

ROINN NA MARA

# MONITORING OF SHELLFISH GROWING AREAS - 1994

by

E. NIXON, D. McLAUGHLIN, A. ROWE AND M. SMYTH

Includes Appendix 1

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## *Summary*

To fulfil the monitoring requirements of the 1979 Council Directive 79/923/EC on the water quality of shellfish waters, water and shellfish samples were collected from 19 major shellfish-growing areas and analysed for physicochemical parameters and chemical contaminants.

At each site temperature, salinity, pH and dissolved oxygen measurements were made and the area was inspected for the presence of petroleum hydrocarbons. Water samples were collected for suspended solids determinations. A representative sample of the shellfish from each area was collected and returned to the laboratory for metal and chlorinated hydrocarbon analyses.

As in previous years, the water quality was good and conformed to 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. Mercury and lead levels were consistently low, however, levels of cadmium in oysters from a number of areas were above average but did not exceed the Dutch human consumption tolerance value. It is known that oysters accumulate metals more readily than mussels and, considering the remoteness of many of these areas, the elevated cadmium levels are not considered to be anthropogenic in origin.

## 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 1994, 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). Based on the results of the 1993 monitoring programme (Nixon et al 1994), samples were collected from 7 of these sites on two occasions, summer and winter, and during winter only at the remaining 12 sites. This paper presents the results of the physicochemical measurements made to assess the water quality at each growing area and the results of analyses carried out on samples of shellfish produced at each of the areas.

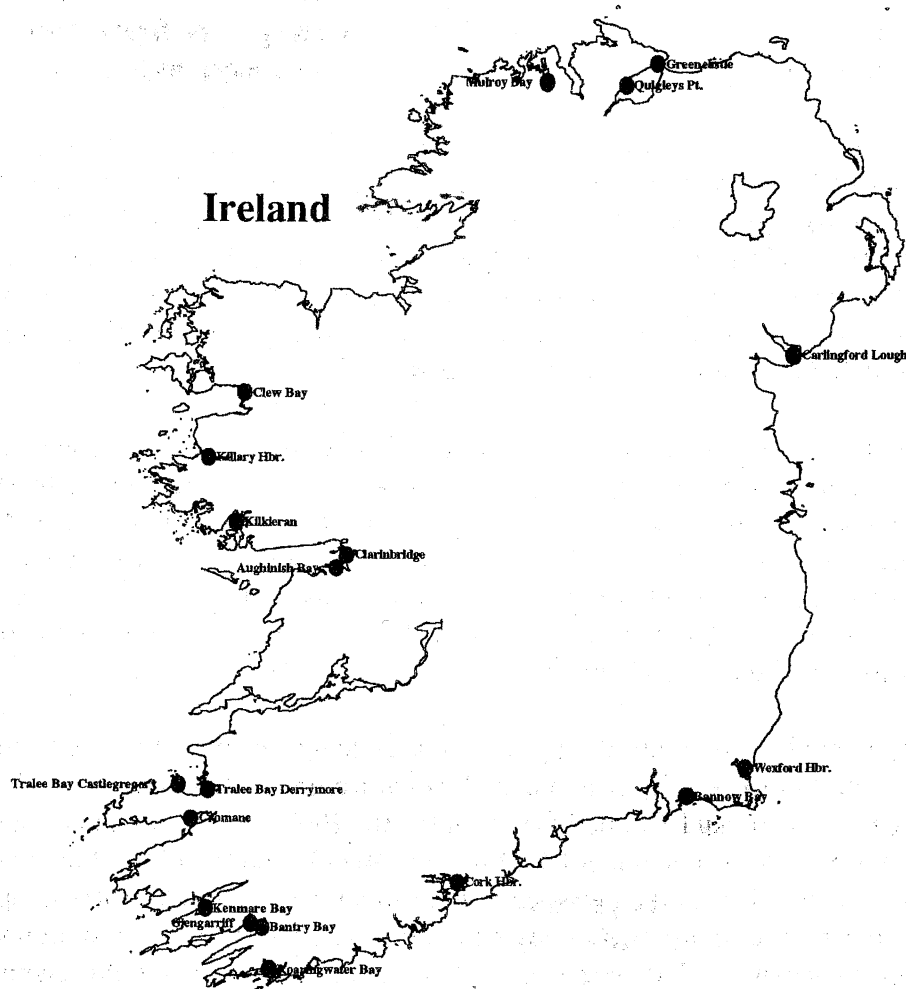


Fig. 1: Location of shellfish-growing areas monitored during 1993.

### Methods and Materials.

The first round of samples were collected in June and July from 7 areas, which were selected, based on the results of the 1993 monitoring programme (Nixon et al 1994), while all 19 areas were sampled during the winter months of November and December. 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<sup>®</sup> multiparameter probe. Samples for suspended solids were returned to the laboratory, filtered through a 0.54 µm membrane and oven dried at 105 °C to constant weight. Representative samples of the main species produced in each of the growing areas were 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, 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, a subsample removed for moisture content, and the remainder split in two; one portion freeze-dried and stored for metal analysis, the other stored at -20°C for chlorinated hydrocarbon analysis.

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 absorption and flame atomic absorption spectrometry. Mercury was determined by vapour generation atomic absorption spectrometry following microwave digestion with nitric acid, potassium permanganate and hydroxylamine sulfate. The mercury digests were stabilised using potassium dichromate.

For chlorinated hydrocarbon analyses, shellfish samples were dried using sodium sulphate and Soxhlet extracted, for 6 hours, with a hexane/dichloromethane mixture. The coextracted lipids were removed by alumina column chromatography followed by separation of the PCBs from the chlorinated pesticides using silica column chromatography. Levels were determined using gas chromatography electron capture detection using a 60 meter fused silica capillary column; a second column of different polarity was used as confirmation.

A separate biotoxin monitoring programme is being carried out by the Fisheries Research Centre, the EU designated National Reference Laboratory on Marine Biotoxins for Ireland (Council Decision 93/383 EEC). The laboratory operates this monitoring programme under EC Directives 91/492 and 91/493 and involves both the testing of shellfish for the presence of toxins and the analysis of water samples for the occurrence of toxin producing phytoplankton. The results of this programme are reported elsewhere. The frequency and timing of the sampling in this chemical monitoring programme is inadequate for the purposes of a comprehensive biotoxin monitoring programme.

## Results and Discussion

The results of the chemical monitoring carried out during 1994 and the biological measurements taken are given in Appendix 1. Generally, the water quality in all areas was good and conformed to the guidelines of the Directive. pH, temperature, suspended solids, salinity and dissolved oxygen measurements met the criteria set down in the Directive in all cases. The low salinity (7.0 psu) in Cromane during November was, however, below the Directive's guideline but within the mandatory requirements.

During the sample collection a visual examination for the presence of petroleum hydrocarbons in the shellfish waters was undertaken. No visible film on the surface of the water, nor a deposit on the shellfish was detected at any of the shellfish-growing areas.

A wide range of metal and chlorinated hydrocarbon contaminants were analysed in the shellfish flesh from each area. Levels of contaminants in shellfish are a good indication of levels that have been present in the water column over a period of time and as such give 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 a number of countries for human consumption and the mercury environmental quality standard of the European and Paris Commissions, Table 1.

**Table 1:** Synopsis of the strictest standard and guidance values applied by various OSPARCOM countries for contaminants in shellfish for the assessment of the possible hazards to human health (Anon, 1990) and the European and Paris Commissions environmental quality standard (EQS) for mercury in fish (EU Directives Nos. 82/176 and 84/156).

Contaminant	Values and Units	Qualifier	Country
Cadmium	0.5 mg kg <sup>-1</sup>	Guidance	Germany/Norway.
Copper	20 mg kg <sup>-1</sup>	Standard	Spain
Lead	0.8 mg kg <sup>-1</sup>	Guidance	Germany
Mercury	0.5 mg kg <sup>-1</sup>	Standard	Germany
Mercury	0.3 mg kg <sup>-1</sup>	E. Q. S.	EU and Paris Commissions
Zinc	50 mg kg <sup>-1</sup>	Guidance	United Kingdom
DDT+DDE+DDD	500 µg kg <sup>-1</sup>	Standard	Finland
HCB	50 µg kg <sup>-1</sup>	Guidance	Norway
α + β HCH	50 µg kg <sup>-1</sup>	Guidance	Norway
Lindane	100 µg kg <sup>-1</sup>	Standard	Finland
CB 28	80 µg kg <sup>-1</sup>	Standard	Germany
CB 52	80 µg kg <sup>-1</sup>	Standard	Germany
CB 101	80 µg kg <sup>-1</sup>	Standard	Germany
CB 138	100 µg kg <sup>-1</sup>	Standard	Germany
CB 153	100 µg kg <sup>-1</sup>	Standard	Germany
CB 180	80 µg kg <sup>-1</sup>	Standard	Germany

### **Aughinish Bay**

Physicochemical measurements, water samples and a sample of *C.gigas* were collected from Aughinish Bay during December 1994. The water quality parameters measured conformed to the requirements of the Directive. For most metals the levels were within the human consumption tolerance values and for the organics, well within these values set by Oslo and Paris Commission (OSPARCOM) countries. The levels of zinc measured in these oysters,  $181 \text{ mg kg}^{-1}$  wet weight, was lower than the 1993 levels of 231 and  $218 \text{ mg kg}^{-1}$  (Nixon et al 1994). The UK guideline of  $50 \text{ mg kg}^{-1}$  applies to food, but excludes shellfish which commonly has levels in excess of  $100 \text{ mg kg}^{-1}$  wet weight, (MAFF 1993).

### **Bannow Bay.**

This site was visited once during 1994, water quality measurements taken were normal for an inshore location during winter. Copper levels in the oysters having been greater than the Norwegian guideline value during 1993, were within this value during 1994. It is worth noting that in the revised table of tolerance levels (Table 1) the standard for copper is  $20 \text{ mg kg}^{-1}$  wet weight for copper. Levels of chlorinated hydrocarbons measured were very low and gave no reason for concern.

### **Bantry Bay.**

Bantry Bay is one of the principal Irish shellfish producing and exporting areas and during 1993/94 season produced 1,900 tonnes of rope grown mussels. As in 1993 the water parameters measured were typical of northern temperate waters. The levels of metals in the soft tissues of the mussels grown in Bantry Bay were within the strictest tolerance values set by OSPARCOM countries and chlorinated hydrocarbon levels measured were very low and well within these tolerance values.

### **Carlingford Lough.**

For the purpose of this monitoring programme, oysters *C.gigas* were sampled from Carlingford Lough, however, mussels are produced in this area but to a lesser extent. In the 1993 monitoring programme the level of cadmium in *C.gigas* ranged from 0.7 to  $0.3 \text{ mg kg}^{-1}$  wet weight, collected during April and November respectively. The April sample was above the guidance value set by Germany and Norway ( $0.5 \text{ mg kg}^{-1}$ ). Because of this relatively high cadmium value, samples of oysters from Carlingford Lough were collected and analysed for metals on two occasions during 1994. As shown in Appendix 1, the level of cadmium measured in both of these samples was  $0.5 \text{ mg kg}^{-1}$  cadmium wet weight, the same as quoted guidance value but within the Dutch standard of  $1 \text{ mg kg}^{-1}$ . Oysters, however, accumulate metals more readily and to higher concentrations than mussels and for this reason levels of metals are generally higher in oysters than in mussels (O'Sullivan *et.al.*, 1991).

Copper and zinc levels were also high in 1993 and 1994, but these metals are not considered detrimental to the environment or to human health. The levels of

chlorinated hydrocarbons were again very low during 1994 and petroleum hydrocarbons were not detected at the site.

Water quality conformed to the requirement of the Directive.

### **Clarinbridge**

The native oyster, *O. edulis*, was sampled from Clarinbridge during December 1994. As in 1993 metal and organic contaminants present in the oysters tissues were very low. The water quality measurements were within the guidelines of the Directive.

### **Clew Bay.**

With the exception of cadmium, the concentration of contaminants in both *O. edulis* and *C. gigas* from Clew Bay were low and well within human consumption guidelines. Cadmium levels ranged from 0.4 to 0.6 mg kg<sup>-1</sup> wet weight over 1993/4, which is above the German and Norwegian guidelines, within the Dutch standard and are not exceptional levels for Irish oysters.

### **Cork Harbour.**

Water and shellfish quality, for the parameters measured in this programme, were similar to 1993 and conformed to the requirements of the Directive.

### **Cromane.**

An unusually high mercury content (0.3 mg kg<sup>-1</sup> wet weight ) detected in mussels from Cromane sampled during November 1993, was not repeated in the 1994 samples. A particularly low salinity was measured in November 1994 which was below the Directives guideline but within the mandatory requirements. This could not have resulted from a discharge as there are no freshwater discharges in the vicinity.

### **Glengarriff.**

Mussel samples were collected from Glengarriff, Bantry Bay, during November 1994. As in 1993, the shellfish produced at Glengarriff contained levels of contaminants well within the human consumption guideline and standards set by OSPARCOM countries. Water quality measurements fully complied with the requirements of the Directive.

### **Greencastle and Quigley's Point, Lough Foyle.**

Samples of mussels were collected at the two Lough Foyle sites during November. All water parameters and contaminants measured in shellfish were similar to the levels detected during the 1993 programme and complied with the requirements of the

Directive. An additional 6 samples of mussels were collected from Lough Foyle during 1994 to monitor the possible effect of a spillage of wood preservative into the River Strule, 36 miles upstream of Lough Foyle, during May 1994. Although the results of these additional samples are not reported here, there was no evidence of an increase in lindane, the component of the spilled preservative most likely to impact on the shellfish in Lough Foyle, in any of these samples.

#### **Kenmare Bay.**

Mussel samples were collected from Kenmare, during November 1994. As in 1993, the shellfish produced at this location contained levels of contaminants well within the human consumption guideline and standards set by OSPARCOM countries. Water quality measurements fully complied with the requirements of the Directive.

#### **Kilkieran Bay.**

With the exception of cadmium, the concentrations of contaminants in *O. edulis* from Kilkieran Bay were low and well within human consumption guidelines. Cadmium levels ranged from 0.4 to 0.5 mg kg<sup>-1</sup> wet weight over 1993/4, which equal the German and Norwegian guidelines, but are not exceptional levels for Irish oysters.

#### **Killary Harbour.**

Levels of all contaminants measured in mussels from Killary were, as was the case in 1993, well within human consumption guidelines and all parameters met the criteria set by the Directive.

#### **Mulroy Bay.**

Levels of all contaminants measured in mussels from Mulroy Bay were, as was the case in 1993, well within human consumption guidelines and standards set by OSPARCOM countries. Water quality measurements fully complied with the requirements of the Directive.

#### **Roaringwater Bay.**

Mussel samples collected during November 1994 had contaminant levels similar to 1993 levels which were in all cases well within human consumption guidelines and standards set by OSPARCOM countries. Water quality measurements fully complied with the requirements of the Directive.



### **Inner and Outer Tralee Bay - Derrymore and Castlegregory.**

Samples of oysters *O. edulis* were collected from inner and outer Tralee Bay during June and November 1994. The water quality parameters measured conformed with the requirements of the Directive on each occasion and at each site. Zinc levels were high during 1994 but were not considered to have human health implication or to impact on the quality of the oysters. Cadmium levels were high in oysters from Tralee Bay, which confirms the finding of the 1993 survey (Nixon *et. al*, 1994). The level of cadmium during 1994 ranged from 0.4 to 0.9 mg kg<sup>-1</sup> wet weight which is above the German and Norwegian guideline but within the Dutch standard of 1 mg kg<sup>-1</sup> wet weight. As previously stated, oysters accumulate metals more readily and to higher concentrations than mussels and for this reason levels of metals are generally higher in oysters than in mussels.

### **Wexford Harbour.**

Water quality parameters were measured and mussels collected from Wexford during July and December 1994. The water quality parameters conformed to the requirements of the Directive and levels of contaminants measured in mussels from Wexford Harbour were well within the human consumption guidelines given in Table 1. During 1993 lead levels were slightly high on both sampling occasions, however, this was not the case in 1994 when levels were lower.

### **Quality Control.**

To check the quality of the data produced during this programme, certified reference materials (CRM) were analysed with each batch of samples. The results of the analyses of the CRMs are shown in Table 2. Because only a limited number of analyses were carried out on the CRMs during this programme (4 or 5), the confidence intervals will remain relatively high compared to the certified values. Considering the type of monitoring being carried out in this programme, the QA results obtained are sufficient to allow for the interpretation and reporting of results. Some difficulties were, however, experienced in the analyses of lead in oyster tissue. During the analyses of some of the oyster samples, the QA results for lead in the oyster certified reference material NBS 1566 was unusually high at  $0.64 \pm 0.34 \mu\text{g g}^{-1}$  dry weight (Table 2). A new vial of NBS 1566 was obtained and analysed 4 times along with a number of the oyster samples that had previously been analysed. During this second batch of analyses the lead value in the new vial was  $0.44 \pm 0.02 \mu\text{g g}^{-1}$  dry weight - much closer to the reference value, while there was essentially no difference in the results of the oyster sample. For this reason, and also that the lead levels were quite low in the oyster samples, it was not considered necessary to reanalyse all the oyster samples.

**Table 2:** Results of the analyses of certified reference materials during the 1994 monitoring programme. See text for information on Pb in oyster tissue.

CRM	Certified Value	FRC Value	No. of Analyses
<b>Mussel Tissue CRM 278</b>	$\mu\text{g g}^{-1}$ dry wt.	$\mu\text{g g}^{-1}$ dry wt.	
Chromium	$0.80 \pm 0.08$	$0.98 \pm 0.42$	4
Cadmium	$0.34 \pm 0.02$	$0.32 \pm 0.08$	4
Copper	$9.60 \pm 0.16$	$9.58 \pm 0.28$	4
Lead	$1.91 \pm 0.04$	$1.71 \pm 0.18$	4
Mercury	$0.188 \pm 0.007$	$0.18 \pm 0.01$	5
Zinc	$76 \pm 2$	$74 \pm 3.5$	4
<b>Oyster Tissue NBS 1566A</b>	$\mu\text{g g}^{-1}$ dry wt.	$\mu\text{g g}^{-1}$ dry wt.	
Chromium	$1.43 \pm 0.46$	$1.57 \pm 0.29$	4
Cadmium	$4.15 \pm 0.38$	$4.13 \pm 0.40$	4
Copper	$66.3 \pm 4.3$	$68.7 \pm 24.9$	4
Lead <sup>1</sup>	$0.37 \pm 0.014$	$0.64 \pm 0.34$	4
Lead <sup>2</sup>	$0.37 \pm 0.014$	$0.44 \pm 0.02$	4
Mercury	$0.06 \pm 0.007$	$0.07 \pm 0.003$	5
Zinc	$830 \pm 57$	$897 \pm 30$	4
<b>Cod Liver Oil CRM 349</b>	$\mu\text{g kg}^{-1}$ dry wt.	$\mu\text{g kg}^{-1}$ dry wt.	
CB 28	$68 \pm 7$	$65 \pm 3$	5
CB 52	$149 \pm 20$	$138 \pm 15$	5
CB 101	$370 \pm 17$	$339 \pm 31$	5
CB 118	$454 \pm 31$	$383 \pm 19$	5
CB 153	$938 \pm 40$	$869 \pm 66$	5
CB 180	$280 \pm 22$	$273 \pm 35$	5

### Proposed Monitoring for 1995.

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 1995 monitoring programme of shellfish growing areas will take into account these provisions along with the 1994 results. Table 3 shows the areas and parameters it is proposed to monitor and the frequency of sampling during 1995.

**Table 3:** The proposed monitoring for 1995.

Sample Location	Species	August	December
Aughinish Bay	<i>C.gigas</i>	Metals	
Bannow Bay	<i>C.gigas</i>	Metals	
Bantry Bay	<i>M.edulis</i>	Metals	
Carlingford Lough	<i>C.gigas</i>	All parameters	Metals
Clarinbridge	<i>O.edulis</i>	Metals	
Clew Bay	<i>O.edulis</i>	Metals	Cadmium
Cork Harbour	<i>C.gigas</i>	All parameters	
Cromane	<i>M.edulis</i>	Metals	
Glengarriff	<i>M.edulis</i>	Metals	
Greencastle	<i>M.edulis</i>	All parameters	
Kenmare Bay	<i>M.edulis</i>	Metals	
Kilkieran	<i>O.edulis</i>	Metals	
Killary Hbr.	<i>M.edulis</i>	Metals	Cadmium
Mulroy Bay	<i>M.edulis</i>	Metals	
Quigley's Pt.	<i>M.edulis</i>	Metals	
Roaringwater Bay	<i>M.edulis</i>	Metals	
Tralee Bay - Castlegregory	<i>O.edulis</i>	Metals	Cadmium
Tralee Bay - Derrymore Isl	<i>O.edulis</i>	Metals	Cadmium
Wexford Hbr.	<i>M.edulis</i>	All parameters	

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# Appendix 1: Results of the 1994 monitoring of shellfish-growing areas.

Sample location	Aughinish Bay	Bannow Bay	Bantry Bay	Carlingford Lough	Carlingford Lough	Clarinbridge	Clew Bay	Clew Bay	Cork Hbr.	Cromane	Cromane	Glengarriff	Greencastle
Date sampled	15-Dec	10-Dec	29-Nov	23-Jun	10-Nov	15-Dec	13-Jul	13-Dec	30-Nov	20-Jun	28-Nov	29-Nov	01-Nov
Latitude	53°09.12	52°13.40	51°41.45	54°01.75	54°01.30	53°12.36	53°52.00	53°52.00	51°52.45	52°07.80	52°08.05	51°42.35	55°11.90
Longitude	09°00.40	06°47.25	09°28.10	06°07.05	06°07.30	08°56.45	09°35.20	09°35.20	08°14.25	09°54.20	09°55.35	09°32.35	06°59.17
Time of hightide	0300	1130	1300	0915	1600	0300	0930	0230	1500	1430	1225	1300	1800
Time of sampling	1213	1245	1530	1415	1000	0900	1030	0206	1245	1700	1115	1200	1255
Species sampled	<i>C. gigas</i>	<i>C. gigas</i>	<i>M. edulis</i>	<i>C. gigas</i>	<i>C. gigas</i>	<i>O. edulis</i>	<i>O. edulis</i>	<i>C. gigas</i>	<i>C. gigas</i>	<i>M. edulis</i>	<i>M. edulis</i>	<i>M. edulis</i>	<i>M. edulis</i>
No. of individuals in sample	25	25	25	25	25	25	25	25	25	25	50	25	50
Method of cultivation	Bottom	Trestle	Rope	Trestle	Trestle	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom	Rope	Bottom
<b>Water Parameters</b>													
Temperature °C	9.4	10.5	11.8	13.0	10.4	8.6	15.8	9.2	10.7	14.3	11.2	10.9	10.3
Salinity psu	31.0	23	33.3	34.7	28.8	26.1	33.5	20.8	28.8	33.3	7.0	30.8	30.7
pH	8.2	8.2	8.1	8.1	7.7	8.0	8.1	8.1	8.0	8.2	8.1	8.1	7.9
Dissolved Oxygen % Saturation	107.5	119	109.8	103	87.7	105.8	97.5	86.3	93.5	125.0	110.7	105.4	105.4
Suspended Solids mg l <sup>-1</sup>	3		28.3	27.1	20.9	1.3	38.6	5.3	11.9	30.7	10.4	36.1	11.5
<b>Shellfish</b>													
Shell length range mm.	103 - 134	72 - 118	40 - 50	77 - 137	75 - 122	62 - 84	708 - 904	68 - 100	60 - 74	43 - 77	57 - 86	42 - 50	47 - 56
Length mean mm	119.2	91.9	45.0	108.5	95.6	74.6	803.3	80.3	67.4	61.1	75.7	46.0	52.4
Length Standard Deviation mm	9.8	13.7	3.0	11.3	11.7	5.7	53.0	9.6	3.7	10.4	5.2	1.8	2.3
Meat weight %	15.8	15.0	42.5	11.7	9.6	N.A.	11.4	9.6	14.8	27.9	30.4	49.1	22.2
Shell weight %	84.2	85.0	57.5	88.3	90.4	N.A.	88.6	90.4	85.2	72.1	69.6	50.9	77.8
Meat water content %	77.4	74.8	77.2	77.1	78.3	76.2	77.7	78.4	77.0	75.4	77.5	78.4	80.4
<b>Metals - mg kg<sup>-1</sup> (ppm)</b>													
Cadmium	0.2	0.2	0.2	0.5	0.5	0.4	0.5	0.6	0.2	n.a.	0.2	0.1	0.1
Chromium	0.02	0.06	0.18	0.22	0.25	0.13	0.21	0.10	0.03	n.a.	0.13	0.22	0.33
Copper	5.1	7.2	1.2	24.6	25.8	1.7	2.9	3.2	14.2	n.a.	1.5	1.1	1.4
Lead	0.13	0.20	0.14	0.30	0.17	0.14	0.07	0.04	0.14	n.a.	0.14	0.04	0.12
Mercury	0.02	0.01	0.01	0.03	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02
Zinc	181.2	166.9	22.9	293.1	390.2	169.1	193.5	266.5	265.0	n.a.	14.4	17.9	12.7
<b>Organics µg kg<sup>-1</sup> (ppb)</b>													
CB Congener 28	0.06	0.07	0.07	n.a.	0.09	0.05	0.10	0.04	0.44	n.a.	0.06	0.07	0.10
CB Congener 31	0.06	0.06	0.08	n.a.	0.07	0.05	0.18	0.08	0.34	n.a.	0.07	0.07	0.10
CB Congener 52	0.09	0.06	0.07	n.a.	0.10	0.05	0.15	0.05	0.41	n.a.	0.04	0.06	0.12
CB Congener 101	0.17	0.15	0.28	n.a.	0.30	0.08	0.33	0.10	0.81	n.a.	0.07	0.22	0.21
CB Congener 118	0.14	0.14	0.15	n.a.	0.32	0.07	0.23	0.06	0.68	n.a.	< 0.15	0.12	0.20
CB Congener 153	0.42	0.44	0.95	n.a.	0.96	0.26	0.98	0.24	1.29	n.a.	0.18	0.67	1.31
CB Congener 156	< 0.1	0.02	0.16	n.a.	0.02	0.02	0.01	< 0.1	0.03	n.a.	0.01	0.01	0.06
CB Congener 105	0.06	0.05	0.07	n.a.	0.13	0.04	0.04	0.02	0.26	n.a.	0.03	0.05	0.09
CB Congener 138	0.25	0.24	0.53	n.a.	0.56	0.19	0.59	0.15	1.01	n.a.	0.13	0.45	1.00
CB Congener 180	0.06	0.06	0.14	n.a.	0.09	0.04	< 0.25	0.01	0.06	n.a.	0.02	0.11	0.35
DDE - p,p'	0.47	1.67	0.30	n.a.	0.86	0.53	0.91	0.22	1.72	n.a.	0.20	0.22	0.88
DDE - o,p'	0.03	< 0.15	0.03	n.a.	0.04	< 0.25	< 0.15	< 0.15	< 0.15	n.a.	0.05	< 0.15	< 0.15
DDT - p,p'	0.14	0.58	0.24	n.a.	0.45	0.06	0.24	0.21	0.25	n.a.	< 0.15	0.18	0.40
DDD - p,p'	0.30	0.02	0.07	n.a.	0.16	0.05	< 0.2	0.02	0.52	n.a.	< 0.15	0.08	0.29
BHC, alpha	0.87	0.07	0.11	n.a.	0.18	< 0.25	0.33	0.16	0.09	n.a.	0.32	0.32	0.08
BHC, gamma (Lindane)	0.19	0.07	0.02	n.a.	0.13	< 0.25	< 0.1	< 0.2	0.12	n.a.	0.10	0.14	0.10
Chlordane, alpha	0.16	0.11	0.11	n.a.	0.10	< 0.2	0.68	0.06	0.13	n.a.	0.10	0.07	0.12
Chlordane, gamma	0.07	< 0.15	0.03	n.a.	0.04	0.02	0.10	< 0.15	0.03	n.a.	0.02	0.01	0.03
Dieldrin	0.14	0.04	< 0.15	n.a.	0.09	< 0.25	0.11	0.04	0.05	n.a.	0.05	0.05	0.08
HCB	0.06	0.06	0.08	n.a.	0.11	0.11	0.11	0.07	0.05	n.a.	0.08	0.08	0.13
trans - Nonachlor	0.17	0.09	0.12	n.a.	0.10	0.05	0.40	0.05	0.11	n.a.	0.07	0.07	0.14

Appendix 1: cont'.... Results of the 1994 monitoring of shellfish-growing areas.

Sample location	Kenmare Bay	Kilkderan	Kilkderan	Killary Hbr.	Mulroy Bay	Quigleys Pt.	Roaringwater Bay	Tralee Bay Castlegregory	Tralee Bay Castlegregory	Tralee Bay Derrymore	Tralee Bay Derrymore	Wexford Hbr.	Wexford Hbr.
Date sampled	29-Nov	14-Jul	14-Dec	14-Dec	02-Nov	02-Nov	30-Nov	21-Jun	28-Nov	21-Jun	28-Nov	19-Jul	10-Dec
Latitude	51°46.00	53°20.45	53°22.13	53°36.30	55°07.55	55°06.66	51°31.07	52°16.62	52°16.30	52°15.08	52°15.45	52°20.29	52°20.29
Longitude	09°49.55	09°38.30	09°39.00	09°49.00	07°40.90	07°10.88	09°25.30	09°59.94	10°00.15	09°49.04	09°50.10	06°24.92	06°24.92
Time of hightide	1300	0945	0200	0300	1930	1830	1500	1500	1225	1530	1225	1600	1100
Time of sampling	1000	1130	1000	0100	1530	1230	0915	1530	1500	1400	1600	0930	1045
Species sampled	<i>M. edulis</i>	<i>O. edulis</i>	<i>O. edulis</i>	<i>M. edulis</i>	<i>M. edulis</i>	<i>M. edulis</i>	<i>M. edulis</i>	<i>O. edulis</i>	<i>O. edulis</i>	<i>O. edulis</i>	<i>O. edulis</i>	<i>M. edulis</i>	<i>M. edulis</i>
No. of individuals in sample	25	25	25	50	50	50	25	25	22	25	25	50	50
Method of cultivation	Rope	Bottom	Bottom	Rope	Rope	Bottom	Rope	Bottom	Bottom	Bottom	Bottom	Bottom	Bottom
<i>Water Parameters</i>													
Temperature °C	11.5	16.2	8.4	9.9	10.3	8.9	10.9	14.3	11.4	14.7	10.4	17.7	10.4
Salinity psu	31.3	33.5	28.7	28.4	33.4	27.3	33.9	35.7	33.6	35	29.6	23.9	27.0
pH	8.0	8.2	8.1	8.2	7.8	7.7	8.0	8.1	8.1	8.1	8.1	8.2	7.9
Dissolved Oxygen % Saturation	110	93.1	115.6	114.5	105.0	101.7	92.4	97.7	121.0	93.6	110.0	86.0	109
Suspended Solids mg l <sup>-1</sup>	10.6	4.0	0.4	8.2	4.4	528	5.4	24.7	10.7	26.9	6.0	8.5	147
<i>Shellfish</i>													
Shell length range mm.	40 - 58	66 - 76	70 - 92	41 - 60	41 - 58	50 - 68	42 - 50	44 - 100	59 - 108	66 - 81	58 - 89	49 - 60	44 - 64
Length mean mm	49.0	72.2	80.0	53.4	50.2	58.2	46.0	69.7	78.5	72.0	73.7	55.0	54.7
Length Standard Deviation mm	4.1	5.7	6.2	3.7	4.5	3.8	2.2	10.8	12.5	4.0	6.7	2.7	3.9
Meat weight %	42.0	7.4	7.8	45.2	36.1	15.9	39.3	10.4	9.2	9.1	8.8	40.8	50.7
Shell weight %	58.0	92.6	92.2	54.8	63.9	84.1	60.3	89.6	90.8	90.9	91.2	59.2	49.3
Meat water content %	77.3	81.2	78.4	77.5	74.6	79.2	75.6	75.1	77.8	74.9	79.7	79.5	79.4
<i>Metals - mg kg<sup>-1</sup> (ppm)</i>													
Cadmium	0.2	0.5	0.4	0.1	0.1	0.2	0.1	0.7	0.9	0.6	0.5	0.2	0.1
Chromium	0.08	0.13	0.02	0.30	0.08	0.42	0.13	0.38	0.15	0.42	0.30	n.a.	0.16
Copper	1.5	2.6	3.0	1.5	1.5	1.7	1.7	15.9	12.9	19.7	16.1	1.7	1.2
Lead	0.13	0.09	0.08	0.09	0.05	0.16	0.20	0.23	0.04	0.05	0.08	0.41	0.33
Mercury	0.01	0.03	0.03	0.02	0.01	0.02	0.01	0.02	0.02	0.03	0.02	0.02	0.01
Zinc	17.8	336.3	317.9	17.6	16.0	14.1	16.6	332.1	362.2	443.8	393.0	13.2	12.9
<i>Organics µg kg<sup>-1</sup> (ppb)</i>													
CB Congener 28	0.04	n.a.	0.05	0.08	0.10	0.11	n.a.	n.a.	0.09	n.a.	0.06	n.a.	0.15
CB Congener 31	0.05	n.a.	0.07	0.09	0.09	0.15	n.a.	n.a.	0.09	n.a.	0.05	n.a.	0.15
CB Congener 52	0.07	n.a.	<0.15	0.06	0.09	0.12	n.a.	n.a.	0.06	n.a.	0.03	n.a.	0.14
CB Congener 101	0.10	n.a.	0.06	0.14	0.13	0.40	n.a.	n.a.	0.10	n.a.	0.13	n.a.	0.49
CB Congener 118	<0.15	n.a.	<0.15	0.12	0.11	0.35	n.a.	n.a.	<0.1	n.a.	0.12	n.a.	0.43
CB Congener 153	0.17	n.a.	0.20	0.25	0.29	0.80	n.a.	n.a.	0.22	n.a.	0.29	n.a.	0.84
CB Congener 156	<0.1	n.a.	<0.1	0.01	0.01	0.03	n.a.	n.a.	0.00	n.a.	<0.1	n.a.	0.04
CB Congener 105	0.03	n.a.	0.01	0.06	0.04	0.14	n.a.	n.a.	0.03	n.a.	0.04	n.a.	0.20
CB Congener 138	0.12	n.a.	0.12	0.20	0.20	0.63	n.a.	n.a.	0.16	n.a.	0.20	n.a.	0.75
CB Congener 180	0.01	n.a.	0.01	0.03	0.02	0.02	n.a.	n.a.	0.02	n.a.	0.02	n.a.	<0.2
DDE - p,p'	0.19	n.a.	0.17	0.35	0.41	0.84	n.a.	n.a.	0.18	n.a.	0.27	n.a.	1.77
DDE - o,p'	<0.15	n.a.	<0.15	0.02	<0.15	<0.15	n.a.	n.a.	0.02	n.a.	0.02	n.a.	0.11
DDT - p,p'	0.07	n.a.	<0.15	0.21	0.12	0.26	n.a.	n.a.	0.14	n.a.	0.20	n.a.	0.37
DDD - p,p'	0.07	n.a.	<0.15	0.15	0.12	0.03	n.a.	n.a.	0.06	n.a.	0.20	n.a.	0.03
BHC, alpha	0.04	n.a.	0.03	0.14	0.12	0.07	n.a.	n.a.	1.79	n.a.	0.90	n.a.	0.07
BHC, gamma (Lindane)	0.28	n.a.	0.03	0.14	0.19	0.02	n.a.	n.a.	0.14	n.a.	0.02	n.a.	<0.15
Chlordane, alpha	0.25	n.a.	0.10	0.16	<0.15	0.08	n.a.	n.a.	<0.15	n.a.	0.12	n.a.	0.10
Chlordane, gamma	<0.15	n.a.	<0.15	0.03	<0.15	0.01	n.a.	n.a.	<0.15	n.a.	0.02	n.a.	<0.15
Dieldrin	0.10	n.a.	0.04	0.05	0.05	0.05	n.a.	n.a.	0.15	n.a.	0.04	n.a.	0.07
HCB	0.08	n.a.	0.07	0.13	0.10	0.09	n.a.	n.a.	0.08	n.a.	0.05	n.a.	0.10
trans - Nonachlor	0.07	n.a.	0.08	0.09	0.11	0.04	n.a.	n.a.	0.05	n.a.	0.05	n.a.	0.11