

# CONCENTRATIONS OF DIOXINS AND DIOXIN-LIKE PCBs IN LIVER FROM ATLANTIC COD FROM 15 FJORDS AND HARBOURS ALONG THE NORWEGIAN COAST.

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## Introduction

Fish liver often accumulate high levels of fat soluble organic pollutants such as dioxins and dioxin-like PCBs, and especially in contaminated areas the levels of these contaminants in fish liver may exceed the levels considered safe for human consumption. For many fjords and harbours along the Norwegian coast, the Norwegian Food Safety Authority has issued dietary advice against consumption of fish liver due to high levels of dioxins and dioxin-like PCBs. Since unborn babies and young children are especially sensitive to these contaminants, the Norwegian Food Safety Authority has also issued general dietary advice that children, women of child-bearing age and pregnant women should not eat fish liver.

This project investigated the content of dioxins and dioxin-like PCBs in liver from 600 Atlantic cod from 15 fjords and harbours along the Norwegian coast. The purpose of the study was to obtain more extensive knowledge about the levels of dioxins and dioxin-like PCBs in cod liver from Norwegian fjords and harbours as a basis for possible revisions of dietary advisories issued for these areas.

## Materials and methods

A total of 600 Atlantic cod from 48 sampling stations within 15 fjords and harbours along the coast of Norway were collected the Institute of Marine Research, Bergen, Norway. The number of sampling stations in each fjord/harbour depended on the size and complexity of the area. Samples were collected from Honningsvåg, Hammerfest, Svolvær and Narvik in the northern part of Norway (between 71°N and 68°N), and from Karmsundet, Stavanger, Sandnes, Egersund, Flekkefjord, Farsund, Lillesand, Tvedestrand, Kragerø, Sandefjord and Tønsberg/Vrengen along the southern coast of Norway.

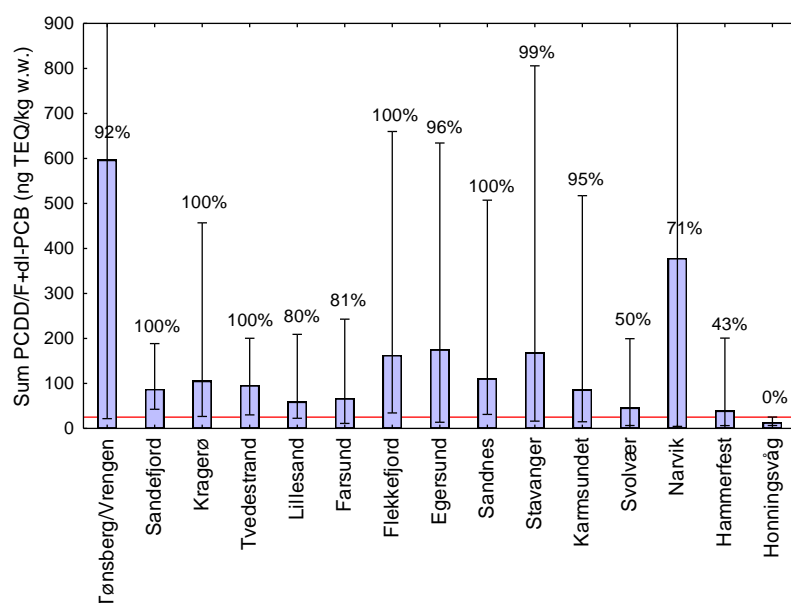
Length and weight of the fish was recorded, and age was determined by analyzing otoliths. The liver of individual fish were weighed and homogenized, and homogenized liver samples were analyzed for fat content and dioxins and dioxin-like PCBs.

Determination of fat content was performed by a gravimetric assay after extraction with ethyl acetate. Determination of dioxins (PCDD/F) and dioxin-like PCBs (dl-PCB) was performed by high resolution gas chromatography combined with high resolution mass spectrometry (HRGC-HRMS) with SIM mode and electron impact ionization after a sample extraction and clean up procedure as follows: Homogenized liver samples were mixed with Hydromatrix® and 27 different <sup>13</sup>C-labelled internal standards. The mixture was extracted with hexane using an Accelerated Solvent Extractor (ASE 300®, Dionex, Sunnyvale, CA, USA). Fat and other matrix components were removed by oxidation in a separate layer of sulphuric acid on silica in the extraction column. Further clean-up was performed using a Power-Prep® instrument (FMS-USA) where successive chromatographic steps were carried out in three columns: Multi-layered silica, basic alumina and activated charcoal. The mobile phase was changed successively from hexane, 2% dichloromethane (DCM) in hexane, 50% DCM in hexane, ethyl acetate and finally back-flush with toluene. The PCDD/PCDF and the non-ortho PCBs were collected in the toluene fraction. The mono-ortho PCBs were collected in the 50% DCM/hexane fraction. The two collected fractions were each evaporated to 10 ml in a TurboVap® concentration Workstation (Zymark, USA) before addition of two <sup>13</sup>C-labelled congeners serving as "recovery standards". The two fractions were then separately analyzed by HRGC/HRMS. The method determines all the 29 compounds on the WHO list: 17 PCDD/PCDF congeners, four congeners of non-ortho PCB (PCB -77, 81, 126

and 169) and eight congeners of mono-ortho PCB (PCB-105, 114, 118, 123, 156, 157, 167 and 189). WHO TEQ was calculated using TEF 1998 values. The method is accredited according to NS-ISO 17025.

### Results and discussion:

The results in this study showed that in most fjords and harbours investigated a large proportion of the cod had very high levels of sum dioxins and dioxin-like PCBs in liver. According to the European Commission regulation 1881/2006<sup>1</sup> which Norway has adopted, the maximum permitted level of sum dioxins and dioxin-like PCBs in fish liver is 25 ng TEQ/kg wet weight. In this study, fish liver from all of the fjords/harbours except Honningsvåg exceeded the EU-limit of 25 ng TEQ/kg wet weight. In nine of the 15 harbours, more than 90% of the fish had concentrations of sum dioxins and dioxin-like PCBs above 25 ng TEQ/kg wet weight, and the average concentration in cod liver was above 25 ng TEQ/kg wet weight in all investigated harbours, except Honningsvåg (Figure 1).



**Figure 1** Mean concentrations of sum dioxins and dioxin-like PCBs (PCDD/F+dl-PCB) in livers of cod sampled in 15 different fjords/harbours during 2009. Error bars indicate minimum and maximum values. Maximum values for Tønsberg/Vrengen and Narvik was 5800 and 7800 ng TEQ/kg wet weight, respectively. The red horizontal line shows the EU's upper limit for sum PCDD/F+dl-PCB in fish liver of 25 ng TEQ/kg wet weight. Numbers above the bars show the percentage of the fish from each location with concentrations above 25 ng TEQ/kg wet weight.

The lowest average concentrations for sum dioxins and dioxin-like PCBs were found in Honningsvåg, Hammerfest and Svolvær with values of 13, 39 and 46 ng TEQ/kg wet weight, respectively. The highest average concentration was found in Tønsberg/Vrengen and was 600 ng TEQ/kg wet weight (Figure 1). Results from surveillance of Atlantic cod in the Barents Sea<sup>2</sup> and preliminary results from an ongoing comprehensive baseline study of Atlantic cod in Norwegian waters (K. Julshamn, personal communication), have shown that in some cases the level of sum dioxins and dioxin-like PCBs in liver may be high even in cod from the open sea. Nevertheless, the results in this study showed that for most fjords and harbours the average concentrations of sum dioxins and dioxin-like PCBs in cod liver were far above what has been found in the open sea to date.

In most fjords and harbours investigated in this study the content of sum dioxin-like PCBs was far higher than the content of PCDD/F in cod liver. The average concentration of PCDD/F was in most cases well below 10 ng TEQ/kg wet weight, and only in Lillesand, Tvedestrand and Kragerø the average concentrations were above this value. The highest average concentration of PCDD/F was found in Kragerø (45 ng TEQ/kg wet weight), and this

was the only harbour in the study where the content of PCDD/F in cod liver was almost as high as the content of sum dioxin-like PCBs.

In all harbours except Lillesand and Tvedestrand fish from several stations were analyzed and the number of sampling stations in each fjord/harbour was determined according to the size and complexity of the area. For some fjords and harbours clear differences were found between the levels of sum dioxins and dioxin-like PCBs in cod liver from different stations, whereas in other fjords/harbours no significant differences were observed between the stations.

The results from this study indicate that liver from Atlantic cod caught in Norwegian fjords and harbours are not safe for human consumption. Based on these results and other recent results from Norwegian fjords and harbours, the Norwegian Food Safety Authority has now issued general dietary advice warning the general population not to eat fish liver from fish caught inside fjords and harbours (inside the sea boundary).

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#### **References:**

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