



Disposal and Re-Utilisation of Fish and Fish Processing Waste (including Aquaculture Wastes)

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1.0 Introduction

1.1 Objectives

The following report results from a desk study conducted by Nautilus Consultants for the Marine Institute as part of the Marine RTDI Measure. The objectives of the study are to further the debate regarding the improved utilisation of fish waste and specifically to:

- 1) Describe the current:
 - a) National and International regulations on the disposal of fish/aquaculture waste.
 - b) Practice for disposal of fish/aquaculture waste.
- 2) Describe the current national infrastructure for handling of fish/aquaculture waste and identify future requirements.
- 3) Quantify by region, season and source, current fish/aquaculture waste arising.
- 4) Estimate trends in amount of waste.
- 5) Reduction at Source
 - a) Assess realistic options for minimisation of fish/aquaculture waste arisings at source.
 - b) Outline where such an approach could be applied and
 - c) evaluate obstacles for the implementation of such a strategy.
- 6) Realistic options for reuse and recycling of fish/aquaculture waste arisings.
- 7) Guidelines and site selection criteria for disposal at sea (in certain emergency situations), taking into account potential transfer of fish diseases.

1.2 National Context

This report, specific to the problems associated with disposal of fish waste generated by the fish processing and aquaculture sectors, comes at a time when the Government's policy objectives to improve the country's record in waste management and disposal are being implemented¹.

A 2002 report by Peter Bacon and Associates on the waste management capacity in Ireland² concluded:

¹ See "Changing Our Ways: A policy statement" by Mr Noel Dempsey, TD, Minister for the Environmental and Local Government, September 1998.

² See "Strategic Review & Outlook of Waste Management Capacity and the Impact on the Irish Economy" Peter Bacon & Associates, July 2002.

- The waste arisings projected in the strategies are too low and have already been superseded. On the basis of the assumptions used in this report, it is estimated that waste arisings in the five regions covered amount to over 2.9 million tonnes in 2002, an increase of 28.8% on 1998. This compares with projected figures in the strategy of total growth in waste from 1998 to 2013 of 23%.
- A lack of spare capacity allowed for in the strategies, means a considerable deficit of waste handling facilities will arise over the next few years. This deficit will exceed 1 million tonnes per annum by 2003 even if the envisaged recycling is achieved. Put in perspective, this is a figure approximately equal to the total amount of household waste produced in a year.
- The ambitious recycling targets will be difficult to achieve without appropriate incentives and management strategies. The strategies aim for an estimated recycling of 45%, a figure some 3 times the current EU average. If achieved an annual market for approximately 1.7 million tonnes of recycled material must be found. This is almost 8 times the volume recycled in 1998, the last year for which figures are available. If this recovered material is not reused then it simply reverts to being additional waste.
- If Ireland achieves a target of 25% recycling of Household and C&I waste, well in excess of the current EU average of 14%, with the thermal facilities proposed, then the most likely outcome is that residual landfill requirement in 2012 will be approximately equal to the requirement in 2002.
- There is little likelihood of sufficient landfill capacity becoming available to accommodate this waste given the problems that are currently being experienced. As a result, Ireland is facing a crisis in the next few years with regard to waste disposal facilities.

The Waste Management Hierarchy is increasingly used as the basis for policy (see fig 1.1) and government and local authorities have set a variety of targets relating to Municipal Solid Waste (MSW) and their obligations regarding landfill facilities. Targets set by government include:

- 50% diversion of household waste away from landfill.
- Minimum 65% reduction in biodegradable waste going to landfill.
- Reduction in the number of landfill sites.

Despite these objectives being found to be over-ambitious both in scale and timing, public bodies are keen to push on and implement the waste management plans that have been developed. Consequently nearly all local authorities no longer accept commercial organic waste at landfills, including seafood waste.

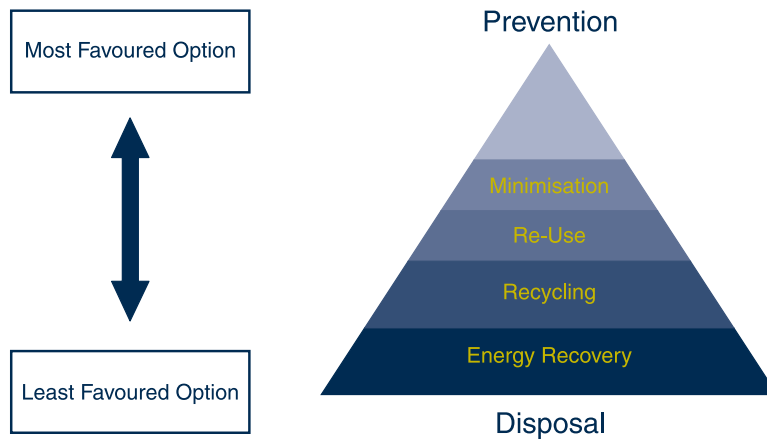


Fig 1.1 Waste Management Hierarchy.

It is estimated that Ireland produced around 80 million tonnes of waste in 1998.⁹ Commercial and Industrial Waste and Municipal Solid Waste have both increased substantially since then, but agricultural waste still accounts for over 70% of national waste arisings. This agricultural waste is returned to the land, which although in need of regulation to avoid localised pollution incidents and eutrophication of water bodies, is a reuse option still in favour and one set to continue.

Figure 1.2 shows the amount of organic waste produced and the disposal routes for a number of sectors. It is assumed that all agricultural waste produced is recycled to land. The first column illustrates that the bulk of food industry material goes to agriculture (either feed or spread on land), but the quantities of fish that can be disposed of in this way are limited by odour and pest nuisance associated with spreading on land and excessive fish in the diet of animals tainting the flavour of the meat.

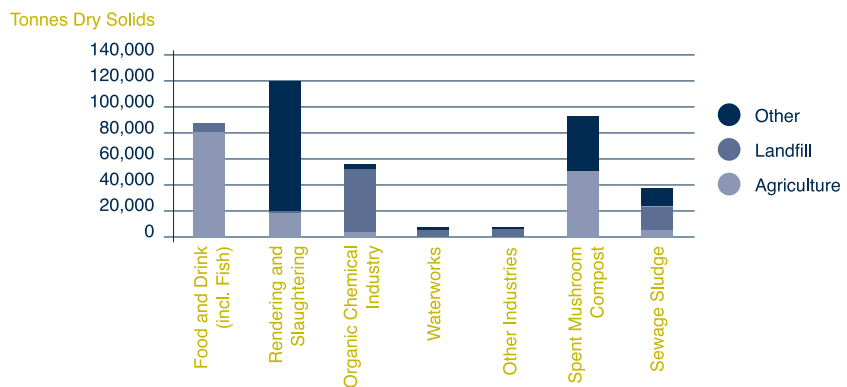


Fig 1.2 Estimated quantities of wastes (tds/annum) produced and proportion spread annually on land in Ireland*
* adapted from EC DG Environment report on Member State non-hazardous waste disposal practices.

The top ten non-hazardous industrial wastes calculated in 1998 are dominated by non-organic waste such as mine tailings. There is also an organic component and “animal tissue from the preparation and processing of meat, fish and other foods of animal origin” amounted to 378,505 tonnes. It can be assumed that around 16% or 60,000 tonnes of this comes from seafood waste. These wastes, along with sludges associated with on-site effluent treatment of organic waste, are the focus of policies attempting to reduce the amount of organic material going to landfill.

1.3 Temporal Context

Although fish processing and aquaculture is not one of the major sources of waste in Ireland, it is a significant contributor to the levels of organic waste from industry. Due to the nuisance factors associated with fish waste and other limitations on its disposal, fish waste is proving to be problematic.

Under the 2000 – 2006 National Development Plan 32m Euro has been allocated to the development of the Seafood Processing sector³, but this accelerated development may be under threat if solutions to the waste management issues of the sector are not found.


Seafood processors are running out of legitimate options for how to dispose of their waste. New licenses for the disposal of fish processing waste at sea are no longer being issued in light of new European regulations on disposal of animal by-products, including fish. Post – BSE far stricter regulations are being put in place regarding the feeding of animals to animals with effects for aquaculture as salmon waste is not permitted to re-enter the food chain as aquaculture feed.

The illegal dumping of many materials including seafood is on the increase in Ireland. In part this is a result of regulatory speed exceeding the development of compliant infrastructure. These issues are discussed in greater detail in Chapter 2 “Regulatory framework”.

In order to determine feasible options for the Irish processing and aquaculture industries the scale of the problem must be quantified. In Chapter 3 the volume of various waste types (whitefish, pelagic, salmon/trout, crustacea, mollusca) are calculated and described. Anticipated trends in waste arisings from target species are also presented. As the logistics associated with waste management focus heavily on transport costs, the volume of these wastes are presented regionally along with the current practices of seafood waste management. This is described in chapter 4.

³ ‘National Waste Database Summary’, EPA, 1998.

⁴ “Building Quality, Value, Scale and Competitiveness” – Seafood Processing Development Programme, DMNR, 2001.



Disposal, even if environmentally sound, is currently seen as the last resort for waste. As the waste hierarchy tree (fig 1.1) shows there are a number of options more preferable to disposal. The most favoured is preventing waste in the first place, but few natural resources are harvested and consumed whole. This is certainly true of fish and shellfish, suggesting that the most that can be asked from producers and processors in terms of raw material is the minimisation of waste. Minimising waste makes economic sense as well as being environmental beneficial and guiding principles for fish processors are discussed in chapter 5.

The largest problem facing fish processors in recent years has been ensuring a sufficient and predictable volume of raw material through the factory. Supply shortages at various times have limited throughputs and profit potential. It is therefore becoming increasingly necessary for processors to maximise revenue from the raw material. Chapter 6 presents options available to seafood processors for reusing and recycling material to turn what was previously considered waste into useful products. In some instances these have the potential to provide additional revenue streams.

Chapter 7 brings together the earlier findings to discuss how individual processors or the sector as a whole can develop waste management strategies that will allow the sustainable growth of the industry in light of current and anticipated events and regulations. Finally Chapter 8 discusses how authorities may encourage this sustainable development through incentives and support, draw-up guidelines for seafood waste management (including emergency measures) that minimise both economic and environmental risks.

2.0 Regulatory Framework for the Disposal of Waste from Fish Production and Processing in Ireland

A wide range of national and EU legislation relating to the disposal of fishery wastes is in place in Ireland. The individual pieces of legislation lay down regulations which have clear implications for the manner in which the fish production and processing sectors deal with both fish derived and other solid wastes, as well as wastewaters from processing activities. This section details the relevant legislative instruments and regulations currently applying to the disposal of fishery wastes. This section also looks ahead to identify the areas likely to be subject to new and increased regulatory control in the future.

2.1 Planning Legislation

Under the *Local Government (Planning and Development) Regulations S.I. No. 86 1994*, before any new development can proceed or before an existing installation can change its use or expand, planning permission must be sought from the Planning Authority, which in most instances is the local authority. One consideration in the planning authority's decision is the appropriateness of the development to the area. In this context, the lack of options for the disposal of waste generated by an activity can form the basis of a refusal to grant planning permission. While this legislative requirement does not directly affect the disposal of fish waste, it may be of secondary relevance by preventing certain activities such as on-site storage of fish waste. This in turn may affect the particular manner in which fish waste and wastewater is handled, stored and treated at a processing facility.

2.2 Licensing

The *Environmental Protection Agency Act, 1992* provides for the licensing of certain categories of activities (as listed in the *First Schedule* of the Act) by an *Integrated Pollution Control* licence (IPC licence). The EPA is the issuing and monitoring body for an IPC licence. Maintenance of an IPC licence imposes strict limits on emissions to air and water and controls maximum levels of other environmental factors such as noise, dust and odours.

An IPC licence imposes far-reaching and onerous technical and operational criteria on the licensee by requiring the implementation of *Best Available Techniques Not Entailing Excessive Cost (BATNEEC)* industry specific guidelines as issued by the EPA. In the context of environmental protection *BATNEEC* guidelines ultimately aim to ensure that the most appropriate technologies and practices are employed in any processes. In addition, an IPC licence requires a comprehensive and prescribed environmental monitoring regime to be maintained by the licence holder.

The terms of IPC licences are rigidly enforced, with prosecutions for breaches of the terms of the licence being vigorously pursued by the EPA. Successful prosecutions carry the likelihood of severe penalties and potentially licence revocation in cases of repeated breaches of licence terms.

With respect to fish production and processing, *the EPA Act, 1992* applies only to the “*manufacture of fish meal and oil*”, as detailed in the *First Schedule of the Act, item 7.5*. Other activities producing fish waste, most notably the disposal of wastewater from processing, are not covered by the Act. Eventually, it is intended to extend the scope of the Act to cover more or all fish processing activities and it is likely that in the future the majority of fish processing units will come under the IPC licensing scheme.

The *Integrated Pollution Prevention and Control Directive* ‘IPPC Directive’ (EU Directive 96/61/EC) was issued in 1999 and will be transposed into national legislation in the future; most likely via an amendment to the *EPA Act, 1992*, although no date for this can currently be given by the appropriate agency. Nevertheless, the requirements of this directive are already being applied in certain circumstances and to some new installations in advance of the transposition of the directive into national legislation.

The most significant impacts of the IPPC legislation relate to waste water emissions and waste water disposal routes. Significantly, it includes some categories of activities not previously covered in the *First Schedule of the EPA Act, 1992* and sets activity thresholds designed to bring more processing and manufacturing units into the licensing net. The IPPC Directive sets a threshold requiring IPC licensing where processing occurs of “*animal raw materials (other than milk) with a finished production capacity greater than 75 tonnes per day⁵*”. Capacity refers to potential production capacity rather than actual production levels. This Directive is therefore of relevance to all of the larger pelagic fish processors, some whitefish processors as well as possibly some fish packing stations associated with fish farms.

The IPCC directive stipulates clearly how licensing systems and requirements are to be implemented in a phased manner. From 30/10/99 all new production facilities with planned production capacity equal to or greater than the threshold of 75 tonnes per day are to be licensed under IPPC. This requirement is also intended to apply to existing production units in the event that ‘substantial change’ in operating procedures or scales (as deemed by the relevant authority) are planned, with effect from the same date. Under the final phase of IPCC Directive implementation, it is intended to licence all existing production units with an output capacity greater than or equal to the threshold limit by a date not later than 30/10/2007.

⁵ Annex 1 Section 6.4 (b). (the term ‘animal’ includes fish and shellfish, as ‘animal’ is not further qualified as referring to mammals only).

As mentioned previously, the transposition of the IPPC Directive into national legislation is yet to occur. In the interim period the EPA are attempting to ensure that all new processing installations meet the standards to be required by IPPC legislation in Ireland, when this is eventually enacted. Compliance is currently dependent on voluntary co-operation on the behalf of individual operators, and the provisions of the IPPC cannot be legally enforced in such circumstances. Enquiries with the relevant authorities as of October 2002, indicated that the timeframe within which the IPPC Directive will be transposed into Irish law remains uncertain.

2.3 Waste Water Discharge Licensing

2.3.1 National Legislation

Irrespective of the scale of individual production units, all producers of fish meal and oils are currently required to hold IPC Licences according to the EPA Act, 1992. Therefore all discharges and emissions are controlled and monitored by the terms of the IPC Licence. IPC licences are administered and monitoring of the operation is the responsibility of the EPA.

In the case of production units not engaged in the production of fishmeal or oils, a wastewater discharge licence must be obtained from the local authority in order for a processor to legally dispose of its wastewater. Disposal of wastewater from food and other processing activities must be carried out in accordance to the provisions of the *Local Government (Water Pollution) Act, 1977* and the *Local Government (Water Pollution) (Amendment) Act, 1990*.

In both licensing scenarios, i.e. production units licensed by the EPA and holding an IPC Licence, or production units licensed by the local authority; the licence terms will include maximum permissible levels for emissions and detail required routine monitoring and reporting.

Licence terms may include the introduction of wastewater emission minimisation measures and may even require the implementation by the licensee of an Environmental Management System (EMS), designed to ensure that the discharge and emission of wastewater is a documented procedure, carried out in a controlled manner.

Wastewater discharge licence terms may restrict wastewater discharges according to predicted levels of output and acceptable environmental impacts. In the event of a processor altering the quantity or nature of wastewater emissions, or where emissions show a detrimental effect on the environment or receiving waters, the local authority or EPA may, under the provisions of the water pollution acts, revise the terms of a wastewater discharge licence.

In general, a discharge licence will only permit the discharge of wastewater with a very small increase in pollutants compared with intake waters. A discharge licence issued under section 4 of the Act allows for public input into licence conditions and enables public objections to the granting of a licence. A production unit discharging wastewater under a discharge licence also becomes directly responsible for any impacts its discharges may have on receiving waters. In contrast, under section 16 of the Act, a licensee is responsible for ensuring that the quality of water being discharged into municipal sewerage facilities meets the environmental standards and limits specified in the licence. The local authority then assumes responsibility for any impacts caused by discharges or emissions from public sewer networks and associated treatment works. Therefore a licence issued under section 16 is essentially a matter between the local authority and the licensee.

Currently, local authority issued discharge licence fees are 380 Euro for an initial application, followed by an annual charge for routine monitoring and reporting, proportionate to the required scale of wastewater monitoring. A third and final charge relates the kg/BOD level of wastewater, although this is not presently collected by most authorities.

Under the *EPA Act, 1992* the EPA has the authority to oversee a local authorities implementation of its statutory environmental functions. In this context the EPA may audit an authorities discharge licensing procedures, monitoring programmes and enforcement. There are no set emission limit regulations for wastewater from fish processing. However, as part of IPC licensing, the EPA has a role in issuing guidelines for emission levels, in accordance with the *BATNEEC* or *Best Available Techniques (BAT)*, as discussed later in greater detail in this section.

2.3.2 EU Legislation

The EU 'Urban Wastewater Treatment Directive' relates to urban wastewater treatment (Council Directive 91/271/EEC) and was adopted by the EU in 1991. The provisions of this directive are transposed into Irish legislation under the *EPA Act, 1992 (Urban Waste Water Treatment) Regulations S.I. No. 419 of 1994*. This has potentially significant implications for the disposal of fish processing wastewater.

The overall aim of the Urban Waster Water Treatment Directive (UWWTD) is to protect receiving waters (including lakes, rivers, estuaries and coastal waters) from pollution by discharge of domestic wastewater. It seeks to achieve this by requiring, as a minimum, that all urban domestic wastewaters receive secondary biological treatment prior to discharge to receiving waters.

Under the UWWTD, domestic wastewaters are defined as “waste waters arising from residential settlements and services which originates from the human metabolism and from household activities” (article 2.2 UWWTD and article 2 of the regulations *S.I. 419, 1994*). It is important to note that the UWWTD does not require all domestic waste waters to receive secondary treatment.

The UWWTD assumes both domestic and industrial waste waters will arise in urban situations and therefore considers total urban waste water as a combination of domestic and industrial waste waters (defined in the UWWTD as “any waste water which is discharged from premises used for carrying on any trade or industry, other than domestic waste water and run-off rain water”). Urban wastewaters are therefore defined as “domestic waste water” or “the mixture of domestic waste water with industrial waste water and/or run-off water”. (*Article 2.1 UWWTD and Article 2 of the Regulations*).

In this context, the UWWTD sets strict emission levels for urban wastewaters. A minimum standard applies to all discharge water and specifies maximum Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids. In the case of discharge of urban waste water to designated ‘sensitive waters’ i.e. waters that are or have been the subject of eutrophication, additional criteria must be met in relation to levels of phosphorous and nitrogen in the discharged water.

Article 2.4 of the UWWTD and Article 2 of the Regulations, state that where industrial and domestic wastewater are in sufficient proximity they should either be “collected and conducted to an urban waste water treatment plant” or conducted “to a final discharge point”.

In circumstances where domestic and industrial waste waters are conducted to an urban waste water treatment plant, the regulations stipulate clearly that the waste waters will be subjected to pre treatments in order to preserve the unimpeded operation of the treatment plant. Furthermore, Article 11 of the UWWTD specifies that where such industrial wastewaters are allowed to enter urban wastewater treatment installations, they are to be the subject of specific authorisations. In Ireland this may take the form of either a local authority e.g. County or City Council, issued discharge licence, or an Integrated Pollution Control Licence, as issued by the EPA; both of which have been described earlier.

In circumstances where industrial waste water is not mixed with domestic waste waters or conducted to an urban waste water treatment plant, all waste water must meet conditions established by prior regulations and be licensed for discharge by the local authority, prior to discharge into receiving waters. Annex III of the UWWTD applies this condition specifically to waste water arising from the food and drinks sectors. The requirement for these conditions to be incorporated into national legislation is met in Ireland by the *Local Government (Water Pollution) Act, 1977*.

The UWWTD allows the discharge of industrial wastewater in an urban area without passing through an urban waste water treatment plant, provided all waste waters are subject to conditions that ensure the protection of the receiving waters from pollution and negative environmental impact. This may have implications for the disposal of waste waters from fish processing and other industries.

Until recently a host of EU Directives set limits for receiving water qualities, intended to protect fresh, estuarine and coastal waters. These were relevant to the discharge of wastewater from the fish processing sector.

These directives included:

- EU Nitrates Directive (91/677/EEC) (mainly targets output from agriculture)
- EU Bathing water quality of rivers, lakes and coastal waters Directive (76/160/EEC)
- EU Drinking Water Directive (98/93/EEC)
- EU Quality of Fresh Waters to Support Fish Life Directive (78/659/EEC)
- EU Quality of Surface Water for Human Consumption Directive (75/440/EEC)
- EU Quality Required for Shellfish Waters Directive (79/923/EEC)

The many different water quality standards and controls laid down by these directives have been reviewed in recent times. This has resulted in the formulation of a new integrated approach to water quality management based upon individual river basins (watersheds). On 23 October 2000, the “Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy” or for short the *EU Water Framework Directive* (WFD) was adopted.

An advantage of the new Framework Directive approach is that it will rationalise the Community's water legislation by replacing many of the “first wave” directives which deal individually with water quality, measurement methods, sampling frequencies and exchange of information. The operative provisions of these directives have been taken over in the Framework Directive, allowing them to be repealed.

In Ireland the vast majority of wastewater arising from the processing of fish is discharged to coastal and estuarine waters. The water quality standards that apply to estuarine and coastal water quality are given as guidelines in the *Technical Memorandum Number 1, Water Quality Guidelines, 1979*⁶.

The *Memorandum* promotes the maintenance of receiving water quality by setting clearly defined water quality objectives (WQO's), which if maintained despite the addition of waste waters can be used as an indicator of the overall health of the system. Key water quality objectives set out in the *Technical Memorandum* include:

- BOD should not exceed 5mg/l
- Oils and grease should not be present in such quantities so as to:
 - form visible films on the surface of the waters
 - form coatings on the beds of watercourses or benthic biota or food sources⁶
- Scum or other floating or suspended solids should not be present in the receiving water in unsightly or deleterious amounts.
- Deposits of solids should be such so as not to affect bottom feeding flora and fauna or spawning or shellfish beds, or to form putrescible or otherwise objectionable sludge deposits.

Under the Urban Waste Water Treatment Directive, provision is made for EU Member States to declare certain receiving waters as '*Sensitive Waters*'. This classification is applied to a body of water in instances where excessive quantities of nutrients are already available in the receiving water system with water quality being compromised by above normal algal growth levels. The addition of further nutrients, suspended solids or increased organic loading of the system (as measured by BOD) is henceforth severely restricted and strict Emission Limit Values (ELV's) for these parameters are deemed the primary control mechanism, with the maintenance of WQO's no longer being the key criteria.

There are presently 10 designated *Sensitive Water* lake and river systems in Ireland. (4 lakes and 6 rivers), none of which have associated fish processing activities in the vicinity. Estuarine and coastal waters can also be designated as *Sensitive*, however there are currently no such water bodies in Ireland. It is therefore unlikely that it will ever become necessary to apply standards based on *Sensitive Water* status designation in the case of fish processing wastewaters discharged to coastal areas.

⁶ An Foras Forbatha, 1970.

2.4 Waste Legislation

2.4.1 General Waste Legislation

The *Waste Management Act, 1996* is the overall legislation establishing the legal framework under which the production, storage, re-use and disposal of all types of wastes is controlled and regulated. In addition, the Act transposes existing EU directives regarding waste legislation and is intended to facilitate the transposition into national legislation of future European waste legislation.

The specific objectives of the *Waste Management Act, 1996* are to provide for:

- A more effective organisation of public authority functions in relation to waste management, which involves new or redefined roles for the Minister, the EPA and local authorities.
- Measures – mainly regulatory powers – designed to improve national performance in relation to the prevention, minimisation and recovery/recycling of all types of wastes, and
- A comprehensive and modern regulatory framework for the application of higher environmental standards, particularly in relation to waste disposal, in response to EU and national waste management requirements.

The core provisions of the Act include:

- An obligation on a person to take all such reasonable steps as are necessary to prevent or minimise the production of waste arising from any agricultural, industrial or commercial activity, or from any product, including steps to be taken at design stage of a product.
- A prohibition on the holding, transportation, recovery or disposal of waste in a manner that causes or is likely to cause environmental pollution.
- A prohibition on the transfer of waste to a person other than an authorised person.
- A prohibition on the recovery or disposal of waste at an unlicensed facility.
- Penalties of up to 12.7 million euro and/or ten years imprisonment for offences.

The *Waste Management Act, 1996* therefore allows for the control of all aspects of waste production, handling, collection, transfer, storage, reuse and disposal. In the context of fish waste disposal, the *Waste Management Act, 1996* has far reaching implications for all producers of fish waste. In general the Act provides a legal framework within which future regulations can be introduced.

Future regulations will be designed to assist in achieving the ultimate objectives of the Act, which are to reduce and reuse waste arisings where possible, thereby ultimately helping to protect the environment from damage caused by inappropriate disposal methods.

The *Dumping at Sea Act, 1996* gives further control over dumping at sea and also gives effect to the Convention for the Protection of the Marine Environment of the North–East Atlantic agreed in Paris in September 1992. The Act further repeals and re–enacts with amendments, the *Dumping at Sea Act, 1981*.

In the context of fish waste from industrial fish processing operations, the *Dumping at Sea Act 1996* allows for the dumping of fish waste at sea under permit from the DCMNR. The definition of ‘dumping’ as provided in the Act expressly does not include the discarding of unprocessed fish or fish offal from fishing vessels. Therefore this latter activity is not regulated for by the Act and apparently remains unregulated at this time. Furthermore, a EU animal by–products legislation specifically excludes this type of waste from its scope also.

2.4.2 Animal By–Products Regulations

The *European Communities Disposal, Processing and Placing on the Market of Animal By–Products Regulations*, (S.I. 257, 1994) is the main instrument regulating the use, sale or disposal of high and low risk animal by–products.

The purpose of the regulations is to implement EU Council Directive No. 90/667/EEC of 1990 as amended by Council Directive No. 92/118/EEC and Commission Decision No. 92/562/EEC of 1992, which lays down the veterinary rules for the disposal and processing of animal by–products for the market and for the prevention of pathogens in feeding stuffs of animal or fish origin.

For the purposes of the legislation, *animal by–product* is defined as “any carcass or part of any carcass of animal origin not intended for direct human consumption with the exception of animal excreta and catering waste”.

Under Regulation 3. (1) “High and low risk animal by–products as listed in Schedule Parts I and II respectively shall not be used, sold, offered for sale, processed, disposed of, incorporated into animal feeding stuffs or pet food, supplied, stored or otherwise dealt with except in compliance with these regulations”.

Under *Schedule I Part I* high risk animal by-products are defined; while under *Schedule I Part II* "fish caught in the open sea for the purposes of fish meal production" and "fresh fish offal from plants manufacturing fish products for human consumption" are classed as low-risk animal by-products.

Under *Regulation 3.*, "Subject to the provisions of *Regulations 5, 9 and 11* animal by-products designated as high risk material or low-risk material shall, as soon as possible, be disposed of by one of the following methods:

- *By processing in an establishment approved or registered in accordance with Regulation 6.*
- *Where necessary, and subject to a licence granted in accordance with Regulation 4, by incineration or burial where in the opinion of a veterinary examiner or marine veterinary examiner, the quantity and the distance to be covered does not justify collecting the by-product."*

The latter provision also applies where, in the opinion of a marine veterinary examiner, there is additional risk caused by the presence of disease in the waste material.

Provided that any fish derived waste material is managed in such a manner that it can be regarded as *product* or *by-product*, *Regulation 5* of the legislation allows the use – under licence – of certain high risk and all low-risk fish by-products for the feeding of zoo, circus or fur animals, packs of hounds and maggot farming for fish bait. The receiver of such material is required to have a permit under *S.I. 257, 1994*. Clearly none of these permitted activities provide a substantial potential use for fish waste in Ireland at present.

With respect to the use of fish by-product material as a product, the Minister for the Marine has the authority to approve a high-risk or a low-risk processing plant for the collection and disposal of animal by-products, where he is satisfied that specified operating criteria are met. Similarly, authority can be given to a rendering plant or user of low-risk material for the exclusive production of fishmeal where specified operating criteria are met. Such rendering plants are required to hold an IPC Licence (*EPA Act, 1992*) and require a permit under *S.I. 257, 1994* for the acceptance of *low-risk animal by-product*.

Under *Regulation 5* a license issued for the use of both high risk and low risk by-product can be used for the feeding of zoo, circus or fur animals as well as other specified animals.

Under Regulation 6, the use of low risk material for the preparation of pet food is permitted, as is the use of low risk material in the preparation of pharmaceutical or technical products and fish meal, under certain broad circumstances.

Regulation 9 relates to intra – Community trade in animal by-product and specifies conditions under which this activity can be engaged in. This is of relevance to the import and/or export of both high and low-risk materials. Controls are set in relation to documentation to accompany all imports or exports of fish waste.

Regulation 10 specifies conditions applying to the transport of animal by-products (see Second Schedule).

As a waste, fish derived material can be destined either for recovery/reuse or as a waste for disposal. With respect to recovery/reuse, the provisions of the *European Communities (Disposal, Processing and Placing on the Market of Animal By-Products) Regulations, S.I. 257, 1994* and the *Waste Management (Permit) Regulations S.I. 165, 1998* apply. Under *S.I. 257 of 1994*, the receiver of waste (facility) is required to be registered or approved, while under *S.I. 165 of 1998* waste recovery and disposal activities must be granted a waste permit by the local authority. Typical recovery activities in the context of fish waste include ensilage and anaerobic digestion. As a waste for disposal, *S.I. 257 of 1994* precludes any fish by-product material going to burial (landfill) unless licensed according to Regulation 3. (3) (b) (v) of *S.I. 257, 1994*. In such circumstances, it is also normal for the operator of a landfill facility to possess a licence from the EPA under the *Waste Management (Licensing) (Amendment) Regulations S.I. 162, 1998*, whether or not it is a local authority or privately operated facility. The disposal of fish waste by composting requires a permit under the *Waste Management (Permit) Regulations, S.I. 165 1998*.

In the past it has been a well known occurrence for fish waste to be dumped at sea by processors who, from time to time, use fishing vessels to remove waste to sea for dumping overboard. Under *Section 5 of the Dumping at Sea Act, 1996* and in accordance with the provisions of the OSPAR convention (discussed below), the DCMNR has in the past issued permits for the disposal at sea of “fish wastes from industrial processing operations”. According to the permit application terms, the granting of a permit for the dumping of fish processing waste at sea would only be considered where it could be shown that other means of disposal have been ruled out for ecological or sound social or economic reasons. Even if proposed for ecological reasons, the dumping of the waste at sea has not always been permitted.

The apparent disparity between the provisions of the *Dumping at Sea Act, 1996* and those of the previously outlined *European Communities Disposal, Processing and Placing on the Market of Animal By-Products Regulations, (S.I. 257, 1994)* with regard to the practice of allowing the dumping of fish waste at sea under permit is the subject of a recent interpretation by the Chief State Solicitor. It is the expressed view of the Chief State Solicitor that whereas in terms of Irish law the Act of 1996 clearly supersedes the terms of the 1994 Regulations, the fact remains that Ireland is bound by its obligations to implement Council Directive 90/667/EEC. Hence the implementation of the permit procedure under the 1996 Act without regard to Ireland's obligations under the Directive would lead to Ireland being in breach of the Directive. As a result of this interpretation issued on November 12th 2002 the DCMNR have responded by bringing to an end the scheme whereby the disposal of fish waste by dumping at sea was permitted in certain circumstances.

Regulation (EC) No 1774/2002 of the European Parliament and Council, dated October 3rd, 2002 lays down health rules concerning animal by-products not intended for human consumption. The main thrust of this regulation is to limit the possible uses of certain animals and by-products not intended for human consumption. The earlier Council Directive (90/667/EEC) discussed above, amended Council Directive 90/425/EEC which established the principle that all animal waste, regardless of its source, may be used for the production of feed material following appropriate treatment. The latest Regulation aims to implement the conclusions of the Scientific Steering Committee that animal by-products not fit for human consumption should not enter the food chain. The implementation date for this newest regulation is May 1st, 2003.

Under the new regulation, all animal by-product material not intended for human consumption is classified as either category 1, 2 or 3. Accordingly, category 1 material (considered highest risk material) must be rendered and/or incinerated, or disposed of by burial in a landfill. Category 2 material includes mass fish farm mortalities arising from biotoxic and or jellyfish sting related events. Category 2 fish material can only be disposed of by rendering and/or incineration, composting, ensiling (and use of the liquor as a fertiliser) or by conversion to biogas at a biogas plant.

Category 3 materials include fish caught in the open sea for the purposes of fishmeal production, as well as animal by-products derived from the production of products intended for human consumption. Parts of slaughtered animals which are fit for human consumption but which are not intended for human consumption are also considered category 3 material, as are parts of slaughtered animals not fit for human consumption but which are not affected by any signs of disease communicable to man or animal and derive from carcasses that are fit for human consumption.

2.4.3 The OSPAR Convention

The Convention for the Protection of the Marine Environment of the North–East Atlantic (“OSPAR Convention”) was opened for signature at the Ministerial Meeting of the Oslo and Paris Commissions in Paris on 22 September 1992.

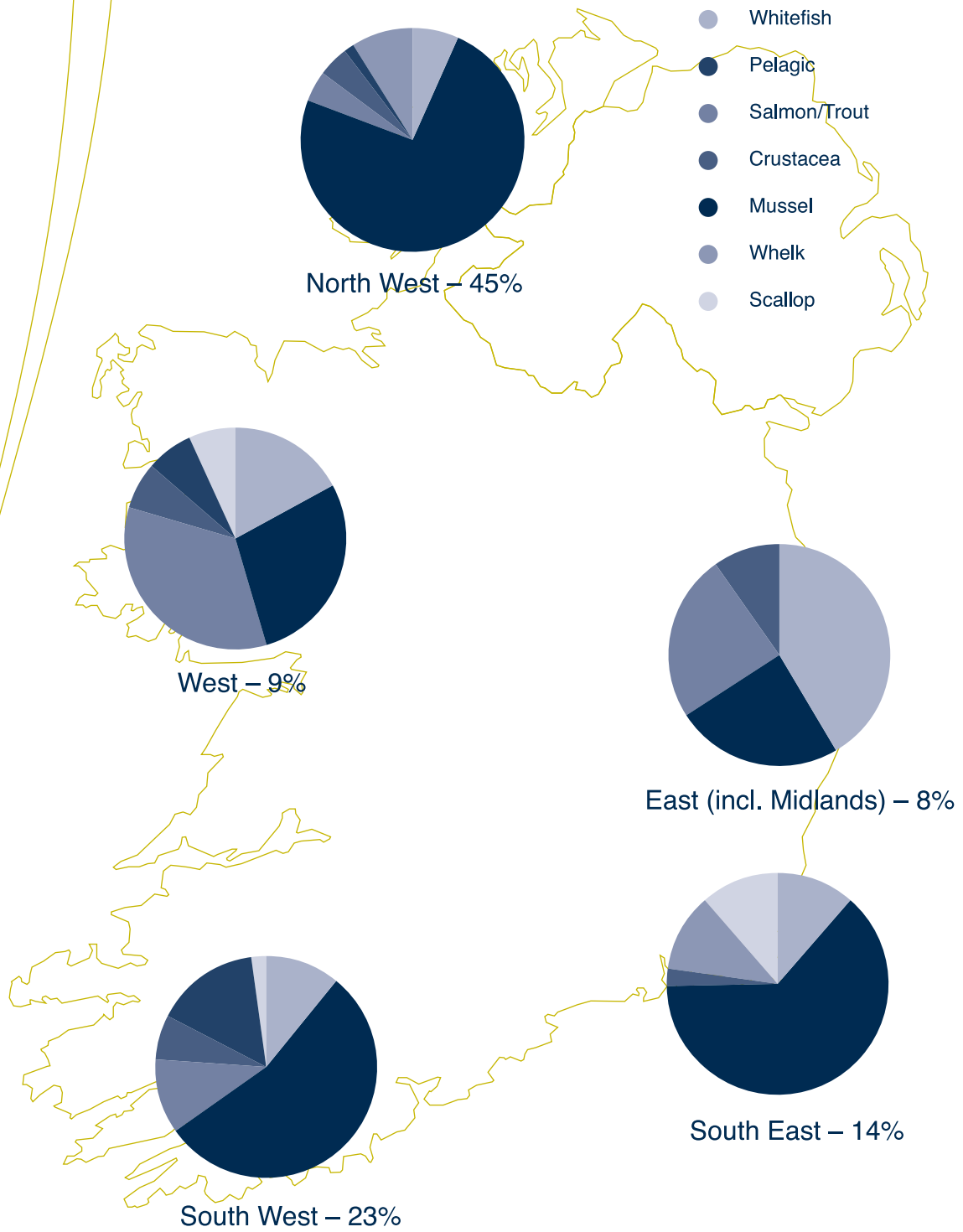
The Convention has been signed and ratified by all of the Contracting Parties to the Oslo or Paris Conventions (Belgium, Denmark, the Commission of the European Communities, Finland, France, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom of Great Britain and Northern Ireland) and by Luxembourg and Switzerland.

The OSPAR Convention entered into force on 25 March 1998. It replaces the Oslo and Paris Conventions, but Decisions, Recommendations and all other agreements adopted under those Conventions continue to be applicable, unaltered in their legal nature, unless they are terminated by new measures adopted under the 1992 OSPAR Convention.

Under ANNEX II, “ON THE PREVENTION AND ELIMINATION OF POLLUTION BY DUMPING OR INCINERATION” Article 3 paragraph 2, the dumping at sea of all wastes or other matter is prohibited, except for *“fish waste from industrial fish processing operations”*. As signatories to the Convention, the dumping at sea of fish waste from industrial fish processing operations is permissible in Ireland, however such dumping must be authorised; in accordance with Article 4 of the Convention which states that *“no wastes or other matter listed in paragraph 2 of Article 3 of the Annex shall be dumped without authorisation by their competent authorities, or regulation”*. Furthermore, *“such authorisation or regulation must be in accordance with the relevant applicable criteria, guidelines and procedures adopted by the Commission in accordance with Article 6 of Annex II”*. In this context, *“it is the duty of the Commission to draw up and adopt criteria, guidelines and procedures relating to the dumping of wastes or other matter listed in paragraph 2 of Article 3, and to the placement of matter referred to in Article 5, of the Annex, with a view to preventing and eliminating pollution”*.

With regard to the dumping of fish waste at sea, Article 4 (3) of the Convention requires that *“each Contracting Party shall keep, and report to the Commission records of the nature and the quantities of wastes or other matter dumped in accordance with paragraph 1 of this Article, and of the dates, places and methods of dumping”*.

3.0 Current National Fish Waste Arisings



Map 1. Current Fish Waste Arisings by Region.

3.1 Whitefish

3.1.1 Processing Solid Waste Arisings

Landings data for whitefish species for the years 1994 – 2000 are presented in Figure 3.1. Total landings for whitefish species for 2000 amounted to 36,680 tonnes live weight. This represents a decline of 22% by volume over the preceding 6 – 7 years. Table 3.1 presents whitefish landings data for 2000 by species.

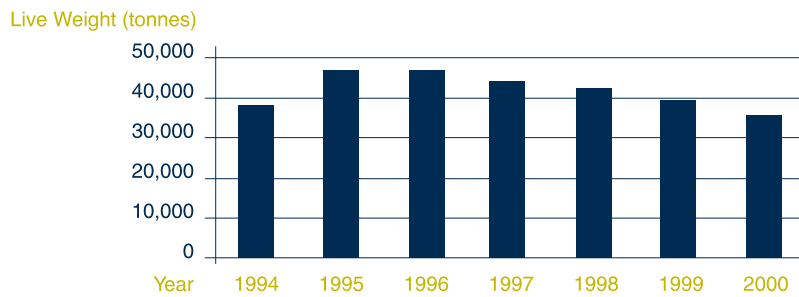


Figure 3.1: Total Landings of Whitefish into Irish Ports 1994 – 2001 (Tonnes Live Weight).
Source: CSO

Species	Landed (tonnes)
Lemon Sole	450.9
Witch	526.5
Spur Dog	881.0
Ling	972.7
Plaice	979.3
White Pollock	993.5
Saithe	1479.4
Ray / Skate	1805.9
Hake	1837.5
Cod	2467.1
Monk/Angler	2978.8
Megrim	3208.8
Haddock	5180.5
Whiting	5974.8
Sub – Total	29736.7
Other w/f species	3852.6
Total	33589.3

Table 3.1: Whitefish Landings by Species 2000 (Tonnes Landed Weight).
Source: CSO

A recent DCMNR survey⁷ of the processing sector concluded that of Irish whitefish landings, 33% goes fresh to market or export, 29% is used in producing chilled fillets, 33% is used to produce frozen fillets (of which approximately 75% are of whiting or haddock), with the remaining balance of 4% going to secondary processing.

Estimates by BIM in 1999⁸ show somewhat greater quantities of whitefish landings going to fresh market or export (43 per %), with only 53% of landings being used for production of chilled and frozen fillets and a further 4% going for secondary processing.

Table 3.2 presents likely solid waste arisings based on the above BIM figures for utilisation of raw materials for the year 2000. Since fish which is landed and sold directly for fresh market or export without further processing do not give rise to a significant waste stream in a commercial sense where these are exported whole, waste arisings from landings are recorded as nil.

Type of Processing	Processed %	Home Landings (tonnes)	Waste%	Total Solid Waste (t)
Fresh Market/Export	43	14,443	0	0
Chilled/Frozen Fillets	53	17,802	40	7,120
Secondary Processing	4	1,343	45	604
Total	100	33,589		7,724

Table 3.2: Solid Waste Arisings by Processing Type for Whitefish, based on Landings Figures for 2000 (Excludes Processing of Imported Fish and Fish Landed into Foreign Ports). Source: DCMNR.

Given that up to 40 percent of landed weight of whitefish (gutted) is converted to waste during primary processing activities, national annual whitefish solid waste arisings are significant at 7,724 tonnes, based on this industry accepted figure for yield.

One of the most pressing issues concerning the development of the whitefish – processing sector in Ireland is a shortage of raw materials. This has led to increasing quantities of fish being imported for processing at installations in Ireland.

⁷ 'The Way Forward for Irish Seafood' Strategy for the development of the Irish seafood processing sector. Report commissioned by DCMNR. INDECON in association with Price Waterhouse Coopers, January 2001.

⁸ 'Strategic Environmental Assessment of the Irish Fish Processing Industry'. Report prepared by the Environment Unit of Enterprise Ireland, on behalf of an Bord Iascaigh Mhara and in association with the Irish Fish Processors and Exporters Association, March 2000.

In 2000, a survey of whitefish processors revealed that some 15.9% of whitefish raw materials were being imported for processing. Based on figures for solid waste arisings from processing of fish landed into Ireland, an additional 1,460 tonnes of solid waste would have been generated from processing of imported fish during 2000. While no more recent data are available, it is likely that this figure has risen since and will continue to do so as processors strive to achieve growth and greater capacity utilisation. The contribution from this source of raw material to the solid waste arisings within the whitefish sector must increasingly be taken into account. Table 3.3 presents estimated total annual whitefish solid waste arisings, based on landings figures for 2000 and data for imports of whitefish in 2000 (DCMNR).

Processing Waste Source	Tonnes
Landings whitefish	7,724
Imports whitefish	1,460
Total	9,184

Table 3.3: Estimated Total Annual Whitefish Solid Waste Arisings 2000.

3.1.2 Future Whitefish Landings

A number of factors are seen as likely to influence future whitefish landings figures. While quota reductions for traditional species such as cod, haddock, whiting and anglerfish will cause continuing reductions in landings for these key species, new species are also likely to come under the quota management regime in the future. This will therefore significantly limit growth potential for whitefish landings. Nevertheless, recent and future investment in the whitefish fleet may lead to improved capacity for exploiting new grounds and non-quota species, which may in turn stabilise landings at or slightly below current levels. However, in the context of solid waste arisings, strategic government plans for investment in the whitefish processing sector aims to achieve an increase in the future proportion and volumes of whitefish being processed into value added products. It is expected therefore that solid waste arisings from whitefish processing will rise substantially in the future over current levels.

For example, where the proportion of landings going to primary processing increases from 53% at present to 80%, an estimated additional 3,628 tonnes of solid waste would be generated, based on landings figures for 2000.

Two further factors are likely to affect the quantities of whitefish being processed in Ireland. Irish vessels land approximately 2,000 tonnes of whitefish annually into foreign ports in the UK, Spain and Norway. Future diversion of these landings to Irish ports for processing in Ireland would lead to a further increase in annual whitefish solid waste arisings of approximately 800 tonnes, based on 2000 landings data. It is also likely that increasing quantities of raw materials will be imported in the future for processing in Ireland, adding further volumes to the whitefish solid waste stream.

Overall, while landings of whitefish into Ireland may continue to decline in the future, actual volumes processed could remain stable or even show some growth. Growth could be catered for by foreign landings diverted to Irish ports, increased quantities of imported raw material and a greater processed proportion of Irish whitefish landings. Therefore it is considered that waste arisings will continue to climb beyond the current estimated level of around 9,000 tonnes.

3.1.3 Regional Distribution of Whitefish Waste Arisings

Landings of whitefish species are fairly evenly distributed around the coast. Landings take place year round on a continuous basis, bad weather excepted. The larger whitefish ports are Greencastle, Killybegs, Rosaveal, Dingle, Casteltownbere, Union Hall, Dunmore East and Howth. Additional landings of smaller quantities of whitefish occur at numerous smaller ports around the country. Geographically, whitefish waste arisings do not fully mirror major whitefish landing ports, as considerable quantities of fish are sold and transported by road for processing at other locations. Many processors however still choose to be located at or close to the principal points of landing and also some smaller landing points.

A DCMNR study commissioned in 2000⁷, gives the regional distribution profile of whitefish processors based on data supplied by the industry and industry supporting agencies including Bord Iascaigh Mhara, Udaras na Gaeltachta and Enterprise Ireland. This regional profile for whitefish processors is presented opposite in Table 3.4. The data presented do not necessarily reflect the actual regional output and volume of waste risings as they are based entirely on processor distribution data and do not take account of different levels of activity.

Region	No of Processors	% of total
Northwest	13	21.3
West	8	13
Southwest	14	23
Southeast	8	13.2
East (inc midlands)	18	29.6
Totals	61	100

Table 3.4 Location of Whitefish Processors by Region, 2000.

The greatest concentrations of whitefish processors are located principally in Donegal, the east of the country (Dublin mainly) and the southwest in Counties Cork and Kerry. However, no data are available concerning the actual output from processors on a regional basis, making it difficult to quantify regional whitefish processing waste streams precisely. Nevertheless, it is reasonable to suggest that whitefish waste arisings would reflect closely the geographical distribution of whitefish processing plants. Based on this premise, the greatest regional solid waste stream from whitefish processing would therefore occur in the east of the country, with other notable regional whitefish waste centres being the northwest (Donegal) and the south west (Cork/Kerry).

Table 3.5 assigns 2000 total whitefish solid waste arisings (Table 3.3) to the regions, based on data for geographical location of processors (Table 3.4). The regions with the greatest volumes of whitefish solid waste arisings are the southwest and southeast combined (2,793 t), the east (2,285 t) and the northwest (1,644 t). Figure 3.2 presents data on solid waste arisings from processing of whitefish on a regional basis for 2000 landings.

Region	No of Processors	Processor Distribution % of Total	Estimated Solid Waste Arisings (t)
Northwest	13	21.3	1,645
West	8	13.1	1,012
Southwest	14	23	1,776
Southeast	8	13.1	1,012
East (inc midlands)	18	29.5	2,279
Totals	61	100	7,724

Table 3.5: Estimated Regional Whitefish Solid Waste Arisings 2000 (Tonnes), Related to Distribution of Processing Plants.
Source: DCMNR

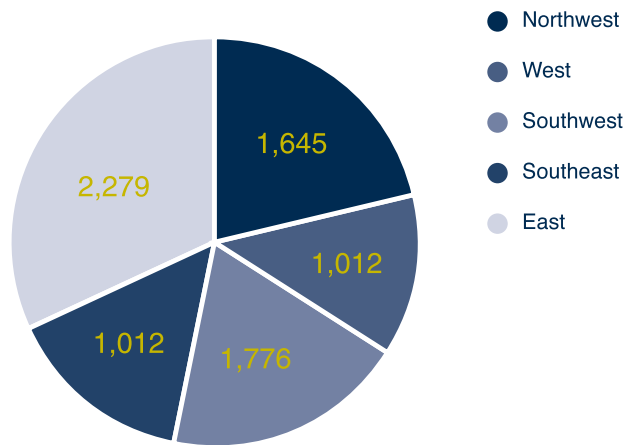


Figure 3.2: Estimated Whitefish Waste Arisings 2000, Related to Distribution of Processing Plants (Tonnes)
Source: DCMNR

3.1.4 Seasonal Aspects of Whitefish Waste Arisings

Due to the polyvalent nature of the Irish whitefish fleet, which periodically switch fishing gears, grounds fished and target species or species mix, many vessels will land a range of fish species over the season. Landings of the main species cod, whiting, haddock, hake, monkfish, saithe and dogfish occur year round. There are peaks for whiting in the spring and a winter peak for cod landings. For many high value, low volume species such as plaice, sole turbot and brill there is little year on year variation in season or landings and annual returns for most of these species are relatively stable, with landings changing only moderately from year to year.

Whitefish solid waste arisings therefore reflect closely the above landings patterns, with a steady stream of solid waste being generated throughout the year. There are occasional drops in waste volumes caused by extended periods of bad weather but these are countered by landings peaks associated with spring whiting fisheries and winter cod.

At no time do large accumulations of waste occur due to exceptional landings. However, whiting landings occasionally peak resulting in low prices and more fish entering into the withdrawal system. In these instances, much of this fish enters the waste stream and is destined for reduction processing.

3.2 Pelagic

3.2.1 Processing Solid Waste Arisings

Data for landings by Irish pelagic vessels into all ports (home and foreign) from 1994 to 2000 are presented in Figure 3.3. The volume of pelagic landings reached 206,282 tonnes live weight in 2000, but has fluctuated considerably since the early 1990's. Pelagic landings peaked at 305,485 tonnes in 1995 before falling to 216,343 tonnes in 1997. Some recovery in landings occurred during 1998, but the trend since then has been downward. The pelagic fisheries sector contributes between 65 and 70 percent of annual landings in Ireland based on volume. Landings of the major pelagic species herring, mackerel, horse mackerel and blue whiting are concentrated in the ports of Killybegs, Castletownbere, Cobh and Dunmore East.

Table 3.6 presents data for pelagic fish landings in 2000 by species. As in previous years, the greatest landings were for mackerel (70,183t), with horse mackerel (55,438t), herring (42,114t) and blue whiting (21,693t) comprising the bulk of the balance of pelagic landings. Smaller quantities of other pelagics, mainly argentinines, pilchards, sprat and tuna are also landed.

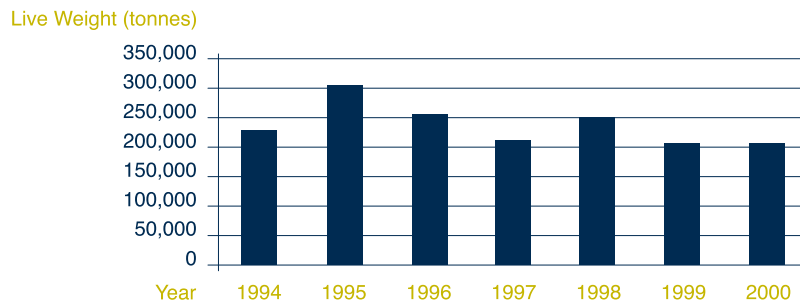


Figure 3.3: Total Landings (All Ports) of Pelagic Fish by Irish Vessels 1994 – 2000
Source: CSO

Species	Landed (tonnes)
Tuna	3,486
Sprat	6,032
Other Pelagic Species	7,337
Blue Whiting	21,693
Herring	42,114
Horse Mackerel	55,438
Mackerel	70,183
Total	206,283

Table 3.6: Pelagic Fish Landings by Species 2000.
Source: DCMNR

Landings of blue whiting and more recently argentines (so called 'industrial' species) and horse mackerel, are used almost exclusively in the production of fishmeal. Fisheries for these species are prosecuted mainly by large offshore vessels fitted with refrigerated seawater tanks (RSW) and based in the North West of the country, where catches are landed close to the IAWS fish meal plant in Killybegs. As fish are landed in the whole ungutted form and go directly for reduction processing, there are no solid waste arisings from processing of these species.

Although there is potential for horse mackerel to be utilised for processing for human consumption, technical difficulties relating to post catch handling and processing of horse mackerel has prevented Irish pelagic fish processors from pursuing these markets to any significant degree to date. However it is recognised that this situation may change in the future. Horse mackerel must be recognised as a potential pelagic processing species and in this context horse mackerel may become a significant component of the pelagic fish processing solid waste stream in the future.

Herring and mackerel are landed primarily for human consumption. Mainly larger vessels fitted with RSW tanks prosecute mackerel fisheries and most landings are to Northwest and west coast ports. Fisheries for herring are also conducted from many smaller vessels, often whitefish vessels holding a herring license, most of which do not have RSW tanks ('dry hold' vessels). Herring are fished chiefly in the Celtic Sea, the Irish Sea and the west coast and are landed into the respective ports in these areas. Landings of mackerel and herring are transported for processing at factories where they are filleted, headed and gutted for freezing, or marinated. These processes give rise to substantial quantities of solid wastes. BIM estimates for the proportions of herring and mackerel going to primary and secondary processing are given in Tables 3.7 and Table 3.8 and are utilised in the estimation of solid waste arisings from the processing of these species based on 2000 home landings.

Type of processing	Processed %	Home Landings (t)	Waste % ⁷	Total solid waste (t)
Chilled/Frozen Whole	9	2,947	0	0
Chilled Deli Cut h&g	7	2,292	32	733
Marinated	32	10,476	60	6,285
Frozen fillets	52	17,025	60	10,215
Total	100	32,740		17,233

Table 3.7: Estimated Solid Waste Arisings by Processing Type for Herring, based on 2000 Home Landings. (Excludes Landings by Irish Vessels into Foreign Ports).
Source: DCMNR/BIM

Type of processing	Processed %	Home Landings (t)	Waste % ⁷	Total solid waste (t)
Chilled/Frozen Whole	83	30,762	60	18,457
Frozen Fillets	15	5,559	60	3,335
Chilled Deli Cut h&g	2	741	32	237
Total	100	37,062		22,030

Table 3.8: Solid Waste Arisings by Processing Type for Mackerel, based on 2000 Home Landings. (Excludes Landings by Irish Vessels into Foreign Ports).
Source: DCMNR/BIM

Total solid waste arisings from the processing of herring and mackerel are presented in Table 3.9, based on 2000 landings data. An estimated 39,263 tonnes of pelagic processing solid waste was generated in 2000.

Species	Solid waste (tonnes)
Herring	17,233
Mackerel	22,030
Total	39,263

Table 3.9: Total Estimated Solid Waste Arisings from Mackerel and Herring Processing, 2000 Home Landings.

With respect to the import of raw materials for processing at pelagic plants, very little pelagic fish is imported in contrast to rising levels of imports of whitefish species. The DCMNR (2001) estimates that imports of pelagic species in 2000 amounted to only 1.7% of raw materials used by pelagic processors.

With respect to albacore tuna fisheries, the majority of landings are transported to continental Europe for processing at canneries, therefore giving rise to no solid wastes in Ireland. Smaller undetermined quantities are processed locally for fresh sale on domestic markets or for secondary processing e.g. smoking, however solid waste arisings from this source are minimal.

Official statistics show that for 2000, a total of 1,343 tonnes of pelagic fish entered into intervention after failing to achieve minimum prices. These were mainly of herring and horse mackerel as detailed further in Table 3.10. Withdrawal pelagics are also taken for reduction processing by the IAWS plant in Killybegs, where they are rendered into fishmeal and oil.

Species	Withdrawn 2000
Herring	563.3
Horse Mackerel	778.6
Other Pelagics	0.6
Total	1,342.8

Table 3.10: Withdrawals of Pelagic Species 2000.

3.2.2 Future Pelagic Fish Landings

Irish **herring** quotas were reduced in 2000 to 43,790 tonnes, having varied from between 54,000 tonnes and 59,000 tonnes between 1994 and 1999. Catches have declined from a high of 71,953 tonnes in 1996 to 42,100 tonnes in 2000. Accordingly, quotas were reduced to 44,000 tonnes in 2000. Evidence of further reductions in landings is emerging as provisional estimates for 2001 landings for herring indicates catches of 40,640 tonnes. Clearly it would appear that exploitation rates for herring are at maximum sustainable levels, if not exceeding these. The most optimistic outlook for herring landings is of continuing small reductions in quotas and landings, until such time as the long-term stability of the various herring stocks are determined. Stock assessments of Celtic Sea herring in the recent past have produced worrying estimates and it is possible that this fishery faces closure in the near future, producing a drastic drop in landings for the herring fleet.

The outlook for **mackerel** landings is also uncertain. While quotas and landings were cut back heavily during the mid 1990's from a landings high of almost 100,000 tonnes in 1994 to less than half that in 1996, recent trends in quotas and landings have been upwards. Western mackerel quota for Ireland in 2000 was 71,052 tonnes, with landings reaching 70,183 tonnes for the year. Provisional landings data for 2001 indicate mackerel landings remained stable, at 70,450 tonnes for that year.

Landings of **horse mackerel** have shown dramatic decline from a peak of 178,000 tonnes in 1995 to landings of 55,438 tonnes in 2000. Provisional figures for 2001 indicate a further small reduction in landings for horse mackerel to 54,900 tonnes.

The decline can be attributed largely to the imposition of quotas on this species in 1998, although Irish landings have so far failed to reach the maximum allowed by quota since this method of management was introduced. The pattern in recent years shows continuing decline, although evidence that this may be stabilising is emerging with 2001 landings down only 540 tonnes on 2000 landings. As previously mentioned, horse mackerel is currently used almost exclusively for fish meal production, however the species can potentially be processed for human consumption. A shift towards the latter use for horse mackerel landings would inevitably add to the processing solid waste stream. However, this is somewhat unlikely to occur without substantial investment in fishing vessels and onshore processing lines. Specialised handling techniques including freezing at sea must be employed in order to preserve the quality of the fish so that it is fit for processing for human consumption, while onshore specialised processing equipment is required for filleting the species due to the presence of lateral spines on the fish.

Blue whiting landings have been unpredictable in recent years. Prior to quota restrictions in 1999, landings of blue whiting grew rapidly during 1997 and 1998. Before this, blue whiting tended to be a species that was targeted opportunistically and only to absorb excess capacity in the fleet, this being reflected by high variability in the landings figures (222 tonnes in 1995, 8700 tonnes in 1994). Blue whiting landings peaked in 1998 at 45,500 tonnes. Quotas for blue whiting have increased marginally in recent years although catches have fallen significantly from the high mentioned earlier. Landings for 2000 were 29,963 tonnes while provisional figures for 2001 landings show that landings reached 29,909 tonnes. Given that the trend for blue whiting quotas has been upward in recent years and considering that landings appear to have stabilised recently, the prospect is that blue whiting stock levels are healthy and that current landings levels can be maintained for the foreseeable future. A considerable proportion of the EU quota for blue whiting has consistently not been allocated and for 1999, the first year in which Ireland was given a quota for blue whiting, the unallocated quota amounted to 127,500 tonnes.

Other pelagic fisheries, such as those for **pilchard** and **argentines** have shown some growth in landings in recent years. Landings of pilchards were 2,500 tonnes in 2000, with provisional estimates for 2001 showing 7,856 tonnes of pilchard were landed. Landings of argentines reached 7,500 tonnes in 2001 according to provisional estimates, up considerably over recent years. Growth potential for this species is unclear however as this species was targeted heavily in previous years before apparently being over fished leading to a collapse in stocks.

Sprat landings are highly variable and recently have declined dramatically from 6,000 tonnes in 2000 to 455 tonnes in 2001 (provisional figure). Sprat fisheries are located mainly off the south west coast and in Donegal Bay and fisheries in both areas have traditionally displayed high variability. Therefore it is quite likely that landings of sprat will increase again in the future. Sprat landings with counts less than 50/kg are utilised in canning at the countries only canning plant located in Donegal, while sprat landings with counts greater than 50/kg tend to be sold into reduction processing.

Landings of **albacore tuna** have fallen from a peak of 4,900 tonnes in 1999 to 3,500 tonnes in 2000. Provisional figures for 2001 show a further decline with albacore tuna landings down to 2,003 tonnes. The decline in tuna landings is accounted for by changing fishing methods in response to a EU ban on fishing for the species using drift nets. Landings of tuna are likely to continue to decline until such time as a suitably efficient alternative method of capture is identified for Irish vessels.

Large proportions of the Irish landings of mackerel, horse mackerel, blue whiting and herring are made into foreign ports. As a result, none of this fish is available to Irish processors for processing either for human consumption or for meal production. Table 3.11 summarises landings data for 2000 showing the percent of Irish landings for these species, which are landed into foreign ports. An increase in mackerel and herring landings to Irish ports would result in an increase in solid waste from the processing. Increased landings of horse mackerel and blue whiting would merely contribute to output of fish meal, with no solid waste arisings from this form of processing.

Species	Percent of Landings	Tonnes
Horse Mackerel	49	27,350
Mackerel	47	33,140
Blue Whiting	21	5,565
Herring	22	9,375
Total		75,430

Table 3.11: Summary of Landings of Pelagic Species by Irish Vessels into Foreign Ports (2000).
Source: CSO

As can be seen from the data, very significant volumes of pelagic fish species are landed into foreign ports by Irish vessels. In 2000, 33,140 tonnes of mackerel were landed chiefly into ports in Norway, the UK, the Netherlands and France, while 27,340 tonnes of Horse mackerel were landed into ports in France and the Netherlands mainly.

Additional throughput by the Irish pelagic processing sector could be achieved by increasing landings of pelagic species into Irish ports. However it is felt that this is unlikely to occur without significant changes in the market for pelagic species as well as changes in the migratory movement of the stocks, which determines to a large degree the point of landing.

3.2.3 Regional Distribution of Pelagic Waste Arisings

Landings of industrial species into Ireland include horse mackerel, blue whiting and argentines and are made mainly into Killybegs. Blue whiting are landed exclusively into Killybegs, while horse mackerel are landed into Rathmullan as well as Killybegs, both in the northwest. Smaller amounts (<1000 tonnes total) were landed into Rossaveal, Dingle and Castletownbere in the west and southwest.

A survey of processors in 1999 revealed that 17 pelagic processors out of 29, or 58.6% of the total number of pelagic processors were located in Co. Donegal, while a further 5, or 17.2%, were located in Co. Cork. The breakdown of pelagic processor by location is given in Table 3.12. As can be seen, the industry is heavily concentrated in the northwest of the country, with smaller pockets of processing activity taking place in the southwest and southeast.

Region	No. of processors	%
Southwest	6	20.6
Northwest	17	58.4
East	1	3.5
Southeast	4	14
West	1	3.5
Total	29	100

Table 3.12 Location of Pelagic Fish Processors by Region, 2000.

The data presented do not necessarily reflect the actual regional output and volume of waste risings as they are based entirely on processor distribution data and do not take account of different levels of activity. However, given that waste arisings will occur principally at location of processing rather than at port of landing, it follows that much pelagic waste arisings occur in Counties Donegal and Cork/Kerry, with appreciable quantities arising also in Counties Waterford and Wexford. Two other pelagic processing plants, one located in Rossaveal and the other in Dublin also give rise to pelagic wastes.

A review of more recent (2002) secondary data relating to the distribution of pelagic processors was conducted as part of this study. Findings revealed that there were 29 processors of herring and mackerel, distributed throughout the regions in precisely the same pattern as that found in the 1999 survey, data for which are summarised in Table 3.12. For the purposes of estimating regional solid waste arisings from processing of herring and mackerel (see Tables 3.7, 3.8), it is appropriate to allocate pelagic waste arisings according to the geographical distribution of processors shown in Table 3.12. Table 3.13 presents regional solid waste arisings from processing of herring and mackerel, based on distribution of processing plants and 2000 landings. Figure 3.4 presents data for regional pelagic waste arisings

County	No. of processors	Solid waste (tonnes)	%
Southwest	6	8,088	20.6
Northwest	17	22,931	58.4
East	1	1,374	3.5
Southeast	4	5,496	14
West	1	1,374	3.5
Total	29	39,263	100

Table 3.13: Estimated Regional Waste Arisings from Processing of Herring and Mackerel for 2000 Landings, based on Distribution of Processing Plants.
Source: DCMNR

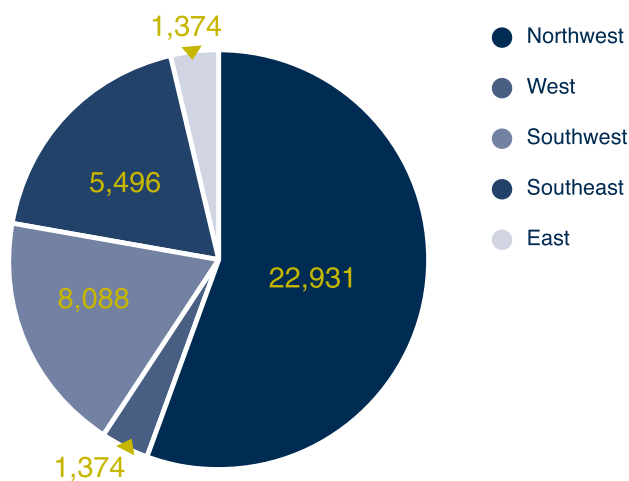


Figure 3.4: Estimated Solid Waste Arisings from Processing of Herring and Mackerel 2000, related to distribution of Processing Plants.
Source: DCMNR

3.2.4 Seasonal Aspects of Pelagic Waste Arisings

Pelagic waste arisings occur mainly between October and April, mirroring the highly seasonal landings pattern. Traditional herring grounds normally open to fishing in October, with mackerel fisheries opening in November. The season extends until February/March. The peak season therefore for waste generation by herring and mackerel processors is October to March. During this period most waste is sent for reduction processing in Killybegs, however smaller amounts have in the past gone to a rendering plant in the midlands, when this has been a more economic option for waste disposal for some processors located in the south and south east of the country. Given that on average 50% of the landed weight of these pelagics finds its way into the waste stream, pelagic processing waste is the largest source of solid fish wastes in Ireland.

In the case of the industrial pelagic fisheries, blue whiting fisheries commence in March and April and extend until May or June. The main season for horse mackerel fisheries are mid July to September. Sprat fisheries occur during the autumn and early winter, while argentinines have been taken recently during the spring and summer.

Albacore tuna fisheries occur exclusively in late summer as the tuna move to the north of the Bay of Biscay and come into range of Irish fishing vessels.

3.3 Salmon and Trout

3.3.1 Production and Processing Solid Waste Arisings

Annual production figures for farmed salmon and trout for the years 1994 – 2000 are shown in Figure 3.5. While all salmon production occurs in seawater, trout production can be broken down approximately 40% saltwater production and 60% freshwater production, with some annual variation. National freshwater production of rainbow trout amounted to 1300 tonnes in 2000.

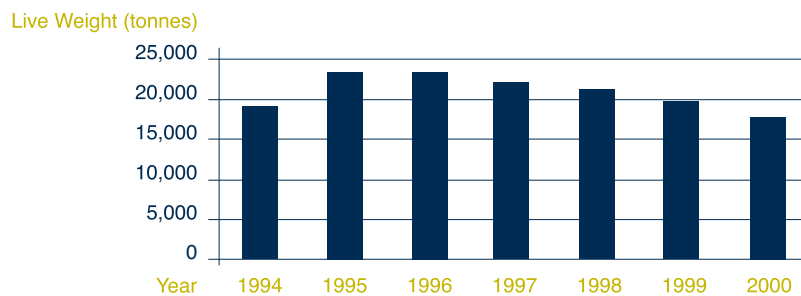


Figure 3.5: Total Annual Finfish Aquaculture Production 1994 – 2000 (tonnes live weight).
Source: CSO

Additionally small quantities of wild salmon are landed annually from the summer drift net fishery. Data for landings of wild salmon for the years 1994–2000 are presented in Table 3.14.

Year	Landings
1994	816
1995	790
1996	688
1997	570
1998	624
1999	515
2000	621

Table 3.14: Annual Landings for Wild Salmon, 1994 – 2000 (tonnes live weight).
Source: DCMNR

3.3.2 Production Waste Arisings Salmon/Trout Aquaculture (Mortalities)

Routine mortalities occurring on fish farms are classed as low risk material under the relevant legislation. Waste arisings from salmon production operations can be estimated using the industry-accepted average of 5 percent loss of total production biomass due to routine mortality from smolt to harvest. Production mortality waste arisings for the salmon/trout sector for 2000 are therefore estimated at 880 tonnes. For healthy stock, waste arisings from routine mortalities tend to occur on a continual basis, but are also temperature related and therefore tend to be somewhat higher in summer.

It is important to note that these estimates are exclusive of exceptional high-risk production waste arisings due to mass mortality or disease related culling of stocks. Instances of mass mortality due to disease or fish kills can lead to exceptional volumes of high-risk solid waste arisings. Once again this is most likely to occur in summer. In terms of waste biomass, even moderate levels of mortality of near harvestable fish can lead to the generation of considerable volumes of waste in a short period. Table 3.15 presents estimates for waste arisings from production of salmon and trout from 1994 – 2000, based on five percent loss to routine mortality. It is important to note that the estimates do not include waste biomass which can and does arise from disease outbreaks and mass mortality caused by natural phenomena. It is felt that waste arisings from these events are too variable and cannot therefore be taken into consideration in annual estimates. However, exceptional volumes of mortality biomass may arise from time to time and poses a problem from the waste management point of view which requires separate consideration.

Year	Salmon Production Waste (t)	Trout Production Waste (t)	Total Production Waste (t)
1994	581	74	655
1995	591	74	665
1996	702	94	796
1997	772	91	863
1998	743	96	839
1999	904	113	1017
2000	883	124	1007

Table 3.15: Presents Estimates for Low Risk Waste Arisings from Routine Production Mortality of Salmon and Trout from 1994 – 2000 (Tonnes).*

Source: Nautilus Estimates

*Does not include wastes from exceptional mortalities, disease related culls or condemnation of fish due to presence of residues.

3.3.3 Processing Waste Arisings Salmon / Trout

Estimates provided by BIM in 1999 show that 70% of salmon produced by aquaculture in Ireland are gutted and packed in preparation for fresh or frozen export and receive no further processing within Ireland. A further 10% of production is processed into fillets while 20% receives advanced secondary processing (mainly smoking). These data are presented in Table 3.16, while Table 3.17 presents estimates for solid waste arisings from the processing of total landings of wild salmon in 2000.

Discussions held with the largest producers of freshwater reared rainbow trout revealed that 35% of trout production receives only gutting and packing for fresh sale, while the balance is filleted for fresh sale, leading to solid waste arisings for this industry as shown in Table 3.18. Similarly, 20% of sea reared trout are gutted and prepared for fresh sale with approximately 20% receiving advanced secondary processing, while the bulk of production (60%) being filleted, leading to waste arisings as shown in Table 3.19.

Type of processing	Processed %	Production (t)	Waste % ⁷	Total solid Waste (t)	Waste Type
Gutting for Export Frozen Whole	70	12,353	11	1,359	Entrails
Filleting	10	1,765	50	882	Heads, Frames, Skin
Advanced Secondary Processing	20	3,530	50	1,765	Heads, Frames, Skin, Pin Bones, Meat
Total	100	17,648	4,006		

Table 3.16: Total Estimated Solid Waste Arisings by Processing Type for Aquaculture Salmon, based on 2000 Production Data (Tonnes).
Source: DCMNR/BIM

Type of processing	Processed %	Production (t)	Waste %	Total solid Waste (t)	Waste Type
Gutting for fresh sale	30	186	11	20	Entrails
Advanced Secondary Processing	70	435	50	218	Heads, Frames, Skin, Pin Bones, Meat
Total	100	621	238		

Table 3.17: Total Estimated Solid Waste Arisings by Processing Type for Wild Salmon, based on 2000 Landings (Tonnes).
Source: Nautilus Estimates

Type of processing	Processed %	Production (t)	Waste %	Total solid Waste (t)	Waste Type
Gutting for Fresh Sale	35	438	11	48	Entrails
Filleting	65	812	50	406	Heads, Frames, Skin, Pin Bones, Meat
Total	100	1,250	454		

Table 3.18: Total Estimated Solid Waste Arisings by Processing Type for Freshwater Reared Rainbow Trout, based on 2000 Production Data (Tonnes).
Source: Nautilus Estimate from Discussions with Trout Growers

Type of processing	Processed %	Production (t)	Waste %	Total solid Waste (t)	Waste Type
Gutting for fresh sale	20	250	11	27	Entrails
Filleting	60	750	50	375	Entrails, Heads, Frames, Skin, Pin Bones, Meat
Advanced Secondary Processing	20	250	50	125	Entrails, Heads, Frames, Skin, Pin Bones, Meat
Total	100	1,250	527		

Table 3.19: Total Estimated Solid Waste Arisings by Processing Type for Saltwater Reared Rainbow Trout, based on 2000 Production Data (Tonnes).

Source: Nautilus Estimate from Discussions with Trout Growers/BIM

Total estimated solid waste arisings for 2000 from processing of all salmon and trout are presented in Table 3.20. The single largest source of solid waste is the processing of aquaculture salmon, which contributes 77% of the total annual solid waste stream from salmon and trout processing.

Table 3.21 presents estimated total solid waste arisings from salmon and trout production and processing for 2000 production and landings figures. Total annual solid waste arisings are estimated at 6,237 tonnes.

Source	Solid Waste (Tonnes)	Percent of Total
Aquaculture Salmon	4,006	77
Wild Salmon	238	4
Freshwater Trout	454	9
Seawater Trout	527	10
Total	5,225	100

Table 3.20: Estimated Total Solid Waste Arisings from Processing of Salmon and Trout, 2000 Production and Landings Data.

Source	Solid Waste (Tonnes)	Percent of Total
Salmon and Trout Production	1,007	16
Salmon and Trout Processing	5,225	84
Total	6,232	100

Table 3.21: Estimated Total Solid Waste Arisings Salmon and Trout, 2000 (Production and Processing).

No figures are available for imports of raw materials for processing by salmon and trout processors in Ireland. However, due to the growth in supply from Irish producers of salmon in recent years and the fact that the vast majority of this production leaves the country with only primary processing, it is unlikely that significant volumes of salmon are being imported for processing in Ireland. With the exception of advanced secondary processing activities such as smoking where raw materials specifications are somewhat tighter and a consistent supply of suitable fish may not always be available, the raw material requirements of the salmon processing sector are met by home production of farmed salmon.

Statistics issued by the DCMNR reveal that no salmon or trout entered into intervention during 2000 and figures for previous years reflect this also. Therefore, no waste arisings occur as a result of finfish aquaculture production entering into EU intervention.

3.3.4 Future Aquaculture Production of Finfish

Finfish production figures in Ireland show a history of steady growth. Under the strategic development plan for the aquaculture sector, output of all aquaculture species is projected to grow from a total of 46,203 tonnes in 1999 to 97,000 in 2008. It is anticipated that increased production of finfish will constitute a significant proportion of this increase in overall output. This is likely to comprise increased salmon output as well as output of new species to aquaculture including both cod and turbot.

Solid waste volumes from salmon processing are likely to grow disproportionately to increases in production output, as greater volumes of raw material are utilised in secondary processing in the future. The greater volume of current production is exported with only primary processing, however increasing competition brought on by ever growing volumes of salmon available on the fresh market is driving the Irish processors to increase revenues generated from salmon production by engaging in value added processing. This inevitably will give rise to substantially increased volumes of solid waste in the future.

The BIM (1999a) Seafood Industry Agenda (2000–2006) programme aims to secure investment into the overall aquaculture sector of Euro 79.4 million, leading to an increase in output of aquaculture reared salmon to 30,000 tonnes by 2006. This would result in increased waste arisings to approximately 9,000 tonnes per annum.

3.3.5 Regional Distribution of Salmon and Trout Waste Arisings

Salmon and seawater rainbow trout production is distributed between Co. Cork and Co. Donegal, with approximately half the production emanating from the Connemara and Mayo region. The balance is produced by large-scale operations in Counties Cork and Donegal. Solid waste arisings for the primary processing of salmon and seawater reared rainbow trout reflect the distribution of production centres, with most salmon being taken to local packing stations for gutting and packing. Table 3.22 gives distribution of salmon producers by region based on data supplied by BIM.

Region	No of Producers	Percent
Southwest	3	19
West	9	55
Northwest	4	26
Total	16	100

Table 3.22 Location of Salmon Producers by Region, 2000.
Source: BIM

Much of the production, primary processing and consequent solid waste arisings occur close to the production centres of the west, northwest and southwest. Considerable quantities of solid wastes are also generated outside of these areas as a result of secondary processing activities. Secondary processing of salmon and trout occurs largely in the east and southwest, with some secondary processing of salmon occurring in most coastal counties of the southern and western seaboard.

Table 3.23 presents estimated regional solid waste arisings for sea-farmed salmon and trout production and primary processing. Estimates relate to wastes generated from production and primary processing only and are based on 2000 data. The estimates give an indication of the quantities of solid wastes arising at or close to the actual farms, but exclude exceptional mortalities.

Region	Waste (t)
Southwest	455
West	1,316
Northwest	622
Total	2,393

Table 3.23: Estimated Regional Solid Waste Arisings for Aquaculture Salmon and Sea – Reared Trout Production and Primary Processing, based on Distribution of Production Units (Includes Low Risk Material).

The total of 2,393 tonnes comprises estimated annual volumes of salmon and seawater reared trout production weight (883 tonnes and 124 tonnes, Table 3.15) as well as wastes from primary processing (gutting only) of these aquaculture species (1,359 tonnes and 27 tonnes, from Tables 3.16 and 3.19).

The regional distribution of solid waste arisings from secondary processing of salmon and sea reared trout, (estimated at some 3,150 tonnes for 2000), are more difficult to describe. Secondary data reveal that quantities of salmon receive secondary processing at many locations throughout the country, but that this activity is concentrated in the east, southwest and west. Often secondary processors of salmon are whitefish processors that process small quantities of salmon and therefore have waste arisings on a year round basis, consisting mainly of heads and frames. Other larger secondary processors are located in the east, south and west, where significant quantities of salmon are used to produce smoked product.

Based on a survey of processors located in the southwest conducted in 2002, 880 tonnes of solid waste was generated from secondary processing of salmon and sea-reared trout within this region. The difference between this finding and the figure cited in Table 3.23 for regional solid waste production from salmon and trout in the southwest of Ireland is accounted for by the transshipment of salmon production from other areas into the southwest for processing, as well as by wastes arising from the processing of wild salmon in the region. Looking at the location of secondary processing facilities in other regions, it is apparent that the balance of secondary processing waste arisings (estimated at 2,270 tonnes for 2000) occurs mainly in the east and west/northwest. According to regional distributions of secondary processors and assuming an even split in volumes processed in each of these latter two regions, approximately 1,135 tonnes each of solid wastes would be generated in the western and eastern regions from secondary processing of salmon. Table 3.24 presents estimated regional solid waste arisings for secondary processing of salmon and sea-reared trout for 2000 based on the above assumption.

Region	Waste (t)	%
Southwest	882	28
West / Northwest	1,134	36
East	1,134	36
Total	3,150	100

Table 3.24: Estimated Regional Solid Waste Arisings for Salmon and Sea – Trout Secondary Processing, 2000.

The overall regional picture of total aquaculture salmon and sea reared trout waste arisings based on the above findings is presented in Figure 3.6.

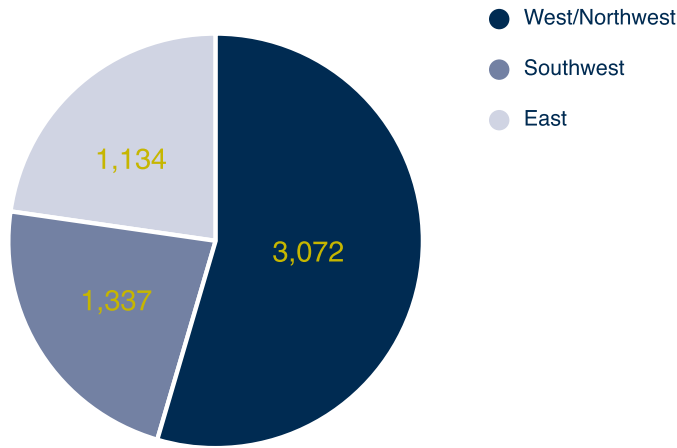


Figure 3.6: Estimated Solid Waste Arisings from Production and Processing of Salmon and Sea Reared Trout for 2000, related to distribution of production units, primary and secondary processing activity (tonnes). Source: DCMNR / Nautilus Estimates

Seasonally, there is not much variation in the output of waste from salmon and sea reared rainbow trout processing, with quantities of fish being harvested all year round. Production schedules are however subject to change and the decision to harvest stock at any given time is increasingly being made according to market conditions. Stable prices are best achieved through ensuring continuity of supply and product quality. Therefore the overall trend is to avoid peaks and troughs in output and the resulting uncertainty in prices that may be brought on by high seasonal variability in output.

Wild salmon are caught between May and July and the national production of approximately 600 tonnes is widely dispersed around the coast. Wild salmon are usually bought by local dealers for primary processing, before being sold on to wholesalers and retail outlets. The small waste arisings from primary processing of wild salmon are therefore widely dispersed among the coastal counties, primarily on the northwest and southwest coasts. Waste arisings from secondary processing are more concentrated with centres in the east and southwest.

Freshwater rainbow trout production is concentrated in the southeast of the country, with 4 large producers accounting for the majority of production. Rainbow trout are gutted and filleted locally (usually on site) before being packed and sent for sale or to meet orders. Waste arisings for this sector therefore are confined to the southeast of the country mainly and occur on site.

3.4 Crustacean

3.4.1 Production, Processing and Solid Waste Arisings

Landings of crustacean species for the years 1994–2000 are presented in Figure 3.7. Total landings of crustaceans in 2000 amounted to 19,100 tonnes. Total landings have seen steady growth with almost a 50% increase in live weight landings over the period.

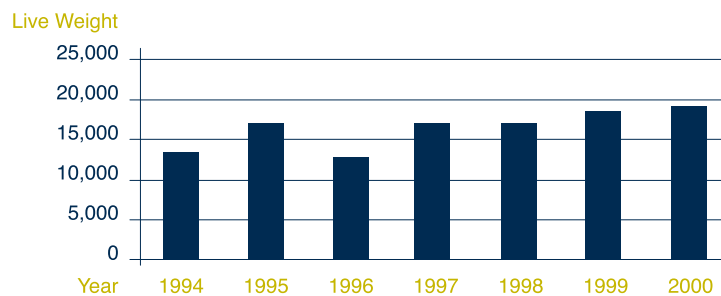


Figure 3.7: Total Landings of Crustacean Species 1994 – 2000.
Source: CSO

Table 3.25 presents landings for crustaceans from 1994 – 2000 by species. For the landings year 2000, the bulk of landings are accounted for by landings of crab (10,295), whole nephrops (Dublin Bay prawns) and nephrops tails (7,709 combined prawn and prawn tail landings). Landings data for prawn tails are for the whole fish equivalent (wfe). Smaller landings of shrimp, crawfish and lobster are also made but contribute less than 1,200 tonnes to total crustacean landings (<10%). Figures for crab landings include landings for edible crab (brown crab), green crab, velvet crab and spider crab. Landings of the latter three species amount to approximately 1,000 tonnes annually. Mainly increased landings of crab account for growth in landings over the period. Combined landings of prawns and prawn tails have a characteristically high degree of annual variability and have varied from a low in 1996 of 5178 tonnes to a high in 1999 of 8492 tonnes.

Landings of edible crab comprised both whole crab and whole fish equivalent (wfe) for landings of crab claws. (The practice of declawing edible crab at sea has recently been prohibited and declawing may only be undertaken onshore or aboard vessels while in harbour. A total of 482 tonnes of crab claws were landed in 2000 and the landings data include the wfe of these landings also).

Year	Crab	Crawfish	Prawns	Lobster	Prawn Tail	Shrimp	Total
1994	6,875	111	2,970	715	2,340	312	13,323
1995	7,689	84	4,077	564	3,164	312	15,890
1996	6,195	64	2,769	574	2,409	399	12,410
1997	8,037	48	3,454	514	3,566	359	15,978
1998	7,970	46	3,998	611	2,952	505	16,082
1999	8,550	35	4,603	597	3,889	551	18,225
2000	10,295	42	4,077	605	3,632	449	9,100

Table 3.25: Landings of Crustacea by Species and Total 1994 – 2000 (Tonnes Live Weight).
Source: CSO

In terms of the processing sector, processing activities for crustacean species in Ireland is limited to cooking and meat extraction for edible crab and crab claws, as well as some processing of prawns and cooking of shrimp. Landings of crawfish, lobster, green crab, velvet crab and spider crab are generally sold to live export markets. Substantial quantities of edible crab are also landed for live export. As such, these landings give rise to no significant solid waste volumes.

BIM estimates for the proportions of brown crab and prawns (whole and tails) going to primary and secondary processing in 1999 are given in Tables 3.26 and 3.27 and are used to estimate solid waste arisings from these species based on 2000 landings.

While very little edible crab or other crustaceans are landed into foreign ports by Irish vessels (54 tonnes of crab and 56 tonnes of prawns in 2000), significant quantities of raw material edible crab and prawns are imported for processing by the shellfish-processing sector. Estimates of imports of raw materials by processors indicate that in 1999, 1,000 tonnes of crab and approximately 4,200 tonnes of prawns were imported for processing in Ireland. Therefore, the importation of raw materials by processors must be taken into account in attempting to estimate total solid waste arisings from the processing of crustaceans.

Smaller quantities (estimated at less than 200 tonnes) of crustaceans are landed into Irish ports annually from foreign vessels. Landings are mainly of prawns and do not contribute significantly to the crustacean processing solid waste stream.

Type of processing	Processed %	Home Landings and Imports (t)	Waste %	Total Solid Waste (t)	Waste Type
Live Export	15	1,401	0	0	
Cooked/Whole Extracted Meat	85	7,939	35	2,779	60% Organics, 40% Shell
Total	100	9,340		2,779	

Table 3.26: Solid Waste Arisings by Processing Type for Edible Crab, based on 2000 Home Landings and Estimated Imports (Excludes Green, Velvet and Spider Crab as well as wfe Crab Claws).
Source: DCMNR/BIM.

Type of processing	Processed %	Home Landings and Imports (t)	Waste %	Total Solid Waste (t)	Waste Type
Direct Export, Fresh Market	40	4,796	0	0	
Frozen Whole	50	5,995	5	300	
Extracted Meat (Tails)	10	1,199	35	420	60% Organics, 40% Shell
Total	100	11,990		720	

Table 3.27: Solid Waste Arisings by Processing Type for Prawns (Whole Prawns and Tails), based on 2000 Home Landings and Estimated Imports.
Source: DCMNR/BIM.

Solid waste arisings from the processing of crustaceans are estimated at 3,499 tonnes for 2000 as summarised in Table 3.28.

Source	Solid Waste (Tonnes)	Percent of Total %
Crab Processing	2,779	79
Prawn Processing	720	21
Total	3,499	100

Table 3.28: Estimated Total Solid Waste Arisings from Processing of Crab and Prawns, 2000.

Official figures supplied by the DCMNR show that for 2000, a total of 44.8 tonnes of crustaceans entered into withdrawal, while the majority of this (21 tonnes was of edible crab), prawn tails (16 tonnes) and whole prawns (7 tonnes) were also withdrawn.

3.4.2 Regional Distribution of Crustacean Processing Waste Arisings

Table 3.29 presents regional landings for edible crab, exclusive of imports, while Table 3.30 presents regional landings for prawns and prawn tails (not wfe), for 2000 landings. The centres for edible crab landings are the northwest (41 percent) and southwest (35 percent), with significant quantities landed into ports in the west also (15 percent). Prawn fisheries and landings of prawns are heavily concentrated in the east of the country where 48% of landings are made, with smaller quantities of the total volume landed recorded for ports in the southeast, southwest and west.

Region	Tonnes	%
Northwest	3,414	41
West	1,288	15
Southwest	2,916	35
Southeast	598	7
East	123	2
Total	8,339	100

Table 3.29: Landings of Edible Crab by Region, 2000.
Source: DCMNR

Region	Tonnes	%
Northwest	144	3
West	750	14
Southwest	918	18
Southeast	907	17
East	2,550	48
Total	5,268	100

Table 3.30: Landings of Prawns by Region, 2000 (Prawns and Prawn Tails Actual Landed Weight).
Source: DCMNR

Table 3.31 presents regional breakdown of crab processor distribution. Processors are distributed close to the centres of landings for edible crab in the northwest and southwest. Based on the location of processors, Figure 3.8 present regional solid waste arisings estimates for brown crab and prawn processing for 2000 (landings and imports).

Region	Crab Processors	Percent
Northwest	4	36.5
West	1	9
Southwest	4	36.5
Southeast	2	18
Total	11	100

Table 3.31: Regional Distribution of Edible Crab Processors.
Source: Nautilus Estimates.

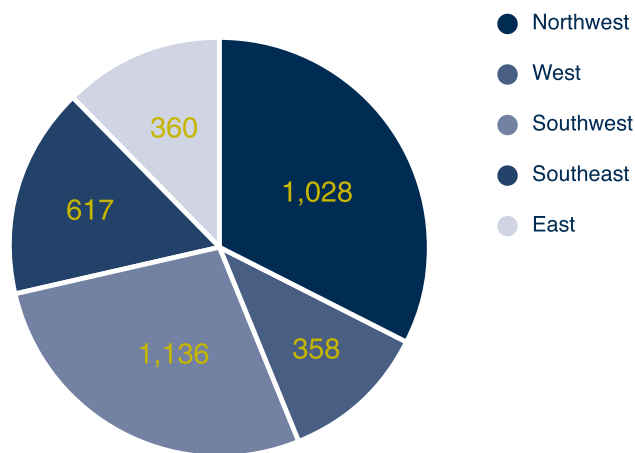


Figure 3.8: Estimated Regional Solid Waste Arisings Brown Crab and Prawn Processing, 2000 Landings and Imports (Tonnes).
Source: DCMNR / Nautilus Estimates

90% of prawns landed receive only primary processing and are sold on the fresh market or are frozen whole for export. The balance estimated at 10% of landings, is comprised mainly of downgraded prawns and prawn tail landings. These are processed for meat extraction or breaded scampi. In this context solid waste arisings from processing of prawns are low, estimated at 720 tonnes for 2000. Quantities of prawns are processed by many small processors distributed throughout the west and southwest, with a concentration in the east also. Solid waste streams from this activity are relatively low. Best estimates based on the distribution of prawn processors suggest 50% of the waste arisings occur in the east, while 20% occurs in the southeast and 15% each in the southwest and west.

3.4.3 Future Landings of Crustaceans

The main species of crustaceans, which are processed in Ireland and give rise to solid wastes, are edible crab and prawns. Landings of prawns are constrained by TAC's and quotas. Present landings are at or close to quota, therefore there is little scope for increasing landings of prawns in the future without significant changes in quota allocation or increases in the TAC for the species. Prawn fisheries appear to be largely stable and current landings are likely to be sustainable. However the annual variability in landings, which is characteristic of prawn fisheries, will remain a feature of this fishery in the future. Efforts are currently in hand at EU level to reduce dramatically fishing mortality of whitefish in the Irish Sea. Due to the whitefish by catch associated with prawn fisheries, it is likely that whitefish quota reductions will effectively restrict prawn fisheries also, leading to reduced landings of prawns in the future from the Irish Sea, the major fishing ground for prawns.

While there are no set TAC's or quotas for edible crab, landings have continued to grow in recent years, with 2001 provisional crab landings indicating catch of approximately 11,500 tonnes. The upward trend in crab landings is expected to continue for the foreseeable future as the crabbing fleet attempts to establish its landings track record in the anticipation of future management of edible crab fisheries by TAC and quota.

3.4.4 Seasonal Landings of Prawns and Edible Crab

As for landings for the whitefish fleet, landings of crustaceans destined for primary and secondary processing remain relatively constant throughout the year and do not display any marked seasonality. Brown crab landings from the northwest peak from July onwards as much of the inshore crabbing fleet commence crab fishing once the salmon drift net fishery ceases. Peaks in generation of wastes from crab processing occur in September/October.

The vivier crabber fleet, which is based in the northwest, lands approximately 60 tonnes per week on a year round basis. Many smaller vessels distributed around the coast make additional landings of brown crab. These are concentrated in the north Mayo, the southwest and increasingly in the south-eastern region. Due to operational limitations of smaller vessels, landings from this source tend to be greatest during good weather and extended periods of bad weather will cause landings from smaller vessels to cease periodically.

Landings of prawns also present some seasonality. The different prawn fishing grounds (Irish Sea, southwest, west and Porcupine Bank) show marked changes in seasonal productivity. Nevertheless, landings are made throughout the year, as the prawn fleet moves around the coast to target the different grounds during periods of peak productivity. A spring / summer peak in landings occur as the Irish Sea and western prawn ground fisheries are exploited extensively. Landings of prawns in the late autumn (October/November) fall off as many of the vessels targeting prawns also hold a herring license and will exploit this opportunity on a seasonal basis.

3.5 Molluscs

3.5.1 Production and Processing Solid Waste Arisings

The sector is dominated by aquaculture production and smaller capture fisheries for whelk and scallops. Production of molluscan shellfish species from aquaculture for the years 1995–2000 is presented in Table 3.32, while landings for molluscan shellfish species capture fisheries are presented in Table 3.33 for the same period.

Growth in aquaculture output over the period has been dramatic, with total output more than doubling. Most of this growth is accounted for by increased bottom grown mussel production, which shows growth in output of 400% over the period. Actual output of rope mussel production declined over the period, however this is largely due to recent problems associated with toxic algae contamination of mussels grown in the southwest, which prevented significant quantities of mussels from being harvested. Production of Gigas oysters also doubled over the period and there is evidence of an emerging scallop farming industry in the latter years. Production of the native *Edulis* oyster and clams declined over the period, although output of these species was low initially.

Output from molluscan capture fisheries over the period has declined from a high of 10,000 tonnes in 1996 to 8,685 tonnes in 2000. Landings of whelk have been variable over the period, although generally around the 4,000 tonne mark. Provisional figures for 2001 landings however show a large year on year increase in whelk landings to 6,300 tonnes. Landings of periwinkles show similar variability but tend to hover about the 3,000 tonne mark. Landings of scallops have increased threefold over the period, with 1,577 tonnes landed in 2000.

Species	1995	1996	1997	1998	1999	2000
Rope Mussels	5,500	7,000	6,694	7,790	6,467	4,045
Bottom Mussels	5,500	7,500	11,458	11,306	9,644	21,615
Gigas Oysters	2,539	4,000	3,135	5,369	6,555	5,031
Edulis Oysters	400	400	400	516	696	266
Clams	103	125	218	233	121	92
Scallops	0	0	24	25	33	61
Total	14,042	19,025	21,929	25,239	23,516	31,110

Table 3.32: Aquaculture Production of Molluscan Species from 1995 – 2000.
Source: BIM

Year	1995	1996	1997	1998	1999	2000
Scallops	423	600	633	693	1,497	1,577
Periwinkles	3,007	2,837	3,142	2,636	3,014	2,634
Whelk	5,952	6,575	3,852	3,667	4,561	4,474
Total	9,382	10,012	7,627	6,996	9,072	8,685

Table 3.33 Landings of Molluscan Shellfish Species 1995 – 2000.
Source: CSO

Figure 3.9 presents total Irish production of molluscan shellfish species for 1995 – 2000. The figures show sustained growth in output over the period.

Live Weight (tonnes)

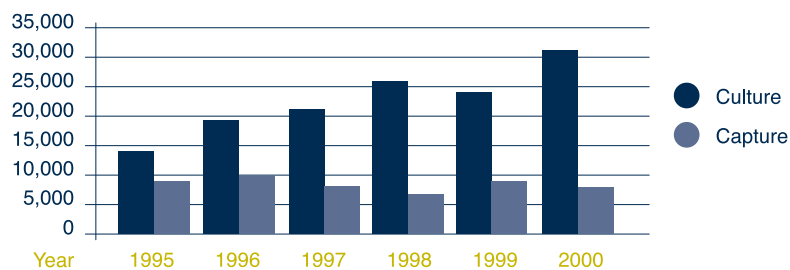


Figure 3.9: Production of Molluscan Species 1994 – 2000 (Tonnes Live Weight).
Source: BIM/CSO

The bulk of Irish molluscan shellfish production is landed into Irish ports and as such little or no significant volume of the landings figures relate to shellfish landed into foreign ports. Similarly, very little molluscan shellfish is either landed by foreign vessels into Irish ports or imported as raw material, for processing at Irish shellfish processing plants. Therefore, in terms of estimating solid waste arisings from processing of molluscs, the above molluscan aquaculture production and landings data represents the total supply of raw material to the processing sector.

3.5.2 Mussels

As the data suggests, mussel production and processing represents the most important area of activity with respect to Irish output of molluscan shellfish. Of the total volume of mussels produced by aquaculture and fishing, it is estimated that 60% are destined for fresh markets abroad and within Ireland and as such receive little or no value added processing. A further estimated 30% of mussels are cooked pasteurised and vacuum packed, either chilled or frozen in the shell. The remaining 10% of mussel production receives advanced secondary processing such as meat extraction.

The bulk of waste generation arises from mussel processing during onshore grading of rope grown mussels. Grading of mussels results in large quantities of rejected mussels due to undersize or damage.

Rope mussels landed for processing are graded at the factory and so give rise to substantial quantities of rejected material onshore. Industry estimates put the generation of rejected material from rope mussel grading at 15 to 30 percent of landed weight. Table 3.34 presents rejected material and solid waste arisings from mussel grading and processing activity, based on 2000 rope mussel production data, and using a conservative industry average of 20 percent rejected material arising from grading. Where mussels are landed for fresh market, a large proportion of the mussels which have been graded out are returned to the sea without ever being landed.

Process Type	Percent Processed	Tonnes	Percent Waste	Solid Waste Total
Grading, Packing for Fresh Sale	50	2,022	20	2,310*
Frozen/Pasteurised Cooked	40	1,618	25	405**
Extracted Meats	10	405	75	305**
Total	100	4,045		3,020

Table 3.34: Estimated Reject and Solid Waste Arisings – Mussels, 2000 Grading and Processing of Rope Mussels.

Source: BIM and Nautilus Estimates from Discussion with Industry

*Much of this grading waste is generated at sea and is returned to the sea without being landed.

**These mussels tend to be graded onshore at the processing plant.

Bottom cultured mussels are graded aboard boats at sea at time of harvest and therefore give rise to little or no rejected material or solid waste onshore from the grading process. In a small number of cases (less than 10% of production) bottom cultured mussels are brought ashore for grading. Volumes of rejected mussels based on this activity are known to be as high as 30%. Rejected material is returned to the sea after grading and is not landed.

An estimated 90% of bottom-cultured mussels are sold on the fresh market, with only 10% being processed. In this regard, onshore solid waste arisings from processing of bottom mussels are negligible.

Table 3.35 provides estimates of by-product and solid waste arisings from grading and processing of bottom cultured mussels, based on 2000 production figures. It is significant that the vast majority of this waste is generated purely from grading out small mussels and that this occurs at sea. Solid waste arisings arising from instances of grading onshore and processing of bottom cultured mussels are estimated to be of the order of 1,500 tonnes per annum.

Process Type	Percent Processed	Tonnes	Percent Waste	Solid Waste Total
Grading at Sea	90	19,454	30	5,836*
Grading Onshore, Frozen/Pasteurised Cooked	10	2,161	32	691**
Total	100	21,615		6,527

Table 3.35: Estimated Reject and Waste Arisings – Mussels, 2000 Grading and Processing of Bottom Cultured Mussels.

Source: BIM and Nautilus Estimates from Discussion with Industry

*Rejected material is returned to the sea without being landed.

**Rejected material from grading and waste from processing.

The above estimates relate to normal mussel production cycles and do not include additional waste arisings, which result from the effects of high levels of biotoxins in mussel stock, which may cause the periodic closure of mussel production areas. As a consequence of prolonged closure of waters to harvesting of mussels, rejection rates encountered at grading in processing plants become elevated, reaching as much as 70%. This is as a result elevated levels of fouling of the stock, a consequence of prolonged grow out time. Additionally, instances of exceptional quantities of waste arising may occur when harvest of stock has been delayed for extended periods due to biotoxin levels, to a point where it is beyond harvest and is considered foul stock. In such instances, large quantities of mussels are condemned and give rise to exceptional quantities of waste. Recent such occurrences gave rise to unofficial estimates of 5,000 to 6,000 tonnes of foul stock, requiring disposal.

3.5.3 Whelks

Landings have varied considerably over the years, reaching a high of 6,000 tonnes in 1996 and a low of 3,700 tonnes in 1998. More recent landings have been around 4,500 tonnes per annum. The entire whelk catch is processed at one of two major whelk processors, located in Counties Wexford and Donegal. Whelk processing consists of cooking and meat extraction. By-products of the processing are substantial and consist of shell waste (60%) and organic material (40%). According to processors of whelks, meat yields for whelk processing vary between 20 and 23% of live weight. Based on 20% meat yield, estimated solid waste arisings for the processing of whelks are presented in Table 3.36 for 2000 landings.

Process	Percent	Tonnes	Waste %	Total waste	Waste type
Cooking and Meat Extraction	100	4,474	80	3,579	60% Shell, 40% Organics
Total	100	4,474		3,579	

Table 3.36: Estimated Solid Waste Arisings, Whelk Processing, 2000 Landings.
Source: CSO, Nautilus Estimates from Industry Consultation

3.5.4 Oysters

Culture of the pacific oyster occurs in most coastal counties of Ireland, but is concentrated in Counties Louth, Wexford, Waterford, Cork, Kerry, Galway, Mayo and Donegal. Production reached 5,031 tonnes in 2000. Potential waste arisings from production of this species are mainly through production mortalities which are on average 25% of grow out stock from spat to harvest. Much routine mortality is removed from oyster trestles during grading and is returned to the sea.

Quantities of shell waste also arise from removal of mortalities at time of harvest. This may give rise to smaller quantities of shell waste on shore. This is estimated at less than 500 tonnes per annum. As production of oysters is exclusively for the fresh market, no processing of this species takes place and there are no further solid waste arisings other than shell waste from routine production mortality and harvest.

3.5.5 Scallops

Landings of scallops have increased in recent years from 600 tonnes in 1997/98 to 1,500 tonnes in 1999 and 2000. Most of the landings were made into ports in the southeast (Kilmore Quay and Dunmore East), 1,150 tonnes in 2000. Additional quantities of scallops are produced by aquaculture in the southwest in recent years, however production is low, at less than 60 tonnes per annum.

Scallops are landed whole in the shell and are taken for primary processing to shellfish processing plants. Typical products are chilled fresh meats and roes, as well as frozen packed fresh meats for the food service industry. Markets are both domestic and export.

Table 3.37 presents solid waste arisings from processing of scallops for 2000 landings.

Process	Percent	Tonnes	Waste %	Total waste (t)	Waste type
Shucking and White Meat Extraction	100	1,577	80	1,261	60% Shell, 40% Organics inc Hepato – Pancreas
Total	100	1,577		1,261	

Table 3.37: Estimated Solid Waste Arisings, Scallop Processing, 2000 Landings.
Source: CSO, Nautilus Estimates from Industry Consultation

3.5.6 Regional Molluscan Processing Solid Waste Arisings

Region	Rope Mussels	Percent	Bottom Mussels	Percent	Total
Northwest	6	9	5	13	11
West	10	15	5	13	15
Southwest	48	74	16	42	64
Southeast	1	2	10	26	13
East	0	0	2	6	2
Total	66	100	38	100	104

Table 3.38: Location of Rope Mussel Producers, 1997 Estimate.
Source: BIM, 1997 Estimates

Based on the above distribution of producers, rejected grading material and solid waste arisings for the sector are estimated as shown in Figure 3.10. The figures are for all waste and include rejected grading material. Overall organic content versus shell weight is approximately 35% organic waste and 65% shell waste.

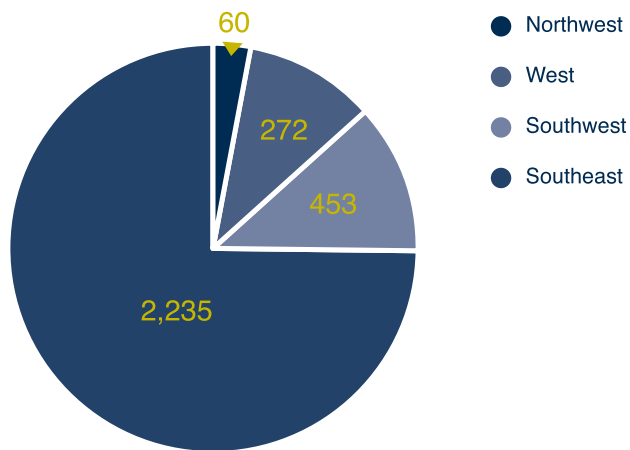


Figure 3.10: Estimated Regional Reject and Solid Waste Arisings for Harvesting and Processing of Rope Mussels 2000. Total Waste 3,020 tonnes.
Source: DCMNR / Nautilus Estimates

Whelk landings are made chiefly into ports in the east and southeast as well as the northwest, although landings are made into most ports around the coast. Processing of whelks takes place at two major processors, one each located in the southeast and northwest. Estimates of quantities processed at each of these locations are based on discussions with the individual processors and estimates of regional waste arisings from the processing of this species are provided in Figure 3.11. Solid wastes are a combination of 60% shell and 40% organic waste.

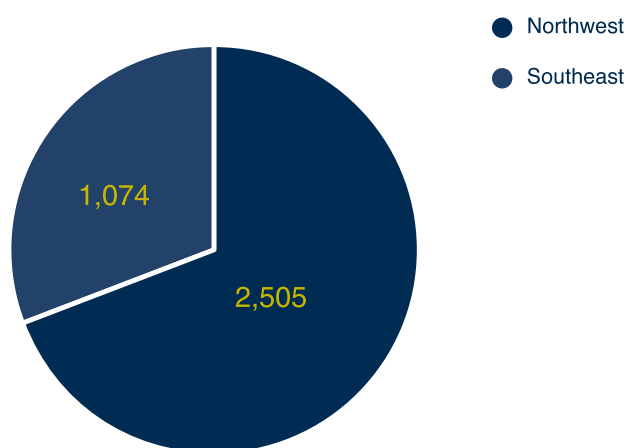


Figure 3.11: Estimated Regional Reject and Solid Waste Arisings for Processing of Whelk, 2000 (tonnes).
Source: Nautilus Estimates from Industry Consultation

Regionally, low levels of onshore shell waste generated by oyster production arise in all oyster production areas. In this context accumulations of shells which cause a significant solid waste volume are occasionally a disposal problem.

Scallops are processed mainly in the southeast, southwest and west. Of the estimated 1,261 tonnes of solid waste arising in 2000, approximately 960 tonnes of this was in the form of shell waste, with the balance comprised of the mantle and entrails. The majority of scallop processing takes place in the southeast, with smaller quantities being processed in the southwest and west.

Based on estimates of 60% of landings being processed in the southeast and 20% each in the southwest and west, the regional waste arisings from scallop processing would be as shown in Figure 3.12.

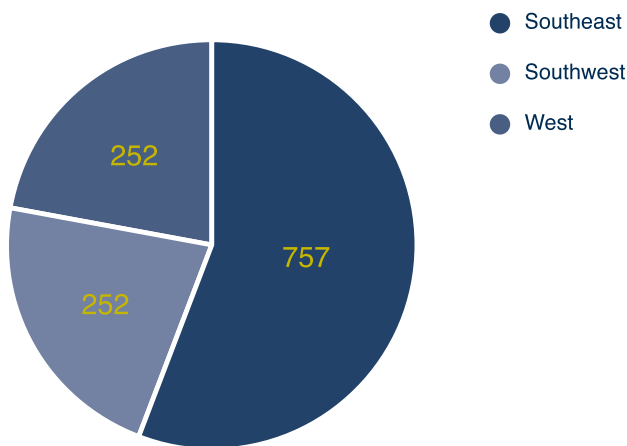


Figure 3.12: Estimated Regional Reject and Solid Waste Arisings for Processing of Scallops, 2000 (tonnes).

3.5.7 Future Molluscan Production

Future output of both bottom and rope grown mussels is expected to rise. Recent improvements in market stability and prices earned for both types of mussels has resulted in renewed investment in the sector with resultant increases in future volumes produced expected. Investment in and development of the mussel industry is in accordance with government policy for the sector, adding to the likelihood of increased output. A growing demand for mussel growing sites has fuelled further technological development, such as that of sub-surface longline technology, which will make the growing of mussels in more exposed locations feasible. To date this activity has largely been confined to sheltered bays.

Further investment in the processing sector is also likely to increase both the number of processors and the volumes of mussels destined for advanced processing. While it is expected that much of the processing will focus on in-shell product, with little additional solid wastes over current levels, some further growth in meat extraction processing is inevitable, giving rise to greater quantities of shell waste in the future.

Output from the bottom culture sector is expected to grow further also, but will ultimately be limited by licensing requirements and the availability of dredged seed for relaying. The potential capacity for dredge harvesting seed mussel is the subject of current research.

Whelk fisheries have been somewhat unstable in recent years and there are concerns amongst fishery managers as to the sustainability of current catch levels. There is little scope for increasing the grounds being fished as whelks are largely considered an inshore species and as such most of the grounds are presently heavily exploited. Provisional landings figures for 2000 show whelk landings increased once again to reach 6,300 tonnes.

Efforts at managing the fishery are however being made and the outlook at best is for home landings of whelks to remain relatively stable, at or somewhat below current levels. No additional solid waste arisings are likely due to increases in processing activity as the entire current catch is processed.

Production of both native and Gigas oysters is expected to increase in the future in line with government policy for developing the sector.

Increased output from scallop capture fisheries has stemmed from the opening of new grounds in recent years, as well as the diversion of effort from other traditional fisheries back into the shellfish sector. Growth potential for scallop capture fisheries is modest due to the relatively sparse distribution of scallop beds. Provisional figures for 2001 landings show a small decline in landings over 2000 figures. Increased aquaculture output of scallops is almost a certainty in the future as the conditions for culturing of this species become more favourable. It is also government policy to support the farming of new species in an attempt to diversify as well as expand the aquaculture sector.

Output of razor clams is expected to continue to grow in the future as more beds are discovered and opened to exploitation. However, as the entire razor clam catch is exported live, there is little by way of solid waste from this source.

3.5.8 Seasonality of Molluscan Production

Rope grown mussels are grown from either rock seed or naturally seeding of mussel ropes. This gives rise to different harvest regimes, depending on seed source. The majority of rope mussels are seeded using seed scraped from rock and are harvested during the summer months when conditions allow. This is likely to change in the future due to the high occurrence of algal biotoxins during the summer months particularly.

Mussels grown on naturally seeded ropes are harvested principally over the winter from October to April. Bottom grown mussels are harvested year round, avoiding the late spring spawning period.

Peak season for whelk landings is from April onwards and continues through the summer months. Consequently this is also the busiest time for processors of whelks. Landings are made several times a week throughout the season, except for during periods of bad weather.

Oysters are harvested mainly in the autumn and spring period, with production peaks for Christmas and Easter markets.

Scallops are fished year round, with the bulk of landings being made into Kilmore Quay. Additional volumes of scallops are landed from the smaller seasonal winter scallop fisheries on the south, southwest and west coast between October and May.

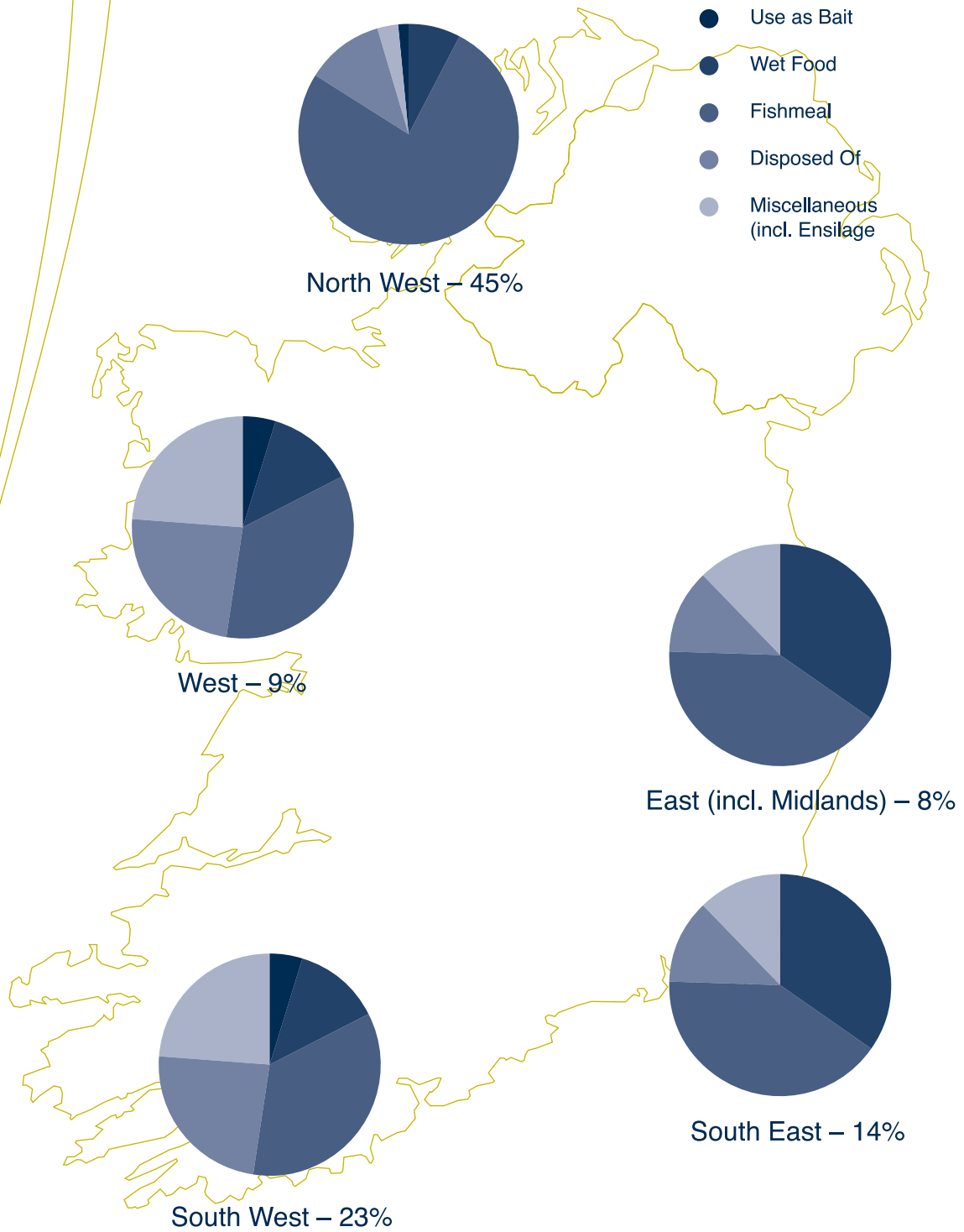
3.6 Summary Fish Processing Solid Waste Arisings

- Table 3.39 provides a summary of national solid waste arisings from the aquaculture, fishing and fish processing sectors in Ireland, based on 2000 data. It is important to note the following:
- The figures for waste arisings are estimates based on the most recent production, landings and processing data which are available.
- For whitefish, pelagic, crustacean and some molluscan species (scallop & whelk), estimates of regional waste arisings are based on location of processing facilities.
- For salmon/trout and other molluscan species, estimates of regional waste arisings are based on location of production and primary processing. In the case of salmon and sea-reared trout, regional waste arisings for secondary processing of these species are also included in the estimates.
- In the case of salmon and trout waste estimates, no account is taken of exceptional waste arisings of high risk mortalities or mortalities due to natural phenomena.
- For mussel production waste, no account is taken for exceptional waste arisings resulting from the closure of bays to harvest for extended periods.

Species Group	Species	Northwest	West	Southwest	Southeast	East (inc. Midlands)	Total Waste (t)	Future Waste Prod. Trends	Solid Waste Types
Whitefish	Whiting, Haddock, Cod, Monks	1,645	1,012	1,776	1,012	2,279	7,724	Decrease	Heads, Frames, Skins, Meat
Pelagic	Herring, Mackerel	22,931	1,374	8,088	5,496	1,374	39,263	Similar	Heads, Frames, Offal, Roe, Skins
Salmon/Trout		3,072 Northwest & West Combined		1,337		1,134	5,543	Increase	Mortalities, Heads, Frames, Offal, Skin, Meat
Crustacea	Crab / Prawns	1,028	358	1,136	617	360	3,499	Reduction (Linked to Whitefish)	Offal & Organics 60% Shell 40%
Mollusca	Mussel	272	453	2,235	60	–	3,020	Increase	Shell 70%, Some Organics
	Whelks	2,505			1,074		3,579	Same	Offal & Organics 40% Shell 60%
	Scallop		252	252	757		1,261	Increase From Aqua–Culture	Offal & Organics 40% Shell 60%

Table 3.39: Summary of National Solid Waste Arisings from the Aquaculture, Fishing and Fish Processing Sectors in Ireland, 2000.

4.0 Disposal of Fish / Aquaculture Waste in Ireland – Current Practice



Map 2: Current Disposal Routes for Seafood Waste in Ireland.

Map 2 and Table 5.1 at the end of section 5 present estimated volumes of solid wastes by type and region being disposed of by various means, based on 2000 production and processing data and corroboration through industry consultation.

4.1 Whitefish Processing Solid Wastes

The main whitefish species landed into Irish ports during 2001 include cod, haddock, whiting, hake, monkfish, ray, plaice, ling and megrim.

4.1.1 Northwest Region

In the northwest region, the majority of local whitefish solid waste arisings are utilised either in the production of fish meal at the United Fish Industries plant in Killybegs, or are collected from processors by one of three large scale commercial mink farms based in the region. Discussions with processors reveal that only small quantities of whitefish waste are reused or disposed of by other methods (principally by use as bait) within this region and the disposal or reuse of whitefish wastes is apparently not a significant problem in this region.

4.1.2 Other Regions

Outside of the northwest region, the disposal and reuse options for white fish waste are similar to those in the northwest. Whitefish waste arisings from the larger processors are taken to Killybegs for reduction processing, as and when sufficient volumes of waste have accumulated so as to justify the related transportation costs.

Where mink farms are located close to processing facilities, substantial quantities of whitefish waste are collected for use as wet feed. A substantial volume of waste is also utilised as bait in commercial trap fisheries for brown crab, green and velvet crab, lobster and whelk.

The larger processors in the east, southeast and parts of the southwest (mainly Co. Cork) reported transporting solid wastes to the UFI plant at Killybegs at regular (weekly or more frequent) intervals via licensed hauliers operating a dedicated fish waste collection service. Currently these processors each have regular, year round solid waste arisings of the order of 5 – 20 tonnes per week, excluding periods of bad weather. Generally waste materials are accumulated in one tonne and half-tonne fish bins on site, which are in turn kept under cold store in a dedicated storage facility, such as a reefer, until collection is made. Maximum storage times under refrigeration are less than seven days, often being only 3 or 4 days.

Most smaller processors located in or near small ports and harbours outside of the northwest report solid waste arisings of between 500kg and 4 tonnes per week. For many of these processors, waste arisings are often irregular in volume and of variable quality and species mix. The disposal method employed varies amongst individual processors, however the passing on to fishermen of solid waste heads and frames for use as bait or as wet feed for commercial mink farming are the main outlets for solid wastes for smaller processors. Disposal of smaller quantities of waste by landfill, composting, rendering (for disposal ultimately by incineration), use in food ingredients and pet food manufacturing as well as dumping at sea are other disposal methods recently or currently used by some processors.

Outside of the northwest, commercial mink farms are located in the east near Portlaoise and in the southwest near Cahersiveen, Co. Kerry. In the locality of these farms, substantial quantities of whitefish wastes are collected from processors in the greater Dublin and west Kerry areas for use as wet feed. Five whitefish processors located in the eastern region confirmed that their waste was being supplied to a mink farm, while all whitefish processing wastes generated in the Dingle and Iveragh Peninsulas are currently collected for use in mink production. A mink farm was previously located near Ring in Co. Waterford, but this ceased production in 1998. During its period of operation, this farm utilised substantial quantities of whitefish waste, which it collected from processors located throughout the east and southeast regions (as far west as Cork city). In part as a consequence of the closure of the farm, the disposal of whitefish wastes is currently a particular problem in the southeast. Although mink prefer oily fish they will consume almost any fish waste.

Volumes of whitefish waste being reused in fish meal production and as bait or wet feed are difficult to estimate. UFI will not disclose information on its annual throughput of whitefish waste, as this is perceived as commercially sensitive information. Nevertheless it appears that the capacity of the fishmeal plant is greater than its current output and no instances of whitefish wastes being refused due to under capacity of the plant are known. The practice of offering waste to both mink farms and fishermen in particular, free of charge, for use as feed and in fishing is a long and widely practiced method of re-using whitefish waste. The practice is also widely perceived as being an acceptable and appropriate use of fish waste by both processors and waste users.

Where whitefish waste is supplied for use as wet feed or bait, it is typically stored in fish boxes and may be removed from the processors' premises on a daily basis if no refrigeration is available, or less frequently when refrigerated storage is available. Those processors with the capacity to do so may freeze solid waste where there is no immediate outlet for the waste as bait for fishing or wet feed. In general wastes are collected free of charge from the processors at frequent intervals by the end users, who absorb all transportation and other costs associated with waste collection.

Volumes of waste being utilised in mink farming are very substantial. Discussions with mink producers revealed that there are five licensed mink farms in Ireland as of November 2002. Collectively it is estimated that some 5,000 tonnes of whitefish and salmon wastes are utilised in mink production annually. Of this, some 3,500 tonnes are required in the northwest region while 1,000 tonnes are required in the east and 600 tonnes in the southwest. Most waste is sourced in the northwest, southwest and east. Demand for fish waste on mink farms is steady and year round. To this end, mink farms can hold or freeze fish waste on site so as to ensure continuity of feed availability for stock.

Many processors have expressed serious concern at the likelihood that mink farms may close in the future due to possible legislative changes facing mink farming operations in Ireland. This eventuality would leave many processors facing the prospect of substantial waste disposal costs and could add considerably to the fish processing waste stream for which there is no current alternative use.

Low levels of solid wastes arise occasionally from the withdrawal of whitefish from the market where these do not make minimum prices. In such instances a number of methods are used to dispose of the waste including reduction processing, use as bait and disposal at sea.

4.2 Pelagic Processing Solid Wastes

The situation with respect to pelagic processing wastes is somewhat different. The only option presently available to pelagic processors is to ship wastes to Killybegs for reduction processing.

Due to high seasonality, limited regional focus and relatively high value of pelagic fisheries processing waste, the waste streams are simpler to manage in the national perspective. In most cases, sales of pelagic (herring and mackerel) wastes represent an additional source of revenue to processing plants, where the waste can be delivered to the plant in a fresh and good condition.

The vast majority of pelagic processing waste is used in the production of fishmeal at UFI in Killybegs. For processors located in the northwest of the country this provides a readily accessible market for their wastes and incurs low transport costs. However, the situation for pelagic processors located in the east, southeast and southwest is different, as transport costs associated with getting their solid wastes to Killybegs for processing often equal the revenues generated from the sale of their waste by-products. On rare occasions waste volumes do not justify haulage by road to Killybegs, and a more cost effective local means of disposal must be sought. Other than use on mink farms, current options for this are practically non-existent. Previously, quantities of pelagic waste were sent for rendering at one of the approved rendering plants located in the south of the country, however this practice has now ceased, in part because of the removal of all subsidies by the Department of Agriculture for fish waste rendering.

Waste produced on site is accumulated in one tonne bins or large capacity hoppers, prior to being tipped into waiting trailers. Little or no storage takes place (maximum overnight) as the oils deteriorate rapidly in pelagic waste and freshness is vital for good quality meal production.

In instances of withdrawal of pelagic species, the entire catch may be sold to meal production, as is the case for all catches of the industrial species.

It is estimated that collectively some 12 – 14,000 tonnes of pelagic processing wastes are transported from the southeast and southwest regions to Killybegs annually.

4.3 Salmon and Trout Solid Wastes

Solid waste arisings from the salmon/trout industry occur both at production and processing stages.

4.3.1 Production Wastes

Overall, the great majority of low risk production mortalities are ensiled on site.

Ensiled liquor is accepted for rendering or reduction processing. Liquor may also be used as an agricultural fertiliser, and may be applied via sub soil injection on tillage land by an authorised person. Typical on farm silage liquor storage capacities are 5 tonnes; with collection being made as and when additional ensiling capacity is required.

High-risk mortalities are generally taken for reduction processing and incineration. In cases where exceptionally large mortalities have occurred in a short time period, it is known that high-risk mortalities have been dumped at sea. Instances of this are attributable mainly to a lack of appropriate waste handling infrastructure, but may also have had the objective of reducing disposal costs, which would otherwise have been incurred if waste were rendered.

Most producers operate strict control over the handling and disposal of high-risk and low-risk mortalities. In this context their production waste arisings are handled and treated in accordance with established procedures and protocol. Nevertheless, some producers have either failed to fully comply. This may be through lack of investment in the appropriate low-risk waste ensiling facilities or inappropriate use of facilities through cost considerations. Ensilage has also been used as a means of disposing of high-risk wastes and some continue to dump both low-risk and high-risk mortalities at sea. Onshore burial of mortalities has also been utilised as a disposal method to a lesser extent by some producers in the past and it is likely that this still occurs from time to time amongst some producers.

Due to the low number of renderers who are able to handle high-risk waste, the disposal of high-risk material can become problematic for producers. Presently only four renderers are actually approved for treatment of high-risk material. Due to the unpredictable nature of these waste arisings, the large volumes concerned and logistics of organising transport, which may require specialised equipment and licensing, mass mortality occurrences have caused significant difficulty at critical times in the past.

4.3.2 Salmon and Trout Processing Wastes

Salmon processing waste arises from both wild and farmed fish, although 90% of waste arisings are from processing of farmed fish. Solid waste arisings from trout production are approximately equal for saltwater and freshwater reared rainbow trout, with annual saltwater production amounting to only 250 tonnes more than is produced in freshwater.

Wastes generated from post harvest gutting and cleaning at packing stations are most commonly ensiled on site, or sent fresh for reduction processing to UFI in Killybegs. In the past there have been problems with the acceptance of this type of waste for reduction processing at certain times of the year, principally during the pelagic season from October to April. As much fish meal is used in the preparation of commercial salmon feeds, a separate processing line must be operated in order to process salmon and trout waste, so as that fish meal from salmon offal or waste is not utilised in the manufacture of salmon feeds.

The operation of a second processing line during the pelagic season has not always been possible in the past. Therefore fresh waste and ensiled liquor from gutting and packing operations have previously been disposed of by rendering or use as liquid fertiliser exclusively during the busy pelagic season. UFI have recently developed a dedicated salmon line and salmon/trout waste can now, reportedly, be accepted for reduction processing on a year round basis. However there still remains some doubt as to whether UFI will be prepared to accept salmon waste in all instances during the pelagic season and there is anecdotal evidence to suggest that they will not. Potential use for salmon and trout meal may in the future arise with the expansion of aquaculture to include new finfish species such as cod.

One large packing station located in the south of Ireland produces up to 700 tonnes of salmon offal from packing operations annually. Much of this is frozen and kept in storage until such volumes exist so as to make transport for reduction processing at UFI viable.

A Connemara packing station produces some 850 tonnes of offal per annum and an additional 100 tonnes of heads and frames. The majority of this waste is ensiled and is either rendered in a Co. Meath plant or is converted to salmon meal at UFI in Killybegs, or is used in agriculture as a liquid fertiliser.

A large producer in the northwest currently disposes of all of its low-risk and processing waste by ensiling, with the ensiled liquor being taken to Northern Ireland for sub soil injection on tillage land. In house investigations are also underway in this firm with respect to composting of solid waste. Trials have recently been initiated to see if composting holds potential for dealing with waste from routine production mortality.

Sludges from Dissolved Air Filtration (DAF) water treatment installations attached to salmon processing plants is treated with formic acid prior to being removed for use as liquid fertilisers.

Additional solid waste arisings in the form of heads and frames occur from the production of salmon fillets for fresh consumption or smoking at many processors located around the country. Undetermined quantities of this waste may be offered to trap fishermen who particularly favour oily fish such as salmon, for use as bait. Waste trimmings from smoke houses are generally collected, frozen and sold for use in the preparation of fish pastes and soups etc.

Producers of freshwater reared rainbow trout presently face particular challenges with respect to the disposal of solid wastes. The closure of landfills to organic wastes and the recent decision by the Department of Agriculture to refuse to subsidise the rendering of fish waste at the National By-Products plant in Co. Tipperary (and other plants), means that two possible solid waste disposal routes have been lost. As a result processors are encountering serious difficulty in disposing of solid wastes. Waste volumes and the geographic spread of these means that it is not often feasible to send these wastes for reduction processing. Of four main producers in the country, one has found an outlet at a distant mink farm, one other ensiles all solid waste for spreading on his own land and two others are exploring options for composting of solid waste. Waste quantities generated are relatively small (two to three tonnes per week) and may deteriorate rapidly as little or no cold storage may be available to them.

4.4 Crustacean Solid Wastes

The main crustacean species landed and processed at plants in Ireland are prawns and brown crab. Smaller quantities of shrimp, velvet crab, green crab and spider crab are also landed, however none of this enters for processing. Therefore there are no significant waste arisings from these latter fisheries.

Much of the edible crab catch is exported live or is cooked and packed whole, giving rise to very little solid waste material. However some meat extraction processing does occur and this gives rise to significant quantities of both shell and organic waste.

Crab processing activity is confined to a small number of operations chiefly in the northwest and southwest. Processors in these areas report significant solid waste disposal problems as disposal in landfill is no longer an option and crab wastes presently offer little potential for further use in these regions. As a consequence considerable volumes of crab processing waste have in the past been disposed of at sea.

Recent legislation applying to crab fisheries stipulates that edible crab must be landed whole. As a direct consequence, de-clawing of crabs must now take place ashore or in harbour. This may result in considerable quantities of crab being returned to the water in harbours around the coast. Due to the fact that the crab may have been out of the water for considerable periods of time, it is unlikely that many of these survive.

A majority of prawns are exported whole, therefore giving rise to little in the way of solid wastes. However it is estimated that 720 tonnes of prawn waste is produced annually in Ireland. Of this, approximately 200 tonnes is frozen and exported to France by processors based in the eastern region, where it is used in production of prawn paste and soups.

A further estimated 250 tonnes of prawn waste are dumped at sea under a DCMNR dumping permit in the south east of the country. The balance of prawn processing wastes are disposed of by small scale composting, dumping at sea and by inclusion (at low levels) in pelagic fish processing waste which is in turn use in reduction processing.

4.5 Molluscan Solid Wastes

The main molluscan species harvested from wild and culture fisheries are mussels, native and pacific oysters, scallops, periwinkles and whelks. The majority of cultured production (oyster and mussel) is utilised fresh and produce is mainly chilled for live export only, giving rise to insignificant quantities of waste. Similarly, winkles and razor clams are exported live and give rise to very little in terms of waste.

With respect to processing activity, reasonably large volumes of mussels (40 percent of production) are processed (cooked and packed) at one of several medium scale processing facilities and a number of much smaller units located around the country and close to centres of production. Scallops are shucked and cleaned for freezing or fresh consumption. The entire whelk catch is cooked and the meats extracted for export chiefly to Korea and Italy. The latter two activities give rise to significant volumes of shell and organic wastes.

For the molluscan production and processing sector, solid waste arisings are in the form of production mortalities containing organic and shell material, as well as shell material and cooked and uncooked organic waste from shucking of scallops and processing of whelks and mussels.

The fate of all mussel grading and processing wastes has not been uncovered during this study. Despite many attempts at contacting larger processors, no information has been forthcoming. One producer located in the west has in the past held a permit for the dumping of mussel waste at sea. An examination of the DCMNR website reveals that no other mussel producers are licensed to dump waste at sea.

While quantities of shell waste arising from scallop processing are small, the curved shell of the scallop is marketable and is generally sold for reuse to companies in France and Italy, while the flat shell may be disposed of by dumping at sea or may be given for use in road fill and drainage.

As is the case for whelk fisheries, much of the national scallop production and processing occurs in the southeast, a region that faces particular difficulty in disposing of fish wastes. It is against this backdrop that much solid waste from processing and large quantities of shell waste (particularly whelk shell) are dumped at sea. Some solid waste materials were previously disposed of by rendering at National By-Products in Tipperary, however this option for waste disposal is no longer available to processors as National By-Products no longer accept fish derived wastes for rendering.

A significant shell waste disposal problem also exists in the Northwest, where large quantities of whelk shell waste (in excess of 2,000 tonnes) are generated. While the processors involved are actively searching for new disposal options and reuse possibilities, much of the waste has in the past been disposed of at sea.

4.6 Current Practice for Disposal of Fish Waste in a Legal Context

In the context of existing waste legislation, the utilisation of whitefish wastes in the production of fish meal is permissible under the *European Communities (Disposal, Processing and Placing on the Market of Animal By-Products) Regulations, S.I. 257, 1994*. However, given that much of the fish meal produced is utilised in the manufacture of commercial salmon feeds, reduction processing of salmon wastes must be done separately to that of all other fish wastes and the end product cannot be utilised in the manufacture of salmon feed.

The use of fish by-product material for human consumption, as occurs in the case of the food ingredients industry, falls outside of the Animals By-Products legislation, but is subject to extensive food safety legislation, as are all fishery products for human consumption.

The disposal of high and low risk fish wastes by processing at approved rendering plants is in accordance with the provisions of the *European Communities (Disposal, Processing and Placing on the Market of Animal By-Products) Regulations, S.I. 257, 1994*.

The burning and/or burial of both high risk and low risk aquaculture mortalities and processing wastes in landfill or elsewhere is permissible only under license according to the provisions of the *European Communities (Disposal, Processing and Placing on the Market of Animal By-Products) Regulations, S.I. 257, 1994*. The burial of aquaculture mortalities that is known to occur in certain areas is therefore illegal, as is the continued burial of fish waste in landfills, where either activity is not the subject of a license issued under this legislation.

The disposal of low risk fish processing waste at sea is contrary to the *European Communities (Disposal, Processing and Placing on the Market of Animal By-Products) Regulations, S.I. 257, 1994*, but appears to be permissible under the provisions of the *Dumping at Sea Act, 1996*. However, a recent determination from the Chief State Solicitor has confirmed that the issuing of permits for the dumping of processing wastes at sea is in breach of the *European Communities (Disposal, Processing and Placing on the Market of Animal By-Products) Regulations, S.I. 257, 1994*. The DCMNR has therefore recently ceased the practice of allowing dumping of waste at sea under a restricted permit regime.

The dumping at sea of both low risk and high risk aquaculture production waste is in breach of aquaculture licence terms and is illegal under both the *European Communities (Disposal, Processing and Placing on the Market of Animal By-Products) Regulations, S.I. 257, 1994* and the *Waste Management Act, 1996*.

The use of ensiled low risk production mortalities and salmon offal from processing as a fertiliser applied by sub-soil injection is legal in instances where this is carried out with the relevant licences under both the *Animal By-Products* legislation and the *Waste Management Act*. This activity is also the subject of extensive investigation by Teagasc before being licensed. As such, its suitability is restricted to good quality tillage land that does not suffer from high run off and is not used to graze animals on.

The disposal of fish waste by composting requires a permit under the *Waste Management (Permit) Regulations, S.I. 165 1998*. At time of writing there were no large scale composting facilities in place for dealing with fish waste. However a small number of trial units are known to be running under the control of waste producers, two of which are the holders of the appropriate permit.

Feeding of fish waste to zoo, circus and fur animals is permitted under section 5 (1) (b) of the *European Communities (Disposal, Processing and Placing on the Market of Animal By-Products) Regulations, S.I. 257, 1994*, however section 5 (1) (c) requires all such waste to be marked with green staining ink prior to supply and there are requirements relating to the transport of such waste under the Second Schedule. There is evidence of some compliance with respect to the above however not all such activity is licensed under the legislation.

Under Section 3 of the *European Communities (Disposal, Processing and Placing on the Market of Animal By-Products) Regulations, S.I. 257, 1994*, the use of low risk or high risk fish waste as shellfish bait would appear to be prohibited, however further detailed interpretation of the instrument is recommended in order to finalise this matter.

All person(s) receiving wastes must also be authorised persons under the provisions of the *Waste Management Act, 1996*. There are further restrictions under the Act relating to the storage, transport and handling of waste in a manner that is likely to cause environmental pollution. Many waste handlers e.g. hauliers and other persons involved in the commercial animal waste disposal trade, are licensed to handle and transport waste. However, there appears to be a general lack of knowledge amongst some processors and fish waste users of the requirements of both the above pieces of legislation. This is especially so in relation to the use of fish waste as bait.

Region	End Use	Whitefish	Pelagic	Salmon/Trout	Crustacean	Mussels	Whelks	Scallops	Total Waste (t)
Northwest	Use as Bait	100	0	50	0	0	0	0	150
	Wet Feed	1,300	100	450	0	0	0	0	1,850
	Fishmeal	245	22,831	100	0	0	0	0	23,176
	Disposed Of	0	0	33	978	272	2,505	0	3,688
	Miscellaneous (inc ensilage)	0	0	300	50	0	0	0	350
West	Use as Bait	262	0	40	0	0	0	0	302
	Wet Feed	500	0	200	0	0	0	0	700
	Fishmeal	100	1,374	500	0	0	0	0	1,974
	Disposed Of	150	0	300	300	453	0	52	1,255
	Miscellaneous (inc ensilage)	0	0	1,100	58	0	0	200	1,358
Southwest	Use as Bait	500	0	100	0	0	0	0	600
	Wet Feed	650	100	200	0	0	0	0	950
	Fishmeal	424	8,088	787	0	0	0	0	9,299
	Disposed Of	200	0	50	1,136	2,235	0	52	3,673
	Miscellaneous (inc ensilage)	0	0	200	0	0	0	200	400
Southeast	Use as Bait	150	0	0	0	0	0	0	150
	Wet Feed	200	0	0	0	0	0	0	200
	Fishmeal	250	5,496	0	0	0	0	0	5,746
	Disposed Of	400	0	0	617	60	1,074	757	2,908
	Miscellaneous (inc ensilage)	8	0	0	0	0	0	0	8
East	Use as Bait	100	0	13	0	0	0	0	113
	Wet feed	1,185	100	470	0	0	0	0	1,755
	Fishmeal	600	1,274	400	0	0	0	0	2,274
	Disposed of	200	0	200	160	0	0	0	560
	Miscellaneous (inc ensilage)	200	0	50	200	0	0	0	450
Total		7,724	39,263	5,543	3,499	3,020	3,579	1,261	63,889

Table 4.1: Destination of Production and Processing Solid Wastes by Origin and Region (estimated), based on 2000 Waste Arisings.

5.0 Options for Waste Minimisation

The concept of waste minimisation was introduced by the US Environmental Protection Agency in 1988. In this concept, the waste prevention approach and its techniques are defined as on-site source reduction of waste by changes of raw materials, technology, operating practices and products. Off-site recycling by direct reuse after reclamation are also considered to be waste minimisation techniques, but these have a distinctly lower priority compared to on-site prevention or minimisation of waste.

This section therefore focuses on the on-site minimisation of waste, but the logic of following the waste hierarchy remains, with prevention being the first step (see figure 7.1 – waste management decision tree). Waste minimisation should be a consideration at every stage in the supply chain, starting with the catching sector (fishing pattern, gear selectivity, handling, storage, etc.).

Several aspects of an operation have an impact upon waste prevention. For a highly perishable raw material such as fish, buying strategies and logistics are vitally important components in maximising the revenue from the raw material and minimising waste with its associated disposal costs.

Most obviously, buying the correct amount of raw material to fulfil customer requirements will result in reduced wastage. In addition, purchasing fresher raw material not only provides a higher quality fresh product with a longer shelf life but can also expand the options for waste disposal to by-products rather than recycling.

Logistics have implications for waste minimisation as efficient supply linkages will reduce spoilage of perishable raw material or processed products and may again result in better quality waste material that can be re-used profitably elsewhere. A processor may consider buying fresh fish risky compared to a more stable frozen supply, as fresh fish degrades quickly (as does the waste arising). The two markets are not, however, always interchangeable and there are still risks and costs associated with frozen product.

Even properly frozen fish has limited storage life. Low temperatures inhibit processes of microbiological decomposition but do not protect against fat oxidation and loss of water. The stability of frozen fish depends on the initial quality of the raw material, the rancidity, the drying process and the storage temperature. Incorrect storage temperatures and poor handling or packaging will all reduce frozen product quality. There are also the costs of thawing the raw material to consider. The widely used practice of thawing frozen product with running water (despite 'dry' alternatives) creates significant costs in energy and water usage.

Waste produced by fish processing operations varies enormously between processors as it is dependent upon:

- Volume, type and form of raw material.
- Form of finished product.
- Scale of enterprise.
- Employee skills and knowledge.
- Efficiency of processes and overall operation (management systems).
- Level of automation and technology employed.
- Season.

As waste production and subsequent disposal is so varied, industry and regulating authorities recommend a waste audit be conducted for each specific fish processing operation. Options for 'waste' disposal will be dependent upon logistics associated with a processing site and surrounding waste management infrastructure as well as the specific volume and type of waste produced. Potential options for the Irish industry are discussed in the next chapter "Options for the re-use or recycling of fish waste".

Until such time that the 'waste' produced by the Irish fish processing industry is a source of additional income rather than an additional cost, minimising the production of that waste must be seen as a priority. This will be increasingly the case in the future as levies and regulatory restrictions are placed on the traditional disposal routes for both solid waste and wastewater generated by the industry.

5.1 Wastewater Minimisation

Water is used extensively in fish processing operations. The table below illustrates some typical water usage rates associated with common product groups.

Type of Business	Water Used to Produce 1 Tonne of Product (m ³)
White Fish Filleting ⁽¹⁾	5.0 – 7.4
White Fish Thawing and Filleting ⁽¹⁾	9.5 – 24.0
White Fish Thawing, Filleting, Enrobing and Freezing ⁽¹⁾	23.4
Pelagic Fish Primary Processing ⁽¹⁾	3.2 – 6.6
Nephrops primary and secondary processing ⁽¹⁾	38.7
Canning ⁽²⁾	34.8
Fishmeal ⁽²⁾	97 (5 fresh, 92 seawater)

Table 5.1: Water Usage Associated with Various Fish Processing Operations.
Source: ⁽¹⁾UK Seafish Industry Authority & ⁽²⁾UNEP

Reasonably detailed literature exists on how companies may reduce both the volume and strength of wastewater produced during fish processing operations⁹. There has been an increased focus on water minimisation in recent years due to the introduction of the EU Waste Water Treatment Directive, which has resulted in a number of Member States developing more specific charging systems for industry for water supply and wastewater treatment.

The specificity of fish processing operations leads most authors to recommend a waste audit for each company as a starting point that may lead to an overall Environmental Management System (EMS). The implementation of audited EMS may prove excessive for small-scale operators, but some general rules do hold true for minimising wastewater volume and strength in fish processing operations at whatever scale including:

Reduced water use through:

- Use of dry cleaning techniques as far as possible.
- Use of trigger valves on hoses.
- Use of minimum water flow rates to equipment.
- Use of containers or conveyors instead of water flume to transport fish or waste.
- Use of air or steam to thaw rather than water.
- Reuse of lightly contaminated water (eg. coolant water) for non-water quality critical processes (i.e. non-food related).

Reduce effluent strength through:

- Reducing contact time between waste and water.
- Separating solid waste from water as close as possible to source using appropriate size screens or altering equipment.
- Avoiding unnecessary cutting up or mashing of waste.
- Not soaking waste in water or passing flowing water over waste.
- Removing the waste from the processing area.
- Keeping waste off the floor or out of the drains if on the floor.
- Separating any solids from effluent in the drains prior to it leaving the premises.

⁹ See "Guidance for fish processors on water and effluent minimisation", 1999, UK Seafish Industry Authority (www.seafish.co.uk); "Cleaner Production Assessment in Fish Processing", UNEP & Danish Environment Protection Agency; "Reducing water and effluent costs in fish processing", Good practice guide (GG187), 1999; "Draft Reference document on Best Available Techniques in the Food, Drink, and Milk Industry" by the European Integrated Pollution Prevention and Control Bureau, April 2002 (<http://eippcb.jrc.es>); "Best Available Technology in the fish industry" Nordic Council of Ministers, 1996.

Most of the solutions are low-cost solutions that are mainly reliant upon adaptations to existing processes, raising staff awareness of the need to minimise waste and appropriate training. Significant waste reductions and water savings can be achieved by any scale of operation with these cleaner production methods and should therefore be addressed before larger operators consider more capital intensive measures such as advanced physical treatment (see opposite).

Reductions of 30% on average in both volume and concentration terms can be achieved by most plants, but far greater reductions are possible depending on current practice. Most large fish processors in the UK and elsewhere have now undertaken wastewater audits and minimisation strategies (see box 1).

Box 1: Two Waste Minimisation Examples From the UK¹⁰ and New Zealand¹¹

Marr Foods Ltd., UK (a major pelagic and whitefish supplier to UK supermarkets producing over 12,000 tonnes/year) achieved estimated cost savings of GB£95,500 per year through a 58% reduction in water use and a 1% increase in yield. Major contributions to the savings were a more efficient defroster and improved cleaning procedures.

Sealord, New Zealand, is a similar sized company to Marr (with 550 fte employees and producing fresh, frozen, canned and fishmeal products) undertook a waste minimisation strategy starting in 1996. Sealord achieved reductions in water, electricity and fuel oil usage through improved heat recovery and staff awareness campaigns. The company developed incentives for staff to reduce waste and present their ideas for waste reduction. Between 1999 and 2001 the company reduced utility bills by 20%. The estimated capital costs of improvements represents less than 40% of annual savings.

The current Best Available Techniques (BAT) as drafted by the European Integrated Pollution Prevention and Control Bureau (EIPPCB) combines cleaner production techniques as outlined above with advanced physical treatment as part of an overall Environmental Management System. If this advanced physical treatment is undertaken in association with cleaner production techniques enterprises can achieve BOD load reductions of around 50%.

¹⁰ "Cutting water and effluent costs: a good practice case study at Marr Foods Ltd" an Environmental Technology Best Practice Guide from DTI and DETR joint programme, UK 2001 (www.etsu.com/etbp/).

¹¹ "Utility waste reduction – why and how" presentation by Nelson McEwan, Site Manager, Sealord Group at SEAFIC 2002 conference, New Zealand (www.seafood.co.nz).

Advanced Physical Treatment goes beyond simple physical treatment of removal of gross solids through screening and trapping waste particles. Advanced physical treatment relates to more advanced screening, such as mechanically raked screens, and also to Dissolved Air Flotation (DAF). DAF plants work by producing micro bubbles to which fats and oils attach and are skimmed off at the surface.

Fine screens are estimated to remove around 10–15% of the BOD load from certain effluents, with DAF plants achieving 20–25%. Chemical dosing (with aluminium sulphate, ferric sulphate or ferric chloride) can be used to improve the DAF process, but this has the disadvantage of chemically contaminating the collected sludge and making re-use as fishmeal less feasible. Food grade flocculants are, however, available to avoid this problem.

Following the physical removal of waste from effluent, biological treatment may be used to reduce BOD levels further. Biological treatment such as bio-filtration or activated sludge treatments effectively bring wastewater into contact with micro-organisms that feed on the nutrients purifying the water. The process requires continuous supply of waste water; a disadvantage for fish processing operations where output varies on a daily and seasonal basis.

Biological treatment is far more involved than advanced physical treatment requiring a dedicated operator and frequent lab testing to ensure efficient operation. It is therefore only likely to be a consideration for large-scale processors with very strict consents to discharge that do so directly into the environment, but decisions will ultimately depend upon the cost comparisons with wastewater charges.

Type of treatment	Euro per kg of BOD removed*
DAF without chemicals	0.39
DAF with chemicals	0.65
Biological treatment	0.61 (rising to 1.2 if chemicals and sewer connection required)
None (discharge to sewer & WWTP)	1.3 (approximate local authority charges)

Table 5.2: Costs associated with effluent treatment options.

*Original costs presented in IR£

Table 5.2 above suggests that high volume water users discharging soluble organic waste may find it more economic to treat wastewater at source if local authorities charge according to volume and strength of effluent and have adequate monitoring in place.

5.2 Solid Waste Minimisation

It can be argued that the term 'waste' is misleading as it suggests there are no uses for processing by-products. The following chapter, 'Options for reuse and recycling of fish waste', shows that this is far from the case and investigates several uses for such material. In this section we refer to waste minimisation as reducing the amount of material left over from producing a seafood product. Waste is produced at several stages from harvesting (and prior to that in the case of aquaculture) through to final sale. It is in the processing of seafood products that encouraging waste minimisation will have the greatest impact and also has the greatest scope for improvement. Minimisation of waste at the processing stage is therefore the focus of this section.

There are waste considerations for fish farms relating to the slaughtering process and mortalities, which pose additional disposal problems. Shellfish farming operations also produce waste during grading and harvesting, which occurs on shore in certain situations. In terms of minimisation and profitability for aquaculture operations an obvious goal is to improve rearing techniques and disease control to reduce these mortalities, but a small percentage of mortality will continue to be part of farm operations. Some risk of occasional mass mortality at fish farms caused through accident, disease, or adverse environmental conditions (harmful algal blooms, jellyfish swarms, storms etc.) will also remain. Contingency plans to deal with the disposal of mortalities will therefore remain an important part of waste management strategies and may require different disposal methods to other fish waste.

Further waste arisings occur from the withdrawal of fish from sale if a predetermined minimum price isn't reached. Low prices may be the result of poor quality or oversupply of product – two different problems requiring different solutions. In recent years this source of waste has, however, diminished to low levels (163.5 tonnes in 2000 based on 30 claims received by DCMNR) and is expected to decrease further in years to come. EC regulations¹² state that such withdrawals should be minimised and should still go to human consumption where at all possible rather than simply being disposed of. The contribution of legislation to waste minimisation will be discussed in 'feasibility for the Irish industry'.

¹² European Council Regulation 104/2000 article 26 states "In view of the security of certain species the destruction of fish withdrawn from the market should be avoided where possible...to this end aid shall be granted for processing, stabilising and storing for human consumption".

Solid waste reduction, as with wastewater reduction should consider improved efficiencies throughout the entire production process from purchasing through to dispatch. Here we will focus on the on-site reduction of waste seafood material. Solid waste associated with fish processing includes fish heads, tails, skin, scales and entrails. Shellfish processing predominantly results in shell waste and organic waste removed during shell cleaning (epiphytes, mussels byssal threads, etc.).

5.2.1 Product Development

The development of new products that utilise a higher proportion of the raw material has both potential benefits and drawbacks. Inedible parts of the fish or shellfish are removed in bulk at the factory and are able to contribute to useful by-products, while the consumer is likely to have no other option but disposal to municipal waste. Market trends show that convenience is increasingly important to consumers suggesting inedible parts are increasingly likely to be removed by processors prior to purchase. It is therefore appropriate and increasingly likely that the problem of what to do with the inedible parts of fish and shellfish will be dealt with at source by processors.

For some species, however, new product development may provide opportunities to utilise more edible parts of the fish within finished products, adding value and increasing yield. Irish seafood consumers are relatively conservative, limiting the domestic market for such products, but consumer attitudes are slowly changing. There is also potential to develop novel products for more adventurous export markets.

The success of any product is dependent upon finding or creating a market that is willing to pay sufficient to allow profitable production of that product. The costs associated with market research and marketing of any new product must be factored into the product development costs. The effort and resources required for product R&D are often barriers to new product development and this will be particularly evident with products derived from 'waste material' where the value is perceived to be low.

5.2.2 Product Yield

Solid waste minimisation by fish processors focuses on gaining maximum product yield from the raw material, which is a function of both the quality of the material itself and how well it is handled. As discussed above, high quality raw material will produce less waste due to lower amounts of spoilage.

Handling practices are closely linked to maintaining a high quality raw material. Poor practices result in more useable material being lost. Loss of useable material can therefore be minimised with good handling, sorting and filleting techniques supported by training and raising awareness with regard to maximising product yield. Efficient staffing also ensures that material is processed in a timely manner. Good management practices therefore tend to result in less wastage of raw material.

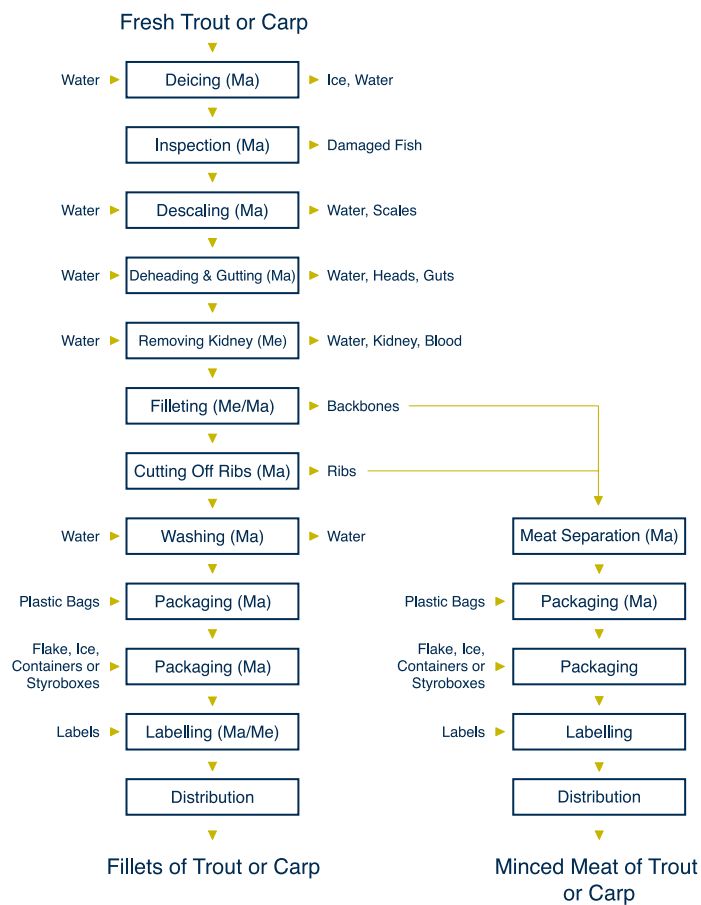


Fig. 5.1: Indicative Input/Output Model for Fish Processing Line. Source: FAO

Improved technology and more training have positive impacts on maximising raw material yield, but it is certainly not always the case that automation increases efficiency. For example, the head of a fish generally constitutes 10 – 20% of the total fish weight and it is cut off as an inedible part. Although many mechanised de-heading machines are available, they may not be as efficient as manual de-heading. A round cut around the operculum results in lowest meat loss. This manual technique is 4 – 5% more efficient than the straight cut commonly used in mechanised systems¹³.

Meat left on the fishes backbone after filleting can be recovered to a high degree using a meat-bone separator. Up to 50% of the total mass of processed backbones can be recovered as meat.

As raw material costs are usually the largest cost associated with an operation it is generally in the processors own interests to ensure maximum yield for increased revenue as well as reduced costs. Processors using frozen product have found that yield can be increased through more efficient thawing as meat/bone separation is made easier if the fish is thoroughly defrosted (see box 1 p.78). Sub – optimal practices may, however, remain, particularly when significant capital outlay is required to improve yield, such as new filleting machines or associated technology. The following section describes some of these barriers to change.

5.3 Barriers to Waste Minimisation¹⁴

Despite attractive economics and significant reductions in environmental impacts, the widespread adoption of Cleaner Production still remains limited. Several studies have addressed the barriers for the adoption of Cleaner Production at the level of individual enterprises, and most often categorised these as:

see overleaf

¹³ "Freshwater fish processing and equipment in small plants" Bykowski P & Dutkiewicz D., Sea Fisheries Institute, Gdynia Poland for FAO, 1996.

¹⁴ Adapted from "Cleaner Production Assessment in Industries" UNEP Production and Consumption Unit, 2002.

Type of Constraints	Sub – Categories
Financial	High cost of external capital for investments in industry.
	Lack of funding mechanisms (lending schemes etc.) appropriate for Cleaner Production investments.
	Perception that investments in Cleaner Production present a high financial risk due to the innovative nature of Cleaner Production.
Economic	Cleaner Production not properly valued by credit providers in their evaluation procedures for lending, equity participation etc.
	Cleaner Production investments are not sufficiently cost effective (compared with other investment opportunities), given present resource prices .
	Immaturity of the company's internal cost calculation and cost allocation practices.
Policy – Related	Immaturity of the company's internal capital budgeting and capital allocation procedures.
	Insufficient focus on Cleaner Production in environmental, technology, trade and industry development and strategies.
	Immaturity of the environmental policy framework (including lack of enforcement, etc.).
Organisational	Lack of leadership for environmental affairs.
	Perceived management risk related to Cleaner Production (e.g., no incentives for managers to put their efforts into implementation of Cleaner Production).
	Immaturity of the environmental management function in the company's operations.
	(General) immaturity of the organisation structure of the company and its management and information systems.
Technical	Limited experience with employee involvement and project work.
	Absence of a sound operational basis (with well established production practices, maintenance schemes etc.).
	Complexity of Cleaner Production (e.g., need to undertake comprehensive assessment to identify appropriate Cleaner Production opportunities).
	Limited accessibility of equipment supportive to Cleaner Production (e.g., high quality engineering small wares for process instrumentation)
Conceptual	Limited accessibility of reliable technical information tailored to the company's needs and assimilative capacities.
	Indifference: perception regarding the own role in contributing to environmental improvement.
	Narrow interpretation or misunderstanding of the Cleaner Production concept.
	(General) resistance to change.

5.4 Feasibility for the Irish Industry

5.4.1 Processors

The waste minimisation options discussed above are all applicable in an Irish context. The uptake of options elsewhere is the result of an increase in industry awareness, which is generally caused by legislative moves towards the 'polluter pays' principle. Increased waste disposal costs have made the waste issue a higher priority for businesses, particularly in the fish processing sector where recent years have seen opportunities to increase revenues through greater production limited by raw material supply shortages. Necessity has indeed been the mother of invention for many processors.

Governments and Industry Authorities in other Member States have attempted to increase awareness amongst processors of waste minimisation strategies often involving low or no cost solutions for reducing water usage and waste production. For many of the reasons outlined in section 4.3, waste minimisation strategies have been slow to appear in the Irish sector. The main factor appears to be slow implementation of 'polluter pays' legislation and its subsequent enforcement, with Irish processors not currently subject to stringent environmental legislation or charged rates by authorities based on full cost recovery.

This situation is expected to change in the coming years as more of the larger fish processing companies are likely to require an Integrated Pollution Control licence from the EPA. Smaller companies will also see greater need to minimise waste as water charges are set to rise in the short to medium term. An overhaul of water pricing policy as part of the Water Services Bill (to be enacted in 2003) will result in higher prices for non-domestic users as the government aims for full cost recovery by 2006. These changes are to be overseen by the new National Water Services Authority (to be established by 2004), which will make it more difficult for local authorities to give special treatment to particular sectors of importance locally.

For solid waste there are obvious benefits to increasing yield from raw material. Capital investment will be required for more efficient technology such as new defrosters, chillers or improved filleting equipment, making the process a gradual one. As reflected in the waste hierarchy, reduction is always likely to be a more economically beneficial option to disposal, even if new revenue-generating disposal methods are implemented.

As in other Member States, trusting that the fish processing sector will recognise the clear economic benefits of waste minimisation will not produce results quickly enough, particularly with regard to reaching the optimistic targets set in “Changing Our Ways”. Some assistance is necessary for industry to achieve lasting change.

Between 1986 and 1997 the Danish government invested some €87 million in a waste preventative programme. Meanwhile, the UK government operates the Envirowise Programme, which helps companies to prevent waste and save money by providing them with free technical assistance. Elements of the scheme, which is reported to have saved UK businesses in excess of €150 million, includes a phone helpline, on-site waste reviews, best practice guides, waste minimisation clubs and training¹⁵. For the UK fish processing sector the Seafish Industry Authority in conjunction with processor organisations have held seminars and provided waste audits for the sector. Seafish has also assisted the UK sector with training in many aspects of fish processing including waste minimisation.

Enterprise Ireland and the EPA both provide assistance and advice to industry on cleaner production and Environmental Management Systems. To date, however, there has been no scheme to improve environmental performance in fish processing specifically. Such a targeted scheme should be considered for fish processors in order to protect the industry from high waste costs in the future and remain competitive within the European market.

5.4.2 Other Sectors

For other producers of seafood waste, ie. aquaculturists and fishermen, the production of waste is clearly something to be avoided as it adversely impacts on revenues from the raw material. In addition to the economic logic of minimising waste, regulations can have an impact upon the creation of waste. For example, landings regulations for certain species (such as crab) which require fishermen to land the whole animal to ensure the minimum landing sizes are being adhered to even though it is only the crab claw that is the marketable item. Without this regulation the rest of the animal would be thrown back while at sea.

Regulations are also in place for fish farmers dictating how disease outbreaks should be dealt with. Culls associated with such events create a waste disposal problem for farmers as mortalities should be disposed of to ensure any part of the animal will not re-enter the food chain or the surrounding environment.

¹⁵ “Key waste management issues in Ireland”, Forfas, December 2001. (www.forfas.ie/publications/waste-management.htm)

Shellfish aquaculturists and processors also risk large waste problems as a result of the pressure of biotoxins such as ASP, DSP, PSP and AZP. Although the monitoring is essential for public safety, the lag time of 2–3 days between harvesting and the results of testing could result in large volumes of harvested or processed product being unmarketable and therefore become a waste problem to be dealt with. New EU regulations in relation to tiered testing of shellfish have the potential to make this a complex and costly waste problem in the future. There are also numerous examples of Harmful Algal Blooms causing environmental and economic damage. These situations are discussed further in the section on waste management – public bodies.

In the above instances, regulatory factors have caused the loss of saleable product. While this loss could be seen as an inevitable risk of these operations, the costs associated with disposal of the resulting waste could be more equitably distributed throughout the sector. Where public sector funding is supporting the development of a fledgling sector, the operators in that sector may also require buffering from such stochastic events.

6.0 Options for Re-Use or Recycling Fish Waste

Although waste can be minimised compared to current levels of production, the fish processing sector will always produce some waste which requires safe and economic disposal. The disposal options open to processors can be broadly divided into two different channels depending on whether the waste can be classified as a product or by-product or whether it is regarded as a waste (for recovery or for disposal).

For material to be regarded as a product or by-product it must be part of a documented quality control procedure, have refrigerated storage segregated by species and have details of its nutritional values. Under the EC regulation¹⁶ laying down the health rules concerning animal by-products not intended for human consumption fish offal is classed as category 3 material deemed low risk waste (see Box 2 and associated disclaimer).

Box 2: Aspects of EC Regulation on Animal By-Products (EC) 1744/2002: Specific to Fish Waste Utilisation¹⁷.

Article 6: Category 3 material shall comprise ... (h) fish or other sea animals, except sea mammals, caught in the open sea for the purposes of fishmeal production; (i) fresh by-products from fish from plants manufacturing fish products for human consumption;...

Annex II: All necessary measures must be taken to ensure that:

(a) Category 1, Category 2 and Category 3 materials are identifiable and kept separate and identifiable during collection and transportation; and
2. During transport, a label attached to the vehicle, container, carton or other packaging material must clearly indicate:

(b) (i) in the case of Category 3 material, the words "not for human consumption",

CHAPTER III... During transportation, a commercial document or, when required by this Regulation, a health certificate must accompany animal by-products and processed products.

2. Commercial documents must specify:

- (a) the date on which the material was taken from the premises;*
- (b) the description of the material, including the information referred to in Chapter I, the animal species for Category 3 material and processed products derived there from destined for use as feed material and, if applicable, the ear-tag number;*
- (c) the quantity of the material;*

¹⁶ Animal By-Products Regulation (EC) 1774/2002, adopted October 2002, expected to apply from the 1st May 2003.

¹⁷ Box 2 is for guidance only – The reader is advised to review the full text of the above regulation and to seek advice from the competent Member State authority responsible for interpreting and implementing the regulation.

- (d) the place of origin of the material;
- (e) the name and the address of the carrier;
- (f) the name and the address of the receiver and, if applicable, its approval number; and
- (g) if appropriate:
 - (i) the approval number of the plant of origin, and
 - (ii) the nature and the methods of the treatment.

ANNEX III: HYGIENE REQUIREMENTS FOR INTERMEDIATE AND STORAGE PLANTS

CHAPTER II: General hygiene requirements

A. Category 3 intermediate plants

1. The plant must not engage in activities other than the importation, collection, sorting, cutting, chilling, freezing into blocks, temporary storage and dispatching of Category 3 material.
2. The sorting of Category 3 material must be carried out in such a way as to avoid any risk of the propagation of animal diseases.
3. All the time during sorting or storage, Category 3 material must be handled and stored separately from goods other than other Category 3 material and in such a way as to prevent any propagation of pathogens and to ensure compliance with Article 22.
4. Category 3 material must be stored properly, and, where appropriate, chilled or frozen, until re-dispatched.

How the left-over material from processing is treated therefore determines what options are available. As segregated storage is required (which may have to be refrigerated if deemed necessary) for all disposal or reuse options, the additional requirements for reuse relate to this material remaining in the quality control loop used for products rather than being seen as waste.

Current practices in Ireland for waste utilisation and disposal are described in detail in section 3. Some of these practices are currently or soon to be prohibited and they very much focus on the disposal of fish waste as a problem material.

A change in attitude to waste management is being encouraged by the Government with increased environmental taxation on options such as landfill and incentive schemes for alternative disposal. The Irish industry needs further encouragement to make the additional step of treating processing material as a potentially profitable by-product rather than waste to be sent for environmentally acceptable disposal.

The disposal of fish waste to landfill or dumping at sea is today considered inappropriate and is anticipated to cease in Ireland in the near future. Economically feasible alternatives are however necessary to prevent processors and aquaculturists being forced or tempted to operate illegally.

This section lists many other potential recycling and re-use options for seafood waste that are currently being undertaken throughout the world and determines their applicability in the context of the Irish industry. The feasibility of these options such as volume and quality produced, logistics, demand or infrastructure will also be considered.

6.1: Recycling

A. Direct Animal Feed

B. Fishmeal and Oil

C. Ensilage

D. Composting

E. Soil Treatments

F. Other Recycled Products

6.2: Reuse as a Food Product or By-Product

G. Additional food products

H. Pharmaceutical products

I. Nutraceutical products

Dealing with mortalities from fish farms will be dependent on farm practice. If 'morts' are regularly collected they may be fresh enough for re-use or recycling, otherwise disposal such as incineration may be the only safe option.

6.1 Recycling

Recycling material involves direct feeding of waste or transforming the waste into low-grade products. The resulting products may re-enter the food chain indirectly through animal feed or soil treatments, but they are no longer fit for direct human consumption. The three most common methods for utilisation of aquatic waste (either from aquaculture or wild stock) are the manufacture of fish meal/oil, the production of silage or the use of waste in the manufacture of organic fertilizer¹⁸.

Direct use of fish wastes for land manuring, or land spreading, is generally discouraged by the uniquely obnoxious odour of putrefying fish and prohibited by risk of pathogen transfer and scavenger and pest problems¹⁹. Using fish waste as a waste material still therefore requires the waste to undergo processing that reduces putrefaction and converts it to a more stable state. The two most common processes are composting and ensilage. Ensiled waste material can also be further processed to create similar end products to the fishmeal process with the production of fish protein concentrate and fish oil. Consequently, using fish waste on land as a fertiliser appears to be economically unattractive compared to recycling to animal feed.

As a result of the BSE outbreak, legislation relating to animal husbandry prohibits the feeding of an animal with any part or by-product from the same species. This is equally applicable to aquaculture operations and means that waste from the salmon industry cannot be recycled and re-enter the salmon food chain as feed. Consequently salmon waste commands a lower price compared to pelagic and whitefish waste as the resulting meal and oil products are limited to the lower-value animal feed market rather than the high-value aquaculture feed market.

¹⁸ "Waste from Processing Aquatic Animals and Animal Products: Implications on Aquatic Animal Pathogen Transfer" Gill, T.A., 2002. FAO fisheries circular no. 956.

¹⁹ "Economic Viability of Commercial Composting of Fisheries Waste by Passive Aeration", Hayes et al, The Compost Council of Cana Symposium, 1994.

Summary	Pros	Cons	Suitable Waste Types				
			Pelagics	Whitefish	Salmon	Crust	Molluscs
Recycling	Simple processes, low capital expenditure compared to human food products, potential for some revenue.	Creation of low value products (meal & oil) entering global commodities market or local market (compost, direct feed).					
A. Direct Feed (bait, fur farm, zoos, etc.)	Little or no processing required so minimal cost.	Limited local market. Limited time for use unless freezing. Deemed morally unacceptable by some (fur farms)	•	•	•	•	•
B. Fishmeal or Fish Oil	Generates revenue from waste Demand for high quality meal and oil increasing.	Capital costs of fish meal plant. Large volumes required to justify construction. Transport costs incurred regularly if some distance from plant.	•	•	•	D	D
C. Ensilage	Time-stable product. Able to operate at a variety of scales. Economic for isolated areas. Similar revenue to fish meal possible.	Similar capital expenditure to fish meal plant if total processed. May need to be part of a larger network to be feasible. Use of hazardous materials (acid).	•	•	•	D	D
D. Composting	Able to operate at a variety of scales, widely available bulking agents (light peat/agricultural waste). Economic for waste generated in isolated areas. Low energy inputs (regular turning).	Low value product with limited market Potential pest & odour problems Requires large unpopulated areas to avoid nuisance factor.	•	•	•	•	D
E. Soil Treatments	High value product compared to compost. Low production costs compared to fishmeal/ensilage. Evaporation required	Would involve considerable effort if no existing manufacturers. Limited market for end products. Only fresh waste useable if enzyme from waste is required rather than added enzyme.	•	•	•	•	•
F. Anaerobic	Energy generation and fertilizer. Can be centralised or on-site. Suitable for remote locations.	Capital costs similar to ensilage, but lower value. Should be combined with agricultural waste requiring linkage. No revenue from waste likely.	•	•	•	D	D

Table 6.1: Summary Table for Pros and Cons of Recycling.

A. Direct Animal Feed

Fish waste unfit for human consumption may still be used directly. Fishermen use waste as bait in potting and lining operations where a preference is given to oily fish waste that is a few days old as it produces larger scent markers when in the water compared to very fresh non-oily waste. Only relatively small amounts of raw material are required in certain locations with significant static gear fisheries and only certain waste types are chosen. In Ireland there is anecdotal evidence that to some extent this disposal route is being used as a cover for dumping at sea as the quantities 'going for bait' exceed demand from bait users.

Animals bred for the fur trade (where meat taint is not an issue) such as mink and fox are fed fish waste. Mink consume over 20 times their body weight annually, foxes consume 35 times their body weight. The fur breeders can use fish waste in the mink diet with up to around 40% wet weight; beyond this some problems (such as yellow fat disease due to thiamine deficiency) may occur. This is a widespread practice in Scandinavian countries, Canada and Russia.

While an environmentally sound practice from a waste disposal viewpoint, many have ethical problems with this disposal route. These broader ethical issues also make the long-term sustainability of this disposal route questionable. The small number of Irish fish processors that are currently supplying fur breeders are therefore looking for alternative uses for their waste.

Fish waste is also fed directly to carnivorous livestock in zoos, circuses, marine parks, fish and fur farms or may become an ingredient in pet food manufacture. Information from pet food manufacturers suggest that quality requirements are very similar to those for human consumption in terms of freshness. Appearance of the raw material is however less important than for products destined for human consumption and there may be some opportunities for edible materials unsuitable for the human market, such as fish offal, to be used in pet food manufacture.

A handful of small-scale pet food manufacturers are based in Ireland and Northern Ireland, along with the larger scale C&D Foods, Co. Longford and Rednut, Co. Kilkenny.

Direct disposal is the lowest cost option for reuse of fish waste as no further processing is required other than crude maceration. As a disposal route for waste, direct animal feed is only feasible for a small number of processors with high local demand and realistically can only account for a small fraction of the total waste produced by the Irish processing industry.

B. To Fishmeal and Oil

Fish meal and fish oil production accounts for around 1/3 of global capture fisheries and totalled 30 million tonnes in 1999²⁰. The majority of global production is centred on the South American reduction fisheries of small bony pelagic species such as anchoveta, argentine and jack mackerel. North East Atlantic pelagic fisheries are based on herring and mackerel, most of which goes to human consumption and horse mackerel and blue whiting, most of which goes to fishmeal. Sprat is often a significant local fishery for Irish pelagic vessels, but the fishery exhibits high annual variation.

The majority of fishmeal and oil produced in Ireland as elsewhere is from these pelagic fisheries, either directly or from waste material produced during processing for human consumption. Whitefish processing waste further contributes to the raw material stream. Waste from the salmon farming and processing sectors are also converted to fishmeal, but must be kept separate for the reasons outlined above.

The processing of fish waste to fish meal and oil is the most widely practiced disposal option throughout Ireland, despite there being only one dedicated fish meal plant (operated by IAWS in Killybegs, Co. Donegal) and other animal rendering plants (such as National By-Products in Co. Tipperary) now refusing to accept fish waste for processing to fish meal.

Important additional revenue can be gained from sale of waste material, transport costs permitting. Processors in the South West of Ireland transport their waste to the fishmeal plant in Killybegs as no other option currently exists, but the high transport costs put them at a disadvantage compared to Killybegs-based processors. The situation in Ireland will be discussed in more detail in later sections, but some general aspects associated with fish meal as a disposal route will be described below.

Fishmeal is used extensively in livestock and aquaculture feed, containing high levels of essential amino acids, such as Lysine (not found in many grain based compounded feeds), micro – nutrients and trace elements. Fish oil is also an important foodstuff, particularly in aquaculture diets and pet foods as well as having industrial uses e.g. soaps.

Fish meal and fish oil are produced by submitting whole fish unsuitable for human consumption (small, bony pelagics such as anchoveta, argentine, Norway pout, capelin and menhaden,) and fish waste to cooking, oil extraction and drying.

²⁰ "The State of World Fisheries and Aquaculture, 2000", FAO.

²¹ "Sources of and Alternative Uses for Herring and other fish Offal in Ireland" Marine Institute, BIM, 2000.

The freshness of the raw material is critical to the quality (and so price) of the finished products. The type of raw material determines the protein, oil and ash content of the resulting meal and oil. Whitefish waste has a low oil and high ash content, while pelagics have high oil and low ash content. Salmon waste also has a high oil content, but the price it commands is far less as the material cannot be used in salmon culture – currently the major customer for high quality feeds in Ireland (although other finfish species are in development).

In Ireland, the demand for fishmeal is primarily from the pig–farming and poultry–farming sectors, followed by the increasing aquaculture sector. The Republic is believed to be only 50% (c. 17,000 tonnes) self–sufficient in the production of fishmeal with imports approaching 17,000 tonnes annually. A further c. 10,000 tonnes is imported into Northern Ireland. Conversely, Ireland exports quantities of fishmeal to the UK market each year²¹.

Irish fish meal and fish oil products enter a highly dynamic global market, which is dictated by the South American reduction fisheries of Peru and Chile. There is no evidence that Irish product will be differentiated from other meal and oil in any way, making the price paid to Irish fish processors ultimately dependent upon the global market. Indeed the fishmeal plant may feel able to offer lower prices for raw material due to few available alternatives for waste disposal.

As a disposal route, transformation to fishmeal is a comparatively attractive option where scale and proximity allow for economic transport to the fishmeal plant and therefore some revenue from the waste. With only one plant in the North West and freshness of material being critical, this option is less attractive to processors outside the North West.

C. Ensilage

For the purposes of this overview the term ‘ensilage’ is used to encompass various forms of hydrolysis as, although strictly only one crude form of hydrolysis, it is the term most commonly used by the industry when discussing the recycling of animal by–products.

Hydrolysis is the process of transforming a solid material into a water–based solution or suspension. By hydrolytically breaking down the organic components of a fish such as its protein, oil (fat) and bone into extremely small parts, fish hydrolysate, a nutritional product, is obtained. Mostly, the protein, characterised by long molecular chains, is divided into its smaller component such as peptides and ultimately amino acids. The number and types of amino acids and their mix determine the nutritional profile of that hydrolysate. The purpose of breaking down the protein is to make the nutritional elements (amino acids) available for easy absorption.

Ensilage that may later be used in the production of animal feed is one of the most economic means of processing fish waste to a stable, useable product. The ensiled liquor produced may, however, ultimately be further processed to meal and oil products very similar to those produced by fishmeal plants.

Several different methods can be used to produce fish silage:

- 1) adding inorganic or organic acids to lower the pH to a point where it is stable;
- 2) addition of inorganic or organic acids to lower the pH to a point at which intrinsic enzymes (which are normally most active around pH 4 and at temperatures between 35 to 40°C) will liquefy the protein, prior to adding additional acid to stabilise the pH to a level that is suitable for storage); and
- 3) adding carbohydrates (such as molasses) and allow fermentation to occur, so that enough acid is produced to stabilise the silage.

The process is containerised and creates a relatively stable product making it feasible for operations producing small, sporadic volumes of waste that are uneconomic for fishmeal production. The silage can be stored for up to 6 months if it is stirred periodically and kept at about 15 – 20°C. This stabilised product is usually aggregated (collection by tanker) for processing at centralised facilities. Following a dewatering process, separation will result in a fishmeal-like material rich in protein and fish oil.

The raw material must be fresh; as with fishmeal production – decomposing offal should not be processed – as these affect the quality of the finished product. If silage is prepared from partially decomposed materials then the histamine levels in the fish silage will reflect what was present initially.

Freshness is usually gauged by measuring Total Volatile Nitrogen (TVN) values or oxide levels (rancidity). These characteristics are measured by purchasers of ensiled material, directly affecting the price offered and high levels (>4% TVN) results in the liquor being unacceptable for further processing. Careful management should prevent this occurring as waste material can be ensiled on site in any quantity.

Ensilage is a simple technological process, but several rules must be observed to obtain a satisfactory final product. The main phases of offal processing are: grinding of offal or whole fish, acidifying of the pulp and liquefying it, which results from a self-digestion (autolysis) process. Adequate mixing is a basic operation of the process. The measured pH should always be the final indicator of a proper level of acidification and should range from 3.5 to 4.5. The pH should never exceed 4.5.

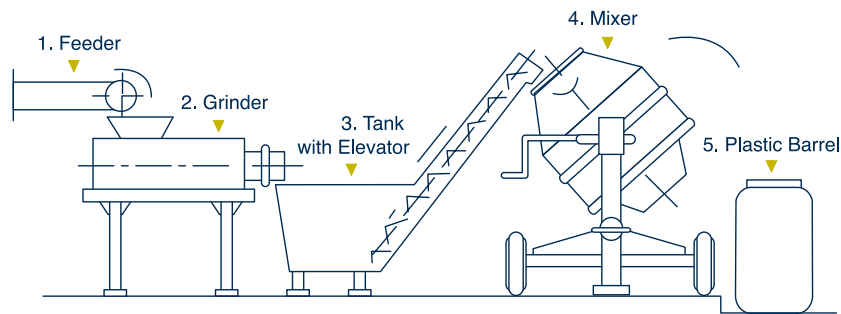


Figure 6.1: Simplified Fish Silage Production Process.
Source: FAO

In small fish processing plants where the volume of offal and fish not used for consumption is low (i.e., 1–2 t/shift), the production of fish silage uses a simple process (Figure 6.1). The processing equipment consists of a grinder (sieve openings 6 – 10 mm in diameter, processing capacity circa 400 kg/hour), dispenser with a worm-wheel unloading conveyor, rotating mixer made of suitable materials with a 150 – l volume drum, and 120 – l plastic barrels. This equipment (Figure 6.1) is manned by an operator who can produce 2t of ensiled material per shift.

For certain areas of Ireland ensiling appears to be a feasible and economically favourable option to either disposal or transport to fishmeal where distances are considerable (ie. the South West, South East and possibly extending to the West coast). The main benefit lies in the potential to create a relatively time-stable product *in-situ*, at a variety of scales and with limited capital outlay. This would be attractive to waste producers that are geographically isolated and/or producing variable quantities and types of fish waste.

Processors and ensilage companies are currently investigating the potential to build an ensilage facility in the South West of Ireland in order to address the waste disposal problems experienced by companies a long distance from the fishmeal plant in the North West. The extent of such facilities – centralised ensilage plant plus bulk storage for ensiled material or with the addition of a dewatering stage – will depend on the amount of waste available to the operation. The intention is for ensiled material to be transported to facilities in Norway for further processing, but increases in throughput in Ireland could make a full processing development feasible in the future.

D. Composting

Composting (more technically described as thermophilic fermentation) results in the break down of complex materials such as proteins, fat, carbohydrates, etc. and also the generation of heat. Processes for the production of fertilizers and other useful end products, including utilising the heat produced in the process, have been developed in Norway and Canada.

The process involves particle size reduction followed by bacterial fermentation at high temperature (usually 50–70°C) accompanied with aeration. Waste with high nitrogen content such as fish waste is mixed with high carbon content waste such as certain agricultural waste or sawdust at an approximate ratio of around 30:1 C:N. Canadian experiences have calculated the optimum mixture to get an appropriate C:N ratio is one part seafood waste to two parts of sawdust. Other studies in Canada showed that sphagnum peat or light brown peat (not used for fuel or horticulture) is an ideal bulking agent. Such material was deemed 'environmentally friendly' if consideration was given to avoiding certain sensitive wetland ecosystems, but it is unlikely that its use in Ireland would be deemed environmentally benign and therefore permitted.

Moderate scale fish composting generally involves static windrows (long piles) 4 – 5 ft high, about 8 ft wide, sometimes passively aerated with built-in perforated pipes near the base of the windrow. Wood chips and sawdust are the recommended "bulking agent" for a carbon source.

Commercial systems are available that include large scale windrow composting where specialised machinery may be required to turn the compost pile adequately. If managed correctly, composting does not create noxious odours if sufficient heat is generated at the appropriate stage. Turned composts or force-aerated static pile composts without a colder envelope tend to lose ammonia that causes odour problems and decreases the fertilizer value of the product. To solve this dilemma between temperature and aeration the Passively Aerated Windrow System (PAWS) was developed in Canada based on internal convection of air within the windrow pile.

Composting of fish waste is, so far, limited to locations where distance from waste handling infrastructure such as fishmeal plants makes alternatives unfeasible and isolation minimises any nuisance problems for communities (Canada, certain areas of the US and Norway). Canadian legislation requires any site to be surveyed and closely monitored before composting operations are permitted. Good site qualities include the following;

- (i) good drainage;
- (ii) away from streams and water bodies (> 1 km);
- (iii) away from habitation (> 1 km);
- (iv) sufficient space for operation and manoeuvring of equipment;
- (v) good wind protection (by natural topography or treed areas);
- (vi) easy accessibility.

Proponents of composting suggest good management should ensure against odour and pest problems. In-vessel systems are, however, available to further reduce the potential for nuisance odours and pests. There are many types of in-vessel system with varying levels of complexity. Small – scale systems of 2 to 3 cubic metres are operated on a batch process, while large – scale systems attempt a continuous process with retention of less than a week for the initial composting phase.

The following criteria are published by the US Natural Resources Conservation Services to define acceptable composting sites²²:

Property Limits for Compost Facilities	Property Limits Units	Minimum Distance from Potential Composting Facility to Resource Concerns	Minimum Downslope Dist. to CF	Minimum Upslope Dist. to CF
Maximum Slope	8.0 Percent	Residence or Well (Neighbour)	500ft	500ft
Maximum Permeability (Least Permeable Horizon > 12" thick)	2.0 Inches/Hr	Adjoining Property Line.	200ft	100ft
Minimum Depth to Bedrock	30.0 Inches	On Farm Well/Spring.	300ft	100ft
Minimum Depth to High Water Table	18.0 Inches	Lake/Pond/River/Wetland	300ft	100ft
Minimum Flooding Event	1 Time Per 25 Yrs	Diversion/Waterway	100ft	25ft
Maximum Fraction 3" Rock (Percent by Weight)	35.0 Percent	Gully/Swale/Ravine	100ft	25ft

Table 6.2: Criteria Necessary for US Composting Sites.
Source: US EPA

²² Conservation Practice Standard: Composting Facility Natural Resources Conservation Service. (No.317), April 2000.

In-vessel composting provides the following advantages²³:

- Waste is retained on-site until stabilised, eliminating the need to transport raw organic material to a centralized composting facility.
- The product is immediately isolated from the environment.
- Composting is uniform and can be completed rapidly, resulting in product stabilization/sanitation normally in 3 to 5 days.
- The raw waste loses offensive odors within 24 hours of composter start-up.
- In-vessel composting can maintain a rapid decomposition process year-round regardless of external ambient conditions.

According to recent reports, home gardeners in the US are willing to pay 4 to 5 dollars US (4.00 – 5.00 Euro) for a one cubic foot bag of fish compost. Profit margins are, however, marginal, with fish compost more highly valued than shrimp compost, which in turn is more expensive than crab compost. Composting operations associated with the blue crab fishery in Chesapeake, U.S. where it is estimated that 4,000 tonnes of waste is produced annually, are unable to run at a profit due to the resulting low value product. Operations were previously subsidised by local authorities, but this support is being phased out leaving processors having to pay for this form of waste disposal rather than gain revenue from it.

Agricultural waste accounts for around 80% of waste arisings in Ireland. Within this mass of waste material, the identification of suitable sources of bulking agents for combination with seafood waste in composting operations should be possible. Less evident are the opportunities to site composting facilities that are of sufficient scale and proximity to deal with waste arisings from major fish processing operations. Objections are regularly lodged against permits for existing composting facilities, without the added risk of pest and odour nuisances from seafood waste.

Although seen as a comparatively 'low-tech' process, composting facilities are to be regulated²⁴, along with biogas plants to ensure they implement HACCP schemes and are approved and monitored by the Competent Authorities. To avoid pathogen transfer there are requirements for the obvious separation of waste and in some instances some form of pre-treatment, increasing a facilities scale and complexity. These new regulatory requirements place additional costs on what is already recognised as a marginal commercial activity.

²³ "In-Vessel Composting of Agricultural and Food Wastes" Cawthon, D. & Jester, S. Department of Agricultural Sciences, Texas A&M University – Commerce (www7.tamu-commerce.edu/agscience/events/ffd/cawthon.htm).

²⁴ Animal By-Products Regulation (EC) 1774/2002.

E. Soil Treatments

An extension of composting is the processing of wastes to form soil treatment products. These may be either solid or more often liquid products that benefit from the specific nutrient make-up of seafood waste, but are processed to a stable, low-odour state. This 'fish fertiliser' is produced in a similar process to ensilage (described below) but differs in that enzymatic digestion continues in order to liquefy all parts of the waste including all proteins and usually water is not evaporated off.

According to North American experience the production ratio of wet fish waste material to liquid fish fertiliser end product is 1.5 or 2 to 1. The following steps are necessary to produce liquid fish fertiliser²⁵:

1. **Grind** mechanically and or manually to increase surface area for digestion.
2. **Digest** using enzymes either within the waste or adding commercially produced proteolytic enzymes.
3. **Pasteurise** by raising the temperature sufficiently to kill micro organisms.
4. **Screen** to remove bones, scales and any other undigested materials.
5. **Preserve** by adding acids (usually phosphoric) and antioxidant to avoid rancidity, bacterial spoilage and mould.
6. **Store or Package** preferably in plastic.

There are a number of manufacturers of liquid fish fertiliser in the US, Canada and New Zealand. Some companies are vertically integrated with fisheries production, such as the Bio-Sea products in New Zealand part of the Sealord group of fishing and processing companies.

Without similar structures in Ireland, a fish waste producer would be required to develop their own production or develop strategic linkages. Although potentially profitable at appropriate scales and frequency of waste production, developing a fish fertiliser venture would require a significant amount of effort. This solution to waste disposal is therefore only suitable in a small number of select cases where the circumstances, inclination and market opportunities exist.

²⁵ "Beyond Waste: Navigating Fisheries By-Products in the North East", Goldhor, S. Centre for Regional Applied Studies, Maine. Funded by NOAA, 2000.

Box 3: Soil Treatments from Shellfish Waste

Dry shellfish fertiliser is sometimes produced in areas associated with significant fisheries. This has high calcium carbonate levels able to help to control pests and neutralise acidic soil. These products enter a niche market of professional market gardeners or keen amateurs and their production still requires careful treatment of waste prior to or during processing in order to avoid rancidity.

Chesapeake Blue Crab Waste

The blue crab fishery in Chesapeake, U.S., supports over 30 processing plants in the region that produce around 4,000 tonnes of waste per annum. For every tonne of crab meat, the processors produce 6 tonnes of shell waste and inedible parts known as 'runny chum'. Landfills in the region no longer accept this waste. The bulk is now composted, but clean, dry shell waste can be ground to contribute to fertilizer. The shell is around 60% calcium carbonate (the remainder being 20% chitin, 20% protein). Capital expenditure for drying, grinding and packaging is required, but the fertiliser is sold to gardeners in the US retail for 3 to 4 euros per kilo.

Tampa Bay Shrimp Waste*

Tampa Bay Fisheries previously sent prawn shell waste and floor scrapings to landfill, but this waste is no longer accepted by the facility. One re-use option for shrimp shells is as a methyl bromide alternative for the strawberry industry. Methyl bromide is a broad-spectrum pesticide that was used at planting time to eliminate nematodes, weeds, and soil-borne pathogens from planting beds, but is now banned. Researchers with the University of Florida have found shrimp shell chitin to have many of the qualities of methyl bromide when used on certain crops. There are, however ongoing investigations into the potential for chitin extraction for pharmaceutical use (far higher capital costs, but higher value product).

*From "Seafood Processing Waste management in the gulf of Mexico region" (www.coastalamerica.gov).

F. Other Recycled Products

There are a number of variations to the main recycling routes for seafood waste described above. Below is presented anaerobic digestion: an option with limited potential solely for fishwaste, but with possibilities in conjunction with farm waste. There are also recycling options specific to wastes with particular properties (eg. shell waste described below).

Anaerobic Digestion (AD)

A recent feasibility study was undertaken in Ireland to assess the potential development of Centralised Anaerobic Digestion (CAD). The work was part of a larger European project entitled AD-nett which aimed to investigate the potential application of AD technology and disseminate information on AD (see project website www.ad-nett.org).



Source: British Biogen²⁶

Anaerobic digesters produce conditions that encourage the natural breakdown of organic matter by bacteria in the absence of air. Anaerobic digestion (AD) provides an efficient and effective method for converting residues from livestock farming and food processing into useful products. The technology has been widely adopted by farms and farmers cooperatives in Denmark. The focus in Denmark has been on centralised plants, because they offer a possible solution to farmers facing legislation on storage capacity for animal manure and demands related to environmental factors.

Feedstocks include animal slurry (from cattle, pigs and chickens) and residues from food processing industries. Other organic materials can also be digested.

Organic waste is put into a digester (a warmed sealed airless container). The materials ferment and are converted into a gas and a solid called the digestate, which in turn can be separated out into fibre and liquor.

²⁶ Anaerobic Digestion of farm and food processing residues: Good Practice Guideline. British Biogen (www.britishbiogen.co.uk).

AD plants vary from small on-farm facilities run by a farmer using only the slurry produced on the farm and using all the resulting products on the farm to larger scale developments known as a Centralised Anaerobic Digester (CAD), taking feedstock from local farmers and food processors and marketing the products on a larger scale. The process is the same whatever the scale but the safe running of the digester and marketing of products is more complex for a CAD scheme.

Digesters are generally continuously stirred and are usually fed with more than one feedstock. The primary feedstock in many instances would be a material with a high potential for pollution; for example, pig slurry with the option for cattle manure in some regions. These feedstocks have a low dry matter content of typically 6 – 10%. A secondary feedstock may be a farm livestock manure, such as poultry litter or droppings, or an agro-industrial waste from food processing; the latter would be particularly valuable as there would usually be a disposal credit associated with their disposal. These feedstocks have a high dry matter content (typically 40 – 70%), which would help maximise gas yields from the plant.

Benefits of AD:

- Reducing emission of greenhouse gases.
- Reducing odour (AD can reduce the odour from farm slurries and food residues by up to 80%).
- Reducing land and water pollution.
- Nutrient recycling.
- Effective waste management.

Costs of AD:

- Operating and capital costs (see table 6.3).
- Control of dangerous emissions – some trace gases found in the biogas are toxic and dangerous to human health (hydrogen sulphide and ammonia). This means the gas must be cleaned and only dealt with by trained operators.
- Traffic – local communities may suffer due to increases in farm traffic to site.
- Animal health – risk of disease transfer with vehicle movements to centralised facility.

AD is likely to be most viable for those people who can utilise all the products effectively. Capital costs associated with AD are estimated to be as little as €400 per cubic metre of digester capacity²⁷. Table 6.3 illustrates the estimated costs associated with large scale and farm scale AD plants. The IRR calculated for both is low (3.1% and 0.2% respectively) with payback periods of 15 to 20 years. The capital costs involved at start up could be reduced to make the economics more attractive, but it appears that government incentives were required for farmers to establish AD systems.

Type of Plant	Centralised AD Plant	Farm Scale Plant
Capacity	1MW Electrical Export	25kW Electrical Export
Capital Cost (ECU)	9,113,000	500,000
Operating Cost (ECU/y)	643,000	8,800
Electricity Price (ECU/kWh)	0.06	0.06
Heat Price (ECU/kWh)	0.01	0.01
Digestate Sales Income (ECU/y)	700,000	20,000
Gate Fee Income (ECU/y)	0	0

Table 6.3: Base Case Assumptions for Generic Plant.
Source: AEA Technology

There is great potential for AD in Ireland based on national waste arisings as animal manures and slurries are a major contributor in Ireland. Fishwaste is considered a suitable secondary feedstock and as such could be disposed of at CAD plants or by arrangement with farmers operating on-site AD plants. In both instances, in light of the marginal economics, a charge for disposal is likely rather than the supplier receiving any revenue from the waste.

Shell Waste

Shellfish shell waste is hard and rich in calcium carbonate – two properties that distinguish it from other organic waste streams. As a result it can be seen as problematic when combined with soft organic waste – ie. the bodies of the molluscs or crustaceans themselves or other fish waste. Alternatively these properties can present specialist markets for recycling of the waste. An example of an Irish product developed from recycled shellfish shell is 'Monashell' (see box 4).

²⁷ Economics of Anaerobic Digestion of Agricultural Waste: Technical Summary I. Higham, AEA Technology Environment, UK. October 1998.

The bulk of waste from the Irish mussel industry arises at the grading and processing stages. The waste is therefore a mix of shell and meat. Volumes are generally small and products for mussels out of the shell are manually shucked. Manually separating the two types of waste would be far too labour intensive. Large volumes of waste may occur with rope culture as a result of protracted closures of areas due to the presence of biotoxins, but these irregular events do not warrant investment in automated technology to produce clean shell waste.

Box 4 – Alternative Uses for Shell Waste

MónaShell is an air filter medium developed by Bord Na Mona.

The product consists of shells coated with a specific blend of centrally selected micro-organisms. Shells contain a high level of CaCO₃ which neutralises acid as it is produced by the action of bacteria. The bacteria are selected for their ability to degrade high levels of H₂S and show optimum performance at pH 7.

The shells act as an active support media associated with a unique system of microbial inoculation. This system allows extreme diurnal variation treatment during periods of nutrient starvation. The system is particularly suitable for the treatment of high and fluctuating levels of H₂S (levels of 5,000 p.p.m. have been successfully treated at efficiencies of >99%). The process is also proving extremely effective for treatment of VOC's and nitrogen-based compounds. The mussel shells used are currently imported from the Netherlands. The potential for this application as a route for shell waste in Ireland has been considered, but low volumes of Irish mollusc shell waste prevent it being considered a viable source. The production of Monashell requires large volumes of consistent, clean, shell material.

Other uses for shell waste include aquarium gravel, chicken grit, mortar and stucco mix, road construction, artificial reefs or cultch for bottom cultivation.²⁸ In these alternative applications there remains a need to minimise the amount of associated soft organic waste. For the type of mollusc shell waste produced by the Irish industry, composting of the waste appears to be the only viable recycling option. The resulting compost would be a calcium – rich compost and could be marketed as such along the same lines as the North American products described in Box 3.

²⁸ See the Pacific Coast Shellfish Grower's Environmental Policy Statement (http://www.pcsga.org/_ECOP/EPS.pdf).

6.2 Reuse as a Human Food Product or By-Product

While a precise division between recycling and reuse of seafood products and by-product is not apparent in the literature, an appropriate split appears to be by the care taken in dealing with the waste. For regulatory compliance material intended for direct human consumption must remain as part of the quality management (HACCP) system, i.e. it must be treated as a food rather than a waste throughout the chain from producer to consumer.

This section describes re-use options for material with the potential to be reused for human consumption, although not all the end-uses described are as food items. It is increasingly recognised that many materials of marine origin contain compounds and elements with beneficial properties as pharmaceutical and nutraceutical (relating to nutrition) products. The list of uses described below is not exhaustive as new opportunities are continually being identified and researched.

The following is a list of some potential seafood by-products²⁹: *Surimi; Fish oils; Fish liver; Fish gelatine; Fish glue; Fish leather; Chitin and Chitosan; Pearl essence; Mother of pearl; Flavourings; Fish Mince*. Some of these options that may not already have been considered by processors, are poorly understood or are thought to be feasible with Ireland's seafood waste arisings are discussed below.

G. Additional Food Products

In attempting to optimise yield (see previous section on waste minimisation), many processors will have already investigated options for additional revenue from their off-cuts and waste material. New markets, processing technology and resulting products are emerging to satisfy more diverse tastes and demanding consumers. Traditionally conservative domestic consumption, particularly of seafood, is changing due to an increasingly global culture, more interest in cuisine and increased foreign travel.

A number of suggestions for further processing and use of 'waste' fish are described below. Critical issues for all of the suggestions below are:

- Maintaining quality of material as a food product (within the QC chain)
- Consistency of supply
- Sufficient volume
- Establishing linkages with secondary food processors
- Effort to investigate and target potential markets (likely to be export markets)

²⁹ From "Animal By-Product processing and utilisation", Ockerman HW and Hansen CL, 2000, 523 pp, CHIPS.

Surimi

Surimi, a word meaning “washed fish”, first appeared four centuries ago in Japan, where fish fillets were crumbled, rinsed in fresh water, seasoned, then shaped and salted to obtain little cakes which were steam cooked. The method is still similar today, generally with whitefish such as hake, bream and whiting being used³⁰.

Modern surimi production is generally focused on large volumes of consistent waste material as the end product price is set by colour, texture and homogeneity of the surimi and it's ability to be cut and shaped as desired. Early European markets for surimi were limited to crab sticks and additions to 'seafood cocktail'. However the increased interest in Japanese cuisine in recent years has contributed to the expansion of surimi-based products and consumption has increased in many European markets.

For Ireland the production of surimi as a solution to waste reuse appears unfeasible as waste streams lack the volumes and consistency of supply (especially of whitefish) necessary to maintain a viable surimi plant that is competitive with existing production in the Far East.

Fish Mince

The term 'fish mince' refers to ground fish produced from small scraps and bone scrapings. Gadoids are the primary species group to undergo this form of processing due to their firm, pale flesh. A primary requirement in the production of fish mince is a deboning machine. For large producers of trimmings, mince may be produced as an additional product in itself to be sold on to value-added processors. For smaller scale operators economic benefit can be found in creating some form of added value product from the mince.

A spectrum of quality grades exist from fillet mince (produced from whole fillets) to V & J cut mince (from the cuts made to remove pinbones from fillets). This 'trim mince' is often used as ingredients in chowders, fish cakes and sausages.

³⁰ “French surimi market, 2001” GAIN report no. 1017, Global Agriculture Information Network, US Department of Agriculture.

Darker, stronger flavoured varieties of mince are produced from material including off-cuts with bloodspots and belly-flaps or 'frame mince'. These minces are as likely to enter the pet food market as go to human consumption, but quality and labeling requirements are similar. All varieties are required to be adequately labelled for species and type of mince as well as storage temperature and date.

Authors suggest that for whole, gutted gadoids, trim mince can comprise around 4 to 5% of wet weight with frame mince comprising around 10% (around half of the weight of the bones could be recovered as reasonable quality frame mince).³¹

A number of Irish processors are already producing value-added products using fish mince. There is however potential to develop this value-added market and increase the amount of processing waste going to mince through improved industry linkages and improved waste handling in order to maintain product quality. To do so would require many changes; not least procedures to ensure the transfer and potential aggregation of material can be done safely under hygienic conditions.

Fish Sauces and Flavourings

The production of fish sauce and other derivatives is a major disposal route for trashfish³² and fish waste in South East Asia. Fish sauce is a staple food ingredient in many Asian dishes and consequently the market for this and related products is vast. The increasing popularity of Asian cuisine in the rest of the world means that it has become a growing global market. It is unlikely, however, that producers outside Asia would be able to compete with existing manufacturers. For such enterprises to be feasible, clear differentiation with suitable branding and a focus on high value domestic markets is required.

Large food processing companies will utilise suitable parts of raw material to flavour soups and sauces, either directly or more commonly following the further processing of material into stock or pastes. One Irish company, Icon Foods, Co. Sligo, specialise in producing flavourings, pastes and stocks from dehydrated fish and shellfish ingredients. It is also understood that an Irish prawn processor already exports prawn shells to a fish paste manufacturer in France. As with all food for human consumption, the material must remain within the supplier's quality control (HACCP) system as well as the end users.

³¹ "Improving the profitability of Finfish Processing Waste" Goldhor, S. & Regenstein, R., 1991, New York Sea Grant Programme (NYSG-T-91-001).

³² A misleading term referring to fish unmarketable for human consumption that is used directly in aquaculture feed or in fishmeal and by-product production.

Increases are anticipated in the markets that such products supply (pre-prepared foods, ready meals) and the freshness and quality of material used is of growing importance to consumers. The current barrier to developing such supply is again quality and consistency of raw material. Fish processors must treat their waste as a food product in order to supply these processors and conform to their HACCP requirements. This reuse option is suited to specialist processors with one or two consistent types of waste rather than processors dealing with a variety of species.

Specialist Asian markets exist for off-cuts, roes and milt that would be discarded by most western consumers. A 'kiriimi' cut, for example, retains the roe sac in the fish and markets exist with Japanese buyers for flatfish 'ribbons' (strips of muscle around the dorsal fins). A limiting factor for Irish processors is the marketing of material to prospective buyers in a timely fashion. However some seasonal opportunities can be anticipated in advance allowing for linkages to be established. The main issue will again be ensuring sufficient volume to justify the marketing effort.

For mixed processors the establishment of close linkages with secondary processors could prove beneficial as product (such as chowders, fish cakes, etc) may be able to be developed on a seasonal basis to deal with off-cuts or offal associated with particular species.

H. Pharmaceutical Products

The full extent of the wealth of marine compounds is still to be realised, but many products of marine origin are already used by the pharmaceutical industry. For example salmon DNA is currently being extracted from roe and marketed to the pharmaceutical industry (BioTec, 1998). There are many thousands of compounds now known of and found in a wide variety of marine species from commonly harvested temperate fish species to rare deepwater corals. The various properties of these compounds are the subject of a great deal of research and investigations into their potential applications lag behind.

A note of caution is necessary here. It is important to recognise the wide gap between potential future applications and existing commercial uses. A market only exists for raw material that supports existing uses not potential future uses. Market forces also dictate the amount that can be gained from a waste product – anything that occurs commonly in large quantities will have a lower price than rarer material. A processors waste material is never likely to be worth its weight in gold to the processor themselves as a great deal more work is required to extract the individual compounds of great value to the pharmaceutical industry.

A priority for pharmaceutical companies is purity. Level of purity will determine whether a product is acceptable as pharmaceutical grade and what price it can command. Achieving the necessary high levels of purity creates significant cost factors for the processor and requires a change to the mind set and the manufacturing process that treats fish by-products as waste.

Two well-documented marine-sourced products are chitin and chitosan. They are presented below as an example of the issues associated with many potential by-products.

Chitin and Chitosan

Two of the most versatile compounds and the focus of intense research effort in recent years are chitin and one of its derivatives, chitosan. New uses for the compound, the second most abundant organic compound on earth after cellulose, are being found all the time. Recent studies have gone beyond pharmaceutical applications to even consider its use in the production of optical fibers³³.

First discovered in 1811, the commercial exploitation of chitin did not really develop until the late 1960s. Since then, there have been many commercial applications including the treatment and purification of drinking and waste waters, shellforming and encapsulating materials, complex formation with heavy metals, photographic, paper, food and textile processing and as a film-former in hair treatments. Special purified chitosan derivatives are also used during surgical procedures and as a blood dialysis membrane. At present glucosamine is the most sold derivative of chitin, and most of the material is sold into the dietary supplement markets for preventing and curing rheumatoid arthritis.

Some Pharmaceutical Applications for Chitosan

1. Surgery: (a) As a haemostatic agent, has potential application in neurosurgery on account of its bio-degradability and tissue compatibility.
(b) To arrest bleeding of extra dural region of sinuses.
2. Dentistry: to arrest bleeding after extraction of teeth.
3. Medicine: (a) Bio-degradable sutures; (b) Artificial skin; (c) Contact lenses; (d) Hypocholesteremic activity; (e) Increase immunity; (f) Anticancer activity; and (g) Wound healing agent in tropical skin ointments and bed sores.

³³ "Optical Fibers from the Sea" in "Research Horizons", a magazine published by the George Tech Research Institute, 2001.

Chitin and therefore chitosan is primarily recovered from the shells of marine crustacea such as prawn and shrimp in which chitin makes up some 20% by dry weight. The proportion of chitin in crab and lobster shell is lower and dominated by calcium carbonate.

In many commercial extraction processes, the protein component of the shell is removed first, followed by the chitin. Fresh prawn waste thoroughly washed in potable water and minced, is treated with chemicals in controlled conditions to obtain a semi-solid mass. This semi solid mass is vacuum dried and pulverized to a fine powder. The protein obtained is found to be safe for consumption by human/animals, meets all the bacteriological/chemical standards. It is also rich in minerals like phosphorus and calcium.

The remaining mass is treated with chemicals once again to obtain pure Chitin. A colourless chitin, if required, can be obtained by using suitable bleach in the process. The Chitin is treated with appropriate chemicals at controlled conditions for conversion of chitin to chitosan. The chitosan of low viscosity is obtained from commercial prawn shell however, for medium and high viscosity special grade Chitosan for specified end use, the process can be modified and quality control measures are adopted to obtain the desired quality of chitosan.

Japan is the world leader in the production of Chitosan (many facilities located in China) with around 90% of a global market worth 4 trillion yen/yr (34.6 billion Euro). The US is also an important producer. Growth has occurred due to the refinement of processing to reduce impurities. Buyer requirements for prawn shells stipulate acceptable levels of moisture (< 10%) and foreign material (< 3%). The properties of chitosan depend largely on the quality of the raw material and its processing. Consequently prices for chitin and chitosan range from 5 Euro for agricultural grade to 300 Euro per kilogram for some pharmaceutical grades.

Today's markets for chitosan in North America and Europe are moving most of the available products into dietary supplement and cosmetics applications. Both of these applications require properties like high purity, high binding capacity and high viscosity. The slow growth of the industry is partly attributable to the negative effects of patents slowing down market development and also the attempts to use chitin products as substitutes for existing ingredients rather than developing novel uses.³⁴

³⁴ "Chitin from Shellfish Processing Waste – Health Benefits Overshadowing Industrial Uses!" Subasinghe, Infofish International, March 1999.

Box 5: Improved Utilisation of Shellfish Waste

Canada*

To ensure better utilisation of all fish resources, the Canadian government prohibited the dumping of shellfish waste. The enforcement of this regulation will be phased in over a two-year period beginning in 2002. In addition, the Department will not restrict existing producers from the crushing and drying of shellfish products however, such processing must be carried out under a processing licence. The intention is to allow for the development of infrastructures that could supply prepared raw material to the industry and provide opportunities for other processing operators.*

A limited number of licences have been issued to companies wishing to produce shellfish waste by-products such as chitin. This will ensure each licensee has the potential to access sufficient raw material to be viable. One processing company, Bio-polymer engineering, has developed agreements with Canadian fisheries that should supply them with around 750 tonnes of chitin annually. They also own the majority of government licenses to harvest langostino, a small lobster-like crustacean that yields high-quality chitin, in waters off Central America. It is estimated that this source could yield 10,000 tons of chitin annually.

**From Newfoundland and Labrador Minister press release on granting shellfish processing licences...*

Northern Ireland**

*Researchers at Queens University, Belfast have been working on the improved utilisation of prawn waste (*Nephrops norvegicus*) associated with this important Irish Sea fishery. A spin-off company, Carapacis Ltd., is now licenced to use the biological process developed (as opposed to the chemical processes that dominate production in Japan and China) to extract the protein, pigment and chitin from the prawn shell waste.*

A 450 litre container can handle 150kg of fresh shell waste and operate on a 6 day process, but this time can be further reduced. Good markets currently exist for the protein and pigment as components in feed for the salmon industry, but marketing of chitin products has taken longer to develop. A variety of pharmaceutical opportunities are also being considered including the combination of prawn shell waste and chicken hatchery shell waste.

A small number of prawn processors are currently linked to the operation, but this is expected to grow as the technology is refined and alternative disposal options are reduced. The potential exists for these 'bioreactors' to be placed in ports where prawn is landed and processed as a centralised facility for the treatment of shell waste.

**Pers. Comm. Dr. M. Healy, School of Chemical Engineering, Queen's University, Belfast.

The difference in value between the newly developed high end products and the low-cost polymers that dominated the industry in the past is one of the main driving forces pushing studies on new applications of chitin and chitosan. Biotechnology sectors in a number of countries in the Far East, Norway, Canada and the US are currently attempting commercial-scale production of high-value bio-products from seafood waste. These countries already engaged in research into re-use of seafood waste are characterised by large volumes of specific waste types associated with commercial fisheries or aquaculture.

In contrast to the countries mentioned above, currently there are no Irish biotechnology sub-sectors that focus on seafood. This is unsurprising given the comparatively small size and varied species of the Irish seafood industry. Research efforts with commercial potential in Ireland are likely to result from addressing specific problems, such as the disposal of prawn shells in the North (see box 5). Even in this instance the purification necessary for the pharmaceutical-grade products would entail further cost, which is currently prohibitive.

The benefit of extracting high-value pharmaceutical products is matched by the extremely large capital costs associated with the extraction process, chemicals and laboratory facilities as well as long lead-in times for R&D and clinical trials.

In Norway over the last decade there has been a concerted effort to develop a sub-sector of the biotechnology industry utilising fish waste. For Norway, with many isolated communities highly dependent upon fish and a GDP where fish makes up around 7% of the total, the foundation of RUBIN in order to gain value and improve utilisation of landed or farmed fish was a logical step. Box 6 presents more information on RUBIN.

Future potential in Ireland is therefore likely to be dependent upon advances elsewhere without large-scale public sector funding of focused research in biotechnology. This seems unlikely for the seafood processing sector, which although growing, remains comparatively small in GDP terms. There are, however, a number of funding routes for Irish researchers wishing to investigate biotechnology linked with seafood, such as from the Science Foundation Ireland (www.sfi.ie).

Greater potential is associated with technology transfer or the export of raw material to established facilities. Future increases to ensure volume associated with consistency of supply appear most likely in aquaculture.

Nutraceutical Products

Probably the most accepted and widely-used nutraceutical product is cod liver oil. It exemplifies nutraceutical products, being a dietary supplement and considered somewhere between a food and a drug. Consequently these products do not require the extensive clinical tests necessary for pharmaceutical products and this has resulted in a myriad of products derived from marine-organisms with health-promoting claims.

The most successful compounds in this group of products are omega-3 oils. These are long chain fatty acids recognised as having beneficial health properties when consumed directly from oily fish. However, changing European and North American consumer tastes have caused our consumption of oily fish species to decrease. Omega-3 oils are therefore extracted from these species and taken as a supplement, added to 'functional foods' such as margarines or fed to animals, which are then consumed.

A number of processing companies in Norway and Canada have recently been established to develop marketable products from waste fish.³⁵ Much of the research was carried out under state programmes focusing on maximising the utilisation of fish waste. Many companies are now commercially viable with products developed and markets in place. The critical factor appears to be ensuring sufficient supply of raw material.


Box 6: Development of Marine By-Products in Norway – RUBIN

RUBIN was founded in 1992 by the seafood industry, fishermen and the research council with funding from central government. In 1998 ownership was handed over to the seafood industry and fishermen's association. The organisation is the coordination and management body for the industry in the development of marine by-products. The aim is to fully utilise fish and add greater value.

The primary focus to the work is research, establishing clusters, improving raw material handling, developing potential by-products and establishing markets for those products. The utilisation of fish waste has undoubtedly increased since the establishment of RUBIN despite raw material decreasing since 1996. Fishmeal and silage production accounts for 77% of utilisation while 10% go to consumer products such as food ingredients, pharmaceuticals or nutraceuticals.

It is still to be seen if the substantial investment of public monies will create a significant new sector assisting in the development of sustainable fishing communities.

³⁵ See www.maritex.com, www.oceanbiosource.com, www.ocean-nutrition.com, www.scanbio.com.



It is clear that a philosophy of maximising the usefulness of the raw material exists in certain companies. Many other products are extracted in addition to oil including bones ground for nutraceutical products (calcium supplement), roe (for caviar or bait fishing), stomachs for human consumption in the Far East and potassium salts derived from milt. Remaining material without a reuse opportunity is ensiled and further processed to protein-rich products and oils.

It is also clear that the volume of these by-products must be sufficient to justify further processing, marketing and transport for onward sale. For Irish processors, volumes are generally too small to justify investment in extraction processes, particularly in the current climate of supply shortages.

Future growth in the salmon industry may present opportunities for salmon-based products. A variety of salmon oil products have been developed including encapsulated omega-3 enriched health supplements which are marketed world-wide through health and natural food stores, pharmacies and even supermarkets (Ocean Nutrition Inc., Bedford, NS, Canada). The products developed so far are generally based on the large capture fisheries of North America rather than from aquaculture production, but this may change in years to come as salmon production reduces the use of chemicals and medicines, adopting organic codes of practice.

7.0 Waste Management by Industry

In the near future greater regulation of waste management of fish processing and aquaculture operations will be introduced with the onus on the operators themselves to arrange appropriate 'disposal' of waste material. This 'polluter pays principle' will mean that neither collection nor disposal of commercial waste by local authorities is likely. Waste management will therefore be an issue that must be addressed by all commercial operators and will become an increasingly significant operational cost that may make a difference to viability and competitiveness.

Within EU policy, there is emerging recognition of the need to move beyond policy and legislative control measures aimed at addressing the management of waste streams generated inside the factory gate, in order to focus more holistically on waste issues at all stages of the product life-cycle³⁶.

The European Commission is currently developing a policy that would facilitate the evaluation of a range of environmental impacts during a products lifetime. Known as the Integrated Product Policy (or IPP), this policy recognises the importance of integrating environmental issues at the product design stage (eco-design) and the role and responsibility of manufacturers in ultimate disposal of the product.

Waste management decisions made by industry are based on the costs and benefits of options. Compliance with regulations can also be reduced to fiscal arguments relating to the perceived risks of being caught and subsequent penalties. It is anticipated that waste management regulations will be enforced with increasingly large penalties for non-compliance after operators are given time and assistance to bring their procedures into line. One of the main short-term introductions will be the expansion of the Integrated Pollution Control (IPC) licencing scheme to include more sectors and smaller operators.

In addition to a stricter regulatory climate, the processing industry is likely to face shortages of raw materials that will only be counteracted in part by increases in aquaculture production. There is also likely to be increased competition from EU and non-EU processors.

7.1 Environmental Management Systems

All of the above point to a need for Irish processors to improve their waste management procedures as part of wider improvements to efficiency. Processors should therefore undertake or commission waste audits. This should be on a scale appropriate to the business and current or anticipated disposal costs with larger processors possibly undertaking audits within the implementation of Environmental Management Systems (EMS).

³⁶ "Key waste management issues in Ireland" Forfas, 2001

As box 1 (page 78) illustrates, many seafood processing companies around the globe have achieved substantial savings based on the findings from waste audits. Conducting a waste audit will quantify production processes in order to establish where savings may be possible. The audit should calculate the scale of potential savings and compare these to the costs of implementation.

A logical step for larger processors would be to integrate the findings from the waste audit into a more holistic Environmental Management System. EMS encourages processors to consider the entire lifecycle of a product by addressing waste issues associated with suppliers, packaging and distribution as well as the product itself.

An increasing proportion of customers will require evidence of traceability, quality and environmental management systems from suppliers. It is therefore in the processors current and future interests to implement systems and have those systems recognised by customers either through their own marketing efforts or by accreditation.

A starting point for industry is to consider cleaner production opportunities; these are generally low or no cost options that may be implemented to reduce energy, water and waste costs as shown in table 7.1 below.

Keep work areas tidy and uncluttered to avoid accidents.

Maintain good inventory control of raw ingredients.

Ensure that employees are aware of the environmental aspects of the company's operations and their personal responsibilities.

Train staff in good cleaning practices.

Schedule maintenance activities on a regular basis to avoid inefficiencies and breakdowns.

Optimise and standardise equipment settings for each shift.

Identify and mark all valves and equipment settings to reduce the risk that they will be set incorrectly by inexperienced staff.

Improve start-up and shut-down procedures.

Segregate waste for reuse and recycling.

Install drip pans or trays to collect drips and spills.

Table 7.1: Checklist of General Housekeeping Ideas.

Source: UNEP Cleaner Production Working Group for the Food Industry, 1999

7.2 Establishing Viable Options

As an operator develops systems for environmental management they must make decisions with regard to which waste utilisation options are viable and appropriate to their operation. Figure 7.1 presents a decision tree illustrating how processors might apply the waste hierarchy to their own operations. The decisions are based on economics, so it is important to ensure that all costs associated with waste management are considered along with opportunities to reduce those costs.

The exercise assumes that disposal *per se* is no longer a viable option with dumping at sea or to landfill prohibited and penalties for illegal dumping of waste sufficient to prevent its consideration as an option. Collection by users (as bait or for fur farms) at no cost is assumed to occur where handling and transport costs to alternative outlets would exceed the revenue gained.

The focus is on gaining maximum revenue from the waste or at least minimising costs of disposal. Currently a disparity exists between operators in the North West – close to the Killybegs fishmeal plant – and operators elsewhere. For operators outside Donegal the costs of transport to the fishmeal plant reduces potential revenue from the waste the further from the plant the waste is generated. The volumes and distances involved are critical, particularly when compared to other waste utilisation routes. Some options may only become viable in conjunction with other waste producers such as farms (for anaerobic digestion), forestry (for composting) or other food processors (for economies of scale). Establishing the necessary linkages may prove problematic where potential partners are also competitors. In these instances assistance from public bodies and the establishment of third parties to deal with waste from a number of sources may be appropriate.

There are also situations where atypical waste loads may arise as a result of aquaculture mortalities or safeguarding public health. In these instances the usual disposal routes may not be available and a contingency plan is required. These are discussed in the next chapter relating to public bodies as special dispensation and assistance may be required by industry.

Prevent

Define Type of Waste Material

Can the Waste Material be Prevented? **Y** ▶

N ▼

Minimise

Can the Waste Material be Minimised? **Y** ▶

N ▼

Re-Use

Can the Material be Re-Used for other Purposes on Site? **Y** ▶

N ▼

Can the Material be Re-Used by Others? **Y** ▶

N ▼

Recycle

Is Material Suitable for Fishmeal? **N** ◀

Y ▶

Does Price as Fishmeal Exceed Transport & Handling Costs? **Y** ▶

N ▼

Do Alternative Recycling Options Exist Locally? **Y** ▶

N ▼

Is Facility Capacity Sufficient for Waste Material? **Y** ▶

N ▼

Develop Composting or Ensilage Capacity* On-Site or Contribute to Central Facility

Remaining Within Quality Control (HACCP)



Shellwaste: Clean, Dry & Grind
Soft Material **Shell**

Undertake Marketing Effort or Seek Marketing Assistance

Send to Fishmeal Plant **Uses as Roadfill, Harling, Soil Conditioner, etc.**

Send to Recycling* **Compost**
Ensilage

*See Text for Feasibility of Development for Ensilage & Composting Capacity

Figure 7.1: Waste Management Decision Tree for Fish Processors.

7.3 Generating Revenue


In recent years there has been a great deal of press relating to valuable marine by-products. A number of reasons are cited for the renewed interest in fisheries by-products. First and foremost is the need to maximise the value of landings as increasing the volume is no longer seen as an option. Despite a wide spectrum of useful by-products that could potentially be extracted from fish waste, processors are still finding disposal a problem. How can waste from the Irish industry generate revenue rather than incur additional costs?

Generating revenue from the waste in localities where there is not currently a facility is likely to require a certain amount of investigation of local and export markets for by-products produced on site or raw material for producers of by-products. Revenue generation from the transfer of waste raw material to other operators is limited as those companies involved in production of by-products will be fully aware of the disposal problems faced.

Niche markets do exist for specific waste types and will require investigation into quality requirements associated with export markets and the establishment of linkages with traders. Assistance from public bodies would be useful in establishing market opportunities and export links. It is probable that processing procedures will need to be adapted to isolate specific wastes (such as fish offal products) and improve the handling and storage of that waste for sale. These niche markets can add value and reduce waste, but they are unlikely to solve the current problems associated with bulk fish waste disposal.

With other reduction and utilisation options already implemented or found to be uneconomic, the recycling of biodegradable waste to fishmeal, ensilage or compost is the remaining option. Centralised facilities require sufficient volume and an appropriate location. Investigations suggest volumes would not justify a second fishmeal plant in the South, leaving compost or ensilage.

Both composting and ensilage are treatments that can be undertaken at a number of scales. With the development of in-vessel composting some of the disadvantages of composting (site availability, pest and odour problems) are removed, but start-up costs are greater (comparable to ensilage). The difference appears to lie in the market price of the end products.



Compost and ensilage in their crude form may go to land (used in horticulture and agriculture respectively) with little or no revenue generated as a result. Further processing of ensiled material produces protein-rich meal and fish oil, which are both highly marketable, but value depends upon the waste protein and oil content. The development of processing facilities for ensiled material is capital intensive and requires significant volumes to be viable. A processor or aquaculturist ensiling waste is therefore dependent upon links to a larger ensilage network to gain revenue from the sale of the waste for further processing.

Composted material has a greater market value when sold to private gardeners rather than in bulk. While Ireland undoubtedly has a growing market of gardening enthusiasts, the market research, product development, packaging and marketing required would discourage most seafood processors from becoming involved.

The over-riding message for industry is that in most instances any additional value gained from waste is proportional to the effort put in: to market research, additional processing, product development, marketing or all of these.

8.0 Waste Management – Public Bodies

Public bodies have roles in waste management to regulate, enforce, monitor and where necessary assist industry in their waste management efforts. Irish authorities are also likely to continue to provide infrastructure for waste collection and disposal for the foreseeable future, but only with regard to domestic municipal waste. Industrial waste, particularly solid waste must now be disposed of or paid for by industry itself.

The Irish processing industry is a sector targeted to grow and so increase its socio-economic contribution to rural economies. So even though the polluter pays principle encourages the costs of waste management to be allocated to the polluters themselves, assistance in dealing with new circumstances and compliance with new regulations could help this sectoral development.


The following section provides recommendations to public bodies with regard to their various roles in the utilisation of fish waste.

8.1 Infrastructure

Central government and local authorities are no longer likely to make waste treatment facilities available to commercial operators, other than wastewater treatment. Even for wastewater the future economics of treatment may point towards on-site treatment rather than paying charges to Municipal Sewage Treatment Works. Recent investigations into the current and future waste capacity in Ireland suggest that there will be a significant shortfall of state – operated facilities³⁷. Additional infrastructure will be required to deal with municipal solid waste. Alternative waste treatment infrastructure for commercial waste must therefore be found or established by the industry themselves.

Where there is a need for new treatment facilities to be established, a critical decision is to what extent waste is to be treated on-site and where centralised facilities would provide the economies of scale necessary. Seafood processors have up to now disposed of their waste off-site and are therefore inexperienced at tackling waste management themselves. The favoured option is therefore likely to be movement of waste off-site, but where regional volumes make centralised facilities unviable or site volumes make regular trips to such facilities unattractive, processors may choose to treat waste on-site. Those processors who opt to treat their waste at source will therefore require technical guidance.

³⁷ Strategic Review & Outlook for Waste Management Capacity and the Impact on the Irish Economy, Peter Bacon & Associates, July 2002.



It is not enough for authorities to simply implement legislation in this instance as many waste recycling facilities refuse to accept seafood waste or the costs applied to disposal at these composting or rendering facilities exceed the cost of transport to the Killybegs plant. Without assistance in redressing the competitive balance, there is the potential for processing activity to increasingly centre around available recycling facilities, i.e. Killybegs, and the benefits to isolated communities elsewhere will be lost.

Even where recycling facilities are developed to cater for waste from the seafood sector, there are likely to be instances associated with mass mortalities in aquaculture where alternative disposal options or additional capacity is required. These additional facilities would only be required infrequently making commercial operation uneconomic. As part of contingency plans (see emergency guidelines section below) established in collaboration with industry, however, centralised facilities could be designed to deal with mass mortalities from aquaculture.

Ensilage appears to be the most appropriate option to deal with 'high' and 'low risk' aquaculture mortalities, although these different categories of material would require separate facilities. Large-scale facilities that are grant-aided should be capable of accepting high-risk waste resulting from any mass mortality incidents. Dealing with this waste can be seen to be for the public good as treatment will minimise negative environmental effects and help to avoid the cost of such an event bankrupting local aquaculture businesses.

An essential piece of infrastructure still to be provided by the state is the transport network. The road network in particular will have a significant role in the economic viability of waste treatment options. Improvements to the national road network will reduce transport times and therefore costs, making the provision of centralised facilities, including the existing fishmeal plant, more attractive as the waste catchment area is increased.

8.2 Assistance to Industry

Considering the volume, variety, dispersion and seasonality of seafood waste being created around Ireland it is clear that certain utilisation options seen at major fisheries centres elsewhere in the world are not viable. It is also evident that government targets and legislative changes are likely to result in a demand for waste utilisation options that already exist as many have already been investigated and novel disposal routes are likely to take too long to develop.

Processors require immediate assistance in conducting waste audits. In line with the “Changing our Ways”, authorities should consider the prevention and minimisation of waste a priority and provide technical assistance to processors in order to accelerate the implementation of waste management measures.

Additional assistance in the form of economic incentives is given throughout the world to encourage the adoption of improved waste management practices. North American authorities subsidise composting schemes so that the facilities can either pay for waste or minimise gate charges for waste reception. The intention is to maintain the viability of a centralised facility while a network of waste suppliers can be established and markets for end products are developed. Ultimately such centralised facilities must prove to be viable without public sector support, but assistance in start-up has been found to be necessary in many instances.

A number of other economic incentives are potentially available to public bodies to encourage better practice. Tax incentives can be based on a simple rate reduction for those implementing sound environmental management or may be directly linked to the end products of improved utilisation to make them more competitive in the market place.

Setting the correct level of economic incentive is essential, as the recycling of waste should not be made more economically attractive than preventing that waste in the first place. It is therefore prudent that financial assistance to the industry of any type, be it a grant for waste treatment facilities or economic incentives for improved utilisation, should be preceded by waste audits being conducted.

Public bodies can ensure that the most appropriate measures are being taken by industry by:

- Individual waste audit being carried out is a prerequisite for funding (either undertaken by the competent authority themselves, or by approved evaluators).
- Establish best practice guidelines for waste audits and seafood waste management.
- Supporting centralised facilities at start-up based on feasibility study being undertaken that illustrates the future viability of the operation.
- Establishing a core of waste management expertise that is accessible by industry.

While the capital costs and R&D required for the development of high value by-products suggest that such products are not the immediate answer, research funding should be committed to improved utilisation and the development of novel products. Support to Ireland's biotechnology sector has the potential to create benefits that result in the sector becoming as significant to rural employment and some local economies as the fisheries and processing sectors are now. Indeed, support to one may create additional benefits for the other.

The Competent Authorities should also undertake market research into by-product markets (scale, quality, handling, seasonality, prices) and provide assistance to potential exporters of by-products.

8.3 Regulation and Enforcement

The regulatory climate is attempting to avoid the disposal of material wherever possible and this has resulted in local authorities no longer accepting fish waste. While this decision has been taken to stop this 'easy option', few decisions have been taken to facilitate alternative waste management strategies for the seafood sector.

With the current lack of facilities for producers of fish waste outside of the North West, processors are faced with large transport bills to operate legitimately. The result is an increase in illegal dumping of seafood material and the inappropriate use of sea disposal as a waste route.

Regulation and the interpretation and enforcement of that regulation should take into account the options available to industry and consequently should be integrated with assistance to the industry. The recent regulations from the EC on disposal of animal by-products are still to be fully clarified and implemented by the Irish authorities with respect to fish waste arisings in Ireland.

It is clear that although most fish waste will be seen as low risk 'category 3' waste, certain situations will result in higher risk fish waste. In these instances alternative contingencies are necessary and these are discussed below.

8.3.1 Contingency Planning

Some problem wastes remain where specific disposal guidelines are necessary to avoid risks to public health or the transfer of disease. These include finfish aquaculture mortalities resulting from detected or anticipated disease outbreaks, such as ISA and area closures associated with biotoxins that accumulate in shellfish.

Mass mortalities of aquaculture species causes specific problems in waste management terms as large volumes of waste are produced in a very short time period and that waste may well be deemed unsafe for disposal by the usual methods. Many mass disposal problems associated with the culture of fish and shellfish are caused by harmful algal blooms (HABS) that either kill the culture species directly due to elevated biotoxin levels, increase the environmental stress by reducing oxygen levels, or make the harvest unsafe.

Guidelines for contingency planning associated with aquatic animal disease outbreaks are presented in the "International Aquatic Animal Health Code" (2002) by the Office International de Epizooties (OIE)³⁸ and propose that contingency planning should include instructions for:

1. Diagnostic procedures in national reference laboratories;
2. Confirmation of diagnosis, if necessary, at an OIE Reference Laboratory;
3. Standing instructions to aquatic animal health personnel in the field;
4. Instructions for handling/disposal of dead aquatic animals at an aquaculture establishment;
5. Instructions for sanitary slaughtering;
6. Instructions for disease control at the local level;
7. Instructions for the establishment of quarantine areas and observation (surveillance) zones;
8. Provisions for controlling movements of aquatic animals in established zones;
9. Disinfection procedures;
10. Following procedures;
11. Surveillance methods for establishing successful eradication;
12. Re-stocking procedures;
13. Compensation issues;
14. Reporting procedures;
15. Provisions for raising public awareness of aquatic animal disease.

³⁸ http://www.oie.int/eng/publicat/en_aqua.htm

8.3.2 Salmon Culture

Guidelines relating to mortalities exist for salmon culture in all the major salmon growing countries. Morts resulting from disease or disease contingency are either removed from the food chain completely or treated in such a way as to sterilise the waste. It is broadly accepted that acid ensiling of such waste is sufficient to sterilise the waste. Norwegian authorities recognise that the inter-species transmission of diseases such as ISA is not possible and this waste can therefore still be used in feed for other species (such as pig feed).

In Scotland mass mortalities not due to disease (ie. due to operational accidents, jellyfish or HABS) are currently sent to fishmeal, while disease morts must be incinerated or go to ensilage. The forthcoming EU regulations could require all morts to be ensiled whether disease-related or not and it is currently unclear whether the resulting ensiled material can be used as feed for other species.

8.3.3 British Columbia

As part of the salmon aquaculture review – a comprehensive study into all aspects of the industry – a study into waste discharges was undertaken.³⁹ Estimated quantities of fish mortalities are 20% for all species and all causes for 1994. Mortality rates are apparently lower for Atlantic salmon than for chinook and coho.

Almost all morts disposal occurs off-site, by composting and ensiling at three licensed facilities in British Columbia. Documented methods range from on site landfill operations to off-site rendering for compost. Contractors are hired to remove morts from the farm site on a regular basis. Virtually all morts are taken to one of two self-sustaining commercial composting facilities: one operated with UBC by a company at Oyster River near Nanaimo, and Bio-Waste located at Black Creek, British Columbia. A facility near Port McNeill was opened in 1995. The Oyster River facility apparently has its compost tested regularly for heavy metals (Hatfield and EVS 1996). One or two very small salmon farming operations use off-site landfills; one uses on-site ensiling for pig food.

³⁹ Waste Discharges Discussion Paper (Part D). Prepared on behalf of the Environmental Assessment Office by Dr. Brenda Burd, Ecostat Research Ltd. and Research Associate, Oceanography Department, University of British Columbia.

8.3.5 Norway

The production of waste by-products and transportation of aquaculture waste in Norway is regulated by the Ministry of Agriculture. By Norwegian law, separate processing facilities must be established to handle either aquaculture waste or “open sea” waste but no one facility may handle both. Thus the potential for cross-contamination of raw material is minimised to keep the waste streams separate.⁴⁰

The ensiling process has been widely adopted in Norway where the ISA virus has been endemic for over 14 years. ISA along with other fish disease is not considered a high-risk in human health terms as it is not transmissible and this defines its disposal mainly to ensilage or fishmeal.

In Norway, animal offal is divided into two major categories: “high risk” and “low risk”. High risk offal includes farm animals which have died of disease, were destroyed in order to prevent the spread of disease, were still born, died in transport, were known to contain chemical residues at the time of slaughter or in the case of farmed fish, individuals which displayed clinical symptoms of transmissible disease or which reveal pathological signs of diseases upon inspection after death.

Special regulations pertain to the handling of high risk fish which normally ensures the thermal destruction of biological hazards such as bacteria, viruses and fungi. Special consideration is given to offal which may reasonably be expected to contain chemical residues such as therapeutic drugs and antibiotics. In this case, appropriate measures must be taken so as to ensure that the residues cannot re-enter the food chain.

High risk offal considered to contain harmful bacteria or viruses must be sterilised or incinerated. Many of these residues are not destroyed by heat sterilisation and therefore other methods of treatment must be developed. One suggestion has been the use of such “problem” waste as mink feed.

The *Regulations Relating to the Establishment and Operation of Fish Farms* provide that cleaning fish and storage of dead fish must not cause annoying odors or serious harm to the environment. The Regulations also prohibit dumping of fish or fish parts. Dead fish must be ground and preserved in acid, although other procedures may be approved if they are shown to better prevent infection and pollution. Dead fish must also be removed from the nets every day in the summer and every other day in the winter. If a fish farm has a high mortality rate or an outbreak of disease, dead fish must be removed every day.

⁴⁰ Waste from Processing Aquatic Animals and Animal Product: Implications on Aquatic Animal Pathogen Transfer by Tom A. Gill, Canadian Institute of Fisheries Technology, Dalhousie University, Canada.

The *Waste Treatment Regulations*, issued by the Ministry of Agriculture under the Interim Fish Diseases Act, set out approved methods and equipment for the destruction of dead fish and wastes and the treatment of effluent from a salmon farm to prevent the spread of infection. Dead fish may be disposed of by incineration, burial at an approved site or delivery to an approved rendering plant. These Regulations also provide the criteria and procedures for approving other new methods and equipment for treating dead fish and effluent originating from aquaculture activities.

8.3.6 Scotland⁴¹

Aquaculture is under the competence of the Scottish Environmental Protection Agency (SEPA). The recent ISA epidemic in Scotland resulted in the formation of the joint Government/Industry Working Party on Infectious Salmon Anaemia to develop guidelines. A code of practice has been developed to minimise the risks of ISA (www.scottishsalmon.co.uk/pdfs/isa.pdf). The working party saw the ensiling of fish waste as best practice in reducing the risk of spread of the disease from waste material. This ensiled material is currently transported to bulk storage facilities in Inverness before being shipped to Norway for further processing to marketable products.

8.3.7 Shellfish Culture

A further problem waste is associated with biotoxins present in shellfish material. Two situations result in this shellfish management problem becoming a waste problem:

1. Hepatopancreas Waste

The shucking of molluscs such as scallops to remove the hepatopancreas, mantle and gills is carried out to avoid the biotoxins (domoic acid produced by certain marine diatoms) that build up in differing amounts throughout the various tissues of the mollusc. Approximately 90% of the toxin is found in the removed material (9% in the gonad and 1% in the adductor muscle) and this waste would therefore pose a risk if it were to re-enter the food chain. Returning the material to sea could also be seen as presenting a risk to animal (domoic acid poisoning has been cited as cause of death of mass sea bird mortalities) and human health and also contributing to future closures.

⁴¹ From regulation and monitoring of marine cage fish farming in Scotland – a procedures manual Attachment X Guidance Note on the Ensiling of Fish and Fish Offal.

The existing UK shellfish regulations already provide detail on waste separation and disposal. Final disposal of inedible parts of processed scallops must be by a recognised route to ensure that there is no possibility of waste entering the food chain (animal or human). Treatment by ensilage (to land), composting or anaerobic digestion is no longer possible for this waste if deemed category 1 waste and consequently will entail very strict disposal requirements.

2. Closure of Shellfish Waters

The closure of shellfish waters can pose a waste management problem as well as an economic problem to those involved in the shellfish industry. The inevitable lag-time of (usually around 2 days) associated with the diagnosis and closure of areas will result in already harvested shellfish being deemed unfit for human consumption. The prolonged closure of areas where rope culture occurs may also result in large volumes of waste being produced as lines must be cleared of the 'foul stock' and prepared for the next growing cycle.

The resulting waste presents problems, as it is a mix of shell and meat. The low value/high volume waste does not justify shucking (a manual process in Irish operations) and cannot be ensiled by acid easily due to the bulk being shell waste. Few options remain other than composting. Composting does not however lend itself to treating many hundreds of tonnes at once and special dispensation may be required for these events as part of a package of assistance to the industry.

9.0 Conclusions and Recommendations

The wide range of legislation that impacts upon disposal has resulted in apparent inconsistencies in the interpretation of permissible disposal routes for fish waste. The increasingly stringent regulations as a result of recent food scares include this waste, but state assistance in dealing with problematic animal by-products waste has not been extended to seafood. With fewer options available to them, businesses in the fish processing sector in Ireland are losing out on potential revenue and, sometimes unwittingly, disposing of material illegally.

Recommendation 1:

The Department of Communication, Marine and Natural Resources and the Department of the Environment should provide clear guidelines for industry on the interpretation of existing and imminent legislation to enable increased compliance with those regulations.

Under the raft of pollution prevention, wastewater and waste management legislation currently in place or soon to be introduced, fish production and processing units will be obliged to comply to more stringent regulations, be charged more for polluting activities and be more strictly monitored.

Recommendation 2:

Industry should take steps to address environmental and specifically waste issues through a waste audit. This action should be undertaken prior to remedial measures being made compulsory through legislation as significant savings can be made and the timescale of implementation can be controlled by the processor. For large processors this could be integrated within an Environmental Management System where such a system is deemed necessary.

Recommendation 3:

The competent authorities (EPA, BIM) should provide technical and financial assistance to the production and processing sectors in undertaking waste audits.

Total solid fish waste arisings are estimated to be around 64,000t. Pelagic waste accounts for over 60% of total waste by volume with the majority landed in the North West. Shellfish waste (crustaceans and molluscs) accounts for nearly 18% despite much being sold in-shell. Any declines in landings from capture fisheries in the last few years are compensated by increases in processing prior to export and growth in supply from the aquaculture sector. Steady growth in processing volume (and therefore potential waste arisings) is expected to continue in the medium term.

The majority of fish waste (66%) is sent for further processing at the fishmeal plant in Killybegs.

Over 18% of waste is currently 'disposed of' and 9% going to wet feed for mink farms. The former is expected to be prohibited or at least discouraged and the latter is seen by some as dubious. As a result, improved utilisation is necessary for an estimated 17,222 t of waste occurring outside the North West. Although much of the remaining waste is suitable for fishmeal, processors outside the North West are disadvantaged due to the high transport costs to the fishmeal plant.

Recommendation 4:

The Competent Authorities should provide technical and financial assistance to producers and processors wishing to establish waste treatment facilities. Such assistance should be provided following a waste audit acceptable to the competent authorities.

High risk wastes (disease-related morts) are sent to rendering plants for processing prior to export. This is an expensive option with fewer plants accepting fish waste since the removal of government subsidies to rendering plants for rendering fish waste. Salmon industry best practice favours ensilage as a method for safe disposal of high risk morts.

Recommendation 5:

Guidelines for the Irish aquaculture industry, including disposal of high risk waste, should be developed in conjunction with the Irish Salmon Growers Association.

In line with the waste management hierarchy, prevention and minimisation of waste is preferable to subsequent utilisation of waste. Operators and public bodies have not taken concerted action to tackle inefficiencies in the fish processing sector.

A wide range of low or no cost options for waste minimisation are applicable to the processing sector resulting in significant savings. Wastewater reductions of 30% are estimated in volume and concentration terms by implementing simple minimisation measures. It is more economic for high volume users to treat wastewater at source if local authorities increase charges to consider strength and volume of effluent.

Considering product development to incorporate more edible parts of the raw material and production changes to increase product yield will minimise solid waste.

A number of potential barriers to waste minimisation exist. For the Irish industry there are few external incentives or sources of assistance to implement waste minimisation measures.

See recommendations 2 and 3

There are a wide variety of potential reuse and recycling options. These range from reusing material for by-products or others recycling waste material by ensilage, composting or anaerobic digestion. The quantity, quality and frequency of waste along with the location of the facility will dictate the viable options for the Irish industry.

Few opportunities exist in Ireland for the development of high value by-products due to insufficient and inconsistent waste volumes. The short-term focus is therefore on ensuring any waste produced provides some revenue to processors rather than it representing a cost. This is already the case in the North West where payment for waste going to fishmeal exceeds handling and transport costs. The fishmeal plant has the capacity to receive all suitable waste arisings in Ireland. Disposal options are therefore dependent upon economics rather than capacity.

Volumes of pelagic landings and fish waste do not appear to justify a further fishmeal plant in Ireland, suggesting alternative options are necessary outside of the North West. The options of centralised facilities on a regional basis affording payment to producers and processors appear limited to ensilage. The region with sufficient volume of waste arisings (other than the North West) is the South West. The critical economic comparison is therefore between payment and transport for ensiled material versus transport to Killybegs and the gate price for fishmeal.

There are also certain waste streams such as shellfish waste which are unsuitable for fishmeal. For these wastes, separation of shell and meat material increases disposal options. Where separation is not feasible, recycling by composting may be appropriate as this can incorporate shell material.

Recommendation 6:

The Competent Authorities should encourage waste management networks on a regional basis in order to achieve the economies of scale necessary for viable treatment facilities.

Large government-funded schemes to improve the utilisation of fish waste are associated with a number of major fisheries centres throughout the world. The Irish processing sector does not have the scale to justify such large investment, but the Irish research sectors can learn from these existing efforts.

Recommendation 7:

Research into novel by-products applicable to the specific characteristics of Irish waste streams (highly dispersed, sporadic, low volume) should be supported.

Recommendation 8:

Market investigation into domestic and export market potential of resulting by-products is essential to determine viability and should therefore be a major consideration in any by-product R&D being supported.

Many within the sector currently fail to recognise the environmental and particularly the economic benefits of adopting the waste hierarchy principles. Although many uses exist for fish waste, the amount of additional value gained from waste is proportional to the effort put into market research, additional processing, product development and marketing.

Recommendation 9:

To accelerate improvements in waste management the Competent Authorities should initiate a scheme for the processing sector:

- clarifying the current and future regulatory requirements,
- providing information and assistance in waste auditing and EMS,
- illustrating the benefits of adopting waste management systems,
- developing guidelines with industry bodies for best practice in minimisation and reuse/recycling
- providing technical and financial assistance to those wishing to adopt waste management measures and improve raw material utilisation
- providing market intelligence on potential markets (domestic and export) for by-products
- providing marketing assistance to companies developing by-products for export markets.

Public bodies are unlikely to directly participate in the collection and treatment of organic waste produced by industry. It is up to the industry themselves to deal with the waste resulting from their operations.

Problem wastes including high risk morts and shellfish waste (mixed shell and meat) may occur at volumes where individual operators would not have the treatment capacity to avoid a public nuisance. For the aquaculture and processing sectors, increasingly important to isolated coastal communities, public provision of assistance is appropriate.

Recommendation 10:

Sector-wide contingency plans should be developed including ensuring sufficient waste processing capacity exists for the sanitary disposal of mass mortalities. The plans and guidelines should be developed in the light of clarification of current and impending regulations on waste disposal.



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