Trace Metal and Chlorinated Hydrocarbon Concentrations in Various Fish Species Landed at Selected Irish Ports, 1997-2000

L. Tyrrell, D. Glynn, A. Rowe, B. McHugh,
J. Costello, C. Duffy, A. Quinn, M. Naughton,
M. Bloxham, E. Nixon and E. McGovern

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L. TYRRELL, D. GLYNN, A. ROWE, B. MC HUGH, J. COSTELLO, C. DUFFY, A. QUINN, M. NAUGHTON, M. BLOXHAM, E. NIXON AND E. MC GOVERN [1]

Marine Institute
Marine Environment and Food Safety Services
Abbotstown, Dublin 15.

[1] Author to whom correspondence should be addressed

ABSTRACT

The Marine Institute samples a range of finfish species landed at five major Irish ports on an annual basis, in accordance with the monitoring requirements of various European legislation designed to ensure food safety.

During 1997 – 2000, a total of 112 samples from 23 different species of finfish were collected from five major Irish fishing ports and analysed for total mercury concentration in the edible tissue (Common names and species names are listed in Appendix 6). The concentration of mercury ranged from 0.03 to 0.18 mg kg^{-1} wet weight in 1997, <0.03 to 0.19 mg kg^{-1} wet weight in 1998, <0.03 to 0.29 mg kg^{-1} wet weight in 1999 and 0.03 to 0.33 mg kg^{-1} wet weight in 2000. These levels are well within the maximum limit of 0.50 mg kg^{-1} wet weight for mercury in fishery products set by the EC. This survey confirms previous studies, which show that Irish seafoods are effectively free from mercury contamination.

Selected samples were also analysed for other trace metals and chlorinated hydrocarbons. Overall, the levels of lead and cadmium detected in the edible portion of the fish were low and well within the standard values of 0.20 and 0.05 mg kg^{-1} wet weight respectively, set by the EU. There are no internationally agreed standards or guidelines available for the remaining trace metals and chlorinated hydrocarbons in fishery products. Therefore results are compared with the strictest standard or guidance value for fish tissue, which are applied by contracting parties to OSPAR. The levels of these additional contaminants are well below the strictest values listed.

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INTRODUCTION

Mercury, which occurs naturally in the earth's crust, can also be introduced into the aquatic environment from mining, agricultural, industrial and other human activities. Once in the aquatic environment mercury can be bioaccumulated in fish tissues. To protect consumers of marine foodstuffs, the EC set a maximum limit for total mercury of 0.50 mg kg^{-1} wet weight in fishery products. For physiological reasons, certain species accumulate mercury more readily than others (Clark *et al*, 1997) and for these species a higher acceptable limit of 1.0 mg kg^{-1} applies. These species are listed in Appendix 5.

Selected samples were also analysed for other trace metals and chlorinated hydrocarbons. Trace metals exist naturally in the environment and many, including chromium, cobalt, copper, iron, manganese, molybdenum, vanadium, strontium, and zinc are essential elements for living organisms. However, some trace metals such as lead and cadmium, which may be introduced into the aquatic environment from anthropogenic activities are not required for metabolic activity and are toxic at quite low concentrations.

To protect consumers of marine foodstuffs, the EC set maximum limits for total lead and cadmium of 0.20 and 0.05 mg kg^{-1} wet weight respectively, in fish muscle under Commission Regulation (EC) No. 466/2001 as amended by Commission Regulation (EC) No. 221/2002 of 6th February. Species with higher acceptable limits of 0.40 and 0.10 mg kg^{-1} for lead and cadmium are listed in Appendix 5, Tables 2 and 3 respectively.

Polychlorinated biphenyls (PCBs) and organo-chlorine pesticides (OCPs) are man-made compounds that are ubiquitous air and water-borne contaminants. These are persistent pollutants with a tendency to bioaccumulate in fish tissues and biomagnify through the food chain (Clark *et al.*, 1997).

Previous results for the analysis of finfish species landed at major Irish ports have been reported (Rowe *et al*., 1998 and Nixon *et al*., 1995, 1994, 1993, 1991). Results from the monitoring of contaminants in shellfish are reported separately (Glynn *et al*., 2003, McGovern *et al*., 2001, Smyth *et al*., 1997 and Nixon *et al., 1994b*). Data on contaminants in the marine biota are also good indicators of water quality (Stapleton *et al*., 2000 and Boelens *et al*., 1999)

Monitoring of contaminants in farmed fish is also carried out by the Marine Institute as part of the implementation of Council Directive 96/23/EC of 29 April 1996 on measures to monitor certain substances and residues thereof in live animals and animal products. Results for this programme are compiled as part of the National Residue Programme by Department of Agriculture, Food and Rural Development.

Marine Institute environmental monitoring reports are available on the Marine Institute website www.marine.ie.

MATERIALS AND METHODS

Sample Collection and Preservation

During the years 1997 – 2000, sampling of fish landed at the major fishing ports of Castletownbere, Dunmore East, Howth, Killybegs and Rossaveal took place on an annual basis. Depending on availability, 10 fish of each species landed were sampled at each of the ports. The length of each fish was recorded and a portion of tissue from each of the 10 fish was pooled to provide a sample. The pooled sample was homogenised prior to being divided into two sub-samples. Sub-samples were placed in either pre-weighed, acid washed glass jars for metal analysis or solvent washed glass jars for chlorinated hydrocarbons. These samples were stored in a freezer at –30ºC. One sub sample was freeze-dried for 48 hours and analysed for trace metals (except mercury). The other sub-sample was analysed for mercury and chlorinated hydrocarbons. The moisture content was determined by drying approximately 1g of unfrozen tissue overnight at 105ºC to constant weight. All samples were analysed for mercury and selected samples from each port were analysed for other trace metals and chlorinated hydrocarbons.

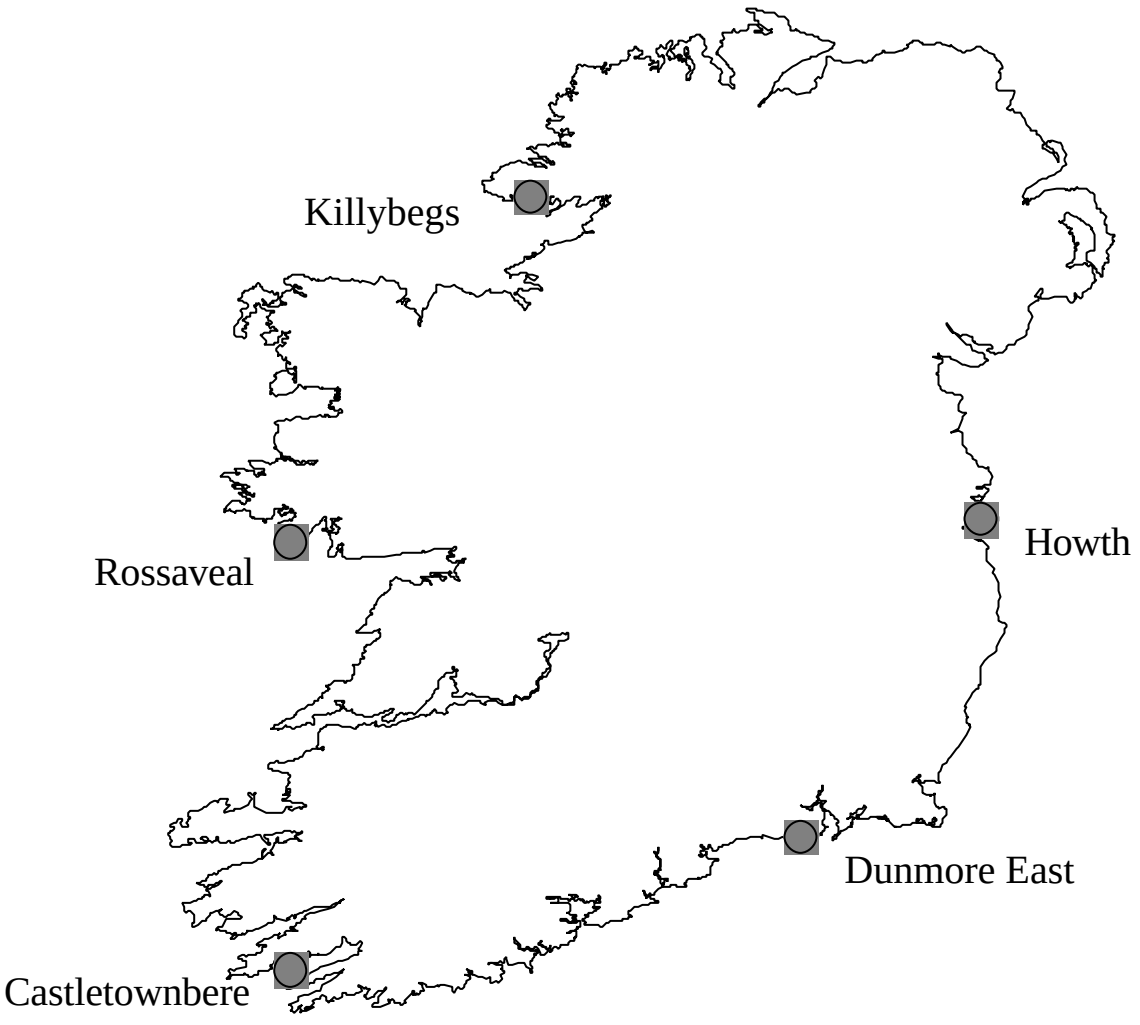

Fig 1. Locations of Irish ports sampled during 1997 - 2000

Mercury Analysis

Concentrated nitric acid (4ml) was added to 0.6 - 0.8g of wet tissue, which was then digested in a laboratory microwave oven (CEM Mars5). After cooling, potassium permanganate was added until the purple colour of the solution stabilized. Sufficient hydroxylamine sulphate/ sodium chloride solution was added to neutralise the excess potassium permanganate and potassium dichromate was added as a preservative. The solution was diluted to 100mls using deionised water. Following reduction of the samples with tin (II) chloride, total mercury concentration was determined by Cold Vapour Atomic Fluorescence Spectroscopy (CV-AFS) using a PSA Merlin Analyser.

Trace Metal Analysis (cadmium, chromium, copper, lead and zinc)

Concentrated nitric acid (4ml) and hydrogen peroxide (4ml) were added to approximately 0.2g freeze-dried tissue, which was then digested in a laboratory microwave oven (CEM Mars5). After cooling, samples were diluted to 50mls with deionised water. Lead, cadmium, chromium and copper concentrations were determined using Graphite Furnace Atomic Absorption Spectrometry with Zeeman background correction (Varian SpectrAA 220Z). Zinc concentrations were determined using Flame Atomic Absorption Spectroscopy (Varian SpectrAA 20 Plus).

Chlorinated Hydrocarbon Analysis

Due to the lipophilic nature of PCBs and OCPs, lipid was extracted from tissue using the method developed by Smedes, (QUASH, 1999; QUASH, 1998). The chlorinated hydrocarbons were removed from the lipids by alumina column chromatography followed by separation of PCBs from the chlorinated pesticides using silica column chromatography. Concentration levels were determined by Gas Chromatography with Electron Capture Detection (GC-ECD) using a Hewlett Packard 5890 gas chromatograph fitted with a 60 metre fused silica capillary column (HT8, J & W Scientific). A second column of different polarity was used as confirmation (CP-SIL 19CB, Chrompack).

Quality Assurance

A comprehensive analytical quality assurance programme underpins testing. This involves routine testing of quality control samples such as blanks, replicates and reference materials (including certified reference materials, (CRMs)) and participation in the QUASIMEME, (Quality Assurance of Information for Marine Environmental Monitoring) international laboratory proficiency-testing scheme. As the availability of appropriate marine certified reference materials is limited (de Boer and McGovern, 2001), reference materials supplied by QUASIMEME, FRS Marine Laboratory, Aberdeen, were used to supplement the use of CRMs. Although not certified, QUASIMEME RMs provide materials of suitable matrix and analyte concentrations and have assigned values derived from intercalibrations involving many expert laboratories in this field. A Z-score between –2 and 2 is generally considered satisfactory for environmental monitoring programmes. The quality assurance results obtained were considered sufficient for the purpose of the monitoring programme and are shown in Table 1.

Table 1: Results of the analyses of different reference materials obtained during the 1997-2000 finfish testing.

a) Certified Reference Materials

CRM	Certified Value (± 95% confidence limit)	Measured Value (Mean ± SD)	No. of Analyses
Mussel Tissue CRM 278R	**mg kg^{-1} dry wt.**	**mg kg^{-1} dry wt.**	
Cadmium	0.348 ± 0.007	0.321 ± 0.03	8
Chromium	0.78 ± 0.06	0.69 ± 0.124	11
Copper	9.45 ± 0.13	9.63 ± 0.41	10
Mercury	0.196 ± 0.009	0.188 ± 0.03	11
Lead	2.00 ± 0.04	1.69 ± 0.20	6
Zinc	83.1 ± 1.7	83.9 ± 6.74	10
Dogfish Muscle DORM2			
Cadmium	0.043 ± 0.008	0.048 ± 0.012	3
Lead	0.065 ± 0.007	0.074 ± 0.007	5
Zinc	25.6 ± 2.3	23.8 ± 2.4	2

Table 1 (continued): Results of the analyses of different reference materials obtained during the 1997-2000 finfish testing.

b) QUASIMEME Reference Materials

Reference Material	Assigned Values	Measured Value (Mean ± SD)	No. of Analyses	Mean Z Score	No. -2<Z<2
QORO67BT (Wet Mussel Tissue)					
PCBs (µg kg^{-1})					
PCB 28	0.23	0.53 ± 0.13	2	3.80	
PCB 31	0.21	0.60 ± 0.17	2	5.23	
PCB 52	0.53	1.16 ± 0.23	2	5.39	
PCB 101	2.10	2.27 ± 0.21	2	0.56	2
PCB 105	0.49	0.44 ± 0.04	2	-0.39	2
PCB 118	1.71	1.65 ± 0.11	2	-0.22	2
PCB 138	3.78	3.46 ± 0.26	2	-0.61	2
PCB 153	5.90	6.13 ± 0.52	2	0.29	2
PCB 156	0.20	0.16 ±0.02	2	-0.55	2
PCB 180	0.36	0.40 ± 0.05	2	0.37	2
Organochlorine Pesticides (µg kg^{-1})					
DDD- p,p'	0.45	0.33 ± 0.03	2	-1.13	2
DDE- p,p'	0.82	0.90 ± 0.06	2	0.55	2
DDT- o,p'	0.18	0.03	2	-2.03	
Dieldrin	0.82	0.36 ±0.24	2	-3.04	1
HCB	0.07	0.09 ± 0.02	2	0.34	2
γ- HCH	0.12	0.30 ± 0.07	2	2.78	1
trans-Nonachlor	0.12	0.09 ±0.01	2	-0.45	2
QORO52BT (Mackerel)					
PCBs (µg kg^{-1})					
PCB 28	0.40	0.51	1	1.13	1
PCB 52	2.34	2.60	1	0.76	1
PCB 101	10.0	10.2	1	0.18	1
PCB 105	1.83	1.59	1	-0.86	1
PCB 118	6.08	5.74	1	-0.41	1
PCB 138	13.5	13.0	1	-0.25	1
PCB 153	20.7	24.4	1	1.40	1
PCB 156	0.71	0.63	1	-0.59	1
PCB 180	2.01	2.00	1	-0.03	1
Organochlorine Pesticides (µg kg^{-1})					
DDD- p,p'	1.49	1.28	1	-0.91	1
DDE- p,p'	2.93	3.20	1	0.65	1
DDT- o,p'	0.31	0.13	1	-1.99	1
HCB	0.09	0.07	1	-0.26	1
γ- HCH	0.07	0.21	1	2.19	
trans-Nonachlor	0.14	0.06	1	-1.24	1

A slight positive bias for early eluting PCBs (28, 31, &52) was noted for the mussel but not for the mackerel material. For p,p'DDT and dieldrin there was a slight negative bias and for ?HCH a slight positive bias. Given the low concentrations of these substances in the reference materials, and considering that the levels measured in samples are at least two orders of magnitude below strictest standard/guidance values available for comparison, the results are considered acceptable for this programme.

RESULTS AND DISCUSSION

European Regulation 466/2001/EC (as amended by regulation 221/2001/EC) sets maximum levels for mercury, cadmium and lead in fish. While the monitoring presented in this report was carried out prior to the adoption of this regulation, results are compared with the values set in the regulation. The maximum levels are set out in the table below.

Table 2: European Regulation 466/2001/EC - Maximum levels for mercury, cadmium and lead in fish

	Mercury mg kg^{-1} wet weight	**Cadmium** mg kg^{-1} wet weight	**Lead** mg kg^{-1} wet weight
Muscle Meat of fish	0.5	0.05	0.2
Selected fish species *Listed in Appendix 5 for each metal*	1.0	0.1	0.4
Crustaceans	0.5	0.5	0.5
Bivalve molluscs	0.5	1.0	1.5
Cephalopods *(without viscera)*	0.5	1.0	1.0

Table 3: Metal Detection Limits (mg kg^{-1} wet weight)

Metal	LOD
Cadmium	0.004
Chromium	0.074
Copper	0.16
Lead	0.021
Mercury	0.01
Zinc	1.21

Mercury

A total of 13 fish muscle samples were analysed for mercury in 1997. Results are shown in Appendix 1 (Table 1a). These samples comprised 7 species taken from 4 major Irish ports. The levels of mercury detected ranged from 0.03 to 0.18 mg kg^{-1} wet tissue weight, with a mean and median of 0.08 and 0.07 mg kg^{-1} respectively. The highest levels detected were found in cod landed in Dunmore East and Howth (0.15 and 0.18 mg kg^{-1} respectively) and prawns landed in Howth (0.14 mg kg^{-1}).

During 1998, a total of 16 samples, comprising 10 species taken from 4 major Irish ports were analysed for mercury. Results are shown in Appendix 2 (Table 2a). The levels of mercury detected ranged from <0.03 mg kg^{-1} to 0.19 mg kg^{-1} wet tissue weight, with a mean and median of 0.08 and 0.07 mg kg^{-1} respectively. The highest levels were found in cod landed in Howth (0.19 mg kg^{-1}) and tuna landed in Castletownbere (0.19 mg kg^{-1}).

A total of 35 fish muscle samples comprising 18 species taken from 5 major Irish ports were analysed in 1999. Results are shown in Appendix 3 (Table 3a). Mercury concentrations ranged from <0.03 mg kg^{-1} to 0.29 mg kg^{-1} wet tissue weight, with a mean and median of 0.09 and 0.06 mg kg^{-1} respectively. The highest levels were found in ling and saithe landed in Killybegs (0.29 and 0.25 mg kg^{-1} respectively).

During 2000, a total of 48 samples, comprising 17 species taken from 5 major Irish ports were analysed for mercury. Results are shown in Appendix 4 (Table 4a). The levels of mercury detected ranged from 0.03 to 0.33 mg kg^{-1} wet tissue weight, with a mean and median of 0.09 and 0.07 mg kg^{-1} respectively. The highest levels were found in megrim landed in Rossaveal (0.33 mg kg^{-1}), black sole and haddock landed in Killybegs (0.21 and 0.27 mg kg^{-1} respectively), and prawns landed in Castletownbere (0.24 mg kg^{-1}).

Overall, the levels of mercury detected in the edible portion of the fish were well within the standard value of 0.5 mg kg^{-1} wet weight set by the EU (note 1 mg kg^{-1} in selected species listed in Appendix 5).

Other Trace Metals

For heavy metal determination, a selection of samples from 1997, 1999 and 2000 was analysed. A total of 12 fish muscle samples were analysed for heavy metals in 1997. Results are presented in Appendix 1 (Table 1b). These samples comprised 7 species taken from 4 major Irish ports. A total of 15 fish muscle samples comprising 8 species taken from 5 major Irish ports were analysed in 1999. Results are shown in Appendix 3 (Table 3b). During 2000, a total of 17 samples, comprising 8 species taken from each major Irish port were analysed for heavy metals. Results are presented in Appendix 4 (Table 4b).

Lead

Lead concentrations in finfish samples from 1997 were low. The highest levels were observed in prawns landed at Howth (<0.062 mg kg^{-1}). Lead concentrations in the remaining samples were less than the limit of detection.

The levels of lead measured in finfish samples from 1999 ranged from less than limit of detection to <0.062 mg kg^{-1} wet weight. The highest levels were found in plaice and haddock from Castletownbere.

Lead concentrations in finfish samples from 2000 were low. The highest levels were observed in haddock (<0.062 mg kg^{-1}) and cod (<0.062 mg kg^{-1}) landed in Dunmore East.

Cadmium

Cadmium concentrations in finfish samples from 1997 ranged from less than detection limit to 0.014 mg kg^{-1} wet weight. The highest levels were detected in prawns landed in Rossaveal (0.014 mg kg^{-1}).

The levels of cadmium measured in finfish samples from 1999 ranged from being less than the detection limit to <0.011 mg kg^{-1} wet weight.

Cadmium concentrations in finfish samples from 2000 ranged from being less than the detection limit to a value of 0.012 mg kg^{-1} wet weight. The highest levels were observed in salmon landed at Dunmore East (0.012 mg kg^{-1}).

Chromium
The levels of chromium measured in finfish samples from 1997 were low and all values were less than the limit of detection (0.074 mg kg^{-1}).

Chromium concentrations in finfish samples from 1999 ranged from less than detection limit to <0.19 mg kg^{-1} wet weight.

The levels of chromium measured in finfish samples from 2000 were low and ranged from less than detection limit to <0.19 mg kg^{-1} wet weight.

Copper
The levels of copper measured in finfish samples from 1997 ranged from less than detection limit to 3.77 mg kg^{-1} wet weight, with a mean of 0.72 mg kg^{-1}. The highest levels of copper were detected in prawns landed in Howth and Rossaveal (3.77 and 2.55 mg kg^{-1} respectively.

Copper concentrations in finfish samples from Irish ports in 1999 ranged from less than detection limit to 0.56 mg kg^{-1} wet weight. The highest levels were found in herring landed in Castletownbere (0.56 mg kg^{-1}).

The levels of copper measured in finfish samples from 2000 ranged from less than detection limit to 0.61 mg kg^{-1} wet weight. The highest levels of copper were observed in mackerel and salmon landed in Dunmore East (0.61 and 0.60 mg kg^{-1} respectively).

Zinc
The levels of zinc measured in samples from 1997 ranged from 1.98 - 11.9 mg kg^{-1} wet weight, with a mean and median of 4.43 and 3.13 mg kg^{-1} respectively. The highest levels of zinc were found in prawns from Howth and Rossaveal (11.9 and 11.5 mg kg^{-1} respectively) and plaice from Dunmore East (3.82 mg kg^{-1}).

Zinc concentrations in finfish samples from 1999 ranged from <1.62 - 4.03 mg kg^{-1} wet weight, with a mean and median of 2.87 and 2.66 mg kg^{-1} respectively. The highest levels were detected in plaice landed in Castletownbere (4.03 mg kg^{-1}) and saithe landed in Killybegs (4.01 mg kg^{-1}).

The levels of zinc measured in finfish samples from 2000 ranged from 1.95 – 3.84 mg kg^{-1} wet weight, with a mean and median of 3.00 and 2.94 mg kg^{-1} respectively. The highest levels of zinc were found in cod landed in Howth and Rossaveal (3.84 and 3.40 mg kg^{-1} respectively).

Overall, the levels of lead and cadmium detected in the edible portion of the fish were low and typically in the region of one order of magnitude less than the maximum limits, set by the EU outlined in Table 2. There are no internationally agreed standards or guidelines available for copper, chromium and zinc in fish for human consumption. However, there is a list of heavy metal standard and guidance values for copper and zinc in fish tissue, which are applied by Contracting Parties to OSPAR (Anon 1992). The values are set out in Table 4.

Chlorinated Hydrocarbons
There are no internationally agreed standards for chlorinated hydrocarbons in fisheries products. The strictest standards and guidance values for these compounds as applied by Contracting Parties to the OSPAR Convention are given in Table 4. Chlorinated

hydrocarbon analyses was carried out on 15 tissue samples collected in 2000, comprising 7 species. Results of these analyses are shown in Appendix 4, Table 4b. These results are very low in comparison with the values presented in Table 4. Highest concentrations were found in mackerel and salmon, both of which are lipid rich fish. This is to be expected due to the lipophilic nature of these compounds.

Table 4: Synopsis of the strictest guidance and standard values applied by various OSPAR countries for contaminants in fish tissue

Contamination	Unit	Qualifiers*	Country
Copper	10 $mg.kg^{-1}$	W/G	Norway
Zinc	50 $mg.kg^{-1}$	W/G	U.K.
DDT and its transformation products	500 $\mu g.kg^{-1}$	W/S	Finland
HCB	50 $\mu g.kg^{-1}$	W/G	Norway
$\alpha + \beta$ HCH	50 $\mu g.kg^{-1}$	W/G	Norway
γ HCH	100 $\mu g.kg^{-1}$	W/S	Finland
$\alpha+\beta+\gamma$ HCH	200 $\mu g.kg^{-1}$	W/G	Norway/Sweden
PCBs	1000 $\mu g.kg^{-1}$	W/G	Norway
PCB 28	80 $\mu g.kg^{-1}$	W/S	Germany
PCB 52	40 $\mu g.kg^{-1}$	W/S	Netherlands
PCB 101	80 $\mu g.kg^{-1}$	W/S	Germany/Netherlands
PCB 118	80 $\mu g.kg^{-1}$	W/S	Netherlands
PCB 138	100 $\mu g.kg^{-1}$	W/S	Germany/Netherlands
PCB 153	100 $\mu g.kg^{-1}$	W/S	Germany/Netherlands
PCB 180	80 $\mu g.kg^{-1}$	W/S	Germany
Aldrin + dieldrin	100 $\mu g.kg^{-1}$	W/S	Finland
Lindane	100 $\mu g.kg^{-1}$	W/S	Finland

*W = wet weight; S = standard; G = guidance value

CONCLUSIONS

Based on the analyses of the 1997 – 2000 samples, total mercury and heavy metal concentrations in the commercial catch landed at 5 major Irish ports is low, which confirms previous studies (Rowe *et al*., 1998; Nixon *et al*., 1994; Nixon *et al*., 1993; O' Sullivan *et al*., 1991 and Nixon *et al*., 1991). All samples tested were well within the limits set by the Commission Regulation (EC) No. 466/2001 for mercury, cadmium and lead. For copper and zinc, levels were well below the strictest guidance values applied by OSPAR member states.

Chlorinated hydrocarbon concentrations were also very low and again confirm previous studies (Bloxham *et al*., 1998; Smyth *et al*., 1997 and Nixon *et al*., 1995, 1994 and 1991). All results were well within the strictest standard and guidance values of OSPAR member states.

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REFERENCES

Anon, (1992). *Monitoring Manual - Principles and Methodology of the Joint Monitoring Programme.* A compilation of standards and guidance values for contaminants in fish, crustaceans and molluscs for the assessment of possible hazards to human health. Oslo and Paris Commissions. Update 1992 - A7.2/92-E.

Bloxham, M., A. Rowe, E. McGovern, M. Smyth and E. Nixon, (1998). Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish and Fin-fish from Irish Waters – 1996. *Fishery Leaflet 179*. Marine Institute, Dublin.

Boelens, R.G.V., D. Maloney, A. Parsons and A. Walsh, (1999). Ireland's Marine and Coastal Areas and Adjacent Seas: an Environmental Assessment. Marine Institute, Dublin.

Clark, R.B., C. Frid and M. Attrill, (1997). Marine Pollution (4th ed.), Clarendon Press, Oxford.

de Boer, J. and E. McGovern, (2001). Certified Reference Materials for Organic Contaminants for use in Monitoring of the Aquatic Environment. *Trends Anal. Chem*., **20**, 140 –159.

Glynn, D., L. Tyrrell, B. McHugh, A. Rowe, J. Costello and E. McGovern (2003). Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish from Irish Waters, 2000. Marine Environment and Health Series No 7, 2002, Marine Institute, Dublin.

McGovern, E., A. Rowe, B. McHugh, J. Costello, M. Bloxham, C. Duffy & E. Nixon (2001). Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish from Irish Waters, 1997-1999. Marine Environment and Health Series No.2, 2001, Marine Institute, Dublin.

Nixon, E., D. McLaughlin, R.G. Boelens, and G. O'Sullivan (1991). Contaminants in Marine Biota - 1990 Monitoring Programme, *Fishery Leaflet* 151, Department of Marine, Dublin.

Nixon, E., A. Rowe, D. McLaughlin (1993). Mercury concentration in fish from Irish waters in 1992. *Fishery Leaflet 156*, Department of Marine, Dublin.

Nixon, E., A. Rowe, D. McLaughlin (1994). Mercury concentration in fish from Irish waters in 1993. *Fishery Leaflet 162*, Department of Marine, Dublin.

Nixon, E., A. Rowe, M. Smyth, D. McLaughlin and J. Silke, (1994b). Monitoring of Shellfish Growing Areas - 1993. *Fishery Leaflet 160*. Department of the Marine, Dublin.

Nixon, E., A. Rowe, M. Smyth, D. McLaughlin and J. Silke, (1995). Monitoring of Shellfish Growing Areas - 1994. *Fishery Leaflet 166*. Department of the Marine, Dublin

O'Sullivan, M.P., E.. Nixon, D. McLaughlin, M. O'Sullivan and D. O'Sullivan, (1991). Chemical contaminants in Irish estuarine and coastal waters, 1978 to 1988. *Fisheries Bulletin No. 10*. Department of the Marine, Dublin.

QUASH, (1998). Draft Report on the QUASH Interlaboratory Study; Determination of Lipid in Fish and Shellfish, Round 1 SBT-2 Exercise 1000, Sponsored by the EU Standards, Measurements and Testing Programme. QUASIMEME Project Office, Marine Laboratory, Aberdeen.

QUASH, (1999). Report on the Proceedings of the QUASH Workshop on Lipid Determination and Biota Sample Handling. Sponsored by the EU Standards, Measurements and Testing Programme. Galway, Republic of Ireland, 30 September – 4 October 1998. QUASIMEME Project Office, Marine Laboratory, Aberdeen.

Rowe, A., E. Nixon, E. McGovern, M. McManus, M. Smyth (1998). Metal and Organo-Chlorine Concentrations in Fin-Fish from Irish Waters, *Fishery Leaflet 176*, Marine Institute, Dublin.

Smyth, M., A. Rowe, E. McGovern and E. Nixon, (1997). Monitoring of Shellfish Growing Areas - 1995. *Fishery Leaflet 174*. Department of the Marine, Dublin

Stapleton, L., M. Lehane and P. Toner, (2000). Ireland's Environment: a Millennium Report. Environmental Protection Agency, Wexford. ISBN 1-84095-016-1

Appendix 1 (Page 1 of 1): Results of monitoring of fish species from selected Irish Ports – 1997

Note: For values reported as "nd" Substances were not detected above the Limit of Detection (LOD)
For values reported as "< value", "value = Limit of Quantitation (LOQ) for the relevant determinand

Table 1a: Mercury (Hg) concentration (mg kg^{-1} wet weight) in the edible tissue, length statistics (mm) and moisture content (%) of representative fish species landed and sampled at selected Irish ports in 1997. Common and species names are listed in Appendix 6.

	Species	MI Reference	Sample Size	Hg	Length Range	Length Mean	Moisture Content
Dunmore East	Cod	ENV 97/341	10	0.15	495-620	556	79.9
27/07/97	Mackerel	ENV 97/332	10	0.08	270-345	305	71.6
	Plaice	ENV 97/336	10	0.03	320-360	339	80.4
Howth	Black sole	ENV 97/365	10	0.05	325-390	359	79.0
01/09/97	Cod*	ENV 97/362	10	0.18	640-810	710	80.2
	Prawn	ENV 97/364	25	0.14	35-45	39	80.0
	Whiting	ENV 97/363	10	0.07	310-390	358	80.3
Killybegs	Cod	ENV 97/343	10	0.06	315-600	407	80.3
16/07/97	Forkbeard	ENV 97/331	10	0.09	355-510	397	79.3
	Plaice	ENV 97/330	10	0.04	250-305	278	79.8
Rossaveal	Cod	ENV 97/312	10	0.07	310-430	360	88.6
26/06/97	Mackerel	ENV 97/306	10	0.04	260-370	328	75.9
	Prawn	ENV 97/311	25	0.08	30-44	37	80.3

note: * = QC duplicate samples analysed and mean reported

Table 1b: Heavy metal concentrations (mg kg^{-1} wet weight) in the edible tissue of representative fish species landed and sampled at selected Irish ports in 1997. Common and species names are listed in Appendix 6. (Lengths, moisture content and MI reference number are as Table 1a)

	Species	Sample Size	Lead	Cadmium	Chromium	Copper	Zinc
Dunmore East	Cod	10	nd	<0.011	nd	<0.44	3.20
27/07/97	Mackerel	10	nd	nd	nd	<0.44	3.05
	Plaice	10	nd	nd	nd	<0.44	3.82
Howth	Black sole	10	nd	nd	nd	nd	3.24
01/09/97	Cod	10	nd	nd	nd	<0.44	2.98
	Prawn	25	<0.062	<0.011	nd	3.77	11.9
	Whiting	10	nd	nd	nd	<0.44	2.53
Killybegs	Cod	10	nd	<0.011	nd	<0.44	2.86
16/07/97	Forkbeard	10	nd	<0.011	nd	<0.44	1.98
	Plaice	10	nd	nd	nd	<0.44	3.21
Rossaveal	Cod	10	nd	nd	nd	<0.44	2.90
26/06/97	Prawn	25	nd	0.014	nd	2.55	11.5

Appendix 2 (Page 1 of 1): Results of monitoring of fish species from selected Irish Ports – 1998

Table 2a: Mercury (Hg) concentration (mg kg^{-1} wet weight) in the edible tissue and length statistics (mm) of representative fish species landed and sampled at selected Irish ports in 1998. Common and species names are listed in Appendix 6.

	Species	MI Reference	Sample Size	Hg	Length Range	Length Mean
Castletownbere	Cod	ENV 98/009	10	0.10	365-420	399
28/07/98	Mackerel	ENV 98/010	10	0.05	310-350	326
	Plaice	ENV 98/002	10	0.03	265-335	308
	Ray *	ENV 98/007	10	0.10	600-745	645
	Tuna	ENV 98/012	6	0.19	660-825	743
Dunmore East	Mackerel	ENV 98/049	10	0.03	265-335	300
20/08/98	Plaice	ENV 98/047	10	0.03	290-360	319
	Whiting	ENV 98/052	10	0.07	310-390	347
Howth	Black sole	ENV 98/081	10	0.07	310-365	337
14/08/98	Cod	ENV 98/055	10	0.19	510-570	531
	Mackerel	ENV 98/058	10	<0.03	295-345	315
	Prawn	ENV 98/082	10	0.06	35-50	41
Killybegs	Saithe	ENV 98/018	10	0.04	435-690	525
14/08/98	Cod	ENV 98/016	10	0.14	450-690	520
	Lemon sole	ENV 98/013	10	0.13	255-365	311
	Mackerel	ENV 98/020	10	0.03	245-320	270

note: * = QC duplicate samples analysed and mean reported

Appendix 3 (Page 1 of 2): Results of monitoring of fish species from selected Irish Ports – 1999

Table 3a: Mercury concentration (mg kg^{-1} wet weight) in the edible tissue, length statistics (mm) and moisture content (%) of various fish species landed and sampled at selected Irish ports in 1999. Common and species names are listed in Appendix 6.

	Species	MI Reference	Sample Size	Hg	Length Range	Length Mean	Moisture Content
Castletownbere	Black sole	ENV 99/287	10	0.04	260-330	289	79.1
29/07/99	Haddock	ENV 99/295	10	0.05	460-595	537	79.1
	Hake	ENV 99/293	10	0.04	340-555	402	80.4
	Herring	ENV 99/292	10	0.09	270-310	286	65.2
	Megrim*	ENV 99/288	10	0.04	290-380	354	78.7
	Anglerfish *	ENV 99/296	10	0.13	420-590	516	82.2
	Plaice	ENV 99/294	10	0.03	275-455	336	78.7
	Whiting	ENV 99/289	10	0.06	320-375	353	80.0
Dunmore East	Black sole	ENV 99/330	10	0.03	245-305	262	79.5
13/08/99	Cod	ENV 99/333	10	0.04	340-405	378	81.2
	Gurnard	ENV 99/331	10	0.09	290-340	310	78.8
	Haddock	ENV 99/326	10	<0.03	305-350	327	80.0
	Lemon sole	ENV 99/329	10	0.05	255-315	282	79.5
	Mackerel	ENV 99/332	10	0.04	295-330	309	65.6
	Plaice	ENV 99/327	6	0.10	420-470	453	78.9
	Ray	ENV 99/328	8	0.03	490-620	561	78.8
	Whiting	ENV 99/325	10	0.04	315-380	341	80.5
Howth	Black sole*	ENV 99/321	10	0.04	320-395	355	80.9
11/08/99	Haddock	ENV 99/322	10	0.06	425-510	486	79.6
	Plaice	ENV 99/323	10	<0.03	275-310	295	79.8
	Whiting	ENV 99/324	10	0.06	390-445	421	81.0
Killybegs	Cod	ENV 99/161	10	0.06	545-900	750	80.1
14/07/99	Haddock	ENV 99/166	10	0.07	370-485	422	80.4
	Ling	ENV 99/168	9	0.29	540-1300	968	79.7
	Megrim	ENV 99/165	10	0.19	380-520	476	79.2
	Anglerfish *	ENV 99/164	10	0.16	400-930	696	83.4
	Saithe	ENV 99/167	5	0.25	690-1120	1027	77.9
	Torsk/Tusk	ENV 99/162	9	0.16	475-650	534	79.3
	Wolf-fish	ENV 99/163	10	0.19	390-820	705	81.6
Rossaveal	Haddock	ENV 99/284	10	0.07	315-380	349	79.3
29/07/99	Megrim	ENV 99/281	10	0.04	270-370	300	77.9
	Anglerfish	ENV 99/283	10	0.18	390-960	628	83.7
	Plaice	ENV 99/286	10	0.04	260-322	293	78.9
	Prawn	ENV 99/282	19	0.21	39-50	44	78.5
	Whiting	ENV 99/285	10	0.10	318-438	383	80.6

note: * = QC duplicate samples analysed and mean reported

Appendix 3 (Page 2 of 2): Results of monitoring of fish species from selected Irish Ports – 1999

Table 3b: Heavy metal concentrations (mg kg^{-1} wet weight) in the edible tissue of representative fish species landed and sampled at selected Irish ports in 1999. Common and species names are listed in Appendix 6. (Lengths, moisture content and MI reference number are as Table 3a)

	Species	Sample Size	Lead	Cadmium	Chromium	Copper	Zinc
Castletownbere	Plaice	10	0.025	nd	nd	nd	4.03
29/07/99	Haddock	10	0.022	nd	nd	nd	2.65
	Herring	10	nd	nd	nd	0.563	<1.61
Dunmore East	Cod	10	nd	nd	nd	<0.44	3.00
13/08/99	Haddock	10	nd	nd	nd	nd	2.49
	Lemon Sole	10	nd	nd	<0.19	<0.44	2.44
	Mackerel	10	nd	nd	nd	<0.44	2.04
Howth	Plaice	10	nd	nd	nd	nd	3.38
11/08/99	Haddock	10	nd	nd	nd	nd	2.50
Killybegs	Haddock	10	nd	<0.011	nd	nd	2.66
14/08/99	Saithe	5	nd	nd	nd	<0.44	4.01
	Cod	10	nd	<0.011	nd	<0.44	3.39
Rossaveal	Plaice	10	nd	nd	nd	nd	3.72
29/07/99	Anglerfish	10	nd	nd	nd	nd	2.94
	Haddock	10	nd	nd	<0.19	<0.44	2.63

Appendix 4 (Page 1 of 4): Results of monitoring of fish species from selected Irish Ports – 2000

Table 4a: Mercury (Hg) concentration (mg kg^{-1} wet weight) in the edible tissue, length statistics (mm) and moisture content (%) of various fish species landed and sampled at selected Irish Ports in 2000. Common and species names are listed in Appendix 6.

	Species	MI Reference	Sample Size	Hg	Length Range	Length Mean	Moisture Content
Castletownbere	Black sole	ENV 00/341	10	0.19	330-415	375	80.2
4/07/00	Cod	ENV 00/343	10	0.05	325-385	352	81.1
	Haddock	ENV 00/346	10	0.05	300-375	353	80.3
	Hake*	ENV 00/352	10	0.07	445-555	490	80.5
	Lemon sole	ENV 00/351	10	0.04	235-290	256	78.6
	Ling	ENV 00/344	10	0.15	495-685	612	78.6
	Mackerel*	ENV 00/342	10	0.04	340-430	370	77.5
	Megrim	ENV 00/350	10	0.06	270-410	324	79.5
	Plaice	ENV 00/349	6	0.04	280-380	322	80.6
	Pollack	ENV 00/347	9	0.05	380-445	412	79.0
	Prawn	ENV 00/353	25	0.24	50-66.6	57	78.1
	Skate/Ray	ENV 00/348	7	0.07	475-845	649	76.8
	Whiting	ENV 00/345	10	0.08	355-435	391	80.2
Dunmore East	Black sole	ENV 00/361	9	0.05	305-340	319	79.7
11/07/00	Cod	ENV 00/370	10	0.05	380-550	420	80.9
	Haddock*	ENV 00/365	10	0.03	275-350	309	80.3
	Hake	ENV 00/366	10	0.03	315-420	365	81.1
	Lemon sole	ENV 00/369	10	0.07	240-295	270	79.1
	Mackerel	ENV 00/368	10	0.06	270-335	312	72.9
	Megrim*	ENV 00/362	10	0.05	325-435	362	78.2
	Salmon	ENV 00/364	5	0.07	615-680	645	66.3
	Whiting	ENV 00/367	10	0.06	275-405	325	81.2
	Witch	ENV 00/363	10	0.09	270-340	298	81.3
Howth	Cod*	ENV 00/373	10	0.07	400-465	428	80.6
27/07/00	Haddock	ENV 00/360	10	0.03	325-480	371	79.7
	Plaice	ENV 00/372	10	0.09	275-370	317	79.9
	Ray	ENV 00/374	10	0.10	360-590	490	80.1
	Whiting*	ENV 00/371	10	0.16	300-346	316	80.8
Killybegs	Black sole	ENV 00/324	10	0.21	305-370	328	81.0
22/06/00	Haddock	ENV 00/322	10	0.27	385-465	434	81.2
	Hake	ENV 00/328	10	0.08	345-400	371	80.1
	Megrim	ENV 00/326	10	0.06	255-310	276	81.2
	Plaice	ENV 00/325	10	0.05	245-310	285	81.3
	Pollack	ENV 00/327	10	0.20	365-540	429	79.4
	Ray	ENV 00/321	10	0.10	425-590	496	77.5
	Whiting*	ENV 00/323	10	0.14	265-305	291	80.4

Appendix 4 (Page 2 of 4): Results of monitoring of fish species from selected Irish Ports – 2000

Table 4a (continued): Mercury (Hg) concentration (mg kg^{-1} wet weight) in the edible tissue, length statistics (mm) and moisture content (%) of various fish species landed and sampled at selected Irish Ports in 2000. Common and species names are listed in Appendix 6.

	Species	MI Reference	Sample Size	Hg	Length Range	Length Mean	Moisture Content
Rossaveal	Black sole	ENV 00/333	10	0.06	275-345	319	79.4
29/06/00	Cod*	ENV 00/329	10	0.04	295-380	332	79.5
	Haddock	ENV 00/338	10	0.12	370-550	462	79.5
	Hake	ENV 00/331	10	0.06	450-585	521	80.3
	Lemon sole*	ENV 00/334	10	0.06	245-340	279	80.5
	Mackerel	ENV 00/332	10	0.03	310-356	333	46.9
	Megrim	ENV 00/336	10	0.33	275-335	305	81.2
	Anglerfish	ENV 00/340	10	0.14	330-465	377	83.0
	Anglerfish	ENV 00/339	10	0.14	325-445	364	84.1
	Plaice*	ENV 00/335	10	0.07	270-340	301	80.1
	Whiting	ENV 00/330	10	0.03	335-380	357	80.1
	Witch	ENV 00/337	10	0.08	265-330	296	81.1

note: * = QC duplicate samples analysed and mean reported

Appendix 4 (Page 3 of 4): Results of monitoring of fish species from selected Irish Ports – 2000

Table 4b: Heavy metal and chlorinated hydrocarbon concentrations (mg kg^{-1} and µg kg^{-1} wet weight respectively) in the edible tissue of representative fish species landed and sampled at selected Irish ports in 2000 Common and species names are listed in Appendix 6. (Lengths, moisture content, MI reference number and sample size are as Table 4a)

	Castletownbere 04/07/00				**Dunmore East** 11/07/00				
	Cod	Ling	Mackerel	Plaice	Cod	Haddock	Mackerel	Salmon	Lemon Sole
Metals (mg kg^{-1} wet wt)									
Cadmium	nd	nd	<0.011	nd	nd	nd	<0.011	0.012	nd
Chromium	nd	nd	nd	nd	nd	nd	nd	nd	nd
Copper	<0.44	<0.44	<0.44	<0.44	0.52	<0.44	0.61	0.60	<0.44
Lead	nd	nd	nd	nd	<0.062	<0.062	nd	nd	nd
Zinc	2.99	2.66	2.42	3.18	2.94	2.73	2.77	1.95	2.49
PCB Congeners (µg kg^{-1} wet wt)									
PCB 28	0.05	0.05	0.07	0.03	0.04	0.03	0.77	1.20	NA
PCB 31	0.04	0.04	0.06	0.03	0.05	0.03	0.96	2.07	NA
PCB 52	0.09	0.10	0.16	0.07	0.09	0.07	1.84	2.84	NA
PCB 101	0.12	0.17	0.31	0.07	0.10	0.07	2.00	1.83	NA
PCB 105	0.06	0.06	0.10	0.01	0.04	0.01	nd	nd	NA
PCB 118	0.11	0.10	0.13	0.03	0.05	0.03	1.18	0.50	NA
PCB 138	0.23	0.25	0.35	0.05	0.15	0.04	2.02	0.06	NA
PCB 153	0.44	0.40	0.56	0.13	0.32	0.09	3.17	1.62	NA
PCB 156	0.02	0.02	0.02	<0.01	0.02	<0.01	0.14	0.08	NA
PCB 180	0.13	0.14	0.17	0.04	0.12	0.03	0.68	0.41	NA
Organochlorine Pesticides (µg kg^{-1} wet wt)									
DDD- p,p'	0.07	0.09	0.13	0.01	nd	nd	0.42	1.19	NA
DDE- p,p'	0.26	0.38	0.57	0.07	0.12	0.02	1.42	4.62	NA
DDT- o,p'	<0.01	0.01	0.03	<0.01	nd	nd	nd	0.20	NA
DDT- p,p'	0.07	0.03	0.07	nd	0.01	nd	nd	0.98	NA
HCB	0.12	0.08	0.12	0.03	0.05	0.04	0.43	1.30	NA
γ- HCH	0.15	0.07	0.10	0.06	0.09	0.08	0.99	0.71	NA
trans-Nonachlor	0.06	0.09	0.17	0.02	0.02	<0.01	0.28	1.36	NA
trans-Chlordane	nd	nd	nd	nd	nd	nd	nd	0.13	NA
Cis-Chlordane	0.09	0.01	0.06	<0.01	<0.01	<0.01	nd	0.31	NA
Total Lipid (%)	0.52	0.54	0.74	0.65	0.59	0.55	4.17	10.62	NA

Notes: NA: Sample not analysed
nd: Not detected

Appendix 4 (Page 4 of 4): Results of monitoring of fish species from selected Irish Ports – 2000

Table 4b (continued): Heavy metal and chlorinated hydrocarbon concentrations (mg kg^{-1} and µg kg^{-1} wet weight respectively) in the edible tissue of representative fish species landed and sampled at selected Irish ports in 2000. Common and species names are listed in Appendix 6. (Lengths, moisture content, MI reference number and sample size are as Table 4a)

	Howth 27/07/00		**Killybegs** 22/06/00		**Rossaveal** 29/06/00			
	Cod	Plaice	Haddock	Plaice	Mackerel	Anglerfish	Cod	Plaice
Metals (mg kg^{-1} wet wt)								
Cadmium	<0.011	nd	nd	nd	<0.011	nd	nd	nd
Chromium	<0.19	nd	nd	nd	nd	nd	nd	nd
Copper	<0.44	<0.44	nd	<0.44	0.49	nd	<0.44	<0.44
Lead	nd	nd	nd	<0.062	nd	nd	nd	nd
Zinc	3.84	3.42	3.16	3.14	2.90	3.77	3.40	3.16
PCB Congeners (µg kg^{-1} wet wt)								
PCB 28	0.85	0.13	0.09	0.13	0.63	nd	NA	0.11
PCB 31	0.66	0.15	0.15	0.09	0.39	0.18	NA	0.13
PCB 52	0.33	0.27	0.20	0.24	1.11	0.29	NA	0.22
PCB 101	0.13	0.20	0.10	0.08	0.76	0.11	NA	0.10
PCB 105	0.03	0.04	0.02	0.02	0.15	0.02	NA	nd
PCB 118	0.05	0.12	0.04	0.04	0.38	0.05	NA	0.03
PCB 138	0.07	0.19	0.07	0.04	0.66	0.13	NA	0.04
PCB 153	0.21	0.31	0.22	0.13	1.17	0.47	NA	0.13
PCB 156	0.02	0.01	0.01	0.01	0.02	0.01	NA	<0.01
PCB 180	0.06	0.08	<0.01	0.03	0.26	0.15	NA	0.03
Organochlorine Pesticides (µg kg^{-1} wet wt)								
DDD- p,p'	0.04	0.05	nd	0.05	nd	0.01	NA	0.01
DDE- p,p'	0.11	0.18	0.06	0.06	0.75	0.41	NA	0.10
DDT- o,p'	nd	nd	nd	0.02	0.02	nd	NA	nd
DDT- p,p'	nd	nd	nd	nd	nd	nd	NA	nd
HCB	0.06	0.05	0.19	0.04	0.20	0.08	NA	0.04
γ- HCH	0.11	0.09	0.06	0.06	nd	0.08	NA	0.06
trans-Nonachlor	0.01	0.01	0.03	0.02	nd	0.12	NA	0.02
trans-Chlordane	0.01	nd	0.07	nd	nd	0.05	NA	nd
cis- Chlordane	<0.01	<0.01	<0.01	<0.01	nd	0.01	NA	<0.01
Total Lipid (%)	0.85	0.65	0.53	0.64	2.00	0.66	NA	0.59

Notes: NA: Sample not analysed
nd: Not detected

Appendix 5 (Page 1 of 2): Selected species, as listed by the European Commission Regulation (EC) No 221/2002, where the higher acceptable limit of total mercury, lead and cadmium concentration apply

Table 1: Selected species where the higher acceptable limit of 1.0 $mg.kg^{-1}$ total mercury concentration applies

Common Name	***Species Name***
Anglerfish	*Lophius species*
Atlantic catfish	*Anarhichas lupus*
Bass	*Dicentrarchus labrax*
Blue ling	*Molva dipterygia*
Bonito	*Sarda sarda*
Eel	*Anguilla species*
Emperor or Orange Roughy	*Hoplostethus atlanticus*
Grenadier	*Coryphaenoides rupestris*
Halibut	*Hippoglossus hippoglossus*
Marlin	*Makaira species*
Pike	*Esox lucius*
Plain bonito	*Orcynopsis unicolor*
Portuguese dogfish	*Cantroscymnes coelolepis*
Rays	*Raja species*
Redfish	*Sebastes marinus, S. mentella, S. viviparus*
Sailfish	*Istiophorus platypterus*
Scabbard fish	*Lepidopus caudatus, Aphanopus carbo*
Sharks	*all species*
Snake mackerel or butterfish	*Lepidocybium flavobrunneum, Ruvettus pretiousus, Gempylus serpens*
Sturgeon	*Acipenser species*
Swordfish	*Xiphias gladius*
Tuna	*Thunnus species and Euthynnus species*

Appendix 5 (Page 2 of 2): Selected species, as listed by the European Commission Regulation (EC) No 221/2002, where the higher acceptable limit of total mercury, lead and cadmium concentration apply

Table 2: Selected species where the higher acceptable limit of 0.4 $mg.kg^{-1}$ total lead concentration applies

Common Name	***Species Name***
Bonito	*Sarda sarda*
Common two-banded seabream	*Diplodus vulgaris*
Eel	*Anguilla species*
Grey mullet	*Mugil labrosus labrosus*
Grunt	*Pomadasys benneti*
Horse mackerel or scad	*Trachurus trachurus*
Sardine	*Sardina pilchardus*
Sardinops	*Sardinops species*
Spotted seabass	*Dicentrarchus*
Tuna	*Thunnus species and Euthynnus species*
Wedge sole	*Dicologoglossa cuneata*

Table 3: Selected species where the higher acceptable limit of 0.1 $mg.kg^{-1}$ total cadmium concentration applies

Common Name	***Species Name***
Bonito	*Sarda sarda*
Common two-banded seabream	*Diplodus vulgaris*
Eel	*Anguilla species*
European anchovy	*Engraulis encrasicholus*
Grey mullet	*Mugil labrosus labrosus*
Horse mackerel or scad	*Trachurus trachurus*
Louvar or Luvar	*Luvarus imperialis*
Sardine	*Sardina pilchardus*
Sardinops	*Sardinops species*
Tuna	*Thunnus species and Euthynnus species*
Wedge sole	*Dicologoglossa cuneata*

Appendix 6 (Page 1 of 1): Finfish sampled during 1997 – 2000 and their corresponding species name

Common Name	***Species Name***
Anglerfish	*Lophius spp.*
Black sole	*Solea solea*
Cod	*Gadus morhua*
Forkbeard	*Phycus blennoides*
Grey Gurnard	*Eutriglia gurnardus*
Haddock	*Melanogrammus aeglefinus*
Hake	*Merluccius merluccius*
Herring	*Clupea harengus*
Lemon sole	*Microstomus kitt*
Ling	*Molva molva*
Mackerel	*Scomber scombrus*
Megrim	*Lepidorhombus whiffiagonis*
Plaice	*Pleuronectes platessa*
Pollack	*Pollachius pollachius*
Prawn	*Nephrophs norvegicus*
Ray	*Raja spp.*
Saithe	*Pollachius virens*
Salmon	*Salmo salar*
Torsk/Tusk	*Brosme brosme*
Tuna	*Thunnus thynnus*
Whiting	*Merlangius merlangus*
Witch	*Glyptocephalus cynoglossus*
Wolf-fish	*Anarhichas lupus*