CONTAMINATION OF FISH IN UNMANAGED UK WATERWAYS: ASSESSMENT OF RISK TO CONSUMERS

Mortimer D N[1], Baskaran C[1], Rose M D[2] , Fernandes A[2]

[1] Food Standards Agency, Aviation House, 125 Kingsway, London, WC2B 6NH, United Kingdom; [2] The Food and Environment Research Agency, Sand Hutton, York, YO41 1LZ, United Kingdom

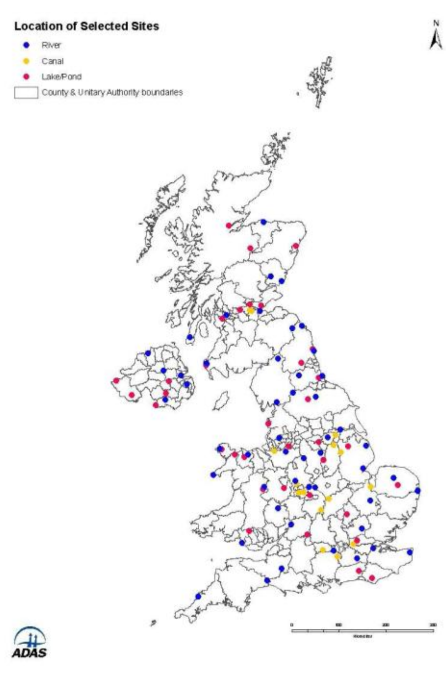
Introduction

Inland waterways, especially those close to industrial areas, are known to be prone to raised levels of historic or localised pollution which can, in turn, lead to contamination of fish. With the exception of farmed trout and eel and a small amount of wild game (mainly salmon), which are commercially marketed and therefore fall under regulatory control, freshwater fish are not part of the traditional UK diet and are not subject to contaminants regulations. However, little is known about the extent to which recreational anglers consume their catch from rivers, lakes and canals although a quick search of the internet will highlight websites where recipes for various coarse fish are exchanged. Furthermore, during the latter part of the decade there has been an influx of immigrants to the UK from countries in Eastern Europe, for whom freshwater fish, notably carp, is a normal part of the diet. This project was carried out to investigate the extent to which coarse fish may be consumed, to measure the contamination in fish taken from targeted areas and thus to assess the potential risk to consumers. The only previous work on freshwater fish carried out by the Food Standards Agency related to an investigation into levels of brominated flame retardants (BFRs) in trout and eel downstream of a BFR production facility.[1]

Materials and methods

The work was divided into a number of stages. First, potentially contaminated watercourses were identified using GIS techniques combined with environmental contamination datasets from a number of sources following an approach used for waterbody characterisation within the scope of the Water Framework Directive.[2] Based on diffuse urban and point source metal and organic pollution, about 100 potentially contaminated sites were selected for consideration (Figure 1). These were further narrowed to a total of 23 sites on the basis of likely level and combination of pollutants; achieving a balance between rivers, lakes and canals; ensuring even geographical distribution across England, Scotland, Wales and Northern Ireland; and presence of angling activity. The second stage comprised a socioeconomic survey of angling and consumption habits based on face-to-face interviews with anglers at the selected sites. There was a target of 50 completed interviews per site, although in some instances these were conducted at several points on a selected watercourse in order to meet the objective. Although there was an attempt to cover as wide as possible a demographic in terms of age, gender, socioeconomic status etc., in particular by staggering the time of visits to sites to cover weekdays, morning/evenings and weekends, the numbers of anglers available at any given time were a limiting factor. The survey was also hampered by adverse

Figure 1. Potential investigation sites



weather conditions and flooding. Nevertheless, the target for completed interviews was achieved (1168 completed questionnaires at 23 sites). The final stage comprised sampling and analysis of fish from some of the sites. Potential sampling sites were selected on the basis of high reported consumption levels; sites where the most frequently-consumed species were found; sites where a number of species were consumed; sites with a high awareness of poaching or consumption by other anglers; sites with a high proportion of non-licence holders; and sites where a wide range of pollutant types were anticipated. In an initial phase, a range of fish species was collected from one of the most heavily fished sites to study species-to-species variations in contaminant levels. Additional samples were obtained from four more sites. These were tested for a range of inorganic and organic contaminants. On the basis of the results from first phase, samples were obtained from a further eight sites and analysed for a reduced range of compounds. Samples were obtained by electro-fishing, netting, conventional fishing and, in the case of the River Trent, were recovered following a cyanide poisoning incident. The samples and analyses are listed in Table 1.

Table 1. Sampling locations and analyses

Phase	Location	Samples	Analytes
1A	Millpond, Sutton-in-Ashfield	Bream, perch, roach	PCDD/Fs, PCBs, PBDD/Fs, PBBs, PBDEs, (including 209), PCNs, organochlorine pesticides, perfluorinated compounds, trace metals, organotins
1B	Thornborough Pond, Newton	Perch	
	River Don, Doncaster	Chub, perch, flounder*, bream, pike, carp, barbel	
	River Thames, London	Perch, bream, roach	
	Dog Kennel Pond, Rotherham	Perch, bream, roach	
2	Greenfield Heritage Lake, Wales	Bronze bream	PCDD/Fs, PCBs, PBDEs, perfluorinated compounds, PCNs, trace elements
	Dog Kennel Pond, Rotherham	Silver bream, perch	
	Chesterfield Canal	Crucian carp, tench	
	Grantham Canal	Perch, bream	
	River Mersey	Bronze bream, perch, rudd, dace	
	Lough Neagh, Northern Ireland	Eel	
	River Trent	Perch, chub, pike, barbel, eel	
	River Gryfe	Brown trout, rainbow trout, flounder*	

*flounder is not a freshwater species but samples were found in brackish water

Only the edible parts of the samples were tested. Analytical methods have been reported elsewhere for chlorinated dioxins/furans and PCBs[3], brominated dioxins/furans, PBBs and PBDEs[4], polychlorinated naphthalenes[5], perfluorinated compounds[6].

Results and discussion

Contaminants in fish. Levels of metals, organochlorine pesticides and organotins were not of concern and are not discussed further here. Levels of brominated dioxins/furans and PBBs were also consistently very low. Results for the other contaminants measured are summarised in Table 2. These results show significant geographical variations in levels of contamination, with different contaminants predominant at different sites. At individual sites, inter-species variation in contamination levels on a whole weight basis was also evident, even between species with similar fat content, but the general profiles of contamination were similar so the variations are likely to have been due to differences in age, duration of exposure and feeding habits. Samples from

Table 2. Summary of halogenated POP results (whole weight basis)

	PCDD/F	PCB	Total TEQ	ΣPBDE	ΣPCN	PFOS
	ng WHO-TEQ/kg (upper bound)			µg/kg	ng/kg	µg/kg
Minimum	0.037	0.063	0.103	0.20	1.11	2
Median	0.33	0.966	1.76	10.9	43.8	43
Mean	2.55	1.82	4.42	20.4	109	50.2
Maximum	26.3	6.54	32.3	130	1197	153

the River Don contained the highest overall levels of contamination. The Don runs through an industrial centre with a history of chlorine chemical manufacture, which also experienced a 'Seveso-type' incident in 1968, and it is known that the river sediment is heavily contaminated, particularly with dioxins.[7] Six of the seven species tested would exceed the European regulatory limit of 4.0 ng WHO-TEQ/kg for dioxins,[8] although this only applies to fish sold commercially. The results for the samples taken from the Don, along with their fat contents, are shown in Table 3.

Table 3. Samples from the River Don (whole weight basis)

Species	Fat %	PCDD/F	PCB	Total TEQ	ΣPBDEs	ΣPCNs	PFOS	PFDeA	PFUnA	PFDoA
		ng WHO-TEQ/kg (upper bound)			µg/kg	ng/kg	µg/kg			
Chub	4.1	9.6	2.0	11.6	34.4	90.9	33	<1	<1	<1
Perch	0.75	3.1	0.5	3.6	11.0	48.9	-	-	-	-
Flounder	1.2	5.7	1.0	6.7	20.5	76.6	107	2	2	5
Bream	4.1	25.4	6.5	31.9	127.6	251	53	1	1	2
Pike	0.44	12.6	2.4	15.0	53.5	150	56	1	<1	<1
Carp	9.1	14.9	5.0	19.9	26.5	204	50	1	<1	<5
Barbel	3.0	26.3	6.0	32.3	105.4	204	76	3	2	5

To examine site-to-site variation within the same species, results are presented in Table 4 for bream which, along with perch, was the most frequently taken species. These results illustrate the strong localised effect of pollution. For instance, although the River Don is undoubtedly most highly contaminated with dioxins and PBDEs, the level of polychlorinated naphthalenes is as high in the comparatively less polluted Millpond and significantly higher in the River Mersey.

Table 4. Contamination levels in bream (whole weight basis)

Location	PCDD/F	PCB	Total TEQ	ΣPBDEs	ΣPCNs	PFOS
	ng WHO-TEQ/kg (upper bound)			µg/kg	ng/kg	µg/kg
Millpond	1.2	2.4	3.6	30.2	292	64
River Don	25.4	6.5	31.9	127	252	53
Dog Kennel Pond	0.19	0.23	0.42	<0.5	13.4	34
Thames, Chertsey	0.11	0.24	0.35	<0.3	14.5	111*
Holywell	1.0	2.8	3.8	8.2	74.6	6
Grantham Canal	0.06	0.08	0.14	<0.3	41.8	8
River Mersey	6.2	3.8	10.0	25.0	1,198	-

* data for perch (bream data unavailable)

Perfluorinated compounds were not measured in all samples and data is unavailable for bream taken from the Thames at Chertsey. However, PFOS levels in perch from Dog Kennel Pond and Grantham Canal are very similar to those in bream from the same locations. In contrast, the level of PFOS in perch from Chertsey was 111 µg/kg, indicating that the Thames, whilst relatively clean with regard to the other contaminants measured, nevertheless is quite highly contaminated with PFOS. This is unsurprising, as Chertsey is very close to where the Thames is joined by the water courses flowing from the site of the Buncefield oil depot explosion in 2005. Massive use of PFOS based foam during the incident led to widespread contamination of local surface and ground water.[9] Other than PFOS, perfluorinated compounds were rarely detected, with the exception of fish taken from the River Trent. In the latter, together with high levels of PFOS, PFDeA and PFDoA were also found in samples of chub, pike, barbel and eel at levels of up to 16 and 7 µg/kg respectively. In addition, PFHpA was found at a level of 8 µg/kg in a sample of chub and PFHxA exceptionally at 5 and 23 µg/kg in two samples of pike. The generally high levels of perfluoroalkyl substances in the Trent would be consistent with its significance as a centre of the textile industry.

Socioeconomic survey and consumption habits. Based on the outcome of 1168 completed questionnaires from 23 waterways, most subjects (87%) were fish consumers in general. However, only about 15% admitted to consuming fish from the interview site and some who did not told the interviewers that they might consume fish caught at other locations. Furthermore, just over half of the subjects were aware of other anglers who consumed their catch and over a third knew of poaching activity, which appeared particularly high on canals. Despite the large majority of anglers favouring ‘catch-and-return’ (some being distinctly hostile to those who retained their catch), around 10% of those questioned admitted that they would consume their catch if reassured about safety, indicating a level of awareness of potential risk. The most commonly consumed species were trout, followed by perch, roach, salmon and rudd. Crayfish were also regularly consumed but these were not included in the investigation as the tails, the parts usually eaten, are very low in fat and therefore unlikely to be a concern with regard to contamination. Finally, there were indications that, of the species currently eaten, consumption of pike was most likely to increase.

Risk to health. This project was not conducted on sufficiently large a scale to produce general advice on risks to health of recreational anglers. Nevertheless, certain conclusions can be drawn. Contamination levels in fish in inland waterways can vary widely from one location to another and can reach significant levels. A proportion of freshwater anglers do consume their catch, occasionally or regularly, and more might consider this if it were possible to give reassurances about safety. On the other hand, without knowledge of contaminant levels, regular consumption of fish from a particular location could be associated with a risk to health and it would certainly be inadvisable to consume fish from watercourses that are known to be contaminated.

Acknowledgements

All work was funded by Food Standards Agency, United Kingdom. The authors also wish to thank all participating staff of the Food and Environment Research Agency and ADAS, UK for their input and support.

References:

1. Brominated flame retardants in trout and eels from the Skerne-Tees river system, Food Standards Agency, 2004 available at: http://www.food.gov.uk/multimedia/pdfs/fsis5204pdf.pdf
2. Environment Agency, 2007. Water Framework Directive, River Basin Characterisation Project, Technical Assessment Methodologies.
3. Fernandes A, White S, D’Silva K, Rose M (2004); *Talanta* 63: 1147–1155.
4. Fernandes A, Mortimer DN, Gem M, Dicks P, Smith F, White S, Rose MD (2009); *Food Additives & Contaminants: Part A*: 26, 918-927
5. Fernandes A, Mortimer DN, Gem M, Smith F, Rose MD, Panton S, Carr M. (2010); *Environmental Science & Technology* 44: 3533–3538.
6. Clarke DB, Bailey VA, Routledge A, Lloyd AS, Hird S, Mortimer DN, Gem M (2010); *Food Additives & Contaminants: Part A*: 27, 530-545.
7. Rose, M (2001); *Food Additives & Contaminants: Part A* 18(12): 1094-8
8. Commission Regulation (EC) No 1881/2006, *Official Journal of the European Union*, 20 December 2006, L364: 5-24.
9. The Buncefield Incident 11 December 2005. The final report of the Major Incident Investigation Board, Volume 2. ISBN 978-0-7176-6318-7.