TRACE METAL AND CHLORINATED HYDROCARBON CONCENTRATIONS IN SHELLFISH FROM IRISH WATERS, 1997-1999

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E. McGovern, A. Rowe, B. McHugh, J. Costello, M. Bloxham, C. Duffy, and E. Nixon.

Marine Institute
Marine Environment and Health Services Division
Abbotstown, Dublin 15.

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ABSTRACT

In accordance with the monitoring requirements of Council Directive 79/923/EEC, on the quality required of shellfish waters, and Council Directive 91/492/EEC, laying down the health conditions for the production and placing on the market of live bivalve molluscs, the Marine Institute collected water and shellfish samples from major shellfish growing areas and analysed for physicochemical parameters, trace metal levels and chlorinated hydrocarbon concentrations. Since, with the exception of mercury, there are no currently applicable European standards for the concentration of these contaminants in shellfish, the levels were compared with the available standards and guidance values for human consumption, as compiled by the Oslo and Paris Commission (OSPAR) countries.

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 cadmium in oyster tissue, which was slightly elevated in the 1999 samples from Clew Bay, Inner Tralee Bay, Aughinish Limerick and Kilkieran. However these levels did not exceed the Dutch human consumption standard value or the EU maximum limit of 1.0 mg kg^{-1} wet weight due to apply from 2002.

This survey confirms previous studies which show Irish shellfish products are effectively free from trace metal and chlorinated hydrocarbon contamination.

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INTRODUCTION

The determination of water quality, trace metal levels and chlorinated hydrocarbon concentrations in shellfish from Irish waters is carried out by the Marine Institute to fulfil the monitoring requirements of legislation including;

- EU Council Directive 79/923/EEC on the quality required of shellfish growing waters,
- EU Directive 91/492/EEC laying down the health conditions for the production and placing on the market of live bivalve molluscs,
- Statutory Instrument (SI) No. 200 of 1994,

and the requirements of the Co-ordinated Environmental Monitoring Programme of the Oslo and Paris Commissions. It also provides valuable information for the National Monitoring Programme.

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 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).

Council Directive 79/923/EEC requires that Member States designate shellfish growing areas. Monitoring of a range of parameters in designated shellfish waters is undertaken to ensure that the quality of the edible species is maintained or enhanced. These include physical (pH, temperature, suspended solids, salinity and dissolved oxygen) and chemical parameters (organo-halogenated substances and heavy metals). Directive 79/923/EEC was transposed into Irish legislation through SI No. 200 of 1994 and this also sets out designated shellfish waters in Ireland.

Sampling during 1993 and 1994 was carried out bi-annually for selected sites. The results of the these surveys (Nixon *et al.*, 1994, 1995) showed that the quality of designated shellfish growing waters was appreciably higher than that which is set out in the guidelines of the Directive, and therefore the frequency of monitoring was reduced to an annual basis in 1995, as is permitted under the Directive. Previous results were published by Nixon *et al.*, (1994); Nixon *et al.*, (1995); Smyth *et al.*, (1997) and Bloxham *et al.*, (1998). This report presents results for 8 sites in 1997 and 5 sites in 1998. In 1999, shellfish from 21 shellfish growing areas were analysed in compliance with the Directive, including a number of areas not formally designated.

The analysis of mercury, cadmium, chromium, copper, lead and zinc was carried out on shellfish from all of the sites with the exception of Carlingford for which mercury was the only metal analysed in 1999. Chlorinated hydrocarbon analysis was carried out on shellfish from 7 sites in 1997, 5 sites in 1998 and 10 sites in 1999. Based on previous results, special attention was given to sites that may be influenced by local anthropogenic sources (Nixon *et al.*, 1994; Nixon *et al.*, 1995; Smyth *et al.*, 1997 and Bloxham *et al*., 1998).

With the exception of mercury (EC Decision 93/351/EEC), there are no currently applicable European standards for trace metals and chlorinated hydrocarbons in fishery products. Therefore the levels were compared with the available standards and guidance values for human consumption set by a number of European countries. Commission Regulation 466/2001/EEC applies from the 5th April 2002 and includes maximum limits for cadmium and lead in foodstuffs, including bivalve molluscs. For reasons of transparency, the mercury maximum limits in fishery products are also transferred to this Regulation and Decision 93/351/EEC is repealed from 8th March 2002.

MATERIALS AND METHODS

Sample collection and preservation

Shellfish samples were collected between August and November each year. Figure 1 shows the areas sampled in 1999. Detailed information on the locations, dates, species sampled, cultivation methods etc. are shown in Appendices 1 - 3.

At each site temperature, salinity, pH and dissolved oxygen measurements were taken *in situ* typically at 1m depth using Hydrolab® multiparameter probes (Datasonde 3® in 1997 and Minisonde® in 1998). These water quality data are unavailable for 1999. At each location the water surface was visually examined for evidence of hydrocarbon contamination. Water samples were collected and returned to the laboratory for the determination of suspended solids. Typically, one litre of water was filtered through a 0.45 μm membrane, which was then washed with purified water and dried at 105 °C to constant weight. Results of the physico-chemical measurements are also shown in Appendices 1 - 3.

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 individuals. In the laboratory, the length of each individual shellfish was recorded following depuration 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 pooled soft tissue was then homogenised and a 1g 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.

Mercury analysis

Nitric acid (4ml) was added to approximately 0.7g of wet tissue and digested in a laboratory microwave oven (CEM MARS 5). After cooling, potassium permanganate was added until the colour of the solution stabilised. Sufficient hydroxylamine hydrochloride was added to neutralise the potassium permanganate and 1ml of potassium dichromate was added as a preservative. The solution was diluted to 100ml with high purity water. Following the reduction of the samples with stannous chloride, the mercury was determined by cold vapour atomic fluorescence spectroscopy using a PSA Merlin Analyser.

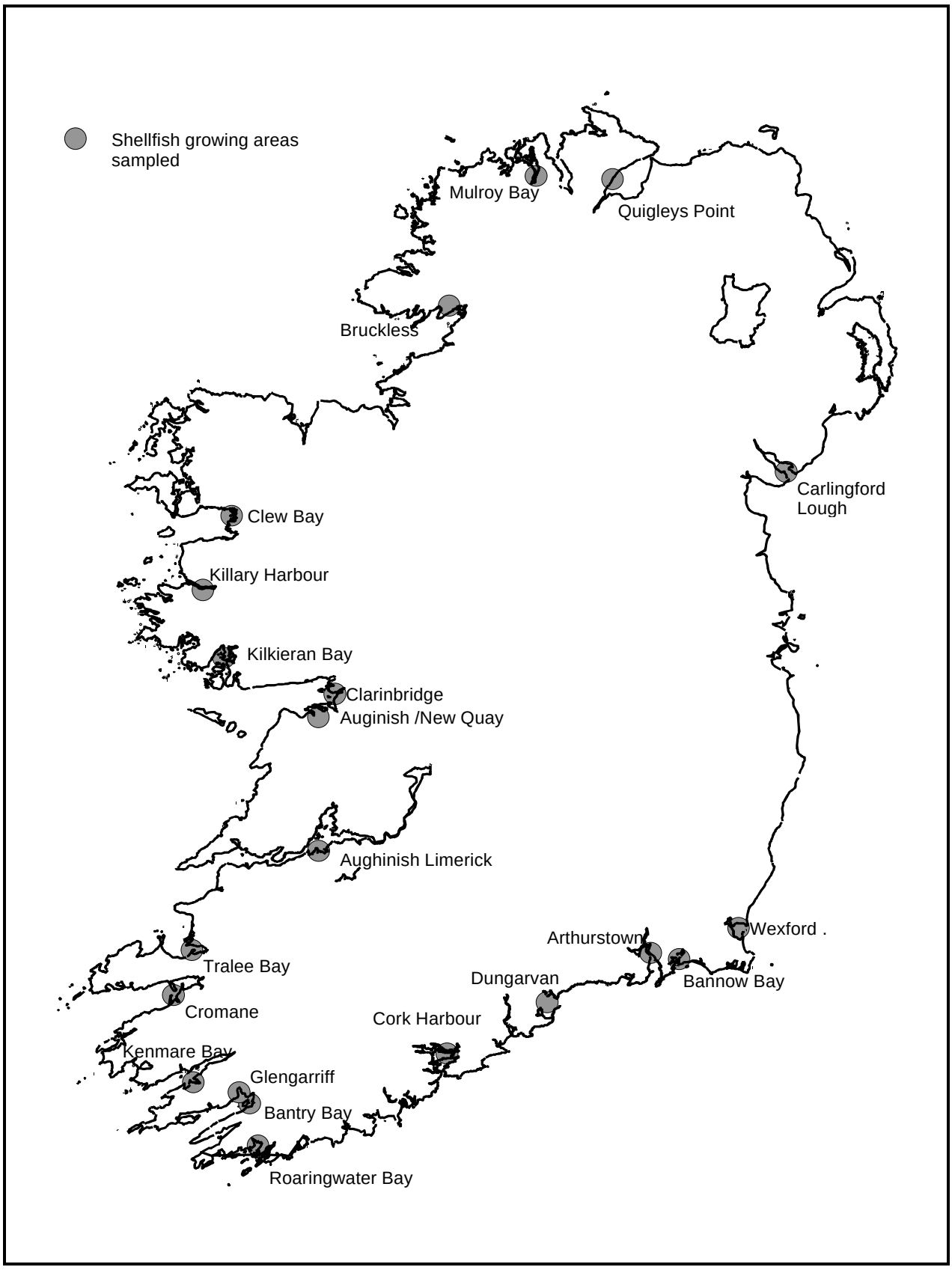

Figure 1. Location of shellfish-growing areas monitored during 1999.

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

Nitric acid (4ml) and hydrogen peroxide (4ml) were added to approximately 0.2g of freeze dried tissue and digested in a laboratory microwave oven (CEM MARS 5). Samples were diluted to 50mls with high purity water and trace metal concentrations were determined using a graphite furnace atomic absorption spectrometer (Varian SpectrAA-400 for copper and chromium, Varian SpectrAA Zeeman 220 for cadmium and lead) or a flame atomic absorption spectrometer (Varian SpectrAA 20 Plus for zinc).

Chlorinated hydrocarbon analysis

Lipids were extracted from the samples using the method developed by Smedes, (QUASH, 1998; QUASH, 1999). The chlorinated hydrocarbons were removed from the lipids by alumina column chromatography followed by separation of the PCBs from the chlorinated pesticides using silica column chromatography. Levels were determined by gas chromatography with electron capture detection (GC-ECD) using a Hewlett Packard 5890 gas chromatograph fitted with a custom made 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 ensure sufficiently high quality data was produced during the 1997-99 shellfish monitoring programme, quality control samples, including reference materials (RMs), were analysed with each batch of samples. As the availability of appropriate marine certified reference materials (CRMs) is limited (de Boer and McGovern, 2001), reference materials supplied by QUASIMEME, (Quality Assurance of Information for Marine Environmental Monitoring), 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.

Between 1 and 5 analyses were carried out on each RM used in this programme, the results of which are shown in Table 1. The quality assurance results obtained were considered sufficient for the purpose of the monitoring programme.

Table 1: Results of the analyses of reference materials obtained during the 1997-99 shellfish testing.

a) Certified Reference Materials

CRM	Certified Value (± 95 % confidence limit)	Measured Value (Mean ± SD)	No. of Analyses
Oyster tissue SRM 1566a	***mg g^{-1} dry wt.***	***mg g^{-1} dry wt.***	
Cadmium	4.15 ± 0.38	4.61 ± 0.08	3
Chromium	1.43 ± 0.46	1.25 ± 0.30	2
Copper	66.3 ± 4.3	66.7 ± 6.1	3
Mercury	0.06 ± 0.01	0.09 ± 0.02	3
Lead	0.37 ± 0.01	0.37 ± 0.08	3
Zinc	830 ± 57	848 ± 37	3
Mussel tissue CRM 278R	***mg g^{-1} dry wt.***	***mg g^{-1} dry wt.***	
Cadmium	0.348 ± 0.007	0.31 ± 0.04	4
Copper	9.45 ± 0.13	9.24 ± 0.18	5
Chromium	0.78 ± 0.06	0.95 ± 0.22	5
Lead	2.00 ± 0.04	1.81 ± 0.33	5
Mercury	0.196 ± 0.009	0.20 ± 0.03	4
Zinc	83.1 ± 1.7	80.8 ± 4.6	4

b) QUASIMEME Reference Materials

Reference Material	Assigned Values	Measured Value (Mean ± SD)	No. of Analyses	Mean Z Score	No. –2<Z<2
QOR062BT (Wet mussel tissue – *Mytilis edulis*)					
PCBs	***mg kg^{-1} wet wt.***	***mg kg^{-1} wet wt.***			
CB Congener 31	0.27	0.62 ± 0.30	3	4.15	1
CB Congener 28	0.33	0.41 ± 0.07	3	0.87	3
CB Congener 52	0.85	1.16 ± 0.33	3	2.01	1
CB Congener 101	3.20	3.48 ± 0.26	3	0.63	3
CB Congener 105	0.83	0.61 ± 0.20	3	-1.46	2
CB Congener 118	2.35	2.19 ± 0.29	3	-0.46	3
CB Congener 138	6.11	6.17 ± 0.90	3	0.08	3
CB Congener 153	9.04	9.41 ± 0.66	3	0.32	3
CB Congener 156	0.42	0.44 ± 0.19	3	0.21	3
CB Congener 180	0.81	0.81 ± 0.06	3	0.00	3
Organochlorine Pesticides					
Dieldrin	0.90	0.93 ± 0.26	3	0.19	3
p,p' DDE	1.34	1.31 ± 0.10	3	-0.14	3
p,p' DDD	0.61	0.45 ± 0.16	3	-1.24	3
Transnonachlor	0.16	0.11 ± 0.04	3	-0.75	3
QTM047BT (Wet flounder tissue - *Plactichthus flesus*)					
	mg kg^{-1} wet wt.	***mg kg^{-1} wet wt.***			
Copper	0.30	0.30	1	0.05	1
Chromium	0.12	0.13	1	0.22	1
Lead	0.03	0.01	1	-0.73	1
Mercury	0.16	0.16 ± 0.01	4	0.16	4
Zinc	6.00	5.3	1	-0.39	1
QTM048BT (Wet mussel tissue – *Mytilis edulis*)					
	mg kg^{-1} wet wt.	***mg kg^{-1} wet wt.***			
Cadmium	0.18	0.15 ± 0.01	3	-0.68	3
Copper	1.80	1.79 ± 0.04	3	-0.03	3
Chromium	0.30	0.27 ± 0.01	3	-0.39	3
Lead	0.33	0.30	1	-0.48	1
Mercury	0.06	0.05 ± 0.00	2	-0.39	2
Zinc	32.7	33.9 ± 0.8	2	0.23	2

RESULTS AND DISCUSSION

Shellfish survey

The results of the biological measurements and physico-chemical monitoring carried out during 1997-99 are given in Appendices 1-3. 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 the water surface was examined for the presence of visible petroleum hydrocarbons. No visible hydrocarbon film or deposition was evident at any of the shellfish-growing areas.

The concentrations of mercury, trace metals and chlorinated hydrocarbon contaminants analysed in the shellfish tissue are presented in Appendices 1-3. The level of contaminants in shellfish is 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 such, Irish shellfish monitoring data has been used for environmental assessments (Boelens *et al.*, 1999; EPA, 2000) as well as for the protection of consumers of Irish seafood products.

As there are no currently applicable European standards for contaminants in shellfish, with the exception of mercury, the levels were compared with the available standards and guidance values set by various OSPAR countries for human consumption. Individual values differ between countries, but the strictest guidance and standard values are presented in Table 2.

Table 2: Synopsis of the strictest guidance and standard 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 (wet weight)	Qualifier	Country
Cadmium	0.5 mg kg^{-1}	Guidance	Germany/Norway
Copper	20 mg kg^{-1}	Standard	Spain[1]
Lead	0.8 mg kg^{-1}	Guidance	Germany
Mercury	0.5 μg g^{-1}	Standard	EU
p,p' 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

Note 1: This value does not apply to Oysters for which a higher value of 60 mg kg^{-1} has been set.

EU Commission Regulation 466/2001/EEC provides maximum levels for mercury, lead and cadmium in foodstuffs, including bivalve mussels, and this regulation will apply from 5th April 2002. For mercury in fisheries products, the provisions of a previous decision (Commission Decision 93/351/EC) are transferred into the new regulation with effect from early 2002. However, the maximum limit of 0.5 mg kg^{-1} wet weight is unchanged with respect to shellfish. A maximum level of 1 mg kg^{-1} wet weight for both cadmium and lead in bivalve molluscs is specified the new regulation.

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 glands (Clark *et al.*, 1997). 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.

Assessment of data for individual shellfish growing areas

Data obtained during monitoring in 1997 to 1999 is examined below for each sampling location and considered with respect to human consumption standards and guidance values and also to previous years monitoring data, available in FRC and MI Fisheries Leaflets (Bloxham *et al.*, 1998; Smyth *et al.*, 1997; Nixon *et al.*, 1995 and Nixon *et al.*, 1994)

Aughinish Bay, New Quay, Co. Clare

A sample of *C. gigas* was collected from Aughinish Bay during 1999. Trace metal concentrations were comparable with previous years and well below human consumption tolerance values as compiled by OSPAR (Table 2). The level of mercury in the meat (0.04 mg kg^{-1} wet weight) was more than 12 times lower than the EU maximum limit for mercury in fisheries products. No organic analysis was carried out on the shellfish from this site.

Aughinish, Limerick

C. gigas was first sampled at this site in 1995 and again in 1996. Sampling in 1999 indicated that cadmium (0.56 mg kg^{-1} wet weight) was slightly above the German/Norwegian guidance value of 0.5 mg kg-^{1}. However, this value is well below the EU maximum limit of 1 mg kg^{-1} for bivalve molluscs due to apply from 2002 (Commission Regulation 466/2001/EEC). A value for copper of 57.9 mg kg^{-1} wet weight is also below, albeit close to the Spanish standard of 60 mg kg^{-1} applied to oysters. This is an average of three results for that sample, one of which exceeded the 60mg kg^{-1} standard (71.8 mg kg^{-1}). This value is higher than previous determinations for copper at this site, (7.5 mg kg^{-1} and 22.4 mg kg^{-1} wet weight in 1995 and 1996 respectively), and may be an anomaly. This will be further investigated in future monitoring at this site.

Other trace metal levels in the 1999 sample were found to be within the OSPAR guideline concentrations. The mercury concentration (0.03 mg kg^{-1} wet weight) was

well within the guideline concentrations given in Table 2. Analysis indicated organochlorines levels to be very low with respect to human consumption standards.

Bannow Bay

This site was visited during 1997 and 1999. *C. gigas* were tested for organics in 1997 and trace metals in 1999. Water quality measurements taken in 1997 indicated a low salinity. This may have been due to a combination of the location, tidal conditions and high freshwater inputs following heavy rain. In 1999, the mercury content of a sample of *C. gigas* was determined and the value, (0.01 mg kg^{-1} wet weight), was found to be very similar to previous years. This was also evident for the other trace metals analysed, all of which were within the tolerance levels given in Table 2. Analysis of the sample collected during 1997 for chlorinated hydrocarbons indicated levels far below strictest (German) tolerance levels as compiled by OSPAR.

Bantry Bay

Bantry Bay was sampled in 1998 and 1999. The water parameters measured at this site in 1998 were, as for all sites, typical of northern temperate waters and conformed to the Directive. The level of mercury in the soft tissues of *M. edulis* grown in Bantry Bay in 1998 and 1999 was 0.02 mg kg^{-1} wet weight, well below the EU 0.5 mg kg^{-1} maximum limit (Table 2). Trace metal levels in the 1998 and 1999 samples were also well within the guideline concentrations and conformed to previous years. Chlorinated hydrocarbon levels in 1998 and 1999 were very low and comparable with previous values.

Bruckless

M. edulis were sampled for this programme from Bruckless in Donegal Bay for the first time in 1999. Trace metal concentrations in mussel tissue were low and well within the human consumption tolerance levels given in Table 2. The mercury concentration of 0.02 mg kg^{-1} wet weight was 25 times lower than the EU maximum limit. No organic analysis was carried out for this site.

Carlingford Lough

Oysters, *C. gigas,* were sampled from Carlingford Lough in 1997 and 1999. Mussels are also produced in this area but to a lesser extent. Water quality parameters measured in 1997 conformed to the Directive. The levels of mercury in 1997 and 1999 were low at 0.05 and 0.04 mg kg^{-1} wet weight respectively. Analyses for other trace metals were carried out in 1997 and results were very similar to previous years monitoring. Levels of PCBs and organochlorine pesticides in 1997 and 1999 were comparable with previous years and were well within tolerance levels compiled by OSPAR (Table 2).

Clarinbridge

The native Atlantic oyster, *O. edulis,* was sampled from Clarinbridge in 1999. As with previous years trace metal levels, including mercury (0.03 mg kg^{-1} wet weight), were low and compared favourably with the strictest tolerance levels available (Table 2). No chlorinated hydrocarbon analysis was carried out.

Clew Bay

A sample of native oysters, *O. edulis*, collected in 1999 was analysed for trace metals. The mercury level was very low at 0.03 mg kg^{-1} wet weight. The cadmium concentration (0.5 mg kg^{-1} wet weight) was measured at the same value as the German/Norwegian guideline but below the EU maximum limit for cadmium that will apply to oysters from 2002 (1 mg kg^{-1} wet weight). The cadmium level is typical of previous years monitoring for which results in the range 0.4 to 0.8 mg kg^{-1} wet weight have been reported. Concentrations of other trace metals were very low and well within human consumption guidelines (Table 2). No chlorinated hydrocarbon analysis was carried out.

Cork Harbour

Cork Harbour oysters, (*C. gigas* and *O. edulis*) were analysed in 1997, 1998 and 1999 and water quality parameters were measured in 1997 and 1998. Water and shellfish quality was similar to previous years and conformed to the requirements of the Directive. Trace metal and chlorinated hydrocarbon levels continued to be very low. Although copper levels very slightly exceeded the Spanish standard of 20 mg kg^{-1} for molluscs in 1998 and 1999, the standard specifically excludes oysters and the values obtained were well below the Spanish standard of 60mg kg^{-1} set for oysters.

Cromane

Both trace metals and organochlorine hydrocarbons were measured in blue mussels, *M. edulis*, from Cromane in 1999. Trace metal concentrations, including mercury, and organochlorine hydrocarbons in shellfish continued to be low and within the tolerance levels set out in Table 2.

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. Four samples of shellfish analysed indicated that levels were within strictest guidance values compiled by OSPAR (Table 2), including chromium and lead. Analysis of *C. gigas* collected in 1997 and 1999 compared very well for all trace metals with the measurements for 1996 and values were within the values set out in Table 2. Water quality measurements taken in 1997 satisfied the requirements of the Directive. Chlorinated hydrocarbons were measured for the first time at Dungarvan in the 1997 *C. gigas* sample and again in the 1999 sample. Levels were low and well within the strictest standards available for PCBs.

Quigley's Point, Lough Foyle

Samples of *M. edulis* were collected at Quigley's Point in 1997, 1998 and 1999 and analysed for both trace metals and organochlorine substances. Water quality parameters in 1997 and 1998 conformed with the requirements of the Directive. Trace metal levels in the shellfish were low as in previous years and mercury was determined as 0.02 – 0.03 mg kg^{-1} wet weight. Trace metal and chlorinated hydrocarbon concentrations in the mussels collected for all three years were well within the strictest standards set by OSPAR countries (Table 2).

Kilmakilloge, Kenmare River
Mussel samples, *M. edulis*, were collected from Kenmare during 1997, 1998 and 1999. Again, the shellfish produced at this location contained levels of trace metals well within the human consumption guidelines and standards set by OSPAR countries and in close agreement with previous years. 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 in 1999 were low and well within human consumption guidelines (Table 2). The cadmium level of 0.57 mg kg^{-1} wet weight was slightly above the German and Norwegian guideline value but well below the new EU maximum limit for bivalve shellfish due to be applied in 2002 and the Dutch consumption standard for bivalve shellfish (1 mg kg^{-1} wet weight). A mercury concentration of 0.05 mg kg^{-1} wet weight was 10 fold lower than the EU standard.

Killary Harbour
Trace metals and chlorinated hydrocarbons were determined for *M. edulis* sampled from Killary Harbour in 1999. The level of trace metals measured was well within human consumption guidelines. Chlorinated hydrocarbon concentrations were also very low.

Mulroy Bay
The levels of trace metals measured in *M. edulis* from Mulroy Bay were low and comparable with previous years. These were well within human consumption guidelines and standards set by OSPAR countries (Table 2). No organic analysis was carried out on the shellfish from this site.

Roaringwater Bay
Mussel samples, *M. edulis*, collected during 1999 had trace metal levels typical of those measured in previous years and which were well within human consumption guidelines and standards set by OSPAR countries. No organic analysis was carried out on the shellfish from this site.

Tralee Bay, Derrymore
Samples of oysters, *O. edulis*, were collected from Tralee Bay in 1999. Trace metal levels continued to be low and were within human consumption guidelines and standards set by OSPAR countries. No organic analysis was carried out on the shellfish from this site.

Arthurstown, Waterford Harbour
Samples of *M. edulis* were collected from Arthurstown in 1997 and 1999. Water quality parameters determined in 1997 fully complied with the Directive. Lead was determined at 0.77 mg kg^{-1} wet weight in 1999, below the German guidance value of 0.8 mg kg^{-1} wet weight and the new EU maximum limit of 1 mg kg^{-1} wet weight (Commission Regulation 466/2001/EEC). The value of 0.22 mg kg^{-1} wet weight determined in 1997 was more typical of lead levels measured in previous monitoring (0.24 mg kg^{-1} in 1996 and 0.38 mg kg^{-1} in 1995). The levels of mercury and other trace metals were low and within the tolerance levels set out in Table 2.

Chlorinated hydrocarbons were detected at low levels and well within the strictest standards available in OSPAR countries. CB congener 153 was determined as 2.05 and 2.20 μg kg^{-1} wet weight in 1997 and 1999 respectively. The German standard for CB congener 153 is 100 μg kg^{-1} wet weight.

Wexford Harbour

M. edulis samples collected from Wexford Harbour in 1997 and 1999 were analysed for trace metals and chlorinated hydrocarbons. The water quality parameters determined in 1997 conformed to the requirements of the Directive. As in previous years the mercury concentration measured in the mussels was very low at 0.02 mg kg^{-1} wet weight when compared with the EU maximum limit of 0.5 mg kg^{-1} wet weight (Table 2). In 1996 a concentration of lead in mussels was detected in excess of both the German standard of 0.8 mg kg^{-1} wet weight and the new EU maximum limit of 1mg kg^{-1} wet weight. It was noted that 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 (Bloxham *et al*., 1998). However, the 1996 mussel sample contained uncharacteristically high levels of lead (1.82 mg kg^{-1}). Levels determined for lead in 1997 and 1999 were 0.25 and 0.41 mg kg^{-1} wet weight respectively and are well within the new EU maximum limit. The 1997 level for lead was the lowest determined in monitoring of this site since the commencement of this programme in 1993 and was over 7 times lower than the 1996 result. The 1999 result was typical of that obtained in previous years. This points to the 1996 result as an anomaly. A cadmium concentration of 0.44 mg kg^{-1} wet weight determined in 1997 was higher than previous years but below the strictest human consumption tolerance levels (Table 2). However, the cadmium concentration of 0.10 mg kg^{-1} wet weight measured in 1999 was more typical of previous years. Other trace metal levels in mussel tissue continued to be low. Levels of organic contaminants measured in mussels from Wexford Harbour were also well within human consumption guidelines.

CONCLUSIONS

The water quality monitored in the shellfish growing areas in 1997 and 1998 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 shellfish from shellfish growing areas were low, which agreed with previous studies (O'Sullivan *et al.,* 1991; Nixon *et al.,* 1991, 1994, 1995; Smyth *et al.,* 1997 and Bloxham *et al*., 1998). All shellfish samples tested for mercury were well within the limit of 0.5 mg kg^{-1} wet weight set by the European Commission's Decision 93/351/EEC.

Chlorinated hydrocarbon concentrations continue to be very low in Irish shellfish, which again confirmed previous studies (Nixon *et al.,* 1991, 1994, 1995; Smyth *et al.,* 1997 and Bloxham *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 with respect to environmental contaminants.

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Appendix 1 (Page 1 of 1): Results of monitoring of shellfish-growing areas - 1997.

	Cork Harbour	Kilmakilloge, Kenmare River	Quigley's Point	Arthurstown, Waterford Harbour	Dungarvan	Wexford Harbour	Bannow Bay	Carlingford
M.I. Reference No.	ENV 970366	ENV 970368	ENV 970374	ENV 970375	ENV 970376	ENV 970377	ENV 970378	ENV 970379
Sampling date	11/08/97	13/08/97	21/08/97	02/09/97	02/09/97	02/09/97	02/09/97	19/09/97
Latitude (N)	51°52'	51°46'	55°6'	52°14'	52°0'	52°20'	53°13'	54°1'
Longitude (W)	8°14'25	9°48'70	7°10'83	6°58'0	7°0'0	6°24'92	6°47'25	6°7'5
Species sampled	*C. gigas*	*M. edulis*	*M. edulis*	*M. edulis*	*C. gigas*	*M. edulis*	*C. gigas*	*C. gigas*
Number of individuals	25	50	50	50	25	50	25	25
Method of cultivation	Bed	Rope	Bed	Bed	Trestle	Bed	Trestle	Trestle
Water parameters								
Temperature °C	18.9	16.0	19.6	15.6	16.5	17.1	16.9	12.7
Salinity PSU.	29.2	34.5	31.6	17	32.6	20.5	2.2	34.1
Water pH	8.17	8.13	8.24	8.01	8.17	8.27	8.54	8.12
DO% saturation	105.4	97.2	105.3	86.1	110.8	120.8	93.2	89.6
Suspended solids mg l^{-1}	1.03	1.11	116	70	16	104	72	30
Shellfish								
Shell length range (mm)	65-115	35-50	54-78	39-59	75-108	40-64	69-120	82-134
Shell length mean (mm)	87.0	41.0	64.0	49.0	89.0	56.0	87.0	108.0
Shell length SD (mm)	13.0	3.1	5.6	5.0	8.9	5.1	12.8	13.5
Meat weight (%)	7.7	43.1	21.6	35.1	10.1	48.4	22.9	9.2
Shell weight (%)	92.3	56.9	78.4	64.9	89.9	51.6	77.1	90.8
Meat water content (%)	76.7	76.2	75.8	82.5	80.3	75.4	NA	89.0
Metals mg kg^{-1} (ppm) wet wt.								
Cadmium	0.19	0.14	0.18	0.35	0.27	0.44	NA	**0.24**
Chromium	0.10	0.08	0.23	0.18	0.3	0.18	NA	**0.13**
Copper	10.9	1.47	1.74	1.66	12.3	1.85	NA	27.7
Lead	0.23	0.09	0.11	0.22	0.39	0.25	NA	0.18
Mercury	0.03	0.02	0.03	0.04	0.02	0.02	NA	0.05
Zinc	157	16.5	153	13.7	209	13.2	NA	362
PCB's µg kg^{-1} (ppb) wet wt.								
CB Congener 28	0.49	NA	0.33	0.48	0.23	0.41	0.39	0.31
CB Congener 31	0.50	NA	0.32	0.39	0.25	0.44	0.45	0.32
CB Congener 52	0.83	NA	0.78	0.78	0.48	0.85	0.78	0.61
CB Congener 101	0.96	NA	0.76	0.91	0.51	0.94	0.52	0.50
CB Congener 118	0.70	NA	0.36	0.63	0.36	0.62	0.23	0.32
CB Congener 153	1.57	NA	1.11	2.05	0.97	1.10	0.74	0.99
CB Congener 156	0.05	NA	0.06	<0.05	n.d.	0.08	n.d.	n.d.
CB Congener 105	0.22	NA	0.19	0.22	n.d.	n.d.	n.d.	0.10
CB Congener 138	0.92	NA	0.74	1.35	0.61	0.95	0.45	0.56
CB Congener 180	0.13	NA	0.14	0.28	0.11	0.20	0.15	0.10
Organic pesticides µg kg^{-1} (ppb) wet wt.								
p,p' DDE	1.33	NA	0.95	1.58	0.86	2.30	1.37	0.66
p,p' DDT	0.06	NA	0.08	0.17	<0.05	0.05	0.10	nd
p,p' DDD	0.42	NA	0.62	0.72	0.17	0.35	0.33	0.42
BCH, alpha (alpha HCH)	0.09	NA	0.11	0.04	0.03	n.d.	n.d.	n.d.
BCH, gamma (lindane)	nd	NA	n.d.	<0.06	0.24	0.10	0.31	n.d.
Cis-Chlordane	<0.06	NA	0.08	0.06	<0.06	<0.06	0.06	n.d.
Trans-Chlordane	nd	NA	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Dieldrin	0.83	NA	0.70	0.75	0.34	0.47	0.65	0.78
HCB	0.24	NA	0.24	0.22	0.15	0.30	0.30	0.22
Total Lipid (%)	2.73	NA	2.13	1.60	1.96	2.32	NA	3.10

Notes NA: Sample not analysed
n.d.: Not detected

Appendix 2 (Page 1 of 1): Results of monitoring of shellfish-growing areas - 1998.

	Quigley's Point	Mulroy Bay	Kilmakilloge, Kenmare River	Bantry Bay	Cork Harbourbr
M.I. Reference No.	ENV 980021	ENV 980022	ENV 980085	ENV 980086	ENV 980089
Sampling date	21/09/98	22/09/98	12/10/98	13/10/98	14/10/98
Latitude (N)	55°6'	55°7'55	51°46'	51°40'	51°52'
Longitude (W)	7°10'83	7°41'4	9°48'50	9°27'60	8°14'25
Species sampled	*M. edulis*	*M. edulis*	*M. edulis*	*M. edulis*	*O. edulis*
Number of individuals	50	50	50	50	25
Method of cultivation	Bed	Rope	Rope	Rope	Bed
Water parameters					
Temperature °C	17.4	14.8	13.8	14.0	14.5
Salinity PSU.	25.1	32.4	33.6	33.8	28.9
Water pH	8.26	8.45	8.5	8.56	8.39
DO % saturation	96.3	86.4	96.6	82.3	90.0
Suspended solids mg l^{-1}	7	3	2.2	4.9	1.8
Shellfish					
Shell length range (mm)	44-61	45-61	48-62.5	44-65	76-105
Shell length mean (mm)	54.0	53.7	54.8	55.0	89.0
Shell length SD (mm)	4.8	3.0	3.3	4.5	8.8
Meat weight (%)	13.5	44.1	42.9	40.2	14.1
Shell weight (%)	86.5	55.9	57.1	59.8	85.9
Meat water content (%)	80.4	75.3	75.6	76.0	77.2
Metals mg kg^{-1} (ppm) wet wt.					
Cadmium	0.27	NA	0.19	0.14	0.26
Chromium	0.32	NA	0.13	0.12	0.14
Copper	1.31	NA	1.33	1.41	23.9
Lead	0.14	NA	0.05	0.12	0.15
Mercury	0.03	NA	0.02	0.02	0.03
Zinc	14.4	NA	23.8	24.9	270
PCB's µg kg^{-1} (ppb) wet wt.					
CB Congener 28	0.27	0.14	0.41	0.47	0.82
CB Congener 31	0.24	0.14	0.31	0.39	0.79
CB Congener 52	0.55	0.16	0.76	0.87	1.61
CB Congener 101	0.46	0.12	0.32	0.43	1.37
CB Congener 118	0.24	0.10	0.17	0.23	1.24
CB Congener 153	0.62	0.24	0.41	1.10	1.90
CB Congener 156	<0.05	<0.05	<0.05	n.d.	0.07
CB Congener 105	0.08	n.d.	0.12	n.d.	n.d.
CB Congener 138	0.46	0.12	0.29	0.61	1.34
CB Congener 180	0.08	<0.05	0.09	0.23	0.22
Organic pesticides µg kg^{-1} (ppb) wet wt.					
DDE - p,p'	0.35	0.13	0.11	0.26	2.40
DDT - p,p'	0.17	n.d.	n.d.	n.d.	0.54
DDD - p,p'	0.46	0.08	n.d.	n.d.	0.87
BCH, alpha (alpha HCH)	n.d.	n.d.	n.d.	n.d.	0.07
BCH, gamma (lindane)	n.d.	n.d.	n.d.	n.d.	0.22
Cis-Chlordane	<0.06	<0.06	<0.06	<0.06	<0.06
Trans-Chlordane	n.d.	n.d.	n.d.	n.d.	n.d.
Dieldrin	0.79	0.50	0.42	0.47	0.97
HCB	0.06	n.d.	0.05	0.05	0.05
Total Lipid (%)	1.42	2.10	NA	2.16	1.88

NA: Sample not analysed
n.d.: Not detected

Appendix 3 (Page 1 of 2): Results of monitoring of shellfish-growing areas - 1999.

	Arthurstown, Waterford Harbour	Aughinish, Limerick	Aughinish, New Quay	Bannow Bay	Bantry Bay	Bruckless	Carlingford	Clarinbridge	Clew Bay	Cork Harbour.	Cromane
M.I. Reference No.	ENV 990335	ENV 990358	ENV 990344	ENV 990334	ENV 990354	ENV 990340	ENV 990360	ENV 990345	ENV 990347	ENV 990351	ENV 990356
Sampling date	11/10/99	18/11/99	10/11/99	11/10/99	16/11/99	20/10/99	29/10/99	11/11/99	11/11/99	15/11/99	17/11/99
Latitude (N)	52°14'	52°37'	53°9'	53°13'	51°41'	54°37'	54°1'	53°12'	53°52'	51°52'	52°7'
Longitude (W)	6°58'0	9°2'50	9°0'40	6°47'25	9°28'45	8°23'6	6°7'5	8°56'45	9°35'20	8°14'25	9°52'83
Species sampled	*M. edulis*	*C. gigas*	*C. gigas*	*C. gigas*	*M. edulis*	*M. edulis*	*C. gigas*	*M. edulis*	*O. edulis*	*O. edulis*	*M. edulis*
Number of individuals	50	25	25	25	50	50	25	50	25	25	50
Method of cultivation	Bed	Trestle	Bed	Trestle	Rope	Rope	Rope	Bed	Rope	Bed	Bed
Shellfish											
Shell length range (mm)	43-65	68-90	68-105	91-128	42-64	49-61	90-110	49-65	67-96	63-80	39-51
Shell length mean (mm)	54.0	82.0	84.0	113.0	54.0	56.0	99.7	56.0	75.0	71.0	43.0
Shell length SD (mm)	4.0	5.0	10.0	9.6	6.0	3.0	7.2	4.0	17.0	5.0	3.0
Meat weight (%)	16.9	9.9	17.9	19.2	30.6	38.4	9.9	29.9	9.6	11.9	6.9
Shell weight (%)	83.1	90.1	82.1	80.8	69.4	61.6	90.1	70.1	90.4	88.1	93.1
Meat water content (%)	76.3	85.0	78.5	75.6	76.5	77.3	73.3	76.0	75.2	76.5	79.7
Total Lipid (%)	1.62	1.26	NA	NA	3.20	NA	NA	NA	NA	1.60	1.30
Water Parametes											
Suspended solids mg l^{-1}	NA	23.9	8.6	NA	2.3	NA	17.0	6.4	4.2	5.6	14.6
Metals mg kg^{-1} (ppm) wet wt.											
Cadmium	0.14	0.56	0.39	0.11	0.09	0.14	NA	0.11	0.50	0.32	0.14
Chromium	0.75	0.15	0.24	0.19	0.32	0.32	NA	0.22	0.25	0.31	0.31
Copper	2.16	57.9	6.36	5.00	1.34	1.55	NA	1.78	4.24	22.6	2.18
Mercury	0.02	0.03	0.04	0.01	0.02	0.02	0.04	0.03	0.03	0.03	0.02
Lead	0.77	0.10	0.18	0.17	0.13	0.09	NA	0.16	0.05	0.08	0.07
Zinc	18.8	359	213	120	28.5	26.0	NA	14.0	268	286	19.5
PCB's µg kg^{-1} (ppb) wet wt.											
CB Congener 28	0.57	0.36	NA	NA	0.60	NA	0.38	NA	NA	0.51	0.19
CB Congener 31	0.10	0.09	NA	NA	0.14	NA	0.44	NA	NA	0.09	0.05
CB Congener 52	0.92	0.66	NA	NA	1.14	NA	0.77	NA	NA	0.74	0.35
CB Congener 101	0.86	0.57	NA	NA	0.51	NA	0.52	NA	NA	0.85	0.34
CB Congener 118	1.20	0.30	NA	NA	0.77	NA	0.35	NA	NA	0.82	0.42
CB Congener 153	2.20	1.20	NA	NA	1.80	NA	0.84	NA	NA	1.49	0.39
CB Congener 156	n.d.	n.d.	NA	NA	n.d.	NA	0.07	NA	NA	<0.05	n.d.
CB Congener 105	n.d.	0.16	NA	NA	n.d.	NA	0.14	NA	NA	n.d.	n.d.
CB Congener 138	1.48	0.73	NA	NA	1.10	NA	0.58	NA	NA	1.09	0.26
CB Congener 180	0.30	0.27	NA	NA	0.18	NA	0.16	NA	NA	0.15	0.08
Organic pesticides µg kg^{-1} (ppb) wet wt.											
DDE - p,p'	0.19	0.05	NA	NA	1.43	NA	0.55	NA	NA	0.91	0.06
DDT - p,p'	0.05	<0.05	NA	NA	<0.05	NA	-	NA	NA	0.24	<0.05
DDD - p,p'	0.86	0.05	NA	NA	0.26	NA	0.35	NA	NA	0.48	0.06
BCH, alpha (alpha HCH)	0.03	0.12	NA	NA	0.03	NA	0.03	NA	NA	0.04	0.15
BCH, gamma (lindane)	n.d.	n.d.	NA	NA	n.d.	NA	0.65	NA	NA	0.26	0.12
Cis-Chlordane	<0.06	<0.06	NA	NA	0.08	NA	0.10	NA	NA	n.d.	<0.06
Trans-Chlordane	n.d.	n.d.	NA	NA	n.d.	NA	0.20	NA	NA	n.d.	n.d.
Dieldrin	0.66	0.87	NA	NA	0.91	NA	0.48	NA	NA	2.31	0.97
HCB	0.11	0.07	NA	NA	0.13	NA	1.74	NA	NA	0.09	0.07
Trans - Nonacholor	<0.06	0.04	NA	NA	0.03	NA	0.42	NA	NA	0.04	0.03

NA: Sample not analysed
n.d.: Not detected

Appendix 3 (Page 2 of 2): Results of monitoring of shellfish-growing areas – 1999 contd.

	Dungarvan	Glengarriff	Inner Tralee Bay	Kilkieran	Killary Harbour	Kilmakilloge	Mulroy Bay	Quigley's Point	Roaringwater Bay	Wexford Harbour
M.I. Reference No.	ENV 990337	ENV 990352	ENV 990357	ENV 990346	ENV 990343	ENV 990355	ENV 990339	ENV 990338	ENV 990353	ENV 990336
Sampling date	13/10/99	16/11/99	17/11/99	11/11/99	11/11/99	17/11/99	21/10/99	21/10/99	16/11/99	13/10/99
Latitude (N)	52°20'	51°42'	52°15'	53°22'	53°36'	51°46'	55°7'	55°6'	51°32'	52°20'
Longitude (W)	7°0'0	9°32'35	9°48'61	9°39'0	9°49'0	9°48'50	7°41'4	7°10'83	9°25'30	6°24'92
Species sampled	*C. gigas*	*M. edulis*	*O. edulis*	*O. edulis*	*M. edulis*	*M. edulis*	*M. edulis*	*M. edulis*	*M. edulis*	*M. edulis*
Number of individuals	25	50	25	25	50	50	50	50	50	50
Method of cultivation	Trestle	Rope	Bed	Bed	Rope	Rope	Rope	Bed	Rope	Bed
Shellfish										
Shell length range (mm)	71-108	44-57	64-84	71-94	47-60	42-53	46-59	46-59	42-56	47-73
Shell length mean (mm)	86.0	49.0	76.0	82.0	53.0	47.0	50.0	53.0	50.0	62.0
Shell length SD (mm)	19.0	3.0	5.0	6.0	3.0	3.0	3.0	3.0	3.0	7.0
Meat weight (%)	8.3	43.1	10.5	6.7	28.8	40.1	43.8	29.0	35.2	32.4
Shell weight (%)	91.7	56.9	89.5	93.3	71.2	59.9	56.2	71.0	64.8	67.6
Meat water content (%)	76.6	75.7	76.9	76.7	76.7	77.9	75.9	79.6	76.9	76.1
Total Lipid (%)	1.66	NA	NA	NA	1.51	NA	NA	1.19	NA	1.42
Water parameters										
Suspended solids mg l^{-1}	NA	2.3	39	12.6	10	6.2	NA	NA	1.67	NA
Metals mg kg^{-1} (ppm) wet wt.										
Cadmium	0.41	0.14	0.53	0.57	0.17	0.09	0.06	0.09	0.05	0.10
Chromium	0.25	0.36	0.16	0.21	0.33	0.17	0.41	0.28	0.21	0.69
Copper	21.8	1.35	39.1	4.34	1.43	1.44	2.01	1.91	1.43	2.03
Mercury	0.02	0.01	0.02	0.05	0.03	0.02	0.02	0.02	0.02	0.02
Lead	0.41	0.08	0.07	0.03	0.09	0.07	0.06	0.10	0.11	0.41
Zinc	346	23.4	378	342	19.4	20.4	18.0	14.4	NA	20.7
PCB's µg kg^{-1} (ppb) wet wt.										
CB Congener 28	0.21	NA	NA	NA	0.20	NA	NA	0.25	NA	0.37
CB Congener 31	0.06	NA	NA	NA	0.06	NA	NA	0.38	NA	0.09
CB Congener 52	0.43	NA	NA	NA	0.37	NA	NA	0.41	NA	0.71
CB Congener 101	0.26	NA	NA	NA	0.27	NA	NA	0.57	NA	0.53
CB Congener 118	0.36	NA	NA	NA	0.24	NA	NA	0.28	NA	0.32
CB Congener 153	1.03	NA	NA	NA	0.42	NA	NA	0.76	NA	1.01
CB Congener 156	n.d.	NA	NA	NA	n.d.	NA	NA	<0.05	NA	n.d.
CB Congener 105	n.d.	NA	NA	NA	0.07	NA	NA	0.11	NA	0.05
CB Congener 138	0.55	NA	NA	NA	0.28	NA	NA	0.55	NA	0.75
CB Congener 180	0.17	NA	NA	NA	0.12	NA	NA	0.16	NA	0.22
Organic pesticides µg kg^{-1} (ppb) wet wt.										
DDE - p,p'	0.14	NA	NA	NA	0.29	NA	NA	0.26	NA	0.46
DDT - p,p'	n.d.	NA	NA	NA	0.12	NA	NA	0.28	NA	0.07
DDD - p,p'	0.12	NA	NA	NA	0.12	NA	NA	n.d.	NA	0.27
BCH, alpha (alpha HCH)	0.15	NA	NA	NA	0.08	NA	NA	n.d.	NA	0.15
BCH, gamma (lindane)	0.29	NA	NA	NA	n.d.	NA	NA	n.d.	NA	<0.06
Cis-Chlordane	0.13	NA	NA	NA	0.11	NA	NA	n.d.	NA	<0.06
Trans-Chlordane	n.d.	NA	NA	NA	n.d.	NA	NA	n.d.	NA	n.d.
Dieldrin	1.07	NA	NA	NA	1.32	NA	NA	n.d.	NA	0.51
HCB	0.06	NA	NA	NA	0.02	NA	NA	0.07	NA	0.08
Trans - Nonacholor	<0.06	NA	NA	NA	0.13	NA	NA	n.d.	NA	0.16

NA: Sample not analysed
n.d.: Not detected

GLOSSARY AND ABBREVIATIONS

Determinants

DDD	4,4'-dichlorodiphenyldichloroethane
DDE	1,1'-dichloro-2-(2-chlorophenyl)-2-(4-chlorophenyl)ethene
DDT	4,4'-dichlorodiphenyl-1,1,1-trichloroethane
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
OCPs	Organochlorine pesticides
PCBs	Polychlorinated biphenyls
Cd	Cadmium
Cr	Chromium
Cu	Copper
Hg	Mercury
Pb	Lead
Zn	Zinc
DO	Dissolved Oxygen

Species

M. edulis	*Mytilis edulis*	Blue mussel
O. edulis	*Ostrea edulis*	Native/flat oyster
C. gigas	*Crassostrea gigas*	Pacific oyster
P. flesus	*Plactichthus flesus*	Flounder

Others

QUASH	Quality assurance of sampling and sample handling (in marine environmental monitoring)
QUASIMEME	Quality assurance of information for marine environmental monitoring
RM	Reference material
CRM	Certified reference material
NA	Not analysed
LOD	Limit of detection
n.d.	Not detected
SI	Statutory Instrument
EU	European Union
AA	Atomic absorption (spectroscopy)
GC-ECD	Gas chromatography with electron capture detection