

**THE EFFECT OF ENVIRONMENTAL LEVELS
OF FRESHWATER CONTAMINANTS
ON JUVENILE ATLANTIC SALMON (*Salmo salar* L.):
IMPLICATIONS FOR MARINE SURVIVAL**

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EXTENDED ABSTRACT ONLY – DO NOT CITE

There is increasing concern over the continuing decline of wild stocks of Atlantic salmon, *Salmo salar*, throughout the North Atlantic, and the impact on commercial and recreational fisheries. Recent research has demonstrated that the freshwater and marine environments cannot be considered in isolation and that conditions within the freshwater zone experienced by Atlantic salmon may be critical to their subsequent survival in the sea. In particular, exposure of juvenile salmon to a range of sub-lethal concentrations of freshwater contaminants, such as pesticides, may operate to reduce survival in fish once they have migrated to sea.

Environmental levels of a wide range of pesticides have previously been shown to deleteriously effect Atlantic salmon reproduction and fecundity, by disrupting pheromone-mediated spawning and reducing fertilisation rates (Moore and Lower, 2001; Moore and Waring, 2001). However, the effects of such exposure on other critical life history stages, for example developing embryos and the parr-smolt transformation, and the subsequent survival of salmon in the sea is less clear. The aim of the present studies was therefore to determine the impacts of freshwater contaminants on smolt physiology, behaviour and marine survival and to further investigate the sub-lethal effects of contaminants on reproduction and the emergence of juvenile salmonids.

Two types of persistent freshwater contaminants were studied: flame retardants and pesticides derived from intensive agriculture. Flame retardants are substances used in the manufacture of a wide range of materials such as plastics and textiles. These chemicals enter the aquatic environment as point sources either through leaching from landfills or from effluents derived from the manufacturing process. The majority of flame retardants contain brominated organic compounds, making them persistent and lipophilic with the ability to bioaccumulate. Pentabromodiphenyl ether (PeBDE), tetrabromobisphenyl-A (TBBPA) and hexabromocyclododecane (HBCD) are the most frequently used brominated flame retardants, and they are all found at low levels in many European rivers (de Wit, 2002). The widespread usage of pesticides in agriculture has resulted in the extensive contamination of many rivers and tributaries supporting salmon populations. Three such pesticides are cypermethrin, a synthetic pyrethroid insecticide primarily used in crop sprays and in sheep dips; diazinon, an organophosphate insecticide; and atrazine, a pre- and post-emergence herbicide used in the control of annual and perennial grass and broad-leaved weeds.

In a series of separate studies, pre-smolts (*Salmo salar*) were continuously exposed to either environmental levels of flame retardants (PeBDE, TBBPA and HBCD) or the pesticides (cypermethrin, diazinon and atrazine). Fish were maintained in a freshwater flow-through system and contaminants were introduced using a peristaltic pump. Dosing periods ranged from 10 to 14 days, or in the case of the atrazine study, a period of 2 months. A number of fish from each group were then sampled for some of the physiological parameters associated with the parr-smolt transformation (plasma ion levels [Na^+ , K^+ , Cl^-], gill Na^+ K^+ ATPase activity and plasma thyroid levels [triiodothyronine, T3; thyroxine, T4]. The remaining fish in each group were subsequently exposed to a seawater challenge test (SWC) for 24 hours to assess osmotic capabilities and adaptation of the fish to saltwater. At the end of this test, all fish were again sampled and the above physiological parameters measured. In the atrazine study, fish were first PIT-tagged, exposed to the pesticide and subsequently released into an experimental stream channel in order to determine any effect of exposure on downstream migratory behaviour.

Exposure of the smolts to the flame retardants (0.5, 5, 10, 50, 100 ngl^{-1}) had little or no effect on gill Na^+ K^+ ATPase activity or plasma Na^+ , K^+ , or Cl^- levels. Thyroid hormone levels significantly increased in the control group following exposure to seawater, but exposure to 0.5 ngl^{-1} PeBDE abolished this increase and both T3 and T4 plasma levels were significantly lower compared to the SWC control. All fish in the groups dosed with higher

levels of PeBDE died during the SWC. Exposure to atrazine ($0.5, 5\mu\text{g l}^{-1}$) also had no effect on the plasma ion levels in smolts, but the gill $\text{Na}^+ \text{K}^+$ ATPase activity was significantly lower in the fish dosed with $0.5\mu\text{g l}^{-1}$ atrazine compared to the SWC control.

Current research is focused on modelling the impacts of environmental levels of both individual pesticides and mixtures on smolts, reproductively mature parr, and developing embryos to determine possible synergistic or additive effects. In one study, salmon eggs and milt were briefly exposed during fertilisation to pesticide-dosed water, before being incubated in artificial redds. Preliminary results indicate that exposure even at this stage of the salmonid life cycle can have implications for the production of quality juveniles, as both timing of emergence and mortality of fry were effected.

In conclusion, exposure of environmental levels of waterborne contaminants within freshwater has been shown to disrupt a number of sensitive stages in the life cycle of the salmon. This has implications for the number of juvenile salmon recruited into the population, their subsequent survival in the marine environment and the numbers of returning adults.

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References

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