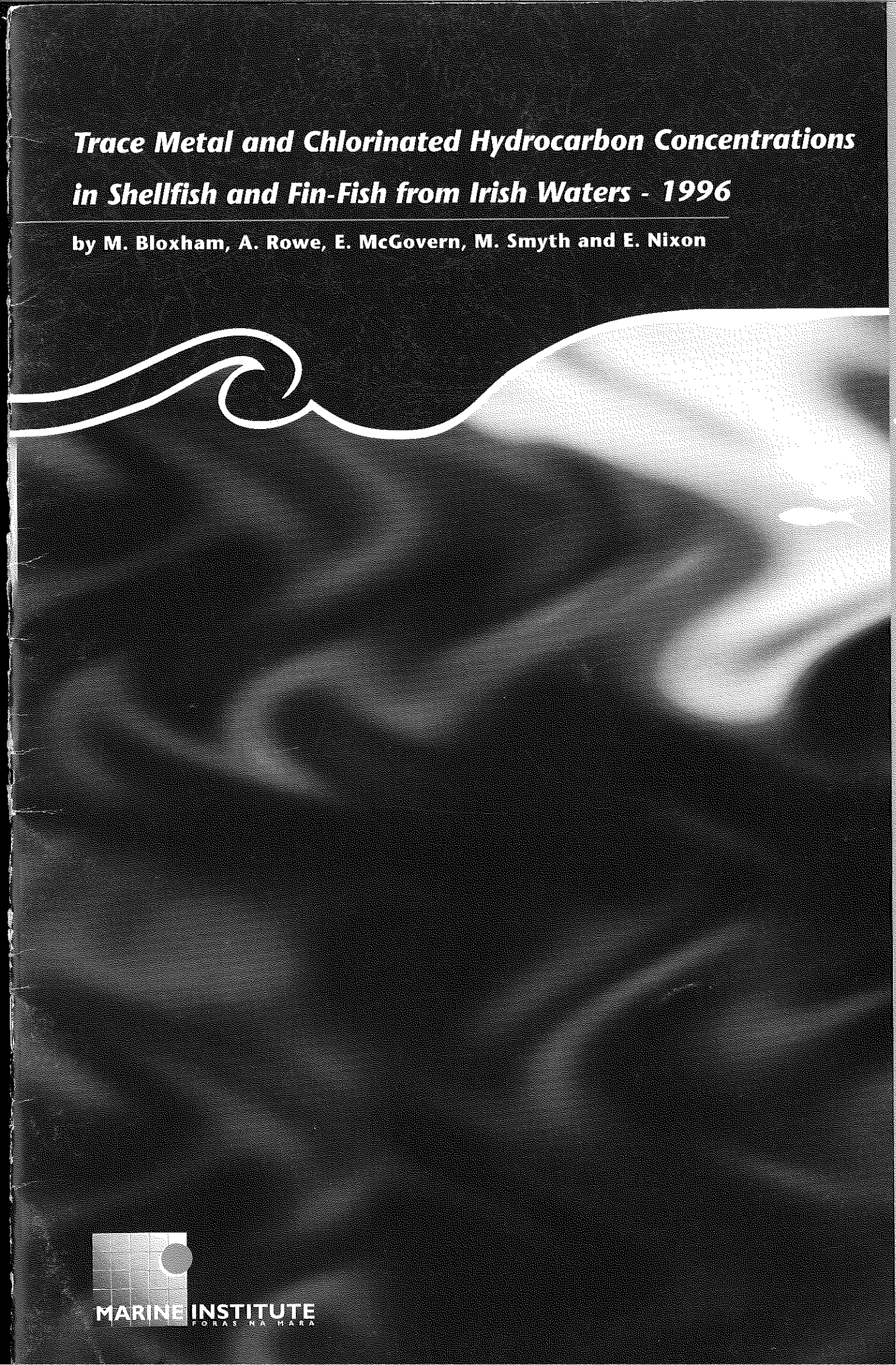
Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish and Fin-Fish from Irish Waters - 1996

by M. Bloxham, A. Rowe, E. McGovern, M. Smyth and E. Nixon



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TRACE METAL AND CHLORINATED HYDROCARBON CONCENTRATIONS IN SHELLFISH AND FIN-FISH FROM IRISH WATERS - 1996

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by

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Summary

In accordance with the monitoring requirements of the 1979 Council Directive 79/923/EC on the quality of shellfish waters, water and shellfish samples were collected from 22 major shellfish growing areas and analysed for physicochemical parameters, trace metal levels and chlorinated hydrocarbon concentrations. Fin-fish were also collected from five Irish fishing ports and analysed for total mercury content in compliance with the European Commission's Decision of 19 May 1993 on mercury in fisheries products. Selected samples of fin-fish were also analysed for trace metal and chlorinated hydrocarbon concentration. As there are no generally accepted European standards for the concentration of these contaminants in shellfish or fin-fish, the levels were compared with the available standards and guidance values compiled by the Oslo and Paris Commission (OSPAR) countries for human consumption.

As in previous years, the water quality from shellfish growing areas was good and conformed to the guidelines and requirements of the Directive. Petroleum hydrocarbons were not observed in any of the shellfish waters or as deposits on the shellfish. Chlorinated hydrocarbon levels were very low, evidence of the clean, unpolluted nature of Irish shellfish and shellfish producing waters. Trace metal levels were consistently low with the exception of lead in mussel tissue from Wexford Harbour, which was elevated, and cadmium in oyster tissue, which was slightly elevated in some samples but did not exceed the Dutch human consumption tolerance value of 1.0 mg kg^{-1}.

The concentration of mercury in fin-fish selected from catches at Irish fishing ports ranged from 0.02 to 0.27 $\mu g\ g^{-1}$ wet weight. These levels were well within the maximum limits set down in the EC Decision for mercury in fisheries products. Chlorinated hydrocarbon and trace metal levels were also very low in fish tissue. This survey confirms previous studies that show Irish fishery products are effectively free from trace metal and chlorinated hydrocarbon contamination.

INTRODUCTION

The determination of water quality, trace metal levels and chlorinated hydrocarbon concentrations in fish and shellfish from Irish waters is carried out to fulfil the monitoring requirements of legislation such as the 1979 European Union Council Directive 79/923/EC, the European Commission Decision of 10 May 1993 and the requirements of the Joint Monitoring Programme of the Oslo and Paris Commissions. It also provides valuable information for the National Monitoring Programme.

Trace metals exist naturally at background levels 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 mercury, lead and cadmium are not required for metabolic activity and are toxic at quite low concentrations.

Although mercury, lead and cadmium occur naturally in the earth's crust, they can also be introduced into the aquatic environment from anthropogenic activities such as mining, industry and agriculture. Once in the aquatic environment these metals can be concentrated in fish tissues. Due to physiological differences between species, certain species will concentrate mercury more readily than others (Clark *et al.*, 1997).

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

SHELLFISH

The 1979 Council Directive 79/923/EC requires that member States monitor physical (pH, temperature, suspended solids, salinity, dissolved oxygen) and chemical parameters (organo-halogenated substances and heavy metals) of designated shellfish waters to ensure that the quality of the edible species is maintained or enhanced. The current programme to monitor shellfish growing waters began in 1993. Sampling during 1993 and 1994 at the 4 designated sites and additional areas considered for designation was carried out bi-annually. However, because the directive allows for reduced sampling where the quality of designated shellfish growing waters is appreciably higher than that which is set out in the guidelines of the directive, the frequency of monitoring was reduced to an annual basis in 1995. Previous results were published by Nixon *et al.*, 1994a; Nixon *et al.*, 1995a and Smyth *et al.*, 1997. During 1996, water and shellfish from 14 areas designated in 1994 were analysed in compliance with the Directive. An additional 9 areas, currently being considered for designation, were monitored in the same way.

The analysis of mercury, cadmium, chromium, copper, lead and zinc was carried out on shellfish from all of the sites described above. Chlorinated hydrocarbon analysis was carried out on shellfish from 10 sites, of which five were selected on the basis that they could be influenced by localised anthropogenic inputs of pollutants. These were Carlingford Lough, Cork Harbour, Greencastle, Wexford Harbour, and Arthurstown, Waterford. Results obtained from the 1993 and 1994 monitoring of shellfish growing waters confirmed this (Nixon *et al.*, 1994a; Nixon *et al.*, 1995a).

FIN-FISH

Following the European Commission's Decision of 19 May 1993 determining analytical methods, sampling plans and maximum limits for mercury in fisheries products, a mercury monitoring programme was put in place for fish landed at the major Irish fishing ports. To protect consumers and avoid possible long-term accumulation of mercury, the EC set a maximum limit for total mercury of 0.5 $\mu g\ g^{-1}$ wet weight in fishery products. A higher acceptable limit of 1.0 $\mu g\ g^{-1}$ was set for the species listed in Table 1. The current programme monitoring mercury in fish landed at Irish fishing ports began in 1993 and has continued since on an annual basis. Previous results were published in *Fishery Leaflets* 156, 162 167 and 176.

During 1996, fin-fish from 5 major Irish fishing ports (Howth, Rossaveel, Castletownbere, Killybegs and Dunmore East) were collected and analysed for mercury. Analysis of trace metals (cadmium, chromium, lead and zinc) and chlorinated hydrocarbons was carried out on fish from Howth, Killybegs and Dunmore East. Fish from catches landed at these 3 ports were considered to be representative of the Irish coastal marine environment, (the Irish Sea, the Atlantic coast and the Celtic Sea). As with shellfish, with the exception of mercury, there are no generally accepted European standards for trace metals and chlorinated hydrocarbons in fish. Therefore the levels were compared with the available standards and guidance values set by a number of countries for human consumption.

Table 1: Selected species, as listed by European Commission Decision, where the higher acceptable limit of 1.0 μg g^{-1} total mercury concentration applies.

Common Name	Species Name
Sharks	all species
Tuna	*Thunnus spp.*
Little tuna	*Euthynnus spp.*
Bonito	*Sarda spp.*
Plain bonito	*Orcynopsis unicolor*
Swordfish	*Xiphias gladius*
Sailfish	*Istiophorus platypterus*
Marlin	*Makaira spp.*
Eel	*Anguilla spp*
Bass	*Dicentrarchus spp*
Sturgeon	*Acipenser spp.*
Halibut	*Hippoglossus hippoglossus*
Redfish	*Sebastes marinus, S. mentella*
Blue ling	*Molva dipterygia*
Atlantic catfish	*Anarhichas lupus*
Pike	*Esox lucius*
Portuguese dogfish	*Cantroscymnes coelolepis*
Rays	*Raja spp.*
Scabbardfishes	*Lepidopus caudatus, Aphanopus carbo*
Anglerfish	*Lophius spp.*

MATERIALS AND METHODS

SAMPLE COLLECTION AND PRESERVATION

Shellfish

Shellfish samples were collected between January and September 1996, from 22 areas (Figure 1). Detailed information on the locations, dates, species sampled, cultivation methods etc. are shown in Appendix 1. At each site temperature, salinity, pH and dissolved oxygen measurements were taken *in situ* using a Hydrolab® multiparameter probe. Results of the physico-chemical measurements are also shown in Appendix 1.

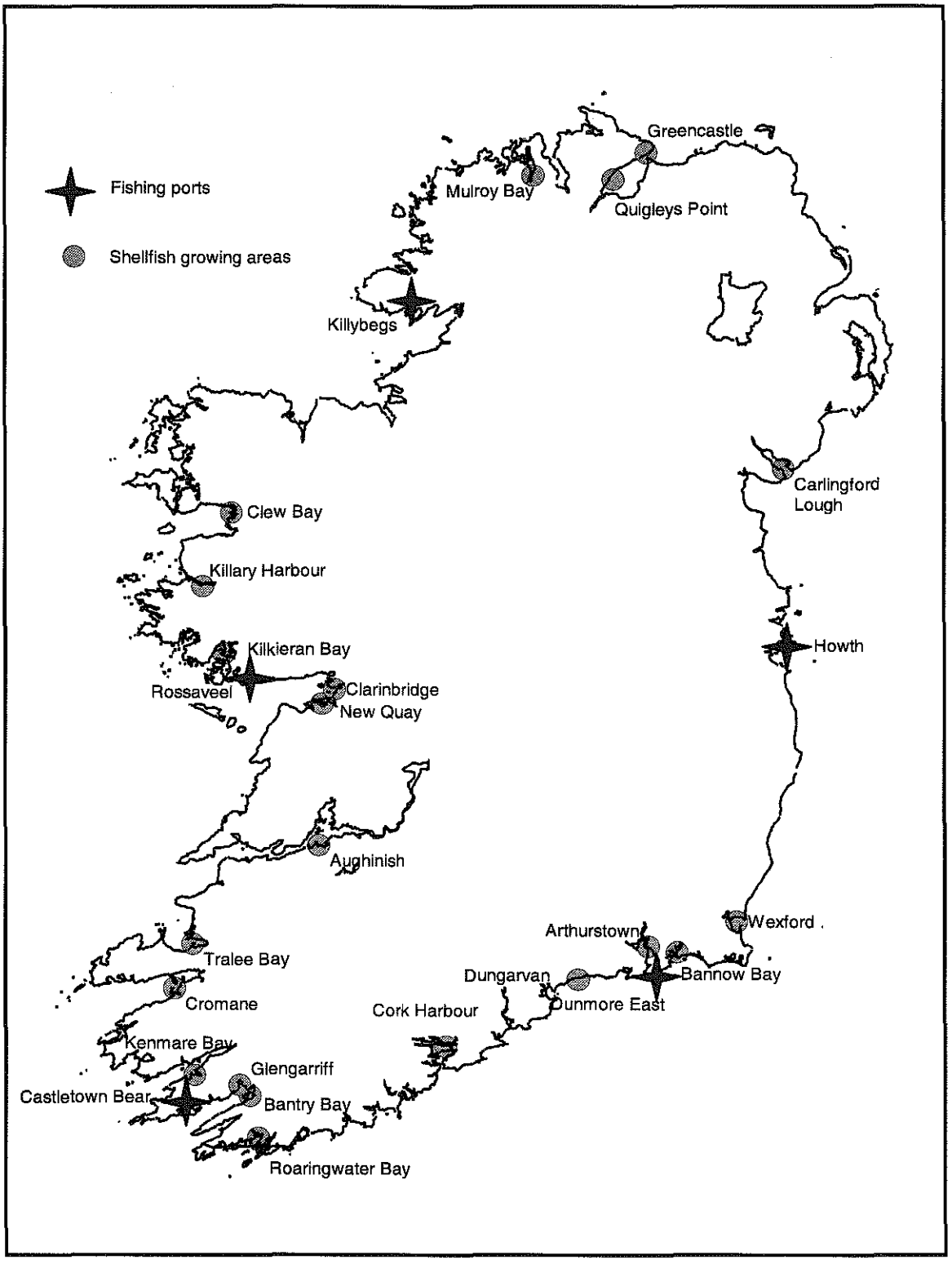
Water samples were collected and returned to the laboratory for the determination of suspended solids. The samples were filtered through a 0.45 μm membrane and dried at 105 °C to constant weight. Representative samples of the main shellfish species produced in each of the growing areas were collected. Mussel samples consisted of 50 individuals and oyster samples consisted of 25. In the laboratory, lengths were recorded and each sample was depurated for 14 to 16 hours in clean seawater collected from the growing area at the time of sampling. The soft tissue or meat was removed from the shells, drained and the percentage meat and shell weight calculated and recorded. The soft tissue was then homogenised and a 1 g sub-sample taken from the homogenate and dried at 105°C for 24 hours to determine the moisture content. The remainder was divided into 2 sub-samples; one portion freeze-dried for 16 hours and stored for metal analysis, the other stored at -20°C prior to mercury and chlorinated hydrocarbon analysis.

Fin-fish

Fish landed at the major fishing ports of Killybegs, Rosaveel, Castletownbere, Dunmore East and Howth were sampled between April and June 1996 (Figure 1). Depending on availability, 10 fish of each species landed were sampled at each of these ports. The lengths of the fish were measured and a portion of the edible tissue was removed from each fish, stored in pre-weighed, acid-washed glass jars and returned to the laboratory. The samples were then weighed, homogenised and divided into 2

sub-samples One sub-sample was freeze-dried for 16 hours and stored for the analysis of trace metals, and the second was stored at –20°C prior to mercury and chlorinated hydrocarbon analysis. The moisture content was calculated from a 1g sub-sample of the homogenate, dried for 24 hours at 105°C.

Figure 1. Location of shellfish-growing areas monitored during 1996.



Mercury analysis

Nitric acid (4 ml) was added to approximately 0.2g of wet tissue and digested in a laboratory microwave oven (Milestone MLS 1200). After cooling, potassium permanganate was added until the colour of the solution had stabilised. Sufficient hydroxylamine hydrochloride was added to neutralise the potassium permanganate. The solution was diluted to 20 ml with distilled-deionised water. Following the reduction of the samples with stannous chloride, the mercury was

determined by the cold vapour flameless atomic absorption spectrometric method (Hatch & Ott, 1968) using a Varian SpectrAA 20 Plus spectrometer fitted with VGA 76 Vapour Generator.

Trace metal analysis (cadmium, chromium, copper, lead and zinc)

Nitric acid (4 ml) and hydrogen peroxide (4 ml) were added to approximately 0.2g of freeze dried tissue and digested in a laboratory microwave oven (Milestone MLS 1200). Following digestion of the samples, trace metal concentrations were determined using a graphite furnace atomic absorption spectrometer (Varian SpectrAA-400) or a flame atomic absorption spectrometer (Varian SpectrAA 20 Plus).

Table 2: Results of the analyses of certified reference materials obtained during the 1996 fin fish and shellfish monitoring programmes.

CRM	Certified Value (± 95 % confidence limit)	FRC Value (± standard deviation)	No. of Analyses
Dogfish muscle DORM-2	**μg g^{-1} dry wt.**	**Mean μg g^{-1} dry wt.**	
Cadmium	0.043 ± 0.008	0.048 ± 0.001	2
Chromium	34.7 ± 5.5	27.9	2
Mercury	4.64 ± 0.26	5.10 ± 0.41	12
Lead	0.065 ± 0.007	< LOD*	4
Zinc	25.6 ± 2.3	26.4 ± 1.37	2
Oyster tissue SRM 1566a	**μg g^{-1} dry wt.**	**Mean μg g^{-1} dry wt.**	
Cadmium	4.15 ± 0.38	3.73 ± 0.09	3
Chromium	1.43 ± 0.46	1.07 ± 0.31	3
Copper	66.3 ± 4.3	63.2 ± 4.5	3
Mercury	0.0642 ± 0.0067	0.0690 ± 0.003	3
Lead	0.371 ± 0.014	0.371 ± 0.070	3
Zinc	830 ± 57	1036 ± 149	3
Mussel tissue CRM 278	**μg g^{-1} dry wt.**	**Mean μg g^{-1} dry wt.**	
Cadmium	0.34 ± 0.02	0.35 ± 0.07	2
Chromium	0.80 ± 0.08	1.04 ± 0.15	2
Copper	9.60 ± 0.16	12.75 ±4.5	2
Mercury	0.199 ± 0.006	0.199 ± 0.006	3
Lead	1.91 ± 0.04	1.91 ± 0.90	2
Zinc	76 ± 2	81 ± 3	2
Cod Liver Oil CRM 349	**μg kg^{-1} dry wt.**	**Mean μg kg^{-1} dry wt.**	
CB Congener 28	68 ± 7	67 ± 3	11
CB Congener 52	149 ± 20	151 ± 9	11
CB Congener 101	370 ± 17	366 ± 23	11
CB Congener 118	454 ± 31	455 ± 35	11
CB Congener 153	938 ± 40	930 ± 94	11
CB Congener 180	280 ± 22	280 ± 26	11
Reference material	**Uncertified values**	**FRC Value**	**No. of Analyses**
Cod Liver Oil CRM 349	**μg kg^{-1} dry wt.**	**Range μg kg^{-1} dry wt.**	
DDE - p,p'	234	181 - 312	7
Alpha-chlordane	20.5	23.8 – 24.9	2
Dieldrin	153	148 - 180	3
Lindane	73	72 - 104	8

* Limit of detection (LOD) for lead 0.2 μg g^{-1} dry weight

Chlorinated hydrocarbon analysis

Wet tissue was dried using anhydrous sodium sulphate and Soxhlet extracted for 6 hours with a hexane/dichloromethane (1:1) mixture. The co-extracted lipids were removed by alumina column chromatography followed by separation of the PCBs from the chlorinated pesticides using silica column chromatography. Levels were determined by gas

chromatographic electron capture detection (GC-ECD) using a Hewlett Packard 5890 gas chromatograph fitted with a 60 metre fused silica capillary column (CP-SIL 8CB, Chrompack). A second column of different polarity was used as confirmation (CP-SIL 19CB, Chrompack).

Quality control

To check the quality of the data produced during the 1996 fin-fish and shellfish monitoring programmes, certified reference materials (CRMs) were analysed with each batch of samples. Between 2 and 11 analyses were carried out on each CRM used in this programme, the results of which are shown in Table 2. The quality assurance results obtained were considered sufficient for the purpose of the monitoring programme.

RESULTS AND DISCUSSION

SHELLFISH SURVEY

The results of the biological measurements and chemical monitoring carried out during 1996 are given in Appendix 1. Generally, the water quality in all areas was good and conformed to the guidelines of the Directive. Parameters such as pH, temperature, suspended solids, salinity and dissolved oxygen measurements met the criteria set down in the Directive in all cases.

During sample collection an examination for the presence of visible petroleum hydrocarbons was undertaken. Neither a visible hydrocarbon film on the surface of the water, nor any deposition on the shellfish was detected at any of the shellfish-growing areas.

The concentration of mercury, trace metals and chlorinated hydrocarbon contaminants analysed in the shellfish tissue are presented in Appendix 1. The level of contaminants in shellfish are a good indicator of contaminant levels present in the water column and can provide valuable information on the quality of the shellfish and the waters in which they are grown.

As there are no generally accepted European standards for contaminants in shellfish, the levels were compared with the available standards and guidance values set by various OSPAR countries for human consumption. The strictest guidance and standard values are presented in Table 3, however some countries have less stringent values.

Table 3: Synopsis of the strictest standard and guidance values applied by various OSPAR countries for contaminants in shellfish for the assessment of the possible hazards to human health (Anon, 1992).

Contaminant	Values and Units	Qualifier	Country
Cadmium	0.5 mg kg^{-1}	Guidance	Germany/Norway
Copper	20 mg kg^{-1}	Standard	Spain
Lead	0.8 mg kg^{-1}	Guidance	Germany
Mercury	0.5 µg g^{-1}	Standard	Germany
pp'DDT and metabolites	500 µg kg^{-1}	Standard	Finland
HCB	50 µg kg^{-1}	Guidance	Norway
α and β HCH	50 µg kg^{-1}	Guidance	Norway
Lindane	100 µg kg^{-1}	Standard	Finland
CB congener 28	80 µg kg^{-1}	Standard	Germany
CB congener 52	80 µg kg^{-1}	Standard	Germany
CB congener 101	80 µg kg^{-1}	Standard	Germany
CB congener 138	100 µg kg^{-1}	Standard	Germany
CB congener 153	100 µg kg^{-1}	Standard	Germany
CB congener 180	80 µg kg^{-1}	Standard	Germany

Oysters are known to accumulate high levels of zinc with concentrations as high as 11,000 mg kg^{-1} wet weight being found in the digestive gland of oysters (Clark *et al.*, 1997). Concentrations of zinc in oysters, *Crassostrea gigas* and

Ostrea edulis, from Irish waters in 1996 ranged from 192.7 - 532.7 mg kg^{-1} wet weight, while the range in mussels, *Mytilus edulis*, was from 11.5 – 27.7 mg kg^{-1} wet weight. The UK is the only country at present to set down a guideline value of 50 mg kg^{-1} for Zn in food, however this excludes shellfish. The level in shellfish is expected to be well in excess of 100 mg kg^{-1} wet weight, (Anon., 1993).

There are no published guidelines for acceptable concentrations of chromium in shellfish. Chromium contamination results mainly from human activities. The range in oysters in this survey was 0.09 - 0.26 mg kg^{-1} wet weight and 0.03 - 0.39 mg kg^{-1} wet weight in mussels.

Aughinish Bay, New Quay, Co. Clare
Physicochemical measurements, water samples and a sample of *C. gigas* were collected from Aughinish Bay during August 1996. The water quality parameters measured conformed to the requirements of the Directive. The level of mercury in the meat (0.03 μg g^{-1} wet weight) was more than 15 times lower than human consumption tolerance values set by OSPAR countries (Table 3) and was comparable with previous years (Nixon *et al.*, 1995a; Smyth *et al.*, 1997). Trace metal concentrations were comparable with 1995 (Smyth *et al.* 1997). No organic analysis was carried out on the shellfish from this site.

Aughinish, Limerick
This site was first sampled for water quality and trace metal levels in *C.gigas* in 1995 although no organic analysis was carried out at that time. Trace metal levels in the 1995 sample were found to be within the OSPAR guideline concentrations (Smyth *et al.*, 1997). The results of the 1996 sample followed the same trend. The mercury concentration (0.01 μg g^{-1} wet weight) was well within the guideline concentrations given in Table 3. Chlorinated hydrocarbon analysis indicated that the levels were very low and gave no reason for concern.

Bannow Bay.
This site was visited during August 1996. Water quality measurements taken were normal for an inshore location during summer. The mercury content of a sample of *C. gigas* was determined and the value (0.03 μg g^{-1} wet weight) was found to be very similar to those of 1994 and 1995 (Nixon *et al.*, 1995a; Smyth *et al.*, 1997). This was also evident for the other trace metals analysed, all of which were within the tolerance level given in Table 3.

Bantry Bay.
As in 1994 and 1995 the water parameters measured at this site were typical of northern temperate waters. The level of mercury in the soft tissues of *M. edulis* grown in Bantry Bay were 25 times lower than the strictest tolerance values set by OSPAR countries (Table 3). Trace metal levels in the 1996 sample were also within the guideline concentrations. Chlorinated hydrocarbon levels were very low (between 50 and 400 times lower than the tolerance levels set out in Table 3) and were comparable with the 1994 values (Nixon *et al.*, 1995a).

Carlingford Lough.
For the purpose of this monitoring programme, oysters *C. gigas* were sampled from Carlingford Lough, although mussels are also produced in this area but to a lesser extent. The levels of mercury and chlorinated hydrocarbons were again very low during 1996 and were comparable with previous years (Nixon *et al.*, 1995; Smyth *et al.*, 1997). The level of cadmium (0.40 mg kg^{-1}) was lower than the 1995 value (0.52 mg kg^{-1}) and was within the guidance value set by Germany and Norway (0.5 mg kg^{-1}) shown in Table 3. Water quality conformed to the requirement of the Directive.

Clarinbridge
The native oyster *O. edulis* was sampled from Clarinbridge during August 1996. Mercury levels in the tissues were low (0.03 μg g^{-1} wet weight) and the water quality measurements were within the guidelines of the Directive. Trace metal levels were similar to 1995 results (Smyth *et al.*, 1997). The cadmium concentration (0.42 mg kg^{-1}) was within the German and Norwegian guidance value. No chlorinated hydrocarbon analysis was carried out.

Clew Bay
With the exception of cadmium, the concentrations of trace metals including mercury in *O. edulis* from Clew Bay were low and well within human consumption guidelines (Table 3). The water quality measurements were also within the guidelines of the Directive. The level of cadmium in the 1996 sample (0.59 mg kg^{-1}) was lower than in 1995 (0.80 mg kg^{-1}) and although this was slightly above the German/Norwegian guideline it was within the Dutch standard of 1. 0 mg kg^{-1} wet weight and was not exceptional for Irish oysters (Nixon *et al.*, 1995a; Smyth *et al.*, 1997). No chlorinated hydrocarbon analysis was carried out.

Cork Harbour
Water and shellfish quality was similar to 1994 and 1995 (Nixon *et al.*, 1995a; Smyth *et al.*, 1997) and conformed to the requirements of the Directive. Trace metal and chlorinated hydrocarbon levels continued to be very low.

Cromane
Trace metal concentrations in shellfish remained low and similar to 1994 and 1995 values (Nixon *et al.*, 1995a; Smyth *et al.*, 1997). Water quality measurements satisfied the requirements of the directive. Chlorinated hydrocarbon analysis was carried out on *M. edulis* tissue for the first time at this site. The levels were very low and were within the tolerance levels set out in Table 3.

Dungarvan
As part of the Water Quality Management Plan, Waterford County Council surveyed Dungarvan harbour for metals, pesticides and organo-halogen compounds in 1993. Shellfish collected from this area were found to contain elevated levels of chromium and lead (Bowman *et al.*, 1996). Water and shellfish samples were collected from 4 sites in the Dungarvan area for the first time during 1996 in accordance with the monitoring requirements of the 1979 Council Directive. Water quality measurements satisfied the requirements of the directive and trace metal levels in *C. Gigas* were within the human consumption guidelines set out in Table 3. Chromium levels in *C. gigas* (0.11 – 0.31 mg kg^{-1} wet weight) were similar to levels found at other Irish shellfish growing areas (0.11 – 0.21 mg kg^{-1} wet weight). Lead concentrations (0.28 – 0.44 mg kg^{-1} wet weight) were within the strictest guidance value of 0.8 mg kg^{-1} wet weight in Table 3.

Glengarriff
Mussel samples were collected from Glengarriff, Bantry Bay, in September 1996. As in 1993, 1994 and 1995 the levels of trace metals in *M. edulis* tissue were well within the human consumption guideline and standards set by OSPAR countries (Table 3). Measurement of chlorinated hydrocarbons was not carried out in 1996, as levels were considered sufficiently low from previous sampling in 1994 (Nixon *et al.*, 1995b). Water quality measurements fully complied with the requirements of the Directive.

Greencastle and Quigley's Point, Lough Foyle
Samples of *M. edulis* were collected at the two Lough Foyle sites during September 1996. Water quality parameters and trace metal levels measured in the shellfish were similar to the levels detected during the 1994 and 1995 programmes (Nixon *et al.*, 1995b; Smyth *et al.*, 1997) and complied with the requirements of the Directive. Chlorinated hydrocarbon concentrations in the mussels collected were within the strictest standards set by OSPAR countries (Table 3) and were comparable with those from 1994 (Nixon *et al.*, 1995b).

Kenmare Bay
Mussel samples were collected form Kenmare during September 1996. Again, the shellfish produced at this location contained levels of trace metals well within the human consumption guideline and standards set by OSPAR countries. Water quality measurements fully complied with the requirements of the Directive. No organic analysis was carried out on the shellfish from this site.

Kilkieran Bay
With the exception of cadmium, the concentrations of trace metals in *O. edulis* from Kilkieran Bay were low and well within human consumption guidelines (Table 3). The cadmium level of 0.38 mg kg^{-1} wet weight was similar to the 1993 and 1994 result. This was within the German and Norwegian guideline value and was not considered exceptional for Irish oysters. The water quality parameters from this site were also well within the requirements of the Directive. No organic analysis was carried out on the shellfish from this site.

Killary Harbour
The level of trace metals measured in *M. edulis* from Killary Harbour was well within human consumption guidelines and the water parameters met the criteria set by the Directive. No organic analysis was carried out on the shellfish from this site.

Mulroy Bay
The levels of trace metals measured in *M. edulis* from Mulroy Bay were comparable with 1994 and 1995 (Nixon *et al.*, 1995a; Smyth *et al.*, 1997) and were well within human consumption guidelines and standards set by OSPAR countries (Table 3). Water quality measurements fully complied with the requirements of the Directive. No organic analysis was carried out on the shellfish from this site.

Roaringwater Bay
Mussel samples collected during September 1996 had trace metal levels similar to 1994 and 1995 values (Nixon *et al.*, 1995a; Smyth *et al.*, 1997), which were well within human consumption guidelines and standards set by OSPAR countries. Water quality measurements fully complied with the requirements of the Directive. No organic analysis was carried out on the shellfish from this site.

Tralee Bay, Derrymore
Samples of oysters *O. edulis* and *C. gigas* were collected from Tralee Bay during August 1996. The water quality parameters measured conformed with the requirements of the Directive. Trace metal levels were lower than the 1994 and 1995 values (Nixon *et al.*, 1995a; Smyth *et al.*, 1997) and were within human consumption guidelines and standards set by OSPAR countries. The levels of zinc in the 1996 oyster samples (241.8 – 320.8 mg kg^{-1}) were lower than the 1995 value (532.8 mg kg^{-1}) and were in the range expected for Irish oysters. Cadmium levels were within the German and Norwegian guideline value (Table 3). No organic analysis was carried out on the shellfish from this site.

Arthurstown, Waterford
Water quality parameters at Arthurstown fully complied with the requirements of the Directive. The level of mercury in *M. edulis* was low and well within the tolerance level set out in Table 3. Traces of chlorinated hydrocarbons were found but these were at µg kg^{-1} concentrations and well within the standards set by OSPAR countries. Trace metal levels were also within the human consumption guidelines given in Table 3.

Wexford Harbour
Water quality parameters were measured and *M. edulis* collected from Wexford Harbour during August 1996. The water quality parameters conformed to the requirements of the Directive. The mercury concentration measured in the mussels was very low at 50 times lower the German standard of 0.5 µg g^{-1} wet weight stated in Table 3. Levels of organic contaminants measured in mussels from Wexford Harbour were also well within human consumption guidelines. Trace metal levels in mussel tissue continued to be low with the exception of lead. Lead concentrations in mussels from this site have historically been within the strictest standard of 0.8 mg kg^{-1} but have been elevated compared with other Irish shellfish growing areas. However all trace metals, including lead, measured in shellfish from this site have followed the same stable pattern over the last 8 years (Nixon *et al.*, 1991, 1994a, 1995a; Smyth *et al.*, 1997). The 1996 mussel sample contained uncharacteristically high levels of lead (1.82 mg kg^{-1}), a value over twice the strictest standard given in Table 3. This unusual result will be followed up in future monitoring programmes.

River Slaney, Wexford
M. edulis was collected from the River Slaney for the first time in August 1996. The level of trace metals in mussels was low and well within the tolerance level set out in Table 3. Levels of organic contaminants measured in mussels were also well within human consumption guidelines given in Table 3.

FIN-FISH SURVEY

The results of the chemical monitoring programme carried out on fish from commercial catches landed at the major Irish fishing ports during 1996 are given in Appendices 2 and 3. The fish were chosen as examples of pelagic and demersal fish groups.

Mercury
During the 1996 monitoring programme, a total of 50 samples of edible tissue covering 17 species were analysed for total mercury. The results are given in Appendix 2. The concentration of mercury in the edible portion of the fish analysed ranged from 0.02 to 0.27 µg g^{-1} wet weight which was well within the European Union human consumption tolerance level of 0.5 µg g^{-1} wet weight. These values are also in accordance with the 1994 and 1995 results of 0.01 to 0.21 and 0.03 to 0.28 µg g^{-1} mercury, respectively (Nixon *et al.*, 1995b; Rowe *et al.*, 1997). The highest concentrations of mercury were detected in white sole landed at Killybegs (0.27 µg g^{-1}), haddock landed at Killybegs (0.24 µg g^{-1}) and whiting landed at Dunmore East (0.20 µg g^{-1}).

All the fish sampled also fell within the stricter EU Environmental Quality Standard (EQS) for mercury, which requires that the mean concentration of mercury in the flesh should not exceed 0.3 µg g^{-1} (76/464/EEC: Council Directive of 4 May 1976). The levels of mercury in cuckoo ray and ling (0.07 to 0.17 µg g^{-1}) were also well within the European Commission Decision for selected species where the higher acceptable limit of 1.0 µg g^{-1} total mercury concentration applies (Table 1).

Trace metals

During the 1996 programme, a total of 10 samples covering 5 fish species from Howth, Killybegs and Dunmore East were analysed for cadmium, chromium, lead and zinc. Fish from catches landed at these 3 ports were considered to be representative of the Irish coastal marine environments. As with shellfish, there are no generally accepted European standards for trace metals concentrations in fish. Therefore the levels were compared with the available standards and guidance values set by a number of countries for human consumption. The strictest guidance and standard values are presented in Table 4, however some countries have less stringent values.

Cadmium levels in all samples analysed were less than the limit of detection (0.006 mg kg^{-1}) and therefore within the strictest standard of 0.1 mg kg^{-1} (Table 4). Lead concentrations were below the limit of detection (0.004 mg kg^{-1}) in all samples apart from plaice collected at Dunmore East and Killybegs. However the level of lead in these samples (0.02 and 0.05 mg kg^{-1} respectively) was well within the strictest standard of 0.5 mg kg^{-1}. Zinc levels were within the UK guidance value of 50 mg kg^{-1}. There are no published guidelines for acceptable concentrations of chromium in fish. However the chromium levels in fish samples collected for this survey were in all cases less than 0.08 mg kg^{-1}.

Chlorinated hydrocarbons

During the 1996 monitoring programme, 8 samples of edible tissue covering 4 fish species were analysed for chlorinated hydrocarbons. The results are given in Appendix 3. Again there are no generally accepted European standards for chlorinated hydrocarbons in fish. Therefore the levels were compared with the available standards and guidance values set by a number of countries for human consumption (Table 4).

Table 4: Synopsis of the strictest standard and guidance values applied by various OSPAR countries for trace metals and chlorinated hydrocarbons in fish for the assessment of the possible hazards to human health (Anon, 1992).

Contaminant	Values and Units	Qualifier	Country
Cadmium	0.1 μg g^{-1}	Standard	Netherlands
Copper	10 μg g^{-1}	Guidance	Norway
Lead	0.5 μg g^{-1}	Standard	Netherlands
Mercury	0.3 μg g^{-1}	Standard	Denmark
Zinc	50 μg g^{-1}	Guidance	United Kingdom
DDT+DDE+DDD	500 μg kg^{-1}	Standard	Finland
HCB	50 μg kg^{-1}	Guidance	Norway
α + β HCH	50 μg kg^{-1}	Guidance	Norway
Lindane	100 μg kg^{-1}	Guidance	Finland
CB congener 28	80 μg kg^{-1}	Standard	Germany
CB congener 52	40 μg kg^{-1}	Standard	Netherlands
CB congener 101	80 μg kg^{-1}	Standard	Germany/Netherlands
CB congener 118	80 μg kg^{-1}	Standard	Netherlands
CB congener 138	100 μg kg^{-1}	Standard	Germany/Netherlands
CB congener 153	100 μg kg^{-1}	Standard	Germany/Netherlands
CB congener 180	80 μg kg^{-1}	Standard	Germany
Aldrin + dieldrin	100 μg kg^{-1}	Standard	Finland

The levels of chlorinated hydrocarbons in the edible portion of the fish analysed were very low and fell well within the strictest standards set by Oslo and Paris Commission (OSPAR) countries (Table 4). The 1996 levels were also comparable with those from 1995. The edible portion of the pelagic species, herring, landed at Killybegs in May 1996 contained the highest concentrations of chlorinated hydrocarbons including the PCB congeners 101, 153, 138, the DDT metabolites, and Lindane and Dieldrin. This would be expected due to the high fat content of herring. However the highest concentration of 3.97 μg kg^{-1} (Dieldrin) was still 25 times lower than the strictest guidance value for Dieldrin of 100 μg kg^{-1} laid down in Table 4.

CONCLUSIONS

The water quality in all the shellfish growing areas in terms of pH, temperature, suspended solids, salinity and dissolved oxygen was good and conformed to the guidelines of the 1979 Council Directive 79/923/EC.

Total mercury and trace metal concentrations in commercial fish catches landed at Irish ports and in shellfish from shellfish growing areas were low, which conformed with previous studies (O' Sullivan *et al.*, 1991; Nixon *et al.*, 1991, 1993, 1994a, 1994b, 1995a, 1995b; Smyth *et al.*, 1997; Rowe *et al.*, 1998). All shellfish samples tested for mercury were well within the limits set by the European Commission's Decision of 19 May 1993. The concentration of mercury in fish was within the European Union human consumption tolerance level of 0.5 $\mu g\ g^{-1}$ wet weight.

Chlorinated hydrocarbon concentrations were also very low in both fish and shellfish, which again confirmed previous studies (Nixon *et al.*, 1991, 1994a; Smyth *et al.*, 1997; Rowe *et al.*, 1998). All results were well within the strictest standards and guidance values of OSPAR member states.

The results of the analyses in this report are indicative of the unpolluted nature of Irish waters and fisheries products.

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Appendix 1: Results of the 1996 monitoring of shellfish-growing areas.

	Aughinish, New Quay, Clare	Aughinish, Limerick	Bannow Bay	Bantry Bay	Carlingford Lough
Date sampled	26-08-96	12-09-96	23-08-96	11-09-96	12-08-96
Latitude	53°09.12	52°38.30	52°13.40	51°41.30	54°01.75
Longitude	09°01.40	09°03.00	06°47.25	09°28.45	06°07.05
Time of high tide	1600	1800	1230	1730	1115
Time of sampling	1400	1200	1345	0930	1630
Species sampled	*C. gigas*	*C.gigas*	*C. gigas*	*M. edulis*	*C. gigas*
No. of individuals in sample	25	25	25	50	25
Method of cultivation	Bottom	Trestle	Trestle	Rope	Trestle
Water Parameters					
Temperature °C	16.7	16.8	16.0	15.6	15.7
Salinity psu	33.1	27.8	33.3	33.7	33.0
pH	8.2	8.1	8.0	8.1	8.1
Dissolved oxygen % saturation	101.0	101.0	100.0	93.4	126.0
Suspended Solids mg l^{-1}	29.0	-	17.0	-	17.7
Shellfish					
Shell length range mm.	71 – 125	67 – 120	84 – 120	42 – 59	86 – 114
Length mean mm	99	92	101	51	96
Length standard deviation mm	18.0	7.0	9.5	4.0	3.8
Meat weight %	11.5	17.9	11.6	-	10.6
Shell weight %	88.5	82.1	88.4	-	89.4
Meat water content %	81.1	76.4	80.3	76.6	77.2
Metals mg kg^{-1} (ppm) wet wt					
Cadmium	0.27	0.39	0.23	0.11	0.40
Chromium	0.11	0.18	0.09	0.43	0.13
Copper	5.5	22.4	9.5	1.1	28.7
Mercury	0.03	0.01	0.03	0.02	0.03
Lead	0.02	0.07	0.09	0.10	0.11
Zinc	192.7	225.9	204.4	20.6	443.6
Organics µg kg^{-1} (ppb) wet wt					
CB Congener 28	-	n.d.	-	0.03	<0.08
CB Congener 31	-	n.d.	-	0.08	1.28
CB Congener 52	-	n.d.	-	0.05	0.04
CB Congener 101	-	0.39	-	0.19	<0.12
CB Congener 118	-	0.28	-	0.15	0.12
CB Congener 153	-	0.56	-	1.00	0.06
CB Congener 156	-	0.06	-	0.32	0.06
CB Congener 105	-	0.68	-	0.05	0.66
CB Congener 138	-	0.23	-	0.52	<0.08
CB Congener 180	-	n.d.	-	0.29	0.15
DDE – p,p'	-	0.62	-	0.25	0.12
DDE – o,p'	-	n.d.	-	n.d.	<0.08
DDT – p,p'	-	0.34	-	0.07	<0.08
DDD – p,p'	-	1.32	-	n.d.	<0.08
BHC, alpha	-	0.86	-	0.09	<0.08
BHC, gamma (Lindane)	-	n.d.	-	0.34	0.49
Chlordane, alpha	-	n.d.	-	0.22	0.38
Chlordane, gamma	-	n.d.	-	0.01	1.71
Dieldrin	-	0.58	-	0.43	0.05
HCB	-	n.d.	-	0.03	0.05
Trans - Nonachlor	-	0.61	-	0.02	<0.08

n.d. not detected

Appendix 1 continued.

	Clarinbridge	Clew Bay, Inishloy	Cork Hbr.	Cromane	Dungarvan Site 1
Date sampled	26-08-96	06-09-96	09-09-96	14-08-96	23-01-96
Latitude	53°12.36	53°52.00	51°52.45	52°07.83	52°04.25
Longitude	08°56.45	09°35.20	08°14.25	09°52.83	07°35.45
Time of high tide	1600	1300	1615	1900	-
Time of sampling	1730	1130	1545	1630	0930
Species sampled	*O. edulis*	*O. edulis*	*C. gigas*	*M. edulis*	*C. gigas*
No. of individuals in sample	25	25	25	50	25
Method of cultivation	Bottom	Bottom	Bottom	Bottom	Bottom
Water Parameters					
Temperature °C	16.7	15.7	17.0	17.1	14.5
Salinity psu	32.1	33.4	31.8	31.2	32.1
PH	8.2	8.1	8.1	8.1	8.0
Dissolved oxygen % saturation	97.6	92.9	104.4	97.1	103.1
Suspended Solids mg l^{-1}	28.0	7.0	-	20.0	-
Shellfish					
Shell length range mm.	64 – 92	66 – 91	71 – 102	54 - 84	75 – 126
Length mean mm	72	77	83	70	91
Length standard deviation mm	7.0	7.6	10.0	6	20
Meat weight %	10.2	8.4	14.8	24.1	12.5
Shell weight %	89.8	91.6	85.2	75.9	87.5
Meat water content %	76.6	85.8	76.8	76.2	77.8
Metals mg kg^{-1} (ppm) wet wt					
Cadmium	0.42	0.59	0.17	0.24	0.34
Chromium	0.13	0.17	0.15	0.27	0.31
Copper	4.1	4.8	14.6	1.6	-
Mercury	0.03	0.03	0.02	0.03	0.04
Lead	0.02	0.08	0.10	0.09	0.34
Zinc	235.9	532.7	300.8	16.3	-
Organics µg kg^{-1} (ppb) wet wt					
CB Congener 28	-	-	0.36	0.02	-
CB Congener 31	-	-	0.21	0.05	-
CB Congener 52	-	-	0.39	0.02	-
CB Congener 101	-	-	0.80	0.05	-
CB Congener 118	-	-	n.d.	0.02	-
CB Congener 153	-	-	1.42	0.06	-
CB Congener 156	-	-	0.09	<0.01	-
CB Congener 105	-	-	0.19	0.02	-
CB Congener 138	-	-	1.01	0.10	-
CB Congener 180	-	-	0.08	0.01	-
DDE - p,p'	-	-	1.13	0.14	-
DDE - o,p'	-	-	n.d.	<0.01	-
DDT - p,p'	-	-	0.12	0.01	-
DDD - p,p'	-	-	0.54	0.03	-
BHC, alpha	-	-	n.d.	0.07	-
BHC, gamma (Lindane)	-	-	n.d.	0.11	-
Chlordane, alpha	-	-	0.14	0.05	-
Chlordane, gamma	-	-	0.65	<0.08	-
Dieldrin	-	-	0.93	0.27	-
HCB	-	-	n.d.	0.02	-
Trans - Nonachlor	-	-	0.31	<0.08	-

n.d. not detected

Appendix 1 continued.

	Dungarvan Site 2	Dungarvan Site 3	Dungarvan Site 4	Glengarriff	Greencastle	Kenmare Bay
Date sampled	23-01-96	23-01-96	23-01-96	10-09-96	03-09-96	11-09-96
Latitude	52°04.50	52°03.25	52°03.50	51°42.35	55°11.90	51°46.25
Longitude	07°35.75	07°33.40	07°35.00	09°32.35	06°58.55	09°48.50
Time of high tide	-	-	-	1515	2200	1645
Time of sampling	1000	1030	1100	1600	1900	1645
Species sampled	*C. gigas*	*C. gigas*	*C. gigas*	*M. edulis*	*M. edulis*	*M. edulis*
No. of individuals in sample	25	24	25	50	50	50
Method of cultivation	Bottom	Bottom	Bottom	Rope	Bottom	Rope
Water Parameters						
Temperature °C	14.5	14.5	14.5	15.7	16.4	15.5
Salinity psu	32.1	32.1	32.1	33.7	29.9	33.7
PH	8.0	8.0	8.0	8.2	8.1	8.0
Dissolved oxygen % saturation	103.1	103.1	103.1	100.1	105.4	88.3
Suspended Solids mg l^{-1}	-	-	-	-	7.1	-
Shellfish						
Shell length range mm.	78 – 127	60 – 98	82 – 100	37 – 50	55 – 76	30 – 56
Length mean mm	100	78	91	44	65	42
Length standard deviation mm	12.4	9.2	5.8	3.0	4.1	4.8
Meat weight %	10.6	10.0	11.7	40.2	15.4	46.7
Shell weight %	89.4	90.0	88.3	59.8	84.6	53.3
Meat water content %	78.6	76.9	76.9	77.3	80.2	75.2
Metals mg kg^{-1} (ppm) wet wt						
Cadmium	0.37	0.41	0.50	0.25	0.13	0.18
Chromium	0.31	0.11	0.31	0.14	0.29	0.11
Copper	19.4	20.8	-	1.4	0.9	1.5
Mercury	0.03	0.04	0.04	0.02	0.02	0.01
Lead	0.41	0.28	0.44	0.11	0.12	0.10
Zinc	381	401	-	27.7	11.5	15.7
Organics µg kg^{-1} (ppb) wet wt						
CB Congener 28	-	-	-	-	0.02	-
CB Congener 31	-	-	-	-	0.02	-
CB Congener 52	-	-	-	-	0.08	-
CB Congener 101	-	-	-	-	0.04	-
CB Congener 118	-	-	-	-	0.08	-
CB Congener 153	-	-	-	-	0.28	-
CB Congener 156	-	-	-	-	n.d.	-
CB Congener 105	-	-	-	-	0.01	-
CB Congener 138	-	-	-	-	0.16	-
CB Congener 180	-	-	-	-	0.05	-
DDE - p,p'	-	-	-	-	0.18	-
DDE - o,p'	-	-	-	-	n.d.	-
DDT - p,p'	-	-	-	-	n.d.	-
DDD - p,p'	-	-	-	-	0.16	-
BHC, alpha	-	-	-	-	n.d.	-
BHC, gamma (Lindane)	-	-	-	-	n.d.	-
Chlordane, alpha	-	-	-	-	0.09	-
Chlordane, gamma	-	-	-	-	n.d.	-
Dieldrin	-	-	-	-	0.17	-
HCB	-	-	-	-	0.02	-
Trans – Nonachlor	-	-	-	-	0.18	-

n.d. not detected

Appendix 1 continued.

	Kilkieran	Killary Hbr.	Mulroy Bay	Quigleys Pt.	Roaring -water Bay
Date sampled	28-08-96	28-08-96	04-09-96	03-09-96	10-09-96
Latitude	53°20.45	53°36.30	55°07.55	55°06.66	51°32.12
Longitude	09°39.00	09°49.00	07°41.04	07°10.88	09°25.30
Time of high tide	1700	1100	-	2200	1600
Time of sampling	1545	1700	-	1720	1215
Species sampled	*O. edulis*	*M. edulis*	*M. edulis*	*M. edulis*	*M. edulis*
No. of individuals in sample	25	50	50	50	25
Method of cultivation	Bottom	Rope	Rope	Bottom	Rope
Water Parameters					
Temperature °C	16.1	14.6	17.4	19.4	16.0
Salinity psu	33.5	14.1	31.9	25.9	33.7
pH	8.0	7.9	8.0	8.2	8.0
Dissolved oxygen % saturation	92.1	88.3	88.7	104.4	95.3
Suspended Solids mg l^{-1}	30.0	14.0	5.0	760.0	-
Shellfish					
Shell length range mm.	67 - 86	42 – 59	52 – 65	48 – 65	48 – 74
Length mean mm	76	51	58	56	58
Length standard deviation mm	5.3	4.6	4.0	4.0	5.5
Meat weight %	8.0	45.8	48.4	21.3	39.6
Shell weight %	92.0	54.2	51.6	78.7	60.4
Meat water content %	79.0	75.2	72.5	76.3	77.1
Metals mg kg^{-1} (ppm) wet wt					
Cadmium	0.38	0.12	0.15	0.17	0.14
Chromium	0.21	0.15	0.03	0.27	0.17
Copper	5.0	1.8	2.3	1.3	1.4
Mercury	0.04	0.03	0.02	0.01	0.02
Lead	0.02	0.02	0.12	0.10	0.14
Zinc	317.3	14.2	15.1	12.9	22.9
Organics					
CB Congener 28	-	-	-	0.10	-
CB Congener 31	-	-	-	0.09	-
CB Congener 52	-	-	-	0.89	-
CB Congener 101	-	-	-	0.26	-
CB Congener 118	-	-	-	0.20	-
CB Congener 153	-	-	-	0.60	-
CB Congener 156	-	-	-	0.04	-
CB Congener 105	-	-	-	0.04	-
CB Congener 138	-	-	-	0.36	-
CB Congener 180	-	-	-	0.06	-
DDE - p,p'	-	-	-	0.49	-
DDE - o,p'	-	-	-	n.d.	-
DDT - p,p'	-	-	-	0.15	-
DDD - p,p'	-	-	-	0.60	-
BHC, alpha	-	-	-	0.23	-
BHC, gamma (Lindane)	-	-	-	n.d.	-
Chlordane, alpha	-	-	-	0.19	-
Chlordane, gamma	-	-	-	0.02	-
Dieldrin	-	-	-	0.65	-
HCB	-	-	-	0.03	-
Trans - Nonachlor	-	-	-	0.29	-

n.d. not detected

Appendix 1 continued.

	Tralee Bay Derrymore	Tralee Bay Denymore	Wexford Harbour	River Slaney, Wexford	Waterford, Arthurstown.
Date sampled	15-08-96	15-08-96	23-08-96	23-08-96	23-08-96
Latitude	52°15.40	52°15.90	52°20.29	52°20.07	52°14.75
Longitude	09°15.10	09°48.50	06°24.92	06°29.00	06°58.00
Time of high tide	1930	1930	1300	1300	1300
Time of sampling	1050	1110	1230	1200	1530
Species sampled	*O. edulis*	*O. edulis*	*M.edulis*	*M.edulis*	*M. edulis*
No. of individuals in sample	25	25	50	50	50
Method of cultivation	Bottom	Bottom	Bottom	Bottom	Bottom
Water Parameters					
Temperature °C	18.6	18.6	17.1	-	17.6
Salinity psu	31.0	31.5	29.2	-	22.6
pH	8.1	8.2	8.2	-	8.0
Dissolved oxygen % saturation	96.3	95.3	111.6	-	96.0
Suspended Solids mg l^{-1}	22.2	16.0	53.0	-	73.3
Shellfish					
Shell length range mm.	62 – 88	58 – 97	45 – 80	48 – 69	44 - 66
Length mean mm	73	76	53	60	54
Length standard deviation mm	6.5	9.2	5.9	4.9	4.9
Meat weight %	10.2	7.9	38.6	34.8	15.9
Shell weight %	89.8	92.1	61.4	65.2	84.1
Meat water content %	79.1	80.9	74.9	75.5	81.0
Metals mg kg^{-1} (ppm) wet wt					
Cadmium	0.39	0.32	0.08	0.11	0.37
Chromium	0.16	0.16	0.07	0.08	0.39
Copper	15.7	16.5	4.9	1.7	1.3
Mercury	0.02	0.04	0.01	0.02	0.03
Lead	0.02	0.04	1.82	0.41	0.24
Zinc	320.8	241.8	15.8	17.4	16.3
Organics µg kg^{-1} (ppb) wet wt					
CB Congener 28	-		0.12	0.10	0.12
CB Congener 31	-	-	0.09	0.08	0.08
CB Congener 52	-	-	0.09	0.56	0.12
CB Congener 101	-	-	0.18	0.09	0.29
CB Congener 118	-	-	0.19	0.07	0.26
CB Congener 153	-	-	0.42	0.04	0.81
CB Congener 156	-	-	0.01	0.16	<0.06
CB Congener 105	-	-	0.08	0.14	0.11
CB Congener 138	-	-	0.31	0.30	0.61
CB Congener 180	-	-	0.03	0.03	0.11
DDE - p,p'	-	-	1.03	1.54	0.94
DDE - o,p'	-	-	0.02	0.03	0.02
DDT - p,p'	-	-	0.04	0.05	0.07
DDD - p,p'	-	-	0.46	0.52	0.40
BHC, alpha	-	-	0.08	0.07	0.06
BHC, gamma (Lindane)	-	-	0.24	0.24	0.23
Chlordane, alpha	-	-	0.04	0.08	0.12
Chlordane, gamma	-	-	0.07	0.02	0.13
Dieldrin	-	-	0.47	0.53	0.27
HCB	-	-	0.02	0.02	0.02
Trans – Nonachlor	-	-	<0.08	<0.08	<0.08

n.d. not detected

Appendix 2: Mercury concentration (mg kg^{-1} wet weight) in the edible portion of fish species landed at Irish ports during 1996.

Port landed And sampling date	Species	Sample size	Length range (mm)	Mean length (mm)	Water content (%)	Hg (mg kg^{-1})
Howth						
(1/4/96)	Cod	10	556 - 916	648	81.3	0.14
	Plaice	10	323 - 365	341	83.7	0.06
	Whiting	10	371 - 516	443	80.6	0.16
	Haddock	10	490 - 693	553	80.7	0.05
	Norway lobster	25	28 - 43	35	81.7	0.10
	Cuckoo ray	10	480 - 670	579	78.0	0.09
Rossaveel						
(2/4/96)	Whiting	10	345 - 450	386	81.3	0.08
	Haddock	10	310 – 430	361	81.6	0.03
	Norway lobster	25	25 – 36	29	80.8	0.08
	Mackerel	10	305 – 375	340	76.2	0.02
	Megrim	10	245 - 340	298	78.9	0.02
	Cod	10	400 – 530	455	80.0	0.07
	Plaice	10	280 – 370	317	82.2	0.06
	Monk	10	286 - 440	390	84.0	0.08
Castletownbere						
(10/5/96)	Cod	10	380 – 505	434	80.7	0.09
	Cuckoo ray	10	540 – 730	583	77.4	0.07
	Haddock	10	360 – 580	435	82.9	0.11
	Black sole	10	320 – 380	350	80.9	0.09
	Hake	10	450 – 660	564	79.9	0.15
	Monk	10	375 – 590	460	82.1	0.13
	John dory	10	255 – 390	341	79.0	0.07
	Megrim	10	285 – 410	340	80.2	0.07
	Plaice	10	300 – 390	323	83.2	0.08
	Lemon sole	10	245 – 380	310	81.3	0.14
	Whiting	10	430 - 480	453	81.4	0.19
Killybegs						
(11/4/96)	Herring	10	247 – 290	266	-	0.06
(17/5/96)	Herring	10	240 – 272	258	72.4	0.10
	Hake	10	400 – 680	513	80.4	0.10
	Ling	10	615 – 695	680	79.1	0.17
	Haddock	10	420 – 540	451	84.1	0.24
	Cod	10	470 – 625	532	81.6	0.10
	Megrim	10	280 – 380	329	85.5	0.06
	White sole	10	315 – 410	364	82.6	0.27
	Monk	10	480 – 570	534	83.8	0.10
	Plaice	10	250 – 290	275	82.2	0.05
Dunmore East						
(17/5/96)	Whiting	10	420 – 480	458	82.0	0.20
	Pollack	10	355 – 480	418	81.1	0.05
	Cod	10	480 – 700	557	82.0	0.13
	Plaice	10	300 – 355	323	81.3	0.05
	Ling	10	640 – 720	670	79.0	0.12
	Cuckoo ray	10	560 - 680	607	78.0	0.08
(21/6/96)	Mackerel	10	255 – 330	288	76.2	0.04
	Hake	10	335 – 435	402	-	0.04
	Megrim	10	320 – 420	380	-	0.07
	White sole	10	280 – 365	325	-	0.13
	Monk	10	400 – 460	430	-	0.08
	Lemon sole	10	235 – 345	260	-	0.05
	Plaice	10	310 – 360	320	80.6	0.03
	Ling	10	504 – 710	520	-	0.11
	Haddock	10	373 - 455	410	-	0.17

Appendix 3: Trace metal concentration (μg g^{-1} wet weight) in the edible portion of fish species landed at Irish ports during 1996. (Lengths, water content and sample size are as in Appendix 2.)

Port landed date sampled	Species	Trace metal conc. - μg g^{-1} Cd	Cr	Pb	Zn
Dunmore East	Mackerel	<0.006	0.08	<0.004	2.7
(21/6/96)	Plaice	<0.006	<0.04	0.02	3.5
	Hake	<0.006	<0.04	<0.004	2.5
(17/5/95)	Cod	<0.006	<0.04	<0.004	2.5
Howth	Plaice	<0.006	<0.04	<0.004	3.0
(1/4/96)	Cod	<0.006	<0.04	<0.004	3.0
Killybegs	Herring	<0.006	<0.04	<0.004	3.4
(17/5/96)	Plaice	<0.006	<0.04	0.05	3.4
	Cod	<0.006	<0.04	<0.004	2.7

< Below the limit of detection

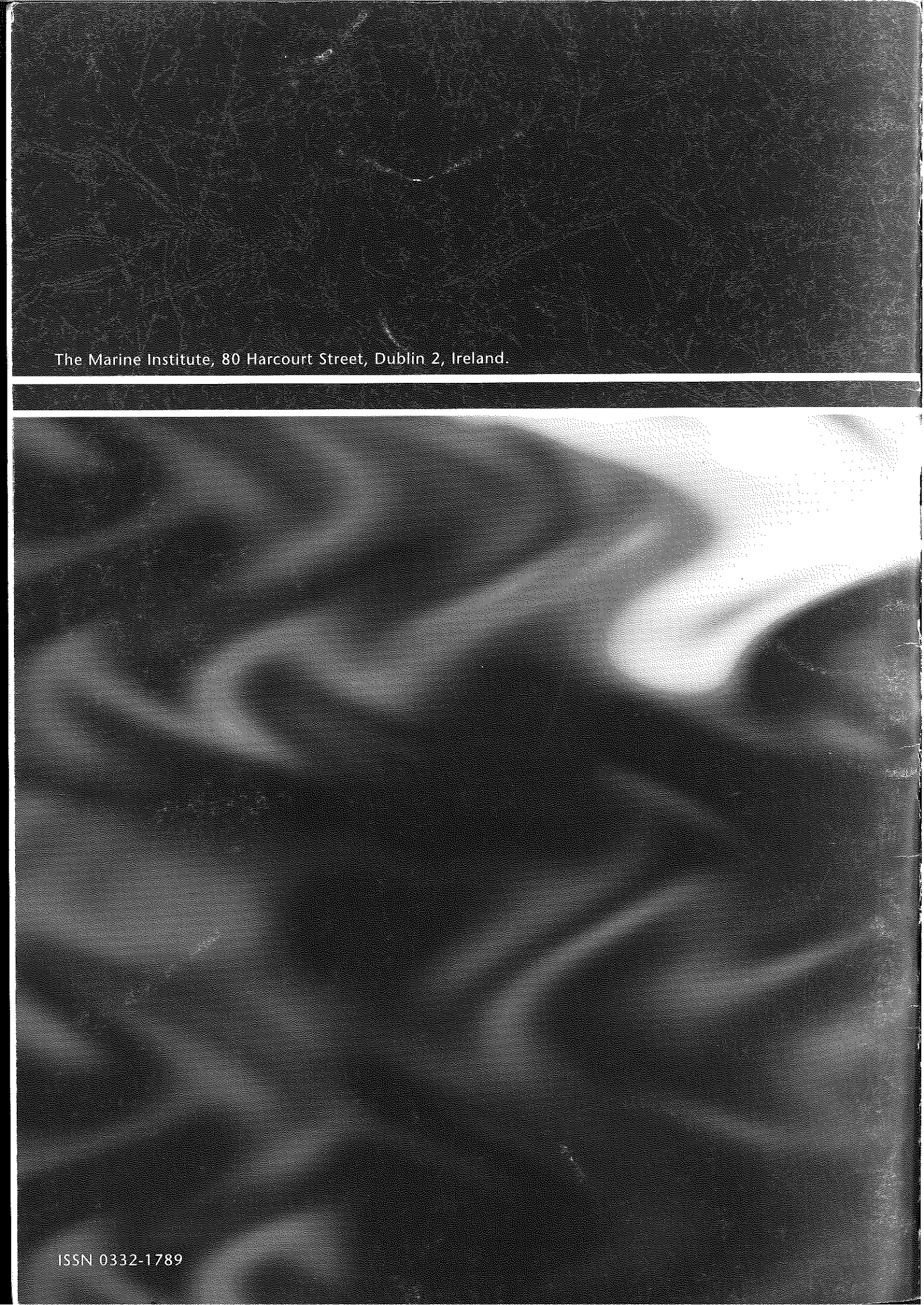
Limits of detection:

Cd	0.006 μg g^{-1} wet weight	Pb	0.004 μg g^{-1} wet weight
Cr	0.04 μg g^{-1} wet weight	Zn	0.1 μg g^{-1} wet weigh

Appendix 4: Chlorinated hydrocarbon concentration (μg kg^{-1} wet weight) in the edible portion of fish species landed at Irish ports during 1996. (Lengths, water content and sample size are as in Appendix 2.)

Chlorinated hydrocarbon concentration (μg kg^{-1})	Howth 1-04-96		Killybegs 11-4-96/17-5-96				Dunmore East 17-05-96	
	Cod	*Plaice*	*Herring*	*Herring*	*Cod*	*Plaice*	*Cod*	*Plaice*
CB Congener 28	0.02	0.02	0.06	0.27	0.03	0.01	0.06	0.04
CB Congener 31	<0.01	0.01	0.03	0.22	0.01	0.01	<0.10	0.02
CB Congener 52	0.01	0.02	0.21	0.59	0.04	0.02	0.06	0.04
CB Congener 101	0.04	0.05	0.37	1.21	0.12	0.05	0.21	0.07
CB Congener 118	0.06	0.03	0.16	0.55	0.09	0.09	0.45	0.28
CB Congener 153	0.38	0.09	0.36	1.35	0.60	1.00	1.35	0.91
CB Congener 156	0.02	0.01	0.03	0.09	0.03	0.03	0.05	0.04
CB Congener 105	0.05	0.03	0.21	0.46	0.09	0.09	0.17	0.09
CB Congener 138	0.02	0.16	0.47	2.15	0.36	0.52	1.00	0.59
CB Congener 180	0.16	0.08	0.22	0.90	0.21	0.44	0.57	0.35
p,p' DDE	0.09	0.06	0.78	2.48	0.65	0.35	0.40	0.42
o,p' DDE	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	n.d.	<0.10
p,p' DDT	0.04	0.04	0.59	1.50	0.07	0.06	0.11	0.05
p,p' DDD	<0.01	0.03	0.19	1.17	0.03	0.09	0.28	<0.01
Gamma BHC (Lindane)	<0.10	0.03	0.19	0.77	0.05	0.04	0.05	0.05
Dieldrin	0.38	0.27	1.84	3.97	0.53	0.35	0.32	0.26
Trans-Nonachlor	0.01	0.01	0.38	0.97	0.15	0.04	0.06	0.02
Alpha Chlordane	<0.10	n.d.	0.28	0.50	0.05	0.02	0.28	0.01
Gamma Chlordane	<0.10	n.d.	<0.10	<0.10	<0.10	<0.10	0.03	<0.10
Alpha BHC	<0.10	<0.10	0.13	0.51	0.02	0.02	0.02	0.01
HCB	0.03	0.03	0.34	0.69	0.15	0.05	0.12	0.09

n.d. not detected



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