

**PAH's - Report on Seafish
survey of UK seafood
smoking businesses and
products.**

**Seafish Report
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Working with the seafood industry to satisfy consumers, raise standards, improve efficiency and secure a sustainable future.

The Sea Fish Industry Authority (Seafish) was established by the Government in 1981 and is a Non Departmental Public Body (NDPB).

Seafish activities are directed at the entire UK seafood industry including the catching, processing, retailing and catering sectors.

Seafish Technology: We promote the sustainable use of fish resources, quality, the reduction of waste and the improvement of safety through practical applied research.



Seafish Technology and Training

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Summary

Polycyclic aromatic hydrocarbons (PaH's) form a large group of chemicals, some of which are known to be toxic. They are produced largely by combustion processes and are present in smoked foods. The European Commission is proposing a maximum permitted limit of 5ppb for the PaH benzo(a) pyrene (BaP) in smoked foods.

To determine the potential impact of this, Seafish has carried out a survey of the size and nature of the fish smoking industry in the UK and has gathered representative samples of its products for analysis.

The survey found the value of smoked fish production in the UK to be over £120 million per annum. A wide variety of products are produced from a range of fish species using modern and traditional kilns, smoked over a variety of woods.

PaH analyses of 33 products showed them all to be well within the proposed EU limit of 5ppb for BaP. Only 2 products exceeded 0.5ppb and the highest level found was 1.34ppb.



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PaHs – Report on Seafish survey of UK seafood smoking businesses and products

1 Introduction

Polycyclic aromatic hydrocarbons (PAHs) form a large group of chemicals, many of which are known to be toxic. They are produced largely by combustion processes, such as the burning of fossil fuels, and are present in smoke. They can be absorbed into the human body through the skin by direct contact, by breathing contaminated air and by eating contaminated food. High temperature cooking processes such as grilling and barbecuing produce PAHs in food, as does the smoking process.

The European Commission is reviewing current EU law on contaminants in food. It has notified its intention to specify maximum permitted levels for PAH's in smoked foods. The current proposals include a limit of 5 ppb of benzo(a)pyrene (BaP) in smoked fish, although the FSA believes that some Member States already have lower limits in national law. BaP is being used as an indicator of general contamination by PAHs.

There is an urgent need to determine the potential impact of this on the UK seafood processing industry.

A literature search has revealed scarcely any data on PAH levels in UK produced smoked seafood. There is limited data from other countries but the smoking practices and products may differ. The data available does suggest that levels depend very much on the type of product and process. Variables include smoking temperature and time, the type of fish (particularly whether oily or not), the surface area of the products in relation to their weight, whether or not the contaminated surface (which may be skin) is consumed, the type of wood used and the nature of the combustion process. German data shows that traditional kilns result in much higher levels of PAHs than the modern kilns that have separate smoke generators.

To address the need for information, Seafish has carried out a survey of known seafood smoking businesses in the UK to determine the size and nature of the trade and, on the basis of this, has gathered representative samples of UK produced smoked seafood products for analysis.

2 Seafood smokers survey

A total of 132 questionnaires have been circulated to the businesses registered on the Seafish suppliers database as smoked product suppliers and to other businesses known to be smokers (whose contact details were provided by industry). The questionnaire is shown in Appendix I. It requested information on the value of trade, the types of products produced and the kilns and wood used.

Not all businesses choose to register on the Seafish supplier database and some of those registered are merely suppliers rather than producers. The survey did not set out to include the specialist salmon and trout smokers as they are not within the remit of Seafish. However, some of the businesses on the supplier database do smoke these fish and we have been notified of a number of specialist salmon and trout smokers, who have now been included in the survey.

The response from the 132 questionnaires is as follows:

Number returned as no longer at that address or not a producer	13
Number of responses providing some data	51
Number of incomplete responses (usually missing value of trade)	10
Number of complete responses	41

The findings of the survey are summarised in graphical form in Appendix II and are tabulated in Appendix III. Where appropriate, data from some of the partially completed responses has been included.

The total value of UK production of smoked seafood shown in the responses is over £120 million per annum. In reality this figure could be considerably higher, given that less than half of the businesses returned the questionnaire and that there may be many other seafood smoking businesses that we are unaware of.

The size distribution of the businesses that responded (Appendix II, Figure 1) shows that about half of the businesses have a smoked seafood production of less than £0.5m per annum but that there are a number of major players with a production of up to £18m per annum. In reality it is thought that there may be many more small-scale producers, supplying niche markets.

The responses show the value of cold smoked production to be about 5 times that of hot smoked production (Appendix II, Figure 2). Haddock, cod and salmon fillets predominate in cold smoked production (Appendix II, Figure 2a) and mackerel fillets predominate in hot smoked production (Appendix II, Figure 2b).

The responses show the value of production in modern kilns to be about 5 times that in traditional kilns, although about a third of the businesses operate traditional kilns (Appendix II, Figures 3 and 4). There is a tendency for the smaller businesses and some large salmon smoking businesses to be using traditional kilns. Again it is thought that in reality there may be many more traditional kilns operated by small-scale producers supplying niche markets.

A wide range of woods, both hardwood and softwood, and mixtures of woods are used by the businesses that responded (Appendix II, Figure 5).

3 Sample collection and PAH analysis

Analysis for PAH's is expensive at about £250 per sample. Funding for the analysis of a representative range of samples was provided by Seafish and by Scottish Enterprise, with the samples provided by industry.

The selection of products for analysis was based on the survey findings to represent the range of product types and processing variables that may affect PAH levels. In practice not all the processors provided samples and a few substitutions had to be made. In addition, one large processor independently arranged for a number of its own products to be analysed and agreed to share the data (which included a smoked salmon product). Where possible, data on the smoking time of each product has also been obtained.

All the analyses, including those privately funded, were carried out by the Central Science Laboratory (CSL), York, using the same methodology. Samples were prepared by homogenising the normally consumed, edible parts of 5 of each type of product. Each sample was analysed for 22 PAHs including BaP, using low resolution gas chromatography and mass spectrometry (UKAS accredited ISO 17025 standard). Further details of the methodology are given in Appendix V.

The results are shown in Appendix IV. The samples analysed and their BaP levels are shown diagrammatically in Figure 6. The full analysis data is tabulated in Table 5. In total there is data on 33 products including 10 sets of privately funded data.

All the BaP results are well below the 5 ppb limit currently proposed, the highest being about 1.34 ppb for a hot smoked, traditional kiln, Arbroath smoky. Only 2 of the 33 products analysed exceeded 0.5 ppb of BaP.

The full analysis data shows considerable variations in levels between the different PAHs and product types and processes. Given the wide range of variables and the relatively small number of samples, it may be difficult to draw further conclusions from the data. The different toxicity of the various PAHs would have to be taken into account.

However, the BaP results indicate generally higher levels in hot smoked products than cold smoked products and, for those hot smoked products, generally higher levels from traditional kilns than modern kilns.

4 Conclusions

The survey has shown that seafood smoking is a substantial industry in the UK with a value of production of over £120m per annum. The industry produces a wide range of products from a variety of fish species, using both modern and traditional kilns and smoking over a variety of woods.

Samples of a representative range of 33 products have been analysed for PAHs. All the products were found to be well within the proposed EU limit of 5ppb of BaP.

Appendix I
The questionnaire

Seafood Smoker's Questionnaire – 1

Note: It is not intended that businesses take a long time researching the information required. The best estimates of the individual business managers are all that is required to build up a picture of the size and nature of the industry.

Name of business

Address of business.....

.....

Approximate annual sales value of all smoked products produced by the business £

Types of smoked products produced (e.g. hot smoked gutted mackerel, kippers, cold smoked haddock fillets, etc.) and approximate percentages of all smoked fish product sales value:

<u>Product Type</u>	<u>Percentage (%) of all sales value</u>
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

Type of kiln used, **traditional** (with the fire at the base of the smoking chamber) or **modern** (with a separate smoke generator, e.g. Afos type) and if both types are used, the approximate percentage of all smoked fish product sales value produced in each type:

<u>Kiln type (traditional or modern)</u>	<u>Percentage (%) of all sales value</u>
.....
.....

Type of wood used (e.g. oak, pine etc.) and if several types are used, the approximate percentage of all smoked fish product sales value produced by each type:

<u>Wood type</u>	<u>Percentage (%) of all sales value</u>
.....
.....
.....

Appendix II
Graphical presentation of survey responses

Size Distribution of Businesses

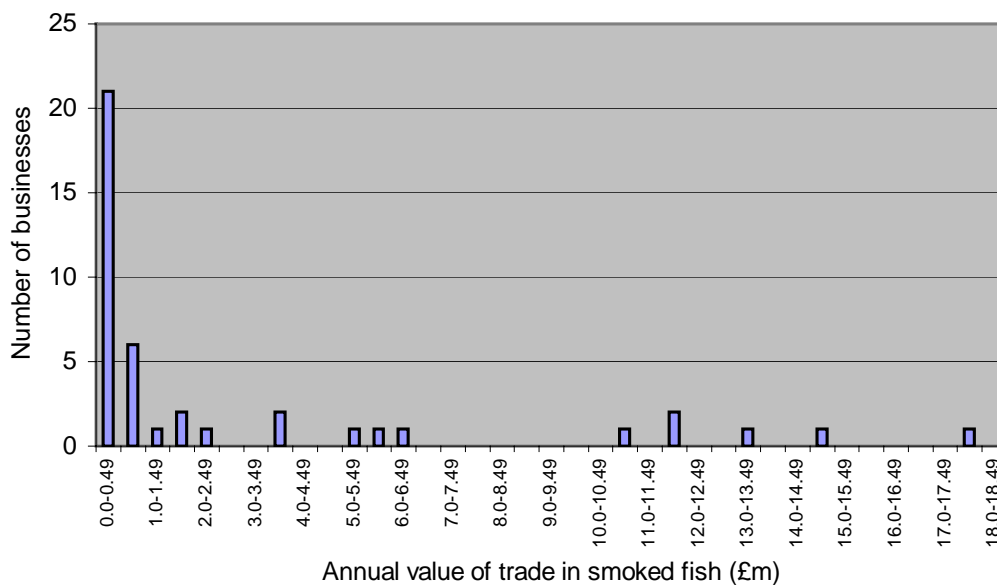


Figure 1. Size distribution of businesses responding to the survey

Product types by value of trade

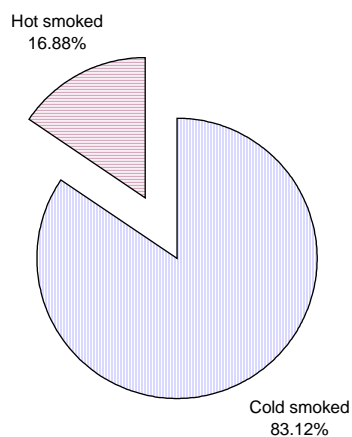


Figure 2. Hot/cold products as percentage of overall value of all smoked fish trade in responses

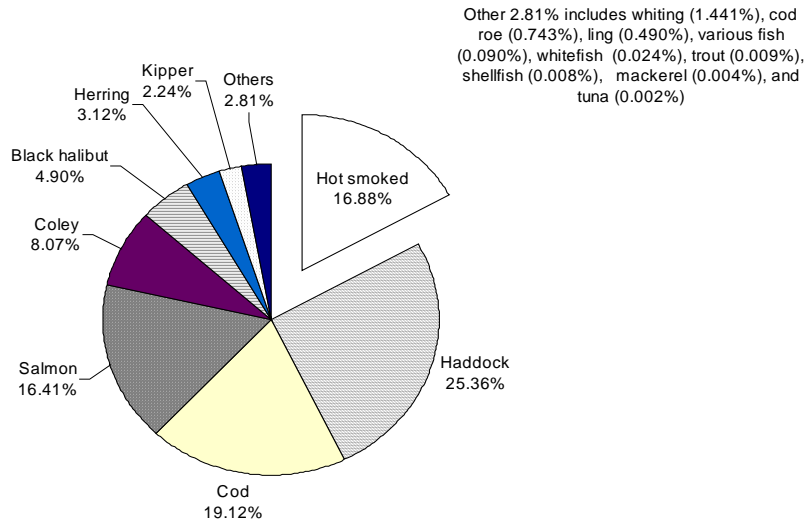


Figure 2a. Breakdown of cold smoked products by species/type as percentage of overall value of all smoked fish trade in responses

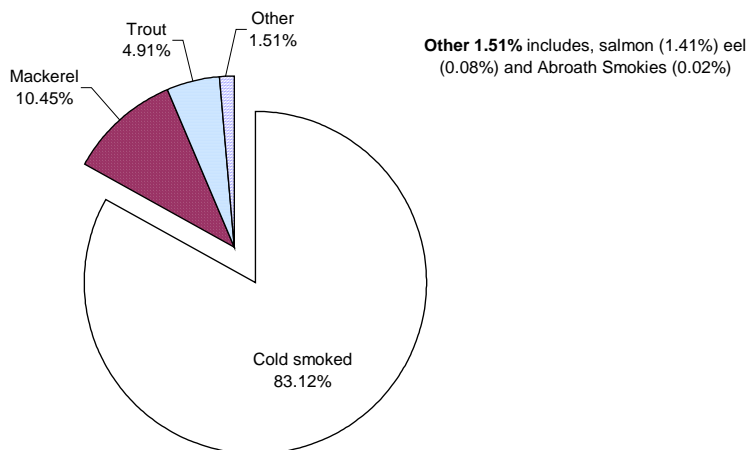


Figure 2b. Breakdown of hot smoked products by species/type as percentage of overall value of all smoked fish trade in responses

Kiln usage by value of trade

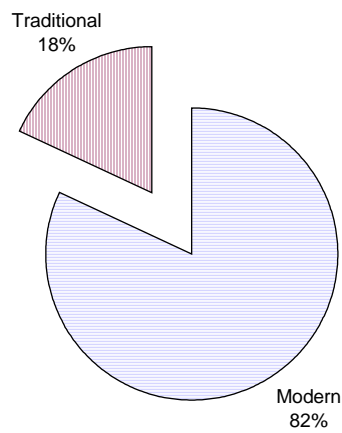


Figure 3. Traditional/modern kiln usage as percentage of overall value of all smoked fish trade in responses

Kiln usage by number of businesses

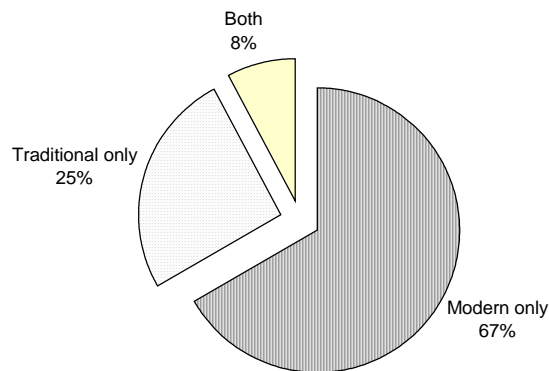


Figure 4. Traditional/modern kiln usage as percentage of number of businesses responding

Wood usage by value of trade

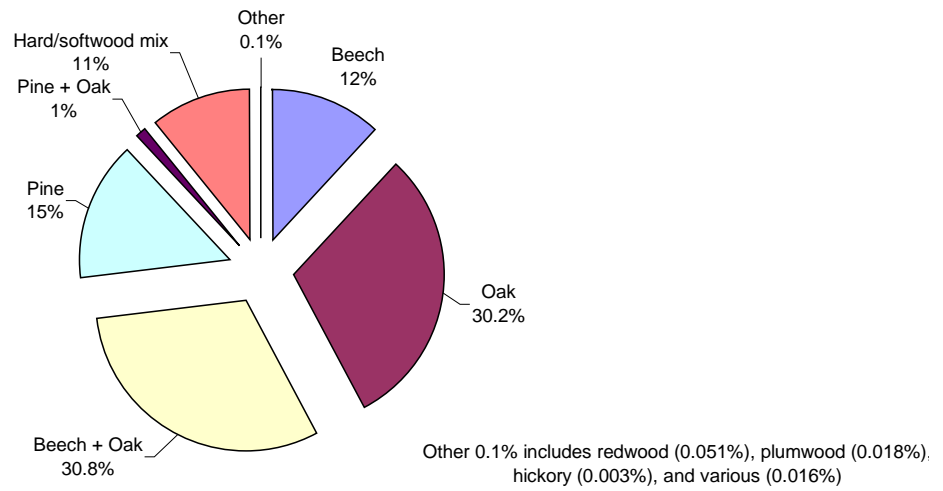


Figure 5. Wood usage as percentage overall value of all smoked fish trade in responses

Appendix III
Tabulated survey data

Number of questionnaires circulated to date	132
Number returned as no longer at that address or not a producer	13
Number of responses providing some data	51
Number of responses incomplete (usually missing overall sales value)	10
Number of complete responses	41

Table 1. Overall breakdown of smoked products in responses

Process type	Product	Number of businesses producing	Product value £ (from number of businesses)
Cold smoked	Haddock	46	31,070,058 (38)
	Cod	24	23,428,844 (19)
	Coley	6	9,883,676 (5)
	Black halibut	1	6,000,000 (1)
	Salmon	21	20,087,045 (17)
	Herring	6	3,820,300 (5)
	Kipper	20	2,740,724 (16)
	Trout	5	1,830,124 (5)
	Whiting	7	1,769,000 (5)
	Cod roe	1	910,000 (1)
	Ling	1	600,000 (1)
	Unspecified	7	139,950 (5)
	Mackerel	4	17,368 (3)
	Shellfish	6	5,591 (5)
	Tuna	1	2,000 (1)
Total			102,304,680
Hot smoked	Mackerel	14	12,453,798 (11)
	Trout	4	4,120,189 (4)
	Salmon	9	1,710,028 (8)
	Eel	3	100,459 (3)
	Arbroath Smokies	2	25,200 (1)
	Total		
Total			120,714,354

Table 2. Breakdown of smoked products from modern kilns in responses

Process type	Product	Number of businesses producing	Product value £ (from number of businesses)
Cold smoked	Haddock	32	25,622,329 (23)
	Cod	18	20,664,508 (15)
	Coley	6	9,883,676 (5)
	Black Halibut	1	6,000,000 (1)
	Salmon	13	10,853,446 (11)
	Herring	4	3,110,300 (3)
	Kippers	15	2,225,524 (14)
	Whiting	6	1,765,000 (4)
	Various	6	109,950 (4)
	Ling	1	600,000 (1)
	Whitefish	1	30,000 (1)
	Trout	3	6,124 (3)
	Mackerel	2	5,368 (2)
	Tuna	1	2000 (1)
	Shellfish	4	853 (2)
Total			80,879,076
Hot smoked	Mackerel	12	12,063,798 (5)
	Salmon	6	1,710,028 (6)
	Trout	4	4,120,189 (4)
	Eels	3	100,459 (3)
	Total		
Total			98,873,550

Table 3. Breakdown of smoked products from traditional kilns in responses

Process type	Product	Number of businesses producing	Product value £ (from number of businesses)
Cold smoked	Haddock	13	5,447,729 (9)
	Cod	4	2,764,336 (3)
	Cod roe	1	910,000 (1)
	Kippers	4	515,200 (2)
	Herring	1	710,000 (1)
	Salmon	8	9,233,600 (4)
	Mackerel	3	402,000 (2)
	Shellfish	1	4,739 (1)
	Trout	2	1,824,000 (2)
	Whiting	1	4000 (1)
	Total		21,815,604
Hot smoked	Arbroath smokies	2	25,200 (1)
	Total		25,200
Total			21,840,804

Table 4. Overall breakdown of wood usage in responses

Wood type	Number of businesses using wood type	Product value £ associated with wood type (from number of businesses)
Beech	12	14,535,722 (11)
Beech + Oak mix	9	37,142,010 (8)
Oak	31	36,435,625 (24)
Pine	11	18,157,590 (8)
Hard/softwood mix	3	12,860,000 (3)
Pine + Oak mix	3	1,503,000 (3)
Other woods	6	90,300 (5)

Appendix IV
Sample selection and PAH analysis results

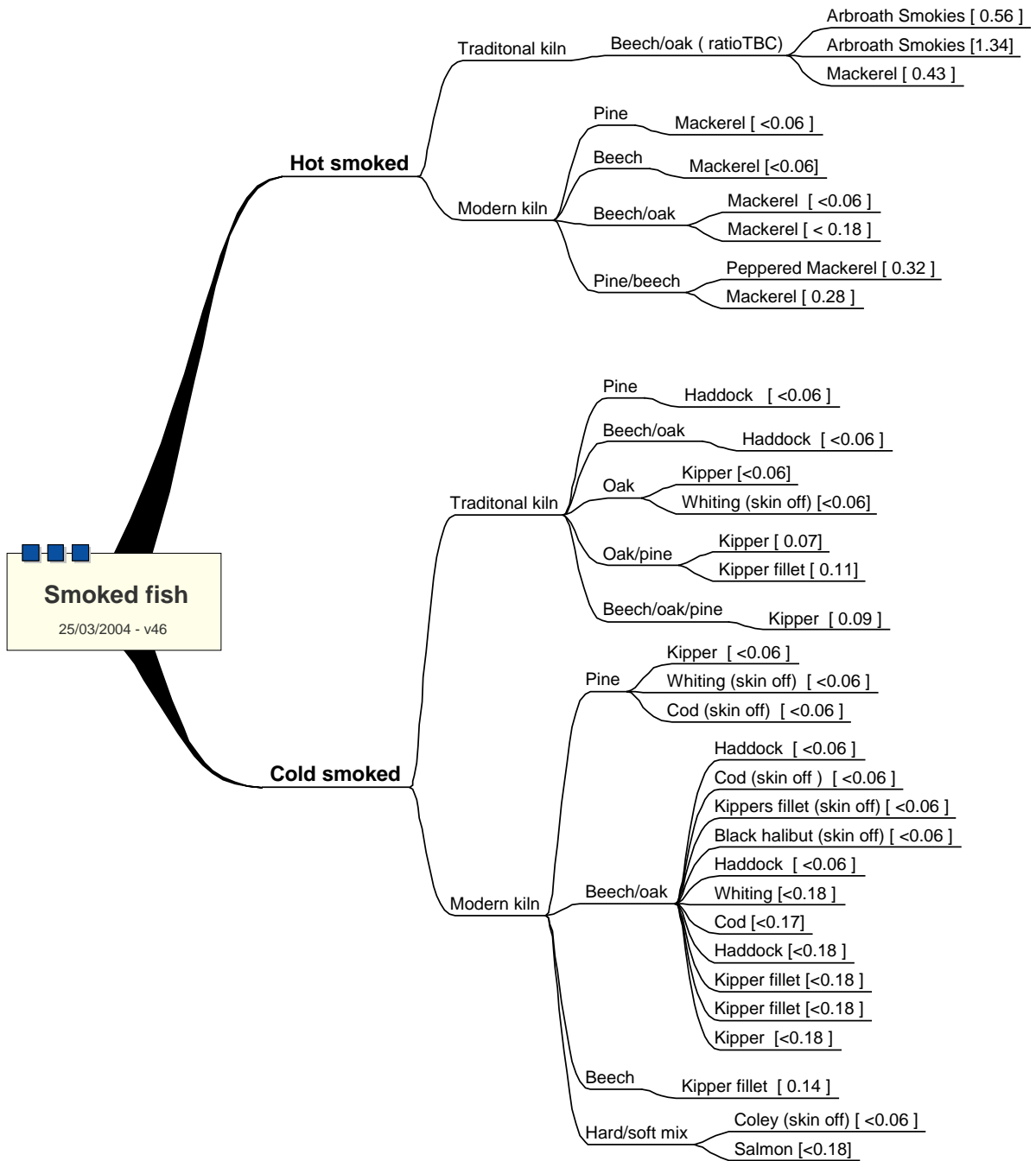


Figure 6. The samples analysed and their BaP results (ppb)

Note: all products are skin on fillets except where stated and Arbroath smokies (whole gutted) and kippers (split whole).

Table 5. Full Results of PAH Analysis

Hot/cold smoked	Kiln type	Wood type	Product	Kiln time (hrs)	PaH type and level (ppb)																					
					acena[ghi]ylene	acena[ph]thene	fluorene	phenanthrene	anthracene	fluoranthene	pyrene	Benzo[ghi]fluoranthene	benz(a)anthracene	Benzo[ghi]perylene	Cyclopenta[c,d]pyrene	chrysene	5-methylchrysene	benzo[ghi]fluoranthene	benzo[ghi]fluoranthene	benzo[k]fluoranthene	benzo[e]pyrene	benzo[a]pyrene	indeno[1,2,3-cd]pyrene	dibenz[ah]anthracene	benzo[ghi]perylene	Anthanthrene
Hot smoked	Traditional	Beech/oak	Arbroath smokies	1.25	8.99	2.43	7.30i*	27.71i*	5.90i*	5.47i*	5.60	0.54	1.02	<0.01	1.57	1.32i	<0.01	0.50	0.36	0.19i	0.41	0.56	0.33	0.06	0.29i	-
			Arbroath smokies	0.45	12.19i*	5.57	8.06i*	35.57i*	6.67i*	6.22i*	9.61	0.83	2.11	<0.02	2.91	2.72i	0.03	1.14	0.85	0.52i	0.95	1.34	0.78	0.16	0.68i	-
			Mackerel	-	10.63i*	4.50	7.33i*	30.95i*	6.03i*	5.72i*	5.90	0.46	0.99	<0.01	0.78	1.61i	<0.01	0.48	0.29	0.15i	0.47	0.43	0.21	0.04	0.22i	-
	Modern	Pine	Mackerel	2.5	8.23i	1.74i	5.04	14.62i*	2.63i	1.36	0.82	0.06	0.07	<0.02	0.07	0.18i	<0.01	<0.03	<0.01	<0.01	0.02	<0.06	<0.02	<0.03	<0.01	<0.1
			Beech	Mackerel	3.5	2.90	1.18	7.44i*	17.21i*	5.05i*	3.26	2.36	0.13	0.29	<0.01	0.11	0.32i	<0.01	<0.03	<0.02	<0.01	0.03	<0.06	<0.02	<0.03	<0.01
		Beech/oak	Mackerel	2	1.78	1.42i	5.65i*	11.88i*	3.01i*	1.93i*	1.69	0.08	0.18	<0.02	0.05	0.23i	<0.01	<0.03	0.02	<0.01	0.03	<0.06	<0.02	<0.03	<0.01	<0.1
			Mackerel	4	7.96	1.62	8.62	18.50i	4.27	4.01	3.70	0.22	0.36	<0.02	0.32	0.53	-	0.11	<0.04	<0.05	0.07	<0.18	<0.04	<0.05	<0.02	<0.1
		Pine/beech	Peppered mackerel	4	13.97	2.21	11.60	25.28i	9.10	9.45	7.27	0.74	1.35	<0.02	1.61	1.46	-	0.32	0.21	0.14	0.23	0.32	0.09i	<0.05	0.06	<0.1
Mackerel	4		8.26	1.38	9.29	27.45i	7.25	8.40	6.27	0.63	1.12	<0.02	1.20	1.27	-	0.29	0.15	0.11	0.21	0.28	0.07i	<0.05	0.04	<0.1		
Cold smoked	Traditional	Pine	Haddock	13.5	1.52	2.11	4.08i	10.87i*	1.73	0.53	0.74	<0.02	0.11	0.05i	0.03	0.19i	<0.01	0.04	0.02	<0.01	0.06	<0.06	<0.02	<0.03	0.02i	<0.1
			Oak/beech	Haddock	12	<0.9	0.94	3.56	5.69	0.77	0.36	0.39	<0.02	0.05	<0.03	<0.01	0.10i	<0.01	<0.03	<0.01	<0.01	0.02	<0.06	<0.02	<0.03	<0.01
		Oak	Kipper	6	5.04	0.95	4.14	6.72	1.58	0.66	0.41	<0.02	<0.02	<0.01	<0.01	0.09i	<0.01	<0.02	<0.01	<0.01	<0.01	<0.06	<0.02	<0.03	<0.01	-
			Whiting (skin off)	6	3.21	1.14	7.00i*	14.84i*	3.30	1.15	0.82	<0.04	0.09	<0.01	<0.04	0.16i	<0.01	<0.04	<0.02	<0.02	0.03	<0.06	<0.02	<0.03	<0.02	-
		Oak/pine	Kipper	15	11.63i*	8.74i*	9.55i*	28.63i*	4.94i*	1.56	1.49	0.06	0.17	<0.01	0.17	0.28i	<0.01	0.06	0.04	0.07i	0.05	0.07	<0.03	<0.03	<0.03	<0.1
			Kipper fillet	15	12.52i*	8.78	6.62i*	35.92i*	6.07	3.01	2.45	0.11	0.25	<0.01	0.27	0.56i	0.04	0.09	0.05	0.11i	0.08	0.11	<0.04	<0.03	<0.04	-
	Beech/ oak/pine	Kipper	-	30.59i*	13.61i*	17.92i*	67.80i*	13.94i*	4.55i*	3.65i*	0.13i	0.38	<0.05	0.09	0.72	<0.01	0.11	0.06	0.10i	0.12	0.09	<0.03	<0.03	<0.03	<0.1	
	Modern	Pine	Kipper	2	7.03i*	1.23i	5.43i	11.32i*	2.61i	0.97	0.80	0.03	0.04	<0.02	0.07	0.06i	<0.01	<0.03	0.01	<0.01	0.02	<0.06	<0.02	<0.03	0.02	<0.1
			Whiting (skin off)	2	5.69i	1.70i	4.50	4.77	0.81	0.51	0.34	0.03	0.04	<0.02	0.03	0.15i	<0.01	<0.02	0.01	<0.01	0.02	<0.06	<0.02	<0.03	<0.01	<0.1
			Cod (skin off)	2	5.98i	0.89	4.04	7.08	1.66	0.60	0.51	0.02	0.03	<0.02	0.04	<0.05	<0.01	<0.03	<0.01	<0.01	0.01	<0.06	<0.02	<0.03	0.01	<0.1
		Beech/oak	Haddock	4	0.98	0.29	1.26	5.56i	0.71	0.50	0.45	<0.02	0.01	<0.03	<0.01	<0.04	<0.01	<0.03	<0.01	<0.01	<0.01	<0.06	<0.02	<0.03	<0.01	<0.1
			Cod (skin off)	4	1.08	0.31	1.73	9.35i	1.17	0.80	0.70	0.02	0.02	<0.03	<0.01	<0.04	<0.01	<0.03	<0.01	<0.01	<0.01	<0.06	<0.02	<0.03	<0.01	<0.1
			Kipper fillet (skin off)	3	6.70	1.13	5.97i*	12.92i*	3.54	1.38	1.00	<0.04	0.05	<0.01	0.07	0.12i	<0.01	<0.02	<0.01	<0.01	<0.02	<0.06	<0.02	<0.03	<0.01	-
			Black halibut (skin off)	4	9.56	2.06	7.17	19.01i	2.91	1.33	1.04	0.03	0.03	<0.03	0.02	0.11i	<0.01	<0.03	<0.01	<0.01	<0.01	<0.06	<0.02	<0.03	<0.01	<0.1
			Haddock	3	6.17	0.87	3.90	11.37i	2.25	0.92	0.72	0.04	0.05	<0.03	0.11	0.07i	<0.01	<0.03	<0.01	<0.01	<0.01	<0.06	<0.02	<0.03	<0.01	<0.1
			Whiting	4.5	14.16	2.10	7.25	22.65i	4.24	2.59	2.11	0.16	0.16	<0.02	0.27	0.24	-	0.10	<0.05	<0.04	0.08	<0.18	0.06i	<0.05	0.05	<0.1
			Cod	3.5	4.33	0.65	3.26	11.06	1.76	0.90	0.79	<0.04	0.05	<0.01	0.03	0.10	-	<0.06	<0.02	<0.03	<0.03	<0.17	<0.04	<0.05	<0.02	<0.1
			Haddock	3.5	1.16	0.38	1.54	7.16	1.13	1.04	1.31	<0.04	0.06	<0.01	0.03	0.10	-	<0.07	<0.01	<0.03	<0.02	<0.18	<0.04	<0.05	<0.02	<0.1
			Kipper fillet	3.5	6.47	1.36	5.91	13.10	2.14	2.30	1.56	0.09	0.08	<0.01	0.08	0.43	-	<0.06	<0.01	<0.03	0.04	<0.18	<0.04	<0.05	<0.02	<0.1
			Kipper fillet	8	7.77	1.65	5.93	11.97	2.15	0.99	0.89	0.04	0.06	<0.01	0.03	0.16	-	<0.07	<0.01	<0.03	0.03	<0.18	<0.04	<0.05	<0.02	<0.1
Kipper			3.5	88.17i	9.67i	33.17	33.88i	17.79	8.79	6.18	0.24	0.25	<0.02	0.52	0.32	-	0.09	<0.04	<0.04	0.06	<0.18	0.06i	<0.05	<0.03	<0.1	
beech	Kipper fillet	0.75	8.29	2.55	6.26i	8.95	2.40i	1.22	1.00	0.08	0.29	<0.02	0.15	0.38i	<0.01	0.10	0.07	0.04	0.07	0.14	0.07	<0.03	0.04	<0.1		
Hard/soft wood mix	Coley (skin off)	2.5	10.06i*	2.53	8.18i*	21.75i*	4.74	1.60	1.17	0.05	0.05	<0.01	0.13	0.05i	<0.01	<0.02	<0.02	<0.01	<0.01	<0.06	<0.02	<0.03	<0.01	-		
	Salmon	15	1.60	0.78	2.31	3.57	0.43	0.32	0.35	<0.01	<0.01	<0.01	<0.01	0.06	-	<0.06	<0.01	<0.03	0.01	<0.18	<0.04	<0.05	<0.02	<0.1		

(i) is indicative due to interference on confirmatory ion, (i*) is indicative due to overload of GCMS system, (-) is data missing

Appendix V
PAH analysis methodology

The compounds determined

22 individual PAHs were analysed in each sample:

acenaphthylene
acenaphthene
fluorene
phenanthrene
anthracene
fluoranthene
pyrene
benzo(ghi)fluoranthene
benz (a) anthracene
benzo(b)naphtha(2,1-d)thiophene
cyclopenta(c,d)pyrene
chrysene
5-methylchrysene
benzo-(b)-fluoranthene
benzo-(j)-fluoranthene
benzo-(k)-fluoranthene
benzo-(e)-pyrene
benzo-(a)-pyrene
indeno-(1,2,3-cd) pyrene
dibenz-(ah)-anthracene
benzo-(g,h,i) perylene
anthanthrene

Outline of Method

The samples were fortified with appropriate ¹³C internal standards and subjected to saponification followed by liquid-liquid extraction. Cleanup was by DMF/cyclohexane partition followed by elution through a silica gel column. Analysis was by low resolution GC-MS.

Quality Control Procedures

The analytical procedure used is UKAS accredited (Testing lab 1642) to the ISO 17025 standard.

In order to demonstrate that adequate confidence can be placed in the results obtained, the following requirements were observed:

- Each batch of samples analysed incorporated a certified reference material (CRM458), for which results were compared with certified or assigned data and laboratory performance (indicative) data [1],
- Each batch of samples analysed included a full reagent blank extract.

References

1. LUTHER W., WIN T., VAESSEN H.A.M.G., VAN DE KAMP C.G., JEKEL A.A., JACOB J., BOENKE A., 1997 "The certification of the mass fraction of Pyrene, Chrysene, Benzo[k]fluoranthene, Benzo[a]pyrene, Benzo[ghi]perylene and Indeno[1,2,3-cd]pyrene in two coconut oil reference materials (CRM458 and CRM459)". Report EUR17545EN, Commission of the European Communities, Community Bureau of Reference.