Assuring Seafood Safety: Contaminants and Residues in Irish Seafood 2004-2008

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Food Safety Authority of Ireland

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Contaminants and Residues in Irish Seafood 2004-2008

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Executive Summary

It is well recognised that consumption of fish, in particular oily fish, has clear health benefits, especially with respect to reducing the risks of cardiovascular disease. It is also known that many environmental contaminants can accumulate in fish and shellfish tissue and that seafood contributes to contaminant intake in the human diet. Certain contaminants, such as trace metals, occur naturally in the marine environment but pollution can lead to elevated concentrations. Other contaminants, such as many persistent organic pollutants (POPs), are man-made and are not found naturally in the environment, although in recent decades many POPs have become ubiquitous due to global atmospheric dispersion. This report presents an overview of the status of contaminants and veterinary residues in Irish seafood, based on the results of the Marine Institute's seafood monitoring and research activities over the period 2004 – 2008, and considers the implications for the seafood consumer.

Nine trace metals were determined in shellfish and finfish originating from Irish waters. Concentrations of mercury, cadmium and lead consistently complied with the EC Maximum Limits for bivalve molluscs, finfish (including farmed finfish) and crustaceans destined for human consumption. Concentrations of other trace metals complied with various other non-statutory threshold values used for this assessment. However, a sample of marlin imported from Indonesia contained levels of mercury in excess of the maximum limit, with high mercury levels also evident in imported swordfish. Data are reported for a variety of POPs, including polychlorinated biphenyls (PCBs), dioxins, various organochlorine pesticides, certain brominated flame retardants, polyfluorinated compounds and polychlorinated naphthalenes. In general POPs were detectable although concentrations were relatively low in Irish seafood. EC maximum levels for dioxins and dioxin-like PCBs, and other criteria such as the strictest standards for POPs in fisheries products for human consumption as applied in various European countries, were consistently met.

As with other farmed animals, farmed finfish take up environmental contaminants from their feed. They are also subject to veterinary treatments which require a withdrawal period to ensure any remaining treatment residue is within safe limits. Surveillance monitoring during 2004 – 2008 indicated that compliance of the fish farming sector with the requirements of the "Residues Directive" (96/23/EC) was good (non compliance 0.06%) and indeed improved over the course of this reporting period following better industry awareness, for example with respect to the unauthorised status of malachite green. Non-compliant results for malachite green and the authorised sea lice treatment emamectin B1a were detected in 2004 and 2005 respectively. 100% compliance was achieved in the years 2006, 2007 and 2008.

An assessment of the risks of intake of environmental contaminants for the average Irish adult seafood consumer was considered in the context of the health benefits of seafood consumption. It is evident that Irish consumers may not achieve recommended dietary intakes of essential long chain n-3 PUFAs for which fish, and especially oily fish, are the primary source. Moreover, estimates are that current intake of mercury, hexachlorobenzene, dioxins and dioxin-like PCBs from seafood consumption are within safe limits established by European Food Safety Authority (EFSA). These findings support current advice from the Food Safety Authority of Ireland (FSAI) that consumers should eat two portions of fish per week, one of which should be oily (e.g. mackerel, herring, salmon). This provides clear health benefits with little risk to the consumer. Data on imported predatory fish also supports continuance of FSAI guidance on consumption of certain predatory fish. This recommends that breastfeeding women, women of childbearing age and young children continue to eat fish, selecting from a wide range of species, but do not eat swordfish, marlin and shark, and limit their consumption of tuna to one fresh tuna steak or two 8oz cans per week. Overall these data are evidence of the relatively clean waters around Ireland and provide reassurance to consumers that Irish seafood is of high quality and safe to eat.

Achoimre Feidhmiúcháin

Aithnítear go forleathan gur iomaí buntáiste sláinte a bhaineann le iasc a ithe, go háirithe iasc olúil, i dtaobh an baol atá ann ón ngalar cardashoithíoch a laghdú. Ach glactar leis freisin go bhféadfadh an-chuid truaillitheoirí comhshaoil a bheith i bhfíochán éisc agus i bhfíochán sliogéisc agus go gcuireann bia mara leis an méid truaillitheoirí a thógann an duine ina aiste bia. Bíonn truaillitheoirí áirithe, mar shampla rianmhiotail, go nádúrtha i dtimpeallacht na mara ach d'fhéadfadh truailliú cur le tiúchana níos airde díobh sin. Tá truaillitheoirí eile ann nach mbíonn go nádúrtha sa chomhshaol cosúil le go leor truailleán orgánach marthanach (POPanna) ar é an duine is cúis leo. Le fiche nó tríocha bliain anuas áfach, mar thoradh ar easrú atmaisféarach domhanda, is iomaí POP uileláithreach atá ann. Tugtar forléargas sa tuarascáil seo ar stádas na dtruaillitheoirí agus na bhfuíoll tréidliachta atá i mbia mara na hÉireann de réir thorthaí ghníomhaíochtaí monatóireachta agus taighde Fhoras na Mara sa tréimhse 2004 – 2008 agus déantar scrúdú inti ar na himpleachtaí don té a itheann bia mara.

Thángthas ar naoi rianmhiotal i sliogéisc agus in iasc eite a tháinig as uiscí na hÉireann. Bhí an tiúchan mearcair, caidmiam agus luaidhe ag teacht go leanúnach le huasteorainneacha an AE maidir le moilisc dhébhlaoscacha, le hiasc eite (iasc eite saothraithe san áireamh) agus maidir le crústaigh atá le hithe ag an duine. Bhí tiúchana rianmhiotail eile ag teacht le luachanna eile tairsí neamhreachtúla éagsúla a úsáideadh don mheasúnú seo. Bhí níos mó mearcair i sampla amháin de mhairlín a iompórtáladh ón Indinéis áfach na a t-uasteorainn agus ba léir leibhéil arda mearcair freisin i gcolgáin iompórtáilte. Tuairiscíodh sonraí maidir le POPanna éagsúla, idir dhéfheinil pholaclóirínithe (PCBanna), dhé-ocsainí, lotnaidicídí orgánaclóirín, lasairmhoillithigh bróimínithe áirithe, chomhdhúile polafluairínithe agus naftailéine polaclóirínithe. Go ginearálta aimsíodh POPanna i mbia mara na hÉireann, cé go raibh na tiúchana díobh sách íseal. Níor sháraigh siad uasleibhéil an AE maidir le dé-ocsainí agus le PCBanna atá cosúil le dé-ocsainí agus cloíodh freisin le critéir eile, mar shampla na caighdeáin is doichte i dtaca le POPanna i dtairgí iascaigh atá le hithe ag daoine, mar a dhéantar i dtíortha eile san Eoraip.

Mar a tharlaíonn go minic le hainmhithe saothraithe eile, is óna gcuid bia a fhaigheann iasc eite saothraithe truaillitheoirí comhshaoil. Cuirtear cóir tréidliachta orthu freisin agus ina dhiaidh sin bíonn tréimhse cúlaithe riachtanach chun a chinntiú go bhfuil aon fhuíoll cóireála laistigh de na leibhéil sábháilte. Léirigh monatóireacht faireachais idir 2004 – 2008 gur chomhlíon earnáil na feirmeoireachta éisc go maith le riachtanais Treoir ón AE maidir le Fuíll (96/23/AE) (neamhchomhlíonadh 0.06%) agus ar ndóigh gur fheabhsaigh sé le linn tréimhse na tuarascála seo mar thoradh ar fheasacht níos fearr sa tionscal, cuir i gcás maidir le stádas neamhúdaraithe na huaine malaicítigh. Aimsíodh torthaí neamhchomhlíonta d'uaine mhalaicíteach agus den chóir leighis údaraithe do mhíolra farraige *emamectin B1a* sna blianta 2004 agus 2005. Comhlíonadh 100% leo sna blianta 2006, 2007 agus 2008.

Breithníodh na rioscaí atá ann don ghnáthdhuine fásta in Éirinn a itheann bia mara truaillitheoirí comhshaoil a thógáil i gcomhthéacs na mbuntáistí sláinte a bhaineann le bia mara a ithe. Is léir go mbeadh an baol ann nach bhfaigheadh tomhaltóirí na hÉireann an iontógáil chothaithe mholta d'aigéid shailleacha pholai-neamhsháithithe (PUFA) n-3 slabhra fada atá riachtanach, a fhaightear ó iasc go príomha agus ó iasc olúil ach go háirithe. Lena chois sin, léiríonn meastacháin go bhfuil an iontógáil reatha de mhearcair, de heicseaclóraibeinséin, de dhé-ocsainí agus de DFP atá cosúil le dé-ocsainí ó bheith ag ithe bia mara, laistigh de na leibhéil sábháilte a bhunaigh an tÚdarás Eorpach um Shábháilteacht Bhia. Tacaíonn na torthaí taighde seo leis an gcomhairle reatha ó Údarás Sábháilteachta Bia na hÉireann (FSAI) gur cheart do thomhaltóirí dhá chuid d'iasc a ithe in aghaidh na seachtaine, iasc olúil (e.g. ronnach, scadán, bradán) ar cheann amháin díobh. Is léir go mbaineann buntáistí sláinte leis sin agus is beag an baol atá an don tomhaltóir. Tacaíonn an taighde ar iasc creachach le treoir leanúnach ón FSAI maidir le hiasc creachach áirithe a ithe. Molann an FSAI gur cheart do mhná a bheadh ag cothú páiste, do mhná atá in aois toirchis, agus do leanaí réimse leathan speiceas a ithe ach gan colgán, mairlín ná siorc a ithe, agus maidir le tuinnín nár cheart níos mó ná stéig tuinnín úr amháin nó dhá channa 8oz a ithe in aghaidh na seachtaine. Ar an iomlán is fianaise é an taighde seo go bhfuil uiscí na hÉireann sách glan agus tugann sé suaimhneas aigne do thomhaltóirí go bhfuil bia mara na hÉireann ar ardchaighdeán agus é slán agus folláin.

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► I Introduction

1.1 Scope of the report

The health benefits of consuming fish are well recognised and nutritionists and health experts advise consumption of fish as part of a balanced diet. Conversely, fish consumption provides one of the most important contributions to human dietary intake of environmental contaminants such as mercury and Persistent Organic Pollutants (POPs). These may have adverse consequences for human health if intake is high and therefore benefits and risks of seafood consumption must be weighed up to provide sound advice to consumers.

The Marine Institute (MI)[1], in conjunction with the Sea Fisheries Protection Authority (SFPA) and the Food Safety Authority of Ireland (FSAI), monitor levels of chemical substances in finfish and shellfish[2] to underpin the quality and safety of seafood produced and landed in Ireland. In addition, the information from the monitoring programmes is supplemented by one-off surveys and research projects, for instance investigations into occurrence of contaminants not included in regular monitoring. Such studies are often collaborations with other national and international agencies or researchers.

This report outlines MI research and monitoring of substances in Irish seafood for the period 2004 - 2008. Specifically the report covers the following areas:

- Environmental contaminants in shellfish and (wild and farmed) finfish ; and
- Residues of veterinary treatments used in finfish aquaculture.

This report primarily relates to Irish capture fisheries and aquaculture although some data are presented for residues and contaminants in processed products including imported fish and those collected at retail level. Other seafood safety monitoring activities undertaken by the Marine Institute, for example, microbiological and biotoxin monitoring of shellfish are not included within the scope of this report.

The implications for Irish consumers are considered and a preliminary assessment of the benefits and risks from seafood consumption are discussed in Chapter 6.

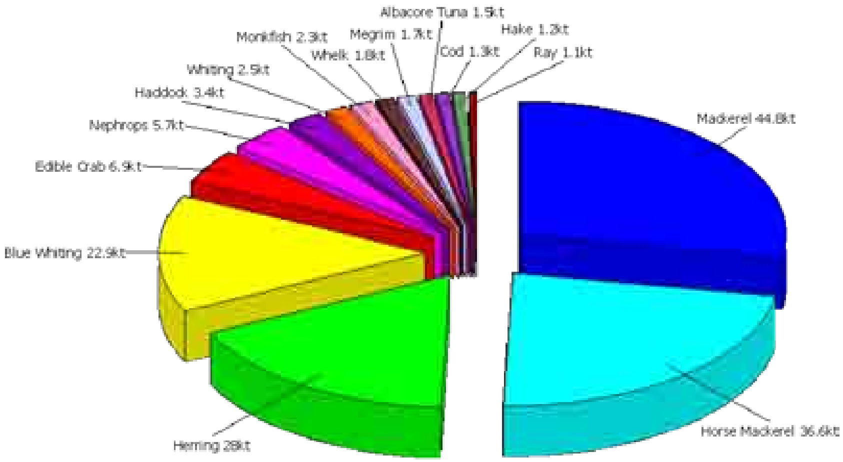
1.2 Seafood industry in Ireland

The seafood sector in Ireland includes wild (capture) fisheries, finfish and shellfish aquaculture and imported products. A good overview of the sector is given in the Consumer Focused Review of the Finfish Supply Chain (Safefood, 2006).

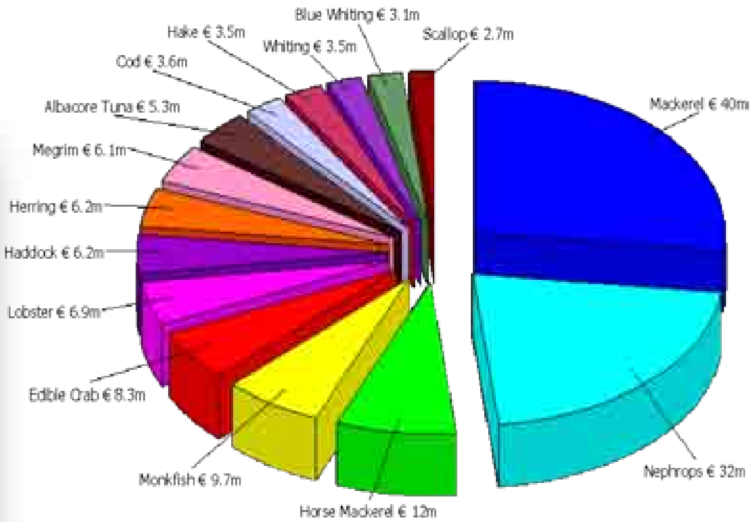
The major Republic of Ireland (ROI) fishing ports are Greencastle, Ailt an Chorráin, Killybegs, Ros an Mhíl, An Daingean, Castletownbere, Union Hall, Dunmore East, Kilmore Quay, Howth and Clogherhead with boats primarily landing from the North Atlantic region. The most important whitefish landed are cod, haddock, whiting, hake, monkfish, plaice and sole. Of the oil-rich fish, herring, mackerel, horse mackerel and blue whiting are the most important. Shellfish landings include wild crustaceans, such as Dublin Bay prawns (*Nephrops norvegicus*) and brown crabs (*Cancer pagurus*). Detailed information on fisheries and landings is available from the "Stock Book" published annually by the Marine Institute (Marine Institute, 2008a) and the Atlas of Commercial Fisheries around Ireland (Anon., 2009).

[1] MI is a state agency of the Department of Agriculture, Food and Marine (DAFM), formerly the Department of Agriculture, Fisheries and Food (DAFF)

[2] For the purpose of this report shellfish refers to bivalve and gastropod molluscs and crustaceans



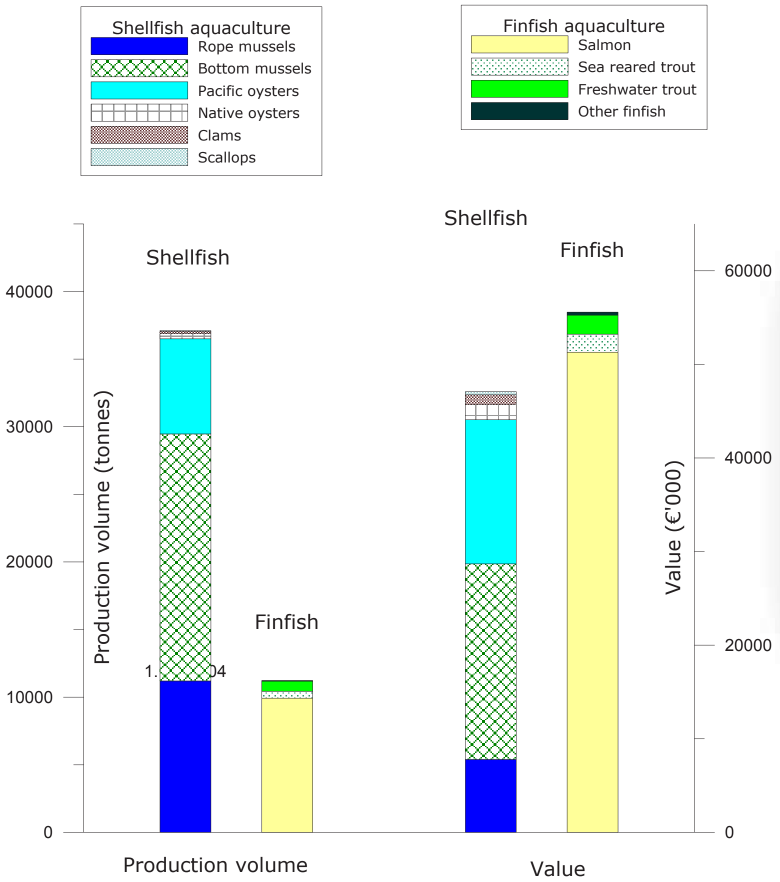
a.) Tonnes



b.) Value

Figure 1.1: Breakdown of the 15 main fish species landed by Irish vessel by kTonnes landed (a) and by value (b) in 2008 (Source data – Anon., 2009).

The main farmed finfish species produced in Ireland are Atlantic salmon (*Salmo salar*) and to a lesser extent sea-reared and freshwater-reared rainbow trout (*Oncorhynchus mykiss*). Cultured shellfish include bivalve molluscs, primarily blue mussel (*Mytilis edulis*), pacific oyster (*Crassostrea gigas*) and native/flat oyster (*Ostrea edulis*). Other finfish and shellfish species are produced but in low quantities. Overviews of aquaculture production can be found in annual Status of Irish Aquaculture reports (Anon., 2008). Aquaculture production volumes and the economic value are summarised in Figure 1.2.



Farmed Cod at MRI Carna Research facility. Cod farming offers an opportunity for aquaculture development in Ireland

Figure 1.2: Irish aquaculture production statistics 2007 (Anon. 2008).

1.3 Health benefits of eating fish

The health benefits of eating fish are well established and fish provides a highly nutritious source of good quality protein, vitamins and minerals. Moreover, unsaturated fats rather than saturated fats predominate in fish. Seafood is a primary source of the long chain n-3 polyunsaturated fatty acids (PUFAs, otherwise known as omega-3 fatty acids), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in the diet with oil-rich fish most abundant in these substances. EPA and DHA cannot be synthesised by humans *de novo* although it can be synthesised, albeit with a low efficiency, from the essential short chain n-3 PUFA α-linolenic acid (ALA) found in plants such as green leafy vegetables. EPA and DHA are associated with a number of health benefits such as reduced risk of cardiovascular disease and protection against stroke (Kris-Etherton *et al*., 2002; Mozaffarian and Rimm, 2006; Nesheim & Yaktine, 2007). The FSAI recommend that consumers eat at least two portions of fish per week, with one portion being an oily fish such as salmon or mackerel. In issuing advice to consumers, the FSAI weighs the risks associated with fish as a dietary source of contaminants against the positive benefits of fish consumption. More information is given in Chapter 6.

1.4 Environmental contaminants and veterinary residues: What are they and how do they get into fish?

Anthropogenic marine pollution by chemical substances is a global phenomenon. Many substances can be distributed over long distances by natural processes and therefore can be detected even in remote areas of the world far removed from the primary sources. Chemical substances that are slow to break down, exhibit an unacceptable level of toxicity and tend to accumulate to higher levels in biological tissue are of particular concern. These are known as PBT substances, i.e. **p**ersistent, liable to **b**ioaccumulate and **t**oxic. Such substances can accumulate in fatty tissue of fish through concentration from the water and uptake from food. Often tissue concentrations increase with ascent of the food chain depending on how effectively the animal can eliminate the substances; a process referred to as *biomagnification*.

Box 1: Environmental Contaminants determined in fish and shellfish - *Trace metals*

Trace metals exist naturally in the environment and many, including chromium, copper, iron and zinc are essential elements for living organisms. Some trace metals such as mercury, lead and cadmium are not required for metabolic activity and can be toxic at quite low concentrations. These three elements occur naturally in the earth's crust, but they can also be introduced into the aquatic environment from activities such as mining, industry and municipal waste. Once in the aquatic environment these metals can be bioaccumulated. The chemical form of metals is also important to their uptake and toxicology. For example microbial activity in the marine environment produces methylmercury which can bioaccumulate in fish. This form is toxic and highest concentrations are associated with long lived predatory fish such as shark, swordfish and marlin. Arsenic also occurs naturally in the marine environment and, as for mercury, seafood is one of the main dietary sources of this element. In marine species this is also predominantly in an organic form. In fish this is primarily arsenobetaine which is in fact considered relatively harmless to consumers as it can be rapidly eliminated from the mammalian body.

Contaminants of concern for seafood consumers may be introduced to the marine environment solely as a result of human activities (e.g. the synthetic pesticide DDT) or may arise due to a combination of anthropogenic inputs and natural occurrence (e.g. mercury which occurs naturally in the earth's crust). The main groups of environmental contaminants covered in this report are trace metals and a range of POPs. More details are given in Box 1 and 2. Many of these substances have been listed for priority action and use of the substances has been, or is in the process of being, phased out or restricted internationally. This may be through, for example, measures of the EC, the OSPAR Convention for Protection of the North East Atlantic (1992) (www.ospar.org) or the Stockholm Convention on Persistent Organic Pollutants (http://chm.pops.int) Nonetheless, the persistence of these substances means that there will be an environmental legacy for many decades.

As with other intensively farmed animals, farmed finfish can be subject to disease and infestation and this has animal welfare, environmental and commercial implications. To maintain animal health, similar procedures are in place for farmed finfish as for other farmed animals and this may involve treatment with approved veterinary medicines, such as antibiotics or anthelminthics, to prevent and/or treat the disease or infestation. The primary medicinal treatments used in aquaculture are antibacterial agents, antifungal agents, antiparasitic treatments (e.g. Sea lice treatments) and are typically administered by bath treatment or medicated feed. Farmed finfish may also accumulate trace metals and POPs from the feed used in rearing fish and specifically the capture fish product used in feed preparations. Therefore, contaminant levels in farmed finfish cannot be considered to reflect pollution status of their local environment. Factsheets on many environmental contaminants and residues in food are available from the FSAI website: www.fsai.ie/resources_and_publications/factsheets.html.

Box 2: Environmental Contaminants determined in fish and shellfish - *Persistent Organic Pollutants*

Dioxins and furans Polychlorinated dibenzodioxins and polychlorinated dibenzofurans, (PCDDs/PCDFs), commonly referred to as dioxins, are produced from incomplete combustion of organic materials in the presence of chlorine. Sources of dioxins include industrial, power generation, waste incineration, and especially uncontrolled combustion processes such as domestic burning (Hayes and Marnane, 2002). Unlike most other organohalogenated substances highlighted below, PCDD/Fs can occur naturally (e.g. forest fires); however human activities are the primary source. Dioxins and furans are extremely toxic and human exposure to these substances is primarily through food. Levels of PCDD/Fs in Irish food are generally low compared with other industrialised countries and are not considered to present a risk to the health of the Irish consumer (FSAI, 2009).

Polychlorinated biphenyls (PCBs) are man-made substances with a molecular structure comprising of a chlorinated biphenyl ring. PCBs were widely used for a variety of purposes, most notably as dieletrics in electrical equipment such as transformers and capacitors. Restrictions on their use in USA and Europe were introduced in the 1970s with use in closed systems such as transformers not permitted since the 1980s in Europe. The EPA has estimated 522,081 litres PCB holdings in Ireland (EPA, 2010) which are a potential source to the aquatic environment, for instance if improper waste disposal practices occur. PCBs are persistent pollutants with a tendency to bioaccumulate in fish and shellfish tissues and biomagnify through the aquatic food chain. Certain PCB congeners exhibit a 'dioxin-like' (dl) toxicity mechanism. The EC Scientific Committee on Food have carried out a risk assessment of dioxins and dioxin-like PCBs in food (SCF, 2000; SCF, 2001), as a consequence of which they concluded that the Tolerable Weekly Intake (TWI) for PCDDs, PCDFs and dl-PCBs should be no more than 14 pg WHO-TEQ/kg body weight (b.w.) and that some of the European population exceed that risk. Consequently the EC have established maximum limits for dioxins, furans and 'dioxin-like' PCBs in food. Use of PCB-contaminated recycled oil in drying ovens for animal feed precipitated the Irish pork dioxin crisis in 2008.

Organochlorine pesticides (OCPs) are synthetic substances used for pest control that are persistent and widespread in the marine environment. Examples include DDT, lindane (γHCH) and 'drins, such as dieldrin. Because of their toxicity, persistence and tendency to bioaccumulate, action has been taken to globally phase out many of these substances and most of the traditional organochlorine pesticides have been banned in Europe for decades. However, because of their persistence they can still be detected in the environment although environmental concentrations are decreasing.

Polychorinated naphthalenes have been commercially used in electric devices but other uses have included preservative for paper and fabric. Furthermore they can be formed during combustion processes. There are 75 possible congeners and there is concern as some have PBT properties and, given the structural similarities to PCBs and dioxins, can exhibit a dioxin-like mode of toxicity (Jakobsun and Asplund 2000, Fernandes *et al*. 2010).

Brominated flame retardants (BFRs) are used in many products such as textiles and electronic goods. These bromine containing organic compounds include polybromodiphenylethers (PBDEs). Different PBDE technical mixtures exist, such as penta, octa and deca bromodiphenylethers, and are based on the degree of bromination. The penta- and octa-BDEs are banned in Europe, although the deca-BDE mixture may still be used. Other BFRs include hexabromocyclododecane (HBCD) and polybrominated biphenyls (PBBs).

Perfluorooctane sulfonate (PFOS) is part of the large family of perfluoroalkyl sulphonate substances (PFAS). PFOS-related substances are used in a number of industries and products including metal plating, electric and electronic parts, fire fighting foam, photo imaging, hydraulic fluids and textiles. (Anon., 2006). PFOS was added to the list of substances for restricted use under the Stockholm Convention on Persistent Organic Pollutants in 2009.

1.5 Consumer protection and food safety legislation

European policy is now a primary driver for many of the programmes underpinning food safety in Ireland. Risk assessment and risk management are separated in the European framework. The European Food Safety Authority (EFSA) provides scientific opinions as a basis for European policy and legislation, which in turn is implemented by the Directorate General for Health and Consumers. Regulation 178/2002/EC lays down the general principles and requirements of food law. Key measures to protect consumers from unacceptable exposure to contaminants in food include setting regulatory limits in line with the ALARA (As Low As Reasonably Achievable) principle and monitoring compliance against such limits. The FSAI is responsible for ensuring food safety in Ireland and is supported by a number of agencies and government departments. In relation to seafood this includes the Marine Institute and the SFPA. If a serious direct or indirect threat to human health from food or feed is identified, the competent authorities are required to issue a notification on the *Rapid Alert System for Food and Feed* (RASFF) to ensure rapid dissemination of information between member states and to facilitate a fast and coherent response. An example of such a response was the recall of Irish pork products following the dioxin incident in 2008. The contamination was initially detected in routine monitoring under the National Residues Control Plan (NRCP).

1.5.1 Environmental Contaminants

The European Commission set maximum limits for certain environmental contaminants in seafood in Commission Regulation 1881/2006/EC as amended by Commission Regulations 565/2008/EC, 629/2008/EC and 420/2011/EC. The maximum limits are set out in Table 1.1 and these limits are used to assess test results in this report, irrespective of when samples were collected[3].

Currently maximum limits are set in fisheries products for three trace metals (mercury, cadmium and lead), dioxins, dl-PCBs, and benzo(a)pyrene as an indicator of PAH contamination. EC maximum levels for foodstuffs are one pillar of their consumer protection strategy with respect to environmental contaminants. Other pillars are the setting of action levels and maximum levels in animal feed. Feedingstuffs are not within the scope of this report.

Where EC and Irish standards are unavailable, data are compared with the strictest standards for contaminants in seafood as applied in other OSPAR[4] contracting countries as compiled by the OSPAR Commission in 1992. These values have no legal status in Ireland and although updated, where MI is aware of a change since compilation, it is recognised that these may not fully reflect current standards or guidance values in member states. Furthermore, the scientific basis of these standards and their relevance for consumer protection in an Irish context is unclear. However, in the absence of other standards they are useful to compare with monitoring data as guidance values (Table 1.2).

[3] Data are assessed against current limits in this report even through these may not have been in place, or differed, when a given sample was taken.
[4] Oslo Paris Convention for the Protection of the Marine Environment of the North East Atlantic 1992.

Table 1.1: A summary of maximum levels in the edible portion of fisheries products for human consumption as presented in Commission Regulation 1881/2006/EC as amended by Commission Regulations 629/2008/EC, Regulation 565/2008/EC and 420/2011/EC.

Units	mg kg^{-1} ww				ng WHO-TEQ[3] kg^{-1} ww (fat marine oils)	
	Cadmium	Lead	Mercury	PAH-Benzo(a)pyrene	PCDD/Fs	PCDD/F & dl-PCBs
Fish[1]	0.05*	0.3	0.5*	2.0	4.0	8.0*
Marine oils					2.0	10.0
Fish liver						25.0
Bivalve molluscs	1.0	1.5	0.5	10.0	4.0	8.0
Cephalopods	1.0	1.0	0.5		4.0	8.0
Crustaceans[2]	0.50	0.5	0.5	5.0	4.0	8.0
Smoked Fishery products	-	-	-	5.0	4.0	8.0

Selected species for which the maximum level of 1 mg kg^{-1} ww for mercury applies

Muscle meat of the following fish :
Anglerfish (*Lophius species*)
Atlantic catfish (*Anarhichas lupus*)
Bonito (*Sarda sarda*)
Eel (*Anguilla species*)
Emperor, orange roughy, rosy soldierfish (*Hoplostethus species*)
Grenadier (*Coryphaenoides rupestris*)
Halibut (*Hippoglossus hippoglossus*)
Kingklip *(Genypterus capensis)*
Marlin (*Makaira species*)
Megrim (*Lepidorhombus* species)
Mullet (*Mullus species*)
Pike (*Esox lucius*)
Plain bonito (*Orcynopsis unicolor*)
Poor cod (*Tricopterus minutes*)
Portuguese dogfish (*Centroscymnus coelolepis*)
Rays (*Raja* species)
Redfish (*Sebastes marinus, S. mentella, S. viviparus*)
Sail fish (*Istiophorus platypterus*)
Scabbard fish (*Lepidopus caudatus, Aphanopus carbo*)
Seabream, pandora (*Pagellus species*)
Shark (all species)
Snake mackerel or butterfish (*Lepidocybium flavobrunneum, Ruvettus pretiosus, Gempylus serpens*)
Sturgeon (*Acipenser species*)
Swordfish (Xiphias gladius)
Tuna (*Thunnus* species, *Euthynnus* species, *Katsuwonus pelamis*)

Selected species for which the maximum level of 0.1 mg kg^{-1} ww for cadmium applies

Muscle meat of the following fish:
Bonito (*Sarda sarda*)
Common two-banded seabream (*Diplodus vulgaris*)
Eel (*Anguilla anguilla*)
Grey mullet (*Mugil labrosus labrosus*)
Horse mackerel or scad (*Trachurus* species)
Louvar or luvar (*Luvarus imperialis*)
Mackerel *(Scomber species)*
Sardine (*Sardina pilchardus*)
Sardinops (*Sardinops species*)
Tuna (*Thunnus* species, *Euthynnus* species, *Katsuwonus pelamis*)
Wedge sole (*Dicologoglossa cuneata*)

Bullet tuna (*Auxis rochei)* 0.20 mg kg^{-1} ww

Anchovy (*Engraulis australis*) 0.30 mg kg^{-1} ww
Swordfish (*Xiphias gladius*) 0.30 mg kg^{-1} ww

Species for which maximum level of 12 ng WHO-TEQ kg^{-1} ww for sum PCCD/F & dl PCBs applies

European eel (*Anguilla anguilla*)

Notes: 1 Where fish are intended to be eaten whole, the maximum level shall apply to the whole fish

2 Regulation 1881/2006 stated that levels applied to crustaceans excludes the brown meat of crab and the head and thorax meat of lobsters and similar large crustaceans (*Nephropidae* and *Palinuridae*). This was clarified by Regulation 420/2011 which states that maximum limits apply "to muscle meat from appendages (legs and claws) and abdomen. For crabs and crab-like crustaceans, the maximum level applies to the appendages only. This definition excludes other parts of crustaceans, such as the cephalothorax of crabs and inedible parts (shell, tail)".

3 Dioxins (PCDD/Fs) and 'dioxin-like'(dl)-PCBs as ng WHO_{1998} TEQ kg^{-1}. See Box 3 and Appendix A.4.1 for TEQ (Toxic Equivalents) explanation.

Table 1.2: Synopsis of the strictest guidance and standard values (wet weight) applied by various OSPAR countries for contaminants in fish and shellfish for the assessment of the possible hazards to human health (OSPAR Update 1992), updated to incorporate new revised Belgian standard for sum of ICES (International Council for the Exploration of the Sea) 7 PCBs (ICES PCB_7 = Sum of PCB congeners 28, 52, 101, 118, 238, 153, 180).

Contaminant	Values	Qualifier	Food Group	Country
	mg kg^{-1}ww			
Copper	20	Standard	Fish, crustacean and molluscs[1]	Spain
Zinc	50	Guidance	Food[2]	UK
	μg kg^{-1}ww			
p,p'-DDT and metabolites	500	Standard	Fish, crustacean and molluscs	Finland
HCB	50	Guidance	Fish, crustacean and molluscs	Norway
$\alpha + \beta$ HCH	50	Guidance	Fish, crustacean and molluscs	Norway
Lindane	100	Standard	Fish, crustacean and molluscs	Finland
Aldrin + dieldrin	100	Standard	Fish, crustacean and molluscs	Finland
Endrin	50	Standard	Fish, crustacean and molluscs	Finland
ICES PCB_7	75	Standard	Seafood	Belgium

Notes: 1 This value does not apply to oysters for which a higher value of 60 mg kg^{-1} has been set.
2 Excludes foodstuffs where naturally higher levels occur

1.5.2 Residues of authorised and unauthorised veterinary treatments

Veterinary treatments authorised for use in finfish have Maximum Residue Limits (MRLs) set at European level, in accordance with Council Regulation (EC) No. 470/2009 and a complete list of pharmacologically active substances and their MRLs, are available in the Annex to Commission Regulation (EU) 37/2010. The MRL is the maximum concentration of a substance allowable in the edible portion of the animal at the time of harvest. The concentration of a veterinary residue in finfish should not exceed this limit although this should take into account the uncertainty associated with the analytical method. Unauthorised treatments, such as ivermectin and malachite green, should not be used and thus have no MRL. In these cases an analytical method decision limit is used to determine whether a sample is compliant or not and this should be at least as low as the Minimum Required Performance Level (MRPL) for the substance if one is prescribed by the EC. Details of current MRLs and decision limits are given in Table 1.3.

Table 1.3: Maximum residues limits, action limits and guideline values used for assessing compliance of finfish aquaculture monitoring results for veterinary residues and unauthorised substances.

Residue		Maximum Level or Action Level[2]	Source
		µg kg^{-1} ww	
Group A Compounds[1]			
Corticosteroids, Methyltestosterone, Betaestradiol, Chloramphenicol and Nitrofurans		These are banned substances and should not be detected.	
Group B Compounds			
Ivermectin		0.4	Decision Limit[3]
Emamectin B1a		100	Maximum Residue Limit[4]
Cypermethrin		50	Maximum Residue Limit[4]
Deltamethrin		10	Maximum Residue Limit[4]
Teflubenzuron		500	Maximum Residue Limit[4]
Diflubenzuron		1000	Maximum Residue Limit[4]
Malachite Green		1.0	Decision Limit[3]
Leuco Malachite Green		1.0	Decision Limit[3]
Antibacterial Substances by Four Plate Method Group B			
Sulphonamides		100	Maximum Residue Limit[4]
Oxytetracycline	(Tetracyclines)	100	Maximum Residue Limit[4]
Oxolinic Acid	(Quinolones)	100	Maximum Residue Limit[4]
Flumequine	(Quinolones)	600	Maximum Residue Limit[4]
Sarafloxacin	(Quinolones)	30	Maximum Residue Limit

Notes:
1 Commission Regulation (EU) No 37/2010 (Table 2) and Directive 2008/97/EC.
2 Maximum residue limits and action level concentrations are on a wet weight basis.
3 These compounds are not authorised for use in finfish, concentrations above the analytical methods decision limit are non-compliant.
4 Commission Regulation (EU) No 37/2010 on pharmacologically active substances and their classification regarding maximum residue limits in food stuffs of animal origin.

1.6 Marine Institute's monitoring programmes 2004-2008

The Marine Institute carries out various monitoring programmes that provides information on chemical substances in seafood. More details can be found in individual chapters of this report but a brief overview is presented here.

Bivalve molluscs:
The MI annually collects shellfish (primarily mussel and oyster) from shellfish growing waters around the Irish coast and samples are analysed for environmental contaminants, specifically trace metals, PCBs and OCPs. Concentrations of these contaminants are assessed against appropriate regulatory limits where available. As shellfish can accumulate contaminants from the water, levels of these pollutants in shellfish flesh provide a good indicator of ambient pollution status over a period of time.

Fish Landings:
The MI annually collects fish from the main ports and selected available species are analysed for environmental contaminants. As with shellfish, the levels of trace metals, polychlorinated biphenyls (PCBs) and organochlorinated pesticides (OCPs) are measured. Over the years a substantial database of contaminant levels in the main fish species landed in Irish waters has been built up. Again, concentrations are assessed against regulatory limits for fish where available. Such limits are often species specific.

Residues in finfish aquaculture:
EU Directive 96/23/EC, commonly known as the "*Residues Directive*", requires all member states to monitor certain 'substances and residues thereof in live animals and animal products'. In Ireland, the Department of Agriculture, Food and Marine (DAFM) co-ordinate the overall programme. Regulation of the aquaculture industry in Ireland is the responsibility of the Sea Fisheries Protection Authority (SFPA). The Marine Institute is tasked with implementing the monitoring programme for farmed finfish in accordance with the residues directive and does so in collaboration with the SFPA and the FSAI.

In accordance with EC Directive 96/23/EC, the MI collect farmed salmon and trout samples throughout the year. Samples are tested to ensure:

- prohibited substances (such as growth promoters) and other unauthorised substances are not being used;
- authorised fish medicines and treatments are being properly used such that residues of these substances do not exceed Maximum Residues Limits (MRLs) set by the EU; and
- levels of environmental contaminants inadvertently introduced from their environment or from feed (derived from capture fisheries) do not exceed regulatory limits.

This programme therefore:

- ensures Irish aquaculture produce is safe for consumption ;
- provides a body of data to assure that Irish farmed finfish is of a high quality - this is particularly important for supporting the export market; and
- promotes good practice in the aquaculture sector.

More detail is given in Chapter 5.

Box 3: Understanding the information presented in this report.

In the following chapters of this report, data are aggregated and summarised for presentation in simple tables and/or graphs. This box provides some background information for readers who may be unfamiliar with such tables or graphs.

Substance groups and congeners: Many persistent organic pollutants are actually groups of related substances with similar chemical structures and sources. Specifically, many organohalogen substances consist of a basic chemical structure, but with different numbers and positions of halogen atoms on the structure. For example, as there are up to 10 positions for chlorine atoms to attach on the biphenyl rings, this means there are 209 permutations of the PCB structure, i.e. potentially up to 209 individual PCB compounds. These are referred to as congeners.

Concentrations and Toxic Equivalents: Contaminant data are generally expressed in this report as *wet-weight concentrations* (i.e. weight of contaminant per weight of fresh tissue sample) and compared to reference concentrations (limits/standards) expressed in the same unit. For example µg kg^{-1} ww is the equivalent of *Parts per Billion* (ppb).

For many related substances where there is a related source and/or similar toxicological properties, concentrations of these individual substances are summed for a sample. Examples are certain marker PCBs, DDT and its metabolites and dioxins (PCDD/Fs). This is carried out for practicality and to facilitate comparisons to reference limits.

For dioxins and furans convention dictates that data are expressed as *Toxic Equivalents* (TEQs). In this case the concentration determined for each individual congener in a sample is multiplied by a *Toxic Equivalency Factor* (TEF) that represents the relative toxicity of that congener. Thus, compared to total concentration, the total (summed) TEQ-concentration for a sample provides a better estimate of the toxicological risk associated with dioxins in that sample, irrespective of congener distribution. TEQs are also available for dioxin-like PCBs, (a subset of PCBs that have the same toxicity mode as dioxins). This report used WHO 1998 TEQs as these are the basis for current EC food legislation for dioxins and dl-PCBs. More detailed information on TEQs is presented in Appendix A.4.1.

Summary Statistics: Tables typically present simple summary statistics for data for individual species or groups of species over the stated period. Typical statistics include the average concentration (arithmetic mean), median concentration (middle value of dataset arranged in order), maximum concentration and the number of samples in the set. A conservative approach is followed by calculation of upperbound means i.e. where values are below limits of detection/quantification, the limits of detection/quantification are themselves used in the calculation.

Graphical presentations: Data are also presented graphically as bar charts or, more frequently, as box-and-whisker plots. Box-and-whisker plots are a convenient way of visually comparing the concentration ranges for related datasets (e.g. cadmium in different shellfish species). The bulk of the data lies within the whiskers and the box represents the range for the "middle" 50% of the data. The asterisks represent individual outliers. A more detailed explanation is given in Appendix A.4.2. Note that, where relevant and practical, reference concentrations (maximum limits) are depicted on the graph. In some instances the measured data lies well below the reference concentration, necessitating use of split axes (example zinc in bivalve molluscs, Chapter 2).

▶ 2 Environmental contaminants in shellfish 2004-2008

2.1 Molluscs

Box 4: Bivalve mollusc monitoring programme:

Since 1993 the Marine Institute has annually sampled and tested whole bivalve shellfish, specifically mussels (*Mytilus edulis*), native oysters (*Ostrea edulis*) and Pacific oysters (*Crassostrea gigas*) from shellfish growing areas around the Irish coastline. This contributes to national food safety monitoring obligations and the requirements of the shellfish waters directive (Directive 2006/113/EEC, formerly Directive 79/923/EC). This programme is also embedded in the Marine Institute's marine environment assessment programmes. Concentrations of contaminants in shellfish flesh provide a good indicator of ambient water quality and 'musselwatch' programmes are used worldwide for coastal monitoring. All samples are tested for nine trace metals. Selected samples are analysed for PCBs and OCPs, focussing on areas where these pollutants would be most likely found, for example where shellfish waters are close to large urban areas or major riverine inputs. Typically approximately 35 areas have been tested annually including approximately 30 shellfish growing areas and also additional environmental monitoring stations (not reported here). In 2008, testing was expanded with the designation of additional shellfish waters in 2008. There are currently 64 designated shellfish growing waters.

Previously published monitoring data can be found in the following reports: Nixon *et al.,* 1991, 1994 and 1995, Smyth *et al.,* 1997, Bloxham *et al.,* 1998, McGovern *et al.,* 2001, Glynn *et al., 2003a,* 2003b and 2004, Boyle *et al., 2006* and Anon., 2008.

The Marine Institute monitors concentrations of trace metals and organochlorine substances in shellfish (Box 4). During the period 2004 – 2008, 232 mollusc samples were collected from shellfish growing waters comprising of 125 blue mussels, 77 Pacific oysters, 24 native oysters and 6 samples of other species. Between 25 and 32 growing areas were sampled annually up to 2007 and in 2008 72 areas were sampled. Figure 2.1 shows the various locations sampled around the Irish coast during this period.

2.1.1 Contaminants in mussels and oysters

A summary of the concentrations of trace metals and organochlorine substances determined in each of the shellfish species (mussels and oysters) are presented in Table 2.1 and Figures 2.2 and 2.3 as box-and-whisker plots. Monitoring data for this period are presented in Appendix B1. The sampling and analysis methodology and quality assurance information is outlined in Appendix A. Maximum limits for food safety purposes are described in Chapter 1.

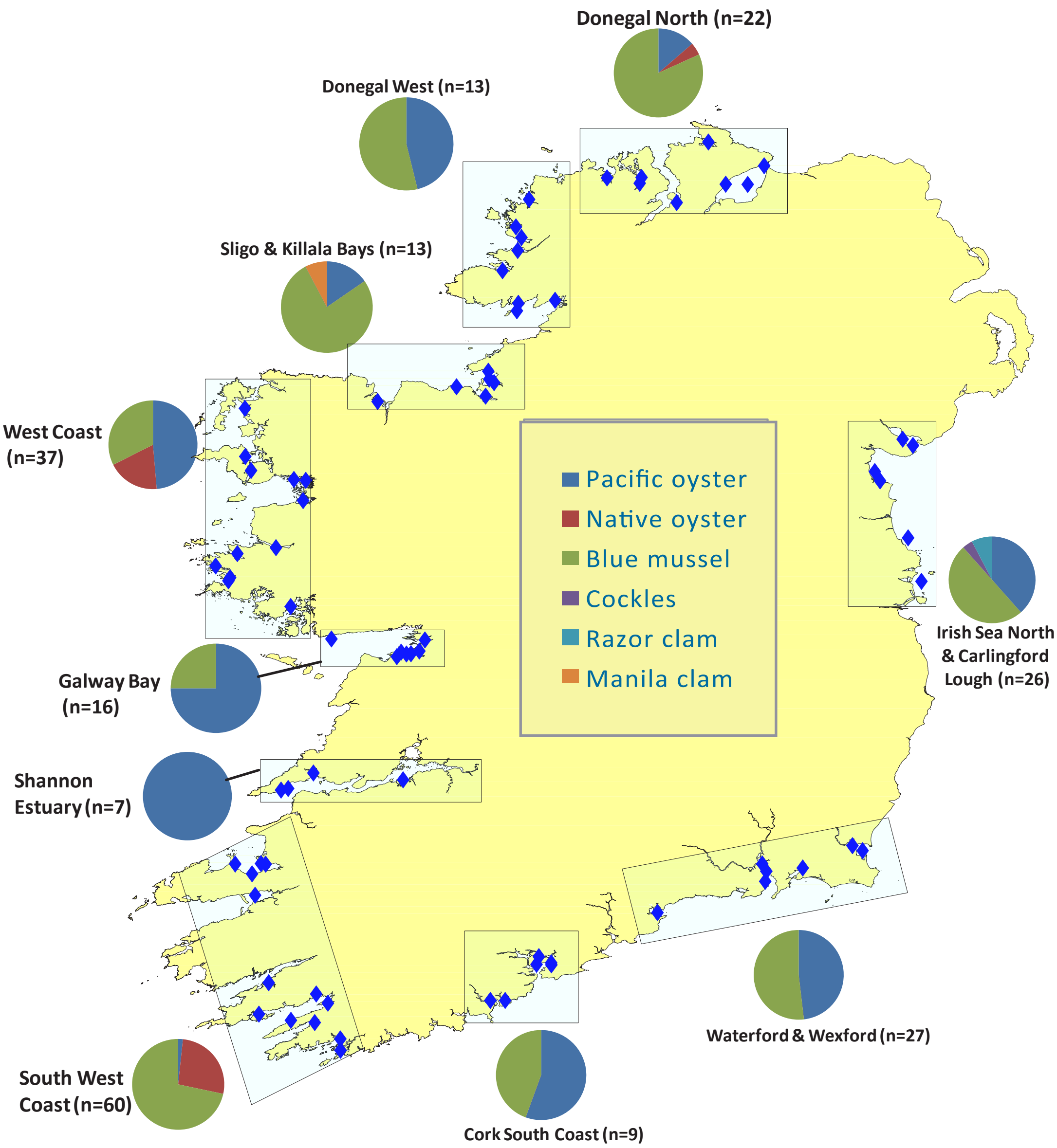


Figure 2.1: Locations of shellfish growing waters sampled for bivalve molluscs during 2004 –2008 and breakdown of species sampled in each region (Please see Appendix B1 for more information)

Table 2.1: Summary statistics of concentrations (upperbound) of (a) trace metals and (b) selected organochlorine contaminants in mussels and oysters from shellfish growing areas sampled during 2004 – 2008.

a) Trace Metals

	mg kg^{-1} ww								
	Arsenic[1]	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
	Blue mussel								
Mean	2.75	0.17	0.24	1.79	0.22	0.03	0.24	0.02	17.6
Median	2.64	0.14	0.19	1.57	0.16	0.02	0.19	0.01	16.8
Maximum	3.91	1.08	2.32	5.44	1.15	0.05	1.01	0.22	31.6
Standard Deviation	0.59	0.12	0.24	0.73	0.17	0.01	0.14	0.03	4.1
Number of Samples	43	125	125	124	125	125	125	125	125
% < LoQ	0.0	0.0	12.1	0.0	8.6	49.1	47.8	29.3	0.0
	Pacific Oyster								
Mean	3.51	0.26	0.15	12.9	0.14	0.02	0.14	0.67	218
Median	3.35	0.26	0.12	10.6	0.13	0.02	0.13	0.57	220
Maximum	5.42	0.64	0.64	45.6	0.47	0.06	0.52	2.78	638
Standard Deviation	1.12	0.11	0.11	8.55	0.08	0.01	0.05	0.51	85.0
Number of Samples	38	77	77	77	77	77	77	77	77
% < LoQ	0.0	0.0	15.6	0.0	9.1	45.5	77.9	0.0	0.0
	Native Oyster								
Mean	2.78	0.63	0.19	16.4	0.08	0.03	0.16	1.67	404
Median	2.40	0.59	0.16	17.7	0.08	0.03	0.13	1.55	407
Maximum	4.45	0.95	0.52	30.2	0.12	0.04	0.44	3.36	596
Standard Deviation	1.07	0.17	0.09	8.61	0.02	0.01	0.06	0.58	85.9
Number of Samples	10	24	24	24	24	24	24	24	24
% < LoQ	0.0	0.0	8.3	0.0	0.0	29.2	62.5	0.0	0.0

Notes: 1 Total arsenic results were determined for samples taken in 2007 and 2008.

b) Organochlorines

	μg kg^{-1} ww							
	PCBs		OCPs					
	CB153	ICES PCB_7 [1]	*p,p'*-DDE	HCB	γHCH	Dieldrin	*cis*-Chlordane	*trans*-Nonachlor
	Blue mussel							
Mean	0.39	1.26	0.39	0.05	0.04	0.27	0.04	0.06
Median	0.31	1.07	0.21	0.03	0.04	0.25	0.03	0.05
Maximum	1.23	3.60	1.66	0.30	0.21	1.18	0.21	0.21
Standard Deviation	0.31	0.84	0.39	0.05	0.04	0.20	0.04	0.05
No. of Samples	52	50	52	52	49	50	45	36
% < LoQ	0.0%		0.0%	28.8%	36.7%	0.0%	0.0%	10.4%
	Pacific Oyster							
Mean	0.33	1.12	0.39	0.04	0.04	0.25	0.09	0.09
Median	0.20	0.88	0.29	0.02	0.04	0.23	0.06	0.09
Maximum	1.33	4.46	1.19	0.31	0.10	0.62	0.29	0.31
Standard Deviation	0.31	0.83	0.32	0.05	0.02	0.14	0.08	0.06
No. of Samples	49	47	45	44	45	44	36	34
% < LoQ	0.0%		2.2%	25.0%	20.0%	0.0%	0.0%	15.6%
	Native Oyster							
Mean	0.23	0.72	0.17	0.03	0.04	0.26	0.04	0.06
Median	0.19	0.55	0.11	0.02	0.04	0.22	0.02	0.04
Maximum	0.54	1.56	0.58	0.11	0.11	0.62	0.15	0.18
Standard Deviation	0.15	0.40	0.17	0.03	0.03	0.19	0.05	0.06
No. of Samples	11	11	9	10	9	9	8	7
% < LoQ	0.0%		0.0%	30.0%	22.2%	0.0%	0.0%	8.3%
	Mussel and oyster							
Mean	0.35	1.14	0.37	0.04	0.04	0.26	0.06	0.07
Median	0.21	0.89	0.22	0.02	0.04	0.23	0.03	0.06
Maximum	1.33	4.46	1.66	0.31	0.21	1.18	0.29	0.31
Standard Deviation	0.30	0.81	0.35	0.05	0.03	0.18	0.06	0.06
No. of Samples	112	108	106	106	103	103	89	77
% < LoQ	0.0%		0.9%	27.4%	28.2%	0.0%	0.0%	11.9%

Notes: 1 For some samples the full suite of 7 congeners was not available. For 2008 samples CB138 and CB 163 were not chromatographically separated. These factors may result in a minor error in sum of ICES PCB_7 for the affected samples

2.1.1.1 Trace metals in mussels and oysters

Shellfish can contain higher concentrations of certain trace metals, such as cadmium and lead, than many other food stuffs including finfish and this is taken into account when maximum limits are set by the European Commission. Furthermore, there are differences in the ability of different shellfish species to regulate certain metals and concentrations can differ widely between related species. For this reason oysters contain higher concentrations of certain metals compared to mussels; most notably zinc, copper, silver and cadmium.

Mercury, cadmium and lead

- Mercury, cadmium and lead concentrations in samples of shellfish collected in Irish waters were consistently below the respective European maximum limits (Regulation 629/2008/EC) with the exception of one mussel sample in 2007 which marginally exceeded the EC maximum limit for cadmium. This exceedance was within the range of uncertainty for the analytical method.

Other trace metals

- For trace metals for which no European limits are set, there were no areas where monitoring shows consistently elevated results compared to other areas.
- Concentrations of copper were considerably lower than the Spanish standard for bivalve molluscs of 20 mg kg^{-1}ww (60 mg kg^{-1}ww oysters) (See Table 1.2).
- Total arsenic was included in monitoring in 2007 for the first time in accordance with the requirements of the shellfish directive. There are no current standards for arsenic in shellfish. It is well known that arsenic can be found in relatively high concentrations in marine fish compared to other foodstuffs of animal origin, but it tends to occur predominantly in organic forms which are considered non-toxic. It should be noted that determination of total arsenic does not discriminate between the non-toxic and toxic inorganic forms of arsenic. There was no clear evidence of appreciably elevated arsenic in any of the samples.

2.1.1.2 "Indicator" PCBs and OCPs

- Levels of *p,p'*-DDE (breakdown product of DDT), dieldrin, *trans*-nonachlor and PCBs were typically low but detectable.
- For aldrin, endrin, DDT and breakdown products (with the exception of *p,p'*-DDE), chlordanes (with the exception of *trans*-nonachlor) and HCHs, levels were low and frequently below the limit of quantification of the analytical method.
- Levels of the ICES 7 indicator-PCBs (ICES PCB_7) were relatively low in Irish shellfish and well below the Belgian national standard for seafood (75 µg kg^{-1}), which is the strictest national standard applied in a European member state.
- Comparison with standards or guidance values available in other OSPAR contracting countries (see Chapter 1; Table 1.2) indicated OCP concentrations in Irish bivalve molluscs to be well below these values; in the region of 3 orders of magnitude lower.
- These very low concentrations of organochlorine contaminants are generally consistent with long-range transport and/or residual contamination associated with historical use. As production/use of most of these organochlorine contaminants has been restricted or ceased altogether the environmental concentrations of these substances are expected to continue to gradually decrease in the future, although their environmental persistence will result in their continued detection in years to come.

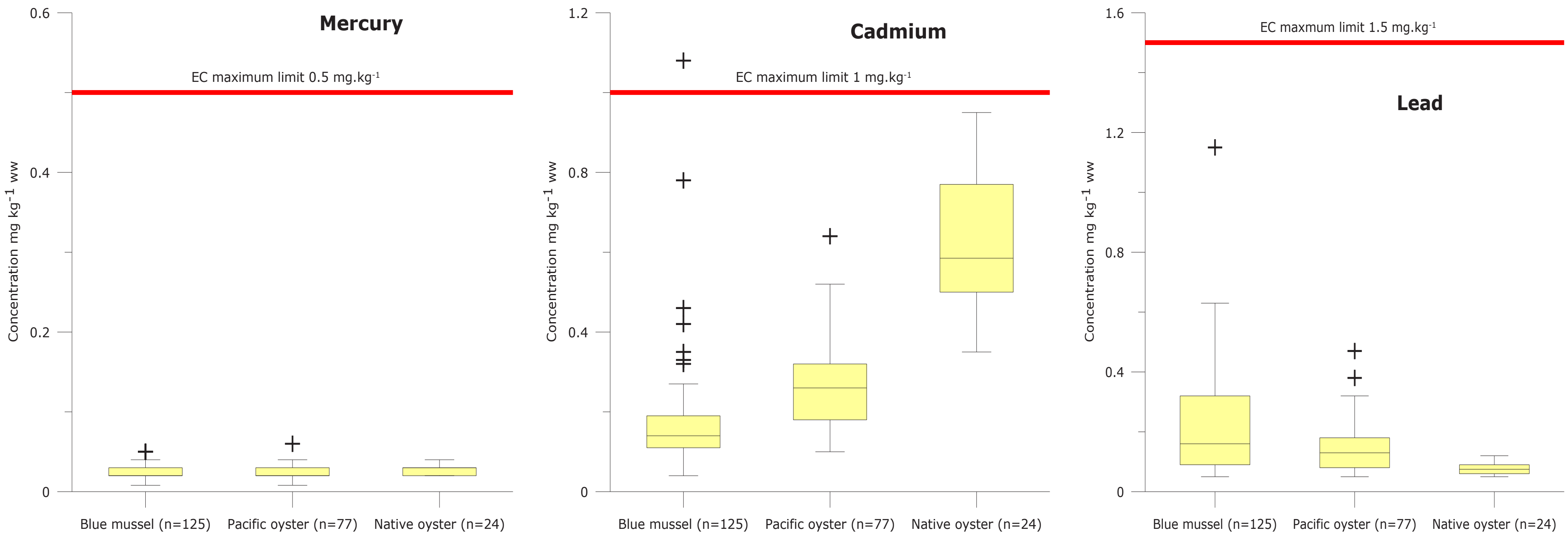


Figure 2.2: Box-and-whisker plots of trace metal concentrations; Mercury, cadmium, and lead (above) and nickel, chromium, arsenic, zinc, silver and chromium (below) in bivalve molluscs sampled from Irish shellfish growing waters 2004 –2008. EU maximum limits are depicted for mercury, cadmium and lead (red lines).

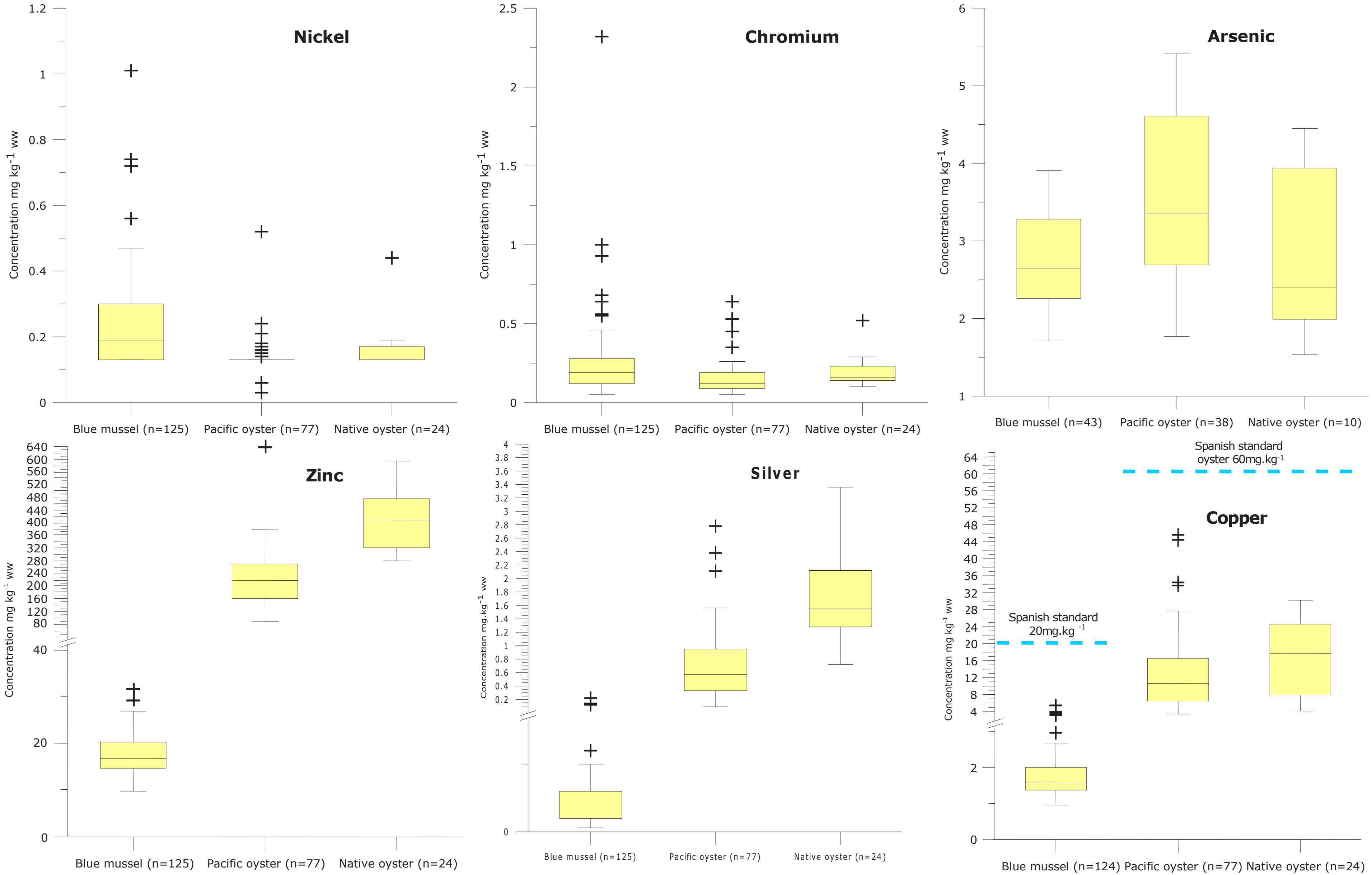


Figure 2.2 continued: Arsenic data refers to 2007 & 2008 only. Where EC limits do not exist and information is available for other European countries limits, these are displayed as broken blue lines. Due to the differences in concentrations between mussels and oysters, broken axes with separate upper and lower linear scales are used for plots of zinc, silver and copper.

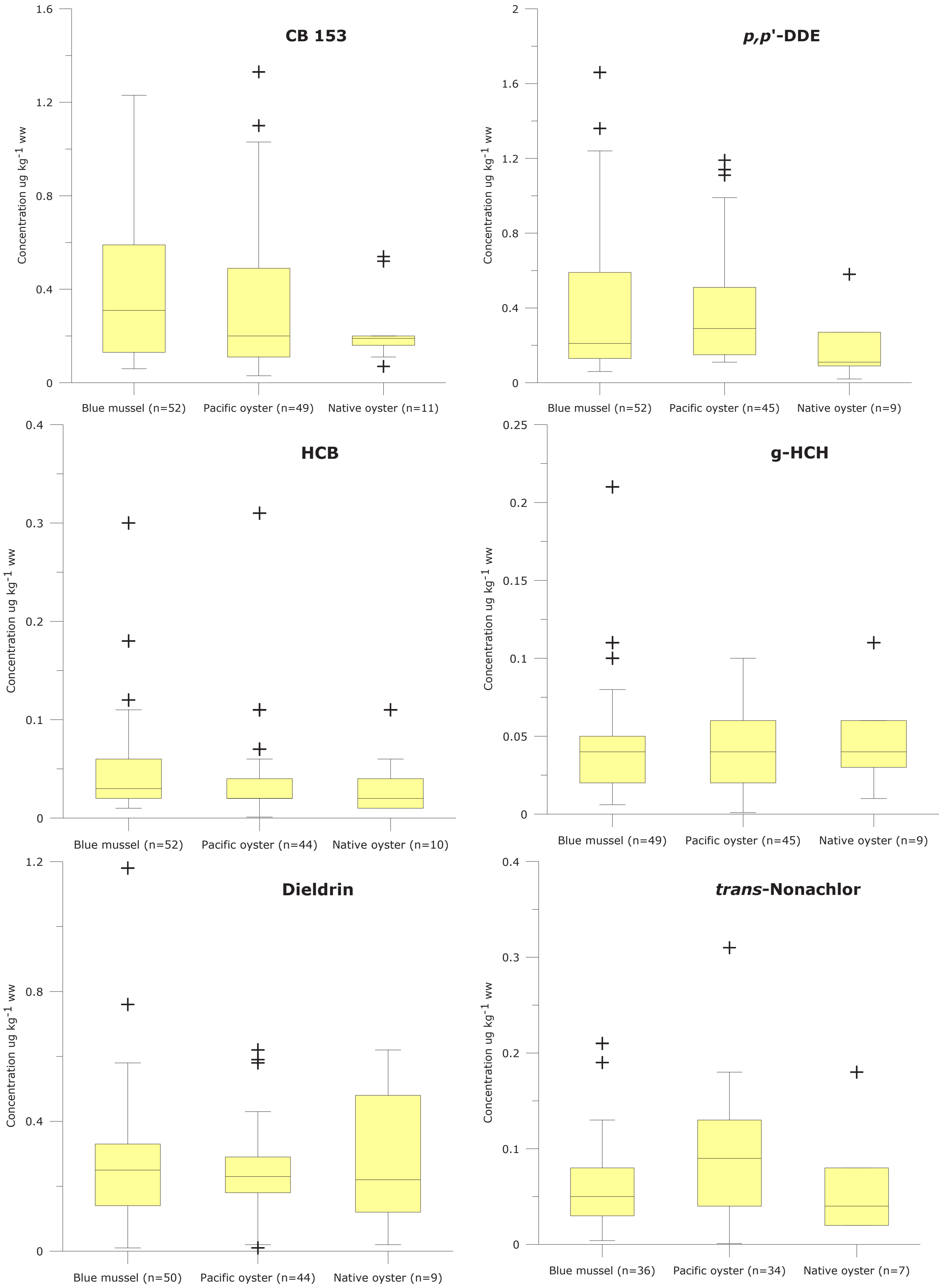


Figure 2.3: Box-and-whisker plots of concentrations of selected persistent organic pollutants (CB153, p,p'-DDE, HCB, γHCH, dieldrin and *trans*-nonachlor) in mussels and oysters sampled from Irish shellfish growing waters 2004 – 2008.

2.1.2 Other bivalve and gastropod molluscs

Although bivalve and gastropod molluscs other than mussel and oyster were not routinely sampled during the 2004 – 2008 period a limited dataset is available for some other species cultivated in Irish waters. Trace metal are presented in Table 2.2. Further information is available in Appendix B.1

Table 2.2: Concentrations of trace metals in individual (pooled) samples of bivalve and gastropod molluscs not included in routine monitoring during 2004 – 2008.

mg kg^{-1} ww												
Year	Common name	Species (Latin)	Tissue	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
	Bivalves											
2008	Cockle	*C. edule*	Whole Tissue	1.72	0.07	0.39	1.91	0.32	<0.02	3.81	0.02	11.0
2008	Razor clam	*E. siliqua*	Whole Tissue	2.22	0.03	0.16	3.91	0.18	<0.02	<0.13	0.56	18.5
2008	Razor clam	*E. siliqua*	Whole Tissue	2.15	0.03	0.12	3.70	0.15	<0.02	<0.13	0.30	18.2
2008	Manila clam	*T. philippinarum*	Whole Tissue	3.54	0.05	<0.05	1.87	<0.05	<0.02	0.19	0.17	12.4
	Gastropods											
2007	Japanese abalone	*H. discus hannai*	Foot Muscle		1.36	0.16	4.28	0.07	0.05	0.85	2.54	13.0
2007	European abalone	*H. tuberculata*	Foot Muscle		6.02	0.09	4.72	0.06	0.04	3.29	3.37	10.9

Bivalve molluscs – Concentrations of trace metals for samples of razor clam, manila clam and cockles were all within the EC limits for mercury, cadmium and lead in bivalve molluscs. Other trace metals and POPs measured were similar in concentrations to mussel and/or oyster with the exception of nickel in cockles. The concentration of nickel in the cockle sample at 3.81 mg kg^{-1} ww was over three times higher than the highest value determined for mussel or oyster and an order of magnitude higher than the mean value for these species. The high nickel concentration in cockles is apparently species specific accumulation as Saavedra *et al*. (2004) also noted high nickel concentrations in this species compared to mussel (*M galloprovincialis*) and clam (*V. pullastra*) in Galicia.

Gastropod molluscs - Abalone

During 2007, trace metal concentrations were determined in the foot muscle of two samples of separate species of abalone obtained from a producer in Ireland. The concentrations of some metals, most notably cadmium and nickel, were higher than that routinely observed for bivalve molluscs. While the cadmium concentrations exceeded the EC maximum limit of bivalve molluscs, abalone is a gastropod mollusc and there are no limits set for trace metals concentrations in gastropods. Nickel concentrations in the foot muscle of the abalone samples, and especially the

H. tuberculata sample which showed similar concentrations to the cockle sample, were also higher than observed for mussels and oysters.

Concentrations of nickel and cadmium measured in cockles and abalone may reflect a propensity of these species to accumulate these metals. Nonetheless this underlines the need for further trace metal concentration data for all shellfish species harvested in Ireland.

2.2 Crustacea

The edible or brown crab (*Cancer pagurus*) fishery is an important fishery on the North Atlantic shelf with Ireland landing approximately 20% of the total catch (FAO Fishstat plus 2008) with much of this exported. During 2007 and 2008, following a series of rapid alerts issued by the Italian authorities, the white meat from the claw of brown crab was tested. The crabs were fished off the northwest Irish coast and landed in Donegal. It is well known that cadmium can accumulate to high levels in the brown meat of crustaceans such as crabs (Davies, 1981, Barrento *et al.,* 2009). The European maximum limit for cadmium in crab applies to the white meat only and explicitly excludes brown meat. Following confusion in interpretation in some European countries this was clarified by Commission Regulation (EU) 420/2011 as relating to the muscle meat from the appendages (legs and claws) only in crabs and crab-like crustaceans (i.e. excludes meat from cephalthorax)[5]. The white meat of the crab claws is the meat most commonly consumed in Ireland although the brown meat is commonly consumed in southern European countries also. Cadmium levels determined in fresh and processed (cooked) crab claw are summarised in Table 3.6. Cadmium concentrations in the samples of fresh crab claw were over an order of magnitude below the EC limit. Concentrations measured in cooked crab claw were apparently higher although no samples breached the EC limit. Concentrations of cadmium in the brown meat (gonads and hepatopancreas) were considerably higher, as anticipated (range: 1.0 – 13.2 mg kg^{-1}ww; mean; 6.4 mg kg^{-1}ww; n=5).

Table 2.3: Summary of cadmium concentrations in fresh and processed white meat of brown crab (*Cancer pagurus*) landed in Ireland and sampled in 2007 & 2008

	mg kg^{-1}ww	
	Cadmium concentration Fresh crab white meat (claw)	Cadmium concentration Cooked crab white meat (claw)
Average concentration	0.013	0.091
Median concentration	0.008	0.045
Maximum concentration	0.045	0.380
Number of samples	12	10
EC Limit	**0.5**	See note

Note: EC maximum limit is for white muscle meat from fresh crab appendages (excluding the brown meat). To apply this limit to processed white crabmeat would require a processing factor to relate the concentration back to unprocessed white meat.

[5] Rapid alerts typically related to homegates of white and brown meat. While white meat is most commonly eaten in some countries brown meat is also eatern by some consumers. For this reason the EC published an information note highlighting that in these countries consumer advice to discourage or limit consumption of brown meat is appropriate http://ec.europa.eu/food/food/chemicalsafety/contaminants/information_note_cons_brown_crab_en.pdf

► 3 Trace Metals in Finfish 2004 -2008

3.1 Trace metals in finfish from Irish capture fisheries

Box 5: Monitoring contaminants in fish landed at Irish ports

Concentrations of contaminants in fish can reflect the ambient levels in the marine environment. The concentrations of contaminants can vary widely between different species and indeed between tissues of an individual fish, reflecting the influence of biological factors on contaminant uptake and elimination. Factors such as diet, fat content, age, condition and ability to regulate or metabolise contaminants are all key factors influencing contaminant levels in fish.

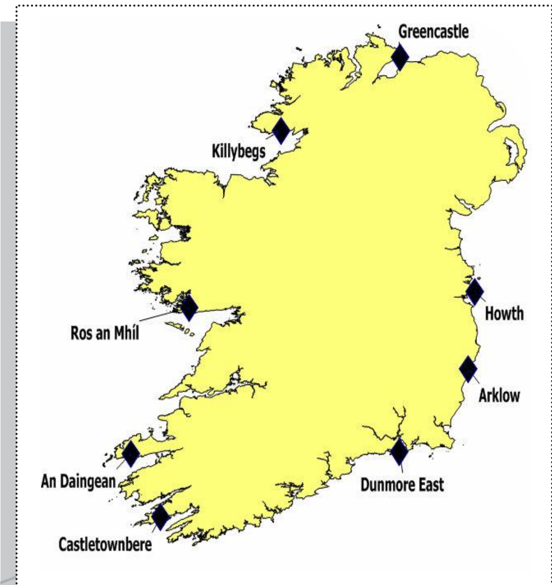
The Marine Institute carries out surveillance monitoring of environmental contaminants, in particular total mercury, in seafood sampled from the capture fisheries as part of a long standing programme. Samples of various fish species, landed at selected Irish ports, are collected on an annual basis and a portion of the edible tissue is analysed for nine trace metals. Organochlorine contaminants are also tested in a subset of samples (see Chapter 4). Over the years this monitoring, supplemented by various projects, has provided a substantial database of contaminant concentrations in a wide variety of fish species landed at Irish ports. As well as checking compliance with European contaminant regulations this information is invaluable in establishing the range of naturally occurring and anthropogenic substances in fish from the north-east Atlantic. These data inform the process of setting realistic maximum limits at European level and provide essential information to support risk assessments of dietary intake of contaminants.

Previously published monitoring results for this programme have been reported in Nixon *et al.* 1994a, 1993, 1995; Rowe *et al.* 1998; Bloxham *et al.* 1998; Tyrrell *et al.* 2003a, 2003b, 2004, 2005;

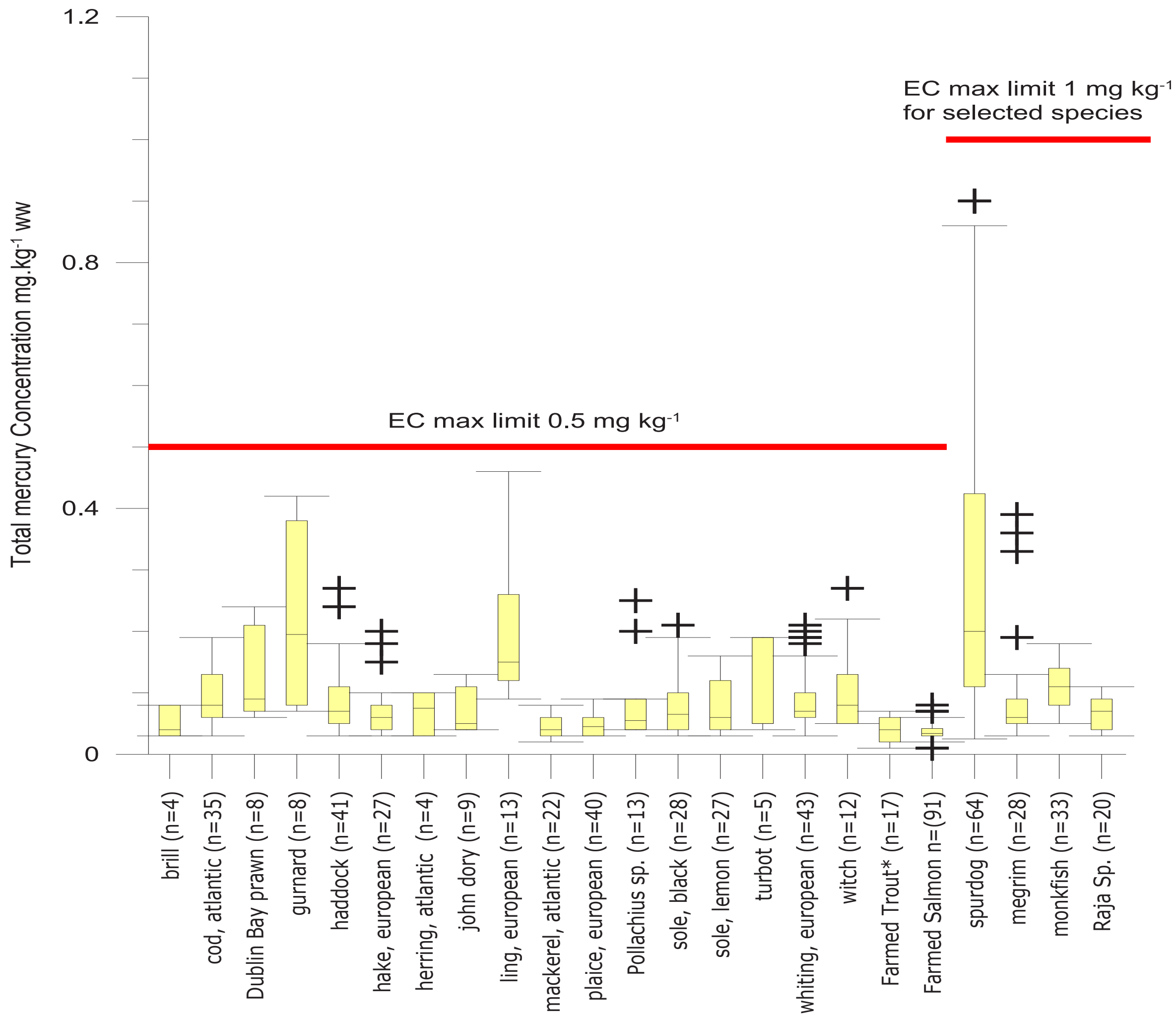
The Marine Institute annually samples a number of fish species landed at Irish ports and analyses the edible portion for trace metals and POPs (Box 5). Table 3.1 shows the ports visited at least once over the period 2004 – 2008 and the number of fish samples collected each year. At least 4 ports were sampled each year. 155 samples were collected during this period covering 31 species. In this assessment some related species are grouped for presentation, for example two monkfish species are grouped as are all gurnard species. Therefore, results are presented for 26 different fishes (i.e. 26 different fish types though not necessarily species). 154 results are available for mercury, 99 for cadmium and lead, 72 for copper, chromium, nickel, silver and zinc, and 20 for total arsenic, the latter having been added to the suite of determinants in 2008. A full description of sampling, preparation and analysis is given in Appendix A.

Table 3.1: Ports sampled during 2004 – 2008.

Port	Number of samples collected					
	2004	2005	2006	2007	2008	Total
Arklow					5	**5**
Castletownbere	8	6		7	10	**31**
Dingle			8			**8**
Dunmore East	9	9	7	7	7	**39**
Greencastle		6			8	**14**
Howth	3	10	5	5		**23**
Killybegs	6			1		**7**
Ros an Mhíl	7	5	5	5	6	**28**
Grand Total	**33**	**36**	**25**	**25**	**36**	**155**



Maximum concentrations of trace metals for finfish species sampled in this programme during 2004-2008 are given in Tables 3.2 and 3.3. For many of these elements the bulk of measurements fall below the limits of quantification of the analytical method. Where this is not the case (mercury, arsenic, copper and zinc) the mean values are also presented. All fish landed and sampled at Irish ports complied with relevant EC regulatory limits for mercury, cadmium and lead. Figure 3.1 presents a box-and-whisker plot of mercury concentrations for various fishes landed at Irish ports and sampled over the period 1996 – 2008. This indicates consistent compliance with the regulatory limits although the upper range for spurdog, gurnard and ling approaches the relevant EC regulatory limit. Full results are given in Appendix B.2



* Sea-reared and freshwater rainbow trout (2004-2008)

Figure 3.1: Box-and-whisker plot of mercury concentrations in fish landed at Irish ports 1996-2008 (minimum of 4 samples) from the Marine Institute database. Red lines indicate the EC maximum limits.

Table 3.2: Maximum and upperbound mean values for mercury, cadmium and lead determined for finfish from Irish waters 2004-2008.

	Mercury				Cadmium			Lead		
	mg kg^{-1} ww				mg kg^{-1} ww			mg kg^{-1} ww		
	ML[1]	Mean[2]	Max	n	ML[1]	Max	n	ML[1]	Max	n
Brill	0.5	**0.040**	0.050	2	0.05	<0.002	1	0.3	<0.008	1
Cod, Atlantic	0.5	**0.085**	0.160	8	0.05	<0.004	6	0.3	<0.050	6
Dogfish, Lesser spotted	1.0		0.430	1	0.05	<0.004	1	0.3	<0.020	1
Eel, European	1.0		0.190	1	0.1	<0.002	1	0.3	<0.050	1
Gurnard	0.5	**0.213**	0.380	3	0.05	<0.002	2	0.3	<0.050	2
Haddock	0.5	**0.084**	0.120	14	0.05	<0.004	9	0.3	<0.060	9
Hake, European	0.5	**0.081**	0.200	10	0.05	<0.004	5	0.3	<0.050	5
John Dory	0.5	**0.080**	0.130	3	0.05	<0.002	2	0.3	<0.050	2
Ling, European	0.5	**0.150**	0.260	5	0.05	<0.004	4	0.3	<0.051	4
Mackerel, Atlantic	0.5	**0.054**	0.080	7	0.1	<0.005	7	0.3	<0.052	7
Megrim	1.0	**0.149**	0.390	8	0.05	<0.002	4	0.3	<0.053	4
Monkfish	1.0	**0.108**	0.160	16	0.05	<0.004	15	0.3	<0.054	15
Mullet, Red	1.0		0.160	1	0.05	<0.002	1	0.3	<0.055	1
Plaice, European	0.5	**0.055**	0.090	13	0.05	<0.004	8	0.3	<0.056	8
Pollock	0.5	**0.037**	0.040	3	0.05	<0.002	2	0.3	<0.008	2
Ray (*Raja* sp.)	1.0	**0.067**	0.090	7	0.05	<0.002	3	0.3	<0.050	3
Saithe	0.5		0.090	1	0.05	<0.002	1	0.3	<0.008	1
Salmon, Atlantic (wild)	0.5		0.100	1	0.05	<0.002	1	0.3	<0.008	1
Salmon, Atlantic (farmed)[6]	0.5	**0.037**	0.08	91	0.05	0.04	91	0.3	0.26	91
Sole, Black	0.5	**0.078**	0.180	9	0.05	<0.002	4	0.3	<0.050	4
Sole, Lemon	0.5	**0.087**	0.160	13	0.05	<0.004	5	0.3	<0.051	5
Spurdog	1.0	**0.503**	0.730	4	0.05	<0.005	4	0.3	<0.052	4
Spurdog[7]	1.0	**0.250**	0.90	60	0.05			0.3		
Turbot	0.5	**0.083**	0.190	4	0.05	<0.004	3	0.3	<0.020	3
Whiting,European	0.5	**0.108**	0.210	15	0.05	<0.004	8	0.3	<0.050	8
Trout (farmed)[8]	0.5	**0.040**	0.07	18	0.05	0.03	18	0.3	0.06	18
Witch	0.5	**0.070**	0.080	3	0.05	<0.004	1	0.3	<0.020	1
Wolffish	0.5		0.190	1	0.05	<0.005	1	0.3	<0.008	1

Notes: 1 Relevant EC maximum limits (MLs) as defined in Regulation 629/2008/EC.
2 Upperbound mean values for where there is more than one sample per species
n= numbers sampled

[6] Sampled as part of the "Residues Directive" (96/23/EC). See Chapter 5 for more information.
[7] Study of mercury in spurdog. Samples collected during Marine Institute fisheries surveys.
[8] Sea reared and freshwater reared rainbow trout (*Oncorhynchus mykiss*) sampled as part of the "Residues Directive" (96/23/EC). See Chapter 5 for more information.

Table3.3: Maximum and upperbound mean values for arsenic, chromium, copper, nickel, silver and zinc determined for finfish from Irish waters 2004 -2008. There are no relevant maximum limits set by the EC for these elements.

	Arsenic			Chromium		Copper			Nickel		Silver		Zinc		
	mg kg^{-1} ww			mg kg^{-1} ww		mg kg^{-1} ww			mg kg^{-1} ww		mg kg^{-1} ww		mg kg^{-1} ww		
	Mean[1]	Max.	n	Max.	n	Mean[1]	Max.	n	Max.	n	Max.	n	Mean[1]	Max.	n
Brill				<0.050	1		0.20	1	<0.030	1	<0.003	1		2.58	1
Cod, Atlantic				0.070	5	**0.27**	0.70	5	<0.060	5	0.010	5	**2.64**	3.48	5
Dogfish, Lesser Spotted				<0.070	1		<0.44	1	<0.061	1	<0.010	1	**6.46**	6.46	1
Eel, European				<0.050	1		0.44	1	<0.030	1	<0.003	1		5.40	1
Gurnard		2.30	1	<0.020	1		<0.20	1	<0.130	1	<0.003	1		2.55	1
Haddock		8.82	1	<0.070	5	**0.41**	0.68	5	<0.060	5	<0.010	5	**2.53**	2.98	5
Hake, European				<0.070	4	**0.25**	0.34	4	<0.060	4	<0.010	4	**2.35**	3.00	4
John Dory		0.61	1	<0.050	1		<0.20	1	<0.030	1	<0.003	1		2.23	1
Ling, European		8.37	1	<0.070	4	**0.30**	0.45	4	<0.060	4	<0.010	4	**2.64**	2.80	4
Mackerel, Atlantic		1.10	1	<0.070	6	**0.74**	1.07	6	<0.130	6	<0.010	6	**3.48**	4.50	6
Megrim		11.6	1	<0.050	4	**0.50**	1.13	4	<0.130	4	<0.013	4	**2.74**	3.23	4
Monkfish	**9.00**	11.2	4	0.230[9]	12	**0.25**	0.58	12	<0.130	12	<0.010	12	**3.02**	3.75	12
Mullet, Red				<0.020	1		0.22	1	<0.030	1	<0.003	1		2.68	1
Plaice, European	**18.9**	28.9	3	<0.050	3	**0.30**	0.48	3	<0.030	3	<0.003	3	**3.62**	3.70	3
Pollock		1.32	1	<0.020	1		<0.20	1	<0.030	1	<0.003	1		2.94	1
Ray		26.7	1	0.070	2	**0.42**	0.63	2	<0.030	2	<0.003	2	**2.95**	3.37	2
Saithe		1.80	1	<0.050	1		<0.20	1	<0.030	1	<0.003	1		3.73	1
Salmon, Atlantic (wild)				0.050	1		0.29	1	<0.030	1	<0.003	1		3.73	1
Sole, Black		2.30	1	0.060	2		<0.20	2	<0.030	2	<0.003	2	**3.27**	3.57	2
Sole, Lemon		35.5	1	<0.070	4	**0.25**	0.40	4	<0.130	4	<0.010	4	**2.62**	3.04	4
Spurdog				0.090	4	**0.58**	0.84	4	<0.130	4	<0.010	4	**2.05**	2.25	4
Turbot				<0.070	3	**0.34**	0.44	3	<0.130	3	<0.010	3	**3.34**	3.69	3
Whiting, European		2.92	1	0.080	4	**0.32**	0.40	4	<0.130	4	<0.003	4	**2.55**	2.81	4
Witch				0.070	1		<0.16	1	<0.060	1	<0.010	1		2.15	1
Wolffish		10.7	1												

Notes: n= numbers sampled   1 Upperbound mean values for where there is more than one sample per species

[9] Maximum concentration for chromium in monkfish was determined as 0.23 mg.kg^{-1} ww. Chromium concentration in all other monkfish samples (n=11) <0.08 mg kg^{-1} ww

3.2 Trace metals in farmed fish

As part of the annual National Residues Control Plan required under the "Residues Directive" (96/23/EC), farmed salmon and trout collected at harvest are sampled and tested for, *inter alia,* mercury, cadmium and lead. Summary data for this are also included in Table 3.2 and Figure 3.1. Concentrations of these elements in Irish farmed fish are consistently within relevant regulatory limits. More information on contaminants and veterinary residues in farmed fish is given in Chapter 5.

3.3 Studies on mercury in predatory fish

3.3.1 Mercury in spurdog (*Squalus acanthias*)

The spurdog, or spiny dogfish, *Squalus acanthias* is a small shark species fished in Atlantic shelf waters. In general, sharks have been reported to accumulate mercury concentrations to a greater extent than many other fish. Consequently the Marine Institute's Marine Environment and Food Safety service group and Fisheries Science service team conducted a survey of mercury levels in spurdog in Irish waters and samples were collected during Marine Institute fisheries surveys in 2005 and 2006. Sixty samples were analysed for total mercury and results are summarised in Table 3.4. As a shark species the higher EC maximum limit of 1 mg kg^{-1} ww applies[10]. All concentrations of total mercury measured were within this limit and the mean value (0.25 mg kg^{-1} ww) was well below. Nonetheless the highest concentrations measured (maximum = 0.9 mg kg^{-1} ww) approached the EC limit.

The primary toxicological concern associated with mercury in the diet is with the organic form, methylmercury, which is a known neurotoxin. This is usually the predominant form of mercury accumulated in fish and therefore, due to the analytical challenge of measuring methylmercury, total mercury is routinely measured and assumed as 100% methylmercury. However, a more accurate assessment of risk requires information on methylmercury concentrations. Six samples representing the range of total mercury concentrations in spurdog were analysed for methylmercury by a specialist laboratory. In these six samples methylmercury accounted for 58% to 100% of total mercury with the lower proportions associated with the higher concentrations of total mercury.

[10] Commission Regulation (EC) No 629/2008 of 2 July 2008 amending (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs (see Section 1).

Table 3.4: Summary statistics for total mercury and methylmercury concentrations in spurdog.

	mg kg^{-1} ww	
	Total Mercury	Methylmercury
Average	0.25	0.42
Median	0.19	0.49
SD	0.22	0.31
Range	0.03 – 0.90	0.03 - 0.75
n	60	6

Note: n=numbers sampled

3.3.2 Total mercury in selected fish sampled at retail level

It is well known that high mercury concentrations are associated with certain large predatory fish species such as swordfish and marlin. Consequently, many food safety agencies worldwide, including the FSAI[11], have issued health advisories recommending that children and women of child bearing age avoid or limit consumption of certain species. In 2008 the Marine Institute collaborated with the FSAI in a survey of mercury in fish sampled at retail level and the results are summarised in Table 3.5. This was primarily aimed at species that can accumulate mercury; specifically tuna, swordfish, marlin, although cod was also sampled. Most fish sampled were imported and where information was available on the origin for the tuna, swordfish and marlin, this indicated they had been sourced from the Pacific or Indian oceans. (see Appendix B.3). Information on the species of tuna or marlin was not available[12]. The results of testing for total mercury are presented in Table 3.5. All seven cod samples, of which six were North Atlantic cod and one from Alaska, were within the EC maximum limit of 0.5 mg kg^{-1} ww. The higher maximum limit of 1.0 mg kg^{-1} ww applies to tuna, swordfish and marlin. All eight tuna samples were within the higher mercury limit. Three of the six swordfish samples marginally exceeded the standard. The highest concentration was for a marlin sample from Indonesia. The mercury concentration in a second marlin sample with origins in Ecuador was more than one order of magnitude lower. The elevated mercury in a marlin sample (3.46 mg kg^{-1} ww) triggered the FSAI to issue a *Rapid Alert* in accordance with EC food legislation.

Table 3.5: Total mercury concentrations in fish sampled at retail 2008

	mg kg^{-1} ww		
	Concentration Range	n	EC Maximum limit
Tuna	0.18 - 0.85	8	1.0
Marlin	0.15 - 3.46	2	1.0
Swordfish	0.43 - 1.37	6	1.0
Cod	0.05 - 0.21	7	0.5

Note: n=numbers sampled

[11] http://www.fsai.ie/details.aspx?id=7160

[12] Tuna is a common name for many species of the family *Scombridae* and mostly in genus *Thunnus*. Albacore (*Thunnus alunga*) is the species landed in Ireland. Five of eight tuna samples were indicated as having been sourced in Sri Lanka with the origin of the other samples not reported

3.4 Assessment of trace metal levels in finfish

Mercury

- Mercury is well known to accumulate in fish tissue, primarily as the toxic methylmercury form. This is most evident in long lived predatory fish. During 2004 - 2008 total mercury levels were monitored in a range of species landed in Ireland and all were found to be within the general standard of 0.5 mg kg^{-1} ww and the higher standard of 1.0 mg kg^{-1} ww applicable for specified species.
- The highest individual recorded concentrations for total mercury in finfish from Irish waters during 2004 - 2008 were for spurdog, lesser spotted dogfish, megrim and gurnard. As spurdog and lesser spotted dogfish are shark species the higher standard applies. A study of total mercury in spurdog indicated that, although levels were higher than for other species monitored, the proportion of methylmercury in a small subset of samples varied greatly and appeared lowest in samples with highest total mercury concentration. More information on methylmercury levels is needed for species with high total mercury.
- Figure 3.1 illustrates over a 12 year period that while there is appreciable inter species differences in the ranges and concentrations of mercury in the edible portion of fish landed at Irish ports, mercury concentrations have been consistently within the appropriate EC limits. This shows spurdog, gurnard and ling has consistently higher mercury concentrations than other species, although it is recognised that data are not available for some key species such as albacore.
- Concentrations of total mercury in farmed salmon and trout are consistently within the relevant EC maximum limit (0.5 mg kg^{-1} ww).
- High levels of mercury were determined in imported samples of swordfish and marlin collected at retail outlets with 3 of 6 swordfish samples marginally exceeding the higher mercury limit but a marlin sample from Indonesia exceeded the limit by more than a factor of 3. Consumers should be aware of the potential for high mercury concentrations in these long lived predatory species.

Cadmium and lead

- All cadmium levels in samples of edible tissue from finfish landed at Irish ports and from farmed salmon and trout in 2004 - 2008 were well within the lower limit of 0.05 mg kg^{-1} ww.
- Similarly concentrations of lead in finfish were well below the EC maximum limit of 0.3 mg kg^{-1} ww applicable.

Other trace metals

- While there are no EC standards for other trace metals tested (copper, chromium, nickel, silver and zinc), copper concentrations are all well within the Spanish standard for fish and zinc levels are well below the UK general food standard (as listed in Table 1.2).
- Fish is one of the main sources of total arsenic in the human diet but this is predominantly as the relatively benign arsenobetaine. Concentrations of toxic inorganic arsenic should also be determined to support risk assessments for seafood consumers.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► 4 Persistent Organic Pollutants in Finfish 2004 - 2008

Persistent organic pollutants (POPs) are global pollutants widely distributed through atmospheric pollution (see Box 2). Given the persistence of these substances and their propensity to bioaccumulate, and indeed magnify up the food chain, concentrations in edible tissues of different fish species are largely governed by biological factors. Key factors include fat (lipid) content, diet of the fish (position in food chain), and age and sex of the fish.

The Marine Institute has carried out surveillance monitoring of indicator PCB and certain OCP concentrations in finfish landed at Irish ports since the early 1990s. Section 3.1 and Box 5 provides information on the Irish port landings monitoring programme for contaminants. During the 2004 -2008 period, 62 samples of finfish landed at Irish ports were collected and tested for indicator PCBs and OCPs and approximately 22 species were sampled during this period. In this assessment some related species are grouped for graphical presentation. This was supplemented by one-off surveys focused on other POPs including:

- a preliminary investigation of brominated flame retardants (BFRs) in farmed salmon (2004)
- an investigation of polychlorinated biphenyls (PCBs), dioxins (polychlorinated dibenzodioxins and polychlorinated dibenzofurans - PCDD/Fs) and BFRs in Irish fish and other seafood sold on the Irish market (see Box 6)
- an investigation of POP levels in European eels from five Irish catchments (see Box 7).

As part of the "Residues Directive" (96/23/EC) (see Chapter 5) farmed fish are also subject to routine surveillance monitoring for indicator PCBs and OCPs. Data from these programmes and projects are presented by substance group below. A full description of sampling, preparation and analysis is given in Appendix A. Marine Institute monitoring data (2004 – 2008) for indicator PCB and OCP in fish landed at Irish ports are presented in Appendix B2.

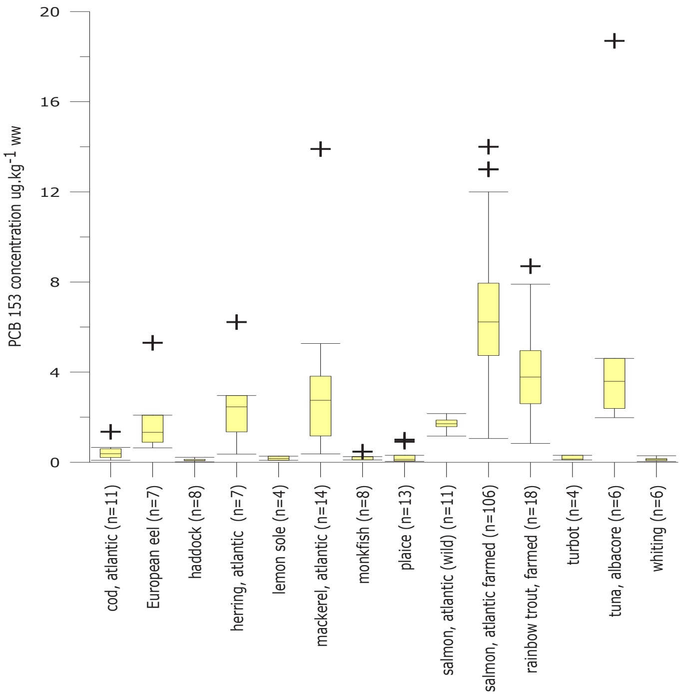
4.1. Organochlorine pesticides in Irish finfish

Table 4.1 shows mean and maximum concentrations of selected OCPs for finfish sampled during 2004-2008. In general OCP levels in Irish fish are very low and often close to the limits of detection of the analytical methods. *p,p'*-DDE (a breakdown product of DDT), dieldrin, HCB and *trans*-nonachlor were generally detected in samples analysed but concentrations of other OCPs, including HCHs such as lindane (*γ*-HCH), aldrin, isodrin, endrin, and chlordanes were detected less frequently and, if detected at all, were present in very low concentrations. Figure 4.1 shows distribution of *p,p'*-DDE, dieldrin and *trans*-nonachlor in various fish. As expected levels are highest in oily fish such as farmed salmon, trout and eel.

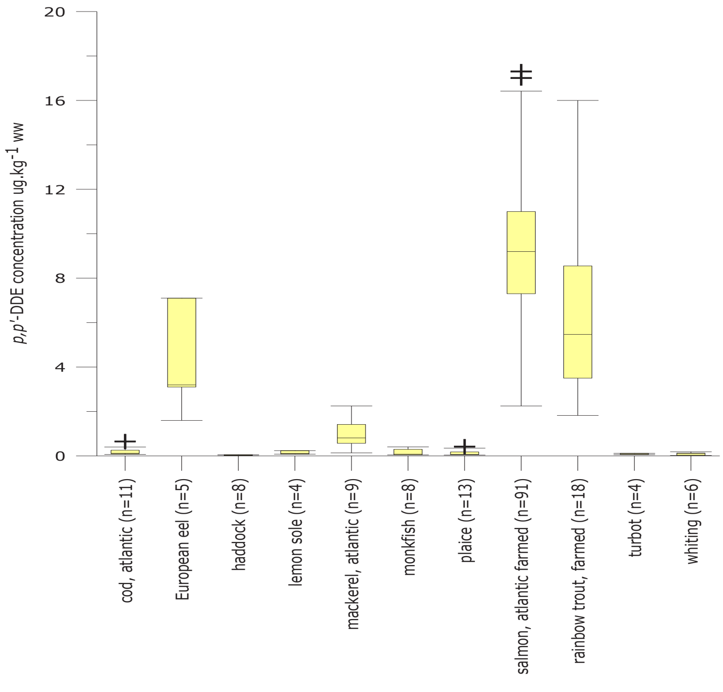
There are no EC standards for OCPs in fish. Concentrations measured were considerably lower (typically over one order of magnitude lower for oily fish and over 3 orders of magnitude for other species) than the strictest known fish standards applied by other OSPAR member states (see Table 1.2). Most of these ubiquitous pesticides have been controlled or phased out for many years through regional or global instruments such as the Stockholm Convention. Consequently the environmental concentrations of OCPs can be expected to continue to decline.

4.2 'Indicator' PCBs in Irish finfish

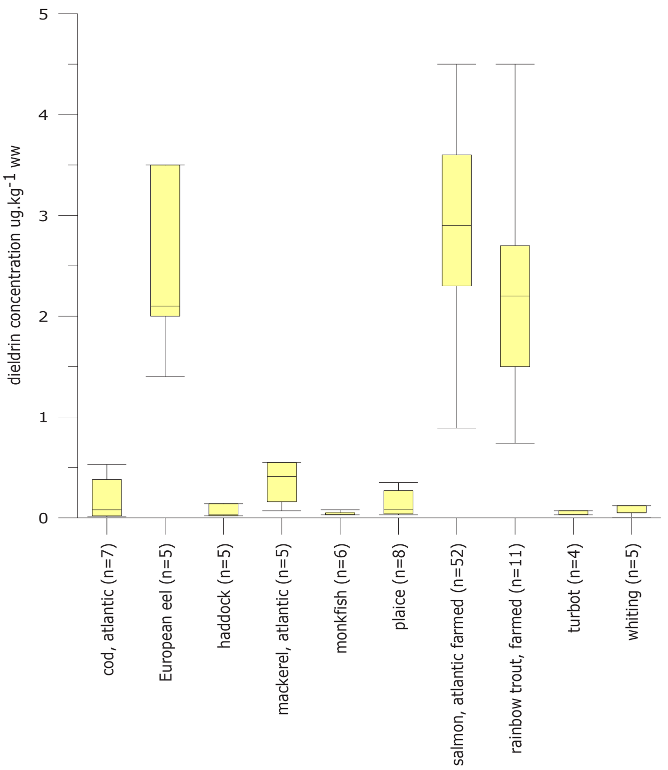
Table 4.1 shows mean and maximum concentrations of indicator PCBs for finfish sampled during 2004-2008. Figure 4.1 presents a box-and-whisker plot of CB153 concentrations for finfish over the period 1996 – 2008. The "ICES 7" PCB congeners are abundant in fish and are commonly used as indicators of PCB contamination. CB153 is typically the dominant PCB congener found in fish tissue and therefore is useful for comparing species. Indicator PCBs were the most abundant POPs determined in finfish during monitoring over the 2004-2008 period. The species exhibiting highest concentrations were the lipid rich species with, spurdog (mean 23.6 µg kg^{-1} ww sum of ICES 7 PCBs; only 2 samples) and farmed salmon (mean 21.0 µg kg^{-1} ww sum of ICES 7 PCBs; n= 73) showing the highest levels. There is no EC regulation setting limits for indicator PCBs in fish tissue although the introduction of such regulations is anticipated. The Belgian standard of 75 µg kg^{-1} ww is currently the strictest national limit applied in Europe for the sum of the ICES 7 PCB congeners. All seafood samples tested during 2004 - 2008 complied with this limit.



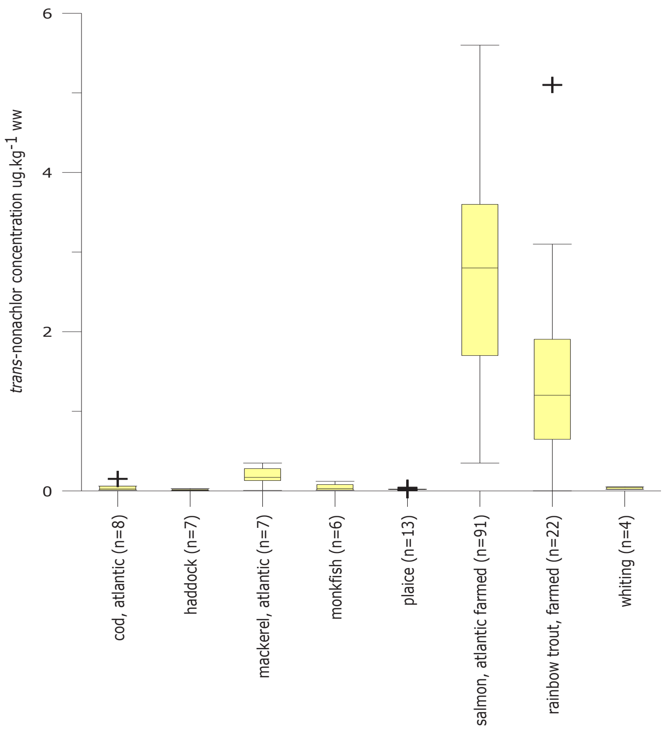
a) CB 153



b) *p,p'*-DDE



c) dieldrin



d) *trans*-nonachlor

Figure 4.1: Box-and-whisker plots for selected POP concentrations in Irish finfish for which there were at least 4 results in database 1996-2008 (farmed fish for 2004 -2008 period).

Table 4.1: Summary of monitoring results for organochlorine contaminants in finfish from Irish waters sampled during 2004 -2008. Upperbound mean and maximum values are shown for indicator PCBs and the most abundant organochlorine pesticides determined. Data are drawn from annual port monitoring programme, the residues monitoring programme for farmed fish (see chapter 5) and various one-off surveys.

	ICES PCB_7[13]			CB153			*p,p'* DDE			Dieldrin			HCB			HCH			*trans*-Nonachlor		
	µg kg^{-1} ww			µg kg^{-1} ww			µg kg^{-1} ww			µg kg^{-1} ww			µg kg^{-1} ww			µg kg^{-1} ww			µg kg^{-1} ww		
	Mean[1]	Max.	n	Mean	Max.	n	Mean	Max.	n	Mean	Max.	n	Mean	Max.	n	Mean	Max.	n	Mean	Max.	n
Brill		0.25	1		0.074	1		0.047	1		0.042	1		0.04	1		<0.008	1			
Cod, Atlantic	**0.95**	1.60	4	**0.383**	0.658	4	**0.115**	0.134	4	**0.040**	0.084	4	**0.05**	0.06	4	**<0.008**	0.010	4	**0.030**	0.030	1
Dogfish, Lesser Spotted		1.16	1		0.440	1		0.170	1		0.080	1		0.02	1		0.010	1		0.030	1
Eel, European	**5.94**	18.1	8	**1.78**	5.30	8	**3.422**	7.1	6	**1.918**	3.5	6		0.14	1	**0.223**	0.45	6	**0.567**	1.6	6
Gurnard		2.84	1		1.108	1		0.599	1		0.200	1		0.04	1		0.025	1		0.025	1
Haddock	**0.23**	0.36	5	**0.079**	0.130	5	**0.022**	0.040	5	**0.051**	0.137	5	**0.05**	0.08	5	**0.013**	0.020	5	**0.011**	0.020	4
Hake, European	**1.23**	2.94	4	**0.466**	1.153	4	**0.318**	0.640	4	**0.108**	0.240	4	**0.13**	0.20	4	**0.015**	0.032	4	**0.192**	0.427	3
Herring	**7.68**	8.44	4	**2.65**	2.96	4															
John Dory		0.23	1		0.089	1		0.036	1		0.047	1		0.04	1		<0.007	1			
Ling, European	**1.01**	2.12	3	**0.390**	0.770	3	**0.177**	0.330	3	**0.050**	0.090	3	**0.04**	0.06	3	**0.010**	0.014	3	**0.022**	0.030	2
Mackerel, Atlantic	**10.88**	42.8	10	**3.803**	13.900	10	**0.691**	1.190	5	**0.327**	0.546	5	**0.30**	0.42	5	**0.070**	0.190	5	**0.155**	0.170	3
Megrim		0.39	1		0.116	1		0.057	1		0.067	1		0.02	1		<0.007	1			
Monkfish	**0.40**	0.58	6	**0.193**	0.250	6	**0.113**	0.300	6	**0.043**	0.080	6	**0.04**	0.10	6	**0.009**	0.010	6	**0.037**	0.080	4
Mullet, Red		1.17	1		0.505	1		0.123	1		0.065	1		0.07	1		<0.007	1			
Plaice, European	**0.23**	0.58	5	**0.081**	0.200	5	**0.060**	0.110	5	**0.055**	0.100	5	**0.03**	0.04	5	**0.019**	0.040	5	**0.020**	0.030	5
Pollock		0.64	1		0.254	1		0.117	1		0.047	1		0.03	1		0.013	1		0.017	1
Ray		0.43	1		0.140	1		0.110	1		0.110	1		0.04	1		0.010	1		0.020	1
Salmon, Atlantic (wild)	**5.49**	6.86	10	**1.70**	2.16	10															
Salmon, Atlantic (farmed)	**21.0**	42.9	73	**6.6**	14.0	91	**9.1**	17.3	91	**2.9**	4.5	52	**2.4**	4.2	91	**0.3**	0.9	91	**2.7**	5.6	91
Sole, Black	**0.29**	0.38	2	**0.093**	0.143	2	**0.046**	0.052	2	**0.126**	0.217	2	**0.01**	0.02	2	**0.018**	0.027	2	**0.015**	0.015	1
Sole, Lemon	**0.51**	0.66	3	**0.204**	0.270	3	**0.154**	0.240	3	**0.123**	0.180	3	**0.05**	0.07	3	**0.012**	0.020	3	**0.035**	0.050	2
Spurdog	**23.6**	36.0	2	**9.15**	14.26	2	**4.20**	5.03	2	**1.05**	1.18	2	**0.67**	0.91	2	**0.060**	0.060	2	**1.17**	1.35	2
Trout, Farmed	**15.0**	26.9	14	**4.0**	8.7	18	**6.2**	16.0	18	**2.3**	4.5	11	**1.7**	4.1	18	**0.2**	0.7	17	**1.8**	5.1	18
Tuna, Albacore	**8.72**	12.4	5	**3.23**	4.61	5															
Turbot	**0.42**	0.68	4	**0.175**	0.313	4	**0.086**	0.123	4	**0.041**	0.065	4	**0.04**	0.05	4	**0.009**	0.010	4	**0.023**	0.027	2
Whiting, European	**0.38**	0.62	5	**0.143**	0.290	5	**0.089**	0.190	5	**0.056**	0.120	5	**0.05**	0.07	5	**0.009**	0.010	5	**0.037**	0.050	3

Note: n= sample numbers

[13] ICES PCB_7 = sum of CBs 28, 52, 101, 118, 138, 153 and 180. Note for 2008 samples CB 52 was not available. This relates to one sample of each of the following species: gurnard, monkfish, black sole, plaice, ling, pollock, mackerel, hake, turbot

4.3 Dioxins, furans and dioxin-like (WHO) PCBs in seafood

Available data on dioxins and furans (PCDD/Fs) and dl-PCBs for the 2004–2008 period are presented in Figure 4.2. The FSAI/MI/BIM survey on dioxins, PCBs and brominated flame retardants in Irish seafood (Box 6, Tlustos *et al.* 2007) indicated that levels of dioxins and furans (PCDDs and PCDFs) in Irish fish and fishery products available on the Irish market were well below existing EC legal limits for these contaminants. The lowest level was found in a sample of canned tuna (0.012 ng WHO TEQ kg^{-1} ww) with the highest level found in a farmed salmon sample (0.82 ng WHO TEQ kg^{-1} ww), compared with the maximum level under the legislation of 4 ng WHO TEQ kg^{-1} ww. The mean value for farmed salmon at 0.54 ng WHO TEQ kg^{-1} ww was over 7 times lower than the maximum limit. Overall the highest value recorded for dioxins (4.37 ng WHO TEQ kg^{-1} ww) was in a European eel sample from a single catchment and this is further discussed in Box 7.

Box 6 FSAI/MI/BIM Dioxin Survey 2004 - 2005

The Marine Institute and the Food Safety Authority of Ireland in collaboration with Board Iascaigh Mhara (Sea Fisheries Board) carried out a surveillance study of the levels of dioxins (PCDDs), furans (PCDFs) polychlorinated biphenyls (PCBs), and brominated flame retardants, specifically polybrominated diphenylethers (PBDEs) and hexabromocyclododecane (HBCD), in a variety of fish species and fishery products available on the Irish market, including fresh and processed products. The study was undertaken because of concern about the possible effects on human health of these bio-persistent environmental contaminants, known to be present in a number of foodstuffs, including seafood. Samples for this one-off study were collected by the Marine Institute during the core monitoring programme of 2004/5 and by the FSAI and BIM at retail level. Sample preparation was carried out at the Marine Institute and analysis was carried out under subcontract by specialist laboratories. Data assessment was carried out by the FSAI and the Marine Institute. More information is presented in Tlustos *et al.* (2007).

The FSAI/MI/BIM seafood study also found levels of the sum of WHO-TEQs for PCDD/Fs and dl-PCBs were well below the maximum limits. The upper-bound mean levels of PCDDs, PCDFs and dl-PCBs expressed as total WHO-TEQs ranged from 0.05 – 2.15 ng WHO TEQ kg^{-1} ww, which can be compared with the maximum level of 8 ng WHO TEQ kg^{-1} ww for the sum of PCDDs, PCDFs and dl-PCBs. Reductions of PCDD/Fs and dl-PCBs in Irish farmed salmon were observed in comparison to levels measured in a previous FSAI/MI survey in 2001 in which a mean level of 4.02 ng WHO TEQ kg^{-1} ww was detected compared with 2.15 ng WHO TEQ kg^{-1} ww in the present study. Concentrations of dl-PCBs in eels were low and therefore even though one European eel sample marginally breached the maximum limit for PCCD/Fs the levels for this sample were well within the relevant maximum limit of for dioxin-like substances (12 ng WHO PCDD/F & dl–PCB TEQ kg^{-1} ww).

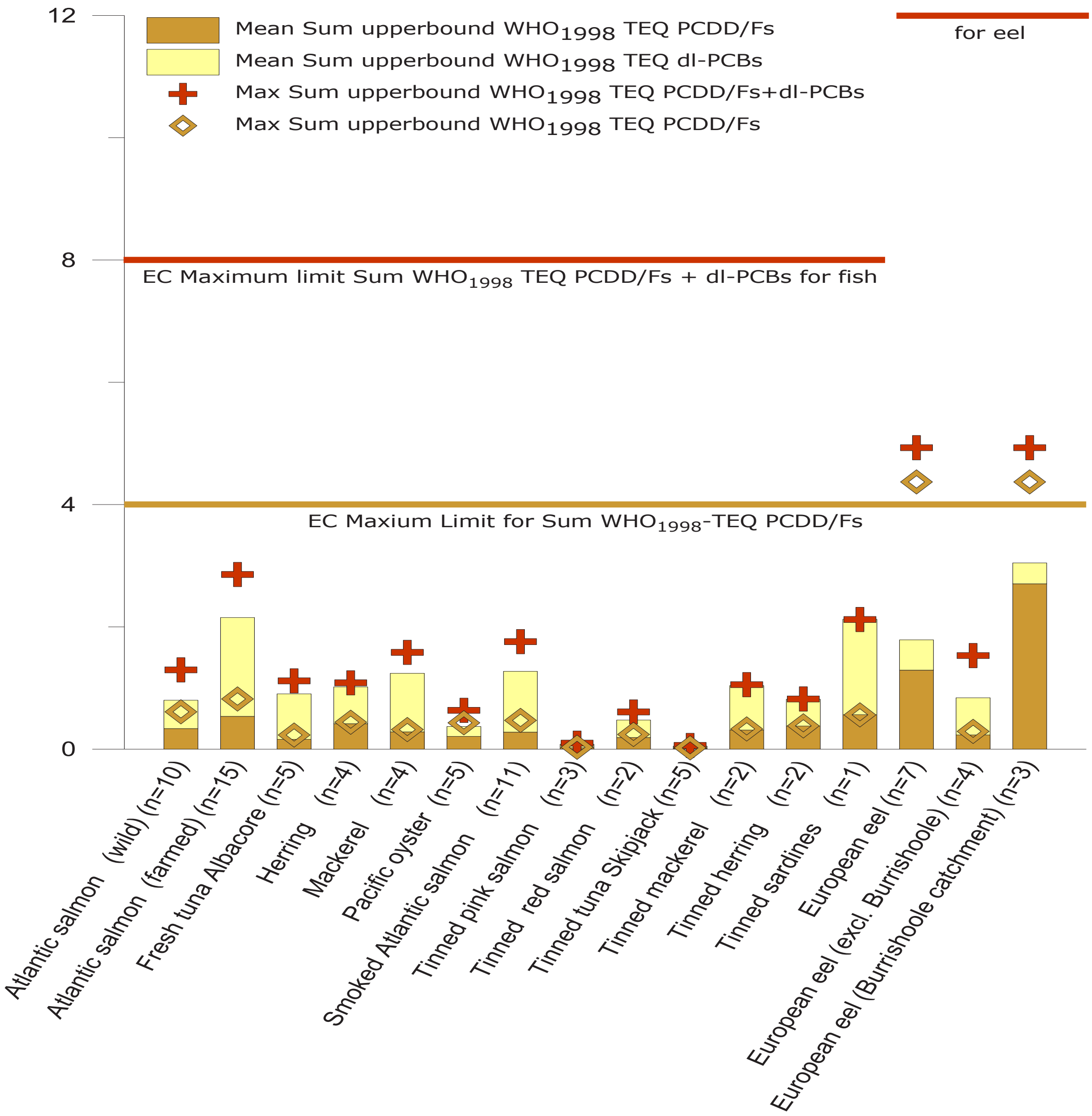


Figure 4.2: Mean upper-bound WHO1998 TEQ PCDD/F & dl-PCB ng kg-1 whole weight in fish species

4.4 Brominated flame retardants (PBDEs & HBCD):

Selected BFRs (PBDE and HBCD) were determined in the FSAI/MI/BIM 'dioxin' study (see Box 6). PBDEs were also included in the eel study (see Box 7) and as of 2008 selected PBDE congeners are included in routine monitoring of fish landed at Irish ports. Summary results of these studies are presented in Table 4.3. BDE congeners 28, 47, 99, 100, 153, 154, and 183 were determined in all the studies. Figure 4.3 presents the concentrations of BDE-47, typically the congener present in highest concentrations, in Irish seafood.

Concentrations of brominated flame retardants in fresh fish and shellfish and other seafood products available on the Irish market were found to be low. Highest concentrations were evident for farmed salmon and European eel (mean 3.02 and 2.11 µg kg^{-1} ww respectively). 11 PBDE congeners were included in analysis of eel samples from five river catchments (see Box 7.). The concentration of the 11 PBDE congeners in the five samples ranged from 1.01 – 7.05 µg kg^{-1} ww. These concentrations were similar or in some cases low compared to reported data for eels from other European countries (McHugh *et al.* 2010). Limited data on HBCD also indicates concentrations to be low.

Box 7 POPs in European eels from five Irish catchments

The European eel (*Anguilla anguilla*) is a relatively high lipid, long lived species that can accumulate POPs. The global eel stock is now in decline and while the cause of the collapse remains unidentified, environmental degradation may be a contributing factor. The Marine Institute undertook a study on levels of dioxins, PCBs, OCPs and certain brominated flame retardant substances (PBDEs, HBCD, TBBPA and PBBs) in eel muscle tissue collected from five Irish catchments: River Suir (Co. Waterford), River Corrib (Co. Galway), Lough Conn (Co. Mayo), River Fane (Co. Monaghan), Burrishoole (Co. Mayo). Five of the samples were of silver eel and two (River Suir and one Burrishoole) were of yellow eel. Three samples tested were from Burrishoole and one from each of the other catchments. With the exception of higher substituted dioxins in three samples collected from one catchment (Burrishoole), dioxin and other POP levels were determined to be low in eels from Irish waters compared to those in other countries (McHugh *et al.* 2010) and of similar concentration range to other lipid-rich fish. The concentrations for 6 'indicator' CBs (1.9 – 18.1 µg kg^{-1} ww) were well below the average reported by EFSA for eels across European countries (mean 223, median 51.0 µg kg^{-1} ww; EFSA 2010), although the EFSA dataset was dominated by samples from the Netherlands (63%). This indicates generally unpolluted Irish river systems with respect to POPs. However, the results for samples from the Burrishoole catchment were unanticipated and high concentrations of higher molecular weight PCDDs, especially OCDD, were observed; concentration ranges of 22.5 – 78.6 µg kg^{-1}ww total PCDD/F for the three Burrishoole samples compared with 1.3 – 1.6 µg kg^{-1}ww total PCDD/F for the samples from the four other catchments. This is an unusual dioxin congener profile suggesting a specific and, given the persistence of these substances and the longevity of eels, possibly historic source. Efforts are underway to pinpoint the origin. Nonetheless, when these results are calculated as TEQ values only one of the three Burrishoole samples marginally exceeded the EC maximum limit for dioxins of 4 ng WHO-TEQ kg^{-1} ww, as OCDD is considerably less toxic than other PCDD/Fs (with a TEQ of 10000 times lower than the most potent congener: 2,3,7,8 TCDD). Dioxin levels from other river systems were over an order of magnitude lower than this limit. Moreover, all results are well within the EC maximum limit for total dioxins and 'dioxin-like' PCBs for eel (12 ng WHO -TEQ kg^{-1} ww) as the PCB levels are very low.

Table 4.2: Sampling details, mean length and standard deviation, estimated mean age and extractable lipid content and organochlorine contaminant concentrations for pooled eel samples from five Irish catchments.

		MI Reference						
	Units	MSC 05/1119	MSC 05/1120	MSC 05/1121	MSC 05/1122	MSC 05/1140	MSC 07/1133	MSC 07/1134
Ecotype		Yellow	Silver	Silver	Silver	Silver	Silver	Yellow
Location		Waterford, River Suir	Mayo, L. Conn	Galway, River Corrib	Monaghan, River Fane	Mayo, Burrishoole	Mayo, Burrishoole	Mayo, L. Feeagh
No. of individuals pooled (n)		10	9	10	10	10	12	15
Mean Length of pooled sample	cm	40.1	47.5	46.4	45.7	48.8	46.4	46.1
Standard deviation	cm	9.92	8.73	9.54	11.6	9.69	8.50	9.60
Mean Age *	yrs	16	20	19	18	32	NA	NA
Extractable Lipid	%	9.18	15.3	14.3	16.0	20.9	17.9	8.28
WHO-TEQ PCB	ng kg^{-1} ww	1.24	0.34	0.28	0.57	0.56	0.30	0.17
WHO-TEQ PCDD/F	ng kg^{-1} ww	0.29	0.22	0.21	0.21	4.37	2.50	1.24
WHO-TEQ PCDD/F & PCB	ng kg^{-1} ww	1.53	0.56	0.49	0.78	4.93	2.80	1.41
ICES PCB_7	µg kg^{-1} ww	18.1	3.63	1.94	7.64	6.77	3.86	2.37

*Mean age is rounded to nearest year

Table 4.3: Concentrations of certain brominated flame retardants determined in edible tissue of fresh fish, shellfish and various processed fish products available on the Irish market (2004 – 2008).

	PBDEs[1]							HBCD[2]		
	BDE-47		BDE-99		Sum of 7 BDEs[4]			Total HBCD[3]		
	$\mu g\ kg^{-1}$ ww							$\mu g\ kg^{-1}$ ww		
	Mean	Max.	Mean	Max.	Mean	Max.	n	Mean	Max.	n
Salmon, Atlantic (wild)	**0.34**	0.41	**0.11**	0.14	**0.67**	0.83	10			
Salmon, Atlantic (farmed)	**1.74**	2.26	**0.58**	1.99	**3.02**	4.61	15	**1.61**	2.67	4
Black Sole		0.01		<0.002		0.04	1			
Eel, European	**1.49**	5.20	**0.05**	0.16	**2.11**	7.00	7			
Gurnard		0.24		0.03		0.49	1			
Haddock		<0.001		<0.001		0.03	1			
Hake		0.19		0.04		0.39	1			
Herring	**0.73**	0.77	**0.11**	0.12	**1.14**	1.19	4			
Ling		0.02		<0.002		0.03	1			
Mackerel	**0.52**	0.70	**0.18**	0.26	**0.95**	1.29	6			
Monkfish		0.02		0.00		0.12	1			
Oyster, Pacific	**0.60**	1.56	**0.39**	1.04	**1.42**	3.57	5			
Plaice		0.01		0.003		0.04	1			
Pollock		0.09		0.01		0.14	1			
Turbot	**0.06**	0.06	**<0.002**	<0.002	**0.12**	0.12	11			
Smoked Salmon	**1.07**	1.35	**0.37**	1.12	**1.91**	3.14	2	**0.68**	0.68	1
Tinned Kipper	**0.63**	0.65	**0.11**	0.13	**1.04**	1.06	2			
Tinned Mackerel	**0.56**	0.67	**0.28**	0.35	**1.19**	1.43	5	**1.01**	1.01	1
Tinned Salmon		0.05		0.02		0.21	1	**<0.10**	<0.10	1
Tinned Sardines	**0.04**	0.04	**0.02**	0.02	**0.20**	0.20	5			
Tinned Tuna	**0.01**	0.01	**0.02**	0.02	**0.17**	0.17	5	**<0.10**	<0.10	2
Tuna, Albacore		0.56		0.06		1.09	1	**0.31**	0.31	1

1 Analysed by Eurofins and MI; 2 Analysed by CSL

3 Total HBCD (sum α,β,γ HBCD); 4 Sum of 7 BDE congeners -BDE 28, 47, 99, 100, 153, 154, 183

n= numbers sampled

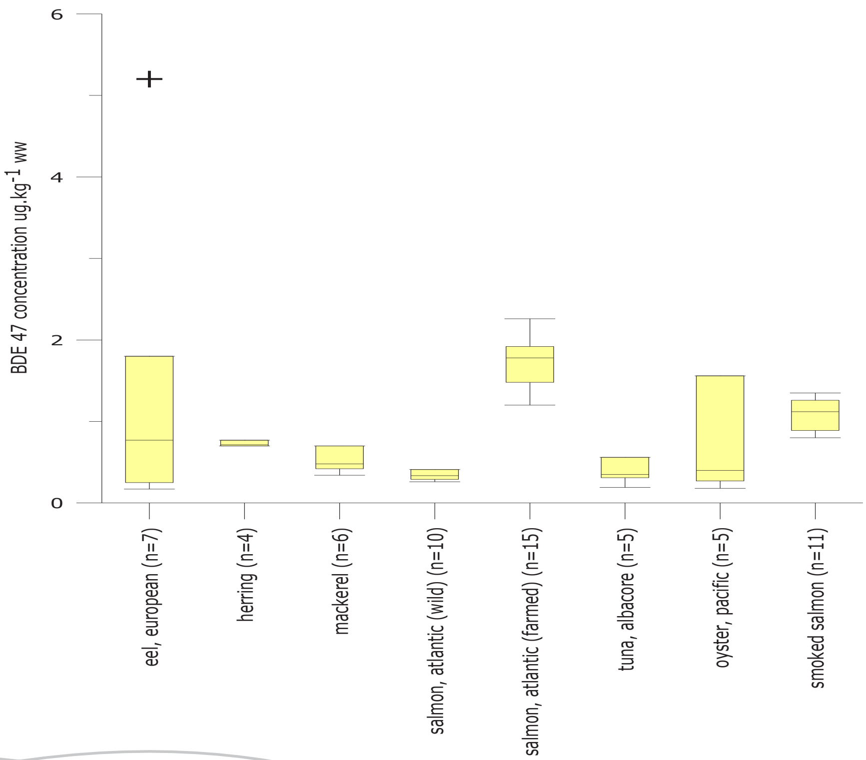


Figure 4.3: Box-and-whisker plot of BDE 47 concentrations (predominant BDE congener in fish) in Irish fish and shellfish.

4.5 Other POPs

4.5.1 Perfluorinated compounds

In 2008 the Marine Institute assisted the FSAI in carrying out a survey of 11 perfluorinated compounds (PFCs) including PFOS and PFOA in Irish fish (FSAI 2010a). Samples analysed included mackerel (n=4), pacific oyster (n=5), farmed salmon (n=5) and farmed trout (n=3). All PFCs determined in oysters were below the laboratories limit of quantification (1 µg kg^{-1} ww for each substance). The substance most frequently detected above this limit of quantification was PFOS but even then all levels were close to the limit (max 2 µg kg^{-1} ww).

4.5.2 Polychlorinated naphthalenes (PCNs)

Table 4.4 presents summary data for PCNs in selected fish species. These data were collected in conjunction with the FSAI as part of a broader one-off study of the concentrations of these compounds in food. Fish contained the highest concentrations of the foodstuffs surveys (FSAI, 2010b). Levels were similar to those observed in a similar study in the UK (Fernandes *et al.*, 2010). PCNs are structurally similar to dioxins and known to have a similar mode of toxicity. As with the UK study it is concluded that, as the calculated TEQ concentrations are more than two orders of magnitude lower than dioxins and PCBs, these levels do not represent a toxicological concern for the consumer (Fernandes *et al.*, 2010).

Table 4.4: Summary data for PCNs in four Irish fish species.

	PCN 52/60			Sum PCN[1]		
	ng kg^{-1} ww			ng kg^{-1} ww		
	Mean	Max.	n	Mean	Max.	n
Mackerel	**5.40**	8.60	4	**7.94**	12.9	4
Pacific oysters	**0.80**	1.60	5	**1.11**	2.30	5
Salmon (farmed)	**32.7**	45.1	5	**43.3**	59.3	5
Trout (farmed)	**2.10**	3.60	3	**4.32**	7.50	3

Notes: 1 Sum PCNs (52/60, 53, 66/67, 68, 69, 71/72, 73, 74, 75).
n-numbers sampled

► 5 Veterinary Treatments and Environmental Contaminants in Finfish Aquaculture (2004 – 2008): " Residues Directive "

BOX 8 "Residues Directive" (EC Directive 96/23) and Aquaculture

EC member states are required to monitor certain 'substances and residues thereof in live animals and animal products' in accordance with EU Directive 96/23/EC. In Ireland, the Department of Agriculture, Food and Marine (DAFM) co-ordinates the programme and this involves many food groups such as cattle, pigs, sheep, goats, aquaculture etc. The Sea Fisheries Protection Authority (SFPA) is responsible for ensuring compliance with this directive in the finfish aquaculture sector and the Marine Institute (MI) implements the monitoring programme on behalf of SFPA. The Food Safety Authority of Ireland (FSAI) co-ordinates the activities of the various departments and agencies involved in delivering this programme.

Surveillance monitoring programme for aquaculture

Annually, member states submit a National Residue Control Plan (NRCP) to the European Commission. This sets out the national surveillance monitoring plan, including species, sample numbers and target substances in line with the specific requirements of the directive. Typically, five individual fish are collected by an authorised officer from a producer at either the fish farms or the packing plants.

Target substances

Samples are tested for a broad range of substances using a variety of modern analytical techniques and these substances are outlined below in Table 5.1. These include specifically prohibited substances (Group A) which are analysed in fish at all stages of production. Substances designated as Group B include authorised treatments such as certain antibiotics and antiparasitics (e.g. sea-lice treatments), substances not authorised for use and environmental contaminants (trace metals and POPs). With the exception of malachite green, where smolt testing is carried out, Group B substances are tested for in samples collected at harvest. A comprehensive quality assurance programme supports the monitoring programme (Annex A presents the analytical methodology utilised).

Action in the event of a positive result and reporting

Samples are deemed compliant with the directive if authorised compounds do not exceed the Maximum Residue Limits (MRL) prescribed by the EC and unauthorised substances are not detected above a defined analytical method *decision limit*. (see Section 1.6). Generally, MRLs will not be exceeded if good husbandry practices are in place and the withdrawal periods are adhered to i.e. the animal is not slaughtered during a set period after treatment. Follow-up action as a consequence of confirmed positive (i.e. non-compliant) results may involve further sampling and investigations, withdrawal of product from the market, suspension of production, and/or criminal proceedings. Results of the residue monitoring plan are reported annually by DAFM to the European Commission and this report is also released into the public domain.

5.1 "Residues Directive" (EC Directive 96/23) and finfish aquaculture

Table 5.1: List of substances included in the Residue plan for farmed finfish.

Substance Group included in			
Group A - Substances having anabolic effect		Group B - Veterinary drugs and contaminants	
A3	Steroids	B1	Antimicrobials (Antibacterial)
A5	Beta-agonists	B2a	Anthelmintics (Antiparasitic)
A6	Compounds included in Table 2 of Commission Regulation (EU) No.37/2010	B2c	Pyrethroids
		B2f	Other pharmacologically active substances
		B3a	Organochlorine compounds
		B3c	Chemical elements
		B3d	Mycotoxins
		B3e	Dyes

Figure 5.1 plots a breakdown of the total number of samples taken as part of the Residue programme in 2004 to 2008. In addition 21 suspect samples were collected in 2004 and 17 suspect samples were also collected in 2005. These suspect samples were tested for malachite green and leuco-malachite green.

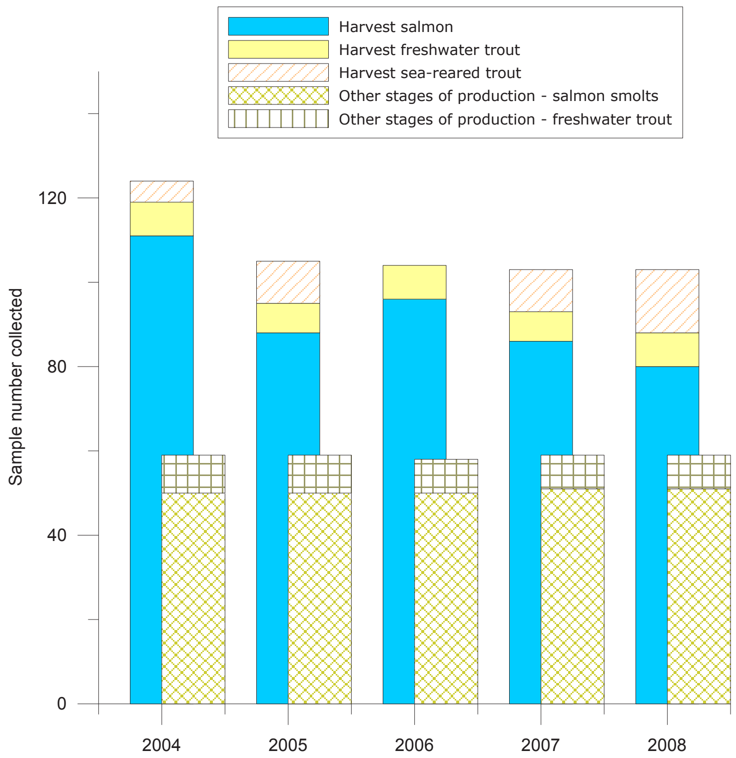


Figure 5.1: Breakdown of targeted surveillance sample numbers for farmed salmon, freshwater and sea-reared trout collected at harvest and salmon smolts and freshwater trout collected at other stages of production, 2004 – 2008.

A detailed summary of the outcome of surveillance monitoring results for 2004 to 2008 is presented in Appendix B3. Figure 5.2 presents the percentage of positive test results determined during surveillance monitoring over recent years. It is evident that there has been a decrease in the level of non-compliance over the years.

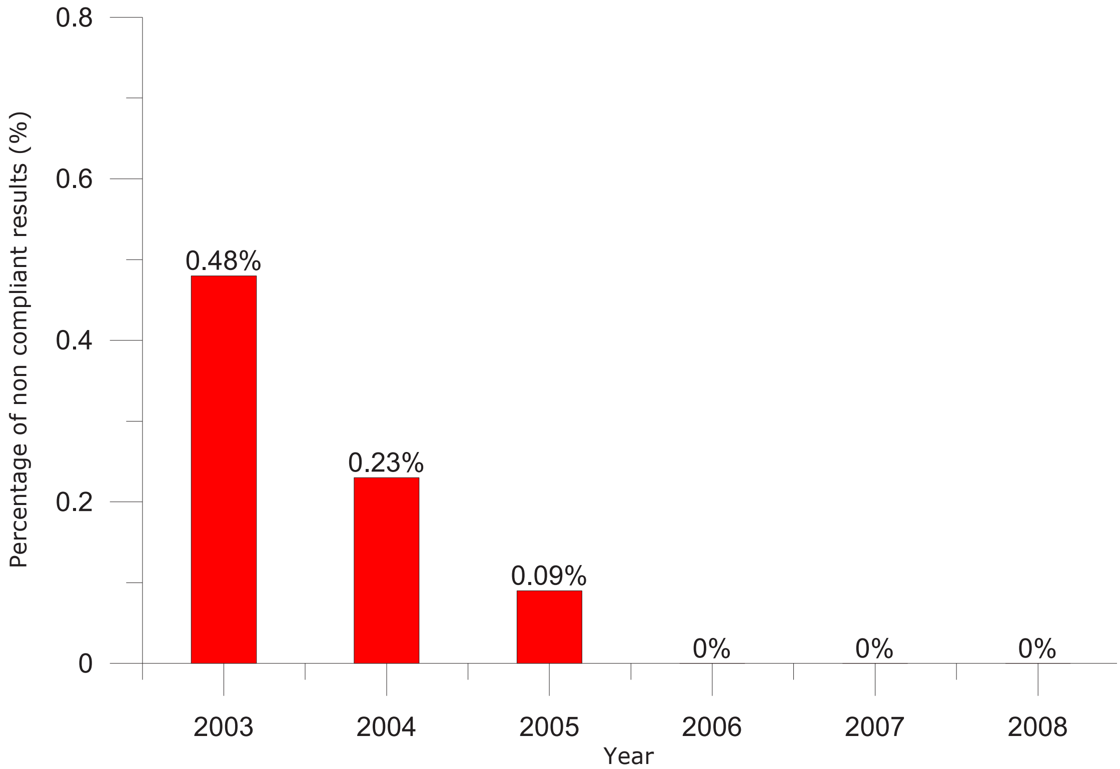


Figure 5.2: Percentage non-compliant residue tests for surveillance monitoring of farmed finfish 2003 - 2008.

The main findings of the 2004 - 2008 residues surveillance monitoring programme are:

1 **Group A - Banned compounds**: No positive (i.e. non-compliant) results were obtained for prohibited substances in the programme since its introduction in 1999.

2 **Group B1 - Antibiotic residues:** No positive (i.e. non-compliant) results were obtained in 2004 – 2008.

3 **Group B2 - Other Veterinary Drugs:** In aquaculture these veterinary drugs are all generally authorised or unauthorised sea-lice treatments (cypermethrin, deltamethrin, teflubenzuron, diflubenzuron, emamectin B1a and ivermectin). In 2005 two surveillance samples from two salmon farms tested positive (i.e. non-compliant) for the authorised sea-lice treatment Emamectin B1a i.e. concentrations above the MRL for Emamectin B1a of 100µg kg^{-1} (wet weight). No other positive (i.e. non-compliant) results were obtained for this or other group B2 compounds in 2004 - 2008.

4 **Group B3 - Malachite Green:** Group B3 substances include dyes (malachite green and its metabolite, leuco malachite green), and environmental contaminants. In 2004, five samples of farmed salmon from one farm, sampled during one sampling event, tested positive (i.e. non-compliant) for

malachite green and leuco-malachite green[14]. A follow-up investigation was carried out by the Department of Communications, Marine and Natural Resources (DCMNR) in 2004 where three suspect samples from two farms were non-compliant (i.e. positive) for malachite green and leuco malachite green. Further follow-up investigations in 2005 were carried out on suspect samples for malachite green and leuco-malachite green, and these were all found to be compliant (i.e. negative). All target (surveillance) samples tested for malachite green and leuco malachite green in 2005, 2006, 2007 and 2008 were found to be compliant i.e. negative.

Malachite Green is a common commercial fabric dye which has been widely used both prophylactically and in the treatment of fungal infection of both fish and eggs for over 60 years. It is also effective against several protozoal infestations, including agents causing proliferative kidney disease (PKD) and ichthyophthiriosis (white spot disease). Its use has been primarily associated with freshwater farms and hatcheries and therefore over recent years, monitoring has been scaled up with freshwater installations particularly targeted. Recent results suggest that as a result of increased industry awareness, supported by monitoring and enforcement, the use of malachite green has ceased.

5 **Group B3 - Contaminants**

Selected trace metals and POPs are monitored in farmed finfish in accordance with the requirements of the "Residues Directive" (96/23/EC). These data are discussed here specifically in the context of this programme but are also included in the tables and graphs of Chapters 3 and 4.

- **Trace Metals**: Levels of mercury, cadmium and lead (Table 5.2) were all very low in Irish farmed finfish and well below the relevant European maximum limits as described in Table 1.1. Typically cadmium concentrations were below the limit of detection, while lead concentrations were generally detected, but at levels below those at which they can be confidently quantified. Mercury concentrations in farmed salmon and trout collected at harvest are included in Figure 3.1 (Chapter 3) and this confirms low levels of mercury in these species. More detailed results for 2004 – 2008 monitoring are presented in Annex B3.
- **OCPs and PCBs**: These substances are found in farmed salmon as they are present in processed fishfeed derived from wild fisheries and can accumulate in the lipid-rich tissue (Berntssen *et al.,* 2011; Bell *et al.,* 2005). There are no EC maximum limits for organochlorine pesticides and for the indicator PCBs measured. A number of OSPAR contracting countries have set standards or guidance values and the strictest of these, in so far as the Marine Institute is aware, are applied as guidance values for the purpose of this programme (Table 1.2). All samples tested since the start of this programme in 1999 are compliant with and indeed well below these strictest guidance levels for indicator PCBs (Belgian standard of 75 $\mu g\ kg^{-1}$ ww for sum of ICES 7 PCBs) and organochlorine pesticides. More information on POPs such as PCBs and dioxins, including levels in farmed fish, is presented in Chapter 4.

[14] Malachite green and leuco malachite green are not included in Table 1 or Table 2 of Commission Regulation (EU) No 37/2010 of 22 December 2002 and have never been evaluated according to this regulation. The use of this substance in food producing animals is therefore illegal.

Table 5.2: Levels of mercury, cadmium, lead and selected POPs during 2004 – 2008 period in:

a) Irish farmed salmon (*Salmo salar*)

	Maximum concentration	Median (mean) concentration	EC Maximum limit	n
Trace Metals				
	mg kg^{-1} ww			
Mercury	0.08	0.035 (0.037)	0.5	91
Cadmium	0.04	<0.005 (<0.005)	0.05	90
Lead	0.26	<0.05 (<0.05)	0.3	90
Organochlorine substances			Other standards	
	µg kg^{-1} ww			
[1]ICES PCB_7	42.9	19.4 (21.0)	75[2]	73
CB 153	14.0	6.3 (6.6)		91
Sum DDTs	22.8	14.4 (13.6)	500[3]	91
***p,p'*- DDE**	17.3	9.2 (9.1)		91
Dieldrin	4.5	2.9 (2.9)		52
HCB	4.2	2.4 (2.4)		91
***γ*HCH**	0.9	0.2 (0.3)		91

b) Freshwater and sea-reared trout (*Oncorhynchus mykiss*).

	Maximum concentration	Median (mean) concentration	EC Maximum limit	n
	Trace Metals			
	mg kg^{-1} ww			
Mercury	0.07	0.04 (0.04)	0.5	17
Cadmium	0.03	<0.005 (<0.005)	0.05	17
Lead	0.06	<0.05 (<0.05)	0.3	17
Organochlorine substances			Other standards	
	µg kg^{-1} ww			
[1]ICES PCB_7	26.9	15.0 (15.0)	75[2]	14
CB 153	8.7	3.8 (4.0)		18
Sum DDTs	27.3	7.8 (9.7)	500[3]	18
p,p'- DDE	16.0	5.5 (6.2)		18
Dieldrin	4.5	2.2 (2.3)		11
HCB	4.1	1.4 (1.7)		18
*γ*HCH	0.7	0.2 (0.2)		17

1 ICES PCB_7= CBs 28, 52,101, 118, 138, 153, 180. 2005 data not included in sum of ICES PCB_7 as not all congeners available

2 Belgian standard

3 Finnish Standard

n=numbers sampled

► 6 Summary assessment by substance and seafood intake assessment

This chapter summarises the findings of previous chapters on a substance group basis and further provides an estimate of intake of selected substances (specifically mercury, PCBs and dioxins) and beneficial oils for the Irish adult seafood consumer.

Food consumption data on fish and fishery products was provided by the FSAI and was derived from the *North/South Ireland Food Consumption Survey (NSFCS)* (IUNA, 2001). Figure 6.1 provides the percentage contribution of different fish and shellfish to total consumption of fishery products in Ireland and shows that salmon, cod and canned tuna are the most commonly consumed fish species in Ireland. In this survey, 66% of those surveyed consumed at least one portion of fish.

Estimates of seafood intake exposure to certain substances are based on average fish consumption by seafood consumers only (66% of the population) combined with mean chemical concentration data collected by the Marine Institute. These estimates are based on the assumption that all fish consumed was correctly recorded in the food consumption survey, that all fish consumed stem from Irish waters, or show comparable concentration of the substances of interest, and that all salmon and trout consumed were sourced from aquaculture (i.e. farmed). Indeed, Miller and Mariani (2010) demonstrated that 25% of cod and haddock randomly sampled at retail level in Dublin were genetically identified as entirely different species from that indicated on the product labels. Similar findings were reported by the FSAI (2011) with almost a fifth of samples being incorrectly identified.

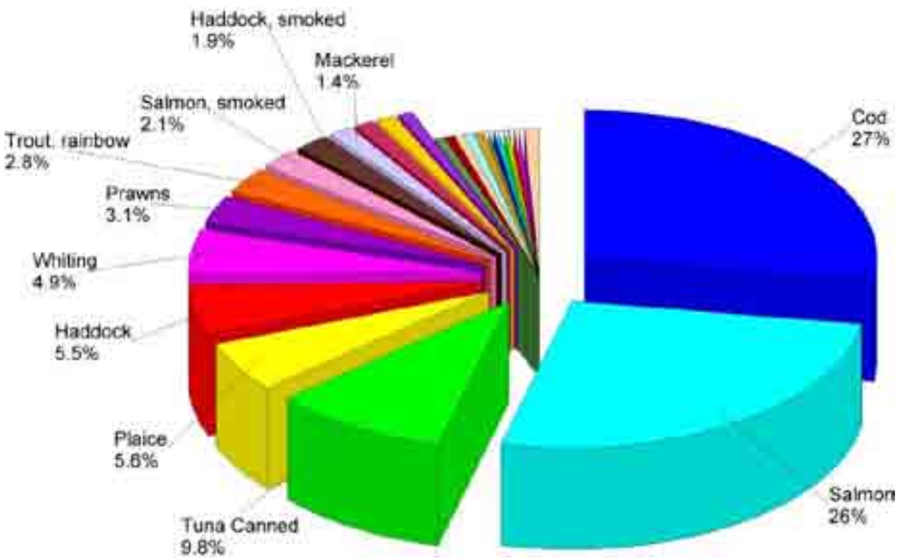


Figure 6.1: Percentage contribution of different fish to total fish intake by consumers only. Data source NSFCS (IUNA 2001).

6.1 Beneficial long chain n-3 PUFAs in fish

Long chain n-3 PUFAs found in fish have established health benefits (see Section 1.3 of this report). As part of the FSAI/MI/BIM dioxin survey in 2004 (Tlustos *et al.,* 2007; Box 6) fatty acid analysis was also undertaken on samples collected and key results are presented in Table 6.1. Figure 6.2 depicts the sum of EPA+DHA in various fish sampled. The highest concentration of EPA+DHA was in albacore tuna (max 6.0%, mean 3.0% EPA +DHA) followed by a single tinned sardine sample (3.5% EPA + DHA). Salmon also exhibited high levels of these beneficial fatty acids (farmed salmon mean 2.3% EPA+DHA). Tinned tuna contained the lowest levels observed in the study (mean 0.13% EPA+DHA).

There is evidence that an intake of EPA plus DHA improves clinical outcomes for coronary heart diseases up to 250mg EPA+DHA per day (Mozaffarian & Rimm, 2006). Other health benefits may require larger doses (SACN, 2004). EFSA reported the recommended dietary intakes proposed by various national and international bodies as ranging between 200 and 500 mg per day EPA + DHA with most recommending the upper end of this range; 400-500 mg per day (EFSA, 2009). This report also noted observed average intakes of between 80 and 420 mg per day in adults in some European countries. The EFSA panel recommended a labelling reference intake value of 250 mg per day (this equates to approximately 1-2 servings of oily fish per week). Nationally, an FSAI report in 1999 reviewing Recommended Dietary Allowances (RDAs) proposed adopting the EU Population Reference Intake (PRI) of n-PUFAs of 0.5 % Dietary Energy but this relates to short chain n-3 PUFA (ALA). The report did not make recommendations specifically for the long chain n-3 PUFAs (EPA + DHA).

A preliminary assessment of intake associated with fishes for which survey data are available was undertaken. Data gaps for three of the most widely consumed fish (cod, haddock and plaice) were supplemented with UK data (SACN, 2004) and the assessment therefore accounts for >80% of the fish consumed by the Irish seafood consumer, including the key oily species. A mean intake of 272mg EPA and DHA per day for seafood consumers was calculated (Table 6.2). This is 109% of the labelling reference intake but below the recommended dietary intakes proposed by many bodies (EFSA, 2009). For instance this equates to 60% of 450 mg per day recommended by the UK Scientific Advisory Committee on Nutrition (SACN, 2004). This assessment suggests that salmon, as a heavily consumed oily fish, contributes over 70% of these essential PUFAs to the seafood consumer's diet.

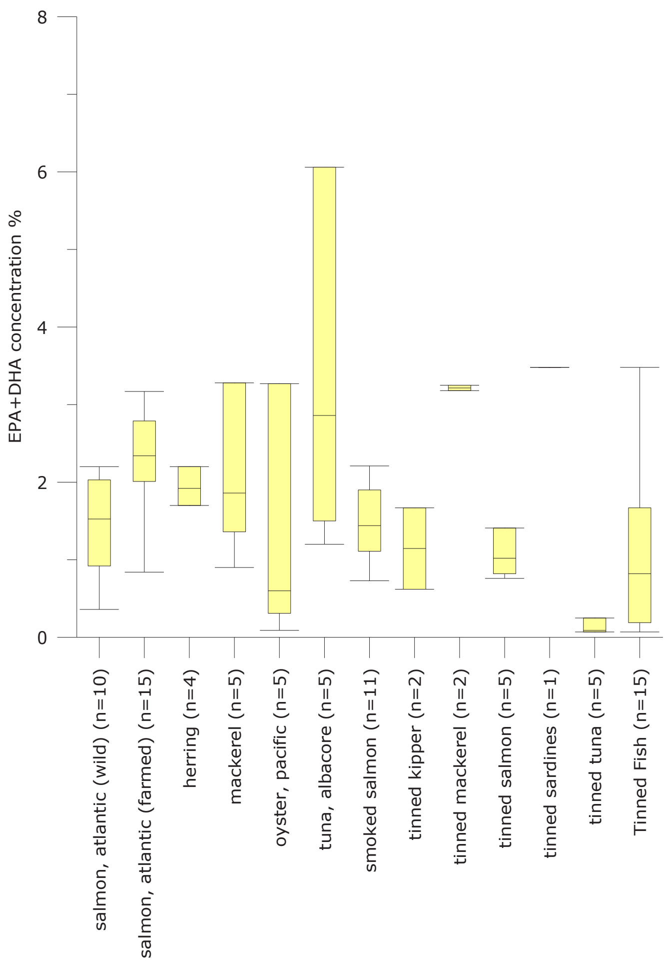


Figure 6.2: Box-and-whisker plot showing % EPA + DHA determined in fresh fish and other seafood products available on the Irish market (source FSAI/MI/BIM study 2004).

Table 6.1: Fatty acid profiling of fish and seafood products available on the Irish market (Source FSAI/MI/BIM study 2004). Results given as the mean and range in brackets,

Species	n	Fat	Polyunsaturated fatty acids	Omega-3 fatty acids	Saturated fatty acids	EPA C20:5	DHA C22:6	EPA+DHA
		%	g $100g^{-1}$	g $100g^{-1}$	g $100g^{-1}$	g $100g^{-1}$	g $100g^{-1}$	g $100g^{-1}$
Salmon, Atlantic (wild)	10	10.4 (4.7 - 12.5)	2.0 (0.6 - 2.9)	1.8 (0.5 - 2.7)	3.1 (1.5 - 4.3)	0.59 (0.13 - 0.97)	0.82 (0.23 - 1.45)	1.4 (0.4 - 2.2)
Salmon, Atlantic (farmed)	15	14.4 (10.0 - 18.0)	3.9 (1.6 - 5.1)	3.0 (1.2 - 4.2)	3.5 (2.0 - 7.9)	0.82 (0.35 - 1.28)	1.5 (0.5 - 2.1)	2.3 (0.8 - 3.2)
Herring	4	11.6 (10.1 - 12.9)	2.5 (2.2 - 2.9)	2.3 (2.0 - 2.6)	3.1 (2.8 - 3.4)	0.74 (0.66 - 0.84)	1.2 (1.0 - 1.4)	1.9 (1.7 - 2.2)
Mackerel	5	9.5 (6.2 - 13.9)	2.4 (1.4 - 4.2)	2.1 (1.1 - 3.8)	3.2 (2.0 - 4.5)	0.60 (0.34 - 1.09)	1.3 (0.6 - 2.2)	1.9 (0.9 - 3.3)
Oyster, Pacific	5	1.7 (1.2 - 2.8)	1.4 (0.2 - 4.8)	1.2 (0.2 - 4.0)	1.5 (0.5 - 4.5)	0.53 (0.05 - 1.65)	0.45 (0.04 - 1.62)	1.0 (0.1 - 3.3)
Smoked Salmon	11	9.9 (8.2 - 11.3)	2.7 (1.4 - 3.8)	2.0 (1.0 - 2.9)	2.4 (1.9 - 3.1)	0.57 (0.31 - 0.84)	0.93 (0.42 - 1.43)	1.5 (0.7 - 2.2)
Tinned Kipper	2	14.3 (14.2 - 14.3)	3.1 (2.7 - 3.5)	1.5 (0.8 - 2.2)	4.1 (2.9 - 5.3)	0.48 (0.29 - 0.66)	0.67 (0.33 - 1.01)	1.1 (0.6 - 1.7)
Tinned Mackerel	2	25.8 (24.7 - 26.9)	4.8 (4.7 - 4.9)	4.1 (3.9 - 4.2)	7.8 (7.0 - 8.5)	1.2 (1.1 - 1.2)	2.1 (2.0 - 2.1)	3.2 (3.2 - 3.3)
Tinned Salmon	5	6.2 (4.2 - 7.7)	2.0 (1.3 - 2.7)	1.8 (1.2 - 2.5)	1.4 (1.0 - 1.7)	0.46 (0.33 - 0.57)	0.61 (0.43 - 0.84)	1.1 (0.8 - 1.4)
Tinned Sardines	1	21.4 (21.4 - 21.4)	8.9 (8.9 - 8.9)	3.8 (3.8 - 3.8)	5.4 (5.4 - 5.4)	2.3 (2.3 - 2.3)	1.2 (1.2 - 1.2)	3.5 (3.5 - 3.5)
Tinned Tuna	5	5.3 (0.3 - 12.6)	2.9 (0.1 - 7.3)	0.2 (0.1 - 0.3)	0.8 (0.1 - 2.0)	0.03 (0.01 - 0.06)	0.10 (0.06 - 0.19)	0.13 (0.07 - 0.25)
Tuna, Albacore	5	11.5 (5.4 - 21.4)	3.7 (1.6 - 7.4)	3.3 (1.3 - 6.6)	4.1 (1.7 - 7.3)	0.66 (0.30 - 1.40)	2.4 (0.9 - 4.7)	3.0 (1.2 - 6.1)

n=numbers sampled

6.2 Overall compliance and contaminant intake assessment

6.2.1 Veterinary treatments, unauthorised and banned substances in farmed finfish

Overall compliance with the "Residues Directive" has improved in recent years and no non-compliant results were detected during surveillance monitoring in years 2006, 2007 and 2008. Use of the unauthorised substance malachite green, previously implicated in a number of instances of non-compliance, was not detected in 2005 – 2008, despite increased surveillance. This indicates improved practices in the industry with respect to this substance.

6.2.2 Trace metals

Mercury

Mercury concentrations in bivalve molluscs from Irish shellfish growing waters were very low and well below the appropriate EC maximum limits. Mercury concentrations can be higher in finfish muscle, especially in predatory long-lived species. Mercury concentrations in fish landed at Irish ports were consistently within EC maximum limits and very low concentrations of mercury were determined in Irish farmed salmon. A one-off survey of mercury in fish at retail showed high concentrations for imported swordfish and one imported marlin sample that was over three times the EC maximum limit.

A preliminary assessment of dietary intake of mercury from fish is shown in Figure 6.3. Mercury data are available for fishes contributing to over 90% (by weight) of seafood intake as recorded in the total diet study. The estimated weekly mean intake of mercury from seafood is 17.1 μg for seafood consumers. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) has established a provisional tolerable weekly intake (PTWI) for methylmercury of 1.6 μg kg^{-1} body weight (EFSA, 2004). This suggests that for adult (70kg) seafood consumers, seafood contributes approximately 15% of the PTWI for methylmercury (conservatively assuming seafood mercury to be 100% methylmercury).

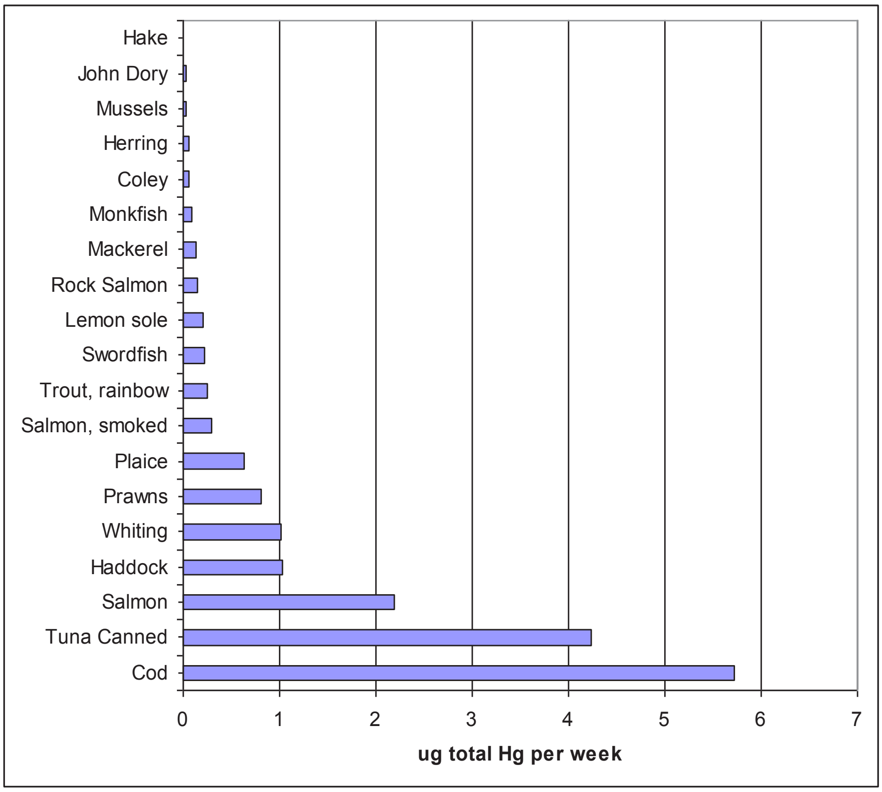


Figure 6.3: Estimated weekly intake of total mercury from seafood for Irish seafood consumers. Consumption data source Food Safety Authority of Ireland. Total mercury data Marine Institute 1996 -2008 (mussels, salmon and trout 2004 – 2008). Salmon and trout assumed to be farm reared.

Cadmium and lead

Cadmium and lead generally occur at higher concentrations in bivalve molluscs than finfish muscle and this is reflected in the higher maximum limits set in European Legislation. Concentrations in bivalve molluscs were consistently within EC maximum limit. Much lower concentrations were determined in the edible tissue of wild finfish landed at Irish ports and all samples complied with the EC maximum limits. While high concentrations of cadmium are well known to occur in brown meat of crustaceans, EC maximum limits exclude brown meat. Cadmium concentrations in the white meat of fresh crab claws were well within EC limits. There are no maximum limits for lead and cadmium in gastropods although two samples measured showed higher concentrations than observed for bivalve molluscs. Cadmium and lead levels were generally less than the limits of quantification in farmed salmon and trout.

Other trace metals

There are no EC limits for other trace metals. Concentrations of chromium, copper, nickel, silver, arsenic and zinc in bivalve molluscs from shellfish areas were as expected with notably higher concentrations of copper, silver and zinc in oysters compared to mussels. This reflects differences in the ability of oysters and mussels to regulate these metals. Trace metal levels in finfish are consistently low.

6.2.3 Persistent organic pollutants

Fish and especially oily fish consumption is a primary source of POPs in the European diet (Kvalem et al., 2009, Bergkvist et al., 2008). Data reported in this report shows that concentrations of PCBs, dioxins and furans, organochlorine pesticides and brominated flame retardants are very low in bivalve molluscs in Irish shellfish growing waters. The highest concentrations for indicator PCBs and organochlorine pesticides were evident for spurdog and farmed salmon but all were within the strictest national standards as applied by OSPAR countries for finfish (i.e. Belgian standard of 75 mg kg^{-1} ww for sum of ICES PCB_7). A one-off survey (Tlustos *et al.,* 2007) also indicated higher concentrations of dioxins and dl-PCBs in farmed salmon compared with other species tested but levels were all within EC limits and the report noted that levels appear to have decreased since a previous survey in 2001.

Results in this report are broadly in agreement with results reported elsewhere for POPs in farmed Atlantic salmon from northern Europe (Jacobs *et al*., 2002, Hites *et al.,* 2004, Shaw *et al.,* 2006, Ikonomou *et al*., 2007). Some authors have given consideration to the risks to consumers and in some instances the risk-benefit trade-off associated with seafood consumption (Foran *et al.,* 2005, Domingo *et al.,* 2006, Domingo 2007, Huang *et al.,* 2006).

A preliminary assessment of seafood related dietary intake of PCBs and dioxins was undertaken (see Table 6.2). Specifically the following contaminants were addressed: CB153 as an indicator PCB, and dioxins and dl- PCBs expressed as total WHO-TEQ. The total estimated mean weekly intake of dioxins and dl-PCBs from seafood was calculated as approximately 170 pg WHO-TEQ (=24.4 pg WHO-TEQ day^{-1}), a little lower than the value of 38 pg WHO-TEQ day^{-1} calculated for dietary intake in Catalonia by Domingo *et al.* (2007). SCF (2001) set a TWI of 14 pg WHO-TEQ kg^{-1} body weight for dioxins and dl-PCBs. This infers that seafood accounts for approximately 17% of the TWI for the adult seafood consumer. These data suggest that farmed salmon, as a heavily consumed and lipid-rich fish prone to accumulating POPs, is the primary seafood source of these contaminants in the diet of Irish seafood consumers accounting for an estimated 75% of the intake associated with seafood.

The WHO have also established TDIs for HCB of 170 ng kg^{-1} body weight per day for non-cancer effects and 160 ng kg^{-1} body weight per day for neoplastic effects (IPCS, 1997). Although data are only available for fishes that represent 77% of the seafood diet by weight, the estimated intake of 6.5 ng day^{-1} from seafood implies that seafood contibutes <0.2% of the TDI for an adult seafood consumer.

There are no TWIs established for BFRs or non-dl-PCBs. However, the UK COT carried out an assessment of the risks associated with consumption of fish from the River Skerne-Tees and concluded that the estimated dietary intakes of PBDEs and HBCD from the consumption of a weekly single portion of fish from the Skerne-Tees river system were unlikely to represent a risk to health. Irish data shows that levels of PBDEs and HBCD are over one and three orders of magnitude lower respectively than the levels at which COT assessed dietary intake. This would suggest that there is a correspondingly greater safety margin for consumers of farmed salmon and other fishery produce (Tlustos *et al*., 2007).

6.3 Benefits and risks of seafood consumption

Table 6.2 summarises the contribution of seafood to contaminant intake in the average adult seafood consumers diet as a proportion of the (p)TWIs and also the contribution of seafood to the RDAs for the long chain n-3 PUFAs. It is evident that for adult seafood consumers, intake of essential long chain n-3 PUFAs is at or even below recommended dietary intake levels, while intake of mercury, dioxins and dl-PCBs remains well within internationally accepted safe thresholds. In line with other studies (Mozaffarian & Rimm, 2006; Domingo *et al.,* 2007; SACN, 2004), this assessment serves to reaffirm current advice that seafood consumption, including one to two portions of oily fish such as salmon, mackerel, herring per week, provides clear health benefits that outweigh the risk associated with intake of contaminants.

Table 6.2: Estimated mean intake of PUFAs EPA + DHA and mercury, CB153 and dioxins and dl-PCBs from fish for the Irish seafood consumer and proportion of RDA/TWI

	Beneficial substances	Harmful substances			
Substance	**EPA+DHA**	**Mercury**	**CB153**	**Dioxins and dl-PCBs**	**HCB**
Units	mg per day	µg wk^{-1}	ng wk^{-1}	pg WHO-TEQ wk^{-1}	ng
Estimated intake from seafood for seafood consumers	272	17	490	171	112
Recommended dietary intake (labelling reference intake) §	200-500 (250)				
(p)TWI 70kg adult		112	NA	980	78400$
% of Recommended dietary intake (labelling reference intake)	136% – 54% (109%)				
%(p)TWI (harmful substances) from seafood for seafood consumers		15%	NA	17%	<0.2%
% fish by weight for which substance data available	81%	93%	90%	90%	77%

Consumption data source NSFCS (IUNA, 2001). Harmful and beneficial substance data: MI & FSAI data supplemented with UK data for highly consumed species where Irish data not available (EPA+DHA in cod, plaice, haddock from SACN 2004; dioxin and dl-PCB cod, plaice, haddock, whiting, prawns, lemon sole from FSAI 2006). Salmon and trout assumed to be farm reared.

§ recommended dietary intake proposed by various national and international agencies (i.e. 200 – 500mg) and, in brackets, labelling reference intake (EFSA, 2009)

$ TDI for neoplastic effects converted to a TWI for 70kg adult

Note: This estimation is based on determination of these parameters in uncooked fish and shellfish. Cooking may alter concentrations of contaminants and PUFAs in tissues.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► 7 Overall conclusions and recommendations

Seafood is the major source of many environmental pollutants to the diet but also is a highly nutritious food. Oily fish in particular are a vital source of the long chain n-3 PUFAs, EPA and DHA, which have well established health benefits.

Key conclusions of this assessment are:

- Concentrations of environmental contaminants, specifically trace metals and certain persistent organic pollutants in Irish fishery products are measurable but are generally low and well within EC maximum limits where such have been set. Preliminary estimates suggest that mean intakes of mercury and dioxin/dl-PCB from seafood are well within (p)TWIs for adult seafood consumers. This is indicative of the generally unpolluted Irish coastal and marine waters and provides reassurance to consumers that Irish seafood is of high quality and safe to eat.
- Compliance with the requirements for contaminants and veterinary residues in farmed fish ("Residues Directive") has been good with an overall non-compliance rate of 0.06% for 2004 – 2008. In 2006, 2007 and 2008 no non-compliant results were detected, suggesting improved awareness and practices within the industry.
- Highest concentrations of POPs are found in lipid-rich fish such as salmon, tuna and mackerel. Specifically, controversies over pollutant levels in farmed salmon have confused consumers about the risks and benefits of its consumption (Hites 2004, EFSA 2005, Shaw 2006). Due to the high lipid content and relatively high consumption, farmed salmon is the predominant seafood source of certain POPs to the Irish diet. Conversely, because of these same factors it is also the primary dietary source of beneficial EPA and DHA, estimated as over 70% of the seafood contribution to the diet. Data presented in this report suggests intake of EPA and DHA from seafood for average seafood consumers is close to, or even below, various RDAs. Farmed salmon is a relatively low cost and readily available source of oily fish, and consequently EPA and DHA, for the consumer. As contaminant levels are within regulatory maximum limits and (p)TWIs, it is evident that the nutritional benefits of consumption of one to two portions per week outweigh the risk associated with contaminant intake. Data from 2004 suggested a decrease in PCDD/F and dl-PCBs in farmed fish compared with a previous study in 2001. Data for dioxins and dl-PCBs in seafood from a repeat sampling exercise in 2010 will be available in 2011.
- Internationally health and food safety agencies generally advise that consumers should include fish as a regular part of the diet. Current advice from the FSAI is that consumers should eat two portions of fish a week, one of which should be oily (e.g. mackerel, herring and salmon). Data presented in this report supports the FSAI recommendation on fish consumption.
- FSAI have issued guidelines on consumption of certain top predatory fish species by breastfeeding women, women of childbearing age and young children. The guidance recommends these groups continue to eat fish, selecting from a wide range of species, but not to eat swordfish, marlin and shark, and to limit consumption of tuna to one fresh tuna steak or two 8oz cans per week. Data presented in this report shows high levels of total mercury in certain imported predatory fish, particularly swordfish and marlin, supporting the continuance of this guidance.

As seafood is an important dietary source for certain contaminants it is necessary that monitoring of contaminants and veterinary residues in fish be continued to:

- provide ongoing assurance of consumer safety and to enable ongoing consumer risk assessments;
- provide data to support the setting of new and practical standards at international level;
- provide factual information as a basis for considered response to food safety scares relating to fisheries produce;
- promote continued good practice within the fish farming industry; and
- provide essential information to underpin the international marketing of Irish seafood as a high quality product from clean waters.

It is recommended that the focus of future seafood monitoring and research activities should take the following into account:

- Polyaromatic hydrocarbons (PAH) should be monitored in shellfish as required by European legislation.
- There are significant data gaps for contaminants in certain shellfish and crustacean species which should be addressed. More data on contaminant levels in predatory fish are also required.
- Occasional one-off surveys of dioxins, dl-PCBs and emerging substances of concern are warranted to provide up-to-date consumer safety information, measure progress with regard to reducing contaminant concentrations in the diet and contribute to the setting of realistic international standards. There are many emerging substances of concern for the marine environment with potential for accumulation in fish tissue. Examples could be perfluorinated compounds and emerging brominated compounds.
- With decreasing levels of OCPs, reduced frequency of monitoring OCPs is appropriate.
- Future research should consider the risk to consumers associated with groups of chemicals acting in combination and consider specific consumer cohorts. More detailed information on seafood consumption patterns would enable improved risk benefit assessments.

References

Anon (2006). Perflourooctane Sulphonate (PFOS). Hazardous Substance Series. OSPAR Commission, 2005, updated in 2006 OSPAR Publication Number 269/2006 ISBN 978-1-905859-03-0. 46pp http://www.ospar.org/documents/dbase/publications/P00269_BD%20on%20PFOS%20_2006%20version_.pdf

Anon. (2008). Status of Irish Aquaculture, 2007. Report compiled by MERC Consultants for Marine Institute, Bord Iascaigh Mhara, Dublin, Údarás na Gaeltachta, http://www.marine.ie/NR/rdonlyres/BFB4C95F-61BD-42D2-8A55-967CC5AD2B0E/0/AQUACULTUREREPORT2006.pdf

Anon. (2009). Atlas of the Commercial Fisheries Around Ireland, Marine Institute, December 2009. ISBN 978 1 902895 46 8. 58 pp. http://www.marine.ie/NR/rdonlyres/2E7A2A9D-61E1-48C1-94C5-B11EAF6A61E0/0/AtlasofCommercialFisheriesAroundIreland09.pdf

Barrento S., Marques A., Teixeira B., Carvahla M.L., Vaz-Pires P. and Nunes M.L. (2009). Accumulation of elements (S, As, Br, Sr, Cd, Hg, Pb,) in Two Populations of *Cancer pagurus*: Ecological Implications to Human Consumption. *Food and Chemical Toxicology* 47, 150 – 156

Bell J.G., McGhee F., Dick J.R., Tocher D.R. (2005). Dioxin and dioxin-like polychlorinated biphenyls (PCBs) in Scottish farmed salmon (*Salmo salar*): effects of replacement of dietary marine fish oil with vegetable oils. *Aquaculture* 243, 205-314

Bentssen M.H.G. Maage A., Juhlsamn K., lundebye A.-K. (2011) Carry over of dietary organochlorine pesticides, PCDD/Fs, PCBs, and brominated flame retardants to Atlantic salmon (*Salmo salar*) fillets. *Chemosphere* 83, 95-103

Bergkvist C., Öberg M., Appelgren M., Becker W., Aune M., Halldin Ankarberg E., Berglund M., Håkansson H. (2008). Exposure to dioxin-like pollutants via different food commodities in Swedish children and young adults. *Food & Chemical Toxicology* 46, 3360-3367

Bloxham M., Rowe A., McGovern E., Smyth M. and Nixon E. (1998). Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish and Fin-fish from Irish Waters – 1996. *Fishery Leaflet 179*. Marine Institute, Dublin. http://www.marine.ie/NR/rdonlyres/872131A5-F0D6-4DBC-93CD-160026B521F4/0/fl179.pdf

Boyle B., Tyrrell L., McHugh B., Rowe A., Monaghan E., Costello J., Glynn D. and McGovern E. (2006). Trace Metal Concentrations in Shellfish from Irish Waters, 2003. *Marine Environment and Health Series, No. 25, 2006.* http://www.marine.ie/NR/rdonlyres/A098688E-C919-40FB-BF24-94704705AC8B/0/MEHSNo25TraceMetalConcentrationsinShellfishfromIrishWaters_2003.pdf

Davies I.M., Topping G., Graham W.C., Falconer C.R., McIntosh A.D. and Saward D. (1981). Field and experimental studies on cadmium in the brown crab Cancer pagurus. *Marine Biology* 64, 291–297

Domingo J.L., Bocio A., Falcó G. and Llobet J.M. (2007). Benefits and risks of fish consumption. Part I. A quantitative analysis of the intake of omega-3 fatty acids and chemical contaminants Toxicology 230 219–226

EFSA (European Food Safety Agency) (2004). Opinion of the Scientific Panel on Contaminants in the Food Chain on a request from the Commission related to mercury and methylmercury in food *The EFSA Journal* 2004; 34, 1-14 http://www.efsa.europa.eu/en/scdocs/doc/34.pdf

EFSA (European Food Safety Agency) (2005). Opinion of the scientific panel on contaminants in the food chain on a request from the European parliament related to the safety assessment of wild and farmed fish. *The EFSA Journal* 2005; 236, 1 – 118 http://www.efsa.europa.eu/en/scdocs/doc/236.pdf

EFSA (European Food Safety Agency) (2009). Scientific Opinion of the Panel on Dietetic products, Nutrition and Allergies on a request from European Commission related to labelling reference intake values for n-3 and n-6 polyunsaturated fatty acids. *The EFSA Journal* 2009; 1176, 1-11

EFSA (European Food Safety Agency) (2010). EFSA Panel on Contaminants in the Food Chain (CONTAM); Scientific Opinion on Arsenic in Food. *The EFSA Journal* 2009; 7(10):1351. [199 pp.]. doi:10.2903/j.efsa.2009.1351.
http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902959840.htm

EFSA (European Food Safety Agency) (2010). Results of the monitoring of dioxin levels in food and feed. *The EFSA Journal* 2010; 8(3):1385[35 pp]
http://www.efsa.europa.eu/en/scdocs/doc/1385.pdf

EFSA (European Food Safety Agency) (2010). Results of the monitoring of non dioxin-like PCBs in food and feed. The *EFSA Journal* 2010; 8(7):1701 [34pp]
http://www.efsa.europa.eu/en/scdocs/doc/1701.pdf

EPA (2010) National Large PCB Holdings Inventory Updated March 2010 and National Small PCB Holdings Inventory Updated January 2010 http://www.epa.ie/downloads/pubs/waste/haz/

FAO (2010). Database: Capture Production 1950-2008
http://www.fao.org/fishery/statistics/software/fishstat/en.

FSAI (1999). Recommended Dietary Allowances for Ireland 1999. Food Safety Authority of Ireland, Dublin.

FSAI (2009). Dioxins and PCBs in food. Toxicology Factsheet Series. Issue 1 May 2009. Food Safety Authority of Ireland Dublin.
http://www.fsai.ie/assets/0/86/204/d2a7dc76-1298-4384-84f7-e3d3c658278a.pdf

Fernandes A, Mortimer D., Gem M., Smith F., Rose M., Panton S. and Carr M. (2010). Polychlorinated Naphthalens (PCNs): Congener Specific Analysis, Occurrence in Food, and Dietary Exposure in the UK. *Environmental Science & Technology*. 44: 3533-3538

Food Standards Agency. (2006). Dioxins and dioxin-like PCBs in farmed & wild fish and shellfish. Food Survey Information Sheet No. 03/06, available at www.food.gov.uk

Foran J.A., Carpenter D.O., Hamilton M.C., Knuth B.A. and Schwager S.J. (2005). Risk-based consumption advice for farmed Atlantic and wild Pacific salmon contaminated with dioxins and dioxin-like compounds Environ Health Perspect 113:552–556

FSAI (2010a) Investigation into levels of perfluoroalkylated substances (PFAs) in meat, offal, fish, eggs, milk and processed products. October 2010. Food Safety Authority of Ireland, Dublin.
http://www.fsai.ie/resources_and_publications/surveys.html#Directory1

FSAI (2010b) Investigation into levels of polychlorinated naphthalenes (PCNs) in carcass fat, offal, fish, eggs, milk and processed products. Monitoring and Surveillance Series. October 2010. Food Safety Authority of Ireland, Dublin. http://www.fsai.ie/resources_and_publications/surveys.html#Directory1

FSAI (2011) Fish Labelling Survey. March 2011. Food Safety Authority of Ireland, Dublin. http://www.fsai.ie/resources_and_publications/surveys.html#Directory1

Glynn D., Tyrrell L., McHugh B., Rowe A., Monaghan E., Costello J. and McGovern E. (2004). Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish from Irish Waters, 2002. *Marine Environment and Health Series, No. 16, 2004.*
http://www.marine.ie/NR/rdonlyres/8BC1102F-AF78-43B7-8BC6-18057C85ACF4/0/MEHS162004.pdf

Glynn D., Tyrrell L., McHugh B., Rowe A., Monaghan E., Costello J. and McGovern E. (2003b). Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish from Irish Waters, 2001. *Marine Environment and Health Series, No. 10, 2003.*
http://www.marine.ie/NR/rdonlyres/592E9E3D-1B45-44E7-A81C-F04836B2EADE/0/mehs10.pdf

Glynn D., Tyrrell L., McHugh B., Rowe A., Costello J. and McGovern E. (2003a). Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish from Irish Waters, 2000. *Marine Environment and Health Series, No. 7, 2003.*
http://www.marine.ie/NR/rdonlyres/1209F8D2-15ED-4E15-869B-D8ECD4DB816F/0/mehs7.pdf

IPCS (1997). Hexachlorobenzene. Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 195).

Hayes F. and Marnane I. (2002). Inventory of Dioxin and Furan Emissions to Air, Land and Water in Ireland for 2000 and 2010. (2000-DS-2-M1) Synthesis Report. Prepared for the EPA by URS Dames & Moore. Environmental Protection Agency, Wexford.

Hites R. A., Foran J. A., Carpenter D. O., Hamilton M. C., Knuth B. A. and Schwager S. J. (2004). Global assessment of organic contaminants in farmed salmon. *Science*, 303: 226-229

Huang A., Hites R.A., Foran J A., Hamilton C., Knuth B.A., Schwager S.J. and Carpenter,D.O. (2006). Consumption advisories for salmon based on risk of cancer and noncancer health effects *Environmental Research* 101: 263–274

Jacobs M.N., Covaci A. and Schepens P. (2002). Investigation of selected persistent organic pollutants in farmed Atlantic salmon (*Salmo salar*), salmon aquaculture feed, and fish oil components of the feed. *Environ. Sci. Technol.*, 36, 2797-2805

Ikonomou M.G., Higgs DA., Gibbs M., Oakes J., Skura B., McKinley S., Balfry S.K., Jones S., Withler R. and Dubetz C. (2007). Flesh quality of market-size farmed and wild British Columbia salmon. Environ Sci Technol. 41(2):353-4

IUNA (2001) *North/South Ireland Food Consumption Survey: Food And Nutrient Intakes, Anthropometry, Attitudinal Data & Physical Activity Patterns*. Food Safety Promotion Board. Abbey Court, Lower Abbey Street, Dublin. http://www.iuna.net/index.php?option=com_content&view=article&id=6&Itemid=18

Jakobsson E., and Asplund L. (2000). Polychlorinated Naphthalenes (PCNs) in *The Handbook of Environmental Chemistry*, Volume 3K, 97-126

Kris-Etherton P.M., Harris W.S. and Appel L.J. (2002). For the Nutrition Committee. AHA scientific statement. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Circulation 106, 2747–2757

Kvalem H.E, Knutsen H.K., Thomsen C., Haugen M., Stigum H., Brantsaeter A.L., Frøshaug M., Lohmann N., Päpke O., Becher G., Alexander J., Meltzer H.M. (2009) Role of dietary patterns for dioxin and PCB exposure. *Molecular Nutrition & Food Research* 53, 1438-1451

Marine Institute (2008a). The Stock Book: Report to the Minister for Agriculture, Fisheries and Food Annual Review of Fish Stocks in 2008 with Management Advice for 2009. November 2008. Marine Institute, Galway.
http://www.marine.ie/NR/rdonlyres/7B67DD30-4D1F-4F7F-9A26-D6058D1D9D98/0/TheStockBook2008.pdf

McGovern E., Rowe A., McHugh B., Costello J., Bloxham M., Duffy C. and Nixon E. (2001) Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish from Irish Waters 1997-1999. *Marine Environment and Health Series, No.2, 2001*
http://www.marine.ie/NR/rdonlyres/8648B32B-EAE4-46B8-8D1C-1AB5459C4FAD/0/mehs2.pdf

McHugh B., Poole R., Corcoran J., Anninou P., Boyle B., Joyce E., Foley B. M. and McGovern E. (2010) The occurrence of persistent chlorinated and brominated organic contaminants in the European eel (*Anguilla anguilla*) in Irish waters. *Chemosphere*. 79(3):305-13

Miller D.D. and Mariani S. (2010). Smoke, mirrors, and mislabelled cod: poor transparency in the European seafood industry. *Front. Ecol. Environ*. 8: 517–521

Mozaffarian D. and Rimm E.B. (2006). Fish intake, contaminants, and human health. Evaluating the risks and the benefits. *JAMA* 296: 1885–1899

Nesheim M.C. and Yaktine A.L. (2007). Seafood Choices: Balancing Benefits and Risks. Institute of Medicine of the National Academy of Sciences. The National Academic Press, Washington, USA. p. 722

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

Nixon E., Rowe A., Smyth M., McLaughlin D. and Silke J. (1994). Monitoring of Shellfish Growing Areas - 1993. *Fishery Leaflet* 160. Department of the Marine, Dublin.

Nixon E., Rowe A., Smyth M., McLaughlin D. and Silke J. (1995). Monitoring of Shellfish Growing Areas - 1994. *Fishery Leaflet* 166. Department of the Marine, Dublin
http://www.marine.ie/NR/rdonlyres/D88646DE-27D5-4543-8366-33B89BE00C4A/0/fl166.pdf

Nixon E., Rowe A. and McLaughlin D. (1994a). Mercury concentration in fish from Irish waters in 1993. *Fishery Leaflet* 162, Department of Marine, Dublin.
http://www.marine.ie/NR/rdonlyres/0F640878-4810-4EDF-8616-C1FC6869230A/0/fl162.pdf

Nixon E., Rowe A. and McLaughlin D. (1993). Mercury concentration in fish from Irish waters in 1992. Fishery Leaflet 156, Department of Marine, Dublin.

Rowe A., Nixon E., McGovern E., McManus M. and Smyth M. (1998). Metal and Organo-Chlorine Concentrations in Fin-Fish from Irish Waters, *Fishery Leaflet* 176, Marine Institute, Dublin.
http://www.marine.ie/NR/rdonlyres/1FB9577C-A023-4261-9712-2CAC59D26937/0/fl176.pdf

SACN (2004). Advice on fish consumption: Benefits and Risks. Scientific Advisory Committee on Nutrition London: TSO. http://www.sacn.gov.uk/pdfs/fics_sacn_advice_fish.pdf

Safefood (2006). "Consumer Focused Review of the Finfish Food Chain 2005" Food Safety Promotion Board. Cork.
http://www.safefood.eu/Global/Publications/Research%20reports/CFRFINFISHREPORT.pdf?epslanguage=en

Savedra Y., González A., Fernández P. and Blanco J. (2004). Interspecific Variation of Metal Concentrations in Three Bivalve Mollusks from *Galicia. Arch. Environ. Contam. and Toxicol*., 47, 341-351

SCF (2000). Opinion of the SCF on the Risk Assessment of Dioxins and Dioxin-like PCBs in Food, adopted on 22 November 2000.http://ec.europa.eu/food/fs/sc/scf/out78_en.pdf

SCF (2001). Opinion on the risk assessment of dioxins and dioxins-like PCBs in food (update based on the new scientific information available since the adoption of the SCF opinion of 22 November 2000). http://ec.europa.eu/food/fs/sc/scf/out90_en.pdf

Shaw S.D., Brenner D., Berger M.L., Carpenter D.O., Hong C-S. and Kannan K. (2006). PCBs, PCDD/Fs, and Organochlorine Pesticides in Farmed Atlantic Salmon from Maine, Eastern Canada, and Norway, and Wild Salmon from Alaska. *Environmental Science & Technology*, 40, 5347-5354

Smyth M., Rowe A., McGovern E. and Nixon E. (1997). Monitoring of Shellfish Growing Areas - 1995. *Fishery Leaflet* 174. Department of the Marine, Dublin http://www.marine.ie/NR/rdonlyres/8D3AFF14-023F-43E4-B254-9B7A15327BA1/0/fl174.pdf

Tlustos C., McHugh B., Pratt, I., Tyrrell L., and McGovern E. (2007). Investigation into levels of dioxins, furans, polycholorinated biphenyls and brominated flame retardants in fishery produce in Ireland. *Marine Environment and Health Series, No. 26, 2006.*
http://www.marine.ie/NR/rdonlyres/AF607D79-A7CC-45A3-995F-4F865F287CE6/0/PopsinfishMEHSNo26.pdf#

Tyrrell L., Twomey M., Glynn D., McHugh B., Joyce E., Costello J. and McGovern E. (2005). Trace Metal Concentrations in Various Fish Species Landed at Selected Irish Ports, 2002, *Marine Environment and Health Series No 20, 2005.*
http://www.marine.ie/NR/rdonlyres/29F2BB43-D9BC-4FAB-8F9F-C321D5DDCCA9/0/MEHS202005.pdf

Tyrrell L., McHugh B., Glynn D., Twomey M., Joyce E., Costello J. and McGovern E. (2004). Trace Metal and Chlorinated Hydrocarbon Concentrations in Various Fish Species Landed at Selected Irish Ports, 2002, *Marine Environment and Health Series No 18, 2003.*
http://www.marine.ie/NR/rdonlyres/35A26F2A-AE1C-43C9-8224-F6F8163F1811/0/MEHSNo182004.pdf

Tyrrell L., Glynn D., McHugh B., Rowe A., Monaghan E., Costello J. and McGovern E. (2003b). Trace Metal and Chlorinated Hydrocarbon Concentrations in Various Fish Species Landed at Selected Irish Ports, 2001, *Marine Environment and Health Series No 13, 2003.*
http://www.marine.ie/NR/rdonlyres/D10A7C85-A864-4BFE-802A-C981CFE2FC96/0/mehs13.pdf

Tyrrell L., Glynn D., Rowe A., McHugh B., Costello J., Duffy C., Quinn A., Naughton M., Bloxham M., Nixon E. and McGovern E. (2003a). Trace Metal and Chlorinated Hydrocarbon Concentrations in Various Fish Species Landed at Selected Irish Ports, 1997-2000, *Marine Environment and Health Series No 8, 2003.*
http://www.marine.ie/NR/rdonlyres/A3CC6422-0B9D-4DA7-9B9A-BBEF306F2D7E/0/mehs8.pdf

Van den Berg M., Birnbaum LS., Denison M., De Vito M., Farland W., Feeley M., Fiedler H., Håkansson H., Hanberg H., Haws L., Rose M., Safe S., Schrenk S., Tohyama C., Tritscher A., Tuomisto J., Tysklind M., Walker N. and Peterson R.E. (2006). The 2005 World Health Organization re-evaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. *Toxicological Science* **93**: 223–241

Selected European Legislation – contaminants and residues in food:

Council Directive 96/23/EC of 29 April 1996 on measures to monitor certain substances and residues thereof in live animals and animal products and repealing Directives 85/358/EEC and 86/469/EEC and Decisions 89/187/EEC and 91/664/EEC.

Council Directive 2008/97/EC of the European parliament and of the Council of 19 November 2008 amending Council Directive 96/22/EC concerning the prohibition on the use in stockfarming of certain substances having a hormonal or thyrostatic action and of beta-agonists.

Council Regulation (EEC) No 2377/90 of 26 June 1990 laying down a Community procedure for the establishment of maximum residue limits of veterinary medicinal products in foodstuffs of animal origin.

Commission Regulation (EU) no 37/2010 of 22 December 2009 on pharmacologically active substances and their classification regarding maximum residue limits in foodstuffs of animal origin.

Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs.

Commission Regulation (EC) No 565/2008 of 18 June 2008 amending Regulation 9EC) 1881/2006 setting maximum levels for certain contaminants in foodstuffs as regards the establishment of a maximum level for dioxind and PCBs in fish liver.

Commission Regulation (EC) No 629/2008 of 2 July 2008 amending Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs.

Commission Regulation (EU) No 420/2011 of 29 April 2011 amending Regulation (EC) No 1881/2006 setting maximum level for certain contaminants in foodstuffs.

Directive 2006/113/EC of the European Parliament and of the Council of 12 December 2006 on the quality required of shellfish waters, repealing and replacing Council Directive 79/923/EEC on the quality required of shellfish waters.

Regulation (EC) No. 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety.

Regulation (EC) No 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption.

Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules.

Annex A Sampling and Analysis Procedures

A.1 Sampling and sample handling

A.1.1 Bivalve shellfish monitoring programme

Samples of the main shellfish species produced in each of the growing areas were collected; mussel samples consisted of 50 individuals and oysters of 25 individuals. Shellfish were depurated overnight in seawater collected from the growing area at the time of sampling. The lengths of individual shellfish were recorded prior to the soft tissue being removed from the shells to be washed and drained. The percentage meat and shell weights were calculated and recorded.

A.1.2 Finfish - Port landings monitoring programme

Depending on availability, 10 fish of each species landed were sampled at each of the ports. The area where the fish were caught was recorded. The length of each fish was recorded and a portion of tissue from each of the 10 fish was pooled to provide a sample.

A.1.3 Sample preparation and storage

The pooled soft tissue from A.1.1 and the pooled samples from A.1.2 were homogenized prior to being divided into three sub-samples. Two sub-samples were stored in pre-weighed acid washed glass jars for metals and mercury, while the third sub-sample was stored in a solvent washed jar for organics. Metal analysis was carried out on freeze dried samples (freeze dried for 48 hours prior to analysis). Mercury and organics analysis was carried out on whole tissue samples, stored at -20°C.

A.1.4 Residues programme - Finfish aquaculture sample collection and Preparation

In accordance with the National Residues Control Plan for Aquaculture under Council Directive 96/23/EC, staff authorized under the Animal Remedies Act, 1993 collected samples at farm or processing plant level. All samples were transported to the laboratory under controlled conditions, while ensuring an unbroken chain of custody. Sub-samples were taken for both analytical and archive purposes and all sub-samples were stored frozen (approximately -20°C).

A.2 Methods of Analysis

A.2.1 Cypermethrin and deltramethrin by gas chromatography electron capture detection (GC-ECD):

Approximately 2g of sample was extracted using a hexane/acetone mixture, followed by liquid/liquid partition with acetonitrile. The extract was then cleaned-up by Florisil® Solid Phase Extraction (SPE) Cartridges. The extract was then evaporated to dryness and reconstituted in 2,2,4-trimethylpentane. The analysis was carried out using Varian CP-3800 Gas Chromatography coupled with Electron Capture Detector (GC-ECD) with a Chrompack 15 metre CP-SIL 8 column.

A.2.2 Ivermectin and emamectin B1a by high performance liquid chromatography (HPLC) with fluorescence detection:

A representative sample (5g) from each fish was homogenized and extracted with methanol. The extract was cleaned up by liquid/liquid partition and solid phase extraction techniques. The resultant residue was derivatised and analysed by High Performance Liquid Chromatography (HPLC) with Fluorescence Detection.

A.2.3 Teflubenzuron and diflubenzuron by HPLC with UV detection:

This method involves the extraction of approximately 3g of tissue with acetonitrile, followed by clean up using liquid/liquid partition and silica SPE. Quantification was carried out by reverse phase HPLC using an acetonitrile/water mobile phase and UV detection. Confirmation and peak purity is evaluated using a photodiode array detector.

A.2.4 Antimicrobial screening:

Antimicrobial screening was carried by the Fish Health Unit of the Marine Institute, using a modification of the Four Plate Test (FPT). The aim of this method was to reveal residues of substances with antibacterial activity by testing pieces of fish tissue using agar plates that had been seeded with suitably sensitive bacterial cultures. This method was qualitative in nature and was used to detect residues of quinolones, tetracyclines, nitrofurans and sulphonamides. Muscle tissue was used to determine antibiotic residues on three of the test plates, while liver tissue was used on the fourth plate.

A.2.5 Malachite green and leuco malachite green:

Until 2006, analysis of malachite green (MG) and leuco malachite green (LMG) was carried out under contract with the Laboratory of the Government Chemist (LGC) UK. The method involved the extraction of approximately 5g of muscle using an ammonium acetate buffer, dichloromethane and acetonitrile, followed by clean-up using liquid/liquid partition, alumina and PRS cartridges. The subsequent determination of malachite green and leuco malachite green was achieved using Liquid Chromatography with tandem Mass Spectrometry detection (LC-MS/MS).

From 2007, analysis of this compound was carried out in house by the Marine Institute. Samples for malachite green (MG) and leuco malachite green (LMG) analysis were extracted by homogenisation with acetonitrile: McIlvain Buffer pH 3 (9:1). The sample extract was cleaned up using solid phase extraction techniques. The eluant was evaporated to dryness and the subsequent determination of malachite green and leuco malachite green was achieved using Liquid Chromatography with tandem Mass Spectrometry detection (LC-MS/MS).

A.2.6 Polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs):

Due to the lipophilic nature of PCBs and OCPs , lipid was extracted from tissue using the method developed by Smedes. Chlorinated hydrocarbons were removed from the lipids by alumina column chromatography, followed by separation of PCBs from the chlorinated pesticides using silica column chromatography. Concentration levels were determined by dual column Gas Chromatography with Electron Capture Detection (GC-ECD), using a Varian 3800 gas chromatograph fitted with a 60 metre fused silica capillary column (HT8, J and W Scientific). A second column of different polarity was used as confirmation (CP-SIL 19CB, Chrompack Varian Inc).

Analysis for WHO polychlorinated biphenyls (PCBs) and PCDD/F was carried out by a subcontracted laboratory (ERGO, Hamburg). Prior to the extraction, 13C-UL-labeled internal standards were added, followed by a solid/lipid extraction and clean up by a multicolumn system. Concentration levels were determined by High Resolution Gas Chromatography and High Resolution Mass Spectrometry (HRGC/HRMS) using a DB-5 capillary column.

A.2.7 Trace metal analysis (cadmium, chromium, copper, lead, nickel, silver and zinc):

Concentrated nitric acid (4ml) and hydrogen peroxide (4ml) were added to approximately 0.2g freeze-dried tissue, which was then digested in a laboratory microwave oven (CEM Mars Xpress). After cooling, samples were diluted to 50ml with deionised water. Lead, cadmium, chromium, copper, nickel and silver concentrations were determined using Graphite Furnace Atomic Absorption Spectrometry with Zeeman background correction (Varian SpectrAA 220Z). Zinc concentrations were determined using Flame Atomic Absorption Spectroscopy (Varian SpectrAA 20 Plus).

A.2.8 Determination of total mercury using cold vapour atomic fluorescence spectroscopy (CVAFS):

Concentrated nitric acid (4ml) was added to 0.6 - 0.8g of wet tissue, which was then digested in a laboratory microwave oven (CEM Mars Xpress). After cooling, potassium permanganate was added until the purple colour of the solution stabilised. Sufficient hydroxylamine sulphate/sodium chloride solution was added to neutralise the excess potassium permanganate and potassium dichromate was added as a preservative. The solution was diluted to 100ml with deionised water. Following reduction of the samples with tin (II) chloride, mercury concentrations were determined by Cold Vapour Atomic Fluorescence Spectroscopy (CV-AFS) using a PSA Merlin Analyzer.

A.2.9 Total arsenic analysis using hydride generation atomic fluorescence spectroscopy (HG-AFS):

Concentrated nitric acid (4ml) and hydrogen peroxide (4ml) was added to 0.2g of dry tissue, which was then digested in a laboratory microwave oven (CEM Mars Xpress). After cooling, an aliquot of this digest was added to a weak solution of potassium persulphate which was then digested for a second time in the microwave oven. This solution was then made up to 100ml in a volumetric flask containing 25ml concentrated hydrochloric acid, and 2ml of potassium iodide (50% m/v) ascorbic acid (10% m/v) solution. Following reduction of the samples with sodium tetraborohydride, arsenic concentrations were determined by Hydride Generation Atomic Fluorescence Spectroscopy (HG-AFS) using a PSA Millennium Excalibur Analyser.

A.2.10 Determination of percentage moisture content:

The moisture content was determined by drying approximately 1g of tissue overnight at 104°C, to constant weight.

A.2.11 Screening for Group A compounds:

Group A compounds were screened for using the Elisa method by subcontracted laboratory (Irish Equine Centre). This method is qualitative in nature and is used to detect residues of corticosteroids, *beta*-agonists and chloramphenicol.

A.2.12 Nitrofuran analysis:

The analysis of nitrofurans was carried out under contract with the National Food Centre. Tissue bound residues of nitrofurans were hydrolyzed with acid and both the released and the free metabolites were derivatised with 2-nitrobenzaldehyde. The nitrophenyl derivatives were extracted with ethyl acetate and determined by LC-MS/MS using deuterated analogues as internal standards for quantification. Samples were analysed for metabolites of furazolidone, furaltadone, nitrofurantoin and nitrofurazone.

A.3 Quality Assurance

Marine Institute are accredited by INAB the Irish National Accreditation board (INAB) to ISO 17025 as detailed in Scope Registration Number 130T. The following table lists the Marine Institute's accreditation status for test methods pertinent to this report.

Table A.1: INAB accreditation awards to ISO17025 for Marine Institute test methods pertinent to this report (Scope registration number 130T)

Analyte/ Test method	Accreditation (Award Date)
Ivermectin and emamectin B1a in finfish	1st July 2002
Mercury in biota	19th May 2003
Lipid content in fish tissue (Resigned 2010)	19th May 2003
Moisture content determination in marine biota	19th May 2003
Antibacterial Screening	19th May 2003
The scope of accreditation notes with respect to sampling for the residues programme: *When Collecting Samples the Laboratory Complies with Council Directive 96/23/EC*	19th May 2003
Teflubenzuron and diflubenzuron in finfish	16th April 2004
Copper in marine biota	20th May 2005
Lead in marine biota	20th May 2005
Cadmium in marine biota	20th May 2005
Cypermethrin & Deltamethrin in finfish	16th June 2006
Nickel in marine biota	16th June 2006
Chromium in marine biota	16th June 2006
Silver in marine biota	16th June 2006
Malachite green and leuco malachite green by LCMSMS	2nd May 2008
Arsenic Total in marine matrices	22 April 2010

Routine quality assurance includes testing of certified reference materials, spiked samples and procedural blanks as part of ongoing analysis, and participation in appropriate proficiency testing schemes and intercalibrations where available. Examples of such schemes include QUASIMEME (Quality Assurance of Information for Marine Environmental Monitoring in Europe) and FAPAS (Food Analysis Performance Assessment Scheme).

A.4 Presentation of Results

A.4.1 Toxicity equivalent factors (TEFs) for reporting of dioxins and dioxin like-PCBs

The toxicity of PCDDs, PCDFs and dioxin-like PCB congeners are expressed using toxic equivalence factors (TEFs) representing the relative toxicity of the compound being measured to the most toxic dioxin congener, TCDD. This in turn reflects the relative strength of binding to the Ah receptor. An arbitrary TEF of 1 is assigned to TCDD, and by multiplying the analytically determined concentrations of each congener in a sample by its corresponding TEF, individual toxicity equivalents (TEQs) are determined. The overall toxicity of a mixture of these compounds is commonly expressed as a single number, the Toxic Equivalent (TEQ), obtained by summing individual compounds concentrations weighted by Toxic Equivalent Factors. While several different TEF schemes have been proposed the results provided in this report are however based on the 1998 scheme for WHO-TEFs as these remain the TEFs stipulated in EC Regulation 1881/2006/EC. It is anticipated that imminent legislation updates will revise these TEFs with WHO2005 TEFs.

Table A.2: World Health Organisation (WHO) toxic equivalency factors (Van den Berg *et al*., 2006): WHO-TEFs 1998 as applied in EC food legislation and as utilised in this assessment and proposed revised values.

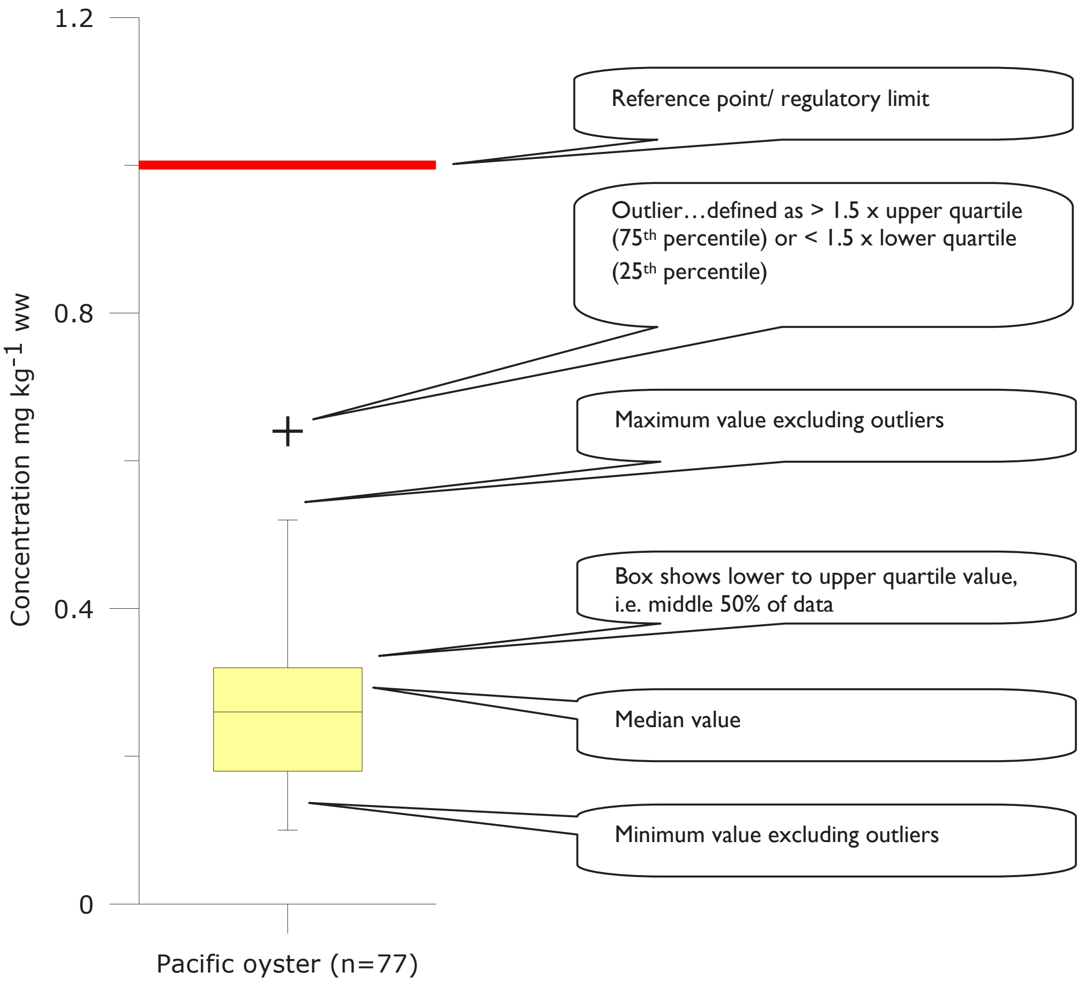
	WHO 1998 TEFs	WHO 2005 TEFs
Chlorinated dibenzo-p-dioxins		
2.3.7.8-Tetra-CDD	1	1
1.2.3.7.8-Penta-CDD	1	1
1.2.3.4.7.8-Hexa-CDD	0.1	0.1
1.2.3.6.7.8-Hexa-CDD	0.1	0.1
1.2.3.7.8.9-Hexa-CDD	0.1	0.1
1.2.3.4.6.7.8-Hepta-CDD	0.01	0.01
OCDD	0.0001	0.0003
Chlorinated dibenzofurans		
2.3.7.8-Tetra-CDF	0.1	0.1
1.2.3.7.8-Penta-CDF	0.05	0.03
2.3.4.7.8-Penta-CDF	0.5	0.3
1.2.3.4.7.8-Hexa-CDF	0.1	0.1
1.2.3.6.7.8-Hexa-CDF	0.1	0.1
1.2.3.7.8.9-Hexa-CDF	0.1	0.1
2.3.4.6.7.8-Hexa-CDF	0.1	0.1
1.2.3.4.6.7.8-Hepta-CDF	0.01	0.01
1.2.3.4.7.8.9-Hepta-CDF	0.01	0.01
OCDF	0.0001	0.0003
Non-ortho–substituted PCBs		
3,3',4,4'-tetraCB (PCB 77)	0.0001	0.0001
3,4,4',5-tetraCB (PCB 81)	0.0001	0.0003
3,3',4,4',5-pentaCB (PCB 126)	0.1	0.1
3,3',4,4',5,5'-hexaCB (PCB 169)	0.01	0.03
Mono-ortho–substituted PCBs		
2,3,3',4,4'-pentaCB (PCB 105)	0.0001	0.00003
2,3,4,4',5-pentaCB (PCB 114)	0.0005	0.00003
2,3',4,4',5-pentaCB (PCB 118)	0.0001	0.00003
2',3,4,4',5-pentaCB (PCB 123)	0.0001	0.00003
2,3,3',4,4',5-hexaCB (PCB 156)	0.0005	0.00003
2,3,3',4,4',5'-hexaCB (PCB 157)	0.0005	0.00003
2,3',4,4',5,5'-hexaCB (PCB 167)	0.00001	0.00003
2,3,3',4,4',5,5'-heptaCB (PCB 189)	0.0001	0.00003

A.4.2 How to interpret Box-and-whisker Plots

The box-and-whisker plot is used to show the distribution of a dataset (at a glance).

In descriptive statistics, a box-and-whisker plot is a convenient way of graphically depicting groups of numerical data through their five-number summaries (the smallest observation (sample minimum excluding outliers), lower quartile, median, upper quartile, and largest observation (sample maximum excluding outliers).

The spacing between the different parts of the box help indicate the degree of dispersion (spread) and skewness in the data, and may also indicate which observations, if any, might be considered outliers.



Annex B

B.1 Contaminant data for Irish shellfish 2004-2008

Table B1.1: Shellfish sampling location: species and number of samples 2004 – 2008

	C.edule	*C. gigas*	*E. siliqua*	*M.edulis*	*O. edulis*	*T.philippinarum*	Grand Total
Achill Sound - North	0	1	0	0	0	0	**1**
Achill Sound - South	0	1	0	0	0	0	**1**
Balbriggan - Skerries	0	0	1	0	0	0	**1**
Ballinakill Bay	0	1	0	0	0	0	**1**
Baltimore Harbour \ Sherkin	0	1	0	0	0	0	**1**
Bannow Bay - Inner	0	6	0	0	0	0	**6**
Bantry Bay - Castletownbere	0	0	0	1	0	0	**1**
Bantry Bay - Glengarriff	0	0	0	6	0	0	**6**
Bantry Bay - Inner	0	0	0	6	0	0	**6**
Bantry Bay - South	0	0	0	1	0	0	**1**
Blacksod Bay	0	0	0	0	1	0	**1**
Carlingford Lough - Inner	0	1	0	5	0	0	**6**
Carlingford Lough - Outer	0	9	0	4	0	0	**13**
Clew Bay - Newport Bay	0	3	0	1	0	0	**4**
Clew Bay - North Bay	0	5	0	4	0	0	**9**
Clew Bay - Westport Bay	0	5	0	0	1	0	**6**
Clifden Bay - Ardbear Bay	0	0	0	1	0	0	**1**
Cork Harbour - Main	0	0	0	1	0	0	**1**
Cork Harbour - North Channel	0	2	0	2	0	0	**4**
Cork Harbour - Rostellan North	0	0	0	1	0	0	**1**
Cork Harbour - Rostellan South	0	1	0	0	0	0	**1**
Cromane	0	0	0	6	0	0	**6**
Donegal Bay	0	1	0	0	0	0	**1**
Dundalk Bay	1	0	0	0	0	0	**1**
Dundalk Bay - Annagasan	0	0	0	4	0	0	**4**
Dungarvan Bay	0	6	0	0	0	0	**6**
Dungloe Bay	0	1	0	0	0	0	**1**
Dunmanus Bay - Inner	0	0	0	1	0	0	**1**
Galway Bay - Aughinish Bay	0	2	0	0	0	0	**2**
Galway Bay - Aughinish Bay \ Kilthuria	0	1	0	0	0	0	**1**
Galway Bay - Aughinish Bay \ Munnia	0	4	0	0	0	0	**4**
Galway Bay - Ballyvaughan \ Poulnaclogh Bay	0	0	0	1	0	0	**1**
Galway Bay - Clarinbridge	0	5	0	1	0	0	**6**
Galway Bay - Kinvara	0	0	0	1	0	0	**1**
Galway Bay - Outer \ Indreabhan	0	0	0	1	0	0	**1**
Gweebarra Bay	0	1	0	0	0	0	**1**
Gweedore Bay	0	1	0	0	0	0	**1**
Inver Bay	0	0	0	1	0	0	**1**

	C.edule	*C. gigas*	*E. siliqua*	*M.edulis*	*O. edulis*	*T.philippinarum*	Grand Total
Kilkieran Bay - North	0	0	0	1	5	0	**6**
Killala Bay	0	1	0	0	0	0	**1**
Killary Harbour - Inner	0	0	0	5	0	0	**5**
Kilmakillogue	0	0	0	6	0	0	**6**
Kinsale	0	1	0	0	0	0	**1**
Lough Foyle	0	0	0	1	0	0	**1**
Lough Foyle - Outer \ Greencastle	0	0	0	1	0	0	**1**
Lough Foyle - Quigley's Point	0	0	0	5	1	0	**6**
Lough Swilly - Inch Lough	0	1	0	5	0	0	**6**
Loughras Beg	0	1	0	0	0	0	**1**
Malahide	0	0	1	0	0	0	**1**
Mannin Bay	0	1	0	0	0	0	**1**
McSwynes Bay - Inner Bay \ Bruckless	0	0	0	6	0	0	**6**
Mulroy Bay - Broadwater	0	0	0	5	0	0	**5**
Mulroy Bay - South	0	0	0	1	0	0	**1**
Oysterhaven	0	1	0	0	0	0	**1**
Roaringwater Bay	0	0	0	6	0	0	**6**
Shannon Estuary - Aughinish	0	4	0	0	0	0	**4**
Shannon Estuary - Carrigaholt	0	1	0	0	0	0	**1**
Shannon Estuary - Poulnasherry Bay	0	1	0	0	0	0	**1**
Shannon Estuary - Rinevella	**0**	1	0	0	0	0	**1**
Sheephaven Bay	0	1	0	0	0	0	**1**
Sligo Bay - Ballysadare Bay	0	0	0	4	0	1	**5**
Sligo Bay - Drumcliff	0	1	0	0	0	0	**1**
Sligo Bay - Outer Bay	0	0	0	1	0	0	**1**
Sligo Bay - Sligo Harbour	0	0	0	1	0	0	**1**
Sligo Bay - Sligo Harbour \ Rosse's Point	0	0	0	4	0	0	**4**
Streamstown Bay	0	1	0	0	0	0	**1**
Tralee Bay - Fenit	0	0	0	0	4	0	**4**
Tralee Bay – Inner	0	0	0	6	6	0	**12**
Tralee Bay - Maharees	0	0	0	2	6	0	**8**
Tralee Bay - Outer	0	0	0	2	0	0	**2**
Trawbreaga Bay	0	1	0	0	0	0	**1**
Trawenagh Bay	0	1	0	0	0	0	**1**
Waterford Harbour - Arthurstown	0	0	0	3	0	0	**3**
Waterford Harbour - Cheekpoint	0	0	0	5	0	0	**5**
Waterford Harbour - Duncannon	0	1	0	0	0	0	**1**
Wexford Harbour - Inner	0	0	0	1	0	0	**1**
Wexford Harbour - Outer	0	0	0	5	0	0	**5**
Total	**1**	**77**	**2**	**125**	**24**	**1**	**230**

Table B1.2: Trace metals in Irish shellfish species for the period 2004 – 2008.

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2004/47	*M.edulis*	07/09/2004	Roaringwater Bay	50	45.8 – 64.4	51.8	3.78	78.2	nd (<0.01)		0.12	<0.19	1.57	<0.03	0.22	0.14	17.2
ENV/2004/48	*M.edulis*	08/09/2004	Bantry Bay - Glengarriff	50	43.1 - 60	51.9	4.14	77.5	<0.03		0.35	nd <0.07	1.4	<0.03	0.28	0.11	26.8
ENV/2004/51	*M.edulis*	08/09/2004	Cromane	50	41.6 – 55.9	48.7	2.99	77.4	<0.03		0.16	<0.19	1.57	<0.03	0.26	0.07	14.6
ENV/2004/49	*M.edulis*	08/09/2004	Kilmakillogue	50	41.8 – 58.5	49.2	3.61	74	<0.03		0.18	nd <0.07	1.45	<0.03	0.15	<0.06	14.2
ENV/2004/50	*O. edulis*	09/09/2004	Tralee Bay - Inner	25	46.9 – 87.7	73.6	7.61	78	1.28		0.51	<0.19	27	<0.03	0.16	0.1	321
ENV/2004/52	*O. edulis*	09/09/2004	Tralee Bay - Maharees	25	57.9 – 95.9	72.5	9.77	78.6	1.68		0.93	<0.19	17.5	0.03	0.19	0.08	367
ENV/2004/53	*C. gigas*	15/09/2004	Dungarvan Bay	25	77.9 - 129	104	11.9	75.4	0.65		0.32	<0.19	14.1	<0.03	0.13	0.47	142
ENV/2004/54	*M.edulis*	15/09/2004	Bantry Bay - Inner	50	44.5 – 57.9	50.5	2.97	78.8	<0.03		0.14	nd <0.07	1.19	<0.03	0.15	0.1	19
ENV/2004/60	*M.edulis*	27/09/2004	Lough Foyle - Outer \ Greencastle	50	48.5 – 60	56.5	2.77	77.6	<0.03		0.16	<0.19	1.27	<0.03	0.35	0.07	13.4
ENV/2004/59	*M.edulis*	28/09/2004	Lough Foyle - Quigley's Point	50	41.2 – 52.5	46.4	2.49	79.5	<0.03		0.33	0.31	1.52	0.03	0.47	0.13	14.4
ENV/2004/62	*C. gigas*	29/09/2004	Lough Swilly - Inch Lough	25	71.5 - 121	97.5	10.1	80.6	1.19		0.28	<0.19	27.1	<0.03	0.16	0.08	222
ENV/2004/61	*M.edulis*	29/09/2004	Lough Swilly - Inch Lough	50	41.8 – 59.1	51.3	4.07	78.8	<0.03		0.15	0.3	1.63	0.03	0.44	0.16	11.5
ENV/2004/56	*C. gigas*	30/09/2004	Shannon Estuary - Aughinish	25	91 - 116	102	5.75	78.8	2.38		0.64	<0.19	27.7	<0.03	0.14	0.15	235
ENV/2004/64	*M.edulis*	30/09/2004	McSwynes Bay - Inner Bay \ Bruckless	50	44.5 – 54.5	48.5	2.43	81.2	nd <0.01		0.14	nd <0.07	1.02	<0.03	<0.14	<0.06	17.1
ENV/2004/63	*M.edulis*	30/09/2004	Mulroy Bay - Broadwater	50	45.5 – 59.4	52.5	4.17	75.6	nd <0.01		0.09	nd <0.07	1.5	nd <0.01	<0.14	<0.06	12.7
ENV/2004/82	*M.edulis*	03/10/2004	Sligo Bay - Outer Bay	50	40.6 – 59	50.3	5.63	78.7	<0.03		0.08	<0.19	1.42	nd <0.01	<0.14	0.27	12.3
ENV/2004/57	*C. gigas*	04/10/2004	Galway Bay - Clarinbridge	25	74.6 - 150	103	19.6	78.3	0.19		0.21	nd <0.07	4.84	0.04	nd <0.06	0.08	102
ENV/2004/85	*M.edulis*	07/10/2004	Killary Harbour - Inner	50	41.1 – 58.5	50	3.91	81.8	<0.03		0.11	<0.19	1.15	<0.03	0.19	<0.06	14.7
ENV/2004/83	*C. gigas*	08/10/2004	Clew Bay - North Bay	25	87 - 116	99.1	7.19	86.1	0.28		0.15	nd <0.07	5.27	<0.03	nd <0.06	<0.06	187

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2004/84	*C. gigas*	08/10/2004	Clew Bay - Westport Bay	25	83.8 - 129	102	12.9	78.6	0.86		0.27	<0.19	6.53	<0.03	<0.14	<0.06	188
ENV/2004/58	*C. gigas*	13/10/2004	Galway Bay - Aughinish Bay \ Kilthuria	25	75.4 - 114	90.4	9.65	81.8	0.5		0.34	<0.19	6.31	0.04	<0.14	0.16	174
ENV/2004/73	*C. gigas*	01/11/2004	Carlingford Lough - Outer	25	93.2 - 140	119	11.6	79.2	1.15		0.26	nd <0.07	15	0.03	nd <0.06	0.15	224
ENV/2004/77	*C. gigas*	01/11/2004	Carlingford Lough - Outer	25	93.1 - 116	104	6.29	75.5	1.22		0.29	nd <0.07	19.5	<0.03	nd <0.06	0.2	252
ENV/2004/74	*M.edulis*	01/11/2004	Carlingford Lough - Inner	50	44.2 – 59.5	53	3.72	73.6	0.06		0.11	<0.19	1.61	<0.03	0.15	0.43	12.9
ENV/2004/75	*M.edulis*	01/11/2004	Carlingford Lough - Inner	50	42.9 – 59.5	51.1	3.71	76.4	<0.03		0.13	<0.19	1.5	<0.03	0.15	0.45	16.1
ENV/2004/76	*M.edulis*	01/11/2004	Carlingford Lough - Outer	50	42.8 - 60	53.5	4.66	78.9	<0.03		0.24	0.21	1.26	<0.03	0.24	0.15	16.5
ENV/2004/79	*C. gigas*	09/11/2004	Bannow Bay - Inner	25	71.8 - 107	93.3	7.94	79.9	0.16		0.11	<0.19	5.25	nd <0.01	nd <0.06	0.12	87.9
ENV/2004/81	*M.edulis*	09/11/2004	Wexford Harbour - Outer	50	44.3 – 59.8	52.2	3.72	75.7	<0.03		0.07	0.2	1.57	<0.03	0.3	0.48	15.4
ENV/2004/80	*M.edulis*	10/11/2004	Waterford Harbour - Cheekpoint	50	40.9 – 57.1	47.6	3.83	72.7	<0.03		0.17	0.37	1.81	<0.03	0.3	0.57	15.2
ENV/2005/45	*C. gigas*	29/08/2005	Clew Bay - Newport Bay	25	64 - 119	91.6	17.3	84.5	0.41		0.24	0.09	6.2	<0.02	<0.13	<0.05	152
ENV/2005/47	*C. gigas*	29/08/2005	Clew Bay - North Bay	25	51.5 - 122	89.4	25	79	0.88		0.39	0.22	10.8	<0.02	0.16	0.06	246
ENV/2005/48	*C. gigas*	29/08/2005	Clew Bay - Westport Bay	25	23.1 - 145	95.1	19.1	80.6	0.79		0.28	0.13	9.54	<0.02	<0.13	<0.05	220
ENV/2005/46	*M.edulis*	29/08/2005	Clew Bay - North Bay	50	44.1 – 59	52.9	3.13	75.8	0.03		0.11	0.09	1.34	<0.02	<0.13	0.05	13.9
ENV/2005/49	*M.edulis*	29/08/2005	Killary Harbour - Inner	50	42 – 57	49.5	3.6	78.1	0.01		0.14	0.15	1.34	0.03	0.16	<0.05	15.4
ENV/2005/50	*O. edulis*	30/08/2005	Kilkieran Bay - North	25	61.1 – 89	74.4	6.98	78.2	1.48		0.49	0.16	4.13	0.03	<0.13	0.07	405
ENV/2005/51	*C. gigas*	05/09/2005	Cork Harbour - North Channel	25	99 - 147	125	11	78.8	0.33		0.12	0.14	8.62	0.04	<0.13	0.21	162
ENV/2005/53	*M.edulis*	06/09/2005	Bantry Bay - Glengarriff	50	45.2 – 60	52	3.66	77.5	<0.01		0.18	0.05	0.96	0.03	<0.13	0.08	14.6
ENV/2005/54	*M.edulis*	06/09/2005	Bantry Bay - Inner	50	44 – 60	52.4	3.32	77.6	<0.01		0.18	0.09	1.41	<0.02	<0.13	0.08	19.8
ENV/2005/52	*M.edulis*	06/09/2005	Roaringwater Bay	50	43.2 – 59.8	51.8	4.39	80.2	<0.01		0.09	0.11	1.45	0.03	<0.13	0.09	17.4
ENV/2005/57	*M.edulis*	07/09/2005	Cromane	50	46 – 60	54	3.6	74.7	<0.01		0.16	0.15	1.39	0.02	0.22	0.07	16.8
ENV/2005/56	*M.edulis*	07/09/2005	Kilmakillogue	50	44.5 – 60	51	3.56	76.7	0.02		0.18	0.24	1.37	0.04	<0.13	<0.05	16.7

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2005/55	*C. gigas*	08/09/2005	Shannon Estuary - Aughinish	25	80.7 – 99.1	87.9	4.9	77.2	2.11		0.52	0.53	24.5	0.03	<0.13	0.19	240
ENV/2005/58	*M.edulis*	15/09/2005	Tralee Bay - Inner	23	42.4 – 67.7	56.4	6.74	76.8	0.22		0.2	0.2	1.45	0.04	0.26	0.14	16.3
ENV/2005/60	*O. edulis*	15/09/2005	Tralee Bay - Fenit	25	58.4 – 90.7	77.1	8.13	81.1	3.36		0.84	0.29	20.7	<0.02	0.19	0.11	445
ENV/2005/59	*O. edulis*	15/09/2005	Tralee Bay - Inner	25	67.6 – 87	76	5.16	77.3	1.59		0.56	0.27	24.8	0.04	0.15	0.1	302
ENV/2005/61	*O. edulis*	15/09/2005	Tralee Bay - Maharees	25	63.4 – 90.2	75	9.24	79	2.16		0.95	0.26	10.9	<0.02	0.17	0.08	279
ENV/2005/63	*M.edulis*	18/09/2005	Sligo Bay - Ballysadare Bay	50	45.3 – 59.7	52.7	4	75.8	0.02		0.12	0.13	1.24	<0.02	0.16	0.28	13.5
ENV/2005/62	*M.edulis*	18/09/2005	Sligo Bay - Sligo Harbour \ Rosse's Point	50	41.8 – 58.1	49.4	4.19	79.9	0.12		0.19	0.2	1.26	0.03	0.26	0.28	20
ENV/2005/64	*M.edulis*	19/09/2005	McSwynes Bay - Inner Bay \ Bruckless	50	42.8 – 60	53.7	4.58	77.5	<0.01		0.2	0.12	1.19	0.03	<0.13	0.07	27
ENV/2005/65	*M.edulis*	19/09/2005	Mulroy Bay - Broadwater	50	37 – 58.2	52.5	3.79	74.6	<0.01		0.12	<0.05	1.55	0.03	<0.13	<0.05	16.1
ENV/2005/68	*M.edulis*	20/09/2005	Lough Foyle	50	40.4 – 60	54.1	4.05	79.9	0.02		0.17	0.36	1.11	0.03	0.28	0.12	16.8
ENV/2005/67	*M.edulis*	20/09/2005	Lough Foyle - Quigley's Point	50	42.3 – 55.4	48.9	3.64	77.9	<0.01		0.16	0.23	1.48	<0.02	0.19	0.09	11.6
ENV/2005/66	*M.edulis*	20/09/2005	Lough Swilly - Inch Lough	50	41.8 – 59.2	51	4.42	77.5	<0.01		0.14	0.14	1.26	0.03	0.19	0.14	13.5
ENV/2005/70	*C. gigas*	21/09/2005	Carlingford Lough - Outer	25	80.5 - 102	93.6	6.19	78.1	1.12		0.24	0.13	18.6	0.02	<0.13	0.17	231
ENV/2005/73	*C. gigas*	21/09/2005	Carlingford Lough - Outer	25	91 - 126	104	9.22	82	1.44		0.22	0.26	19.7	<0.02	<0.13	0.16	266
ENV/2005/71	*M.edulis*	21/09/2005	Carlingford Lough - Inner	50	40 – 59.3	52.9	4.38	75.8	0.02		0.1	0.19	1.49	<0.02	0.15	0.51	16.1
ENV/2005/72	*M.edulis*	21/09/2005	Carlingford Lough - Inner	50	43.2 – 58.9	51.3	3.71	77.9	0.04		0.17	0.26	1.36	<0.02	0.24	0.61	17.7
ENV/2005/69	*M.edulis*	21/09/2005	Carlingford Lough - Outer	50	44.9 – 60	54.8	3.07	79.9	0.01		0.09	0.23	1.14	0.02	<0.13	0.11	12.1
ENV/2005/74	*M.edulis*	29/09/2005	Dundalk Bay - Annagasan	50	40.5 – 57.1	46.3	3.96	75.6	0.04		0.2	0.45	1.42	0.03	0.16	0.26	16.8
ENV/2005/78	*M.edulis*	03/10/2005	Waterford Harbour - Arthurstown	50	46 – 59.5	52.4	3.64	78	<0.01		0.14	0.24	1.49	0.03	0.21	0.47	13.4
ENV/2005/79	*M.edulis*	03/10/2005	Waterford Harbour - Cheekpoint	50	36.5 – 57.2	46	3.92	77.6	<0.01		0.17	0.33	1.55	0.02	0.28	0.44	11.9
ENV/2005/76	*M.edulis*	03/10/2005	Wexford Harbour - Outer	50	43 – 59.5	51.7	4.5	75.5	0.01		0.04	0.15	1.41	0.02	0.14	0.2	9.7

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2005/77	*C. gigas*	04/10/2005	Bannow Bay - Inner	25	78.4 - 122	97.2	9.27	75.5	0.12		0.12	0.08	5.44	<0.02	<0.13	0.12	93.5
ENV/2005/80	*C. gigas*	04/10/2005	Dungarvan Bay	25	85.6 - 141	110	15	75.8	0.65		0.26	0.26	13.4	0.03	<0.13	0.26	174
ENV/2005/81	*C. gigas*	18/10/2005	Galway Bay - Aughinish Bay \ Munnia	25	81.6 - 128	99.4	11.9	81.6	0.43		0.21	0.13	5.56	0.03	<0.13	0.14	182
ENV/2005/82	*C. gigas*	18/10/2005	Galway Bay - Clarinbridge	25	80 - 110	95.5	10.7	78.8	0.19		0.19	0.15	4.14	<0.02	<0.13	0.14	109
ENV/2006/24	*C. gigas*	10/08/2006	Galway Bay - Aughinish Bay \ Munnia	25	87.5 - 120	102	7.9	77.6	0.35		0.24	0.17	5.37	0.03	0.13	0.12	179
ENV/2006/27	*M.edulis*	14/08/2006	McSwynes Bay - Inner Bay \ Bruckless	50	46 – 59.5	53.9	3.4	78.9	0.04		0.27	0.09	1.33	<0.02	0.17	<0.05	25.7
ENV/2006/25	*M.edulis*	14/08/2006	Sligo Bay - Ballysadare Bay	50	45.5 – 59.5	52.2	3.6	78.7	0.02		0.21	0.26	1.5	<0.02	0.31	0.34	18.1
ENV/2006/26	*M.edulis*	14/08/2006	Sligo Bay - Sligo Harbour \ Rosse's Point	50	45.5 – 60	53.8	4.3	78.6	0.14		0.22	0.33	1.57	0.02	0.38	0.34	29.3
ENV/2006/29	*M.edulis*	15/08/2006	Lough Foyle - Quigley's Point	50	41.5 – 60	53	4.2	81.7	<0.01		0.16	0.33	1.5	<0.02	0.32	0.13	14.1
ENV/2006/28	*M.edulis*	15/08/2006	Lough Swilly - Inch Lough	50	48.5 – 60	53.6	3.1	78.5	0.02		0.18	2.32	1.73	0.02	0.36	0.23	14.3
ENV/2006/30	*M.edulis*	16/08/2006	Mulroy Bay - Broadwater	50	45.5 – 58.5	51.3	3.2	78.2	<0.01		0.11	0.1	1.96	<0.02	<0.13	0.2	17.2
ENV/2006/31	*C. gigas*	28/08/2006	Galway Bay - Clarinbridge	25	79.5 - 154	120	17.2	82.2	0.38		0.24	0.14	8.41	0.04	<0.13	0.13	288
ENV/2006/33	*M.edulis*	30/08/2006	Killary Harbour - Inner	50	43.5 – 59.5	50.8	4.2	78.8	0.03		0.13	0.11	1.69	<0.02	0.14	0.07	17.3
ENV/2006/32	*O. edulis*	30/08/2006	Kilkieran Bay - North	25	73 – 97	82.1	5.4	79.6	1.63		0.53	0.16	5.75	0.04	<0.13	0.06	488
ENV/2006/39	*C. gigas*	04/09/2006	Clew Bay - North Bay	25	84 - 120	94.2	7.7	80.9	0.67		0.48	0.35	11.7	0.03	0.24	0.06	311
ENV/2006/40	*C. gigas*	04/09/2006	Clew Bay - Westport Bay	25	87.5 - 148	119	12.7	80.6	0.54		0.34	0.16	8.02	0.04	0.14	0.06	267
ENV/2006/41	*M.edulis*	04/09/2006	Clew Bay - North Bay	50	42 – 55.5	49.4	3.2	76.5	0.04		0.14	0.14	2.26	<0.02	0.18	0.09	17.4
ENV/2006/42	*C. gigas*	13/09/2006	Carlingford Lough - Outer	25	81 - 122	101	9.9	77	0.95		0.23	0.1	19.6	0.02	0.52	0.2	272
ENV/2006/43	*C. gigas*	13/09/2006	Carlingford Lough - Outer	25	75.5 - 119	91.9	9.6	78.8	1.17		0.18	0.1	18.3	0.02	0.15	0.22	248
ENV/2006/44	*M.edulis*	13/09/2006	Carlingford Lough - Outer	50	43.5 – 56	49.3	3	79	0.02		0.21	0.25	1.83	0.04	0.4	0.62	19.6
ENV/2006/51	*C. gigas*	28/10/2006	Dungarvan Bay	25	85.5 - 122	103	9.2	80	0.66		0.33	0.22	13.2	<0.02	<0.13	0.21	214

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2006/50	*M.edulis*	28/10/2006	Waterford Harbour - Cheekpoint	50	41 – 57	47.5	2.8	81	<0.01		0.16	0.41	1.46	<0.02	0.35	0.43	13.2
ENV/2006/49	*C. gigas*	29/10/2006	Bannow Bay - Inner	25	78 – 153	95.9	16.1	75.9	0.09		0.11	0.09	5.2	<0.02	<0.13	0.15	103
ENV/2006/52	*M.edulis*	01/11/2006	Dundalk Bay - Annagasan	50	44 – 55	49.6	2.6	75.6	<0.01		0.2	0.31	1.56	0.02	0.37	0.32	15.5
ENV/2006/53	*M.edulis*	08/11/2006	Tralee Bay - Inner	50	40 – 58.5	45	4.5	79.1	0.04		0.78	0.64	1.98	0.03	0.72	0.34	22.2
ENV/2006/54	*M.edulis*	08/11/2006	Tralee Bay - Inner	50	34.5 – 53.5	40.1	4.5	79.2	0.05		0.25	0.23	1.67	0.04	0.33	0.15	17.5
ENV/2006/56	*M.edulis*	09/11/2006	Tralee Bay - Maharees	50	30.5 – 50	39.7	3.8	76.2	0.01		0.27	0.32	1.39	0.03	0.35	0.21	22.9
ENV/2006/55	*M.edulis*	09/11/2006	Tralee Bay - Outer	50	40 – 50	44.1	2.8	76.6	0.04		0.32	1	1.82	0.04	0.43	0.18	19.1
ENV/2006/58	*O. edulis*	09/11/2006	Tralee Bay - Fenit	25	79 – 103	86.7	4.5	80	0.72		0.63	0.25	8.52	<0.02	0.19	0.09	294
ENV/2006/59	*O. edulis*	09/11/2006	Tralee Bay - Inner	25	64.5 – 83	76.5	4.4	77.5	1.28		0.57	0.15	24.6	<0.02	0.14	0.1	357
ENV/2006/57	*O. edulis*	09/11/2006	Tralee Bay - Maharees	25	64.5 – 94	78	6.9	81.8	0.87		0.72	0.23	14.2	0.03	0.18	0.12	457
ENV/2006/60	*C. gigas*	20/11/2006	Shannon Estuary - Aughinish	25	85 - 113	98.5	7.4	83.2	1.22		0.4	0.08	18.5	<0.02	0.14	0.14	185
ENV/2006/65	*M.edulis*	21/11/2006	Bantry Bay - Glengarriff	50	45 – 58.5	51.4	3	74.8	0.01		0.11	0.14	1.8	<0.02	0.21	0.12	16.2
ENV/2006/64	*M.edulis*	21/11/2006	Bantry Bay - Inner	50	41.5 – 55	50.3	3.1	79	0.02		0.11	0.15	1.62	<0.02	0.18	0.18	20.8
ENV/2006/63	*M.edulis*	21/11/2006	Roaringwater Bay	50	44.5 – 59.5	52.8	3.3	76	0.01		0.09	0.17	1.72	<0.02	0.14	0.16	14.9
ENV/2006/67	*M.edulis*	22/11/2006	Cromane	50	52.5 – 71	61.6	4.7	79.6	0.01		0.18	0.18	1.8	<0.02	0.2	0.12	14.8
ENV/2006/66	*M.edulis*	22/11/2006	Kilmakillogue	50	40 – 54	44.8	2.9	79.7	0.01		0.12	0.11	2.23	<0.02	<0.13	0.06	12.5
ENV/2007/40	*O. edulis*	02/08/2007	Kilkieran Bay - North	25	61 – 98	74.9	8.2	82.8	1.37		0.43	0.1	4.3	0.03	<0.13	0.07	374
ENV/2007/46	*C. gigas*	07/08/2007	Carlingford Lough - Outer	25	87 - 109	100	5.7	76.8	0.62		0.16	0.11	13.9	<0.02	<0.13	0.17	171
ENV/2007/48	*C. gigas*	07/08/2007	Carlingford Lough - Outer	25	104 - 145	123	9.6	78.8	0.72		0.21	0.13	13.3	0.03	<0.13	0.18	226
ENV/2007/49	*M.edulis*	07/08/2007	Carlingford Lough - Outer	50	51.5 – 60	56.2	2.4	83	0.02		0.09	0.21	1.18	0.02	0.13	0.16	13.9
ENV/2007/47	*M.edulis*	07/08/2007	Dundalk Bay - Annagasan	50	40.5 – 57.5	50.2	4.4	76.5	<0.01		0.14	0.19	1.66	<0.02	0.15	0.31	14.4
ENV/2007/45	*M.edulis*	07/08/2007	Lough Foyle - Quigley's Point	50	42.5 – 58	48.7	3.8	80.6	<0.01		0.25	0.56	2.34	0.02	0.41	0.15	20
ENV/2007/44	*M.edulis*	07/08/2007	Lough Swilly - Inch Lough	50	42 – 59.5	49.8	3.5	79.8	<0.01		0.11	0.21	1.27	0.03	0.29	0.08	9.84

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2007/43	*M.edulis*	07/08/2007	Mulroy Bay - Broadwater	50	40.5 – 56.5	48.7	4.3	80.9	<0.01		0.09	0.09	1.67	<0.02	0.14	<0.05	18.5
ENV/2007/50	*M.edulis*	12/08/2007	McSwynes Bay - Inner Bay \ Bruckless	50	40 – 55.5	44.8	4	80.1	<0.01		0.21	0.31	1	0.02	0.24	0.06	18.3
ENV/2007/52	*M.edulis*	12/08/2007	Sligo Bay - Ballysadare Bay	50	41 – 59.5	50.1	4.5	82.3	0.02		0.1	0.17	1.53	<0.02	0.18	0.24	15
ENV/2007/51	*M.edulis*	12/08/2007	Sligo Bay - Sligo Harbour \ Rosse's Point	50	51.8 – 58.5	51.8	4.1	80.4	0.06		0.19	0.3	1.21	0.03	0.2	0.22	20.3
ENV/2007/54	*C. gigas*	14/08/2007	Bannow Bay - Inner	25	76 - 104	91.5	7.4	80.3	0.51		0.18	0.12	14.5	<0.02	<0.13	0.13	150
ENV/2007/57	*C. gigas*	14/08/2007	Dungarvan Bay	25	72.5 - 116	96.6	9.1	77.8	0.48		0.23	0.12	10.6	<0.02	<0.13	0.18	133
ENV/2007/55	*M.edulis*	14/08/2007	Waterford Harbour - Arthurstown	50	43.5 - 60	53	3.7	83.4	<0.01		0.16	0.38	2.24	<0.02	0.38	0.43	14.1
ENV/2007/56	*M.edulis*	14/08/2007	Waterford Harbour - Cheekpoint	50	40 – 53.5	46.7	3.6	82	<0.01		0.23	0.41	2.46	<0.02	0.33	0.57	15.8
ENV/2007/53	*M.edulis*	14/08/2007	Wexford Harbour - Outer	50	50.5 – 69	61.1	3.6	76.2	0.01		0.07	0.23	2.25	<0.02	0.21	0.35	16.3
ENV/2007/58	*C. gigas*	16/08/2007	Clew Bay - North Bay	25	67.5 - 152	102	18.6	80.7	0.75		0.32	0.15	9.93	0.02	<0.13	<0.05	253
ENV/2007/60	*C. gigas*	16/08/2007	Clew Bay - Westport Bay	25	70 - 111	90.2	10.7	80.3	0.67		0.28	0.11	10.6	0.02	<0.13	<0.05	261
ENV/2007/59	*M.edulis*	16/08/2007	Clew Bay - North Bay	50	40 – 52	44.8	2.8	76.8	0.02		0.13	0.14	1.47	<0.02	0.19	0.06	14
ENV/2007/61	*M.edulis*	21/08/2007	Kilmakillogue	50	42.5 – 54.5	46.6	2.7	78	0.03		0.22	0.07	1.37	<0.02	<0.13	<0.05	13.4
ENV/2007/63	*M.edulis*	22/08/2007	Bantry Bay - Glengarriff	50	46 – 59.5	52.2	2.9	77.1	0.03		0.15	0.14	1.28	<0.02	<0.13	0.06	15.7
ENV/2007/62	*M.edulis*	22/08/2007	Bantry Bay - Inner	50	46 – 60	53.4	3.4	76.1	0.02		0.16	0.09	1.26	<0.02	<0.13	0.12	23.5
ENV/2007/64	*M.edulis*	22/08/2007	Cromane	50	42.5 – 58.5	49.9	3.1	77.2	0.02		0.11	0.18	1.63	<0.02	0.21	0.09	13.9
ENV/2007/65	*C. gigas*	29/08/2007	Galway Bay - Aughinish Bay \ Munnia	25	80 - 107	92.2	6.9	82.3	0.35		0.24	0.09	3.43	0.02	<0.13	0.09	151
ENV/2007/66	*M.edulis*	30/08/2007	Killary Harbour - Inner	50	45 – 59.6	51.6	3.4	77.5	0.02		0.09	0.12	1.83	<0.02	0.24	<0.05	15.4
ENV/2007/67	*C. gigas*	12/09/2007	Shannon Estuary - Aughinish	25	84 - 109	92.5	6.3	83.8	2.78		0.52	0.13	45.6	0.02	0.17	0.18	340
ENV/2007/70	*M.edulis*	19/09/2007	Cork Harbour - North Channel	50	40 – 51.5	44.2	3.1	74.1	0.02		0.17	0.18	1.66	0.03	<0.13	0.61	17.5
ENV/2007/69	*M.edulis*	19/09/2007	Roaringwater Bay	50	42 – 56	46.6	2.9	77.3	<0.01		0.09	0.1	1.48	<0.02	<0.13	0.1	15.9

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2007/82	*M.edulis*	30/10/2007	Tralee Bay - Inner	50	41 – 53	46.1	3.2	80.7	0.05		1.08	0.68	1.31	0.05	0.56	0.33	24.2
ENV/2007/80	*O. edulis*	30/10/2007	Tralee Bay - Fenit	25	73 – 94	82.3	7	79.9	2.37		0.76	0.12	17.9	0.03	<0.13	0.06	513
ENV/2007/79	*O. edulis*	30/10/2007	Tralee Bay - Inner	25	71 – 92	82	5.7	79.5	2.12		0.53	0.15	20.3	0.02	<0.13	0.06	318
ENV/2007/81	*O. edulis*	30/10/2007	Tralee Bay - Maharees	25	64.5 – 101	81	9.7	79.5	1.64		0.84	0.2	13.9	<0.02	<0.13	0.06	289
ENV/2007/85	*M.edulis*	31/10/2007	Tralee Bay - Inner	50	45 – 59.5	50.9	3.1	80.3	0.03		0.25	0.46	1.08	0.05	1.01	0.11	14.8
ENV/2007/83	*M.edulis*	31/10/2007	Tralee Bay - Maharees	50	40 – 54.5	43	2.5	79.9	0.02		0.42	0.39	1.05	0.03	0.37	0.25	21.5
ENV/2007/84	*M.edulis*	31/10/2007	Tralee Bay - Outer	50	40 – 56	46.1	4.3	77.7	<0.01		0.25	0.26	1.09	0.04	0.34	0.14	22.4
ENV/2007/87	*H. discus hannai**	19/11/2007		25	39 - 53	46.5	3.43	71.7	2.54		1.36	0.16	4.28	0.05	0.85	0.07	13
ENV/2007/86	*H. tuberculata **	19/11/2007		25	42.5 - 54	48.7	3.16	74.3	3.37		6.02	0.09	4.72	0.04	3.29	0.06	10.9
ENV/2007/88	*C. gigas*	27/11/2007	Galway Bay - Clarinbridge	25	81.5 - 125	102	11.8	80.9	0.19		0.16	0.06	4.36	nd <0.008	<0.13	0.09	92
ENV/2008/28	*M.edulis*	05/08/2008	McSwynes Bay - Inner Bay \ Bruckless	50	45 – 58.5	51.3	3.9	79.1	0.01	3.88	0.17	0.27	3.13	<0.02	0.33	0.1	26.1
ENV/2008/31	*M.edulis*	06/08/2008	Lough Foyle - Quigley's Point	50	40 – 56.5	46.2	4.6	80.4	<0.01	3.16	0.26	0.93	5.44	0.03	0.74	0.22	19.7
ENV/2008/30	*M.edulis*	06/08/2008	Lough Swilly - Inch Lough	50	41.5 – 55	47.9	3.6	82	<0.01	3.34	0.13	0.21	2.36	0.03	0.33	0.2	13.5
ENV/2008/29	*M.edulis*	06/08/2008	Mulroy Bay - Broadwater	50	42 – 58.5	50.6	3.6	79.1	<0.01	3.34	0.14	0.2	2.96	<0.02	0.27	0.1	21.4
ENV/2008/32	*M.edulis*	07/08/2008	Sligo Bay - Ballysadare Bay	50	41 – 58	49.8	4.3	77.3	0.02	2.89	0.19	0.37	3.97	0.02	0.35	0.35	21.2
ENV/2008/33	*M.edulis*	07/08/2008	Sligo Bay - Sligo Harbour \ Rosse's Point	50	45 – 59	51.3	3.2	77.9	0.02	2.71	0.19	0.55	5.43	0.02	0.42	0.22	20.5
ENV/2008/35	*C. gigas*	12/08/2008	Galway Bay - Clarinbridge	25	82.5 - 125	101	12.8	84.3	0.16	2.29	0.17	0.06	4.11	0.02	<0.13	0.09	93.9
ENV/2008/36	*M.edulis*	12/08/2008	Galway Bay - Clarinbridge	50	52.5 – 72.5	64.5	4.5	78.2	0.04	3.35	0.19	0.16	2.2	0.04	0.19	0.26	19.5
ENV/2008/34	*O. edulis*	12/08/2008	Kilkieran Bay - North	25	60 – 93.5	79.5	7.3	79.4	1.52	4.01	0.52	0.15	6.29	0.04	<0.13	0.06	510
ENV/2008/37	*C. gigas*	13/08/2008	Clew Bay - North Bay	25	81 - 117	99.1	8.9	78.4	0.58	5.21	0.35	0.14	9.47	0.04	<0.13	0.06	224
ENV/2008/39	*C. gigas*	13/08/2008	Clew Bay - Westport Bay	25	85.5 - 129	99.8	9.7	79.6	0.79	5.02	0.35	0.18	12.3	0.02	<0.13	0.06	267
ENV/2008/38	*M.edulis*	13/08/2008	Clew Bay - North Bay	50	47 -57	51.1	2.4	79.4	0.02	3.32	0.13	0.11	2.16	0.03	0.17	0.08	20.9

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2008/40	*C. gigas*	18/08/2008	Galway Bay - Aughinish Bay \ Munnia	25	86 - 115	99.2	9.1	79	0.49	5.29	0.24	0.08	7.53	0.02	<0.13	0.1	203
ENV/2008/49	*M.edulis*	21/08/2008	Killary Harbour - Inner	50	42 – 60	51.1	6	82.2	0.02	1.71	0.1	0.15	1.61	0.03	0.2	0.05	14
ENV/2008/59	*M.edulis*	02/09/2008	Bantry Bay - Glengarriff	50	44 – 69	56	4.3	77.7	0.01	2.12	0.1	0.08	1.64	0.02	<0.13	0.05	20.8
ENV/2008/58	*M.edulis*	02/09/2008	Cromane	50	44.5 – 70.5	59.8	5.95	79.4	<0.01	2.45	0.18	0.23	1.94	0.03	0.26	0.1	16.9
ENV/2008/56	*C. gigas*	03/09/2008	Carlingford Lough - Outer	25	81 - 113	93	6.4	81.2	0.8	3.29	0.22	0.1	15.1	<0.02	<0.13	0.16	206
ENV/2008/54	*M.edulis*	03/09/2008	Dundalk Bay - Annagasan	33	38 – 57	46.9	4.9	82.2	0.04	3.22	0.19	0.28	1.65	0.03	0.32	0.33	16.8
ENV/2008/57	*M.edulis*	03/09/2008	Roaringwater Bay	50	40.5 – 52.5	46.2	2.9	76.9	<0.01	2.28	0.08	0.12	3.65	<0.02	0.19	0.09	18.8
ENV/2008/65	*C. gigas*	16/09/2008	Dungarvan Bay	25	77 - 134	100	16.6	80.3	0.32	2.88	0.15	0.12	8.31	<0.02	<0.13	0.17	111
ENV/2008/62	*M.edulis*	16/09/2008	Waterford Harbour - Arthurstown	50	42 – 53	48.1	2.8	77.9	<0.01	2	0.19	0.26	3.09	0.02	0.26	0.39	19.1
ENV/2008/63	*M.edulis*	16/09/2008	Waterford Harbour - Cheekpoint	50	41.5 – 55.5	48.6	3.1	79.9	<0.01	1.85	0.19	0.25	2.15	<0.02	0.25	0.39	15.7
ENV/2008/64	*C. gigas*	17/09/2008	Bannow Bay - Inner	25	68.5 – 93.5	83.1	6.1	77	0.11	2.69	0.1	0.07	6.47	<0.02	<0.13	0.11	110
ENV/2008/60	*M.edulis*	17/09/2008	Wexford Harbour - Outer	50	41.5 – 59.5	48.8	4.4	77.4	<0.01	2.41	0.08	0.27	2.68	<0.02	0.37	0.37	16.1
ENV/2008/74	*M.edulis*	30/09/2008	Tralee Bay - Inner	50	44 – 56	47.8	2.8	81.2	0.02	3.53	0.46	0.28	1.39	0.04	0.29	0.22	23.1
ENV/2008/73	*O. edulis*	30/09/2008	Tralee Bay - Fenit	25	59.5 – 99.5	81.5	8.5	78.7	2.09	2.42	0.87	0.15	20.2	0.04	<0.13	0.06	596
ENV/2008/72	*O. edulis*	30/09/2008	Tralee Bay - Inner	25	65.5 – 93.5	78.5	6.4	79.5	1.43	2.12	0.46	0.14	24	0.02	<0.13	0.06	343
ENV/2008/84	*M.edulis*	29/10/2008	Cork Harbour - Main	49	42 – 60	51.8	3.8	76.3	nd (<0.003)	2.13	0.07	0.09	2.4	0.02	<0.13	0.55	21.1
ENV/2008/83	*M.edulis*	29/10/2008	Cork Harbour - North Channel	47	42 – 58	50.8	3.35	72.5	<0.01	2.09	0.1	0.09	1.9	0.03	<0.13	0.39	16
ENV/2008/86	*M.edulis*	30/10/2008	Bantry Bay - Inner	50	49 – 60	55.1	2.8	78.8	0.02	2.26	0.09	0.09	1.46	<0.02	<0.13	0.11	21.9
ENV/2008/87	*M.edulis*	30/10/2008	Kilmakillogue	50	40.5 – 58.5	46.7	3.6	78.5	0.01	2.33	0.1	0.1	2.09	0.02	<0.13	<0.05	14.8
ENV/2008/90	*M.edulis*	04/11/2008	Kilkieran Bay - North	50	40.5 – 55	48.5	3.45	77.2	nd (<0.003)	3.76	0.1	0.13	2.26	<0.02	<0.13	0.17	18.6
ENV/2008/91	*M.edulis*	05/11/2008	Dunmanus Bay - Inner	50	41 – 57	49.8	3.5	76.7	<0.01	2.48	0.09	0.12	2.02	nd (<0.008)	<0.13	0.16	17.5

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2008/88	*M.edulis*	05/11/2008	Galway Bay - Ballyvaughan \ Poulnaclogh Bay	50	42.5 – 52	47.4	2.91	83.7	0.02	2.26	0.08	0.13	1.2	<0.02	0.14	0.18	11
ENV/2008/89	*M.edulis*	05/11/2008	Galway Bay - Kinvara	50	40 – 53.5	46.2	3.51	76.4	<0.01	3.2	0.11	0.1	3.86	0.02	<0.13	0.16	19.8
ENV/2008/92	*M.edulis*	05/11/2008	Roaringwater Bay	50	41 – 56.5	49.6	2.82	74.2	<0.01	2.37	0.09	0.14	2.35	nd <0.008	<0.13	0.18	15.8
ENV/2008/95	*C. gigas*	06/11/2008	Baltimore Harbour \ Sherkin	25	95 - 130	116	8.43	79.6	0.95	3.88	0.29	0.25	18.6	0.03	<0.13	0.16	303
ENV/2008/94	*C. edule*	10/11/2008	Dundalk Bay	60	24 - 43.5	32	5.03	79.6	0.02	1.72	0.07	0.39	1.91	<0.02	3.81	0.32	11
ENV/2008/96	*E. siliqua*	10/11/2008	Balbriggan - Skerries	25	132 - 190	163	16.8	76.6	0.56	2.22	0.03	0.16	3.91	<0.02	<0.13	0.18	18.5
ENV/2008/93	*M.edulis*	10/11/2008	Bantry Bay - Inner	50	42 – 55	49.8	3.72	78.5	<0.01	2.59	0.12	0.17	1.74	<0.02	<0.13	0.17	24.6
ENV/2008/98	*C. gigas*	11/11/2008	Achill Sound - North	25	80 - 146	115	15.7	81.9	0.45	5.2	0.29	0.08	10.3	0.03	<0.13	0.06	380
ENV/2008/97	*C. gigas*	11/11/2008	Achill Sound - South	25	82 - 139	116	14.5	81.6	0.15	4.43	0.11	0.11	6.54	0.03	<0.13	0.07	198
ENV/2008/100	*C. gigas*	11/11/2008	Ballinakill Bay	25	87 - 124	102	10.3	83.1	0.57	3.41	0.35	0.45	16.8	0.02	0.21	0.08	324
ENV/2008/101	*C. gigas*	11/11/2008	Mannin Bay	25	61.5 - 126	83	16.5	84	0.41	5.42	0.37	0.64	16.2	0.03	0.16	0.12	302
ENV/2008/99	*C. gigas*	11/11/2008	Streamstown Bay	25	85 - 137	103	10.2	80.3	0.4	3.55	0.25	0.25	9.32	0.02	<0.13	0.08	244
ENV/2008/102	*T. philippinarum*	11/11/2008	Sligo Bay - Ballysadare Bay	50	36.5 – 44.5	41	1.66	80	0.17	3.54	0.05	<0.05	1.87	<0.02	0.19	<0.05	12.4
ENV/2008/104	*C. gigas*	12/11/2008	Killala Bay	25	78 - 131	110	16.1	82.4	0.29	2.97	0.1	0.12	5.82	<0.02	<0.13	0.08	151
ENV/2008/105	*M.edulis*	12/11/2008	Clifden Bay - Ardbear Bay	50	42.5 – 57	49.3	3.4	80	<0.01	2.84	0.11	0.14	2	<0.02	<0.13	0.18	23.1
ENV/2008/103	*O. edulis*	12/11/2008	Blacksod bay	25	69 – 100	84.2	6.98	79.9	1.11	4.45	0.5	0.16	7.93	0.03	<0.13	0.07	408
ENV/2008/107	*C. gigas*	13/11/2008	Dungloe Bay	23	75.5 - 111	92.6	8.6	83.6	0.33	5.3	0.17	0.07	5.69	0.03	<0.13	0.11	210
ENV/2008/111	*C. gigas*	13/11/2008	Galway Bay - Aughinish Bay	25	84 - 133	104	13	80.6	0.5	5.41	0.27	0.06	8.49	0.02	<0.13	0.16	217
ENV/2008/112	*C. gigas*	13/11/2008	Galway Bay - Aughinish Bay	25	93 - 149	114	13.5	81.2	0.57	4.79	0.34	0.09	8.97	0.02	<0.13	0.15	273
ENV/2008/108	*C. gigas*	13/11/2008	Sheephaven Bay	25	78.5 - 121	102	12.2	83.5	0.37	2.77	0.43	0.1	10.3	0.02	<0.13	0.07	275
ENV/2008/106	*C. gigas*	13/11/2008	Trawbreaga Bay	19	84 - 130	100	11.6	78.8	0.56	2.89	0.27	0.09	16.5	<0.02	<0.13	0.09	242
ENV/2008/109	*M.edulis*	13/11/2008	Mulroy Bay - South	50	45.5 – 60	53	4.14	82.4	<0.01	3.1	0.12	0.15	3.31	nd <0.008	<0.13	0.1	23.6

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2008/110	*O. edulis*	13/11/2008	Kilkieran Bay - North	25	66 – 103	79.9	8.02	83.5	1.52	3.32	0.42	0.1	5.34	0.04	<0.13	0.05	410
ENV/2008/114	*C. gigas*	16/11/2008	Shannon Estuary - Carrigaholt	25	59.5 - 145	91.1	21.4	85	1.29	2.89	0.52	0.17	34.4	0.02	0.14	0.14	349
ENV/2008/116	*C. gigas*	16/11/2008	Shannon Estuary - Poulnasherry Bay	24	94 - 148	114	14.5	79.9	0.95	3.47	0.24	0.11	11.8	0.03	<0.13	0.2	194
ENV/2008/115	*C. gigas*	16/11/2008	Shannon Estuary - Rinevella	25	83.5 - 109	90.5	6.63	83.4	1.56	4.05	0.29	0.1	20.7	0.04	<0.13	0.16	330
ENV/2008/119	*C. gigas*	17/11/2008	Bannow Bay	25	78.5 - 139	111	15	73.9	0.17	2.1	0.12	0.11	7.08	nd <0.008	<0.13	0.16	113
ENV/2008/121	*C. gigas*	17/11/2008	Kinsale	1				79.7	0.25	2.6	0.13	0.15	15.3	<0.02	<0.13	0.27	211
ENV/2008/117	*C. gigas*	17/11/2008	Waterford Harbour - Duncannon	25	76 - 134	103	14.6	78	1.07	2.34	0.34	0.53	33.7	<0.02	0.14	0.32	275
ENV/2008/118	*E. siliqua*	17/11/2008	Malahide	25	145 - 176	161	5.89	77.2	0.3	2.15	0.03	0.12	3.7	<0.02	<0.13	0.15	18.2
ENV/2008/127	*C. gigas*	18/11/2008	Clew Bay - Newport Bay	16	77 - 137	110	17	81.9	0.95	4.64	0.3	0.17	12.7	0.03	0.18	0.27	310
ENV/2008/126	*C. gigas*	18/11/2008	Donegal Bay	25	77 - 120	101	9.37	82.2	0.31	3.44	0.29	0.09	9.5	0.03	<0.13	0.07	202
ENV/2008/122	*M.edulis*	18/11/2008	Bantry Bay - Glengarriff	50	48.5 – 71	60.5	5.3	77.6	<0.01	2.49	0.1	0.1	1.37	<0.02	<0.13	0.24	19.9
ENV/2008/125	*M.edulis*	18/11/2008	Inver Bay	50	44.5 – 76	63.4	6.15	81.1	<0.01	3.28	0.23	0.42	2.38	0.05	0.28	0.19	22
ENV/2008/123	*M.edulis*	18/11/2008	Wexford Harbour - Inner	50	48 – 71.5	58.9	4.6	83	<0.01	2.07	0.11	0.37	2.42	<0.02	0.36	0.35	12.7
ENV/2008/124	*M.edulis*	18/11/2008	Wexford Harbour - Outer	50	41.5 – 66	55.2	6.18	79.8	<0.01	2.64	0.13	0.41	1.69	0.03	0.46	0.63	22.3
ENV/2008/113	*O. edulis*	18/11/2008	Lough Foyle - Quigley's Point	25	68 – 95.5	81.8	7.1	79	1.39	1.54	0.35	0.17	25.7	<0.02	<0.13	0.08	452
ENV/2008/128	*M.edulis*	19/11/2008	Carlingford Lough - Inner	50	44.5 – 59	51.2	3.45	74.7	0.02	2.78	0.1	0.23	2.12	<0.02	0.18	1.15	15.3
ENV/2008/129	*M.edulis*	24/11/2008	Bantry Bay - Castletownbere	50	40.5 – 60	49.9	5.25	77.5	<0.01	2.95	0.11	0.32	1.8	<0.02	0.14	0.31	21.7
ENV/2008/137	*C. gigas*	25/11/2008	Clew Bay - Newport Bay	20	85 - 136	107	12.5	81	0.62	4.61	0.31	0.15	9.82	0.03	<0.13	0.1	258
ENV/2008/134	*C. gigas*	25/11/2008	Dungarvan Bay	25	72.5 - 123	87.1	11.9	78	0.64	2.94	0.27	0.2	16.5	<0.02	<0.13	0.3	222
ENV/2008/132	*C. gigas*	25/11/2008	Gweebarra Bay	22	103 - 185	143	19.5	78.8	0.34	3.29	0.32	0.11	6.09	<0.02	<0.13	0.1	162
ENV/2008/135	*C. gigas*	25/11/2008	Gweedore Bay	25	93 - 140	108	13.5	85.6	0.18	2.04	0.15	<0.05	4.33	<0.02	nd <0.03	<0.05	142
ENV/2008/131	*C. gigas*	25/11/2008	Loughras Beg	25	88 - 122	98.1	7.86	79	0.12	1.77	0.12	<0.05	4.43	<0.02	<0.13	0.06	100

					mm				mg kg^{-1} ww								
MI Reference	Species (Latin)	Date	Station	n	Length (range)	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2008/130	*C. gigas*	25/11/2008	Trawenagh Bay	25	80.5 - 141	111	16.5	77.7	0.2	3.47	0.27	0.1	6.49	<0.02	<0.13	0.08	146
ENV/2008/136	*M.edulis*	25/11/2008	Clew Bay - Newport Bay	50	43.5 – 57	48.9	2.76	78.6	<0.01	3.32	0.1	0.19	2.44	<0.02	0.19	0.13	15.9
ENV/2008/133	*O. edulis*	25/11/2008	Tralee Bay - Inner	25	73 – 92.5	80.1	4.88	80.3	1.58	1.99	0.66	0.22	29.5	0.02	<0.13	0.07	478
ENV/2008/139	*C. gigas*	26/11/2008	Sligo Bay - Drumcliff	25	96 - 150	121	13.1	82.5	0.59	2.53	0.3	0.15	12	<0.02	0.14	0.12	255
ENV/2008/141	*M.edulis*	26/11/2008	Cromane	50	48 – 68.5	61.2	5.17	78.3	nd <0.003	3.61	0.17	0.2	2.51	0.05	<0.13	0.34	31.6
ENV/2008/138	*M.edulis*	26/11/2008	Sligo Bay - Sligo Harbour	50	45.5 – 59	52.6	3.39	78.6	<0.01	2.49	0.11	0.21	2.51	<0.02	0.17	0.23	17.3
ENV/2008/140	*M.edulis*	27/11/2008	Kilmakillogue	50	41.5 – 52	46.7	2.49	77.8	<0.01	2.2	0.09	0.09	1.56	<0.02	<0.13	0.07	14.7
ENV/2008/142	*M.edulis*	01/12/2008	McSwynes Bay - Inner Bay \ Bruckless	50	43 – 56.5	50.2	3.36	83.3	<0.01	3.91	0.17	0.13	1.21	0.03	0.21	0.15	25.9
ENV/2008/144	*M.edulis*	03/12/2008	Bantry Bay - South	50	42 – 59.5	51.7	4.31	75.3	<0.01	2.24	0.11	0.11	1.65	<0.02	<0.13	0.2	21.2
ENV/2008/143	*M.edulis*	03/12/2008	Galway Bay - Outer \ Indreabhan	50	44.5 – 60	51.6	3.58	78.1	0.04	3.2	0.15	0.11	1.71	<0.02	0.18	0.21	22.1
ENV/2008/145	*O. edulis*	08/12/2008	Tralee Bay - Maharees	25	73 – 91	81.7	5.11	78.6	2.59	2.37	0.77	0.11	30.2	0.03	<0.13	0.08	514
ENV/2008/146	*C. gigas*	10/12/2008	Cork Harbour - North Channel	25	79 - 147	113	18.5	81.2	0.59	2.03	0.19	0.1	19.8	0.03	<0.13	0.27	291
ENV/2008/148	*C. gigas*	10/12/2008	Cork Harbour - Rostellan South	11	101 - 148	127	14.8	77.9	1.53	2.14	0.29	0.2	44.4	0.06	<0.13	0.38	638
ENV/2008/147	*M.edulis*	10/12/2008	Cork Harbour - Rostellan North	50	43.5 – 56	50	3.31	75.6	<0.01	2.05	0.15	0.2	1.85	0.03	0.13	0.53	17.9
ENV/2008/55	*C. gigas*		Carlingford Lough - Inner	25	82 - 110	99.4	6.6	81.1	1.33	3.54	0.21	0.08	20.1	0.02	<0.13	0.16	298
ENV/2008/120	*C. gigas*		Oysterhaven	1				79	0.27	2.91	0.17	0.14	11	<0.02	<0.13	0.19	234
ENV/2008/50	*O. edulis*		Clew Bay - Westport Bay	25	69 – 107	88.9	9.97	75.9	1.23	3.94	0.64	0.52	8.61	0.03	0.44	0.08	347
ENV/2008/149	*O. edulis*		Tralee Bay - Maharees	24	71.5 – 91.5	79.1	4.77	82.8	2.17	1.6	0.6	0.11	21.6	0.03	<0.13	0.09	438

Notes: n= number of individuals pooled for sample
* for abalone foot muscle was analysed
nd: not detected

Table B1.3: Organochlorine substances in Irish shellfish 2004 -2008

	µg kg^{-1} ww																								
MI Reference	Species	% Lipids	CB101	CB118	CB138*	CB153	CB180	CB28	CB52	SCB7	CCDAN	OCDAN	TCDAN	TNONC	SDanes (WW)	DDEOP	DDEP	DDTOP	DDTPP	SDDTs	TDEOP	TDEPP	HCHG	HCB	DIELD
ENV/2004/47	*M. edulis*	1.71	0.08	0.07	0.17	0.27	<0.01	0.09	0.04	0.73	0.03	0.01	0.03	0.05	0.12		0.16	0.08	<0.4			<0.06	0.04	0.03	0.02
ENV/2004/49	*M. edulis*	2.34	0.1	0.08	0.12	0.2	<0.01	0.08	0.17	0.76	0.04	<0.01	0.07	0.06	0.18		0.18	<0.08	<0.4			<0.06	0.03	0.04	0.01
ENV/2004/50	*O. edulis*	2.06	0.14	0.17	0.34	0.52	<0.05	<0.05	0.06	1.33															
ENV/2004/52	*O. edulis*	1.92	0.04	0.16	0.1	0.2	<0.01	0.03	0.07	0.61	0.02	0.01	<0.01	0.05	0.09		0.09	<0.08	<0.4			<0.06	0.03	0.02	0.02
ENV/2004/53	*C. gigas*	3.10	0.2	0.22	0.31	0.54	0.07	0.04	0.06	1.44															
ENV/2004/56	*C. gigas*	2.04	0.22	0.22	0.38	0.78	0.14	<0.03	0.04	1.8															
ENV/2004/57	*C. gigas*	3.27	0.09	0.08	0.12	0.29	<0.03	<0.03	0.04	0.67															
ENV/2004/58	*C. gigas*	1.71	0.12	0.13	0.22	0.49	<0.01	0.03	0.13	1.13	0.04	0.01	<0.01	0.05	0.11		0.48	<0.08	<0.4			<0.06	0.02	0.02	0.01
ENV/2004/59	*M. edulis*	1.56	0.35	0.29	0.45	0.78	<0.01	0.06	0.15	2.09	0.06	0.01	0.02	0.07	0.16		0.72		<0.4			<0.06	0.03	0.06	0.02
ENV/2004/62	*C. gigas*	2.02	0.06	0.06	0.09	0.24	0.04	<0.03	<0.03	0.55															
ENV/2004/79	*C. gigas*	2.20	0.1	0.22	0.22	0.42	0.04	0.04			<0.01	0.01	0.02	0.06	0.1		0.74	0.12	<0.4			0.43	0.07	0.07	0.03
ENV/2004/81	*M. edulis*	1.66	0.17	0.28	0.49	0.65	0.04	<0.01			<0.01	<0.01	0.02	0.03	0.07		1.36	<0.08	<0.4			0.39	0.06	0.05	0.03
ENV/2004/82	*M. edulis*	2.36	0.23	0.14	0.24	0.19	0.01	0.07			0.03	0.01	<0.01	0.05	0.1		0.19	<0.08	<0.4			0.25	0.08	<0.01	0.04
ENV/2004/84	*C. gigas*	2.24	<0.06	0.05	0.07	0.17	0.03	0.03			<0.01	<0.01	<0.01	0.02	0.05		0.3		<0.4			0.12	0.05	<0.01	0.03
ENV/2005/45	*C. gigas*	1.50	0.06	0.05	0.1	0.15	0.02	0.05	0.05	0.48							0.12		0.04			0.03	0.04	0.02	0.35
ENV/2005/48	*C. gigas*	2.33	0.29	0.08	0.09	0.2	0.02	0.04	<0.02	0.74							0.11		0.03			0.03	0.05	0.04	0.26
ENV/2005/49	*M. edulis*	2.35	0.06	0.05	0.09	0.12	0.01	0.04	0.03	0.4							0.1		0.03			0.03	0.05	0.03	0.41
ENV/2005/50	*O. edulis*	1.83	0.05	0.05	0.1	0.16	0.02	0.03	0.04	0.45							0.11		<0.03			0.02	0.06	0.02	0.48
ENV/2005/51	*C. gigas*	2.40	0.29	0.35	0.36	0.82	0.05	0.09	0.09	2.05							0.64		0.05			0.2	0.05	0.02	0.35
ENV/2005/52	*M. edulis*	1.71	0.05	0.08	0.08	0.14	<0.02	0.03	0.02	0.42							0.08		0.05			0.02	0.05	0.02	0.43
ENV/2005/55	*C. gigas*	2.20	0.09	0.08	0.1	0.21	0.03	0.03	0.02	0.56							0.21		0.03			0.11	0.04	0.02	
ENV/2005/59	*O. edulis*	1.88	0.19	0.29	0.35	0.54	0.04	0.11	0.04	1.56							0.58		0.15			0.28		0.04	0.62
ENV/2005/62	*M. edulis*	1.74	0.38	0.32	0.34	0.5	0.08	0.19	0.3	2.11							0.4		0.17			0.14		0.09	1.18
ENV/2005/64	*M. edulis*	1.54	0.36	0.34	0.59	0.73	0.06	0.16	0.06	2.3							1.09							0.12	

MI Reference	$\mu g\ kg^{-1}$ ww																							
	Species	% Lipids	CB101	CB118	CB138*	CB153	CB180	CB28	CB52	SCB7	CCDAN	OCDAN	TCDAN	TNONC	SDanes (WW)	DDEOP	DDEP	DDTOP	DDTPP	SDDTs	TDEOP	TDEPP	HCHG	HCB	DIELD
ENV/2005/66	*M. edulis*	1.84	0.24	0.27	0.44	0.7	0.09	0.14	0.17	2.05							1.24							0.08	
ENV/2005/67	*M. edulis*	1.69	0.26	0.19	0.42	0.51	0.05	nd <0.07	0.09	1.59	0.03	nd <0.02	0.02	0.03	0.1	0.02	0.59	0.01	0.07	1.16	0.11	0.36	0.11	0.03	0.29
ENV/2005/73	*C. gigas*	2.83	0.22	0.26	0.52	0.65	0.04	nd <0.07	0.06	1.82	0.01	nd <0.02	nd <0.01	0.03	0.07	0.02	0.5	nd <0.01	0.02	0.9	0.1	0.25	0.04	nd <0.01	0.43
ENV/2005/74	*M. edulis*	2.62	0.26	0.24	0.56	0.59	0.05	nd <0.1	0.07	1.87	0.04	nd <0.02	nd <0.01	0.06	0.13	0.03	0.49	0.02	0.08	1.02	0.09	0.31	0.04	0.02	0.41
ENV/2005/76	*M. edulis*	1.95	0.19	0.22	0.26	0.39	0.04	0.12	0.12	1.34							1.16		<0.03			0.23	0.04	0.05	0.32
ENV/2005/79	*M. edulis*	1.85	0.54	0.48	0.75	1.23	0.14	0.2	0.26	3.6							1.07		0.06			0.48	0.02	0.03	0.2
ENV/2005/80	*C. gigas*	2.78	0.14	0.23	0.24	0.49	0.03	0.07	0.04	1.24							0.31		0.06			0.13	0.04	0.02	0.02
ENV/2006/24	*C. gigas*	2.59	<0.06	0.01	<0.06	0.1	nd <0.02	nd <0.02	nd <0.02	0.29	0.12	nd <0.004					0.17	nd <0.08	nd <0.02				<0.06	nd <0.02	0.08
ENV/2006/25	*M. edulis*	1.66	<0.06	0.02	0.07	0.13	<0.06	<0.06	nd <0.02	0.42	0.18	nd <0.004					0.1	nd <0.08	<0.06			nd <0.08	nd <0.02	nd <0.02	0.14
ENV/2006/27	*M. edulis*	1.67																							
ENV/2006/28	*M. edulis*	1.72	0.07	0.06	0.11	0.29	<0.06	<0.06	<0.06	0.71	<0.06	0.02					0.45	nd <0.08	nd <0.02			<0.25	nd <0.02	nd <0.02	0.25
ENV/2006/30	*M. edulis*	1.77	0.07	0.05	0.06	0.17	nd <0.02	<0.06	0.09	0.52	<0.06	0.01					0.22	nd <0.08	<0.06			nd <0.08	nd <0.02	nd <0.02	0.21
ENV/2006/31	*C. gigas*	2.05																							
ENV/2006/33	*M. edulis*		<0.06	0.03	<0.06	0.11	nd <0.02	<0.06	nd <0.02	0.36	<0.06	nd <0.004					0.13	nd <0.08	nd <0.02			nd <0.08	nd <0.02	nd <0.02	0.15
ENV/2006/49	*C. gigas*	3.56	0.11	0.11	0.14	0.41	<0.06	<0.06	0.37	1.26	<0.06						1.14	nd <0.08	0.06			0.26	<0.06	nd <0.02	0.29
ENV/2006/50	*M. edulis*	1.63	0.47	0.34	0.59	1.19	0.09	0.15	0.4	3.23	<0.06	nd <0.004					0.99	nd <0.08	nd <0.02			0.43	nd <0.02	<0.06	0.28
ENV/2006/51	*C. gigas*	2.04	0.18	0.23	0.2	0.64	<0.06	0.07	0.11	1.49	<0.06	0.02					0.43	nd <0.08	nd <0.02			<0.25	0.08	nd <0.02	0.18
ENV/2006/52	*M. edulis*	2.11	0.35	0.37	0.48	0.72	<0.06	<0.06	0.27	2.31	<0.06						0.44	nd <0.08	<0.06			<0.25	<0.06	<0.06	0.43
ENV/2006/58	*O. edulis*	1.76	<0.06	0.03	0.06	0.16	nd <0.02	nd <0.02	<0.06	0.41	nd <0.02	<0.01					0.09	nd <0.08	<0.06				nd <0.02	<0.06	0.12
ENV/2006/60	*C. gigas*	2.19	0.24	0.19	0.31	0.8	0.11	<0.06	0.1	1.81	nd <0.02	0.01					0.65	nd <0.08	nd <0.02				<0.06	nd <0.02	0.19
ENV/2006/64	*M. edulis*	1.78	0.14	0.09	0.28	0.91	0.21	<0.06	0.09	1.78	nd <0.02	0.03					0.2	nd (<0.08)	<0.06				<0.06	nd <0.02	0.11
ENV/2006/66	*M. edulis*	1.77	0.07	0.05	0.07	0.17	<0.06	<0.06	<0.06	0.54	nd <0.02	nd <0.004					0.16	nd (<0.08)	0.07				<0.06	<0.06	<0.06
ENV/2007/40	*O. edulis*	1.18	0.06	0.05	0.15	0.19	0.03	0.05	nd <0.02	0.55	0.01	nd <0.01	nd <0.01	0.02	0.05	nd <0.01	0.05	nd <0.01	nd <0.01	0.1	nd <0.01	nd <0.01	nd <0.01	nd <0.01	0.22
ENV/2007/45	*M. edulis*	1.37	0.22	0.12	0.42	0.55	0.11	nd <0.05	0.09	1.56	nd <0.01	nd <0.01	nd <0.01	nd <0.01	0.04	nd <0.01	0.24	nd <0.01	0.04	0.46	0.05	0.11	nd <0.01	0.02	0.19
ENV/2007/46	*C. gigas*	3.35	0.2	0.22	0.44	0.61	0.05	nd <0.05	0.08	1.65	0.04	nd <0.01	0.01	0.04	0.1	0.02	0.47	0.01	0.05	0.89	0.12	0.22	0.02	nd <0.01	0.62
ENV/2007/47	*M. edulis*	1.58	0.14	0.15	0.33	0.39	0.03	nd <0.05	0.04	1.13	0.03	nd <0.01	nd <0.01	0.02	0.07	nd <0.01	0.24	nd <0.01	0.05	0.47	0.05	0.11	nd <0.01	0.01	0.42

	µg kg^{-1} ww																								
MI Reference	Species	% Lipids	CB101	CB118	CB138*	CB153	CB180	CB28	CB52	SCB7	CCDAN	OCDAN	TCDAN	TNONC	SDanes (WW)	DDEOP	DDEP	DDTOP	DDTPP	SDDTs	TDEOP	TDEPP	HCHG	HCB	DIELD
ENV/2007/50	*M. edulis*	1.78	nd <0.02	0.02	nd <0.05	0.07	nd <0.01	nd <0.05	nd <0.02	0.24	0.01	nd <0.01	nd <0.01	0.03	0.06	nd <0.01	0.1	nd <0.01	0.02	0.17	0.01	0.02	nd <0.01	nd <0.01	0.08
ENV/2007/59	*M. edulis*	1.54	nd <0.02	0.02	0.06	0.08	nd <0.01	nd <0.05	nd <0.02	0.26	0.02	nd <0.01	nd <0.01	0.02	0.06	nd <0.01	0.06	nd <0.01	nd <0.01	0.11	nd <0.01	nd <0.01	nd <0.01	0.02	0.23
ENV/2007/62	*M. edulis*	1.74	0.13	0.08	0.34	0.62	0.21	nd <0.05	0.04	1.47	0.03	0.01	nd <0.01	0.02	0.07	nd <0.01	0.14	nd <0.01	0.04	0.27	0.02	0.05	0.01	0.02	0.26
ENV/2007/63	*M. edulis*	2.16	0.12	0.06	0.33	0.49	0.07	nd <0.05	0.03	1.15	0.03	nd <0.01	nd <0.01	0.03	0.08	nd <0.01	0.09	nd <0.01	0.01	0.15	0.01	0.02	0.01	0.02	0.27
ENV/2007/69	*M. edulis*	1.32	0.05	0.06	0.1	0.13	nd <0.01	nd <0.05	0.02	0.42	0.01	nd <0.01	nd <0.01	0.02	0.05	nd <0.01	0.08	nd <0.01	0.01	0.13	nd <0.01	0.01	nd <0.01	nd <0.01	0.1
ENV/2007/70	*M. edulis*	1.77	0.31	0.28	0.64	0.74	0.06	0.08	0.11	2.22	0.02	nd <0.01	0.01	0.03	0.07	0.02	0.65	nd <0.01	0.03	0.97	0.11	0.15	0.02	0.01	0.56
ENV/2007/88	*C. gigas*	1.92	nd <0.02	0.04	0.08	0.14	nd <0.01	nd <0.05	nd <0.02	0.36	0.03	nd <0.01	nd <0.01	0.03	0.08	nd <0.01	0.3	0.01	0.06	0.55	0.05	0.12	nd <0.01	nd <0.01	0.2
ENV/2008/88	*M. edulis*	1.11	<0.02	0.02	0.05	0.06	0.01	0.05	<0.1	0.31	0.12	0.01	<0.02	0.1	0.25		0.25	0.01	0.02			0.16	0.03	0.05	0.37
ENV/2008/89	*M. edulis*	1.55		0.16	0.2	0.31	0.05	0.13	0.33	1.18	0.14	0.03	0.03				0.28		0.01			0.15	0.02	0.03	0.44
ENV/2008/90	*M. edulis*	1.53	0.08	0.03	0.06	0.12	0.02	0.08	0.12	0.51	0.03	0.004	<0.02	0.03	0.08		0.13	<0.02	0.04			0.16	0.04	0.02	0.15
ENV/2008/91	*M. edulis*	1.45	<0.24	0.2	0.12	0.14	0.03	0.19	0.33	1.25	<0.01	<0.22	0.01	0.08	0.32		0.17		<0.42			0.04	0.07	0.03	0.25
ENV/2008/92	*M. edulis*	1.69		0.34	0.34	0.31	0.02	0.37	0.27	1.65	<0.01		0.08	0.08			0.22		<0.01			0.05	0.006	0.05	0.39
	M. edulis	1.50	0.09	0.07	0.17	0.36	0.08	0.03	0.09	0.89	0.03	0.009	<0.22	0.06	0.32		0.13	0.04	<0.05			0.12	0.05	0.01	0.11
ENV/2008/94	*C. edule*	0.66	<0.02	0.04	0.08	0.1	0.01	0.09	<0.1	0.44	<0.1	0.02	<0.1	<0.1	0.32		0.14		<0.01			0.009	0.008	0.05	0.16
ENV/2008/95	*C. gigas*	2.02	0.01	0.02	0.1	0.09	0.03	0.15	0.17	0.57	0.05	0.003	0.05	0.07	0.17		0.23	0.13	0.06			0.19	0.04	0.01	0.25
ENV/2008/96	*E. siliqua*	1.25	0.1	0.12	0.11	0.09	0.01	0.13	0.2	0.76	0.05	<0.01	<0.01	0.03	0.1		0.25		<0.01			0.13	<0.01	0.02	0.42
ENV/2008/97	*C. gigas*	1.05	0.1	0.09	0.06	0.1	0.02	0.03		0.4	0.21	0.02	<0.02	0.14	0.39		0.11		<0.02			0.04	nd <0.001	0.05	0.21
ENV/2008/98	*C. gigas*	0.84	0.17	0.05	0.05	0.06	0.01	<0.02	<0.1	0.46		<0.02		0.03			0.12	0.04	<0.02			0.02	0.01	0.04	0.18
ENV/2008/99	*C. gigas*	1.07	0.1	0.04	0.07	0.07	0.02	0.03	<0.05	0.38	0.21	0.009	0.01	0.12	0.35		0.14	0.16	<0.02				0.04	0.04	0.19
ENV/2008/100	*C. gigas*	0.95	0.16	0.07	0.09	0.1	0.01	0.07	<0.45	0.95		0.02	<0.02	0.16			0.18	0.04	<0.02			0.06	0.03	0.05	0.2
ENV/2008/101	*C. gigas*	0.76	<0.25	0.05	0.13	0.15	0.02	<0.03	0.43	1.06	0.29	<0.03	<0.03	0.12	0.47		0.13		<0.03			0.46	<0.07	0.06	0.23
ENV/2008/103	*O. edulis*	0.79	0.05	0.02	0.09	0.07	0.01	<0.02	0.05	0.31	0.15	0.01	0.02	0.08	0.26				<0.02			0.01	0.04	0.04	0.15
ENV/2008/104	*C. gigas*	0.95	0.04	0.05	0.06	0.09	0.01	<0.007	<0.43	0.69	0.13	0.02	0.02	0.13	0.3		0.14		0.02			0.04	0.02	0.04	0.2
ENV/2008/105	*M. edulis*	0.86	0.04	0.04	0.11	0.12	0.04	0.13		0.48	0.21		<0.02	0.13			0.19	nd <0.001	0.06				<0.02	0.07	0.29
ENV/2008/106	*C. gigas*	1.63	0.06	0.05	0.06	0.04	0.01	0.08		0.3	0.28	<0.005	<0.04	0.1	0.43		0.18					0.29	<0.05	0.05	0.42
ENV/2008/107	*C. gigas*	0.95	0.08	0.05	0.11	0.21	0.02	0.1	<0.1	0.67		0.009	<0.02	0.18			1.19	0.06	0.02			0.02	0.009	0.04	0.2

	µg kg^{-1} ww																							
MI Reference	Species	% Lipids	CB101	CB118	CB138*	CB153	CB180	CB28	CB52	SCB7	CCDAN	OCDAN	TCDAN	TNONC	SDanes (WW)	DDEOP	DDEP	DDTOP	DDTPP	SDDTs	TDEOP	TDEPP	HCHG	HCB	DIELD
ENV/2008/108	*C. gigas*	0.81	<0.03	0.02	0.06	0.09	0.01	0.11	<0.49	0.81	0.15	<0.005	<0.02	0.16	0.34		0.51	0.04	0.02			0.04	0.02	0.04	0.27
ENV/2008/109	*M. edulis*	1.45	0.25	0.31	0.16	0.26	0.03	0.36	0.36	1.73	<0.01	nd <0.001	0.09	0.06	0.16		0.27		0.17				<0.21	0.03	0.26
ENV/2008/110	*O. edulis*	1.79	<0.1	0.15	0.17	0.18	0.04	<0.11	0.17	0.92	0.03		0.02	0.18			0.13	<0.05	0.03			0.15	0.11	0.01	
ENV/2008/111	*C. gigas*	1.87	0.06	0.03	0.04	0.1	0.03	0.02	0.32	0.6	0.02	<0.02	nd <0.1	0.04	0.18		0.29	<0.02	0.11			0.45	0.05	0.03	0.24
ENV/2008/112	*C. gigas*	1.54		0.16	0.14	0.15	0.09	0.22	0.32	1.08	0.17	nd <0.01	<0.09	0.05	0.32		<0.27					0.09	0.07	0.03	0.21
ENV/2008/114	*C. gigas*	0.86	0.12	0.04	0.1	0.15	0.03	0.08	0.06	0.58			0.03	0.09			0.15	<0.02	0.04			0.13	0.02	0.04	0.21
ENV/2008/115	*C. gigas*	1.04	0.13	0.04	0.1	0.13	0.02	0.12	0.28	0.82	0.16		0.05	0.13			0.15	nd <0.001	0.03			0.16	0.04	0.04	0.2
ENV/2008/116	*C. gigas*	1.37		0.29	0.15	0.35	0.04	0.11	<0.23	1.17	0.15	<0.01	0.02				0.16		0.09			0.09	0.01	0.01	0.3
ENV/2008/117	*C. gigas*	2.41		0.64	0.51	1.1	0.17	<0.11	0.27	2.8	0.05	nd <0.01	nd <0.09	0.14	0.29		1.11		0.3			0.27	0.01	0.03	0.23
ENV/2008/118	*E. siliqua*	0.84	0.04	0.09	0.06	0.1	<0.02	0.03	0.08	0.42			0.02	0.02			0.18	nd <0.001	0.04			0.11	0.02	0.05	0.32
ENV/2008/119	*C. gigas*	2.59		0.09	0.15	0.49	0.04	0.34	<0.1	1.21	0.07	<0.01	0.04	0.31	0.43		0.48		<0.42			0.16	<0.01	0.02	0.43
ENV/2008/120	*C. gigas*	0.93	0.11	0.12	0.06	0.24	0.02	0.09	0.24	0.88	0.14	<0.02	<0.004	0.14	0.3		0.34	<0.02	0.03			0.1	0.03	0.04	0.34
ENV/2008/121	*C. gigas*	2.42		0.61	<0.7	0.63	0.06	0.22	0.47	2.69	0.16	<0.09	<0.1	0.09	0.44		0.7		0.01			0.3	<0.1	0.01	0.58
ENV/2008/122	*M. edulis*	1.70	0.13	0.06	0.19	0.36	0.05	0.11	0.06	0.96	0.03	nd <0.001	<0.22	0.05	0.3		0.12	0.06	0.19			0.12	0.05	0.02	0.29
ENV/2008/123	*M. edulis*	1.17	<0.01	0.22	0.29	0.51	0.03	<0.05	<0.2	1.31	<0.03	<0.02	0.06	0.19	0.3		1.66	<0.03	<0.03			0.45	0.03	0.04	0.76
ENV/2008/124	*M. edulis*	1.66	0.04	0.15	0.22	0.32	0.04	0.06	0.09	0.92	0.02	0.02	<0.1	0.02	0.16		0.82	0.03				0.23	0.04	0.01	0.14
ENV/2008/125	*M. edulis*	0.91	0.04	0.04	0.08	0.11	0.02		<0.16	0.45	<0.02	<0.1	<0.02	0.03	0.17		0.11	0.05	<0.02			0.09	<0.006	0.01	0.17
ENV/2008/126	*C. gigas*	1.11	0.08	0.04	0.08	0.13	0.01	<0.67	<0.16	1.17	0.04		0.05	nd <0.001			0.2	0.09	nd <0.006			<0.14	0.04	0.02	0.29
ENV/2008/127	*C. gigas*	1.24		0.13	0.16	0.17	<0.11	0.09	0.22	0.88	0.02	nd <0.000 9	nd <0.09	0.05	0.16		0.11	0.2	0.06			0.21	0.07	0.07	0.15
ENV/2008/128	*M. edulis*	1.24	0.43	0.44	0.72	1.13	<0.11	0.11	0.18	3.12	0.03	<0.04	nd <0.09	0.009	0.17		0.64	0.05	0.3			0.65	0.02	<0.11	0.33
ENV/2008/129	*M. edulis*	1.40	0.18	0.38	<0.79	0.41	0.06	0.22	0.42	2.46	<0.01	<0.07	0.04	0.04	0.16		0.16		0.13			0.04	0.06	0.04	0.3
ENV/2008/130	*C. gigas*	1.71	0.11	0.08	0.11	0.22	0.03	0.09	nd <0.03	0.67	0.01	<0.15	0.03	0.09	0.28		0.12	<0.22	nd <0.006		<0.13	<0.13	0.04	0.02	0.28
ENV/2008/131	*C. gigas*	2.43	0.03	0.07	0.08	0.08	0.01	0.14	nd <0.02	0.43	0.04	<0.18	nd <0.005	0.12	0.35		0.15	0.03	0.05			<0.11	0.03	0.02	0.28
ENV/2008/132	*C. gigas*	1.76	nd <0.001	0.01	<0.05	0.03	<0.11	0.25	<0.16	0.61	0.07		0.07	0.11			0.37		0.09			0.26	0.06	0.01	0.26
ENV/2008/133	*O. edulis*	1.25	<0.11	0.11	0.19	0.11	0.06	<0.11	<0.11	0.8	0.02	0.02	0.11	<0.02	0.17		0.18	nd <0.0009	0.1			0.4	0.05	<0.11	0.12
ENV/2008/134	*C. gigas*	1.95		0.39	0.29	0.37	0.11	0.05	<0.2	1.41	0.04		nd <0.09	0.02			0.31		0.12			0.2	0.08		0.18

	µg kg^{-1} ww																							
MI Reference	Species	% Lipids	CB101	CB118	CB138*	CB153	CB180	CB28	CB52	SCB7	CCDAN	OCDAN	TCDAN	TNONC	SDanes (WW)	DDEOP	DDEP	DDTOP	DDTPP	SDDTs	TDEOP	TDEPP	HCHG	HCB	DIELD
ENV/2008/135	*C. gigas*	1.44	<0.38	0.14	0.18	0.13	<0.1	<0.36	<0.18	1.47	0.03	<0.1	0.05	0.08	0.26		0.99	0.04	nd <0.007			0.24	0.03	nd <0.001	0.23
ENV/2008/136	*M. edulis*	1.69	0.04	0.07	0.04	0.13	0.04	<0.25	0.16	0.73	0.03	nd <0.001	<0.02	0.06	0.11		0.15	<0.01	0.02			0.06	0.04	0.02	0.22
ENV/2008/137	*C. gigas*	1.36		0.1	0.11	0.13	0.04	<0.11	<0.11	0.6	<0.02	0.02	nd <0.09				0.15	nd <0.0009				0.25	0.05	<0.11	0.14
ENV/2008/138	*M. edulis*	1.10	0.15	0.1	0.14	0.13	0.006	0.1	<0.11	0.74	0.03	0.03	nd <0.09	0.12	0.27		0.15	0.1	0.1			0.17	0.04	<0.11	0.11
ENV/2008/139	*C. gigas*	2.15	0.02	0.06	0.03	0.11	0.05	0.07	0.07	0.41	0.03	nd <0.001	<0.02	0.04	0.09		0.16	0.01	0.04			0.19	0.04	0.01	0.17
ENV/2008/140	*M. edulis*	1.23	0.21	<0.11	<0.11	0.14	0.01	0.12	0.3	1	0.02	0.04	<0.02	0.21	0.29		0.15	0.01	0.07			0.04	0.05	nd <0.02	0.14
ENV/2008/141	*M. edulis*	1.53	<0.11	0.36	0.37	0.33	0.05	0.19	<0.11	1.52	0.1	<0.02		nd <0.004			0.36	0.03	0.24			0.27	<0.11	0.18	0.31
ENV/2008/142	*M. edulis*	0.80	<0.11	0.04	0.15	0.09	<0.11	0.15	<0.11	0.76	0.06	<0.04		0.1			0.14	0.005	0.07			0.08	<0.1	<0.11	0.27
ENV/2008/143	*M. edulis*	0.92	0.06	0.04	0.09	0.09	0.02	0.02	<0.18	0.5	<0.03	<0.08	0.04	<0.05	0.2		0.22	0.08	0.12			0.22	0.04	0.02	0.25
ENV/2008/144	*M. edulis*	1.51	0.02	0.04	0.1	0.16	0.02	0.07	0.12	0.53	0.04	0.02	0.01	0.03	0.1		0.11	<0.05	0.07			0.1	0.04	0.02	0.17
ENV/2008/145	*O. edulis*	1.88	0.04	0.05	0.08	0.2	0.03	0.06	<0.05	0.51	0.01	0.009	<0.02	0.04	0.08		0.27	<0.02	nd <0.01			nd <0.09	0.05	0.01	0.23
ENV/2008/146	*C. gigas*	1.45	1.3	0.61	1.03	1.03	0.05	0.19	0.25	4.46	0.06	0.02	nd <0.09	0.13	0.3		0.92	0.05	0.23			0.54	0.07	<0.11	0.24
ENV/2008/147	*M. edulis*	0.87	0.37	0.29	0.54	0.78	0.05	<0.03	<0.17	2.23	0.07	0.08	0.09	0.08	0.32		0.64	0.06				0.33	0.02	0.3	0.58
ENV/2008/148	*C. gigas*	1.50		0.42	0.53	1.33	0.07	<0.67	<0.15	3.17	0.12		0.11	0.13			0.99	0.07				0.46	0.02	0.31	0.59
ENV/2008/149	*O. edulis*	1.67	0.04	0.05	0.08	0.19	0.01	0.03	0.02	0.42	0.02	nd <0.001	<0.02	0.03	0.07		0.02	<0.02	<0.05			<0.2	0.03	0.02	0.34

Notes: *CB138 and CB163 were tested for 2008 samples only
nd: not detected

B.2 Contaminant data in finfish landed at Irish ports and sampled at retail 2004-2008

Table B2.1: Trace metals in finfish landed and sampled at Irish ports, 2004 – 2008.

					mg kg^{-1} ww								
MI Reference	Common name	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2004/037	Brill	291.0	17.6	80.9						<0.03			
ENV/2006/07	Brill	338.0	22.0	79.1	<0.003		<0.002	<0.05	0.2	0.05	<0.03	<0.008	2.58
ENV/2004/065	Cod, Atlantic	500.0	41.6	80.6	<0.01		<0.004	<0.07	<0.16	0.03	<0.06	<0.02	2.51
ENV/2005/010	Cod, Atlantic	406.0	52.4	80.7						0.1			
ENV/2005/024	Cod, Atlantic	382.0	38.4	80.6						0.08			
ENV/2005/034	Cod, Atlantic	439.0	44.7	80.7			<0.002			0.12		<0.05	
ENV/2006/015	Cod, Atlantic	496.0	49.8	80.5	0.01		<0.002	0.06	0.28	0.07	<0.03	<0.008	3.39
ENV/2006/019	Cod, Atlantic	541.0	69.1	80.0	<0.003		<0.002	0.05	0.7	0.16	<0.03	<0.008	3.48
ENV/2007/039	Cod, Atlantic	297.0	25.0	81.6	<0.003		<0.002	<0.02	<0.20	0.06	<0.03	<0.008	1.82
ENV/2007/072	Cod, Atlantic	406.5	33.9	80.4	<0.003		<0.002	<0.02	<0.02	0.06	<0.03	<0.05	1.99
ENV/2004/020	Dogfish, Lesser Spotted	566.0	74.8	78.1	<0.01		<0.004	<0.07	<0.44	0.43	<0.06	<0.02	6.46
ENV/2005/032	Eel, European	909.0	284.5	78.0	<0.003		<0.002	<0.05	0.44	0.19	<0.03	<0.05	5.4
ENV/2006/022	Gurnard, Grey	328.0	23.2	75.5			<0.002			0.08		<0.05	
ENV/2008/079	Gurnard, Grey	310.0	24.9	76.6	nd <0.003	2.3	nd <0.002	nd <0.02	<0.2	0.38	<0.13	nd <0.008	2.55
ENV/2005/038	Gurnard, Red	365.0	41.2	78.7						0.18			
ENV/2004/033	Haddock	318.5	31.0	79.8	<0.01		<0.004	<0.07	<0.16	0.06	<0.06	<0.02	2.18
ENV/2004/039	Haddock	401.0	76.9	78.1						0.07			
ENV/2005/013	Haddock	354.0	23.0	79.7	<0.003		<0.002	<0.02	0.48	0.08	<0.03	0.06	2.54
ENV/2005/022	Haddock	393.0	28.2	81.2	<0.003		<0.002	<0.05	0.54	0.09	<0.03	<0.05	2.61
ENV/2005/025	Haddock	393.0	27.1	79.4			<0.002			0.1		<0.05	
ENV/2005/030	Haddock	388.0	29.0	79.0						0.09			
ENV/2006/020	Haddock	423.0	48.6	79.8	<0.003		<0.002	0.05	0.68	0.12	<0.03	<0.05	2.98
ENV/2006/09	Haddock	433.0	14.4	79.5						0.04			
ENV/2007/026	Haddock	375.0	17.7	79.7			<0.002			0.11		<0.05	
ENV/2007/028	Haddock	388.0	8.9	79.1			<0.002			0.07		<0.05	
ENV/2007/036	Haddock	294.0	20.7	81.1						0.04			
ENV/2007/073	Haddock	332.0	16.2	78.6			<0.002			0.09		<0.008	
ENV/2008/018	Haddock	654.0	51.8	81.8						0.12			
ENV/2008/041	Haddock	358.0	18.1	79.9						0.09			
ENV/2008/066	Haddock	342.0	19.3	78.9	nd <0.003	8.82	nd <0.002	<0.05	<0.2		nd <0.03	<0.05	2.34
ENV/2004/026	Hake, European	474.5	68.1	81.1						0.09			
ENV/2004/045	Hake, European	362.0	48.3	79.8	<0.01		<0.004	<0.07	<0.16	<0.03	<0.06	<0.02	2.2
ENV/2005/019	Hake, European	339.0	17.3	81.1						0.04			
ENV/2005/043	Hake, European	453.0	31.8	79.9	<0.003		<0.002	<0.05	<0.20	0.2	<0.03	<0.05	2.2
ENV/2006/017	Hake, European	388.0	25.9	80.8						0.06			
ENV/2006/06	Hake, European	399.0	86.8	80.7			<0.002			0.08		<0.008	
ENV/2007/025	Hake, European	362.0	22.5	81.2	<0.003		<0.002	<0.05	0.31	0.04	<0.03	<0.008	1.99

					mg kg^{-1} ww								
MI Reference	Common name	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2007/074	Hake, European	358.0	32.3	80.4	<0.003		<0.002	<0.02	0.34	0.03	<0.03	<0.008	3
ENV/2008/012	Hake, European	586.0	89.7	79.1						0.18			
ENV/2008/021	Hake, European	448.0	56.2	81.0						0.06			
ENV/2006/04	John Dory	282.0	24.8	78.9	<0.003		<0.002	<0.05	<0.20	0.04	<0.03	<0.05	2.23
ENV/2007/032	John Dory	342.0	34.5	78.8						0.07			
ENV/2008/017	John Dory	428.0	32.2	80.0		0.61	nd <0.002			0.13		nd <0.008	
ENV/2004/066	Ling, European	605.5	52.3	79.4	<0.01		<0.004	<0.07	0.45	0.13	<0.06	<0.02	2.24
ENV/2005/035	Ling, European	679.0	121.1	79.6	<0.003		<0.002	<0.02	<0.20	0.26	<0.03	<0.05	2.76
ENV/2007/027	Ling, European	493.0	65.5	80.1	<0.003		<0.002	<0.05	0.36	0.09	<0.03	<0.008	2.8
ENV/2008/019	Ling, European	764.0	114.0	79.8						0.15			
ENV/2008/043	Ling, European	616.0	57.0	79.2	nd <0.003	8.37	nd <0.002	nd <0.02	<0.2	0.12	nd <0.03	nd <0.008	2.77
ENV/2004/021	Mackerel, Atlantic	295.0	10.8	73.2	<0.01		<0.004	<0.07	<0.44	0.04	<0.06	<0.02	2.52
ENV/2005/012	Mackerel, Atlantic	313.0	32.6	74.2	<0.003		<0.005	<0.05	0.89	0.06	<0.03	<0.05	2.95
ENV/2006/010	Mackerel, Atlantic	315.0	17.2	71.6			<0.005			0.03		<0.05	
ENV/2006/018	Mackerel, Atlantic	315.0	28.9	71.9	<0.003		<0.002	0.07	0.85	0.08	<0.03	<0.008	3.28
ENV/2007/022	Mackerel, Atlantic	240.0	20.9	72.3	<0.003		<0.005	<0.05	0.64	0.03	<0.03	<0.05	4.33
ENV/2007/037	Mackerel, Atlantic	279.0	25.1	78.4	<0.003		<0.005	<0.05	1.07	0.08	<0.13	<0.05	3.28
ENV/2008/022	Mackerel, Atlantic	312.0	14.9	69.8	nd <0.003	1.1	nd <0.002	<0.05	0.55	0.06	nd <0.03	nd <0.008	4.5
ENV/2004/031	Megrim	340.5	37.0	80.5						0.06			
ENV/2004/040	Megrim	308.0	26.4	77.6						<0.03			
ENV/2005/040	Megrim	333.0	37.9	78.5	<0.003		<0.002	<0.02	0.25	0.08	<0.13	<0.05	1.99
ENV/2006/023	Megrim	347.0	30.4	80.2	<0.003		<0.002	<0.05	1.13	0.39	<0.13	<0.008	2.91
ENV/2007/075	Megrim	345.0	28.1	79.0	<0.013		<0.002	<0.02	0.3	0.06	<0.03	<0.008	3.23
ENV/2008/011	Megrim	456.0	60.9	80.1						0.36			
ENV/2008/023	Megrim	367.0	39.8	79.5	nd <0.003	11.6	nd <0.002	<0.05	0.32	0.08	nd <0.03	nd <0.008	2.81
ENV/2008/044	Megrim	375.0	30.8	79.2						0.13			
ENV/2004/018	Monkfish	300.5	21.4	83.0			<0.004			0.07		<0.02	
ENV/2004/027	Monkfish	464.4	89.0	81.5	<0.01		<0.004	<0.07	<0.16	0.15	<0.06	<0.02	2.8
ENV/2004/029	Monkfish	486.0	127.7	81.6	<0.01		<0.004	<0.07	<0.16	0.16	<0.06	<0.02	2.36
ENV/2004/038	Monkfish	470.4	114.6	84.2	<0.01		<0.004	<0.07	<0.16	0.15	<0.06	<0.02	2.95
ENV/2004/043	Monkfish	345.0	51.3	83.5	<0.01		<0.004	<0.07	<0.44	0.1	<0.06	<0.02	3.26
ENV/2005/023	Monkfish	523.0	78.0	81.2			<0.002			0.07		<0.05	
ENV/2005/036	Monkfish	471.0	75.2	83.6						0.12			
ENV/2005/039	Monkfish	309.0	39.7	83.1	<0.003		<0.002	0.23	0.35	0.06	<0.13	<0.05	2.82
ENV/2006/014	Monkfish	455.0	41.9	82.0			<0.002			0.05		<0.008	
ENV/2006/035	Monkfish	450.0	91.9	82.8	<0.003		<0.002	0.07	0.58	0.13	<0.03	<0.008	3.39
ENV/2007/023	Monkfish	582.0	51.6	83.3	<0.003		<0.002	<0.02	<0.20	0.09	<0.03	<0.008	2.77
ENV/2007/034	Monkfish	395.0	35.0	81.3	<0.003		<0.002	<0.02	<0.20	0.11	<0.03	<0.008	3.52
ENV/2008/014	Monkfish	664.0	71.8	83.2	nd <0.003	11.2	nd <0.002	nd <0.02	<0.2	0.15	nd <0.03	nd <0.008	3.75
ENV/2008/045	Monkfish	454.0	19.2	83.2	nd <0.003	8.42	nd <0.002	nd <0.02	<0.2	0.12	nd <0.03	nd <0.008	2.46

Table B2.1 (contd.): Portfish Metals

					mg kg^{-1} ww								
Sample	Common name	Length (mean)	Length (stdev)	Moisture %	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
ENV/2008/076	Monkfish	463.0	36.2	82.4	nd <0.003	8.18	nd <0.002	nd <0.02	<0.2	0.1	nd <0.03	nd <0.008	3.26
ENV/2008/013	Monkfish, Black bellied	454.0	98.5	82.8	nd <0.003	8.18	nd <0.002	nd <0.02	<0.2	0.1	nd <0.03	nd <0.008	2.94
ENV/2007/029	Mullet, Red	290.0	27.4	79.9	<0.003		<0.002	<0.02	0.22	0.16	<0.03	<0.05	2.68
ENV/2004/023	Plaice, European	312.5	13.6	78.5						0.04			
ENV/2004/032	Plaice, European	341.0	31.3	80.5						0.05			
ENV/2004/035	Plaice, European	329.5	16.2	78.9			<0.004			0.04		<0.02	
ENV/2004/042	Plaice, European	283.0	21.5	80.1			<0.004			<0.03		<0.02	
ENV/2005/015	Plaice, European	286.0	22.0	80.0						0.05			
ENV/2005/020	Plaice, European	317.0	45.4	79.9	<0.003		<0.002	<0.05	0.48	0.06	<0.03	<0.05	3.6
ENV/2005/041	Plaice, European	318.0	13.2	78.7			<0.002			0.08		<0.05	
ENV/2006/08	Plaice, European	304.0	15.6	77.7						0.05			
ENV/2006/036	Plaice, European	332.0	15.1	80.1			<0.002			0.05		<0.05	
ENV/2007/076	Plaice, European	339.0	30.1	81.0						0.09			
ENV/2008/046	Plaice, European	280.0	19.8	81.7		16.7	nd <0.002			0.08		<0.05	
ENV/2008/067	Plaice, European	334.0	25.7	79.2	nd <0.003	28.9	nd <0.002	nd <0.02	0.21	0.05	nd <0.03	<0.05	3.56
ENV/2008/078	Plaice, European	311.0	11.5	80.0	nd <0.003	11.2	nd <0.002	nd <0.02	<0.2	0.05	nd <0.03	nd <0.008	3.7
ENV/2008/047	Pollock	461.0	41.5	79.9	nd <0.003	1.8	nd <0.002	<0.05	<0.2	0.09	nd <0.03	nd <0.008	3.73
ENV/2006/011	Pollock, Black	573.0	69.8	80.2						0.04			
ENV/2006/013	Pollock, Black	471.0	29.5	80.1			<0.002			0.04		<0.008	
ENV/2008/026	Pollock, Black	393.0	30.5	80.0	nd <0.003	1.32	nd <0.002	nd <0.02	<0.2	0.03	nd <0.03	nd <0.008	2.94
ENV/2004/025	Prawn, Common	28.5	3.1	78.8						0.08			
ENV/2004/022	Ray, Cuckoo	479.0	45.1	76.0						0.04			
ENV/2005/09	Ray, Cockoo	586.0	35.8	76.7						0.07			
ENV/2005/029	Ray, Cockoo	585.0	28.7	76.2	<0.003		<0.002	0.07	0.63	0.09	<0.03	<0.05	2.53
ENV/2005/033	Ray, Cockoo	526.0	24.4	77.0						0.08			
ENV/2008/077	Ray, Spotted	501.0	31.1	82.4						0.04			
ENV/2007/077	Ray, Thornback	563.0	63.2	76.5	<0.003		<0.002	<0.02	<0.20	0.07	<0.03	<0.008	3.37
ENV/2008/024	Ray, Thornback	714.0	65.1	76.8		26.7	nd <0.002			0.08		nd <0.008	
ENV/2006/012	Salmon, Atlantic	621.0	72.4	67.9	<0.003		<0.002	0.05	0.29	0.1	<0.03	<0.008	3.73
ENV/2004/024	Sole, Black	262.0	12.7	78.3						0.03			
ENV/2004/030	Sole, Black	282.0	18.7	79.3						<0.03			
ENV/2005/016	Sole, Black	261.0	16.9	79.0			<0.002			0.07		<0.05	
ENV/2005/037	Sole, Black	266.0	28.2	79.2						0.09			
ENV/2006/034	Sole, Black	354.0	11.1	79.8			<0.002			0.11		<0.05	
ENV/2007/030	Sole, Black	342.0	17.0	80.7	<0.003		<0.002	0.06	<0.20	0.08	<0.03	<0.05	2.97
ENV/2008/015	Sole, Black	369.0	15.5	80.1	nd <0.003	2.3	nd <0.002	nd <0.02	<0.2	0.18	nd <0.03	nd <0.008	3.57
ENV/2008/069	Sole, Black	324.0	19.0	78.4						0.07			
ENV/2008/075	Sole, Black	292.0	13.2	79.7						0.04			
ENV/2004/019	Sole, Lemon	287.8	20.2	78.3	<0.01		<0.004	<0.07	<0.16	0.04	<0.06	<0.02	2.6
ENV/2004/034	Sole, Lemon	296.0	19.3	81.4	<0.01		<0.004	<0.07	<0.16	0.05	<0.06	<0.02	2.36
ENV/2004/044	Sole, Lemon	257.0	26.7	79.1						0.07			
ENV/2005/017	Sole, Lemon	256.0	14.4	78.5						0.1			

					mg kg^{-1} ww								
Sample	**Common name**	**Length (mean)**	**Length (stdev)**	**Moisture %**	**Ag**	**As**	**Cd**	**Cr**	**Cu**	**Hg**	**Ni**	**Pb**	**Zn**
ENV/2005/021	Sole, Lemon	252.0	17.2	80.0						0.13			
ENV/2005/028	Sole, Lemon	286.0	14.2	79.9						0.06			
ENV/2005/042	Sole, Lemon	275.0	24.8	79.9						0.12			
ENV/2006/016	Sole, Lemon	282.0	26.5	79.7						0.11			
ENV/2007/024	Sole, Lemon	266.0	24.1	80.8			<0.002			0.16		<0.05	
ENV/2007/031	Sole, Lemon	391.0	57.5	79.4						0.07			
ENV/2007/035	Sole, Lemon	254.0	20.1	79.7	<0.003		<0.002	<0.05	0.28	0.03	<0.13	<0.008	2.46
ENV/2008/042	Sole, Lemon	281.0	18.5	80.4						0.15			
ENV/2008/070	Sole, Lemon	306.0	17.5	77.8	nd <0.003	35.5	nd <0.002	nd <0.02	0.4	0.04	nd <0.03	nd <0.008	3.04
ENV/2004/067	Spurdog	700.0	44.2	73.3	<0.01		<0.004	<0.07	<0.44	0.26	<0.06	<0.02	1.72
ENV/2005/08	Spurdog	820.0	14.1	75.2	<0.003		<0.002	<0.05	0.36	0.43	<0.03	<0.05	2.25
ENV/2005/014	Spurdog	930.0		73.2	<0.003		<0.002	0.09	0.84	0.73	<0.13	<0.05	2.03
ENV/2005/027	Spurdog	699.0	35.9	75.4	<0.003		<0.005	<0.05	0.67	0.59	<0.03	<0.05	2.18
ENV/2006/05	Turbot	298.0	22.3	79.2	<0.003		<0.002	0.06	<0.20	0.05	<0.13	<0.008	3.29
ENV/2006/037	Turbot	329.0	14.3	80.3	<0.003		<0.002	<0.05	0.39	0.05	<0.03	<0.008	3.69
ENV/2008/016	Turbot	453.0	41.2	80.2						0.19			
ENV/2004/036	Turbot	300.5	22.0	79.3	<0.01		<0.004	<0.07	<0.44	0.04	<0.06	<0.02	3.03
ENV/2004/017	Whiting, European	327.0	17.0	80.6						0.09			
ENV/2004/028	Whiting, European	452.0	43.6	80.9			<0.004			0.15		<0.02	
ENV/2004/046	Whiting, European	413.0	40.2	80.5						0.06			
ENV/2005/011	Whiting, European	358.0	17.2	81.0						0.09			
ENV/2005/018	Whiting, European	334.0	19.7	81.5	<0.003		<0.002	<0.05	0.4	0.21	<0.13	<0.05	2.81
ENV/2005/026	Whiting, European	285.0	19.7	78.9	<0.003		<0.002	0.08	0.35	0.09	<0.03	<0.05	2.41
ENV/2005/031	Whiting, European	313.0	18.6	80.3						0.19			
ENV/2006/021	Whiting, European	313.0	24.0	79.6			<0.002			0.08		<0.05	
ENV/2006/038	Whiting, European	329.0	14.3	80.2	<0.003		<0.002	0.06	0.34	0.05	<0.03	<0.008	2.25
ENV/2007/033	Whiting, European	455.0	14.7	79.7	<0.003		<0.002	<0.02	<0.20	0.14	<0.03	<0.008	2.72
ENV/2007/038	Whiting, European	314.0	38.1	80.7			<0.002			0.05		<0.008	
ENV/2007/078	Whiting, European	345.0	21.2	80.7						0.09			
ENV/2008/025	Whiting, European	352.0	16.7	80.6						0.08			
ENV/2008/048	Whiting, European	382.0	24.0	81.2						0.18			
ENV/2008/071	Whiting, European	328.0	21.4	80.2		2.92	nd <0.002			0.07		nd <0.008	
ENV/2004/041	Witch	284.5	26.4	80.7	<0.01		<0.004	<0.07	<0.16	0.08	<0.06	<0.02	2.15
ENV/2008/027	Witch	335.0	33.0	82.2						0.07			
ENV/2008/068	Witch	324.0	27.8	79.3						0.06			
ENV/2008/020	Wolffish, Atlantic	876.0	99.4	82.9		10.7	<0.005			0.19		nd <0.008	

Table B2.2: Organochlorine substances in finfish landed and sampled at Irish ports, 2004 – 2008.

			μg kg^{-1}																					
MI Reference	Common name	% Lipids	CB101	CB105	CB118	CB138	CB149	CB153	CB156	CB170	CB18	CB180	CB28	CB31	CB44	CB52	Sum ICES CB7	ALD	CCDAN	DDEPP	DDTOP	DDTpp	DIELD	END	HCB
ENV/2006/07	Brill	0.5	0.027		0.024	0.059	0.029	0.074		0.007	<0.002	0.019	0.01	0.008	0.071	0.041	0.25	<0.007	<0.007	0.047	<0.007	<0.139	0.042	<0.007	0.036
ENV/2004/065	Cod, Atlantic	0.4	0.02	0.01	0.03	0.05		0.09	<0.01			0.02	0.01			<0.01	0.23			0.1		<0.01	0.04		0.06
ENV/2006/015	Cod, Atlantic	0.3	0.081		0.132	0.28	0.029	0.442		0.064	<0.002	0.123	0.013	0.008	0.02	0.037	1.11	<0.007	0.008	0.115	<0.002	<0.139	0.013	<0.002	0.058
ENV/2006/019	Cod, Atlantic	0.2	0.033		0.131	0.214	0.018	0.343		0.05	<0.002	0.118	<0.007	<0.007	0.017	0.013	0.86	<0.007	<0.007	0.134	<0.007	<0.139	0.024	<0.007	0.02
ENV/2007/072	Cod, Atlantic	0.6	0.058		0.17	0.413	<0.037	0.658		<0.008	<0.01	0.24	<0.037	<0.037	0.017	0.02	1.60	<0.002	0.009	0.112	<0.007	0.014	0.084	<0.002	0.061
ENV/2004/020	Dogfish, Lesser Spotted	0.6	0.04	0.06	0.16	0.34		0.44	0.02			0.15	0.02			<0.01	1.16			0.17		<0.01	0.08		0.02
ENV/2005/032	Eel, European	1.4	0.22	0.16	0.5	0.83		1.19	0.07			0.45	0.06			0.04	3.29			0.53		0.03	0.31		0.14
ENV/2008/079	Gurnard, Grey	1.3	0.227	0.135	0.48	0.686	NA	1.108	0.063	NA	ND	0.29	0.054	<0.19	0.037	NA	2.84	ND	0.074	0.599	ND	0.15	0.2	ND	0.041
ENV/2004/033	Haddock	0.5	0.02	0.01	0.03	0.05		0.07	<0.01			0.02	<0.01			<0.01	0.21			0.02		<0.01	0.02		0.07
ENV/2005/013	Haddock	0.5	0.02	0.02	0.05	0.1		0.13	0.01			0.04	0.01			<0.01	0.36			0.04		<0.01	0.05		0.06
ENV/2005/022	Haddock	0.4	0.02	0.01	0.03	0.06		0.08	<0.01			0.03	0.01			<0.01	0.24			0.03		<0.01	0.03		0.08
ENV/2006/020	Haddock	0.4	0.013		0.028	0.064	0.009	0.096		0.018	<0.002	0.04	0.009	<0.007	<0.007	0.018	0.27	<0.007	<0.007	0.011	<0.007	<0.042	0.137	<0.002	0.037
ENV/2008/066	Haddock	0.6	<0.006	<0.002	0.009	0.015	0.005	0.021	<0.002	NA	0.006	<0.003	<0.002	0.009	<0.007	NA	0.06	ND	0.004	0.009	ND	0.004	0.02	0.003	0.011
ENV/2004/045	Hake, European	0.8	0.07	0.03	0.08	0.16		0.23	0.01			0.05	0.02			0.02	0.63			0.18		0.02	0.09		0.13
ENV/2005/043	Hake, European	0.4	0.08	0.03	0.07	0.15		0.19	0.01			0.07	0.01			0.02	0.59			0.33		0.04	0.06		0.1
ENV/2007/074	Hake, European	0.5	0.066		0.078	0.202	<0.037	0.29		<0.008	<0.01	0.084	<0.037	<0.037	0.023	0.019	0.78	<0.002	0.008	0.124	<0.007	0.011	0.041	<0.002	0.073
ENV/2008/012	Hake, European	1.4	0.336	0.126	0.42	0.708	NA	1.153	<0.08	NA	0.011	0.298	0.029	0.018	0.046	NA	2.94	ND	0.342	0.64	<0.02	ND	0.24	0.022	0.198
ENV/2006/04	John Dory	0.4	0.02		0.022	0.056	0.014	0.089		0.01	<0.002	0.023	<0.007	<0.007	<0.007	0.012	0.23	<0.002	<0.007	0.036	<0.007	<0.139	0.047	<0.007	0.043
ENV/2005/035	Ling, European	0.4	0.14	0.11	0.32	0.57		0.77	0.05			0.27	0.02			0.03	2.12			0.33		0.03	0.09		0.05
ENV/2007/027	Ling, European	0.4	0.04		0.066	0.168	<0.037	0.326		<0.008	<0.01	0.085	<0.037	<0.01	0.033	0.013	0.74	<0.002	0.02	0.149	<0.007	0.022	0.022	0.01	0.062
ENV/2008/043	Ling, European	0.6	0.006	0.011	0.025	0.047	0.015	0.074	0.006	NA	0.005	<0.01	<0.003	0.009	<0.005	NA	0.17	ND	0.026	0.052	ND	ND	0.039	0.005	0.02
ENV/2004/021	Mackerel, Atlantic	4.2	0.57	0.22	0.63	1.26		1.87	0.07			0.51	0.11			0.12	5.07			0.81		0.04	0.16		0.42
ENV/2005/012	Mackerel, Atlantic	4.6	0.55	0.23	0.6	1.14		1.67	0.1			0.57	0.1			0.13	4.76			0.89		0.19	0.41		0.31
ENV/2006/018	Mackerel, Atlantic	6.4																							
ENV/2007/022	Mackerel, Atlantic	4.5	0.289		0.229	0.537	<0.037	0.829		<0.008	<0.01	0.216	0.07	<0.01	0.014	0.12	2.29	<0.002	0.104	0.427	0.057	0.137	0.451	0.058	0.315
ENV/2007/037	Mackerel, Atlantic	0.7	0.122		0.095	0.273	<0.037	0.37		<0.008	<0.01	0.101	<0.037	<0.01	0.044	0.045	1.04	<0.002	0.013	0.136	<0.007	0.016	0.07	<0.007	0.136
ENV/2008/022	Mackerel, Atlantic	9.1	1.044	0.358	1.428	2.244	NA	3.821	0.196	NA	<0.09	<0.62	<0.12	NA	<0.13	NA	9.28	ND	0.462	1.19	<0.05	0.406	0.546	ND	0.302
ENV/2006/023	Megrim	0.4	0.036		0.048	0.09	0.036	0.116		0.02	<0.002	0.045	0.011	0.008	0.016	0.048	0.39	0.022	<0.007	0.057	<0.002	<0.139	0.067	<0.002	0.019
ENV/2004/029	Monkfish	0.4	0.02	0.01	<0.02	0.05		0.25	0.01			0.08	0.02			0.01	0.45			0.11		<0.01	0.08		0.06

Table B2.2 (contd.): Organochlorine substances in finfish landed and sampled at Irish ports, 2004 – 2008.

		μg kg^{-1}																									
MI Reference	Common name	HCHA	HCHB	HCHG	HEPC	OCDAN	TCDAN	TDEPP	TNONC	DDEOP	TDEOP	ENDB	ENDS	HCEPT	BD100	BD153	BD154	BD183	BDE28	BDE47	BDE99	Sum BDE7	CB7	SumDDT	SumDDT 4	Sum 'drins	Sum 'danes
ENV/2006/07	Brill	<0.007	<0.002	0.008	<0.002	0.011	<0.002	<0.139															0.25	0.33	0.33	0.06	0.02
ENV/2004/065	Cod, Atlantic	<0.01	<0.01	<0.01				0.02	0.03														0.23	0.13	0.13	0.04	0.03
ENV/2006/015	Cod, Atlantic	<0.007	<0.002	0.008	<0.002	0.017	<0.007	<0.139															1.11	0.40	0.40	0.02	0.03
ENV/2006/019	Cod, Atlantic	<0.007	<0.002	<0.007	<0.002	0.012	<0.002	<0.139															0.86	0.42	0.42	0.04	0.02
ENV/2007/072	Cod, Atlantic	<0.007	<0.002	<0.007	<0.002	0.032	0.04	<0.147															1.60	0.28	0.28	0.09	0.08
ENV/2004/020	Dogfish, Lesser spotted	<0.01	<0.01	0.01				<0.01	0.03														1.16	0.19	0.19	0.08	0.03
ENV/2005/032	Eel, European	0.016	<0.01	0.03				0.1	0.06														3.29	0.66	0.66	0.31	0.06
ENV/2008/079	Gurnard, Grey	0.012	ND	0.025	0.012	0.012	0.005	0.451	0.025	0.029	ND	ND	NA	ND	0.105	0.041	0.071	<0.003	<0.003	0.237	0.031	0.49	2.84	1.23	1.20	0.20	0.13
ENV/2004/033	Haddock	<0.01	<0.01	<0.01				<0.01	0.01														0.21	0.04	0.04	0.02	0.01
ENV/2005/013	Haddock	<0.01	<0.01	0.01				0.01	0.02														0.36	0.06	0.06	0.05	0.02
ENV/2005/022	Haddock	<0.01	<0.01	0.02				<0.01	0.01														0.24	0.05	0.05	0.03	0.01
ENV/2006/020	Haddock	0.007	<0.007	0.013	<0.002	0.017	<0.007	<0.139															0.27	0.20	0.20	0.15	0.03
ENV/2008/066	Haddock	0.005	<0.006	0.011	0.003	0.005	ND	0.013	0.003	0.023	ND	ND	NA	<0.001	<0.002	0.003	0.004	0.015	<0.002	<0.001	ND	0.02	0.06	0.05	0.03	0.02	0.02
ENV/2004/045	Hake, European	0.01	<0.01	0.01				0.04	0.05														0.63	0.24	0.24	0.09	0.05
ENV/2005/043	Hake, European	<0.01	<0.01	<0.01				0.08	0.1														0.59	0.45	0.45	0.06	0.10
ENV/2007/074	Hake, European	<0.007	<0.002	<0.007	<0.002	0.024	0.024	<0.147															0.78	0.29	0.29	0.05	0.06
ENV/2008/012	Hake, European	0.018	ND	0.032	0.037	0.048	0.041	0.342	0.427	ND	0.007	ND	NA	ND	0.057	0.014	0.037	ND	0.057	0.188	0.036	0.39	2.94	1.01	1.00	0.26	0.89
ENV/2006/04	John Dory	<0.007	<0.002	<0.007	<0.002	0.01	<0.002	<0.139															0.23	0.32	0.32	0.06	0.02
ENV/2005/035	Ling, European	<0.01	<0.01	<0.01				0.12	0.03														2.12	0.48	0.48	0.09	0.03
ENV/2007/027	Ling, European	0.009	<0.002	<0.007	<0.002	0.028	0.014																0.74	0.18	0.18	0.03	0.06
ENV/2008/043	Ling, European	0.007	<0.003	0.014	0.005	0.009	<0.001	0.009	0.015	0.023	ND	ND	NA	ND	0.003	<0.002	<0.002	0.004	0.003	0.016	<0.002	0.03	0.17	0.09	0.06	0.05	0.06
ENV/2004/021	Mackerel, Atlantic	0.03	0.03	0.04				0.08	0.13														5.07	0.93	0.93	0.16	0.13
ENV/2005/012	Mackerel, Atlantic	0.037	<0.01	0.09				0.2	0.17														4.76	1.28	1.28	0.41	0.17
ENV/2007/022	Mackerel, Atlantic	0.075	<0.002	0.022	<0.002	0.211	0.096	0.462															2.29	1.08	1.08	0.51	0.41
ENV/2007/037	Mackerel, Atlantic	0.016	<0.002	<0.007	<0.002	0.089	0.052	<0.147															1.04	0.31	0.31	0.08	0.16
ENV/2008/022	Mackerel, Atlantic	<0.02	<0.09	0.19	0.071	<0.02	ND	0.392	0.164	NA	ND	ND	NA	<0.02	0.093	<0.04	ND	ND	<0.004	0.43	0.084	0.61	9.28	2.05	2.04	0.57	0.73
ENV/2006/023	Megrim	<0.007	0.019	<0.007	<0.007	0.027	<0.002	<0.139															0.39	0.34	0.34	0.09	0.04
ENV/2004/029	Monkfish	<0.01	<0.01	0.01				0.02	0.04														0.45	0.14	0.14	0.08	0.04

Table B2.2 (contd.): *Organochlorine substances in finfish landed and sampled at Irish ports, 2004 – 2008.*

			µg kg-1																					
MI Reference	Common name	% Lipids	CB101	CB105	CB118	CB138	CB149	CB153	CB156	CB170	CB18	CB180	CB28	CB31	CB44	CB52	Sum ICES CB7	ALD	CCDAN	DDEPP	DDTOP	DDTPP	DIELD	END	HCB
ENV/2004/038	Monkfish	0.5	0.03	0.01	0.02	0.06		0.2	<0.01			0.06	<0.01			<0.01	0.39			0.3		<0.01	0.05		0.1
ENV/2005/039	Monkfish	0.4	0.02	0.01	0.02	0.05		0.11	<0.01			0.03	0.01			<0.01	0.25			0.08		<0.01	0.04		0.04
ENV/2006/035	Monkfish	0.3	0.014		0.009	0.034	0.013	0.103		0.011	<0.002	0.027	<0.007	<0.002	0.012	0.011	0.21	<0.007	<0.007	0.053	<0.002	<0.139	0.026	<0.007	0.021
ENV/2007/023	Monkfish	0.3	<0.037		0.04	0.125	<0.037	0.249		<0.008	<0.01	0.079	<0.037	<0.01	0.011	0.009	0.58	<0.002	<0.007	0.084	<0.007	<0.007	0.034	<0.002	0.027
ENV/2008/076	Monkfish	0.5	0.014	0.019	0.044	0.11	0.023	0.248	0.013	NA	0.006	0.096	<0.007	0.004	<0.006	NA	0.52	ND	0.018	0.048	<0.004	0.023	0.027	0.002	0.019
ENV/2007/029	Mullet, Red	0.7	<0.037		0.102	0.301	<0.037	0.505		<0.008	<0.01	0.174	<0.037	<0.01	0.008	0.015	1.17	<0.007	0.008	0.123	<0.007	0.022	0.065	<0.002	0.069
ENV/2004/035	Plaice, European	0.7	<0.02	<0.01	<0.02	0.03		0.04	<0.01			0.01	<0.01			<0.01	0.14			0.04		<0.01	0.04		0.03
ENV/2004/042	Plaice, European	0.6	<0.02	<0.01	0.02	0.04		0.06	<0.01			0.02	<0.01			<0.01	0.18			0.04		<0.01	0.04		0.03
ENV/2005/020	Plaice, European	0.6	0.06	0.03	0.07	0.16		0.2	0.01			0.06	0.02			0.01	0.58			0.11		<0.01	0.07		0.04
ENV/2005/041	Plaice, European	0.6	<0.01	0.01	0.02	0.03		0.05	<0.01			0.01	0.01			0.01	0.14			0.05		<0.01	0.1		0.03
ENV/2008/046	Plaice, European	0.7	0.005	<0.005	0.017	0.033	<0.002	0.054	0.003	NA	0.003	<0.005	ND	ND	<0.006	NA	0.12	ND	0.014	0.059	<0.005	0.009	0.025	0.004	0.01
ENV/2008/026	Pollock, Black	0.7	0.043	0.043	0.113	0.177	0.022	0.254	0.017	NA	0.004	0.05	<0.003	0.111	<0.01	NA	0.64	ND	0.026	0.117	<0.003	0.022	0.047	<0.001	0.029
ENV/2005/029	Ray, Cockoo	0.5	0.06	0.02	0.06	0.11		0.14	0.01			0.04	0.01			<0.01	0.43			0.11		0.02	0.11		0.04
ENV/2007/030	Sole, Black	0.4	<0.037		0.013	<0.037	<0.037	0.042		<0.008	<0.01	0.009	<0.037	<0.037	<0.002	0.019	0.19	<0.007	<0.002	0.052	<0.007	<0.002	0.035	<0.002	0.024
ENV/2008/069	sole, Black	0.8	0.03	0.016	0.05	0.102	0.011	0.143	<0.006	NA	0.009	<0.04	0.018	0.021	0.025	NA	0.38	ND	0.023	0.039	ND	0.018	0.217	<0.002	<0.001
ENV/2004/019	Sole, Lemon	0.5	0.02	0.02	0.04	0.09		0.13	<0.01			0.04	0.01			<0.01	0.34			0.08		<0.01	0.1		0.04
ENV/2004/034	Sole, Lemon	0.6	0.04	0.03	0.08	0.17		0.27	0.01			0.06	0.02			0.02	0.66			0.24		0.03	0.18		0.07
ENV/2007/035	Sole, Lemon	0.7	<0.037		0.047	0.139	<0.037	0.212		<0.008	<0.01	0.059	<0.037	<0.01	0.009	<0.008	0.54	<0.002	<0.007	0.141	<0.007	0.008	0.089	<0.007	0.048
ENV/2004/067	Spurdog	5.2	1.32	0.47	1.48	2.78		4.03	0.16			1.12	0.19			0.36	11.28			5.03		0.46	1.18		0.91
ENV/2005/014	Spurdog	6.0	1.35	0.76	2.47	11.23		14.26	0.31			5.92	0.26			0.46	35.95			3.37		0.62	0.92		0.42
ENV/2006/05	Turbot	0.7	0.031		0.032	0.085	0.028	0.131		0.012	<0.002	0.033	<0.007	<0.007	<0.007	0.019	0.34	<0.007	0.017	0.086	<0.007	<0.139	0.065	0.011	0.043
ENV/2006/037	Turbot	0.4	0.02		0.024	0.056	0.016	0.095		0.011	<0.002	0.023	<0.007	<0.002	<0.007	0.011	0.24	<0.007	<0.007	0.057	<0.002	<0.042	0.028	<0.007	0.028
ENV/2008/016	Turbot	0.6	0.032	0.034	0.093	0.178	0.04	0.313	0.013	NA	0.007	<0.06	<0.008	<0.001	<0.007	NA	0.68	ND	0.035	0.123	<0.004	0.022	0.04	0.005	0.03
ENV/2004/036	Turbot	0.4	0.04	0.02	0.05	0.1		0.16	<0.01			0.04	<0.01			<0.01	0.41			0.08		<0.01	0.03		0.05
ENV/2004/028	Whiting, European	0.4	0.04	0.03	0.06	0.13		0.16	0.01			0.05	0.01			0.02	0.47			0.09		0.03	0.12		0.07
ENV/2005/018	Whiting, European	0.4	0.02	0.03	0.03	0.16		0.29	0.02			0.1	0.01			0.01	0.62			0.19		0.01	0.05		0.05
ENV/2005/026	Whiting, European	0.4	0.03	0.03	0.07	0.13		0.16	0.01			0.06	0.01			<0.01	0.47			0.12		0.02	0.06		0.06
ENV/2006/038	Whiting, European	0.5	0.009		0.008	0.026	<0.007	0.033		<0.007	<0.002	<0.007	0.009	0.039		0.018	0.11	<0.007	<0.007	0.025	<0.007	<0.042	0.045	<0.007	0.042
ENV/2007/033	Whiting, European	0.1	<0.037		0.016	0.042	<0.037	0.072		<0.008	<0.01	0.015	<0.037	<0.01	<0.008	<0.008	0.23	<0.002	<0.007	0.019	<0.007	0.007	<0.007		<0.007

Table B2.2 (contd.): *Organochlorine substances in finfish landed and sampled at Irish ports, 2004 – 2008.*

		μg kg^{-1}																								
MI Reference	Common name	HCHA	HCHB	HCHG	HEPC	OCDAN	TCDAN	TDEPP	TNONC	DDEOP	TDEOP	ENDB	ENDS	HCEPT	BD100	BD153	BD154	BD183	BDE28	BDE47	BDE99	Sum BDE7	SumDDT	SumDDT4	Sum 'drins	Sum 'danes
ENV/2004/038	Monkfish	0.01	0.01	<0.01				0.02	0.08														0.33	0.33	0.05	0.08
ENV/2005/039	Monkfish	<0.01	<0.01	<0.01				0.02	0.02														0.11	0.11	0.04	0.02
ENV/2006/035	Monkfish	<0.007	<0.002	<0.007	<0.002	<0.007	<0.007	<0.139															0.33	0.33	0.04	0.02
ENV/2007/023	Monkfish	0.008	<0.002	<0.007	<0.007	0.03	0.023	<0.147															0.25	0.25	0.04	0.07
ENV/2008/076	Monkfish	0.006	0.01	0.009	0.007	0.004	ND	0.013	0.009	0.02	ND	ND	NA	<0.001	0.01	0.002	0.007	0.008	0.069	0.02	0.003	0.12	0.11	0.09	0.03	0.04
ENV/2007/029	Mullet, Red	0.009	<0.002	<0.007	<0.007	0.051	0.053	<0.147															0.30	0.30	0.07	0.12
ENV/2004/035	Plaice, European	<0.01	<0.01	0.01				0.01	0.03														0.06	0.06	0.04	0.03
ENV/2004/042	Plaice, European	<0.01	<0.01	<0.01				0.01	0.02														0.06	0.06	0.04	0.02
ENV/2005/020	Plaice, European	<0.01	<0.01	0.04				0.01	0.02														0.13	0.13	0.07	0.02
ENV/2005/041	Plaice, European	<0.01	<0.01	0.02				0.01	0.02														0.07	0.07	0.10	0.02
ENV/2008/046	Plaice, European	0.007	<0.004	0.015	0.003	0.005	ND	0.007	0.009	0.02	ND	ND	NA	<0.001	0.008	0.009	0.003	ND	ND	0.012	0.003	0.04	0.10	0.08	0.03	0.03
ENV/2008/026	Pollock, Black	0.006	<0.006	0.013	0.003	0.009	ND	0.025	0.017	0.019	ND	ND	NA	ND	0.018	0.005	<0.002	0.014	ND	0.085	0.011	0.13	0.19	0.17	0.05	0.06
ENV/2005/029	Ray, Cockoo	<0.01	<0.01	<0.01				0.04	0.02														0.17	0.17	0.11	0.02
ENV/2007/030	Sole, Black	<0.007	<0.002	0.009	<0.002	0.027	0.019	<0.04															0.10	0.10	0.04	0.05
ENV/2008/069	Sole, Black	0.008	ND	0.027	0.032	0.005	ND	0.013	0.015	0.031	ND	ND	NA	ND	0.005	0.014	0.006	ND	<0.001	0.009	<0.002	0.03	0.10	0.07	0.22	0.08
ENV/2004/019	Sole, Lemon	<0.01	<0.01	0.01				0.01	0.02														0.10	0.10	0.10	0.02
ENV/2004/034	Sole, Lemon	<0.01	<0.01	0.02				0.04	0.05														0.31	0.31	0.18	0.05
ENV/2007/035	Sole, Lemon	0.015	<0.002	<0.007	<0.002	0.038	0.032	<0.147															0.30	0.30	0.10	0.08
ENV/2004/067	Spurdog	0.11	0.18	0.06				1.15	1.35														6.64	6.64	1.18	1.35
ENV/2005/014	Spurdog	0.04	<0.01	0.06				1.21	0.98														5.20	5.20	0.92	0.98
ENV/2006/05	Turbot	0.021	<0.007	<0.007	<0.007	0.009	<0.007	<0.139															0.37	0.37	0.08	0.04
ENV/2006/037	Turbot	<0.007	<0.002	<0.007	<0.002	<0.007	<0.002	<0.139															0.24	0.24	0.04	0.02
ENV/2008/016	Turbot	0.005	0.016	0.01	0.004	0.008	ND	0.015	0.027	0.025	<0.001	ND	NA	ND	0.016	0.018	0.015	ND	<0.003	0.064	<0.002	0.11	0.19	0.16	0.05	0.08
ENV/2004/036	Turbot	<0.01	<0.01	<0.01				<0.01	0.02														0.10	0.10	0.03	0.02
ENV/2004/028	Whiting, European	0.01	<0.01	0.01				0.05	0.05														0.17	0.17	0.12	0.05
ENV/2005/018	Whiting, European	<0.01	<0.01	<0.01				0.02	0.04														0.22	0.22	0.05	0.04
ENV/2005/026	Whiting, European	<0.01	<0.01	<0.01				0.04	0.02														0.18	0.18	0.06	0.02
ENV/2006/038	Whiting, European	<0.007	0.009	<0.007				<0.139															0.21	0.21	0.06	0.02
ENV/2007/033	Whiting, European	<0.007	<0.002	<0.007				<0.04															0.07	0.07	0.01	0.02

Table B2.3: Mercury concentrations (mg kg^{-1} wet weight) and moisture content (%) in the edible tissue of individual retail fish species sampled by FSAI, July 2008.

Species	MI Reference	Origin	Mercury Concentration[1]	Moisture Content	EC limit
Tuna	MSC/08/1108	Sri Lanka	**0.21**	73.7	**1.0**
	MSC/08/1109	Sri Lanka	**0.59**	79.8	**1.0**
	MSC/08/1110	Sri Lanka	**0.42**	75.8	**1.0**
	MSC/08/1111	na	**0.18**	74.4	**1.0**
	MSC/08/1112	na	**0.21**	73.6	**1.0**
	MSC/08/1113	Sri Lanka	**0.22**	76.7	**1.0**
	MSC/08/1114	Sri Lanka	**0.44**	74.7	**1.0**
	MSC/08/1115	na	**0.85**	75.1	**1.0**
Marlin	MSC/08/1116	Indonesia	**3.46**	76.9	**1.0**
	MSC/08/1117	Ecuador	**0.15**	75.0	**1.0**
Swordfish	MSC/08/1118	Sri Lanka	**1.24**	74.2	**1.0**
	MSC/08/1119	na	**1.37**	76.1	**1.0**
	MSC/08/1120	na	**1.18**	77.4	**1.0**
	MSC/08/1121	Sri Lanka	**0.55**	61.1	**1.0**
	MSC/08/1122	n.a.	**0.43**	75.4	**1.0**
	MSC/08/1123	Sri Lanka	**0.73**	67.7	**1.0**
Cod	MSC/08/1124	North Atlantic	**0.21**	83.1	**0.5**
	MSC/08/1125	North Atlantic	**0.08**	82.8	**0.5**
	MSC/08/1126	North Atlantic	**0.12**	79.4	**0.5**
	MSC/08/1127	North Atlantic	**0.07**	81.7	**0.5**
	MSC/08/1128	North Atlantic	**0.11**	78.7	**0.5**
	MSC/08/1129	North Atlantic	**0.07**	80.1	**0.5**
	MSC/08/1130	Alaska	**0.05**	81.8	**0.5**

Notes : n.a. = Information relating to origin not available
1 selected samples were analysed in duplicate during initial analysis. All samples with a value in excess of 0.8 mg kg^{-1} were reanalysed to confirm the result.

B.3 "Residues Directive" monitoring results for finfish aquaculture target sample

Table B3.1: 2004 Summary Table of Residue Monitoring Results for Target Samples (salmon and trout).

Residue	Group	Number Examined	Non-Compliant[2]	Detection limit ($\mu g\ kg^{-1}$) [1]
Group A				
Corticosteroids	A3	91	0	0.6
Methyltestosterone	A3	53	0	Various
Betaestradiol	A3	53	0	Various
Beta-agonists	A5	91	0	6.0
Chloramphenicol	A6	91	0	1.0
Nitrofurans	A6	51	0	1.0
Group B				
Antibacterial Screening:				
Tetracyclines	B1	124	0	Various
Nitrofurans	B1	124	0	Various
Quinolones	B1	124	0	Various
Sulphonamides	B1	124	0	Various
Emamectin benzoate	B2a	130	0	9.0
Ivermectin	B2a	129	0	0.4
Cypermethrin	B2c	121	0	9.0
Deltamethrin	B2c	91	0	5.0
Teflubenzuron	B2f	124	0	77
Diflubenzuron	B2f	124	0	112
CB Congener 28	B3a	25	0	0.01
CB Congener 31	B3a	25	0	0.03
CB Congener 52	B3a	25	0	0.05
CB Congener 101	B3a	25	0	0.03
CB Congener 105	B3a	25	0	0.01
CB Congener 118	B3a	25	0	0.01
CB Congener 138	B3a	25	0	0.03
CB Congener 153	B3a	25	0	0.01
CB Congener 156	B3a	25	0	0.01
CB Congener 180	B3a	25	0	0.01
HCB	B3a	25	0	0.01
α-HCH	B3a	25	0	0.01
γ-HCH	B3a	25	0	0.01
cis-Chlordane	B3a	25	0	0.01
trans-Nonachlordane	B3a	25	0	0.03
trans-Chlordane	B3a	25	0	0.01
DDD-*p,p'*	B3a	25	0	0.05
DDE-*p,p'*	B3a	25	0	0.01
DDT-*p,p'*	B3a	25	0	0.03
Lead	B3c	25	0	20
Cadmium	B3c	25	0	4
Mercury	B3c	25	0	14
Aflatoxins	B3d	7	0	0.1
Malachite Green	B3e	90	5	2.0
Leuco Malachite Green	B3e	90	5	2.0
% Lipids		25	0	-

Notes: 1 Limit of Detection (LOD) for organochlorine compounds are averages as LOD is sample dependant.
2 Action Limit (reference Table 1.3 in Section 1.5.2)

Table B3.2: 2005 Summary Table of Residue Monitoring Results for Target Samples (salmon and trout).

Residue	Group	Number examined	Non-Compliant[2]	Detection limit (µg kg^{-1})[1]
	Group A			
Corticosteroids	A3	54	0	0.6
Methyltestosterone	A3	46	0	Various
Betaestradiol	A3	45	0	Various
Beta-agonists	A5	54	0	6.0
Chloramphenicol	A6	54	0	1.0
Nitrofurans	A6	49	0	1.0
	Group B			
Antibacterial Screening:				
Tetracyclines	B1	105	0	Various
Nitrofurans	B1	105	0	Various
Quinolones	B1	105	0	Various
Sulphonamides	B1	105	0	Various
Emamectin B1a	B2a	104	2	9.0
Ivermectin	B2a	104	0	0.4
Cypermethrin	B2c	104	0	9.0
Deltamethrin	B2c	94	0	5.0
Teflubenzuron	B2f	105	0	77
Diflubenzuron	B2f	105	0	112
CB Congener 28	B3a	21	0	0.01
CB Congener 31	B3a	21	0	0.03
CB Congener 101	B3a	21	0	0.03
CB Congener 105	B3a	21	0	0.01
CB Congener 118	B3a	21	0	0.01
CB Congener 138	B3a	21	0	0.03
CB Congener 153	B3a	21	0	0.01
HCB	B3a	21	0	0.01
α--HCH	B3a	21	0	0.01
γ -HCH	B3a	21	0	0.01
trans-Nonachlordane	B3a	21	0	0.03
DDD-*p,p'*	B3a	21	0	0.05
DDE-*p,p'*	B3a	21	0	0.01
Lead	B3c	21	0	20
Cadmium	B3c	21	0	4
Mercury	B3c	21	0	10
Aflatoxins	B3d	7	0	0.1
Malachite Green	B3e	85	0	2.0
Leuco Malachite Green	B3e	85	0	2.0
% Lipids		21	0	

Notes: 1 Limit of Detection (LOD) for organochlorine compounds are averages as LOD is sample dependant.
2 Action Limit (reference Table 1.3 in Section 1.5.2)

Table B3.3: 2006 Summary Table of Residue Monitoring Results for Target Samples (salmon and trout).

Residue	Group	Number Examined	Non-compliant[2]	Detection Limit (µg kg^{-1})[1]
Group A				
Corticosteroids	A3	53	0	2.0
Methyltestosterone	A3	47	0	1.0
Betaestradiol	A3	44	0	1.0
Beta-agonists	A5	51	0	1.5
Chloramphenicol	A6	51	0	1.0
Nitrofurans	A6	51	0	1.0
Group B				
Antibacterial Screening:				
Tetracyclines	B1	104	0	Various
Nitrofurans	B1	104	0	Various
Quinolones	B1	104	0	Various
Sulphonamides	B1	104	0	Various
Emamectin B1a	B2a	104	0	9.0
Ivermectin	B2a	104	0	0.4
Cypermethrin	B2c	104	0	3.0
Deltamethrin	B2c	104	0	1.0
Teflubenzuron	B2f	104	0	77
Diflubenzuron	B2f	104	0	112
α-HCH	B3a	21	0	0.2
b-HCH	B3a	21	0	0.1
γ-HCH	B3a	21	0	0.7
δ-HCH	B3a	21	0	0.4
DDT-*o,p'*	B3a	21	0	0.04
DDT-*p,p'*	B3a	21	0	0.04
DDD-*o,p'*	B3a	21	0	0.1
DDD-*p,p'*	B3a	21	0	0.04
DDE-*o,p'*	B3a	21	0	0.02
DDE-*p,p'*	B3a	21	0	0.06
Hexachlorobenzene	B3a	21	0	4.0
Aldrin	B3a	21	0	0.1
Dieldrin	B3a	21	0	0.04
Endrin	B3a	21	0	0.1
Isodrin	B3a	21	0	0.03
cis-Chlordane	B3a	21	0	0.02
trans-Chlordane	B3a	21	0	0.02
oxy- Chlordane	B3a	21	0	0.1
trans-Nonachlordane	B3a	21	0	0.02
ICES 7 PCBs[3]	B3a	21	0	-
CB Congener 28	B3a	21	0	0.9
CB Congener 52	B3a	21	0	0.6
CB Congener 101	B3a	21	0	1.0
CB Congener 118	B3a	21	0	0.8
CB Congener 138	B3a	21	0	1.0
CB Congener 153	B3a	21	0	1.0
CB Congener 180	B3a	21	0	0.5
Lead	B3c	21	0	8
Cadmium	B3c	21	0	2
Mercury	B3c	21	0	8
Aflatoxins	B3d	7	0	0.1
Malachite Green	B3e	85	0	2.0
Leuco Malachite Green	B3e	85	0	2.0

Notes: 1 Limit of Detection (LOD) for organochlorine compounds are averages as LOD is sample dependant.
2 Action Limit (reference Table 1.3 in Section 1.5.2)
3 ICES 7: sum of the following 7 CB congeners – PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 and PCB 180

Table B3.4: 2007 Summary Table of Residue Monitoring Results for Target Samples (salmon and trout).

Residue	Subgroup	Number Examined	Non-Compliant[2]	Detection Limit (µg kg^{-1})[1]
Group A				
Corticosteroids	A3	53	0	1.5
Methyltestosterone	A3	47	0	1.0
Betaestradiol	A3	48	0	1.5
Chloramphenicol	A6	54	0	0.25
Nitrofurans	A6	46	0	1.0
Group B				
Antibacterial Screening:				
Tetracyclines	B1	103	0	Various
Nitrofurans	B1	103	0	Various
Quinolones	B1	103	0	Various
Sulphonamides	B1	103	0	Various
Emamectin B1a	B2a	103	0	5.0
Ivermectin	B2a	103	0	0.4
Cypermethrin	B2c	103	0	5.5
Deltamethrin	B2c	103	0	2.4
Teflubenzuron	B2f	103	0	84
Diflubenzuron	B2f	103	0	93
α-HCH	B3a	21	0	0.2
b-HCH	B3a	21	0	0.1
γ-HCH	B3a	21	0	0.7
δ-HCH	B3a	21	0	0.4
DDT-o,p'	B3a	21	0	0.04
DDT-p,p'	B3a	21	0	0.04
DDD-*o,p'*	B3a	21	0	0.1
DDD-*p,p'*	B3a	21	0	0.04
DDE-*o,p'*	B3a	21	0	0.02
DDE-*p,p'*	B3a	21	0	0.06
Hexachlorobenzene	B3a	21	0	4.0
Aldrin	B3a	21	0	0.1
Dieldrin	B3a	21	0	0.04
Endrin	B3a	21	0	0.1
Isodrin	B3a	21	0	0.03
cis-Chlordane	B3a	21	0	0.02
trans-Chlordane	B3a	21	0	0.02
oxy- Chlordane	B3a	21	0	0.1
trans-Nonachlordane	B3a	21	0	0.02
ICES 7 PCBs[4]	B3a	21	0	-
CB Congener 28	B3a	21	0	0.9
CB Congener 52	B3a	21	0	0.6
CB Congener 101	B3a	21	0	1.0
CB Congener 118	B3a	21	0	0.8
CB Congener 138	B3a	21	0	1.0
CB Congener 153	B3a	21	0	1.0
CB Congener 180	B3a	21	0	0.5
Lead	B3c	21	0	8
Cadmium	B3c	21	0	2
Mercury	B3c	21	0	8
Aflatoxins	B3d	7	0	0.1
Malachite Green[3]	B3e	85	0	2.0
Leuco Malachite Green[3]	B3e	85	0	2.0

Notes:
1. Limit of Detection (LOD) for organochlorine compounds are averages as LOD is sample dependant
2. Action Limit (reference Table 1.3 in Section 1.5.2)
3. MG & LMG samples analysed in-house and by subcontract laboratory (LGC) in 2007; Action level is method dependent, therefore; Action Level for MI: 1 µg kg^{-1}; Action Level for LGC: 2µg kg^{-1}
4. ICES 7: sum of the following 7 CB congeners – PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 and PCB 180

Table B3.5: 2008 Summary Table of Residue Monitoring Results for Target Samples (salmon and trout).

Residue	Subgroup	Number Examined	Non- Compliant[2]	Detection Limit (µg kg^{-1})[1]
Group A				
Corticosteroids	A3	52	0	1.5
Methyltestosterone	A3	46	0	1.5
17β-oestradiol	A3	46	0	1.5
Chloramphenicol	A6	53	0	0.25
Nitrofurans	A6	12	0	1.0
Nitroimidazole	A6	14	0	4.9
Group B				
Antibacterial Screening:				
Tetracyclines	B1	103	0	Various
Nitrofurans	B1	103	0	Various
Quinolones	B1	103	0	Various
Sulphonamides	B1	103	0	Various
Emamectin B1a	B2a	103	0	9.0
Ivermectin	B2a	103	0	0.4
Cypermethrin	B2c	103	0	4.0
Deltamethrin	B2c	103	0	4.0
Teflubenzuron	B2f	103	0	80
Diflubenzuron	B2f	103	0	86
ICES 7 PCBs[3]	B3a	21	0	-
Pentachlorobenzene	B3a	21	0	0.01
Hexachlorobenzene	B3a	21	0	0.02
Heptachlor	B3a	21	0	0.05
HCP-cis	B3a	21	0	0.03
HCP-trans	B3a	21	0	0.21
Aldrin	B3a	21	0	0.04
Toxaphene 26	B3a	21	0	0.17
Toxaphene 50	B3a	21	0	0.16
Toxaphene 62	B3a	21	0	0.27
Octachlorstyrene	B3a	21	0	0.02
Dieldrin	B3a	21	0	0.08
Eindrin	B3a	21	0	0.12
Mirex	B3a	21	0	0.02
Endosulphane sulphate	B3a	21	0	0.07
α-Endosulphane	B3a	21	0	0.32
β-Endosulphane	B3a	21	0	0.61
Chlordane-trans	B3a	21	0	0.02
Chlordane-cis	B3a	21	0	0.02
Chlordane-oxy	B3a	21	0	0.09
Nonachlordane-trans	B3a	21	0	0.02
α -HCH	B3a	21	0	0.07
β -HCH	B3a	21	0	0.06
γ-HCH	B3a	21	0	0.06
σ -HCH	B3a	21	0	0.07
DDD-*o,p'*	B3a	21	0	0.03
DDD-*p,p'*	B3a	21	0	0.03
DDT-*o,p'*	B3a	21	0	0.05
DDT-*p,p'*	B3a	21	0	0.05
DDE-*o,p'*	B3a	21	0	0.03
DDE-*p,p'*	B3a	21	0	0.04
Lead	B3c	21	0	8
Cadmium	B3c	21	0	2
Mercury	B3c	21	0	8
Aflatoxins	B3d	7	0	0.1
Malachite Green	B3e	87	0	1.0
Leuco Malachite Green	B3e	87	0	1.0

Notes: 1 Limit of Detection (LOD) for organochlorine compounds are averages as LOD is sample dependant.
2 Action Limit (reference Table 1.3 in Section 1.5.2)
3 ICES 7: sum of the following 7 CB congeners – PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 and PCB 180

Glossary and abbreviations

ADI	Acceptable daily intake
ALA	Alpha-linolenic acid
ALARA	As Low As Reasonably Achieved
Bioaccumulation	Accumulation of a substance within the tissues of an organism
Biomagnification	Process whereby concentrations of certain substances increase up the food chain
BDEs	Bromodiphenylethers
BFRs	Brominated Flame Retardants
BIM	Bord Iascaigh Mhara (Irish Sea Fisheries Board)
b.w.	Body weight
CMG	Case Management Group
CVAFS	Cold Vapour Atomic Fluorescence Spectroscopy
DAFM	Department of Agriculture, Food and Marine
DCMNR	Department of Communication, Marine and Natural Resources
DDE	By product of DDT
DDT	Dichlorodiphenyltrichloroethane
DHA	Docosahexaenoic acid
dl-PCB	Dioxin-like PCB
EC	European Commission
EEC	European Economic Community
EFSA	European Food Safety Authority
EPA	Eicosapentaenoic acid
FPT	Four plate test
FSAI	Food Safety Authority of Ireland
g	Gram
GC-ECD	Gas chromatography electron capture detection
HBCD	Hexabromocyclododecane
HCB	Hexachlorobenzene
HCH	Hexachlorohexane
Hg	Mercury
HG-AFS	Hydride Generation Atomic Fluorescence Spectroscopy
HPLC	High performance liquid chromatography
ICES	International Council for the Exploration of the Sea
ICES PCB_7	Sum of 7 PCB congeners: CBs 28, 52, 101, 118, 138, 153, 180
IUNA	Irish Universitite Nutrition Alliance
JECFA	Joint FAO/WHO Expert Committee on Food Additives
Kg	Kilogram (1000g)
LC-MS/MS	Liquid chromatography with tandem Mass Spectrometry detection
LGC	Laboratory of the Government Chemist
LOD	Limit of Detection
LOQ	Limit of Quantification

mg	Milligram (0.001g)
MI	Marine Institute
ML	Maximum Limit
MRLs	Maximum Residues Limits
MRPL	Minimum Required Performance Level
m/v	Mass per volume
n	Number of samples
NA	Not available
nd	Not detected
ng	Nanogram (0.000000001 g)
NRCP	National Residue Control Plan
NSFCS	North/South Ireland Food Consumption Survey
OCPs	Organochlorine pesticide
PAH	Polyaromatic hydrocarbons
PBDEs	Polybrominated diphenylethers
PBT	Persistant, Liable to Bioaccumulate and Toxic
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzo-*p*-dioxins
PCDFs	Polychlorinated dibenzofurans
PCDD/F	Abbreviation for PCDDs and PCDFs
PCNs	Polychlorinated naphthalenes
PFAS	Perfluoroalkyl sulphonate substances
PFCs	Polyfluorinated compounds
PFOA	Polyfluoroctanoic acid
PFOS	Polyfluoroctane sulphonates
PKD	Proliferative Kidney Disease
POP	Persistant Organic Pollutants
PTWI	Provisional Tolerably Weekly Intake
PUFA	Polyunsaturated fatty acid
RASFF	Rapid Alert System for Food and Feed
RDA	Recommended dietary allowance
SACN	Scientific Advisory Committee on Nutrition (UK)
SCF	Scientific Committee on Food
SFPA	Sea Fisheries Protection Authority
SPE	Solid Phase Extraction
TEQ	Toxic equivalents
TEF	Toxic equivalence factors
TDI	Tolerable Daily Intake
TWI/PTWI	Tolerable Weekly Intake/ Provisional TWI
µg	Microgram (0.000001g)
UK COT	United Kingdom Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment
Upper-bound	Analytical results below the LOQ are set at the LOQ value for calculation purposes
WHO	World Health Organisation
w.w.	wet weight

Species list

Common name	Latin name
Fish	
Brill	*Scophthalmus aquosus*
Cod, Atlantic	*Gadus morhua*
Dab	*Limanda limanda*
Dab, Long rough	*Hippoglossoides platessoides*
Dogfish, Lesser Spotted	*Scyliorhinus canicula*
Eel, European	*Anguilla anguilla*
Grenadier, Rock	*Coryphaenoides rupestris*
Gurnard	*Triglidae*
Gurnard, Grey	*Eutrigla gurnardus*
Gurnard, Red	*Aspitrigula cuculus*
Haddock	*Melanogrammus aeglefinus*
Hake, European	*Merluccius merluccius*
Herring, Atlantic	*Clupea harengus*
John Dory	*Zeus faber*
Ling, European	*Molva molva*
Mackerel, Atlantic	*Scomber scombrus*
Megrim	*Lepidorhombus whiffiagonis*
Monkfish	*Lophius piscatorius*
Monkfish, Black bellied	*lophius budegassa*
Mullet, Red	*Mullus surmuletus*
Perch, Ocean	*Sebastes marinus*
Plaice, European	*Pleuronectes platessa*
Pollock	*Pollachius virens*
Pollock, Black	*Pollachius pollachius*
Prawn, Common	*Palaemon serratus*
Ray, Cockoo	*Raja naevus*
Ray, Spotted	*Raja montagui*
Ray, Thornback	*Raja clavata*
Rockfish, Deepwater	*Sebastes mentella*
Salmon, Atlantic	*Salmo salar*
Scallop, Common	*Pecten maximus*
Shrimp, Common	*Crangon crangon*
Sole, Black	*Solea solea*
Sole, Common	*Solea vulgaris*
Sole, Lemon	*Microstomus kitt*
Spurdog	*Squalus acanthias*
Trout, Brown	*Salmo trutta*
Trout, Rainbow (farmed)	*Oncorhynchus mykiss*
Tuna, Albacore	*Thunnus alalunga*
Turbot	*Psetta maxima*
Turbot	*Reinhardtius hippoglossoides*
Tusk/Torsk	*Brosme brosme*
Whiting, European	*Merlangius merlangus*
Witch	*Glyptocephalus cynoglossus*
Wolffish, Atlantic	*Anarhichas lupus*
Wolffish, Spotted	*Anarhichas minor*

Common name	Latin name
Molluscs and Crustacea	
Blue Mussel	*Mytilus edulis*
Oyster, Pacific	*Crassostrea gigas*
Oyster, Native	*Ostrea edulis*
Manila Clam	*Tapes philippinarum*
Razor Clam	*Ensis siliqua*
Clam, Truncate softshell	*Mya truncata*
Cockle	*Cerasastoderma edule*
Abalone, Japanese	*Haliotis discus hannai*
Abalone, European	*Haliotis tuberculata*
Brown Crab	*Cancer pagurus*
Lobster, Common spiny	*Palinurus elephas*
Lobster, Norway	*Nephrops norvegicus*

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