Trace Metal and Chlorinated Hydrocarbon Concentrations in Various Fish Species Landed at Selected Irish Ports, 2001

L. Tyrrell, D. Glynn, B. McHugh, A. Rowe, E. Monaghan,
J. Costello and E. McGovern

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L. TYRRELL, D. GLYNN, B. MCHUGH, A. ROWE, E. MONAGHAN,
J. COSTELLO AND E. MCGOVERN [1]

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

[1] Author to whom correspondence should be addressed

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ABSTRACT

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

During 2001, a total of 44 samples from 20 different species of finfish were collected from six major Irish fishing ports and analysed for total mercury concentration in the edible tissue (Common names and species names are listed in Appendix 3). The concentration of mercury ranged from less than the limit of quantitation (0.03 mg kg^{-1} wet weight) to 0.42 mg kg^{-1} wet weight with a mean and median of 0.09 and 0.07 mg kg^{-1} respectively. These levels are within the maximum limit of 0.50 mg kg^{-1} wet weight for mercury in fishery products set by the EC (1 mg kg^{-1} for selected species). This survey confirms previous studies, which show that Irish seafood is 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 the OSPAR Convention. The levels of these additional contaminants are well below the strictest values listed.

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INTRODUCTION

This study provides the results of analysis, by the Marine Institute, of total mercury concentrations in the edible portion of various fish species. Mercury, which occurs naturally in the earth's crust, can also be introduced into the aquatic environment via 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*, 2001) and for these species a higher acceptable limit of 1.0 mg kg^{-1} applies. These species are listed in Appendix 2, Table 1.

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. Once in the aquatic environment, these metals can be concentrated in fish tissues.

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. Species with higher acceptable limits of 0.40 and 0.10 mg kg^{-1} for lead and cadmium are listed in Appendix 2, Tables 2 and 3 respectively.

Polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) are man-made compounds that are ubiquitous environmental contaminants. These are persistent pollutants with a tendency to bioaccumulate in fish tissues and biomagnify through the food chain (Clark *et al*, 2001).

Previous results for the analysis of finfish species landed at major Irish ports have been reported (Tyrrell *et al*, 2003; Bloxham *et al*, 1998; Rowe *et al*, 1998; Nixon *et al*, 1995, 1994a, 1993, 1991 and O' Sullivan *et al*, 1991). Results from the monitoring of contaminants in shellfish are reported separately (Glynn *et al*, 2003a; Glynn *et al*, 2003b; McGovern *et al*, 2001; Bloxham *et al*, 1998; Smyth *et al*, 1997 and Nixon *et al*, 1994b). Data on contaminants in 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 and Food.

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

MATERIALS AND METHODS

Sample Collection and Preservation

During 2001, fish landed at the major fishing ports of Castletownbere, Dunmore East, Howth, Killybegs, Rossaveal and Dingle were sampled. 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 edible muscle 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. These samples were stored in pre-weighed, acid washed glass jars in a freezer at < -20ºC. 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 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.

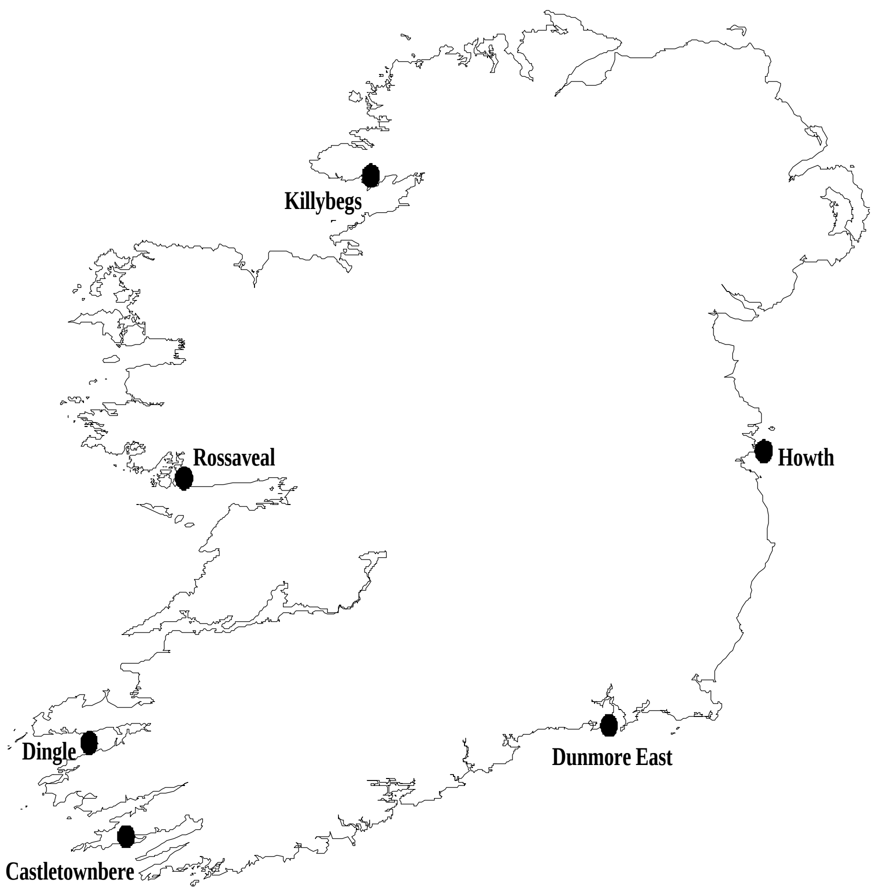

Figure 1. Locations of Irish ports sampled during 2001.

Mercury Analysis

Concentrated nitric acid (4ml) was added to 0.6 - 0.8g of accurately weighed 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 stabilised. 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 with deionised water. Following reduction of the samples with tin (II) chloride, mercury concentrations were 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 of accurately weighed 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). 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 dual column 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 within the chemistry unit. 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 reported in Table 1. A small negative bias was observed for some organochlorine pesticides. Given the low concentrations in the reference materials and in the samples, this was adjudged to be acceptable for these purposes.

Table 1: Results of the analyses of different reference materials obtained during the 2001 finfish testing.

a) Certified Reference Materials

Reference Material	Assigned Values	Measured Value (Mean ± SD)	No. of Analyses	Mean |Z| Score	No. –2<Z<2
Mussel Tissue CRM 278R					
Metal (mg kg^{-1} wet weight)					
Cadmium	0.348	0.29 ± 0.07	2	-0.88	2
Copper	9.45	8.10 ± 0.21	2	-1.10	2
Chromium	0.78	0.77 ± 0.26	2	-0.12	2
Lead	2.00	1.85 ± 0.09	2	-0.56	2
Mercury	0.196	0.17 ± 0.02	6	-0.65	6
Zinc	83.1	77.7 ± 5.58	2	-0.48	2
Dogfish Muscle DORM2					
Metal (mg kg^{-1} wet weight)					
Cadmium	0.043	0.05 ± 0.002	2	1.02	2
Mercury	4.64	5.21 ± 0.41	6	0.97	6
Zinc	25.6	24.0 ± 5.30	2	-0.38	2

b) QUASIMEME Reference Materials

Reference Material	Assigned Values	Measured Value (Mean ± SD)	No. of Analyses	Mean |Z| Score	No. -2<Z<2
Herring Tissue QORO58BT					
PCBs (µg kg^{-1})					
PCB 101	3.14	3.56 ± 0.29	2	0.96	2
PCB 105	0.84	0.95 ± 0.03	2	0.71	2
PCB 118	2.44	2.20 ± 0.11	2	-0.67	2
PCB 138	4.70	4.70 ± 0.04	2	-0.29	2
PCB 153	5.57	5.36 ± 0.16	2	-0.29	2
PCB 156	0.36	0.12 ± 0.01	2	-2.53	0
PCB 180	1.11	1.20 ± 0.01	2	0.48	2
Organochlorine Pesticides (µg kg^{-1})					
DDD- p,p’	2.85	2.01 ± 0.04	2	-2.08	0
DDE- p,p’	6.26	6.08 ± 0.11	2	-0.21	2
DDT- o,p’	0.37	0.10 ± 0.01	2	-2.83	0
DDT- p,p’	0.81	0.30	1	-3.40	0
HCB	1.43	1.45 ± 0.05	2	0.10	2
γ - HCH	2.14	1.07 ± 0.29	2	-3.38	0
trans-Nonachlor	1.33	1.13 ± 0.11	2	-0.94	2

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 (mg kg^{-1} wet weight).

	Mercury	Cadmium	Lead
Muscle meat of fish	0.5	0.05	0.2
Selected fish species*	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

Note: * Listed in Appendix 2 for each metal

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

Metal	LOD
Cadmium	0.004
Chromium	0.07
Copper	0.16
Lead	0.02
Mercury	0.01
Zinc	1.21

Mercury

A total of 44 fish muscle samples were analysed for mercury in 2001. Results are reported in Appendix 1, Table 1a. These samples comprised 20 species of finfish collected from six major Irish fishing ports. The levels of mercury detected ranged from being less than the limit of quantitation (0.03 mg kg^{-1}) to 0.42 mg kg^{-1} wet tissue weight, with an upper bound mean and median of 0.08 and 0.06 mg kg^{-1} respectively. The highest levels detected were found in gurnard landed in Killybegs (0.42 mg kg^{-1}) and ling landed in Castletownbere (0.26 mg kg^{-1}).

Overall, the levels of mercury detected in the edible portion of the fish were within the standard value of 0.5 mg kg^{-1} wet weight set by the EU (Note: A limit of 1 mg kg^{-1} applies to selected species listed in Appendix 2, Table 1).

Other Trace Metals

Heavy metal analysis was carried out on 16 tissue samples collected in 2001. These samples comprised 12 species taken from 6 major Irish ports. Results of these analyses are shown in Appendix 1, Table 1b.

Lead

Lead was not detected in 11 finfish samples and was present at concentrations below the limits of quantitation for the other 5 samples tested.

Cadmium

Cadmium was not present above the limit of detection (0.04 mg kg^{-1} wet weight) in 15 of the 16 samples tested. Cadmium was determined in prawns landed in Rossaveal (0.04 mg kg^{-1} wet weight).

Chromium

Chromium was not detected in 14 of the 16 samples tested and levels were below the limit of quantitation (0.19 mg kg^{-1} wet weight) in the remaining 2 samples.

Copper

Copper was not detected (LOD 0.16 mg kg^{-1} wet weight) in seven samples. Concentrations were below the limit of quantitation (0.44 mg kg^{-1} wet weight) in a further 5 samples. Copper was measured at 0.50 mg kg^{-1} wet weight in anglerfish from Rossaveal and 0.57 and 1.02 in John Dory and cod respectively from Howth. The highest levels of copper were detected in prawns landed in Rossaveal (2.56 mg kg^{-1}).

Zinc

Zinc concentrations in finfish samples from 2001 ranged from being less than the limit of quantitation (<1.61 mg kg^{-1} wet weight) to 12.0 mg kg^{-1} wet weight, with an upper bound mean and median of 3.62 and 3.22 mg kg^{-1} respectively and a middle bound mean and median of 3.57 and 3.22 mg kg^{-1} respectively. The highest levels were detected in prawns landed in Rossaveal (12.0 mg kg^{-1}) and cod landed at Dunmore East (5.01 mg kg^{-1} wet weight).

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 and outlined in Appendix 2, Tables 2 and 3. There are no internationally agreed standards or guidelines available for copper, chromium and zinc in fish for human consumption. However, there is a compilation of standard and guidance values for contaminants in fish tissue, applied by Contracting Parties to OSPAR (Anon 1992). Values are set out in Table 4. All samples analysed were below the strictest guidance values for copper and zinc in fish listed therein. None of the countries have set guidance values or standards for chromium in fish.

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 Oslo and Paris Conventions are given in Table 4. Chlorinated hydrocarbon analyses was carried out on 11 tissue samples collected in 2001, comprising 11 species. Results of these analyses are shown in Appendix 1, Table 1b. These results are very low in comparison with the values given in Table 4 below. Highest concentrations were found in mackerel and tuna, both of which are lipid rich fish. This is to be expected due to the lipophilic nature of these compounds. Higher levels are to be expected in large oily fish, such as tuna, as this reflects bioaccumulation of these substances due to high lipid content, diet and relative longevity. Levels of organochlorines in the tuna sample are considerably higher than other fish species sampled, but are between four and twenty times lower than the strictest standards for PCB congeners and pesticides as listed in Table 4.

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 2001 samples, total mercury and heavy metal concentrations in the commercial catch landed at 6 major Irish ports are low, which confirms previous studies (Tyrrell *et al*, 2003; Rowe *et al*, 1998; Nixon *et al*, 1994a, 1993 and 1991 and O' Sullivan *et al*, 1991). All samples tested were well within the limits set by the Commission Regulation (EC) No. 466/2001 as amended by Commission Regulation (EC) No. 221/2002, 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 (Tyrrell *et al*, 2003; Bloxham *et al*, 1998; Rowe *et al*, 1998 and Nixon *et al*, 1995, 1994a and 1991). There are no EU standards for organochlorine pesticides and for PCBs. The highest concentrations of chlorinated hydrocarbons were detected in a tuna sample, as would be expected due to their lipid content, longevity and diet. The levels measured in this sample were within strictest standards available in OSPAR contracting countries.

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Appendix 1 (Page 1 of 4): Results of monitoring of fish species from selected Irish Ports – 2001

Table 1a: 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 2001. Common and species names are listed in Appendix 3.

	Species	MI Reference	Sample Size	Hg	Length Range	Length Mean	Moisture Content
Castletownbere	Anglerfish	ENV 2001/321	15	**0.11**	290 – 520	364	84.3
02/08/01	Cod*	ENV 2001/328	10	**0.14**	510 – 630	564	79.3
	Haddock*	ENV 2001/323	10	**0.05**	300 – 420	349	83.2
	Hake	ENV 2001/322	11	**0.10**	320 – 650	455	81.0
	Lemon Sole*	ENV 2001/326	10	**0.12**	220 – 280	262	79.1
	Ling	ENV 2001/329	9	**0.26**	590 – 1150	746	61.5
	Megrim	ENV 2001/325	10	**0.09**	240 – 470	312	79.0
	Plaice*	ENV 2001/327	10	**0.04**	270 – 370	315	79.6
	Whiting*	ENV 2001/324	10	**0.06**	300 – 400	349	79.7
Dunmore East	Black Sole	ENV 2001/333	10	**0.05**	250 – 295	275	79.7
13/8/01	Cod	ENV 2001/336	10	**0.06**	325 – 420	368	81.4
	[1]Tub Gurnard	ENV 2001/339	10	**0.07**	320 – 370	341	76.4
	Haddock	ENV 2001/338	10	**0.04**	260 – 405	325	79.9
	John Dory	ENV 2001/334	9	**0.04**	255 – 305	281	80.6
	Lemon Sole	ENV 2001/331	10	**0.06**	245 – 300	266	79.1
	Mackerel	ENV 2001/335	10	**<0.03**	290 – 340	318	67.1
	Megrim	ENV 2001/330	10	**0.05**	355 – 420	383	80.5
	Plaice	ENV 2001/332	10	**0.04**	310 – 360	324	79.4
	Skate/Ray	ENV 2001/340	10	**0.03**	400 – 600	511	76.5
	Whiting	ENV 2001/337	10	**0.09**	315 – 350	334	80.9
Rossaveal	Anglerfish	ENV 2001/376	10	**0.08**	420 – 605	492	82.6
17/10/01	Black Sole	ENV 2001/377	10	**0.16**	345 – 430	385	79.9
	Hake	ENV 2001/380	10	**0.05**	365 – 475	429	81.7
	Megrim	ENV 2001/378	10	**0.05**	260 – 350	291	79.2
	Prawn*	ENV 2001/375	24	**0.07**	384 – 456	416	80.2
	Whiting	ENV 2001/379	10	**0.05**	360 – 625	430	81.4
Killybegs	Black Sole	ENV 2001/348	10	**0.12**	260 – 400	319	80.7
21/08/01	[1]Grey Gurnard	ENV 2001/349	10	**0.42**	510 – 635	580	77.8
	Haddock	ENV 2001/344	10	**0.07**	385 – 505	444	80.3
	Hake	ENV 2001/350	10	**0.08**	350 – 475	430	81.2
	John Dory	ENV 2001/342	10	**0.05**	245 – 350	312	79.2
	Megrim	ENV 2001/346	10	**0.10**	295 – 430	368	78.7
	Plaice	ENV 2001/347	10	**0.05**	310 – 455	367	78.5
	Torsk/Tusk	ENV 2001/343	9	**0.10**	475 – 655	564	77.7
	Whiting*	ENV 2001/345	9	**0.06**	340 – 445	381	79.2

Notes: * = QC duplicate samples analysed and mean reported
[1]Tentative Identification. May have been different gurnard species
For values reported as "< value", "value = Limit of Quantitation (LOQ) for the relevant determinand

Appendix 1 (Page 2 of 4): Results of monitoring of fish species from selected Irish Ports – 2001

Table 1a (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 2001. Common and species names are listed in Appendix 3.

	Species	MI Reference	Sample Size	Hg	Length Range	Length Mean	Moisture Content
Howth	Anglerfish	ENV 2001/399	4	**0.10**	580 – 620	603	87.7
26/10/01	Brill	ENV 2001/400	10	**<0.03**	340 – 405	379	79.4
	Cod	ENV 2001/397	6	**0.05**	495 – 575	526	80.4
	Haddock	ENV 2001/401	10	**0.03**	435 – 500	467	79.1
	John Dory	ENV 2001/402	7	**0.05**	265 – 325	281	79.1
	Pollock	ENV 2001/404	11	**0.09**	420 – 540	476	79.4
	Skate/Ray	ENV 2001/403	10	**0.07**	520 – 650	608	76.6
	Whiting	ENV 2001/398	12	**0.06**	290 – 380	320	82.2
Dingle 20/08/01	[2]Tuna	ENV 2001/341	1	**0.17**	-	750	61.5

Notes: * = QC duplicate samples analysed and mean reported
[2] Tuna sample is believed to be albacore. This is unconfirmed and the sample may have been a different tuna species.
For values reported as “< value”, “value = Limit of Quantitation (LOQ) for the relevant determinand

Appendix 1 (Page 3 of 4): Results of monitoring of fish species from selected Irish Ports – 2001

Table 1b: Heavy metal and chlorinated hydrocarbon concentrations (mg kg^{-1} and µg kg^{-1} wet weight respectively) in the edible tissue of fish species landed and sampled at selected Irish ports in 2001. Common and species names are listed in Appendix 3. (Lengths, moisture content and sample size are as Table 1a)

Port	**Castletownbere**			**Dunmore East**			**Rossaveal**		
Date Sampled	02/08/01			13/08/01			17/10/01		
Species	Haddock	Lemon Sole	Megrim	Black Sole	Cod	Mackerel	Anglerfish	Prawn	Whiting
MI Reference	ENV 01/323	ENV 01/326	ENV 01/325	ENV 01/333	ENV 01/336	ENV 01/335	ENV 01/376	ENV 01/375	ENV 01/379
Metals									
Cadmium	nd	nd	nd	nd	nd	nd	nd	0.04	nd
Chromium	nd	nd	nd	nd	nd	nd	nd	nd	nd
Copper	nd	nd	nd	<0.44	nd	<0.44	0.50	2.56	<0.44
Lead	nd	nd	<0.06	<0.06	nd	nd	nd	<0.06	nd
Zinc	<1.61	2.20	1.64	4.23	5.01	3.15	3.98	12.0	3.27
PCB Congeners									
PCB 28	0.03	na	NA	na	NA	1.36	NA	0.04	NA
PCB 31	0.09	na	NA	na	NA	3.84	NA	0.12	NA
PCB 52	0.02	na	NA	na	NA	1.08	NA	0.03	NA
PCB 101	0.08	na	NA	0.13	NA	4.05	NA	0.11	NA
PCB 105	0.01	0.02	NA	0.03	NA	0.90	NA	0.02	NA
PCB 118	0.03	0.04	NA	0.06	NA	2.01	NA	0.05	NA
PCB 138	0.05	0.05	NA	0.06	NA	3.57	NA	0.06	NA
PCB 153	0.07	0.09	NA	0.11	NA	3.68	NA	0.08	NA
PCB 156	<0.01	<0.01	NA	<0.01	NA	0.10	NA	<0.01	NA
PCB 180	0.01	0.01	NA	0.02	NA	1.26	NA	0.01	NA
Organochlorine Pesticides									
DDD- p,p’	0.01	0.17	NA	0.02	NA	2.79	NA	0.03	NA
DDE- p,p’	0.05	0.09	NA	0.07	NA	2.25	NA	0.07	NA
DDT- p,p’	<0.01	0.01	NA	nd	NA	0.56	NA	<0.01	NA
HCB	0.04	0.03	NA	0.03	NA	0.02	NA	0.03	NA
γ - HCH (Lindane)	0.08	0.09	NA	0.11	NA	3.78	NA	0.08	NA
trans-Nonachlor	0.01	0.02	NA	0.02	NA	0.35	NA	0.01	NA
trans-Chlordane	0.01	0.02	NA	0.02	NA	0.34	NA	0.01	NA
Cis-Chlordane	<0.01	0.01	NA	0.01	NA	0.09	NA	<0.01	NA
Aldrin	<0.01	<0.01	NA	<0.01	NA	nd	NA	<0.01	NA
Isodrin	<0.01	nd	NA	nd	NA	0.56	NA	0.02	NA
Endrin	<0.01	nd	NA	nd	NA	<0.21	NA	nd	NA
Total Lipid (%)	0.51	0.46	NA	0.69	NA	12.0	NA	0.60	NA

Notes: NA: Sample not analysed
nd: Not detected
na: Not available
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

Appendix 1 (Page 4 of 4): Results of monitoring of fish species from selected Irish Ports – 2001

Table 1b (continued): Heavy metal and chlorinated hydrocarbon concentrations (mg kg^{-1} and µg kg^{-1} wet weight respectively) in the edible tissue of fish species landed and sampled at selected Irish ports in 2001. Common and species names are listed in Appendix 3. (Lengths, moisture content and sample size are as Table 1a)

Port	**Killybegs**			**Howth**			**Dingle**
Date Sampled	21/08/01			26/10/01			20/08/01
Species	John Dory	Plaice	Whiting	Anglerfish	Cod	John Dory	Tuna
MI Reference	ENV 01/342	ENV 01/347	ENV 01/345	ENV 01/399	ENV 01/397	ENV 01/402	ENV 01/341
Metals							
Cadmium	nd	nd	nd	nd	nd	nd	nd
Chromium	<0.19	nd	nd	nd	<0.19	nd	nd
Copper	nd	nd	nd	<0.44	1.02	0.57	<0.44
Lead	nd	nd	nd	nd	<0.06	<0.06	nd
Zinc	3.17	2.42	2.24	3.31	4.13	3.37	2.14
PCB Congeners							
PCB 28	NA	0.05	0.03	0.03	0.06	0.03	3.87
PCB 31	NA	0.22	0.13	0.10	0.15	0.11	15.8
PCB 52	NA	0.04	0.04	0.03	0.04	0.03	4.56
PCB 101	NA	0.13	0.13	0.10	0.15	0.10	19.8
PCB 105	NA	0.02	0.02	0.02	0.03	0.02	5.13
PCB 118	NA	0.04	0.04	0.04	0.07	0.04	8.70
PCB 138	NA	0.05	0.05	0.09	0.07	0.04	14.7
PCB 153	NA	0.08	0.08	0.24	0.11	0.07	18.7
PCB 156	NA	<0.01	<0.01	0.01	0.03	<0.01	0.71
PCB 180	NA	0.01	0.01	0.10	0.02	0.01	5.92
Organochlorine Pesticides							
DDD- p,p'	NA	0.03	0.11	0.03	0.03	0.02	13.0
DDE- p,p'	NA	0.09	0.13	0.06	0.07	0.07	47.7
DDT- p,p'	NA	0.01	0.01	nd	0.02	<0.01	8.09
HCB	NA	0.03	0.08	0.02	0.04	0.04	7.62
γ - HCH (Lindane)	NA	0.10	0.09	0.06	0.12	0.07	10.7
trans-Nonachlor	NA	0.01	0.05	0.01	0.01	0.01	8.12
trans-Chlordane	NA	0.01	0.04	nd	0.01	0.01	7.76
Cis-Chlordane	NA	<0.01	0.02	0.01	<0.01	0.01	2.74
Aldrin	NA	<0.01	<0.01	<0.01	0.01	<0.01	1.77
Isodrin	NA	0.02	0.02	0.01	0.02	0.01	2.23
Endrin	NA	nd	<0.01	nd	<0.01	<0.01	2.27
Total Lipid (%)	NA	0.82	0.67	0.49	0.60	0.59	11.6

Notes: NA: Sample not analysed
nd: Not detected
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

Appendix 2 (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 applies

Table 1: Selected species where the higher acceptable limit (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 2 (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 applies

Table 2: Selected species where the higher acceptable limit (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 (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 3: Finfish sampled during 2001 and their corresponding species name

Common Name	***Species Name***
Anglerfish	*Lophius spp.*
Black sole	*Solea solea*
Brill	*Scopthalmus rhombus*
Cod	*Gadus morhua*
Grey gurnard	*Eutriglia gurnardus*
Tub gurnard	*Trigla lucerna*
Haddock	*Melanogrammus aeglefinus*
Hake	*Merluccius merluccius*
John Dory	*Zeus faber*
Lemon sole	*Microstomus kitt*
Ling	*Molva molva*
Mackerel	*Scomber scombrus*
Megrim	*Lepidorhombus whiffiagonis*
Plaice	*Pleuronectes platessa*
Pollock	*Pollachius pollachius*
Prawn	*Nephrops norvegicus*
Ray/Skate	*Raja spp.*
Torsk/Tusk	*Brosme brosme*
Tuna	*Thunnus alalunga*
Whiting	*Merlangius merlangus*