The impact of a brominated flame retardant on olfactory function in Atlantic salmon (*Salmo salar* L.) smolts

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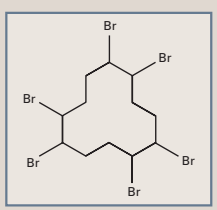
Introduction

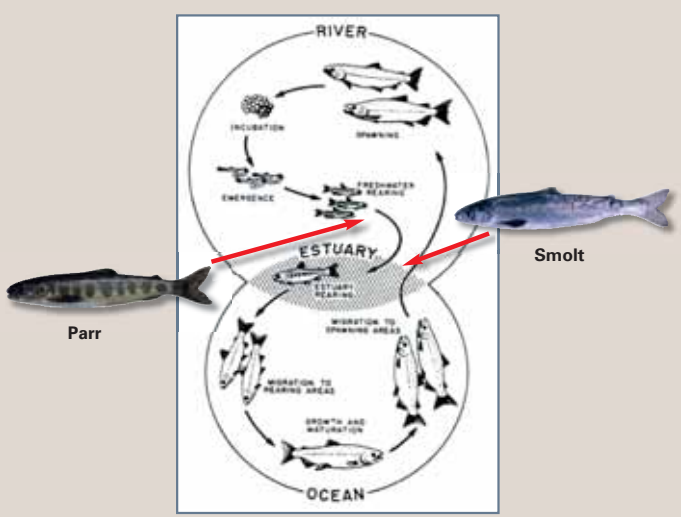
The decline in wild stocks of Atlantic salmon throughout the North East Atlantic has been attributed to a variety of factors operating in both the freshwater and marine environments. Salmon may be exposed to a suite of contaminants throughout their life-cycle, such as pesticides which can disrupt olfactory mediated reproduction by abolishing or reducing the ability of the male fish to detect and respond to the reproductive priming pheromone released by the female (Moore & Waring,1995; Waring & Moore, 1997; Moore & Lower, 2001).

Here we studied the impact of contaminants on olfaction during the parr-smolt transformation. This transitional period occurs in the spring and involves a series of changes in morphology, physiology and behaviour as the juvenile parr in freshwater pre-adapt to a life in the marine environment. It is during this stage that imprinting of the olfactory memory to population specific pheromones or river odours is considered to occur which allows salmon to return with such accuracy to their natal rivers to spawn.

It has been suggested that olfactory imprinting is linked to changes in the thyroid hormone thyroxine. One group of chemicals which are known to disrupt the thyroid endocrine system are the brominated flame retardants. One flame retardant hexabromocyclododecane (HBCD) used mainly in thermal insulation foams is found in many estuarine sediments, as well as in effluents from sewage treatment works and landfill sites. Laboratory studies were carried out to assess the effect of HBCD on olfactory function during the parr-smolt transformation in Atlantic salmon.



Structure of HBCD ($C_{12}H_{18}Br_6$)



Life cycle of Atlantic salmon highlighting freshwater parr and marine smolt stages

Methods

- Atlantic salmon pre-smolts of hatchery origin were placed in two 1000-litre tanks with a constant flow-through of freshwater at 2 litre min^{-1} with no recirculation. Photoperiod and temperature were ambient and the study was carried out during the peak migratory period for these fish
- Control fish (n=83) were exposed to the methanol carrier, while the second tank of fish (n=86) was exposed to a nominal concentration of 5ng l^{-1} HBCD. Stock solutions were added to the tank via a multichannel peristaltic pump and silicon tubing and vigorously mixed by aeration.
- Throughout the 30 day dosing period in freshwater, samples of fish (n=5) were removed weekly and the olfactory responses of each fish to smolt urine were measured using an electro-olfactogram (EOG). EOG recording measures trans-epithelial voltage gradients from the surface of the olfactory epithelium and is considered to reflect multi-unit cell activity.
- The olfactory response to smolt urine (10^4 dilution) was tested as it has previously been shown to elicit a strong response from the olfactory epithelium of salmon. Urine is further considered to be the source of pheromones involved in kin recognition, imprinting and homing (Moore *et al.* 1994). The urine was collected from 3 smolts using a small cannula inserted into the bladder of each fish.
- The amplitude of each EOG response was measured from the baseline to the peak of each phasic displacement and expressed in millivolts (mV), and compared using Holm Sidak multiple comparison test.

Dosing of tanks with a multichannel peristaltic pump

Acknowledgement

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References

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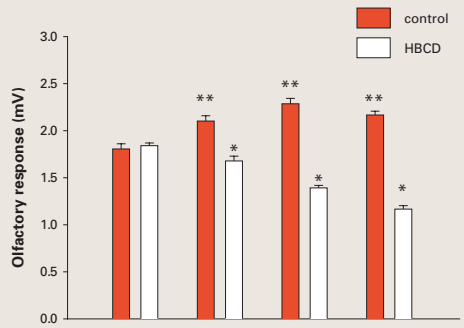
Results



*Seasonal olfactory responses recorded from salmon smolts after exposure to HBCD (n=5 per date); or carrier control (n=5 per date). *P<0.001 compared to values observed during the HBCD baseline sample on 29th March; **P<0.001 compared to values observed during the control baseline sample on 29th March.*

- Olfactory response to conspecific smolt urine increased weekly in the control group compared to the baseline sample (29th March). There was a 20% increase in olfactory response to urine from the baseline sample to the final sample 30 days later (27th April)
- In those fish exposed to HBCD over a 30 day period, olfactory sensitivity decreased significantly at each weekly interval. There was a decrease of 37% in olfactory sensitivity to urine between the baseline and final sampling dates.

Discussion

- These results demonstrate that exposure to the brominated flame retardant HBCD may modify olfactory function in Atlantic salmon smolts.
- Modification of olfactory function during smoltification may affect imprinting to the natal river and significantly affect the ability of the adult salmon to home to their natal river.
- These results contribute to our understanding of the impact of contaminants on olfactory function in salmon, although further studies are required to determine the mode of action and any behavioural effects.
- Analysis is ongoing on the associated impact of HBCD on the thyroid endocrine system during the parr-smolt transformation that will further increase our knowledge of contaminant impacts at this sensitive stage in the salmon life cycle.

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