Fishery Leaflet 151

Contaminants in marine biota

1990 monitoring programme

E R Nixon, D McLaughlin, R G Boelens
and G O'Sullivan

Department of the Marine.

Dublin 1991

Contaminants in Marine Biota - 1990 Monitoring Programme

Marine Environmental Series 2/91

by

E.R. Nixon, D. McLaughlin, R.G. Boelens and
G. O' Sullivan

Fisheries Leaflet 151 December 1991

Department of the Marine Dublin 2

SUMMARY

In 1990, samples of fish from commercial catches landed in Ireland, and fish and shellfish collected at Irish coastal sites, were analysed in accordance with the requirements of the Joint Monitoring Programme (JMP) of the Oslo and Paris Commissions (OSPARCOM). The methodologies employed were consistent with JMP Purpose A: Significance to human health, and JMP Purpose C: Existing geographical distributions. The levels of heavy metals and chlorinated hydrocarbon compounds were generally low: well below the internationally accepted levels for protection of human health, and below the levels known to be of significance to marine life. Higher than Irish average levels were found in areas such as Dublin Bay, Cork Harbour, Mornington on the river Boyne, and the Barrow and Rogerstown Estuaries. These are all adjacent to densely populated and industrialised catchments and coasts. There were no cases of serious contamination.

INTRODUCTION

Under the Conventions for the Prevention of Marine Pollution by Dumping from Ships and Aircraft (Oslo) and the Convention for the Prevention of Marine Pollution from Land Based Sources (Paris), known jointly as the OSPARCOM, participating countries are required to monitor their marine environments, with a view to assessing the existing level of marine pollution and the effectiveness of measures for the reduction of marine pollution from land based sources. These monitoring programmes are coordinated by the Joint Monitoring Group (JMG) into the Joint Monitoring Program (JMP). The data generated from these programmes are collected, stored and periodically evaluated by The International Council for the Exploration of the Sea (ICES).

The monitoring activities which focus on selected chemical contaminants, are classified according to their purpose and frequency of monitoring (JMG 1990), and are broadly defined as;

Purpose A: Human health - mandatory every second year, where levels fall within the "upper" range of observed values for purpose D. In all other cases monitoring for purpose C will be sufficient to asses whether there is a risk for human health.

Purpose B: Biological effects - no frequency fixed.

Purpose C: Existing levels and geographical distribution - every 5 years.

Purpose D: Temporal trend assessment and effectiveness of measures taken - yearly.

The Fisheries Research Centre (FRC) of the Department of the Marine is the laboratory responsible for Ireland's marine monitoring programme and a significant proportion of the laboratory's resources is directed towards these activities. The programme design takes into account the recommendations of the JMG as well as national priorities and technical resources. Routine monitoring provides an essential database to determine the environmental quality of Irish coastal waters and to assess trends in contamination levels.

This paper presents results and preliminary comments on the 1990 JMP monitoring programme which involved the analysis of selected heavy metals and chlorinated hydrocarbons in fish and shellfish for Purposes A and C.

METHODS

SPECIES SELECTION:

The common mussel, Mytilus edulis is a useful organism for monitoring of localized bioavailable contaminants in coastal and estuarine environments (Granby 1987). The analysis of the livers of dermersal bottom-feeding fish, such as plaice, provides information on many contaminants of the near-shore marine environment.

Purpose A:

Cod, whiting and prawns were collected from a number of fishing ports (Dunmore East, Rosaveel and Killybegs) and plaice and prawns were taken directly from the sea by FRC staff on board the RV Lough Beltra. Port samples were randomly selected at the markets, whereas samples from the Lough Beltra were representative of the catch. Analyses were carried out on a homogenised sample of the flesh from either 25 or 50 specimens, depending on the species.

Purpose C:

Mussels and two species of bottom feeding demersal fish, plaice and sole, were used to examine geographical distribution of contaminants. Samples of mussels from 20 sites around the coast (Fig. 1) were collected during February and March 1990. After purging for 12 - 24 hours in clean seawater from the collection area, 50 mussels between 40 and 60 mm. were opened, rinsed with distilled deionised water and left to drain before homogenisation. The moisture content was determined on a subsample of the homogenized material, and the remainder was divided and stored deep

frozen in plastic containers for selected heavy metals analysis, and in aluminum foil for organochlorine analysis.

Samples of plaice were taken from three near-shore areas on the east, west and south coasts; on the south coast, sole were also sampled. Sampling was carried out by FRC staff on board the RV Lough Beltra. Twenty-five fish of each species, representative of the catch, were collected and their lengths and weights recorded prior to deep freezing at -20 deg.C. On return to the laboratory, the livers were removed, homogenized, and stored as described above for analysis.

Heavy Metals:

For heavy metal (Cd,Cu,Pb,Zn) determinations, samples were prepared by wet digestion in nitric acid for 16 hours at 110 deg.C, followed by evaporation to near dryness and redigestion in 30% hydrogen peroxide for 16 hours. Samples were then quantitatively transferred to volumetric flasks, made up to volume with 2.8% nitric acid and analysed using a Varian Model 400 atomic absorption spectrophotometer fitted with graphite furnace and autosampler and using deuterium background correction (Borg et al, 1981)

Mercury analysis required wet digestion, under reflux, by sulphuric and nitric acid (2:1) for 3 hours and oxidation with potassium permanganate; excess potassium permanganate was neutralised with hydroxylamine hydrochloride. Samples were then reduced with stannous chloride (Hatch and Ott, 1968) and analysed by cold-vapour atomic absorption spectrometry (model - Varian VGA 76).

Analytical quality assurance was assessed using DOLT-1 and DORM-1 certified reference materials supplied by the National Research Council of Canada, Table 1.

PCBs and Chlorinated Hydrocarbons:

Following grinding with sodium sulphate, samples for organochlorine analysis were soxhlet extracted with 10% acetone in hexane for 4 hours, evaporated and quantitatively transferred to 10ml graduated test tubes. Following lipid determination, the extract was concentrated to give a solution containing 50mg of lipid per ml. 1.0 ml of this extract was passed through an alumina column to remove the lipid, followed by separation of the PCBs, HCB, pp-DDE and op-DDD from the other chlorinated hydrocarbon pesticides on a silica column. (Allchin et al 1989). Analysis was by dual column gas chromatography using a Hewlett Packard 5880 fitted with an electron capture detector and a HP7673 auto sampler. Chromatograms were stored on a Shimadzu CR4AX integrator for processing.

As recommended by ICES, 7 individual polychlorinated biphenyl (PCB) congeners IUPAC nos 28, 52, 101, 118, 138, 153, 180 were analysed (Duinker et al 1988). PCB 1254 concentrations are calculated based on the sum of these 7 congeners accounting for an estimated 37% of PCB 1254.

Certified reference material CRM No.349 from the Community Bureau of Reference (E.C.) was analaysed with each batch of samples for PCB and chlorinated hydrocarbon measurements for data quality assurance purposes, Table 1.

RESULTS AND DISCUSSION

Purpose A: Human Health

Results of the analysis of the edible portions of cod, prawns, plaice and whiting are given in Appendix 1 and summarized in Fig.2. In all cases the concentrations of contaminants measured were well below the standards for human health protection applied by OSPARCOM countries (O'Sullivan *et al.* in press).

Purpose C: Geographical Distribution

Coastal and estuarine environments:

Results of analyses of mussel samples are shown in Appendix 2. Mercury levels at all sites were below the arbitrary "lower" level of 0.1 mg/kg wet wt. adopted by the JMG on the basis of historical data sets from the OSPARCOM area. In the case of cadmium, 80% of the sites sampled were below the arbitrary "lower" level (2 mg/kg dry wt.), while the remaining 4 sites, Oranmore, Rogerstown, Carlingford and Tralee were within the "medium" level of 2-5 mg/kg dry wt. The JMP have established an "upper" level of 1.0 mg/kg for PCB in mussels. Only a few samples of mussels collected in OSPARCOM areas exceed this value. In this study all sites showed PCB levels in mussels to have been less than 0.05 mg/kg and at 75% of the sites less that 0.011 mg/kg.

Mussel samples were collected from areas that are subject to minimal anthropogenic inputs, and also from areas of high population and industrial activity. Taking into account previous surveys, a number of areas are identified as consistently having contaminant levels in the upper quartile range (i.e. upper 25%). These "elevated" areas include Dublin, Cork (Ringaskiddy), Mornington on the Boyne downstream of Drogheda, Passage East downstream of Waterford. Rogerstown also fell within this group; the elevated level here may perhaps be explained by the proximity of a municipal tiphead.

Other areas where "elevated" levels were detected for a small number of contaminants were Tralee Bay for DDTs and cadmium; Oranmore for DDTs, lead and mercury; Carlingford, Clew Bay and Kilkieran for selected chlorinated hydrocarbon pesticides.

Although these areas are described as "elevated" because they fall in the top 25% of Irish sites, they would generally be considered as clean areas in European terms. However, caution must be exercised when comparing data with environmental reference values, as these are by no means environmental standards.

In outer Cork Harbour all contaminants measured, with the exception of PCBs, ppDDE and Lindane (which were slightly higher), were within the concentration ranges found in mussels sampled during 1989 (Boelens et al. 1990).

Near-Shore Waters

Plaice from Dublin Bay and Galway Bay and plaice and sole from the Celtic Sea, off Dungarvan, were collected and analysed for contaminants in the liver. In addition, fish flesh was analysed for mercury. Results are given in Appendix 3 and summarized graphically by area in Fig 3.

Dungarvan plaice showed chlorinated hydrocarbon pesticide levels in liver similar to, but slightly lower than, plaice from Galway and Dublin.
On the other hand, PCBs, particularly CB153, CB138 and CB180, were higher in the Dungarvan plaice; these congeners contain the 234 and 245 substitution pattern (fig 4) which renders them highly resistant to metabolic transformations (Focardi 1988). The Dungarvan sample contained a greater number of larger fish than samples from the other two sites.

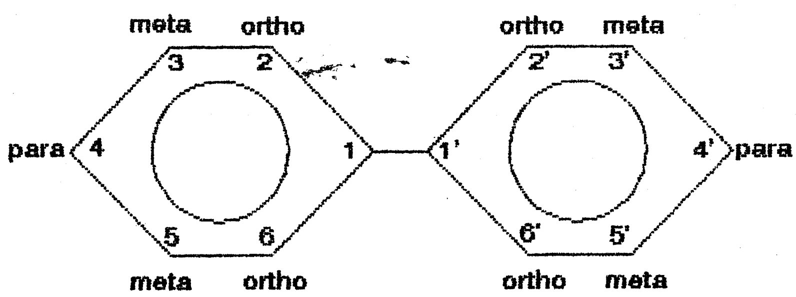


Fig 4: Structure of biphenyl, showing the sites available for chlorine substitution.

The sample of sole collected from the Celtic Sea contained the highest concentrations of PCB congeners (2 to 3 times higher for all congeners), which may reflect different feeding habits to those of plaice. Cod and whiting from Celtic Sea analysed for purpose A in this study, have been shown to have high levels of PCBs in the flesh (6.9 and 6.8 ug/kg PCB 1254 respectively) relative to the levels in fish from other Irish coastal waters. This indicates a need for further monitoring of fish and other materials from the Celtic Sea to establish whether these higher levels are due to local sources or, for example, a function of different uptake rates, diets and movement patterns of the species concerned.
It should be noted that these PCB levels are more than 200 times below the strictest standards for human health protection applied by OSPARCOM countries.

CONCLUSION

Marine organisms from a number of Irish coastal and estuarine areas have been described as having "elevated" levels (i.e. among the higher levels to be found in biota from Ireland's marine environments) for many of the contaminants analysed. These include Dublin Bay, Cork Harbour, Mornington on the Boyne, the Barrow and Rogerstown Estuaries. In certain other areas, eg. Tralee Bay, Oranmore, Carlingford Lough, Kilkieran Bay and Clew Bay only a few contaminants showed "elevated" levels. Monitoring will be continued in all of these areas. The Celtic Sea will receive special attention to ascertain whether PCB levels are in fact higher than other near shore waters and, if so, efforts will be made to detect their source.

Bearing in mind the definition of "elevated" levels, it can be reasonably deduced from this survey that fish and shellfish from Irish marine environments generally contain low levels of the metals and organic contaminants measured.

ACKNOWLEDGMENTS

The authors would like to thank the skipper and crew of the RV Lough Beltra, Dr. Mairin O'Sullivan, Mr. Paul Gleeson and Dr. Christopher Moriarty for their assistance.

REFERENCES

Allchin, C.R., C.A. Kelly and J.E. Portmann (1989). Methods of analysis for chlorinated hydrocarbons in marine and other samples. Analytical Methods 6. MAFF, Lowestoft.

Boelens, R.G., E.R. Nixon and D.McLaughlin (1990). Levels of Metals and Organic contaminants in mussels Mytilus edulis from Cork Harbour - 1989. Fisheries Leaflet 148. Department of the Marine, Dublin 2.

Borg, H., A. Edin, K. Holm, and E. Skold, (1981). Determination of metals in fish livers by flameless atomic absorption . Water Research 15,1291-95.

Duinker, J.C., D.E. Schultz and G. Petrick (1988). Selection chlorinated biphenyl congeners for analysis in environmental samples. Marine Pollution Bulletin. 19, 19-25.

Focardi, S., C. Leonzio and C. Fossi (1988). Variations in Polychlorinated Biphenyl Congener Composition in Eggs of Mediterranean Water Birds in Relation to Their Position in the Food Chain. Environ. Pollut. 52. 243-255.

Granby, K, 1987. Levels of Hydrocarbons and Chlorinated Compounds in the Danish Sea Areas, 1985-1986. Report of the Marine Pollution Laboratory 12. Charlottenlund, Denmark.

Hatch, W.R and W.L. Ott, (1968). Determination of submicrogram quantities of mercury by atomic absorption spectrophotometry. Anal. Chem. 40, 2085-2087.

JMG (1989). Oslo and Paris Commissions Monitoring Manual.

O'Sullivan, M.P., E.R. Nixon, D. McLaughlin, Ml. O'Sullivan and D. O'Sullivan (in press). Chemical contaminants in Irish esturine and coastal waters, 1978 to 1988. Fisheries Bulletin 10, Dublin (in press).

Van der Valk, F. (1989). Overview of standards for contaminants in fishery products. ICES C.M. 1989/E:18

Table 1: QA for 1990 JMP Programme.

PCB and Organochlorines:BCR Cod liver oil, CRM 349. No.

Results quoted are ug/kg. The uncertainty is at 95% confidence interval of the mean. One standard deviation is given in brackets.
Number of analysis = 4

	FRC Values	Certified Values
CB 28	70 +/-14 (8)	68 +/-7
CB 52	145 +/-5 (3)	149 +/-20
CB 101	368 +/-11 (7)	370 +/-17
CB 118	477 +/-16 (10)	456 +/-31
CB 138	786 +/-39 (24)	765 +/-45
CB 153	939 +/-63 (40)	938 +/-40
CB 180	282 +/-13 (8)	282 +/-22
CCDAN	16 +/-3 (2)	
TCDAN	17 +/-2 (1)	
TNONC	36 +/-8 (5)	
DDEOP	36 +/-17 (11)	
DDEPP	323 +/-8 (5)	
DDTPP	40 +/-44 (27)	
DIELD	135 +/-13 (8)	
HCB	61 +/-5 (3)	
HCHA	22 +/-5 (3)	
HCHG	50 +/-9 (6)	
TDEPP	164 +/-13 (8)	

Heavy Metals: NRCC Dogfish liver, DOLT-1.

Results quoted are mg/kg. The uncertainty is at 95% confidence interval of the mean. One standard deviation is given in brackets.
Number of analysis = 3.

	FRC Values	Certified Values
Cd	4.39 +/-1.42 (0.57)	4.18 +/-0.28
Cu	20.0 +/-5.3 (2.1)	20.8 +/-1.2
Pb	1.59 +/-0.50 (0.20)	1.36 +/-0.29
Hg	0.31 +/-0.02 (0.01)	0.225+/-0.037
Zn	87.0 +/-14.8 (6.0)	92.5 +/-2.3

FIG1: SAMPLE LOCATIONS

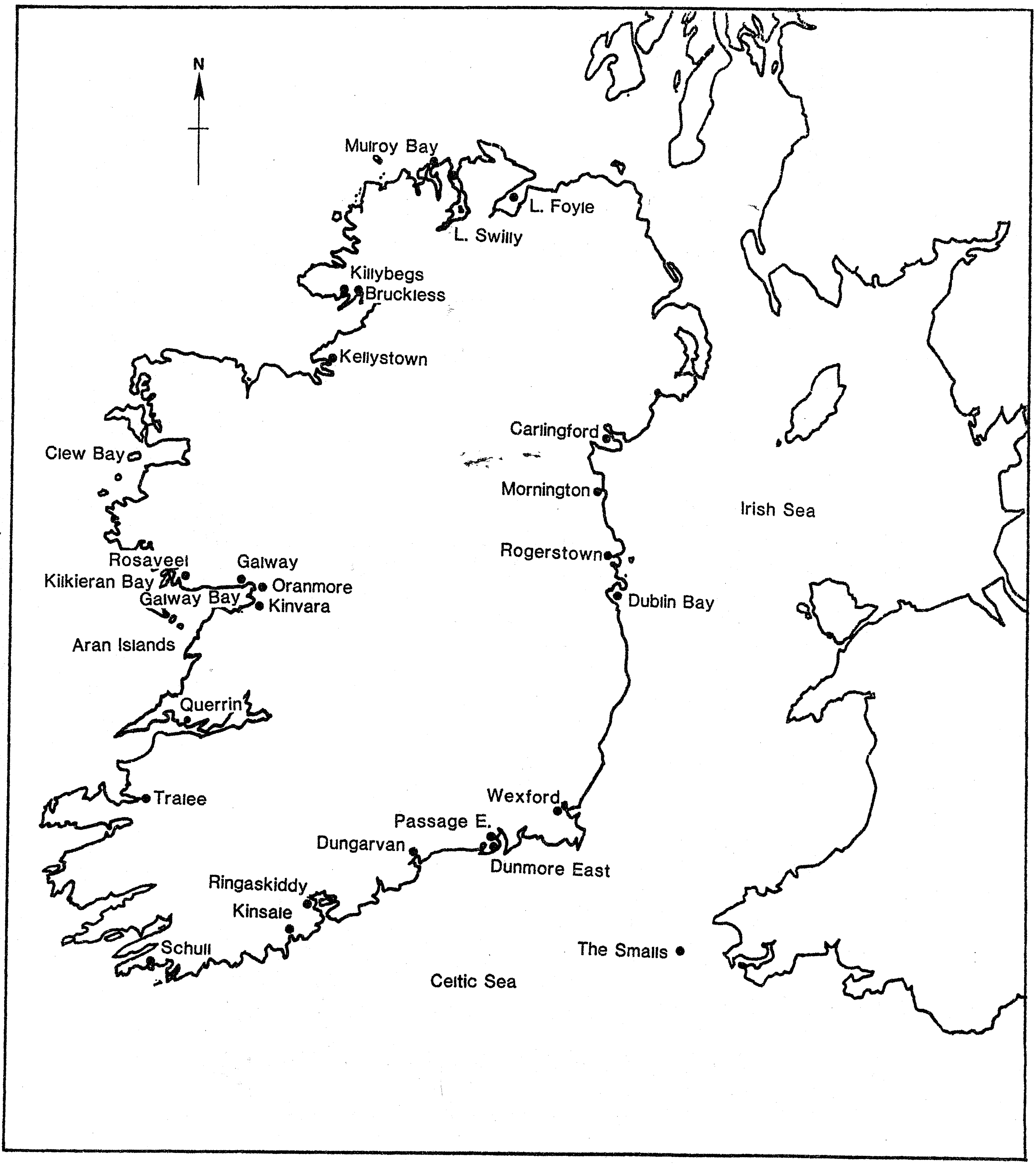


Fig 2: Concentrations of contaminants in edible portions of commerical species from Irish waters. Human health protection standards of various ICES countries (Van Der Valk 1989) are shown in brackets.

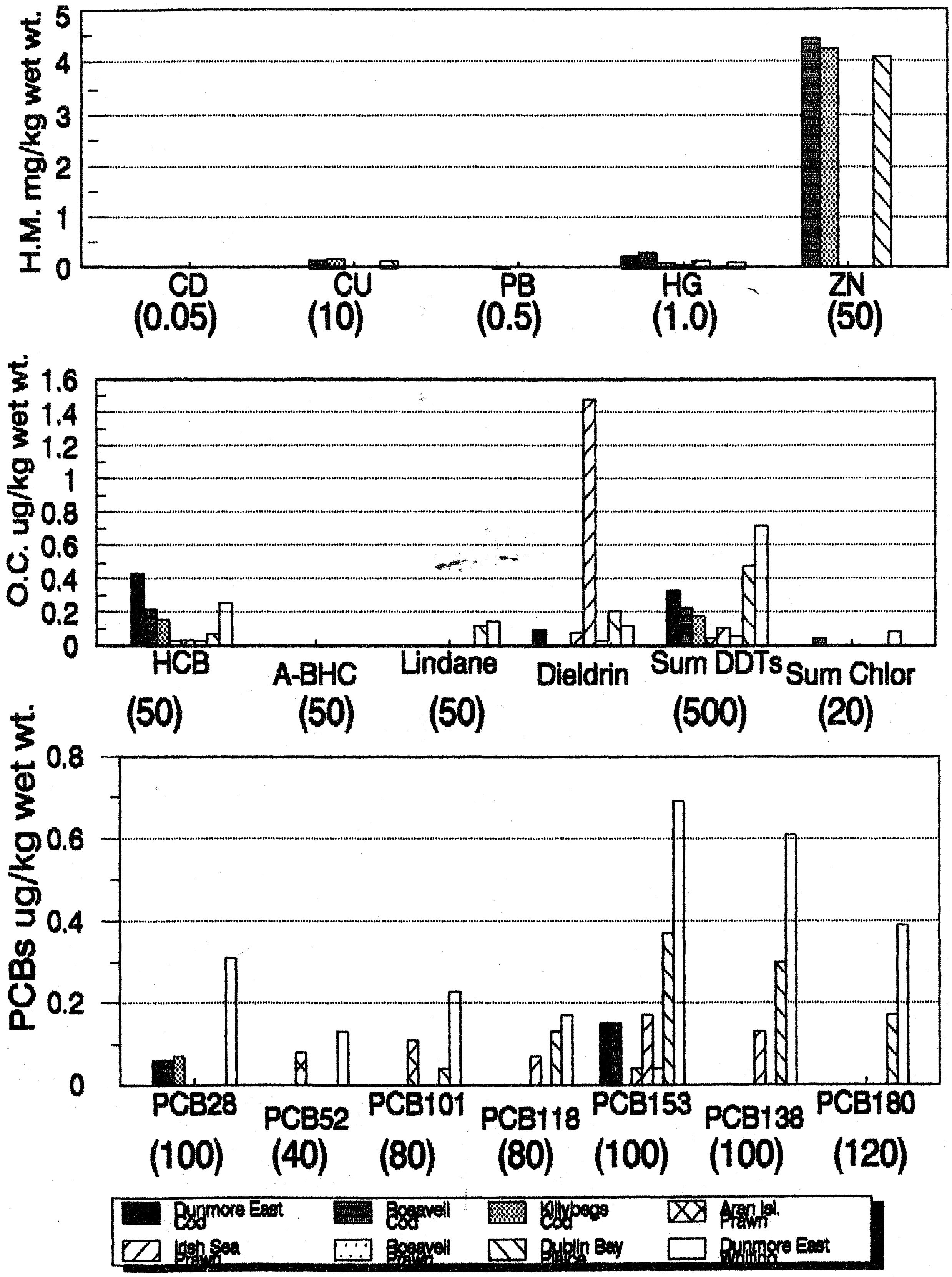
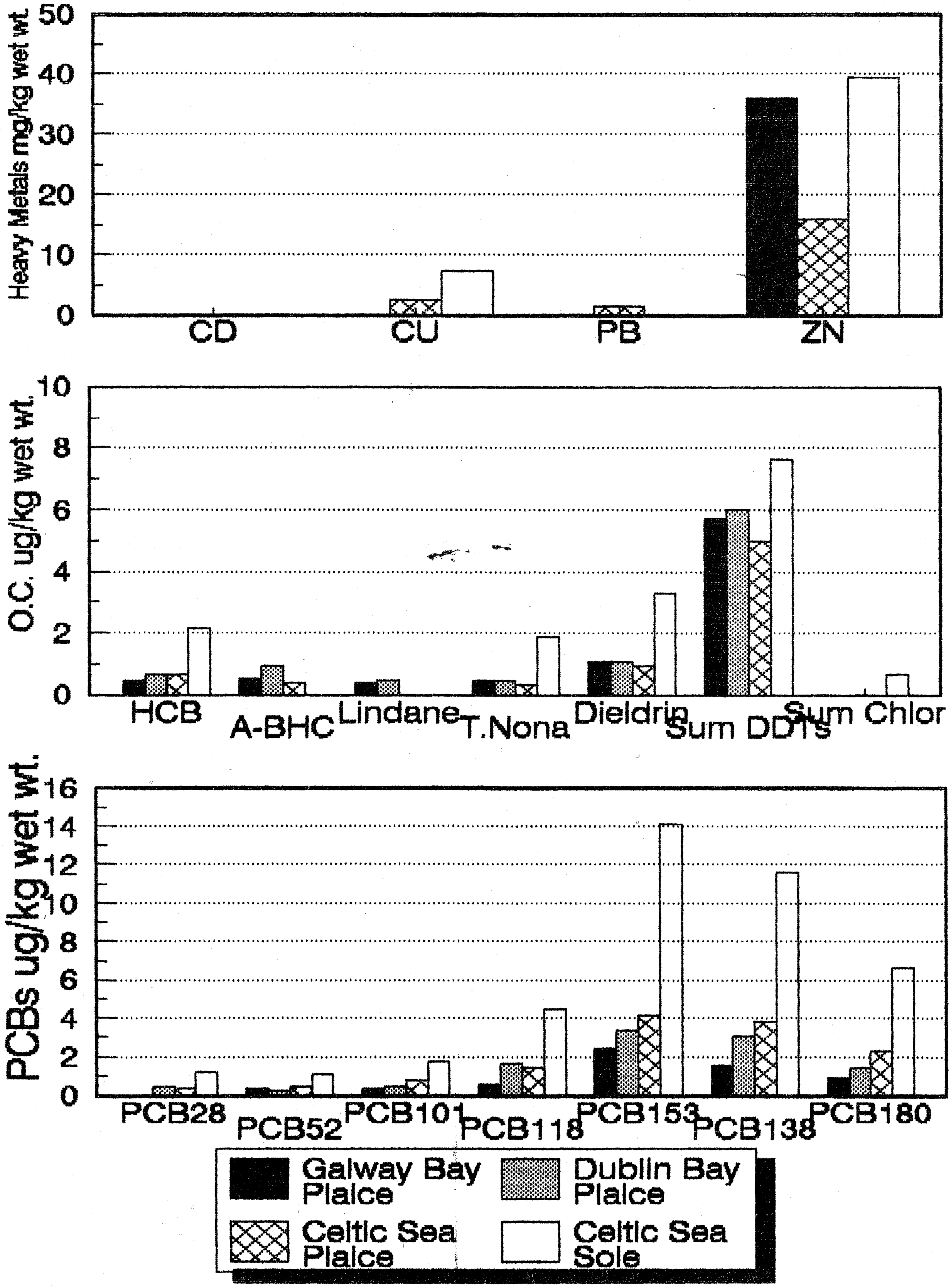


Fig 3:Concentrations of contaminants in fish liver.



Appendix 1: Purpose A; Chlorinated hydrocarbons (OC) and heavy metals (HM) in fish for human consumption.
Results as ug/kg wet wt. for OC and mg/kg wet wt. for HM.
nd: not detected, na: not analysed

Sampling Port	Dunmore East	Rosaveel	Killybegs	L.Beltra	L.Beltra	Rosaveel	Dunmore East	L.Beltra
Sample Origin	The Smalls	West Coast	N.W. Coast	Aran	Irish Sea	West Coast	The Smalls	Dublin Bay
Species	Cod	Cod	Cod	Prawn	Prawn	Prawn	Whiting	Plaice
Tissue	Flesh	Flesh	Flesh	Tails	Tails	Tails	Muscle	Muscle
Min Lt. (mm)	580	585	635	---	---	---	290	205
Max Lt.(mm)	950	915	995	---	---	---	470	235
Mean Lt.(mm)	785	774	874	---	---	---	347	225
%Dry Wt.	18.7	19	18.3	21.4	n.a	17.5	18.6	19.1
% Fat	.2	.1	.1	.1	.3	1.1	.3	.4
Chlorinated Hydrocarbons								
HCB	.44	.22	.16	.03	.04	.03	.26	.07
A-BHC	nd	nd	nd	n.d	n.d	nd	nd	nd
Lindane	nd	nd	nd	n.d	n.d	nd	.15	.12
G-Chloro	nd	nd	nd	n.d	n.d	nd	nd	nd
A-Chlor	nd	.05	nd	n.d	n.d	nd	.09	nd
T.Nona	nd	nd	nd	n.d	n.d	nd	nd	nd
Dieldrin	.1	nd	nd	.08	1.48	.03	.12	.21
ppDDT	nd	nd	nd	n.d	0	nd	nd	.08
ppDDE	.34	.23	.18	.05	.11	.06	.39	.32
opDDE	nd	nd	nd	n.d	n.d	nd	.12	.08
ppDDD	nd	nd	nd	n.d	n.d	nd	.21	nd
PCB28	.17	.06	.07	n.d	n.d	nd	.31	nd
PCB52	.05	nd	nd	.08	n.d	nd	.13	nd
PCB101	.13	nd	nd	.11	n.d	nd	.23	.04
PCB118	.3	nd	nd	n.d	.07	nd	.17	.13
PCB153	.85	.15	nd	.04	.17	.04	.69	.37
PCB138	.64	nd	nd	n.d	.13	nd	.61	.3
PCB180	.45	nd	nd	n.d	0	nd	.39	.17
PCB 1254	6.9	.57	.18	.63	.99	.11	6.77	2.69
Sum DDTs	.34	.23	.18	.05	.11	.06	.72	.48
Sum Chlor	nd	.05	nd	nd	nd	nd	.09	nd
Heavy Metals								
CD	n.a	nd	nd	n.a	n.a	n.a	n.a	nd
CU	n.a	.16	.18	n.a	n.a	n.a	n.a	.14
PB	n.a	nd	.02	n.a	n.a	n.a	n.a	nd
HG	.24	.3	.1	.06	.15	n.a	.13	.05
ZN	n.a	4.44	4.25	n.a	n.a	n.a	n.a	4.09

Appendix 2: Purpose C; Chlorinated hydrocarbons and heavy metals in whole mussels.
Results as ug/kg wet wt. for OC and mg/kg wet wt. for HM
nd: not detected na: not analysed

Location	Rogerstown	Kinsale	L.Foyle	Bruckless	Mornington	Ringaskiddy	Querin	L.Swilly	Kellystown	Dublin Bay
Min Lt. (mm)	45	44	46	46	51	43	41	51	48	47
Max Lt.(mm)	57	59	59	59	60	58	52	60	59	58
Mean Lt.(mm)	52	50	53	52	57	51	44	57	53	52
Flesh Wt. (g)	138.4	178.8	134	128.7	174.5	165	102.4	166.4	178.1	212.5
Shell Wt. (g)	514	473	642	207	579	529	337	558	613	560
%Dry Wt.	18.5	16.5	17	14.9	20.9	18.5	17.6	18.9	17.2	0
% Fat	1.1	1	1	.6	1	2.2	1.9	2	1.9	2.5
Chlorinated Hydrocarbons										
HCB	.05	nd	.05	.03	.09	.06	.07	.07	.06	.07
A-BHC	.9	.15	nd	nd	.4	.31	.25	.26	.19	.3
Lindane	.57	.26	.23	.12	.33	.27	.19	.22	.23	.45
G-Chloro	.09	nd	nd	nd	nd	nd	.32	nd	nd	nd
A-Chlor	.1	nd	nd	nd	nd	nd	nd	nd	nd	nd
T.Nona	.15	nd	.37	nd	.25	nd	nd	nd	nd	nd
Dieldrin	.85	.73	.93	.27	.93	.96	.42	.63	1.3	1.54
ppDDT	.15	nd	nd	nd	nd	nd	nd	nd	nd	nd
ppDDE	1.44	1.3	.98	.2	1.57	1.65	.45	.52	.24	1.64
opDDE	.52	.07	.35	nd	.95	nd	nd	nd	nd	nd
ppDDD	.51	.99	.99	nd	1.1	1.33	.8	.36	nd	1.84
PCB28	.29	.24	.26	nd	.52	.91	.17	.18	nd	.78
PCB52	.19	.08	1.58	nd	.2	.94	nd	nd	nd	.37
PCB101	.24	.17	.26	.15	.3	2.38	.09	.03	nd	.48
PCB118	.67	.27	.38	.04	.56	2.6	.17	.17	nd	.77
PCB153	1.43	.6	.86	.18	1.4	2.64	.53	.54	.18	1.76
PCB138	1.35	.47	.76	.12	1.16	2.94	.4	.32	.12	1.5
PCB180	.23	nd	nd	nd	.15	.18	nd	nd	nd	.33
PCB 1254	11.74	4.87	10.93	1.29	11.44	33.6	3.62	3.29	.8	16.02
Sum DDTs	2.62	2.36	2.32	.2	3.62	2.98	1.25	.88	.24	3.48
Sum Chlor	.2	nd	nd	nd	nd	nd	.32	nd	nd	nd
Heavy Metals										
CD	.43	.16	.27	.19	.25	.24	.18	.23	.19	.36
CU	1.83	1.33	1.2	1.06	1.44	1.58	1.32	1.61	1.03	2.22
PB	1.88	.41	.23	.2	.75	1.26	.33	.38	.77	2.02
HG	.05	.02	.03	.04	.03	.05	.05	.05	.02	.05
ZN	23.37	15.89	12.81	18.98	19.65	29.41	16.35	16.9	18.98	26.8

Appendix 2: Purpose C; Chlorinated hydrocarbons and heavy metals in whole mussels.
----------- Results as ug/kg wet wt. for OC and mg/kg wet wt. for HM
con't... nd: not detected na: not analysed

Location	Carlingford	Clew Bay	Kinvara	Wexford	Tralee	Oranmore	Scull	Kilkernan	Mulroy	Passage East
Min Lt. (mm)	45	46	43	42	43	45	42	44	46	42
Max Lt.(mm)	57	59	60	60	60	60	59	58	60	55
Mean Lt.(mm)	52	51	52	51	52	52	53	50	56	47
Flesh Wt. (g)	102.1	174.8	198.9	162	117.6	118.8	126.7	80.23	174.4	151
Shell Wt. (g)	603	561	531	474	694	475	611	239	298	736
%Dry Wt.	17.5	20.3	17.4	24.5	19	10.9	17.9	18.8	18.9	24.5
% Fat	2	2.4	.2	1.3	1.2	.9	1.3	1.3	1.3	1.1
Chlorinated Hydrocarbons										
HCB	.42	.43	.08	.39	.39	.32	.2	.39	.14	.22
A-BHC	.19	.43	nd	.49	.15	.18	nd	.26	.11	nd
Lindane	.35	.29	nd	nd	.2	.14	.17	.26	.14	.22
G-Chloro	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
A-Chlor	nd	nd	.08	nd	nd	.16	.11	nd	nd	nd
T.Nona	.13	.17	.02	nd	nd	.11	.11	.21	.14	nd
Dieldrin	.93	.35	.1	.64	.56	.74	.31	nd	.44	.66
ppDDT	.32	.63	nd	nd	nd	nd	nd	nd	nd	nd
ppDDE	.23	.51	.05	.8	.52	1.68	.41	.5	.35	1.52
opDDE	.7	1.33	.3	nd	7.98	.37	.54	1.45	.39	nd
ppDDD	.8	nd	nd	.4	.28	1.76	.29	nd	.28	1.03
PCB28	.3	.17	.05	.32	.26	.26	.35	.12	.1	.82
PCB52	.05	nd	nd	nd	nd	nd	.12	nd	nd	nd
PCB101	.09	.25	nd	nd	nd	nd	.05	.12	nd	.59
PCB118	.29	.08	nd	.24	nd	.15	.24	nd	nd	.59
PCB153	.95	.34	.04	.55	.46	.67	.46	.57	.22	1.88
PCB138	.72	.24	.03	.43	.31	.42	.35	.41	nd	1.29
PCB180	nd	nd	nd	nd	nd	nd	.07	nd	nd	nd
PCB 1254	6.41	2.88	.3	4.13	2.72	3.99	4.39	3.29	.85	13.78
Sum DDTs	2.05	2.47	.35	1.2	8.78	3.81	1.24	1.95	1.02	2.55
Sum Chlor	nd	nd	.08	nd	nd	.16	.11	nd	nd	nd
Heavy Metals										
CD	.45	.25	.23	.22	.59	.25	.35	n.a	n.a	.4
CU	1.48	1.76	1.2	2.64	2.14	1.02	1.76	n.a	n.a	1.27
PB	2.28	.4	.64	.52	.52	1.42	.73	n.a	n.a	1.16
HG	.06	.04	.03	.02	.04	.06	.05	n.a	n.a	.02
ZN	22.91	23.92	20.19	22.79	19.32	18.8	18.1	n.a	n.a	18

Appendix 3: Purpose C; Chlorinated hydrocarbons and heavy metals in fish liver, and mercury in flesh.

Results as ug/kg wet wt. for OC and mg/kg wet wt. for HM

na: not analysed nd: not detected

Location	Galway Bay	Dublin Bay	Celtic Sea Off Dungarvan	Celtic Sea Off Dungarvan
Species	Plaice	Plaice	Plaice	Sole
Min Lt. (mm)	190	205	167	205
Max Lt.(mm)	290	235	327	300
Mean Lt.(mm)	223	225	232	255
%Dry Wt.	22.2	21.6	22.7	25.7
% Fat	4.1	3.7	4.1	7.1
Chlorinated Hydrocarbons				
HCB	.5	.67	.67	2.17
A-BHC	.51	.94	.43	nd
Lindane	.38	.47	nd	nd
G-Chloro	nd	nd	nd	nd
A-Chlor	nd	nd	nd	.68
T.Nona	.44	.49	.35	1.91
Dieldrin	1.11	2.43	.95	3.28
ppDDT	.26	1.13	nd	nd
ppDDE	3	3.86	3.45	7.66
opDDE	2.48	1.06	nd	nd
ppDDD	nd	nd	1.56	nd
PCB28	nd	.48	.4	1.2
PCB52	.39	.27	.47	1.12
PCB101	.32	.47	.86	1.78
PCB118	.58	1.64	1.5	4.49
PCB153	2.48	3.37	4.21	14.15
PCB138	1.59	3.05	3.87	11.62
PCB180	.94	1.41	2.31	6.7
PCB 1254	16.8	28.56	36.32	109.65
Sum DDTs	5.73	6.04	5.01	7.66
Sum Chlor	nd	nd	nd	.68
Heavy Metals				
CD	.18	n.a	.18	.2
CU	.3	n.a	2.73	7.38
PB	.22	n.a	1.7	.18
HG	.05	n.a	.05	.05
ZN	35.96	n.a	15.89	39.46
Mercury in Flesh				
Hg In Flesh	.04	.05	.06	.04
% Dry Wt.	17.5	19.1	18.6	20.9