# *Monitoring of shellfish growing areas-1995*

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# MONITORING OF SHELLFISH GROWING AREAS - 1995

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by

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*Summary*

In accordance with the monitoring requirements of the 1979 Council Directive 79/923/EC on the water quality of shellfish waters, water and shellfish samples were collected from 21 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 visible 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. Levels of cadmium in oysters from a number of areas were slightly elevated but did not exceed the Dutch human consumption tolerance value of 1 mg $kg^{-1}$ (ppm) wet weight.

## Introduction

The 1979 Council Directive 79/923/EC requires that member states monitor physical (pH, temperature, suspended solids, salinity, dissolved oxygen) and chemical parameters (organohalogenated substances, heavy metals) of designated shellfish waters to ensure that the quality of the edible species is maintained or enhanced. Living organisms require trace amounts of some heavy metals, including cobalt, copper, iron, manganese, molybdenum, vanadium, strontium, and zinc. Many of these heavy metals exist naturally, at background levels, in the environment. Polychlorinated biphenyls and organochlorine pesticides are entirely man-made pollutants and do not occur naturally.

The current programme to monitor shellfish growing waters began in 1993. Sampling in 1993 and 1994, at designated sites, was carried out twice in each year. Subsequently the frequency of monitoring at these sites was once a year, where conditions had been shown to be in accordance with the directive. Previous results have been published in *Fishery Leaflet* 160 and 166.

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 (Bioassay, LC-MS) and the analysis of water samples for the occurrence of toxin producing phytoplankton. The results of this programme are reported elsewhere.

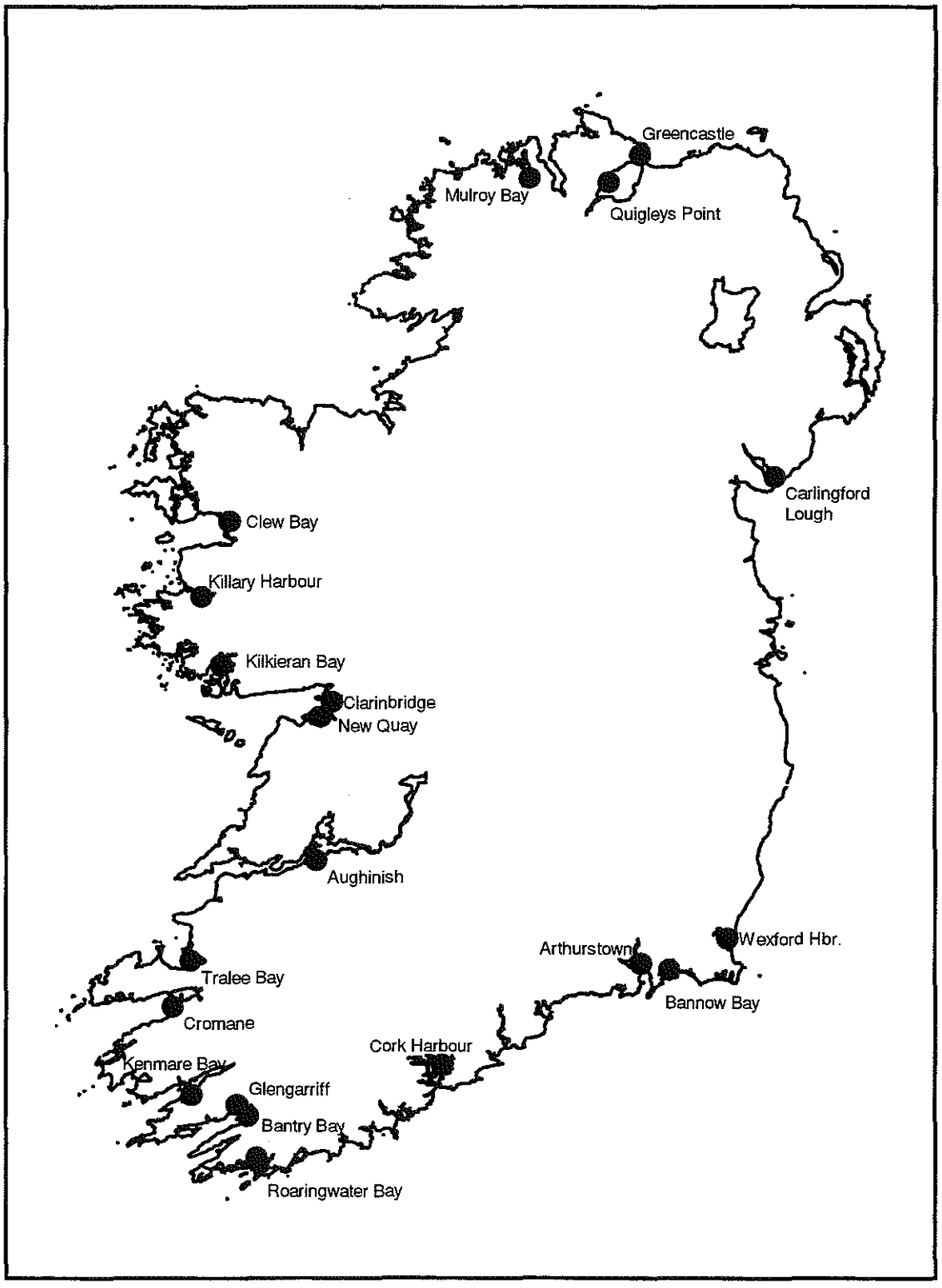
During 1995, water and shellfish from the four areas designated in 1982 were analysed in compliance with the Directive. An additional 17 areas, currently being considered for designation, were monitored in the same way (Fig. 1). The directive allows for reduced sampling where the quality of designated shellfish growing waters is appreciably higher than that which is set out in the guidelines of Annex 1 of the directive. Based on the results of the 1993 & 1994 monitoring programmes, the frequency of monitoring was reduced and samples were collected from 21 sites during 1995.

Analysis for chlorinated hydrocarbons was carried out on five sites based on the possibility of localised anthropogenic inputs of pollutants :- Carlingford Lough, Cork Harbour, Greencastle, Wexford Harbour, and at Arthurstown, Waterford. The other sites were considered to be influenced only by atmospheric inputs of organic contaminants. Results obtained from the 1993 and 1994 monitoring on shellfish growing waters bear this out. 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.

## Materials and methods

Samples were collected in June and July, 1995, from 21 areas. 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.

**Figure 1. Location of shellfish-growing areas monitored during 1995.**




Samples for suspended solids were returned to the laboratory, filtered through a 0.45 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 these 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 sub-sample 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 cold vapour generation atomic absorption spectrometry following microwave digestion with nitric acid, potassium permanganate and hydroxylamine sulphate. 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 (1:1) mixture. The co-extracted lipids were removed by alumina column chromatography followed by separation of the PCBs from the chlorinated pesticides using silica column chromatography. Levels were determined using gas chromatography electron capture detection using a 60 meter fused silica capillary column; a second column of different polarity was used as confirmation.

**Table 1: Results of the analyses of certified reference materials during the 1995 monitoring programme.**

| CRM | Certified value | FRC value/range | No. of analyses |
|---|---|---|---|
| **Mussel tissue CRM 278** | **µg $g^{-1}$ dry wt.** | **µg $g^{-1}$ dry wt.** | |
| Chromium | 0.80 ± 0.08 | 0.83 - 0.88 | 2 |
| Cadmium | 0.34 ± 0.02 | 0.30 | 1 |
| Copper | 9.60 ± 0.16 | 9.05 – 9.23 | 2 |
| Lead | 1.91 ± 0.04 | 1.73 | 2 |
| Mercury | 0.188 ± 0.007 | 0.17 – 0.19 | 4 |
| Zinc | 76 ± 2 | 71.80 – 72.05 | 2 |
| **Oyster tissue NBS 1566A** | **µg $g^{-1}$ dry wt.** | **µg $g^{-1}$ dry wt.** | |
| Chromium | 1.43 ± 0.46 | 0.98 - 1.51 | 2 |
| Cadmium | 4.15 ± 0.38 | 3.80 - 5.83 | 2 |
| Copper | 66.3 ± 4.3 | 59.85 - 67.13 | 2 |
| Lead | 0.37 ± 0.014 | 0.37 – 0.38 | 2 |
| Mercury | 0.06 ± 0.007 | 0.05 – 0.07 | 3 |
| Zinc | 830 ± 57 | 914.23 – 924.80 | 2 |
| **Cod liver Oil CRM 349** | **µg $kg^{-1}$ dry wt.** | **µg $kg^{-1}$ dry wt.** | |
| CB 28 | 68 ± 7 | 68 | 1 |
| CB 52 | 149 ± 20 | 143 | 1 |
| CB 101 | 370 ± 17 | 386 | 1 |
| CB 118 | 454 ± 31 | 479 | 1 |
| CB 153 | 938 ± 40 | 981 | 1 |
| CB 180 | 280 ± 22 | 270 | 1 |

*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 1. From 1 to 4 analyses were carried out on the CRMs during this programme. The QA results obtained were sufficient for the purpose of this monitoring programme.

## Results and discussion

The results of the chemical monitoring carried out during 1995 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. Parameters such as pH, temperature, suspended solids, salinity and dissolved oxygen measurements met the criteria set down in the Directive in all cases.

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

The concentration of metal and chlorinated hydrocarbon contaminants analysed in the shellfish flesh results are presented in Appendix 1. 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 provide valuable information on the quality of the shellfish and the waters in which they are grown.

**Table 2: 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, 1992)**

| Contaminant | Values and Units | Qualifier | Country |
|---|---|---|---|
| Cadmium | 0.5 mg $kg^{-1}$ | Guidance | Germany/Norway |
| Copper | 20 mg $kg^{-1}$ | Standard | Spain |
| Lead | 0.8 mg $kg^{-1}$ | Guidance | Germany |
| Mercury | 0.5 mg $kg^{-1}$ | Standard | Germany |
| Zinc | 50 mg $kg^{-1}$ | Guidance | United Kingdom |
| DDT+DDE+DDD | 500 µg $kg^{-1}$ | Standard | Finland |
| HCB | 50 µg $kg^{-1}$ | Guidance | Norway |
| $\alpha + \beta$ HCH | 50 µg $kg^{-1}$ | Guidance | Norway |
| Lindane | 100 µg $kg^{-1}$ | Standard | Finland |
| CB 28 | 80 µg $kg^{-1}$ | Standard | Germany |
| CB 52 | 80 µg $kg^{-1}$ | Standard | Germany |
| CB 101 | 80 µg $kg^{-1}$ | Standard | Germany |
| CB 138 | 100 µg $kg^{-1}$ | Standard | Germany |
| CB 153 | 100 µg $kg^{-1}$ | Standard | Germany |
| CB 180 | 80 µg $kg^{-1}$ | Standard | Germany |

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. The strictest guidance and standard values are presented in Table 2, however some countries have less stringent values. Where values in this survey may have exceeded some of the standards set out above they still satisfied values set by other European countries.

Concentrations of zinc in oysters, *Crassostrea gigas* and *Ostrea edulis*, ranged from 112.0-532.8 mg $kg^{-1}$ wet weight, while the range in mussels was from 10.5-27.8 mg $kg^{-1}$ wet weight. Oysters are known to accumulate high levels of zinc. The UK is the only country at present to set down a guideline value of 50 mg $kg^{-1}$ for Zn in food, but excludes shellfish. The expected level in shellfish is well in excess of 100 mg $kg^{-1}$ (ppm) wet weight, (MAFF 1993).

There are no published guidelines for acceptable concentrations of chromium in shellfish. Chromium contamination results mainly from human activities. The range in oysters in this survey, both species, was 0.06 - 0.41 mg $kg^{-1}$ wet weight and 0.09 - 0.59 mg $kg^{-1}$ wet weight in mussels.

*Aughinish Bay, New Quay, Clare*
Physicochemical measurements, water samples and a sample of *C gigas* were collected from Aughinish Bay during July 1995. The water quality parameters measured conformed to the requirements of the Directive. For metals the levels were within the human consumption tolerance values set by Oslo and Paris Commission (OSPARCOM) countries.

*Aughinish, Limerick*
This site was not sampled in previous years, oysters were sampled from this area. All the metal levels were within the guideline concentrations of Table 2. No organics analysis was carried out.

*Bannow Bay.*
This site was visited once during 1995, water quality measurements taken were normal for an inshore location during summer. The heavy metal content of a sample of *C. gigas* was determined. Values for heavy metals were very similar to those of 1994, none of them exceeded the tolerance levels given in Table 2.

*Bantry Bay.*
Bantry Bay is one of the principal Irish shellfish producing and exporting areas and during 1994/95 season produced 1,900 tonnes, of rope-grown mussels. As in 1994 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 /EU countries, Table 2.

*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 1995 monitoring programme the level of cadmium in *C. gigas* was 0.52 mg $kg^{-1}$ wet weight, similar to the levels measured in 1994. This is the same as the cadmium guidance value set by Germany and Norway (0.5 mg $kg^{-1}$) and within the Dutch standard of 1 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). The levels of chlorinated hydrocarbons were again very low during 1995. Water quality conformed to the requirement of the Directive.

*Clarinbridge*
The native oyster *O. edulis* was sampled from Clarinbridge during July 1995. Metal contaminants present in the tissues were very low. The cadmium concentration (0.46 mg $kg^{-1}$) was within the German and Norwegian guidance value. The water quality measurements were within the guidelines of the Directive.

*Clew Bay*
With the exception of cadmium, the concentration of contaminants in *O. edulis* from Clew Bay were low and well within human consumption guidelines. The cadmium level 0.8 mg $kg^{-1}$ wet weight was above the German and Norwegian guidelines, but within the Dutch standard of 1 mg $kg^{-1}$ wet weight and was not exceptional for Irish oysters.

*Cork Harbour*
Water and shellfish quality, for the parameters measured in this programme, was similar to 1994 and conformed to the requirements of the Directive. Organochlorines and organics continued to be very low.

*Cromane*
Heavy metal concentrations in shellfish remained low and similar to 1994 values. Water measurements satisfied the requirements of the directive.

*Glengarriff*
Mussel samples were collected from Glengarriff, Bantry Bay, in July 1995. As in 1993 and 1994 the levels of heavy metals were well within the human consumption guideline and standards set by OSPARCOM countries. Measurement of organics was not repeated in 1995 as levels were considered sufficiently low from previous sampling. 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 July 1995. Water parameters and metal contaminants measured in shellfish were similar to the levels detected during the 1994 programme and fully complied with the requirements of the Directive. Organic concentrations for mussels collected at Greencastle were below the strictest standards laid down by Germany.

*Kenmare Bay*
Mussel samples were collected form Kenmare, during July 1995. Again, 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. The cadmium level of 0.45 mg $kg^{-1}$ wet weight was similar again to 1993/94 result and close to the German and Norwegian guideline value, was not exceptional for Irish oysters.

*Killary Harbour*
Levels of heavy metals measured in mussels from Killary were well within human consumption guidelines and all water parameters met the criteria set by the Directive.

*Mulroy Bay*
Levels of heavy metals measured in mussels from Mulroy Bay were, as was the case in 1994, 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 1995 had trace metal levels similar to 1994 values, 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 Tralee Bay during June 1995.
Sampling of the outer Tralee Bay was discontinued due to the poor returns of oysters from dredging in 1995. The water quality parameters measured conformed with the requirements of the Directive. The zinc level of 532.8 mg $kg^{-1}$ wet weight was again high during 1995 but was not considered to have human health implications or to impact on the quality of the oysters.
Cadmium levels remained high in oysters from Tralee Bay and similar to the finding of the 1993/94 surveys (Nixon *et. al,* 1994). The level of cadmium in 1995 was 0.64 mg $kg^{-1}$ wet weight which is above the German and Norwegian guideline value but within the Dutch standard of 1 mg $kg^{-1}$ wet weight. As previously stated, oysters accumulate metals more readily and to higher concentrations than mussels and for this reason concentrations of metals are generally higher in oysters.

*Arthurstown, Waterford*
Water quality parameters were measured for the first time at Arthurstown in July 1995. The levels of metal contaminants in mussels were low in all cases and well below the tolerance levels set out in Table 2. Traces of PCBs were found and residues of DDT & its metabolites, lindane and dieldrin pesticides but these were at µg $kg^{-1}$ concentrations and well below the standards given in Table 2.

*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. The mercury concentration monitored was well below the German standard of 0.5 mg $kg^{-1}$ wet weight. Levels of organic contaminants measured in mussels from Wexford Harbour were well within the human consumption guidelines given in Table 2.

## Acknowledgements

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**Appendix 1: Results of the 1995 monitoring of shellfish-growing areas.**

| | Aughinish, New Quay, Clare | Aughinish, Limerick | Bannow Bay | Bantry Bay | Carlingford Lough | Clarinbridge | Clew Bay, Inishloy |
|---|---|---|---|---|---|---|---|
| Date sampled | 28-July | 16-July | 21-July | 15-July | 21-July | 28-July | 23-July |
| Latitude | 53°09.12 | 52°37.50 | 52°13.40 | 51°41.30 | 54°01.75 | 53°12.36 | 53°52.00 |
| Longitude | 09°01.00 | 09°02.50 | 06°47.25 | 09°28.45 | 06°07.05 | 08°56.45 | 09°35.20 |
| Time of hightide | 1200 | 0912 | 1300 | 0955 | 1115 | 1745 | 1700 |
| Time of sampling | 1245 | 1015 | 1615 | 0830 | 0900 | 1930 | 1510 |
| Species sampled | *C. gigas* | *C.gigas* | *C. gigas* | *M. edulis* | *C. gigas* | *O. edulis* | *O. edulis* |
| No. of individuals in sample | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Method of cultivation | Bottom | Bottom | Trestle | Rope | Trestle | Bottom | Bottom |
| *Water Parameters* | | | | | | | |
| Temperature °C | 19.5 | - | 23.5 | 20 | 18.6 | 17 | 18 |
| Salinity psu | 33 | - | 29.7 | 30 | 34.6 | 31.5 | 35 |
| pH | | - | 8.2 | - | 8.0 | - | - |
| Dissolved oxygen % saturation | | - | 114 | - | 104 | - | - |
| Suspended Solids mg $l^{-1}$ | 5.08 | - | 14.9 | 1.4 | 2.0 | 3.0 | 3.9 |
| *Shellfish* | | | | | | | |
| Shell length range mm. | 85 -133 | 86 -110 | 80 - 124 | 44 - 65 | 86 - 130 | 63 - 78 | 63 - 98 |
| Length mean mm | 106.6 | 95.8 | 102.6 | 52.5 | 104.6 | 70.0 | 74.8 |
| Length standard deviation mm | 9.75 | 6.1 | 13.2 | 4.5 | 10.2 | 4.3 | 7.9 |
| Meat weight % | 11.70 | 14.6 | 11.4 | 44.3 | 15.4 | 15.2 | 7.6 |
| Shell weight % | 88.30 | 85.4 | 88.6 | 55.7 | 84.6 | 84.8 | 92.4 |
| Meat water content % | 78.1 | 81.1 | 76.1 | 77.0 | 77.4 | 76.3 | 78.1 |
| ***Metals* mg $kg^{-1}$ (ppm) wet wt** | | | | | | | |
| Aluminium | 30.6 | 30.6 | 43.6 | 16.5 | 24.0 | 27.9 | 10.4 |
| Cadmium | 0.30 | 0.48 | 0.29 | 0.52 | 0.5 | 0.46 | 0.81 |
| Chromium | 0.06 | 0.1 | 0.41 | 0.09 | 0.25 | 0.07 | 0.08 |
| Copper | 4.2 | 7.5 | 8.5 | 25.3 | 25.8 | 3.6 | 1.9 |
| Lead | 0.04 | 0.18 | 0.17 | 0.17 | 0.17 | 0.06 | 0.03 |
| Mercury | 0.01 | 0.01 | 0.04 | 0.01 | 0.02 | 0.03 | 0.03 |
| Zinc | 140.1 | 187.6 | 198.6 | 20.30 | 388.3 | 336.8 | 296.1 |
| ***Organics* µg $kg^{-1}$ (ppb) wet wt** | | | | | | | |
| CB Congener 28 | n.a. | n.a. | n.a. | n.a. | 0.17 | n.a. | n.a. |
| CB Congener 31 | n.a. | n.a. | n.a. | n.a. | 0.12 | n.a. | n.a. |
| CB Congener 52 | n.a. | n.a. | n.a. | n.a. | 0.10 | n.a. | n.a. |
| CB Congener 101 | n.a. | n.a. | n.a. | n.a. | 0.16 | n.a. | n.a. |
| CB Congener 118 | n.a. | n.a. | n.a. | n.a. | 0.12 | n.a. | n.a. |
| CB Congener 153 | n.a. | n.a. | n.a. | n.a. | 0.32 | n.a. | n.a. |
| CB Congener 156 | n.a. | n.a. | n.a. | n.a. | 0.06 | n.a. | n.a. |
| CB Congener 105 | n.a. | n.a. | n.a. | n.a. | 0.10 | n.a. | n.a. |
| CB Congener 138 | n.a. | n.a. | n.a. | n.a. | 0.44 | n.a. | n.a. |
| CB Congener 180 | n.a. | n.a. | n.a. | n.a. | 0.02 | n.a. | n.a. |
| DDE - p,p' | n.a. | n.a. | n.a. | n.a. | 0.10 | n.a. | n.a. |
| DDE - o,p' | n.a. | n.a. | n.a. | n.a. | 0.03 | n.a. | n.a. |
| DDT - p,p' | n.a. | n.a. | n.a. | n.a. | 0.12 | n.a. | n.a. |
| DDD - p,p' | n.a. | n.a. | n.a. | n.a. | 0.42 | n.a. | n.a. |
| BHC, alpha | n.a. | n.a. | n.a. | n.a. | 0.20 | n.a. | n.a. |
| BHC, gamma (Lindane) | n.a. | n.a. | n.a. | n.a. | 1.92 | n.a. | n.a. |
| Chlordane, alpha | n.a. | n.a. | n.a. | n.a. | 0.08 | n.a. | n.a. |
| Chlordane, gamma | n.a. | n.a. | n.a. | n.a. | 0.11 | n.a. | n.a. |
| Dieldrin | n.a. | n.a. | n.a. | n.a. | 1.04 | n.a. | n.a. |
| HCB | n.a. | n.a. | n.a. | n.a. | 0.03 | n.a. | n.a. |
| trans - Nonachlor | n.a. | n.a. | n.a. | n.a. | 0.22 | n.a. | n.a. |

**Appendix 1: continued.**

| | Cork Hbr. | Cromane | Glengarriff | Greencastle | Kenmare Bay | Kilkieran | Killary Hbr. |
|---|---|---|---|---|---|---|---|
| Date sampled | 14-July | 16-July | 15-July | 9-July | 15-July | 28-Jul | 23-July |
| Latitude | 51°52.45 | 52°07.80 | 51°42.35 | 55°12.60 | 51°46.00 | 53°20.45 | 53°35.50 |
| Longitude | 08°14.25 | 09°54.20 | 09°32.35 | 06°58.50 | 09°49.55 | 09°38.30 | 09°46.00 |
| Time of hightide | 0835 | 0900 | 0830 | 1930 | 0830 | 0800 | 1700 |
| Time of sampling | 1100 | 1145 | 1045 | 1039 | 0715 | 1000 | 1220 |
| Species sampled | *C. gigas* | *M. edulis* | *M. edulis* | *M. edulis* | *M. edulis* | *O. edulis* | *M. edulis* |
| No. of individuals in sample | 25 | 25 | 25 | 50 | 25 | 25 | 50 |
| Method of cultivation | Bottom | Bottom | Rope | Bottom | Rope | Bottom | Rope |
| *Water Parameters* | | | | | | | |
| Temperature °C | 20 | 20 | 20 | 20 | 20 | 17.5 | 18.5 |
| Salinity psu | 30 | 27.0 | 28.5 | 27 | 31.0 | 29.5 | 31.5 |
| pH | 7.8 | - | - | - | - | - | - |
| Dissolved oxygen % saturation | - | - | - | - | - | - | - |
| Suspended Solids mg $l^{-1}$ | 16.7 | 5.4 | 1.1 | 5.1 | 1.68 | 6.8 | 7.1 |
| *Shellfish* | | | | | | | |
| Shell length range mm. | 73 - 114 | 57 -74 | 47 - 73 | 54 - 73 | 46 - 64 | 66 - 90 | 42 - 55 |
| Length mean mm | 90.6 | 67.8 | 57.8 | 62.5 | 54.2 | 75.5 | 47.9 |
| Length standard deviation mm | 11.1 | 4.1 | 5.8 | 4.1 | 3.9 | 5.2 | 3.8 |
| Meat weight % | 16.2 | 25.6 | 41.7 | 24.1 | 44.4 | 9.4 | 49.2 |
| Shell weight % | 83.8 | 74.4 | 58.4 | 75.9 | 55.6 | 90.6 | 50.8 |
| Meat water content % | 75.5 | 77.1 | 77.0 | 81.1 | 77.3 | 77.5 | 74.9 |
| ***Metals* mg $kg^{-1}$ (ppm) wet wt** | | | | | | | |
| Aluminium | 42.4 | 48.4 | 24.2 | 92.5 | 14.3 | 58.3 | 12.4 |
| Cadmium | 0.14 | 0.22 | 0.13 | 0.08 | 0.30 | 0.45 | 0.15 |
| Chromium | 0.15 | 0.21 | 0.40 | 0.59 | - | 0.10 | 0.10 |
| Copper | 7.5 | 1.6 | 1.5 | 1.0 | 1.5 | 4.0 | 1.44 |
| Lead | 0.23 | 0.11 | 0.01 | 0.17 | 0.06 | <0.10 | 0.05 |
| Mercury | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.03 | 0.01 |
| Zinc | 112.0 | 13.7 | 27.8 | 10.5 | 16.1 | 264.2 | 16.67 |
| ***Organics* µg $kg^{-1}$ (ppb) wet wt** | | | | | | | |
| CB Congener 28 | 0.48 | n.a. | n.a. | 0.02 | n.a. | n.a. | n.a. |
| CB Congener 31 | 0.23 | n.a. | n.a. | 0.05 | n.a. | n.a. | n.a. |
| CB Congener 52 | 0.14 | n.a. | n.a. | 0.03 | n.a. | n.a. | n.a. |
| CB Congener 101 | 0.30 | n.a. | n.a. | 0.07 | n.a. | n.a. | n.a. |
| CB Congener 118 | 0.22 | n.a. | n.a. | 0.04 | n.a. | n.a. | n.a. |
| CB Congener 153 | 0.48 | n.a. | n.a. | 0.11 | n.a. | n.a. | n.a. |
| CB Congener 156 | 0.02 | n.a. | n.a. | 0.01 | n.a. | n.a. | n.a. |
| CB Congener 105 | 0.11 | n.a. | n.a. | 0.06 | n.a. | n.a. | n.a. |
| CB Congener 138 | <0.36 | n.a. | n.a. | 0.16 | n.a. | n.a. | n.a. |
| CB Congener 180 | 0.07 | n.a. | n.a. | 0.02 | n.a. | n.a. | n.a. |
| DDE - p,p' | 0.68 | n.a. | n.a. | 0.40 | n.a. | n.a. | n.a. |
| DDE - o,p' | 0.29 | n.a. | n.a. | 0.02 | n.a. | n.a. | n.a. |
| DDT - p,p' | 0.28 | n.a. | n.a. | 0.19 | n.a. | n.a. | n.a. |
| DDD - p,p' | 0.10 | n.a. | n.a. | 0.05 | n.a. | n.a. | n.a. |
| BHC, alpha | 0.06 | n.a. | n.a. | 0.06 | n.a. | n.a. | n.a. |
| BHC, gamma (Lindane) | 0.11 | n.a. | n.a. | 0.05 | n.a. | n.a. | n.a. |
| Chlordane, alpha | 0.07 | n.a. | n.a. | 0.05 | n.a. | n.a. | n.a. |
| Chlordane, gamma | 0.04 | n.a. | n.a. | 0.03 | n.a. | n.a. | n.a. |
| Dieldrin | 0.74 | n.a. | n.a. | 0.09 | n.a. | n.a. | n.a. |
| HCB | 0.02 | n.a. | n.a. | 0.02 | n.a. | n.a. | n.a. |
| trans - Nonachlor | 0.06 | n.a. | n.a. | 0.15 | n.a. | n.a. | n.a. |

**Appendix 1 continued.**

| | Mulroy Bay | Quigleys Pt. | Roaring -water Bay | Tralee Bay Derrymore | Wexford Hbr. | Waterford, Arthurstown. |
|---|---|---|---|---|---|---|
| Date sampled | 9-July | 9-July | 30-Nov | 21-Jun | 14-Dec | 22-July |
| Latitude | 55°07.55 | 55°06.66 | 51°32.00 | 52°15.40 | 52°20.29 | 52°14.75 |
| Longitude | 07°40.90 | 07°10.88 | 09°25.30 | 09°5010 | 06°24.92 | 06°58.00 |
| Time of hightide | - | 1930 | 0830 | 0930 | - | 1615 |
| Time of sampling | 1715 | 1300 | 1545 | 1630 | 1045 | 1630 |
| Species sampled | *M. edulis* | *M. edulis* | *M. edulis* | *O. edulis* | *M.edulis* | *M. edulis* |
| No. of individuals in sample | 50 | 50 | 25 | 25 | 50 | 50 |
| Method of cultivation | Rope | Bottom | Rope | Bottom | Bottom | Bottom |
| *Water Parameters* | | | | | | |
| Temperature °C | 20.1 | 24 | 20 | 22 | 6.8 | 24.5 |
| Salinity psu | 34.6 | 31.5 | 28.0 | 31 | 26.3 | 28.7 |
| pH | 8.0 | 8.1 | - | - | 8.3 | 8.3 |
| Dissolved Oxygen % Saturation | 108.2 | 101.0 | - | - | 93.3 | 140 |
| Suspended Solids mg $l^{-1}$ | 2.8 | 104.4 | 1.0 | 1.2 | 295.6 | 5.6 |
| *Shellfish* | | | | | | |
| Shell length range mm. | 42 - 62 | 52 - 74 | 46 - 67 | 61 - 96 | 47 - 65 | 48 - 67 |
| Length mean mm | 51.2 | 60.6 | 58.3 | 74.8 | 55.6 | 54.4 |
| Length standard deviation mm | 4.3 | 5.2 | 5.7 | 8.7 | 3.8 | 4.0 |
| Meat weight % | 45.8 | 16.8 | 44.9 | 53.9 | 40.5 | 33.3 |
| Shell weight % | 54.2 | 83.2 | 55.1 | 46.1 | 59.5 | 66.7 |
| Meat water content % | 78.2 | 80.4 | 78.4 | 66.7 | 73.3 | 75.1 |
| ***Metals* mg $kg^{-1}$ (ppm) wet wt** | | | | | | |
| Aluminium | 47.6 | 34.1 | 33.9 | 96.4 | - | 10.3 |
| Cadmium | 0.13 | 0.23 | 0.13 | 0.64 | - | 0.14 |
| Chromium | 0.46 | 0.47 | 0.41 | 0.25 | -. | 0.17 |
| Copper | 1.5 | 1.4 | 1.4 | 27.1 | - | 7.6 |
| Lead | 0.04 | 0.17 | 0.18 | 0.15 | - | 0.38 |
| Mercury | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.01 |
| Zinc | 14.3 | 13.0 | 19.8 | 532.8 | - | 12.0 |
| ***Organics* µg $kg^{-1}$ (ppb) wet wt** | | | | | | |
| CB Congener 28 | n.a. | n.a. | n.a. | n.a. | 0.16 | 0.26 |
| CB Congener 31 | n.a. | n.a. | n.a. | n.a. | 0.12 | 0.15 |
| CB Congener 52 | n.a. | n.a. | n.a. | n.a. | 0.21 | 0.39 |
| CB Congener 101 | n.a. | n.a. | n.a. | n.a. | 0.54 | 0.58 |
| CB Congener 118 | n.a. | n.a. | n.a. | n.a. | 0.23 | 0.39 |
| CB Congener 153 | n.a. | n.a. | n.a. | n.a. | 0.41 | 1.26 |
| CB Congener 156 | n.a. | n.a. | n.a. | n.a. | 0.04 | 0.07 |
| CB Congener 105 | n.a. | n.a. | n.a. | n.a. | 0.13 | 0.18 |
| CB Congener 138 | n.a. | n.a. | n.a. | n.a. | 0.80 | 1.00 |
| CB Congener 180 | n.a. | n.a. | n.a. | n.a. | 0.12 | 0.03 |
| DDE - p,p' | n.a. | n.a. | n.a. | n.a. | 1.26 | 0.45 |
| DDE - o,p' | n.a. | n.a. | n.a. | n.a. | 0.07 | 0.14 |
| DDT - p,p' | n.a. | n.a. | n.a. | n.a. | 0.29 | 1.60 |
| DDD - p,p' | n.a. | n.a. | n.a. | n.a. | 0.05 | 0.80 |
| BHC, alpha | n.a. | n.a. | n.a. | n.a. | 0.11 | 0.16 |
| BHC, gamma (Lindane) | n.a. | n.a. | n.a. | n.a. | 0.72 | 0.75 |
| Chlordane, alpha | n.a. | n.a. | n.a. | n.a. | 0.22 | 0.13 |
| Chlordane, gamma | n.a. | n.a. | n.a. | n.a. | 0.07 | 0.24 |
| Dieldrin | n.a. | n.a. | n.a. | n.a. | 0.71 | 1.57 |
| HCB | n.a. | n.a. | n.a. | n.a. | 0.06 | 0.03 |
| trans - Nonachlor | n.a. | n.a. | n.a. | n.a. | 0.29 | 0.07 |

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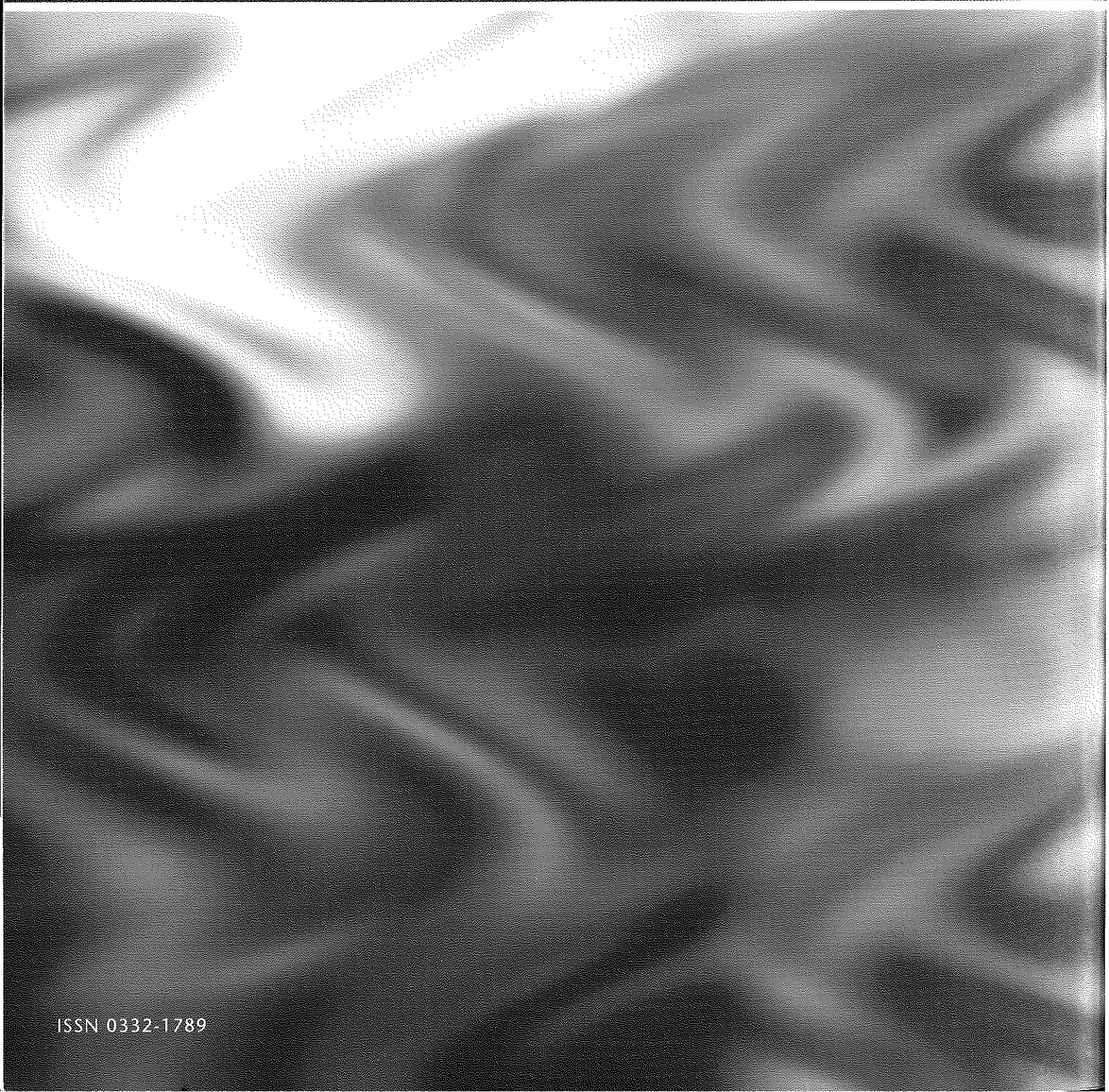

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