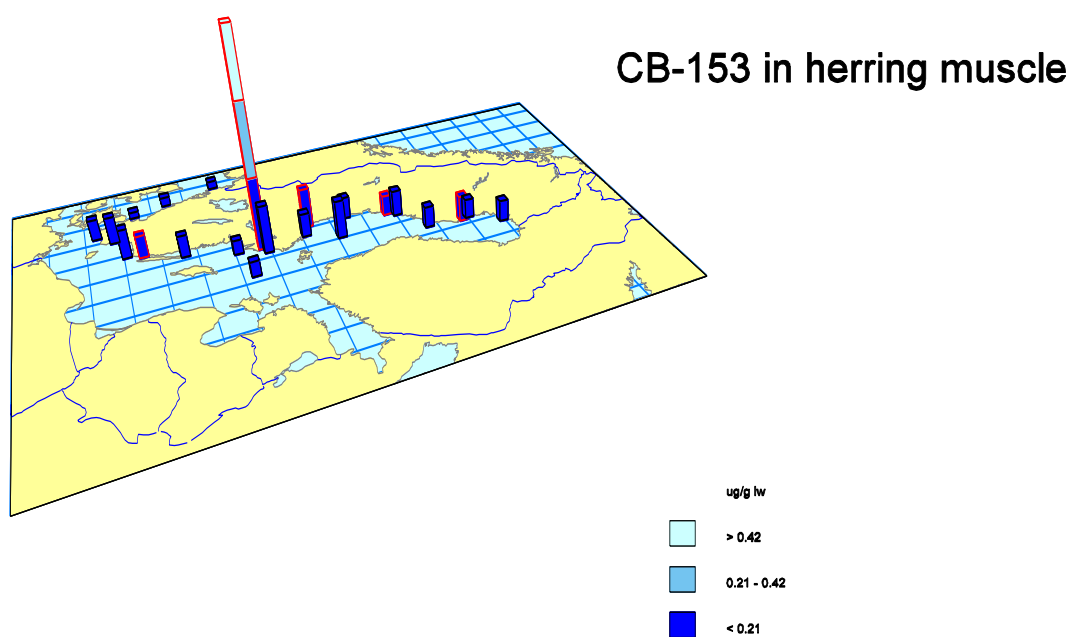
##### *Conventions, aims and restrictions*

The Minister Declaration from 1996, within HELCOM, and the declaration in Esbjerg 1995, calls for measures for toxic, persistent, bioaccumulating substances like PCBs to have ceased completely in the year 2020.

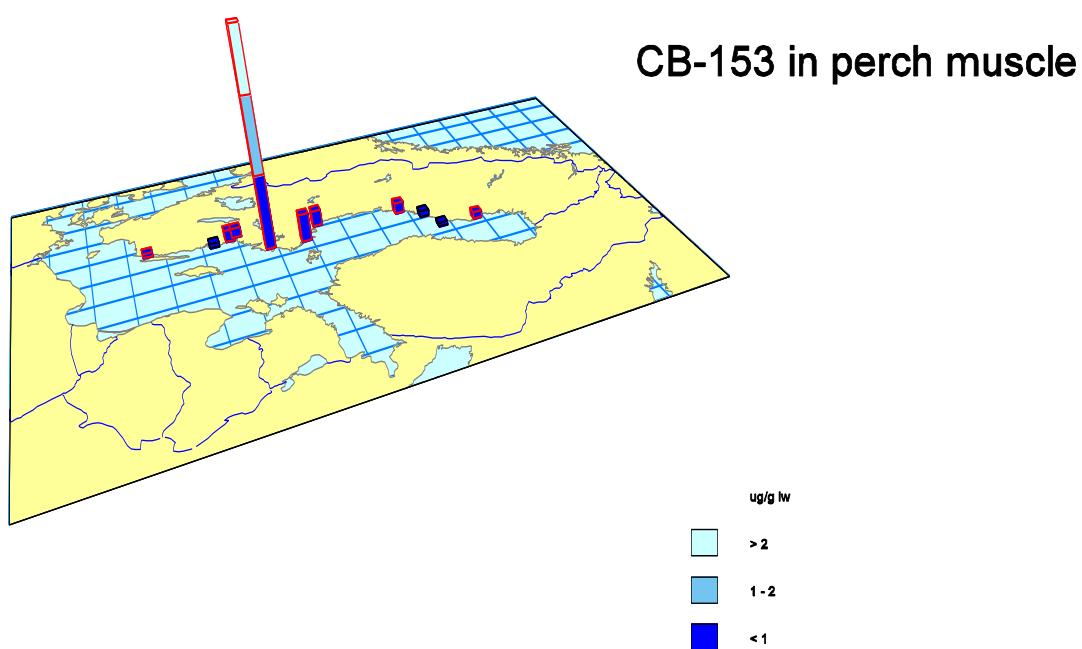
PCB is one of the initial 12 Persistent Organic Pollutants (POPs) included in The Stockholm Convention on POPs, an international agreement requiring measures for reducing or preventing release of dangerous substances into the environment.

In 1973, PCB use was banned in Sweden, except for within sealed systems. In 1978, all new use of PCBs was forbidden.

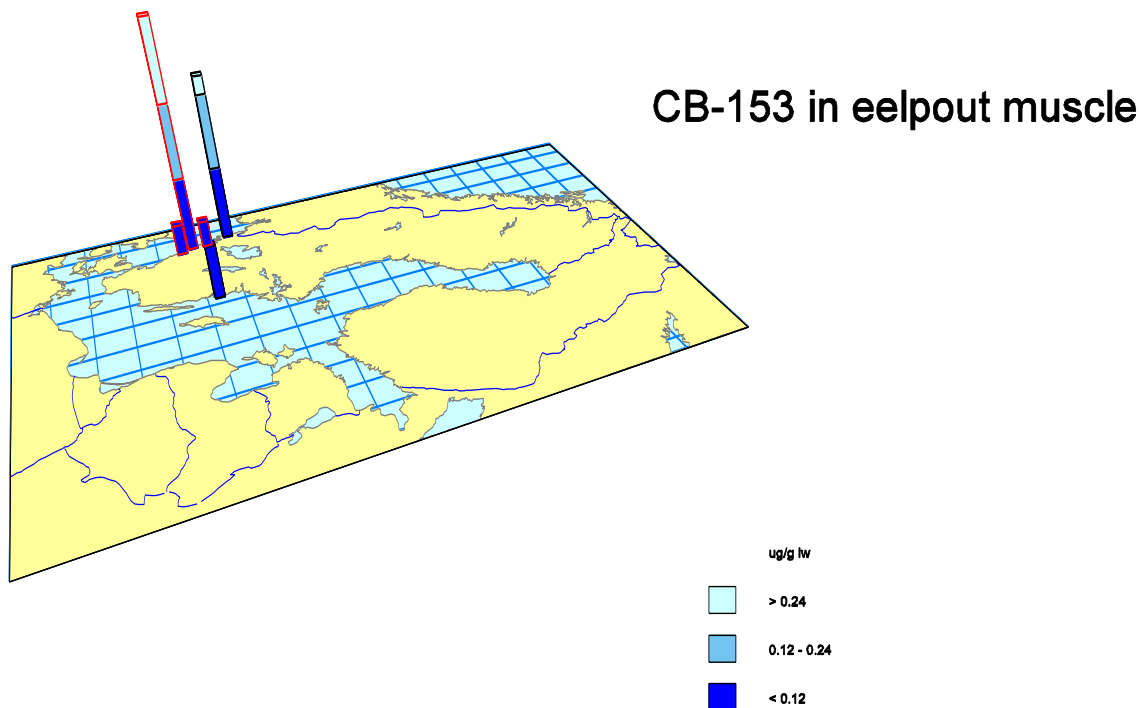
*Spatial variation*



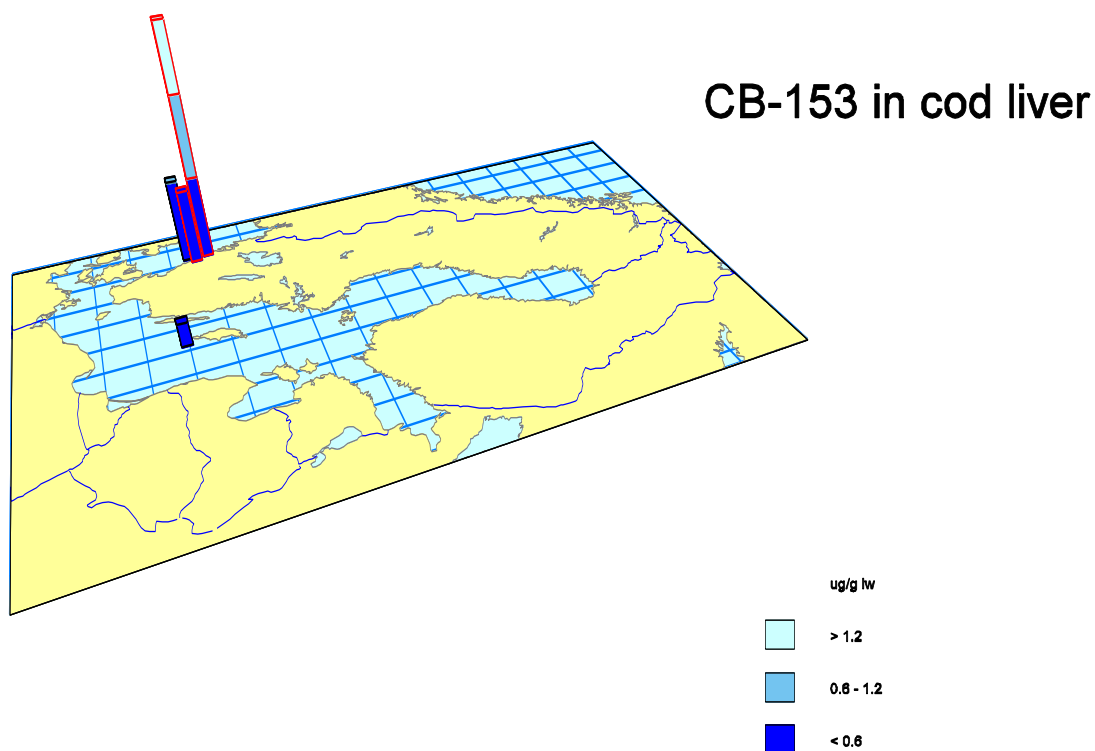
**Figure 4.3.1.** Spatial variation in concentration of CB-153 ( $\mu\text{g/g lw}$ ) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.2.** Spatial variation in concentration of CB-153 ( $\mu\text{g/g lw}$ ) in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.3.** Spatial variation in concentration of CB-153 ( $\mu\text{g/g lw}$ ) in eelpout muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.4.** Spatial variation in concentration of CB-153 ( $\mu\text{g/g lw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.3.1.** Differences in CB153 concentration in herring muscle ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .0569 | .0750 | .0181       | .153        |
| Örnsköldsviksfjärden | 6  | .0742 | .0580 | -.0162      | .348        |
| Yttre Fjärden        | 42 | .0676 | .115  | .0474       | <b>.000</b> |
| Lilla Värtan         | 42 | .0544 | .613  | .559        | <b>.000</b> |
| Torsås               | 42 | .0850 | .0645 | -.0205      | <b>.043</b> |

**Table 4.3.2.** Differences in CB153 concentration in perch muscle ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | .0575 | .090  | .0325       | <b>.000</b> |
| Örnsköldsviksfjärden | 35 | .0575 | .143  | .0855       | <b>.000</b> |
| Yttre Fjärden        | 35 | .0646 | .214  | .149        | <b>.000</b> |
| Östhammarsfjärden    | 30 | .0617 | .375  | .313        | <b>.000</b> |
| Lilla Värtan         | 30 | .0617 | 2.83  | 2.76        | <b>.000</b> |
| Inre Slätbaken       | 30 | .0617 | .155  | .0928       | <b>.000</b> |
| Bråviken, n Svindra  | 30 | .0617 | .0905 | .0288       | <b>.000</b> |
| Bråviken, s Esterön  | 30 | .0617 | .107  | .0448       | <b>.000</b> |
| Bråviken, n Esterön  | 30 | .0617 | .118  | .0558       | <b>.000</b> |
| Torsås               | 30 | .0617 | .0545 | -.0072      | .298        |

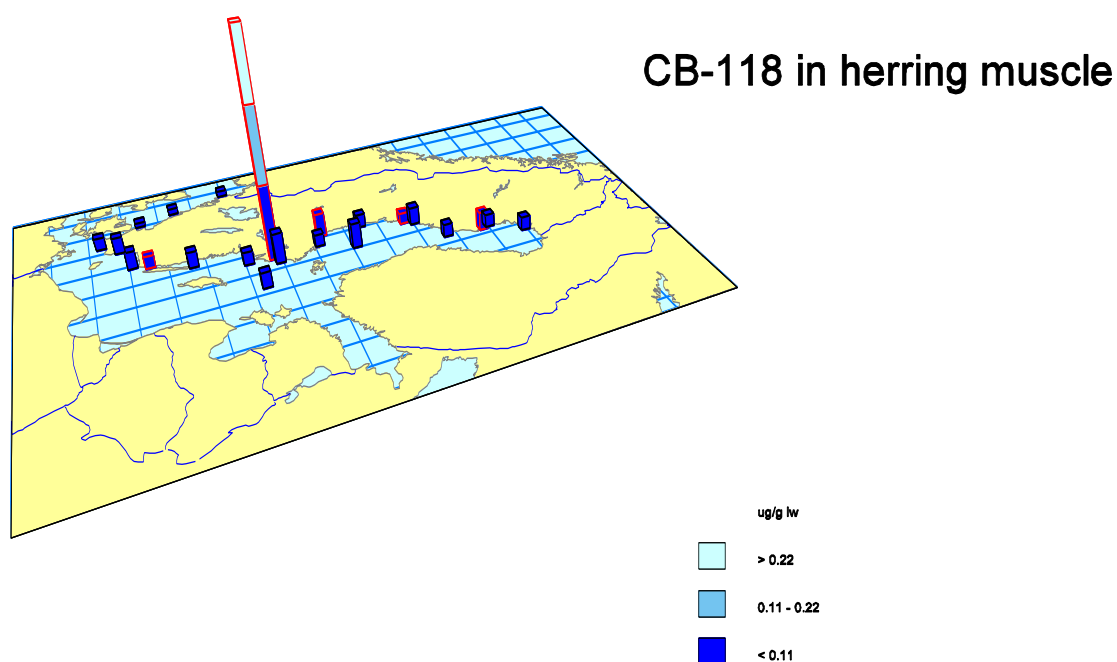
**Table 4.3.3.** Differences in CB153 concentration in cod liver ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 29 | .604  | 1.70  | 1.09        | <b>.000</b> |
| Kungsbackafjorden | 29 | .604  | .537  | -.0674      | <b>.045</b> |

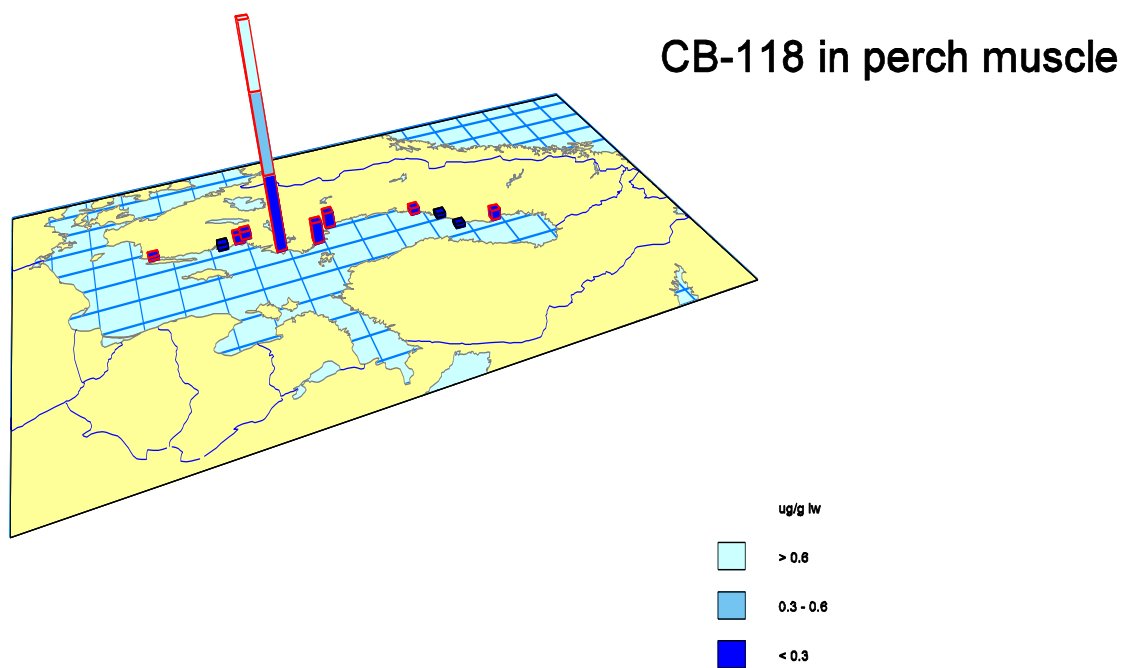
The concentration of CB-153 in herring muscle was rather similar at all the sites (ranging between 0.06 and 0.11  $\mu\text{g/g lw}$ ), except Lilla Värtan, which had more than six times as high concentration (0.61  $\mu\text{g/g lw}$ ) (Fig. 4.3.1). The concentration of CB-153 was significantly higher compared to the reference stations in herring from Lilla Värtan and Yttre Fjärden



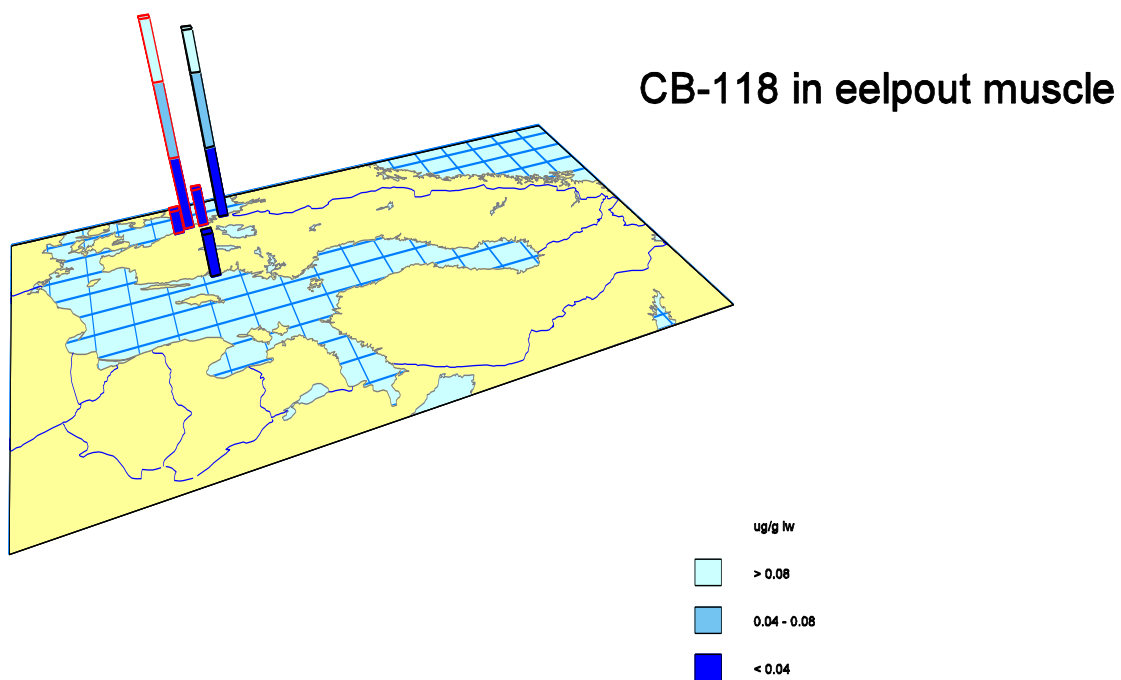
(Table 4.3.1). The concentration of CB-153 in perch muscle was also highest at Lilla Värtan, 2.8  $\mu\text{g/g lw}$ . At the other sites, the concentration ranged between 0.055 to 0.37  $\mu\text{g/g lw}$ , where the lowest concentration was found in Torsås (Fig. 4.3.2). All perch polluted sites, except Torsås had significantly higher concentrations compared to their respective reference sites (Table 4.3.2). In eelpout muscle, the highest concentration was found in Rivö fjord, 0.37  $\mu\text{g/g lw}$ , while Kungsbackafjorden and Halsefjord and Askeröfjord had lower but similar concentrations, 0.04  $\mu\text{g/g lw}$  (Fig. 4.3.3). In cod liver, Rivö fjord had the highest concentration, 1.7  $\mu\text{g/g lw}$ , while Kungsbackafjorden had around 3 times lower concentration, 0.54  $\mu\text{g/g lw}$  (Fig. 4.3.4). The concentration at Rivö fjord was significantly higher compared to its reference site (Table 4.3.3).



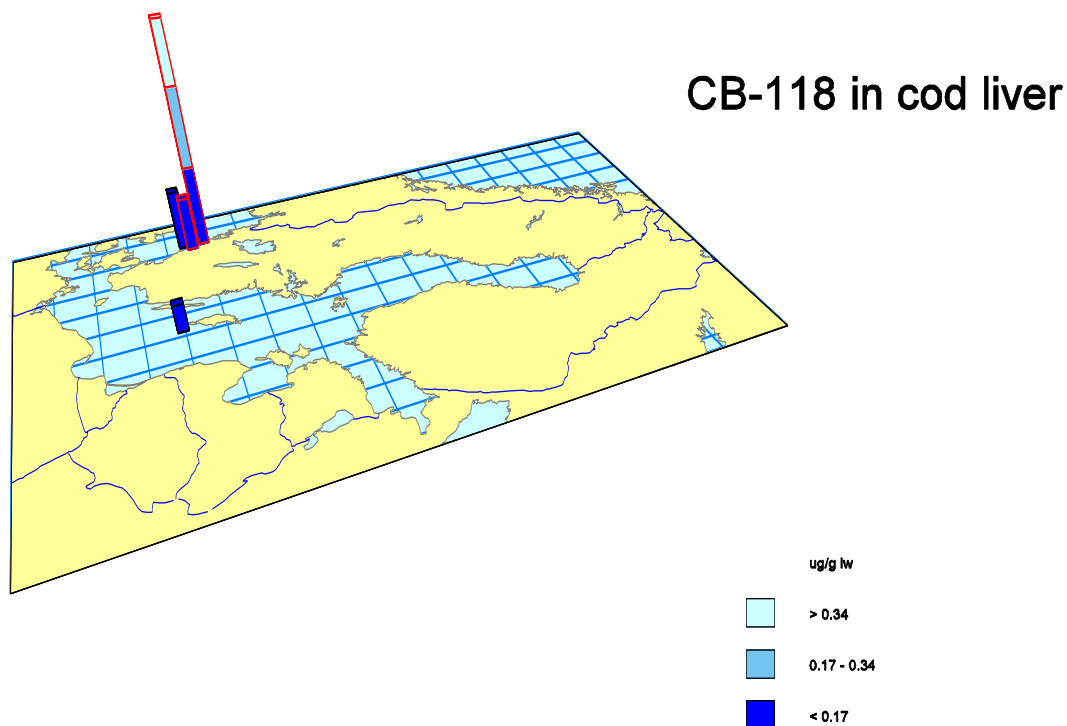
**Figure 4.3.5.** Spatial variation in concentration of CB-118 ( $\mu\text{g/g lw}$ ) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.6.** Spatial variation in concentration of CB-118 ( $\mu\text{g/g lw}$ ) in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.7.** Spatial variation in concentration of CB-118 ( $\mu\text{g/g lw}$ ) in eelpout muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.8.** Spatial variation in concentration of CB-118 ( $\mu\text{g/g lw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.3.4.** Differences in CB118 concentration in herring muscle ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .0187 | .0265 | .0078       | .062        |
| Örnsköldsviksfjärden | 6  | .0253 | .0160 | -.0093      | .109        |
| Yttre Fjärden        | 42 | .0173 | .0345 | .0172       | <b>.000</b> |
| Lilla Värtan         | 42 | .0223 | .322  | .300        | <b>.000</b> |
| Torsås               | 42 | .0259 | .0180 | -.0079      | <b>.007</b> |

**Table 4.3.5.** Differences in CB118 concentration in perch liver ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p    |
|----------------------|----|-------|-------|-------------|------|
| Skelleftebukten      | 35 | .0144 | .0370 | .0226       | .000 |
| Örnsköldsviksfjärden | 35 | .0144 | .0240 | .0096       | .000 |
| Yttre Fjärden        | 35 | .0204 | .0590 | .0386       | .000 |
| Östhammarsfjärden    | 30 | .0210 | .0830 | .0620       | .000 |
| Lilla Värtan         | 30 | .0210 | .839  | .818        | .000 |
| Inre Slätbaken       | 30 | .0210 | .0355 | .0145       | .000 |
| Bråviken, n Svindra  | 30 | .0210 | .0270 | .0060       | .008 |
| Bråviken, s Esterön  | 30 | .0210 | .0315 | .0105       | .000 |
| Bråviken, n Esterön  | 30 | .0210 | .0375 | .0165       | .000 |
| Torsås               | 30 | .0210 | .0140 | -.0070      | .003 |

**Table 4.3.6.** Differences in CB118 concentration in cod liver ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p    |
|-------------------|----|-------|-------|-------------|------|
| Rivö fjord        | 30 | .125  | .473  | .348        | .000 |
| Kungsbackafjorden | 30 | .125  | .112  | -.0133      | .088 |

For CB-118 in herring muscle, the highest concentration was found in Lilla Värtan, 0.32  $\mu\text{g/g lw}$ . The other sites had more than ten times lower concentrations, where the lowest were found in Örnsköldsviksfjärden and Torsås (0.016 and 0.018  $\mu\text{g/g lw}$  respectively) (Fig. 4.3.5). Herring from Yttre fjärden and Lilla Värtan had significantly higher concentrations of CB-118 compared to their respective reference site (Table 4.3.4). Also for perch, Lilla Värtan had the highest concentration, 0.84  $\mu\text{g/g lw}$ , while the other sites were lower and ranging between 0.014 to 0.083  $\mu\text{g/g lw}$ , where the lowest concentration was found in Torsås (Fig. 4.3.6). All perch polluted sites, except Torsås, had significantly higher concentrations compared to their respective reference site (Table 4.3.5). Eelpout from Rivö fjord had the highest concentration of CB-118, 0.11  $\mu\text{g/g lw}$ , compared to Kungsbackafjorden which had the lowest concentration, 0.013  $\mu\text{g/g lw}$  (Fig. 4.3.7). In cod liver, the highest concentration was found in Rivö fjord (0.47  $\mu\text{g/g lw}$ ) and the lowest was found in Kungsbackafjorden (0.11  $\mu\text{g/g lw}$ ) (Fig. 4.3.8). At Rivö fjord the concentration was significantly higher compared to its reference site (Table 4.3.6).

#### *Comparison between species*

Generally, concentrations of CB-153 and CB-118 were 2-3 times higher in perch muscle than in herring muscle, except for Skelleftebukten and Torsås, which had similar concentrations among the two species. CB-118 and CB-153 in cod muscle from Kungsbackafjorden was 4 and 6 times as high respectively compared to eelpout muscle from the same site, while at Rivö fjord, the concentrations were similar.

#### *Comparison with target value*

The PCBs are evaluated in relation to EACs since no EQS are developed. The target value for CB-153 is set to 1600 µg/kg lw (1.6 µg/g lw) and for CB-118 24 µg/kg lw (0.024 µg/g lw).

The concentrations of CB-153 are in general below the target value for all fish species but with exceptions for cod from Rivöfjorden (Gothenburg harbour) with concentrations of 1.7 µg/g lw and perch from Lilla Värtan with concentrations of 2.8 µg/g lw.

For CB-118 almost all polluted stations have concentrations above the target value. Exceptions are Torsås (herring and perch) with concentrations below target value and Örensköldsviksfjärden where herring have concentrations below the target value and perch at target value levels. Also eelpout from Kungsbackafjord and Askeröfjord show concentrations below the target value.

The maximum value, according to EC foodstuff regulation, for the sum of CB-28, CB-52, CB-101, CB-138, CB-153, CB-180 in fish muscle is set to 75 ng/g wet weight. This value is exceeded by the high PCB concentrations found in herring muscle from Lilla värtan with a mean concentration of 99 ng/g wet weight (calculated from the appendix, table 2).

### **4.3.2 DDTs, Dichlorodiphenylethanes**

#### *Usage, production and sources*

DDT is a persistent synthetic pesticide that primarily degrades to DDE and DDD. It is still used in some countries as it is an effective pesticide against mosquitoes and hence malaria. The presence of DDT and its metabolites in the Arctic area indicates long range transport (Welch et al. 1991).

Temporal trend monitoring show significant decreasing trends of DDT and its metabolites over time (Bignert et al, 2014)

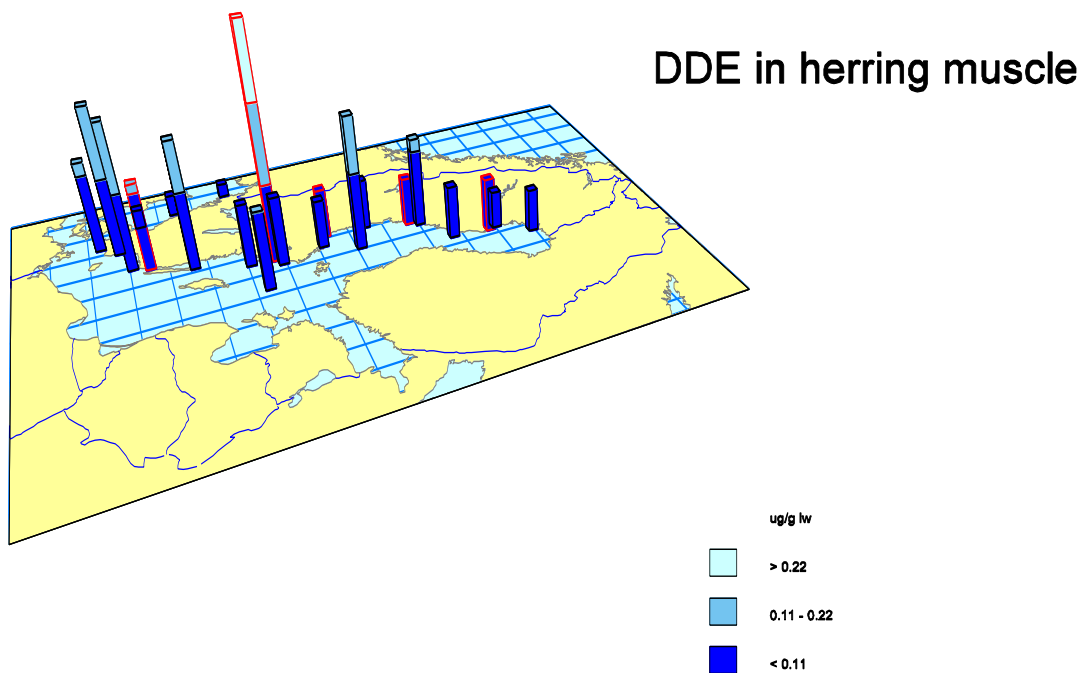
#### *Conventions, aims and restrictions*

DDT is one of the initial 12 Persistent Organic Pollutants (POPs) included in The Stockholm Convention on POPs, an international agreement requiring measures for reducing or preventing release of dangerous substances into the environment.

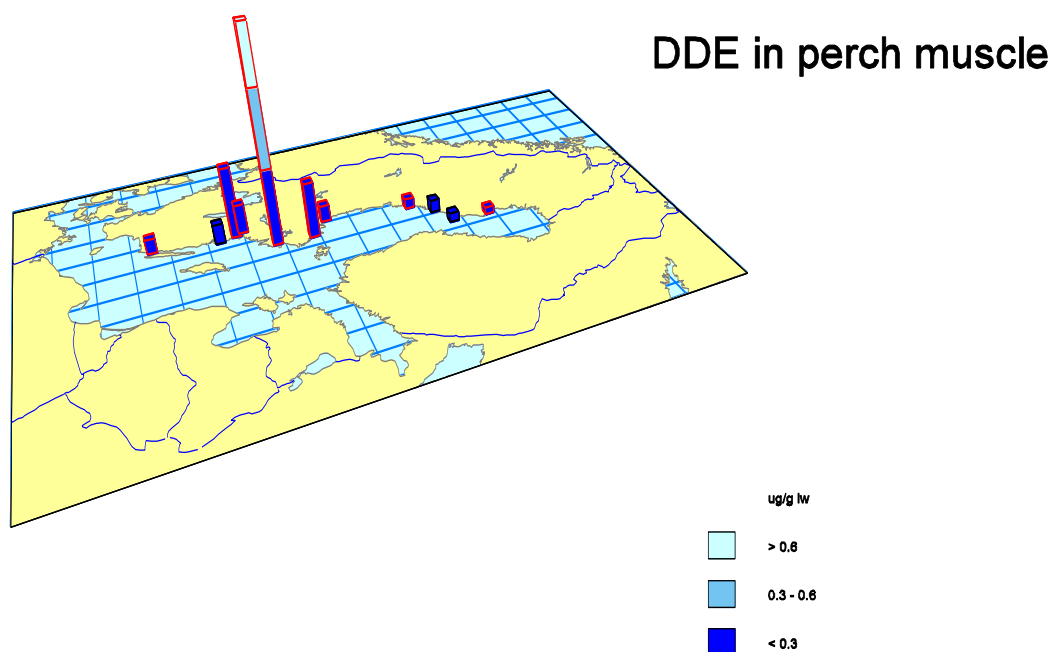
The Stockholm Convention was adopted in 2001 and entered into force in 2004. In Sweden, DDT was partially banned as a pesticide in 1970, and completely banned in 1975 due to its persistence and environmental impact.

In western European countries, the use of DDT ceased around 1990, although heavy use was banned between 1970 and 1975 in most countries bordering the Baltic Sea.

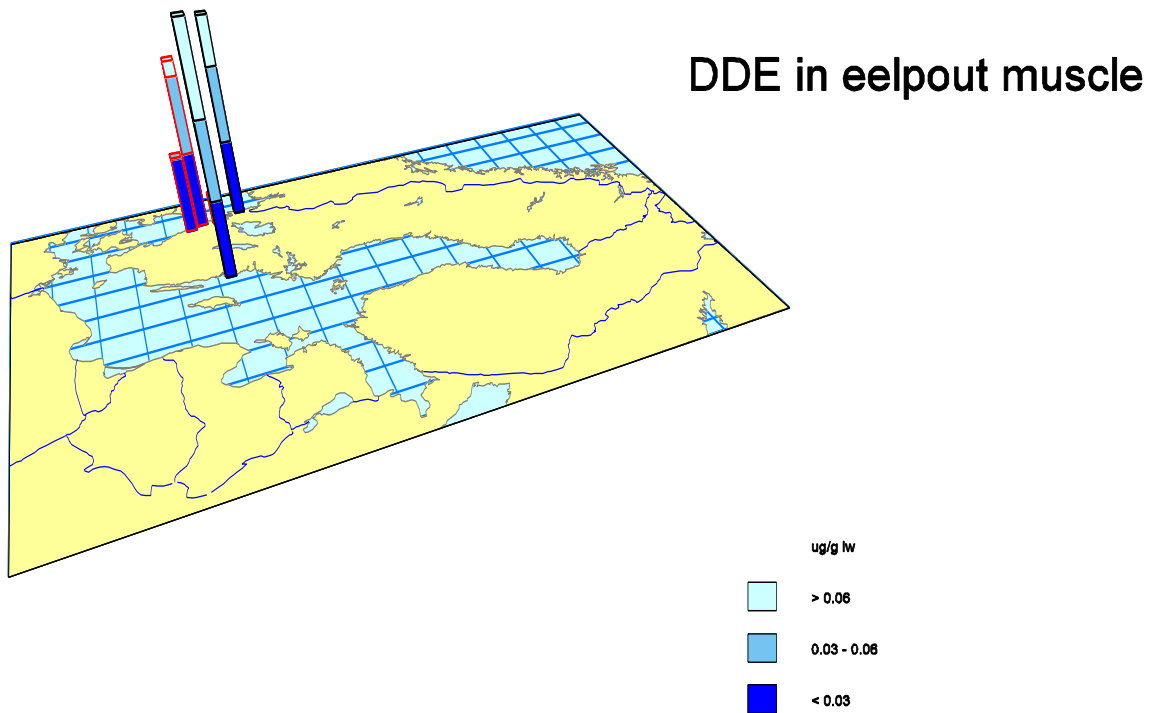
### Spatial variation



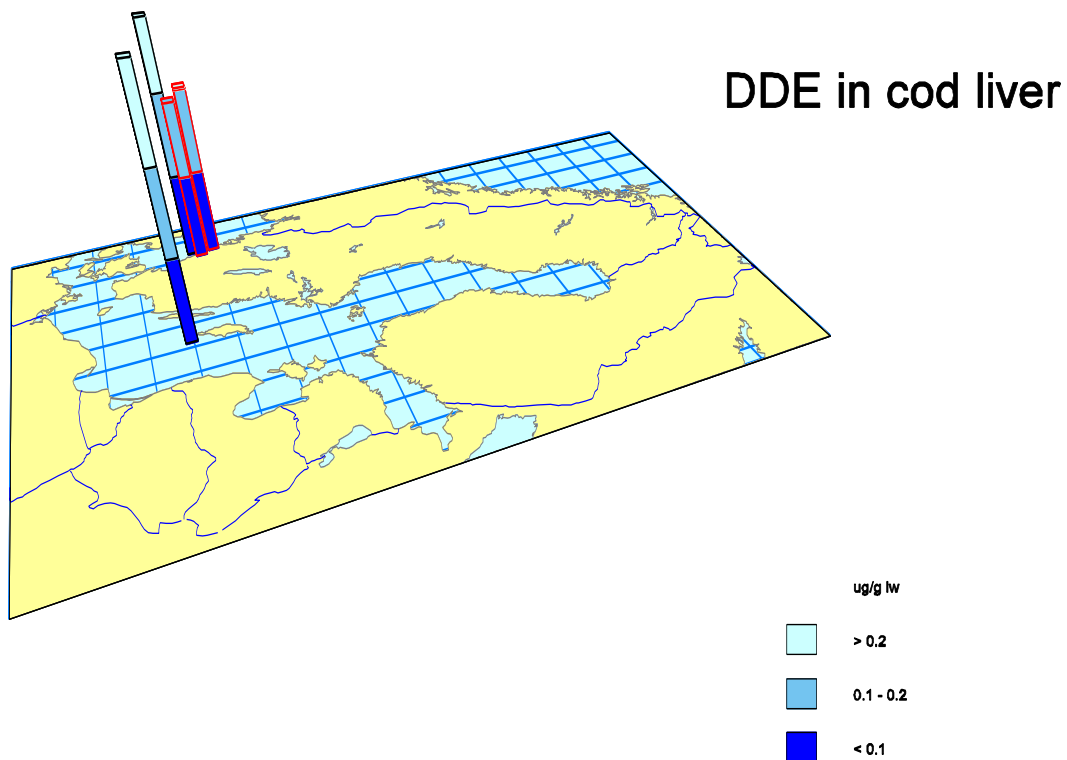
**Figure 4.3.9.** Spatial variation in concentration of DDE ( $\mu\text{g/g lw}$ ) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.10.** Spatial variation in concentration of DDE ( $\mu\text{g/g lw}$ ) in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.11.** Spatial variation in concentration of DDE ( $\mu\text{g/g lw}$ ) in eelpout muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.12.** Spatial variation in concentration of DDE ( $\mu\text{g/g lw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.3.7.** Differences in DDE concentration in herring muscle ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .0534 | .0765 | .0231       | .074        |
| Örnsköldsviksfjärden | 6  | .128  | .0685 | -.0593      | .053        |
| Yttre Fjärden        | 42 | .0687 | .0705 | .0018       | .840        |
| Lilla Värtan         | 40 | .0903 | .324  | .233        | <b>.000</b> |
| Torsås               | 42 | .206  | .123  | -.0831      | <b>.001</b> |

**Table 4.3.8.** Differences in DDE concentration in perch muscle ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | .0371 | .0265 | -.0106      | <b>.000</b> |
| Örnsköldsviksfjärden | 35 | .0371 | .0395 | .0024       | .384        |
| Yttre Fjärden        | 35 | .0726 | .0640 | -.0086      | .322        |
| Östhammarsfjärden    | 30 | .0767 | .218  | .141        | <b>.000</b> |
| Lilla Värtan         | 30 | .0767 | .826  | .749        | <b>.000</b> |
| Inre Slätbaken       | 30 | .0767 | .277  | .200        | <b>.000</b> |
| Bråviken, n Svindra  | 30 | .0767 | .102  | .0253       | <b>.013</b> |
| Bråviken, s Esterön  | 30 | .0767 | .118  | .0408       | <b>.000</b> |
| Bråviken, n Esterön  | 30 | .0767 | .120  | .0428       | <b>.000</b> |
| Torsås               | 30 | .0767 | .0570 | -.0197      | <b>.050</b> |

**Table 4.3.9.** Differences in DDE concentration in cod liver ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | .285  | .202  | -.0829      | <b>.000</b> |
| Kungsbackafjorden | 30 | .285  | .191  | -.0944      | <b>.000</b> |

DDE in herring muscle was highest in Lilla Värtan, 0.32  $\mu\text{g/g lw}$ . The other sites ranged between 0.07 and 0.12  $\mu\text{g/g lw}$ , where the lowest concentration was found in Örnsköldsvik (Fig. 4.3.9). Herring from Lilla Värtan had significantly higher concentration compared to its reference site (Table 4.3.7). Also for DDE in perch muscle, Lilla Värtan had the highest



concentration (0.83 µg/g lw). The other sites ranged between 0.027 to 0.22 µg/g lw, where the lowest concentration was found in Skelleftebukten (Fig. 4.3.10). The majority of the perch polluted sites were significantly higher compared to their respective reference site (Table 4.3.8). For eelpout muscle, the highest concentration of DDE was found in Rivö fjord (0.07 µg/g lw) and the lowest in Halsefjord and Askeröfjord (0.01 µg/g lw) (Fig. 4.3.11). The concentrations in cod liver were similar between the two sites, approximately 0.2 µg/g lw at both (Fig. 4.3.12). None of the polluted cod sites had higher concentrations compared to their respective reference (Table 4.3.9).

#### *Comparison between species*

DDE concentration in herring was generally 2-4 times higher compared to perch, except Yttre Fjärden, where concentrations were similar, and Lilla Värtan, where perch instead had 2.5 times higher concentration. DDE in cod muscle was 3 times higher compared to eelpout muscle at Kungsbackafjorden, while at Rivö fjord the concentrations were almost similar.

#### *Comparison with target value*

DDE is evaluated in relation to EAC since no EQS are developed. The target value for DDE is set to 5 µg/kg ww. The results for DDE presented in this report are expressed as concentration in lipid weight. The target value has thereby been recalculated to represent the corresponding value in lipid weight by using the mean lipid weight of each species.

Target value expressed in lipid weight:

Herring (lipid content 3.3 %): 0.15 µg/g lw

Perch (lipid content 0.67 %): 0.75 µg/g lw

Eelpout (lipid content 0.95 %): 0.53 µg/g lw

Cod (lipid content in liver 13.7 %): 0.038 µg/g lw

Cod (lipid content in muscle 0.42 %): 1.25 µg/g lw

The DDE concentrations in both herring and perch samples from Lilla Värtan exceed the calculated target values with concentrations of 0.32 and 0.83 µg/g lw respectively. Concentrations at other sites in herring and perch and also in all eelpout sites are below the target value.

Cod concentrations in liver are exceeding the target value while the muscle concentrations are below the target value. The difference in outcome of the comparison to the target value are a result of the high lipid content in liver compared to muscle and also from probable higher accumulation of DDE in liver compared to muscle, around the double concentration in liver compared to muscle expressed in lipid weight (muscle concentrations of DDE in cod are approximately half).

### **4.3.3 HCHs, Hexachlorocyclohexanes**

#### *Usage, production and sources*

Technical HCH contains various isomers and most of them were used as insecticides.

Temporal trend monitoring show significant decreasing trends of HCH isomers over time (Bignert et al, 2014)

#### *Conventions, aims and restrictions*

HCHs are three of the initial 12 Persistent Organic Pollutants (POPs) included in The Stockholm Convention on POPs, an international agreement requiring measures for reducing or preventing release of dangerous substances into the environment.

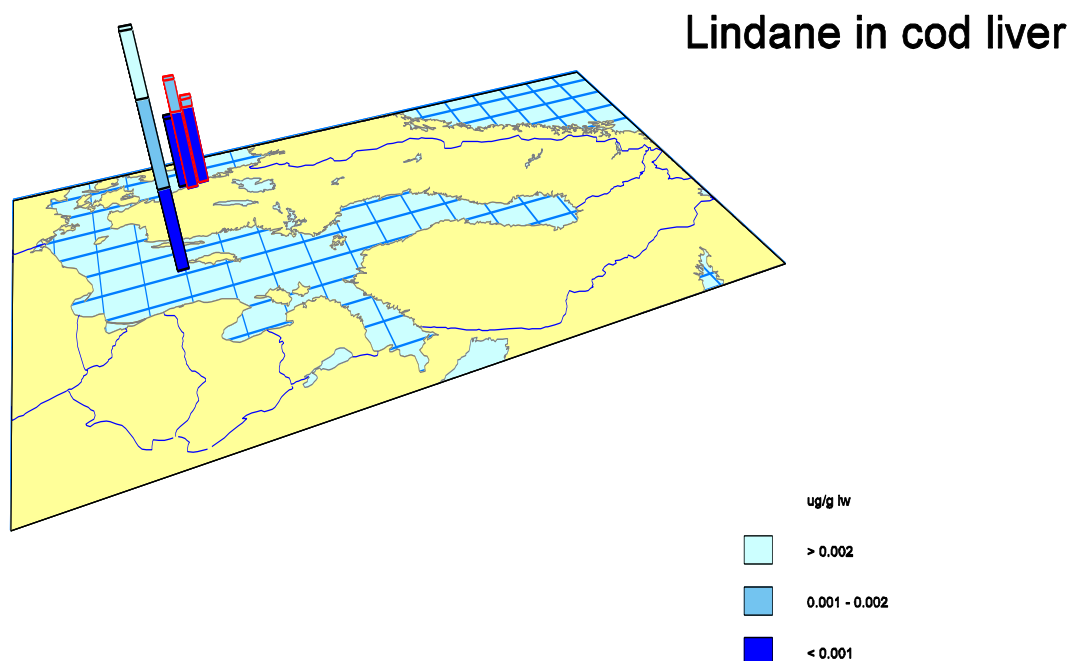
In Sweden, the use of lindane was severely restricted in 1970, and subsequently prohibited for use in agriculture in 1978 because of its suspected carcinogenic properties and persistence. Remaining use was banned in 1988/89.

The use of technical HCH stopped in countries around the Baltic between 1970 and 1980. Today, only a few countries worldwide still produce lindane (Stockholm convention).

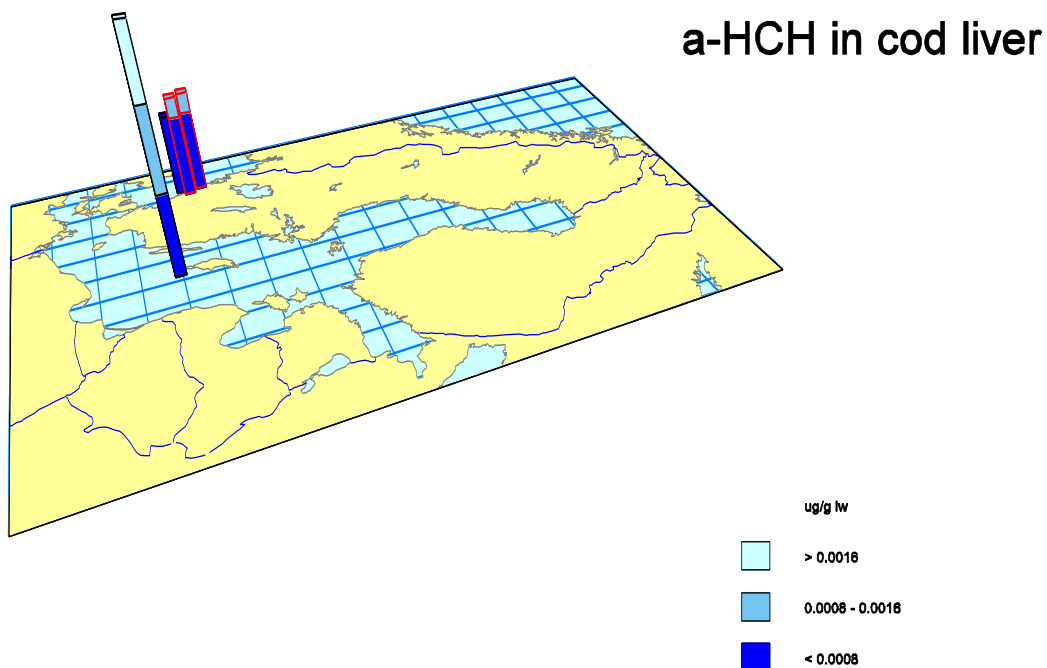
#### *Spatial variation*

Lindane and  $\alpha$ -HCH are only above LOQ in cod liver samples – no maps are presented for the other species (polluted sites)

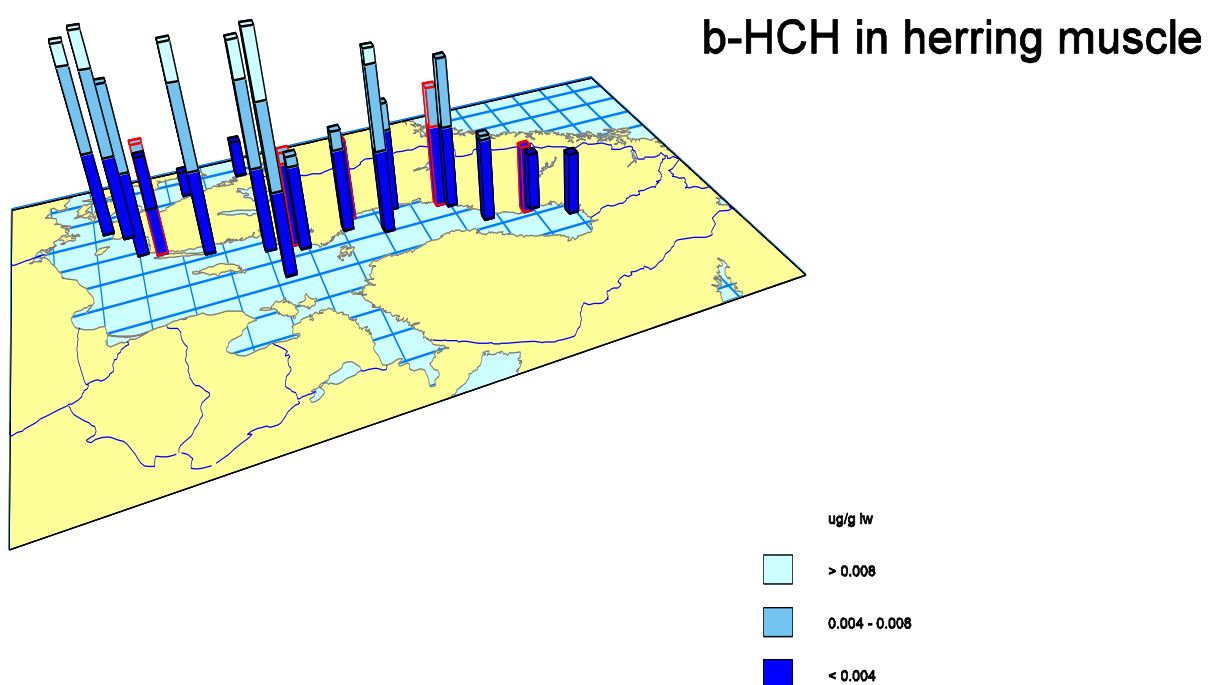
$\beta$ -HCH is below LOQ at all perch and eelpout sites (polluted) and perch and eelpout are therefore not presented.



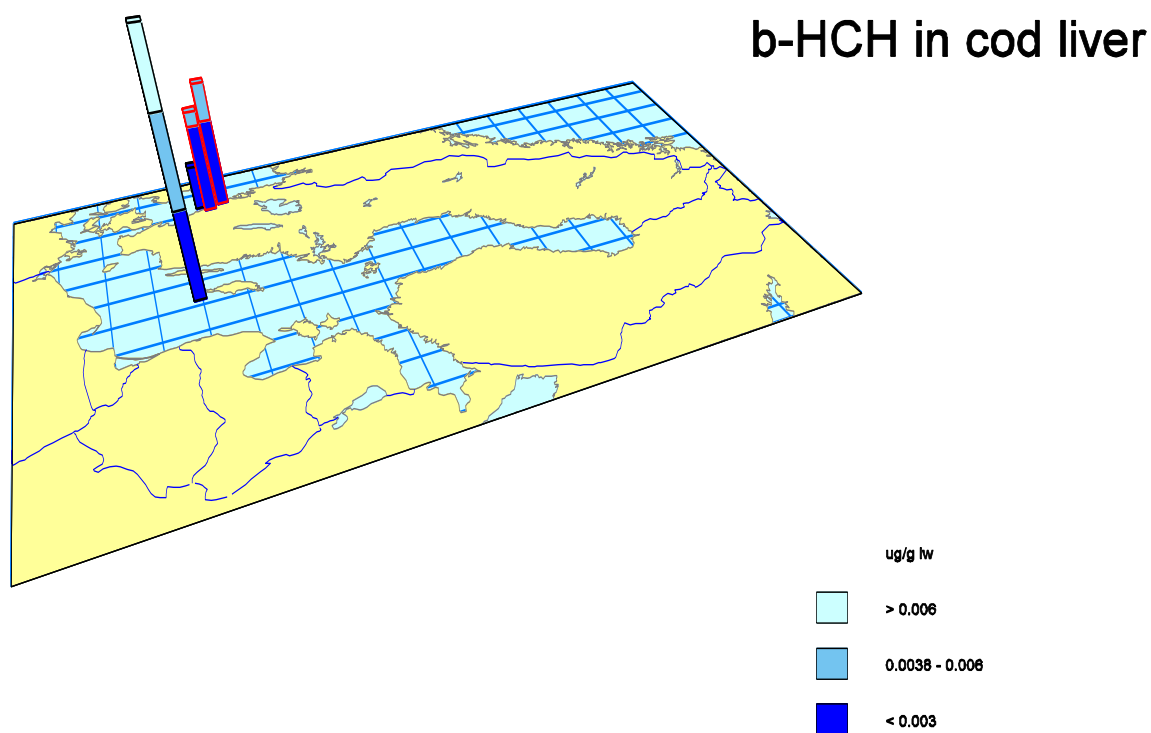
**Figure 4.3.13.** Spatial variation in concentration of lindane ( $\mu\text{g/g lw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.14.** Spatial variation in concentration of  $\alpha$ -HCH ( $\mu\text{g/g lw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.15.** Spatial variation in concentration of  $\beta$ -HCH ( $\mu\text{g/g lw}$ ) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.16.** Spatial variation in concentration of  $\beta$ -HCH ( $\mu\text{g/g lw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.3.10.** Differences in  $\alpha$ -HCH concentration in cod liver ( $\mu\text{g/g lipid weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p    |
|-------------------|----|-------|-------|-------------|------|
| Rivö fjorden      | 30 | .0008 | .0010 | .0002       | .000 |
| Kungsbackafjorden | 30 | .0008 | .0010 | .0002       | .000 |

**Table 4.3.11.** Differences in  $\beta$ -HCH concentration in herring muscle ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p    |
|----------------------|----|-------|-------|-------------|------|
| Skelleftebukten      | 6  | .0028 | .0033 | .0005       | .244 |
| Örnsköldsviksfjärden | 6  | .0073 | .0059 | -.0014      | .086 |
| Yttre Fjärden        | 42 | .0049 | .0039 | -.0010      | .000 |
| Lilla Värtan         | 42 | .0089 | .0045 | -.0044      | .000 |
| Torsås               | 42 | .0080 | .0053 | -.0027      | .000 |

**Table 4.3.12.** Differences in  $\beta$ -HCH concentration in cod liver ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p    |
|-------------------|----|-------|-------|-------------|------|
| Rivö fjord        | 30 | .0015 | .0043 | .0028       | .000 |
| Kungsbackafjorden | 30 | .0015 | .0035 | .0020       | .000 |

**Table 4.3.13.** Differences in Lindan concentration in cod liver ( $\mu\text{g/g lipid weight}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p    |
|-------------------|----|-------|-------|-------------|------|
| Rivö fjorden      | 28 | .0009 | .0011 | .0002       | .000 |
| Kungsbackafjorden | 28 | .0009 | .0014 | .0005       | .000 |

The concentration of  $\alpha$ -HCH in cod liver were the same at the two sites, 0.001  $\mu\text{g/g lw}$  (Fig. 4.3.14). The two polluted sites had significantly higher concentrations compared to the reference site (Table 4.3. 10). For  $\beta$ -HCH in cod liver, the concentration was somewhat higher in Rivö fjord (0.0043  $\mu\text{g/g lw}$ ) than in Kungsbackafjorden (0.0035  $\mu\text{g/g lw}$ ) (Fig. 4.3.16). Both of the polluted sites had significantly higher concentration in cod liver compared to their respective reference (Table 4.3.12). For  $\beta$ -HCH in herring muscle, the highest concentration was found in Örnköldsviksfjärden (0.0059  $\mu\text{g/g lw}$ ) and the lowest concentration was found in Skelleftebukten (0.0033  $\mu\text{g/g lw}$ ) (Fig. 4.3.15). None of the herring polluted sites had higher concentrations compared to the reference sites (Table 4.3.11). Concentrations of lindane in cod liver were similar between the two sites, 0.0011 and 0.0014  $\mu\text{g/g lw}$  at Kungsbackafjorden and Rivö fjord respectively (Fig. 4.3.13). The concentrations at the two polluted sites were significantly higher compared to the reference site (Table 4.3.13)

#### *Comparison between species*

No comparisons between species were done for HCHs since levels were below LOQ for some of the compounds for some species.

#### *Comparison with target value*

HCHs are evaluated in relation to a translation of the EQS set for surface water according to Lilja et al. 2010. This calculated target value for HCHs is set to 2.6  $\mu\text{g/kg ww}$  in marine biota. In order to make this target value comparable to the concentrations presented in the maps a recalculation has been made to represent the corresponding value in lipid weight by using the mean lipid weight of the for each species.

Target value expressed in lipid weight:

Herring (lipid content 3.3 %): 0.079  $\mu\text{g/g lw}$

Cod (lipid content in liver 13.7 %): 0.019  $\mu\text{g/g lw}$

The concentrations of  $\alpha$ -,  $\beta$ -,  $\gamma$ -HCH were below the target value at all stations for all species.

#### **4.3.4 HCB, Hexachlorobenzene**

##### *Usage, production and sources*

The use of the highly persistent HCB as a fungicide is banned in the Baltic countries. Although it may still reach the environment as a by-product of many chlorinating processes, for example pentachlorophenol and vinyl chloride monomer production, we have reason to expect a decrease in biological samples from the Baltic.

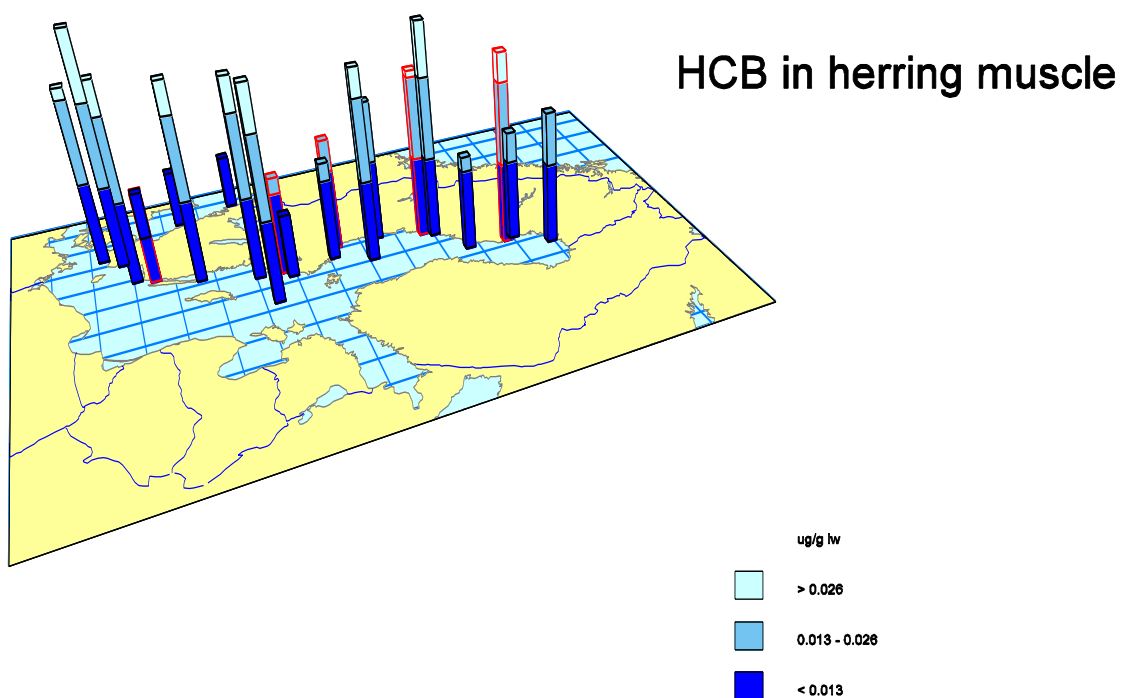
Temporal trend monitoring show significant decreasing trends of HCB over time (Bignert et al, 2014)

##### *Convention, aims and restrictions*

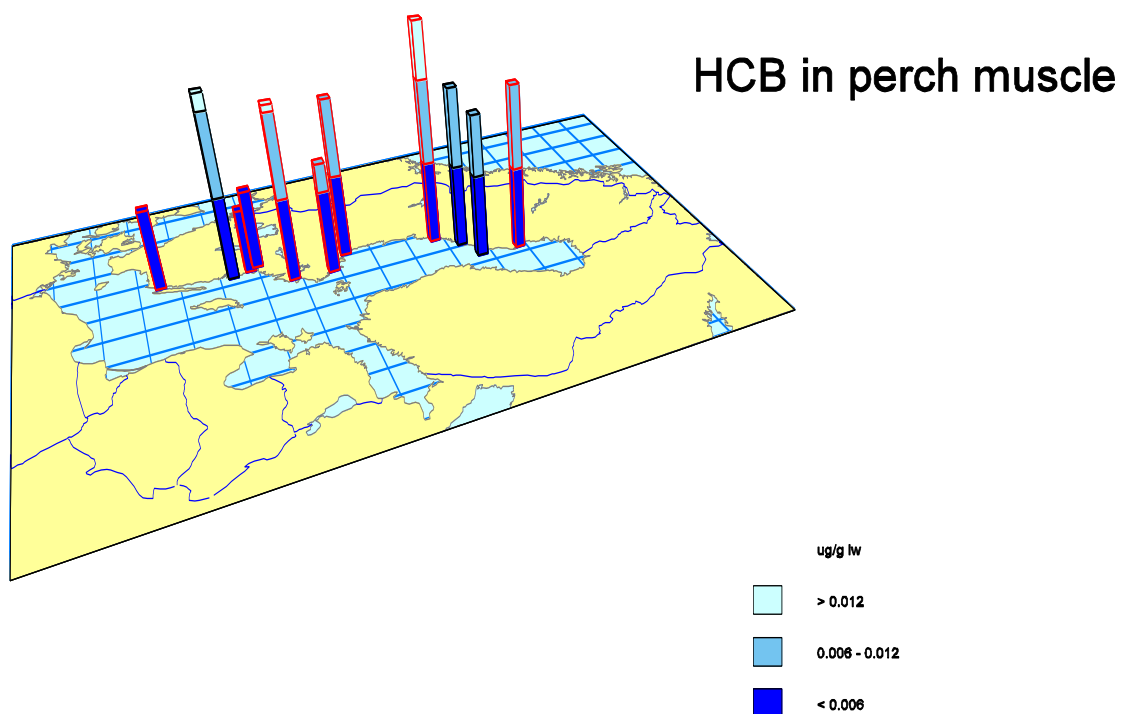
HCB is one of the initial 12 Persistent Organic Pollutants (POPs) included in The Stockholm Convention on POPs, an international agreement requiring measures for reducing or preventing release of dangerous substances to the environment.

In 1980, HCB was withdrawn from the market in Sweden because of its carcinogenic effects on experimental animals and its persistence.

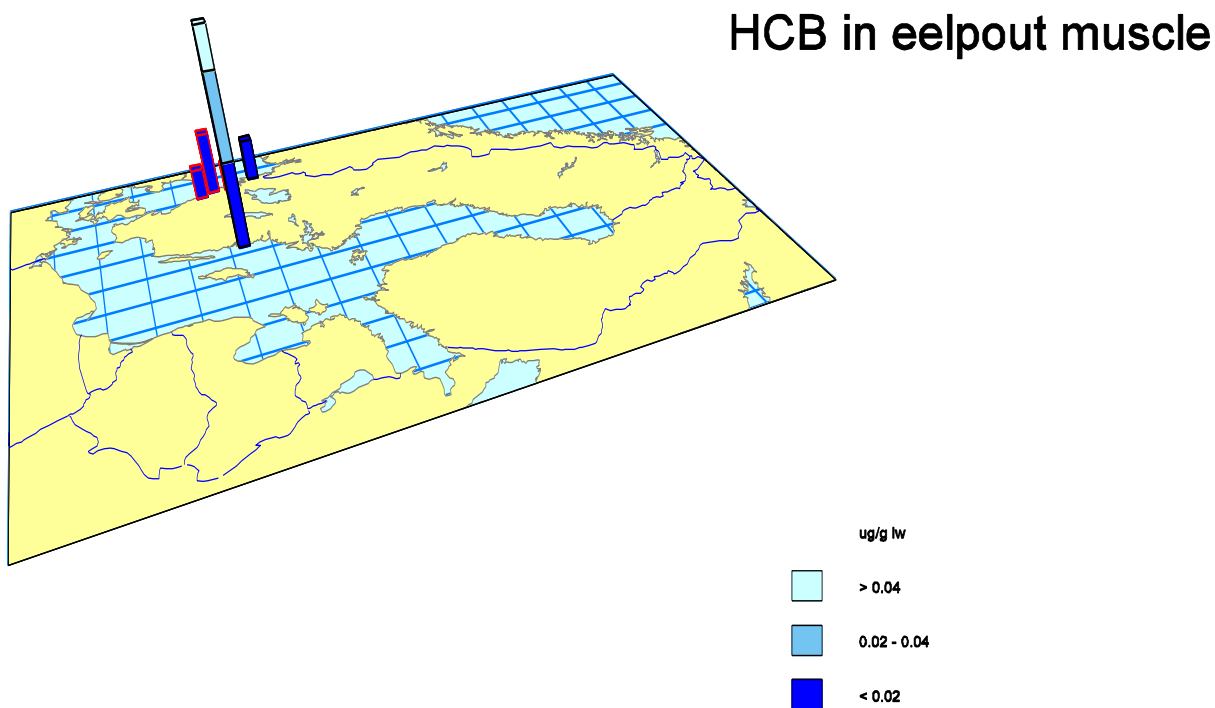
The use of HCB as a fungicide is banned in the Baltic countries.



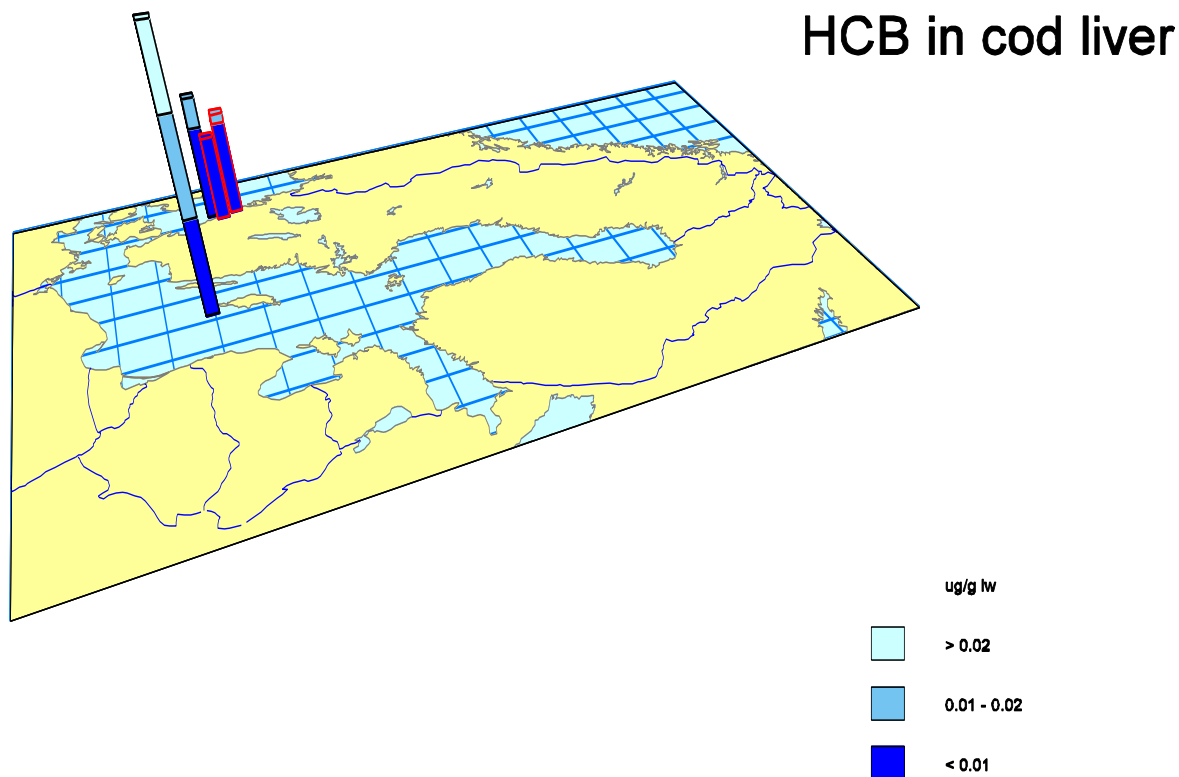
**Figure 4.3.17.** Spatial variation in concentration of HCB ( $\mu\text{g/g lw}$ ) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.18.** Spatial variation in concentration of HCB ( $\mu\text{g/g lw}$ ) in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.19.** Spatial variation in concentration of HCB ( $\mu\text{g/g lw}$ ) in eelpout muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.20.** Spatial variation in concentration of HCB ( $\mu\text{g/g lw}$ ) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Table 4.3.14.** Differences in HCB concentration in herring muscle ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .0178 | .0305 | .0127       | <b>.001</b> |
| Örnsköldsviksfjärden | 6  | .0345 | .0270 | -.0075      | .190        |
| Yttre Fjärden        | 42 | .0159 | .0180 | .0021       | .186        |
| Lilla Värtan         | 42 | .0283 | .0155 | -.0128      | <b>.000</b> |
| Torsås               | 42 | .0313 | .0145 | -.0168      | <b>.000</b> |

**Table 4.3.15.** Differences in HCB concentration in perch muscle ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 35 | .0106 | .0120 | .0014       | <b>.046</b> |
| Örnsköldsviksfjärden | 35 | .0106 | .0160 | .0054       | <b>.000</b> |
| Yttre Fjärden        | 35 | .0130 | .0115 | -.0015      | .307        |
| Östhammarsfjärden    | 30 | .0132 | .0080 | -.0052      | <b>.003</b> |
| Lilla Värtan         | 30 | .0132 | .0125 | -.0007      | .667        |
| Inre Slätbaken       | 30 | .0132 | .0046 | -.0086      | <b>.000</b> |
| Bråviken, n Svindra  | 30 | .0132 | .0046 | -.0086      | <b>.000</b> |
| Bråviken, s Esterön  | 30 | .0132 | .0051 | -.0081      | <b>.000</b> |
| Bråviken, n Esterön  | 30 | .0132 | .0051 | -.0081      | <b>.000</b> |
| Torsås               | 30 | .0132 | .0058 | -.0074      | <b>.000</b> |

**Table 4.3.16.** Differences in HCB concentration in cod liver ( $\mu\text{g/g lw}$ ) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | .0132 | .0110 | -.0022      | .237        |
| Kungsbackafjorden | 30 | .0132 | .0090 | -.0043      | <b>.030</b> |

For HCB in herring muscle there seemed to be a geographical gradient with higher concentrations in the north and decreasing towards the south. The highest concentration was found in Skelleftebukten (0.031  $\mu\text{g/g lw}$ ) and the lowest concentration was found in Torsås

(0.015 µg/g lw) (Fig. 4.3.17). Herring from Skelleftebukten had significantly higher concentration of HCB compared to its reference sites (Table 4.3.14). For perch there also seemed to be a spatial pattern with higher concentrations in the north and decreasing towards the south. The highest concentration was found in Örnköldsviksfjärden (0.016 µg/g lw) and the lowest concentration was seen in Inre Slätbaken (0.0046 µg/g lw) (Fig. 4.3.18). Perch from Skelleftebukten and Örnköldsviksfjärden had significantly higher concentration of HCB compared to their respective reference (Table 4.3.15). In eelpout muscle, the highest concentration was found in Rivö fjord (0.015 µg/g lw) and the lowest concentration was found in Halsefjord and Askeröfjord (0.006 µg/g lw) (Fig. 4.3.19). In cod liver, the concentrations were similar between the sites, 0.009 µg/g lw at Kungsbackafjorden and 0.011 µg/g lw at Rivö fjord (Fig. 4.3.20). None of the sites had significantly higher concentrations compared to the references (Table 4.3.16).

#### *Comparison between species*

HCB concentrations were 2-3 times higher in herring muscle compared to perch muscle, except for Lilla Värtan and Yttre fjärden, where concentrations were similar between the two species. Cod muscle was below LOQ and therefore it was not possible to make a comparison with eelpout muscle.

#### *Comparison with target value*

The target value for HCB is set to 10 µg/kg ww (EQSbiota). The results for HCB presented in this report are expressed as concentration in lipid weight. The target value has thereby been recalculated to represent the corresponding value in lipid weight by using the mean lipid weight of each species.

Target value expressed in lipid weight:

Herring (lipid content 3.3 %): 0.30 µg/g lw

Perch (lipid content 0.67 %): 1.5 µg/g lw

Eelpout (lipid content 0.95 %): 1.1 µg/g lw

Cod (lipid content in liver 13.7 %): 0.073 µg/g lw

Cod (lipid content in muscle 0.42 %): 2.4 µg/g lw

Concentrations of HCB are at concentrations below the target value at all stations for all species.

### **4.3.5 PCDD/PDCF, Polychlorinated Dioxins and Dibenzofurans**

#### *Usage, production and sources*

Dioxins are unintentionally created during combustion of organic materials. They are highly toxic and carcinogenic.

Polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) consist of 17 congeners considered to be of toxicological importance (210 congeners in total). PCDD/Fs are formed in several industrial processes and from most combustion processes (e.g., municipal waste incineration and small scale burning in poorly controlled conditions). The use of chlorine gas during pulp bleaching processes was formerly an important producer of PCDD/Fs.

Atmospheric deposition is the most important active source of PCDD/Fs to the Baltic Sea today (Sellström et al. 2009). The origin of the substances in air is, however, not fully known, although there are indications of strong impact of long-range atmospheric transport from south-western and southern Europe. It is also uncertain how historical emissions and secondary sources contribute, and how PCDD/Fs are accumulated in the food chain.

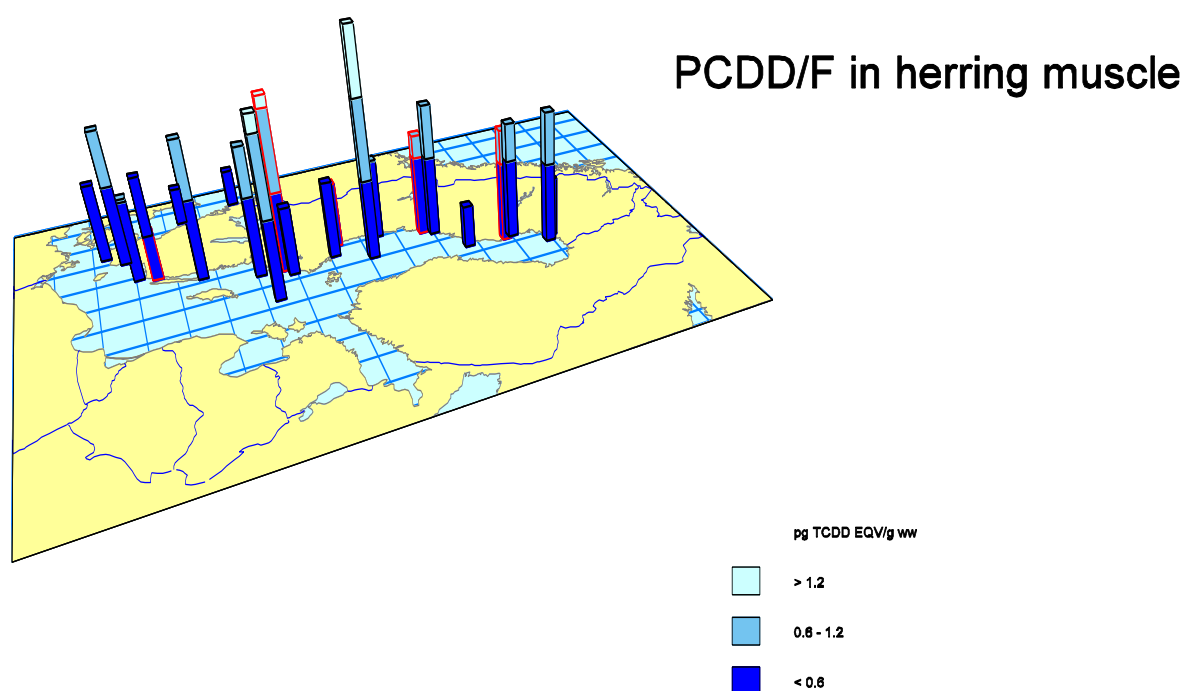
#### *Convention, aims and restrictions*

Releases of dioxins from industrial installations are mainly regulated by the IPPC Directive and the Waste Incineration Directive.

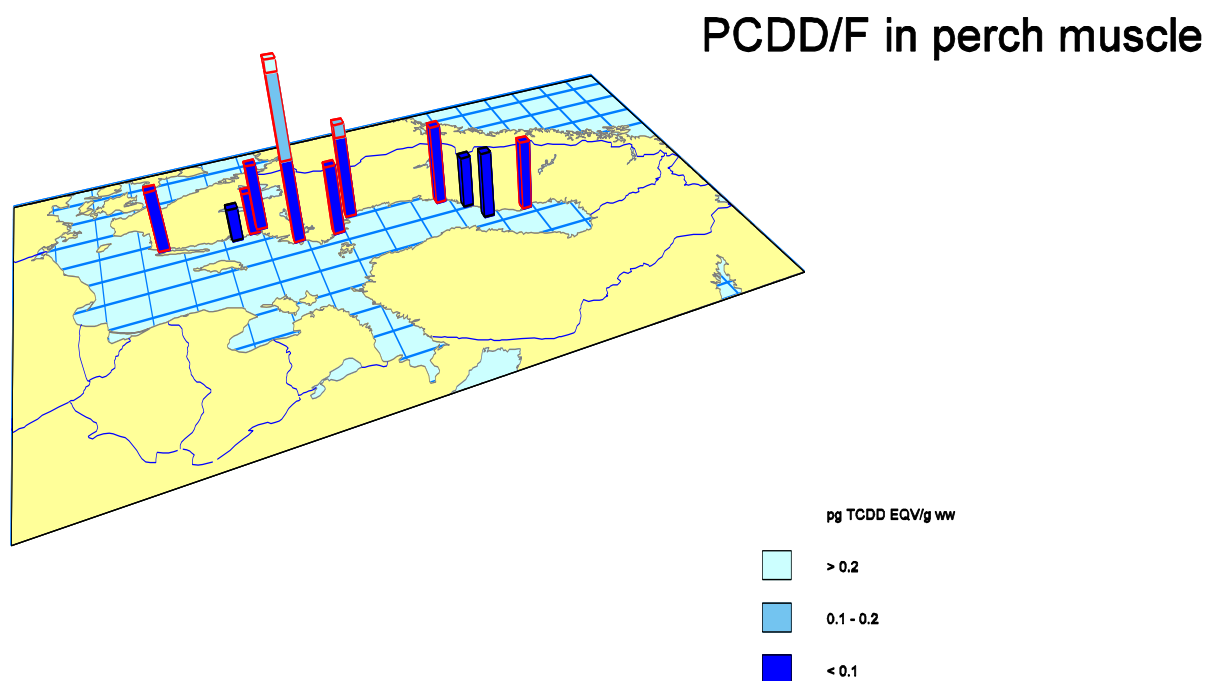
Dioxins are comprised by the objective of HELCOM's strategy for hazardous substances that is to continuously reduce discharges, emissions and losses of hazardous substances, with a goal of their eventual cessation by the year 2020. The ultimate aim is to achieve concentrations in the environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. This objective was adopted in 1998, and dioxins have been selected as one of the priority substances for immediate action.

PCDD/PCDF are part of the initial 12 Persistent Organic Pollutants (POPs) included in The Stockholm Convention on POPs, an international agreement requiring measures for reducing or preventing release of dangerous substances to the environment.

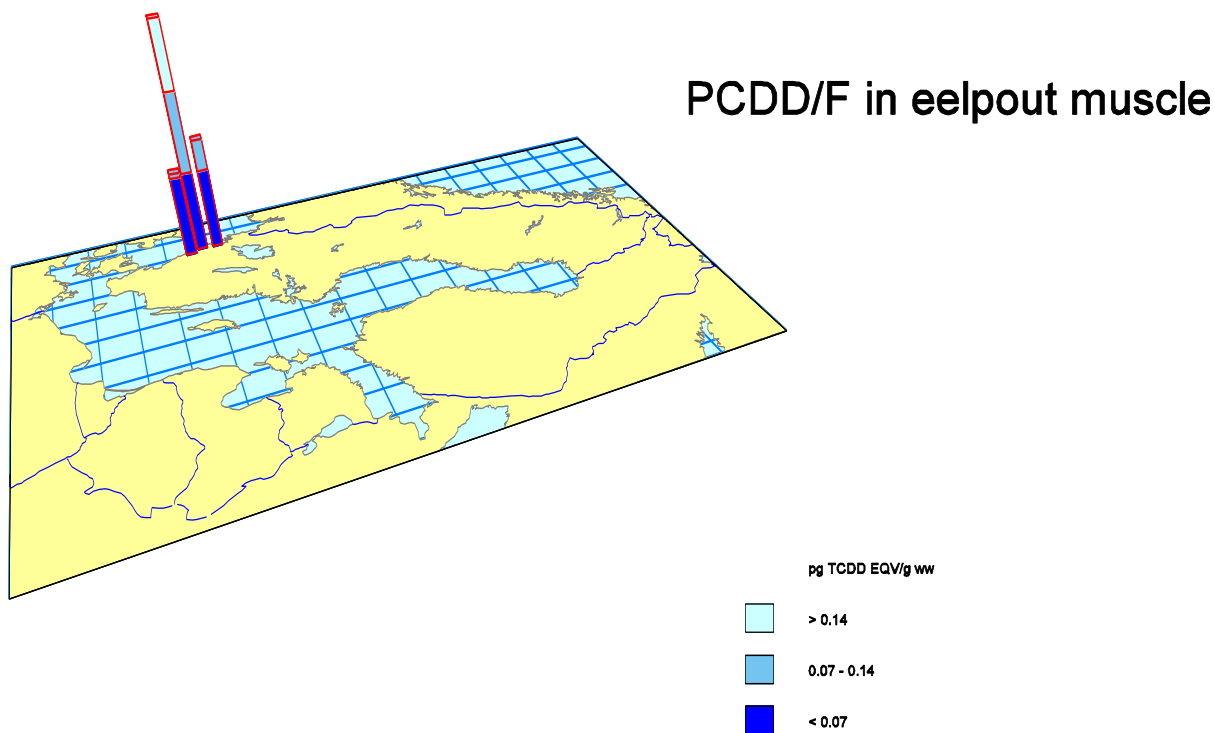
A dioxin and PCB strategy, including actions in the area of feed and food contamination and actions related to the environment including release reduction, was adopted by the EU in 2001.



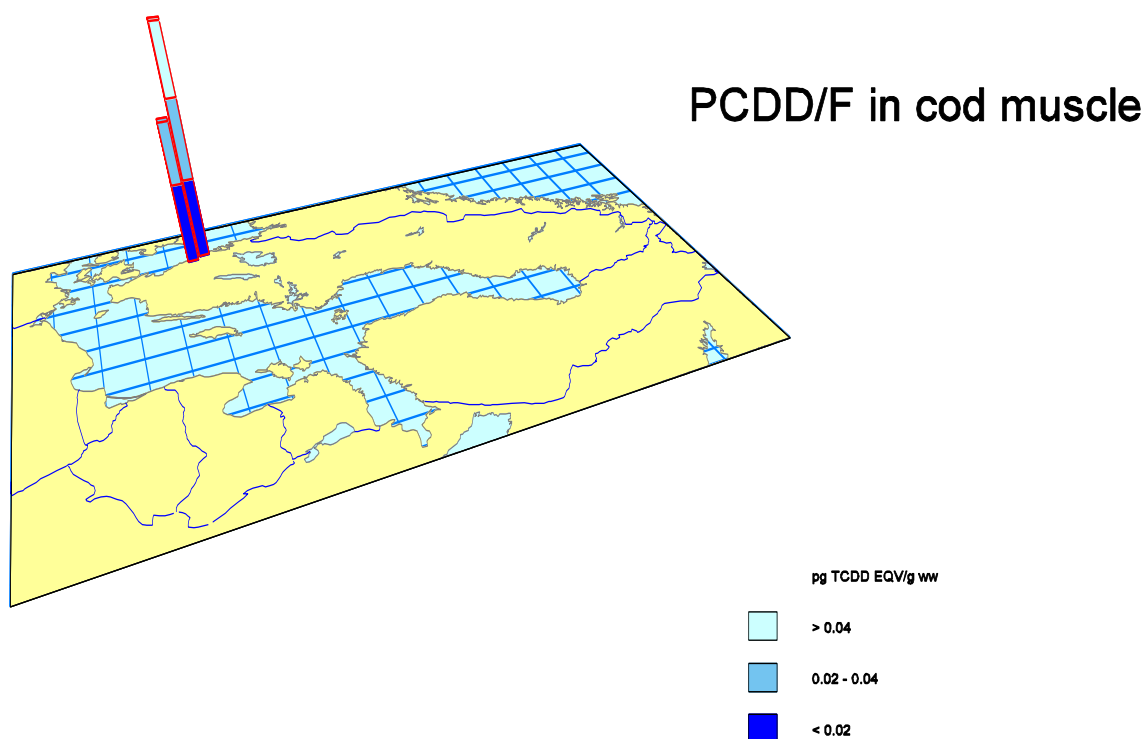
**Figure 4.3.21.** Spatial variation in concentration of PCDD/F (pg TEQ<sub>05</sub> /g ww) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.22.** Spatial variation in concentration of PCDD/F (pg TEQ<sub>05</sub> /g ww) in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.23.** Spatial variation in concentration of PCDD/F (pg TEQ<sub>05</sub> /g ww) in eelpout muscle. Blue bars with a red line represent the polluted sites.



**Figure 4.3.24.** Spatial variation in concentration of PCDD/F (pg TEQ<sub>05</sub> /g ww) in cod muscle. Blue bars with a red line represent the polluted sites.

**Table 4.3.17.** Differences in PCDD/F concentration in herring muscle (pg TEQ<sub>05</sub> /g ww) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

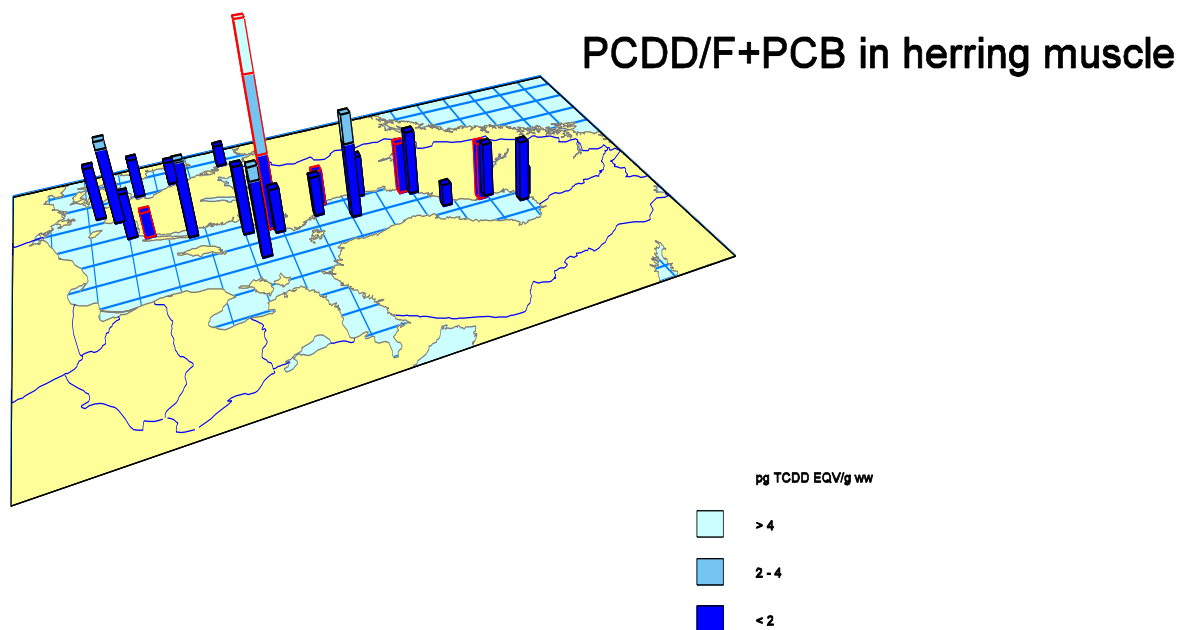
| Sampling site        | n | Meanr | Meanp | meanp-meanr | p           |
|----------------------|---|-------|-------|-------------|-------------|
| Skelleftebukten      | 4 | .884  | .855  | -.0285      | .887        |
| Örnsköldsviksfjärden | 4 | .999  | .771  | -.229       | .126        |
| Yttre Fjärden        | 8 | .579  | .490  | -.0899      | .411        |
| Lilla Värtan         | 8 | .741  | 1.29  | .547        | <b>.001</b> |
| Torsås               | 8 | .620  | .359  | -.261       | <b>.028</b> |

**Table 4.3.18.** Differences in PCDD/F concentration in perch muscle (pg TEQ<sub>05</sub> /g ww) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

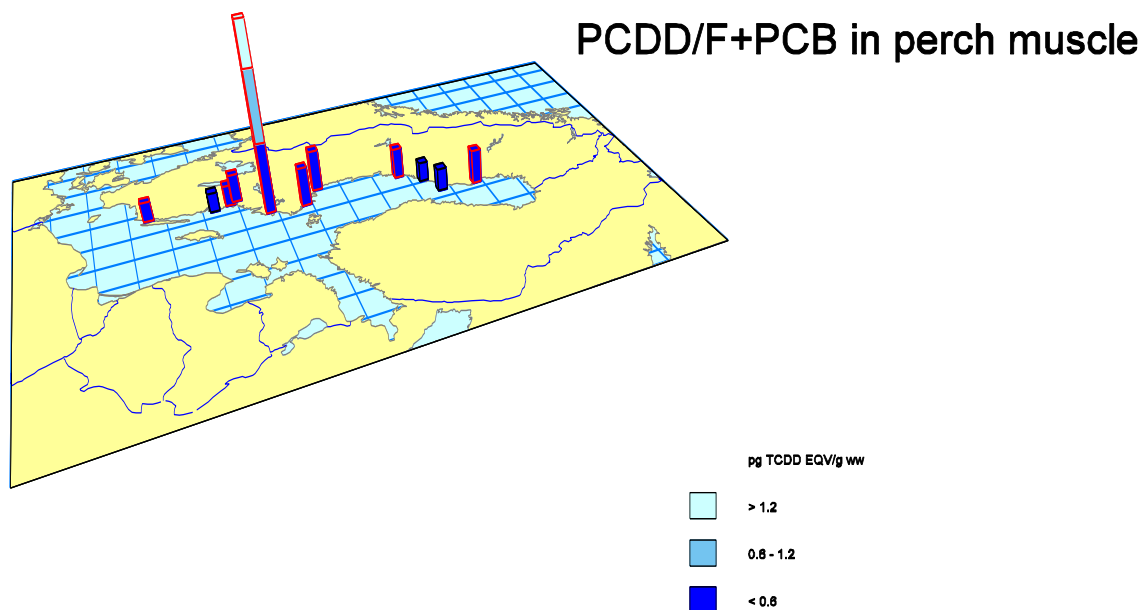
| Sampling site        | n | Meanr | Meanp | Meanp-Meanr | p           |
|----------------------|---|-------|-------|-------------|-------------|
| Skelleftebukten      | 4 | .0715 | .0845 | .0130       | .095        |
| Örnsköldsviksfjärden | 4 | .0715 | .0965 | .0250       | <b>.019</b> |
| Yttre Fjärden        | 4 | .0510 | .116  | .0650       | <b>.005</b> |
| *Östhammarsfjärden   | 2 |       | .0835 |             |             |
| *Lilla Värtan        | 2 |       | .215  |             |             |
| *Inre Slätbaken      | 2 |       | .0510 |             |             |
| *Bråviken, n Svindra | 2 |       | .0770 |             |             |
| *Bråviken, s Esterön | 2 |       | .0800 |             |             |
| *Bråviken, n Esterön | 2 |       | .0820 |             |             |
| *Torsås              | 2 |       | .0740 |             |             |

\* These polluted sites had too few values from reference sites to be able to retrieve a statistical comparison.

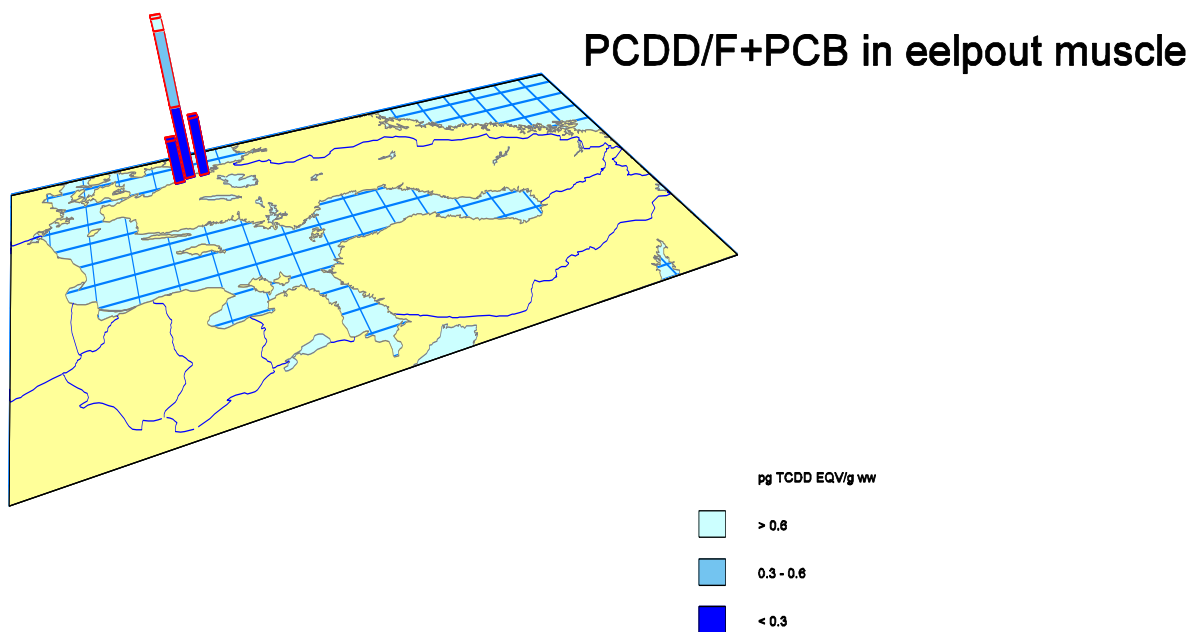
For PCDD/F in herring muscle, no clear spatial pattern was seen. The highest concentration was found in Lilla Värtan (1.29 pg TEQ<sub>05</sub>/g ww) and the lowest was found in Torsås (0.36 pg TEQ<sub>05</sub>/g ww) (Fig. 4.3.21). Herring from Lilla Värtan had significantly higher concentration compared to its reference site (Table 4.3.17). Also in perch muscle, the highest concentration was found in Lilla Värtan (0.21 pg TEQ<sub>05</sub>/g ww). Inre Slätbaken had the lowest concentration in perch muscle (0.05 pg TEQ<sub>05</sub>/g ww) (Fig. 4.3.22). Perch from Örnsköldsviksfjärden and Yttre Fjärden had significantly higher concentration compared to their respective reference (Table 4.3.18). In eelpout muscle, the concentration was highest in Rivö fjord (0.20 pg TEQ<sub>05</sub>/g ww) and lowest in Kungsbackafjorden (0.07 pg TEQ<sub>05</sub>/g ww) (Fig. 4.3.23). Also in cod muscle, the concentration of PCDD/F was highest in Rivö fjord (0.06 pg TEQ<sub>05</sub>/g ww) and lowest in Kungsbackafjorden (0.04 pg TEQ<sub>05</sub>/g ww) (Fig. 4.3.24).



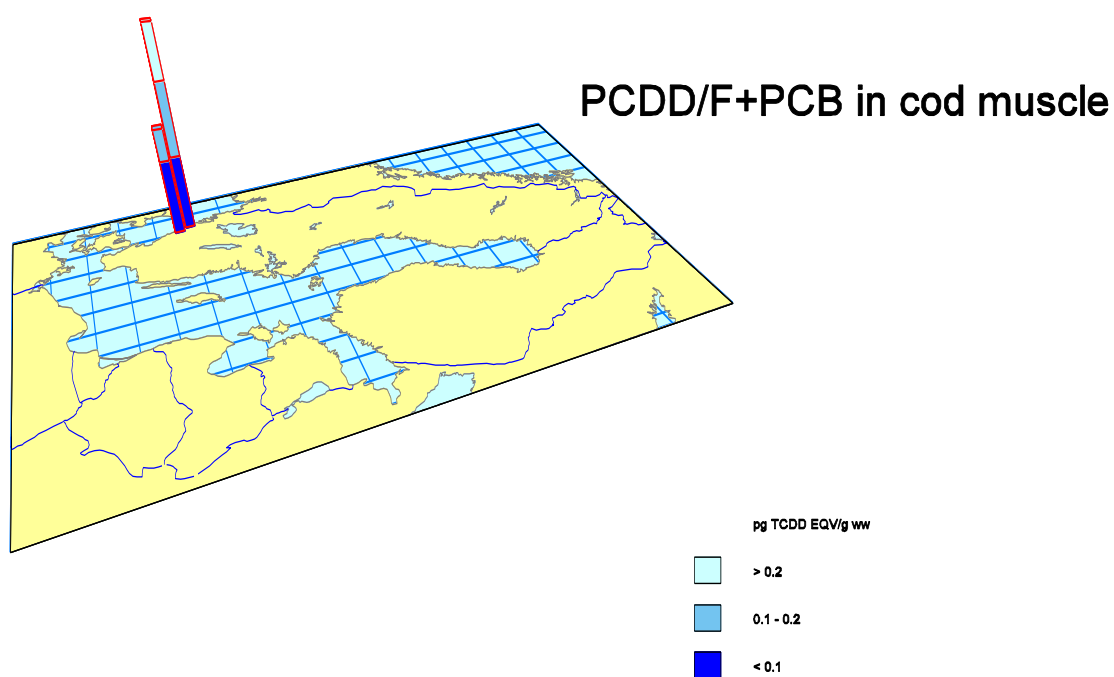
**Figure 4.3.25.** Spatial variation in concentration of PCDD/F+dl-PCBs (pg TEQ<sub>05</sub> /g ww) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.26.** Spatial variation in concentration of PCDD/F+dl-PCBs (pg TEQ<sub>05</sub> /g ww) in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.27.** Spatial variation in concentration of PCDD/F+dl-PCBs (pg TEQ<sub>05</sub>/g ww) in eelpout muscle. Blue bars with a red line represent the polluted sites.



**Figure 4.3.28.** Spatial variation in concentration of PCDD/F+dl-PCBs (pg TEQ<sub>05</sub>/g ww) in cod muscle. Blue bars with a red line represent the polluted sites.



**Table 4.3.19.** Differences in PCDD/F+dl-PCBs concentration in herring muscle (pg TEQ<sub>05</sub>/g ww) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n | Meanr | Meanp | meanp-meanr | p           |
|----------------------|---|-------|-------|-------------|-------------|
| Skelleftebukten      | 4 | 1.46  | 1.55  | .0903       | .773        |
| Örnsköldsviksfjärden | 4 | 1.72  | 1.38  | -.336       | .162        |
| Yttre Fjärden        | 8 | 1.06  | .963  | -.0995      | .556        |
| Lilla Värtan         | 8 | 1.49  | 5.27  | 3.78        | <b>.000</b> |
| Torsås               | 8 | 1.19  | .679  | -.515       | <b>.027</b> |

**Table 4.3.20.** Differences in PCDD/F+dl-PCBs concentration in perch muscle (pg TEQ<sub>05</sub>/g ww) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n | Meanr | Meanp | meanp-meanr | p           |
|----------------------|---|-------|-------|-------------|-------------|
| Skelleftebukten      | 4 | .179  | .291  | .112        | <b>.006</b> |
| Örnsköldsviksfjärden | 4 | .179  | .258  | .0787       | <b>.017</b> |
| Yttre Fjärden        | 4 | .164  | .349  | .185        | <b>.002</b> |
| *Östhammarsfjärden   | 2 |       | .330  |             |             |
| *Lilla Värtan        | 2 |       | 1.57  |             |             |
| *Inre Slätbaken      | 2 |       | .175  |             |             |
| *Bråviken, n Svindra | 2 |       | .210  |             |             |
| *Bråviken, s Esterön | 2 |       | .230  |             |             |
| *Bråviken, n Esterön | 2 |       | .260  |             |             |
| *Torsås              | 2 |       | .165  |             |             |

\* These polluted sites had too few values from reference sites to be able to retrieve a statistical comparison

The concentration of PCDD/F+dl-PCBs in herring muscle showed a similar pattern as PCDD/F – with the highest concentration in Lilla Värtan (5.27 pg TEQ<sub>05</sub>/g ww) and the lowest in Torsås (0.68 pg TEQ<sub>05</sub>/g ww) (Fig. 4.3.25). Lilla Värtan had significantly higher concentration in herring compared to its reference site (Table 4.3.19). For perch, the pattern is the same as for herring, the highest concentration found in Lilla Värtan (1.57 pg TEQ<sub>05</sub>/g ww) and the lowest in Torsås (0.17 pg TEQ<sub>05</sub>/g ww) (Fig. 4.3.26). Skelleftebukten, Örnsköldsviksfjärden, and Yttre fjärden had significantly higher concentrations in perch than their respective reference (Table 4.3.20). In eelpout, Rivö fjord had the highest concentration (0.65 pg TEQ<sub>05</sub>/g ww) and the lowest concentration was found in Kungsbackafjorden (0.18 pg TEQ<sub>05</sub>/g ww) (Fig. 4.3.27). Cod muscle showed the same pattern as eelpout – highest concentration in Rivö fjord (0.27 pg TEQ<sub>05</sub>/g ww) and lowest concentration in Kungsbackafjorden (0.14 pg TEQ<sub>05</sub>/g ww) (Fig. 4.3.28).

#### *Comparison between species*

PCDD/F in herring muscle was 5-10 times higher compared to perch muscle and PCDD/F+dl-PCB was 3-5 times higher. PCDD/F in eelpout muscle was twice as high as in cod muscle and PCDD/F+dl-PCB was up to two times higher in eelpout compared to cod.

#### *Comparison with target value*

The target value used for dioxins ( $\Sigma$ PCDDs+PCDFs+dl-PCBs) is set to 0.0065  $\mu\text{g/kg ww}$  (6.5 pg/g ww) (EQSbiota). All stations have concentrations below the target value.

### **4.3.6 Polybrominated flame retardants**

#### *Usage, production and sources*

Polybrominated diphenyl ethers (PBDEs) are produced as three different technical products; penta-, octa and deca bromo diphenyl ether (BDE). Each of these products includes a few major congeners. For pentaBDE these are BDE-47, -99, and -100. OctaBDE contains mainly BDE-183, while decaBDE includes almost exclusively BDE-209 (LaGuardia et al. 2006). Hexabromocyclododecan (HBCDD) is produced as a mixture of three stereoisomers -  $\alpha$ -,  $\beta$ - and  $\gamma$ -HBCDD (Covaci et al. 2006). Both PBDEs and HBCDD are used as additive flame retardants incorporated into materials such as plastics and textiles in products that need to be prevented from catching fire.

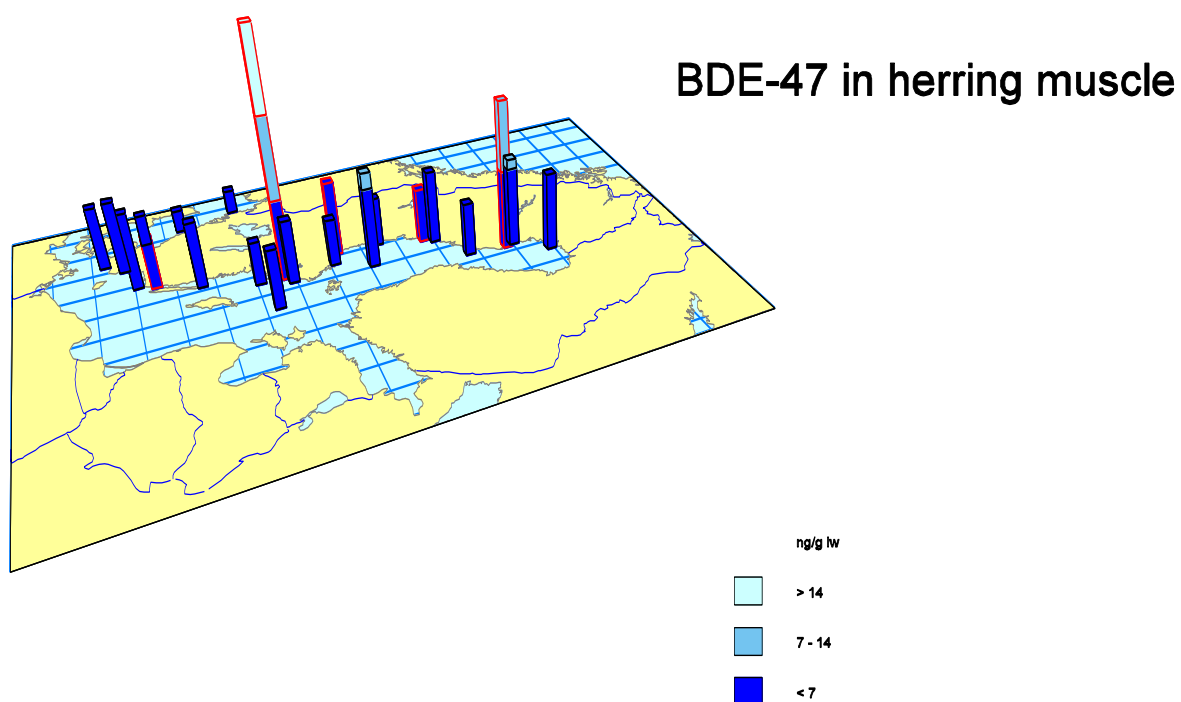
PBDEs leak into the environment during production, use, or disposal of such products. PBDEs are mainly spread via diffuse distribution in the atmosphere and in rivers. HBCDD is bioaccumulative, lipophilic and persistent, and accumulates in the food-web.

#### *Convention, aims and restrictions*

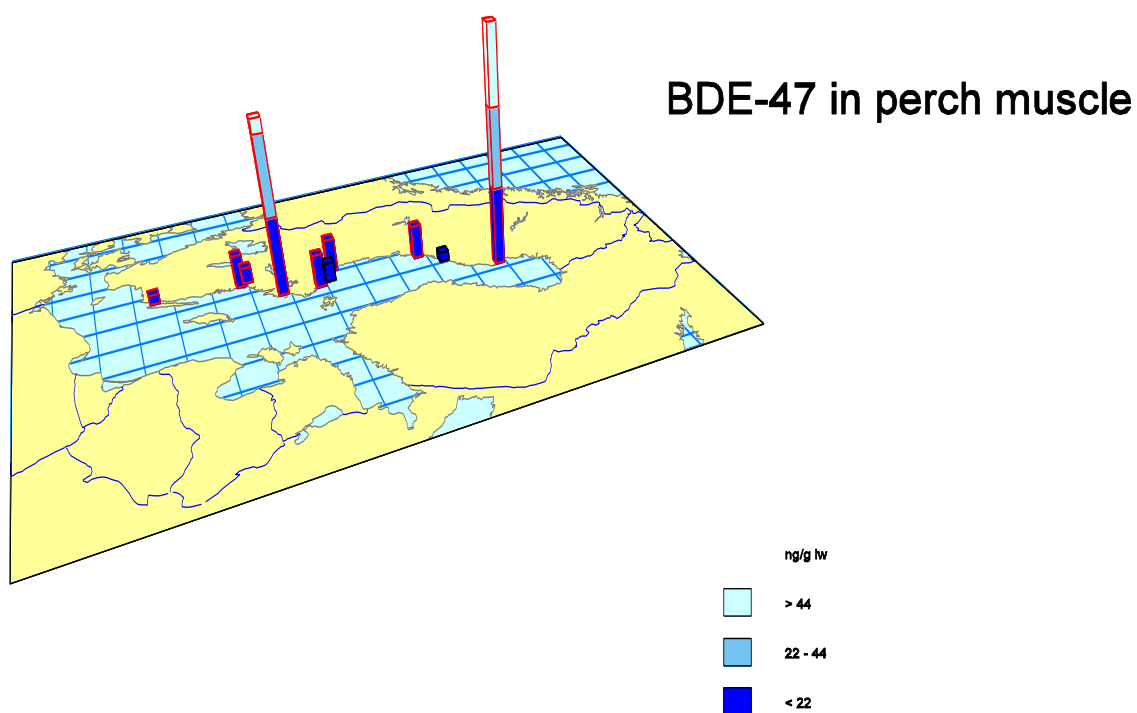
The PBDEs tetrabromodiphenyl ether, pentabromodiphenyl ether, hexabromodiphenyl ether and heptabromodiphenyl ether are among the nine new Persistent Organic Pollutants (POPs) included in The Stockholm Convention on POPs. Within the EU, the penta- and octaBDE products were banned for use in 2004.

A Swedish ban of decaBDE was established in 2007, but this ban was withdrawn when decaBDE was included in the RoHS directive in 2008. PBDEs are also on the list of prioritized substances within the Water Framework Directive.

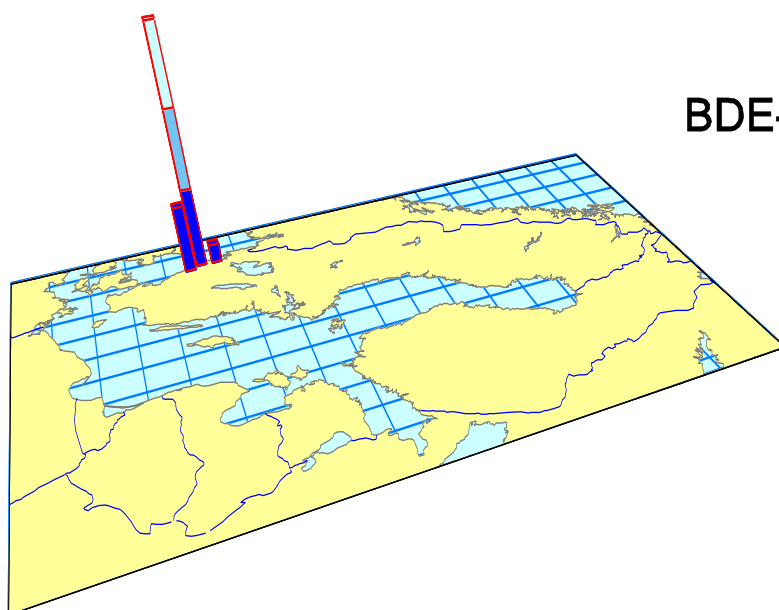
HBCDD is under review by the Persistent Organic Pollutants Review Committee (POPRC) as a proposed substance to be listed under the Stockholm Convention (Arnot et al. 2009).



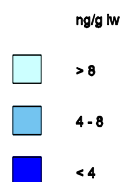
**Figure 4.3.29.** Spatial variation in concentration of BDE-47 (ng/g lw) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



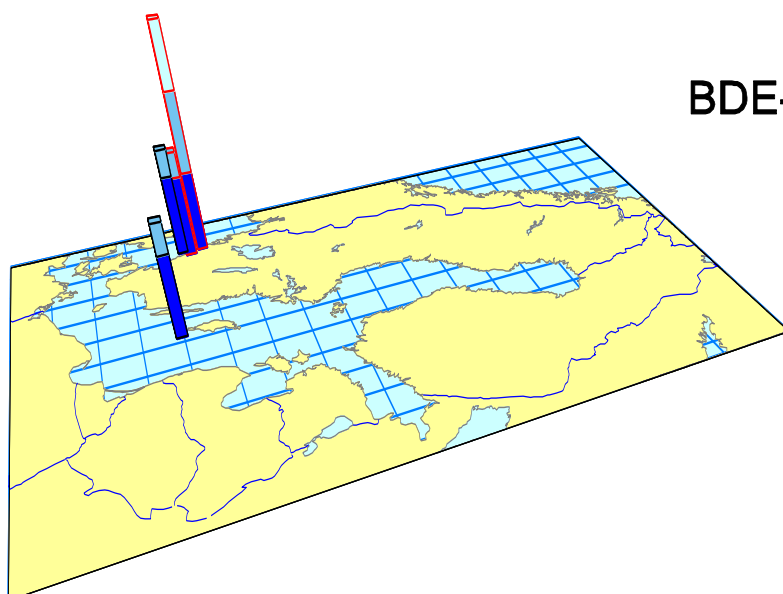
**Figure 4.3.30.** Spatial variation in concentration of BDE-47 (ng/g lw) in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



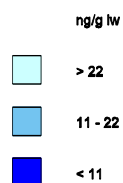
## BDE-47 in eelpout muscle



**Figure 4.3.31.** Spatial variation in concentration of BDE-47 (ng/g lw) in eelpout muscle. Blue bars with a red line represent the polluted sites.



## BDE-47 in cod liver



**Figure 4.3.32.** Spatial variation in concentration of BDE-47 (ng/g lw) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

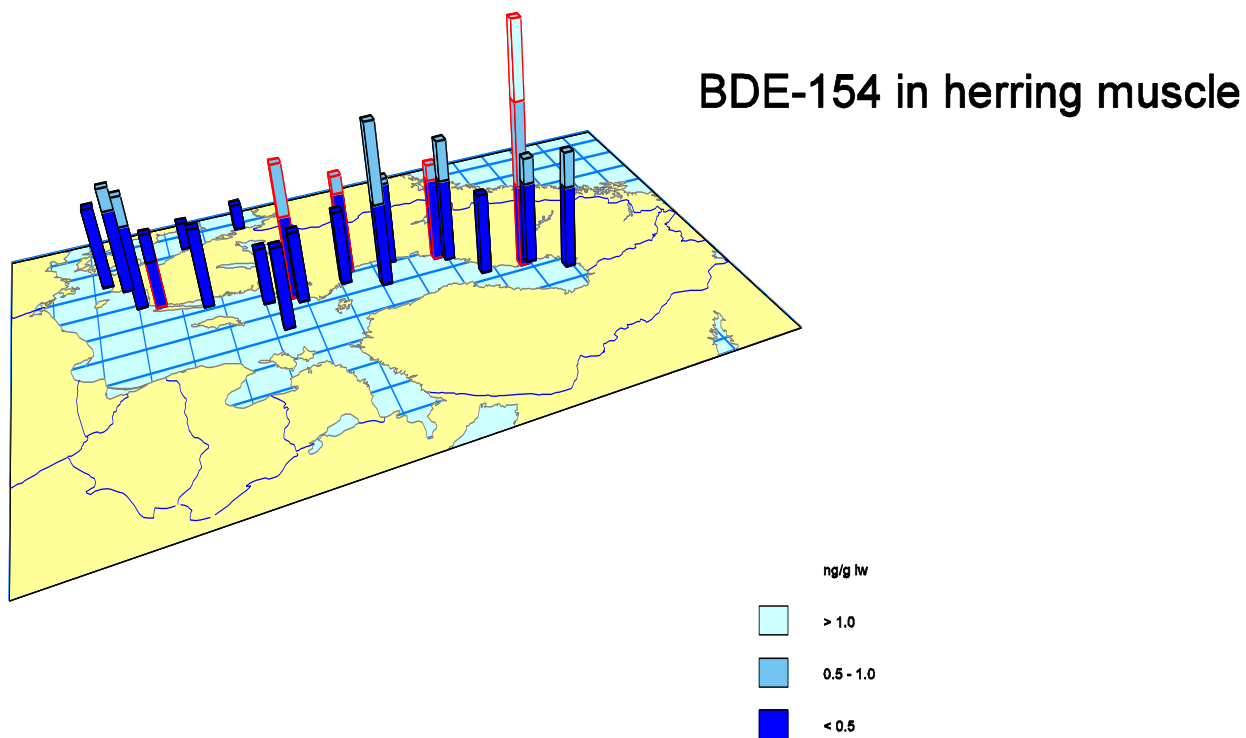
**Table 4.3.21.** Differences in BDE47 concentration in herring muscle (ng/g lw) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | 7.85  | 13.1  | 5.25        | <b>.011</b> |
| Örnsköldsviksfjärden | 6  | 6.45  | 4.80  | -1.65       | .177        |
| Yttre Fjärden        | 41 | 4.12  | 6.60  | 2.48        | <b>.000</b> |
| Lilla Värtan         | 42 | 4.01  | 21.0  | 17.0        | <b>.000</b> |
| Torsås               | 42 | 6.68  | 4.30  | -2.38       | <b>.001</b> |

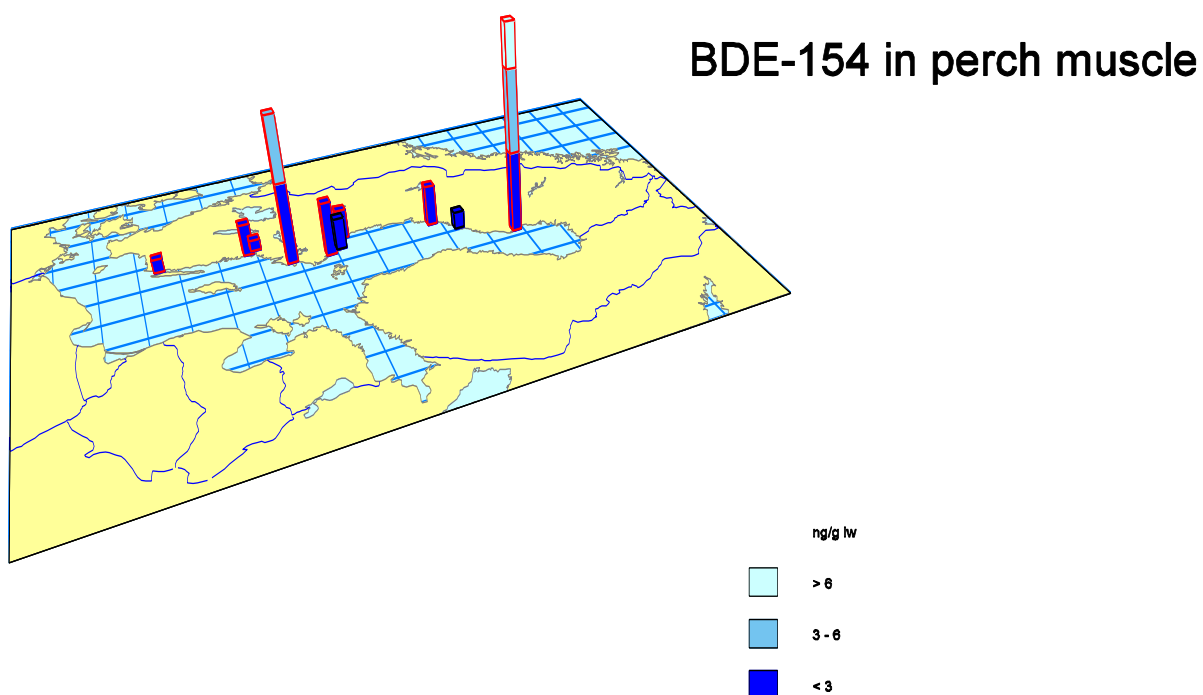
**Table 4.3.22.** Differences in BDE47 concentration in cod liver (ng/g lw) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | 14.7  | 31.0  | 16.3        | <b>.000</b> |
| Kungsbackafjorden | 30 | 14.7  | 14.5  | -.239       | .859        |

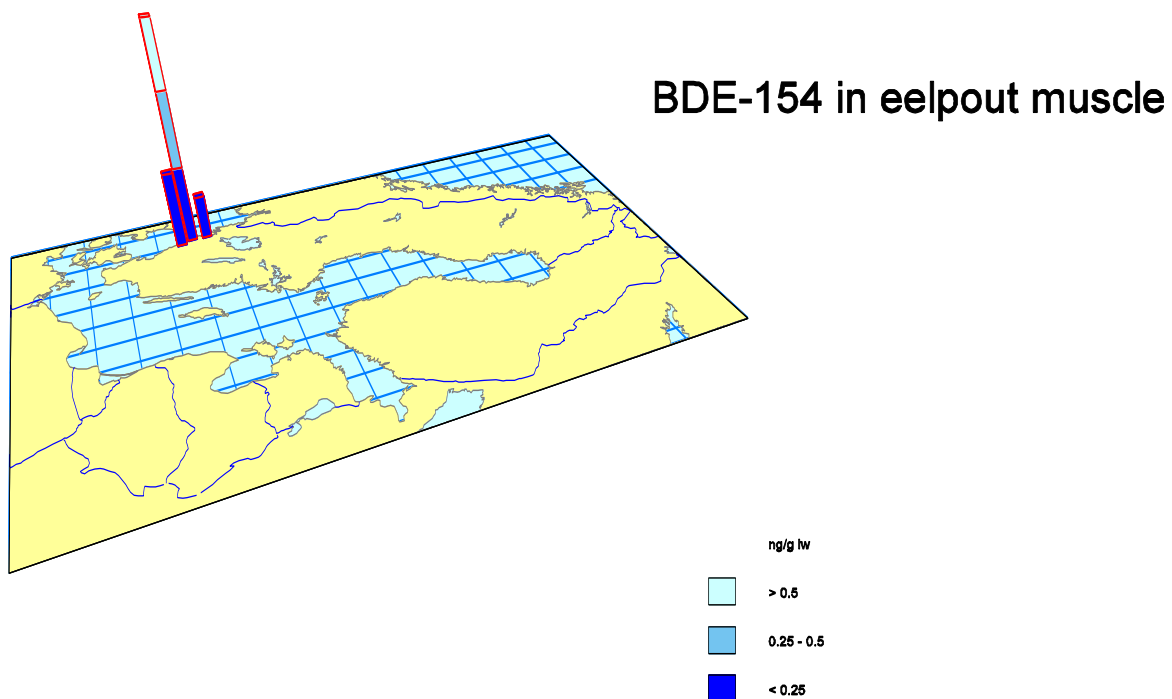
No clear spatial pattern of BDE-47 in herring muscle was seen. The highest concentration was found in Lilla Värtan (21 ng/g lw) and the lowest in Torsås (4.3 ng/g lw) and Örnsköldsviksfjärden (4.8 ng/g lw) (Fig. 4.3.29). Herring in Skelleftebukten, Yttre Fjärden, and Lilla Värtan had significantly higher concentration of BDE-47 compared to their respective reference site (Table 4.3.21). In perch muscle, the highest concentration was found in Skelleftebukten, with a concentration of 66 ng/g lw, but high concentrations was also seen in Lilla Värtan (48 ng/g lw). The lowest concentration was found in Torsås (2.6 ng/g lw) (Fig. 4.3.30). The concentration of BDE-47 in eelpout muscle was variable, the highest concentration, 12 ng/g lw, was found in Rivö fjord and the lowest, 0.9 ng/g lw, in Halsefjord and Askeröfjord (Fig. 4.3.31). In cod liver, Rivö fjord had the highest concentration, 31 ng/g lw and Kungsbackafjorden had the lowest concentration, 15 ng/g lw (Fig. 4.3.32). Cod in Rivö fjord had significantly higher concentration of BDE-47 compared to its reference site (Table 4.3.22).



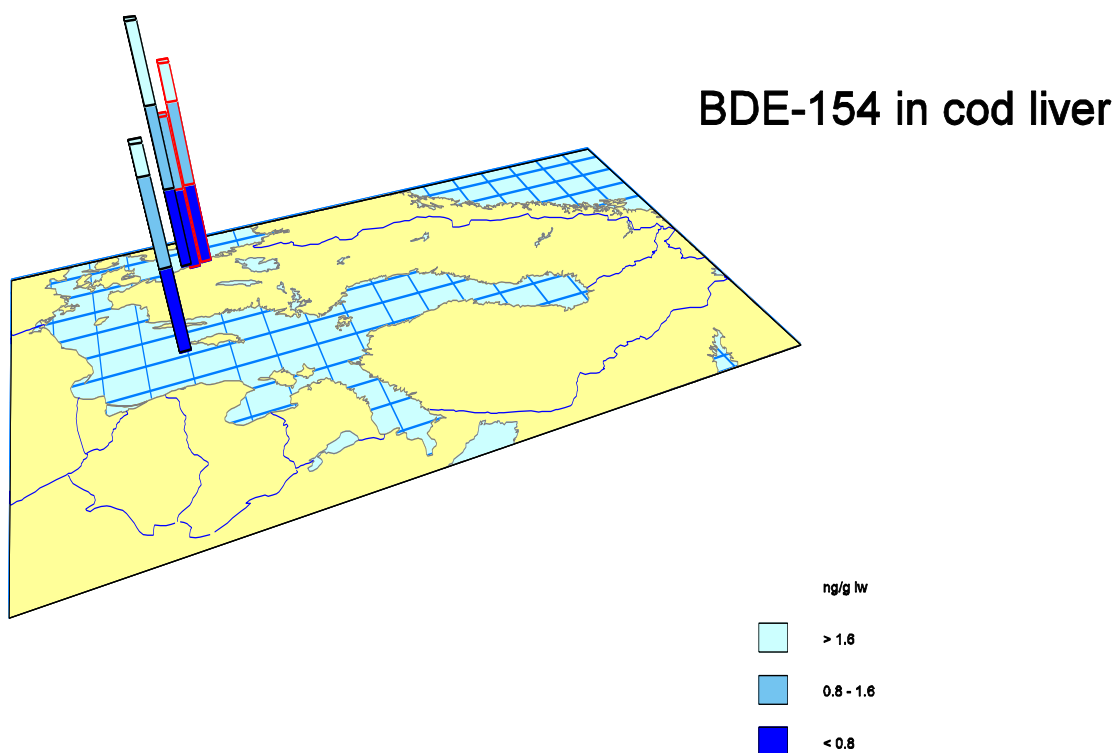
**Figure 4.3.33.** Spatial variation in concentration of BDE-154 (ng/g lw) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.34.** Spatial variation in concentration of BDE-154 (ng/g lw) in perch muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.35.** Spatial variation in concentration of BDE-154 (ng/g lw) in eelpout muscle. Blue bars with a red line represent the polluted sites.



**Figure 4.3.36.** Spatial variation in concentration of BDE-154 (ng/g lw) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.3.23.** Differences in BDE154 concentration in herring muscle (ng/g lw) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

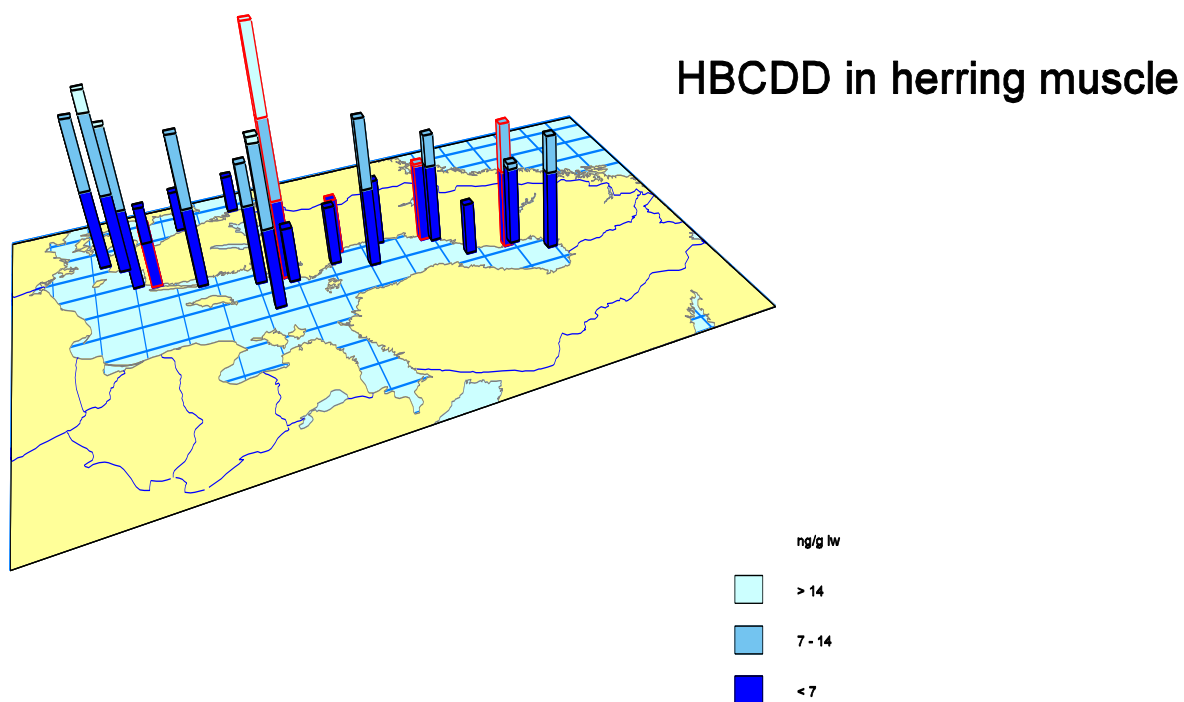
| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .657  | 1.45  | .793        | <b>.001</b> |
| Örnsköldsviksfjärden | 6  | .746  | .595  | -.151       | .138        |
| Yttre Fjärden        | 41 | .449  | .605  | .156        | <b>.001</b> |
| Lilla Värtan         | 42 | .351  | .805  | .454        | <b>.000</b> |
| Torsås               | 42 | .675  | .435  | -.240       | <b>.002</b> |

**Table 4.3.24.** Differences in BDE154 concentration in cod liver (ng/g lw) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

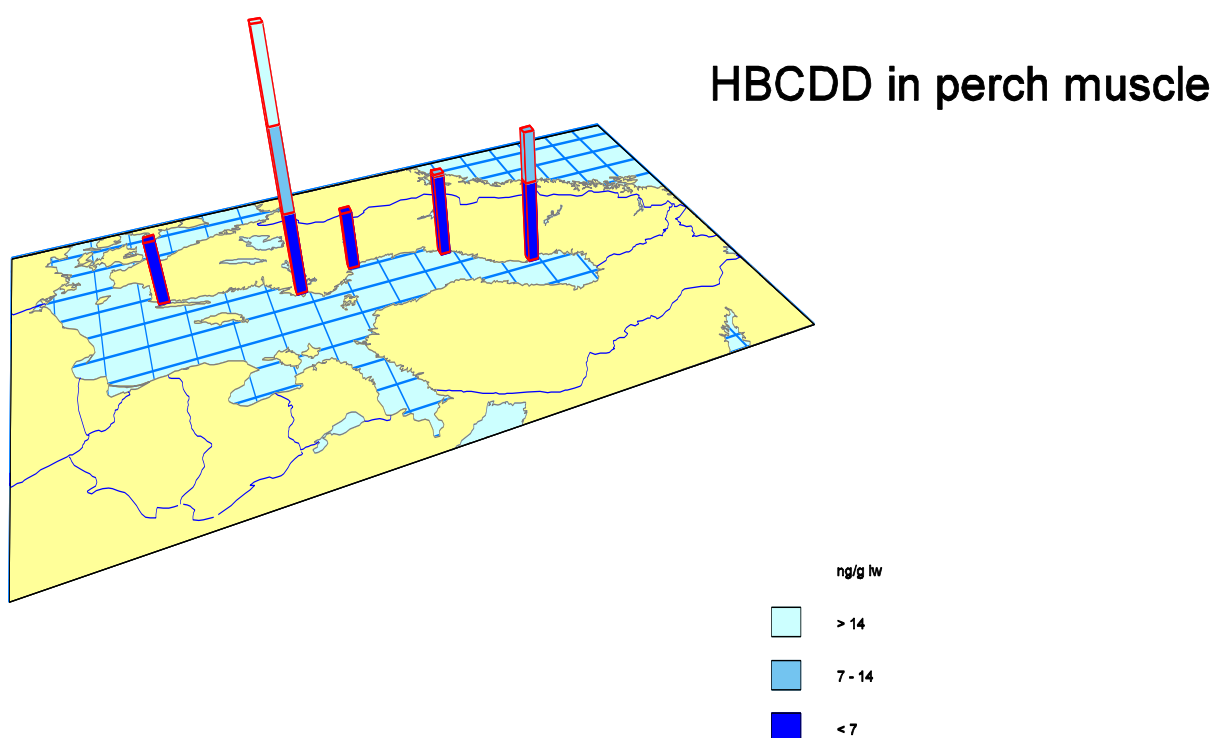
| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | 2.35  | 1.95  | -.398       | <b>.027</b> |
| Kungsbackafjorden | 30 | 2.35  | 1.50  | -.848       | <b>.000</b> |

The highest concentration of BDE-154 in herring muscle was found in Skelleftebukten (1.5 ng/g lw) and most other sites had approximately one third of that concentration, where the lowest concentration was found in Torsås (0.4 ng/g lw) (Fig. 4.3.33). The concentration of BDE-154 in herring was significantly higher in Skelleftebukten, Yttre Fjärden, and Lilla Värtan compared to their respective reference sites (Table 4.3.23). In perch muscle, the pattern for BDE-154 was similar as for BDE-47 – the highest concentration found in Skelleftebukten (7.6 ng/g lw) followed by Lilla Värtan (5.4 ng/g lw). The lowest concentration for BDE-154 in perch was seen in Bråviken (0.4 ng/g lw) and in Torsås (0.5 ng/g lw) (Fig. 4.3.34). In eelpout muscle, Rivö fjord had the highest concentration (0.7 ng/g lw) and Halsefjord and Askeröfjord had the lowest (0.2 ng/g lw), the same pattern as seen for BDE-47 (Fig. 4.3.35). In cod liver, the concentrations among sites was rather similar, but Rivö fjord had slightly higher concentration (2 ng/g lw) than Kungsbackafjorden (1.5 ng/g lw) (Fig. 4.3.36). In cod, none of the polluted sites had significantly higher concentration compared to the reference sites (Table 4.3.24).

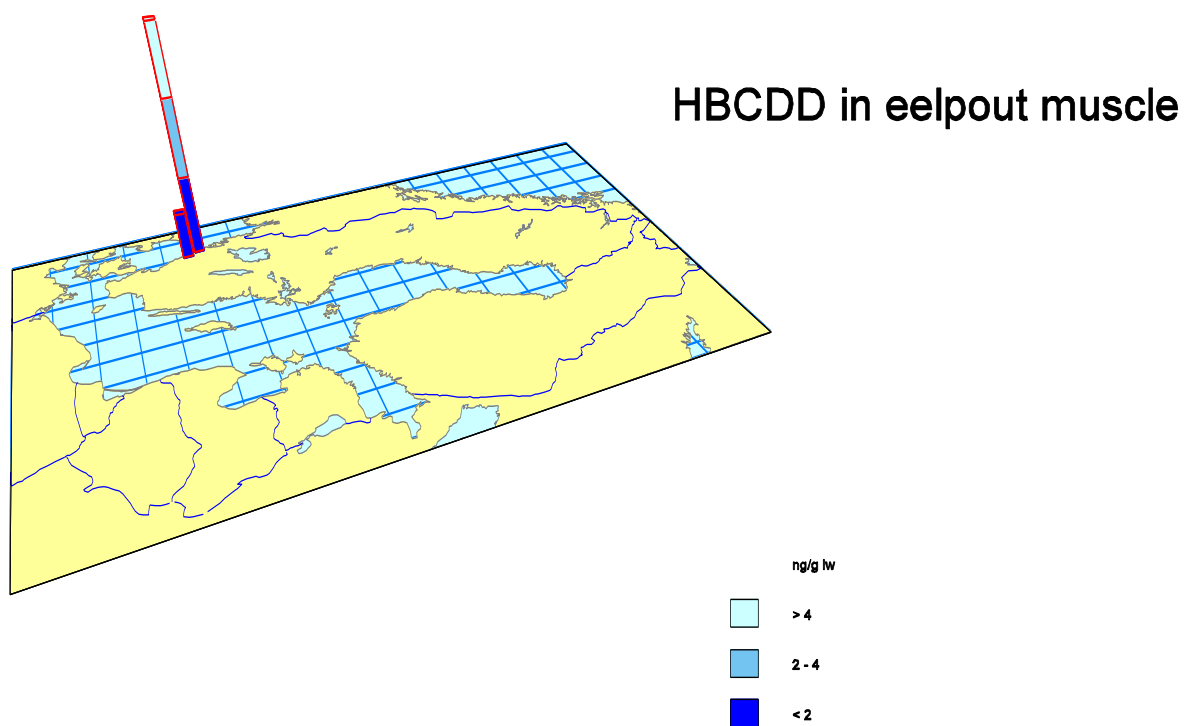




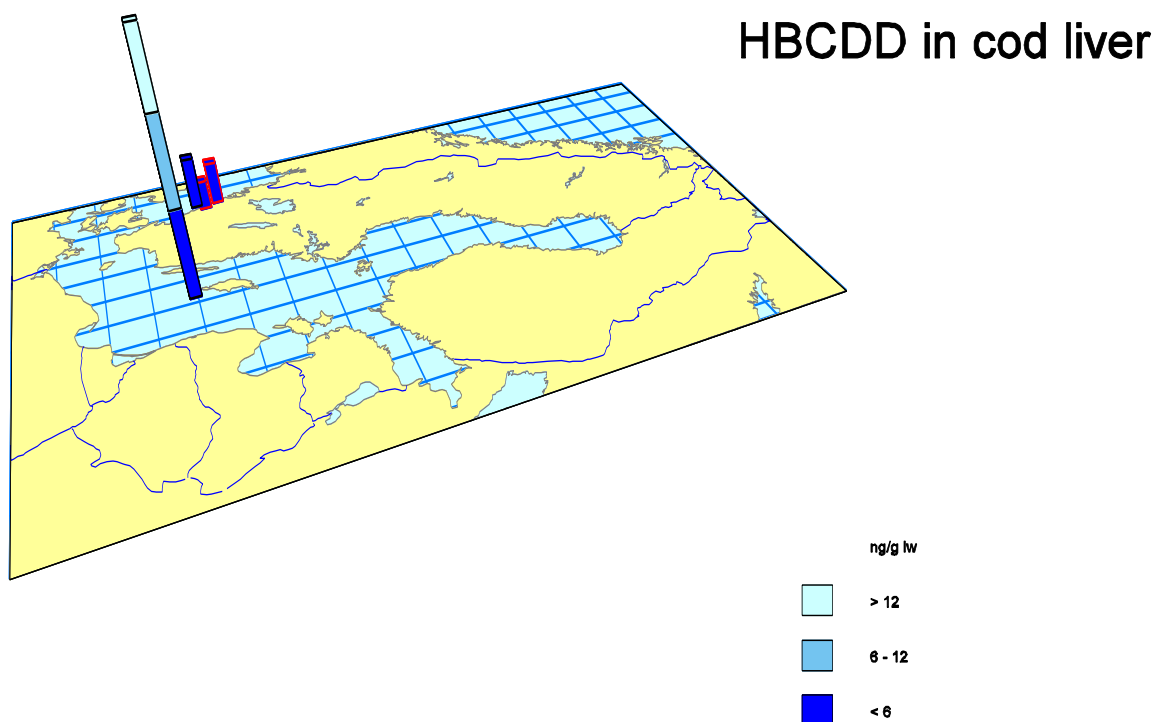
**Figure 4.3.37.** Spatial variation in concentration of HBCDD (ng/g lw) in herring muscle. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.38.** Spatial variation in concentration of HBCDD (ng/g lw) in perch muscle. Blue bars with a red line represent the polluted sites.



**Figure 4.3.39.** Spatial variation in concentration of HBCDD (ng/g lw) in eelpout muscle. Blue bars with a red line represent the polluted sites.



**Figure 4.3.40.** Spatial variation in concentration of HBCDD (ng/g lw) in cod liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

**Table 4.3.25.** Differences in HBCDD concentration in herring muscle (ng/g lw) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | 7.52  | 11.3  | 3.78        | <b>.005</b> |
| Örnsköldsviksfjärden | 6  | 9.83  | 7.20  | -2.63       | .133        |
| Yttre Fjärden        | 41 | 5.25  | 5.00  | -.248       | .703        |
| Lilla Värtan         | 42 | 9.84  | 21.5  | 11.7        | <b>.000</b> |
| Torsås               | 42 | 14.0  | 5.40  | -8.65       | <b>.000</b> |

**Table 4.3.26.** Differences in HBCDD concentration in cod liver (ng/g lw) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, and p-value.

| Sampling site     | n  | Meanr | Meanp | meanp-meanr | p           |
|-------------------|----|-------|-------|-------------|-------------|
| Rivö fjord        | 30 | 3.55  | 2.90  | -.650       | .143        |
| Kungsbackafjorden | 30 | 3.55  | 1.95  | -1.60       | <b>.001</b> |

HBCDD in herring muscle showed a similar pattern as BDE-47, where Lilla Värtan had the highest concentration (22 ng/g lw) followed by Skelleftebukten (11 ng/g lw). The lowest concentrations were found in Yttre fjärden (5.0 ng/g lw) and Torsås (5.4 ng/g lw) (Fig. 4.3.37). Herring in Skelleftebukten and Lilla Värtan had significantly higher concentrations of HBCDD compared to their respective reference site (Table 4.3.25). In perch muscle, Lilla Värtan had the highest concentration of HBCDD (14 ng/g lw). The lowest concentration was found in Inre Slätbaken (1.0 ng/g lw) and Torsås (1.1 ng/g lw) (Fig. 4.3.38). In eelpout muscle, Rivö fjord had five times higher concentration of HBCDD (5.8 ng/g lw) compared to Kungsbackafjorden (1.1 ng/g lw) (Fig. 4.3.39). Concentrations of HBCDD in cod liver was rather similar between the two sites, the highest concentration was found in Rivö fjord (2.9 ng/g lw) while Kungsbackafjorden had lower (2.0 ng/g lw) concentration (Fig. 4.3.40), and none of these were significantly higher compared to the reference site (Table 4.3.26).

#### *Comparison between species*

For BDE-47, generally perch muscle had 2-5 times higher concentrations compared to herring muscle, except in Torsås where herring muscle had twice as high concentration compared to perch. For BDE-154, perch muscle had 2-7 times higher concentration compared to herring muscle, except in Torsås where the concentrations were similar. In contrast, for HBCDD herring muscle had approximately 2-6 times higher concentration compared to perch muscle. Cod muscle at Kungsbackafjorden had twice as high concentration of BDE-47 compared to eelpout muscle from the same site, while the concentrations in the two species were the same at Rivö fjord. For BDE-154, cod muscle had 2-5 times higher concentration compared to eelpout muscle. For HBCDD no comparison between species could be done because the cod muscle concentrations were below LOQ.

#### *Comparison with target value*

The target value for PBDEs is 0.0085 µg/kg ww (EQSbiota) set for the sum of BDE-28, 47, 99, 100, 153, and 154. The results for PBDEs presented in this report are expressed as concentration in lipid weight. The target value has thereby been recalculated to represent the corresponding value in lipid weight by using the mean lipid weight of each species.

Target value expressed in lipid weight:

Herring (lipid content 3.3 %): 0.25 ng/g lw

Perch (lipid content 0.67 %): 1.27 ng/g lw

Eelpout (lipid content 0.95 %): 0.89 ng/g lw

Cod (lipid content in liver 13.7 %): 0.065 ng/g lw

Cod (lipid content in muscle 0.42 %): 2.0 ng/g lw

Concentrations of PBDEs exceed the target value in all species at all stations.

The target value for HBCDD is set to 167 µg/kg ww (EQSbiota). The results for HBCDD presented in this report are expressed as concentration in lipid weight. The target value has thereby been recalculated to represent the corresponding value in lipid weight by using the mean lipid weight of each species.

Target value expressed in lipid weight:

Herring (lipid content 3.3 %): 5 060 ng/g lw

Perch (lipid content 0.67 %): 24 900 ng/g lw

Eelpout (lipid content 0.95 %): 17 600 ng/g lw

Cod (lipid content in liver 13.7 %): 1 220 ng/g lw

Cod (lipid content in muscle 0.42 %): 39 800 ng/g lw

Concentrations of HBCDD are well below the target value for all stations and species. The highest reported value was in herring from Lilla Värtan with a concentration of 21.5 ng/g lw with the target value more than 200 times higher.

#### **4.3.7 PFAS, Perfluoroalkyl substances**

##### *Usage, production and sources*

Perfluoroalkyl chemicals have been used industrially and commercially since the early 1950s. They are found in a wide range of products e.g. grease proof packaging such as food boxes (microwave food), fire-fighting foams, outdoor clothing, Teflon and many cleaning and personal care products. PFOA is used in the production process of fluoropolymers such as PTFE. PFOS was used in Scotchguard products, which was sprayed on furniture and carpets to give a grease/stain proof layer. In 2000, the main producer of these products, 3M, started phasing out production of PFOS and PFOS-related chemicals (Buck et al. 2011).

Perfluoroalkyl acids (PFAAs) are a subgroup of PFASs containing a perfluorinated carbon chain and a hydrophilic acid group. PFAAs are strong surfactants with an extraordinary surface tension lowering potential. In the environment they can have two sources - direct from manufacturing and use, and indirect from degradation of volatile precursor compounds (Buck et al. 2011). PFOA and perfluorononanoic acid (PFNA) are intentionally produced perfluoroalkyl carboxylic acids (PFCAs) and therefore a large portion of the PFOA and

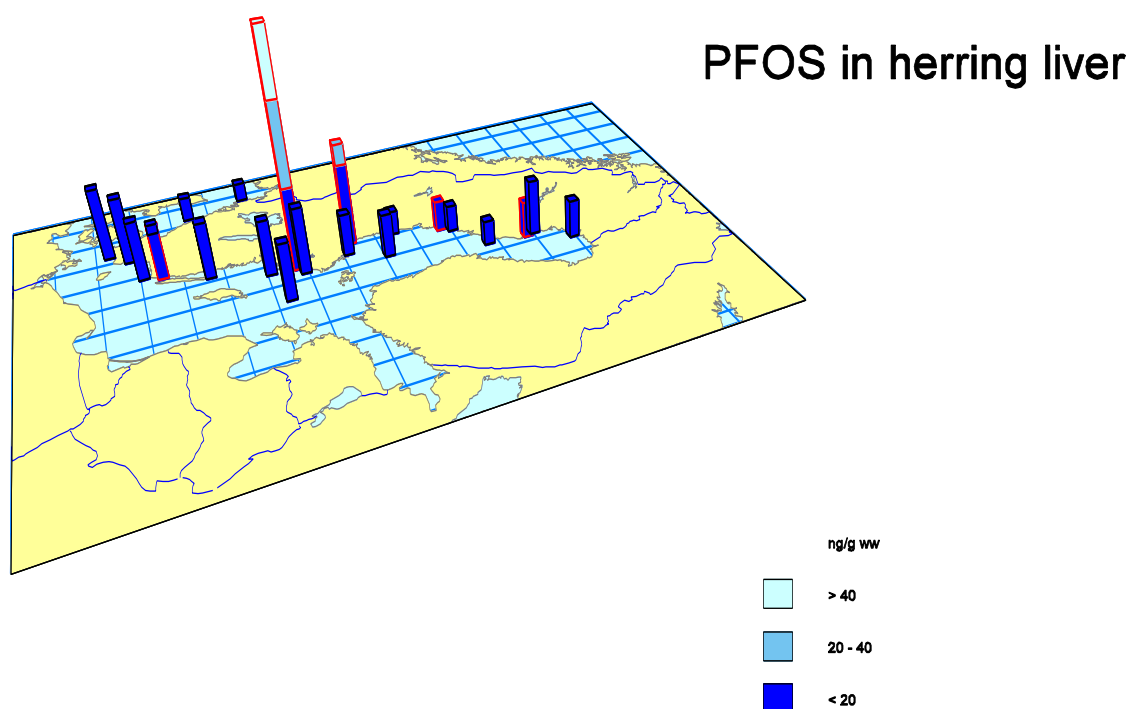
PFNA found in the environment probably originates from direct sources (mainly the production process of fluoropolymers, Prevedouros et al. 2006), waterborne and atmospheric transport to remote locations. Therefore, sewage treatment plant effluent from industry or larger cities could represent hot-spots. In contrast, longer-chain PFCAs than PFNA, e.g. PFUnDA (perfluoroundecanoic acid) and PFTrDA (perfluorotridecanoic acid) are unintentionally produced substances, and their presence in the environment is probably due to both direct sources (impurities in PFOA and PFNA production) and indirect sources (atmospheric transport and degradation of precursors, Buck et al. 2011).

#### *Convention, aims and restrictions*

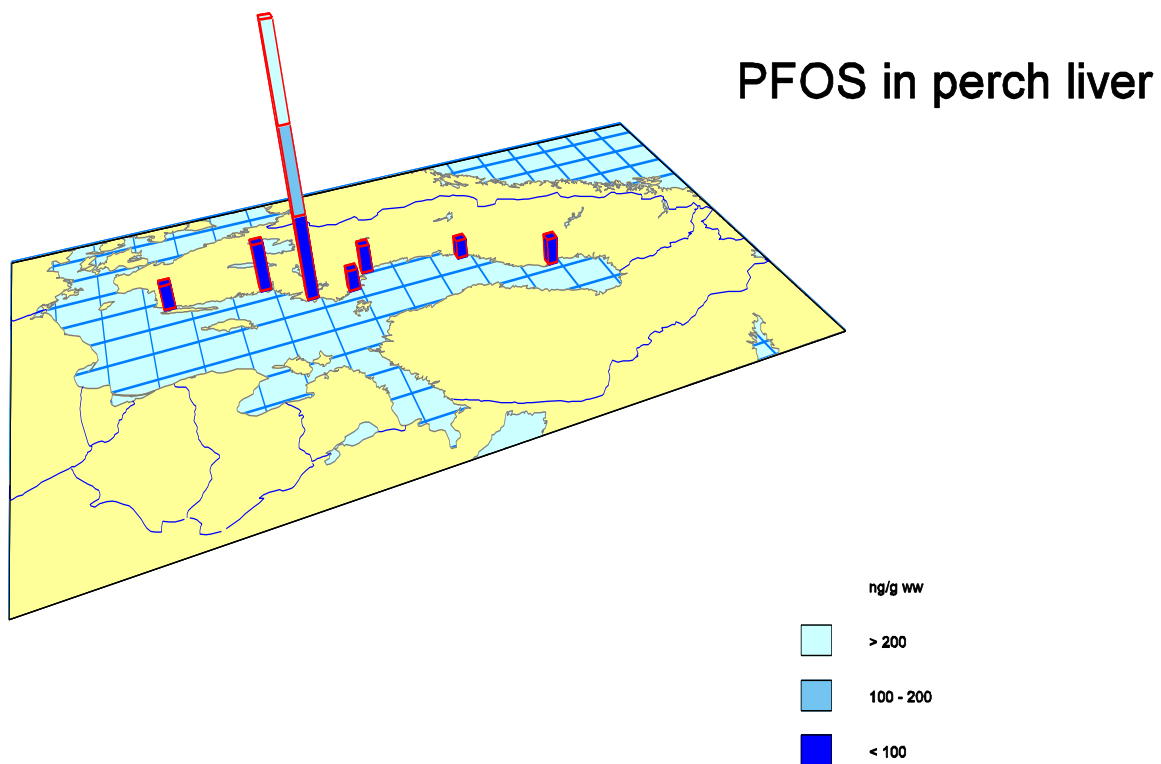
PFOS, its salts, and perfluorooctane sulfonyl fluoride are among the nine new Persistent Organic Pollutants (POPs) included in Annex B in The Stockholm Convention on POPs, but it is listed with exemptions (UNEP 2009).

The use of PFOS and its derivatives is restricted in the EU by the Marketing and Use Directive 2006/122/EC.

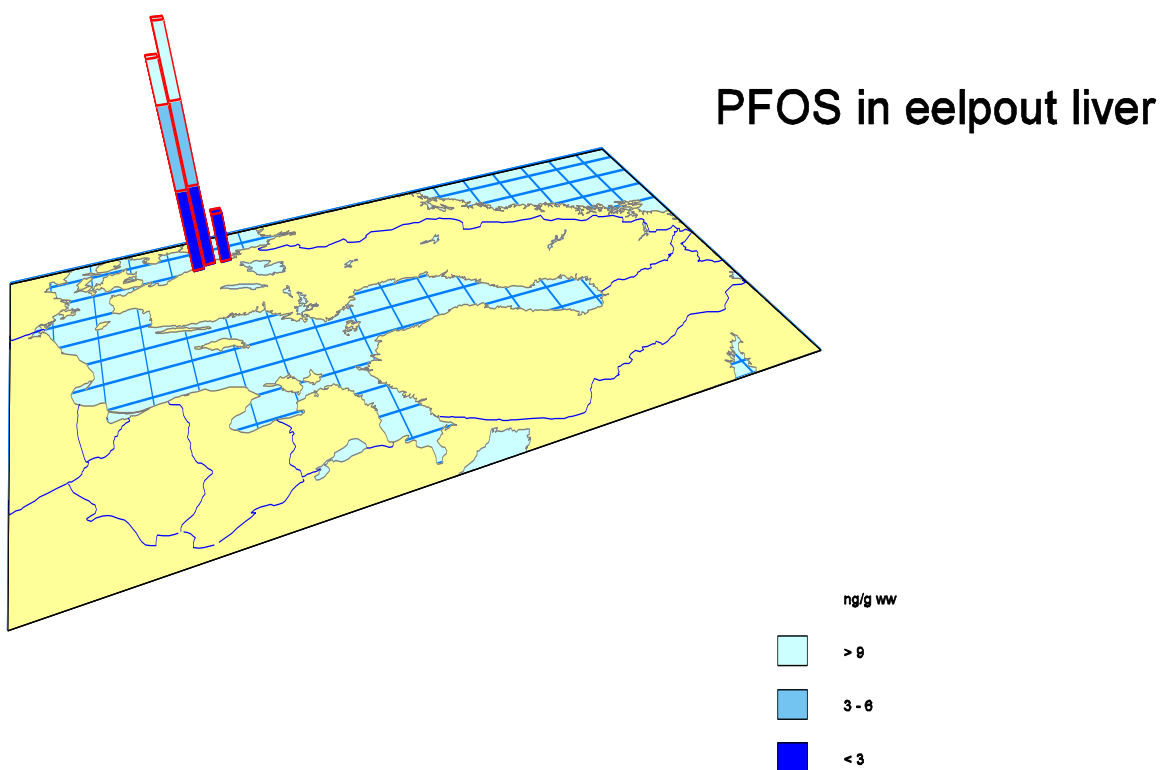
#### *Spatial variation*



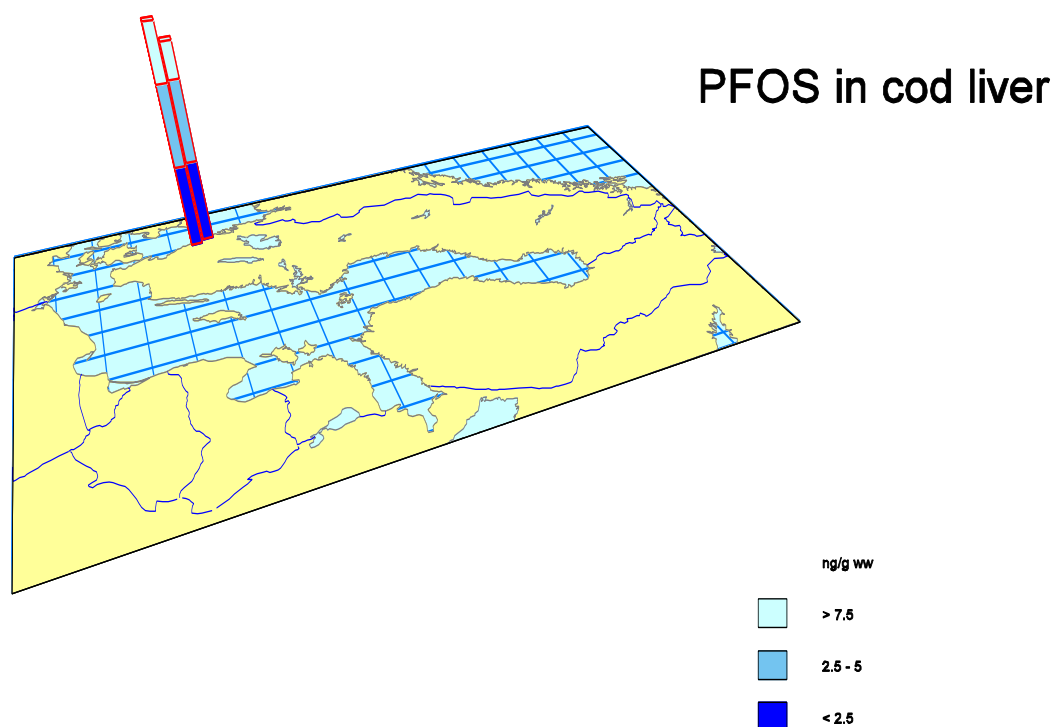
**Figure 4.3.41.** Spatial variation in concentration of PFOS (ng/g ww) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.



**Figure 4.3.42.** Spatial variation in concentration of PFOS (ng/g ww) in perch liver. Blue bars with a red line represent the polluted sites.



**Figure 4.3.43.** Spatial variation in concentration of PFOS (ng/g ww) in eelpout liver. Blue bars with a red line represent the polluted sites.



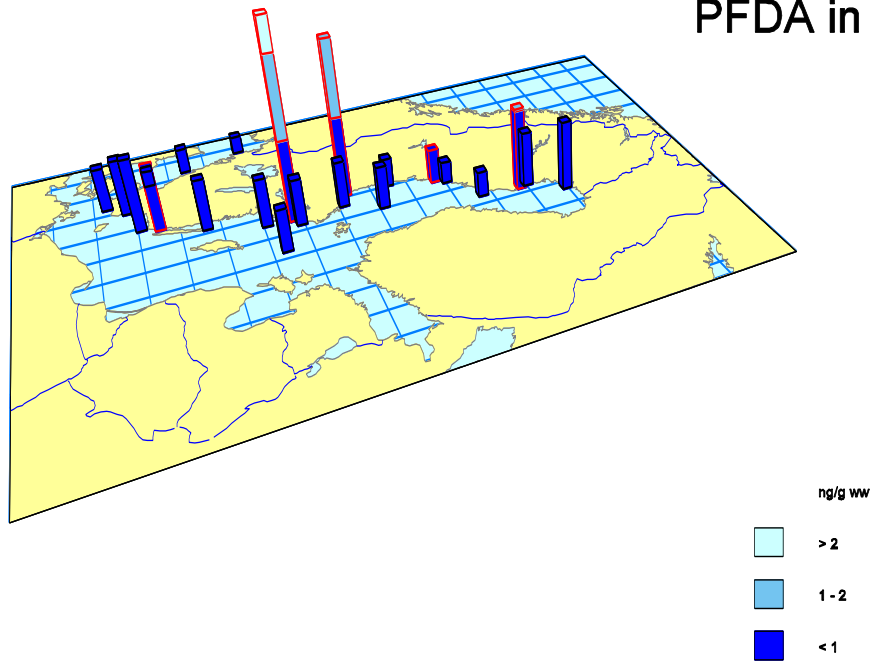
**Figure 4.3.44.** Spatial variation in concentration of PFOS (ng/g ww) in cod liver. Blue bars with a red line represent the polluted sites.

**Table 4.3.27.** Differences in PFOS concentration in herring liver (ng/g ww) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site        | n  | Meanr | Meanp | meanp-meanr | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | 13.5  | 8.82  | -4.67       | .072        |
| Örnsköldsviksfjärden | 6  | 6.30  | 7.37  | 1.07        | .171        |
| Yttre Fjärden        | 6  | 10.2  | 25.0  | 14.8        | <b>.000</b> |
| Lilla Värtan         | 12 | 14.8  | 56.0  | 41.2        | <b>.000</b> |
| Torsås               | 6  | 14.2  | 12.4  | -1.78       | .407        |

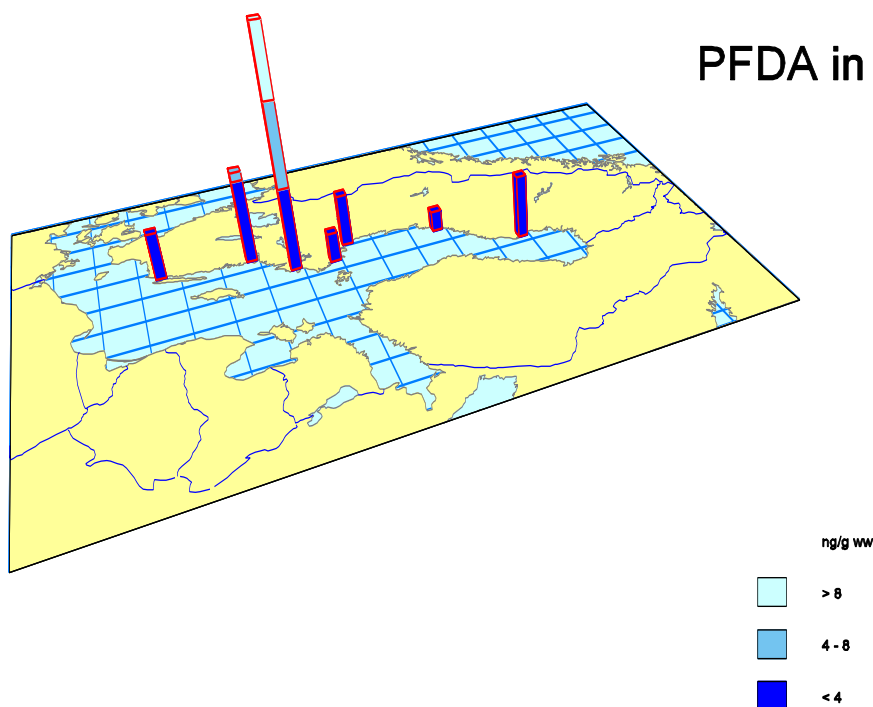
PFOS concentration in herring liver was highest in Lilla Värtan, 56 ng/g ww, and the lowest concentration was seen in Örnsköldsviksfjärden (7.4 ng/g ww) (Fig. 4.3.41). Concentration of PFOS was significantly higher in Lilla Värtan and Yttre Fjärden compared to the reference sites (Table 4.3.27). The same pattern was also seen for perch liver, where Lilla Värtan had a concentration of 306 ng/g ww, and the lowest concentration was found in Örnsköldsviksfjärden with a concentration of 21 ng/g ww (Fig. 4.3.42). In eelpout liver, Kungsbackafjorden and Rivö fjord had almost similar concentrations, even though the highest was found in Rivö fjord (8.6 ng/g ww). Halsefjord and Askeröfjord had approximately four times lower concentration (1.8 ng/g ww) (Fig. 4.3.43). The two cod sites had similar concentrations, 6.1 and 6.8 ng/g ww for Rivö fjord and Kungsbackafjorden respectively (Fig. 4.3.44).

## PFDA in herring liver



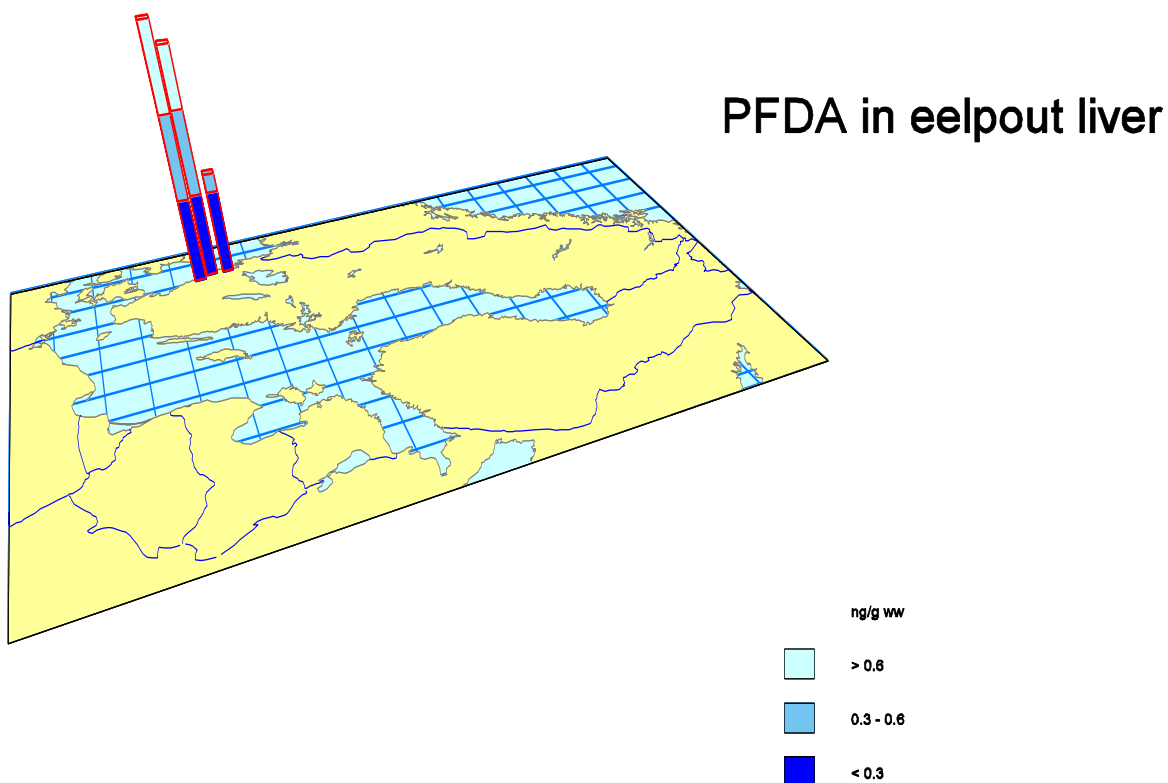
**Figure 4.3.45.** Spatial variation in concentration of PFDA (ng/g ww) in herring liver. Blue bars with a red line represent the polluted sites and blue bars without the red line the reference sites.

## PFDA in perch liver

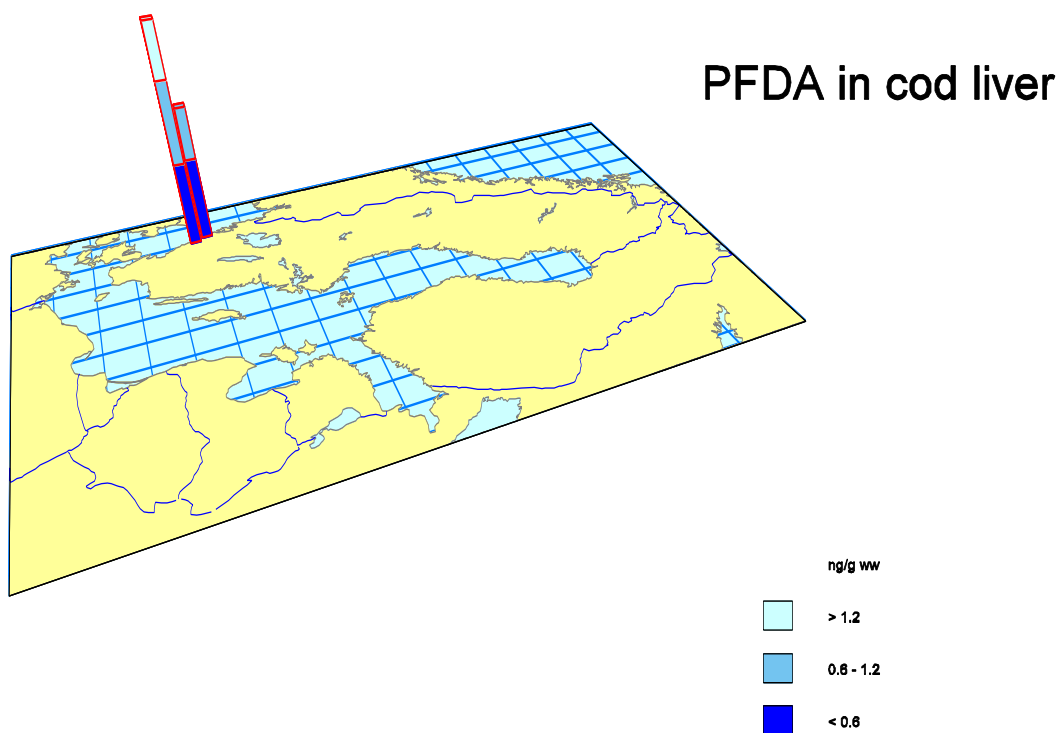


**Figure 4.3.46.** Spatial variation in concentration of PFDA (ng/g ww) in perch liver. Blue bars with a red line represent the polluted sites.





**Figure 4.3.47.** Spatial variation in concentration of PFDA (ng/g ww) in eelpout liver. Blue bars with a red line represent the polluted sites.



**Figure 4.3.48.** Spatial variation in concentration of PFDA (ng/g ww) in cod liver. Blue bars with a red line represent the polluted sites.

**Table 4.3.28.** Differences in PFDA concentration in herring liver (ng/g ww) between each polluted site and reference sites closer than 100 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site        | n  | Meanr | Meanp | meanr-meanp | p           |
|----------------------|----|-------|-------|-------------|-------------|
| Skelleftebukten      | 6  | .683  | 1.03  | .342        | <b>.004</b> |
| Örnsköldsviksfjärden | 6  | .265  | .420  | .155        | <b>.008</b> |
| Yttre Fjärden        | 6  | .570  | 1.94  | 1.37        | <b>.000</b> |
| Lilla Värtan         | 12 | .581  | 2.42  | 1.83        | <b>.000</b> |
| Torsås               | 6  | .888  | .780  | -.108       | .063        |

For PFDA in herring liver, Lilla Värtan had the highest concentration, 2.4 ng/g ww and the lowest concentration was found in Örnsköldsviksfjärden, 0.4 ng/g ww (Fig. 4.3.45). The concentration of PFDA was significantly higher in all polluted sites except Torsås compared to the reference sites (Table 4.3.28). In perch liver, the highest concentration was found in Lilla Värtan (11.4 ng/g ww) and the lowest was seen in Örnsköldsviksfjärden (0.97 ng/g ww) (Fig. 4.3.46). In eelpout liver, Kungsbackafjorden and Rivö fjord had similar concentrations (0.9 and 0.8 ng/g ww respectively). In Halsefjord and Askeröfjord the concentration was lower (0.4 ng/g ww) (Fig. 4.3.47). In cod liver, the concentration of PFDA was highest in Kungsbackafjorden (1.6 ng/g ww) while Rivö fjord had lower concentration (0.98 ng/g ww) (Fig. 4.3.48).

#### *Comparison between species*

PFOS and PFDA in perch liver were generally 2-6 times higher than in herring liver. PFOS and PFDA in cod and eelpout liver were rather similar, with exception for PFDA at Kungsbackafjorden, where the concentration was almost twice as high in cod compared to eelpout.

#### *Comparison with target value*

The target value for PFOS is set to 9.1 µg/kg ww (9.1 ng/g ww) (EQSbiota).

PFOS was analysed in both liver and muscle and the concentrations in liver compared to muscle are much higher. In comparison to the target value the outcome are different depending on the matrix evaluated.

The liver concentrations of PFOS exceed the target value in perch from all sites and also for herring at all sites except for Skelleftebukten and Örnsköldsviksfjärden. The concentrations in eelpout and cod are however at concentrations below the target value even in the liver samples. Concentrations in muscle are below the target value at all stations and all species except for perch from Lilla Värtan where the levels are clearly elevated with a mean concentration of 20 ng/g ww even in muscle.

The target value is set to protect the most sensitive species and for PFOS it is considered to be human health. In relation to this, muscle tissue would be a more proper matrix for target value evaluation.

#### 4.3.8 Chloroalkanes

##### *Usage, production and sources*

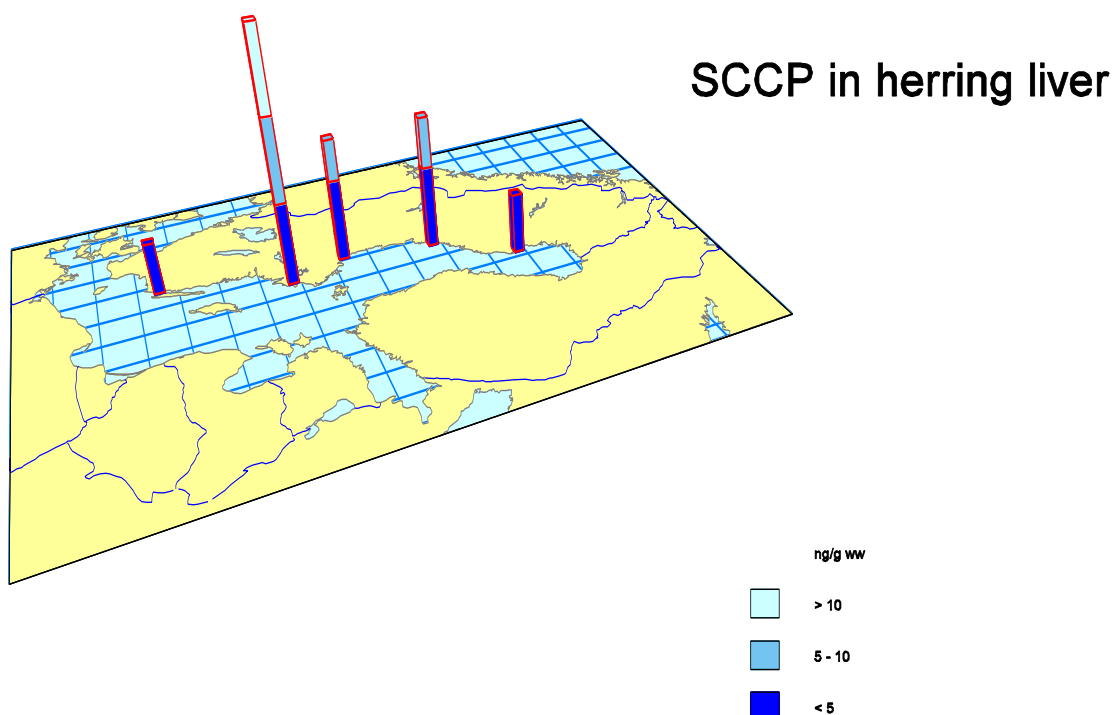
Chloroalkanes have been used in rubber and PVC plastics industry as flame retardant, plasticizer and adhesive, in paint industry and for treating and coating metals (Naturvårdsverket, 2008; HELCOM, 2009).

##### *Convention, aims and restrictions*

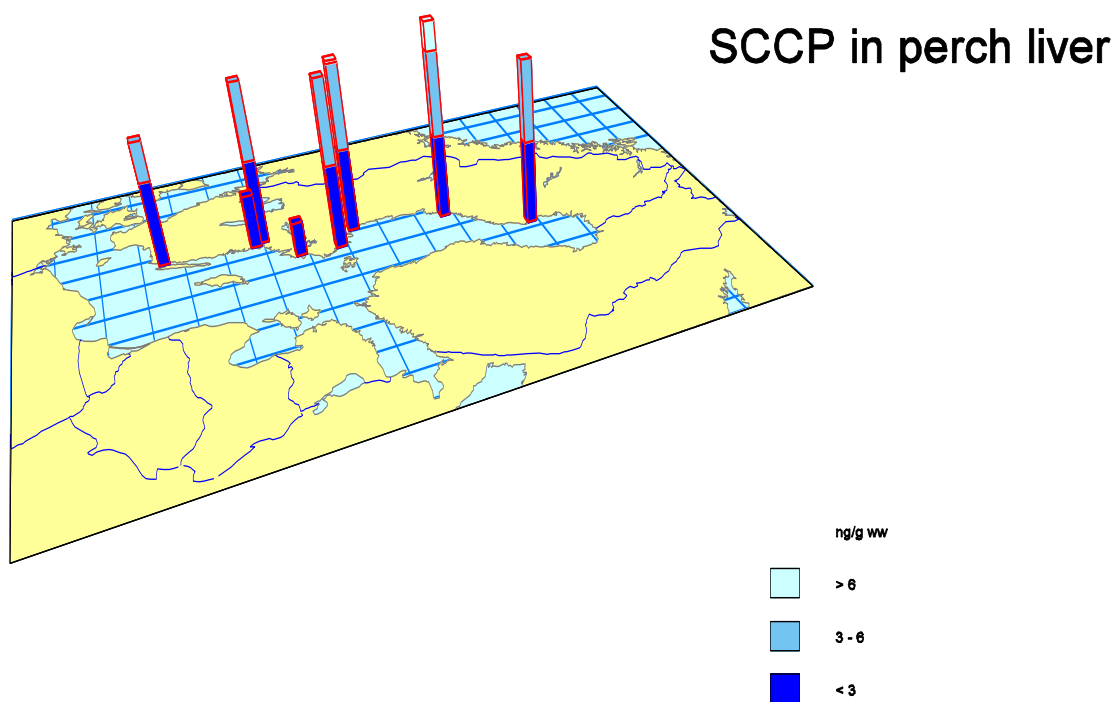
Chloroalkanes are listed as one group of substances of the 33 priority substances in the Water Framework Directive (WFD) (Directive 2008/105/EC). Short-chained chlorinated paraffins (SCCP) are also under review for inclusion in the Stockholm convention of POPs and they have also been proposed to be added to the list of substances subject to authorization under REACH-regulation (1907/2006).

Since 2002 short-chained chlorinated paraffins has been banned in EU for usage in leader oils and for treating metals (Bergbäck & Jonsson, 2008).

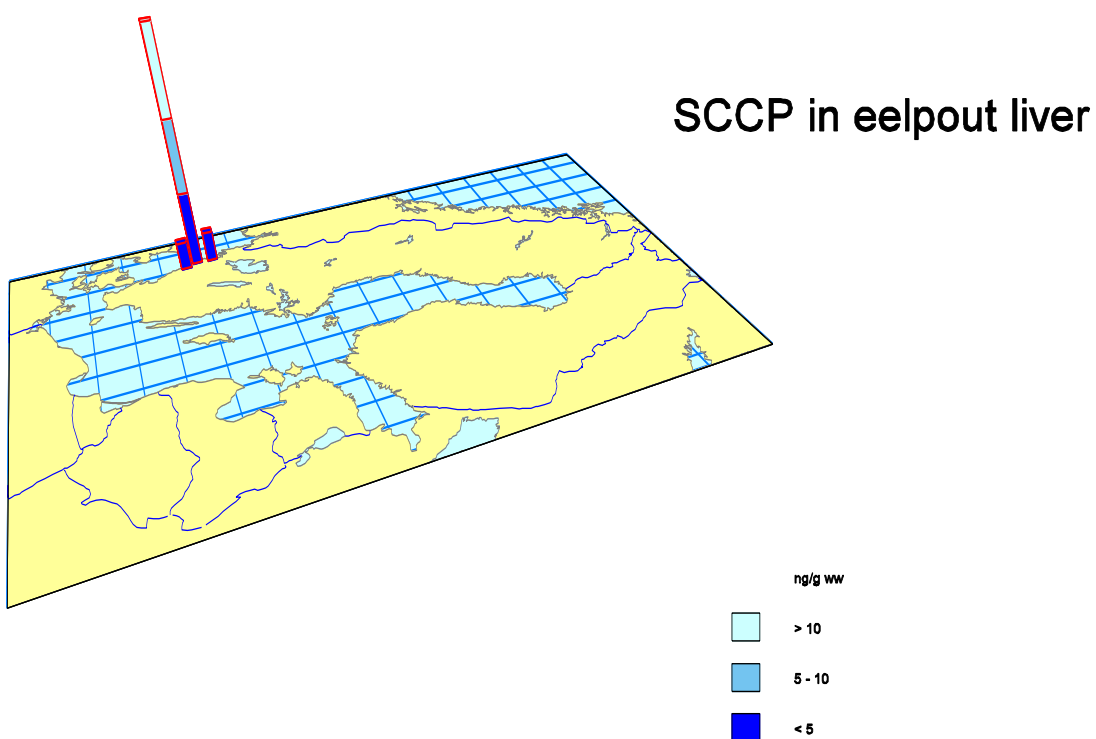
##### *Spatial variation*



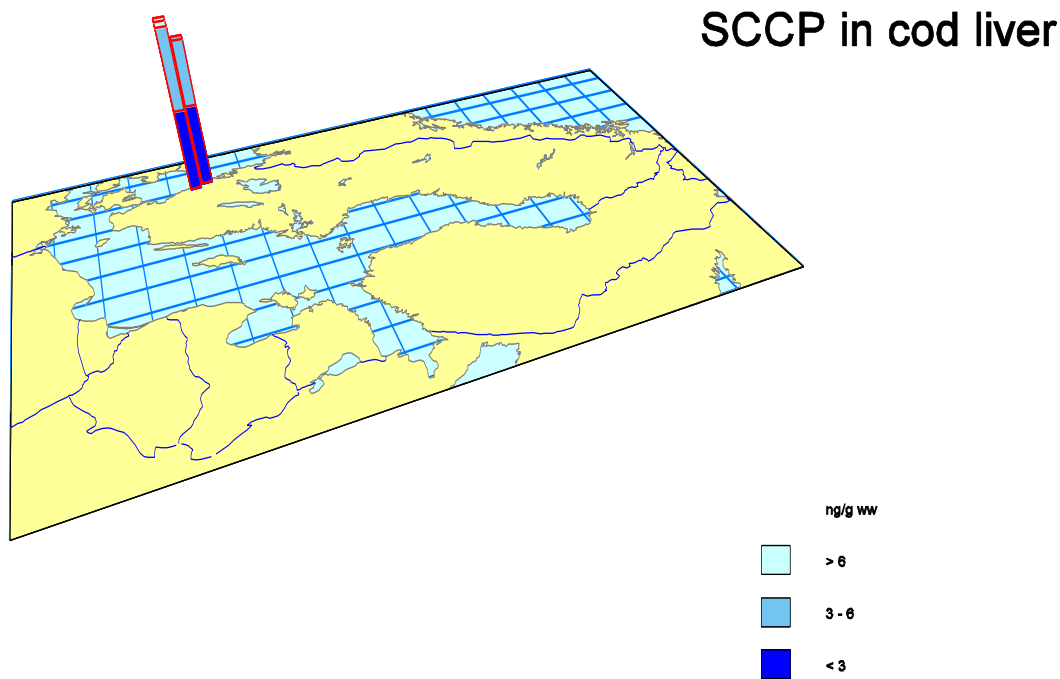
**Figure 4.3.48.** Spatial variation in concentration of short-chained chlorinated paraffins (SCCP) (ng/g ww) in herring liver. Blue bars with a red line represent the polluted sites.



**Figure 4.3.49.** Spatial variation in concentration of short-chained chlorinated paraffins (SCCP) (ng/g ww) in perch liver. Blue bars with a red line represent the polluted sites.

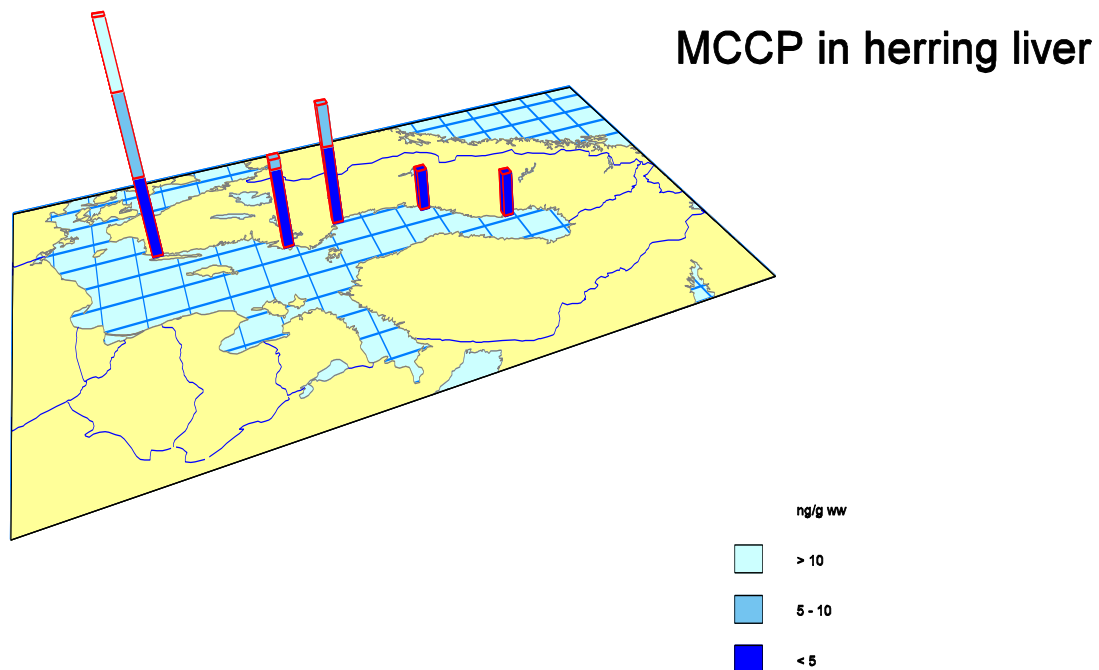


**Figure 4.3.50.** Spatial variation in concentration of short-chained chlorinated paraffins (SCCP) (ng/g ww) in eelpout liver. Blue bars with a red line represent the polluted sites.

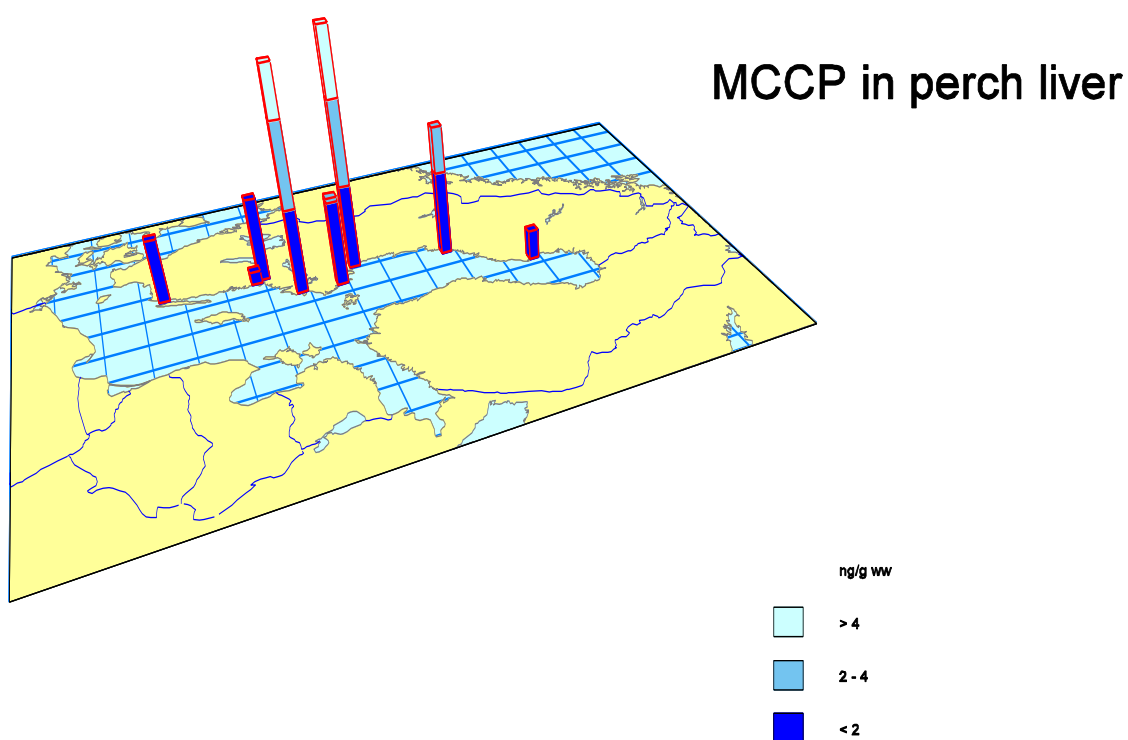


**Figure 4.3.51.** Spatial variation in concentration of short-chained chlorinated paraffins (SCCP) (ng/g ww) in cod liver. Blue bars with a red line represent the polluted sites.

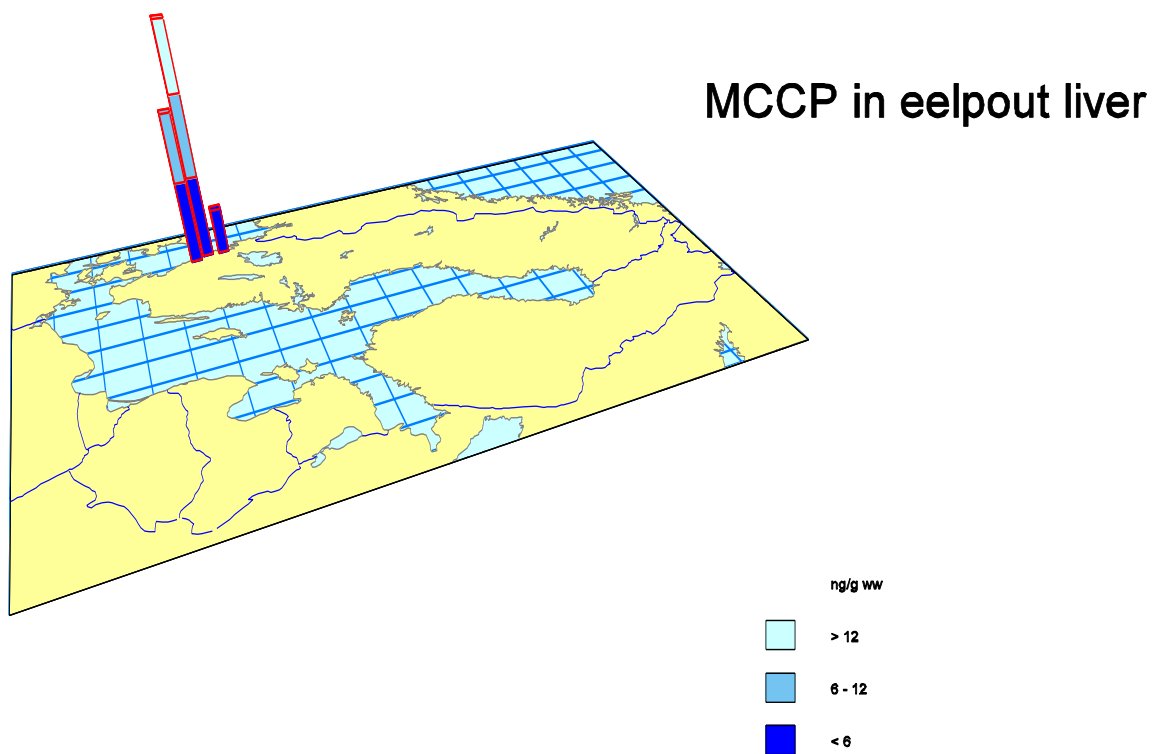
No clear spatial patterns were seen for SCCP in herring or perch. In herring liver, the highest concentration was found in Lilla Värtan (15 ng/g ww) and the lowest was found in Torsås (3.1 ng/g ww) (Fig. 4.3.48). In perch liver, Örnköldsviksfjärden had the highest concentration (7.0 ng/g ww), while Lilla Värtan had the lowest (1.2 ng/g ww) (Fig. 4.3.49). In eelpout liver the highest concentration was found in Rivö fjord (16 ng/g ww), Kungsbackafjorden and Halsefjord and Askeröfjord had similar concentrations (1.8 and 2.0 ng/g ww respectively) (Fig. 4.3.50). In cod liver, the concentrations were rather similar, 5.4 and 6.2 ng/g ww for Rivö fjord and Kungsbackafjorden respectively (Fig. 4.3.51).



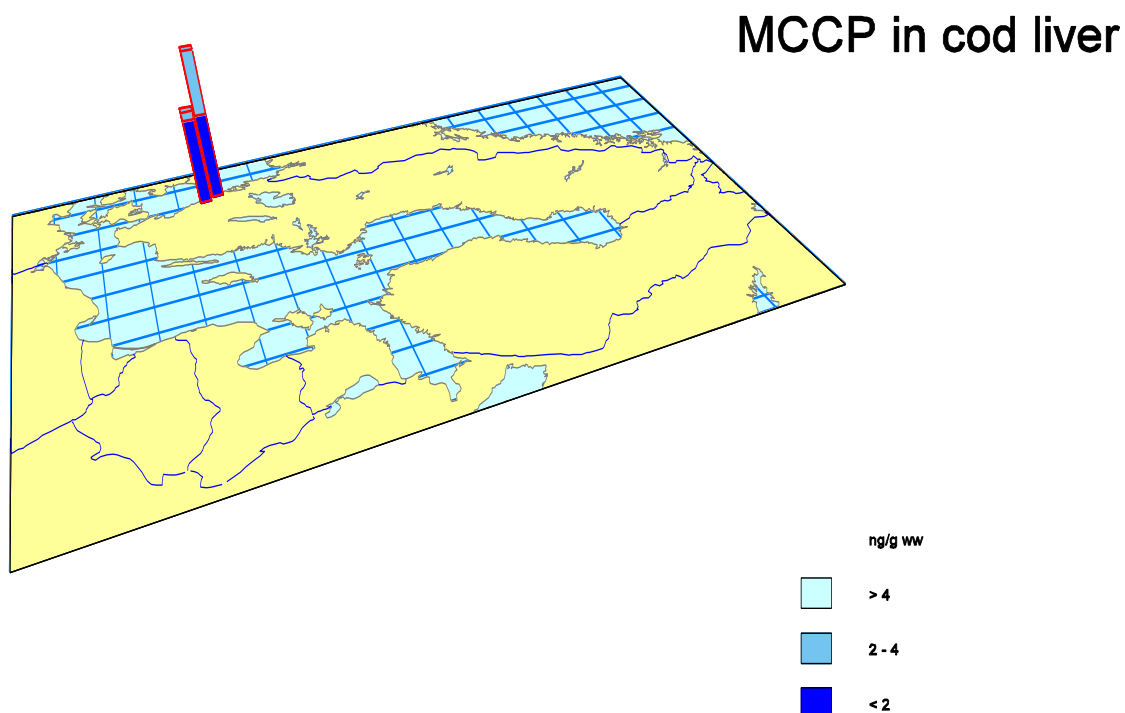
**Figure 4.3.52.** Spatial variation in concentration of middle-chained chlorinated paraffins (MCCP) (ng/g ww) in herring liver. Blue bars with a red line represent the polluted sites.



**Figure 4.3.53.** Spatial variation in concentration of middle-chained chlorinated paraffins (MCCP) (ng/g ww) in perch liver. Blue bars with a red line represent the polluted sites.



**Figure 4.3.54.** Spatial variation in concentration of middle-chained chlorinated paraffins (MCCP) (ng/g ww) in eelpout liver. Blue bars with a red line represent the polluted sites.



**Figure 4.3.55.** Spatial variation in concentration of middle-chained chlorinated paraffins (MCCP) (ng/g ww) in cod liver. Blue bars with a red line represent the polluted sites.

Medium-chain chlorinated paraffins (MCCP) in herring liver seemed to increase from north towards south. Here the highest concentration was found in Torsås (14 ng/g ww) and the lowest concentrations were seen in Skelleftebukten (2.8 ng/g ww) and Örnsköldsviksfjärden (2.6 ng/g ww) (Fig. 4.3.52). In perch liver, no clear spatial pattern was seen. The highest concentrations were found in Yttre fjärden (5.6 ng/g ww) and Lilla Värtan (5.2 ng/g ww) and the lowest concentration was found in Inre Slätbaken (0.3 ng/g ww) (Fig. 4.3.53). Eelpout liver from Rivö fjord had the highest concentration of MCCP, 17 ng/g ww, and Halsefjord and Askeröfjord had the lowest concentration, 3.3 ng/g ww (Fig. 4.3.54). In cod liver, Rivö fjord had the highest concentration, 3.5 ng/g ww and Kungsbackafjorden had the lowest, 2.2 ng/g ww (Fig. 4.3.55).

#### *Comparison between species*

SCCP in herring liver and perch liver was comparable among some of the sites, however, at Lilla Värtan the concentration in herring was 12 times higher compared to perch and in Skelleftebukten herring had twice as high concentration than perch. Also for MCCP, concentrations in herring and perch liver were similar between most of the sites, but in Skelleftebukten and Torsås the concentrations in herring were 5 and 9 times higher respectively.

The concentration of SCCP was 3 times higher in eelpout liver at Rivö fjord compared to cod liver, while the opposite was seen at Kungsbackafjorden. For MCCP, the concentration was 5 times higher in eelpout than cod.

#### *Comparison with target value*

The target value for SCCP is set to 16 600 µg/kg ww (16 600 ng/g ww) (QSbiota). The concentrations reported for SCCP are far below the target value for all stations and species. The highest value was found for eelpout from Rivö fjord at 16 ng/g ww compared to target level 16 600 ng/g ww.

No national target value for biota is agreed upon for MCCP.

### **4.3.9 Di-(2-ethylhexyl)-phthalate (DEHP)**

#### *Usage, production and sources*

DEHP is the most commonly used plasticizer in PVC plastics. It is used as softener in plastics and rubber, in medical devices, construction products, and children's toys. DEHP is also used in non-polymer materials such as lacquers and paints, adhesives, fillers and printing ink, cosmetics and clothing (Huang et al. 2008; Naturvårdsverket 2008; Carnevali et al. 2010). It is the most abundantly used of all phthalates.

#### *Restrictions*

DEHP is on REACH Authorization list under Annex XIV ([www.dehp-facts.com](http://www.dehp-facts.com)). The compound will be phased out in EU and no later than 2015 special permission is necessary in order to use or sale this compound (KEMI 2012). However, DEHP is already banned in EU for use in children's toys and childcare articles (EU Directive 2005/84/EC).



#### *Spatial variation*

The concentration reported as LOQ for DEHP in eelpout, perch and cod muscle is 6 ng/g ww, and between 6 and 12 ng/g ww for herring muscle. All stations showed concentrations below LOQ except for eelpout from Rivö fjord (9.0 ng/g ww) and perch from Bråviken (Svindra north) (11 ng/g ww). Also two herring stations, Yttre fjärden and Lilla Värtan, showed quantifiable concentrations of 6.5 and 9.9 ng/g ww respectively, although below the highest reported LOQ level for herring.

#### *Comparison between species*

No comparisons were made since most concentrations were below LOQ.

#### *Comparison with target value*

The target value for DEHP is set to 3 200 µg/kg ww (3 200 ng/g ww) (QSbiota). The concentrations at all stations, in all species show concentrations below the target value. The concentrations for most samples were below the level of quantification (<12 ng/g ww).

### **4.3.10 Hexachlorobutadiene (HCBd)**

#### *Usage, production and sources*

HCBd has been used as solvents for textile products such as colour, or different impregnation agents (Naturvårdsverket 2008). It has also been used as a chemical intermediate in rubber compounds manufacturing (Vorkamp et al 2004). Thus, higher concentrations can be found e.g. around industries or other point sources. HCBd can also be formed as a by-product in the manufacture of chlorinated hydrocarbons (Stockholm Convention of POPs, 2011).

#### *Convention, aims and restrictions*

Hexachlorobutadiene is under review for inclusion in the Stockholm Convention of POPs.

#### *Spatial variation*

Concentrations in all samples were below the reported concentration for LOQ, 0.05 ng/g ww.

#### *Comparison between species*

No comparisons were made since all concentrations were below LOQ.

#### *Comparison with target value*

The target value for HCBd is set to 55 µg/kg ww (55 ng/g ww) (QSbiota). All samples were below the LOQ reported as 0.05 ng/g ww and thus far below the target value.

### **4.3.11 Pentachlorobenzene**

#### *Usage, production and sources*

There is no known usage of pentachlorobenzene in Sweden. But it might indirectly be a decay product in Quintozene (a fungicide) and in hexachlorobenzene, which was used during the

1960s to 1980s. Pentachlorobenzene is otherwise used in dielectric fluids. It has also been used as intermediary in flame retardants and for production of other chemicals (Naturvårdsverket 2008). Pentachlorobenzene is also a metabolite to Lindane. The use of lindane was restricted in 1970 in Sweden, and in 1988/1989 it was totally banned. In Sweden the usage of pentachlorobenzene has been very limited compared to several other countries and therefore low amounts of this compound will probably be found in the environment (Esbjörnsson 2002).

#### *Convention, aims and restrictions*

Pentachlorobenzene is listed as one of the nine new POPs under the Stockholm Convention of POPs.

#### *Spatial variation*

Concentrations in all samples were below the reported concentration for LOQ, 0.05 ng/g ww.

#### *Comparison between species*

No comparisons were made since all concentrations were below LOQ.

#### *Comparison with target value*

The target value for PeCB is set to 367 µg/kg ww (367 ng/g ww) (QSbiota). All samples were below the LOQ reported as 0.05 ng/g ww and thus far below the target value.

### **4.3.12 Organotin compounds (OTCs)**

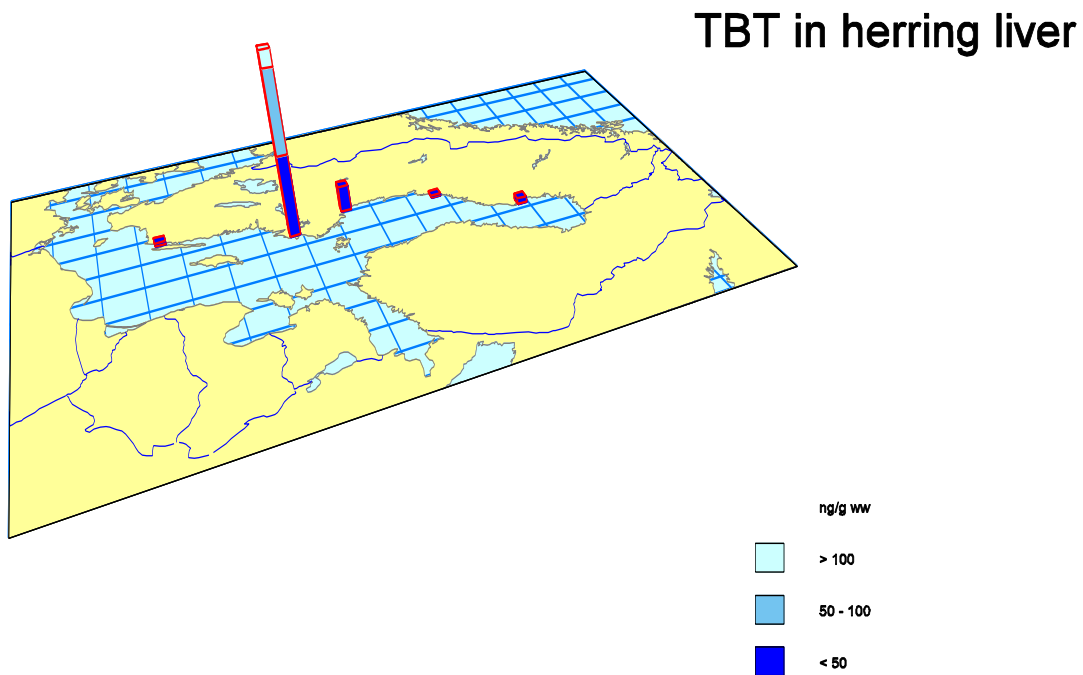
#### *Usage, production and sources*

The main usage of both TBT and TPhT was as antifouling agents in paints for preventing the attachment of barnacles and slime on boats. The paint was primarily used on ship hulls, docks, buoys, and fishnets, and from where it could slowly leach into the waters. TBT and TPhT has also been used as wood preservative in industry and agriculture and as a stabilizer in PVC plastics manufacturing (Encinar et al. 2001; Naturvårdsverket 2008; Sternberg et al. 2010).

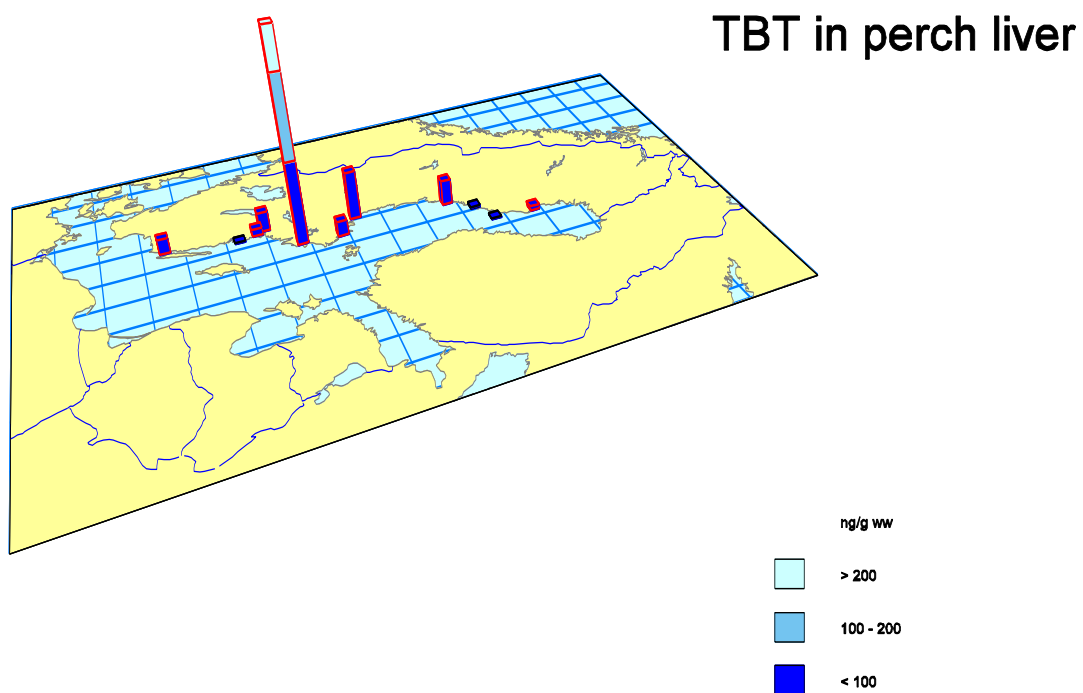
#### *Restrictions*

Since 1989 the usage of TBT on small boats (less than 25 m) has been banned in Sweden and since 1993 all usage of TBT has been prohibited. In EU a ban on small boats came in 1999. In 1998 the Marine Environmental Protection Committee (MEPC) of the International Maritime Organization (IMO) voted to impose a worldwide prohibition on the application and presence of TBT and other organotin compounds within 5 years (2003, painting with TBT-based paint on boats) and 10 years (2008, total ban on the presence of TBT and other OTC's). The total international ban on TBT and other OTC's entered into force in September 2008.

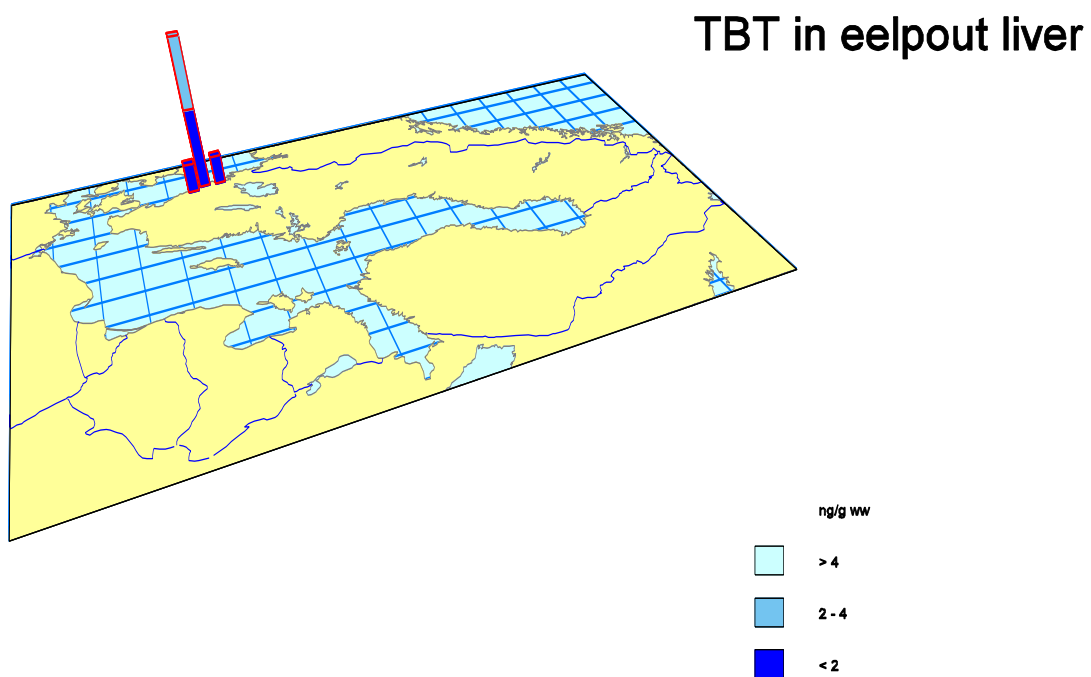
#### *Spatial variation*



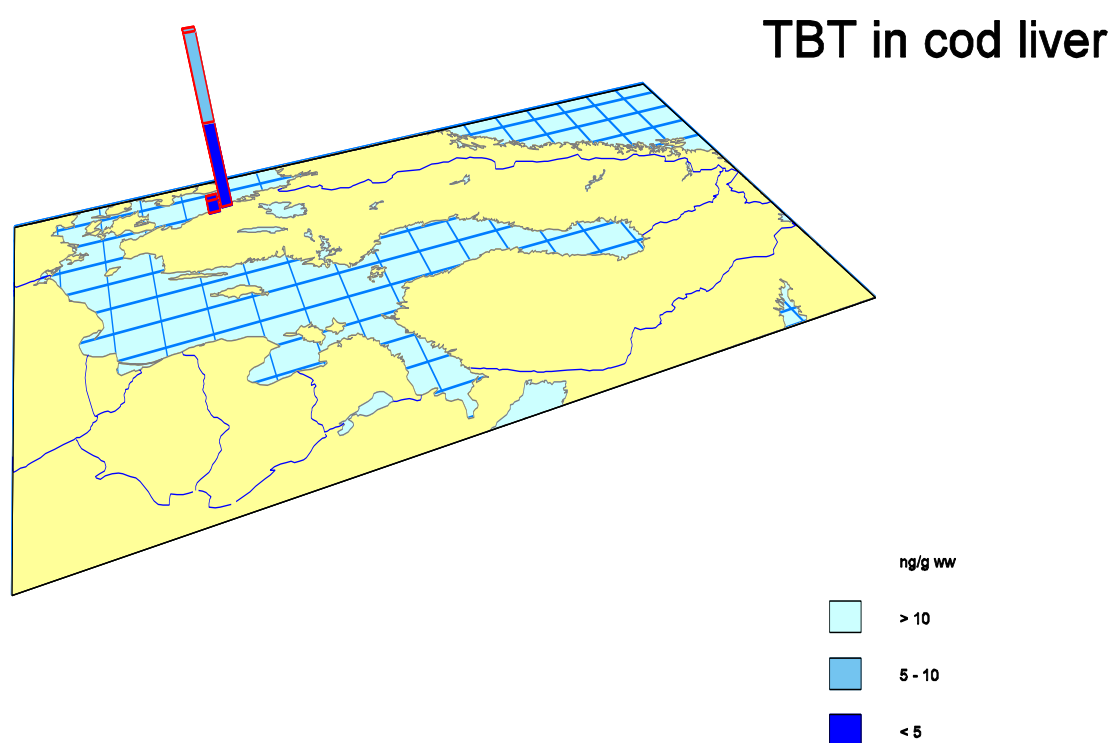
**Figure 4.3.56.** Spatial variation in concentration of TBT (ng/g ww) in herring liver. Blue bars with a red line represent the polluted sites.



**Figure 4.3.57.** Spatial variation in concentration of TBT (ng/g ww) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without a red line the reference sites.



**Figure 4.3.58.** Spatial variation in concentration of TBT (ng/g ww) in eelpout liver. Blue bars with a red line represent the polluted sites.

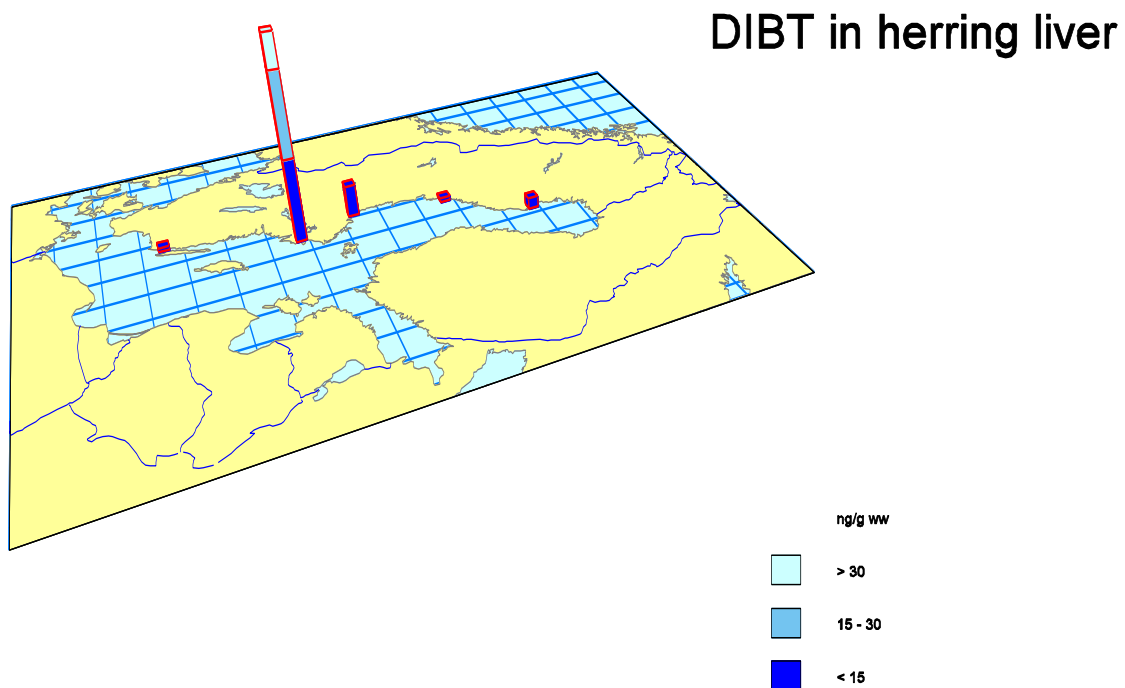


**Figure 4.3.59.** Spatial variation in concentration of TBT (ng/g ww) in cod liver. Blue bars with a red line represent the polluted sites.

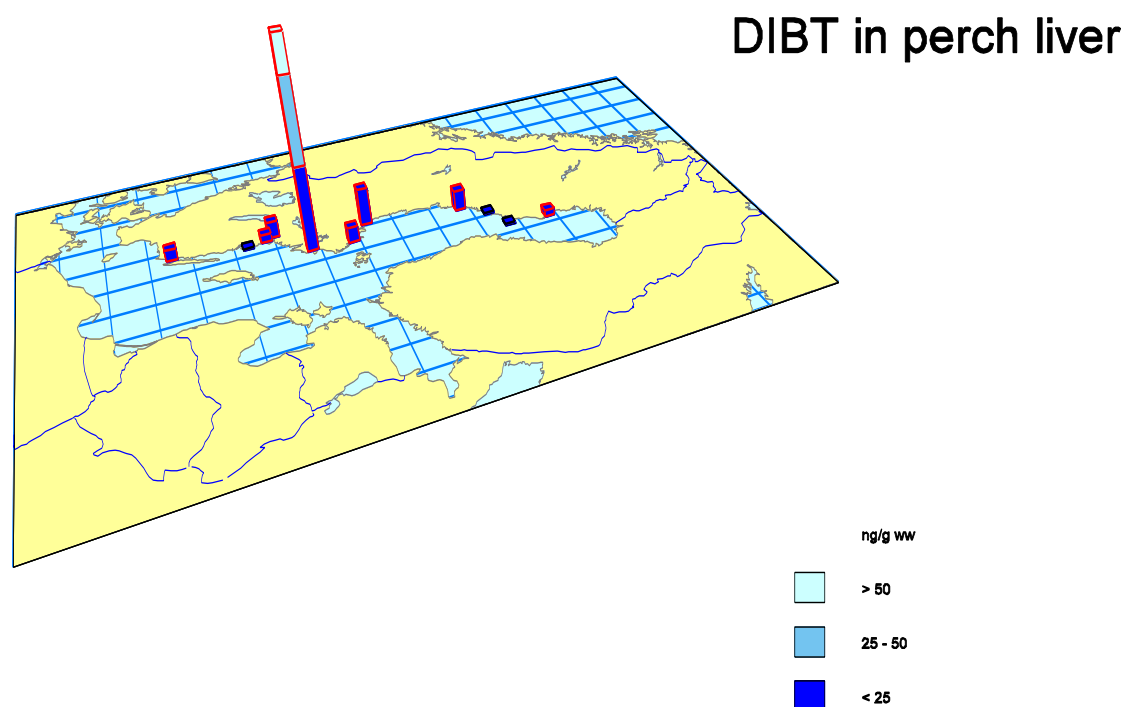
**Table 4.3.29.** Differences in TBT concentration in perch liver (ng/g ww) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site        | n | Meanr | Meanp | meanp-meanr | p    |
|----------------------|---|-------|-------|-------------|------|
| Skelleftebukten      | 6 | 1.26  | 5.20  | 3.94        | .000 |
| Örnsköldsviksfjärden | 6 | 1.26  | 30.0  | 28.7        | .000 |
| Yttre Fjärden        | 6 | 1.28  | 58.0  | 56.7        | .000 |
| Östhammarsfjärden    | 3 | .751  | 18.0  | 17.2        | .000 |
| Lilla Värtan         | 3 | .751  | 250   | 249         | .000 |
| Inre Slätbaken       | 3 | .751  | 8.00  | 7.25        | .002 |
| Bråviken             | 3 | .751  | 23.0  | 22.2        | .000 |
| Torsås               | 3 | .751  | 18.0  | 17.2        | .000 |

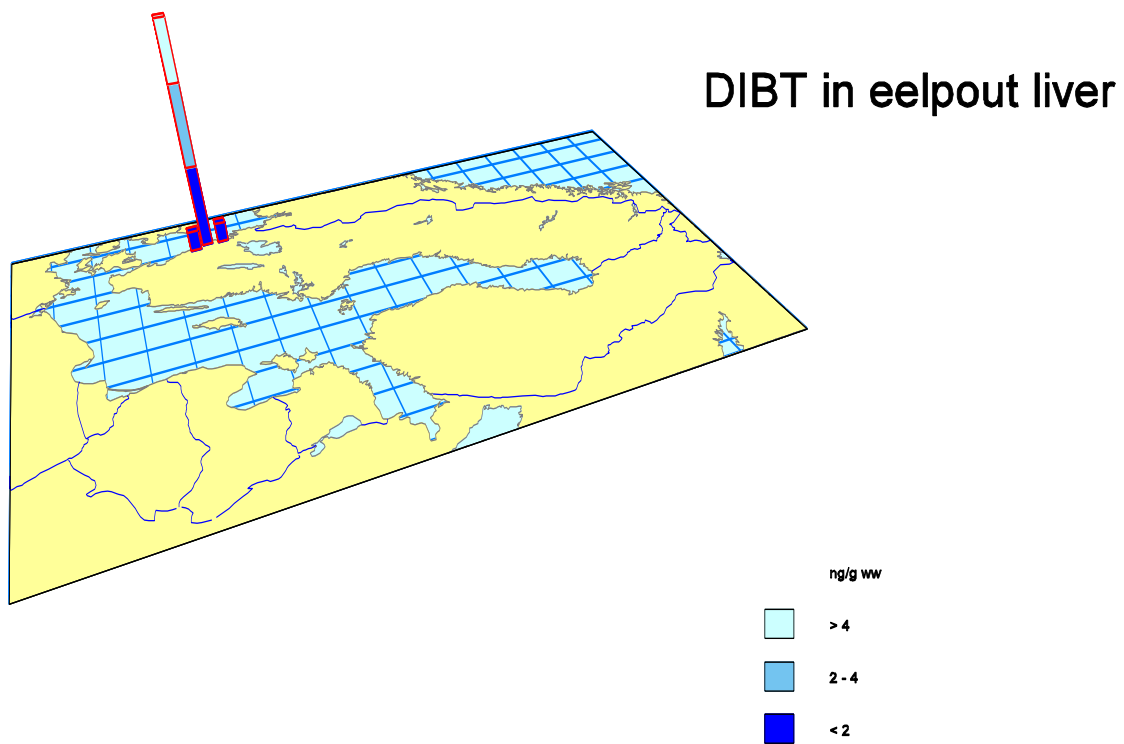
Concentration of TBT in herring was highest in Lilla Värtan (110 ng/g ww), while the other sites ranged between 1.1 and 16 ng/g ww, where the lowest concentration was seen in Örnsköldsviksfjärden (Fig. 4.3.56). Also in perch liver, the highest concentration was found in Lilla Värtan, 250 ng/g ww. The lowest concentration was seen in Skelleftebukten (5.2 ng/g ww) (Fig. 4.3.57). In eelpout liver, Rivö fjord had the highest concentration, 3.8 ng/g ww, while Kungsbackafjorden and Halsefjord and Askeröfjord had lower concentrations (0.7 ng/g ww) (Fig. 4.3.58). Cod liver from Rivö fjord had approximately 14 times higher TBT concentration (10 ng/g ww) compared to Kungsbackafjorden (0.7 ng/g ww) (Fig. 4.3.59).



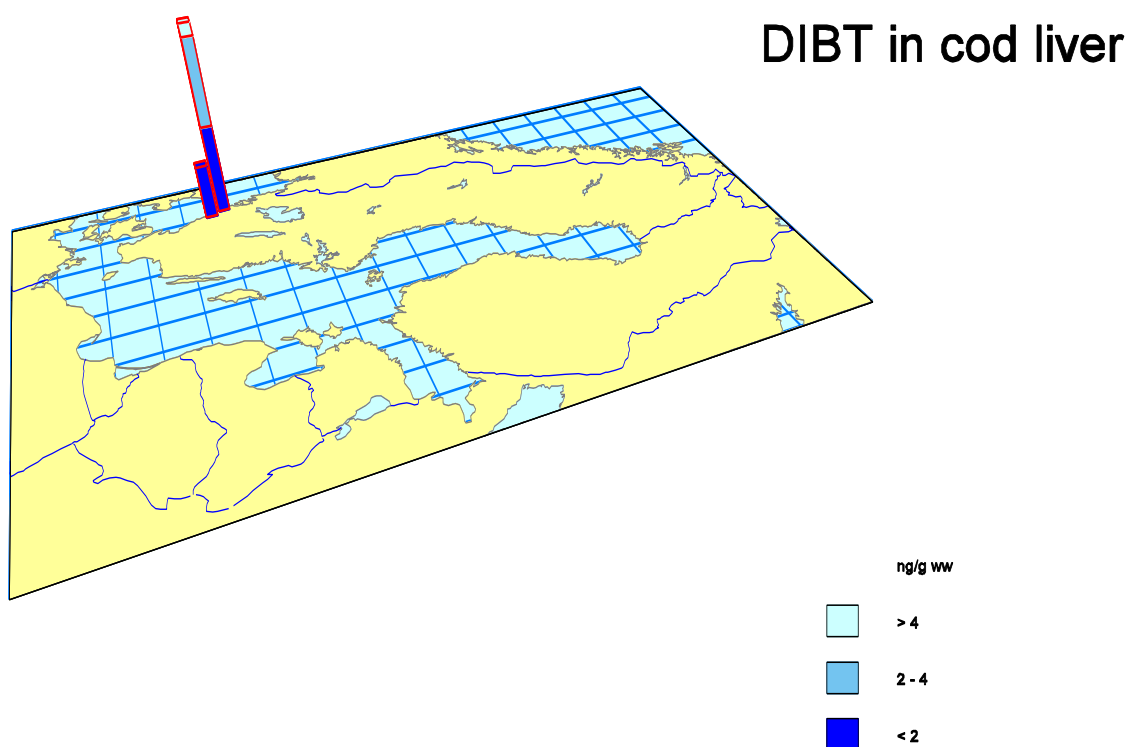
**Figure 4.3.60.** Spatial variation in concentration of DiBT (ng/g ww) in herring liver. Blue bars with a red line represent the polluted sites.



**Figure 4.3.61.** Spatial variation in concentration of DiBT (ng/g ww) in perch liver. Blue bars with a red line represent the polluted sites and blue bars without a red line the reference sites.



**Figure 4.3.62.** Spatial variation in concentration of DiBT (ng/g ww) in eelpout liver. Blue bars with a red line represent the polluted sites.



**Figure 4.3.63.** Spatial variation in concentration of DIBT (ng/g ww) in cod liver. Blue bars with a red line represent the polluted sites.

**Table 4.3.30.** Differences in DIBT concentration in perch liver (ng/g ww) between each polluted site and reference sites closer than 350 km tested with one-sample t-test. Sampling site, n=number of reference sites, meanr=mean value for the reference sites, meanp=mean value for the polluted site, var=variance for the reference sites and p-value.

| Sampling site        | n | Meanr | Meanp | Meanp-meanr | p           |
|----------------------|---|-------|-------|-------------|-------------|
| Skelleftebukten      | 6 | .401  | 1.80  | 1.40        | <b>.000</b> |
| Örnsköldsviksfjärden | 6 | .401  | 6.00  | 5.60        | <b>.000</b> |
| Yttre Fjärden        | 6 | .401  | 11.0  | 10.6        | <b>.000</b> |
| Östhammarsfjärden    | 3 | .354  | 4.40  | 4.05        | *           |
| Lilla Värtan         | 3 | .354  | 61.0  | 60.6        | *           |
| Inre Slätbaken       | 3 | .354  | 2.20  | 1.85        | *           |
| Bråviken             | 3 | .354  | 4.67  | 4.31        | *           |
| Torsås               | 3 | .354  | 3.30  | 2.95        | *           |

\*the compared reference values are all below LOQ and the selected test is thus not suitable and therefore p-values are missing



Concentrations of DiBT in herring liver showed a similar pattern as TBT – highest concentration in Lilla Värtan (36 ng/g ww) and lowest concentrations in Örensköldsviksfjärden and Torsås (0.7 ng/g ww) (Fig. 4.3.60). DiBT in perch liver also showed a similar pattern as that for TBT, with the highest concentration found in Lilla Värtan, 61 ng/g ww and the lowest in Skelleftebukten, 1.8 ng/g ww (Fig. 4.3.61). In eelpout liver, Rivö fjord had the highest concentration (8.2 ng/g ww) while Kungsbackafjorden and Halsefjord and Askeröfjord had more than ten times lower concentrations (0.7 ng/g ww) (Fig. 4.3.62). Cod liver from Rivö fjord had the highest concentration (4.3 ng/g ww) and Kungsbackafjorden had one third of that concentration (1.2 ng/g ww) (Fig. 4.3.63).

#### *Comparison between species*

TBT in perch liver was usually higher compared to herring liver, at most sites with between 2-9 times but as high as 27 times for Örensköldsviksfjärden. For DiBT, the concentrations were also higher in perch than in herring, generally 2-8 times higher.

TBT in cod liver was 2.5 times higher compared to eelpout liver, but only in Rivö fjord, in Kungsbackafjärden the concentrations were comparable between species. For DiBT on the other hand, eelpout in Rivö fjord were twice as high compared to cod, but at Kungsbackafjärden, cod liver had almost two times higher concentration.

#### *Comparison with target value*

TBT is evaluated in relation to a translation of the EQS set for surface water according to the method reported in Lilja et al. 2010. This calculated target value for TBT in fish liver is set to 10.4 µg/kg ww (10.4 ng/g ww).

All perch stations exceed the target value except Inre Slätbaken and Skelleftebukten. The highest concentrations are reported from Yttre fjärden and Lilla Värtan, these two stations also exceed the target value in herring while the other herring sites are below. Concentrations in eelpout and cod are below the target value at all stations.

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## Appendix

Table 1. Data on metal concentrations (Hg in ng/g fresh weight and the other metals in ug/g dry weight) in the different species at the different sites. Each sample consists of a homogenate of 12 individuals. Column one shows identity numbers for the samples included in the analyses. Column two shows the different species names; ZOAR=eelpout, CLUP=herring, PERC=perch, GADU=cod. Column 3-5 shows site names and their respective coordinates. TOTL=total fish length, TOTW=total fish weight. AGE shows the mean age for all the specimens included. FPRC=fat percentage, MDPRC=muscle dry percentage, LDPRC=liver dry percentage, LW=liver weight. Minus sign means that the value is below LOQ.

| ACCNR           | GENUS | SITE                 | LATDEG  | LONDEG  | TOTL | TOTW  | AGE | FPRC | MDPRC | LDPRC | LW  | HG  | PB    | CD   | CU | ZN  | NI    | CR    | AG   | AS   | SE   | SN    |
|-----------------|-------|----------------------|---------|---------|------|-------|-----|------|-------|-------|-----|-----|-------|------|----|-----|-------|-------|------|------|------|-------|
| C11/02274-02285 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.6 | 76.2  | 4   | 0.74 | 21.3  | 42    | 1.9 | 34  | 0.02  | 0.19 | 17 | 88  | -0.06 | -0.06 | 0.09 | 4.87 | 2.73 | 0.06  |
| C11/02286-02297 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 21.1 | 41.1  | 3   | 1    | 21.3  | 44    | 0.8 | 26  | 0.03  | 0.2  | 18 | 78  | -0.05 | -0.05 | 0.1  | 5.71 | 3.13 | -0.05 |
| C11/02299-02310 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 23.5 | 62.5  | 4   | 1    | 21.1  | 48    | 0.9 | 89  | 0.05  | 0.06 | 8  | 56  | -0.06 | -0.06 | 0.06 | 4.55 | 2.04 | 0.08  |
| C11/02311-02322 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 22.8 | 58.3  | 4   | 1.1  | 20.3  | 43    | 0.7 | 88  | 0.08  | 0.12 | 10 | 76  | -0.06 | -0.06 | 0.13 | 7.07 | 2.7  | 0.06  |
| C11/02351-02362 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 21.8 | 60.2  | 2   | 1    | 23.1  | 55    | 1.5 | 13  | 0.01  | 0.03 | 21 | 73  | -0.05 | -0.05 | 0.05 | 2.41 | 2.04 | 0.07  |
| C11/02363-02374 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 22.6 | 65.1  | 2   | 0.94 | 22.5  | 47    | 1.5 | 14  | -0.01 | 0.04 | 26 | 91  | -0.06 | -0.06 | 0.06 | 3.13 | 2.59 | 0.13  |
| C11/02577-02588 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 40.8  | 5   | 3.8  | 21.9  | 26    | 0.4 | 22  | 0.1   | 1.78 | 13 | 99  | 0.07  | -0.06 | 0.07 | 2.57 | 7.73 | 0.09  |
| C11/02589-02600 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 39.1  | 6   | 2.4  | 22.1  | 26    | 0.4 | 32  | 0.13  | 2.56 | 14 | 97  | 0.15  | -0.05 | 0.05 | 2.99 | 8.95 | 0.05  |
| C11/03758-03769 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 34.2  | 5   | 3.1  | 22.1  | 31    | 0.4 | 15  | 0.02  | 1.48 | 10 | 73  | 0.1   | -0.05 | 0.04 | 3.2  | 4.82 | -0.05 |
| C11/03770-03781 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 33.9  | 6   | 3.7  | 23.1  | 30    | 0.4 | 23  | 0.02  | 1.71 | 9  | 78  | 0.12  | -0.06 | 0.03 | 3.34 | 5.14 | 0.06  |
| C11/01239-01250 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 17.3 | 36.9  | 5   | 2.9  | 23.4  | 30    | 0.5 | 55  | 0.28  | 0.81 | 10 | 73  | -0.06 | -0.06 | 0.02 | 1.46 | 3.91 | 0.11  |
| C11/01251-01262 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 11.7 | 38.6  | 6   | 2.9  | 23    | 30    | 0.4 | 56  | 0.17  | 0.89 | 8  | 69  | -0.05 | -0.05 | 0.02 | 1.46 | 3.99 | -0.05 |
| C11/01086-01097 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.5 | 39    | 4   | 5.4  | 25.9  | 34    | 0.6 | 84  | 0.19  | 0.31 | 10 | 63  | -0.05 | -0.05 | 0.13 | 1.35 | 3.67 | 0.13  |
| C11/01098-01109 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.6 | 37.9  | 6   | 4.4  | 25.6  | 31    | 0.7 | 149 | 0.21  | 0.54 | 10 | 76  | 0.07  | -0.06 | 0.13 | 1.75 | 4.14 | 0.14  |
| C11/04419-04430 | CLUP  | Torsås               | 56.4167 | 16.1333 | 18   | 51.3  | 7   | 2    | 23.4  | 30    | 0.8 | 57  | 0.04  | 0.81 | 11 | 73  | 0.08  | -0.06 | 0.02 | 2.07 | 5.29 | -0.06 |
| C11/04431-04442 | CLUP  | Torsås               | 56.4167 | 16.1333 | 14.7 | 52.3  | 9   | 2    | 22.8  | 29    | 0.9 | 63  | 0.04  | 1.14 | 10 | 70  | 0.09  | -0.06 | 0.02 | 2.08 | 5.47 | 0.07  |
| C11/02552-02563 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 73.2  | 6   | 0.62 | 20.4  | 25    | 0.6 | 118 | 0.07  | 6.37 | 12 | 105 | 0.1   | -0.05 | 0.02 | 1.58 | 7.82 | 0.05  |
| C11/02564-02575 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 74    | 6   | 0.75 | 20.6  | 23    | 0.9 | 129 | 0.09  | 5.05 | 15 | 114 | 0.1   | -0.06 | 0.02 | 3.74 | 8.84 | -0.06 |
| C11/03658-03669 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 16.8 | 55    | 4   | 0.8  | 20.7  | 26    | 0.7 | 134 | 0.02  | 0.39 | 11 | 84  | 0.1   | -0.06 | 0.03 | 4.76 | 3.88 | 0.07  |
| C11/03670-03681 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 15.6 | 56.7  | 4   | 0.69 | 21    | 25    | 0.7 | 121 | 0.02  | 0.42 | 9  | 102 | 0.07  | -0.05 | 0.03 | 4.66 | 4.56 | 0.1   |
| C11/01289-01300 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 19.4 | 84.1  | 4   | 0.78 | 21.1  | 25    | 1.2 | 228 | 0.03  | 0.47 | 8  | 93  | -0.05 | -0.05 | 0.01 | 4.77 | 4.39 | 0.09  |
| C11/01301-01312 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 16.5 | 70.1  | 4   | 0.72 | 21.1  | 25    | 0.9 | 177 | 0.05  | 0.45 | 9  | 98  | -0.05 | -0.05 | 0.01 | 4.34 | 5.12 | 0.14  |
| C11/07321-07332 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 19.5 | 89.5  | 5   | 0.66 | 20.5  | 24    | 0.8 | 70  | 0.01  | 0.44 | 13 | 97  | -0.06 | -0.06 | 0.01 | 5.39 | 3.94 | 0.06  |
| C11/07333-07344 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 18.5 | 69.2  | 6   | 0.55 | 20    | 22    | 0.6 | 41  | 0.02  | 0.25 | 9  | 100 | 0.06  | -0.05 | 0.01 | 1.61 | 4.23 | 0.11  |
| C11/01186-01197 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 19   | 65.7  | 5   | 0.63 | 19.6  | 22    | 0.7 | 221 | 0.06  | 0.78 | 11 | 98  | 0.12  | -0.06 | 0.05 | 4.99 | 4.88 | 0.68  |
| C11/01198-01209 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 18.1 | 61.3  | 6   | 0.6  | 19.6  | 22    | 0.5 | 178 | 0.07  | 0.88 | 12 | 101 | 0.14  | -0.05 | 0.08 | 4.3  | 4.91 | 0.52  |
| C11/01214-01225 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 16.9 | 80.6  | 4   | 0.73 | 19.7  | 24    | 0.8 | 86  | 0.02  | 0.77 | 15 | 102 | -0.06 | -0.06 | 0.01 | 3.39 | 4.25 | -0.06 |
| C11/01226-01237 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 17.4 | 59.8  | 4   | 0.57 | 19.7  | 23    | 0.6 | 99  | 0.03  | 0.08 | 7  | 79  | -0.06 | -0.06 | 0.01 | 4.04 | 4.51 | -0.06 |
| C11/04396-04407 | PERC  | Torsås               | 56.4167 | 16.1333 | 18.5 | 82.2  | 3   | 0.52 | 20.7  | 26    | 1.4 | 73  | -0.01 | 0.79 | 9  | 101 | -0.05 | -0.05 | 0    | 2.58 | 4.19 | -0.05 |
| C11/04408-04418 | PERC  | Torsås               | 56.4167 | 16.1333 | 17.9 | 77.1  | 3   | 0.8  | 20.8  | 26    | 1.4 | 73  | -0.01 | 0.1  | 10 | 88  | -0.05 | -0.05 | 0.01 | 4.32 | 4.71 | 0.05  |
| C11/02402-02413 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 30.2 | 240.3 | 1   | 12   | 19.3  | 33    | 3.7 | 48  | 0.04  | 0.15 | 42 | 110 | 0.1   | -0.06 | 1.55 | 9.72 | 5.88 | 0.07  |
| C11/02414-02425 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.1 | 140.9 | 1   | 17   | 19.6  | 38    | 2.8 | 35  | 0.01  | 0.59 | 20 | 64  | 0.07  | -0.06 | 0.8  | 7.21 | 2.99 | -0.06 |
| C11/02427-02438 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 28.5 | 212.8 | 1   | 11   | 18.3  | 31    | 2.6 | 84  | 0.02  | 0.22 | 13 | 77  | 0.11  | -0.06 | 0.39 | 6.52 | 3.47 | 0.1   |
| C11/02439-02450 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 25.5 | 141.4 | 1   | 15   | 18.8  | 31    | 2.2 | 65  | 0.02  | 0.1  | 11 | 80  | 0.11  | 0.08  | 0.34 | 6.53 | 3.66 | 0.37  |

Table 2. Data on concentrations of chlorinated substances (ug/g lipid weight) in the different species at the different sites. Each sample consists of a homogenate of 12 individuals. Column one shows identity numbers for the samples included in the analyses. Column two shows the different species names; ZOAR=eelpout, CLUP=herring, PERC=perch, GADU=cod, GADUL=cod liver. Column 3-5 shows site names and their respective coordinates. TOTL=total fish length, TOTW=total fish weight. AGE shows the mean age for all the specimens included. FPRC=fat percentage, MDPRC=muscle dry percentage, LW=liver weight. Minus sign means that the value is below LOQ.

| ACCNR           | GENUS | SITE                 | LATDEG  | LONDEG  | TOTL | TOTW  | AGE | FPRC | MDPRC | LW    | DDE   | DDD    | DDT    | LINDAN  | AHCH    | BHCH    | HCB    | CB-28   | CB-52   | CB-101 | CB-118 | CB-153 | CB-138 | CB-180 |
|-----------------|-------|----------------------|---------|---------|------|-------|-----|------|-------|-------|-------|--------|--------|---------|---------|---------|--------|---------|---------|--------|--------|--------|--------|--------|
| C11/02274-02285 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.6 | 76.2  | 4   | 0.74 | 21.3  | 1.917 | 0.025 | -0.005 | -0.008 | -0.0054 | -0.0054 | -0.0054 | 0.007  | -0.0054 | -0.0054 | -0.005 | 0.011  | 0.043  | 0.024  | 0.008  |
| C11/02286-02297 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 21.1 | 41.1  | 3   | 1    | 21.3  | 0.778 | 0.036 | -0.004 | 0.006  | -0.004  | -0.004  | -0.004  | 0.007  | -0.004  | -0.004  | 0.005  | 0.014  | 0.054  | 0.029  | 0.011  |
| C11/02299-02310 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 23.5 | 62.5  | 4   | 1    | 21.1  | 0.933 | 0.062 | 0.012  | 0.013  | -0.0041 | -0.0041 | -0.0041 | 0.015  | 0.0063  | 0.0082  | 0.029  | 0.104  | 0.299  | 0.18   | 0.057  |
| C11/02311-02322 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 22.8 | 58.3  | 4   | 1.1  | 20.3  | 0.655 | 0.07  | 0.01   | 0.016  | -0.0037 | -0.0037 | -0.0037 | 0.014  | 0.0057  | 0.0068  | 0.026  | 0.118  | 0.439  | 0.241  | 0.103  |
| C11/02351-02362 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 21.8 | 60.2  | 2   | 1    | 23.1  | 1.496 | 0.01  | -0.004 | -0.006 | -0.0041 | -0.0041 | -0.0041 | 0.006  | -0.0041 | -0.0041 | 0.008  | 0.019  | 0.038  | 0.023  | 0.006  |
| C11/02363-02374 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 22.6 | 65.1  | 2   | 0.94 | 22.5  | 1.465 | 0.012 | -0.004 | -0.006 | -0.0043 | -0.0043 | -0.0043 | 0.006  | -0.0043 | -0.0043 | 0.008  | 0.022  | 0.046  | 0.027  | 0.007  |
| C11/02577-02588 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 40.8  | 5   | 3.8  | 21.9  | 0.436 | 0.051 | 0.005  | 0.011  | -0.0042 | -0.0042 | -0.0042 | 0.03   | -0.0042 | -0.0042 | 0.019  | 0.017  | 0.05   | 0.034  | 0.016  |
| C11/02589-02600 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 39.1  | 6   | 2.4  | 22.1  | 0.38  | 0.102 | 0.006  | 0.016  | -0.005  | -0.005  | -0.005  | 0.031  | -0.005  | 0.0082  | 0.035  | 0.036  | 0.1    | 0.071  | 0.034  |
| C11/03758-03769 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 34.2  | 5   | 3.1  | 22.1  | 0.396 | 0.062 | 0.015  | -0.008 | -0.0052 | -0.0052 | 0.0059  | 0.024  | -0.0052 | 0.0056  | 0.018  | 0.015  | 0.05   | 0.038  | 0.019  |
| C11/03770-03781 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 33.9  | 6   | 3.7  | 23.1  | 0.401 | 0.075 | 0.016  | -0.008 | -0.0043 | -0.0043 | 0.0059  | 0.03   | -0.0043 | 0.0064  | 0.024  | 0.017  | 0.066  | 0.045  | 0.026  |
| C11/01239-01250 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 17.3 | 36.9  | 5   | 2.9  | 23.4  | 0.499 | 0.059 | 0.039  | -0.008 | -0.0055 | -0.0055 | -0.0055 | 0.019  | -0.0055 | 0.01    | 0.053  | 0.032  | 0.111  | 0.085  | 0.037  |
| C11/01251-01262 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 11.7 | 38.6  | 6   | 2.9  | 23    | 0.449 | 0.082 | 0.029  | -0.008 | -0.0054 | -0.0054 | -0.0054 | 0.017  | -0.0054 | 0.0099  | 0.049  | 0.037  | 0.119  | 0.086  | 0.043  |
| C11/01086-01097 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.5 | 39    | 4   | 5.4  | 25.9  | 0.629 | 0.22  | 0.382  | -0.009 | -0.0059 | -0.0059 | -0.0059 | 0.014  | 0.1008  | 0.1614  | 0.35   | 0.235  | 0.446  | 0.332  | 0.122  |
| C11/01098-01109 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.6 | 37.9  | 6   | 4.4  | 25.6  | 0.666 | 0.427 | 0.676  | -0.1   | -0.0046 | -0.0046 | 0.0049  | 0.017  | 0.1352  | 0.287   | 0.677  | 0.409  | 0.78   | 0.573  | 0.219  |
| C11/04419-04430 | CLUP  | Torsås               | 56.4167 | 16.1333 | 18   | 51.3  | 7   | 2    | 23.4  | 0.837 | 0.099 | 0.015  | 0.011  | -0.004  | -0.004  | 0.0051  | 0.011  | -0.004  | -0.004  | 0.013  | 0.016  | 0.06   | 0.039  | 0.015  |
| C11/04431-04442 | CLUP  | Torsås               | 56.4167 | 16.1333 | 14.7 | 52.3  | 9   | 2    | 22.8  | 0.895 | 0.147 | 0.025  | 0.007  | -0.004  | -0.004  | 0.0054  | 0.018  | -0.004  | 0.0044  | 0.018  | 0.02   | 0.069  | 0.043  | 0.015  |
| C11/02552-02563 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 73.2  | 6   | 0.62 | 20.4  | 0.563 | 0.02  | -0.006 | -0.01  | -0.0064 | -0.0064 | -0.0064 | 0.014  | -0.0064 | -0.0064 | 0.023  | 0.03   | 0.082  | 0.049  | 0.026  |
| C11/02564-02575 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 74    | 6   | 0.75 | 20.6  | 0.912 | 0.033 | -0.005 | -0.008 | -0.0054 | -0.0054 | -0.0054 | 0.01   | -0.0054 | -0.0054 | 0.029  | 0.044  | 0.098  | 0.057  | 0.027  |
| C11/03658-03669 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 16.8 | 55    | 4   | 0.8  | 20.7  | 0.706 | 0.044 | 0.029  | 0.014  | -0.005  | -0.005  | -0.005  | 0.017  | -0.005  | -0.005  | 0.044  | 0.025  | 0.152  | 0.105  | 0.068  |
| C11/03670-03681 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 15.6 | 56.7  | 4   | 0.69 | 21    | 0.707 | 0.035 | 0.021  | 0.011  | -0.0058 | -0.0058 | -0.0058 | 0.015  | -0.0058 | -0.0058 | 0.039  | 0.023  | 0.134  | 0.097  | 0.059  |
| C11/01289-01300 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 19.4 | 84.1  | 4   | 0.78 | 21.1  | 1.178 | 0.065 | 0.021  | 0.008  | -0.0052 | -0.0052 | -0.0052 | 0.012  | -0.0052 | 0.0101  | 0.085  | 0.056  | 0.212  | 0.131  | 0.063  |
| C11/01301-01312 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 16.5 | 70.1  | 4   | 0.72 | 21.1  | 0.854 | 0.063 | 0.026  | -0.008 | -0.0056 | -0.0056 | -0.0056 | 0.011  | -0.0056 | 0.0095  | 0.089  | 0.062  | 0.216  | 0.15   | 0.073  |
| C11/07321-07332 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 19.5 | 89.5  | 5   | 0.66 | 20.5  | 0.769 | 0.131 | 0.006  | 0.009  | -0.0061 | -0.0061 | -0.0061 | 0.011  | -0.0061 | 0.0077  | 0.055  | 0.054  | 0.195  | 0.126  | 0.07   |
| C11/07333-07344 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 18.5 | 69.2  | 6   | 0.55 | 20    | 0.572 | 0.305 | -0.007 | -0.011 | -0.0073 | -0.0073 | -0.0073 | -0.007 | -0.0073 | 0.0089  | 0.116  | 0.112  | 0.554  | 0.318  | 0.234  |
| C11/01186-01197 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 19   | 65.7  | 5   | 0.63 | 19.6  | 0.667 | 0.98  | 0.429  | -0.1   | -0.0064 | -0.0064 | -0.0064 | 0.015  | 0.0799  | 0.2311  | 1.109  | 0.972  | 3.337  | 2.374  | 0.942  |
| C11/01198-01209 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 18.1 | 61.3  | 6   | 0.6  | 19.6  | 0.522 | 0.671 | 0.301  | -0.1   | -0.0067 | -0.0067 | -0.0067 | 0.01   | 0.054   | 0.1604  | 0.914  | 0.706  | 2.313  | 1.647  | 0.656  |
| C11/01214-01225 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 16.9 | 80.6  | 4   | 0.73 | 19.7  | 0.787 | 0.216 | 0.01   | 0.013  | -0.0055 | -0.0055 | -0.0055 | -0.006 | -0.0055 | -0.0055 | 0.031  | 0.028  | 0.122  | 0.071  | 0.038  |
| C11/01226-01237 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 17.4 | 59.8  | 4   | 0.57 | 19.7  | 0.57  | 0.338 | 0.013  | 0.018  | -0.0071 | -0.0071 | -0.0071 | -0.007 | -0.0071 | -0.0071 | 0.049  | 0.043  | 0.187  | 0.109  | 0.058  |
| C11/04396-04407 | PERC  | Torsås               | 56.4167 | 16.1333 | 18.5 | 82.2  | 3   | 0.52 | 20.7  | 1.416 | 0.061 | -0.008 | -0.012 | -0.0077 | -0.0077 | -0.0077 | -0.008 | -0.0077 | -0.0077 | 0.009  | 0.014  | 0.057  | 0.037  | 0.012  |
| C11/04408-04418 | PERC  | Torsås               | 56.4167 | 16.1333 | 17.9 | 77.1  | 3   | 0.8  | 20.8  | 1.443 | 0.053 | -0.005 | 0.008  | -0.005  | -0.005  | -0.005  | 0.006  | -0.005  | -0.005  | 0.008  | 0.014  | 0.052  | 0.033  | 0.013  |
| C11/02402-02413 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 30.2 | 240.3 | 1   | 0.39 |       |       | 0.108 | -0.01  | -0.015 | -0.0102 | -0.0102 | -0.0102 | -0.01  | -0.0102 | -0.0102 | 0.023  | 0.075  | 0.323  | 0.173  | 0.071  |
| C11/02414-02425 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.1 | 140.9 | 1   | 0.42 |       |       | 0.069 | -0.01  | -0.014 | -0.0096 | -0.0096 | -0.0096 | -0.01  | -0.0096 | -0.0096 | 0.013  | 0.044  | 0.185  | 0.101  | 0.035  |
| C11/02427-02438 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 28.5 | 212.8 | 1   | 0.42 |       |       | 0.087 | -0.009 | -0.014 | -0.0095 | -0.0095 | -0.0095 | -0.009 | -0.0095 | 0.0118  | 0.078  | 0.166  | 0.604  | 0.344  | 0.153  |
| C11/02439-02450 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 25.5 | 141.4 | 1   | 0.43 |       |       | 0.083 | -0.009 | -0.014 | -0.0092 | -0.0092 | -0.0092 | -0.009 | -0.0092 | -0.0092 | 0.081  | 0.145  | 0.504  | 0.297  | 0.128  |
| C11/02402-02413 | GADUL | Kungsbackafjorden    | 57.4    | 12.0667 | 30.2 | 240.3 | 1   | 12   | 19.3  | 3.717 | 0.242 | 0.014  | 0.013  | 0.0014  | 0.001   | 0.0035  | 0.01   | 0.0034  | 0.0052  | 0.041  | 0.136  | 0.697  | 0.403  | 0.128  |
| C11/02414-02425 | GADUL | Kungsbackafjorden    | 57.4    | 12.0667 | 25.1 | 140.9 | 1   | 17   | 19.6  | 2.756 | 0.139 | 0.009  | 0.009  | 0.0013  | 0.001   | 0.0035  | 0.008  | 0.0028  | 0.0046  | 0.026  | 0.087  | 0.376  | 0.202  | 0.078  |
| C11/02427-02438 | GADUL | Rivö fjord           | 57.6833 | 11.7667 | 28.5 | 212.8 | 1   | 11   | 18.3  | 2.597 | 0.237 | 0.045  | 0.004  | 0.0011  | 0.001   | 0.0046  | 0.012  | 0.0186  | 0.0313  | 0.186  | 0.577  | 2.19   | 1.327  | 0.581  |
| C11/02439-02450 | GADUL | Rivö fjord           | 57.6833 | 11.7667 | 25.5 | 141.4 | 1   | 15   | 18.8  | 2.228 | 0.167 | 0.034  | 0.005  | 0.0011  | 0.0009  | 0.004   | 0.01   | 0.0064  | 0.0224  | 0.151  | 0.368  | 1.205  | 0.734  | 0.327  |

Table 3a. Data on concentrations of PCDD/F (pg/g lipid weight) in the different species at the different sites. Each sample consists of a homogenate of 12 individuals. Column one shows identity numbers for the samples included in the analyses. Column two shows the different species names; ZOAR=eelpout, CLUP=herring, PERC=perch, GADU=cod. Column 3-5 shows site names and their respective coordinates. TOTL=total fish length, TOTW=total fish weight. AGE shows the mean age for all the specimens included. FPCR=fat percentage. Minus sign means that the value is below LOQ.

| ACCNR           | GENUS | SITE                 | LATDEG  | LONDEG  | TOTL | TOTW  | AGE | FPCR | TCDD | PECDD | HXCDD1 | HXCDD2 | HXCDD3 | HPCDD | OCDD | TCDF | PECDF1 | PECDF2 | HXCDF1 | HXCDF2 | HXCDF3 | HXCDF4 | HPCDF1 | HPCDF2 | OCDF |
|-----------------|-------|----------------------|---------|---------|------|-------|-----|------|------|-------|--------|--------|--------|-------|------|------|--------|--------|--------|--------|--------|--------|--------|--------|------|
| C11/02274-02285 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.6 | 76.2  | 4   | 0.81 | 1.1  | 1.8   | -0.5   | -0.5   | -0.5   | 3.8   | 4.8  | 22   | 4.5    | 6.6    | 1.4    | 0.8    | 2.6    | 4.2    | 2.5    | -0.7   | -1   |
| C11/02286-02297 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 21.1 | 41.1  | 3   | 0.85 | 1.2  | 2.2   | -0.5   | -0.5   | -0.5   | 4.3   | 6    | 20   | 4.3    | 8.9    | 1.6    | 4.6    | 8.6    | -0.5   | 2.3    | -0.7   | -1   |
| C11/02299-02310 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 23.5 | 62.5  | 4   | 0.93 | 2.3  | 3.9   | -0.5   | 2      | -0.2   | 4.5   | 5.1  | 66   | 14     | 22     | 3.9    | 1.3    | 2.6    | 3.6    | 2.1    | -0.7   | -1   |
| C11/02311-02322 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 22.8 | 58.3  | 4   | 0.91 | 1.9  | 3.7   | -0.5   | 2.3    | -0.5   | 5.2   | 4.9  | 76   | 16     | 22     | 4      | 1.7    | 2.1    | 3      | 2.7    | -0.7   | -1   |
| C11/02351-02362 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 21.8 | 60.2  | 2   | 1.22 | 0.78 | 3     | 1.1    | 1.3    | 0.71   | 2.5   | 3.7  | 23   | 3.7    | 5      | 2      | 0.87   | 2      | 2.7    | 2.5    | 0.73   | 3    |
| C11/02363-02374 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 22.6 | 65.1  | 2   | 1.06 | 0.88 | 3.2   | 0.93   | 1.1    | -0.5   | 2.9   | 3.7  | 16   | 2.9    | 5.3    | 1.1    | 0.48   | 1.7    | 2.9    | 1.3    | -0.7   | 2.2  |
| C11/02577-02588 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 40.8  | 5   | 3.64 | 1.4  | 3.8   | 0.92   | 3.9    | -0.2   | 0.8   | 1.5  | 41   | 7.5    | 36     | 1.4    | 1.8    | 2.1    | 1      | 0.76   | -0.3   | -0.4 |
| C11/02589-02600 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 39.1  | 6   | 3.05 | 1.7  | 4     | 1.3    | 7.2    | 0.61   | 1.2   | 0.92 | 43   | 10     | 62     | 2.2    | 2.8    | 3.1    | 1.3    | 1      | -0.3   | -0.4 |
| C11/03758-03769 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 34.2  | 5   | 3.89 | 1.4  | 3.1   | 0.44   | 2.3    | -0.2   | 0.9   | 0.93 | 24   | 4.7    | 24     | 1      | 1.2    | 1.4    | 0.54   | 0.93   | -0.3   | -0.4 |
| C11/03770-03781 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 33.9  | 6   | 4.79 | 1.6  | 3.3   | 0.82   | 3.5    | 0.39   | 1.3   | 1.1  | 29   | 7      | 36     | 2      | 2.5    | 2.3    | 0.82   | 1.1    | -0.3   | -0.4 |
| C11/01239-01250 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 17.3 | 36.9  | 5   | 3.39 | 2.2  | 3.1   | 0.45   | 3.2    | -0.2   | 1.2   | 1.2  | 30   | 3.9    | 17     | 0.68   | 1.1    | 1.7    | 0.91   | 1.6    | -0.3   | -0.4 |
| C11/01251-01262 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 11.7 | 38.6  | 6   | 3.37 | 1.8  | 2.7   | 0.57   | 3.5    | 0.37   | 1.3   | 1.5  | 25   | 4.1    | 24     | 0.8    | 1.1    | 1.5    | 1      | 1      | -0.3   | -0.4 |
| C11/01086-01097 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.5 | 39    | 4   | 4.82 | 1.5  | 2.2   | 0.45   | 1.6    | 0.24   | 1.8   | 2    | 40   | 3.3    | 34     | 0.64   | 0.7    | 0.7    | 0.64   | 0.75   | -0.3   | -0.4 |
| C11/01098-01109 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.6 | 37.9  | 6   | 5.54 | 2.6  | 3.9   | 0.48   | 2.4    | 0.26   | 1.9   | 3.2  | 71   | 5      | 51     | 0.91   | 1.2    | 1      | 0.61   | 1      | -0.3   | -0.4 |
| C11/04419-04430 | CLUP  | Torsås               | 56.4167 | 16.1333 | 18   | 51.3  | 7   | 2.14 | 1.3  | 3     | 0.8    | 2.1    | 0.39   | 1.7   | 1.6  | 21   | 5.4    | 25     | 1.3    | 1.6    | 2.1    | 2.1    | 1.3    | -0.3   | -0.4 |
| C11/04431-04442 | CLUP  | Torsås               | 56.4167 | 16.1333 | 14.7 | 52.3  | 9   | 1.89 | 1.6  | 3.5   | 1.4    | 3.1    | 0.47   | 2.1   | 2.5  | 27   | 8.3    | 37     | 1.9    | 2.2    | 2.8    | 2.2    | 1.9    | -0.3   | -0.4 |
| C11/02552-02563 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 73.2  | 6   | 0.56 | 1.6  | 2.6   | 1.5    | 2.6    | 0.7    | 6     | 28   | 31   | 7      | 16     | 2.1    | 1      | 4.2    | 6.5    | 2.7    | -0.7   | 5.5  |
| C11/02564-02575 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 74    | 6   | 0.57 | 1.9  | 3.2   | 1.7    | 2.8    | -0.5   | 4.8   | 23   | 28   | 5.9    | 19     | 2.1    | 1.5    | 4.5    | 5.9    | 3.3    | -0.7   | 4.9  |
| C11/03658-03669 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 16.8 | 55    | 4   | 0.59 | 2.1  | 2.8   | 7.1    | 8.5    | 8.1    | 62    | 81   | 29   | 7.1    | 19     | 8.1    | 6.6    | 13     | 11     | 32     | 9.5    | 29   |
| C11/03670-03681 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 15.6 | 56.7  | 4   | 0.58 | 1.9  | 2.4   | -0.5   | 2.2    | -0.5   | 20    | 100  | 23   | 4.1    | 12     | 1.9    | 1.2    | 2.7    | 6.3    | 4.4    | -0.7   | 7.3  |
| C11/01289-01300 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 19.4 | 84.1  | 4   | 0.71 | 5.2  | 3.5   | -0.5   | 2.4    | -0.5   | 13    | 63   | 32   | 3.5    | 11     | 1.1    | 0.83   | 2      | 4      | 1.6    | -0.7   | -1   |
| C11/01301-01312 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 16.5 | 70.1  | 4   | 0.7  | 5.2  | 3.4   | -0.5   | 2.4    | -0.5   | 4.8   | 14   | 34   | 4.8    | 10     | 1.4    | 0.64   | 2.2    | 5.6    | 2.4    | -0.7   | -1   |
| C11/07321-07332 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 19.5 | 89.5  | 5   | 0.6  | 2.9  | 4.7   | -0.5   | 2.7    | -0.5   | 9.3   | 12   | 17   | 4.6    | 12     | 0.79   | 1      | 2.9    | 5.6    | 3.4    | -0.7   | -1   |
| C11/07333-07344 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 18.5 | 69.2  | 6   | 0.52 | 3.2  | 5.4   | -0.5   | 2.9    | -0.5   | 9.1   | 12   | 22   | 7      | 12     | 1.8    | 0.91   | 3.9    | 7      | 2.2    | -0.7   | -1   |
| C11/01186-01197 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 19   | 65.7  | 5   | 0.57 | 7.4  | 5.9   | 2.1    | 3.3    | -0.5   | 14    | 40   | 49   | 6.4    | 64     | 1.8    | 1.4    | 3.6    | 6.9    | 1.8    | -0.7   | -1   |
| C11/01198-01209 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 18.1 | 61.3  | 6   | 0.58 | 5.8  | 5.3   | 1.7    | 2.1    | -0.5   | 10    | 23   | 45   | 4.5    | 58     | 1.4    | 0.87   | 3.8    | 5.8    | 1.2    | -0.7   | -1   |
| C11/01214-01225 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 16.9 | 80.6  | 4   | 0.62 | 1.5  | 2.5   | -0.5   | 1.1    | -0.5   | 4.5   | 10   | 10   | 1.3    | 6.3    | 1.3    | -0.5   | 2.7    | 5.8    | 1.5    | -0.7   | -1   |
| C11/01226-01237 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 17.4 | 59.8  | 4   | 0.57 | 1.1  | 2.6   | -0.5   | 1.5    | -0.5   | 5.9   | 19   | 11   | 1.5    | 9.9    | 0.94   | -0.5   | 3.4    | 5.4    | 1.6    | -0.7   | -1   |
| C11/04396-04407 | PERC  | Torsås               | 56.4167 | 16.1333 | 18.5 | 82.2  | 3   | 0.58 | 1.5  | 3.3   | 2      | 1.8    | -0.5   | 4.3   | 14   | 23   | 4.3    | 14     | 1.6    | 0.82   | 2.9    | 6.8    | 2.3    | -0.7   | -1   |
| C11/04408-04418 | PERC  | Torsås               | 56.4167 | 16.1333 | 17.9 | 77.1  | 3   | 0.56 | 1.9  | 3.1   | 2.3    | 1.9    | -0.5   | 4.2   | 14   | 23   | 5      | 13     | 1.1    | 0.9    | 3.8    | 6.5    | 2.3    | -0.7   | -1   |
| C11/02402-02413 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 30.2 | 240.3 | 1   | 0.34 | -0.2 | 3.3   | 2.7    | 3      | -0.5   | 8.3   | 18   | 27   | 9.2    | 6.5    | 3.5    | 3.6    | 5.3    | 10     | 3.4    | -0.7   | -1   |
| C11/02414-02425 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.1 | 140.9 | 1   | 0.39 | -0.2 | 3.8   | 2.1    | 2.9    | -0.5   | 7.9   | 14   | 16   | 5.2    | 2.4    | 2.6    | 1.9    | 5.5    | 8.6    | 2.9    | -0.7   | -1   |
| C11/02427-02438 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 28.5 | 212.8 | 1   | 0.47 | -0.2 | 2.1   | 2.4    | 3.3    | -0.5   | 5.2   | 16   | 77   | 30     | 4.2    | 4.3    | 4.3    | 3.9    | 8.9    | 3.9    | -0.7   | -1   |
| C11/02439-02450 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 25.5 | 141.4 | 1   | 0.41 | -0.2 | 2.1   | 2.1    | 3      | -0.5   | 5.2   | 17   | 52   | 20     | 2.6    | 3.7    | 3      | 4.7    | 9      | 3      | -0.7   | -1   |



Table 3b. Data on concentrations of PCDD/F+dl-PCB (pg/g lipid weight) in the different species at the different sites. Each sample consists of a homogenate of 12 individuals. Column one shows identity numbers for the samples included in the analyses. Column two shows the different species names; ZOAR=eelpout, CLUP=herring, PERC=perch, GADU=cod. For information of coordinates for the sites and biological parameters, see table 3a. Minus sign means that the value is below LOQ.

| ACCNR           | GENUS | SITE                 | CB-77 | CB-81 | CB-126 | CB-169 | CB-105 | CB-114 | CB-118U | CB-123 | CB-156 | CB-157 | CB-167 | CB-189 | TCDDQV* | CBEQV | TCDDQ05 | CBEQ05 |
|-----------------|-------|----------------------|-------|-------|--------|--------|--------|--------|---------|--------|--------|--------|--------|--------|---------|-------|---------|--------|
| C11/02274-02285 | ZOAR  | Kungsbackafjorden    | 160   | 8     | 120    | 12     | 4800   | 260    | 16000   | 190    | 3200   | 550    | 2000   | 380    | 9.6     | 16    | 8.2     | 13     |
| C11/02286-02297 | ZOAR  | Kungsbackafjorden    | 180   | 9     | 110    | 12     | 4300   | 270    | 14000   | 190    | 3000   | 630    | 1900   | 400    | 12      | 15    | 9.7     | 12     |
| C11/02299-02310 | ZOAR  | Rivö fjord           | 690   | 26    | 360    | 22     | 39000  | 1900   | 130000  | 1300   | 21000  | 4500   | 12000  | 1800   | 26      | 67    | 21      | 43     |
| C11/02311-02322 | ZOAR  | Rivö fjord           | 820   | 30    | 460    | 29     | 46000  | 2300   | 150000  | 1900   | 26000  | 5500   | 16000  | 2500   | 26      | 83    | 22      | 54     |
| C11/02351-02362 | ZOAR  | Askeröfjord          | 480   | 21    | 110    | 7.6    | 8200   | 340    | 25000   | 390    | 3000   | 570    | 2000   | 200    | 9.9     | 16    | 8.8     | 12     |
| C11/02363-02374 | ZOAR  | Askeröfjord          | 420   | 19    | 120    | 7.7    | 9500   | 400    | 29000   | 370    | 3000   | 690    | 2000   | 250    | 9.3     | 18    | 8.2     | 14     |
| C11/02577-02588 | CLUP  | Skelleftebukten      | 240   | 9     | 150    | 43     | 6100   | 380    | 17000   | 250    | 3000   | 610    | 2000   | 360    | 29      | 20    | 21      | 17     |
| C11/02589-02600 | CLUP  | Skelleftebukten      | 230   | 7     | 210    | 81     | 9300   | 610    | 27000   | 360    | 5000   | 1100   | 2000   | 680    | 43      | 29    | 31      | 25     |
| C11/03758-03769 | CLUP  | Örnsköldsviksfjärden | 170   | 5     | 110    | 28     | 4400   | 270    | 13000   | 180    | 3000   | 530    | 1000   | 350    | 20      | 15    | 15      | 13     |
| C11/03770-03781 | CLUP  | Örnsköldsviksfjärden | 190   | 6     | 130    | 40     | 6300   | 380    | 18000   | 240    | 4000   | 730    | 2000   | 520    | 27      | 19    | 20      | 15     |
| C11/01239-01250 | CLUP  | Yttre fjärden        | 280   | 6     | 120    | 21     | 9500   | 520    | 32000   | 450    | 6000   | 1000   | 3000   | 560    | 18      | 20    | 14      | 14     |
| C11/01251-01262 | CLUP  | Yttre fjärden        | 220   | 6     | 120    | 28     | 9600   | 550    | 32000   | 340    | 6000   | 1100   | 3000   | 590    | 20      | 20    | 15      | 14     |
| C11/01086-01097 | CLUP  | Lilla Värtan         | 4000  | 87    | 440    | 26     | 70000  | 3300   | 210000  | 3800   | 26000  | 5100   | 14000  | 1800   | 25      | 91    | 19      | 55     |
| C11/01098-01109 | CLUP  | Lilla Värtan         | 6100  | 120   | 760    | 42     | 130000 | 7200   | 380000  | 6200   | 46000  | 9100   | 24000  | 3200   | 40      | 160   | 30      | 96     |
| C11/04419-04430 | CLUP  | Torsås               | 180   | 6     | 120    | 39     | 4600   | 320    | 15000   | 160    | 3000   | 650    | 1300   | 310    | 20      | 16    | 15      | 14     |
| C11/04431-04442 | CLUP  | Torsås               | 190   | 6     | 150    | 56     | 5500   | 370    | 18000   | 180    | 3100   | 690    | 1400   | 360    | 28      | 20    | 21      | 18     |
| C11/02552-02563 | PERC  | Skelleftebukten      | 700   | 75    | 260    | 24     | 12000  | 1100   | 40000   | 820    | 7700   | 1400   | 4200   | 810    | 18      | 37    | 14      | 29     |
| C11/02564-02575 | PERC  | Skelleftebukten      | 940   | 110   | 400    | 30     | 17000  | 1300   | 56000   | 1000   | 9500   | 1800   | 5300   | 870    | 20      | 54    | 16      | 44     |
| C11/03658-03669 | PERC  | Örnsköldsviksfjärden | 360   | 23    | 250    | 18     | 7500   | 410    | 25000   | 350    | 9100   | 1400   | 5400   | 1400   | 25      | 34    | 21      | 27     |
| C11/03670-03681 | PERC  | Örnsköldsviksfjärden | 370   | 23    | 260    | 17     | 7500   | 400    | 26000   | 370    | 9800   | 1500   | 6100   | 1400   | 14      | 36    | 12      | 28     |
| C11/01289-01300 | PERC  | Yttre fjärden        | 670   | 36    | 300    | 16     | 18000  | 1000   | 57000   | 1000   | 12000  | 2100   | 6900   | 1300   | 19      | 46    | 17      | 34     |
| C11/01301-01312 | PERC  | Yttre fjärden        | 720   | 34    | 280    | 15     | 17000  | 1000   | 62000   | 1000   | 13000  | 2300   | 7100   | 1400   | 19      | 45    | 16      | 32     |
| C11/07321-07332 | PERC  | Östhammarsfjärden    | 700   | 38    | 260    | 24     | 16000  | 1100   | 50000   | 910    | 10000  | 1700   | 5300   | 1100   | 17      | 40    | 14      | 29     |
| C11/07333-07344 | PERC  | Östhammarsfjärden    | 970   | 45    | 530    | 49     | 27000  | 2200   | 120000  | 1500   | 29000  | 4200   | 18000  | 4300   | 19      | 87    | 16      | 61     |
| C11/01186-01197 | PERC  | Lilla Värtan         | 6400  | 370   | 2300   | 100    | 280000 | 13000  | 880000  | 17000  | 170000 | 34000  | 100000 | 17300  | 53      | 461   | 40      | 279    |
| C11/01198-01209 | PERC  | Lilla Värtan         | 5310  | 330   | 1600   | 72     | 190000 | 8200   | 660000  | 12000  | 120000 | 22900  | 72000  | 12200  | 47      | 325   | 35      | 196    |
| C11/01214-01225 | PERC  | Inre Slätbaken       | 300   | 18    | 150    | 13     | 6700   | 460    | 24000   | 390    | 5400   | 920    | 3300   | 700    | 9.4     | 22    | 8.1     | 17     |
| C11/01226-01237 | PERC  | Inre Slätbaken       | 440   | 25    | 220    | 22     | 12000  | 840    | 45000   | 720    | 8700   | 1500   | 5500   | 1100   | 11      | 34    | 9       | 25     |
| C11/04396-04407 | PERC  | Torsås               | 350   | 17    | 140    | 14     | 4100   | 190    | 12000   | 220    | 2400   | 500    | 1700   | 300    | 16      | 17    | 13      | 15     |
| C11/04408-04418 | PERC  | Torsås               | 350   | 17    | 160    | 14     | 4600   | 200    | 14000   | 220    | 2700   | 570    | 1900   | 340    | 16      | 20    | 13      | 17     |
| C11/02402-02413 | GADU  | Kungsbackafjorden    | 390   | 15    | 300    | 47     | 21000  | 1100   | 69000   | 700    | 14000  | 3100   | 7500   | 1600   | 13      | 49    | 11      | 35     |
| C11/02414-02425 | GADU  | Kungsbackafjorden    | 320   | 10    | 220    | 33     | 13000  | 670    | 43000   | 500    | 8100   | 1900   | 5000   | 1000   | 9.3     | 33    | 8.7     | 25     |
| C11/02427-02438 | GADU  | Rivö fjord           | 710   | 18    | 420    | 53     | 42000  | 2000   | 140000  | 1900   | 27000  | 5800   | 16000  | 3000   | 16      | 79    | 15      | 51     |
| C11/02439-02450 | GADU  | Rivö fjord           | 680   | 17    | 390    | 41     | 37000  | 1800   | 130000  | 1600   | 24000  | 5200   | 14000  | 2400   | 12      | 72    | 11      | 47     |

Table 4. Data on concentrations of brominated substances (ng/g lipid weight) in the different species at the different sites. Each sample consists of a homogenate of 12 individuals. Column one shows identity numbers for the samples included in the analyses. Column two shows the different species names; ZOAR=eelpout, CLUP=herring, PERC=perch, GADU=cod, GADUL=cod liver. Column 3-5 shows site names and their respective coordinates. TOTL=total fish length, TOTW=total fish weight. AGE shows the mean age for all the specimens included. FPRC=fat percentage, MDPRC=muscle dry percentage. Minus sign means that the value is below LOQ. \* means that results are lacking.

| ACCNR           | GENUS | SITE                 | LATDEG  | LONDEG  | TOTL | TOTW  | AGE | FPRC | MDPRC | BDE-47 | BDE-99 | BDE-100 | BDE-153 | BDE-154 | HBCDD | BDE-28 |
|-----------------|-------|----------------------|---------|---------|------|-------|-----|------|-------|--------|--------|---------|---------|---------|-------|--------|
| C11/02274-02285 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.6 | 76.2  | 4   | 0.74 | 21.3  | 2.8    | 0.35   | 0.35    | -0.3    | -0.3    | -1    | -0.3   |
| C11/02286-02297 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 21.1 | 41.1  | 3   | 1    | 21.3  | 3.9    | 0.49   | 0.72    | 0.22    | 0.28    | 1.6   | -0.2   |
| C11/02299-02310 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 23.5 | 62.5  | 4   | 1    | 21.1  | 12     | 1.4    | 2.2     | 0.55    | 0.72    | 5.4   | -0.2   |
| C11/02311-02322 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 22.8 | 58.3  | 4   | 1.1  | 20.3  | 12     | 1.6    | 2.1     | 0.71    | 0.72    | 6.2   | -0.2   |
| C11/02351-02362 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 21.8 | 60.2  | 2   | 1    | 23.1  | 0.86   | -0.2   | 0.3     | -0.2    | -0.2    | *     | -0.2   |
| C11/02363-02374 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 22.6 | 65.1  | 2   | 0.94 | 22.5  | 1      | 0.29   | 0.33    | -0.2    | -0.2    | *     | -0.2   |
| C11/02577-02588 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 40.8  | 5   | 3.8  | 21.9  | 9.2    | 4.1    | 1.8     | 0.71    | 1       | 8.6   | 0.7    |
| C11/02589-02600 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 39.1  | 6   | 2.4  | 22.1  | 17     | 4.6    | 3.6     | 1.07    | 1.9     | 14    | 0.78   |
| C11/03758-03769 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 34.2  | 5   | 3.1  | 22.1  | 4.3    | 1.2    | 1.2     | -0.3    | 0.48    | 6.5   | -0.3   |
| C11/03770-03781 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 33.9  | 6   | 3.7  | 23.1  | 5.3    | 1.5    | 1.5     | -0.3    | 0.71    | 7.9   | -0.3   |
| C11/01239-01250 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 17.3 | 36.9  | 5   | 2.9  | 23.4  | 6      | 2.4    | 1.2     | 0.3     | 0.49    | 4.5   | -0.3   |
| C11/01251-01262 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 11.7 | 38.6  | 6   | 2.9  | 23    | 7.2    | 2.3    | 1.5     | 0.32    | 0.72    | 5.5   | -0.3   |
| C11/01086-01097 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.5 | 39    | 4   | 5.4  | 25.9  | 14     | 4.5    | 2.6     | 0.4     | 0.63    | 17    | 0.3    |
| C11/01098-01109 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.6 | 37.9  | 6   | 4.4  | 25.6  | 28     | 7.4    | 4.7     | 0.64    | 0.98    | 26    | 0.61   |
| C11/04419-04430 | CLUP  | Torsås               | 56.4167 | 16.1333 | 18   | 51.3  | 7   | 2    | 23.4  | 3.5    | 0.55   | 1.1     | -0.2    | 0.4     | 4.2   | -0.2   |
| C11/04431-04442 | CLUP  | Torsås               | 56.4167 | 16.1333 | 14.7 | 52.3  | 9   | 2    | 22.8  | 5.1    | 0.68   | 1.6     | -0.2    | 0.47    | 6.6   | -0.2   |
| C11/02552-02563 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 73.2  | 6   | 0.62 | 20.4  | 62     | 52     | 14      | 6.3     | 7.9     | 1.4   | 2.1    |
| C11/02564-02575 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 74    | 6   | 0.75 | 20.6  | 69     | 41     | 13      | 4.9     | 7.3     | 2.2   | 3      |
| C11/03658-03669 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 16.8 | 55    | 4   | 0.8  | 20.7  | 9.8    | 4.8    | 3.5     | 0.57    | 1.5     | 2.1   | -0.3   |
| C11/03670-03681 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 15.6 | 56.7  | 4   | 0.69 | 21    | 9      | 3.6    | 3.3     | 0.56    | 1.5     | 1.7   | -0.3   |
| C11/01289-01300 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 19.4 | 84.1  | 4   | 0.78 | 21.1  | 9.3    | 4.5    | 2.7     | 0.48    | 1.2     | 2.5   | -0.3   |
| C11/01301-01312 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 16.5 | 70.1  | 4   | 0.72 | 21.1  | 9.2    | 5.3    | 2.5     | 0.54    | 0.97    | 1.9   | -0.3   |
| C11/07321-07332 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 19.5 | 89.5  | 5   | 0.66 | 20.5  | 6.6    | 0.89   | 2.5     | -0.3    | 1.4     | 2     | -0.3   |
| C11/07333-07344 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 18.5 | 69.2  | 6   | 0.55 | 20    | 12     | 0.93   | 5.8     | -0.4    | 2.6     | -2    | -0.4   |
| C11/01186-01197 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 19   | 65.7  | 5   | 0.63 | 19.6  | 62     | 27     | 19      | 3.7     | 6.9     | 20    | 0.61   |
| C11/01198-01209 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 18.1 | 61.3  | 6   | 0.6  | 19.6  | 34     | 8.5    | 9.8     | 1.6     | 3.9     | 8     | -0.3   |
| C11/01214-01225 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 16.9 | 80.6  | 4   | 0.73 | 19.7  | 7.4    | 2.7    | 2       | 0.35    | 0.93    | 1.3   | -0.3   |
| C11/01226-01237 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 17.4 | 59.8  | 4   | 0.57 | 19.7  | 11     | 4.2    | 3.3     | 0.59    | 1.4     | -1    | -0.4   |
| C11/04396-04407 | PERC  | Torsås               | 56.4167 | 16.1333 | 18.5 | 82.2  | 3   | 0.52 | 20.7  | 3.1    | -0.4   | 0.79    | -0.4    | 0.6     | -2    | -0.4   |
| C11/04408-04418 | PERC  | Torsås               | 56.4167 | 16.1333 | 17.9 | 77.1  | 3   | 0.8  | 20.8  | 2      | -0.3   | 0.54    | -0.3    | 0.39    | -1    | -0.3   |
| C11/02402-02413 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 30.2 | 240.3 | 1   | 0.39 |       | 8.6    | -0.5   | 2.9     | -0.5    | 0.72    | -2    | -0.5   |
| C11/02414-02425 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.1 | 140.9 | 1   | 0.42 |       | 5.3    | -0.5   | 1.7     | -0.5    | 0.54    | -2    | -0.5   |
| C11/02427-02438 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 28.5 | 212.8 | 1   | 0.42 |       | 13     | -0.5   | 3.7     | -0.5    | 0.71    | -2    | -0.5   |
| C11/02439-02450 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 25.5 | 141.4 | 1   | 0.43 |       | 13     | -0.5   | 3.5     | -0.5    | 0.62    | -2    | -0.5   |
| C11/02402-02413 | GADUL | Kungsbackafjorden    | 57.4    | 12.0667 | 30.2 | 240.3 | 1   | 12   | 19.3  | 15     | 0.094  | 5.3     | -0.1    | 1.8     | 2.3   | 0.33   |
| C11/02414-02425 | GADUL | Kungsbackafjorden    | 57.4    | 12.0667 | 25.1 | 140.9 | 1   | 17   | 19.6  | 14     | 0.13   | 3.9     | -0.1    | 1.2     | 1.6   | 0.37   |
| C11/02427-02438 | GADUL | Rivö fjord           | 57.6833 | 11.7667 | 28.5 | 212.8 | 1   | 11   | 18.3  | 30     | 0.87   | 8.3     | 0.14    | 2       | 3.2   | 0.43   |
| C11/02439-02450 | GADUL | Rivö fjord           | 57.6833 | 11.7667 | 25.5 | 141.4 | 1   | 15   | 18.8  | 32     | 0.96   | 7.7     | 0.26    | 1.9     | 2.6   | 0.7    |

Table 5a. Data on concentrations of perfluoroalkylated substances liver (ng/g wet weight) in the different species at the different sites. Each sample consists of a homogenate of 12 individuals. Column one shows identity numbers for the samples included in the analyses. Column two shows the different species names; ZOAR=eelpout, CLUP=herring, PERC=perch, GADU=cod. Column 3-5 shows site names and their respective coordinates. TOTL=total fish length, TOTW=total fish weight. AGE shows the mean age for all the specimens included. Minus sign means that the value is below LOQ.

| ACCNR           | GENUS | SITE                 | LATDEG  | LONDEG  | TOTL | TOTW  | AGE | PFHXA | PFHPA | PFOA | PFNA | PFDA  | PFUNDA | PFODA | PFTRDA | PFTEDA | PFPEDA | PFBS | PFHXS | PFOS   | PFDS  | FOSA | LFOSA | BFOSA | LPFOS  | BPFS  | LPFDS |
|-----------------|-------|----------------------|---------|---------|------|-------|-----|-------|-------|------|------|-------|--------|-------|--------|--------|--------|------|-------|--------|-------|------|-------|-------|--------|-------|-------|
| C11/02274-02285 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.6 | 76.2  | 4   | -2.0  | -0.1  | 0.37 | 0.49 | 1.19  | 1.08   | 0.46  | 0.71   | 0.1    | -0.05  | -0.1 | -0.1  | 7.37   | -0.05 | 0.63 | 0.59  | 0.04  | 6.39   | 0.98  | -0.05 |
| C11/02286-02297 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 21.1 | 41.1  | 3   | -2.0  | -0.1  | 0.49 | 0.48 | 0.62  | 0.92   | 0.32  | 0.41   | -0.1   | -0.05  | -0.1 | -0.1  | 7.68   | -0.05 | 0.2  | 0.2   | -0.01 | 6.29   | 1.38  | -0.05 |
| C11/02299-02310 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 23.5 | 62.5  | 4   | -2.0  | -0.1  | 0.14 | 0.3  | 0.76  | 1.31   | 0.63  | 0.78   | -0.1   | -0.05  | -0.1 | -0.1  | 8.17   | 0.09  | 0.5  | 0.5   | -0.01 | 6.8    | 1.37  | -0.05 |
| C11/02311-02322 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 22.8 | 58.3  | 4   | -2.0  | -0.1  | 0.15 | 0.31 | 0.87  | 1.48   | 0.67  | 0.86   | -0.1   | -0.05  | -0.1 | 0.13  | 9.03   | -0.05 | 0.51 | 0.5   | 0.01  | 7.67   | 1.36  | -0.05 |
| C11/02351-02362 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 21.8 | 60.2  | 2   | -2.0  | -0.1  | 0.15 | 0.16 | 0.31  | 0.36   | 0.17  | 0.19   | -0.1   | -0.05  | -0.1 | -0.1  | 1.4    | -0.05 | 0.17 | 0.16  | 0.02  | 0.99   | 0.41  | -0.05 |
| C11/02363-02374 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 22.6 | 65.1  | 2   | -2.0  | -0.1  | 0.17 | 0.2  | 0.42  | 0.53   | 0.19  | 0.18   | -0.1   | -0.05  | -0.1 | -0.1  | 2.26   | -0.05 | 0.14 | 0.14  | -0.01 | 1.76   | 0.51  | -0.05 |
| C11/02577-02588 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 40.8  | 5   | -2.0  | -0.1  | 0.28 | 1.49 | 1.13  | 1.38   | 0.48  | 0.9    | -0.1   | -0.05  | -0.1 | -0.1  | 8.09   | -0.05 | 0.38 | 0.24  | 0.15  | 7.44   | 0.64  | -0.05 |
| C11/02589-02600 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 39.1  | 6   | -2.0  | -0.1  | 0.33 | 1.21 | 0.92  | 1.49   | 0.42  | 0.87   | -0.1   | -0.05  | -0.1 | 0.21  | 9.55   | -0.05 | 0.55 | 0.43  | 0.12  | 8.66   | 0.89  | -0.05 |
| C11/03758-03769 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 34.2  | 5   | -2.0  | -0.1  | 0.43 | 0.79 | 0.42  | 0.74   | 0.21  | 0.57   | -0.1   | -0.05  | -0.1 | -0.1  | 6.97   | -0.05 | 0.51 | 0.36  | 0.15  | 6.09   | 0.89  | -0.05 |
| C11/03770-03781 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 33.9  | 6   | -2.0  | -0.1  | 0.36 | 0.79 | 0.42  | 0.75   | 0.22  | 0.5    | -0.1   | -0.05  | -0.1 | 0.14  | 7.77   | -0.05 | 0.71 | 0.45  | 0.26  | 6.97   | 0.8   | -0.05 |
| C11/01239-01250 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 17.3 | 36.9  | 5   | -2.0  | -0.1  | 0.66 | 2.43 | 2.21  | 2.3    | 1.03  | 1.24   | 0.13   | -0.05  | -0.1 | 0.21  | 24.87  | 0.16  | 1.23 | 1.04  | 0.19  | 23.67  | 1.19  | 0.08  |
| C11/01251-01262 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 17.5 | 38.6  | 6   | -2.0  | -0.1  | 0.54 | 1.84 | 1.67  | 2.03   | 1.06  | 0.88   | -0.1   | 0.03   | -0.1 | 0.19  | 25.2   | 0.13  | 1.15 | 1.02  | 0.13  | 23.62  | 1.58  | 0.13  |
| C11/01086-01097 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 18   | 39    | 4   | -2.0  | -0.1  | 1.1  | 1.02 | 2.48  | 1.3    | 1.55  | 1.01   | 0.33   | 0.06   | -0.1 | 0.72  | 56.61  | 0.39  | 3.6  | 3.09  | 0.52  | 54.2   | 2.42  | 0.27  |
| C11/01098-01109 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 18.1 | 37.9  | 6   | -2.0  | -0.1  | 1.06 | 0.87 | 2.35  | 1.07   | 1.66  | 0.9    | 0.54   | 0.11   | -0.1 | 0.57  | 55.35  | 0.62  | 6.56 | 5.79  | 0.76  | 51.86  | 3.5   | 0.36  |
| C11/04419-04430 | CLUP  | Torsås               | 56.4167 | 16.1333 | 19.6 | 51.3  | 7   | -2.0  | -0.1  | 2.34 | 2.09 | 0.67  | 0.83   | 0.21  | 0.62   | -0.1   | -0.05  | -0.1 | 0.37  | 11.63  | -0.05 | 1.11 | 0.9   | 0.21  | 10.51  | 1.12  | -0.05 |
| C11/04431-04442 | CLUP  | Torsås               | 56.4167 | 16.1333 | 19.6 | 52.3  | 9   | -2.0  | -0.1  | 2.19 | 2.19 | 0.89  | 0.89   | 0.22  | 0.52   | -0.1   | -0.05  | -0.1 | 0.39  | 13.26  | -0.05 | 0.78 | 0.64  | 0.13  | 11.53  | 1.73  | -0.05 |
| C11/02552-02563 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 73.2  | 6   | -2.0  | -0.1  | 0.45 | 3.45 | 3.55  | 3.7    | 1.28  | 1.14   | 0.16   | 0.13   | -0.1 | 0.16  | 39.38  | -0.05 | 0.12 | 0.08  | 0.04  | 34.45  | 4.93  | -0.05 |
| C11/02564-02575 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 74    | 6   | -2.0  | -0.1  | 0.21 | 2.18 | 2.58  | 4.33   | 1.19  | 1.76   | 0.13   | 0.06   | -0.1 | -0.1  | 23.03  | 0.08  | 0.05 | 0.05  | -0.01 | 19.3   | 3.73  | -0.05 |
| C11/03658-03669 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 16.8 | 55    | 4   | -2.0  | -0.1  | 0.24 | 1.1  | 1.07  | 1.64   | 0.43  | 1.02   | 0.21   | 0.09   | -0.1 | 0.26  | 21.11  | -0.05 | 0.05 | 0.04  | 0.01  | 16.32  | 4.79  | -0.05 |
| C11/03670-03681 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17   | 56.7  | 4   | -2.0  | -0.1  | 0.34 | 1.1  | 0.88  | 1.35   | 0.5   | 0.26   | -0.1   | -0.05  | -0.1 | 0.29  | 21.77  | -0.05 | 0.05 | 0.03  | 0.01  | 15.86  | 5.91  | -0.05 |
| C11/01289-01300 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 19.4 | 84.1  | 4   | -2.0  | -0.1  | 0.19 | 2.17 | 2.4   | 2.43   | 1.08  | 1.61   | 0.35   | 0.12   | -0.1 | 0.21  | 32.75  | 0.2   | 0.12 | 0.1   | 0.02  | 28.16  | 4.59  | 0.07  |
| C11/01301-01312 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 18   | 70.1  | 4   | -2.0  | -0.1  | 0.42 | 2.06 | 2.61  | 2.8    | 1.29  | 1.76   | 0.14   | -0.05  | -0.1 | 0.21  | 33.83  | 0.29  | 0.12 | 0.1   | 0.02  | 29.24  | 4.59  | 0.12  |
| C11/07321-07332 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 19.5 | 89.5  | 5   | -2.0  | -0.1  | 0.2  | 1.27 | 1.55  | 2.08   | 0.79  | 1.19   | 0.66   | 0.31   | -0.1 | -0.1  | 23.53  | 0.15  | 0.04 | 0.04  | -0.01 | 20.21  | 3.32  | -0.05 |
| C11/07333-07344 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 18.5 | 69.2  | 6   | -2.0  | -0.1  | 0.07 | 0.74 | 1.25  | 1.48   | 0.49  | 1.15   | 0.5    | 0.15   | -0.1 | -0.1  | 25.03  | 0.11  | 0.02 | 0.02  | -0.01 | 21.94  | 3.09  | -0.05 |
| C11/01186-01197 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 19   | 65.7  | 5   | -2.0  | -0.1  | 0.16 | 1.18 | 13.22 | 7.49   | 8.1   | 4.39   | 6.9    | 1.48   | -0.1 | 0.65  | 448.5  | 5.43  | 1.58 | 1.41  | 0.18  | 401.21 | 47.29 | 2.34  |
| C11/01198-01209 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 18.1 | 61.3  | 6   | -2.0  | -0.1  | 0.12 | 0.78 | 9.56  | 5.72   | 4.49  | 1.75   | 2.9    | 0.77   | -0.1 | 0.82  | 164.12 | 3.24  | 1.13 | 0.99  | 0.14  | 139.17 | 24.95 | 1.45  |
| C11/01214-01225 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 18.4 | 80.6  | 4   | -2.0  | -0.1  | 0.17 | 1.79 | 4.71  | 3.63   | 1.27  | 0.94   | 1.12   | 0.4    | -0.1 | 0.12  | 56.33  | 0.36  | 0.21 | 0.19  | 0.02  | 50.08  | 6.26  | 0.07  |
| C11/01226-01237 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 17.4 | 59.8  | 4   | -2.0  | -0.1  | 0.16 | 1.69 | 4.14  | 2.98   | 1.06  | 0.84   | 0.89   | 0.41   | -0.1 | -0.1  | 56.72  | 0.35  | 0.15 | 0.13  | 0.02  | 50.87  | 5.85  | 0.09  |
| C11/04396-04407 | PERC  | Torsås               | 56.4167 | 16.1333 | 18.5 | 82.2  | 3   | -2.0  | -0.1  | 0.8  | 3.62 | 2.65  | 2.73   | 0.7   | 1.38   | 1.37   | 0.18   | -0.1 | 0.2   | 34.93  | 0.17  | 0.15 | 0.13  | 0.02  | 29.76  | 5.17  | -0.08 |
| C11/04408-04418 | PERC  | Torsås               | 56.4167 | 16.1333 | 17.9 | 77.1  | 3   | -2.0  | -0.1  | 1.05 | 4.17 | 1.87  | 2.22   | 0.67  | 0.95   | 0.73   | 0.24   | -0.1 | 0.27  | 23.27  | 0.1   | 0.19 | 0.17  | 0.03  | 19.7   | 3.57  | 0.05  |
| C11/02402-02413 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 30.2 | 240.3 | 1   | -2.0  | -0.1  | 0.42 | 1.14 | 1.64  | 2.43   | 1.89  | 1.42   | 0.68   | 0.14   | -0.1 | -0.1  | 7.18   | -0.05 | 1.62 | 1.53  | 0.09  | 5.71   | 1.48  | -0.05 |
| C11/02414-02425 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.1 | 140.9 | 1   | -2.0  | -0.1  | 0.36 | 1.3  | 1.57  | 1.53   | 0.47  | 0.59   | 0.33   | 0.13   | -0.1 | -0.1  | 6.35   | -0.05 | 0.96 | 0.9   | 0.05  | 5.1    | 1.25  | -0.05 |
| C11/02427-02438 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 28.5 | 212.8 | 1   | -2.0  | -0.1  | 0.18 | 0.52 | 0.94  | 1.01   | 0.46  | 0.82   | 0.4    | 0.2    | -0.1 | -0.1  | 6.15   | 0.05  | 1.71 | 1.61  | 0.1   | 4.88   | 1.27  | 0.05  |
| C11/02439-02450 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 25.5 | 141.4 | 1   | -2.0  | -0.1  | 0.19 | 0.48 | 1.02  | 1.2    | 0.46  | 0.82   | 0.66   | 0.15   | -0.1 | -0.1  | 6.06   | 0.06  | 1.34 | 1.24  | 0.1   | 4.83   | 1.23  | 0.06  |

Table 5b. Data on concentrations of perfluoroalkylated substances in muscle (ng/g wet weight) in the different species at the different sites. Each sample consists of a homogenate of 12 individuals. Column one shows identity numbers for the samples included in the analyses. Column two shows the different species names; ZOAR=eelpout, CLUP=herring, PERC=perch, GADU=cod. Column 3-5 shows site names and their respective coordinates. TOTL=total fish length, TOTW=total fish weight. AGE shows the mean age for all the specimens included. Minus sign means that the value is below LOQ.

| ACCNR           | GENUS | SITE                 | LATDEG  | LONDEG  | TOTL | TOTW  | AGE | PFHXA | PFHPA | PFOA  | PFNA | PFDA  | PFUNDA | PFDOA | PFTRDA | PFTEDA | PFPEA | PFBS  | PFHXS | LPFOS | BPPOS | PFOS  | LPFDS | BPFD  | PFDS  | LFOSA | BFOSA | FOSA  |
|-----------------|-------|----------------------|---------|---------|------|-------|-----|-------|-------|-------|------|-------|--------|-------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| C11/02274-02285 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.6 | 76.2  | 4   | -0.02 | -0.03 | 0.04  | 0.13 | 0.25  | 0.35   | 0.31  | 0.18   | 0.12   | 0.02  | -0.02 | -0.02 | 1.12  | 0.21  | 1.33  | -0.01 | -0.01 | -0.01 | 0.09  | -0.01 | 0.09  |
| C11/02286-02297 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 21.1 | 41.1  | 3   | -0.02 | -0.03 | 0.05  | 0.08 | 0.18  | 0.27   | 0.12  | 0.13   | -0.05  | 0.02  | -0.02 | -0.02 | 0.89  | 0.15  | 1.03  | -0.01 | -0.01 | -0.01 | 0.07  | -0.01 | 0.07  |
| C11/02299-02310 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 23.5 | 62.5  | 4   | -0.02 | -0.03 | 0.03  | 0.04 | 0.11  | 0.21   | 0.12  | 0.16   | -0.05  | 0.01  | -0.02 | -0.02 | 0.67  | 0.12  | 0.79  | -0.01 | -0.01 | -0.01 | 0.17  | -0.01 | 0.17  |
| C11/02311-02322 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 22.8 | 58.3  | 4   | -0.02 | -0.03 | 0.04  | 0.04 | 0.13  | 0.29   | 0.13  | 0.17   | -0.05  | 0.02  | -0.02 | -0.02 | 0.75  | 0.14  | 0.89  | -0.01 | -0.01 | -0.01 | 0.19  | -0.01 | 0.19  |
| C11/02351-02362 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 21.8 | 60.2  | 2   | -0.02 | -0.03 | 0.03  | 0.04 | 0.05  | 0.13   | 0.05  | 0.06   | -0.05  | -0.01 | -0.02 | -0.02 | 0.07  | -0.05 | 0.07  | -0.01 | -0.01 | -0.01 | 0.04  | -0.01 | 0.04  |
| C11/02363-02374 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 22.6 | 65.1  | 2   | -0.02 | -0.03 | 0.04  | 0.04 | 0.06  | 0.12   | 0.06  | 0.07   | -0.05  | -0.01 | -0.02 | -0.02 | 0.16  | -0.05 | 0.16  | -0.01 | -0.01 | -0.01 | 0.05  | -0.01 | 0.05  |
| C11/02577-02588 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 40.8  | 5   | -0.02 | -0.03 | 0.04  | 0.11 | 0.07  | 0.1    | -0.05 | 0.07   | -0.05  | -0.01 | -0.02 | -0.02 | 0.5   | -0.05 | 0.5   | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| C11/02590-02600 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 39.1  | 6   | -0.02 | -0.03 | 0.04  | 0.09 | 0.06  | 0.11   | -0.05 | 0.1    | -0.05  | 0.02  | -0.02 | -0.02 | 0.43  | -0.05 | 0.43  | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| C11/03758-03769 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 34.2  | 5   | -0.02 | -0.03 | 0.03  | 0.05 | -0.03 | 0.03   | -0.05 | 0.03   | -0.05  | -0.01 | -0.02 | -0.02 | 0.3   | -0.05 | 0.3   | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| C11/03770-03781 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 33.9  | 6   | -0.02 | -0.03 | -0.02 | 0.06 | -0.03 | 0.09   | -0.05 | 0.08   | -0.05  | -0.01 | -0.02 | -0.02 | 0.51  | -0.05 | 0.51  | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| C11/01239-01250 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 17.3 | 36.9  | 5   | -0.02 | -0.03 | 0.04  | 0.1  | 0.06  | 0.11   | 0.07  | 0.14   | -0.05  | -0.01 | -0.02 | -0.02 | 1.08  | 0.09  | 1.16  | -0.01 | -0.01 | -0.01 | 0.01  | -0.01 | 0.01  |
| C11/01251-01262 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 11.7 | 38.6  | 6   | -0.02 | -0.03 | 0.05  | 0.11 | 0.09  | 0.13   | 0.06  | 0.11   | -0.05  | -0.01 | -0.02 | -0.02 | 0.98  | 0.06  | 1.04  | -0.01 | -0.01 | -0.01 | 0.02  | -0.01 | 0.02  |
| C11/01086-01097 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.5 | 39    | 4   | -0.02 | -0.03 | 0.08  | 0.07 | 0.12  | 0.08   | 0.15  | 0.2    | 0.07   | 0.01  | -0.02 | 0.03  | 3.1   | 0.15  | 3.25  | 0.02  | -0.01 | 0.02  | 0.1   | 0.02  | 0.12  |
| C11/01098-01109 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.6 | 37.9  | 6   | -0.02 | -0.03 | 0.09  | 0.09 | 0.14  | 0.12   | 0.18  | 0.18   | 0.07   | -0.01 | -0.02 | 0.05  | 3.29  | 0.14  | 3.43  | 0.01  | -0.01 | 0.01  | 0.11  | -0.01 | 0.11  |
| C11/04419-04430 | CLUP  | Torsås               | 56.4167 | 16.1333 | 18   | 51.3  | 7   | -0.02 | -0.03 | 0.13  | 0.15 | 0.06  | 0.08   | -0.05 | 0.08   | -0.05  | -0.01 | -0.02 | 0.03  | 0.64  | 0.09  | 0.72  | -0.01 | -0.01 | -0.01 | 0.03  | -0.01 | 0.03  |
| C11/04431-04442 | CLUP  | Torsås               | 56.4167 | 16.1333 | 14.7 | 52.3  | 9   | -0.02 | -0.03 | 0.15  | 0.12 | 0.06  | 0.08   | -0.05 | 0.06   | -0.05  | -0.01 | -0.02 | 0.03  | 0.67  | 0.09  | 0.76  | -0.01 | -0.01 | -0.01 | 0.03  | 0.01  | 0.04  |
| C11/02552-02563 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 73.2  | 6   | -0.02 | -0.03 | 0.04  | 0.21 | 0.25  | 0.36   | 0.25  | 0.26   | 0.05   | 0.03  | -0.02 | -0.02 | 1.32  | 0.16  | 1.49  | -0.01 | -0.01 | -0.01 | 0.01  | -0.01 | 0.01  |
| C11/02564-02575 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 74    | 6   | -0.02 | -0.03 | -0.02 | 0.21 | 0.21  | 0.37   | 0.16  | 0.31   | 0.06   | 0.03  | -0.02 | -0.02 | 1.35  | 0.19  | 1.54  | -0.01 | -0.01 | -0.01 | 0.02  | -0.01 | 0.02  |
| C11/03658-03669 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 16.8 | 55    | 4   | -0.02 | -0.03 | 0.02  | 0.12 | 0.05  | 0.17   | 0.05  | 0.05   | -0.05  | -0.01 | -0.02 | -0.02 | 0.97  | 0.24  | 1.21  | -0.01 | -0.01 | -0.01 | 0.01  | -0.01 | 0.01  |
| C11/03670-03681 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 15.6 | 56.7  | 4   | -0.02 | -0.03 | 0.04  | 0.1  | 0.07  | 0.11   | -0.05 | 0.1    | -0.05  | -0.01 | -0.02 | 0.02  | 1     | 0.31  | 1.31  | -0.01 | -0.01 | -0.01 | 0.02  | -0.01 | 0.02  |
| C11/01289-01300 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 19.4 | 84.1  | 4   | -0.02 | -0.03 | -0.02 | 0.21 | 0.26  | 0.35   | 0.25  | 0.2    | 0.11   | -0.01 | -0.02 | -0.02 | 1.98  | 0.22  | 2.2   | 0.01  | 0.02  | 0.03  | 0.02  | -0.01 | 0.02  |
| C11/01301-01312 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 16.5 | 70.1  | 4   | -0.02 | -0.03 | 0.03  | 0.15 | 0.21  | 0.32   | 0.14  | 0.17   | 0.09   | -0.01 | -0.02 | -0.02 | 1.67  | 0.2   | 1.87  | -0.01 | -0.01 | -0.01 | 0.02  | -0.01 | 0.02  |
| C11/07321-07332 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 19.5 | 89.5  | 5   | -0.02 | -0.03 | 0.02  | 0.12 | 0.12  | 0.22   | 0.07  | 0.12   | -0.05  | -0.01 | -0.02 | -0.02 | 1.28  | 0.17  | 1.45  | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| C11/07333-07344 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 18.5 | 69.2  | 6   | -0.02 | -0.03 | -0.02 | 0.08 | 0.09  | 0.18   | 0.07  | 0.12   | -0.05  | -0.01 | -0.02 | -0.02 | 1.23  | 0.11  | 1.35  | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| C11/01186-01197 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 19   | 65.7  | 5   | -0.02 | -0.03 | -0.02 | 0.08 | 0.98  | 0.67   | 0.84  | 0.66   | 0.39   | 0.04  | -0.02 | -0.02 | 28.53 | 1.8   | 30.33 | 0.12  | 0.08  | 0.2   | 0.17  | -0.01 | 0.17  |
| C11/01198-01209 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 18.1 | 61.3  | 6   | -0.02 | -0.03 | -0.02 | 0.06 | 0.62  | 0.44   | 0.41  | 0.33   | 0.13   | -0.01 | -0.02 | 0.04  | 8.76  | 0.95  | 9.72  | 0.05  | 0.08  | 0.13  | 0.09  | 0.01  | 0.1   |
| C11/01214-01225 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 16.9 | 80.6  | 4   | -0.02 | -0.03 | 0.03  | 0.13 | 0.28  | 0.34   | 0.12  | 0.13   | -0.05  | -0.01 | -0.02 | -0.02 | 2.83  | 0.22  | 3.05  | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 | -0.01 |
| C11/01226-01237 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 17.4 | 59.8  | 4   | -0.02 | -0.03 | 0.03  | 0.15 | 0.25  | 0.38   | 0.11  | 0.08   | -0.05  | -0.01 | -0.02 | -0.02 | 3.06  | 0.23  | 3.29  | -0.01 | -0.01 | -0.01 | 0.01  | -0.01 | 0.01  |
| C11/04396-04407 | PERC  | Torsås               | 56.4167 | 16.1333 | 18.5 | 82.2  | 3   | -0.02 | -0.03 | 0.04  | 0.35 | 0.21  | 0.34   | 0.07  | 0.11   | -0.05  | -0.01 | -0.02 | -0.02 | 1.73  | 0.24  | 1.96  | -0.01 | -0.01 | -0.01 | 0.02  | -0.01 | 0.02  |
| C11/04408-04418 | PERC  | Torsås               | 56.4167 | 16.1333 | 17.9 | 77.1  | 3   | -0.02 | -0.03 | 0.03  | 0.25 | 0.18  | 0.25   | 0.06  | 0.13   | -0.05  | -0.01 | -0.02 | -0.02 | 1.28  | 0.18  | 1.45  | -0.01 | -0.01 | -0.01 | 0.02  | -0.01 | 0.02  |
| C11/02402-02413 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 30.2 | 240.3 | 1   | -0.02 | -0.03 | 0.03  | 0.08 | 0.12  | 0.18   | 0.06  | 0.12   | -0.05  | -0.01 | -0.02 | -0.02 | 0.47  | 0.09  | 0.56  | -0.01 | -0.01 | -0.01 | 0.17  | -0.01 | 0.17  |
| C11/02414-02425 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.1 | 140.9 | 1   | -0.02 | -0.03 | 0.03  | 0.03 | 0.1   | 0.11   | 0.15  | 0.05   | 0.1    | -0.05 | -0.01 | -0.02 | 0.37  | 0.06  | 0.43  | -0.01 | -0.01 | -0.01 | 0.15  | -0.01 | 0.15  |
| C11/02427-02438 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 28.5 | 212.8 | 1   | -0.02 | -0.03 | 0.02  | 0.09 | 0.07  | 0.1    | -0.05 | 0.06   | -0.05  | -0.01 | -0.02 | -0.02 | 0.38  | 0.08  | 0.47  | -0.01 | -0.01 | -0.01 | 0.24  | 0.03  | 0.27  |
| C11/02439-02450 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 25.5 | 141.4 | 1   | -0.02 | -0.03 | 0.05  | 0.07 | 0.09  | 0.19   | 0.07  | 0.08   | -0.05  | -0.01 | -0.02 | -0.02 | 0.52  | 0.14  | 0.65  | -0.01 | -0.01 | -0.01 | 0.4   | 0.02  | 0.42  |

Table 6. Data on concentrations of DEHP, HCB, PCB, HCB (ng/g wet weight) in the different species at the different sites. Each sample consists of a homogenate of 12 individuals. Column one shows identity numbers for the samples included in the analyses. Column two shows the different species names; ZOAR=eelpout, CLUP=herring, PERC=perch, GADU=cod. Column 3-5 shows site names and their respective coordinates. TOTL=total fish length, TOTW=total fish weight. AGE shows the mean age for all the specimens included. FPRC=fat percentage, MDPRC=muscle dry percentage, LW=liver weight. Minus sign means that the value is below LOQ.

| ACCNR           | GENUS | SITE                 | LATDEG  | LONDEG  | TOTL | TOTW  | AGE | FPRC | MDPRC | LW    | DEHP | HCB   | PCB   | HCB   |
|-----------------|-------|----------------------|---------|---------|------|-------|-----|------|-------|-------|------|-------|-------|-------|
| C11/02274-02285 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.6 | 76.2  | 4   | 0.81 | 21.3  | 1.917 | -6   | -0.05 | -0.05 | -0.05 |
| C11/02286-02297 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 21.1 | 41.1  | 3   | 0.85 | 21.3  | 0.778 | -6   | -0.05 | -0.05 | -0.05 |
| C11/02299-02310 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 23.5 | 62.5  | 4   | 0.93 | 21.1  | 0.933 | 9    | -0.05 | -0.05 | 0.094 |
| C11/02311-02322 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 22.8 | 58.3  | 4   | 0.91 | 20.3  | 0.655 | -6   | -0.05 | -0.05 | 0.057 |
| C11/02351-02362 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 21.8 | 60.2  | 2   | 1.22 | 23.1  | 1.496 | -6   | -0.05 | -0.05 | -0.05 |
| C11/02363-02374 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 22.6 | 65.1  | 2   | 1.06 | 22.5  | 1.465 | -6   | -0.05 | -0.05 | 0.069 |
| C11/02577-02588 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 40.8  | 5   | 3.64 | 21.9  | 0.436 | -12  | -0.05 | -0.05 | -0.05 |
| C11/02589-02600 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18.1 | 39.1  | 6   | 3.05 | 22.1  | 0.38  | -12  | -0.05 | -0.05 | -0.05 |
| C11/03758-03769 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 34.2  | 5   | 3.89 | 22.1  | 0.396 | -12  | -0.05 | -0.05 | -0.05 |
| C11/03770-03781 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 33.9  | 6   | 4.79 | 23.1  | 0.401 | -12  | -0.05 | -0.05 | -0.05 |
| C11/01239-01250 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 17.3 | 36.9  | 5   | 3.39 | 23.4  | 0.499 | -6   | -0.05 | -0.05 | 0.028 |
| C11/01251-01262 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 11.7 | 38.6  | 6   | 3.37 | 23    | 0.449 | 6.5  | -0.05 | -0.05 | 0.035 |
| C11/01086-01097 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.5 | 39    | 4   | 4.82 | 25.9  | 0.629 | 9.9  | -0.05 | -0.05 | 0.26  |
| C11/01098-01109 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 16.6 | 37.9  | 6   | 5.54 | 25.6  | 0.666 | -12  | -0.05 | -0.05 | 0.38  |
| C11/04419-04430 | CLUP  | Torsås               | 56.4167 | 16.1333 | 18   | 51.3  | 7   | 2.14 | 23.4  | 0.837 | -12  | -0.05 | -0.05 | 0.15  |
| C11/04431-04442 | CLUP  | Torsås               | 56.4167 | 16.1333 | 14.7 | 52.3  | 9   | 1.89 | 22.8  | 0.895 | -12  | -0.05 | -0.05 | 0.61  |
| C11/02552-02563 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 73.2  | 6   | 0.56 | 20.4  | 0.563 | -6   | -0.05 | -0.05 | -0.05 |
| C11/02564-02575 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 74    | 6   | 0.57 | 20.6  | 0.912 | -6   | -0.05 | -0.05 | -0.05 |
| C11/03658-03669 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 16.8 | 55    | 4   | 0.59 | 20.7  | 0.706 | -6   | -0.05 | -0.05 | -0.05 |
| C11/03670-03681 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 15.6 | 56.7  | 4   | 0.58 | 21    | 0.707 | -6   | -0.05 | -0.05 | -0.05 |
| C11/01289-01300 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 19.4 | 84.1  | 4   | 0.71 | 21.1  | 1.178 | -6   | -0.05 | -0.05 | -0.05 |
| C11/01301-01312 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 16.5 | 70.1  | 4   | 0.7  | 21.1  | 0.854 | -6   | -0.05 | -0.05 | -0.05 |
| C11/07321-07332 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 19.5 | 89.5  | 5   | 0.6  | 20.5  | 0.769 | -6   | -0.05 | -0.05 | -0.05 |
| C11/07333-07344 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 18.5 | 69.2  | 6   | 0.52 | 20    | 0.572 | -6   | -0.05 | -0.05 | -0.05 |
| C11/01186-01197 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 19   | 65.7  | 5   | 0.57 | 19.6  | 0.667 | -6   | -0.05 | -0.05 | -0.05 |
| C11/01198-01209 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 18.1 | 61.3  | 6   | 0.58 | 19.6  | 0.522 | -6   | -0.05 | -0.05 | -0.05 |
| C11/01214-01225 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 16.9 | 80.6  | 4   | 0.62 | 19.7  | 0.787 | -6   | -0.05 | -0.05 | -0.05 |
| C11/01226-01237 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 17.4 | 59.8  | 4   | 0.57 | 19.7  | 0.57  | -6   | -0.05 | -0.05 | -0.05 |
| C11/04396-04407 | PERC  | Torsås               | 56.4167 | 16.1333 | 18.5 | 82.2  | 3   | 0.58 | 20.7  | 1.416 | -6   | -0.05 | -0.05 | -0.05 |
| C11/04408-04418 | PERC  | Torsås               | 56.4167 | 16.1333 | 17.9 | 77.1  | 3   | 0.56 | 20.8  | 1.443 | -6   | -0.05 | -0.05 | -0.05 |
| C11/02402-02413 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 30.2 | 240.3 | 1   | 0.34 | 19.3  | 3.717 | -6   | -0.05 | -0.05 | -0.05 |
| C11/02414-02425 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 25.1 | 140.9 | 1   | 0.39 | 19.6  | 2.756 | -6   | -0.05 | -0.05 | -0.05 |
| C11/02427-02438 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 28.5 | 212.8 | 1   | 0.47 | 18.3  | 2.597 | -6   | -0.05 | -0.05 | -0.05 |
| C11/02439-02450 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 25.5 | 141.4 | 1   | 0.41 | 18.8  | 2.228 | -6   | -0.05 | -0.05 | -0.05 |

Table 7. Data on concentrations of organotin compounds and chlorinated paraffins (ng/g wet weight) in the different species at the different sites. Each sample consists of a homogenate of 24 individuals. Column one shows identity numbers for the samples included in the analyses. Column two shows the different species names; ZOAR=eelpout, CLUP=herring, PERC=perch, GADU=cod. Column 3-5 shows site names and their respective coordinates. TOTL=total fish length, TOTW=total fish weight. AGE shows the mean age for all the specimens included. LW=liver weight. Minus sign means that the value is below LOQ.

| ACCNR           | GENUS | SITE                 | LATDEG  | LONDEG  | TOTL | TOTW  | AGE | LW    | MBT | DIBT | TBT | MPT | DIPT | TPT | MOT | DIOT | SCCP | MCCP |
|-----------------|-------|----------------------|---------|---------|------|-------|-----|-------|-----|------|-----|-----|------|-----|-----|------|------|------|
| C11/02274-02297 | ZOAR  | Kungsbackafjorden    | 57.4    | 12.0667 | 23.4 | 58.7  | 3   | 1.348 | -1  | -1   | -1  | -1  | -1   | -1  | -1  | -1   | 1.8  | 11   |
| C11/02299-02322 | ZOAR  | Rivö fjord           | 57.6833 | 11.7667 | 23.2 | 60.4  | 4   | 0.794 | 1.8 | 8.2  | 3.8 | -1  | -1   | -1  | -1  | -1   | 16   | 17   |
| C11/02351-02374 | ZOAR  | Askeröfjord          | 58.0667 | 11.7667 | 22.2 | 62.6  | 2   | 1.481 | -1  | -1   | -1  | -1  | -1   | -1  | -1  | -1   | 2    | 3.3  |
| C11/01239-01262 | CLUP  | Yttre fjärden        | 60.7    | 17.3    | 17.4 | 37.8  | 5   | 0.474 | 3.1 | 5.7  | 16  | -1  | -1   | -1  | -1  | -1   | 7.5  | 7.6  |
| C11/01086-01109 | CLUP  | Lilla Värtan         | 59.3333 | 18.1667 | 18   | 38.5  | 5   | 0.648 | 48  | 36   | 110 | -1  | -1   | -1  | -1  | -1   | 15   | 5.6  |
| C11/04419-04442 | CLUP  | Torsås               | 56.4167 | 16.1333 | 19.6 | 51.8  | 8   | 0.866 | -1  | -1   | 2   | -1  | -1   | -1  | -1  | -1   | 3.1  | 14   |
| C11/02577-02607 | CLUP  | Skelleftebukten      | 64.65   | 21.35   | 18   | 39.2  | 6   | 0.547 | -1  | 2    | 3.6 | -1  | -1   | -1  | -1  | -1   | 3.7  | 2.8  |
| C11/03758-03781 | CLUP  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 17.6 | 34    | 5   | 0.398 | -1  | -1   | 1.1 | -1  | -1   | -1  | -1  | -1   | 8.1  | 2.6  |
| C11/07321-07344 | PERC  | Östhammarsfjärden    | 60.25   | 18.4167 | 19   | 79.3  | 5   | 0.671 | -1  | 4.4  | 18  | -1  | -1   | -1  | -1  | -1   | 6    | 2.1  |
| C11/01289-01312 | PERC  | Yttre fjärden        | 60.7    | 17.3    | 18.7 | 77.1  | 4   | 1.016 | 1.4 | 11   | 58  | -1  | -1   | -1  | -1  | -1   | 6.1  | 5.6  |
| C11/03658-03681 | PERC  | Örnsköldsviksfjärden | 62.8833 | 18.2833 | 16.9 | 55.9  | 4   | 0.707 | 1.3 | 6    | 30  | -1  | -1   | -1  | -1  | -1   | 7    | 3.1  |
| C11/02552-02575 | PERC  | Skelleftebukten      | 64.65   | 21.25   | 18.7 | 73.6  | 6   | 0.737 | -1  | 1.8  | 5.2 | -1  | -1   | -1  | -1  | -1   | 5.9  | 0.7  |
| C11/01186-01209 | PERC  | Lilla Värtan         | 59.3333 | 18.1667 | 18.5 | 63.5  | 5   | 0.594 | 5.2 | 61   | 250 | -1  | 1.8  | -1  | -1  | -1   | 1.2  | 5.2  |
| C11/01214-01237 | PERC  | Inre Slätbaken       | 58.45   | 16.5667 | 17.9 | 70.2  | 4   | 0.679 | -1  | 2.2  | 8   | -1  | 6.3  | 6   | 1.7 | -1   | 1.9  | 0.3  |
| C11/04396-04418 | PERC  | Torsås               | 56.4167 | 16.1333 | 18.2 | 79.7  | 3   | 1.429 | -1  | 3.3  | 18  | -1  | 5.8  | -1  | -1  | -1   | 4.4  | 1.5  |
| C11/02402-02425 | GADU  | Kungsbackafjorden    | 57.4    | 12.0667 | 27.7 | 190.6 | 1   | 3.237 | -1  | 1.2  | -1  | -1  | -1   | -1  | -1  | -1   | 6.2  | 2.2  |
| C11/02427-02450 | GADU  | Rivö fjord           | 57.6833 | 11.7667 | 27   | 177.1 | 1   | 2.412 | 2.9 | 4.3  | 10  | -1  | -1   | 1.1 | 1.4 | -1   | 5.4  | 3.5  |

