MANAGING THE DIOXIN PROBLEM IN THE BALTIC REGION WITH FOCUS ON SOURCES TO AIR AND EDIBLE FISH
BALTICPOPS – A 2-YEAR SWEDISH EPA RESEARCH PROGRAM

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Introduction

The reasons behind continuously high levels of dioxins in Baltic edible fish, in contrast to levels in nearby seas, have not been resolved[1]. The TEQ-levels of Baltic fish have been relatively constant since the mid 1980s[1], and this is problematic since levels of fatty fish frequently exceed the EU limits for food and feed thus limiting their commercial value. Although many questions remain, recent research and other investigations have successfully shed light on the dioxin pollution situation of the Baltic Sea[1-14]. Several studies point towards the dominant importance of the atmosphere as a dioxin source to the Baltic Sea[1,4,7,10,15]. It has also been shown that elevated dioxin levels in sediments are mainly found in shore regions near industrialized/urbanised areas[6,7].

BalticPOPs is a 2-year research program to further investigate the dioxin pollution problem in the Baltic Sea. The program is funded by the Swedish EPA, and it aims at *i*) identifying the cause for the lack of a decrease in dioxin levels in Baltic fish, *ii*) identifying the major emissions sources of dioxins (and other POPs) that are impacting the Baltic, and *iii*) investigating the effects of various measures to reduce dioxin levels in Baltic fish. The ultimate goal is to find the best strategy to manage the dioxin problem in the Baltic Sea. In addition, a monitoring strategy that can be applied to follow up the management strategies will be developed, and recommendations on how environmental contamination with dioxins and other POPs could be evaluated in an international context will be provided.

The program started in 2010 and is thus in an early stage. Considering the project's large geographical scale and international character (including scientists from Sweden, Finland and Russia), it is important to widely disseminate information on the research program as well as to discuss the approach and first results with other dioxin scientists. The Dioxin conference offers a perfect opportunity to present the program's approach and discuss some of the preliminary results.

Materials and methods

The Baltic Sea pollution problem is likely linked to a multitude of current and historical activities, and the processes governing POP fate and bioaccumulation are complex. To manage the POP pollution problem, a better understanding of the complex interactions of the different processes is required. We are therefore using a multidisciplinary approach with experts from many research fields. The research is organised into three work packages (WPs):

- WP1 - Why are dioxin levels of fatty fish from the Baltic Sea so high?
- WP2 - Inventory of atmospheric emission sources for dioxins and other POPs.
- WP3 - Synthesis of the results of WP1 andWP2 with other knowledge.

WP1 is divided into four interrelated tasks, focusing on understanding the spatial and temporal dioxin contamination dynamics in Baltic Sea herring and sediment:

Task 1A	Understanding the spatial variation of dioxin levels in the Baltic herring
Task 1B	Understanding the seasonal variation and time trends of dioxin levels in Baltic herring
Task 1C	Are dioxins that reach the Baltic Sea via the atmosphere bioavailable?
Task 1D	How has the pollution situation in the Baltic region changed over time?

Tasks 1A and 1B are strongly coupled and will be executed in parallel and in close collaboration between partners. Two methods will be used in consort to test the hypotheses in 1A and 1B. First, statistical techniques will be used to identify significant features in the comprehensive data available on dioxin levels in fish from the Baltic with respect to time, location, contamination in other media, and biological variables. Second, bioenergetics modelling will be used to test whether these observations are consistent with current scientific understanding, and if not, to test different explanations. In Task 1C, the issue of bioavailability of atmospherically deposited dioxins will be addressed with a novel experimental approach. In Task 1D, the long-term dioxin pollution changes will be explored by analysis of sediment cores from various parts of the Baltic Sea. Other POPs, such as non-planar PCBs and HCB, will be included in the analyses when relevant for identifying significant features or testing explanations.

WP2 includes two main interrelated research tasks:

Task 2A	Atmospheric emission and deposition of dioxins
Task 2B	Tracing atmospheric sources for dioxins and other POPs

The first step of Task 2A includes modelling the atmospheric supply of POPs to the Baltic Sea. A high-resolution atmospheric transport model for POPs (MSCE-POP) will be used to predict dioxin concentrations in air and deposition over the Baltic based on the emissions across the EMEP region. Model simulations will be compared to measurements previously made at Scandinavian sampling sites[14]. In the second step, the reliability of the model estimates will be assessed by comparing the EMEP model's predictions of dioxins supplied to the Baltic region for 2006-2007 with the estimates from the source allocation based on stable air mass back trajectories for two of the air sampling sites. The two methods will be scrutinized to determine if there are any consistent discrepancies between measured and predicted levels in samples with similar back trajectories. In the third step, the potential extent of dioxin revolatilisation and soil particle resuspension from soil to air will be assessed using modelling techniques applied to existing monitoring data for air and soils.

In Task 2B, atmospheric sources for dioxins will be traced by receptor modeling. Computed source characteristics obtained by PMF (a multivariate receptor modeling technique) will be related to real source pollution composition. To accomplish this, the dioxin and metal content of air sampled at Aspvreten (located in a rural area ~80 km south of Stockholm) will be measured. Since atmospheric emission source categories may yield similar dioxin fingerprints, additional chemical species (primarily metals) are added to the field measurements and the modelling. For candidate source patterns, an in-house database will be utilised in combination with new measurements.

Previous and new knowledge will be combined and evaluated in WP3, the system synthesis. This WP will benefit largely from WP1 and WP2. The work will employ the multimedia fate and transport model POPCYCLING-Baltic as a knowledge synthesising tool, building on the work and experience gained in preparing a previous Baltic Sea mass balance study[10]. In this previous study, POPCYCLING-Baltic was used to calculate mass balances for dioxins

and other selected POPs in the whole Baltic Sea as well as separate basins. A bioaccumulation model was used to predict the concentrations in herring from the output from POPCYCLING-Baltic. Some limitations in the models were identified and will be addressed in the planned research in WP1 and 2. The new knowledge will allow these synthesis tools to be better parameterised and evaluated.

Results and discussion

As pointed out earlier, the program is in an early stage and the main purpose of the poster presentation is to spread information about the program, and to discuss the approach with other dioxin researchers. Among the subtasks that have started, preliminary results are already available for two of them. The time trend study of the pollution loads to the Baltic Sea sediments (Task 1D), clearly indicates a decline in dioxin levels over time. The trend is consistent for a vast majority of the 6 cores that so far were studied. EMEP modelling studies suggest a decrease of ~60% in atmospheric deposition to the Baltic Sea from 1990 to 2006[16] consistent with the sediment core results. The direct emissions to the Baltic Sea from industries in the Baltic region likely decreased substantially from the 1970s to the early 1990s, but after this, no pronounced changes can be expected. Because atmospheric deposition is thought to be the dominant source of dioxins to the Baltic Sea[10], levels of dioxins in the surface water of the Baltic are expected to be declining as a consequence of declining atmospheric deposition. Furthermore, it is generally believed that POP levels in pelagic fish are linearly proportional to the freely dissolved concentrations in the water column. If this was the case, then we would expect to see a decline in fish levels in recent times, which is clearly not the case. The stable dioxin fish levels could be explained by the fact that biota levels do not follow a general decreasing trend in the sediments and water column due to changes in ecological factors, e.g. decreased growth rate[17], Peltonen et al.[17] put forward the "decreased growth" hypothesis, successfully predicted the dioxin and PCB concentrations in herring of various ages from the Bothnian Sea using a bioenergetics accumulation model, and obtained good agreement with measured data on a TEQ-basis. Further work in WP1 in the BalticPOPs program will be focused on how current sources, such as local sediment hotspots and atmospheric emissions, affect levels in fish, and if emission reductions will be effective at reducing fish levels in the near future.

Preliminary results are also available for the modelling of the atmospheric supply of dioxins to the Baltic Sea using the atmospheric transport model developed at MSC-East (EMEP) and based on the emissions across the EMEP region (Task 2A). The results indicate that the model largely underestimates atmospheric deposition for the Baltic region (by more than one order of magnitude in some cases), probably mainly due to underestimation of national emissions when reporting to EMEP, rather than model fate process inaccuracies. The model can be used to determine the origin of dioxins in air masses for different model simulations. The model comparisons with observed air concentrations are particularly poor when dioxins in air masses have their origins in Eastern Europe, suggesting that there are large gaps in emission inventories in these regions.

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