Cytological and biochemical biomarkers in adult female perch \((Perca fluviatilis)\) in a chronically polluted gradient in the Stockholm recipient (Sweden)

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**Abstract**

By measuring a battery of cytological and biochemical biomarkers in adult female perch \((Perca fluviatilis)\), the city of Stockholm (Sweden) was investigated as a point source of anthropogenic aquatic pollution. The investigation included both an upstream gradient, 46 km westwards through Lake Mälaren, and a downstream gradient, 84 km eastwards through the Stockholm archipelago. Indeed, there was a graded response for most of the biomarkers and for the muscle concentrations of \(\Sigma PBDE\), four organotin compounds and PFOS in the perch. The results indicated severe pollution in central Stockholm, with poor health of the perch, characterised by increased frequency of micronucleated erythrocytes, altered liver apoptosis, increased liver catalase activity, decreased brain aromatase activity, and decreased liver lysosomal membrane stability. Some biomarker responses were lowest in the middle archipelago and increased again eastwards, indicating a second, partly overlapping, gradient of toxic effects from the Baltic Sea.

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1. Introduction

This is the last of three articles presenting the analyses of biomarkers and environmental pollutants in adult female perch \((Perca fluviatilis)\) from a 130 km long aquatic pollution gradient with the city of Stockholm as a point source. The two previous articles presented 13 basic physiological and eight biochemical biomarkers, as well as chemical analysis of six dichlorodiphenyltrichloroethanes (DDTs), 17 polychlorinated biphenyls (PCBs), three hexachlorocyclohexanes (HCHs), and hexachlorobenzene (HCB) (Hansson et al., 2006b; Linderoth et al., 2006). The present article includes four cytological and four additional biochemical biomarkers, as well as chemical analysis of 16 polybrominated diphenyl ethers (PBDEs), four organotin compounds, and perfluorooctane sulfonate (PFOS).

The investigation differed from most other biomarker studies in that the pollution source was a large city and not a more or less specific industrial site. The main objectives of the investigation were: (1) to investigate the assumed pollution gradient with Stockholm as a point source of anthropogenic substances, using a battery of biomarkers, as well as measuring muscle concentrations of some well-known environmental pollutants; (2) to provide a basis for comparison in future studies of the development of the pollution situation over time; and (3) to investigate the health status of a sedentary fish species in the Stockholm recipient.

Perch has a long history as a sentinel species for anthropogenic pollution (Balk et al., 1996; Sandström et al., 2005; Hansson et al., 2006a; Hanson et al., 2009). It has a wide distribution in fresh and brackish waters in the northern hemisphere (Craig, 1987) and is relatively easy to catch. It is big enough for inner organs and blood to be sampled for physiological and biochemical analysis. It is also relatively sedentary, which has been explicitly demonstrated in at least three investigations (Craig, 1974; Kipling and Le Cren, 1984; Böhling and Lehtonen, 1985). Informative is also the large number of studies of perch in pollution gradients (Andersson et al., 1988; Ericson et al., 1998; Hansson et al., 2006b; Linderoth et al., 2006).