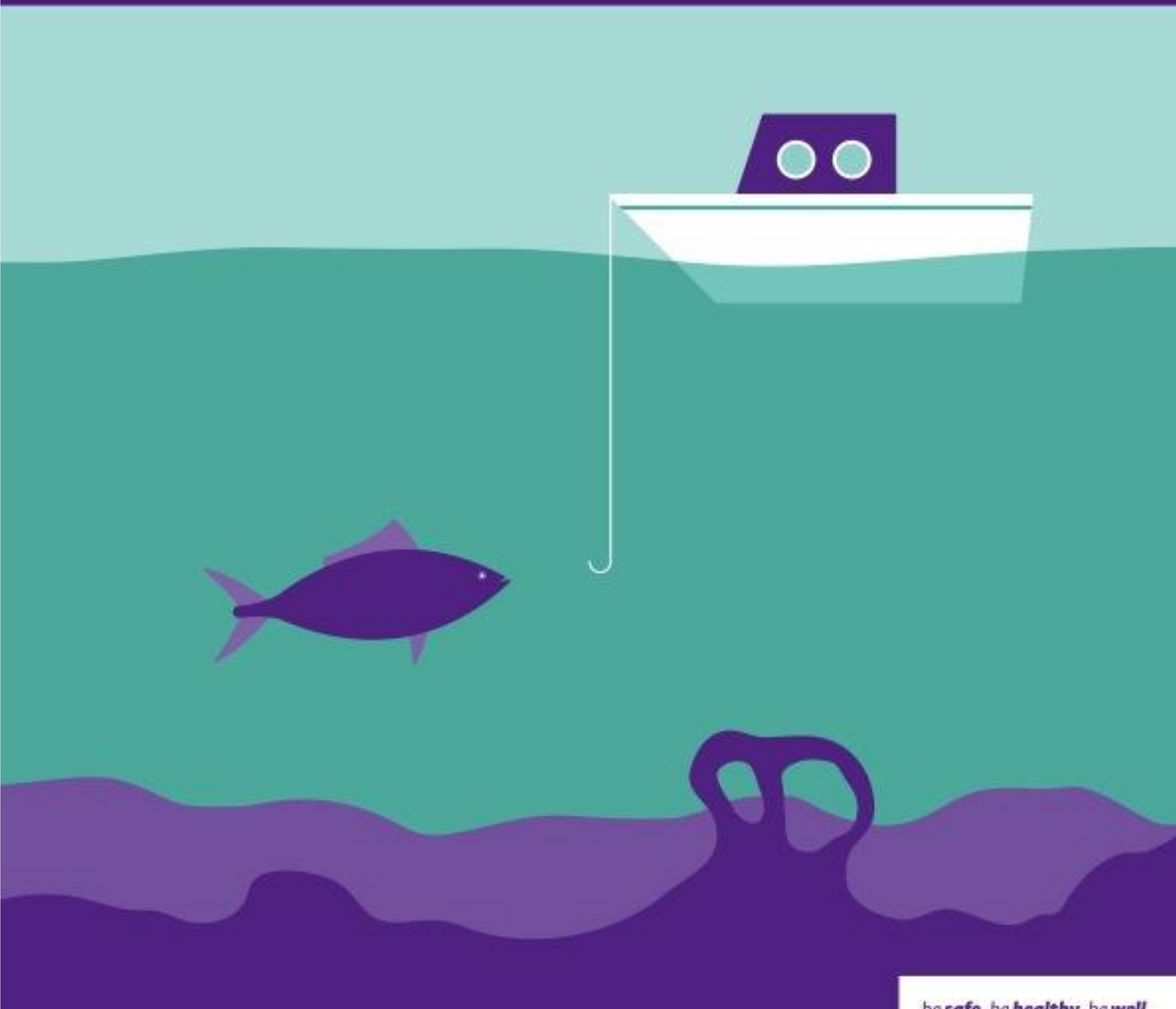
safefood

Consumer Focused Review

of the Finfish Food Chain

2012



be **safe** be **healthy** be **well**

Finfish report

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Abbreviations

ADI	Acceptable Daily Intake
BFR	Brominated Flame Retardant
BIM	Bord Iascaigh Mhara
BIP	Border Inspection Post
CDSC	Communicable Disease Surveillance Centre
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CFP	Common Fisheries Policy
CFU	Colony Forming Unit
CIEH	Chartered Institute of Environmental Health
CO	Carbon Monoxide
COC	Committee on Carcinogenicity
COM	Committee on Mutagenicity
COT	Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment
DAFF	Department of Agriculture, Fisheries and Food
DARD	Department of Agriculture and Rural Development
DART	Diet and Reinfarction Trial
DBT	Dibutyltin
DCMNR	Department of Communications, Marine and Natural Resources
DDT	Dichlorodiphenyltrichloroethane
DEFRA	Department of the Environment, Food and Rural Affairs
DHA	Docosahexanoic Acid
EFSA	European Food Safety Authority

EFSIS	European Food Safety Inspection Service
EHO	Environmental Health Officer
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agriculture Organisation
FDA	Food and Drug Administration
FSA	Food Standards Agency
FSAI	Food Safety Authority of Ireland
FSTC	Food Safety Training Council
FTE	Full Time Equivalent
FVO	Food and Veterinary Office
GB	Great Britain
GL	Guidance Level
GTA	Group Training Association
HACCP	Hazard Analysis and Critical Control Point
HBCD	Hexabromocyclododecane
HbCO	Carboxyhaemoglobin
HCH	Hexachlorocyclohexane
HSE	Health Service Executive
IAWS	Irish Agricultural Wholesale Suppliers
IBEC	Irish Business and Employers' Confederation
IMB	Irish Medicines Board
IOI	Island of Ireland
IPRI	Industrial Pollution and Radiochemical Inspectorate
IQFC	International Food Quality Certification
IUNA	Irish Universities Nutrition Alliance
JECFA	Joint FAO/WHO Expert Committee on Food Additives

LARNET	Local Authorities Radiation Network
LMG	Leucomalachite Green
LOD	Limit of Detection
LOQ	Limit of Quantitation
LWE	Live Weight Equivalent3333
MAFF	Ministry of Agriculture, Fisheries and Food
MAP	Modified Atmosphere Packaging
MG	Malachite Green
MI	Marine Institute
MID	Minimum Infectious Dose
MRL	Maximum Residue Level
MRPL	Minimum Required Performance Limit
MS	Member State(s)
MT	Metric Tonnes
MUFA	Monounsaturated Fatty Acid
NDNS	National Diet and Nutrition Survey
NI	Northern Ireland
NOAEL	No Observed Adverse Effect Level
NSIFCS	North South Ireland Food Consumption Survey
OSPAR	Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic
OTC	Organotin Compound
PBDD	Polybrominated Dibenzo-p-dioxin
PBDE	Polybrominated Diphenyl Ether
PBDF	Polybrominated Dibenzofuran
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzo-p-dioxin

PCDF	Polychlorinated Dibenzo-furan
POM	Prescription-only Medicines
POP	Persistent Organic Pollutant
PPM	Parts Per Million
PTWI	Provisional Tolerable Weekly Intake
PUFA	Polyunsaturated Fatty Acid
RASFF	Rapid Alert System for Food and Feed
RDA	Recommended Daily Allowance
RIFE	Radioactivity in Food and the Environment
RIPH	Royal Institute of Public Health
ROI	Republic of Ireland
ROP	Reduced Oxygen Packaging
RSPH	Royal Society for Promotion of Health
SACN	Scientific Advisory Committee on Nutrition
SCF	Scientific Committee for Food
Seafish	Seafish Industry Authority
SFO	Sea Fisheries Officer
TBB	Total Body Burden
TBBPA	Tetrabromobisphenol A
TBT	Tributyltin
TCDD	Tetrachlorodibenzo-p-dioxin
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalent
TDI	Tolerable Daily Intake
TMA	Trimethylamine
TMAO	Trimethylamine Oxide
TPT	Triphenyltin

VMD	Veterinary Medicines Directorate
VMP	Veterinary Medicinal Product
VRC	Veterinary Residues Committee
WHO	World Health Organization

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Executive summary

In 2005 ***safe*food** initiated a programme which involved two comprehensive food chain screening exercises per year over a three year period. Each review profiled a specific food category, identifying and describing the relevant food safety issues pertaining to it at various points along the food chain, and identifying opportunities to communicate the human health benefits to various stakeholders. The primary focus of these reviews was directly pertaining to food safety and nutrition issues. However, other concerns identified by the consumer not directly related to food safety were discussed, e.g. animal welfare, the environmental impact of the industry, etc.

As a considerable period of time has passed since these Consumer Focused Reviews were published, ***safe*food** wishes to revisit each of these in order to update their content. This will ensure consumers on the island of Ireland (IOI) are informed of any changes that have come about since 2005.

As for the previous CFR, this review of the fish food chain focuses on caught and farmed finfish, and smoked salmon. There are several significant food safety risks inherent in the shellfish food chain; however, the advice of the External Group convened to oversee this review was that the regulatory framework in place to govern these risks is comprehensive, and that many of these risks have been well documented.

Consumer research

To explore consumer perceptions, attitudes and behaviour in relation to finfish, ***safe*food** conducted both quantitative and qualitative research on the IOI as part of this review.

Results of the quantitative research

Recent quantitative research involving 2,041 respondents found that there was an increase in the frequency of consumption of fish since 2005. In 2010 fifty nine per cent of consumers reported eating fish once a week or more, whereas in 2005 this figure was forty eight per cent. Reported frequency of consumption increased for all fish types including fresh white and fresh oily fish, tinned fish and fish in batter. The proportion of people who said that they never eat fish remained unchanged at one in five (18%).

Consumers were most concerned about the freshness of fish in 2010 and 2005. Nowadays, respondents are less concerned about how fish is cooked than five years ago. Furthermore, the level of concern associated with dyes and labelling have also reduced, whereas the issue of fish stocks and sustainability are on the increase.

Qualitative research results

Qualitative research was carried out among a variety of socioeconomic groups including both consumers and non consumers of fish to gain insight into consumer attitudes to fish. The focus groups found that consumers considered fresh white and oily fish, and cooked and flash frozen fish to be safe foods. However, tinned fish and frozen fish in batter/ breadcrumbs were considered less safe. Shellfish were considered to be the least safe fish, mainly due to their potential to trigger food poisoning and/ or allergic reactions. Consumers in both 2010 and 2005 were confused with regard to how long fish could be kept frozen, defrosting fish and the use of microwaves to defrost fish. Both the preparation and cooking of fresh fish were considered problematic for consumers. They felt that they didn’t have the confidence to cook fresh fish whereas frozen fish was perceived as convenient i.e. cooking instructions were readily available on the packaging.

Health benefits were regarded as the leading motivation for eating fish. Fish was also regarded as an excellent protein source, and a good source of vitamins, minerals and other nutrients. Non-fish eaters admitted that although they don’t eat fish themselves, they would be willing to give fish to their children. Barriers to fish consumption were the smell and appearance of whole fish, the presence of bones, childhood memories of eating fish, taste, freshness and display of fish, price and processing. On a positive note, for 2005 and 2010, consumers were found to have a high overall confidence in the safety of fish and deemed it safer than fresh meat.

Finfish supply chain

The caught finfish industry has been historically, and remains, very important to the economy of the IOI. However, in recent years the industry has come under increasing pressures as worldwide stocks of traditionally caught fish, such as cod and haddock, have been drastically reduced, and restrictions have been imposed on the industry. In contrast, the aquaculture industry has seen great success with rapid growth in the numbers of farms on the island. However, it would appear that in the past couple of years this industry has plateaued. As a result, novel innovations are now being explored such as the farming of new species e.g. cod and turbot. In the ROI, the national finfish harvest volume decreased between 2006 and 2007, which also reduced in value by 4.8 per cent. The aquaculture sector in NI produced in excess of 1,097 tonnes of finfish in 2009, valued at £2.5 million (€2.97 million) compared to 523 tonnes of finfish in 2005, valued at £1.16 million (€1.36 million)(1).

There has been a substantial increase in the amount of finfish imported into the ROI between 2005 and 2009. Canned tuna is the largest single product component of the ROI seafood imports and continues to rise. However in contrast, there has been a significant decline in the total amount of finfish exported from the ROI into the EU market. A decline in the gross sales turnover of the fish processing sector for NI was observed between 2004 and 2008. In 2008, the value recorded was £69.7 (€81.3) million compared to £75 (€87) million in 2004.

Food microbiology and fish

From a microbiological perspective, a number of risks in the finfish food chain exist. However, these are not as significant as in other foods because, in many cases, the pathogenic bacteria that may be found on fish do not have an opportunity to multiply to numbers that can cause food poisoning. This is because putrefying organisms grow more rapidly and it is therefore likely that such fish products would be rejected for quality reasons, such as the development of off-odours and other taste defects, before consumption. Freshness of fish and fish products was the primary concern of consumers in both quantitative and qualitative research.

Smoked salmon can be a source of infection from *Listeria* and hence care should be taken in the handling and storage of this product, particularly for those groups considered to be at high risk. ***safe*food** recommends that pregnant women should eat smoked fish only if they are home cooked or reheated fully – in the case of smoked salmon this would be as an ingredient in a food that will be cooked before consumption (2).Further information is available at http://www.safefood.eu.

To address concerns with respect to the nutritional and safety aspects of farmed versus caught fish; in 2005 the European Food Safety Authority (EFSA) produced an assessment on the safety of wild and farmed fish. In its summary the report stated that from a food safety perspective, there are no differences between farmed and wild (caught) fish. While this report is somewhat reassuring to the consumer it must be noted that only six countries (excluding NI or ROI) were chosen for the assessment and thus the results may not be a representative sample of the EU situation as a whole.

Toxicology

Contamination of finfish with chemical contaminants has been highlighted as a concern in the media and elsewhere. The issues that have received greatest attention are dioxin in farmed salmon and mercury in certain species of tuna. The level of dioxins and dioxin-like polychlorinated biphenyls (PCBs) reported in fish sampled from waters around the IOI have been well below European Community Maximum levels to date.

The presence of histamine is a cause of concern in the fish food chain, particularly in relation to tuna. It is generally accepted that the bacteria responsible for mediating histamine production do not grow at the temperatures used during proper cold-storage, thus the presence of this biogenic amine is indicative of mishandling and poor temperature control of the product at some point. Once formed in fish, biogenic amines are capable of withstanding temperatures in excess of normal cooking processes.

Legislation

Numerous changes in legislation have occurred between 2005 and 2010. There has been a change in legislation in relation to food safety, fish feed, third country imports, residue surveillance, electronic recording and reporting, traceability and labelling. The introduction of and amendments to legislation are highlighted and discussed throughout this report. In July 2010, the Sea Fisheries Protection Agency (SFPA) released their 'Guide to Compliance for the Irish Inshore Fleet'. In essence, this guide provides a method for the SFPA to trace the boats that fish came from and also where the fish subsequently went to.

Nutrition and fish

Fish is a nutrient dense food. Both the Food Standards Agency (FSA) and the Food Safety Authority of Ireland (FSAI) recommend a minimum weekly consumption of two portions of fish, one of which is to be oily. The recent National Adult Nutrition Survey (NANS) indicates some changes in fish consumption. The authors found that 53 per cent of adults now consume fish, with a larger proportion of the population consuming white fish than oily fish. For fish consumers only, this translates into a mean daily intake of all fish of 48 grams per day. When compared to the results of the North South Food Consumption Survey (NSFCS) from 2001 these studies indicate that there has been a substantial decrease in the proportion of the population who consume fish. However, the results must be interpreted with caution. The NSFCS measured food intake over seven days while the NANS used 4-day records. Given that fish is often eaten by consumers less than once a week, these methodological differences may explain some of the apparent reduction in consumption. In contrast the amount of fish eaten by consumers of fish has increased.

The National Children's Food Survey indicates that about one third of children consume fish. The mean intake was 9 g/day. Similar intakes were found in the National Diet and Nutrition Survey where children and young people aged 4-18years were consuming approximately half the amount of fish to UK adults at 11g/day.

Fish provides a rich source of many nutrients particularly protein, n-3 polyunsaturated fatty acids (PUFA), iodine and vitamin D. There are many health benefits associated with fish. Stronger evidence exists in relation to reduced risk of cardiovascular disease, and an essential role in the early development of the central nervous system, with weaker evidence relating to issues such as immune function, cognition, depression and cancers.

The nutritional composition of fish however is affected by the preservation (the exception being freezing) and processing techniques used. The addition of ingredients to fish plays a major role in determining the energy, fat, carbohydrate and salt content of the product. This has implications for consumers in choosing fish products and in preparing and cooking fish in the home.

Food labelling

The importance of correct labelling on products applies across the food chain, from primary processors to retailers and caterers. The wording of any origin information should be clear and unambiguous, as country of origin of fish was a concern of consumers.

In 2010, new legislation regarding labelling of fish adds new commercial designations for species of fish that have come onto the market in recent years. The fish must be labelled whether it was captured at sea, or from inland waters, or farmed. In addition, if the fish was captured at sea the label must specify from which sea area. The pursuit of sustainable development of fish stocks as an objective has become increasingly important globally in recent years. Seafish have developed the Responsible Fishing Scheme, in an attempt to raise standards in the catching sector. In July 2010, new EU rules on organic food labelling, including the requirement to display a new EU logo, came into force. The 'Euro leaf' is obligatory on pre-packaged organic food products that have been produced in any of the EU member states and meet the necessary standards. Finally Eco-labelling and certification of capture fisheries and aquaculture is a rapidly developing sector.

Quality assurance schemes

In NI there are two relevant quality schemes run by the Sea Fish Industry Authority – the British Retail Consortium (BRC) Global Standard for Food Safety or Storage and Distribution and the Safe and Local Supplier Approval (SALSA). The corresponding authority in the ROI is Bord Iascaigh Mhara (BIM).

Key findings

Consumers

- There has been an increase in the frequency of consumption of fish since 2005. In 2010 fifty nine per cent of consumers reported eating fish once a week or more, whereas in 2005 this figure was forty eight per cent.

- Market research showed that the reported frequency of consumption increased for all fish types including fresh white and fresh oily fish, tinned fish and fish in batter. The proportion of people who said that they never eat fish remained unchanged at one in five (18%).

- Key consumer concerns for 2005 and 2010 were freshness of fish, pollutants, contaminants, food poisoning and correct defrosting procedures for fish.There was a reduction in concern about how fish is cooked, the use of dyes and labelling over the past few years, while the issue of fish stocks and mercury awareness was a greater concern in 2010 than it was in 2005.

- In 2005 and 2010, consumers were found to have a high overall confidence in the safety of fish and deemed it safer than fresh meat.

- In 2005, 49 per cent and 42 per cent of consumers considered fish to either a 'very healthy food' or a 'healthy food', respectively. This increased to 62 per cent and 31 per cent respectively in 2010.

- Barriers to fish consumption were the smell and appearance of whole fish, the presence of bones, childhood memories of eating fish, taste, freshness and display of fish, price and processing.

- For the general population, health professionals recommend that consumers should eat two portions of fish per week, one being an oily fish. Where possible fresh fish should be chosen over processed.

- The health benefits of fish are well documented particularly in relation to heart health. Much recent media focus has been on the cognitive benefits of fish and fish oils, although this remains to be scientifically substantiated.

- Due to potential contamination with mercury, women of childbearing age should be advised that consumption of a single portion of predatory fish such as shark, swordfish and marlin per week should be avoided during, or prior to, pregnancy. This level of consumption is not considered to pose a health risk to adults in general. For children younger than 14, occasional consumption of these species is not considered to pose a health risk. For women of childbearing age, pregnant women or nursing mothers, consumption of two tuna steaks (weighing about 140g cooked or 170g raw), or four cans of tuna, per week, will not pose a health risks to the foetus or neonate. There is no reason for adults or children, in general, to restrict their tuna intake.

- Women of child-bearing age and women who are pregnant or breastfeeding can have up to two portions of oily fish per week. Adults and children in general can have up to four portions of oily fish per week. Consumers should be advised that canned tuna does not contribute to a portion of oily fish as the essential n-3 PUFA in tuna are destroyed during the canning process.

Primary producers, transporters and processors

- On the IOI, there are controls, systems and legislation in place which aim to control both microbiological and chemical hazards in the supply chain, and thereby, minimise the risk to consumers.
- The safety of the food supply chain is regulated by legislation primarily enforced by the Food Standards Agency in NI and the Food Safety Authority in the ROI.

- There are monitoring programmes on the IOI that frequently test for dioxins, heavy metals, malachite green/leucomalachite green, organotin compounds and many other substances.

- Good hygiene practices are vital in the production of superior quality, safe seafood. The quality of fish is directly related to the time of capture and how the fish are handled, in particular during gutting, washing, boxing and icing.

- The risk to human health resulting from contamination of fish with pathogens from aquatic environments and pathogens that are naturally present on fish is low whereas, the risks from contamination of fish with pathogens from the animal/human reservoir is high and appear to be higher in coastal and inland aquatic environments than open waters.

- In July 2010, the Sea Fisheries Protection Agency (SFPA) released their 'Guide to Compliance for the Irish Inshore Fleet'. In essence, this guide provides a method for the SFPA to trace the boats that fish came from and also where the fish subsequently went to.

- The Electronic Recording and Reporting System (ERS) in Ireland is currently being introduced on a phased basis to fishing vessels.

Retailers and Caterers

- In 2010, new legislation regarding labelling of fish adds new commercial designations for species of fish that have come onto the market in recent years. The fish must be labelled whether it was captured at sea or from inland waters or farmed. In addition, if the fish was captured at sea the label must specify from which sea area.
- In July 2010, new EU rules on organic food labelling, including the requirement to display a new EU logo, came into force. The 'Euro leaf' is obligatory on pre-packaged organic food products that have been produced in any of the EU member states and meet the necessary standards.

- In NI there are two relevant quality schemes run by the Sea Fish Industry Authority – the British Retail Consortium (BRC) Global Standard for Food Safety or Storage and Distribution and the Safe and Local Supplier Approval (SALSA). The corresponding authority in the ROI is Bord Iascaigh Mhara (BIM).

- Hazard Analysis and Critical Control Points (HACCP) and training are at the core of good food safety practices and should be implemented.

- The pursuit of sustainable development of fish stocks as an objective has become increasingly important globally in recent years. Seafish have developed the Responsible Fishing Scheme (RFS), in an attempt to raise standards in the catching sector.

- Eco-labelling and certification of capture fisheries and aquaculture is a rapidly developing sector.

Policy makers and legislators

- In spite of the known health benefits of fish, consumption on IOI remains very low. Organisations, including those involved in the marketing of fish and in public health promotion, should advocate and encourage the consumption of fish and also address the issues that exist as barriers to purchase/consumption.

- A large proportion of consumers were unclear as to the correct defrosting procedure for fish and were worried that this could lead to food poisoning. Therefore information on this issue should be highlighted for consumers.

- Consumers are becoming more aware of mercury levels in fish.

Further information with regard to food safety can be obtained from previous consumer focused reviews carried out by ***safe*****food**. These reviews covered the areas of the beef, poultry, fruit and vegetable, dairy, pork supply chain and food origin. These reviews can be found at www.safefood.eu.

1 Introduction

Key findings:

The quantitative research carried out in 2010 found that here has been an increase in the frequency of consumption of fish since 2005. In 2010 fifty nine per cent of consumers reported eating fish once a week or more, whereas in 2005 this figure was forty eight per cent.

Market research showed that the reported frequency of consumption increased for all fish types including fresh white and fresh oily fish, tinned fish and fish in batter. The proportion of people who said that they never eat fish remained unchanged at one in five (18%).

Consumers were most concerned about the freshness of fish in 2005 and 2010. Pollutants and contaminants were the next concerns. There was a considerable increase in concern regarding food poisoning.

Respondents in 2010 (37 per cent) were much less concerned about how fish is cooked when compared to five years ago (54 per cent). The levels of concern associated with dyes and labelling have also reduced in this period (by 9 per cent and 10 per cent, respectively), while the issue of fish stocks is a greater concern in 2010 than it was in 2005, perhaps indicating the higher profile of environmental issues on the IOI in recent years.

In 2005, 49 per cent and 42 per cent of consumers considered fish to be either a ‘very healthy food’ or a ‘healthy food’, respectively. This increased to 62 per cent and 31 per cent respectively in 2010.

Consumers were unclear as to the correct defrosting procedure for fish and were worried that this could lead to food poisoning.

Fish was regarded as a 'treat food' or 'comfort food'. Barriers to fish consumption were smell and appearance of whole fish, the presence of bones, childhood memories of eating fish, taste, freshness and display of fish, price and processing.

In 2005 and 2010, consumers were found to have a high overall confidence in the safety of fish and deemed it safer than fresh meat.

An increase in mercury awareness was observed between 2005 and 2010.

1.1 Background to *safe*food

***safe*food**, the Food Safety Promotion Board, espouses a vision of an environment where consumers have confidence in the food they eat. In order to create this environment, ***safe*food** works in close collaboration with its partners in food safety and nutrition.

Essentially, ***safe*food** works in four key areas; education, research, nutrition and consumer communications. The role of ***safe*food** is determined by its governing legislation, which sets out its functions. These functions are summarised as follows:

- Promotion of food safety
- Research into food safety
- Communication of food alerts
- Surveillance of food borne disease
- Promotion of nutrition
- Research into nutrition
- Promotion of scientific co-operation and linkages between laboratories
- Development of cost-effective facilities for specialised laboratory testing.

***safe*food's** functions also include the provision of independent science-based assessment of the food chain and the organisation has a role in giving advice on the nutritional aspects of certain foods.

1.2 Objective and terms of reference of the reviews

In order to address in part its function in relation to carrying out independent science-based assessment of the food chain, as well as adopting the theme of complementary working and added value, in 2005 ***safe*****food** initiated a programme which over the course of a three year period reviewed a number of food chains. Each review focused on a particular food category (or process) with the objectives of:

- Providing consumers with the most relevant and pertinent information available to enable them to make informed choices with respect to the food they eat.
- Helping consumers understand (a) how the food safety system works, (b) the efforts being taken by the regulators, producers, and industry, to reduce the inherent risks, and (c) the prudent sensible steps that can be taken to address both perceived and potential risks.
- Providing opportunities to promote good practice along the food chain.

The purpose of the reviews is to profile the food category, identify and describe the relevant food safety issues pertaining to it at various points along the food chains, and to identify opportunities to communicate the human health benefits to, and influence the behaviour of the various stakeholders.

The general terms of reference of each review are:

To report on foods in light of their impact on human health and consumer concerns, and in particular to:

1. Profile the food category, identify and describe the issues relevant to human health at various points along the food chain.
2. Report on how the food safety system works across the entire food chain.
3. Identify opportunities to communicate the human health benefits and potential risks of this food category to the consumer.
4. Examine the various communication needs of all stakeholders to influence the behaviour across the food chain.

5. Identify opportunities to highlight recommended best practices and develop communication programmes based on stakeholder needs.

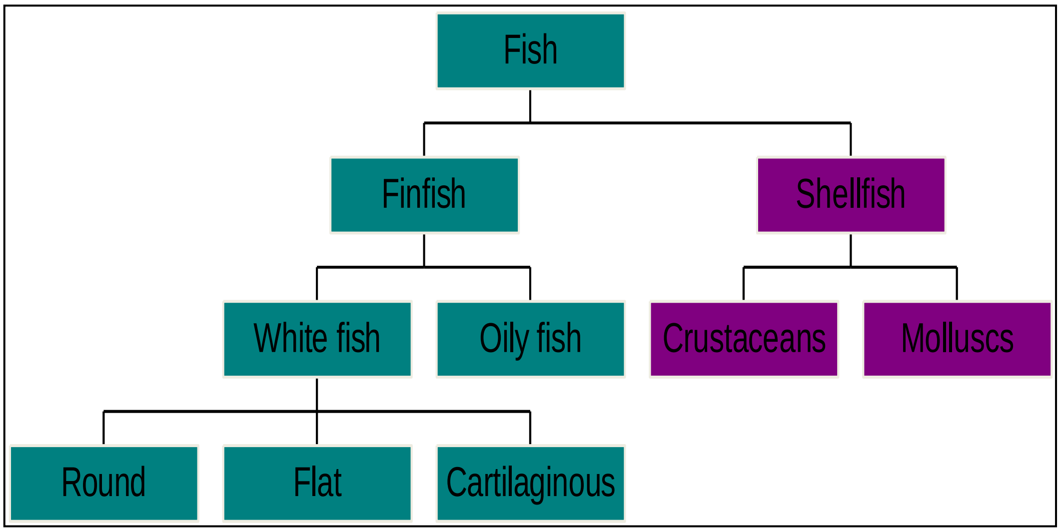
The primary objective of these reviews is directly pertaining to food safety and nutrition issues. However, a number of other issues, not directly related to food safety, will be discussed such as training, labelling, fish welfare, environmental impact of the aquaculture industry, etc.

1.3 Consumer focused review of finfish

1.3.1 Background

Fish may be classified into two main categories - finfish and shellfish (Figure 1.1).

Figure 1.1 Fish classification



This review of the fish food chain will focus only on finfish; both caught (also termed 'captured' or 'wild') and farmed. Other than smoked salmon, the review will not include any secondary processed products, except from a nutritional perspective.

Within the finfish category, there are two subdivisions; demersal (also termed 'white fish') and pelagic ('oily fish'). Demersal fish live on or near the sea bed and include cod, haddock, plaice, whiting, monkfish, sole, and hake. Pelagic fish swim in mid-waters or near the surface and include herring, mackerel, horse mackerel, whitebait, tuna, and salmon. For a comprehensive list of white and oily fish types, the reader should refer to Appendix A.

There are several significant food safety risks inherent in the shellfish food chain. The advice of the External Group convened in 2005 to oversee the original review was that the regulatory framework in place to govern these risks is comprehensive and that many of these risks have already been well documented. The Group considered that both producers and consumers are highly aware and informed of the risks involved with shellfish. The Group's advice was that the focus of this review should be on the finfish sector, which is not as well served in the above respects.

The Group suggested that the final report should, however, collate and provide a compendium of the relevant legislation, reports and other information sources with respect to shellfish production and consumption. This compendium may be found in the Annex to this report.

1.3.2 Food safety risks in finfish from a consumer perspective

1.3.2.1 Quantitative research

***safe*food** conducts annual market research during which it determines consumers' attitudes and behaviour in relation to particular foods and food preparation habits. In its June 2005 research, 816 consumers were asked whether they consumed and how often they consumed fish. Furthermore they were asked about any food safety concerns that they may have with respect to fish. Consumers were also questioned on their awareness of the benefits of fish consumption. In 2010, the questioning criteria was essentially the same as that carried out in 2005, however the sample size included 2,041 consumers. This was to allow comparisons to be made and to determine if people's attitudes and beliefs towards fish consumption have changed on the island of Ireland during that period.

Over the years, an increase was clearly observed in the number of consumers who reported consuming fish 'three to five times a week' and 'once a week' whereas a decrease was observed for the number of consumers consuming fish a 'couple of times a month' and 'once a month' (Table 1.1). There were no differences observed for consumers that 'never' consumed fish. Bord Bia (2010) carried out similar research into consumers attitudes to seafood and they found that 43 per cent of the 619 consumers they questioned consumed fish once a week. This was mainly due to the tradition of 'fish on Fridays' (3). Consumers were more aware of cod and salmon (88 per cent) than any other species.

Table 1.1 Frequency of fish consumption on the IOI

Frequency	2005 (%)	2010 (%)
Once a week	34	39
3-5 times a week	14	20
Once a month	12	11
Couple of times a month	20	11
Never	18	18

Included in Table 1.2 are unprompted concerns relating to fish production, preparation and consumption for 2005 and 2010. In 2005, the freshness of fish was the main concern for consumers on the IOI, followed by pollutants and contaminants. The same top concerns were found in 2010. However, an increase in concern regarding food poisoning was recorded. Of the respondents examined, the number of people concerned about food poisoning has increased somewhat since 2005.

Table 1.2 Top six unprompted concerns of consumers regarding fish production, preparation and consumption, IOI

Concerns	per cent concerned	
	2010 n=2,041	**2005** n=816
Freshness	28	21
Pollution/contaminants	14	12
Food poisoning	10	6
Cooked properly	8	5
Origin of the fish	5	5
Mercury	3	2

Table 1.3 outlines the issues that these consumers were most concerned about when prompted with a series of statements regarding fish. It is evident from Table 1.3 that in 2005 and 2010, the freshness of fish was a key concern (same observed for unprompted concerns, see Table 1.2). In general, there was a decrease in the level of overall concern in 2010 for 'freshness of fish', 'risk of food poisoning' and 'water quality', just to name a few. Interestingly, respondents in 2010 (37 per cent) were much less concerned about how fish is cooked when compared to five years ago (54 per cent). The levels of concern associated with dyes and labelling have also reduced in this period (by 9 per cent and 10 per cent, respectively), while the issue of fish stocks is a greater concern in 2010 than it was in 2005, perhaps indicating the higher profile of environmental issues on the IOI in recent years.

Table 1.3 Prompted Issues consumers were concerned about regarding fish, IOI

Concerns	Per cent concerned	
	2010 n= 2,041	**2005** n= 816
The freshness of the fish you eat	63	70
The quality of the water	56	60
Fish stocks	52	42
The presence of pollutants in fish production	51	54
The risk of food poisoning from fish and/or shellfish	50	62
Dye added to fish colour	44	53
The presence of mercury in fish	42	43
How fish is cooked	37	54
How fish is labelled	34	44
Pregnant women eating fish	31	30
How fish is packaged	30	37
Farmed fish	30	31
Smoking processes	23	28

With regard to fish consumption, in 2005 and 2010, consumers were given a series of questions and asked (without prompting) what one issue (if any) they were most concerned about when considering consumption of fish. The presence of pollutants was found to be the top concern in 2010 (Table 1.4) whereas in 2005, 'the freshness of fish' was the main concern. The 'risk of food poisoning as a result of eating fish' remains prominent on the list, with 13 per cent of respondents were concerned about this in 2010 (a reduction of 4 per cent since 2005). The presence of mercury is still a concern for respondents, (7 per cent in 2005 and 10 per cent in 2010). Also, among the participants examined in 2010, water quality featured among their concerns, with nine per cent of participants citing this.

Table 1.4 Top five unprompted issues consumers were most concerned about regarding fish on the IOI

Concerns	Per cent concerned	
	2010 n=2041	**2005** n=816
The presence of pollutants in fish	18	10
The freshness of the fish you eat	17	20
The risk of food poisoning from fish or shellfish	13	17
The presence of mercury	10	7
Water quality	9	N/D
Pregnant women eating fish	3	5

The frequency of consumption of types of fish consumed by the respondents was examined and the results are outlined in Table 1.5. Overall it was found that the reported frequency of consumption increased for all fish types including fresh white and fresh oily fish, tinned fish and fish in batter.

. Table 1.5 Frequency of fish consumption by type, IOI

	Year (2005: n=670, 2010: n=1640)	Everyday	3 to 5 times a week	Once a week	Couple of times a month	Once a month	Never
Fresh white fish	**2005**	1%	8%	32%	29%	19%	10%
	2010	1%	12%	40%	18%	18%	10%
Fresh oily fish	**2005**	1%	4%	14%	25%	25%	30%
	2010	1%	8%	24%	17%	20%	28%
Fish in batter	**2005**	-	3%	15%	20%	26%	36%
	2010	-	4%	25%	18%	27%	24%
Tinned fish	**2005**	1%	7%	16%	22%	21%	33%
	2010	2%	7%	22%	16%	19%	32%

In 2005, 49 per cent and 42 per cent of respondents considered fish to be either a 'very healthy food' or a 'healthy food', respectively. The corresponding values were found to be 62 per cent and 31 per cent, respectively, in 2010.This suggests an increase in positivity towards fish with almost universal support for the idea that fish is healthy. The unprompted reasons as to why consumers held these beliefs are shown in Table 1.6. As recorded in 2005, the main reason why respondents believe fish is a (very) healthy food is because it is rich in oils. Low fat content was found to be the second most popular reason why fish was regarded as a 'healthy food'; however this was lower in 2010 in comparison to 2005 (30 per cent and 42 per cent, respectively). High protein- and low cholesterol-content were also given as reasons why fish is a 'healthy food' for both 2005 and 2010.

Table 1.6 Unprompted rationales for fish being considered healthy (IOI data).

Rationale	Per cent considered	
	2010 n=1910	**2005** n=816
Rich in oils	56	59
Its low fat content	30	42
High in protein	22	27
High in Vitamin C	16	14
Low in cholesterol	15	20
Don’t know	7	7

1.3.2.2 Qualitative research

Qualitative research was commissioned by ***safe*food** in 2005 and in 2010 to examine the changes in attitudes or behaviours during that time and to elicit consumers’ perceptions of the fish supply chain in relation to:

a. Behaviour, motivations and barriers towards purchase/consumption,

b. Storage, preparation, cooking and consumption and

c. Associated contamination and microbiological risk.

In 2005, six qualitative discussion groups were conducted amongst regular fish consumers in the Republic of Ireland (ROI) and Northern Ireland (NI) from a mixture of socio-economic backgrounds. Age, gender, locations (urban/rural and coastal/inland) and type of fish purchased (i.e. fresh, frozen, tinned etc.) were inherent in the recruitment criteria. Similar discussion groups were held in 2010, with two additional groups being examined; these were (i) adults who did not eat fish and (ii) adults in the post-family life stage (see Table 1.7 below).

Table 1.7 Finfish qualitative group schedule for 2010

Group	Location	Life stage	Socio profile	Gender
1	Dublin	Mums, younger family	BC1	Female
2	Mullingar	Mums, older family	C2D	Female
3	Belfast	Mums, older family	C2D	Female
4	Omagh	Mums, younger family	BC1	Female
5	Dublin	Young adults, no children, mix of single and married or partnered	BC1C2	Mix
6	Waterford	Empty Nesters, ½ Retired	BC1	Mix
7	Dublin	Mix of working and stay at home mums, age 30-45	C2D	Female

Frequency of fish consumption

From examining the quantitative research, in 2005 it was determined that almost one in three people on the IOI did not eat fish, whereas this value decreased to one in five in 2010. An objective of the focus group discussions was to establish 'why fish consumption had increased during this time period?' Respondents were of the opinion that fish consumption had primarily increased due to health consciousness, with foreign holidays and travelling, along with category development (e.g. availability of new convenience products, new varieties of fish available) expanding consumer's repertoire. In 2005 and 2010, it was evident that, overall, consumers acknowledged fish as a healthy food. Research carried out by Bord Bia (2010) into Irish consumer attitudes to seafood reported similarly that the popularity of seafood has grown in recent years, due to the greater choice of seafood available to the consumer (3).

Perceptions of fish in relation to other foods

In relation to the public's perceptions of fish, similar findings were found for the focus groups held in 2005 and 2010. Consumers regarded fish as one of the healthiest foods available. In particular, oily fish were considered to be healthiest, as they contain omega 3 oils. Fresh fish was ranked higher than cooked fish. Meats were ranked lower than fish due to their higher saturated fat content, and were considered to be less digestible. Respondents also expressed concern in relation to cholesterol in other meats. Participants believed foods such as frozen fish in batter or breadcrumbs, sausages and pizza were the least healthy.

Figure 1.2 Consumer ranking of foods based on 'healthy' and 'least healthy'.

Healthy

Oily fish
Fresh fish
Cooked fish
Meat

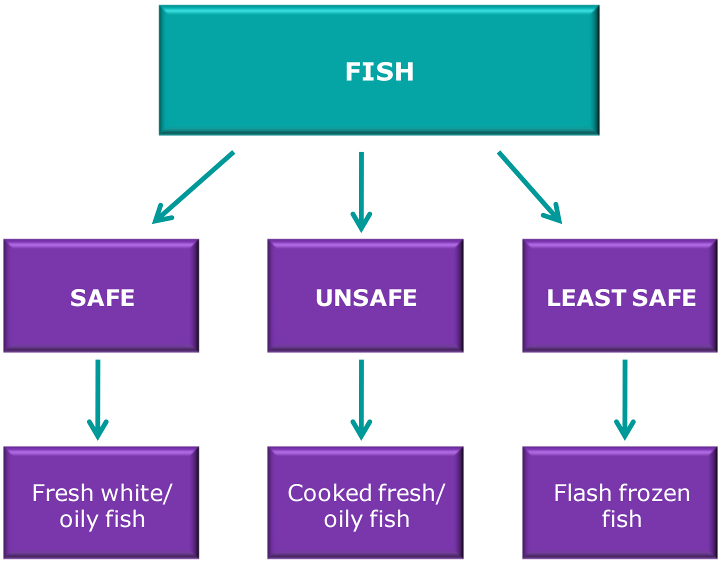
Least healthy

Frozen fish/ batter/ breadcrumb

Sausages and pizza

With regard to food safety, fresh white/ fresh oily fish, cooked fresh/ cooked oily and flash frozen fish were considered to be safe foods. However, tinned fish and frozen fish in batter/ breadcrumbs were considered less safe. Shellfish were considered to be the least safe fish, mainly due to their potential to trigger food poisoning and/ or allergic reactions.

Figure 1.3 Consumers perception of fish and food safety



Top of mind associations

Positive associations for fish were observed at the 2010 focus groups including fresh fish eaters, frozen fish eaters, and non-fish eaters. Fish was regarded as a 'treat' or 'comfort' food. Smell was thought of as either an 'appealing' or 'disgusting' attribute, whereas the presence of bones was regarded as a major drawback. Many respondents viewed frozen fish as a 'quicker' and 'healthier' alternative to meat. In the case of non-fish eaters, many described how they were forced to eat fish as children and made a conscious decision not to eat fish in their adult lives. Many non-fish eaters viewed fish as a 'status' food, eaten by rich celebrities. Furthermore, they associated fish with people on low calorie diets and older people who simply eat fish out of traditional values.

Motivations and facilitators for eating fish:

Health benefits were regarded as the leading motivation for eating fish. Participants believed increased fish consumption lead to improvement of many specific health conditions. Fish was also regarded as an excellent protein source, and a good source of vitamins, minerals and other nutrients. Non-fish eaters admitted that although they don't eat fish themselves, they would be willing to give fish to their children. Similar results were found by Bord Bia (2010) where they reported that family dynamics was a promoter of fish consumption. They reported that consumers wanted to 'do the best for their family and give them the best start in life'(3).

The benefits of fish from a nutrition perspective were well recognised in 2005 and 2010. In 2005, consumers mainly linked the benefits of fish with brain development rather than its proven beneficial links to heart health. Some consumers indicated that they had increased their consumption of oily fish during their own pregnancies as a result of these health benefits. More recently (2010) consumers stated that fish was beneficial to overall health and wellbeing, and had a plethora of nutritional benefits including high protein and omega-3 oil content. Fish was also mentioned as a suitable food for individuals on low-calorie diets. Also, consumers listed specific health aspects such as brain and cardiac function and cancer resistance.

Barriers to and limiting factors on fish consumption

In the 2010 discussion groups, a number of barriers to fish consumption were identified. These included taste, doubts over freshness of fresh fish i.e. lack of dates and open air display, aversion to the bones, smell and appearance of whole raw fish, price and processing. Furthermore, same day consumption was a limiting factor for purchasing fresh fish. Similarly barriers were found in 2005, however inconvenience (consumers considered fish to go off rapidly and must be consumed as soon as purchased); riskiness (food poisoning, freshness); poor access to the supply of fresh fish and not 'filling' were noted in 2005 only.

In 2005, frozen fish was considered to be less healthy due to the batter/breadcrumb coatings of some of these products. Again, this was the opinion held by the participants of the 2010 groups. The consumers that took part in the focus groups of 2010 also spoke of their fears about compromises to the cold chain (i.e. thawing and re-freezing) which could potentially result in foodborne illness. These participants also believed frozen fish lacked flavour following the freezing process, but those who were in favour of frozen fish spoke of how it was cheaper than fresh fish and that it was convenient and could be stored for varying lengths of time (i.e. it is non-perishable). Interestingly, although many viewed fish in breadcrumbs/ batter as being less healthy in comparison to fresh fish, participants still believed that breaded/ battered fish was a healthier option than other breaded/ battered meat products such as chicken goujons/ dippers. Also, tinned fish was considered to be healthier than frozen fish in batter/ breadcrumbs among the 2010 participants, although it was considered to have become more expensive in recent years.

Category development and experimentation

In general, it appears that fish consumption on the IOI has increased in the last five years. Health consciousness is believed to be the primary driver of this increase, along with the wider choice and types of fish available. Other reasons may be the higher incidence of fish featuring on cookery programmes and the availability of new convenience products in recent years, such as fish that is ready to cook in sealed containers etc. In addition, many respondents were of the opinion that people who already eat fish are also increasing their consumption. Participants expressed that the establishment of new fish shops and restaurants on the IOI indicated an increase in demand, mainly due to a higher awareness of health consciousness. They also believed that holidays and travel have positively impacted the increase in popularity of fish (i.e. due to more people trying various types of fish, thus expanding repertoire). The availability of fish in discount mulitples on the IOI may also have contributed to the increased levels of fish consumption.

Shopping for fish

A number of issues associated with shopping for fish were discussed during the focus groups in 2010, these are summarised as follows:

Fish suppliers:

Due to the perceived short shelf life of fish, consumers were reliant on their supplier to ensure them of its freshness. In general, there was more trust amongst consumers of independent fishmongers over other retailers. Other issues surrounding suppliers were (i) hygiene, (ii) display and (iii) quality. In relation to hygiene – participants at the focus groups described how they ensured suppliers were applying industry regulations with respect to handling, hand washing etc. Hygiene was described as 'vital' to confidence in the quality of the product during the 2010 discussion groups. Many participants were cautious when purchasing fish, and would check whether staff members were wearing gloves and aprons, there were no flies and that fish were covered with plenty of ice in the display units. Participants also aired their concerns about how fish are displayed, and told of how they were concerned about fish being stored at the correct temperature (for both fresh and frozen produce). In addition, consumers queried the safety of particular own branded fish products. This was also the case in 2010, with consumers being more confident in purchasing well known brands as a form of 'quality assurance'.

Transport to the home:

This was a strong concern for participants who took part in the 2005 discussion groups. Consumers were conscientious about transporting fish (both fresh and frozen) home quickly and correctly, and indicated the use of cooler bags. Certain supermarkets were named as providing adequate packaging for fresh fish. This was not found to be a main concern in 2010.

Storage, preparation and cooking

Storage of fish was not a major concern for participants who attended the 2010 focus groups. This was not an issue raised in 2005 either, as consumers indicated that they were careful in their storage habits of fish. In 2005, participants were very cautious when it came to the storage of fish, considering it to be a highly perishable commodity, and they tended to consume fresh fish on day of purchase. In some cases this was considered to be a barrier to consumption. In the 2010 discussion groups, participants stated they would be anxious to cook fresh fish on the day of purchase. If this was not possible many would either not purchase it, or alternatively freeze it on the day it was bought. In 2005, there was confusion over how long fish could be kept frozen. Over 50 per cent of the participants in the focus groups held in 2005 reported defrosting fish and other foods outside of the refrigerator. Also, a concern raised in the same year was uncertainty about the use of microwaves to defrost foods. Many consumers saw the preparation of fish prior to cooking as a barrier to consumption. This was also found in the 2010 discussion groups with many admitting they would be more willing to buy fish in a restaurant rather than attempt to cook it themselves. Also, some consumers felt that they did not have the confidence to cook fresh fish properly and this impacted on their fish consumption. In contrast, this was not an issue when it came to consumers of frozen fish as instructions were seen to be readily available on the packaging. Similar results were observed in 2005. In addition, an issue which was discussed during the 2010 focus groups was sustainability. The main concern of participants (particularly those with an in-depth knowledge of the fishing industry) was that scarcity of certain types of fish in Irish waters will drive up prices making fish less affordable.

Consumer confidence and concerns

In 2010, consumers were found to have a high overall confidence in the safety of fish. As in 2005, it is deemed safer than fresh meat. In comparison, in 2010, there was some increase in concern over sustainability, likely influenced by observed price increases in the market and marketing of replacement varieties. In 2005 there was low awareness of the risk of mercury poisoning whereas in 2010, there was moderate concern, but combined with a very specific sense of where the threshold for acceptable risk lies. Furthermore, there was some concern over pollution, but the majority of consumers didn't consider the risk severe and felt that it can be limited by avoiding fish from waters known to be contaminated.

In 2005, consumers deemed that the place of origin and suppliers of fish were the key risk areas along the food chain as these were outside the control and knowledge of the consumer. It was assumed that correct health regulations and practices were applied along the chain. However, consumers saw little evidence of this (e.g. quality marks) and bad experiences undermined latent trust.

When asked about specific aspects of the food chain a number of issues arose in 2005 including:

Water environment quality:

Consumers questioned the controls in place and monitoring of same. More information on the long term effect of effluent/chemical spills into the environment was sought. This was also raised as an issue of concern in 2010, with inland groups being anxious about fish caught in waters polluted by agricultural waste, while coastal groups were worried about nuclear contamination from Sellafield. However, as stated earlier these risks were considered less severe for fish than issues associated with other meats.

Origin of fish:

This was an important issue for consumers. There was an assumption that both fresh and frozen fish was of IOI origin. The lack of information on products was criticised. In 2010, this was listed as a concern, in particular, for the older participants in the discussion groups. Many stated they would prefer to buy Irish or Northern Irish fish (i.e. from Irish waters, caught by fishermen employed on the IOI).

Farmed fish:

There was little or no awareness of specific fish farming issues, such as, lice or colour. In general, fish farming was not considered an area of major concern. This was evident again in 2010, where only a minority of participants were interested in whether the fish they were consuming was wild or farmed. Many preferred wild fish as it was believed to have a stronger flavour.

In general, knowledge of food safety risks associated with fish consumption was low amongst all consumers in 2005. There was little knowledge of heavy metal contamination. Among those who were aware of mercury contamination, the risk was associated with tuna but there was little understanding with respect to how and where this occurs. There was vague knowledge that at risk groups such as pregnant women should control their intake of oily fish. Most of this information was sourced from magazines and lifestyle articles. However, in 2010 participants demonstrated a higher level of confidence in the safety of fish, with consumers believing that Irish and European food standards were trustworthy. Any concerns were mostly in relation to consumption of shellfish and to mercury poisoning, but participants were aware that this occurrence is limited to consumption of oily fish and shellfish. Pollution of the waters that fish live in was also a concern in 2010, but many believed this risk was lower than risks associated with meats.

Consumers had little awareness or concern of the microbiological risks of fish, instead concerns focussed on freshness. There was no recognition of the potential risks of bacteria such as *Listeria* in association with fish. In 2005, some consumers had heard of the risk of ‘worms’ in fish as the result of media attention at that time. This was no longer cited as a concern during the 2010 discussion groups.

Media influence

During the focus groups held in 2010, participants described how television programmes such as 'Come Dine with Me' had provided more access to recipes using fish. In addition, such programmes had helped people to develop new preparation- and cooking-skills, and inspired them to be more adventurous when planning meals. Participants were also aware of new media campaigns that had been launched in 2010, for example a campaign by Bord Bia. In addition, documentaries describing the journey of fish along the food chain, and the care taken to ensure that fish are delivered to markets as fresh and safe as possible, have captured the attention of consumers on the IOI, and appear to have had a positive influence on people's perceptions of fish.

Future indications – promoting fish consumption among non-fish eaters

Over the course of the 2010 qualitative research, a discussion group was held specifically for non–fish eaters in order to determine (i) why they don't eat fish and (ii) what would persuade them to eat fish. Many non-fish eaters were aware of the health benefits of fish, and were willing to give fish to their children but reluctant to eat it themselves. Approaches that may help increase fish consumption include:

- Cost: if fish was the same price as beef, chicken etc. more people may be willing to eat it. Given the economic situation in 2010 cost is a major factor in influencing purchases, especially when shopping for a family.
- Point-of-purchase recommendations: if supermarket and fish-counter staff could inform people of how to correctly store, prepare and cook fish more individuals may be willing to experiment.
- Presentation: if fish were presented more attractively in covered display units with heads and tails removed consumers may be more willing to purchase and eat fish.

1.4 Conclusions

Consumers reported and increased consumption of fish and display and awareness of the health benefits of fish. The barriers to fish consumption observed in 2005 remain and freshness of fish continues to be the main concern.

2 The finfish supply chain

Key Findings

- Fish is a highly perishable product and like all foods must be handled and stored correctly. Much effort has been spent on educating the primary producers (fishermen/farmers), by bodies such as BIM and Seafish, of the importance of 'care of the catch' and in particular the correct use of ice to store the fish/catch. This is particularly pertinent in the prevention of the development of histamine.
- In 2007, world per capita consumption of fish was estimated to be 16.7 kg (4), an increase of 0.6 kg since 2001.
- The Irish Sea (ICES[1] Division VIIa) is the primary region from which Northern Ireland (NI) landings occur. It accounts for 26.2 per cent of cod catches, 26.3 per cent of haddock and 99.8 per cent of herring.
- The North Atlantic [ICES Divisions VI and VII (excluding VIId and VIIe)] is the primary region from which the ROI landings occur (5). The most important whitefish landed are whiting, cod, haddock, monkfish and hake. Of the oil-rich fish, herring, horse-mackerel, mackerel and blue whiting are the most important
- In 2008, total finfish landings for NI were valued at £10 million (€11.7 million[2]), equivalent to 15,000 tonnes and were considerably less than those observed for 2004 (26,300 tonnes, with a corresponding value of £13.9 million (€16.2 million).
- Total landings in the ROI of all fish types in 2008 amounted to 222,678 tonnes in volume, a considerable decrease (15.7 per cent) from 2004 when the landings amounted to 264,200 tonnes.

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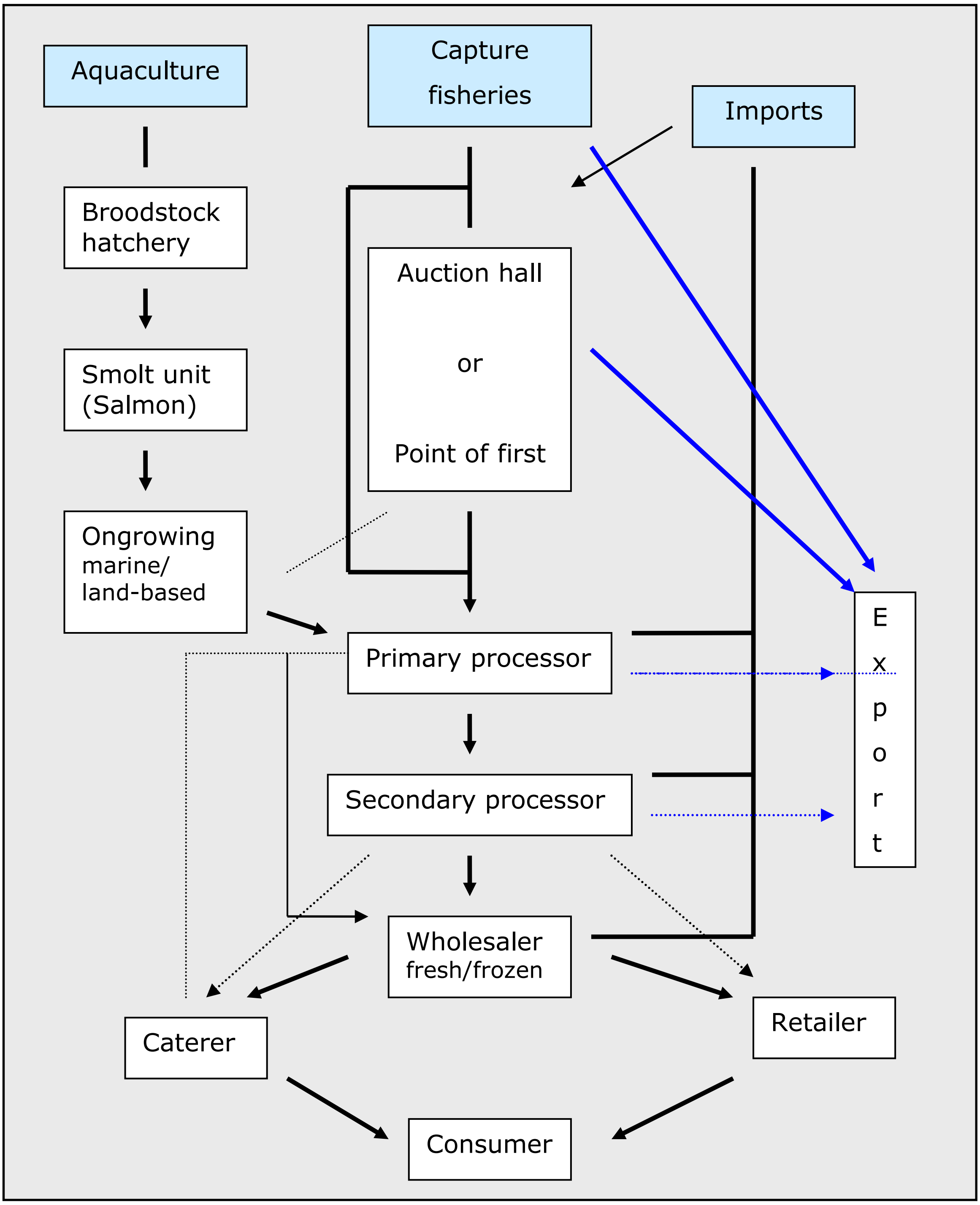
[1] ICES = International Council for the Exploration of the Sea
[2] Average currency rate for 2010: source Revenue.ie (€1 is equivalent to £0.85784).

- The main finfish species farmed at sea in the ROI are salmon (85 to 95 per cent of annual finfish production by volume) and rainbow trout whereas in NI the main finfish species are Brown and Rainbow Trout.
- The aquaculture sector in the ROI has been showing an overall decline in recent years, with the volume of fish produced reducing by just over 14,000 tonnes between 2003 and 2008.
- In terms of value, the aquaculture sector on the Island of Ireland (IOI) has fluctuated between 2003 and 2008, but was essentially worth €3.8 million (£3.3 million) less in 2008 than 2003.
- In 2009, figures from BIM show that the ROI imports of finfish alone were valued at €112.1 million (£96.2 million), equivalent to 40,871 tonnes. The corresponding figure for 2004 stood at €103.7 million (£89 million).
- Canned tuna is the largest single product component of the ROI seafood imports and continues to rise. In 2009, over five thousand tonnes of canned tuna was imported into the ROI, a three per cent increase from the previous year.
- The gross sales turnover of the fish processing sector in NI was £69.7 (€81.3) million for 2008. Of this, £15.9 (€18.5) million was sold in NI and the rest, £53.8 (€62.7) million (79 per cent) exported outside NI.
- In the ROI, the total exports (caught and farmed, finfish and shellfish) were valued at just over €179 million (£154 million) in 2009, with almost €101.6 million (£87 million) exported to markets in the EU. These values have halved since 2004, when total exports were valued at €377 million (£323 million), and exports to EU markets valued at €316 million (£271 million).

2.1 Introduction

The structure of the finfish sector on the IOI is quite complex. There are three main areas: capture fisheries; aquaculture; and imports (both capture and aquaculture) (Figure 2.1). In this chapter, each of the sectors will be described in terms of its economic significance and also the processes that occur within that particular sector and are specific to it. Current data for the retail and food service sectors on the IOI is not broken down in terms of caught/farmed fish, and finfish/shellfish. Consequently these sectors will be dealt with separately. The review will begin by looking at the current global and European situations in relation to fisheries (including finfish and shellfish).

Figure 2.1 Structure of the finfish sector on the IOI (Adapted from CEN workshop agreement 2002 (6))



2.2 The global and European perspective

Information available confirms that the global potential for marine capture fisheries has been reached, despite local differences in landings (7). Consequently, a tightly controlled approach to the management of fisheries should be adhered to in order to prevent over-exploitation of world fish stocks (7). The world catch figures for 2008 stood at 142 million tonnes, 63 per cent of which was obtained from capture fisheries, with the remaining percentage resulting from aquaculture (8). In terms of landings by species groups on an international scale, capture of demersal species (e.g. cod, whiting, haddock) has shown a substantial decline since the 1970s. However, landings of larger pelagic species (e.g. tuna, swordfish) have shown a steady increase since the 1990s, whereas landings of smaller pelagic species (e.g. mackerel, horse mackerel, herring) have been declining since the mid 1990's (5).

Trends in relation to world capture fisheries figures and aquaculture have remained broadly similar since 2003 with the same countries being the leading producers (Table 2.1). In 2008, China caught the largest volume of fish at 14.8 million tonnes. Peru had the second largest catch volume at 7.4 million tonnes. Indonesia, the US and Japan each caught between four and five million tonnes (5, 4.4 and 4.3 million tonnes, respectively) (8). In Europe, Norway caught the largest volume of fish (2.4 million tonnes), followed by Iceland (1.3 million tonnes), Spain (0.92 million tonnes), Denmark (0.69 million tonnes) and France (0.46 million tonnes) (8). A comparison of catch figures (captured fisheries and aquaculture) from 2003 and 2008 is provided in Table 2.1. Of the 80 million tonnes of fish caught in 2007, 60 per cent were caught in the Pacific Ocean, 27 per cent were caught in the Atlantic and 13 per cent in the Indian Ocean (9). The tonne value for the Atlantic Ocean is the same as those recorded in 2003 (27 per cent) whereas there was an increase of 21 per cent for the amount of fish caught in the Pacific Ocean (60 per cent in 2003 and 81 per cent in 2008) (Table 2.1). Following the devastating tsunami of 2004, fish captures from the Eastern Indian Ocean decreased (7) but began to increase again in 2006 and 2007.

Capture fisheries and aquaculture supplied the world with approximately 142 million tonnes of food fish in 2008. Aquaculture is, for the first time ever, set to contribute half of the fish consumed by the human population worldwide (7). Worldwide, the sector has grown dramatically since the 1960s, and is growing more rapidly than other animal food-producing sectors. In contrast to capture fisheries (which stopped growing at the beginning of the 1980s), the aquaculture sector has maintained an average annual growth rate of 8.7 per cent since 1970. This figure does not take into account the aquaculture growth rate for China, which was determined to be 6.5 per cent in 2008 (9).

Production in 2008 (68.3 million tonnes, including aquatic plants, with China accounting for 62.5 per cent) was 2.4 per cent higher than in 2006 (8, 10). In 2002, world production (of fish and aquatic plants) stood at 51.4 million tonnes, with China contributing 71 per cent of this amount. The trends observed for leading fish producers, both globally and on a European level have remained similar in recent years (Table 2.1).

Table 2.1: Capture fisheries and aquaculture production values (millions of tonnes) in 2003 and 2008 (Source: FAO 2010a and b (8, 11))

	2003	2008
World catch	132.5	142.3
Capture fisheries and aquaculture combined		
China	45.6	47.5
Peru	6.1	7.4
Indonesia	5.7	6.6
USA	5.5	4.8
Japan	5.5	4.9
Capture fsheries:		
World (excl. China)	73.5	74.9
China	16.7	14.8
Peru	6.1	7.4
Indonesia	4.7	5
US	4.9	4.4
Japan	4.6	4.3
Norway	2.6	2.4
Iceland	2	1.3
Denmark	1.04	0.7
Spain	0.9	0.9
France	0.63	0.5
Aquaculture:		
World (excl. China)	13.4	19.8
China	28.9	32.7
India	2.2	3.5
Vietnam	0.94	2.5
Indonesia	1	1.7
Norway	0.6	0.8
Spain	0.3	0.25
France	0.25	0.24
Italy	0.18	0.18
UK	0.18	0.18

The aquaculture sector, excluding China, contributed 19.8 million tonnes to food fish supplies in 2008; compared with 74.9 million tonnes from capture fisheries (China produced 32.7 million tonnes from aquaculture and 14.8 million tonnes from capture fisheries) (8). China produced the largest volume of fish in 2008, followed by India at 3.5 million tonnes. Vietnam, Indonesia and Thailand each produced between 1.3 and 2.1 million tonnes (8). In 2007, global aquaculture production of food fish was mainly from freshwater (57.7 per cent) (8) (Table 2.1).

In Europe, in 2008 the leading aquaculture producers were Norway (0.84 million tonnes), Spain (0.25 million tonnes), France (0.24 million tonnes), Italy (0.181 million tonnes) and the UK (0.179 million tonnes) (8) (FAO, 2010)[3] (Table 2.1).

2.2.1 Employment and the fish sector

The number of individuals earning an income from primary sector employment in fisheries and aquaculture worldwide in 2006 reached approximately 43.5 million (7) (an increase of 5.5 million since 2002), with a further four million people engaged in primary production of fish on an occasional basis (2.5 million of which were based in India) (7).

2.2.2 Fish consumption

In terms of global consumption, the average per capita consumption of fish and fishery products in the period 1999 to 2001 was estimated to be about 16.1 kg, 21 per cent higher than in 1992 (13.1 kg). In 2007, world per capita consumption was estimated to be 16.7 kg (4), an increase of 0.6 kg since 2001. Consumption figures for other regions are detailed in Table 2.2 below. Fish consumption in the ROI has increased in recent years, with the average per capita consumption rising from 16.8 kg in 2002 to 21.35 kg in 2008.

Table 2.2 Average percentage per capita fish consumption, 2002 and 2007 (kg) (4)

	World (per cent)	Iceland (per cent)	EU (per cent)	Portugal (per cent)	ROI (per cent)	UK[1] (per cent)
2002	16.1	91.5	24.2	57.4	16.8	20.0
2007	16.7	87.4	22.03	54.82	21.35	20.35

[1]UK includes NI data

[3] FAO (2003) *Yearbooks of Fishery Statistics – Summary Tables 2003*, http://www.fao.org/fi/statist/statist.asp, 14 December 2005.

2.3 Capture fisheries on the IOI

The fishing fleet on the IOI is comprised of vessels of all sizes. In 2008, the Northern Ireland (NI) fishing fleet comprised of 147 fishing vessels over ten metres in length and 204 vessels measuring ten metres and under (9). This number has increased by ten vessels since 2004.

Figures available from 2007 showed that the fishing fleet in the Republic of Ireland (ROI) comprises of approximately 1,700 boats (12). This is a considerable increase since 2004, when the number of boats in the fishing fleet stood at 1,400. The inshore fleet, which represents 80 per cent of the fleet, consists of small vessels less than 15 metres in length, and operates within 12 miles off the ROI coast (13). These small boats fish the inshore waters for mainly shellfish and some line-caught fish (e.g. mackerel and Pollack) on a seasonal basis (14). The remainder of the fleet fish for demersal and pelagic species up to 200 miles off the ROI coast. The pelagic fleet consists mainly of vessels equipped with refrigerated seawater tanks, specialising in fishing for herring, mackerel and horse mackerel. These vessels land their catch principally in Killybegs in Donegal. The rest of the fleet (excluding the small boats) is mainly engaged in trawling or seining[4] for whitefish and prawns. Further information on Fishing Fleet in the ROI and boat types can be obtained from Bord Iascaigh Mhara (15).

2.3.1 Licensing

Any boat intended to be used for commercial sea fishing requires a licence and it is an offence to engage in fishing without this authorisation. The licensing authority in the ROI is the Registrar General of Fishing Boats, Department of Agriculture, Fisheries and Food (DAFF). The licensing authority in NI is the Fisheries Division of the Department of Agriculture and Rural Development (DARD).

2.3.2 Landings

The Irish Sea (ICES[5] Division VIIa) is the primary region from which NI landings occur. It accounts for 26.2 per cent of cod catches, 26.3 per cent of haddock and 99.8 per cent of herring (16). The fishing districts in NI are predominantly Kilkeel and Portavogie, but also include the North Coast and Ardglass. In 2008, total finfish landings were valued at £10 million (€11.7 million[6]), equivalent to 15,000 tonnes (Table 2.3) (9). These landings values are considerably less than those observed for 2004 (26,300 tonnes), with a corresponding value of £13.9 million (€16.2 million). In 2008, landings to the major ports in NI (i.e. Ardglass, Kilkeel and Portavogie) amounted to 18,300 tonnes, with a corresponding value of £21 million (€24.5 million). Shellfish accounted for the bulk of these landings (49.8 per cent total volume), followed by pelagic (40.5 per cent total volume), and demersal (9.7 per cent total volume). For value, the trend is quite different, with demersal fisheries accounting for 12.6 per cent of

[4] Seining is a fishing technique where fish are caught in the net and are then harvested from the pond.
[5] ICES = International Council for the Exploration of the Sea
[6] Average currency rate for 2010: source Revenue.ie (€1 is equivalent to £0.85784).

total landings, with pelagic and shellfish species accounting for 16.8 and 70.6 per cent, respectively. While the volume of fish (both finfish and shellfish) that landed decreased by 12.3 per cent between 2004 and 2008, the value of these landings increased by almost 40 per cent during this time. This increase in value is believed to be due to less fish being caught, resulting in premium prices.

Table 2.3 NI Fish Landings from 2004 and 2008 (9).

	2004		**2008**	
Type	Quantity ('000 tonnes)	Value (£/ €[1] million)	Quantity ('000 tonnes)	Value (£/ € million)
Demersal	6.3	6.4/ 7.5	2.9	4.3/ 5
Pelagic	20.0	7.5/ 8.7	12.1	5.7/ 6.6
Shellfish	7.9	10.8/ 12.6	14.9	24/ 28
Total	34.1	24.7/ 28.8	29.9	34/ 39.6

[1]Currency values based on average value for 2010 (Source: Revenue.ie).

Fishing ports are located around the ROI coastline from Clogherhead in Co. Louth to Greencastle in Co. Donegal. The major fishing ports in the ROI are Greencastle, Burtonport, Killybegs, Rossaveal, Dingle, Castletownbere, Union Hall, Dunmore East, Kilmore Quay, Howth and Clogherhead.

The North Atlantic [ICES Divisions VI and VII (excluding VIId and VIIe)] is the primary region from which the ROI landings occur (5). The most important whitefish landed are whiting, cod, haddock, monkfish and hake. Of the oil-rich fish, herring, horse-mackerel, mackerel and blue whiting are the most important (5).

There are many small ports around the coast and on the islands around the ROI where small-boat fishermen use traditional fishing skills. These fishermen fish for lobster, crawfish, crab, oysters, scallops and salmon on a seasonal basis.

Total landings in the ROI of all fish types in 2008 amounted to 222,678 tonnes in volume, a decrease (15.7 per cent) from 2004 when the landings amounted to 264,200 tonnes. Most notably, the amount of pelagic fish landed reduced by 35,000 tonnes during this period of time. The total fish landed in 2008 (finfish and shellfish) had an associated value of €214.1 million (£183.7 million), which was a decrease of almost 10 per cent when compared to the figure for 2004. Interestingly, the amount of demersal fish landed increased by 24,000 tonnes between 2004 and 2008, but the value increased by €49 million (£42 million) [see Table 2.4 (a)] (17). A comparison of values for 2003 and 2008 is summarised in Table 2.4 (a) and demonstrates major changes in landings and values. The most economically valuable finfish species landed by Irish vessels in 2008 are shown in Table 2.4 (b).

Pelagic species accounted for the bulk of landings in 2008, 72.8 per cent of the total by volume. The corresponding figures for demersal and shellfish were 16.6 per cent and 10.2 per cent, respectively. In value terms, the trend is somewhat different, with demersal fisheries accounting for 40 per cent of the total landings, pelagic species 23 per cent and shellfish 37 per cent.

Table 2.4 (a) ROI Fish Landings (17)

	2004		2008	
Type	Quantity ('000 tonnes)	Value (€[1]/ £ million)	Quantity ('000 tonnes)	Value (£/ € million)
Demersal	32.9	56.9/66.3	37	85.9/ 73.7
Pelagic	197.6	56.9/66.3	162.3	49.3/ 42.9
Shellfish	33.7	81.7/95.2	22.7	79.2/ 68
Total	264.2	195.5/227.9	222.7	214.4/ 184.6

[1]Currency values based on average value for 2010 (Source: Revenue.ie).

Table 2.4 (b) Most economically valuable finfish species landed by irish vessels in 2008 (5)

Species	Live weight tonnes	Landed weight tonnes	Value (€)	Value (£[1])
Mackerel	44,767	44,767	39,959,734	34,279,052
Horse Mackerel	36,631	36,631	11,521,366	9,883,489
Monkfish	2,837	2,269	9,658,905	8,285,795
Haddock	3,715	3,397	6,208,644	5,326,023
Herring	27,975	27,975	6,154,596	5,279,658
Megrim	1,745	1,662	6,118,324	5,248,543
Albacore Tuna	1,522	1,522	5,321,422	4,564,928
Cod	1,524	1,292	3,582,421	3,073,144
Hake	1,392	1,244	3,509,386	3,010,491
Whiting	2,564	2,451	3,453,799	2,962,806

[1]Currency values based on average value for 2010 (Source: Revenue.ie).

The biology of finfish species landed on the IOI can be obtained from the Marine Institute (MI) (18).

2.3.3 Employment

The number of fishermen in NI has reduced by 33 per cent since 1999. In 2008, the total number of fishermen (of both finfish and shellfish) in NI was 625. This value has shown hardly any variation since 2004 (619 fishermen). Part-time fishermen account for approximately 20 per cent of the total, a proportion that has changed little over the last ten years (9). The total number employed in the fish catching sector in NI stood at 654 in 2009. This was made up of 541 full time and 113 part time employees (19). The total number of fishermen in the ROI at present is 4,987 (14).

2.3.4 Harvesting methods

Fishing methods are diverse and are generally classed as 'active' (fishing gear is actively moved through water or across the seabed) or 'passive' (this is less mobile, gear is fixed in one place or allowed to drift with the current).

Some of the main techniques for passive fishing are: gill nets; potting; long lining; drift net fishing; and tangle nets. Those used for active fishing include: trawling; pair trawling; beam trawling; dredging; seining; and jigging. Further, detailed information on fishing methods can be accessed from BIM (15) or the Sea Fish Industry Authority (Seafish) for information pertaining to the ROI and NI, respectively.

Once caught, fish are stored on board the fishing trawlers either on ice or in chilled water tanks.

2.4 Aquaculture on the IOI

Aquaculture is defined by the Food and Agriculture Organisation (FAO)(20) as 'the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc.' Farming also implies individual or corporate ownership of the stock being cultivated.

The modern Irish aquaculture industry began in the 1970's and has experienced significant challenges in the last few years. This industry provides employment and generates income in rural Ireland. The national finfish harvest volume decreased from the 12,726 tonnes in 2006 to 11,238 tonnes in 2007. The total value of the harvest reduced by 4.8 per cent, giving a total finfish production value of €58.4 million (50.1 million) in 2007 (21). The aquaculture sector in NI produced in excess of 999 tonnes of finfish in 2007, valued at £1.85 million (€2.16 million) (1). See Appendix B for further information.

2.4.1 Licensing

Anyone operating a fish farm in NI is required to hold a fish culture licence granted by DARD under Section 11 of the Fisheries Act (NI) 1966. It is an offence to operate a fish farm without a fish culture licence or in contravention of the conditions of a fish culture licence, which are enforced by the DARD Fisheries Inspectorate. Aquaculture licences in the ROI are granted by the Coastal Zone Management Division, DAFF under the Fisheries (Amendment) Act, 1997 and Foreshore Act, 1933. A person aggrieved by a decision of the Minister on an aquaculture licence application, or by the revocation or amendment of an aquaculture licence, may make an appeal to the independent Aquaculture Licence Appeals Board (22).

In 2007, there were 573 active licenses in the ROI. These were distributed among 13 coastal and eight inland counties. Approximately 59 per cent of licences were held in three counties, namely Donegal (122), Galway (113) and Cork (105). Of these licenses, 75 were for finfish (21). In 2004, there were 589 aquaculture licenses, distributed amongst 11 coastal and eight inland counties. There has been a decline in production in the aquaculture finfish sector (particularly salmon) over the past number of years, due to market conditions (low prices), disease problems (Pancreas Disease in particular), and in particular, licensing issues. Very few new aquaculture licenses have been issued over the last five years. The overall aquaculture industry in NI is much smaller with 81 aquaculture licences, of which 33 are for finfish farms (16).

2.4.2 Production

There are five main areas of marine aquaculture in NI; Carlingford Lough, Strangford Lough, Belfast Lough, Larne Lough and Lough Foyle. These are all primarily concerned with shellfish cultivation. There is an organic salmon farm at Glenarm, with sea cages at Waterfoot, Co. Antrim. NI also has an inland aquaculture industry, concentrating mainly on Brown and Rainbow Trout. Salmon and trout production by commercial fish farms was valued at just over £1.6 million (€1.9 million) in 2003, a volume of 743 tonnes (23). Finfish production in NI for 2009 was 1,120.4 tonnes and was valued at £3.2 million (€3.7) million (16).

The main finfish species farmed at sea in the ROI are salmon (85 to 95 per cent of annual finfish production by volume) and rainbow trout (24). Marine finfish farming is conducted in five western seaboard counties – Donegal, Mayo, Galway, Kerry and Cork. Land-based finfish aquaculture exists in a number of counties. There is a marine pump-ashore turbot farm in Mayo with a 600 tonne capacity. Research is ongoing into the feasibility of culturing new species such as cod. There is a significant research project on cod currently being undertaken in the West of Ireland where cod is being farmed at sea off the coast of Galway. Other land based aquaculture projects include the farming of the freshwater species, perch. There are two perch hatcheries in counties Cavan and Sligo, along with two perch grow-out units in counties Tipperary and Monaghan. The licensed grow-out capacity for these two farms is 140 tonnes of perch. In addition, a newly licensed farm with a 50 tonne license has recently been approved (14).

The aquaculture sector in the ROI has been showing an overall decline in recent years, with the volume of fish produced reducing by just over 14,000 tonnes between 2003 and 2008. Since 2003, the national finfish harvest has been steadily declining by 11-17 per cent per annum (Table 2.5). In 2007, the national finfish harvest stood at 11,238 thousand tonnes, which is a reduction of 6,600 since 2003. In terms of value, the aquaculture sector has fluctuated between 2003 and 2008, but was essentially worth €3.8 million (£3.3 million) less in 2008 than in 2003.

With the exception of 2006, the value of the finfish harvest in the ROI has been showing a year-on year decline since 2003. In particular, in the case of Irish farmed salmon, the total market value reduced from €52.7 million (£45.5 million) in 2006 to €51.2 million (£43.9 million) in 2007. In 2009, Irish farmed salmon was worth €46.9 million (£40.2 million). The average price per tonne of Atlantic salmon is continuing to increase. This increase is evident across all salmon products. The average value of fresh chilled salmon was €7.7 million per tonne (£6.6 million) in 2009, a 46 per cent increase on the 2008 value of €5.3 million (£4.6 million) per tonne. The average value of prepared salmon products was €5.2 million (£4.5 million) per tonne in 2009; this was a 55 per cent increase from the value of €3.4 million (£2.9 million) in 2008. Smoked salmon products retained their high value of €20.7 million (£17.5 million) per tonne in 2009. This increase in value of salmon products may be attributed to quality initiatives and the development of organic farmed salmon which is attracting premium prices. However, there was a general decrease evident across all other species produced, in accordance with the global trend in the reduced value of seafood. There was also a slight drop in total value of ROI seafood exports to €327.6 million (£281 million) in 2009 (a decrease of 3.4 per cent on 2008 exports), despite the 50 per cent increase in the average price per tonne achieved for salmon (14).

Table 2.5 ROI finfish aquaculture production in recent years (21).

	Volume ('000 tonnes)				Value (€/ £ million)			
	2003	**2004**	**2006**	**2007**	**2003**	**2004**	**2006**	**2007**
	-	-	-	-	2,000/ 1,716	2,337/ 2,005	3,378/ 2,898	2,869/ 2,461
Ova/ smolt								
Salmon	16,347	14,067	11,174	9,923	54,198/ 46,493	51,289/ 43,998	52,711/ 45,218	51,294/ 44,002
Sea-reared trout	370	282	546	507	1,200/ 1,029	860/ 738	2,444/ 2,097	1,932/ 1,657
Freshwater trout	1,081	889	970	760	2,318/ 1,988	2,116/ 1,815	2,658/ 2,280	2,027/ 1,739
Other finfish	40	25	36	48	350/ 300	300/ 257	221/ 190	317/ 272
Total finfish	17,838	15,263	12,726	11,238	60,066/ 51,527	56,902/ 48,813	61,412/ 52,682	58,439/ 50,131
Total aquaculture	62,516	58,354	57,422	48,350	101,848/ 87,369	98,127/ 84,177	124,660/ 106,938	105,730/ 90,699

2.4.3 Employment

In 2007, 287 people were employed in the finfish aquaculture industry in the ROI, which equates to 203 full time equivalent (FTE) positions. This was a reduction of 12 per cent from 2006 (21), and quite a notable decrease from the number employed in 2004 (534 people). In 2007, it was reported that the aquaculture sector in NI directly employed 113 full time and 48 part time employees (1). This would appear to be a significant increase in personnel when compared to previous years, as in 2004. For example, there was only 36 full time and 12 part-time staff employed in finfish aquaculture in NI. However, DARD NI are reliant on figures supplied by industry and accurate or complete returns may not have been submitted (16).

In 2004, 364 people were employed in the salmon sector as FTEs. However, in 2006 the number of FTEs decreased to 133, but went on to increase to 196 in 2007. In the case of freshwater trout, there were 19 people employed as FTEs in 2007. Also, the number employed in the sea-reared trout sector showed a significant reduction (50 per cent) from that recorded in 2006 (21).

Table 2.6 Employment in the finfish aquaculture industry on the IOI in 2004 and 2007 (21).

	Full-time		Part-time		Casual		Total		FTE	
	2004	2007	2004	2007	2004	2007	2004	2007	2004	2007
NI	36	113	12	48	-	-	48	161	-	-
ROI	275	164	160	55	51	68	486	287	364	203
Total	311	277	172	103			534	448		

Part-time: 10-30 hours/week throughout the year or 13-39 weeks of working 40 hours per week.

Casual: <10 hours/week throughout the year or <13 weeks of working 40 hours per week.

FTE: 1 Part-time = 0.5 FTE, 1 Casual = 0.1667 FTE.

2.4.4 Production methods

Juvenile finfish, such as salmon, are produced in land-based hatcheries and then transferred to sea cages for growing to market size. Inland systems, such as ponds and raceways may also be used, in particular for freshwater farming of species such as trout, perch, turbot and halibut. Land-based tanks can also be used in hatcheries for either freshwater or seawater species, most commonly salmon or eel. Pen cultivation is used in open waters to grow species like salmon and trout.

Further information on finfish aquaculture production methods can be obtained from BIM (15) or Seafish (25). A virtual tour (*aquatour*) of some finfish farms can be taken on the homepage of the Federation of European Aquaculture Producers (26). A description of the lifecycle of a farmed salmon can be obtained from BIM (27).

2.5 Imports

In EU terms, import means a product sourced from countries outside of the EU i.e. not intra community trade. For the purpose of this review, however, import describes a product sourced outside of the IOI i.e. can be from a member state (MS) or a Third Country. Figures available for imports onto the IOI do not distinguish between finfish/shellfish and caught/farmed fish, thus this section will describe general 'fish' imports.

The IOI is becoming increasingly reliant on imports. Large processing firms tend to import the majority of their supplies. Imports are driven by shellfish and more recently white fish. Sources of imported white fish include the Faroe Islands, Norway and Iceland. Figures for NI imports are not available separately to overall UK figures. In 2009, figures from BIM show that the ROI imports of finfish alone were valued at €112.1 million (£96.2 million), equivalent to 40,871 tonnes. The corresponding figure for 2004 stood at €103.7 million (£89 million). The leading suppliers to the ROI market in 2009 were Germany (€12.9/ £11.1 million), the Netherlands (€5.9/ £5.1 million), Iceland (€5.3/ £4.5 million) and Denmark (€4.6/ £4 million). In 2004, the leading suppliers of finfish were the UK, Germany, Denmark, the Netherlands and Iceland (€82/ £70, €4/ £3.4, €4/ £3.4, €2/ £1.7 and €1.5/ £1.3 million, respectively). Canned tuna is the largest single product component of the ROI seafood imports and continues to rise. In 2009, over five thousand tonnes of canned tuna was imported into the ROI, a three per cent increase from the previous year (14).

2.6 Exports

2.6.1 Northern Ireland

The gross sales turnover of the fish processing sector in NI was £69.7 (€81.3) million for 2008. Of this, £15.9 (€18.5) million was sold in NI and the rest, £53.8 (€62.7) million (79 per cent) exported outside NI. Sales outside NI were as follows: £23.1 (€27) million to Great Britain, £9.7 (€11.3) million to the ROI, £19.2 (€22.4) million to the rest of Europe and £1.9 (€2.2) million outside Europe. In 2008, 28 fish processing businesses were recorded in NI, employing 633 FTEs (28).

2.6.2 Republic of Ireland

In the ROI, the total exports (caught and farmed, finfish and shellfish) were valued at just over €179 million (£154 million) in 2009, with almost €101.6 million (£87 million) exported to markets in the EU. These values have halved since 2004, when total exports were valued at €377 million (£323 million), and exports to EU markets valued at €316 million (£271 million). France is the ROIs main export market accounting for 14 per cent of total exports. Other key markets include the UK (8 per cent of total exports), Spain and Germany (both 6 per cent of total exports), and Italy (1.6 per cent of total exports). The finfish aquaculture export market in the ROI (salmon only) is currently worth just over €32 million (£27.5 million), or in terms of volume, just over 4,200 tonnes. These values have also reduced considerably since 2004, when salmon exports were valued at €50 million (£43 million), corresponding to 14,000 tonnes. The bulk of the tonnage is sold in the fresh gutted format. In 2009, approximately 12,000 tonnes of salmon were cultivated in the ROI, and of this, 74 per cent was organic. However, this value is expected to fall by the end of 2010, with 67 per cent of the total salmon produced being organic (14). On a European level, the ROI is the leading producer of organic salmon (29).

Approximately 60 per cent of farmed salmon production in 2009 was sold to France, A further 15.3 and 12.5 per cent of farmed salmon was sold to the UK and Germany, respectively. The balance went mainly to other EU countries. Of the farmed salmon exported to Europe, approximately 50 per cent ends up being sold for smoking, whereas in the ROI, just over 30 per cent of the sales volume is smoked. Nearly all of the fresh trout produced in 2007 (valued at €3.9/ £3.3 million) was sold on the home market (14).

2.7 Processing

Primary processing of finfish includes cutting, filleting, pickling, peeling, washing, chilling, packaging, heading and gutting.

Secondary processing includes brining, smoking, cooking, freezing, canning, deboning, breading, battering, vacuum and controlled packaging, and the production of ready meals.

As outlined in Chapter one, the scope of this review includes smoked salmon as the only secondary process to be considered.

2.7.1 Smoking

Smoking has been used as a means of food preservation for centuries. It reduces the water activity and also forms a more membranous surface which acts as a physical barrier to the entry of microorganisms. In addition, the smoke contains a variety of compounds such as formaldehydes and phenols that are known to have bacteriostatic and bactericidal properties (30).

Smoked salmon production involves a number of steps, namely, filleting, salting, drying, smoking, trimming and packaging. Salting is the first step in the preservation process. Salt may be applied as dry salt, wet salt/brine (by soaking or by injection of the brine into the skin) or a combination of both. Dry salting is still used for smoked salmon and sometimes larger fish. Salmon is dry salted for longer periods; thus it is a cured product which does not need to be cooked. After salting, the fish is air-dried and then smoked. Salmon can be smoked by one of two methods:

(i) Cold Smoking – temperature of the fish does not exceed 30°C, thus the fish needs to be cooked before it is eaten (except salmon and sea trout, if dry salted). This method is more prevalent on the IOI. In addition to cold smoking, there is another process known as 'liquid smoking'. Liquid smoking is regarded as a more controllable, consistent process when compared to gas smoking (31). However, fish that have undergone liquid smoking are not ready to eat (RTE), and require further cooking before consumption (32).

(ii) Hot Smoking – temperature is gradually increased during the smoking process up to approximately 80°C and held for a short cooking period.

After processing the salmon products are generally vacuum packaged and stored at chilled temperatures.

Further information on processing forms and methods can be obtained from BIM (33).

2.8 Retail sector

As mentioned earlier in this chapter, it is not possible to delineate between retail figures for caught/farmed fish or finfish and shellfish based on the current data available for the IOI. The generic term 'seafood' is used in this data to describe these sectors.

2.8.1 Northern Ireland

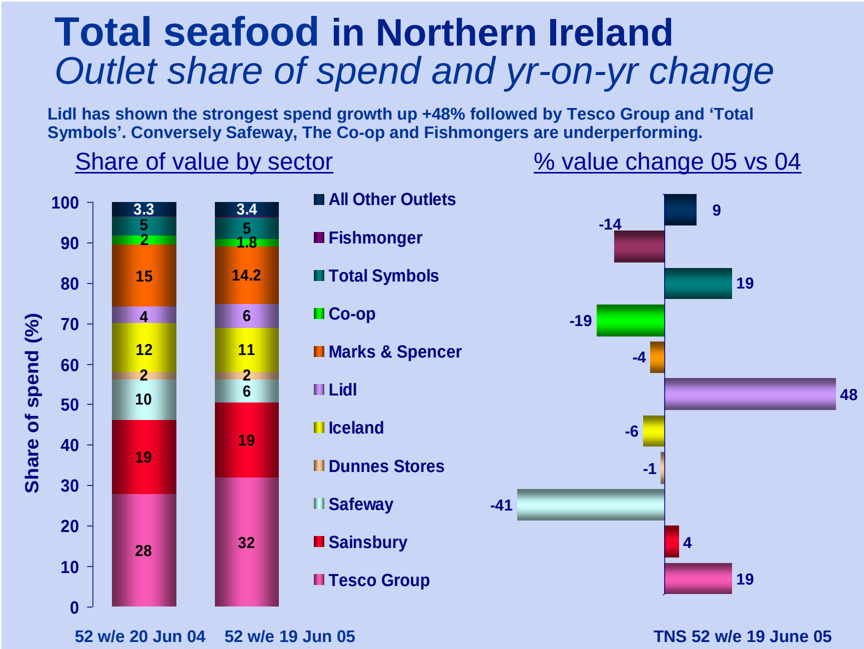
In NI, the retail market for seafood is worth over £46 million (€54 million) (Table 2.7). Expenditure on seafood in NI rose three per cent, with volume up seven per cent, year ending June 2005. This was primarily due to the increase in the chilled seafood market which saw growth of 17 per cent in volume. Due to changes in government departments, data from 2005 to present is unavailable.

Table 2.7 NI retail seafood sector

	June 2003 - 04	June 2004 - 05	Per cent change
Total seafood			
Expenditure (£000s)	44,630	46,122	3
Expenditure (€000s)	52,026	49,102	
Volume (tonnes)	6,761	7,244	7
Chilled seafood			
Expenditure	25,147	26,367	5
Expenditure (€000s)	29,314	30,737	
Volume	3,097	3,616	17
Frozen seafood			
Expenditure	19,483	19,755	1
Expenditure (€000s)	23,061	23,029	
Volume	3,664	3,628	-1

In terms of trade outlets, supermarkets dominate the seafood retail market, with over 91 per cent share of spend. Fishmongers continue to lose market share (Figure 2.2).

Figure 2.2 **Outlet share of spend on total seafood in NI**



Source: Calvo, M. (2005) 'The Retail market for Seafood in Northern Ireland'. London: Seafish.

Natural seafood (i.e. unprocessed or primary processed) is responsible for the greatest share of total seafood in NI, over half the total volume of chilled seafood purchased and just under half of total expenditure (Figure 2.3).

Figure 2.3 NI seafood sectors in retail (per cent value)

Source: Calvo, M. (2005) 'The Retail market for Seafood in Northern Ireland'. London: Seafish.

The most popular species at retail level include, cod (29 per cent), salmon (26 per cent), and haddock (11 per cent).

2.8.2 Republic of Ireland

Figures available from BIM for March 2010, have shown the value of fish is down by approximately seven per cent (close to €13.7 million/ £11.8 million), due to price decreases. This is mainly due to consumers purchasing smaller volumes. However, sales of fresh fish have managed to increase their share of the total fish market in the past year, after losing some of its share in 2009. Consumers have been purchasing across more sectors as penetration has increased for both fresh and frozen fish. In addition, the purchase frequency has increased (14). The retail value of seafood was worth €136 million (£117 million) (14,400 tonnes) in 2004. The fish market is showing nine per cent value growth year on year driven by an increase in the demand for fresh fish. As the fresh market grows, the frozen is in decline, with more competition from other sectors, such as pizza and poultry (34). At the end of December 2009, the retail fish market in the ROI was still dominated by breaded fish (31.6 per cent volume) however, followed by filleted fish (27.1 per cent volume) (Figure 2.4).

In 2009, the most popular fresh fish species at retail level included salmon (39.8 per cent volume), cod (8.3 per cent volume), haddock (6.8 per cent volume), whiting (4 per cent volume) and mackerel (4.8 per cent volume) (14) .

Figure 2.4 Total fish: market split annually, ROI

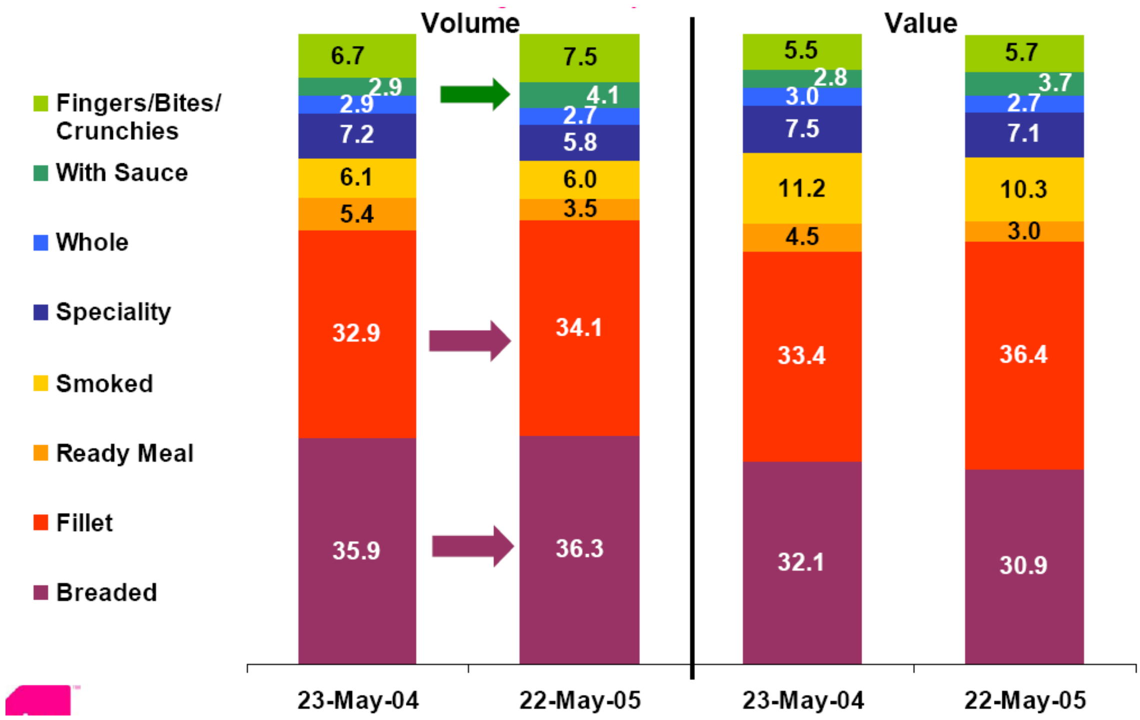
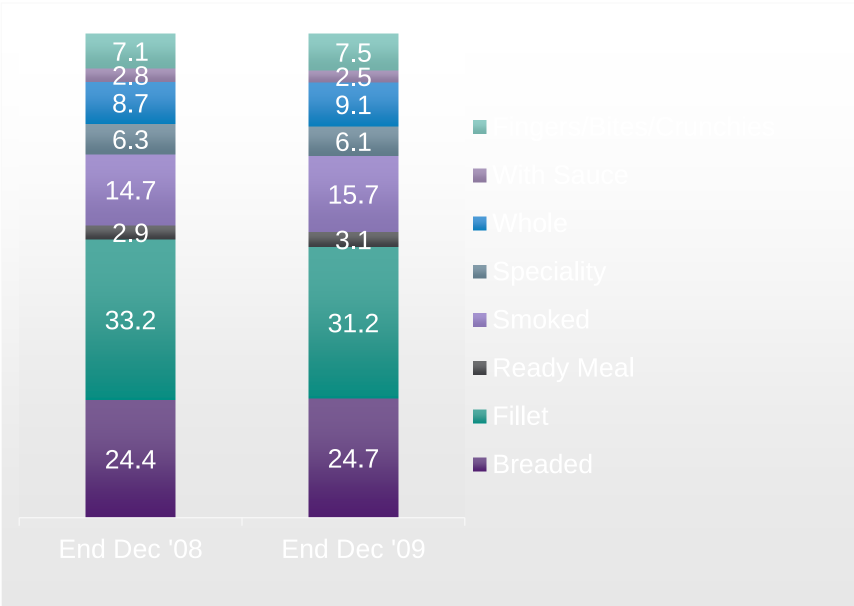
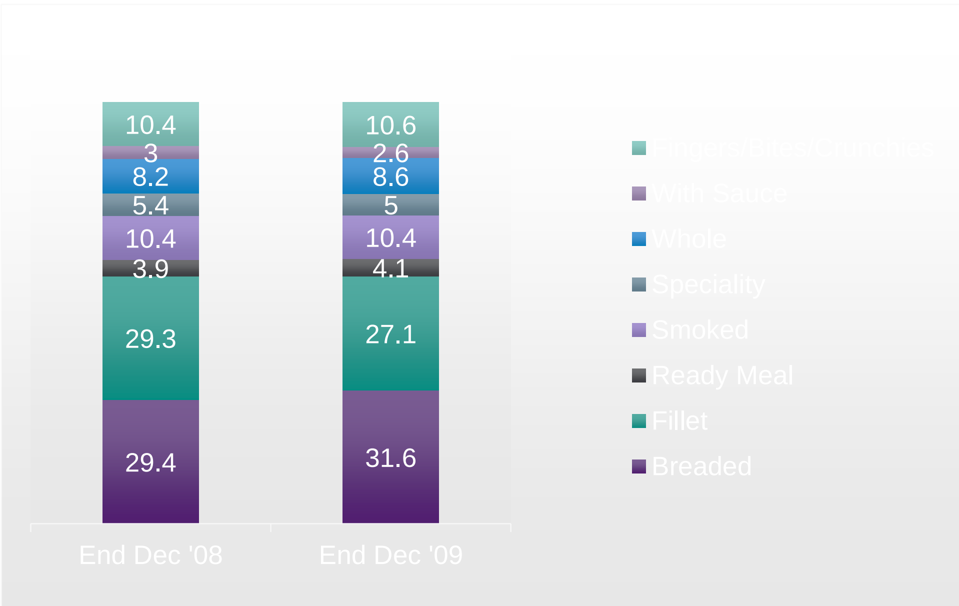


Figure 2.4 **Total fish: market split annually, ROI**

(a) Market breakdown in terms of value



(b) Market breakdown in terms of volume



2.9 Catering (food service) sector

The food service sector covers a range of outlets including fish and chip shops, canteens, hotels, restaurants and schools.

In NI, it is estimated that in 2001, consumers bought £1.45 million (€1.69 million) of seafood from these outlets. The sector is dominated by the traditional fish and chip shops. Current data is not available.

An estimated 57,547 tonnes (live weight equivalent; LWE) of seafood were consumed in food service outlets in ROI in 2007, an increase of almost 20,000 since 2004. Hotels and restaurants make up 65 per cent of the foodservice market or 64 per cent by value (€88.32/ £75.8 million). The majority of seafood sales are in hotels and restaurants, but pub sales of seafood are increasing (14). National supplies of salmon and cod are not adequate to meet the demand of Irish retail and food service markets. Consequently, there is a reliance on imports (14).

2.10 Conclusions

There have been substantial changes in the finfish sector since this report was first published in 2005. For instance, there is a considerable decline in the volume of landings and total value of finfish, with employment reducing in the sector. While the aquaculture industry is small but growing in NI, the sector has experienced decline in ROI over the past five year. The same period saw a tightening of regulations with regard to licensing, production, monitoring etc.

ROI figures show an increase in imports, while the value of exports have halved since 2004. Canned tuna is the largest single product component of the ROI seafood imports. For NI figures are only available for 2008 when 79 per cent of fish processed in NI was exported.

In NI expenditure increased slightly in the retail sector mainly due to an increase in the chilled seafood market. At retail level in ROI the value of the finfish market is down marginally but fresh fish has increased market share. Food service outlets in the ROI have also experienced an increase in the consumption of seafood.

3 Food safety microbiological issues

Key findings

- Finfish are generally regarded as safe and highly nutritious foods, however a wide variety of viruses, bacteria and parasites are reported worldwide as having been implicated in finfish related outbreaks.
- There is vast variation worldwide in the burden of seafood-related human infections. The factor most commonly associated with infections is the consumption of raw or undercooked seafood.
- In NI between 2005 and 2009 there has been only one reported foodborne outbreak associated with finfish and was related to scrombotoxin. The suspect vehicle was tuna and was associated with two ill persons. For the ROI, salmon was one of three suspected foods associated with a foodborne outbreak between 2004 and 2009. However it was noted that salmon was not definitively isolated as the cause of the outbreak.
- Good hygiene and hygiene practices are vital in the production of superior quality, safe seafood. The quality of fish is directly related to the time of capture and how the fish are handled, in particular during gutting, washing, boxing and icing.
- The risk to human health resulting from contamination of fish with pathogens from aquatic environments and pathogens that are naturally present on fish is low whereas, the risk from contamination of fish with pathogens from the animal/human reservoir is high and appears to be higher in coastal and inland aquatic environments than open waters.

3.1 Introduction

Finfish are generally regarded as safe and highly nutritious foods. However, they have been associated with certain food safety issues. A wide variety of viruses, bacteria and parasites are reported worldwide as having been implicated in finfish related outbreaks (35). Finfish-borne illnesses can be categorised as infections or intoxications (Table 3.1).

Table 3.1 Types of finfish-borne illnesses (36)

Type of Illness		Causative agent	
Infections	Microbial	*Listeria monocytogenes, Salmonella* sp., *Shigella* sp., *Vibrio parahaemolyticus, V. cholerae, Escherichia coli*	
	Parasitic	Nematodes, Cestodes, Trematodes	
	Viral	Hepatitis A, Norovirus	
Intoxications	Chemical	Heavy Metals (Mercury, Cadmium, Lead), Nitrites, Sulphites	
	Biotoxins	Histamine	
	Microbial	Bacterial	*Staphylococcus aureus, Clostridium botulinum*

The majority of seafood-related infectious outbreaks are linked to shellfish, or more specifically molluscs, rather than to finfish. The factor most commonly associated with infections is the consumption of raw or undercooked seafood. In countries with higher seafood consumption, or where seafood is traditionally eaten raw, a larger percentage of foodborne illnesses can be attributed to its consumption. There is a vast variation worldwide in the burden of seafood-related human infections, e.g. more than 70 per cent in Japan, 20 per cent in Australia and an estimated seven percent in England and Wales (37).

A hazard is a biological, chemical or physical agent in, or condition of, food with the potential to cause harm. In contrast, risk is the estimated probability and severity of adverse health effects in exposed populations consequential to hazards in food. Thus there is a fundamental difference between a biological hazard and a risk, and this distinction is very evident in finfish-related human infections. A large number of fish species worldwide are potential sources of medically important zoonotic hazards. However, the actual infectious disease risk associated with finfish infections is quite low. Epidemiological evidence linking finfish to human infection is very limited.

The safety of aquaculture products for human consumption is of public health significance. There are many different methods of farming fish, ranging from intensive commercial operatives to extensive small scale or subsistence systems. Food safety hazards vary according to the system, management practices, and the environment. The risk of contamination by biological and chemical agents, however, is greater in fresh water and coastal ecosystems than in open seas.

In 1999, the Food and Agriculture Organisation (FAO) adopted the Code of Conduct for Responsible Fisheries, addressing the issues such as the use of human and animal excreta as fertilizers and the safety of food and food additives in fish farming (35). There are limited data on the levels of foodborne illness associated with farmed (as distinct from caught) finfish. Infectious disease surveillance systems and current microbiological techniques cannot systematically differentiate whether human infections are caused by wild or farmed fish.

Some surveillance data and surveys categorise fish collectively as 'seafood', combining the impact of finfish- and shellfish-related illness. In addition, certain complex dishes comprise both finfish and shellfish as a stew or in a sauce or garnish. These issues can lead to confusion and difficulties in differentiating the precise vehicle in some cases of human infection. Regarding the attributable risk of finfish to the overall burden of foodborne disease in Northern Ireland (NI), due to the small population size and relatively small numbers of foodborne outbreaks there is little data on which to undertake studies (38).

3.1.1 Estimates of infectious disease risks from finfish

Data from population-based studies and surveillance systems have been analysed to estimate the impact of infectious disease and risks associated with eating finfish.

A major study of data from England and Wales (1996 to 2000) found that finfish accounted for one per cent of cases and two per cent of deaths annually as a percentage of the total annual impact of foodborne disease acquired and occurring in England and Wales (i.e. indigenous) (Table 3.2) (39). Furthermore, finfish alone accounted for one per cent of all general practitioner cases, one per cent of hospital cases and one per cent of hospital days resulting from indigenous foodborne disease in England and Wales. These figures illustrate the relatively minor impact of fish on the overall burden of foodborne disease in these countries. The review also documented the impact of mixed and unspecified seafood-related infections.

Seafood does not comprise a major element of the diet in England and Wales. Although the risk of disease is higher for seafood (41 cases/million servings) than for red meat (24 cases/million servings), red meats accounted for much more illness (17 per cent of cases) than did seafood (7 per cent of cases) (39).

The estimated risk associated with the ingestion of finfish was very low at eight cases/million servings (39).

Table 3.2 Estimated annual impact of indigenous foodborne disease, by food group and type, England and Wales (1996 – 2000) (39).

Food group/type	Cases (per cent)	Deaths (per cent)	Case-fatality rate*
Poultry	502,634(29)	191(28)	38
Eggs	103,740(6)	46(7)	44
Red meat	287,485(17)	164(24)	57
Beef	115,929(7)	67(10)	58
Pork	46,539(3)	24(4)	53
Lamb	46,239(3)	27(4)	59
Seafood	116,603(7)	30(4)	26
Fish	22,311(1)	10(2)	47
Shellfish	77,019(4)	16(2)	21
Mixed/ Unspecified Seafood	17,273(1)	4(1)	24
Vegetable/fruit	49,642(3)	14(2)	29

* Deaths/100,000 cases

The infectious disease outbreak surveillance system in the Republic of Ireland (ROI) reported 187 infectious disease outbreaks in 2004 (of which 169 were infectious intestinal disease [IID] outbreaks) which increased significantly to 468 in 2009 (264 IID). As for IID outbreaks where finfish was suspected, only one outbreak during 2004-2009 mentioned a finfish (salmon) however this was one of 3 suspected foods mentioned in the investigation and not definitively isolated as the cause of the outbreak (40).

In NI between 2005 and 2009 there has been only one reported foodborne outbreak associated with finfish (41). This outbreak in October 2006 was related to scrombotoxin and the suspect vehicle was tuna and was associated with two ill persons (42). Scombrotoxic fish poisoning is linked to eating fish from the family that includes tuna, mackerel, and herring. It is caused when fish and fish products are not refrigerated correctly. Warmer temperatures allow bacteria to multiply and produce a chemical called histamine at levels that can make people ill if it's eaten. Cooking the fish will not destroy histamine.

There have been no reported foodborne outbreaks associated with finfish in the ROI between 2005 and 2009 (Personal Communication) (43)

3.2 Microbiological issues

3.2.1 Introduction

It is common for human pathogenic bacteria to be detected in raw foods; in particular those of animal origin, and therefore raw fish or raw fish products should be considered as potential sources of pathogenic bacteria. The origin of the indigenous microflora associated with fish is from naturally occurring constituents of the aquatic environment (which may be part of the natural flora of fish) as well as exposure to microorganisms from the general environment. The resulting microbial contamination leads to levels of indigenous pathogenic bacteria in fish that are quite low and it is normal for some growth of the pathogen to be required before human illness may be produced (44). Consequently, the main control measure for these pathogens is to prevent their growth in the product.

In general terms, bacterial food poisoning organisms may be categorised as those that mediate their effects through either intoxication or an infection (Table 3.1).

3.2.2 Microbiological hazards from the aquatic environment and the human/animal reservoir

There are a number of pathogenic bacteria indigenous to the aquatic environment and naturally present on fish. However, the risk to human health resulting from contamination of fish with pathogens from this particular environment is low. Examples of such pathogenic bacteria include *Clostridium botulinum, Vibrio* species *and Aeromonas.*

In contrast to indigenous pathogens originating from the aquatic and general environments, the risk to human health resulting from contamination of fish with pathogens from the animal/human reservoir is high. The presence of such pathogens on fish and fish products is typically the result of poor hygiene, whether it is associated with the food handler, the food processing environment, or poor water quality. Examples of such pathogenic bacteria include *Salmonella* spp., *Escherichia coli*, *Shigella*, *Campylobacter*, *Vibrio* species, *Clostridium botulinum* and *Listeria monocytogenes*.

The prevalence of bacterial pathogens from the animal/human reservoir appears to be higher in coastal and inland aquatic environments than open waters (35), presumably because of the effects of agricultural run-off and human sewage outlets. Also, it would be expected that mesophilic pathogenic bacteria would be better adapted to tropical compared to temperate waters.

Some pathogens from the animal/human reservoir have a low Minimum Infectious Dose (MID), for example *Shigella* spp. and *Campylobacter jejuni*. Thus, the growth of these organisms in the product may not be required for it to present a risk to human health, especially in ready-to-eat (RTE) products and those intended to be eaten raw. Proper cooking will destroy these pathogens. Nevertheless, potential for cross-contamination to other foods within food preparation areas exists, and it is important that food handlers recognise the risks and minimise the potential for the spread of these organisms. The main preventative measure is therefore to apply good hygienic and manufacturing practices throughout the food supply chain.

3.2.2.1 Salmonella spp.

Salmonella spp. are among the most important causes of human gastro-intestinal disease worldwide. Studies have indicated a higher prevalence of *Salmonella* in tropical than in temperate waters (35).

The largest ever *Salmonella livingstone* outbreak described in the literature occurred in Norway and Sweden in July 2001 and was associated with contaminated processed fish products. There were 60 cases and three deaths (45).

Disease surveillance reports from public health authorities in Europe and North America indicated that infections associated with the consumption of finfish products constitute a very low risk to public health with respect to salmonellosis (37).

3.2.2.2 Escherichia coli

Escherichia coli (*E.coli*) strains are capable of causing foodborne disease and there is good evidence for the occurrence of waterborne infection caused by *E. coli* O157:H7. Nevertheless, based on available epidemiological evidence, finfish borne *E. coli* infection poses a very low risk (39).

3.2.2.3 Shigella

Shigella species represent a potential hazard but very low risk of infection related to finfish consumption. The presence of *Shigella* is indicative of poor hygienic handling as humans are its natural reservoir and faecal-oral is the primary route of infection. *Shigella* is not naturally present in water (44) and outbreaks have typically involved contamination of RTE food during its preparation by an asymptomatic carrier.

3.2.2.4 Campylobacter

Campylobacter infection risk associated with finfish is similarly very low. *Campylobacter* spp. are widespread in the intestinal tract of warm-blooded animals used for food production. They may therefore readily contaminate raw meat, raw milk and raw milk products. However, they are not part of the normal flora of unpolluted aquatic environments, but are commonly isolated from wastewater (35).

3.2.2.5 Vibrio Species

Currently 12 species of *Vibrio* are known to be associated with human infections acquired by consumption of contaminated foods and water. In general, the infectious dose necessary to cause intestinal disease is high and the risk associated with eating fish is therefore likely to be low. Vibrio is usually a risk associated with fish from warmer waters. *Vibrio cholerae* serotypes have been associated with the consumption of raw fishery products. There are no reported cases resulting from imported finfish, whereas shellfish (especially oysters and clams) are frequently implicated in other parts of the world. There have been three laboratory reports of *V. cholera* since 1992, one per year during 1994, 2002, and 2005[7]. Cholera is practically unknown on the Island of Ireland (IOI), for example, in the ROI there were no notified cases of Cholera up to 1999, and since then there has been one case annually in 2000, 2001 and 2002 and none in 2003. From 1990 to the present day, there have been three notified cases of Cholera in NI, one in each year during 1993, 1994 and 2005 (46).

3.2.2.6 Clostridium botulinum

Clostridium botulinum (*C. botulinum*) is classified into toxin types from A to G. The types that are pathogenic to humans are toxin types A, B, E and F. The majority of botulism outbreaks in the northern and temperate regions are associated with fish, and in most cases type E was the responsible type. All types of fish products, except raw fish to be cooked immediately before consumption, have been involved in outbreaks of botulism, however, the majority of outbreaks have been associated with fermented fish (47).

C. botulinum causes botulism, the neurotoxic life-threatening food borne illness. This pathogen is often isolated from fish. However, toxin production is prevented by proper handling and processing. To date there have been no finfish–related cases reported in Western Europe.

3.2.2.7 Listeria monocytogenes

Listeria monocytogenes (*L. monocytogenes*) may be found in the intestines of humans and animals (without causing illness), and can also be isolated from many RTE foods, including seafood, fruit, vegetables, dairy and meat products. This microorganism is frequently isolated from aquaculture products from temperate regions. Fish and smoked fish, in particular smoked salmon, have caused sporadic cases of listeriosis in vulnerable populations, including the elderly, immunocompromised individuals, pregnant women and neonates. Effective control of *L. monocytogenes* is product, process and facility specific. Cold smoked products such as smoked salmon may harbour *L. monocytogenes*, and during storage the number of bacteria may reach levels that can cause illness (48).

In foods, such as soft mould-ripened cheeses, pâtés and cold-smoked salmon, *Listeria* may be present in higher numbers. The presence of concentrations of the pathogen in foods of less than 100 colony

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[7] Personal communication, Brian Smyth, CDSC(NI), 8 March 2006.

forming units (cfu) per gram, is considered to present only a low risk and eating foods containing higher levels of *L. monocytogenes* is generally the cause of illness.

During the period between 1991 and 2002, a total of 22 outbreaks of listeriosis were reported in 9 different countries in Europe and three of these outbreaks (14 per cent) were associated with processed fish products (49). Consumers who eat cold smoked salmon and certain other ready-to-eat fish products such as sushi are at risk. Since 2004, there have been a total of 74 notifications of listeriosis in the ROI, with an average of 12 cases per year. In 2006, there were just seven notifications, whereas in 2007 there were 21 known cases of listeriosis (50). However, data is not available as to the cause of these incidences of listeriosis in the ROI. In NI, there have been 31 reported cases of listeriosis since 2004, with the highest number of incidences (11) being reported in 2008 (51). Forty-three Rapid Alert System for Food and Feed (RASFF) notifications were received in 2009 for *L. monocytogenes* in fish, of which 13 related to smoked salmon (52).

New legislation on the Microbiological Criteria for Foodstuffs, which came into effect on the 1st of January 2006 (as part of the 'Hygiene Package' – Appendix C), specifies the criteria for *L. monocytogenes* in RTE foods (including smoked salmon). This legislation requires five samples (each 25g) of the foodstuff to be taken and *L. monocytogenes* must be absent in all five.

3.2.2.8 Aeromonas

The genus *Aeromonas* contains species pathogenic to animals (including fish) and man. The species *A. hydrophila*, *A. sobria* and *A. caviae* have been linked to human gastroenteritis. *Aeromonas* species are common, natural members of freshwater environments (53). These organisms can also be isolated from marine and estuarine environments (54). The *A. hydrophila* group is very commonly found in fish and fish products at levels between 102 and 106 cfu/g. *Aeromonas* species have been implicated as spoilage organisms of raw packed salmon (55) and fish from warm tropical waters (56).

Although the motile aeromonads as a group are mesophilic, several studies have demonstrated that many environmental (food derived) strains grow well at chill temperatures (57, 58). The organisms are able to grow in both vacuum and modified atmosphere packed products (53). Limitation of growth requires a combination of chilling, salting and/or acidification.

3.2.3 Other biological hazards

3.2.3.1 Biogenic Amines - Histamine

The metabolic activities of certain spoilage bacteria in fish can result in the production of compounds that cause a food-borne chemical intoxication. These compounds can provoke a rapid onset (within minutes to two hours) of symptoms (58), following ingestion of the affected product. Initial symptoms suggest an allergic response with facial flushing and sweating, burning-peppery taste sensations about the mouth and throat, dizziness, nausea, and headache. These can progress to facial rash, hives, edema, short term diarrhoea and abdominal cramps. Severe cases may blur vision, and cause respiratory stress and swelling of the tongue. Symptoms usually last for four to six hours approximately and rarely exceed one to two days.

The compounds responsible are termed biogenic amines of which histamine is the most commonly recognised substance associated with such toxicity. Biogenic amines are produced in foods by decarboxylation of corresponding amino acids (Table 3.3). It has been proposed that the toxicity of histamine may be potentiated by other biogenic amines (59).

Table 3.3 Amino acid precursors and biogenic amines formed in food products*

Amino acid precursor	Biogenic amine
Histidine	Histamine
Ornithine	Putrescine
Putrescine**	Spermidine
Lysine	Cadaverine
Tyrosine	Tyramine
Arginine	Agmatine

* *Adapted from (60)*, ** Not an amino acid

Histamine poisoning is often referred to as scombrotoxin poisoning due to its frequent association with scromboid fish, such as tuna and mackerel. Other scromboid fish (including sardines and pilchards) and salmon have also been implicated.

Under EU labelling legislation, fish (and products thereof) are classed as a food allergen (because of the risk of histamine production) and consequently their presence must be indicated in the labelling of a product (see Section 6.1.1).

In 2009, there were 59 notifications made through the RASFF regarding histamine in fish, of which 31 concerned tuna. Levels of histamine of several thousand parts per million (ppm) were common (52).

The bacteria responsible for mediating histamine production do not grow at temperatures used for proper cold-storage. Thus, the presence of this biogenic amine is indicative of mishandling and temperature abuse of the product at some point along the food chain. Members of the family Enterobacteriaceae, such as *Morganella morganii*, *Klebsiella pneumoniae*, *Proteus vulgaris* and *Hafnia alvei,* are considered the most important biogenic amine forming bacteria in fish. The temperature minimum for histamine production remains a controversial subject, with the production of significant amounts below 10°C unlikely with these mesophilic enteric bacteria (61). Biogenic amine production has also been linked to psychrotrophic lactic acid bacteria.

Biogenic amines are very thermostable. Once formed, they are capable of withstanding temperatures in excess of normal cooking processes. There is currently no treatment capable of removing biogenic amines, thus preventing or limiting their production is the only option available. The methods used by the fish industry for the control of biogenic amine formation are as follows (60):

1. Rapid chilling of fish immediately after death to guard against rapid formation of the decarboxylase enzymes.
2. Good hygienic practices on-board, at landing and during processing to avoid cross-contamination or recontamination of fish by bacteria capable of amino acid decarboxylation.

Thus, it is essential that strict control of the cold chain is maintained at all stages during distribution, marketing, end user storage and preparation activities.

Criteria for Histamine levels in certain fish species

The Microbiological Criteria for Foodstuffs, as mentioned previously, specify limits for the levels of histamine permissible in certain fish species [Scombridae (Mackerel and Tuna), Clupeidae (Herring), Engaurlidae (Anchovies), Coryfenidae, Pomatomidae, Scombresosidae] during their shelf-life. Legislation specifies that nine fish must be tested from each batch. The mean histamine value for fishery products of the above fish species must not exceed 100 mg/kg as determined by a reliable, scientifically recognised method [e.g. high performance liquid chromatography (HPLC) method (62)]. Two samples may have a value of >100 mg/kg but less than 200 mg/kg, but no sample may have a value exceeding 200 mg/kg. Fishery products of the above fish species that have undergone enzyme maturation treatment in brine, are permitted to have higher histamine levels but not more than twice the above limits (i.e. 200 and 400 mg/kg).

3.2.3.2 Parasites

Virtually all animals host a variety of parasitic organisms. Control of parasites in domestic animals has been successful, with consumers rarely encountering macroscopic parasites in products from these animals. There is no similar opportunity to control parasitic infections in most seafood products that are harvested from the wild. Thus the presence of parasites in fish is common (63). The majority of parasitic organisms associated with fish reside in tissues, such as the visceral organs, which are discarded during preparation for the market. These parasites are of little concern from a public health and economic perspective (63).

Despite this, there are more than 50 species of helminth (or worm) parasites from fish and shellfish that are known to cause disease in man. These typically belong to the roundworm group known as nematodes, or to the tapeworm group of flatworms known as cestodes. A third group, the trematodes, are flatworms related to cestodes and associated with marine fishes. Most are rare and cause only a mild illness and all are acquired through the ingestion of raw, lightly marinated, or insufficiently cooked seafood where infective stages of the parasites are present in the flesh in a free or encysted state (64).

Parasitic helminths have complicated life cycles with fish being an intermediate host and marine vertebrates final hosts in which the sexually mature adult worms are found. Spread is not directly from fish to fish and frequently sea-snails or crustaceans are involved as first intermediate hosts. Infection of humans may be part of the life cycle, or an opportunistic side track causing disruption to the life cycle (60).

Lifecycles of parasites can be quite diverse. For both demersal and pelagic fish, the pattern of infection between and within fish species is driven by features such as feeding habits and habit utilisation. In the case of nematodes, anisakids (i.e. nematodes belonging to *Anisakis* spp.) typically utilise marine mammals or fish-eating birds as definitive hosts, with planktonic/ benthic crustaceans acting as intermediate hosts, and fish as the main transport hosts. A wide range of fish species can carry larval anisakids, including in the fish flesh, thus representing the pathway for human infections. It may be the case either that fish become infected after ingesting free-swimming larvae, or larvae can be transferred from crustaceans to plankton-eating cetaceans (e.g. dolphins, whales), thereby skipping the fish transport host. After final moulting, maturation and copulation, the female worms shed eggs within their faeces, which subsequently embryonate and hatch in the water, releasing free-swimming third-stage larvae. When an infected fish is eaten by another fish the encapsulated larvae become digested, thus repeating the larval fish host cycle. This is important from an epidemiological and food safety perspective, as the repeated transfer of larvae between fish within the natural food chain may result in extensive accumulation especially in larger and older fish, which can harbour hundreds or even thousands of encapsulated larvae.

For cestodes, the lifecycle is quite complex, and requires three hosts for completion. After the egg hatches in water, the motile embryo is ingested by a copepod, and develops to the first larval stage. Following ingestion of an infected copepod by a fish, the larva is released and enters the tissue of the host and develops to the second stage (pleroceroid, 1-3cm in length). Pleroceroids may remain inactive for several years, but can re-encyst several times in other predatory fish. Approximately one month after ingestion of an infected fish, the parasite develops in the intestine of fish-eating mammals or birds into the adult tapeworm (65).

Consumption of raw or undercooked or marinated fish is the main source of infection with *Diphyllobothrium* for humans. In particular, fish prepared for sushi may pose a high risk for exposure (65).

Adult *Anisakis simplex* are found mainly in the gastrointestinal tract of cetaceans (e.g. dolphins, porpoises, baleen whales), whereas the adults of *Pseudoterranova* spp. and *Phocascaris* spp. live in pinnipeds (e.g. seals, sea lions, walrus). The latter occur only in the northern hemisphere, including arctic waters (65). Grey seals are the major final host of *Pseudoterranova* in Scottish waters, and the population size has grown considerably since the 1960s. Increases in *Pseudoterranova* have been attributed to the rise in seal numbers. However, according to EFSA (65), without more knowledge of the population dynamics in definitive and intermediate host populations and the relative importance of different hosts in the transmission of the parasite, a clear explanation is not possible.

Infections by such parasites are prevalent in only a few areas in the world where there is a cultural habit of eating raw or inadequately cooked fish, such as southeast and East Asia. Furthermore, in the EU as part of the controls laid down in the Hygiene Package (Regulation 853/2004), visual inspection for parasites is stipulated, as well as the requirement that all parts of fish, which are to be consumed raw or almost raw, must be subjected to a freezing process of -20°C. This also applies to fish that are to be heated to a temperature of less than 60°C (e.g. smoked fish). The freezing process will kill any parasites that may be present in the fish.

Parasite checks

As mentioned above, Regulation (EC) No 853/2004 stipulates a requirement on fishery establishments to confirm the absence of visible parasites in fish or fishery products by visual checks before placing them on the market. Fish or parts of fish, from which obvious infestation with parasites has been removed, must not be placed on the market for human consumption. Visible parasite means a parasite or a group of parasites that has a dimension, colour or texture which is clearly distinguishable from fish tissues.

Visual inspection for the purpose of detecting parasites is carried out by means of non-destructive examination without optical means of magnifying and under good light conditions, including, if necessary, candling. Where fish are manually eviscerated, visual inspection should be carried out in a continuous manner by the operative at the time of evisceration and washing.

Other control measures for parasites are possible before harvesting. These include the selection of the type and size of the fish to be caught. This is based upon knowledge of the feeding habits of the fish species as well as a consideration of environmental conditions prevailing in the associated fishing waters. In fact, parasites tend to accumulate within their hosts during their lifetime so that older, larger fish are likely to harbour greater numbers than smaller, younger fish. The rapid chilling and/or gutting of fish will also reduce the number of parasites present in the flesh, since this will limit their migration from the gut (66). It has also been suggested that rupture of fish intestines is more likely if fish are caught soon after they have been feeding. In this situation, enzyme levels in intestinal tracts will be high, bellies distended, and the flesh much more susceptible to bruising and belly burn. Following breakage, worms may migrate into the edible flesh (61).

In 2009, there were 48 notifications through RASFF for the presence of the larvae of a nematode parasite Anisakis in fish, mainly in fresh mackerel and hake (52).

Nematodiosis (specifically Echinococcus and Trichinosis) has been notifiable in the ROI in humans since 1 January 2004. There had been no notifications of Echinococcus prior to 2007, but there were two cases in 2008 and 1 case in 2009 (67). However, there have been many incidences of Trichinosis in the ROI in the last few years. Data available has shown that between 2005 and 2008, there were approximately 300 cases of Trichinosis (68). It is not a notifiable disease in NI if it causes food poisoning (personal communication Communicable Disease Surveillance Centre NI).

3.2.4 Fish processing

3.2.4.1 Handling fish

The care with which fish are handled, and the hygienic conditions prevailing, are important contributors to the quality of the product. The use of pitchforks and gaffing hooks (wooden poles with a nail at the end) and other implements that pierce the flesh of fish, act as a source of contamination and should be discouraged. The puncture sites created by these implements can act as areas where spoilage is initiated. Other systems pump fish around. It must be stressed that whatever method is used to handle fish, this should aim to minimise bruising and other injury as this will diminish the quality of the product and serve to accelerate the spoilage process.

3.2.4.2 Filleting

Filleting by hand is a skill. The filleters generally remove the two fillets from fish, which are conveyed to and from them by conveyor belts. Where there is a supply of appropriately sized fish, then cutting fish by machine may be a faster and more profitable alternative. It also has the advantage that it minimises handling of the product and may therefore be a more hygienic process eliminating the potential for transfer of pathogens from the food handler to the fish.

3.2.4.3 Chemical treatments and processing aids

Fish may be stored in ice made from water with the addition of various additives, such as potassium sorbate or salt. These have a beneficial role in protecting against bacterial growth. Dips may also be used; these may have preservatives such as benzoic acid in combination with a food-grade acid included to extend the shelf-life.

Following filleting and skinning, the fish may be treated chemically with a dip or spray of a polyphosphate and/or brine solution to firm up the flesh. The dip tank represents a potential source of bacterial cross-contamination and thus should be emptied and replaced frequently.

3.2.4.4 Smoked salmon

The process of smoking has been used by man for thousands of years to extend the shelf-life of foods. However, today it is used to meet consumer demands.

The main microbiological safety issues for smoked salmon are related to risks associated with *L. monocytogenes* and *C. botulinum*. Advice for consumer groups in relation to smoked salmon has focussed on the *L. monocytogenes* risk for vulnerable groups. Advice in Australia states that pregnant women should avoid cold-smoked salmon (69), however, in the UK the Food Standards Agency (FSA) does not advise pregnant women to avoid this food. ***safe*food** recommends that pregnant women should eat smoked fish only if they are home cooked or reheated fully – in the case of smoked salmon this would be as an ingredient in a food that will be cooked before consumption (2). Notifications to the RASFF for the presence of *L. monocytogenes* in smoked salmon are typically based upon detection of the pathogen in 25g samples (70). In the ROI, BIM annually tests approximately 400 samples of ready-to-eat smoked salmon for the presence of the pathogen and detection rates of three percent have been reported (71).

The two main processes used to produce smoked salmon have already been outlined (Section 2.6.1). The Food Safety Authority of Ireland (FSAI) observed in its 2005 report on *Listeria* that because smoking criteria are not standardised in the ROI, it would be expected that the effect of smoking on pathogens such as *L. monocytogenes*, and the inhibitory effect smoking has during storage, may vary for cold-smoked and hot-smoked fish from different producers (48).

A definition of the cold smoking process is that fish are subjected to smoke at a temperature where the product undergoes only incomplete heat coagulation of protein. The processing parameters are considered insufficient to provide a listericidal effect in the product and inoculation studies have demonstrated rapid growth of the pathogen in vacuum packed cold-smoked fish products (from 10^3 cfu/g to 10^7-10^8 cfu per gram in two to four weeks (60). Although this growth appears to be less in naturally contaminated products; with levels above 10^4 cfu per gram rarely being detected, even at end of shelf life (69). It is worth noting that inadequately controlled hot-smoking operations may also offer insufficient heat treatments to deactivate *L. monocytogenes* present, and therefore more closely resemble cold-smoking operations in this respect. The FSAI has issued advice that the hot smoking process, where appropriate, should ensure an internal temperature of 70°C for two minutes (or 75°C instantaneously) or equivalent to ensure a 10^6 reduction of *L. monocytogenes* cells (48). This recommended heat process is significantly above the 60°C limit typically used to define the hot smoking process.

With respect to *C. botulinum*, because of the widespread distribution of the pathogen in natural environments, concerns are not linked to the mere presence of vegetative cells or spores of psychrotrophic non-proteolytic *C. botulinum* in the food product. The packaging environment and temperature can significantly influence risk factors associated with *C. botulinum,* since the pathogen is an obligate anaerobe and eliminating or reducing oxygen concentrations enhances the potential for germination, growth, and toxin production of the organism.

Refrigeration temperatures below 3.0 to 3.3°C will inhibit the growth of proteolytic *C. botulinum* and non-proteolytic *C. botulinum*. However, achieving these consistent low temperature controls is not a realistic expectation throughout the entire food supply chain. The use of appropriate concentrations of salt may also be used in combination with temperature control to prevent the growth of *C. botulinum (60)*. As a general safeguard, salting to achieve a salt-on-water concentration of at least 3.5 per cent for chilled stored (<10°C) cold-smoked fish is essential for reduced oxygen packaged cold-smoked fish. Such a combination of salt and low temperature has been considered sufficient for control of the hazard (69). Moreover, the presence of a competitive microflora of spoilage organisms in the product is also favourable, since *C. botulinum* competes poorly against high levels of background microorganisms. Ironically, it is worth noting that strict adoption and adherence to food hygiene and Hazard Analysis at Critical Control Points (HACCP) principles in smoking operations may therefore adversely affect the product safety by reducing the competitive microflora present. However, this should not be relied upon, to act as an effective or reproducible control point (69).

3.2.5 Growth of microorganisms in fish – spoilage and safety issues

Fish is a highly perishable product. The fact that it spoils so easily presents considerable challenges for maximising its shelf-life potential during distribution and marketing activities. The standard way of handling finfish is to keep them properly iced throughout distribution, thus keeping the temperature close to that of melting ice.

Regulation (EC) No 853/2004 amended by Regulation (EC) No 558/2010 specifies that fishery products must be kept at a temperature approaching that of melting ice (0°C) from the point of catching, to prevent the growth of spoilage or pathogenic microorganisms and maintain fish quality.

Ice serves three essential functions; it cools, washes, and moisturises the product. If the ice is not made from clean water then there is the potential for it to serve a fourth and undesirable function, by acting as a source of psychrotrophic and psychrophilic bacteria.

To affect the optimal heat transfer and perform its cooling function, maximum contact between the ice and the product is required. Therefore, the size and distribution of the ice pieces is important, as well as the ratio of ice to fish on a weight-by-weight basis.

Removal of surface bacteria by melt water is best achieved by maintaining the temperature of the storage environment at 2 to 3°C, so that melting occurs at a suitable rate. The moisturising role of ice is linked to this effect, such that the surface of the fish is kept wet and the humidity is maintained at high levels. This is particularly important given the drying effect resulting from the air-flow rates in refrigeration units and consumers' requirements for fish that 'glisten'.

3.2.5.1 Shelf-life

The shelf-life of fish may be defined as the length of time that the product will remain unspoiled and can be safely placed in the marketplace from the time it is caught. For commercially major species, during normal fish handling procedures, the shelf-life is between 14 and 17 days. Under the same conditions, fish from warmer, tropical water will last 21 to 24 days (61). The disparity in the shelf-life potentials, depending upon origin, may be explained by the different microflora present in temperate and tropical waters. In the former, psychrotrophic and/or psychrophilic bacteria may be part of the natural flora that are not found in tropical waters. These cold tolerant bacteria are pre-adapted to grow at low temperatures and thus, cause more rapid spoilage effects at storage temperatures.

The typical spoilage odour of fish is produced by the utilisation of nitrogenous compounds, particularly trimethylamine oxide (TMAO). This compound is produced by bacteria, such as pseudomonads and *Altermonas putrefaciens*, leading to the production of volatile aromatic compounds, including trimethylamine (TMA). TMA is thought to react with fish fats leading to the typical spoilage odour associated with the product.

From a safety perspective, substantial growth of pathogens in fish will only be evident at temperatures above 5°C. Rapid growth of spoilage organisms would be expected to proceed before pathogenic bacteria or their toxins reach levels sufficient to cause illness. Thus, it is likely that such fish products would be rejected for quality reasons because of the development of off-odours and other sensory defects before pathogens would reach levels presenting a safety risk. Furthermore, in borderline situations, proper cooking of raw fish will destroy the vegetative cells of any pathogens that may be present.

In the qualitative discussion groups held in both 2005 and 2010, consumers were overly cautious when it came to storage of fish, considering it to be a highly perishable commodity and tended to purchase on the day of consumption. In some cases this was a barrier to consumption. In view of existing evidence, if the cold chain is properly maintained, fish can be held for up to several weeks from the time of harvest to consumption. The FSA and BIM recommend that fresh fish in good condition and stored properly should last a day or two after purchase. The important message is that correct temperature control is essential in preserving the quality of the product. Therefore consumers should be advised to minimise the length of time that fresh fish are out of refrigerated storage by purchasing at the end of the shopping trip, returning straight home and placing directly in the fridge. The use of cool bags to keep the product cold during transport should be considered, particularly in warm weather. It is important to note that pre-packaged fish are required to display use by dates and consumers should be confident that these represent the storage period throughout which the product would be expected to maintain high quality and consumer acceptability.

Additionally, all fish can be successfully frozen. Fresh white fish can be frozen for a maximum of 6 months, while oil-rich fish is best if used within 3 months. Previously frozen fish should not be refrozen.

3.2.6 Food safety regulation of the finfish supply chain

Under the Food Safety Authority of Ireland Act 1998, as amended, the FSAI is the responsible agency charged with protecting consumers' health and interests by ensuring that food produced, distributed or marketed in the ROI meets the highest standards of food safety and hygiene; and ensuring that food complies with legal requirements or where appropriate, with recognised standards. The agencies responsible for such activities in NI are the FSA and DARD.

The Hygiene Package covers all aspects of the food chain (including the fish supply chain from capture to placing on the market) from a food hygiene perspective.

Annex III to Regulation (EC) No 854/2004, amended by Regulation (EC) No 1021/2008 on the hygiene of foodstuffs, sets out the official controls of production and placing on the market of fishery products. These include the following activities to monitor production conditions:

1. Inspection of fishing vessels.
2. Checks on the conditions of landing and first sale.
3. Inspection at regular intervals of establishments and factory vessels (wherever registered) to check in particular -
    a) Whether the conditions for approval are still fulfilled;
    b) Whether the fishery products are handled correctly;
    c) The cleanliness of the premises, facilities and instruments and staff hygiene; and
    d) Whether any necessary identification marks are put on correctly.
4. Inspection of the wholesale and auction markets.
5. Checks on storage and transport conditions.

This piece of legislation also states that the official controls of fishery products must include at least the following elements:

a) Organoleptic examinations
b) Freshness indicators
c) Histamine
d) Residues and contaminants
e) Microbiological checks
f) Parasites
g) Poisonous fishery products.

Regulation (EC) 852/2004, amended by Regulation (EC) No 219/2009 requires all food businesses to be registered with the competent authority. It also stipulates that food business operators should apply the principles of the system of HACCP in order to identify critical control points that need to be kept under control in order to guarantee food safety. Food Business Operators must ensure that where and how the food is produced is hygienic, and that the premises are kept clean and properly equipped. Staff members must observe good personal hygiene practices, and be properly supervised and trained.

Commission Regulation (EC) No 2073/2005, amended by Commission Regulation (EC) No 365/2010 on microbiological criteria for foodstuffs, specifies microbiological standards for shellfish only. However, the legislation states that microbiological criteria, including sampling plans and methods of analysis, may be laid down if a need to protect public health arises.

3.2.6.1 Food safety control onboard vessels and at fish processing plants

Enforcement of fishery legislation in NI is carried out ashore and at sea by the Sea Fisheries Inspectorate of DARD with officers permanently stationed at Kilkeel, Ardglass and Portavogie (the main landing sites for caught fish) and the North Coast (salmon fishery). DARD operates a Fishery Protection Vessel, the ‘Ken Vickers’, which carries out routine patrols in the Irish Sea to observe and inspect fishing vessels and patrols the North Coast Salmon Fishery. Inspections are also made in harbour to ensure compliance with EU, UK and NI legislation and vessel landings are routinely checked to ensure compliance with UK licensing conditions. The FSA (Fish and Shellfish Hygiene Unit in the Primary Production Division) is responsible for implementing public health requirements for fishery products. Hygiene legislative requirements onboard fishing vessels and at primary processing plants are enforced by Environmental Health Officers (EHOs) who are employed by District Councils.

In January 2007, the Sea Fisheries Protection Authority (SFPA) was established, under the Provisions of the Sea Fisheries and Maritime Jurisdiction Act 2006. This is the competent authority for the

Enforcement of Sea Fisheries Protection and Seafood Safety Legislation on the island of Ireland, and in Irish territorial waters. The principal objectives of the SFPA are firstly to ensure that the marine fish and shellfish resources from the waters around the IOI can be consumed safely, and also that such fish and shellfish are exploited sustainably (72). Sea Fisheries Protection Officers (SFPOs) are based at the SFPA's headquarters in Clonakilty, and at a network of regional offices around the coast, including offices at the main fishing harbours of Castletownbere, Dingle, Dublin, Dunmore East, Galway, Howth, Killybegs, Mahon and Rossaveal. SFPOs work closely with other government agencies such as the Naval Service, FSAI and MI, in the implementation of fisheries control and seafood safety programmes. These SFPOs (through service contracts with the FSAI) also ensure compliance with hygiene regulations through inspection, sampling and auditing of vessels and processing plants.

Codes of practice

Seafish, BIM and other organisations have drawn up a number of Good Practice Guides or Codes of Practice over recent years in order to provide practical advice to fishermen on how to meet the legal requirements (73-78). These guides/codes of practice provide the guidelines, specification and standards for the consistent production of superior quality finfish in compliance with all relevant national and international regulations.

Auction sites of first sale/markets/wholesalers

All auction sites of first sale fish in NI are required to be designated as such by the Fisheries Division, DARD. All buyers of first sale fish, bought directly from fishing vessels and sellers of first sale fish at a designated auction site in NI, are required to be registered with the Fisheries Division, DARD. In the ROI, all auction centres, wholesale markets and buyers must be registered with the SFPA.

Auction centres and wholesale markets are inspected by EHOs (NI) and SFPOs (ROI) to ensure they comply with the required standards of structural hygiene and cleanliness.

3.2.6.2 Food safety control in retail and catering establishments

Northern Ireland

In NI District Councils, via EHOs, have responsibility at the point where food enters a distribution network and retain control until sale to the final consumer. EHOs regularly inspect food premises with the frequency of inspection based upon assessment of the risk the business poses i.e. whether the business trades with a small or large customer base; whether that customer base is local, regional or national; if customers are likely to be within the susceptible groups for *E. coli* O157; and whether the foods handled are of a type more or less likely to present a risk to food safety.

The role of the EHO includes ensuring that managers and staff understand the possible hazards that the foods they handle could create for consumers, and facilitating the knowledge and capacity to control those risks to an acceptable level. Where inspecting officers identify food safety risks, they operate a hierarchy of measures from provision of advice to formal letters, legal notices requiring action, and instigation of legal proceedings. Where significant risks are posed to the public by the condition or operation of a business, it may be closed immediately.

In addition to a programme of inspections, EHOs undertake sampling of foods along the food chain to determine their microbiological fitness. Sampling programmes are co-ordinated by the NI Food Liaison Group and frequently link with regional or national sampling surveys. Unsatisfactory results are followed up and may result in a review of food handling practices or could even result in product recall and formal action being taken against a business.

Republic of Ireland

The Health Service Executive (HSE) employs EHOs and carries out official food control activities through service contracts with the FSAI. EHOs are responsible for implementing national and EU laws on food safety and hygiene. The role of the EHO in the ROI is similar to that of his/her counterpart in NI.

Further to registration, inspections will be carried out using a risk based approach which will determine the nature, frequency and type of inspection, with due regard being given to the nature of the risk presented by the business, the history of compliance with food safety legislation and the outcomes of previous inspections.

3.3 Conclusion

On the IOI, there are controls, systems and legislation in place that aim to control microbiological hazards in the supply chain and, thereby, minimise the risk to consumers' health. In NI between 2005 and 2009 there has been only one reported foodborne outbreak associated with finfish and was related to scrombotoxin. The suspect vehicle was tuna and was associated with two ill persons. For the ROI, salmon was one of three suspected foods associated with a foodborne outbreak between 2004 and 2009. However it was noted that salmon was not definitively isolated as the cause of the outbreak. Overall fish is deemed to be a safe and nutritious product.

4 Food safety – toxicological issues

Key findings

- There are monitoring programmes on the island of Ireland that frequently test for dioxins, heavy metals, malachite green/leucomalachite green, organotin compounds and many other substances. There is also legislation in place that governs the maximum levels for each of these.
- The most recent data available (2004-2006) from the Food Safety Authority of Ireland (FSAI), Marine Institute and Bord Iascaigh Mhara (BIM) for ROI showed that the levels of dioxins in Irish fish and fishery products available on the Irish market were well below existing European Committee legal limits.
- The most recent survey of fish from the UK showed low levels of dioxins and PCBs in all samples analysed with only sporadic individual or composite exceedances of the maximum limits. Data is not available for NI only.

4.1 Toxicological issues

A number of toxicological issues relating to finfish have been raised through the media or from scientific studies in recent years. Some are recurrent (such as dioxins), while others have been successfully addressed through legislation, regulation, surveillance and other mechanisms. In this section, a number of these issues will be discussed; namely persistent organic pollutants (dioxins, brominated flame retardants, pesticides), heavy metals, malachite green/leucomalachite green, organotin compounds, carbon monoxide, veterinary medicinal products, radioactivity, and fish feed. In addition, recent concerns surrounding vitamin A supplements will be discussed.

4.1.1 Persistent organic pollutants

Dioxin congeners & dioxin-like PCBs

The term 'dioxin' generally refers to a group of chemicals known as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Dioxins are formed during combustion processes when the element chlorine is present, for example in the incineration of municipal waste. They can also be formed during natural combustion processes such as forest fires, or can occur as by-products of industrial processes, such as bleaching of paper pulp using chlorine. Due to their lipophilic characteristics, dioxins are highly resistant to degradation processes. Thus, they can persist in the environment and are subsequently taken up into the food chain by animals and fish. High levels of PCBs and dioxins may be found in fatty tissues such as liver, and as a consequence, fish liver oils. It is believed that 90 per cent of human exposure to dioxins and PCBs occurs as a result of consuming foods containing these contaminants. The presence of dioxins and PCBs in food has been a concern for many years, particularly following the dioxin crisis which occurred in Belgium in 1999, when industrial transformer oil containing dioxins was included in fat that was being recycled for animal feed. This resulted in the contaminants entering the food chain. A similar incident happened in Ireland in 2008, which lead to contamination of pigmeat and to a lesser extent, beef (79).

Of the 75 PCDDs, 135 PCDFs and 209 polychlorinated biphenyl (PCB) congeners that have been identified, seven PCDDs, ten PCDFs and 13 PCBs are thought to have biological effects similar to technical dioxin, 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (TCDD). In addition, certain brominated and mixed chlorinated/ brominated congeners are known to induce comparable biological and toxic responses. This has facilitated the development of a 'toxic equivalency' approach in which the toxicity of mixtures of these compounds relative to TCDD can be determined. This is recorded as 'toxic equivalents', or 'TEQs', and since the WHO has been instrumental in determining TEQs for each compound, the toxic equivalents are generally reported as 'WHO-TEQs' (80, 81). Although several different Toxic Equivalence Factor (TEF) schemes have been proposed, the most commonly used scheme is that of WHO-TEQs, which was developed by the WHO-ECEH (European Centre for Environment and Health of the World Health Organisation). Although these have been updated by WHO-ECEH recently, the scheme is not yet widely in use (79).

Toxic effects of dioxin and dioxin-like PCBs

Consensus has not been reached regarding the carcinogenic potential of dioxin. The 1985 US Environmental Protection Agency (EPA) report confirmed that dioxin is a cancer hazard to humans and reaffirmed its position in 2003 that there is no known 'safe dose' or 'threshold' below which dioxin will not cause cancer (82). This position is currently contested by other agencies within the US and the EU including the US National Academy Research Council (83). In 1997, TCDD was classified as a class 1, or 'known human', carcinogen by the International Agency for Research on Cancer which is part of the WHO (84). In 2001, the US National Toxicology Program upgraded TCDD from 'Reasonably Anticipated to be a Human Carcinogen' to 'Known to be a Human Carcinogen' (85). In contrast, the UK Committee on Carcinogenicity (COC) reaffirmed in 2001 its earlier conclusion that TCDD should be regarded as a 'probable human carcinogen' (86). However, expert bodies such as the EU Scientific Committee for Food (SCF) and WHO are of the opinion that the carcinogenic effects of dioxins do not occur at levels below a certain threshold (79). In addition to cancer, exposure to dioxin is associated with a number of toxic manifestations including effects on reproduction, diabetes, learning disabilities, immune system suppression, lung problems, skin disorders and lowered testosterone levels. The reproductive and developmental effects are severe and manifest at much lower levels than those associated with cancer. Dioxin is a known endocrine disrupter but is not known to be genotoxic.

Dioxin behaviour in the aquatic environment

Dioxin accumulates in the environment including aquatic sediments or material suspended in water. In aquatic sediments, the persistence half-life of TCDD in lake water has been estimated to be more than and may be greater than 50 years. TCDD is generally resistant to biodegradation (87).

Dioxin bioconcentrates in aquatic organisms, however, this varies considerably within and between species. Bioconcentration is also influenced by the dioxin compound as well as the fat content, age and size of the aquatic organisms exposed, and migration, spawning and feeding patterns (88). TCDD bioconcentrates up to 64, 000 times in fish (89). In 1999, the UK Ministry of Agriculture, Fisheries and Food (MAFF) published the results of a survey for dioxins, furans and PCBs in samples of fish taken during the previous years (90). Table 4.1 shows the concentrations of these compounds in terms of toxic equivalents of TCDD (91).

Estimated tolerable daily intake for dioxin and dioxin-like PCBs

The UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) considered a number of toxicity studies when establishing a tolerable daily intake (TDI) for dioxin and dioxin-like PCBs. One study on the developmental effects of TCDD identified the lowest critical toxicity endpoint as a decrease in sperm count in rats (92). A TDI of two pg[8]/kg bw/day for women of childbearing age was derived based on long-term intake. The COT considered this value appropriate as a TDI for dioxins and dioxin-like compounds and concluded that it was protective against other adverse effects including carcinogenicity. The TDI was reconfirmed in the COT statement of 2007 (93). The TDI is a conservative estimate and broadly agrees with the WHO, EU Scientific Committee on Food (SCF) and the Joint FAO/WHO Expert Committee on Food Additives (JECFA) recommendations. However, it was considered that, for other segments of the population, an alternative and less stringent safety guideline would be appropriate. In this regard, a 'guideline level' for long-term average intake of eight pg WHO-TEQ/kg bw/day was derived from the outcome of a rat carcinogenicity study (94). It was considered that this level of exposure would not be associated with an appreciable increase in cancer risk.

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[8] pg = picograms

Table 4.1 Concentrations (ng[1] WHO-TEQ/kg fresh weight) of dioxins, PCBs and dioxins and PCBs combined from marine fish landed or imported into the UK during 1995/96.

Species	Dioxin		PCBs		Dioxin & PCBs combined	
	Mean	Range	Mean	Range	Mean	Range
UK Landed						
Cod	0.04	0.01-0.08	0.08	0.01-0.30	0.12	0.03-0.38
Haddock	0.03	0.01-0.07	0.03	0.01-0.06	0.06	0.03-0.10
Plaice	0.28	0.06-0.52	0.47	0.17-0.84	0.75	0.23-1.27
Whiting	0.04	0.01-0.08	0.11	0.01-0.33	0.14	0.02-0.38
Herring	2.44	0.34-3.76	6.15	0.46-10.38	8.59	0.8-13.85
Mackerel	0.66	0.14-1.70	2.45	0.34-6.02	3.11	0.48-7.49
Salmon	0.82	0.62-0.99	2.38	1.28-2.99	3.20	2.15-3.95
Trout	0.27	0.07-0.74	0.86	0.22-2.35	1.13	0.30-3.09
Imported						
Cod	0.03	0.01-0.09	0.05	0.01-0.16	0.09	0.03-0.25
Haddock	0.03	0.01-0.05	0.03	0.01-0.08	0.06	0.02-0.13
Plaice	0.30	0.25-0.34	0.46	0.32-0.64	0.76	0.57-0.94
Salmon	0.57	-	2.03	-	2.60	-
Red fish	0.50	0.40 - 0.59	1.51	1.42 - 1.59	2.00	1.82 - 2.18

[1]ng = nanograms

NB: Total concentrations of dioxins and PCBs may not equal the sum of individual dioxins and PCBs values due to rounding, and because the highest and lowest concentrations of dioxins and PCBs were not always found in the same samples.

Note: The 'guideline level' for long-term average intake is 8pg WHO-TEQ/Kg bw/day.

Estimated body burden of dioxins in the ROI and the UK

The estimated half life of TCDD in the human body is seven years implying a considerable bioaccumulation potential. The level of dioxins in human breast milk is accepted as a proxy for the total dioxin body burden, not only for nursing mothers, but for the general population. Human milk contains, on average, about four grams of lipid per 100 ml, and many lipid-soluble compounds, including dioxin and dioxin-like PCBs, that are present in mother's adipose tissue, will also be present in the milk. It is assumed that these levels are representative of those in plasma, serum lipid and adipose tissue and reflect the overall body burden. A number of studies have looked at the levels of dioxins in breast milk (95-102). Studies conducted in Birmingham and Glasgow in 1987/1988 and 1993/1994 have shown a decrease in the breast milk dioxin concentration with time (101, 102). A similar trend was evident in other EU and non-EU countries from the mid 1970's to the late 1990's (97-100). This corroborates with US data indicating a peak in exposure to dioxin-like compounds during the 1960s followed by a year on year decline ever since (80).

In the ROI, dioxin levels in human breast milk were investigated as part of a WHO co-ordinated study in 2001-2003 (95). A level of 7.72 pg/g fat was recorded for PCDDs/PCDFs (WHO-TEQ; range 6.19 to 8.82), 4.57 pg/g fat for dioxin-like PCBs (WHO-TEQ; range 2.72 to 5.19) and 60 ng[69]/g fat total indicator PCBs (range 41 to 65). The PCDDs/PCDFs levels in the ROI samples were comparable to those in the US, Norway and the Czech Republic and lower than those recorded in the other western European countries investigated [the UK did not participate in this study). The ROI dioxin-like PCB and total indicator PCB levels were amongst the lowest of the European values in the 26 countries investigated (95)].

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[69] ng = nanogram

Dioxin exposure via dietary intake

Humans receive approximately 90 per cent of their total daily intake of dioxin and dioxin-like chemicals via their food. In the US, the best estimate of PCDD/PCDF and dioxin-like PCB intake in adults from the late 1990's was 43 and 23 pg WHO-TEQ, respectively, giving a total of 0.9 pg WHO-TEQ/kg[70] bw/day[71] based on an average adult body weight of 75 kg (82). The intake of dioxin and dioxin-like chemicals varies considerably with age; current intake in children aged one to five years is estimated to be 3.3 pg WHO-TEQ/kg bw/day, while values for the six to eleven and 12 – 19 year age groups show the decreasing trend with increasing age with average intakes of 1.8 and 1.1 pg WHO-TEQ/kg bw/day, respectively. As in the US, studies in Britain clearly show a decreasing dietary intake of dioxin and dioxin-like chemicals on a per weight basis with increasing age (103-107). The dietary intake level of dioxin and dioxin-like chemicals in the diet of the population on the IOI has not been determined.

Dioxin exposure via dietary intake of fish

The European Commission set maximum limits for certain environmental contaminations in food in Commission Regulation 1881/2006/EC as amended by Commission Regulation 629/2008/EC. Currently maximum limits are set in fisheries products for three trace metals (mercury, cadmium and lead), dioxins (PCDD/Fs), dioxin-like PCBs, and benzo (a)pyrene as an indicator of PAH contamination (108). Within the EU, Regulation 2375/2001 amending Regulation 466/2001 establishes the maximum limits for PCDD/Fs in muscle meat of fish and fish products (4 pg WHO-TEQ /g wet weight) and fish oil intended for human consumption (2 pg WHO-TEQ /g fat). Regulation 199/2006 confirms these limits but establishes a limit for total PCDD/Fs and dioxin-like PCBs of 8 pg WHO-TEQ /g wet weight with a higher value for eel (12 pg WHO-TEQ/g wet weight). Table 4.2 below gives an overview of the maximum levels in the edible portion of fisheries products for human consumption (108)

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70 kg = kilogram

71 bw/day = body weight per day

Table 4.2 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 Regulation 629/2008/EC [adapted from McGovern *et al.* (2011) (108)]

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

The FSAI conducted an investigation into the levels of dioxin and dioxin-like PCBs in each of 15 samples of wild salmon, farmed salmon and farmed trout, three samples of fish oil and 12 samples of cod liver oil (109, 110). The analyses focused on seven PCDDs, ten PCDFs and 14 dioxin-like PCBs. Wild salmon, farmed salmon and farmed trout were found to contain low levels of dioxins and dioxin-like PCBs. The dioxin levels were all less than the EU maximum limit of 4 ng WHO-TEQ/kg wet weight. The results indicated that farmed salmon had higher levels of dioxin than wild salmon, with wild salmon and farmed trout having comparable levels. Dioxin-like PCB levels were slightly higher than the dioxin levels in the same sample. Again these were highest in farmed salmon. All levels were less than the EU maximum limit of 8 ng WHO-TEQ/kg wet weight. Similar in 2002, the FSA carried out a survey on dioxins and dioxin-like PCBs in fish oil supplements (111). The authors reported an upper intake level in the range of <0.1 to 7.1 pg WHO-TEQ/kg bw/day. They noted that certain fish oil supplements, if taken at the recommended daily dose, would lead to a higher intake of dioxin than would be obtained from dietary sources. This broadly agrees with the FSAI findings.

Between 2004 and 2006, the FSAI, Marine Institute and BIM carried out a surveillance study of levels of dioxins, furans, PCBs and brominated flame retardants (BFRs) specifically polybrominated diphenylethers (PBDEs) and hexabromocyclododecane (HBCD), in a variety of fish species and fishery products including fresh and processed products available on the Irish market (112). The authors found that the levels of PCDDs and PCDFs in Irish fish and fishery products available on the Irish market were well below existing EC legal limits. The lowest level was found in a sample of canned tuna (0.012 ng WHO TEQ/kg whole weight) with the highest level found in a farmed salmon sample (0.82 ng WHO TEQ/kg whole weight). The levels were also below the new limits for dioxin-like PCBs and for the sum of WHOTEQs for PCDDs, PCDFs and dioxin-like PCBs. Overall the findings were similar to the FSAI survey in 2002 (112).

The most recent survey of fish from the UK showed low levels of dioxins and PCBs in all samples analysed with only sporadic individual or composite exceedances of the maximum limits (113). In the review of dioxin intake from the consumption of fish and shellfish, the COT (UK) based its conclusions on the highest intake estimates of dioxin and dioxin-like PCBs which were recorded in the 1997 total diet study namely, mean and high-level intake estimates of 1.7 and 3.1 pg WHO-TEQ/kg bw/day, respectively (114). The most recent estimate of exposure of the UK population from the consumption of fish was made in 2002 which gave mean and high-level intake estimates of 0.9 and 1.7 pg WHO-TEQ/kg bw/day, respectively (115). Average and high-level exposures were calculated for a number of fish species. The mean daily adult consumption of fish was calculated to be 31.8 g/day which was associated with an upper exposure estimate of 0.6 pg TEQ/kg bw/day. This increased to 3.9 pg TEQ/kg bw/day for high-level consumption of 90.1 g/day.

Scientific opinions

The UK Committee on Toxicology (COT) based its recommendations for dioxins on the TDI and guidance level (GL) values of 2 and 8 pg WHO-TEQ/kg bw/day, respectively (114). The former value is protective of the most sensitive group, namely the developing foetus while the latter value is thought to be sufficiently protective of the general population following a lifetime's exposure. In this context it is clear that, for certain species of fish (such as herring and eel), even the consumption of one portion per week could result in a breach of the TDI. Of course the TDI is based on long-term exposure and short-term exceedences may be devoid of any real threat of adverse health effects. It is, however, impossible to specify the duration or magnitude of such a short-term exceedance (113). It is worth noting that the estimated dietary intake of dioxin and dioxin-like PCBs from oily fish was based on an assumed adult body weight of 60 kg which is rather low for a western population. In addition, these estimates are based on data collected over a decade ago and dioxin levels are known to have decreased significantly in most matrices during this period.

The risk of adverse health effects may be even lower for consumers on the IOI. The IOI and UK dietary surveys suggest that fish consumption is similar, possibly lower on the IOI. If we assume that consumption reflects marketing data, then the BIM market analysis for May 2005 gives a rough indication of the prevalence of particular species in the diet in the ROI (34). This indicates a predominance of salmon and white fish such as haddock and cod. Importantly, herring, which has consistently registered one of the highest readings for dioxin and dioxin-like PCBs, is not listed while kippers constitute a very small proportion of filleted fish (0.6 per cent of the total volume) and smoked fish (3.3 per cent of the total volume).

The COT recommendations did not distinguish between farmed and wild fish (111). That said, a study conducted in 2004 of contaminants in salmon (116) reported similar levels of dioxin and PCBs in UK farmed salmon to those found in the 1998 MAFF study (106). The 2001 FSAI study registered increased levels of dioxin and dioxin-like PCBs in farmed salmon albeit based on a small sample size. In their safety assessment of wild and farmed fish, the European Food Safety Authority (EFSA) were unable to reach a definitive conclusion with regard to differences in the levels of dioxin, dioxin-like PCBs and non-dioxin-like PCBs in wild and farmed salmon and trout (117). This was due to the limitations of the database. However, the report suggested that levels in farmed fish were certainly more controllable since these depended on the levels in the constituents of fish feed (118). The possibility of reducing the contamination risk by substituting fish feed constituents with others thought to carry a lower contamination risk was discussed. It was noted that this could compromise the nutritional quality of the farmed fish. Sourcing the same constituents from other, less contaminated, sources was also discussed and this procedure is current practice in the farmed fishing industry on the IOI (118, 119).

Brominated flame retardants (BFRs)

Background

BFRs are widely used in the plastic, polymer, electrical appliance and textile industries as fire retardants. Three classes of BFRs are currently produced in high volumes: PBDEs, tetrabromobisphenol A (TBBPA), and HBCD. BFRs are precursors of polybrominated dibenzo-p-dioxins (PBDDs) and polybrominated dibenzofurans (PBDFs) and there is evidence that they are converted into these compounds under certain environmental conditions (120-123). Like the dioxin group of compounds, BFRs have been shown to be persistent organic pollutants (POPs) in the environment and to bioaccumulate in biota, especially at the higher trophic levels in the food chain. The half lives of many of these compounds in environmental matrices is substantial: for instance, HBCD has a half life of up to 25 days in water and has been extracted from sediments that are several decades old (124, 125). Although production of several PBDEs has been banned in the EU and is being phased out in the US, a large number of products containing these flame retardants are still in use. Therefore, release into the environment will continue throughout product lifecycles, potentially for several more decades. Within the PBDEs as a group, the lower brominated congeners are the most toxic and accumulate at the highest rates and levels in wildlife and human tissue samples (122). Higher brominated PBDEs undergo degradation in the environment to the more persistent and toxic lower brominated congeners. This has also been shown to occur *in vivo* (126, 127).

Toxicology

The toxicological information available on BFRs is incomplete. The bulk of the information obtained to date has come from animal studies. Adverse effects following acute exposure to BFRs have not been documented. Several adverse effects on health have been recorded after chronic exposure including neurobehavioral toxicity, endocrine disruption (thyroid hormone disruption and possible estrogenic activity), immunotoxicity, possible carcinogenicity, and developmental and reproductive effects (118, 124, 128, 129). A ‘No Observed Adverse Effect Level’ (NOAEL) for neurodevelopmental toxicity of these compounds has not been established. A TDI has not been established. There are no data on the toxicity of exposure to mixtures of BFRs.

Exposure and body burden

BFRs have been detected in human tissues including blood, fat and breast milk even in individuals with no known exposure (122, 130). Human exposure is primarily via ingestion of contaminated material although inhalation of contaminated particles may also contribute to total exposure (126, 131). Dietary exposure is thought to occur primarily through the consumption of contaminated fish and also meat, eggs and fatty foods such as dairy products, fats and oils. Studies estimating dietary exposure of BFRs are limited.

The congener pattern for most fish samples is similar to the congener profiles found in humans who consume fish, with a predominance of tetra-BDE and penta-BDE. This suggests fish as a significant dietary source of PBDEs and consequently a significant contributor to the body burden of lower brominated congeners (130).

Concentrations in fish

BFRs, in particular the lower brominated congeners, bio accumulate in fish. There is also evidence for the metabolism of higher brominated PBDEs to lower brominated PBDEs in fish (132-136). PBDEs have been detected in freshwater fish (median 48 ng/g lipid) (137). In a Swedish study, HBCD was detected in all environmental and biotic matrices analysed with relatively high concentrations detected in herring (7-51 ng/g lipid) (132). Studies from the US, where PBDEs are still manufactured, show much higher levels. One study which focussed on fish bought in supermarkets returned PBDE levels ranging from 8.5 to 3078 pg/g wet weight (median 1725 pg/g wet weight) (138).

In the ROI, the MI sampled a total of seven individual farmed salmon from seven different salmon farms as part of its 2004 sampling programme (139). PBDEs and HBCD were detected in all samples, although for a number of these congeners concentrations were less than the analytical Limit of Quantitation (LOQ). The upper mean concentration for the sum of the 17 PBDEs was 3.05 ± 0.58 µg/kg while that for HBCD was 1.17 ± 0.26 µg/kg. Based on dietary differences, it was considered that wild salmon would have lower levels of these compounds (farmed salmon feed is usually high in fish oil, which is a source of BFRs). The FSAI and MI repeated this analysis in 2007 and levels were broadly similar to those from the 2004 study (140). The UK FSA has analysed samples of trout and eel from the Skerne-Tees river system (95). (This area was chosen based on earlier studies which confirmed the presence of PBDEs and HBCD in fish samples taken from the North Sea originating from a point source of pollution in the Skerne-Tees catchment area (141-143)). Concentrations of up to 197 and 288 µg PBDE /kg wet weight were recorded in trout and eel, respectively, while concentrations of HBCD in these species were up to 6758 and 9432 µg/kg wet weight, respectively (129).

Scientific opinions

The EU policy of eliminating BFRs, which commenced in the early 1990's, would appear to have contributed to a lower body burden of BFRs in the European consumer compared to their counterpart in the US (138, 144, 145) . In the UK, the COT tentatively concluded that (based on worst case scenario) the available toxicological data does not indicate an appreciable health risk to the adult or the developing foetus following exposure to BFRs (146).

BFR levels in the ROI farmed salmon (as measured in the 2007 FSAI/MI study) were over one order of magnitude lower for PBDEs and three orders of magnitude lower for HBCD than those levels recorded in the FSA study. This indicates an even greater safety margin for consumers of farmed salmon than that on which the UK COT based its most recent advice. The ROI report concluded that the levels determined were very unlikely to present a health risk to Irish consumers. Nonetheless, the COT has recommended continued surveillance, particularly in fatty foods, of those BFR compounds which are not due to be phased out (91).

Pesticides of concern in finfish

Background

The removal of certain pesticides from the EU market has been based on a number of criteria including the potential for bioaccumulation and persistence in the environment (147). Those of most concern are the organochlorine compounds. The Stockholm Convention on POPs, which came into force in 2004, has called for the total elimination of organochlorine pesticides such as aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, dichlorodiphenyltrichloroethane (DDT) and toxaphene (all POPs) and also dioxins, furans and PCBs (148).

Surveillance in the EU

Although the levels of persistent pesticides in the environment are decreasing, a number of compounds continue to present a contamination concern, particularly in finfish species. Persistent pesticides can bioaccumulate in the fatty tissue of finfish.

The EFSA report on the safety of wild and farmed fish (117) focussed on two pesticides, namely camphechlor and hexachlorocyclohexane. Camphechlor is a non-systemic contact and stomach insecticide which was used as a replacement for DDT in the 1970's. Relatively high levels have been detected in fish, fish oil, marine mammals and sea birds. Liver, thyroid, kidney and immunological effects as well as developmental and reproductive toxicity have been recorded (149). Hexachlorocyclohexane (HCH) is also an insecticide and is associated with liver hyperplasia and/or liver tumours as well as neurotoxicity and weak estrogenic activity (150). It is rapidly absorbed following ingestion and has been detected in breast milk.

Surveillance in the ROI

In the ROI the MI monitors organochlorine pesticides in fish on a regular basis including DDT and its metabolites, hexachlorocyclohexanes (e.g. lindane), hexachlorobenzene, aldrin, dieldrin, isodrin, endrin, transnonchlor and chlordanes. Farmed fish are tested for sea lice treatments including cypermethrin, deltamethrin, ivermectin, emamectin, teflubenzuron and diflubenzuron. The MI has also determined the occurrence of the organochlorine pesticide, toxaphene, in waters off the IOI coast in 2003, although this compound is not routinely included in the testing programme (151). Toxaphene has been banned in the US since 1982 based on its environmental persistence, bioaccumulation potential and carcinogenic properties (152). A Maximum Residue Level (MRL) of 0.1 mg/kg has been established in Germany and Austria while the Canadian authorities have established an Acceptable Daily Intake (ADI) of 0.2 μg/kg bw/day (153-155).

The investigation into the Monitoring, Analysis and Toxicity of Toxaphene in Marine Foodstuffs report of 1998, proposed a TDI of 6.9 μg/kg bw/day based on tumour promotion potency (156). Previous studies have shown toxaphene levels in fish samples from the European Atlantic in excess of this MRL value (157). In the ROI, one study revealed that among 55 samples from a number of marine species (including 15 open ocean and deep sea finfish species) analysed for three indicator toxaphene congeners, highest concentrations were observed in farmed fish and in deep sea species. This reflects higher lipid content and increased longevity in these species, respectively. No sample exceeded the MRL of 0.1 mg/kg. Lipid-normalised residue values did not show a geographical variation but values for farmed fish were again clearly elevated.

Using BIM consumption data from 1998 (158), the average daily fish consumption in ROI was estimated at 24.1 g/day resulting in a toxaphene exposure of 0.3 μg/day. The IUNA study, however, determined an upper consumption estimate for fish of 86 g/day (159). This intake level will still give a toxaphene exposure less than the Canadian ADI. No adverse health effects were predicted from the consumption of fishery products in the ROI. As part of the 2009 National Residue Monitoring Programme, 126 aquaculture samples were analysed for organochlorine and organophosphorus compounds. There were no non-compliances (160).

Surveillance in Northern Ireland (NI)

DARD monitors organochlorine pesticides in fish. Among the compounds routinely analysed are aldrin/dieldrin, endrin, alpha, beta, and gamma-HCH, hexachlorobenzene, heptachlor (inc. heptachlor epoxide), DDT (inc. pp-DDD, DDE, DDT and op-DDT), chlordane (inc alpha-, gamma- and oxychlordane) and endosulfan (inc alpha- and beta-endosulfan and edosulfan sulphate). This can be expanded to include other compounds as well.

Perfluoroalkylated substances

Background

Fluorine is the most electronegative and consequently, most reactive element in the periodic table. Due to its high level of reactivity, it cannot be found in nature in its elemental state. Fluorine exists as either inorganic fluorides or as organic fluoride compounds, with the former being much more abundant in the global environment (161). The first major source of inorganic fluorides is the weathering of fluoride minerals (such as fluorapatite, fluorite and cryolite). Volcanoes are regarded as the second major natural source (through release of gases with hydrogen fluoride) into the atmosphere, followed by marine aerosols. Volcanoes are believed to release 60-6,000 kilotonnes of inorganic fluorides into the atmosphere, whereas marine aerosols release approximately 20 kilotonnes of inorganic fluorides per year (162). The digestive system is the main route of fluoride intake. After ingestion, about 75-90 per cent is absorbed into the gastrointestinal tract, and transported by the blood and accumulated in teeth and bones. Fluoride can be found in many foodstuffs, with some foods (e.g. fish) containing higher levels of fluoride than others. Although fluoride is an essential microelement for animals and humans, as it protects against dental caries (particularly in childhood), excessive exposure can damage the skeletal tissues (163).

In recent years, there has been a lot of attention on perfluoroalkylated substances. These are fluorinated compounds that are notable for their chemical inertness and have a wide ranging industrial application, especially in the plastics and fabric industries (164). All of these compounds are anthropogenic and are found widely in the environment. Two of these compounds in particular have given cause for concern following revelations as to their prevalence in foodstuffs, especially fish. These are perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA).

Toxicology

In animal studies, PFOS has been shown to cause liver, thyroid, blood and developmental toxicity while PFOA is associated with liver, developmental and reproductive toxicity. Both compounds are possible endocrine disruptors (165). While both compounds have been shown to cause liver tumours in rats by non-genotoxic modes of action, the epidemiological evidence from exposed workers shows no increased cancer risk. There is tentative epidemiological evidence for an association between PFOA exposure and disturbances in blood parameters including cholesterol, triglyceride and thyroid hormone levels and also reduced birth weight. EFSA has established a Tolerable Daily Intake (TDI) of 150 ng/kg bw per day for PFOS. and 1500 ng/kg bw per day for PFOA (166).

Fluoridated compounds in the aquatic environment – occurrence and toxicity

In water, inorganic fluorides for the most part remain in solution as fluoride ions under conditions of relatively low pH and hardness. These fluoride ions usually remain in solution even in the presence of ion-exchange materials such as bentonite clays and humic acids (162). However, they may be removed from water by the precipitation of calcium carbonate, calcium phosphate, calcium fluoride or magnesium fluoride. Aquatic organisms living in soft waters may be more susceptible to fluoride pollution than those living in hard or seawaters. This is because the bioavailablity of fluoride ions is reduced with increasing water hardness (161).

Fish can take up fluoride directly from the water or to a much lesser extent, from food. This uptake is a function of fluoride concentration in the aquatic medium, exposure time and water temperature (167). Although fluoride can be eliminated (as F^- ions) via excretory systems of fish, it can cause hardening of hard tissues (mainly in marine crustaceans), due to the combination of fluoride with calcium and phosphorous to give fluorapatite (168). It has long been known that the toxic action of fluoride on the health of animals (both aquatic and terrestrial) resides in the fact that fluoride ions act as enzymatic poisons. Conversely, they inhibit enzyme activity and as a consequence, interrupt metabolic processes such as glycolysis and synthesis of proteins (169).

Concentrations in fish

Fish and fish products are a significant source of exposure to perfluoroalkylated substances for humans (170). PFOS and PFOA have been found in fish samples in European marine and inland waterways. In the 2008 FSA survey, PFOS, PFOA and other PFCs were found mainly in fish, shellfish, crustaceans and offal food groups (171). Both PFOS and PFOA have been shown to bioaccumulate in fish. However, it is worth noting that concentrations in fish liver are consistently higher than in fish muscle (165). No tolerable limits for PFOS or PFOA or other perfluoroalkylated substances have been established for fish meat.

Exposure and body burden

Although perfluorinated compounds are amphipathic in nature and tend not to accumulate in fatty tissue, PFOS and PFOA are exceptions to this rule and both bioaccumulate in humans. Seafood consumption is one of the main determinants of human body burden for a range of perfluoroalkylated substances including PFOS and PFOA. This is especially true in areas of industrial pollution such as the Baltic Sea (172). Exposure can occur from food and non-food sources, the latter being more important for childhood exposures. Indicative estimates of dietary exposure to PFOS are 60 ng/kg body weight (bw) per day for average consumers increasing to 200 ng/kg bw per day for high fish consumers. Although high fish consumers may exceed the TDI, as yet, there is considerable uncertainty around these estimates. Indicative estimates of dietary exposure to PFOA are two ng/kg body weight (bw) per day for average consumers increasing to six ng/kg bw per day for high fish consumers although higher fish consumption do not necessarily translate into higher PFOA exposures. Both exposure estimates are well below the TDI. In the 2008 FSA survey on fluorinated chemicals in food, the estimated average adult dietary intake for both PFOS and PFOA was 10 ng/kg bw/day with high level dietary exposure estimated at 20 ng/kg bw/day. These are well below the EFSA TDIs (171).

Scientific opinions

Increased regulation of PFOS/PFOA worldwide together with successes in finding suitable industrial alternatives should result in a decrease in environmental and consequently human exposure levels. The 2008 FSA survey did not detect PFOS/PFOA or other perfluorinated compounds at levels that would be considered 'highly contaminated'. EFSA have concluded that adverse health effects due to PFOS or PFOA exposure in the general population are unlikely, but noted uncertainties with regards to the developmental effects of PFOA. The Authority has called for more data on the pathways of human exposure and levels in food in order to monitor trends in exposure.

4.1.2 Heavy metals

Trace metals in the aquatic environment – occurrence and toxicity

Trace metals occur naturally in the earth's crust and seepage into water bodies is therefore inevitable. Naturally occurring levels have been augmented by anthropogenic activities, including the burning of fossil fuels and various industrial processes. Several trace metals are essential for human health including chromium, copper, iron, manganese and zinc. Other trace metals such as arsenic, cadmium, lead and mercury are not essential for normal metabolism and can be toxic at low concentrations.

In aquatic environments, trace metals can enter the food chain and biomagnify with increasing trophic level. The degree of contamination in fish will depend not only on the type of exposure but also on the trophic level that the species occupies, as well as any species-specific physiological attributes that influence the body burden of trace metals (173). Of the non-essential trace metals, arsenic, cadmium, lead and mercury are known to bioaccumulate in finfish.

Mercury can undergo biotransformation into organic forms by anaerobic bacteria in the aquatic environment. The organic forms of mercury, especially methylmercury, are fat soluble and have the potential to bioaccumulate. Therefore, these provide greatest cause for concern with regard to human health. Mercury can accumulate in certain body organs such as the brain, kidney, liver, hair, and skin, especially as a result of chronic exposure. The biological half life of methyl mercury is approximately

65 days. The symptoms of mercury poisoning develop some time after exposure and are non-specific. The neurological, gastrointestinal and renal systems are most commonly affected. Organic mercury can cross the placenta and induce spontaneous abortion or teratogenic effects, even in the absence of clinical signs of toxicity in the mother. There is evidence of adverse effects on cognitive development following exposure *in utero*.

Aquatic burdens of arsenic, cadmium and lead can also exist in both organic and inorganic forms. Unlike mercury, the organic forms of cadmium and arsenic are less toxic than the elemental forms, while the organic and inorganic forms of lead have similar toxicities. Lead exposure results in disturbances in the haematopoietic and nervous systems, as well as kidney damage. Inorganic arsenic also causes adverse effects on the haematopoietic system as well as skin and lung irritation. Both organic and inorganic arsenic and cadmium are associated with adverse effects on the nervous system and gastrointestinal tract. Cadmium exposure also results in adverse effects on the immune system, bone and kidneys. The genotoxic potential of both arsenic and cadmium has been verified and both elements are associated with an increased risk of developing certain types of cancer. All three elements have adverse effects on reproduction, lead being the most potent. Lead exposure has also been linked to behavioural disturbances in children who were exposed *in utero*.

Regulatory exposure limits

Within the EU, the maximum permitted level of total mercury in fish meat is 500 µg/kg wet weight for most species, and 1 mg/kg for specific fish species, including tuna (174). Similarly, the maximum permitted level of cadmium in fish fillets is 50 µg/kg for most species, and 100 µg/kg for certain species of fish. The EU maximum permitted level for total mercury, cadmium and lead in fish feed is 100, 500 and 5000 µg/kg, respectively. Two maximum permitted levels have been determined for organic and inorganic arsenic, 6000 and 2000 µg/kg, respectively (175).

Based on information obtained during occurrences of mercury (methylmercury) poisoning in Japan and Iraq, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) concluded that adverse effects of methylmercury in adults are manifested in the most sensitive individuals at blood levels of 200-500 µg/L and hair levels of 50-120 µg/g corresponding to a body burden of approximately 500-800 µg/kg body weight. In 1972, JECFA established a Provisional Tolerable Weekly Intake (PTWI) of 300 µg of total mercury per person of which no more than 200 µg should be present as methylmercury (expressed as mercury); these amounts are equivalent to 5 µg and 3.3 µg, respectively, per kg of body weight (176). In 2003, JECFA revised this PTWI to 1.6 µg/kg bw/week in order to be protective of the developing foetus.

The UK COT has endorsed the JECFA PTWI values of 3.3 µg/kg bw/week methylmercury for adults and 1.6 µg/kg bw/week for the developing foetus. It considers the US EPA reference dose of 0.7 µg/kg bw/week (for adults) to be over-protective. This value was based on evidence from the Faroe Islands linking exposure to mercury through consumption of whale meat to subtle, yet adverse, neurophysiological changes in children (177). A similar study in the Seychelles found no adverse effects from fish consumption alone (178). JECFA has also established PTWIs for inorganic arsenic, cadmium and lead – namely 2.14, 1.0 and 3.6 µg/kg bw/day.

Trace metal levels in finfish on the IOI

While mercury in food other than fish is usually present at concentrations below 60 µg/kg, most species of oceanic fish have mercury levels of approximately 150 µg/kg. The large carnivorous species (e.g. swordfish and tuna) usually fall in the range of 200-1500 µg/kg. With few exceptions, methylmercury accounts for virtually all the mercury in both freshwater and marine fish.

Regulation 78/2005/EC established maximum permissible limits for mercury, lead and cadmium in fish meat while national standards for copper and zinc were those established by Norway and the UK, respectively, who are signatories to the Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR). Since no limits have been established at EU or national level for the concentration of chromium, nickel or silver in fish meat, the default is the limit of detection or quantification (Table 4.3).

The most recent published estimate of the trace metal content in edible fish tissue in the ROI was made in 2003, when 45 samples from 22 finfish species were analysed for trace metal content (Table 4.3) (179). The samples were taken from finfish landed at five fishing ports – Castletownbere, Dunmore East, Howth, Killybegs and Rossaveal. The analyses focussed on eight trace metals, though not all samples were analysed for all eight metals. Arsenic analysis was not conducted during this survey.

Table 4.3 Regulatory maximum permissible levels, national guidance values and default guidance values for certain trace metals in finfish species.

Contaminant	Limit in fish muscle meat (g/kg wet weight)	Limit in selected species (g/kg wet weight)	Selected species
Regulation 221/2002/EC			
Mercury	500	1,000	*
Lead	200	400	**
Cadmium	50	100 (300 in swordfish)	***
OSPAR			
Copper	10,000 (Norway)		Guidance value
Chromium	70/190		LOD/LOQ
Nickel	60		LOD
Silver	10		LOD
Zinc	50,000 (UK)		Guidance value

Note: No limits have been established at EU or national level for the concentration of chromium, nickel or silver in fish muscle. In this case the limit of detection (LOD) is the default limit.

*Anglerfish, Atlantic catfish, Bass, Bonito, Eel, Emperor or Orange roughy, Grenadier, Halibut, Marlin, Megrim, Mullet, Pike, Plain bonito, Poor cod, Portuguese dogfish, Rays, Redfish, Sail fish, Scabbard fish, Seabream, Shark, Snake mackerel or Butterfish, Sturgeon, Swordfish, Tuna

**Bonito, Common two-banded seabream, Eel, Grey mullet, Grunt, Horse mackerel or scad, Sardine, Sardinops, Spotted seabass, Tuna, Wedge sole

***Bonito, Common two-banded seabream, Eel, European anchovy, Grey mullet, Horse mackerel or scad, Louvar or Luvar, Sardine, Sardinops, Tuna, Wedge sole

In this analysis (Table 4.4), mercury was detected in all fish species investigated, regardless of their origin. A breach of the established limit was recorded in dogfish meat landed at Howth (600 µg/kg wet weight). Dogfish is a species of shark and, as such, is a member of a group of fish in which, along with tuna, high levels of mercury accumulation have been shown. However, dogfish is generally not consumed on the IOI and therefore, no public health risk currently exists.

Mercury levels in tuna were not investigated in the 2003 survey as there were no significant landings of tuna species at any ROI ports. Albacore tuna samples (n = five) from a landing in Castletownbere in 1995 were analysed for mercury content which, at 80 µg/kg wet weight, were substantially lower than the EU limit. Tuna (n = 20) analysed as part of the 2002 UK survey of mercury in imported fish and UK farmed fish gave a mean mercury concentration of 400 µg/kg (180). The species of tuna was not described in this report. Several species are known to exist off the coast of the IOI, particularly bluefin and albacore.

In general, no other breaches of EU and other limits for trace metals in finfish meat were recorded in the decade 1994 – 2003.

Salmon (fresh or farmed), sea trout and freshwater trout are routinely monitored under the ROI residue monitoring programme for mercury, cadmium and lead content. There have been no reports of non-compliances of these heavy metals since 2002.

Table 4.4 Trace metal concentrations in finfish meat from samples landed at IOI ports in 2003

Species	Total samples	Total number of trace metal concentrations/ sample	Hg	Pb	Cd	Cu	Cr	Ni	Ag	Zn
			(µg[1]/kg wet weight Edible Tissue)							
Black Sole	4	9-10	30-90	◊	◊	-	-	-	-	-
Dogfish	1	7	600*	◊	◊	1210	220*	◊	◊	2960
Ray	1	10	50	◊	◊	440	◊	◊	◊	3670
Cuckoo Ray	1	9	110	-	-	-	-	-	-	-
Dab	1	8	40	-	-	-	-	-	-	-
Lemon Sole	3	8-10	40-60	◊	◊	440	◊	◊	◊	3500
Megrim	2	10	30-60	-	-	-	-	-	-	-
Plaice	4	8-10	30-80	◊	◊	440	◊	◊	◊	3700-4320
Turbot	1	10	60	◊	◊	◊	◊	◊	◊	3820
Witch	2	7-10	50-80	-	-	-	-	-	-	-
Mackerel	1	9	30	◊	◊	530	◊	◊	◊	3730
Black Pollock	1	10	50	-	-	-	-	-	-	-
Cod	4	2-10	80-100	◊	◊	-	-	-	-	-
Haddock	4	10	40-180	◊	◊	◊	◊	◊	◊	2860
Hake	3	10-11	30-70	◊	◊	440	◊	◊	◊	3230
Monkfish	3	10	80-120	◊	◊	440	◊	◊	◊	3070
Pollock	1	10	60	-	-	-	-	-	-	-
Whiting	5	6-10	50-90	◊	◊	440	190**	◊	◊	2950-3150
John Dory	1	10	110	◊	◊	◊	◊	◊	◊	3360
Red Gurnard	1	8	210	◊	◊	440	◊	◊	◊	3240

Note: ◊ = not detected, - = not analysed

[1]µg = microgram

* Sample landed in Howth

** Samples landed at Killybegs and Dunmore East

In the UK, fresh or frozen salmon was shown to have a mean total mercury content of 50 µg/kg (91). Atlantic salmon in Norwegian farms were sampled and analysed for mercury content on five occasions between 1995 and 2003 giving a contamination range of 15 – 39 µg/kg wet weight (n = 225) (181). Also in the UK FSA survey, the average mercury content in large predatory fish predisposed to the mercury bioaccumulation (including marlin, shark, swordfish and fresh and canned tuna) was 1100, 1500, 1400, 400 and 190 µg/kg, respectively.

Other trace metals

Cadmium and lead were detected in the 2002 MI study but the levels were within EU limits (182). The cadmium and lead contents reported for commercial salmon sampled in Norwegian farms (n = 225) was less than one and 10 µg /kg, respectively (181). Similarly, cadmium and lead levels in fish meat analysed in the UK MAFF multi-element survey of the most commonly consumed fish species were all less than the EC permissible levels. Chromium levels were above the LOQ in dogfish landed at Howth and at the LOQ in whiting landed at Castletownbere and Killybegs. Although as mentioned earlier these are insignificant for human health as dogfish is not a food species. The levels of chromium in whiting correspond to an increase of 58 per cent above the recommended daily allowance of 120 µg /day, assuming that a kilogram of whiting is eaten over 24 hours. This is an unrealistic consumption scenario in the longer-term. Therefore, the recorded levels are probably without any health consequences.

Trace metal exposure via dietary intake

Mercury

Normal or background blood mercury concentration in unexposed individuals is usually less than 0.2 µg/l, the exceptions being those with a high dietary intake of fish. Blood mercury levels are a good indicator of acute (but not chronic) exposure, especially to methylmercury which is readily absorbed and concentrates in the erythrocytes. A high blood:plasma ratio is characteristic of methylmercury exposure. The half life of mercury in blood is approximately 44 days (183). Mercury excretion via the urine is a good indicator of inorganic mercury exposure whereas elimination of organic mercury is primarily via the faeces. No correlation has been established between blood, plasma or urine mercury levels and overt clinical signs of mercury intoxication. However, it has been noted that for chronically exposed workers, urinary levels > 50 µg/l are associated with increased frequency of tremor.

In the UK, the estimated daily dietary exposure to total mercury from all sources for the average adult is 3.1 µg/day (equivalent to 0.044 µg/kg bw/day) and 6.4 µg/day (equivalent to 0.09 µg/kg bw/day) for high-level consumers of fish (Table 4.5) (184). However, high level adult consumers of fish or shellfish were estimated to be exposed to 11 μg/day (equivalent to 0.16 μg/kg bw/day).

A number of studies carried out in the UK have clearly shown the influence of fish species and consumer age on dietary mercury exposure from fish intake (Table 4.6). The NDNS results indicated that 97.5 percent of the population have dietary intakes of mercury less than 1.6 μg/kg bw/week (185).

Table 4.5 Estimated dietary intake of mercury from oily fish and the rest of the diet for an adult of 60 kg bodyweight

	Herring	Mackerel	Salmon	Trout	Fresh Tuna	Swordfish
Concentration[a] (μg /g wet weight)	0.09	0.05	0.05	0.06	0.40	1.40
Intake from one portion fish per week[b] (μg/kg bw/week)	0.21	0.12	0.12	0.14	0.93	3.27
Intake from rest of the diet[c] (μg/kg bw/week)	0.21	0.21	0.21	0.21	0.21	0.21
per cent PTWI or guidance level for methylmercury[d,e]						

Portions per week	Herring		Mackerel		Salmon		Trout		Fresh Tuna		Swordfish	
	%PTWI	%GL	%PTWI	%GL	%PTWI	%GL	%PTWI	%GL	%PTWI	%GL	%PTWI	%GL
1	13	6	7	4	7	4	9	4	58	28	204	99
2	26	13	15	7	15	7	18	8	117	57	408	198
3	39	19	22	11	22	11	26	13	175	85	613	297
4	53	25	29	14	29	14	35	17	233	113	817	396

a Concentrations in oily fish species and cod taken from surveys for mercury in marine fish 1995-97 (cod, herring and mackerel) and 2002 (salmon and trout). Predominantly but not exclusively in the form ofmethylmercury.

b Assumes 140 g portion size for all fish

c Averaged weekly intake of mercury from the non-fish part of the diet (0.06 μg/kg bw/week) and from one portion of cod per week (0.15 μg/kg bw/week). Provided for information, but not included in the comparison with the PTWI and guidance level

d PTWI = 1.6 μg/kg bw/week for methylmercury for susceptible groups

e Guideline level for less susceptible subgroups = 3.3 μg/kg bw/week for methylmercury.

Table 4.6 Estimated intake of total mercury or methylmercury (ng/kg bw/day) from fish in the UK diet

	Toddlers	Age 4 to 6	Age 7 to 10	Age 11 to 14	Age 15 to 18	Adults
Total mercury intake per total population*						
Whole diet	120	110	89	61	51	50
Salmon	26	26	16	13	11	8.6
Canned tuna	120	76	56	46	39	36
Methylmercury intake based on an average portion size**						
Portion size (g)	50	60	85	140	105	140
Fresh tuna	200	170	160	170	94	11
Canned tuna	94	80	74	79	44	54
Shark	750	630	600	630	360	430
Swordfish	660	560	530	560	320	380
Marlin	540	460	430	460	260	310

*Based on consumption data from UK dietary and nutrition surveys.

**Consumption data for shark, swordfish and marlin was not available from NDNS.

Note: Mercury safe limit = 0.5 mg/kg (500,000 ng/ kg) for fish in general, but 1 mg/Kg (1,000,000 ng/ kg) for certain larger predatory species including shark, swordfish, marlin, and tuna. Methylmercury safe limit = 1.6 μg/ kg (1,600ng/kg) body weight (186).

Cadmium and lead

Cadmium exposure is primarily through food consumption and tobacco smoke. In the 1997 UK Total Diet Study, fish were shown to contribute approximately two percent of the total dietary exposure to cadmium and less than one percent of the total dietary exposure to lead (184).

Arsenic

Unlike cadmium and lead, fish is the main source of arsenic in the diet, mostly in the organic arsenobetaine form. In the 1997 UK Total Diet Study, fish contributed 94 per cent of the average population dietary exposure to arsenic (184). The estimated average adult dietary exposure to total arsenic from fish is 1.63 μg/kg bw/day while exposure to inorganic arsenic is 0.008 μg/kg bw/day. For high level consumers, dietary exposure to total arsenic from fish is 4.64 μg/kg bw/day while exposure to inorganic arsenic is 0.023 μg/kg bw/day.

Scientific opinions

Mercury

The US Food and Drug Administration (FDA) has recommended that pregnant women, breastfeeding mothers, and young children should avoid eating fish which are known to have a naturally high mercury content (>1 ppm) including shark, swordfish, and fresh and frozen tuna (these restrictions do not apply to canned tuna which consists of smaller, shorter-lived species with lower mercury levels) (187).

In 2003 the COT in the UK issued advice for consumers, indicating that consumption of one portion of shark, swordfish or marlin per week by adults, and 'occasionally' by children younger than 14 years, was not considered to pose a health risk to these groups even though the JECFA PTWI could be exceeded. Tuna, although not having mercury levels as high as the other species indicated, is far more important for human exposure due to its trophic level and high consumption. Consumption of two portions of fresh tuna or four portions of canned tuna per week (the portion sizes being the same) by women of childbearing age, pregnant women or nursing mothers, was not considered to pose a health risk to the developing foetus or the neonate. The PTWI of 3.3 µg/kg bw/week was considered to be appropriate for breastfeeding mothers as the intake by the neonate would be within the PTWI of 1.6 µg/kg bw/week.

Adverse effects on human health at any life stage are unlikely due to the average and high-level exposures to methylmercury in the different fish species for which consumption data is available. Nonetheless, consumption of a single portion (140 g) of shark, swordfish or marlin per week may result in a breach of the 3.3 µg/kg bw/week guideline which may present a health risk to the developing foetus (Table 4.6).

The COT assessed the contribution made by fish to the total mercury intake of infants (6 to 12 months) and, in so doing, took the precautionary approach of assuming that all exposure was to the more toxic organic form. It concluded that the JECFA PTWI of 1.6 µg/kg bw/week was appropriate as a safety guideline and that the quantities of infant foods consumed would not give rise to health concerns with regard to mercury, or indeed other elements analysed as well. It advised monitoring of mercury levels in infant foods.

The EFSA advice given in its 2005 report on the safety of wild and farmed fish mirrors the advice of UK COT (188). EFSA acknowledged the possibility of some high level consumers of certain species of tuna exceeding the JECFA PTWI of 1.6 µg/kg bw/wk but that, in practice, these consumers would not exclusively eat the bluefin and albacore species which are known to have the highest levels of methylmercury. Dietary intake calculations for total mercury in Norwegian women conducted by the

Norwegian Food Safety Authority showed that even high level consumers (95^{th} percentile) are below the PTWI of 1.6 µg/kg bw/week (188). Nonetheless, given the critical toxicological endpoint on which the PTWI was based, EFSA has already recommended that women of childbearing age, pregnant or breastfeeding, as well as young children, should select fish from a wide range of species without giving undue preference to top predatory fish such as swordfish and tuna. Pregnant women eating up to two portions of fish per week are unlikely to exceed the PTWI for methylmercury, provided that one of these portions is not bluefin or albacore tuna. EFSA acknowledged that the canned tuna sold on the European market is unlikely to be bluefin or albacore species but rather smaller, less contaminated species such as skipjack.

In 2008, EFSA released a scientific opinion on mercury as an undesirable substance in animal feed (189). In this report it was mentioned that methylmercury bioaccumulates and biomagnifies along the food chain, particularly in the aquatic food chain, with long-living carnivorous fish and marine mammals exhibiting highest contents. In recent years, a substantial number of feed materials from member states of the European Community have undergone analysis for total mercury, and it has been established that total mercury concentrations are below the maximum level specified in the feedingstuffs legislation. The most common source of mercury in feed materials is fishmeal. However, in this category no sample exceeded the maximum level of 0.5 mg/kg. In contrast, approximately eight per cent of the complete feedingstuffs for fish exceeded the maximum level of 0.1mg/kg. The maximum concentration reported in farmed salmonids was found to be approximately five times lower than the EU maximum level for mercury in fish for human consumption of two fish meals, as recommended by nutritionists, without appreciable health risks (189).

Arsenic

In its 2003 report, the UK COT concluded that the toxicological data available at the time for arsenicals would not permit an adequate assessment of safety. However, based on the evidence for a genotoxic and carcinogenic potential for inorganic arsenic, the COT evoked the ALARA principle – human exposure should be As Low As Reasonably Achievable (ALARA). That said, they acknowledged the lack of evidence for adverse effects in humans resulting from arsenic exposure via the consumption of fish concluding that exposure via this source is unlikely to constitute a health hazard (190). The COT assessed the contribution made by fish to the total arsenic intake by infants (6 – 12 months). As is the case for mercury, they concluded that the quantities of infant foods consumed would not give rise to health concerns with regard to arsenic. Once again the ALARA principle was evoked.

In addition, EFSA released a scientific opinion on arsenic in food in 2009 (191). Prior to releasing this opinion, EFSA made a call for data on arsenic in foods in 15 European countries, and in excess of

100,000 results on arsenic concentrations in various foods were submitted by the participating countries. The results were subsequently disseminated by EFSA. Approximately 98 per cent of the results were reported as total arsenic, and only a few investigations differentiated between the various arsenic species. Fish and seafood were reported as having one of the highest total arsenic levels. Of the organic forms of arsenic, arsenobetaine, the major form in fish and most seafood, is widely assumed to be of no toxicological concern and will not be discussed any further here. However, inorganic arsenic is a cause for concern. According to the results of the EFSA's study, the relative proportion of inorganic arsenic in fish and seafood was found to be small but_tended to decrease as the total arsenic content increased, and this ratio varied depending on the seafood type. Based on the limited data available on inorganic arsenic obtained during this study, fixed values for inorganic arsenic of 0.03mg/kg in fish and 0.1mg/kg in seafood were considered to be realistic for calculating human dietary exposure. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) had established a provisional tolerable weekly intake (TWI) of 15µg/kg body weight However, the EFSA Panel on Contaminants in the food chain (CONTAM Panel) established that inorganic arsenic causes cancer of the lung, urinary tract and skin, and that a range of adverse effects had been reported at exposure levels lower than those reviewed by the JECFA. Thus, the CONTAM panel concluded that the JECFA panel provisional tolerable weekly intake (PTWI) of 15µg/kg b.w. is no longer appropriate and, in its assessment, focused on more recent data showing effects at lower doses of inorganic arsenic than those considered by the JECFA (191).

Cadmium

The recommendations issued by the COT with regard to fish intake were not influenced by concerns over cadmium levels in fish or in fish-based infant foods (91). It was acknowledged that cadmium levels in those fish species sampled under the UK MAFF multi-element survey were all below EU limits (184).

Since publication of the previous finfish consumer focused review (192), the CONTAM panel was asked by the European Commission to assess the risks to human health related to the presence of cadmium in foodstuffs. Approximately 140,000 reports covering the period from 2003 to 2007 on cadmium occurrence in various food commodities were received from 20 European countries for consideration. Seaweed, fish and seafood were listed among the foods containing the highest cadmium concentrations. Prior to this, a health based guidance value for cadmium of 7µg/kg b.w. per week (i.e. the PTWI) was established by the Joint FAO/WHO Expert Committee on Food Additives, and this value was endorsed by the Scientific Committee for Food. However, the CONTAM panel established a TWI for cadmium of 2.5 µg/kg b.w. It was also determined that the mean exposure for adults across Europe is close to, or slightly exceeding, the TWI of 2.5 µg/kg b.w., with certain subgroups such as vegetarians, children, smokers and people living in highly contaminated areas exceeding the TWI by about two-fold (193).

Lead

Similarly, the recommendations issued by the UK COT with regard to fish intake were not influenced by concerns over lead levels in fish of in fish-based infant foods (91). It was acknowledged that lead levels in those fish species sampled under the UK MAFF multi-element survey were all below EU limits (184).

In recent years, the CONTAM panel of EFSA issued a call for data in order to determine lead concentrations in various foodstuffs. Approximately 140,000 results of lead concentrations in a range of food commodities and tap water were submitted by 14 member states and Norway. Of these results, 94,126 data sets (from 2003-2009) were regarded as suitable for calculating lead concentrations in the various food categories. The lead level in approximately two-thirds of the samples was below the limit of detection or limit of quantification. Neither fish nor seafood were included in the list of 'major contributors' to lead exposure (194).

4.1.3 Malachite green/leucomalachite green

Malachite green (MG) is a synthetic dye and fungicide used in the aquaculture industry, particularly in the treatment of fish eggs. Neither MG nor its metabolites have ever been sponsored as a veterinary medicine in the context of EU Council Regulation 2377/90. As such, no MRL has been established and the substance is not listed in annex IV to the regulation. The administration of these substances to food-producing animals is prohibited throughout the EU since 2002. Therefore, MG and its metabolites are contaminants for which there are no acceptable levels in foodstuffs. Approximately 80 per cent of absorbed MG is metabolised to leucomalachite green (LMG) *in vivo* (195, 196). Unlike the parent compound, which is rapidly excreted, LMG accumulates in muscle tissue (the half life in trout muscle is approximately 40 days) (195). Therefore, this is the more likely residue to be detected in samples taken for routine or targeted analysis.

Toxicology

In 1999, the UK Committee on Mutagenicity (COM) concluded that, on the basis of the toxicological evidence available, MG should be regarded as having genotoxic potential (197). This was reinforced in 2004 when COM revisited this issue and reiterated that LMG should be regarded as an *in vivo* mutagen (198, 199). The COC (UK) has considered it prudent to regard LMG as a genotoxic carcinogen (200). This precautionary classification has also been adopted by EFSA (201).

Reference point for regulatory surveillance

MG/ LMG are the most frequent reason for violation of the EU rules regarding products of farmed fish. The residues found in farmed fish products may originate from environmental pollution due to past uses, and therefore may be unavoidable (202). As mentioned previously there is no established MRL for MG and its metabolites. Instead, Commission Decision 2004/25/EC of 22 December 2003 established a Minimum Required Performance Limit (MRPL) of 2 µg/kg for the sum of MG and LMG residues in meat of aquaculture products. The function of the MRPL is to harmonise analytical capability, irrespective of methodology, and thereby facilitate a more cohesive approach to enforcement across MS. This limit establishes the concentration at, or above which, enforcement action must be taken. However, a lowest concentration requiring action is not specified, which means that enforcement action is dictated by the sensitivity of the analytical methodology used. This has been addressed by Commission Decision 2005/34/EC, which lays down new harmonised standards for the testing of certain residues in products of animal origin imported from Third Countries. Under this new risk management approach, the isolated detection of residues of a prohibited substance, below the relevant MRPL, will not act as a barrier to those products entering the EU market.

In the UK, the Veterinary Residues Committee (VRC) has recommended using the LOQ as the benchmark above which a given sample should be considered positive for that particular compound and enforcement action should be taken (203). Breaches of either the LOQ or MRPL do not automatically indicate an increased risk to human health but rather provide a trigger for the relevant authority to evaluate the potential for increased risk and reinforce best practice.

Surveillance outcomes

ROI

In 2004, 91 samples taken from three finfish species in the ROI – salmon (72), freshwater trout (17) and sea trout (two) – were tested for MG and LMG residues. Five salmon samples were non-compliant for both residues. In 2007, 162 sample fish were taken from fish farms and packing plants in the ROI at harvest or other stages of production, consisting of salmon (137), sea-reared trout (10) and fresh-water trout (15). No non-compliant results were obtained for malachite or leucomalachite green (21).

The Sea Fisheries Protection Authority (SFPA), with support from the Marine Institute (MI), is responsible for residue controls on farmed finfish under the national residue-monitoring plan. In 2009, trace levels of LMG were detected on a fish farm. The subsequent on-farm investigation resulted in restriction on movement of fish off the farm, follow-up sampling, precautionary culling of fish and subsequent enhanced monitoring. MG was also detected in a consignment of catfish from Thailand during the 2009 monitoring programme, but at a level thought not to be of significance for human health. MG was not recorded in fish samples under the 2006, 2007 or 2008 monitoring programmes (32).

UK

The UK National Surveillance Scheme for home-produced products of animal origin is co-ordinated by the VRC. In addition, the VRC orchestrates a non-statutory surveillance scheme that targets specific areas of concern, primarily in imported produce. This complements the National Surveillance Scheme which is limited in scope to national production (203). Where breaches of the EU MRPL are detected, notices requiring the slaughter and disposal of the contaminated fish are issued.

Under the 2008 statutory National Surveillance Scheme (204), all of 12 salmon and 10 of 11 trout muscle samples were at or above the MRPL for MG/LMG at concentrations up to seven and 50.0 μg/kg, respectively. These were follow-up samples from the 2007 monitoring programme. Under this programme, leucomalachite green residues were detected in one of 129 farmed salmon samples tested (0.78 per cent) and in one of 108 farmed trout samples tested (0.93 per cent). The salmon non-compliance was attributed to residue carry-over from a previous contamination (205). In NI, the FSA does not have a monitoring programme in place for MG/ LMG in fish. EC Regulation 854/2004, which outlines the official controls for products of animal origin intended for human consumption, including fishery products, states that official controls are to include checks on residues and contaminants. At present, monitoring arrangements are due to be put in place to control the levels of residues and contaminants in accordance with Community legislation. Such official controls would be carried out by the District Councils in NI at land establishments during routine inspections (206). As part of the UK's National Plan for Residues, a small number of fish (approximately five) from NI are tested each year for a range of dyes, including MG. There have never been any incidences of fish testing positive for MG (206).

Scientific opinions

There is no evidence for an adverse effect on human health following consumption of finfish containing residues of MG. Recommendations have not been issued by regulatory bodies with regard to specific actions to be taken by consumers who may have consumed contaminated fish. However, given the concerns over the genotoxic and carcinogenic potentials from *in vitro* and *in vivo* studies, MG is prohibited for use as an aquaculture veterinary medicine throughout the Western world.

Alternative veterinary medicinal treatments are available such as Pyceze® which received a provisional marketing authorisation for use on fish eggs in early 2002. Despite such alternatives, MG and LMG are still being detected, in the ROI and the UK, albeit in decreasing frequency, in the tissues of farmed finfish.

4.1.4 Organotin compounds

Background

Organotin compounds (OTC) have a number of industrial uses. Mono- and disubstituted OTCs are used as stabilizers while the trisubstituted OTCs have broad spectrum biocidal properties. The use of OTCs as antifouling agents in boat paints is the primary source of aquatic contamination by these compounds. Being highly lipophilic, trisubstituted OTCs are readily absorbed and bioaccumulate through the marine food chain and consequently contaminated marine food species are likely to be the main source of human exposure.

Toxicology

EFSA published its assessment of the health risks to consumers associated with exposure to organotins in foodstuffs in 2004 (132). This investigation focused on a number of OTC compounds including tributyltin (TBT), triphenyltin (TPT) and dibutyltin (DBT) which are the OTCs primarily found in fish and fish products. These compounds bioaccumulate through the food chain and are associated with a broad spectrum of toxicity in biota including reproductive and developmental toxicity, genotoxicity, carcinogenicity and neurotoxicity. TBT and TPT are also possible endocrine disruptors. The critical toxicological endpoint for human health is immunotoxicity and a critical NOAEL of 25 µg/kg bw/day has been established. Based on the similar mechanism of action and immunotoxic potency of OTCs, EFSA established a TDI of 0.25 µg/kg bw/day.

Contamination levels

In 2004, the Scientific Panel on Contaminants in the Food Chain of EFSA issued an opinion on the health risks to consumers associated with exposure to OTCs in foodstuffs (132). This took into account the final report of the 2003 Scientific Co-operation assessment of dietary exposure to OTCs within the EU Member States. Eight countries - Belgium, Denmark, France, Germany, Greece, Italy, Norway and The Netherlands - delivered the available data on the occurrence of OTCs in food products, i.e. fish and seafood products. Based on fully aggregated data, the estimated concentration medians of TBT, DBT, and TPT were 7.0, 2.5 and 4.0 µg/kg of fresh weight, respectively, and the corresponding mean values being about four- to seven-fold higher. Concentrations of OTC in other seafood, such as molluscs and crustaceans, are generally higher than in finfish (132).

Human exposure

Using seafood consumption in Norway as a model of high seafood consumption in Europe, the combined intake of TBT, DBT and TPT was estimated from median concentration to be 0.018 µg/kg bw/day (approximately seven percent of the proposed group TDI). The same intake calculated on mean basis was 0.083 µg/kg bw/day (about 33 percent of the proposed group TDI). The intakes for high consumers, calculated on median and mean concentrations were 0.037 and 0.17 µg/kg bw/day, respectively, which represents approximately 15 percent and 70 percent of the group TDI. The EFSA Panel noted that the consumption of fish, mussels and other marine animals from highly contaminated area, such as the vicinity of harbours and heavily used shipping routes, may lead to OTC intake that exceed the group TDI (132). A ban on the use of OTCs on ships (including fishing vessels) has been proposed by the EU Commission (133).

4.1.5 Carbon monoxide

Background

Carbon monoxide (CO) has been used as a food preservative throughout history by the mere fact that it is a component of smoke and therefore the smoking process used in food preservation. More recently, the gas became a component of the reduced oxygen packaging (ROP) and modified atmospheric packaging (MAP) processes which were introduced in the 1960s. Since the 1970's, a number of patents have been lodged for use of CO as a colour preservative in different variety of meats, including fish (134). However, it was not until 1999 that a specific patent for fish treatment was lodged with regard to frozen seafood (135).

Currently CO is applied to a variety of seafood as a pure gas, as a component of filtered 'tasteless' smoke, or as a gas blend that mimics 'tasteless smoke'. The mode of application is either passive introduction in enclosures or packaging, active addition to a pressurized chamber, or post-harvest euthanasia of farmed fish. Commercial use of CO treatment of fish products is increasing, primarily driven by the US market where regulatory acceptance of the process still prevails (136). The potential for CO treatment to mask deficits in quality such as colour deterioration, as well as the generation of biogenic amines, has been noted. However, the facilitation of freezing, which CO treatment allows, will safeguard against these quality problems.

In particular, CO has been used in recent years to maintain the appearance of tuna fish. Fresh tuna fish is a bright red colour, due to the presence of an oxygenated ferrous form of myoglobin (i.e. oxymyoglobin) in the muscle tissue. However, over time, the bright red colour changes to brown due to the chemical effect of atmospheric oxygen. In order to maintain the bright red colour, tuna fillets are commonly treated with CO in the modified atmosphere packaging. The CO reacts with myoglobin to form a very stable cherry-red coloured carboxy-Mb complex (Mb-CO). This complex is much more resistant to oxidation than oxymyoglobin, and is not transformed into brown myoglobin. Although CO masks the fish ageing, it does not prevent spoilage. Taking this into consideration, it makes it very difficult for the consumer to evaluate the freshness of the tuna. Furthermore, in the case of histidine rich fish (e.g. tuna, mackerel, sardines, herring, swordfish), the fraudulent use of CO provides an additional risk as histamine can be formed by the action of bacterial decarboxylase on histidine, which can result in a toxicological effect (207).

Regulatory issues

Treatment of fish with CO is not permitted in the EU, and is not included in the list of the allowed food additives (Directive 1995/2/EC, Directive 2006/52/EC) (207). However, certain non-EU countries such as Norway still permit the use of CO treatments for seafood. Therefore, although the use of CO is not permitted in the ROI, it may be present in fish imported from Third Countries.

The application of tasteless smoke is also an issue of concern in the EU. Certain MS have pointed out that the EU consumer is being misled as to the freshness of fish products due to the practice of 'cold smoking' or 'clear smoking', i.e. treatment with filtered smoke. The fish is labelled 'lightly smoked (208, 209). However, the technique does not impart a smoky flavour or the typical colour which results from smoking, but is nevertheless considered as a smoking process and therefore perfectly legal. The EU Standing Committee on the Food Chain and Animal Health has agreed that, if a product is labelled as 'smoked', it must have a smoky flavour. It also concluded that 'clearsmoke technology' was an indirect way of adding carbon monoxide to food and evoked EU Directive 91/493/EEC on fishery products. This legislation (which has since been replaced by the Hygiene Package) requires that treatments applied to inhibit the development of pathogenic micro-organisms, or constituting an important element in the preservation of the product, must be scientifically recognised or formally approved.

Toxicology and exposure

CO exerts a toxic effect on the body by sequestering haemoglobin as carboxyhaemoglobin (HbCO), thereby rendering this ineffective for oxygen transport. The natural background levels of CO are 0.01 to 0.9 mg/m^3 air. These levels rise up to 60 mg/m^3 in urban areas due to anthropogenic sources (210). CO is also formed in the human body through normal metabolic processes (211). The normal background level of HbCO is approximately 0.5 percent of total haemoglobin. This rises to 0.7 to one per cent as a result of inhaling urban air. The average HbCO concentration in non-smokers is 1.2 to 1.5

per cent. This rises to approximately three to four per cent in smokers (138). Adverse effects such as reduced attention have been recorded at concentrations above two percent while anoxia and death occur at concentrations of 30 to 50 percent or more of the total haemoglobin (211). The generally accepted NOAEL for HbCO is 1.5 percent (212).

Very little information exists in the literature on the exposure to CO following consumption of meat that has been treated with CO gas. Human feeding trials with CO treated fish have substantiated previous conclusions that CO treated seafood does not pose a health threat to consumers (180). The EU Scientific Committee for Food (SCF) has determined the amount of HbCO added to the normal background 0.5 percent level in human blood would be negligible following ingestion of 250g of fresh meat (not specified) treated with CO (213). In addition, high CO_2/low CO gas mixtures inhibit the growth of bacteria in meat products when stored at 4°C.

Scientific opinions

There is considerable ambiguity internationally in the approaches taken to the use of CO as a food preservative both by regulatory agencies and industry. While the presence of CO in fish meat has no direct implications for consumer health *per se*, it could potentially mask deficits in quality which themselves may have significant health risks (213). Ironically, CO treatment may actually guard against such deficits when applied properly as was noted with CO-treated tuna, in which the development of cadaverine and histamine levels is less problematic than in tuna without prior CO exposure (214). Nevertheless, elevated biogenic amine levels could pose a potential health hazard in situations involving the misuse of CO.

More stringent labelling has been called for internationally on the use of CO, either as a pure gas or as a component of the smoking process.

4.1.6 Veterinary medicinal products

The authorisation of veterinary medicinal products

All veterinary medicinal products (VMPs), as defined in Directive 2001/82/EC of the European Parliament and of the Council, as amended by Directive 2004/28/EC, for use in the treatment of finfish produced in the aquaculture industry on the IOI must be authorised. This includes homeopathic VMPs.

In the ROI the Irish Medicines Board (IMB) is the designated competent authority for the licensing of VMPs (including immunological VMPs) and advises the Minister for Agriculture and Food therein. In the UK, and hence in NI, the Veterinary Medicines Directorate (VMD) is responsible for the licensing of

VMPs. VMPs controlled under this legislation are not for sale to the general public and require a prescription from authorised personnel.

Current EU legislation requires the establishment of an MRL for all pharmacologically active substances in VMPs marketed in the EU for administration to food-producing animals. The conditions for establishing an MRL are set out in Council regulation (EEC) No. 2377/90 as amended by Council Regulation (EEC) No 581/2009. Annex V to this regulation specifies the toxicological information required for the establishment of a MRL including pharmacodynamic, pharmacokinetic, single dose, repeated dose, tolerance, reproductive and developmental toxicity studies as well as mutagenicity, carcinogenicity and immunotoxicity studies. The microbiological effects of residues in terms of the human gut flora, and organisms and microorganisms used for industrial food-processing are investigated and any epidemiological data is also taken into consideration. The regulation also applies to vaccines.

Veterinary medicinal products authorised for use in the finfish aquaculture industry on the IOI.

As of August 2009, a total of 14 products based on 12 active substances were approved for marketing in the ROI and UK as VMPs for use in finfish aquaculture (eight products in the ROI, ten products in the UK). All are prescription-only medicines (POM). This information is available at http://www.ema.europa.eu.

In addition, a further 13 vaccine-based products are licensed for use in finfish aquaculture, 8 products by DAFF in ROI and 10 products by the Veterinary Medicines Directorate in the UK. As these are vaccines, the concepts of ADI and MRL are not relevant. The setting of a withdrawal period is also unnecessary. A lag time between vaccination and exposure to the live pathogenic agent is recommended and for these vaccines, varies between 210 and 500 degree days.

Surveillance for drug residues in finfish meat on the IOI

Under EU Council Directive 96/23/EC, both the ROI and the UK are required to implement residue surveillance plans and to submit their programmes to the European Commission for approval. These plans focus on both home-produced and imported animal products (from within the EU and from Third Countries). Sampling is usually conducted on a targeted basis with samples being taken at both farm and primary processing levels. In addition, the use of VMPs is monitored on an ongoing basis mainly through inspections at commercial premises involved in their distribution. Where a positive result is detected, a follow-up investigation is conducted at the farm of origin with a view to taking the necessary enforcement measures up to and including legal action, if appropriate.

In the ROI, DAFF is responsible for implementation of this Directive and the FSAI have a coordinating role. The DAFF have responsibility for implementing the residues control plan for aquaculture and also for enforcement. The SFPA implements the surveillance monitoring programme on behalf of the DAFF. In relation to finfish, the SFPA operate under the powers of the Sea Fisheries and Maritime Jurisdiction Act 2006. This enables the SFPA to enforce the requirements of finfish farms under the Food Safety Authority of Ireland Act (1998), S.I. No. 432 of 2009 European (Food and Feed Hygiene) Regulations 2009, Animal Remedies Act 1993 and S.I. No. 786 of 2007 European Communities (Animal Remedies, No. 2) Regulations 2007. Under service contract to the FSAI, the SFPA along with support from the Marine Institute is responsible for residue controls on farmed finfish for the national residue-monitoring plan. Essentially, the MI are the competent authority for residue sampling and analysis, whereas the SFPA is the competent authority for verification of compliance with animal remedy and food hygiene regulations on finfish aquaculture farms (32).

Following detection of a confirmed non-compliance, a Case Management Group comprising SFPA, FSAI, and MI decides on follow-up action. The SFPO involved in the case of detection is responsible for conducting further investigation and enforcement (where applicable) (32). In NI this responsibility rests with DARD who are responsible for collection and analysis of samples for the National Surveillance Scheme in NI on behalf of the UK Veterinary Medicines Directorate (VMD). DARD also carries out follow-up investigations in NI.

Surveillance outcomes ROI

In 2009, over 700 tests for 1,750 substances were carried out on 146 samples of farmed finfish for a range of residues under the National Residue Monitoring Programme. No non-compliances were recorded on this occasion or in any of the programmes since 2005 (160).

Surveillance outcomes Northern Ireland

In 2007 and 2008, under the UK National Surveillance Scheme, a number of analyses were carried out on farmed fish including hormones, annex IV substances (215), and antimicrobials including tetracyclines, quinalones, and anthelmintics. No residues were detected at concentrations at or above the relevant reference points (216). Under the 2008 programme, two of 301 samples of imported Farmed Fish were above the MRL for Enrofloxacin.

4.1.7 Radioactivity

Radioactivity has been around since the earth was created, and exists naturally in the atmosphere, soil, sea and rivers. In addition, radiation is produced by humans during energy production and military operations. Considering this, it is hardly surprising that some radioactivity gets into our food.

It has been established that the vast majority of the radioactivity found in foods is from natural (i.e. not man-made) sources. However, monitoring programmes are in place to ensure the levels of radioactivity in foods do not exceed levels above those which are acceptable (217). For instance the nuclear disaster in Japan in March 2011 lead to tighter restrictions being placed on food imported into the EU from Japan. Tinned tuna is of most concern however at the time of writing there had been no reports of contaminated tinned tuna imported into the EU from Japan.

Background and surveillance in the ROI

Marine radioactivity above natural background levels results from anthropogenic sources including nuclear power generation, industrial and medical waste and fallout from nuclear testing. In the ROI, the Radiological Protection Institute is the competent authority charged with sampling and analysis of aquatic matrices, including finfish, for radioactivity.

Sampling is carried out around the ROI coast but with an emphasis on sites in the North East of the Irish Sea in order to monitor radioactive discharges from Britain into the Irish Sea. Sampling is undertaken by Institute staff with the assistance of the MI and the DAFF. This data is used to assess the exposure of the population on the ROI from marine sources of radiation, mostly following the consumption of fish and shellfish. The programme involves sampling finfish, shellfish, algae and sediment but not all of these matrices are sampled at each sampling point. In addition the programme includes samples of imported marine produce. The total sample numbers analysed in 2008, 2007 and 2006 were 480, 428 and 435, respectively, of which 232, 228 and 220 were from finfish and shellfish.

Monitoring results for the ROI

Following the 2008 monitoring programme, the exposure of consumers with a high consumption of seafood (200 g of fish and 20 g of shellfish per day) was estimated to be 0.38 microsieverts (μSv) for the whole year (218). This essentially continued the decreasing trend in exposure from this source since 1982 and was less than the EU and national statutory exposure limit of 1000 μSv from controllable sources for the year (219). In comparison, the average annual dose received by consumers on ROI from all sources of radiation is 3,950 μSv.

The most significant radionuclide in terms of exposure from the consumption of finfish and shellfish is caesium (isotope 137) followed by technetium (isotope 99), both of which originate in the Sellafield Nuclear Reprocessing Plant. The caesium-137 concentrations in fish and shellfish in 2008 were similar to those detected in previous years. The highest levels were recorded in whiting caught in the North

East (0.7 Bq/kg, fresh weight). Technetium-99 and Plutonium isotopes (namely 238, 239 and 240) were also measured in some species but were not detected. Levels of anthropogenic radioactivity in the marine environment remain low and do not pose a significant risk to human health.

UK (including NI) monitoring results

In NI, the Northern Ireland Environment Agency's (NIEA) Industrial Pollution and Radiochemical Inspectorate (IPRI) monitors radioactivity, including the impact of Sellafield discharges into the Irish Sea, on the NI coastal environment. The IPRI arranges for samples of seaweed, sediment, fish, nephrops, and winkles to be collected quarterly and analysed. The marine life samples are obtained as far as possible from commercial landings at Kilkeel and Portavogie.

The results are published annually in the Radioactivity in Food and the Environment (RIFE) reports which represent a comprehensive summary of results across the UK from programmes sponsored by the Environmental Agency (England and Wales), the Northern Ireland Environment Agency (NI), the Scottish EPA and the FSA. The report is published after an assessment is conducted by the Centre for Environment, Fisheries and Aquaculture Science.

The 2008 RIFE report (220) concluded that the general population was mostly exposed to radioactivity from natural sources. Monitoring artificial radioactivity in NI showed that consumer doses were all less than 2 per cent of the annual limit of 1,000 μSv for members of the public. As in previous surveys, the highest doses of radiation were in fish/ shellfish consumers in Cumbria. Here, the radioactivity dose for 2004 was estimated at 0.62 μSv which is still less than EU or UK statutory limits. This exposure was attributed primarily to ongoing and historic discharges from Sellafield and other industrial plants. That said, the report concluded that discharges from nuclear licensed sites do not pose a significant risk to public health and that all doses are within legal limits.

Radioactivity from natural sources was the most significant source of exposure to communities in areas remote from nuclear sites. Man-made radionuclides only contributed a small proportion of the total public radiation dose. Several radionuclides are analysed in finfish samples taken from various locations around the UK coasts as well as imported finfish produce. Levels, where detected, were low and of no significance for human health, both in the 2008 and 2007 monitoring programmes (220, 221).

4.1.8 Fish feed

Governing legislation

Regulation (EC) No 1831/2003 *on additives for use in animal nutrition supersedes Directive 70/524/EEC and establishes an EU-wide procedure for authorising the marketing and use of feed additives as well as defining rules for labelling.* Similarly, Directive 82/471/EEC concerning certain products used in animal nutrition establishes this procedure for bioproteins. The procedure for authorisation and marketing of feed additives and bioproteins is dynamic with new amendments continuously added to the list of the authorised additives in feedingstuffs published in application of Article 9t (b) of Council Directive 70/524/EEC.

As specified in this article, a number of substances are sanctioned for use as feed additives in finfish farming including antioxidants, trace elements, binders, anti-caking agents and coagulants, vitamins and provitamins (with the exception of vitamin D_2), emulsifying and stabilizing agents, thickeners and gelling agents, and colourants including canthaxanthin and astaxanthin, etc. The formulation of organic feeding stuffs is covered under Council Regulation (EC) 2092/91 as amended by Council Regulation (EC) No 834/2007 and its subsequent amendments. In ROI, DAFF is the designated competent authority for issuing national marketing authorisations for animal feed constituents. In the UK, and hence NI, the FSA Animal Feed Unit supports these assessments with the technical assistance of the Health and Safety Executive, the Veterinary Laboratories Agency and other advisers.

Farmed finfish feed on the IOI

Feed used in the farmed finfish industry on IOI is supplied by a number of companies, with Skretting (a subsidiary of the Nutrico group) being the lead supplier on IOI (222). Finfish feed consists of a series of pellet-based feed formulations that are designed to maximise growth potential and survival at each stage in development from fry to adulthood. The feed consists of approximately 60 per cent fish meal, 20 per cent fish oil and 12 per cent wheat, with vitamins, minerals and soya constituting the remainder. The fish meal is low temperature quality and is selected for its low ash content ensuring a low phosphorus level in the feed. Thus, the fish meal is the sole source of amino acids in the diet. In ROI, Origin Enterprises are the leading suppliers of fish meal and oil. Origin Enterprises is located at Killybegs, which is the country's major fish-landing port. The parent company of Origin Enterprises is the Irish Agricultural Wholesaler Society (IAWS). In February 2009, Origin and Austevoll Seafoods ASA ('Austevoll') announced that they were to combine their respective Irish, UK and Norwegian fishmeal and fish operations, operating as Welcon Invest AS ('Welcon') (223). Fishmeal is usually derived from herring or mackerel, depending on the season. At certain times of the year however, these species are replaced by imported Pacific species from Peru and Chile. This changeover is a consequence of seasonal availability of herring and mackerel and the need to maintain adequate levels of certain amino acids in the farmed fish diet which are crucial for the prevention of cataracts. Stress-reducing formulations are also available for administration during periods of stressful environmental conditions e.g. during the summer months. The 'active' ingredient in these formulations is primarily increased glucan and vitamin concentrations. Brood stock feed formulations are also available designed to maximise egg production and egg/ fry survival.

Some food producers also provide organic finfish feed formulations. The specification of organic feed is fundamentally the same as conventional feed. However, certified organic (non-conventionally grown, GM-free) wheat and soya are used. The fish meal and oil are derived from material that is fit for human consumption and which have been obtained strictly within quota.

The constituents of all aquaculture feed formulations are entirely derived from natural foodstuffs. No synthetic products are used and growth promoters are banned. The exception is pharmaceuticals that are licensed for use in finfish aquaculture and which are designed to be administered orally via the food. A comprehensive listing of licensed pharmaceutical and immunological products authorised by the Irish Medicines Board (IMB) (ROI) and the Veterinary Medicines Directorate (VMD) (UK) for use in finfish aquaculture is available on their respective websites (224, 225). These substances represent the majority of licensed pharmaceuticals. Since these are prescription-only medicines, a Veterinary Written Directive is required from a licensed practitioner who also supplies the prescribed medication. The majority of pharmaceutical additions involve emamectin for the treatment and control of sea lice and oxytetracycline for the treatment and control of furunculosis.

Finfish feedingstuffs surveillance

A body of EU and national legislation exists to ensure minimum standards in the production and transportation of animal feeding stuffs within the EU and ultimately to safeguard the well being of the consumer. The most important pieces of legislation are Council Directives 95/53/EC as amended by Council Directive 2001/46/EC and 2002/32/EC.

Council Directive 2001/46/EC establishes the principles governing the organisation of official inspections in the field of animal nutrition and requires MS to co-ordinate their annual inspection programmes at EU level. Council Directive 2002/32/EC and its subsequent amendments, detail undesirable substances in animal feedingstuffs and establish maximum limits for heavy metals, dioxin, aflatoxin B1, certain pesticides, botanical impurities and feed additives. The feedingstuffs analysed for the presence of undesirable substances and products include feed materials, additives, premixtures and compound feedingstuffs. The constituents in feedingstuffs are also analysed for the presence of undesirable substances and products.

Controls are implemented through inspections and sampling of feedingstuffs at all stages of the feed chain, including importation, storage, manufacture and use at farm level. Feedingstuffs used in the finfish aquaculture industry are included in this inspection scheme. The competent authorities on IOI with responsibility for implementing the scheme are DAFF and DARD. In addition to the statutory surveillance performed by the designated competent regulatory authorities, due diligence testing is performed by the companies involved in feed production. While the results of such testing are considered confidential and are not disclosed to the public, positive results are disclosed to the FSAI or the FSA.

Although the results of the various analyses performed on particular categories of feedingstuffs or feedingstuff constituents are reported, it is unknown if any positive results were associated with constituents destined for aquaculture feed production. This applies to cereals and cereal products, minerals and fish, other marine animals, their products and by-products. In the 2008 inspection programmes orchestrated by DAFF, compound feedingstuffs used in the finfish aquaculture industry proved negative for dioxins and PCBs, micro organisms and processed animal protein (Appendix D) (226). Cadmium and copper were detected in a single sample. In addition, two non-compliances were detected for crude oils and fats in feed destined for ROI aquaculture industry in 2008.

In addition to the annual official inspection programme, the European Commission requests that MS undertake a coordinated risk-based monitoring programme on a number of specified targets including all imported feed materials from Third Countries (227). As part of this targeted programme, MS are requested to analyse certain industrial by-products used in feedingstuff formulation for dioxin contamination resulting from drying or other types of processing.

4.1.9 Vitamin A supplements

Vitamin A (also known as retinol) is a fat-soluble vitamin and can be acquired by eating a varied and balanced diet. This vitamin has a number of important functions, such as maintaining healthy skin and mucus linings, strengthening the immune system and aiding night-vision. Good sources of vitamin A include cheese, eggs, milk and oily fish, with liver being a particularly rich source. It is recommended that men and women consume 0.7mg/day and 0.6mg/day, respectively. However, some research has shown that excessive intake of vitamin A (>1.5mg/day) over many years may have a negative impact on bones, making them more likely to fracture in old age (228). Continuous high intakes can also cause headaches, liver damage (including cirrhosis), diarrhoea, vomiting and, during pregnancy, birth defects (229). Supplements such as fish liver oil, may contain high levels of vitamin A. Therefore, it is important that individuals taking supplements containing vitamin A do not consume more than the recommended amount of 1.5mg/day from their food and supplements (228). In particular, pregnant women should avoid taking vitamin A, as having large amounts of this vitamin can harm the foetus. (228).

4.2 Conclusions

There are monitoring programmes on the island of Ireland that frequently test for dioxins, heavy metals, malachite green/leucomalachite green, organotin compounds and many other substances in fish and fish feedingstuffs. Legislation is in place that governs the maximum levels for each of these. The most recent data available (2004-2006) from the FSAI, Marine Institute and BIM showed that the levels of dioxins in Irish fish and fishery products available on the Irish market were well below existing European Committee legal limits. The most recent survey of fish from the UK showed low levels of dioxins and PCBs in all samples analysed with only sporadic individual or composite exceedances of the maximum limits.

5 Regulatory issues

Key findings

- Safety controls for imports of fish and fish products from Third Countries to the IOI are carried out at designated Border Inspection Posts (BIPs).
- The BIPs are situated in strategic locations in ROI and NI and are under the supervision of the FSAI and FSA, respectively. The Food and Veterinary Office of the European Commission routinely audits the controls exercised at these BIPs.
- Fish and fish products imported into the EU may only originate from a Third Country, or part of a Third Country, approved by the EU.
- In July 2010, the Sea Fisheries Protection Agency (SFPA) released their 'Guide to Compliance for the Irish Inshore Fleet'. In essence, this guide provides a method for the SFPA to trace the boats that fish came from and also where the fish subsequently went to.
- The Electronic Recording and Reporting System (ERS) in ROI is currently being introduced on a phased basis to fishing vessels.
- In 2009, fish (including shellfish and finfish) accounted for 22 per cent of alert notifications and 20 per cent of information notifications made through the Rapid Alert System for Food and Feed. Fifty nine notifications regarded histamine in fish, of which 31 concerned tuna. Levels of histamine of several thousand parts per million (ppm) were common.
- In 2009, there were 48 notifications for the presence of the larvae of a nematode parasite Anisakis in fish, mainly in fresh mackerel and hake.

5.1 Introduction

Numerous changes in legislation have occurred between 2005 and 2010. Legislative changes in relation to food safety, fish feed and residue surveillance are discussed elsewhere in this report. In this chapter, legislation relating to third country imports, traceability and recall, and electronic recording and reporting will be highlighted.

5.2 Third country import controls

Live animals or animal products imported into the EU may only originate from a Third Country, or part of a Third Country, approved by the Community via routine audits conducted by the Food and Veterinary Office (FVO). The establishments from which products are derived must be approved in accordance with the relevant EU legislation by the competent authority of the Third Country. Third country establishments from which fisheries products are exported to the EU must have public health legislation and inspection systems in place (for the particular products exported only) equivalent to those in the EU.

A summary of some of the EU legislation relevant to Third Country finfish imports is contained in Table 5.1.

Table 5.1 Legislation relating to third country imports

Legislation (as amended)	Concerns
Commission Decision 97/296/EC (amended by Commission Decision 2005/501/EC)	Draws up the list of third countries from which the import of fishery products for human consumption is authorised.
Council Directive 97/78/EC	Lays down principles for veterinary checks on products imported from third countries
Commission Regulation (EC) 136/2004	Lays down procedures for veterinary checks at EU BIPs on imports from third countries
Council Directive 2002/99/EC*	Establishes animal health rules governing the production, processing, distribution and introduction of products of animal origin for human consumption, including aquaculture products
Regulation (EC) 854/2004*(amended by Regulation (EC) 1021/2008)	Lays down specific rules for the organisation of official controls on products of animal origin intended for human consumption
Regulation (EC) 882/2004*	Official controls performed to ensure the verification of compliance of feed and food law, animal health and animal welfare
Commission Decision 2001/67/EC	Each shipment of fishery products must be accompanied by a health certificate using the model provided by this legislation
Commission Decision 2003/858/EC (amended by Commission Decision 2004/914/EC)	Lays down the animal health conditions and verification requirements for imports of live fish, their eggs and gametes intended for farming, and live fish of aquaculture origin and products thereof intended for human consumption
Commission Decision 2005/501/EC	Sets out EU-approved exporting countries for fish and fishery products

*Part of New Hygiene Package

The European Commission's Directorate General for Health and Consumer Protection (SANCO) have issued a document relating to EU import requirements for seafood and other fishery products (230).

5.2.1 European commission, food and veterinary office

The function of the FVO is to ensure effective control systems through the evaluation of compliance with the requirements of EU food safety/quality, veterinary and plant health legislation, both within the EU and in Third Countries exporting to the EU. The FVO does this mainly by carrying out inspections in MS and in Third Countries exporting to the EU.

Each year the FVO develops an inspection programme, identifying priority areas and countries for inspection. In order to ensure that the programme remains up to date and relevant, it is reviewed mid-year. The FVO makes recommendations to the country's competent authority to deal with any shortcomings revealed during the inspections. Following an inspection, the competent authority can be requested to present an action plan to the FVO on how it intends to address any shortcomings. Together with other Commission services, the FVO evaluates this action plan and monitors its implementation through a number of follow-up activities.

The Central Competent Authority in NI is the FSA. The FSA's Fish and Shellfish Hygiene Unit of the Primary Production Division is responsible for implementing the public health requirements for bivalve molluscs and fishery products. Enforcement of the relevant legislation is primarily the responsibility of the Local Food Authorities. In the ROI, the Central Competent Authority is the FSAI. The DAFF is responsible for the control of all fishery products from production up to the point of retail, while the Health Service Executive (HSE), through Environmental Health Officers (EHOs), is responsible for the retail and catering of fishery products.

In its role, the FVO, where appropriate, may highlight areas where the Commission may need to consider clarifying or amending legislation or areas where new legislation might be required. In addition, the FVO produces other reports, such as summaries of the results of inspections or the annual EU-wide pesticide residues monitoring reports. The FVO also publishes an annual report on its activities, which reviews the progress of its inspection programme and presents the global results.

FVO audit missions to the IOI

The most recent FVO audit mission to the UK (including NI) relating to fishery products was undertaken during October 2004 (231), which was a follow-up to a previous mission in 2002 (232). A number of shortcomings were reported during this follow-up mission, for example a number of establishments were non-compliant with the requirements of Council Directives 91/493/EEC and

91/492/EEC (note: both of these directives have been repealed since 01.01.2006 when the hygiene package came into effect), infrequent control of fishing vessels, etc.

During October 2004 the most recent FVO audit pertaining to fishery products was conducted on the ROI (233), a follow-up to a previous mission (234). There were a number of commendations relating to audits performed by the FSAI with respect to laboratories; the issuing and distribution to SFOs of Codes of Practice and Guidance Notes for fishery products, including fishing vessels; and training conducted by the DAFF and FSAI. However, a number of deficiencies were noted such as insufficient number of specialised SFOs, and the absence of the implementation of written procedures, codes of practice and of supervisory controls. In 2008 a general audit was carried out by the FVO in Ireland (235). Shortcomings in relation to fishery products and outstanding issues from the previous mission were highlighted. The official control system in place governing the production and placing on the market of fishery products in Ireland was therefore considered as not fully compliant with Community legal requirements at that time.

FVO audit missions to other Member States

In 2004, a series of eight inspections covered fishery products and live bivalve molluscs produced in MS (236). The aim was to evaluate the improvements made since the previous inspection series in 2001/2002, particularly for the main risks presented by such food, and to examine the implementation and control of the HACCP systems in place for the handling, preparation, and processing of fishery products. Very little progress was noted, with the exception of one MS for live bivalve molluscs, and a second MS in the areas of competent authority establishment control and evaluation/verification of the HACCP systems in place. For the other MS, control of these sectors was deemed to be still unsatisfactory.

FVO audits to third countries

A series of 12 inspections covered fishery products and live bivalve molluscs imported from Third Countries in 2004 (236). The countries visited ranged from unsatisfactory to very serious with risks for consumer health. The FVO concluded that some of the fishery products exported presented a low risk and did not require drastic safeguard measures. Actions taken as a result of the inspections included:

- The suspension, by the competent authority, of certain exports;
- Requests, from the Commission to the competent authority, for systematic controls of consignments for the main hazards;
- A review of the list of establishments and vessels approved for export to the EU;

- Information from the Commission to the MS for increased controls and analyses on fishery products imported from certain Third Countries;
- The suspension, in some cases, of the automatic pre-listing of vessels and establishments, pending satisfactory guarantees and actions from the competent authority;
- Encouraging these countries to consider this sector as a priority for development actions, using Community or MS funds to improve both production conditions and competent authority control activities.

5.2.2 Border Inspection Posts

Imports of fish and fishery products from Third Countries must come through designated Border Inspection Posts (BIPs) and be subjected to a series of checks before they are allowed access to the EU market. Third Country import controls can be undertaken in any one MS before the product is allowed to circulate freely in other MS, which effectively means that each MS is dependent on every other state to ensure that imports are controlled. It should be noted that the BIP is not always in the country of final destination of the product. The BIPs are situated in strategic locations in each MS and are under the supervision of the relevant competent authority of the MS. The FVO routinely audits the controls carried out in these BIPs.

The list of BIPs operating within the EU is drawn up in Commission Decision 2001/881/EC, as amended by Commission Decision 2004/408/EC. There are currently five BIPs on the IOI, namely Dublin Airport, Dublin Port, Shannon Airport, Belfast Airport and Belfast Port.

Council Directive 97/78/EC governs the organisation of veterinary checks on products entering the EU from Third Countries. Such imports must be accompanied by health certification signed by an official veterinarian in the country of export and must be presented at the BIP at point of entry into the EU. The animal (including fishery) products must be appropriately wrapped, packaged and labelled with a health mark. The importer must be registered with the competent authority and must give 24 hours advance notification to the latter.

All consignments from Third Countries undergo a complete documentary and identity check, while physical checks are carried out at frequencies laid down in EU law under Commission Decision 94/360/EC. Sampling for laboratory analysis may also be carried out. Foods failing to comply with the control checks may be detained for further examination, returned to the exporting country or destroyed. All rejections are notified to the EU Commission and if there is a public health risk, this is communicated to all MS via the RASFF. Once the shipment has met the required conditions it is released for free circulation within the EU. Copies of the Health Certificate and the BIP clearance document must accompany the consignment to its destination.

The Competent Authority in the MS carries out initial monitoring of controls at BIPs. In the case of the ROI, this is done by the DAFF on behalf of the FSAI and in NI by DARD. The FVO is required to inspect BIPs; the frequency and scope of which is defined based on risk analysis, as outlined by Commission Decision 2005/13/EC. Where the operation or the facilities for checking product at a BIP is considered inadequate, approval of the BIP may be withdrawn. The findings of BIP Audits conducted by the FVO in MS in 2003 show that there were minor non-compliances in the areas of staff training, identification and selection of consignments, working procedures, supervision of transit trade, hygiene and documentation (236). In addition, a number of major non-compliances were also found, mainly related to facilities and equipment in BIPs.

5.3 Product traceability and recall

In recent years there have been a series of high profile food scares, which have focussed attention on how the supply chain operates, from production through processing, and finally distribution. Such 'scares' have the potential to seriously damage consumer confidence in the food chain, whether they present real or perceived food safety risks. They have also highlighted serious deficiencies in traceability systems and also in European Law. This resulted in the formulation and adoption of EU Commission Regulation (EC) No. 178/2002 which lays down the general EU principles and requirements of food law including traceability and recall requirements. This regulation was implemented as of 1st January 2005, with full compliance required by January 1st, 2007.

In July 2010, the SFPA released their 'Guide to Compliance for the Irish Inshore Fleet' (237). This document sets out the legal requirements in place for fishing vessels under 15 metres in length operating in Irish inshore waters. In essence, this guide provides a method for the SFPA to trace the boats that fish came from and also where the fish subsequently went to. All boats over ten metres in length must complete an EU fishing logbook, and the log sheet and landing declaration for each trip is required to be submitted to SFPA offices within 48 hours. Vessels under ten metres in length are not required to complete a log book, but may volunteer to do so if they wish. In addition, all buyers of first sale fish (i.e. fish offered for first sale following landing from a vessel) must submit a sales note. Prior to this, they must register as a fish buyer with the DAFF, a requirement of S.I. No. 260 of 2007 Sea Fisheries (First Marketing of Fish) regulations, 2007. Only registered and licensed fishing vessels may sell first sale fish. However, if an individual purchases fish not exceeding 10kg for private consumption in any one day, they are not required to submit a sales note. Furthermore, transport documentation must accompany fish when going to a place of first sale from a fishing vessel (237). The following information should appear on the transport documents:

- Name and registration number of landing vessel.
- FAO code, catch area, quantity (in kg), and presentation of each species.
- Place and age of loading, vehicle identification and destination of the consignment.
- Name and address of consignee.

The SFPA also inspect approved establishments and monitor their finfish traceability records. In particular, the SFPA monitor labelling to ensure the company's approval number and batch code for the product are clearly stated on the packaging (as set out under EC Regulation 178/2002) (32).

5.3.1 Product traceability

In today's global food market, effective traceability and product recall systems are paramount, even in the best-managed food business where an issue involving the safety of a foodstuff may occur.

Article 18 of regulation No. 178/2002 requires that traceability of 'food, feed, food producing animals, and any other substance intended to be, or expected to be, incorporated into a food or feed shall be established at all stages of production, processing and distribution'.

In the event of a foodborne hazard being identified in a particular batch of fish, or a case of foodborne illness associated with consumption of fish having been reported, a full seafood traceability system will permit identification of where that fish had originated, the raw materials involved in its production (in the case of aquaculture); who handled the fish since it was caught; how it has been stored during transit; and the final destination of the product. This information will enable a rapid and targeted recall of potentially hazardous product, thereby preventing any further food safety problems.

Current legislation for traceability of fish and fish products is described in EU Council Regulation 104/2000 and Commission Regulation 2065/2001. This regulation states that at the point of consumer purchase, the following aspects should be documented:

- Species (trade name and/or Latin name)
- Production method ('Caught at sea', 'Caught in inland waters' or 'Farmed')
- Catch area. For fish caught at sea the FAO area must be stated. For fish from inland waters the country of origin must be given and for farmed fish the country of the final development of the product must be given.

These are the first implemented demands for traceability for fish products in the EU system and more demands will follow in the years to come. For instance, the catch area demand is very broad and currently only requires a distinction between fish from the whole North Sea and the Baltic Sea for catches from the North of Europe. This has far reaching consequences if, for example, pollution is detected in a small sea area in the North Sea, then all fish caught from the North Sea must be recalled (55).

Tracefish

At the time of publication of the first edition of ***safe*food**'s Finfish CFR (192), the *Tracefish* scheme was in operation. However, this scheme has since come to an end. The *Tracefish* concept was essentially an electronic system of chain traceability which was developed under the patronage of the European Commission in its Concerted Action Project QLK1-2000-00164 (238) which ran from the end of 2000 for two years. This project sought to develop a traceability scheme for the seafood industry and the project culminated in agreement on three specifications that provide a basis for traceability in the industry.

Three specifications were developed as CEN Workshop Agreements and specific requirements were set out at the various stages along the food chain.

1. An information specification for captured fish distribution chains (239);
2. An information specification for farmed distribution chains (240); and
3. A technical specification for the electronic encoding of the data.

The Tracefish specifications for captured and farmed fish outlined the traceability information that seafood businesses should have been aiming to provide under EU legislative requirements at that time.

They also included additional requirements for businesses that brought in fish and materials from outside of the *Tracefish* domain. Participation in the scheme was voluntary. The method of identifying the goods traded was based on the EAN.UCC system (241) that had already been in use throughout the world. In addition, it was anticipated that an EU funded project, SEAFOODPlus (242), would build on the *Tracefish* project and deal with practical implementation of traceability systems in the seafood industry.

The Irish electronic recording and reporting system

The Electronic Recording and Reporting System (ERS) in Ireland is currently being introduced on a phased basis to fishing vessels. The legislation governing these electronic logbooks is EC Regulation

1077/2008. This will be overseen by an Inter-Departmental Implementation Group drawn from DAFF, the SFPA, the Department of Defence and the Naval Service. The SFPA are responsible for providing the fishing vessel element of Ireland's ERS solution, while DAFF are responsible for the shore based element, known as the ERS hub. The fishing vessel element of the system is called the ERS Terminal, and consists of the hardware, software and communications components required to record the logbook data on the fishing vessel, and to subsequently transmit the data to the ERS hub. The first phase of the project will involve the installation of ERS terminals on approximately 75 fishing vessels >24m in length. The second phase will involve approximately 130 vessels between 15 and 24 metres in length. It is anticipated these vessels will be fitted with terminals by January 2011. The third phase, which should be implemented by July 2011, will see a further 100 vessels >12m in length becoming ERS compliant by the January 2010 deadline. The Irish Authorities went to the market in 2009, with the aim of finding an ERS solution that would provide value for money, and minimise operational costs for fishermen and the State. All possible options were examined, and solutions that would utilise the Inmarsat C technology (previously used for the Vessel Monitoring System) were considered. While the initial capital costs would be relatively small, the operating costs would be expensive for fishermen. It is essential that the technology used would be proofed and capable of adapting to any regulatory changes for the next ten years or more. After much discussions, it was decided that the Irish solution should be IP (Internet Protocol) based. The Irish ERS Terminal uses a customised version of the vCatch software provided by the Danish company Sirius IT. All skippers are required to undertake training in using this software, and to register with DAFF/ the SFPA (32).

Illegal, underreported and unregulated fishing

Illegal, underreported and unregulated (IUU) fishing encompasses unauthorised fishing and all fishing activities that are a serious breach of national, regional or international rules. It is estimated that this costs between $10 billion and $24 billion globally each year, which is equivalent to almost 20 per cent of worldwide reported catches. IUU is regarded as the biggest global threat to the sustainable management of fish stocks (Seafish, 2009). In order to prevent, deter and eliminate importation of IUU fishery products into the European Community, the EU introduced a new regulation (No. 1005/2008) in January 2010. This regulation created new requirements on fish and fisheries products entering the EU market from third countries (i.e. non-EU member states) (243).

The main provisions of Regulation No. 1005/2008 are set out below:

- Catch certification scheme:
    - This will improve traceability of all fishery products that are traded, and are an essential part of the Regulation. All imported fishery products must be accompanied by a catch certificate, which must be issued by the flag state of the catching vessel. Catch certificates must accompany the fishery product throughout the supply chain, and are required upon entry into the EU. However, the catch certification scheme will not apply to aquaculture products obtained from fry or larvae, freshwater fish, ornamental fish or certain molluscs (further excluded products are listed in Annex I of the_Regulation). Simplified catch certificates are available for non-EU fishing vessels, such as for small scale artisanal fisheries. Also, catch documentation schemes for certain Regional Fisheries Management Organisations (RFMO) are acceptable. In some instances, catch certificates are required to accompany exports of fishery products from member states to non-EU countries for processing and subsequent re-entry to the EU. Importers are also able to apply for Approved Economic Operator (APEO) status if they have a proven track record of good traceability and record-keeping practices. In addition, Border Inspections will be carried out by Port Health Authorities to ensure IUU catch certificates are present and correct.
- Port state control measures:
- All third country fishing vessels must issue prior notification and declaration of landings and transhipments at designated ports. If inspection shows that a vessel has engaged in IUU activity, it will not be authorised to land or tranship its catch.
- Community alert system:
- If there are well founded doubts over the compliance of fishing vessels or fishery products from non-EU countries, the European Commission may publish an alert notice on its website and in its Official Journal. Such alerts may in turn lead to the prevention of entry of vessels/ products.
- A list of non co-operating third countries:

- The Regulation includes powers that can identify non co-operating third countries and in turn take action against them if they are suspected of IUU fishing practices. Again, any such countries will be made known on the Commission's website and in its Official Journal.
- A harmonised system of proportionate and dissuasive sanctions for serious infringements: The Regulation consists of effective, proportionate and dissuasive sanctions for any serious infringements to deter operators from entering into or supporting IUU fishing practices. For serious infringements, the maximum sanction that can be imposed by member states is at least five_times the value of the fishery products, or eight times the value of the fishery products for repeated infringements within a five year period. Criminal sanctions may also be applied.

5.3.2 Product recall

The objective of a product recall is to protect public health by informing consumers of the presence on the market of a potentially hazardous foodstuff and by facilitating the efficient, rapid identification and removal of the unsafe foodstuff from the distribution chain. There are two levels of product recall:

1) Recall – the removal of unsafe food from the distribution chain extending to food sold to the consumer, and
2) Withdrawal – the removal of an unsafe food from the distribution chain (does not extend to food sold to the consumer).

Regulation (EC) No. 178/2002, in addition to laying down the requirements for product traceability and recall, also established RASFF which is a notification system operated by the European Commission to exchange information on identified hazards between MS. In each MS there must be a single liaison contact point to deal with alerts arising within that State, or issued by RASFF. The FSA NI and the FSAI in ROI are the primary contact points on the IOI.

Notifications of alerts are issued by the single liaison contact point within each MS to official agencies and food businesses relating to an identified hazard and are classified as either one of two categories, 'For Action' or 'For Information'. Action is required when there is an identified direct or indirect risk to consumers. Information alerts do not require action, but relate information concerning a food or feed product that is unlikely to pose a risk to health, e.g. inform relevant authorities of consignments blocked at border inspection posts.

The FSAI has issued a Guidance Note (244) relating to Product Recall and Traceability (applicable only to food) and also a Code of Practice on Food Incidents and Food Alerts (245). A similar guidance document has been issued by FSA NI, Guidance Note on EC Directive 178/2002 (246), and includes guidance on product recall and traceability.

In the ROI, a 'National Crisis Management Plan' was developed by the FSAI in conjunction with all of the official agencies so that a structured, coordinated and efficient response to any food safety crisis can be employed where the event arises. The FSA has set up an Incidents Taskforce to strengthen existing controls in the food chain so that the possibility of future food incidents occurring may be reduced. It also aims to improve the management of such incidents when they do occur (247).

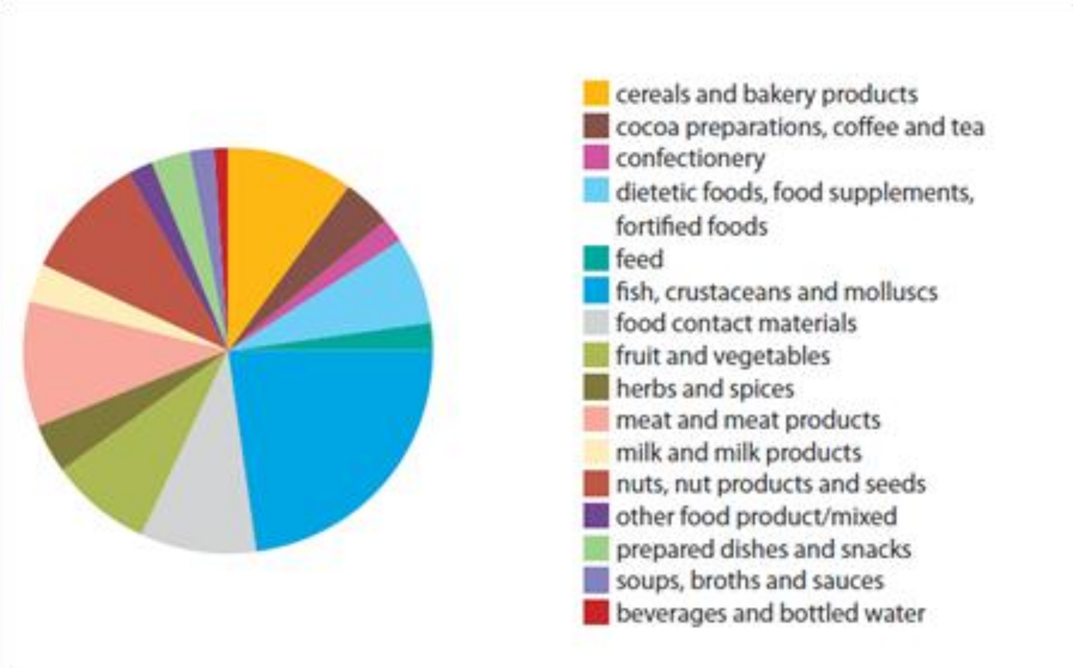
RASFF notifications

Fish (including finfish and shellfish) accounted for the highest number of notifications to the EU RASFF in 2004. Fish accounted for 24 per cent (168 out of 691) of alert notifications and 20 percent (373 out of 1,897 – second highest to nut and nut products, and snacks at 40 percent) of information notifications (248).

Notifications involving fish with increased occurrence and/or of particular interest in 2004 included cadmium and mercury in swordfish and cephalods (primarily originating from South East Asia), residues of veterinary medicinal products (mainly originating from South East Asia), *L. monocytogenes* in fishery products (predominantly in chilled tuna that was subsequently vacuum packed in the Netherlands, country of origin primarily Indonesia) and Anisakis in fresh fish (mainly in fresh mackerel from Norway and Denmark and anglerfish from the UK). As for the latter years, i.e. 2005, 2006, 2007, 2008 and 2009, there were 196, 175, 208, 109 and 121 alert notifications for fish (including crustaceans and molluscs) respectively. In 2008, RASFF reported 26 cases of food poisoning regarding fish. One case in France involved pre-cooked frozen mussels from the ROI. These mussels contained Azaspiracid Shellfish Poisoning toxins (azaspiracid, >160µg/kg – ppb). This resulted in a large outbreak. Another outbreak of food poisoning occurred in Norway and in this instance oysters from the UK contained a norovirus which resulted in six cases of food poisoning.

In 2009, fish (including shellfish and finfish) accounted for 22 per cent of alert notifications and 20 per cent of information notifications (Figure 5.1). An increase in the number of notifications for mercury contamination was reported in 2009. This increase may have been due to the increased importation of fish species from a fishing territory in which higher levels of mercury are known to be present.

Figure 5.1Alert notifications by product category for 2009



Listeria monocytogenes was reported more frequently in 2009 due to a rise in notifications relating to processed fish, for example, smoked salmon from Italy. Furthermore, *Clostridium botulinum* (type E) was suspected in vacuum packed smoked whitefish (Coregonus lavaretus) from Finland, with raw material from Canada and infected three people. Histamine was found in raw white sashimi tuna carpaccio from Spain and in canned sardine fillets in sunflower oil from Tunisia and on both occasions, one person was infected.

5.4 Conclusion

Safety controls for imports of fish and fish products from Third Countries to the IOI are carried out at designated Border Inspection Posts (BIPs). A series of checks are carried out before they are allowed access to the EU market. The BIPs are situated in strategic locations in ROI and NI and are under the supervision of the FSAI and FSA, respectively. The Food and Veterinary Office of the European Commission routinely audits the controls exercised at these BIPs.

Fish and fish products imported into the EU may only originate from a Third Country, or part of a Third Country, approved by the EU.

Over the past few years, there has been an improvement in technology with regard to traceability and fish. In July 2010, the Sea Fisheries Protection Agency (SFPA) released their 'Guide to Compliance for the Irish Inshore Fleet'. In essence, this guide provides a method for the SFPA to trace the boats that fish came from and where the fish subsequently went to. Furthermore, the Electronic Recording and Reporting System (ERS) in Ireland is currently being introduced on a phased basis to fishing vessels.

In 2009, fish (including shellfish and finfish) accounted for 22 per cent of alert notifications and 20 per cent of information notifications. An increase in the number of notifications for mercury contamination was reported in 2009. This increase may have been due to the increased importation of fish species from a fishing territory in which higher levels of mercury are known to be present.

6 Nutrition

Key findings

- Fish is a rich source of protein. The protein present is rich in essential amino acids and is therefore considered to be high quality that is comparable to lean meats such as chicken.
- Oily fish provide one of the richest sources in the diet of essential n-3 long chain PUFA namely, eicosapentanoic acid (EPA) and docosahexanoic acid (DHA).
- Oily fish are a rich source of the fat soluble vitamins A, D and E. A portion of oily fish can contribute between 50 – 200 percent to the recommended daily allowance (RDA) for Vitamin D for most adults.
- In ROI the recent National Adults Nutrition Survey indicates that since 2001, there has been a decrease in the proportion of the population who consume fish but an increase in the amount of fish eaten by consumers of fish.
- The Ntional Adult Nutrition Survey found that fifty three per cent of adults in ROI now consume fish, with a larger proportion of the population consuming white fish (37 per cent) than oily fish (23 per cent). For fish consumers only, mean daily intake of all fish of 48g/day, 41g/day for white fish, 38g/day for oily fish.
- Data from the NDNS showed that 20 per cent of consumers in the UK consumed coated white fish (mean intake in consumers 41 g/day), 35 per cent consumed other white fish (63 g/day) and 20 per cent consumed oily fish (54 g/day).
- Fish contributes little to the population's macronutrient intakes on IOI

due to the current low intake of fish and fish products.

- Fish and fish products contribute a variety of micronutrients including selenium, iodine, vitamin B12 intakes and, most significantly, to vitamin D intake.

- The strongest evidence for health benefits of consuming fish includes cardiovascular health and foetal and infant neurodevelopment and growth. Most of these benefits can be attributed to oily fish and the presence of n-3 PUFA.

- Research on fish consumption and cognitive development, maintenance of cognitive function, depression and sever psychiatric disorders, allergies and chronic inflammatory diseases and cancer is ongoing but more research is required to confirm a beneficial effect.

6.1 Nutritional composition of fish

In nutritional terms fish is classified as either white or oily. The nutritional value of fish is well recognized, particularly as a good source of protein. In more recent times, oily fish and fish oils have received much attention for their health benefits.

Fish is a rich source of protein because the majority of the edible portion of fish is muscle. The protein present is rich in essential amino acids and is therefore considered to be high quality that is comparable to lean meats such as chicken. Table 6.1 provides nutritional composition data for selected nutrients in commonly consumed fish.

The fat or lipid content of fish depends on the type of fish. White fish such as cod and haddock contain approximately one to two grams of fat per 100g raw fish. In contrast, oily fish such as salmon and mackerel have a fat content greater than 16 percent per 100g raw fish. Polyunsaturated fatty acids (PUFA) are the predominant lipid present in fish, with only small amounts of monounsaturated fatty acids (MUFA) and saturated fats present. Oily fish provide one of the richest sources in the diet of essential n-3 long chain PUFA namely, eicosapentanoic acid (EPA) and docosahexanoic acid (DHA). DHA is the biologically active form and can be synthesized from EPA. These fatty acids are essential components of cell membranes and participate in metabolism, in particular in the immune system. During the course of evolution, humans have lost the ability to synthesize these fatty acids and now require a dietary source.

Oily fish are a rich source of the fat soluble vitamins A, D and E. There are very few other dietary sources of Vitamin D. A portion of oily fish can make a significant contribution of between 50 – 200 percent to the recommended daily allowance (RDA) for Vitamin D for most adults.

Table 6.1 Nutritional content per 100g of commonly consumed fish (249)

Type of fish	Energy		Water	Protein	Fat		Carbo-hydrate	Vitamin A	Vitamin D	VitaminB12	Iron	Selenium	Iodine
	Kcal	kJ	G	g	Total g	n-3 fatty acids	g	µg	µcg	µg	mg	µg	µg
Cod, raw	80	337	80.8	18.3	0.7	0.3	0	2	Tr	1	0.1	28	100
Haddock, raw	81	345	79.4	19.0	0.6	0.2	0	Tr	0.3	1	0.1	27	250
Plaice. Raw	79	336	79.5	16.7	1.4	0.1	0	Tr	Tr	1	0.3	37	33
Whiting, raw	81	344	80.7	18.7	0.7	0.1	0	Tr	Tr	N	0.1	25	80
Lemon sole, raw	83	351	81.2	17.4	1.5	No data	0	Tr	Tr	1	0.5	60	N
Herring, raw	190	791	68	17.8	13.2	1.8	0	44	19.0	13	1.2	35	29
Kipper, raw	229	952	61.2	17.5	17.7	2.4	0	32	8.0	10	1.6	32	55
Salmon, raw	180	750	67.2	20.2	11	1.8	0	13	5.9	4	0.4	26	37
Mackerel, raw	220	914	64	18.7	16.1	1.8	0	45	8.2	8	0.8	30	140
Trout, rainbow raw	125	526	7607	19.6	5.2	1	0	49	10.6	5	0.3	18	13
Tuna, raw	136	573	70.4	23.7	4.6	1.4	0	26	7.2	4	1.3	57	30

N = present in significant amounts but no reliable data on levels available

Tr = trace

Fish are the richest source of iodine in the diet with two fish meals a week meeting a weekly requirement for iodine. Fish are also a rich source of selenium, providing 20 to 60 μg selenium per 100g raw fish compared to the RDA of 55 μg/d. Sardines, oysters and shrimps are good sources of calcium in the diet but most other seafood provide only small amounts of calcium. Iron is found in low concentrations in fish but is in the form of haem iron which is more readily absorbed than non haem iron.

In 2005 EFSA evaluated the nutritional composition of both farmed and caught fish (117). It was reported that the feed used can influence the nutritional composition of farmed fish, in particular both the total fat and fatty acid composition. The feed of farmed fish may be manipulated to mimic the feed of fish in the wild resulting in a nutritional composition which may be comparable.

In general, farmed fish tend to have higher whole body lipid levels than caught fish but with a lower concentration of essential n-3 long chain PUFA. However, as the whole body lipid concentration is still higher in farmed fish, the amount of essential n-3 long chain PUFA provided per portion of caught and farmed fish will be similar.

6.1.1 Effects of processing and cooking on nutritional content of fish

Canning, smoking and freezing are commonly used methods to preserve fish and these can influence the nutritional composition of the product (Table 6.2). Freezing itself has little impact on the nutritional content of fish and is the one method of preservation that provides a product nutritionally and texturally equivalent to that of the fresh product.

Table 6.2: Nutrient content of selected fish and fish products to illustrate the effect of processing and cooking on nutrient composition (249).

Fish	Energy		Water	Protein	Fat		Sodium (Na)	Vitamin D	Vitamin B_{12}	Selenium (Se)	Iron (Fe)
	Kcal	kJ	g	g	Total (g)	EPA & DHA (mg)	mg	mcg	mcg	mcg	mg
Cod, raw	80	337	80.8	18.3	0.7	0.3	60	Tr	1	28	0.1
Cod baked	96	408	76.6	21.4	1.2	No data	340	Tr	2	34	0.1
Cod poached	94	396	77.7	20.9	1.1	No data	110	Tr	2	33	0.1
Cod steamed	83	350	79.2	18.6	0.9	0.3	65	Tr	2	30	0.1
Cod, frozen, raw	72	306	82.4	16.7	0.6	0.2	71	Tr	1	27	0.1
Cod, frozen, grilled	95	402	78	20.8	1.3	No data	91	Tr	2	33	0.1
Cod, in batter, fried	247	1031	54.9	16.1	15.4	No data	160	Tr	2		0.5
Cod, in batter, frozen, baked	211	863	57	12.8	11.8	0.1	650	Tr		15	0.5
Cod, smoked	79	333	78	18.3	0.6	0.2	1170	Tr	1	28	0.1
Cod, in parsley sauce, frozen, boiled	84	352	82.1	12	2.8	No data	260	Tr			0.1
Mackerel, fried	272	1130	(55)	24	19.5	No data	81	6.4	11	38	1
Tuna, canned in brine	99	422	74.6	23.5	0.6	No data	320	4	4	78	1
Tuna, canned in oil	189	794	63.3	27.1	9	0.4	290	3	5	90	1.6
Fish fingers, cod, frozen	170	713	63.1	11.6	7.8	0.2	470	Tr	1	19	0.7
Fish fingers, cod, grilled	200	838	55.7	14.3	8.9	No data	440	Tr	1	23	0.8
Fish fingers, cod, fried	238	994	53.8	13.2	14.1	No data	450	Tr	1	21	0.8
Fish fingers, economy, frozen	171	718	62.1	11.5	8.2	No data	340	Tr	1	19	0.9

N = present in significant amounts but no reliable data on levels available

Tr = trace

No data = no data available

6.1.1.1 Canning

During the canning process there is little effect on the overall nutritional composition of fish as many of the nutrients present are stable and not affected by the heating process applied during canning. However, the exception to this is tuna. The species of tuna generally chosen for canning are those with lighter coloured meat, and are lower in fat content and hence, fat soluble vitamins and essential n-3 PUFA (skipjack and yellowfin) (250). Allied to this, the tuna is cooked prior to the canning process resulting in further lipid loss and the destruction of a significant proportion of the n-3 long chain PUFA that are present. Due to the resulting very low levels of essential n-3 long chain PUFA in canned tuna, it is thus considered by nutritionists to be a white fish. Smoking and brining, which often accompany the canning process, result in a loss of water and a subsequent concentration of the remaining nutrients.

The biggest impact canning and freezing have on the nutritional composition of fish results from the ingredients that are added to the fish during the processes. For example, most canned fish is usually stored in brine, oil, or a sauce. Canning in oil and sauce, even when drained before consuming, will increase the fat and salt content of the fish. Canning in brine increases the salt content of the fish. Many fresh and frozen fish products are either coated in breadcrumbs, batter, or a sauce prior to sale for consumers. Such products are higher in fat and salt and lower in protein and micronutrients then the equivalent fresh product.

6.1.1.2 Cooking methods

Cooking methods also affect the nutritional composition of a fish product (Table 6.2). Poaching results in the leaching out of up to half of the water soluble vitamins and minerals present in fish, while baking or cooking in dry heat will result in water loss to various degrees depending on the method employed. Frying fish increases the fat content of the product with white fish absorbing fat more readily than oily fish. Furthermore, fish coated in breadcrumbs or batter will absorb more fat than when uncoated, and this holds for any other cooking method which utilises fat as a cooking medium.

Cooking with heat destroys some of the n-3 long chain PUFA present in oily fish. Nevertheless, compared with other dietary sources, the cooked fish still remains a rich source of these essential fatty acids. The effect of heat on the fatty acid composition of a food depends on the components present in the food and the level and length of heat applied (250). The major type of fat present in fish, PUFA, is reactive in the presence of oxygen resulting in altered composition of the fatty acid profile. The presence of minerals such as iron in fish can accelerate these reactions while antioxidant vitamins act to minimise them.

Excessive heat can result in the denaturing of fish proteins. When proteins are cooked in the presence of carbohydrates the Maillard reaction is initiated which results in the essential amino acid lysine being rendered biologically inactive (251). This may have implications for individuals who rely on fish as their major source of essential fatty acids and protein (i.e. non meat eaters but who eat fish) and who consume fish in a breaded or battered form.

6.2 Dietary consumption patterns

The National Diet and Nutrition Survey (NDNS) (2008-9) of adults and children (252) is a continuous cross-sectional survey of the food consumption, nutrient intakes and nutritional status of people aged 18 months and older living in private households in the UK. It covers all four countries of the UK and is designed to be representative of the UK population. In ROI, the North South Ireland Food Consumption Survey (NSIFCS) provided data on the consumption of fish amongst adults on IOI collected in the late 1990s (159). This has since been updated in 2011 with the publication of results from the National Adult Nutrition Survey (NANS). This was a cross sectional survey that was conducted between October 2008 and April 2010 by the Irish Universities Alliance (IUNA) in the ROI only. In total, 1,500 adults aged 18 to 64 years of age (740 men, 760 women) took part. Individuals were selected for participation from the Data Ireland (An Post) database of free-living adults. The sample was representative of the population with respect to age, gender, social class, and urban/rural location. ***safe*food** commissioned additional analysis on fish consumption as part of this report (253). The National Children's Food Survey (NCFS), National Teens Food Survey (NTFS) and Survey of Lifestyle, attitudes and Nutrition (SLAN) in adults also provide data on fish intake.

The consumption of fish on IOI in the late 1990s was low. According to the NSIFCS (251) the average consumption of fish and fish products across the adult population aged 18 to 64 years was 23 g/d. When the data was further interrogated, 66 percent of the population studied were identified as consumers of fish and fish products, with the average consumption in this group being 35 g/d. This intake is comparable to the recommended intake of two portions of fish per week, for example, one portion of fresh cod (uncoated) of 120 g and one fresh salmon fillet of 100 g. The recent NANS study indicates some changes in fish consumption. The authors found that 53 per cent of adults now consume fish, with a larger proportion of the population consuming white fish (including white fish dishes and breaded white fish; 37 per cent) than oily fish (including oily fish dishes; 23 per cent). For fish consumers only, this translates into a mean daily intake of all fish of 48g/day, 41g/day for white fish, 38g/day for oily fish and 22g/day for shellfish and shellfish dishes (Table 6.3). While these studies indicate that since 2001, there has been a substantial decrease in the proportion of the population who consume fish, the results must be interpreted with caution. The NSIFCS measured food intake over a 7-day period while the NANS used 4 day records. Given that fish is often eaten by consumers less than once a week, these methodological differences may explain some of the apparent reduction in consumption.

Table 6.3 Percentage of adults of the total population consuming fish and mean daily intake (MDI) of fish for fish consumers

Adults consuming fish	53 per cent
Adults consuming white fish[1]	37 per cent
Adults consuming oily fish[2]	23 per cent
Total MDI	48g/day
MDI white fish	41g/day
MDI oily fish	38g/day
MDI shellfish and shellfish dishes	22g/day

[1]including white fish dishes and breaded white fish, [2] including oily fish dishes

Gender differences were noted in the survey. Mean daily intakes of fish were higher for men than for women. However, a slightly larger proportion of females (56 per cent) were fish consumers compared to males (49 per cent). White fish consumption was greater than oily fish. The report found the 36 per cent of males and 38 per cent of females consumed white fish (white fish, white fish dishes and breaded/ deep fried white fish) whereas 20 per cent of males and 25 per cent of females consumed oily fish (oily fish and oily fish dishes). With regard to breaded or deep fried fish, 17 per cent of men and women consumed a daily intake of 46.67g/ day and 34.67g/ day respectively.

Fish intakes increased with age for both males and females. The lowest mean daily intakes and proportion of fish consumers was in the 18-35 year age group. Mean daily intakes of oily fish were particularly low in this age group (approx. 4g/day for both) when compared to white fish. The NCFS indicates that about one third of children consume fish (Table 6.6) and this increased with age when data was compared to the findings of the NTFS.

Food consumed at home made the greatest contribution to total fish intakes, followed by foods eaten outside of the home and those consumed in other people's homes. Supplements containing fish oil were consumed by 11 per cent of the population.

Similar intakes were found in the NDNS (115, 254) where men and women consumed an average of 26 and 22g/day of fish and fish products per day (Table 6.4). Children and young people aged 4-18years were consuming approximately half the amount of fish to adults at 11g/day (Table 6.4). Data from the Low Income NDNS indicates that fish consumption is slightly higher among low income groups when compared to that of the results from year 1 of the NDNS which is representative of all social class groupings (255) (Table 6.5).

Table 6.4 Consumption of total fish and fish type in the National Diet and Nutrition Survey of adults aged 19-64 years and children 4-18 years (adapted from (255))

a. Mean (SD) quantities of food consumed (g/d): consumers, by age

	Males (g/d (per cent consumers))		**Females (g/d (per cent consumers))**	
Age (years)	4-18 (n233)	19-64 (n181)	4-18 (n229)	19-64 (n253)
White fish coated or fried inc fish fingers	28 (33)	41 (20)	29 (21)	35 (21)
Other white fish/shellfish/canned tuna	38 (20)	63 (35)	29 (29)	43 (35)
Oily fish	24 (8)	54 (20)	39 (9)	39 (29)

b. Mean (SD) daily consumption of fish including contribution from composite dishes, by age and sex (g/d)

	Males		**Females**	
Age group	**4-18 (N233)**	**19-64 (N181)**	**4-18 (N229)**	**19-64 (n253)**
Total fish	11	26	11	22
White fish	6	10	5	7
Oily fish	2	7	3	9
Canned tuna	2	6	2	3

Table 6.5. Daily consumption of fish (g) for all (including non-consumers) and for consumers only, and percentage consuming for all adults and children, by sex from the Low Income Diet and Nutrition Survey (adapted from (255))

	Men (n=946)			Women (n=1850)		
	total	consumers	per cent consumers	total	consumers	per cent consumers
White fish coated or fried	12	51	23	9	42	21
White fish dishes and white fish not coated or fried	6	58	11	6	54	11
Oily fish and dishes	5	37	13	7	42	16

Table 6.6 Mean values of food group intakes (g/d) in the national Children's Food Survey and National Teens Food Survey

a. NCFS

	Mean intake for all	per cent consumer	Mean intake among consumers only
Fish & fish products	8	47	16
Fish dishes	1	4	30

b. NTFS

	Mean intake for all (g/d)	per cent Consumers	Mean intake among consumer only (g/d)
Fish & fish products	9	37	23
Fish dishes	2	3	48

The NDNS survey 2008/9 showed that coated or fried white fish was the most commonly consumed type in toddlers and younger children while white fish and canned tuna was the most commonly consumed type in adults. Mean consumption of fish and fish dishes overall was slightly higher in toddlers, younger children and adults compared with previous surveys but there was little change in older children. This has partly been attributed to the reclassification of canned tuna as a white fish during data analysis.

In 2004, the Scientific Advisory Committee on Nutrition (SACN) reviewed its advice on fish consumption in an attempt to balance the benefits and risks of the food commodity (256). During its deliberations the Committee reviewed the portion sizes of fish consumed by different age groups as determined by the older NDNS surveys (Table 6.7). The average portion size consumed by adults in GB was comparable to a typical medium to large portion sizes for most fresh fish that is neither coated nor fried (91, 257). Data in the most recent rolling survey has not been analysed yet to the degree of portion size.

Table 6.7 National Diet and Nutrition Surveys fish portion sizes (adapted from SACN (91))

Age	Sex	Number	Portion sizes (g)			Per cent of sample
(years)			Min	Mean	Max	Consuming fish
1.5-4.5	M&F	1675	2	47	170	6
4-6	M	184	21	57	78	5
	F	171	8	68	162	10
7-10	M	256	40	85	178	8
	F	226	14	84	170	8
11-18	M	237	48	137	237	7
	F	238	13	137	196	6
15-18	M	179	49	114	354	8
	F	210	18	97	198	4
19-64	M	766	10	148	340	20
	F	958	4	143	350	21

Excludes fish coated in batter and breadcrumbs, canned fish, smoked fish, and fish in recipe dishes

6.3 Contribution of fish to nutrient intakes

6.3.1 Macronutrients

Data from the NANS reported that fish provided three per cent of energy to adults in ROI. It also made a minor contribution to fat (3 per cent) intakes in the total population; however, a greater contribution was yielded to protein (6 per cent). The previous NSIFCS indicated a similar contribution to macronutrient intakes from fish and fish products (258, 259). NANS data showed that both men and women derived significantly more protein ($p<0.001$) from fish and fish products with increasing age (four percent protein in the 18 to 35 year olds compared to six percent protein in the 51 to 64 year olds).

Among adults in the NDNS survey in 2003, fish and fish dishes provided men and women with seven per cent and eight per cent of their protein intake, respectively (185). Fish and fish products contributed to three per cent and four per cent total fat intake in men and women; three per cent saturated fat intake; three per cent trans fatty acids intake.

Among children and young people in the most recent NDNS survey showed that fish and fish products contributed to two percent total energy intake; four and five percent protein intake of boys and girls, respectively; two percent total fat intake; two percent saturated fat intake; 3 and 2 percent trans fatty acids intake of boys and girls (252). In ROI the NCFS and NTFS also found low contributions of fish to macronutrients primarily due to the low intake of fish in these population groups (260).

6.3.2 Micronutrients

Data from NANS indicated that fish and fish products contributed a variety of nutrients including selenium (15 per cent), iodine (7 per cent), vitamin D (14 per cent) and vitamin B12 (13 per cent) intakes (261) (262).

The LINDNS is the most recent UK data that looks at the impact of fish and fish dishes on micronutrient intake (Table 6.8).

Table 6.8 Contribution of fish and fish dishes to the nutrient intake (per cent) in adults and children in the low income NDNS in UK

a. Adults 19-65+ years

	Total men (n=946)	Total women (n=1850)	Total (n=2796)
Energy	2	3	3
Protein	6	7	6
Total fat	3	4	4
Saturated fat	2	2	2
Trans fatty acid	3	3	3
MUFA	3	4	4
PUFA N-3	9	11	11
PUFA N-6	4	5	4
Retinol	2	2	2
Vitamin D	10	12	11
Iron	2	3	3
Calcium	3	3	3
Sodium	4	4	4
Potassium	3	3	3
Zinc	3	3	3
Iodine	10	10	10

b. Children 2-18 years

	Boys (n=439)	Girls (n=493)	Total (n=932)
Energy	2	1	2
Protein	4	4	4
Total fat	2	2	2
Saturated fat	1	1	1
Trans fatty acid	3	2	2
MUFA	2	2	2
PUFA N3	4	5	4
PUFA N6	3	3	3
	Boys (n=439)	**Girls (n=493)**	**Total (n=932)**
Retinol	1	1	1
Vitamin D	5	6	5
Iron	1	2	2
Calcium	2	1	2
Sodium	3	3	3
Potassium	2	2	2
Zinc	1	2	1
Iodine	7	7	7

Vitamin D is one of the most significant contributions that fish makes to micronutrient intake, especially among adults. This is comparable to previous NDNS surveys.

Fish contributes little to the population's energy and protein intakes on IOI due to the current low intake of fish and fish products. Older NDNS data suggests that fish and fish products are contributing significantly to PUFA intake and in particular essential n-3 PUFA. In terms of micronutrients, the contribution of fish to vitamin D intake appears to be the most significant influence that fish has on the population of IOI.

6.4 Health benefits of consuming fish

6.4.1 Introduction

The benefits of consuming fish have been extensively documented and only summary information is provided in this report. Reports by SACN (91), WHO (263) and Hooper et al. (264), provide detailed evidence of the health benefits of fish consumption. These benefits include improved cardiovascular health, and foetal and infant neurodevelopment and growth. Most of these benefits can be attributed to oily fish and in particular to the presence of n-3 PUFA.

6.4.2 Cardiovascular disease

There is overwhelming evidence to indicate a beneficial role of fish consumption for cardiovascular health. The relationship between fish consumption and the risk of cardiovascular disease has been studied since the 1970s. Eskimos were observed to have a high intake of fat, primarily from oily fish, yet maintained a healthy serum lipid profile and prolonged blood clotting times. In 2003, the WHO stated that there is convincing evidence that fish and fish oil consumption decrease the risk of cardiovascular disease (263). This evidence pointed towards a benefit among high risk individuals only. Populations such as on IOI with a high incidence of cardiovascular disease may benefit. This research has been supported by data such as that seen in the Diet and Reinfarction Trial (DART) where two year mortality rates were reduced by 29 percent in individuals who received advice to eat oily fish twice a week (265). The same findings have been reached by other studies in the area (117, 266). In a more recent review of the data, benefits were found not only for high risk individuals but also for the general population who showed reduced risk from consuming low levels of fish (one portion of fish per week) (267). However, in contrast to high risk individuals, no benefit was observed among the general population in increasing fish consumption beyond one portion.

Despite the wealth of supporting evidence, there remains conflicting information in the literature (263, 265, 268). However, the differences may be attributed to the quality of data included; differences in study design; the length of follow up; and the type of fish consumed. Nevertheless, the Scientific and Medical Communities agree that there is overwhelming evidence to support fish consumption for cardiovascular health.

SACN reviewed the evidence for a protective role of fish in the prevention of stroke (91) and found the evidence to be inconclusive. A further recent review concluded however that fish consumption can confer substantial risk reduction (12 per cent in a linear model) compared to no fish consumption (269). It has also been proposed that n-3 PUFA intake during early life may prevent the development of hypertension (the major risk factor in the aetiology of heart disease) in later life through the regulation of pro-inflammatory molecules that regulate the elasticity of blood vessels (270).

The potential mechanisms through which n-3 PUFA may protect against cardiovascular disease include antithrombotic and anti-arrhythmic effects; and decreased heart rate variability and resting blood pressure. n-3 PUFA are known to reduce plasma triacylglycerol levels while having no effect on high density lipoproteins (HDL); however, they are known to elevate low density lipoproteins (LDL). This highlights the need to consider the overall dietary pattern given the fact that other dietary components have a far greater effect on LDL.

The European Food Safety Authority has published opinions on proposed health claims relating to fish oil consumption (271). Claims relating to EPA and DHA and maintenance of normal cardiac function, blood pressure and triglyceride levels have been approved, whereas claims relating to glucose levels, HDL cholesterol and LDL cholesterol were rejected.

The WHO recommends regular fish consumption i.e. one to two portions per week, each containing an equivalent of 200 to 500 mg of EPA and DHA, for cardiovascular health. The high incidence of cardiovascular disease on IOI places its population in the high risk category. This evidence would underpin an appropriate public health strategy based on increasing the consumption of fish rich in DHA and EPA on IOI. This recommendation is supported by SACN and FSAI (91, 272).

6.4.3 Infant neurodevelopment and growth

DHA is essential for the development of the central nervous system (CNS). During the last trimester of pregnancy and the first postnatal months there is a growth spurt in the development of the CNS with an increase in DHA content observed in the cerebrum and the retina. The increased requirement for DHA during this period must come from the mother, either through transfer through the placenta or through breast milk if the mother is breastfeeding. It has been hypothesized that fish consumption during pregnancy can affect foetal neurodevelopment and growth. SACN reviewed the evidence supporting a beneficial effect of fish consumption on neurodevelopment and growth during pregnancy (91). It included outcomes such as gestational length; recurrence of preterm delivery; and visual development. Some of the evidence suggests a positive association between increased maternal n-3 PUFA intake and these outcomes, particularly in low birth weight populations. The SACN report also indicates that these benefits may also be relevant in populations with a low n-3 PUFA intake such as the UK and ROI and support the recommendation to increase consumption of fish. No adverse effects were observed on foetal neurodevelopment and growth among women who increased their n-3 PUFA intake during pregnancy. Currently formula is not supplemented with n-3 PUFA due to adverse effects observed on postnatal growth (91).

6.5 Other health benefits

6.5.1 Cognition

As previously described, a growth spurt in the development of the CNS occurs in the last trimester of pregnancy and in the first postnatal months. The evidence for a role of prenatal n-3 PUFA intake in cognitive development has recently been reviewed (273). On the basis of eight studies it calculated that an increase in maternal DHA dietary intake of one gram per day would increase a child's IQ by 1.5 points. The authors do point out that the findings are not consistent in all studies evaluated and that such an increase in DHA intake would be extremely difficult to achieve through dietary fish intake alone. Nevertheless, the results are supportive of current dietary recommendations for fish intake during lactation and also for the benefits of breastfeeding.

Recent years have also shown a growing interest in the effect of diet in the maintenance of cognitive function. A large scale epidemiological study of fish consumption among older Dutch adults (Kalmijn, 1997) and a prospective study of US elderly individuals (Morris, 2003) have found promising results for reduced risk of cognitive decline, dementia and Alzheimer's disease. Further research is required to confirm these findings.

6.5.2 Depression and severe psychiatric disorders

The brain contains one of the highest concentrations of DHA in the body. Preliminary evidence indicates that lower concentrations of n-3 PUFA are found in individuals with mood disorders such as bipolar disorders and schizophrenia (274). A cross sectional study of a number of countries found an inverse relationship between the incidence of bipolar disorders and the average national consumption of seafood (275). However, the authors do point out the low incidence of these conditions and the fact that they did not control for a number of confounding factors.

A review of the evidence for the use of n-3 PUFA in the treatment of psychiatric disorders indicates potential benefit (273, 276). It is important to note, however, that few good quality studies exist. The focus of the evidence is on therapeutic treatment in a small number of individuals with very high doses of n-3 PUFA as a supplement. Such doses would be unachievable through dietary fish intake.

6.5.3 Allergy prevention and chronic inflammatory diseases

It is well established that dietary fatty acids influence the intensity of the inflammatory response through regulation of the production of cytokines and proinflammatory agents in humans (277). A diet containing n-3 PUFA results in a less intense response than a diet containing no n-3 PUFA thus preventing over stimulation of the immune system. In recent decades the ratio of n-6:n-3 PUFA has been rising due to shifts in dietary consumption patterns and the increased use of sunflower and corn oils in food manufacturing. In addition the reported increase in prevalence of chronic immune diseases such as asthma, allergic rhinitis and arthritis may be attributed to a decline in n-3 PUFA. EFSA reviewed the limited evidence indicating a role for fish and n-3 PUFA in these conditions and concluded that the data does indicate a beneficial effect (249). However, large doses of n-3 PUFA were used in many studies. Research is ongoing with newer studies examining the effects of fish consumption on autoimmune disorders e.g. eczema, asthma and food intolerances in specific population groups such as pregnant women (Mikaye (2009), Calvani (2006)

6.5.4 Cancer

The role of fish consumption and cancer has focused on two types of cancer – colorectal and nasopharyngeal. The evidence for both has been recently reviewed by the World Cancer Research Fund and American Institute for Cancer Research (278). In relation to colorectal cancer it was highlighted that there is a substantial amount of data available but the results are inconsistent, and residual confounding by meat could not be excluded. As a result the WCRF and AICR concluded that there was limited evidence suggesting that eating fish protects against colorectal cancer. In relation to nasopharyngeal cancer the WCRF and AICR concluded that Cantonese-style fish was a probable cause of the disease. This type of fish is a fermented and salted using a specific method and consumption if any on IOI is negligible.

6.6 Dietary patterns and health

From a public health perspective assessing dietary patterns rather than single foods or nutrients offers many advantages for evaluating the impact of diet on health. This approach takes into account the fact that individuals eat foods and not individual nutrients and also the highly interrelated nature of dietary exposures (279). It is therefore often difficult to extract the specific impact of a single food or nutrient on health. For example, diets high in fibre tend to also be high in vitamin C, folate, vitamin A, magnesium and potassium, while whole-grain consumption is positively associated with fruit, vegetable and fish intakes.

In the US, epidemiologists have investigated dietary patterns and their association with chronic disease (280-282) . In the analysis of the Health Professionals Follow-up Study, two clear dietary patterns emerge – the 'prudent diet' and 'Western diet'. Higher fish consumption is one of the characteristics of the 'prudent diet' along with higher intakes of vegetables, fruit, legumes, whole grains and poultry. The 'Western diet' is associated with higher intakes of red meat, processed meat, refined grains, sweets and desserts. The prudent diet has been associated with lower risks of cardiovascular disease and its biomarkers (277, 283), such as endothelial function and inflammation (284). In analysis of the Framingham study five dietary patterns emerged, with foods such as fish being a component of the 'Healthy Eating' pattern (280, 281). Similar to the previous findings, dietary patterns were associated with variations in chronic disease risk (281, 285).

Dietary pattern data provides valuable data and highlights the value of evaluating the health benefits of fish in the context of the overall diet.

6.7 Conclusions

The latest surveys in the UK and ROI show that consumption of fish among consumers is in line with recommended intakes. However, the proportion of the population on the IOI consuming fish remains relatively low. The key benefits of fish consumption are in the provision of high quality protein and from oily fish, vitamin D and n-3 fatty acids. Scope remains to promote these benefits among consumers.

The strongest evidence for health benefits of consuming fish includes cardiovascular health and foetal and infant neurodevelopment and growth. Most of these benefits can be attributed to oily fish and the presence of n-3 PUFA. Research on fish consumption and cognitive development, maintenance of cognitive function, depression and sever psychiatric disorders, allergies and chronic inflammatory diseases and cancer is ongoing. However, more research is required to confirm a beneficial effect.

7 General issues

Key findings

- In 2010, new legislation regarding labelling of fish added new commercial designations for species of fish that have come onto the market in recent years. The fish must be labelled whether it was captured at sea or from inland waters or farmed. In addition, if the fish was captured at sea the label must specify from which sea area.
- In July 2010, new EU rules on organic food labelling, including the requirement to display a new EU logo, came into force. The 'Euro leaf' is obligatory on pre-packaged organic food products that have been produced in any of the EU member states and meet the necessary standards.
- In NI there are two relevant quality schemes run by the Sea Fish Industry Authority – the British Retail Consortium (BRC) Global Standard for Food Safety or Storage and Distribution and the Safe and Local Supplier Approval (SALSA). The corresponding authority in the ROI is Bord Iascaigh Mhara (BIM).
- The pursuit of sustainable development of fish stocks as an objective has become increasingly important globally in recent years. Seafish have developed the Responsible Fishing Scheme (RFS), in an attempt to raise standards in the catching sector.
- Eco-labelling and certification of capture fisheries and aquaculture is a rapidly developing sector.

7.1 Introduction

The following chapter includes issues that, although not food safety issues *per se*, were cited as concerns from a consumer perspective through qualitative discussion groups in both 2005 and 2010. Thus it is necessary to address these issues in the context of this review. The chapter also covers other aspects of the food safety continuum at the core of ensuring food safety, for example, training.

7.2 Labelling

Labelling allows consumers to make informed decisions about the food they eat and also builds confidence in products. The general labelling of fish products is governed by Council Directive 2000/13/EC on the Labelling, Presentation and Advertising of Foodstuffs, and by Council Regulation (EC) No. 2065/2001 which lays down detailed rules for the application of Council Regulation (EC) No. 104/2000 regarding common organisation of the markets in fishery and aquaculture products.

7.2.1 General food labelling requirements

Council Directive 2000/13/EC, and amendments thereof, sets out general provisions on the labelling of pre-packaged foodstuffs to be delivered to the ultimate consumer. Sale of loose (over the counter) non-prepackaged food (when it is packaged on the premises from which it is to be sold), is governed by Article 14 of Directive 2000/13/EC. This legislation permits individual Member States (MS) to decide what labelling information needs to be shown, and how it should be displayed, subject to the condition that the consumer still receives sufficient information. The only requirement for foods sold loose specified on the IOI is that the name of the product must be given.

Directive 2000/13/EC is implemented in the ROI by the European Communities (Labelling, Presentation and Advertising of Foodstuffs) Regulations 2002 (S.I. No. 483 of 2002) and in NI by the Food Labelling Regulations (NI) 1996 (SR NI 1996 No. 383), as amended. Enforcement of this legislation lies with the Food Safety Authority Ireland (FSAI) in the ROI and the District Councils in NI.

Directive 2003/89/EEC, amending directive 2000/13/EC, concerns the labelling of allergens in foodstuffs. Under this regulation fish (and products thereof) is classed as a food allergen and consequently its presence must be indicated in the labelling of a product.

7.2.2 Specific fish labelling requirements

Council Regulation (EC) No. 104/2000 and Commission Regulation 2065/2001 detail labelling requirements for fishery and aquaculture products intended for the retail sector. As outlined in Chapter 3 (section 3.5.1), information concerning the commercial designation, the production method, and the catch area must be provided either on the label, the packaging, or by means of a commercial document accompanying the product.

Commission Regulation 2065/2001 outlines detailed rules as regards informing consumers about fishery and aquaculture products. These rules apply to fish products that are sold loose from fish counters or pre-packed at retail sale to the final consumer [i.e. fresh, frozen and chilled fish; fish and shellfish that has not been cooked/processed; dried, salted or brined fish; smoked fish (whether hot or cold smoked); crustaceans (except crustaceans which are both cooked and peeled); and molluscs (except cooked molluscs)]. However this does not apply to enrobed (i.e. coated or encased), recipe or canned products.

There are a number of guidance notes available in relation to the fish labelling regulations (286-290). Most notably, new legislation came into force in 2010 in relation to fish labelling in England, Scotland, Wales and NI (291). This new legislation adds new commercial designations for species of fish that have come onto the market in recent years. The purpose of these regulations is to ensure fish are labelled correctly and consistently at the point of sale so that the consumer is aware of whether the fish was captured at sea or from inland waters or farmed. In addition, if the fish was captured at sea the label must specify from which sea area (291).

7.2.3 Lot marking

Council Directive 89/396/EEC and its subsequent amendments, concern the indication marks identifying the lot to which a foodstuff belongs (lot or batch number). This directive is applicable to pre-packaged fish products. This directive does not apply to fish products which:

(i) Are not pre-packaged at point of sale;

(ii) Are packaged at the request of the purchaser; or

(iii) Are pre-packaged for immediate sale.

The date of minimum durability, or 'use by' date, may (in conformity with Council Directive 79/112/EC, as amended by Council Directive 1999/10/EC and its subsequent amendments) serve as the lot indication, provided it is indicated precisely.

7.2.4 Identification marks

Council Directive 853/2004/EC states that food business operators must ensure that 'products of animal origin', including fishery products, have an identification mark (in compliance with certain criteria laid down in the directive) to facilitate traceability. For that purpose, the following information must appear on the packaging or, in the case of a non-packaged product, in the accompanying documents:

- Abbreviated name of the country in which the establishment is located, e.g. IE for Ireland, or UK for the United Kingdom;

- Identification of the establishment[12] or factory vessel by its official approval number; and
- One of the following abbreviated forms of 'European Union': CE - EC - EG - EK - EF – EY.

All the letters and figures must be fully legible and grouped together on the packaging in a place where they are visible from the outside without any need to open the packaging. This enables an enforcement officer to identify the factory in which the product was packaged. All such establishments, that meet the specified hygiene requirements and are licensed, are allocated a code number which is part of the identification mark along with the code of the particular country. The competent authority in each country is obliged to maintain a list of approved premises.

Identification marking is an important element of any traceability system. However, it should not be confused with, or related to, country of origin as is often the case. A product, produced in one country can be exported to another country where it is repackaged and relabelled, can bear the identification mark of the factory in which the latter took place.

7.2.5 Country of origin

There is no statutory definition of 'place of origin or provenance' in the Food Labelling Regulations 1996 or of 'origin or provenance' in Directive 2000/13/EC (292). However, there is specific EU commodities legislation that requires country of origin information for beef, veal, fresh fish, shellfish (whether pre-packed or loose), wine, most fresh fruit and vegetables, honey, olive oil, and poultry meat imported from outside the EU (292).

The Food Labelling Regulations 1996 states that food products readily available to the consumer should be labelled with:

> *'particulars of the place of origin or provenance of the food. If failure to give such particulars might mislead a purchaser to a material degree as to the true origin or provenance of the food'*

[12] Establishment refers to place of production.

There are various other types of origin labelling which may be displayed on fish and fish products (293).

'Farmed' or 'Agriculture' is a new definition for origin which was introduced in the Organic regulation, where organic produce will be labelled according to whether the raw materials come from the EU or non-EU (Third Country) agriculture.

When two or more countries are involved in the production of a good, the origin of the good must be determined in accordance with Article 24 of Council Regulation No. 2913/92, establishing the Communities Customs Code which states: 'Goods whose production involved more than one country shall be deemed to originate in the country where they underwent their last, substantial, economically justified processing, or working in an undertaking equipped for that purpose and resulting in the manufacture of a new product or representing an important stage of manufacture'. This means that a product whose main ingredients have been sourced outside of IOI can be described as being a product of IOI when it is processed within IOI. For instance, the labelling of smoked fish products can be misleading, e.g. salmon which was produced in Scotland, but smoked in Ireland, should be described for example as '[Scottish] salmon smoked in Ireland' and not 'Irish smoked salmon'.

The importance of not misleading consumers by inaccurately labelling products applies across the food chain, from primary processors to retailers and caterers. This is highlighted in the general food labelling legislation. The wording of any origin information should be clear and unambiguous. The Food Standards Agency in NI have issued guidance on country of origin labelling (294).

7.2.6 Nutrition labelling

The nutrition labelling of foodstuffs is governed by Council Directive 90/496/EEC, as amended by Commission Directive 2008/100/EC. This piece of legislation states that nutrition labelling is compulsory when a nutrition claim is made. In this instance, and in other instances where nutrition labelling is provided voluntarily, the information given must consist of one of two formats - group one (the 'Big Four') or group two (the 'Big Eight'). Group one consists of energy value, protein, carbohydrate and fat; while, group two consists of the latter four plus sugars, saturates, fibre, and sodium. Nutrition labelling may also include starch, polyols, mono-unsaturates, polyunsaturates, cholesterol and any minerals or vitamins that are listed in the legislation.

Nutrition information must be given 'per 100g or 100ml'. It may also be given 'per serving size', provided that the serving size is also stated.

This piece of legislation applies to prepackaged foodstuffs to be delivered to the ultimate consumer and also foodstuffs intended for supply to 'mass caterers', i.e. restaurants, hospitals, canteens, etc. It does not however, apply to non-pre-packaged foodstuffs packed at the point of sale at the request of the purchaser or pre-packaged with a view to immediate sale.

7.2.7 Organic fish

In January 2009, EC 834/2007 on organic production and labelling of such products came into force. This repeals the former Regulation (EC 2092/91). The term 'organic' applies only to farmed fish. Organic production methods may also be included in labelling of products, where the appropriate requirements are met.

The EU legislation governing organic production includes requirements on labelling of products at the point of sale. An organic product produced according to the EU regulations, should bear the indication 'organic' on the labelling, advertising material or commercial documents. Packaged organic food must indicate the name and/ or code number of the organic certification body (see Appendix E for the list of organic certification bodies on the IOI). In July 2010, new EU rules on organic food labelling, including the requirement to display a new EU logo, came into force. The 'Euro leaf' is obligatory on pre-packaged organic food products that have been produced in any of the EU member states and meet the necessary standards. Other private, regional or national logos will continue to appear alongside the EU label. The 'Euro leaf' logo stays optional for non-packed and imported organic products. In addition to the logo, the revised labelling rules also include the compulsory indications of place of farming of the products' ingredients and code number of the body in charge of the controls. Operators should be in compliance with these rules by July 2012 (295, 296). Organic products imported from Third Countries must conform to EU standards.

At the end of 2004, there were no internationally agreed specific regulations for organic aquaculture. However, regulations were introduced in 2007 (Council Regulation (EC) No. 834/2007) on organic production and labelling of organic products (297). This repealed regulation (EEC) No. 2092/91. For the sake of consistency with Community legislation in other fields, in the case of plant and livestock production, Member States should be allowed to apply within their own territories, national production rules which are stricter than the Community organic production rules, provided that these national rules also apply to non-organic production and are otherwise in conformity with Community law. As of 2006, no requirements had been provided for aquaculture, but it was anticipated that these would be elaborated at a future date (298).

7.3 Quality assurance schemes

7.3.1 Northern Ireland

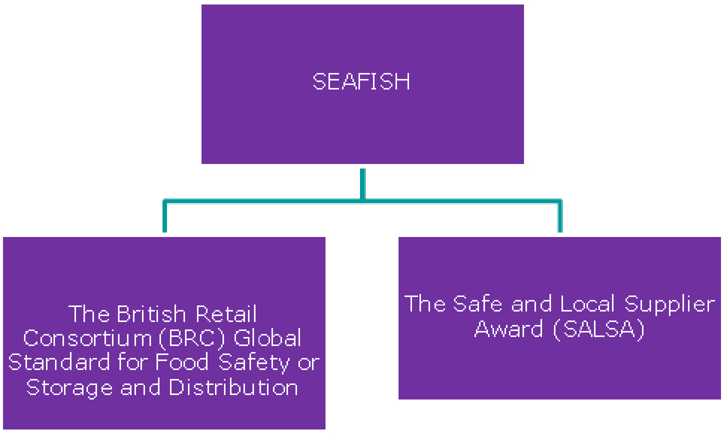
In NI there are two relevant quality schemes run by the Sea Fish Industry Authority – the British Retail Consortium (BRC) Global Standard for Food Safety or Storage and Distribution and the Safe and Local

Supplier Approval (SALSA) (Figure 7.1) (299). SALSA is a joint venture between four main trade organisations representing the UK food chain; the British Retail Consortium (BRC), the British Hospitality Association (BHA), the Food and Drink Federation (FDF) and the National Farmers Union (NFU). Both the BRC and SALSA schemes assist businesses in raising standards in the seafood processing and wholesaling sectors, covering issues such as Hazard Analysis Critical Control Point (HACCP), staff training, design of premises, traceability, pest control and complaint handling. Holding either of these certifications demonstrates the capacity of a company to adhere to the highest standards, in turn leading to enhanced customer confidence, and greater commercial benefits. Seafish offer financial support to processors and wholesalers wishing to undertake recognised standard-raising certification.

Seafish also offer a range of quality assurance training courses (300) to those employed in the seafood industry, including the following:

- Introduction to Food Hygiene: This course is accredited by the Royal Environmental Health Institute of Scotland (REHIS), and is suitable for low-risk seafood operations (e.g. fishermen, primary processors, non food handlers).
- Foundation Food Hygiene Certificate: Accredited by the Chartered Institute of Environmental Health, and suitable for high-risk operations such as fish fryers and secondary processors.
- Introduction to HACCP in the Seafood Industry: This course is also accredited by REHIS, and is suitable for management, quality or technical staff, HACCP team members and key on-line staff.
- Introduction to Food Safety in Fish and Chip Shops: Essentially designed to train owners, managers and staff responsible for monitoring in fish and chip shops.
- Caring for Your Catch: This course is suitable for skippers and crews of fishing vessels.
- Assessing and Maintaining Seafood Quality: Suitable for anyone buying, assessing or handling seafood in the processing sector. This course is based on Torry or Quantization Index Modulation (QIM) systems (299).

Figure 7.1 **Quality schemes in NI (299)**

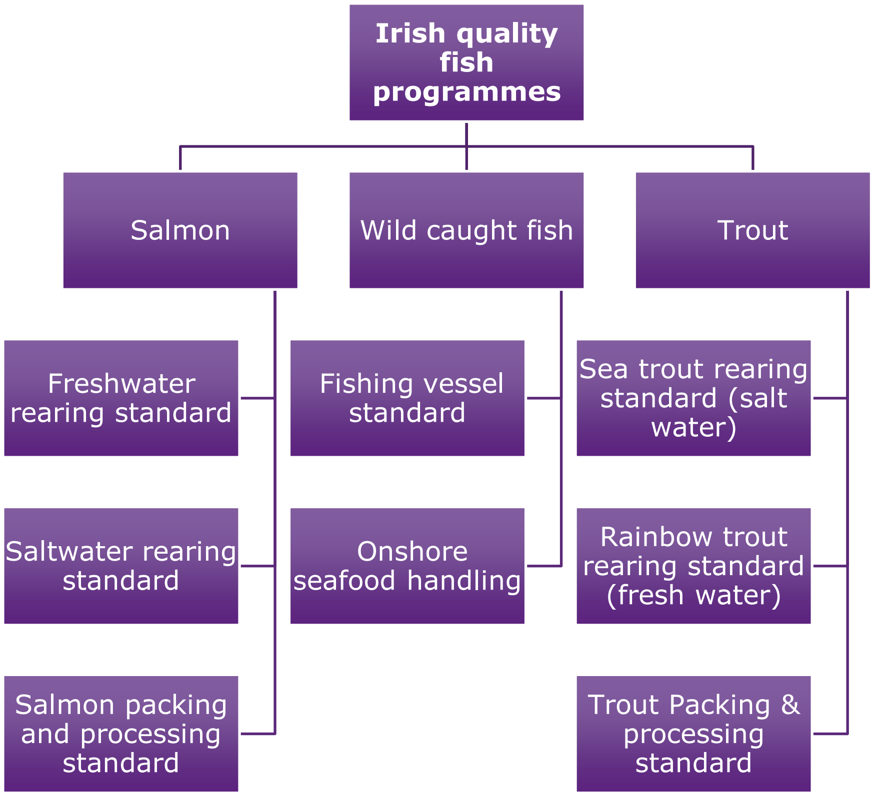


7.3.2 Republic of Ireland

Bord Iascaigh Mhara (BIM) is involved in a number of programmes that assist fishermen to land and market high quality, responsibly caught seafood through their local cooperative. In addition, BIM has set up third-party accredited schemes for aquaculture that guarantee a top quality product. All of these schemes fall under the umbrella of the Quality Seafood Programme (QSP) (301). For the wild catching sector, there is the BIM Seafood Stewardship Programme, which is based on internationally accredited ISO 65 standards. This programme assures responsible fishing practices and the hygiene, handling and quality of fish caught, landed and sold by Irish fishing businesses. ISO 65 accreditation gives the Stewardship Programme recognition and a credible position on the international marketplace, and ensures that products certified under the programme are identified at a recognised level of assurance. Demonstration of compliance with ISO 65 accreditation is through rigorous on-vessel assessment by a competent, third party certification body (14).

Essentially, the purpose of the Seafood Stewardship Programme is to provide the Irish fishing industry with a 'Certification of Best Practice' for their fish at the highest level of market acceptance. Certification of standards under this programme demonstrates a commitment which will in turn communicate to customers and consumers the responsibility of fishermen, and the provenance, freshness and quality of Irish fish. The Seafood Stewardship Programme has two complimentary standards; Fishing Vessel and Onshore Seafood Handling Guide (Figure 7.2). Each of these standards is designed to be practical and easy to implement, and will provide a means to bring together the many aspects of best practice, common place in the industry, that remain unrecognised at an international level. Operators document their actions and provide the necessary documentary evidence in the BIM Seafood Environment Management Systems Manual, which was developed in close consultation with industry. A principal objective of the Stewardship Programme is to promote consumer confidence in the methods used by Irish fishermen and those who handle Irish fish, from the time of capture to the point of sale. This programme was the result of pro-active discussions and interaction with fishermen, packers, processors, markets, regulators, standards and certification experts. It is reflective of the level of awareness of an ever-perceptive public, and provides a platform from which the practices of the industry can be measured (14). The Fishing Vessel Standard contains Annexes, with each one being tailored for a specific type of fishing activity (i.e. demersal whitefish, nephrops, shellfish and pelagic). Applicants who are successful in their pursuit of achieving the BIM Seafood Stewardship Programme are referred to and listed as 'certified seafood stewards'. These stewards receive a Sea Fisheries Stewardship Plaque for their vessel or premises, and can access logos and certain branded promotional items. In addition, products obtained from certified seafood stewards may be eligible for BIM Quality Programme Branding and BIM Market Support, provided they meet the required specifications (14).

Figure 7.2 Quality schemes in ROI



The QSP is a recognisable assurance scheme for seafood (both wild and farmed), which allows members to demonstrate their commitment to the environment along with producing an excellent product. The QSP is independently accredited to the international standards EN45011/ ISO-65, the international 'gold standard' for product certification. Each of the quality programmes has a detailed product specification, production and harvesting standards. Participation in the schemes is voluntary and companies that meet the required standards throughout the supply chain can use the quality mark.

Standards take account of best industry practice with respect to food safety; employee and animal welfare; social responsibility; and legislative requirements. In terms of finfish, there are currently standards for Salmon (302), Wild Salmon, Salmonid Species, and Trout (77). In recent years, these standards fall into the category of the Global Trust Certification Ltd (303) (Registration No. 6002), which has been accredited by the Irish National Accreditation Board (INAB). The principal aim of

Global TRUST Certification Ltd. is to undertake product certification in compliance with I.S. EN 45011:1998 (ISO/ IEC Guide 65:1996).

The catching standard of the Quality Wild Salmon Scheme makes reference to training; hygiene; capture; and handling of fish; maintenance; equipment; pest control; and traceability. The rearing standards of both the salmon and trout schemes cover key technical aspects including environmental management and monitoring; rearing practices; management; stockmanship and welfare; pre-harvest, harvest, post-harvest practices; and traceability. The packaging and processing standards relate to personnel; factory and product management; traceability; complaints and recall; HACCP; and product criteria.

Both the Irish Quality Salmon and Trout Schemes make reference to the quality of the feed used. This involves a declaration that the feed used adheres to all Feeding stuffs Regulations and that the feed supplied meets the legal requirements for the following specification:

- Feed must not be derived from genetically modified organisms.
- Feed must exclude all animal products with the exception of fish products.
- All fish products must come from sustainable sources.
- The use of ingredients derived from salmonoids, any material likely to cause taint in the flesh of the fish and of growth promoters is prohibited.

7.4 Food hygiene and quality

During the qualitative discussions held in both 2005 and 2010, consumers stated that they relied on their fish suppliers to ensure them of its freshness. The assessment of quality is very subjective; however a number of parameters can be used by consumers themselves when assessing the quality of fresh fish at the point of sale (Table 7.1) (304).

During the focus groups held in September 2010, participants expressed their concerns for the quality of fresh fish. Many participants told of how the cleanliness of the premises was vital. They paid attention to a host of factors when buying fresh fish, such as the amount of ice surrounding the fish, the absence of flies and whether or not staff were wearing gloves and aprons. Respondents also stated they would be anxious to cook fresh fish on the day it was bought as fish is a highly perishable food. However, most participants had a high level of confidence in the safety of fish, and were aware that many concerns attached to shellfish (food poisoning, allergies) were not associated with finfish.

Table 7.1 **Parameters to assess the quality of fish [extracted from BIM, 2003 (304)]**

Appearance	Eyes	• Bright, bulging • Clear cornea • Shining black
	Gills	• Glossy, bright red or pink • Clear mucus, if present
	Skin	• Colours distinct and particular to species • Glossy • Scales adhering tightly • Clear mucus, if present
	Belly (whole fish)	• No indication of burst belly
	Belly Cavity (gutted fish)	• No viscera or blood visible • Lining intact • Flesh adhering to bones
	Flesh	• Raw, transparent, translucent look • No discolouration along back bone area or belly flaps • No indication of 'gaping' • No bruising or blood spotting
Texture	Firm and elastic to touch	
	Springs back into place when pressed with finger	
	Skin feels smooth to touch (not all species)	
Smell	Inoffensive	
	Slight sea smell	

7.5 Training

Food handlers must receive training in food hygiene in accordance with the Hygiene Package, specifically Regulation (EC) No 852/2004 on the hygiene of foodstuffs. This is the case for all food business operators (FBOs), part-time, full-time or casual, or whether they are employed in the public or private sector. Training is a major focal point in quality assurance schemes and in quality standards such as British Retail Consortium, EFSIS and ISO 9000:2000.

7.5.1 Northern Ireland

To ensure that industry has access to the training it needs, Seafish supports a network of industry-led Group Training Associations (GTAs). These organise training throughout the UK where and when they are needed[13]. The Seafish Training and Accreditation Department is based at the Humber Seafood Institute in Grimsby, and supports training in the onshore sectors of the seafood industry, including the processing, retailing and foodservice sectors. The Seafood Training Academy is responsible for training in NI. A committee of elected industry members manages the GTAs and employs Training Coordinators and/or Training Officers to ensure that local training needs are met. GTA staff act as information sources, advisors, and direct trainers, and can organise and facilitate training courses on a variety of topics. Seafish also provide a number of training resources on their website (305). Courses available include fish filleting, seafood smoking and a range of quality assessment training programmes.

Food handlers must receive appropriate supervision, and be instructed and/ or trained in food hygiene, to enable them to handle food safely. Those responsible for developing and maintaining the business's food safety procedures, based on HACCP principles, must have received adequate training. The requirements for training should be seen in the context of the nature and size of the business. There is no legal requirement to attend a formal training course or get a qualification, although many businesses may want their staff to do so. The necessary skills may also be obtained in other ways, such as through on-the-job training, self-study or relevant prior experience. The operator of the food business is responsible for ensuring this happens.

The FSA does not provide a database of training providers in NI but recommend three professional bodies for food safety training: the Chartered Institute of Environmental Health (CIEH), the Royal Institute of Public Health (RIPH), and the Royal Society for the Promotion of Health (RSPH) (206).

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[13] Seafish (2005) *Group Training Associations*, http://www.seafish.org/sea/training.asp?p=ef154, 20 December 2005.

7.5.2 Republic of Ireland

BIM is responsible for general training within the seafood industry in the ROI. It is a statutory requirement to train seafood handlers in food hygiene matters (306). Members of staff, who handle, prepare and process seafood must have an appreciation of the fundamentals of good food hygiene as stated in the General Food Hygiene Regulations. This training covers the hygiene pre-requisites as set out by the National Standards Authority of Ireland (NSAI) codes of practice.

Under The Irish Seafood National Programme 2007-2013, BIM now provides FETAC training courses and expert support to assist seafood businesses to achieve adherence to the necessary hygiene and food safety standards. In terms of food safety training, BIM offer (i) Seafood Hygiene Management (306), (ii) Risk Based HACCP for Seafood Business (307) and (iii) Auditing for Seafood Businesses (308). Information pamphlets for each of these are available on the BIM website (15). In addition to these training courses, BIM also provide the opportunity to earn a Certificate in Seafood Processing at FETAC Level 5, which includes a module on Manual Fish Filleting. The FSAI has a clearly defined food safety training policy (309). In 1999, the FSAI established the Food Safety Training Council (FSTC), which comprises representatives from education and training, the food industry, and inspectors from the official agencies with responsibility for food safety. The FSTC advises the FSAI on the contribution to food safety through training; agreeing levels of skills required for best practice in food safety; and guidelines for assessing the impact of food safety training in the work environment. The FSAI, with input from the FSTC, has set training standards for the foodservice, retail, and manufacturing sectors. These standards are outlined in a series of food safety training guides covering three levels of skills: induction; additional; and for management.

The FSAI has published a Guidance Note on the Inspection of Food Safety Training and Competence (No. 12) (310), the purpose of which is to establish a consistent approach to the inspection of the training and competence of operational staff dealing with food, and the provision of advice to food businesses in relation to training. In conjunction with this, FSAI has developed a number of training programmes including: 'Food Safety and You', induction training programme for new staff in the food service industry. This programme is available in eight languages including Lithuanian, Latvian, Mandarin, Polish Portuguese, Romanian, Spanish and English.

The FSAI has also constructed an on-line database of professional food safety training providers in the ROI.

7.6 Sustainability

As stated earlier in Chapter 2, information available confirms that the global potential for marine capture fisheries has been reached, despite differences in local landings (7).

Sustainable development is generally defined as development that meets the needs of the current generation without compromising the ability of the future generations to meet their own needs (311). The pursuit of sustainable development of fish stocks as an objective has become increasingly important globally in recent years. Policy makers are requesting more information on how to measure progress towards sustainable development objectives. The European Commission has clear biological targets for sustainability, but sustainability will only be achieved by setting long-term goals and adhering to them (312). Seafish have developed the Responsible Fishing Scheme (RFS, (313)) in an attempt to raise standards in the catching sector. This scheme gives assurance to the supply chain that fish from the vessel were caught responsibly. It was created in response to the needs of the seafood supply chain, and to demonstrate their commitment to the responsible sourcing of seafood. The RFS is based on a publicly available specification from the British Standards Institution (BSI), and is an independent, audited assessment of the application of good practice by a vessel skipper and crew in their fishing operations. It is anticipated that this scheme will become a condition of supply over time. In addition, the Marine Stewardship Council's (MSC) fishery certification is awarded to those engaging in sustainable fishing practices (314).

Sustainable development is generally recognised as having three dimensions; economic, social and environmental. Fisheries managers and policy makers have been grappling in recent years to develop indicators that measure progress across all these dimensions. The main purpose in developing sustainability indicators is to assist in assessing the performance of fisheries policy and management; and to stimulate action to better pursue sustainable fisheries objectives. In EU terms, fisheries and aquaculture are managed under the Common Fisheries Policy (CFP), first established in 1983. The initial CFP used biological indicators in the development of stock assessment and management plans; however it paid little attention to the development of economic and social indicators and how these could be related to resource and environmental issues. In 2002, the CFP was reformed with the aim to achieve biologically, environmentally and economically sustainable fisheries, through the development of long-term management objectives; a new policy for fleet control; better application of the rules; and more stakeholder involvement. In April 2009, the European commission issued a Green Paper analysing the shortcomings of the CFP and opened a public consultation which lasted until the end of 2010 (315). This led to the preparation of a reform package, consisting of legislative proposals and communications. This new package is being submitted to the European Parliament and Council. The Commission aims for adoption and entry into force of the new framework by 1 January 2013. All regulations under the CFP are adopted at Community level and implemented in all MS as fish cannot be designated to a particular country.

Certain deep sea fish are currently commercially exploited. These are especially vulnerable to over fishing due to longevity and low fecundity. The MI publishes an annual stock book (316), which contains information concerning the stock levels around ROI.

7.6.1 Eco-labelling

The European Community has developed an eco-label award scheme (governed by Council Regulation (EEC) No 880/92) designed to promote products that have a reduced environmental impact compared to other products. The scheme also provides consumers with accurate and scientifically based information and guidance on products.

As a consequence of the large number of eco-labelling schemes in operation, the European Commission issued a draft publication entitled 'A Community Approach towards Eco-Labelling of Fisheries Products' in February 2001 (317).

A consultation process was undertaken in early spring 2006 in relation to the interest of eco-labelling in the fishing sector. Eco-labelling may contribute to the promotion of responsible fishing and to raising awareness of sustainability. Eco-labelling and certification of capture fisheries and aquaculture is a rapidly developing sector. Studies become obsolete very quickly, as schemes continuously strive to adapt and improve their approaches and methodologies. A number of papers and reports have been published in recent years (318). Due to this increased interest in eco-labelling for the seafood sector, FAO has been developing guidelines for fisheries and aquaculture. However, it should be noted that such guidelines are voluntary and not universally applicable to all schemes in existence. Guidelines for eco-labelling of fisheries have been approved, but the aquaculture guidelines are still under development. Both the fisheries and draft aquaculture guidelines cover environmental aspects, but the latter also include food safety, animal health and welfare, and social issues. For more information on this subject, the reader is referred to a report by FSIG (318).

7.7 Environmental impact of the aquaculture industry

Aquaculture is accused of having damaging environmental effects, although many of these effects remain to be scientifically substantiated (319). Some of the concerns are centred on the issues of eutrophication, escapees, alien species and Genetically Modified Organisms.

7.7.1 Eutrophication

The effect of nitrogen and phosphorous releases from farmed animal excretion, faeces or uneaten food from individual farms, is generally of little importance compared to the regional inflow of nutrients in open water masses. Nevertheless, it can be significant in the farm area and its immediate surroundings. The impact on biodiversity depends on the number and the extent of the sites and their location. In enclosed areas with large or numerous farms, nutrient enrichment and the risk of eutrophication are significant issues.

There is no evidence that eutrophication is an issue with fish farms on the IOI. In 2001, the MI repeated a study carried out by Professor Richard Gowen (320) in the 1980's on water quality in South Connemara where the greatest density of fish farms occurs. The study found that there had been no significant change in water quality in over a decade of marine farming in the area (321).

7.7.2 Escapees, alien species and genetically modified organisms

Invasive non-native plants and animals have been described as the second greatest threat to biodiversity worldwide after habitat destruction (322). Escaped fish inter-breeding with native populations may induce long-term damage through the loss of genetic diversity. The introduction of foreign species may lead to biodiversity threats if the released or escaped exotics become established in their new environment. Introduction of new species may lead to the introduction of diseases, both to farmed and wild stocks. However, as yet there is no evidence to support this theory. New fish health legislation introduced in an EU framework directive in 2006 should strictly limit the movement of live fish to reduce the risk of the spread of disease within the EU or from imports of live fish from Third Countries.

The accidental or deliberate release of transgenic fish (fish that have been genetically altered by the addition, deletion, or reposition of a gene, by means that are not possible under natural conditions or processes) raises public concern in terms of risk to the environment. Transgenic fish, however, are not used in Europe. Salmon farming organisations on the IOI and internationally have clear policy against the use of transgenic fish for the production of food. The Irish Salmon Grower's Association is committed to assist the Irish Salmon Industry in reducing any opportunity for salmon to escape from farms as a result of failure by management, equipment or procedure (323). It is recognised that there is a potential for unavoidable natural catastrophes or uncontrollable outside forces that may damage fish farms and potentially cause escapes. However, the aim of the ISGA code of practice is to ensure all measures within the control of the farmer are managed to the highest standards (323). With regard to record keeping, in order to quantify the number of escaped fish should an incident occur, adequate stock records must be maintained. Details such as numbers, types, origin and year classes of fish per pen unit should be recorded. In the event of an escape, farmers should co-operate in informing the respective authorities so that appropriate actions can be taken (323).

The ROI has a strong record of escapee prevention. The MI monitors every single wild salmon landing annually since the early 1990's and has consistently found that less than one per cent of all landings are escapees from salmon farms. Some years ago, the Irish Salmon Grower's Association signed up to a Code of Containment (324) with the MI and the North Atlantic Salmon Conservation Organisation. This code aims to minimise the risk of escapees from farms.

7.7.3 ECOPACT™

ECOPACT™ was established in 2003 as a new initiative developed by BIM in cooperation with the Irish Shellfish Association and the Irish Salmon Growers Association. It is a documented scheme (323) designed to bring about the widespread introduction of environmental management systems (EMS) in the aquaculture industry on the ROI. The scheme is also available in NI (325). A NI ECOPACT™ supplementary booklet details the legislative requirements for each environmental aspect considered and must be consulted in conjunction with the main ECOPACT™ handbook.

7.8 Farmed fish welfare

Fish farmed for food are included within the scope of Council Directive 98/58/EC concerning the protection of animals kept for farming purposes. However, there is no specific EU legislation relating to the welfare of fish and the Annex to the Directive, containing detailed provisions, is not applicable to fish. At the 47th meeting of the Council of Europe Standing Committee for the Protection of Animals kept for Farming Purposes a set of recommendations for farmed fish was adopted (326). The World Organisation for Animal Health (OIE) is also currently compiling a chapter on fish welfare, which will be included in future editions of the OIE Aquatic Animal Health Code.

7.9 Marine environmental protection

Fishing pressure exerts a considerable impact on marine ecosystems and despite efforts to improve management of these ecosystems many problems still remain. Exploitation of many stocks continues to be beyond levels they can sustain and, in some cases, the status of a large number of stocks cannot be fully assessed due to a lack of suitable data (327). Monitoring and assessment of the marine environment is carried out in accordance with a range of international requirements. Of particular relevance are various EU directives and the Joint Assessment and Monitoring Programme under the OSPAR Convention for the Protection of the North East Atlantic (328). The purposes of the individual programmes are many; for example compliance monitoring, assessing environmental quality and identifying issues and problems, measuring trends in environmental parameters with respect to various pressures or measures taken.

7.9.1 Northern Ireland

A National Marine Monitoring Programme was initiated in the UK in the late 1980's to provide an overview of the quality of the marine environment in the UK (329). DARD undertakes monitoring of NI waters. The Marine Environment Monitoring Group published the UK National Marine Monitoring Programme Second Report in 2004. This summarises data obtained from chemical and biological analyses of seawater, sediment, biota, shellfish and fish during the period 1999-2001. DEFRA have also published a similar document which provides an integrated assessment of UK seas (330).

No microbiological analyses are undertaken under the Marine Monitoring Programmes on the IOI, except in shellfish production areas.

More information on the long-term effects of long term effect of effluent/chemical spills into the environment was demanded during the qualitative discussion groups held during the course of this review.

7.9.2 Republic of Ireland

In 2003 the EPA, with the MI and a number of other agencies, published a compilation of marine monitoring activities and requirements (331). This listed all monitoring programmes in the ROI under the following themes: physical aspects; ecological integrity and biodiversity; water quality and trophic status; hazardous substances; food safety and human health; and radioactive substances. December 2006 saw the commencement of monitoring under the EU Water Framework Directive 2000/60/EC, as amended by Directive 2009/31/EC.

ECOPACT enables the fishing industry to work to the highest standards and to produce a top quality product in a viable and efficient manner. The scheme covers every aspect of the aquaculture industry, including husbandry, maintenance and the interaction of farm-related activities with the surrounding environment. The acceptance of the ECOPACT scheme by the Irish industry represents a powerful commitment to environmentally sustainable operations and to standards that are well beyond those required by law (332). BIM has a similar initiate with wild capture. The fishing industry globally is facing increasing pressure to demonstrate sustainable and responsible practices in order to maintain market and resource access. In this context BIM, in close collaboration with the fishing industry has developed a Seafood Environmental Management System (SEMS) for the Catching sector tailored specifically for Irish fishing vessels to help demonstrate their responsible practices. This is an applied model of a more traditional Environmental Management System. The SEMS is designed to drive continual improvement in environmental and responsible fishing practices and can be adapted to fit the priorities and characteristics of a specific vessel operating in any fishery or fisheries. Such an operator based approach to environmental performance with commercial certification applications can be seen as complementary tool to the traditional fisheries management framework. The system is based around three pillars of_Responsible Practices, Quality and Provenance with a code of conduct incorporating technical annexes on the three principles (14).

7.10 Aquaculture monitoring

The Fish Health Unit (FHU) of the MI monitors the health of all stocks of farmed fish in the ROI. Imported fish (which have a certificate that has been issued by another member state or a Third Country) are examined by the FHU before the animals enter the country to ensure compliance with both national and EU Legislation. Also, the FHU provide certification of fish being exported for further farming. On August 1st 2008, EU Directive 2006/88/EC was implemented in the ROI through the European Communities (Health of Aquaculture Animals and Products) Regulations 2008 (SI 261 of 2008). This Directive requires all aquaculture production businesses to be authorised, and is built on the successful elements of the existing aquatic animal health regime. It also introduced new measures to reflect developments in the sector. The main objective of the Directive is to raise standards of aquaculture health throughout the EU, and to control the spread of diseases while maintaining the freedom to trade. This Directive replaces previous legislation established by Directives 91/67/EEC and 93/53/EC in relation to finfish health, and provides a comprehensive risk-based approach to disease surveillance. The Directive also implements controls on the movement of potential vector and susceptible species, and provides a structure for declaring the health status of member states and areas within them (333).

7.10.1 Sea lice monitoring and control

Sea lice are a group of parasitic copepods found on fish worldwide. There are two species of sea lice commonly found on cultured salmonids in marine conditions around the coast of Ireland, *Caligus elongatus* Nordmann, which infests over 80 different species of marine fish and *Lepeophtheirus salmonis* Krǿyer (the salmon louse), which infests only salmon, trout and closely related species. *L. salmonis* is regarded as the more serious parasite on salmon, in terms of prevalence and effects (334). Salmon, both wild and cultured, go to sea from fresh water free of lice and only pick up the infestation after they enter the marine phase of their lives (334). However, they generally have the most commercially damaging effect on cultured salmon, with major economic losses. They affect salmon in a variety of ways: reducing growth; causing external damage, which reduces the value and marketability of the fish; and at high infestation levels can cause death. Sea lice are naturally occurring external parasites and have no human health implications.

In 1991, in response to concerns about the possible impacts of sea lice from salmon farms on wild populations of sea trout, a National Sea Lice Monitoring Plan was initiated in the ROI by the then

Department of Marine and Natural Resources (now DAFF). In 1992/93 the programme was expanded and this culminated in the publication of the 'Offshore Finfish Farms – Sea Lice Monitoring and Control Protocol' in May 2000 (335). Under the National Sea Lice Monitoring Plan when lice levels exceed pre-set treatment trigger levels, advice is given by the DAFF to the farmer to treat the affected stock. All fish farms in the ROI undergo lice inspections 14 times per year. One lice inspection takes place each month at each site where fish are present, with two inspections taking place each month during the spring period of March to May. For the spring period, targets are set at very rigorous levels of 0.3 to 0.5 egg-bearing (ovigerous) lice per fish. Outside of this, a level of 2.0 egg bearing lice acts as a trigger for treatment. Where measurements at a farm exceed these target levels, the MI issues a 'Notice to treat' to the licensee (334).

Only one inspection takes place in the December/January period. The results of sea lice surveys are published annually by the MI, with detailed monitoring results reported by farm (336, 337). In 2008, 333 sea lice inspections were carried out on salmonids and it was determined that 74.9 per cent of Atlantic salmon samples and 96.3 per cent of rainbow trout samples were below the treatment trigger levels outlined in the Monitoring Protocol No. 3 for offshore finfish farms (338). Sea lice levels nationally in 2008 have shown an overall improvement when compared to 2007 levels, particularly in the North West region, reflective of an increase in effort. Sea lice numbers above the treatment trigger levels in the West were similar to 2007. However, overall sea lice levels were lower in 2008 and showed less variability. The presence of pancreas disease and challenges from water borne irritants (e.g. jellyfish and certain species of phytoplankton) can be detrimental to fish health and lead to increased difficulties in the control of sea lice, particularly in the summer months. A slight increase (approximately 0.5˚C) in sea temperature in recent years may also lead to an acceleration in the life cycles of sea lice, along with an increased reproductive output (338).

Sea lice are not a concern in NI because, as mentioned in Chapter two, there is only one salmon farm in NI and as the site itself is highly exposed, it makes attachment extremely difficult. The company has its own veterinary program to monitor for sea lice infestation, and DARD carry out monthly inspections (16).

7.10.2 Benthic monitoring

Finfish farming results in inputs to the marine environment in the form of uneaten food and faecal material. This oxygen-consuming organic material falls to the seafloor and can result in stress on the benthic environment that, in turn, can lead to changes in the benthic community structure (decreased faunal diversity and increased abundance of opportunistic species associated with deteriorative conditions e.g. worms).

In 2001, the then Department of Communications, Marine and Natural Resources (DCMNR), now the Department of Agriculture, Fisheries and Food (DAFF) in the ROI introduced benthic monitoring protocols for finfish sites[14] (339). The seabed under and adjacent to finfish aquaculture sites in the ROI is monitored annually by way of a survey at production and smolt sites. This survey is the responsibility of the aquaculture licence holder who must submit survey reports to the DAFF annually. In 2007, of the 33 sites requested to submit benthic monitoring reports, all except one (97 per cent) returned a report. This is a major improvement from 2004 and 2005, which only had respondent rates of 50 per cent and 60 per cent, respectively (21). All of the reports for which reports were submitted during 2007 had conditions that were within agreed environmental standards, therefore were deemed acceptable. Although all sites were deemed compliant in 2007, two individual reports highlighted problems mostly related to uneaten feed reaching the seafloor and heavy coverage of bacterial mats. These issues can be alleviated by managing feed input and reducing stock densities (21).

7.10.3 Finfish health status monitoring

The disease classification outlined in EU Directive 91/67/EEC forms the basis for trade in live fish within the EU. According to this framework, both the ROI and NI have obtained the highest classification possible for farmed finfish and can trade freely with any country within the European Community, and beyond. The Fish Health Unit (FHU) of the MI is the Irish National Reference Laboratory for finfish, mollusc and crustacean diseases. The laboratories of the FHU are Irish National Accreditation Board (INAB) accredited to ISO 17025 standards. In addition, the FHU is the competent authority for the implementation of aquatic animal health legislation in the ROI. Aquatic health monitoring is carried out under EU and national legislation, and certification is provided for fish and shellfish being exported for further farming (340). The MI supports both the aquaculture and the inland fisheries sector in maintaining Ireland's superior fish health status. The FHU also provides statutory services in line with EU directives and support (333). It is on the basis of maintaining 'Approved Zone Status' in both the ROI and NI that statutory testing for fish diseases is carried out by the Competent Authorities or their agents.

EU Directive 2006/88/EC was implemented in Ireland in August 2008, through the European Communities (Health of Aquaculture Animals and Products) Regulations 2008 (S.I. 261 of 2008). This Directive requires all aquaculture production businesses to be authorised building on successful elements of the existing aquatic animal health regime and introduces new measures to reflect developments in the sector. The principle aim of the Directive is to raise standards of aquaculture health throughout the EU and to control the spread of disease while maintaining the freedom to trade.

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[14] Site refers to area where finfish are produced.

This Directive replaces previous legislation established by Directives 91/67/EEC and 93/53/EEC in relation to shellfish health (333). According to EU Directive 2006/88/EC (discussed earlier in section 6.9), member states are obliged to ensure a risk-based animal health surveillance scheme is applied to all farms. The objective of the scheme is to detect (i) increased mortality and (ii) the presence of the diseases listed in Part II of Annex IV of the Directive. The frequency of these surveillance visits is determined by the health categorisation of the individual installation (340). None of the microorganisms associated with diseases in fish on the IOI affect human health.

In NI, the Fisheries Inspectorate Division of DARD normally inspect licensed fish farms twice a year and take samples of fish for laboratory analysis in line with Commission Decision 2001/183/EC (fish) and Commission Decision 2002/308/EC (molluscs), as amended. The licence holder must ensure the fish farm is open for inspection to an officer of the Department at all reasonable times and provide samples of fish as required, free of charge.

7.11 Conclusions

There has been a significant change in legislation regarding fish since 2005. The introduction of new legislation relating to the labelling of fish in 2010 includes new commercial designations for species of fish that have come onto the market in recent years. In July 2010, new EU rules on organic food labelling, including the requirement to display a new EU logo, came into force. The pursuit of sustainable development of fish stocks as an objective has become increasingly important globally in recent years. Seafish have developed the RFS, in an attempt to raise standards in the catching sector. Eco-labelling and certification of capture fisheries and aquaculture is a rapidly developing sector.

8 Conclusions

8.1 Finfish food chain

The food environment on the island of Ireland (IOI) has changed dramatically over the past decade. With regard to fish, there have been notable changes in consumer consumption, fish landings, fish stocks, industry (technology, processing), products, packaging and legislation between 2005 and 2010.

Changes in the fish supply

For Northern Ireland (NI), while the volume of fish (both finfish and shellfish) that landed decreased by 12.3 per cent between 2004 and 2008, the value of these landings increased by almost 40 per cent. This increase in value is believed to be due to reduced availability, resulting in premium prices. As for the Republic of Ireland (ROI) the total fish landed in 2008 decreased by almost 10 per cent when compared to the figure for 2004. Similar to NI, while the amount of demersal fish landed increased by 24,000 tonnes between 2004 and 2008, the value increased significantly (€49 million (£42 million)) (17).

With regard to aquaculture, in the ROI, the national finfish harvest volume decreased between 2006 and 2007, which also reduced in value by 4.8 per cent. The aquaculture sector in NI has grown in recent years producing in excess of 1,097 tonnes of finfish in 2009, valued at £2.5 million (€2.97 million) compared to 523 tonnes of finfish in 2005, valued at £1.16 million (€1.36 million)(1).

There has been a substantial increase in the amount of finfish imported into the ROI between 2005 and 2009. Canned tuna is the largest single product component of the ROI seafood imports and continues to rise. However in contrast, there has been a significant decline in the value of finfish exported from the ROI into the EU market. In 2004 the value was €316 million (£271 million) whereas in 2009 it was worth €101.6 million (£87 million). A decline in the gross sales turnover of the fish processing sector for NI was observed between 2004 and 2008. In 2008, the value recorded was £69.7 (€81.3) million for 2008 compared to £75 (€87) million in 2004.

Key food safety (microbiology and toxicology) issues

From a food safety perspective, finfish can be regarded as a relatively safe food, however, some issues exist, particularly in relation to the allergen histamine, correct handling and storage of fish at all stages along the food chain, contamination of the fish chain from substances such as heavy metals and dioxins, and the potential presence of pesticides and other residues. In NI between 2005 and 2009 there has been only one reported foodborne outbreak associated with finfish. This was related to scrombotoxin and affected two individuals. The suspect vehicle was tuna. For the ROI, salmon was one of three suspected foods associated with a foodborne outbreak between 2004 and 2009. However it was noted that salmon was not definitively isolated as the cause of the outbreak.

Numerous changes in legislation have occurred between 2005 and 2010. Legislative changes in relation to food safety, fish feed and residue surveillance are discussed throughout this report for the IOI as well as legislation relating to third country imports, traceability and recall, and electronic recording and reporting.

One example of development in this area is the Sea Fisheries Protection Agency's (SFPA) 'Guide to Compliance for the Irish Inshore Fleet', which was released in July 2010. In essence, this guide provides a method for the SFPA to trace the boats that fish came from and also where the fish subsequently went to. Furthermore, the Electronic Recording and Reporting System (ERS) in ROI is currently being introduced on a phased basis to fishing vessels.

Changes in consumption and research on health benefits

Consumers reported an increase in the frequency of consumption of fish since 2005. In 2010 fifty nine per cent of consumers reported eating fish once a week or more, whereas in 2005 this figure was forty eight per cent. These self reported findings were somewhat in contrast to the findings of national surveys in ROI and the UK. The latest surveys in the UK and ROI show that consumption of fish among consumers is in line with recommended intakes. However, the proportion of the population on the IOI consuming fish remains relatively low. The key benefits of fish consumption are in the provision of high quality protein and from oily fish, vitamin D and n-3 fatty acids. Scope remains to promote these benefits among consumers.

The strongest evidence for health benefits of consuming fish includes cardiovascular health and foetal and infant neurodevelopment and growth. Most of these benefits can be attributed to oily fish and the presence of n-3 PUFA. Research on fish consumption and cognitive development, maintenance of cognitive function, depression and sever psychiatric disorders, allergies and chronic inflammatory diseases and cancer is ongoing. However, more research is required to confirm a beneficial effect.

Changes in consumer attitudes and behaviour

Consumers were most concerned about the freshness of fish in 2005 and 2010. Interestingly, consumers in 2010 (37 per cent) were much less concerned about how fish is cooked when compared to five years ago (54 per cent). The levels of concern associated with dyes and labelling have also reduced in this period (by 9 per cent and 10 per cent, respectively), while the issue of fish stocks is a greater concern in 2010 than it was in 2005, perhaps indicating the higher profile of environmental issues on the IOI in recent years. Overall, consumers were found to have a high overall confidence in the safety of fish and deemed it safer than fresh meat for both 2005 and 2010. Consumers awareness of mercury in fish as a food safety issue has increased. In general, consumers perceived fish to be healthy. This perception had also increased since 2005.

8.2 Key findings

This review collated and considered the information available in the public domain (regulatory and scientific) on the health and safety implications of the food supply chain. On the basis of the evidence the review highlights a number of key findings for stakeholders in the food supply chain, including legislators and policy makers, producers, transporters and processors, as well as retailers and consumers.

8.2.1 Primary producers, transporters and processors

On the IOI, there are controls, systems and legislation in place which aim to control both microbiological and chemical hazards in the supply chain, and thereby, minimise the risk to consumers.

The safety of the food supply chain is regulated by legislation primarily enforced by the Food Standards Agency in NI and the Food Safety Authority in the ROI.

There are monitoring programmes on the IOI that frequently test for dioxins, heavy metals, malachite green/leucomalachite green, organotin compounds and many other substances.

Good hygiene and hygiene practices are vital in the production of superior quality, safe seafood. The quality of fish is directly related to the time of capture and how the fish are handled, in particular during gutting, washing, boxing and icing.

The risk to human health resulting from contamination of fish with pathogens from aquatic environments and pathogens that are naturally present on fish is low whereas, the risks from contamination of fish with pathogens from the animal/human reservoir is high and appear to be higher in coastal and inland aquatic environments than open waters.

In July 2010, the Sea Fisheries Protection Agency (SFPA) released their 'Guide to Compliance for the Irish Inshore Fleet'. In essence, this guide provides a method for the SFPA to trace the boats that fish came from and also where the fish subsequently went to.

The Electronic Recording and Reporting System (ERS) in Ireland is currently being introduced on a phased basis to fishing vessels.

8.2.2 Retailers and caterers

In 2010, new legislation regarding labelling of fish adds new commercial designations for species of fish that have come onto the market in recent years. The fish must be labelled whether it was captured at sea or from inland waters or farmed. In addition, if the fish was captured at sea the label must specify from which sea area.

In NI there are two relevant quality schemes run by the Sea Fish Industry Authority – the British Retail Consortium (BRC) Global Standard for Food Safety or Storage and Distribution and the Safe and Local Supplier Approval (SALSA). The corresponding authority in the ROI is Bord Iascaigh Mhara (BIM).

HACCP and training are at the core of good food safety practices and should be implemented.

The pursuit of sustainable development of fish stocks as an objective has become increasingly important globally in recent years. Seafish have developed the Responsible Fishing Scheme (RFS), in an attempt to raise standards in the catching sector.

Eco-labelling and certification of capture fisheries and aquaculture is a rapidly developing sector.

8.2.3 Consumers

There has been an increase in the frequency of consumption of fish since 2005. In 2010 fifty nine per cent of consumers reported eating fish once a week or more, whereas in 2005 this figure was forty eight per cent.
Market research showed that the reported frequency of consumption increased for all fish types including fresh white and fresh oily fish, tinned fish and fish in batter. The proportion of people who said that they never eat fish remained unchanged at one in five (18%).

Key consumer concerns for 2005 and 2010 were freshness of fish, pollutants, contaminants, food poisoning and correct defrosting procedures for fish.There was a reduction in concern about how fish is cooked, dyes and labelling over the past five years, while the issue of fish stocks and mercury awareness was a greater concern in 2010 than it was in 2005.

In 2005 and 2010, consumer were found to have a high overall confidence in the safety of fish and deemed it safer than fresh meat.

In 2005, 49 per cent and 42 per cent of consumers considered fish to either a 'very healthy food' or a 'healthy food', respectively. This increased to 62 per cent and 31 per cent respectively in 2010.

Barriers to fish consumption were smell and appearance of whole fish, the presence of bones, childhood memories of eating fish, taste, freshness and display of fish, price and processing.

The health benefits of fish are well documented particularly in relation to heart health. Much recent media focus has been on the cognitive benefits of fish and fish oils, although this remains to be scientifically substantiated.

For the general population, health professionals recommend that consumers should eat two portions of fish per week, one being an oily fish. Where possible fresh fish should be chosen over processed.

Due to potential contamination with mercury, women of childbearing age should be advised that consumption of a single portion of predatory fish such as shark, swordfish and marlin per week should be avoided during, or prior to, pregnancy. This level of consumption is not considered to pose a health risk to adults in general. For children younger than 14, occasional consumption of these species is not considered to pose a health risk. For women of childbearing age, pregnant women or nursing mothers, consumption of two tuna steaks (weighing about 140g cooked or 170g raw), or four cans of tuna, per week, will not pose a health risks to the foetus or neonate. There is no reason for adults or children, in general, to restrict their tuna intake.

Women of child-bearing age and women who are pregnant or breastfeeding can have up to two portions of oily fish per week. Adults and children in general can have up to four portions of oily fish per week. Consumers should be advised that canned tuna does not contribute to a portion of oily fish as the essential n-3 PUFA in tuna are destroyed during the canning process.

8.2.4 Policy makers and legislators

In spite of the known health benefits of fish, consumption on IOI remains very low. Organisations, including those involved in the marketing of fish and in public health promotion, should advocate and encourage the consumption of fish and also address the issues that exist as barriers to purchase/consumption.

A large proportion of consumers were unclear as to the correct defrosting procedure for fish and were worried that this could lead to food poisoning. Furthermore, consumers are becoming more aware of mercury levels in fish.

Further information with regard to food safety can be obtained from previous consumer focused reviews carried out by ***safe*****food**. These reviews covered the areas of the beef, poultry, fruit and vegetable, dairy, pork supply chain and food origin. These reviews can be found at www.safefood.eu.

Appendices

Appendix A Types of oily (fatty) and white (non-oily) fish (source: www.fsa.gov.uk)(341)

Oily fish		White fish		
Salmon	Bloater	Cod	Dover sole	Pomfret
Trout	Cacha	Haddock	Flounder	Marlin
Mackerel	Carp	Plaice	Flying fish	Red fish
Herrings	Hilsa	Coley	Hake	Red snapper
Sardines	Jack Fish	Whiting	Hoki	Rohu
Pilchards	Katla	Lemon Sole	John Dory	Sea bass
Kipper	Anchovies	Skate	Kalabasu	Sea brem
Eel	Pangas	Halibut	Ling	Shark
Whitebait	Sprats	Catfish	Monkfish	Tilapia
Orange roughby	Swordfish	Ayr	Parrot fish	Tinned tuna
Tuna (fresh only)		Rock Salmon/ Dogfish	Red & grey mullet	Turbot
		Pollack		

Appendix B NI aquaculture: finfish production (16)

Year	Volume (tonnes)	Value (€)	Value (£)
2000	1,310	2,741,770	2,352,000
2001	1,186	2,914,296	2,500,000
2002	1,186	2,679,986	2,299,000
2003	919	2,403,711	2,062,000
2004	743	1,879,138	1,612,000
2005	523	1,362,269	1,168,609
2006	594	1,471,235	1,262,085
2007	933	2,316,859	1,987,495
2008	699	1,946,988	1,670,205
2009	1097	2,971,404	2,548,990

Appendix C The hygiene package

The new Hygiene Package comprises the following legislation:

- Regulation 852/2004 on the hygiene of foodstuffs.
- Regulation 853/2004 laying down specific hygiene rules for food of animal origin.
- Regulation 854/2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption.
- Directive 2002/99 laying down the animal health rules governing the production, processing, distribution and introduction of products of animal origin for human consumption.
- Directive 2004/41 repealing certain directives concerning food hygiene and health conditions for the production and placing on the market of certain products of animal origin intended for human consumption and amending Council Directives 89/662 and 92/118 and amending Decision 95/408.
- Regulation 2073/2005 on microbiological criteria for foodstuff

Appendix D Analysis of feeding stuffs for undesirable substances & products in compound feeding stuffs destined for the ROI finfish aquaculture industry: 2008 (source:).

Analysis			Total analysed 2008	Non-compliances 2008
Undesirable substances	**Heavy metals**	**Arsenic**	**3**	**0**
		Cadmium	**3**	**1**
		Lead	**3**	**0**
		Mercury	**3**	**0**
	Dioxins and PCBs	**Dioxins (PCDD + PCDF)**	**4**	**0**
		Dioxin-like PCBs	**4**	**0**
		Non dioxin like PCBs	**4**	**0**
Micro-organisms	**Micro organisms**	**Salmonella**	**6**	**0**
Unauthorised substances and products	**PAP**	**PAP Terrestrial origin**	**11**	**0** **0**
		PAP fish origin	**11**	**0** **0**

Appendix E Organic certification bodies on IOI

DAFF in the ROI has approved three organic organisations for certification and inspection services, namely

(i) Bio-dynamic Agricultural Association of Ireland ('Demeter'),

(ii) Irish Organic Farmers and Growers Association (IOFGA), and

(iii) Organic Trust Ltd.

DARD in NI has approved three organic organisations in addition to the above:

(iv) Soil Association,

(v) Organic Farmers and Growers, and

(vi) Organic Food Federation.

Annex

Compendium of shellfish information

This review focussed solely on the finfish food chain. However, if you are interested in learning about the processes and regulatory controls in place with respect to the shellfish (crustaceans and bi-valve molluscs) food chain, you are referred to the following websites and information portals.

General food safety and shellfish information

- Food Safety Authority of Ireland www.fsai.ie
- Food Standards Agency Northern Ireland http://www.food.gov.uk/northernireland/
- ***safe*food**, the Food Safety Promotion Board www.safefood.eu
- Department of Fisheries and Food www.agriculture.gov.ie/
- Sea Fisheries Protection Agency www.sfpa.ie/
- Bord Iascaigh Mhara www.bim.ie
- BIM Handling and Quality Guides http://www.bim.ie/our-services/your-environment/forfishermen/fish-handling-nd-quality-guid/
- Marine Institute http://www.marine.ie/
- Seafish http://www.seafish.org/

Other sea fish websites of interest:

- The Seafood Information Network http://sin.seafish.org/portal/site/sin/
- The Seafood Training Academy http://www.seafoodacademy.org/
- Responsible Fishing Scheme http://rfs.seafish.org/
- Aquaculture and Fisheries Development Centre, UCC http://www.ucc.ie/en/afdc/

- DARDNI Fisheries Site http://www.dardni.gov.uk/index/fisheries-farming-and-food.htm

Specific food safety information with respect to shellfish including monitoring programmes

General sites:

- FSAI's Irish Shellfish Monitoring Programme www.fsai.ie/monitoring_and_enforcement/monitoring/shellfish.html Food Standards Agency: Food Safety Regulation and Monitoring of the Shellfish Harvesting Industry http://www.food.gov.uk/foodindustry/farmingfood/shellfish/
- FSA Northern Ireland – Surveillance Work: Shellfish Monitoring Programme http://www.food.gov.uk/science/research/devolvedadmins/nirelandresearch/northernireland research/
- Food and Veterinary Office http://ec.europa.eu/food/fvo/index_en.cfm

Documentation:

- Results of 2nd Quarter National Survey 2003 (European Commission Co-ordinated programme for the Official Control of foodstuffs for 2003) - Bacteriological Quality/Safety of Cooked Crustaceans and Molluscan Shellfish http://www.fsai.ie/uploadedFiles/cooked_crustraceans_molluscan.pdf
- http://www.fsai.ie/uploadedFiles/ProductionArea_Desingation2006.PDF

Legislation:

- Northern Ireland Food Regulations – General http://www.foodlaw.rdg.ac.uk/uk/reg-ni.htm
- The Surface Waters (Shellfish) (Classification) Regulations (Northern Ireland) 1997 http://www.opsi.gov.uk/sr/sr1997/Nisr_19970489_en_1.htm
- Legislation: Fish and Fishery Products (ROI & EU Legislation) http://www.fsai.ie/uploadedFiles/Corrigendum_to_Regulation_EC_No_853_2004.pdf
- General Legislation: http://www.fsai.ie/legislation/index.asp

Traceability:

- Traceability in Aquaculture http://www.piscestt.com/FileLibrary per cent5C12 per cent5CTraceability2004.pdf

Quality/code of practice:

- BIM Quality Seafood Programme http://www.bim.ie/our-services/grow-your-business/farmedfishqualitylabelling/

FSAI Code of Practice on Marine Biotoxins http://www.fsai.ie/uploadedFiles/Monitoring_and_Enforcement/Monitoring/Shellfish_Monitoring/biotoxin_cop.pdf *Consumer Leaflets/Information Packs*

- BIM Seafood Handbook http://www.bim.ie/uploads/text_content/docs/BIM per cent20Seafood per cent20Handbook.pdf

Miscellaneous:

- Trace Metal and Chlorinated Hydrocarbon Concentrations in Shellfish from Irish Waters 2002 – Marine Institute (Marine, Environment and Health Series No. 16, 2004) http://www.marine.ie/NR/rdonlyres/8BC1102F-AF78-43B7-8BC6-18057C85ACF4/0/MEHS162004.pdf
- Proceedings of the 9th Irish Shellfish Safety Scientific Workshop – 2009 – Marine Institute (Marien Environment and Health Series No. 37 http://www.marine.ie/NR/rdonlyres/15915971-A83D-48F0-8306-D100901AD699/0/mehs37.pdf
- Shellfish News - a regular publication produced and edited by the Centre for Environment, Fisheries & Aquaculture Science CEFAS on behalf of the Department for Environment, Food and Rural Affairs (DEFRA) Fisheries Division II, London as a service to the British shellfish farming and harvesting industry. http://www.cefas.defra.gov.uk/publications/shellfish-news.aspx
- Joint Institute for Food Safety & Applied Nutrition: Compendium of Information Concerning Fish and Shellfish Products and Contaminants http://www.foodrisk.umd.edu/commodity/animal/fish_shellfish/index.cfm

Glossary

Anthropogenic: caused by humans.

Aquaculture: the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated.[15]

Bactericidal: an agent that destroys bacteria.

Bacteriostatic: an agent, such as a chemical or biological material, that inhibits bacterial growth.

Benthic: the bottom of a sea or lake, or the collection of organisms living on or in sea or lake bottoms.

Biota: the combined flora and fauna of a region.

Bivalve: possesses two shells; examples include mussels, oysters, scallops, cockles, etc.

Cephalopods: do not possess an outer shell but have one internal shell; examples include squid, cuttlefish, octopus, etc.

Congener: a member of the same kind, class, or group.

Crustaceans: mobile creatures with hard segmented shells and flexible joints; examples include crabs, lobsters, shrimps, nephrops (scampi, langoustines), crawfish, etc.

Degree day: degree day withdrawal period refers to the product of the water temperature and the number of days, e.g., 400° refers to 50 days at 8° or 40 days at 10°.

Demersal: live on or near the sea bed. Also termed 'White Fish', include cod, haddock, plaice, whiting, monkfish, sole, hake, etc.

Finfish: a general term used to describe demersal and pelagic fish.

Haematopoietic system: the bodily system of organs and tissues, primarily the bone marrow, spleen, tonsils, and lymph nodes, involved in the production of blood.

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[15] http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/007/y5751e/y5751e08.htm (date accessed: 12th December 2005)

Intoxication: the bacterium produces a toxin in a food product and it is the ingestion of the pre-formed toxin and not the bacterium itself that causes illness. Most intoxications require high numbers of the toxin-producing organisms to be present (10^5 to 10^8 cells per gram).

Infection: the food is the source of the bacterium and depending on the Minimum Infectious Dose (MID) and the initial contamination levels of the organism in question; multiplication in the food product may or may not be necessary.

Mesophilic: term used to describe an organism whose optimum growth temperature lies within a range generally accepted as circa 20 to 45°C.

Molluscs: a general term used to describe univalve, bivalve and cephalods.

Obligate anaerobe: an organism which grows only under anaerobic conditions (i.e. without oxygen).

Pelagic: swims in mid-waters or near the surface. Also termed 'Oily Fish', include herring, mackerel, horse mackerel, whitebait, tuna, salmon, etc.

Proteolytic: facilitates the hydrolytic breakdown of proteins into simpler, soluble substances such as peptides and amino acids, as occurs during digestion.

Pschrophilic: term used to describe an organism which grows optimally at or below 15°C, which has an upper limit of growth of ca. 20°C, and which has a lower limit for growth of 0°C or below.

Psychrotrophic: term used to describe an organism which can grow at low temperatures (e.g. 0 to 5°C) but which has an optimum growth temperature > 15°C and an upper limit for growth > 20°C.

Seafood: collective term for both finfish and shellfish.

Shellfish: a general term used to describe crustaceans and molluscs.

Trophic: 'of or re

lating to nutrition', 'a trophic level on the food chain'.

Univalve: possesses one shell (also referred to as gastropods); examples include periwinkles and whelks.

Zoonose: a disease of animals that can be transmitted to humans.

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