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MONITORING OF SHELLFISH GROWING AREAS - 1993

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AND J. SILKE

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Summary

During 1993, water and shellfish from 19 major growing areas were monitored for chemical parameters in accordance with the 1979 Council Directive 79/923/EC.

At each site temperature, salinity, pH, dissolved oxygen and suspended solids measurements were taken and shellfish samples were returned to the laboratory for metal, chlorinated hydrocarbon and algal biotoxin determinations.

Generally, water quality in all areas was good and conformed to the guidelines of the Directive. The highest levels of metals recorded were: cadmium in Tralee Bay (0.4 to 0.7 μgg^{-1}) and Carlingford Lough (0.3 to 0.7 μgg^{-1}) and lead in Wexford Harbour (0.5 μgg^{-1}). Mercury in all cases was low with the exception of Cromane during November when levels of 0.3 μgg^{-1} was detected. Chlorinated hydrocarbons levels were extremely low and indicate the clean nature of Irish shellfish, unpolluted by these synthetic organic compounds. Algal biotoxins were not detected in any samples.

Introduction

The 1979 Council Directive 79/923/EC requires that member states monitor chemical parameters of designated shellfish waters to ensure that the quality of the edible species is maintained or enhanced. During 1993, water and shellfish from the four areas designated in 1982 were analysed in compliance with the Directive. An additional 15 areas, currently being considered for designation, were monitored in the same way (Fig. 1). This paper gives details of observations and analyses made at each of the 19 areas in spring and autumn.

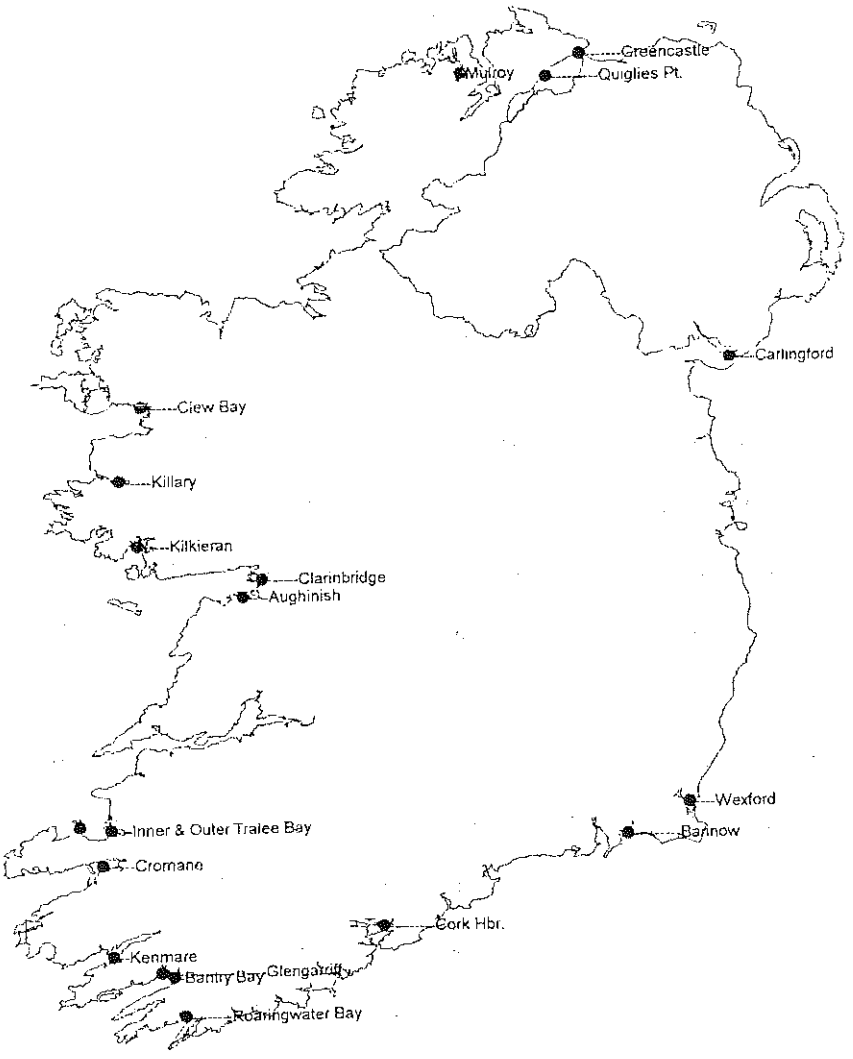

Fig 1: Location of shellfish areas monitored during 1993.

Methods and Materials.

The first round of samples were collected in April and May and the second in November. Details of 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. Samples for suspended solids were returned to the laboratory, filtered through a 0.54 µm membrane and oven dried to constant weight at 105 °C. A representative sample of the main species produced in each growing area was collected, for mussels this consisted of 50 individuals and for oysters 25 individuals. In the laboratory lengths were recorded and each sample was depurated for 14 to 16 hours in clean seawater from the area prior to the removal of flesh for analyses. Following homogenisation, a subsample was removed for moisture content and the remainder was split in two, one portion freeze-dried and stored for metal analysis, the other stored at -20°C for chlorinated hydrocarbon analysis.

For algal biotoxin determinations the digestive glands of undepurated shellfish were removed and stored at -20°C until testing.

Cadmium, chromium, copper, lead and zinc were analysed on the homogenate of the soft tissue following microwave digestion in Teflon pressurised vessels with nitric acid and hydrogen peroxide. Metal levels were determined by graphite furnace atomic adsorption and flame atomic adsorption spectrometry. Arsenic was determined by hydride generation atomic absorption spectrometry following dry ashing and destruction of the ash with nitric acid. Mercury was determined by hydride generation atomic absorption spectrometry following digestion with nitric and sulphuric acids.

Chlorinated hydrocarbons were soxlet extracted and cleaned-up using alumina and silica column chromatography. Levels were determined using gas chromatography electron capture techniques.

The algal biotoxins diarrhetic (DSP) and paralytic (PSP) shellfish toxins were tested using approved rat and mouse bioassay techniques.

Results and discussion.

The results of this monitoring are contained in Appendix 1. Generally the water quality in all areas was good and conformed to the guidelines of the Directive. All pH measurements met the criteria set down in the Directive (between 7 and 9 pH units) with one exception, Aughinish at 6.3 on 5 May. Temperature, suspended solids, salinity and dissolved oxygen measurements conformed to the requirements of the directive in all cases. Petroleum hydrocarbons were not visible at any sites.

A wide range of metals and chlorinated hydrocarbons were analysed in the shellfish flesh from each area. 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 a number of countries for human consumption and the mercury environmental quality standard of the Paris Commission, Table 1.

Table 1: Summary of the strictest values set by various countries for levels of contaminants in shellfish for human consumption (Anon, 1991) and the Paris Commission environmental quality mercury standard.

Contaminant	Guidance/Standard Values	Country
Cadmium	0.5 $\mu g g^{-1}$	Germany
Copper	10 $\mu g g^{-1}$	Norway
Lead	0.8 $\mu g g^{-1}$	Germany
Mercury	0.5 $\mu g g^{-1}$	Germany
Mercury	0.3 $\mu g g^{-1}$	Paris Commission.
Zinc	50 $\mu g g^{-1}$	U.K.
DDT+DDE+DDD	500 $\mu g\ kg^{-1}$	Finland
HCB	50 $\mu g\ kg^{-1}$	Norway
Lindane	100 $\mu g\ kg^{-1}$	Finland
CB 28	80 $\mu g\ kg^{-1}$	Germany
CB 52	80 $\mu g\ kg^{-1}$	Germany
CB 101	80 $\mu g\ kg^{-1}$	Germany
CB 138	100 $\mu g\ kg^{-1}$	Germany
CB 153	100 $\mu g\ kg^{-1}$	Germany
CB 180	80 $\mu g\ kg^{-1}$	Germany

Copper and zinc levels in oysters from a number of areas were higher that the values shown in Table 1. These included Cork Harbour, Bannow Bay, Carlingford Lough, Aughinish Bay, inner and outer Tralee Bay, Kilkieran and Clew Bay. Both copper and zinc are readily accumulated by oysters and these levels are not considered detrimental to the environment or human health. The concentrations in all mussel samples were below 10 $\mu g g^{-1}$ for copper and below 50 $\mu g g^{-1}$ for zinc.

Cadmium levels ranged from 0.08 $\mu g g^{-1}$ in mussels from Greencastle to 0.7 in oysters from outer Tralee Bay and Carlingford Lough. Levels of cadmium were generally high in both inner and outer Tralee Bay, although on only one occasion (outer Tralee Bay in April) did levels exceed the German guideline value of 0.5 $\mu g g^{-1}$. Cadmium in oysters from Carlingford Lough ranged from 0.7 $\mu g g^{-1}$ in April to 0.3 $\mu g g^{-1}$ in November. Levels of cadmium in Clew Bay and Kilkieran oysters were also quite high. Previous monitoring carried out by FRC (O' Sullivan *et.al*, 1991, Nixon *et. al*, 1991) also identified these same locations as having elevated cadmium levels. Cadmium is a List 1 (Anon, 1983) substance and frequent monitoring of levels in Tralee Bay, Carlingford Lough, Clew Bay, Kilkieran Bay is required to ensure the quality of shellfish.

With the exception of Wexford, lead levels were less than 0.35 $\mu g g^{-1}$. The lead concentration in Wexford mussels were higher than expected (0.5 $\mu g g^{-1}$) on both occasions but did not exceed the German guideline value of 0.8 $\mu g g^{-1}$. However, as lead is considered to be one of the more toxic metals, the monitoring of Wexford Harbour for lead in mussels will continue at the current frequency of twice per year.

Mercury levels were generally very low with the exception on Cromane during November when a level of 0.3 μgg^{-1} was detected in mussels. As the mercury concentration in Cromane mussels during April was 0.02 μgg^{-1}, this was an unusually high level but was confirmed by triplicate analyses.

Arsenic and chromium were determined in all shellfish samples and concentration ranged from 0.4 to 2.3 $\mu gg^{-1}$and 0.03 to 0.5 μgg^{-1} respectively. These levels do not pose a threat to the consumer and essentially reflect natural levels in molluscs.
Ten individual PCB congeners and 11 chlorinated pesticides were determined in the shellfish flesh. In all cases the levels of chlorinated hydrocarbon compounds measured were extremely low and indicate the clean unpolluted nature of Irish shellfish from these synthetic organic compounds.

All samples were tested for the naturally occurring algal toxins diarrhetic (DSP) and paralytic (PSP) shellfish toxins using bioassay techniques. No toxicity was detected in any of the samples, however it should be noted that algal toxicity would not be expected during the sampling periods.

Quality Control.

To check the quality of the data produced during this programme, certified reference materials (CRM) were analysed with each batch of samples analysed. Target values were set for each parameter measured in the various CRM used, if these values were not met the entire batch of samples was reanalysed. The results of the CRM are shown in Table 2. Where unexpectedly high or low results were obtained in samples from a particular area, the samples were reanalysed in duplicate and in all cases the second set of analyses were not significantly different from the first analysis.

Table 2: Results of the analyses of certified reference materials during the 1993 monitoring programme.

CRM	Certified Value	FRC Value	No. of Analyses
Mussel Tissue CRM 278	**µg/g dry wt.**	**µg/g dry wt.**	
Chromium	0.80±0.08	0.83± 0.16	6
Cadmium	0.34 ±0.02	0.35± 0.02	18
Copper	9.60 ±0.16	9.65 ±0.31	18
Lead	1.91±0.04	1.98± 0.17	18
Mercury	0.188 ±0.007	0.21 ±0.06	11
Zinc	76 ±2	76 ±1	18
Oyster Tissue NBS 1566A	**µg/g dry wt.**	**µg/g dry wt.**	
Chromium	1.43 ±0.46	1.34 ±0.29	5
Cadmium	4.15 ±0.38	4.08 ±0.40	5
Copper	66.3 ±4.3	65.9 ±3.77	5
Lead	0.37 ±0.014	0.38 ±0.04	5
Mercury	0.06 ±0.007	0.14 ±0.07	11
Zinc	830 ±57	887 ±33	5
Cod Liver Oil CRM 349	**µg/kg dry wt.**	**µg/kg dry wt.**	
CB 28	68 ±7	70 ±4	13
CB52	149 ±20	149 ±10	13
CB101	370 ±17	330 ±16	13
CB118	454 ±31	435 ±15	13
CB153	938 ±40	870 ±61	13
CB180	280 ±22	268 ±12	13

Proposed Monitoring for 1994.

Provision is made in the Directive to reduce the frequency of monitoring when the quality of shellfish and shellfish waters is appreciably higher than that set out by the Directive and where there is no pollution or risk of deterioration in the quality of the water. The 1994 monitoring programme of shellfish growing areas will take into account these provisions along with the 1993 results. Table 3 shows the areas and parameters it is proposed to monitor and the frequency of sampling during 1994. Shellfish from Lough Foyle will be monitored for organohalogenated substances as a result of a spillage of wood preservative into the Strule River during May 1994.

Table 3: The proposed monitoring for 1994

Sample Location	Parameters 2 Quarter	Parameters 4 Quarter
Aughinish Bay	---	All parameters
Bannow Bay	---	All parameters
Bantry Bay	---	All parameters
Carlingford Lough	Metals	All parameters
Castlegregory (Outer Tralee)	Metals	All parameters
Clarinbridge	---	All parameters
Clew Bay	Metals	All parameters
Cork Harbour	---	All parameters
Cromane	Mercury	All parameters
Derrymore Isl (Inner Tralee)	Metals	All parameters
Glengarriff	---	All parameters
Greencastle	Organohalogens	All parameters
Kenmare Bay	---	All parameters
Kilkieran	Metals	All parameters
Killary Hbr.	---	All parameters
Mulroy Bay	---	All parameters
Quiglies Pt.	Organohalogens	All parameters
Roaringwater Bay	---	All parameters
Wexford	Metals	All parameters

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References:

References:

Anon, 1991. Update of the compilation of standards for contaminants in fish and shellfish for human protection purposes. *Sixteenth meeting of the Joint Monitoring Group, Brighton 26 January - 1 February 1991*. JMG 16/Info.8-E.

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

Nixon, E.R., D. Mc Laughlin, R.G. Boelens and G.O'Sullivan, 1991. Contaminants in marine biota 1990 monitoring programme. *Fisheries Leaflet 151*. Department of the Marine, Dublin.

Appendix 1. Monitoring results from shellfish-growing stations.

Sample location	Aughinish Bay	Aughinish Bay	Bannow Bay	Bannow Bay	Carlingford L.	Carlingford L.	Castlegregory	Castlegregory	Clarinbridge	Clarinbridge	Clew Bay	Clew Bay	Cork Harbour
Date sampled	03-May-93	11-Nov-93	29-Apr-93	17-Nov-93	26-Apr-93	16-Nov-93	22-Apr-93	23-Nov-93	03-May-93	11-Nov-93	05-May-93	09-Nov-93	19-Apr-93
Latitude (N)	53° 09.00'	53° 09.20'	52° 13.40'	52° 13.40'	54° 01.75'	54° 01.75'	52° 16.60'	52° 16.50'	53° 12.60'	53° 12.48'	53° 53.20'	53° 51.30'	51° 52.90'
Longitude (W)	09° 01.70'	09° 02.00'	06° 47.25'	06° 47.25'	06° 07.60'	06° 07.60'	10° 00.50'	10° 00.50'	08° 55.35'	08° 55.30'	09° 37.45'	09° 35.00'	08° 14.00'
Time of high tide	1520	1430	1400	900	410	1200	1730	1500	1550	1430	630	1215	1705
Time of sampling	1245	1609	1100	1230	1030	900	1315	1520	1430	1038	1030	1038	1525
Species sampled	*O.edulis*	*C.gigas*	*C.gigas*	*C.gigas*	*C.gigas*	*C.gigas*	*O.edulis*	*O.edulis*	*O.edulis*	*O.edulis*	*O.edulis*	*O.edulis*	*C.gigas*
No. of individuals in sample	25	25	25	25	25	25	25	25	25	25	25	25	25
Method of cultivation	Bottom	Bottom	Trestles	Trestles	Trestle	Trestle	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom	Bed
Water													
Temperature °C	12	9.6	13.6	8.8	12.5	7.8	11	8.7	12.3	8.7	11.6	9.1	11.4
Salinity psu	31.8	26.4	34.5	18.9	32	24.5	33.9	25.7	31	23.2	32.2	26	28.7
pH	6.3	7.8	7	7.9	7	7.7	8.2	7.9	8.1	7.8	8.2	7.8	8.3
Dissolved Oxygen % Saturation	92	100	130	97.2	134	91	138	104	93	97	92	100	Not analysed
Suspended Solids mgl-1 (ppm)	3.9	3.8	15.5		6.6	9.4	2.9	7.9	3.3	6.6	3.9	6.7	10.3
Shellfish													
Minimum Length mm	50	75	78	72	93	87	59	63	61	66	69	70	85
Maximum Length mm	100	118	124	112	118	124	100	92	84	82	89	96	160
Mean Length mm	62	98	95	93	106	102	77	77	70	76	80	84	115
Metals													
Arsenic ugg-1 (ppm)	0.5	1	0.5	0.8	0.7	2	0.6	1.6	1.5	1.2	1.7	1.2	0.9
Cadmium ugg-1 (ppm)	0.4	0.3	0.2	0.3	0.7	0.3	0.7	0.4	0.35	0.26	0.4	0.5	0.34
Chromium ugg-1 (ppm)	0.2	0.3	0.03	0.12	0.2	0.2	0.25	0.4	0.16	0.18	0.2	0.2	0.2
Copper ugg-1 (ppm)	2.5	5.3	5.7	21	33.3	7.4	13.6	12.8	1.9	2.3	2.6	3.4	21.6
Lead ugg-1 (ppm)	0.05	0.09	0.12	0.13	0.26	0.09	0.04	0.05	0.08	0.03	0.03	0.02	0.32
Mercury ugg-1 (ppm)	0.02	0.05	0.01	0.01	0.04	0.02	0.02	0.06	0.02	0.05	0.02	0.12	0.03
Zinc ugg-1 (ppm)	231	218	109	305	572	146	313	379	159	136	187	280	244
Chlorinated Hydrocarbons													
CB Congener 28 ugkg-1 (ppb)	< 0.3	< 0.3	<0.3	<0.3	<0.3	0.3	0.38	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.7
CB Congener 31 ugkg-1 (ppb)	< 0.4	< 0.4	<0.4	<0.4	<0.4	<0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
CB Congener 52 ugkg-1 (ppb)	< 0.5	< 0.5	<0.5	<0.5	<0.5	0.52	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CB Congener 101 ugkg-1 (ppb)	< 0.5	0.4	<0.5	1.2	<0.5	1.53	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.5
CB Congener 105 ugkg-1 (ppb)	< 0.3	< 0.3	<0.3	<0.3	<0.3	0.5	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.6
CB Congener 118 ugkg-1 (ppb)	< 0.4	0.5	< 0.4	0.6	< 0.4	1.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	1.4
CB Congener 138 ugkg-1 (ppb)	< 0.5	0.6	<0.5	0.99	<0.5	2.7	0.23	0.4	< 0.5	0.31	< 0.5	0.4	1.6
CB Congener 153 ugkg-1 (ppb)	< 0.3	1.25	<0.3	1.6	0.37	4.3	0.24	0.6	< 0.3	0.41	< 0.3	0.5	2.9
CB Congener 156 ugkg-1 (ppb)	< 0.6	< 0.6	<0.6	<0.6	<0.6	<0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6
CB Congener 180 ugkg-1 (ppb)	< 0.7	< 0.7	<0.7	<0.7	<0.7	0.4	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	0.4
DDE-p,p' ugkg-1 (ppb)	0.55	2.1	2.16	7.99	0.62	4.9	<0.7	0.6	0.93	1.1	0.4	0.6	4
DDE-o,p ugkg-1 (ppb)	0.8	0.7	1.54	0.97	<1.0	<1.0	<1.0	<1.0	1.15	<1.0	0.8	<1.0	2.5
DDT-p,p' ugkg-1 (ppb)	< 0.9	< 0.9	0.85	3.04	<0.9	2.1	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	1.9
DDD-p,p' ugkg-1 (ppb)	< 0.8	1.3	0.57	2.68	<0.8	4.2	< 0.8	0.5	0.95	< 0.8	< 0.8	0.6	1.6
BHC, alpha ugkg-1 (ppb)	< 0.9	6	<0.9	2.51	<0.9	1.9	< 0.9	< 0.9	< 0.9	3.84	< 0.9	0.9	< 0.9
BHC, gamma (Lindane) ugkg-1 (pp	< 0.9	< 0.9	0.89	1.23	<0.9	2	< 0.9	< 0.9	< 0.9	0.6	1	0.4	< 0.9
Chlordane, alpha ugkg-1 (ppb)	< 0.7	< 0.7	2.55	1.21	<0.7	<0.7	< 0.7	0.5	< 0.7	< 0.7	0.6	< 0.7	< 0.7
Chlordane, gamma ugkg-1 (ppb)	< 0.8	< 0.8	<0.8	<0.8	<0.8	<0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Dieldrin ugkg-1 (ppb)	0.94	<1.0	2.15	0.24	1.22	0.5	1.37	<1.0	1.58	<1.0	0.6	<1.0	2.8
HCB ugkg-1 (ppb)	< 0.7	< 0.7	<0.7	<0.7	<0.7	<0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
trans-Nonachlor ugkg-1 (ppb)	< 0.8	< 0.8	0.33	0.27	<0.8	0.7	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	0.8

Appendix 1. (contd.) Monitoring results from shellfish-growing stations.

Sample location	Cork Harbour	Cromane	Cromane	Derrynore I.	Derrynore I.	Glengarriff	Glengarriff	Greencastle	Greencastle	Kenmare Bay	Kenmare Bay	Kilkieran
Date sampled	25-Nov-93	22-Apr-93	24-Nov-93	22-Apr-93	23-Nov-93	21-Apr-93	24-Nov-93	06-May-93	08-Nov-93	21-Apr-93	24-Nov-93	04-May-93
Latitude (N)	51° 52.90'	52° 08.00'	52° 08.00'	52° 15.60'	52° 15.60'	51° 43.3'	51° 43.40'	55° 12.25'	55° 11.88'	51° 46.75'	51° 46.00'	53° 20.65'
Longitude (W)	08° 14.00'	09° 53.20'	09° 53.20'	09° 50.00'	09° 50.00'	09° 32.9'	09° 32.90'	06° 58.55'	06° 59.92'	09° 50.00'	09° 49.20'	09° 39.00
Time of hightide	1530	1800	1330	1610	1500	1743	1400	730	1400	1621	1330	1630
Time of sampling	900	1700	1010	1200	1645	900	1555	1215	1008	1140	1330	1030
Species sampled	*C.gigas*	*M.edulis*	*M.edulis*	*O.edulis*	*O.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*O.edulis*
No. of individuals in sample	25	50	50	25	25	50	50	50	50	50	50	25
Method of cultivation.	Bed	Bottom	Bottom	Bottom	Bottom	Suspension	Suspension	Bottom	Bottom	Suspension	Suspension	Bottom
Water												
Temperature °C	6.5	12.4	7.4	12.2	6.3	10.6	10.4	9.6	9.9	11	10.7	12.2
Salinity psu	20.2	25.2	16.9	31.6	22.6	34	27	32.5	26.3	34.8	27.4	32.4
pH	7.7	8	7.9	8.2	7.9	8.2	7.8	8.2	7.8	8.2	7.8	8.2
Dissolved Oxygen % Saturation	96.4	138	104	107	106	108	104	99	92	100	100	87
Suspended Solids mgl-1 (ppm)	6.5	6	5	4.6	14.2	2	2.9	7.4	5.1	0.1	3.2	2
Shellfish												
Minimum Length mm	84	48	43	62	70	43	41	43	40	48	42	70
Maximum Length mm	175	61	59	81	97	59	59	63	60	60	56	88
Mean Length mm	121	57	54	70	75	53	49	56	53	55	48	79
Metals												
Arsenic ugg-1 (ppm)	1.1	1.9	2.2	1.7	1	0.6	1	0.6	2	0.5	1	0.7
Cadmium ugg-1 (ppm)	0.26	0.15	0.2	0.49	0.43	0.16	0.24	0.15	0.08	0.15	0.2	0.37
Chromium ugg-1 (ppm)	0.13	0.3	0.3	0.32	0.2	0.12	0.23	0.42	0.28	0.14	0.36	0.15
Copper ugg-1 (ppm)	9.9	1.6	1.7	20.3	18.3	1.25	1.44	1.3	1.22	1.4	1.5	3.3
Lead ugg-1 (ppm)	0.26	0.1	0.1	0.07	0.01	0.12	0.12	0.13	0.1	0.1	0.13	0.04
Mercury ugg-1 (ppm)	0.06	0.02	0.3	0.02	0.02	< 0.1	< 0.1	0.02	0.03	< 0.1	< 0.1	0.03
Zinc ugg-1 (ppm)	224	16.2	17.7	310	294	19.9	21.9	12.8	10.8	19	19.7	365
Chlorinated Hydrocarbons												
CB Congener 28 ugkg-1 (ppb)	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
CB Congener 31 ugkg-1 (ppb)	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
CB Congener 52 ugkg-1 (ppb)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.52	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CB Congener 101 ugkg-1 (ppb)	3.6	< 0.5	< 0.5	< 0.5	0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
CB Congener 105 ugkg-1 (ppb)	1.1	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
CB Congener 118 ugkg-1 (ppb)	3.4	< 0.4	< 0.4	< 0.4	0.6	< 0.4	< 0.4	0.3	0.3	< 0.4	< 0.4	0.1
CB Congener 138 ugkg-1 (ppb)	3.9	< 0.5	0.34	< 0.5	1	< 0.5	1.5	0.5	< 0.5	< 0.5	< 0.5	< 0.5
CB Congener 153 ugkg-1 (ppb)	7.2	< 0.3	0.44	0.31	1.4	< 0.3	2	1	< 0.3	< 0.3	0.51	< 0.3
CB Congener 156 ugkg-1 (ppb)	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6
CB Congener 180 ugkg-1 (ppb)	0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
DDE-p,p' ugkg-1 (ppb)	12.8	<0.7	0.6	0.64	1.5	0.6	0.6	<0.7	<0.7	0.84	0.77	<0.7
DDE-o,p' ugkg-1 (ppb)	< 1.0	<1.0	<1.0	0.92	0.6	1.2	< 1.0	<1.0	<1.0	1.27	< 1.0	0.8
DDT-p,p' ugkg-1 (ppb)	1.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9
DDD-p,p' ugkg-1 (ppb)	4.5	< 0.8	< 0.8	< 0.8	1.1	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	0.4
BHC, alpha ugkg-1 (ppb)	< 0.9	< 0.9	1.65	1.1	7.6	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9
BHC, gamma (Lindane) ugkg-1 (pp	1.7	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	< 0.9	0.6	< 0.9	0.7	< 0.9
Chlordane, alpha ugkg-1 (ppb)	0.8	0.41	< 0.7	2.7	0.5	< 0.7	< 0.7	0.7	< 0.7	< 0.7	< 0.7	0.8
Chlordane, gamma ugkg-1 (ppb)	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	0.5	< 0.8	< 0.8	0.3
Dieldrin ugkg-1 (ppb)	< 1.0	1.15	<1.0	<1.0	<1.0	1.4	< 1.0	0.9	0.3	1.9	< 1.0	0.9
HCB ugkg-1 (ppb)	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7
trans-Nonachlor ugkg-1 (ppb)	0.4	< 0.8	< 0.8	< 0.8	0.6	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	0.2

Appendix 1. (contd.) Monitoring results from shellfish-growing stations.

Sample location	Kilkieran	Killary Hbr.	Killary Hbr.	Mulroy Bay	Mulroy Bay	Quigleys Pt.	Quigleys Pt.	Roaringwater	Roaringwater	Wexford Hbr.	Wexford Hbr.	Whiddy I.	Whiddy I.
Date sampled	10-Nov-93	04-May-93	09-Nov-93	06-May-93	08-Nov-93	06-May-93	08-Nov-93	19-Apr-93	25-Nov-93	29-Apr-93	17-Nov-93	20-Apr-93	25-Nov-93
Latitude (N)	53° 22.14'	53° 35.90'	53° 36.20'	55° 07.55'	55° 09.07'	55° 06.66'	55° 07.30	51° 32.75'	51° 31.60'	52° 20.29'	52° 20.25'	51° 42.15'	51° 41.30'
Longitude (W)	09° 39.07'	09° 45.00'	09° 46.30'	07° 40.90'	07° 41.04'	07° 10.88'	07° 10.50'	09° 24.5'	09° 25.40'	06° 24.92'	06° 25.34'	09° 28.50'	09° 28.50'
Time of high tide	1330	1700	1220	730	1450	800	1400	1620	1600	1300	800	1712	1230
Time of sampling	1220	1515	1713	1630	1545	1030	1230	1115	1625	1010	1000	1215	1000
Species sampled	*O.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*	*M.edulis*
No. of individuals in sample	25	50	50	50	50	50	50	50	50	50	50	50	50
Method of cultivation.	Bottom	Suspension	Suspension	Suspension	Suspension	Bottom	Bottom	Suspension	Suspension	Bottom	Bottom	Suspension	Suspension
Water													
Temperature °C	9.1	12.2	9.7	12.1	9.2	11.6	8.73	10.2	9.1	12.4	9.6	10.8	10.3
Salinity psu	25.7	32.6	21.5	32.5	26.1	28	23.3	32.4	25.7	29	26.1	33.9	27.3
pH	7.7	8.3	7.9	8.4	7.8	8.2	7.9	Not analysed	7.7	7	7.9	8.2	7.7
Dissolved Oxygen % Saturation	96	94	99	90	90	100	90	111	100	88	99.7	105	97
Suspended Solids mgl-1 (ppm)	0.6	2.6	4.1	1.8	3.9	3.15	2.4	3.5	0.2	3.2		2.2	3.3
Shellfish													
Minimum Length mm	67	47	41	45	44	47	42	41	41	43	50	43	41
Maximum Length mm	88	62	61	62	60	63	63	54	61	71	59	59	60
Mean Length mm	77	54	51	55	54	56	53	49	50	56	55	52	48
Metals													
Arsenic ugg-1 (ppm)	2.3	0.6	1.7	0.4	2.3	0.7	2	1.9	1.9	Not Analysed	1.9	Not analysed	0.9
Cadmium ugg-1 (ppm)	0.47	0.1	0.1	0.15	0.14	0.1	0.2	0.15	0.15	0.2	0.2	0.1	0.2
Chromium ugg-1 (ppm)	0.17	0.1	0.1	0.11	0.17	0.3	0.5	0.16	0.23	0.42	0.2	0.1	0.3
Copper ugg-1 (ppm)	5.9	1.4	1.7	1.2	1.5	1.4	1.6	1.2	1.6	1.7	1.5	1.3	1.5
Lead ugg-1 (ppm)	0.04	0.04	0.08	0.04	0.07	0.2	0.2	0.11	0.15	0.5	0.5	0.1	0.2
Mercury ugg-1 (ppm)	0.07	0.02	0.06	0.02	0.04	0.02	0.04	< 0.1	< 0.1	0.02	0.04	0.01	0.04
Zinc ugg-1 (ppm)	447	16.5	14.1	23.5	16.5	12.8	15	18.5	20.6	18.1	15.6	20	24
Chlorinated Hydrocarbons													
CB Congener 28 ugkg-1 (ppb)	< 0.3	< 0.3	< 0.3	<0.3	<0.3	0.3	< 0.3	< 0.3	< 0.3	<0.3	<0.3	< 0.3	< 0.3
CB Congener 31 ugkg-1 (ppb)	< 0.4	< 0.4	< 0.4	<0.4	<0.4	< 0.4	< 0.4	< 0.4	< 0.4	<0.4	<0.4	< 0.4	< 0.4
CB Congener 52 ugkg-1 (ppb)	< 0.5	< 0.5	< 0.5	<0.5	<0.5	< 0.5	< 0.5	< 0.5	< 0.5	<0.5	<0.5	< 0.5	< 0.5
CB Congener 101 ugkg-1 (ppb)	0.5	< 0.5	0.5	<0.5	0.63	0.3	0.8	< 0.5	0.7	<0.5	0.53	< 0.5	0.4
CB Congener 105 ugkg-1 (ppb)	< 0.3	< 0.3	< 0.3	<0.3	0.21	0.2	0.2	< 0.3	< 0.3	<0.3	0.21	< 0.3	0.1
CB Congener 118 ugkg-1 (ppb)	0.2	< 0.4	0.3	< 0.4	0.6	0.3	0.6	< 0.4	< 0.4	< 0.4	0.44	0.1	0.2
CB Congener 138 ugkg-1 (ppb)	0.5	< 0.5	0.7	<0.5	1.15	0.6	1.2	< 0.5	0.62	<0.5	1.14	< 0.5	0.9
CB Congener 153 ugkg-1 (ppb)	0.8	< 0.3	0.9	<0.3	1.45	0.9	1.5	< 0.3	0.7	<0.3	1.13	< 0.3	0.9
CB Congener 156 ugkg-1 (ppb)	< 0.6	< 0.6	< 0.6	<0.6	<0.6	< 0.6	< 0.6	< 0.6	< 0.6	<0.6	<0.6	< 0.6	< 0.6
CB Congener 180 ugkg-1 (ppb)	< 0.7	< 0.7	< 0.7	<0.7	<0.7	< 0.7	< 0.7	< 0.7	< 0.7	<0.7	<0.7	< 0.7	0.4
DDE-p,p' ugkg-1 (ppb)	1.14	0.5	2	<0.7	1.28	1.1	1.9	< 0.7	1.26	1.4	1.43	0.7	0.6
DDE-o,p' ugkg-1 (ppb)	<1.0	1.1	<1.0	0.53	0.37	1.3	1.4	< 1.0	< 1.0	1.1	<1.0	1.3	< 1.0
DDT-p,p' ugkg-1 (ppb)	< 0.9	< 0.9	0.7	<0.9	<0.9	0.7	< 0.9	< 0.9	< 0.9	0.7	<0.9	2	< 0.9
DDD-p,p' ugkg-1 (ppb)	< 0.8	< 0.8	0.8	<0.8	0.9	1.2	1.9	< 0.8	< 0.8	0.5	0.8	< 0.8	0.4
BHC, alpha ugkg-1 (ppb)	< 0.9	< 0.9	< 0.9	<0.9	<0.9	< 0.9	< 0.9	< 0.9	< 0.9	<0.9	0.32	< 0.9	0.8
BHC, gamma (Lindane) ugkg-1 (pp	< 0.9	< 0.9	< 0.9	0.81	0.5	0.9	< 0.9	0.9	0.8	<0.9	<0.9	1.2	< 0.9
Chlordane, alpha ugkg-1 (ppb)	< 0.7	< 0.7	0.5	0.15	0.34	< 0.7	< 0.7	< 0.7	< 0.7	1.1	<0.7	< 0.7	< 0.7
Chlordane, gamma ugkg-1 (ppb)	< 0.8	< 0.8	< 0.8	<0.8	<0.8	< 0.8	< 0.8	< 0.8	< 0.8	<0.8	<0.8	< 0.8	< 0.8
Dieldrin ugkg-1 (ppb)	<1.0	1	<1.0	1.46	0.43	1.6	<1.0	1.4	< 1.0	1.3	<1.0	1.4	< 1.0
HCB ugkg-1 (ppb)	< 0.7	< 0.7	< 0.7	<0.7	<0.7	< 0.7	< 0.7	< 0.7	< 0.7	<0.7	<0.7	< 0.7	< 0.7
trans-Nonachlor ugkg-1 (ppb)	< 0.8	< 0.8	< 0.8	<0.8	<0.8	< 0.8	< 0.8	< 0.8	< 0.8	<0.8	<0.8	< 0.8	< 0.8