Strategic Waste Management and Minimisation in Aquaculture

Scottish Aquaculture Research Forum

Final Report

June 2008

Thistle Environmental Partnership

Acknowledgements

This project was commissioned by the Scottish Aquaculture Research Forum (SARF), and funded by:

- SARF;
- Highlands and Islands Enterprise (HIE); and,
- Highland Council.

The generous financial support of the above organisations is acknowledged.

This project centred around an industry survey and consultations. The survey was completed by a large proportion of the Scottish industry, with many companies providing very detailed returns. Many in the industry, as well as related stakeholders, were also involved in consultations. All organisations engaged with interest and enthusiasm, and their contributions were essential to the successful conclusion of this project.

It should be noted that this is an independent report which is presented in good faith and represents the views of the authors.

Contents

Executive Summary

1. This study aimed to provide 'ball-park' estimates of current arisings and disposal routes of the key Scottish salmon farming waste streams and to identify opportunities and barriers to improve waste management practices. It excluded wastes discharged under licence to water. The study included a survey, consultations and a workshop. Key findings are summarised below.
2. It is estimated that approximately 9,300[1] tonnes per annum (tpa) of waste arise from Scottish salmon farming. This is apportioned as: 59% from sea water routine wastes, 30% from sea water non-routine wastes, 11% from freshwater routine waste and a negligible amount of freshwater non-routine wastes.
3. There is a marked regional differentiation to arisings which is linked to differences in the scale of the industry on a regional basis.
4. Plastics and fish mortalities were estimated to be the two most dominant waste streams (around 35% each). Timber, paper and cardboard, and steel were each estimated at 8%, domestic wastes as 4% and special waste as 1%. Plastics included feed bags, cages, nets and feed pipes, whilst steel was mostly cages and walkways.
5. Approximately 59% of waste is landfilled, 18% recycled (or reused[2]), 18% incinerated with energy recovery, 2% incinerated without energy recovery and 2% disposed of to land. The location of waste management facilities does not reflect the location of arisings.
6. Some 95% of incineration with energy recovery relates to the disposal of fish mortalities at Widnes (estimated as about 1,630 tpa) which, although including energy recovery, is not considered sustainable due to the transport distance.
7. An infrastructure has developed for the recycling of feed bags from sea sites on the West Coast using boat transport. Feed bags from Shetland are sent to Hong Kong for recycling under a scheme operated by the Shetland Islands Council.
8. The consultations and workshop undertaken for this project indicated considerable concern about the lack of facilities for handling fish mortalities – both routine and event related – in Scotland. However, it is understood that a new plant located at Brechin, which will take ensiled fish mortalities for oil extraction followed by incineration, is just commencing operations. An assessment of the extent to which the initial operations of the Brechin plant will meet the need for a sustainable Scottish disposal route for fish mortalities should be undertaken. Depending upon the findings of this assessment, research into alternative treatment methods for fish mortalities should be undertaken as a priority, with the aim of gaining one or more technologies approved under the Animal By-Products Regulations. This should include composting, anaerobic digestion and rendering. Public and private sector approaches should be encouraged and external funding considered.

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1. It should be noted that results are based on survey findings and, whilst a relatively high response rate was obtained, especially from sea water sites, not all wastes were included by respondents and estimates were used. Figures are presented as 'ball-park' estimates and should be treated with caution due to the assumptions used in data extrapolation.

2. This excludes the upgrading and refurbishment of plastic cages which is an important element of reuse that was not captured by the survey returns.

9. This report recommends that an aquaculture waste working group should be established, with a sub-group for fish mortalities.
10. This report recommends that an assessment of the provision for mortality events and related contingency planning should be undertaken as a priority with external funding considered.
11. Fish farmers' representatives should open a dialogue with the Scottish Government to represent the industry in regard to the possible removal of the remote area derogation that allows disposal of fish mortalities to landfill on the mainland (due to the establishment of the National Fallen Stock Scheme) which would impact on several small companies regarding routine mortalities, and the industry in regard of event mortalities. The derogation should not be removed until viable and sustainable alternatives are put in place throughout the proposed areas capable of handling both routine and event mortalities.
12. The industry should engage with the Scottish Government and the European Commission in regard to the forthcoming review of the Animal By-products Regulations to consider whether a more appropriate approach can be developed for the aquaculture industry.
13. A research project into biosecurity issues in regard to the reuse of bags within and outwith the industry should be undertaken to identify the feasibility of feed bag reuse. Depending upon the results of this work, a pilot study should be set up to assess the feasibility of reusing feed bags within and outwith the industry.
14. There is the potential for considerably more redundant plant and equipment to be reused (recycled) than at present, rather than recycling by chipping for re-manufacture. This could be enhanced through the establishment of a scheme to put waste producers in touch with potential users and supported by a short annual symposium on waste management issues, perhaps included as part of the programme at fish farming conferences and exhibitions and a range of other measures recommended in the body of the report.
15. Plant and equipment should be designed to facilitate reuse (and recycling). It is recommended that a research project(s) is undertaken with industry collaboration.
16. There is considerable opportunity for the community recycling sector to provide a service to the fish farming industry and this should be encouraged. This activity could include provision of a mobile chipping service for plastic cages and redundant equipment.
17. To increase the sustainability of waste management, it is recommended that:

a) The industry should enter into a dialogue with the local authorities to improve the recycling service offered to fish farmers.

b) Research projects are undertaken to assess the potential impacts from anti-foulants on the reuse/recycling of nets, and into net longevity. Projects should be considered to assess the benefits and impacts of sea transport for aquaculture and related industries.

18. Regular information on waste arisings and disposal should be obtained for use by the industry and as a basis for policy decisions. This could take one of several forms including: an independent survey; combined with the FRS Annual Production Survey; and/or an enhanced SEPA cross sectoral survey.

19. A study similar to this should be undertaken in regard to fish processing, feed manufacture and other upstream and downstream elements of the supply chain.
20. It is recommended that the Scottish salmon [and other aquaculture] industry reports on its environmental impacts and initiatives, either as a cross sector report or reports by individual companies.

Chapter 1 Introduction

1.1 Scope and Objectives

Thistle Environmental was commissioned by the Scottish Aquaculture Research Forum (SARF) to undertake a project on strategic waste management and minimisation in aquaculture.

The objectives of the project were to:

1. Provide 'ball-park' estimates of current arisings and disposal routes of the key waste streams in Scottish aquaculture.
2. Identify opportunities and barriers to improve waste management practices for key waste streams in Scottish aquaculture in line with the waste hierarchy[3].
3. Develop scenarios to address the barriers identified in Objective 2 and exploit the opportunities for more sustainable waste management practices.
4. Present and discuss the project findings with selected stakeholders.

The project scope was restricted to Scottish salmon farming (freshwater and sea water). 'Key waste streams' were defined as: feed packaging plastics, plastic containers, redundant equipment, special wastes and fish mortalities. Effluent discharged under licence from tanks and cages and hatchery silage was excluded.

This approach to the project is detailed in Chapter 2, the findings in Chapter 3, Waste Arisings, and Chapter 4, Disposal Routes. A discussion of the findings is presented in Chapter 5, and Conclusions and Recommendaitons are presented in Chapter 6. Technical information is appended.

1.2 Previous Studies

Several previous studies have been undertaken in regard to waste management in Scottish aquaculture. Although this project did not include a literature review element, cognisance of these studies has been taken where relevant. Previous aquaculture waste projects in Scotland include:

- 'Fish Farming Waste Feed Bags Study,' by Thistle Environmental for Business Environment Partnership, 2004.
- 'Developing a Framework for a Sustainable Fish Waste Management Infrastructure,' by the Scottish Environmental Protection Agency (SEPA) on behalf of The Scottish Fish Waste Management Group, 2005.
- 'Aquaculture Waste Data Report,' by Thistle Environmental for SEPA, 2005.
- 'Fin Fish Disposal of Redundent Materials and Equipment Feasibility Study (Phase 1),' by m^2 Consulting for Shetland Amenity Trust, 2005.
- 'Fin Fish Activities, Disposal of Redundant Materials and Equipment, Best Practice Guidelines,' m^2 Consulting for Shetland Amenity Trust, 2005.
- 'Aquaculture Waste Minimsiation Guide,' Thistle Environmental for SEPA, 2005.

[3] A concept used by policy makers, business and organisations to identify in general terms the most appropriate environmental option for waste management, from waste minimisation (the preferred option), followed by reuse, recycle/compost, recovery and then disposal (the least favoured option).

Chapter 2 Approach

2.1 Introduction

The project comprised three phases which are detailed below:

i) Fish farm survey;

ii) Consultations; and,

iii) Workshop

2.2 Fish Farm Survey

Data and information to meet the requirements of Objective 1 were obtained from a survey of Scottish salmon farmers. Two self-completion survey forms were developed, based to some extent on the SEPA 2005 project (Thistle Environmental, 2005) and the current SEPA waste data survey[4]. The first form was aimed at freshwater tank/hatchery sites and the second at cage sites (freshwater and sea water). The latter was designed at the shore base level[5] which was considered more appropriate for aggregating data as described later in this section. Both questionnaires (included as Appendices 1 and 2) covered similar topics, including:

- Introduction to the project
- General company information
- Feed bags
- Waste plastic containers
- Special wastes
- Redundant plant and equipment
- Fish mortalities
- Skipped waste
- Wooden pallets
- Other comments
- Classification data
- Contact information

One difficulty with interpreting data on waste from sea water salmon farms is normalisation, i.e. assessing waste arisings in relation to unit of production. This is because the timescale of production does not easily fit into year long segments[6] and waste arisings are not uniform over the production cycle. For this reason, a shore base approach had advantages, since the averaging of data across a number of individual sites would help render anomalies less significant. This is not an issue for freshwater salmon farms since production can be considered on an annual basis.

Questionnaires were sent to a total of fifteen fish farming companies in Scotland. These were selected to be representative of the nature and types of Scottish companies as well as accounting for a large proportion of total production (approximately 96% of Scottish sea water production by tonnage, and the majority of freshwater).

[4] SEPA undertakes a waste survey of commerce and industry on a three yearly basis. The first survey in 2004 did not include fish farming, although the recent survey of 2007 did. Whilst the findings from the recent survey are not yet available, it is understood that the response rate from fish farmers was limited (SEPA, 2008, pers. comm.).

[5] Most (but not all) Scottish sea water operations are grouped around shore bases. These bases provide support functions (such as warehousing, maintenance, office and staff facilities) to one or more sites (typically between three and six).

[6] Smolts are typically ongrown at sea for a period of between 14 to 22 months (Marine Harvest, 2008) prior to harvest. The actual timescale varies according to company policy, operating procedures and market conditions.

Eleven of the 15 companies replied with completed, or largely completed, questionnaires, a response rate of 73%. Two companies did not complete survey returns, but provided detailed information on waste management and disposal in telephone and face to face discussions which effectively boosts the response rate to 87%. Additional telephone discussions were also held with two other fish farming companies, who were not included in the original survey, which have also been included within the findings.

In terms of tonnage, information was received from over 95% of the industry and, for data, approximately 67%. In regard to the sea water sites, returns were provided for 62 sites operating from 19 shore bases. In the year 2006, the year most companies provided data for, there were 157 sites in operation in Scotland (with an additional 95 not producing) (Fisheries Research Services, 2007). Therefore the survey obtained data from represented 40% of the industry by operational site.

Six freshwater returns were received, including tank and loch based sites, from two companies. This represented some 6.5 million (m) smolts which, in 2006, were approximately 16% of the total 40.8m smolts produced. Whilst lower than for the sea water sites, the response was sufficient to allow useful interpretation.

In many cases, questionnaire returns were backed up by phone calls to individual companies, including head office and site managers/supervisors, to confirm areas of uncertainty or request further information.

In most cases, data was then extrapolated to give an average figure of waste per tonne of production for sea sites and, for freshwater, waste per thousand smolts. This was then aggregated across the industry to provide totals for Scotland and individual regions. Notes on how the data has been estimated are included as Appendix 3.

It should be noted that, although the survey, especially in regard of the sea sites, achieved a high response rate, the data is based upon a sample approach with a certain amount of estimation by respondents. Further, data extrapolation and aggregation was based on certain assumptions. Therefore, the figures presented in this report should be considered as ‘ball-park’ estimates of waste arisings and should be treated with caution. Additional work may be required to provide more robust (independently verified) figures prior to the implementation of policy measures or investment.

2.3 Consultations

Consultations were undertaken with a wide range of organisations, both within and outwith the industry. These were informal and included face to face meetings and telephone discussions. The consultations built on the survey findings and were tailored to the organisation concerned. A full list of consultees is provided in Appendix 4.

At the start of the project, it had been intended that a series of regional stakeholder events would be held in various locations across Scotland with a particular emphasis on group discussions with fish farmers. However, due to poor attendance at the first event held in Lerwick, it was decided to replace this with face to face meetings and phone calls which produced more results.

2.4 Workshop

A half day workshop was held at the Highland and Islands Enterprise offices in Inverness on 20th March 2008 to present and discuss the project findings. Invitations were sent to selected organisations to try to balance industry representation with wider stakeholders, including representatives of the Scottish Government, the regulatory authorities and the waste management industry. A total of 21 people attended (listed in Appendix 5). The workshop generated interesting debate with considerable contribution from attendees which is reflected where appropriate in this report.

Chapter 3 Waste Arisings

3.1 Introduction

This chapter presents the findings in respect of waste arisings from Scottish salmon farms. Chapter 4 details the waste handling measures and waste disposal routes identified from the survey. Notes on how the figures have been estimated are provided in Appendix 3.

The survey asked respondents to provide data for the most recent 12 month period for which data was available. In all but three cases respondents provided data for January to December 2006. The exceptions were: April 2006 to March 2007, September 2006 to August 2007 and November 2006 to October 2007. Since the returns largely centered on 2006, production data (FRS, 2007) from that year has been used when extrapolating the data.

This chapter first presents the estimated total waste arisings. It then considers sea water operations followed by freshwater, for both routine and non-routine wastes, and concludes with a section on regional arisings. Routine wastes are those arising on a regular and frequent basis, such as feed bags and packaging wastes. Non-routine wastes occur on a periodic or ad hoc basis, an example being redundant cage nets.

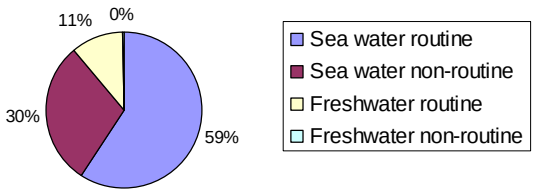
3.2 Total Arisings

The extrapolated survey results indicate that a total of approximately 9,300 tonnes per annum (tpa) of waste arise from salmon farming in Scotland. These can be broken down into sea water and freshwater production and also routine and non-routine arisings. These breakdowns are presented numerically and graphically below.

Table 3.1 Total Estimated Scottish Salmon Farming Waste Arisings (by Weight)

Category	Tonnes per Annum
Sea water: routine	5,495
Sea water: non-routine	2,753
Freshwater: routine	1,001
Freshwater: non-routine	20
Total	**9,270**

Figure 3.1 Total Estimated Scottish Salmon Farming Waste Arisings (by Weight)



Note: 'freshwater non-routine' is actually 0.2%, but figures have been rounded to the nearest whole number and hence this is shown as 0% in the pie chart.

From Table 3.1 and Figure 3.1, it is evident that of the four categories, sea water routine wastes account for about 60% of total estimated waste arisings from Scottish salmon farming. Sea water non-routine wastes account for another 30%, with freshwater routine making up the bulk of the remainder. Freshwater non-routine waste was found to be negligible (0.2%). However, it should be noted that several categories of non-routine wastes, for example redundant plant and equipment, were not captured for freshwater sites by questionnaire responses and so this category would be larger in reality, although still small compared to sea water non-routine wastes.

Figure 3.2 Estimated Scottish Salmon Farming Sea Water and Freshwater Waste Arisings (by Weight)

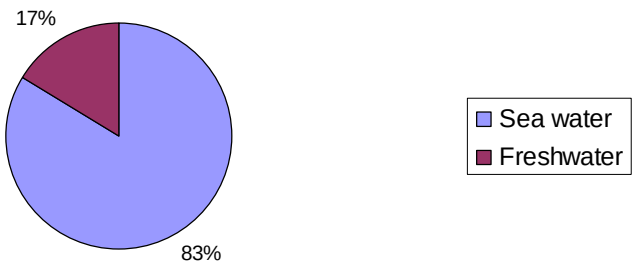


Table 3.1 and Figure 3.2 confirm that sea water wastes, both routine and non-routine, are by far the most dominant of the two forms of salmon production, with an estimated 89% of arisings. Freshwater waste accounted for just 11%. This is not surprising given that sea water stocks are larger and hence consume considerably more food than their freshwater counterparts, resulting in greater quantities of waste feed bags. Cages and nets are also much larger and typically are replaced more frequently on sea sites due to the greater stresses of the marine environment. Indeed, more smolts are now produced from tank and raceways than loch sites[7], which do not use cages and nets at all. Further, fish mortalities from sea water are much heavier than freshwater.

[7] 18.7m smolts were produced from cages in 2006 and 22.1m from all other forms of production (Fisheries Research Services (FRS), 2007).

Figure 3.3 Estimated Scottish Salmon Farming Routine and Non-Routine Waste Arisings (by Weight)

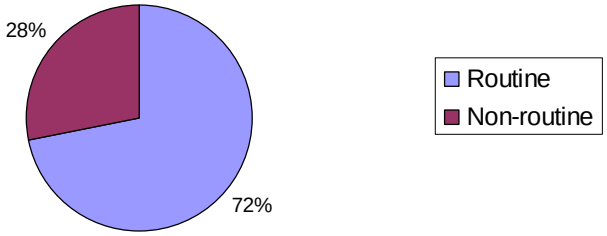


Figure 3.3 illustrates that routine wastes from both sea water and freshwater were estimated as nearly three quarters (70%) of total waste arisings, with non-routine wastes comprising almost a third.

The survey allowed an assessment of waste arisings according to the type of material, and these findings are presented below. Since this estimate was based on estimates made by consultees and a number of assumptions, these figures should be viewed with caution.

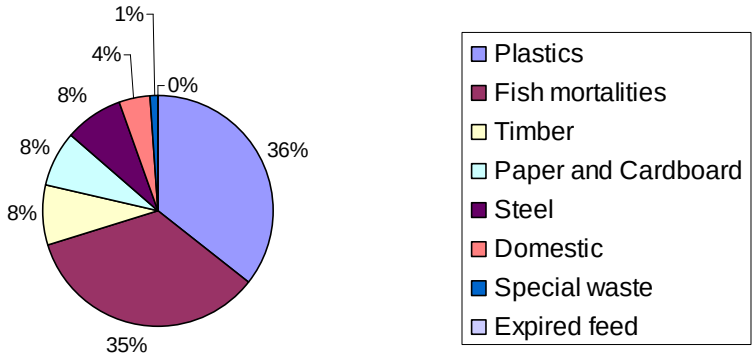
Table 3.2 Total Estimated Scottish Salmon Farming Waste Arisings by Material (by Weight)

Category	Sea Water (tpa)	Freshwater (tpa)	Totals (tpa)
Plastics	2,933	360	3,293
Fish mortalities	3,028	170	3,198
Timber	555	224	779
Paper and cardboard	618[2]	91[2]	709
Steel	766	0[1]	766
Domestic	225	166	391
Special wastes	102	2	104
Expired feed	0[2]	8	8
Total	**8,227**	**1,021**	**9,857**

Notes:

1. There would be some steel wastes from freshwater production, but these were not identified in the survey returns. This would be expected to be a relatively small proportion of total wastes.
2. There would be some expired feed wastes from sea water production, but these were not identified in survey returns from sea water sites. This would be a very small proportion of total wastes.

Figure 3.4 Total Estimated Scottish Salmon Farming Waste Arisings by Material (by Weight)



Note: 'expired feed' is actually 0.05%, but figures have been rounded to the nearest whole number and hence this is shown as 0% in the pie chart.

Table 3.2 and Figure 3.4 show that across the industry as a whole (sea water and freshwater, routine and non-routine) the largest waste stream is plastics, estimated as just over one third (36%) of all wastes. This is closely followed by fish mortalities at just under one third (35%). Timber, paper and cardboard, and steel were all 8%, followed by domestic wastes 4%. Special waste was estimated as 1% and expired feed as a negligible 0.05%.

Domestic wastes were not defined in the survey questionnaire, but were put down by companies under the 'other' category in regard to the contents of their skips (Question Seven). These are the wastes arising from office and staff accommodation and would include food waste, drinks cans, plastic bottles and paper and cardboard. Therefore, to a limited extent, this category may overlap with other categories.

Special wastes[8] were a specific item in the survey (Question Four). It is clear that, from a weight perspective, special wastes are relatively insignificant.

3.3 Sea Water: Routine Wastes

Sea water routine waste arisings were divided into four broad categories based on how wastes are handled on site following an assessment of the survey returns:

i) Feed bags;

ii) Skipped wastes;

iii) Special wastes; and,

iv) Fish mortalities.

It should be noted that the above has excluded two of the categories on the data forms – plastic containers and wooden pallets. Plastic containers have not been included in this section as a separate waste stream due to irregular information provided in the returns which made data extrapolation difficult. This is not considered a limitation

[8] A legal term defining wastes which are considered more difficult to handle. Note that in other parts of the UK, the term 'hazardous wastes' is used instead.

since they would account for a relatively small amount of total wastes. Pallets were excluded since it was apparent that their use had reduced dramatically in the recent past due to changes in feed delivery, as well as the increased use of plastic pallets, thereby suggesting that wooden pallets are becoming of lesser importance. Nevertheless, both are considered in Chapter Four, Disposal Routes.

The estimated sea water routine wastes are presented below in respect of these four broad categories.

Table 3.3 Sea Water Routine Wastes, Broad Categories (by Weight)

Category	Tonnes per Annum	Waste (Tonnes) per Tonne of Production[1]
Skipped wastes	3,000	0.023
Fish mortalities	2,014	0.015
Feed bags	379	0.003
Special wastes	102	0.001
Total	**5495**	**-**

1. Figures are rounded and are based on 2006 production of 131,847 tonnes (FRS 2007).

Figure 3.5 Sea Water Routine Wastes, Broad Categories (by Weight)

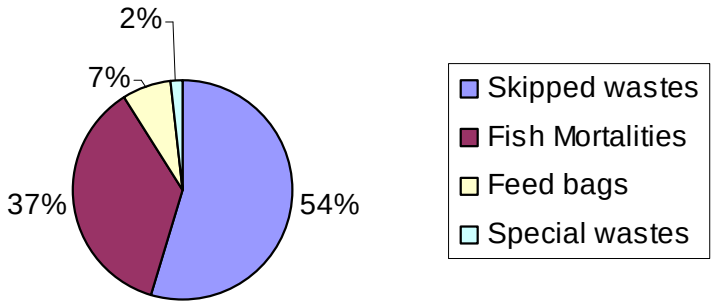
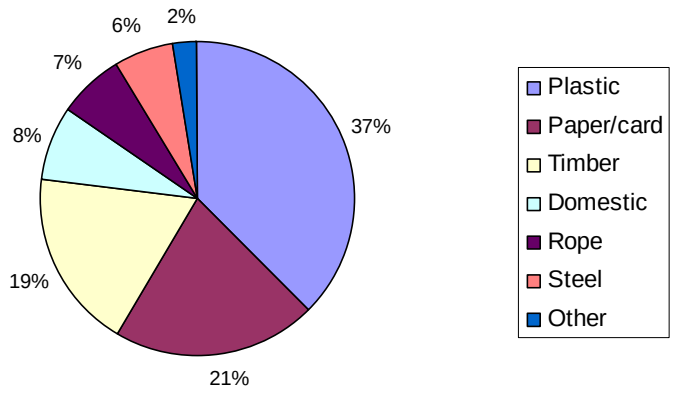


Table 3.3 suggests that the total Scottish salmon farm routine sea water wastes are approximately 5,500 tonnes per annum. The largest category, by weight, at just over half (54%) is skipped wastes, followed by fish mortalities at about over one third (37%). The remaining categories, of feed bags (7%) and special wastes (2%) are relatively small.

In regard to special wastes, respondents were asked to identify specific items common to many fish farms such as waste oils, oil filters, batteries and fluorescent tubes. It should be noted that assumptions have been made about the weight of these items in order to undertake the above estimate and since many companies did not complete this section, or only gave it limited attention, the figure for special wastes should be considered with caution.

Respondents were asked to estimate the contents of their skips. This was based on visual assessment and, whilst there is the potential for errors due to the subjectivity of this approach and the fact that wastes would change over time during the production cycle, it gave a useful insight into the different wastes disposed of within skips. Should a more accurate quantification be required, waste compositional analysis is recommended. The survey form asked for an approximate percentage for three main waste streams, plastic, timber and paper/cardboard, as well as for 'other' arisings which respondents were asked to specify. The results are presented in Figure 3.6 below.

Figure 3.6 Estimated Sea Water Skipped Wastes



Note: plastic, timber and cardboard were the only defined categories for this question in the survey. The remaining categories were specified by respondents in their replies. The 'other' category on the pie chart relates to nets and polystyrene which were specified by respondents at relatively low proportions (2.3% and 0.1%, respectively).

From the above figures, the largest proportion of skipped wastes is plastic at approximately one third (37%) followed by paper/cardboard and timber, both at about one fifth, which together accounted for just over three quarters of the average skip content. This was followed by relatively small proportions of domestic type wastes (taken to mean food wastes, cans, plastic bottles etc as well as newspaper and office paper – although the latter may have been captured instead under paper/card), rope, steel, nets and polystyrene.

When evaluating skipped wastes, it should be noted that some companies/sites may use the skip to dispose of certain waste streams, whilst others may use different waste management practices. For example, as described elsewhere, most sea water producers segregate waste feed bags, although one did include them within the general skip and hence they are reflected in these figures. Also, most companies included nets elsewhere in the survey form since they may be disposed of by net servicing companies, although one company included them in skipped wastes. Another example is polystyrene wastes; some companies would have polystyrene from floats for steel cages under non-routine wastes, but one included it in this section.

3.4 Sea Water: Non-Routine Wastes

Sea water non-routine wastes arise on a one-off or periodic basis. They have been divided into six broad categories based on the type of waste following an assessment of the survey returns:

i) Fish mortality events (mortalities from one-off incidents such as disease etc);

ii) Plastic cages;

iii) Steel cages;

iv) Nets;

v) Plastic feed pipes; and,

vi) Floats (plastic covered polystyrene used in metal cage groups and pontoons).

It should be noted that non-routine wastes may fluctuate over time because some items may be stored for quite long periods of time before disposal for strategic reasons (e.g. holding on to plant and equipment in case of future use), difficulties in identifying a disposal route, or bulking up wastes to make disposal more cost efficient. Also, event mortalities may vary considerably between years depending upon whether there has been a disease outbreak or other major mortality incidents such as, for example, a significant predator attack, algal bloom or jelly fish problem. Therefore, non-routine wastes could be considerably different from year to year, although some variance will have been averaged out in this report by the relatively high number of survey returns.

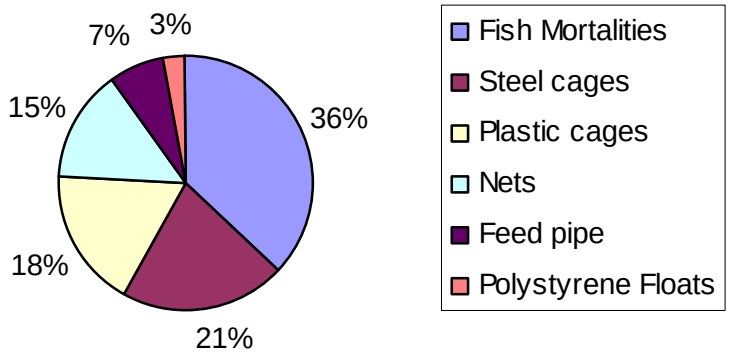
The estimated sea water non-routine wastes are presented below, by number and proportion.

Table 3.4 Sea Water Non-Routine Wastes (by Weight)

Category	Tonnes per Annum	Waste per Tonne of Production[1]
Event mortalities	1,014	0.008
Steel cages	580	0.004
Plastic cages	489	0.004
Nets	401	0.003
Plastic feed pipes	193	0.002
Polystyrene floats	76	0.001
Total	**2753**	**-**

1. Figures are rounded and are based on 2006 production of 131,847 tonnes (FRS 2007).

Figure 3.7 Estimated Sea Water Non-Routine Wastes (by Weight)



Fish mortalities are the largest estimated waste stream by weight of non-routine sea water wastes, accounting for about one third (36%). Steel and plastic cages each account for about one fifth. Nets are estimated as 15%, feed pipe as 7% and polystyrene floats as 3%.

3.5 Freshwater: Routine Wastes

Freshwater routine waste arisings were divided into three broad categories based on how wastes are handled on site following an assessment of the survey returns:

i) Skipped wastes;

ii) Special wastes; and,

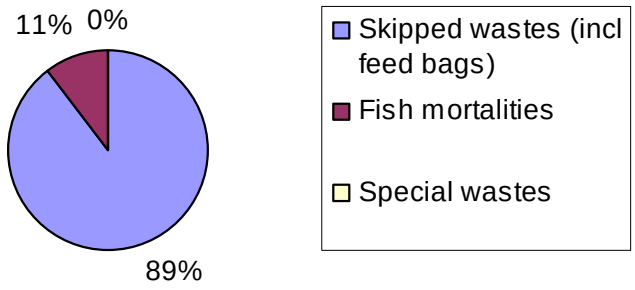
iii) Fish mortalities.

Unlike sea water sites, waste feed bags were more likely to be disposed of as skipped wastes from freshwater sites, which is the reason for not according them a separate category. Plastic containers and wooden pallets have not been included, for reasons highlighted in Section 3.3. Estimated arisings are presented below.

Table 3.5 Freshwater Routine Wastes, Broad Categories (by Weight)

Category	Tonnes per Annum
Skipped wastes	830
Fish mortalities	170
Special wastes	2
Total	**1002**

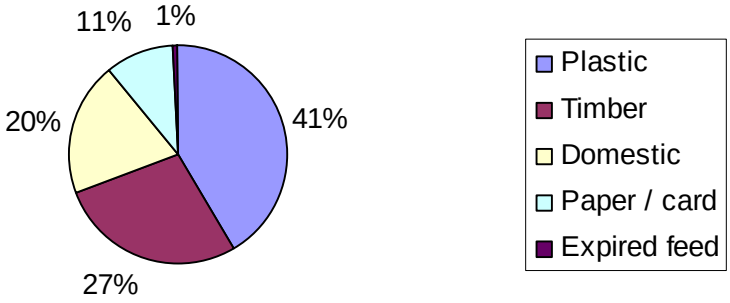
Figure 3.8 Estimated Freshwater Routine Wastes (by Weight)



Note, Special wastes are actually 0.2%, but figures have been rounded to the nearest whole number and therefore this category appears as 0% in the pie chart.

Table 3.5 suggests that the total Scottish salmon freshwater wastes are approximately 1,000 tpa. By far the largest category, by weight, is skipped wastes (83%), followed by fish mortalities (17%) and a very small amount of special wastes 0.2%). Based on farmer's estimates, the content of skipped wastes is estimated below.

Figure 3.9 Estimated Freshwater Skipped Wastes



From Figure 3.9, the largest proportion of skipped wastes is plastic (41%), followed by timber (27%). Together, these two waste streams accounted for, on average, just over two thirds of the skip content by weight. This was followed by 20% of domestic type wastes (taken to mean food wastes, cans, plastic bottles etc. as well as newspaper and office paper, although the latter may have been captured instead under paper/card estimated as a separate waste stream above as 11%). There was also a small amount of expired feed, estimated by one company only as 1%.

The same comment applies regarding skipped wastes as for sea water above, that some companies/sites may use the skip to dispose of certain waste streams whilst others may use different waste management practices.

As a proportion, plastics are a little higher in freshwater than sea water skips which is perhaps due to the tendency to dispose of feed bags within skips. Timber quantities are also higher, probably due to a greater use of pallets for feed delivery[9], as are domestic wastes and paper/cardboard lower. Whilst rope, nets, steel and polystyrene were not identified – reflected in part by the proportion of tank sites in the survey where such wastes would not be expected – it should be remembered that the response rate from freshwater sites was smaller than from sea water and there would be some such wastes in practice at freshwater loch sites.

3.6 Freshwater: Non-Routine Wastes

Following an assessment of the survey returns, freshwater non-routine waste arisings can be divided into six broad categories:

i) Nets;

ii) Fish mortality events (mortalities from one-off incidents, such as disease etc);

iii) Cages (circles, steels and wooden);

iv) Other plant and equipment;

v) Special wastes; and,

vi) Construction and demolition wastes.

The only category where sufficient information was provided on returns to allow a quantifiable estimate of freshwater non-routine wastes was that of nets, estimated to account for some 20 tpa across Scotland.

In respect of the other categories, it is considered that most are likely to be relatively small, at least in comparison to sea water sites, for the reasons highlighted below.

- Although there can be mortality events, these are less likely in tank sites and, should they occur, the resulting tonnage is relatively small due to the small size of freshwater fish.
- Freshwater cages are not replaced as frequently as sea water cages, due to the reduced exposure and structural stress. Further, there is an increasing proportion of tank sites (FRS, 2007) and, compared with sea water sites, there is less opportunity to expand and hence upgrade equipment at freshwater cage sites

[9] Many freshwater sites receive deliveries in 25kg bags which are delivered on pallets – wooden and plastic.

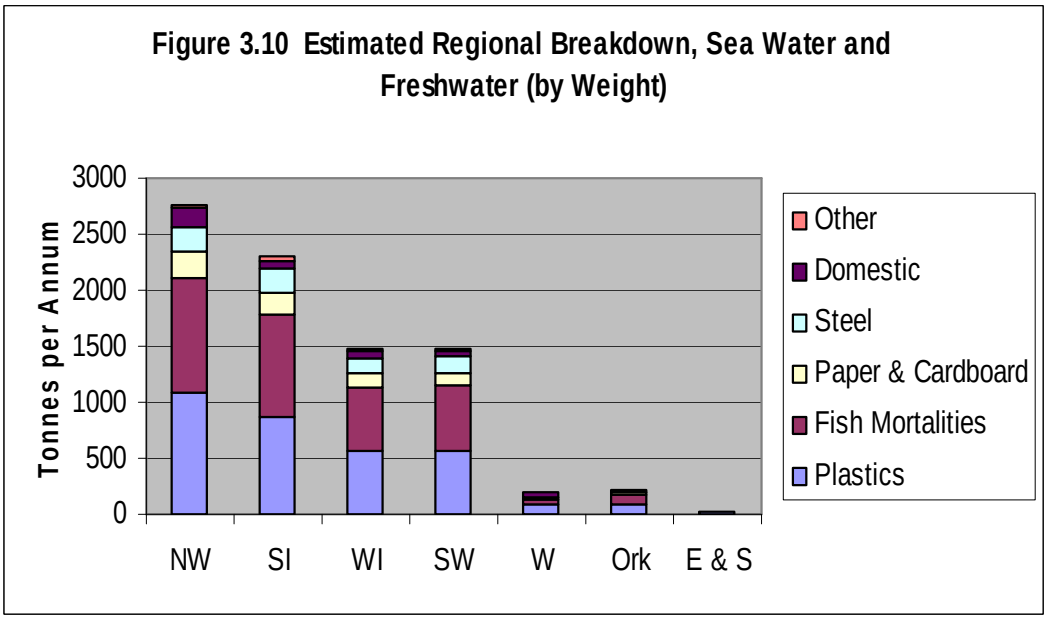
- Freshwater sites are expected to have less mineral oil dependant plant and hence generate less special wastes (waste oils and oil filters) from servicing than sea water sites. Many tank sites are on mains power, although fluorescent tube use would be greater due to use in tank site buildings.

Construction and demolition wastes might be expected to be more pronounced for freshwater sites than sea water due to the greater amount of buildings and infrastructure at a tank site. Upgrades and site consolidation may occur periodically resulting in such wastes. However, across the industry, such work would be rare and although no data has been captured during this survey (presumably because no such work was in progress at the sites from which survey forms were returns), this is not considered a limitation of the project because of the infrequency of such work.

3.7 Regional Breakdown

An estimation of regional arisings was made based on the data presented in the above sections. This was undertaken by aggregating the total waste arisings for sea water and freshwater operations, both routine and non-routine, and dividing them by regional production figures for 2006 (FRS, 2007). The estimated figures are presented below.

Figure 3.10 Estimated Regional Breakdown, Sea Water and Freshwater (by Weight)



Notes:

NW: North West (the Highlands) (sea water and freshwater)

SI: Shetland Islands (sea water and freshwater)

WI: Western Isles (sea water and freshwater)

SW: South West (Argyll and Bute) (sea water only)

W: West (Argyll and Bute) (freshwater only)

Ork: Orkney Islands (sea water and freshwater)

E&S: East and South (Scottish mainland outwith West, North West and South West) (freshwater only)

Figure 3.10 shows that the North West of Scotland generates significantly more salmon farming waste (an estimated 589 tpa, or 24% greater) than any other region. This is followed by the Shetland Islands, which is some 53% greater than the third and fourth regions, Western Isles and the South West. The remaining regions are all relatively small, accounting for 250 tpa or less. In the case of the West, and East and South regions, this is because they contain freshwater farms only, and although Orkney has sea water production, this is relatively small scale compared to other regions of Scotland.

Chapter 4 Waste Handling and Disposal

4.1 Introduction

This chapter describes the methods for handling waste on site and the disposal routes employed by Scottish salmon farmers. The information, based on the survey and consultations described in Chapter Two, is presented in sections according to the material types quantified in Chapter Three.

Waste handling and disposal routes are, to an extent, changing entities depending upon the choice of suppliers and the economics of different options at the time. Therefore, this chapter represents a 'snapshot' in time, and change should be expected; indeed there has been some change during the course of this study.

It is therefore recommended that the survey is repeated on an annual basis, perhaps using a representative sampling approach, to provide information for the industry, stakeholders and policy makers. This could be combined with the existing Annual Production Survey by FRS or by an alternative mechanism. The usefulness and practicalities of such a survey should be discussed with the farmers' representatives, the Scottish Salmon Producers Organisation (SSPO) and Shetland Aquaculture, as well as the Scottish Environmental Protection Agency (SEPA), the Scottish Government and relevant local authorities.

Although SEPA has an undertaking to conduct a waste survey of industry and commerce every three years, which includes the fish farming sector, the returns from 2007 (the first survey that included fish farming) are understood to be low and the data is not collected in a way that easily allows aggregation across the sector. An alternative to the suggestion above of a sector standard is for the industry to work with SEPA with a view to enhance the response rate and usefulness of their survey. In regard of fish mortalities, SEPA may be in a position to provide information depending upon what records they hold in this regard; this should be discussed with the relevant department.

4.2 Plastics

4.2.1 Feed Bags

Feed bags account for an estimated 379 tpa from sea water sites and 24tpa from freshwater sites. The majority of feed is delivered in one tonne plastic bags, along with half tonne and 25kg bags. The smaller sized bags are mainly used for sites where feed is handled manually – smolt producers and some of the smaller sea sites, as well as at sea immediately following smolt transfer. The half tonne and one tonne bags have the advantage of allowing bulk handling and are mainly used on the larger sea sites where feed can be stored on barges, although they may also be used at the larger freshwater tank sites.

From the survey results, it is estimated that approximately 20,000 half tonne and 120,400 one tonne bags are used in sea water production per annum and 358,300 25kg bags. In freshwater sites, bag use was estimated from production data since insufficient information was provided in survey returns; suggesting 193,800 25kg bags and 255 one tonne bags per year.

The 25kg bags are made of polyethylene. The half tonne and one tonne bags comprise an inner and outer bag; the inner is polyethylene and the outer

polypropylene. The outer provides strength, protection from moisture and retains any leached oils from the feed.

Over the past few years, there have been two main recycling routes used by Scottish salmon farmers, namely Solway Recycling in Dumfries and GI Waste Solutions in Alness. Recycling has been problematic up until recently, and many companies did not recycle, as a result of the difficulties outlined below.

- The residual fish (and in some cases vegetable) oils remaining in the bags from the feed are typically considered a contaminant by the recycling industry. This has meant that they are unacceptable to most recyclers and may require cleaning and be considered at a lower value.
- Recyclers prefer single plastics; the twin materials of the bulk bags have rendered these difficult to recycle without segregating into individual materials.
- Even after segregating, the polypropylene outers of the bulk bags have often been difficult to recycle.
- The distance to either of the two recycling companies has rendered recycling more expensive than landfill for many sites.
- It is understood that one of the companies has not always been able or willing to receive waste feed bags from the industry over recent years, whilst the production of the other has been somewhat faltering resulting in inconsistent service.
- The feed manufacturers (and fish farmers) have been against providing a full recycling infrastructure (i.e. taking feed bags back to their manufacturing sites) due to the biosecurity risk of disease transfer.

However, over the recent past, a recycling infrastructure has developed in Scotland for salmon farmers based on a four way relationship between the fish farmers, haulage companies, feed manufacturers and GI Waste Solutions. The feed manufacturers have been instrumental in developing this approach, often based on requests from customers, and recycling is now a standard element within many feed contracts.

There have been two key infrastructure developments that have enabled feed bag recycling from sea sites on a large scale:

- The increased use of boat transport for deliveries by the three main Scottish feed manufacturers (Biomar Ltd, EWOS Ltd, and Skretting UK and Ireland Ltd); and,
- A consistent recycling service from GI Waste Solutions at Alness.

The use of boat delivery has allowed bags to be brought back on the feed delivery boats and bulked up by baling ashore at the dockside(s) for onward transport by lorry to Alness, ensuring that bags are handled efficiently and allowing cost-effective transport. Further, in most cases, bags do not actually go on to the fish farm site since they are suspended over the hopper by crane and cut or spiked to discharge feed, which reduces the disease risk. In those cases where bags are received on to the site, they are disinfected prior to collection by the next feed boat.

All the feed companies use boat transport to some extent, with different companies using different routes. A summary is provided below although, in reality, the situation is more complex and companies may use other routes and combinations.

- Biomar Ltd, based in Grangemouth, transports by road and sea to Shetland where it operates a sea delivery service to local companies.
- Ewos Ltd, located at Bathgate, uses dock facilities at Ayr for delivery by vessel to the west coast.
- Skretting UK and Ireland, located in Invergordon, transports by road to Kishorn in Wester Ross for onward sea transport by Ferguson Transport Ltd to sites on the West Coast and the Western Isles.

Respondents were asked how feed bags were disposed of. The results are below.

Table 4.1 Estimated Disposal Routes of Waste Feed Bags

Disposal Route	Freshwater	Sea Water	Totals
All recycled	1	14	15
Some recycled, some land-filled	2	3	5
All land-filled	4	3	7
Other (specify)	0	0	0
Don't know	0	1	1
Totals	**7**	**21**	**28**

Base: 28 survey returns plus two verbal responses representing 13 companies.

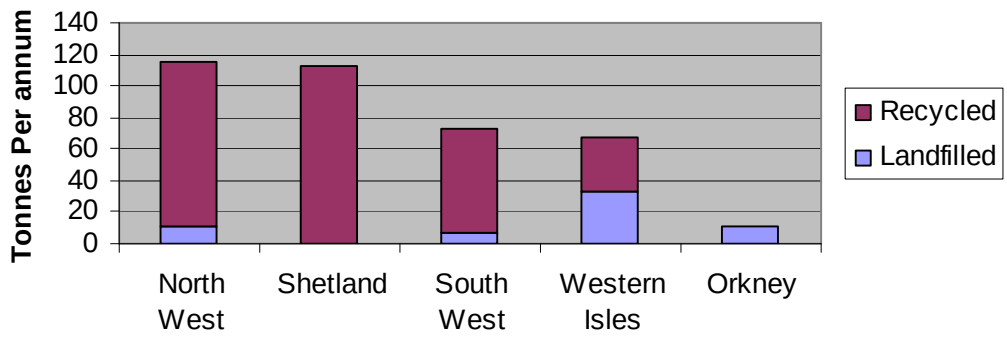
Notes: there were six returns from Shetland sea water sites where responses were given as 'some recycled, some landfilled,' 'all land filled' or 'don't know' which have been revised to 'all recycled' following discussions with Shetland Islands Council.

All companies that recycled from areas outwith Shetland currently use GI Waste Solutions at Alness[10]. Discussions with the Shetland Islands Council (SIC) confirmed that bags were sent to Hong Kong for recycling via a scheme operated by SIC, which intercepts bags at the landfill facility and bulks them up for onward transport. This is understood to be more cost effective than other recycling options. GI Waste Solutions informed the Inverness workshop that the China route would decline in the near future due to legislative changes in China.

From the survey and follow up consultations, it is estimated that approximately 87% of feed bags from sea sites are now recycled. This is summarised by region below.

[10] In some cases, a different company name was put on the survey form, such as GI's former name or the feed company which has been changed to GI Waste Solutions as appropriate.

Figure 4.1 Sea Site Feed Bags: Disposal Routes



From Figure 4.1, the recycling of feed bags from sea sites is more prevalent in the North West, Shetland Islands and South West that either the Western Isles or Orkney. Figure 4.2 illustrates this by proportion for each region below.

Figure 4.2 Sea Site Feed Bags, Landfill v Recycling

Respondents were asked how they handled feed bags on site. Of particular interest was the use of balers, which helps make transport – whether for recycling or landfill – more economic by increasing the load density. However, given the prevalence of boat transport for returning feed bags, which means that fewer companies are storing bags on site, this information has not been analysed. It is recommended that companies which continue to transport bags by road and do not currently bale investigate doing so.

Follow up discussions with major freshwater companies confirmed that the majority of sites do not recycle feed bags.

4.2.2 Plastic Containers

Plastic containers from pharmaceutical products, disinfectants and related products arise from freshwater and sea water sites. The survey asked respondents to list the size and number of plastic containers for the products they used. This question was, however, only answered by a relatively small proportion of the companies and so the results have not been analysed.

Companies were also asked how their waste plastic containers were disposed of. Responses for sea water sites are presented below.

Table 4.2 Disposal of Plastic Containers from Sea Water Sites

	No of Companies	% of Scottish Production
Recycle	2	31
Mix of Recycle & Landfill	3	38
Landfill	4	23
Not included	-	8

Note:

- 'Not included' includes those who did not answer as well as those not included in the survey.
- 'Recycle' was taken to also mean reuse by some respondents.

From Table 4.2, there is a mixture of approaches to the disposal of plastic containers from sea water sites, with some companies recycling, some landfilling and some doing both. By recycling, some companies actually meant reusing on site for cage weights (after filling with concrete or an aggregate) or for holding other liquids.

The returns for the disposal of freshwater containers were not analysed due to the lack of responses, although it was apparent that there was also a mixed response, with some companies recycling and some landfilling.

It should also be noted that by 'recycling,' some companies mean that the supplier takes the containers away; it is not necessarily known that the containers are recycled. From informal discussions with some site supervisors, it is understood that very often suppliers do not offer to take containers back/recycle, but may do so if asked.

One barrier to the reuse of chemical containers is that the practice is not permitted by a certification scheme which some farmers comply with. The Global G.A.P. Integrated Farm Assurance criteria do not permit the reuse of chemical containers.

Although a tonnage has not been estimated in respect of waste plastic containers, it is not expected to be a large proportion of total wastes by weight.

4.2.3 Plastic Cages

Consultations indicated that discarded plastic cages – estimated as just under 500 tpa in Chapter 3 – were being reused or recycled. The trend has been an increased use of, and increased size, of plastic cages. Companies are now usually looking at plastic cages with a circumference of 100m, whilst previously it was 80m and, before that, 60m. Assuming it is structurally sound and appropriate for the intended use, a small diameter cage can usually be extended to a larger size, thereby facilitating reuse. This service, which may include refurbishment and upgrading, is offered by the main cage manufacturers, particularly the Scottish based Fusion Marine Ltd.

Cages that are recycled are cleaned, cut into segments and chipped, either on site or remotely. It appears that this service has been provided by several companies in the past, particularly from England, by mobile shredder although there has been some difficulty in identifying a reliable and consistent service.

A scheme was set up in Shetland to assist fish farmers in recycling cages by the SIC; if farmers brought cages to Lerwick, the Council would arrange for and cover the costs of recycling. It is understood that this service was under-utilised, and chipping has not happened to date.

On the Western Isles, Orosay Net Station is taking cages for reuse and recycling into other products (without chipping), particularly for drainage pipes etc. There has also been some recycling of plastic cages for use in pontoons both within and outwith the industry, although just one company mentioned such a use on this survey.

Discarded plastic cages are considered an eyesore in certain areas. SEPA confirmed that visual issues were a key source of complaints in regard to the industry from the general public, although this also applied to other industries (Thistle Environmental, 2008). This was also a concern raised by Scottish Natural Heritage (SNH) at the Inverness workshop. There is a current SARF project assessing the impacts of aquaculture on tourism; it is recommended that cognisance be taken of the findings in due course by the industry in regard to waste storage.

4.2.4 Plastic Feed Pipes and Floats

Feed pipes were not specifically asked about in the survey, although one respondent mentioned that they disposed of approximately 1000m per annum, some of which was used for drainage. From this and other consultations, it was estimated in Chapter 3 that there might be some 193 tpa of feed pipe. There were different comments about whether this was recycled or landfilled; it is apparent that both routes apply.

Cushion floats, used to provide buoyancy to steel cages, were mentioned by three companies in the survey, totalling perhaps 150 to 200 floats during 2006, all of which went to landfill. Floats have a plastic outer and are filled with expanded polystyrene. The plastic in floats and the polystyrene can be recycled but the polystyrene to a lesser extent due to the high volume to weight ratio which usually renders it uneconomic.

4.2.5 Ropes and Nets

The use of discarded nets for geotechnical purposes is not new, although the survey only identified one fish farm recycling nets in this way. This was being undertaken through Orosay Net Station in the Western Isles, which processes a significant volume and stated that demand was outstripping supply. Another company mentioned that old nets were used in gardens. It is apparent that most other nets are currently being landfilled, although this was difficult to confirm since most nets are disposed of by the net servicing companies.

Ropes no longer suitable for use on moorings are usually reused where possible, although not all can be reused due to there being insufficient other uses for rope and also it may be in a poor condition after use at sea. No rope was being recycled; this is difficult in practice due to fouling and the nature of the material. Whilst the amount of ropes vary, and were difficult for companies to estimate, it was apparent that this

can be significant on an ad hoc basis, with one company, for example, mentioning four van loads taken to landfill from one site.

4.3 Fish Mortalities

The survey asked companies whether they treat fish mortalities *on site*. Respondents were given a choice of five categories and could select more than one. The answers are provided below.

Table 4.3 Treatment of Fish Mortalities *on Site*

	Freshwater	Sea Water	Totals
Ensiled	5	14	19
Incinerated	0	5	5
Other (specify)	0	0	0
No, not treated on site	2	5	7
Don't know	0	0	0
Did not answer	0	1	1
Totals	**7**	**25**	**32**

Base: 26 survey returns plus two verbal responses representing 13 companies, one of which did not answer this question.

Notes:
- Ensiling is a process whereby fish mortalities are macerated and then dosed with formic acid to reduce the pH to ≤ 4. This process produces a liquid waste which is stable and hence can be kept on site pending disposal without concerns over odour, biosecurity and hygiene issues.
- The totals add up to more than the base, since respondents could select more than one answer.
- Two respondents selected 'other' and noted that they store mortalities on site in bins. Since this is not a treatment, this was changed to 'no, not treated on site.'
- Since the survey was completed, follow up discussions with two companies has revealed that they have now changed to on-site incineration of ensiled mortalities at three sea water sites which had been identified in the survey as landfill from one shore base and no treatment for the other two; this updated information was incorporated into the above table.

From Table 4.3, almost two thirds of survey respondents (61%) ensile on site, including five of seven freshwater and 14 of 24 sea water sites/shore bases. Of the remainder, five sea water shore bases incinerate and a total of seven (two freshwater and five sea water) do not treat. One did not answer. Some companies pre-treat prior to incineration with maceration and / or ensiling.

The survey then asked where fish mortalities are *disposed* of, and by whom. The findings are presented below.

Table 4.4 Disposal Route of Fish Mortalities

	Freshwater	Sea Water	Totals
Burial on-site[1]	1	0	1
Burial off-site[2]	0	2	2
Landfill	1	7[3,4]	8
Incineration[5] (Widnes)	5	16	21
Incineration[5] (Lerwick)	0	12	12
Stornoway	0	1	1
Don't know	0	1	1
Not answered	0	1	1
(Incineration on-site)	0	3[6]	3
Totals	**7**	**43**	**50**

Base: 26 survey returns plus two verbal responses representing 13 companies, one of which did not answer this question. Note that several respondents gave more than one answer to this question, so the total is higher than the base.

Notes:
1. With a SEPA exemption under the Waste Management Licensing Regulations 1994 as amended.
2. With approval from the authorities.
3. Four respondents in the Shetland Islands stated that SIC disposed of their fish mortalities. Discussions with SIC indicated that routine mortalities would be incinerated at the Lerwick waste to energy plant whilst major event mortalities would be most likely landfilled.
4. One respondent in the Shetland Islands noted a major fish mortality event; with reference to note 3 above, this has been included as a landfill disposal route.
5. Incineration in a waste to energy plant.
6. The figures for *on-site* incineration were not specifically included in the answer categories on the survey for this question (which asks about *off-site* disposal), since they were addressed in the previous question (on-site treatment). However, they are relevant to the final disposal route, and so have been included here. Since the survey was completed, follow up discussions with two companies has revealed that they have now changed to on-site incineration of ensiled mortalities at three sea water sites which had been identified in the survey as different forms of treatment (landfill from one shore base and no treatment for the other two); this was incorporated into the above table.

From Table 4.4, the most frequent route for fish mortality disposal is by off-site incineration with energy recovery, either at Widnes in Merseyside or at Lerwick in the Shetland Islands. The Widnes plant is operated by Granox Ltd and the Lerwick one by the SIC. Consultations with fish farmers indicate that on-site incineration is gaining increased interest; all on-site incinerators have been set up within the past two to three years, with four within the past year and several more are being established at the present time. The following table shows disposal routes on a regional basis, based on the survey returns and consultations.

Table 4.5 Disposal of Fish Mortalities: Regional Variations

	North West	Shetland	South West	Western Isles	Orkney
Incineration: On Site	Minority	Minority	Minority	None	Some
Incineration: Widnes	Majority	None	Majority	Some	None
Incineration: Lerwick	None	Some	None	None	Some
Landfill	Minority	Majority	Minority	None	None
Burial: On Site	None	None	None	None	None
Burial: Off Site	None	None	None	Some	None

Based on an interpretation of survey returns, consultations and regional production figures (FRS, 2007), an estimate of the disposal routes for freshwater, sea water and total mortalities was made and are provided below.

Figure 4.3 Estimated Disposal Routes of Sea Water Fish Mortalities

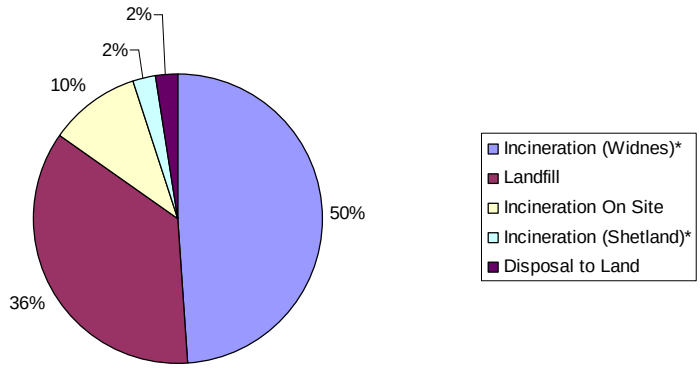
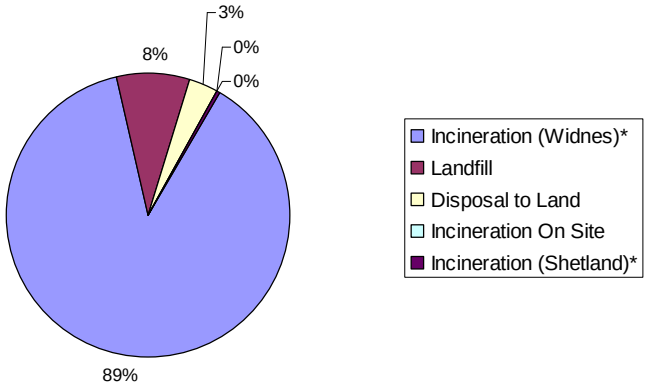
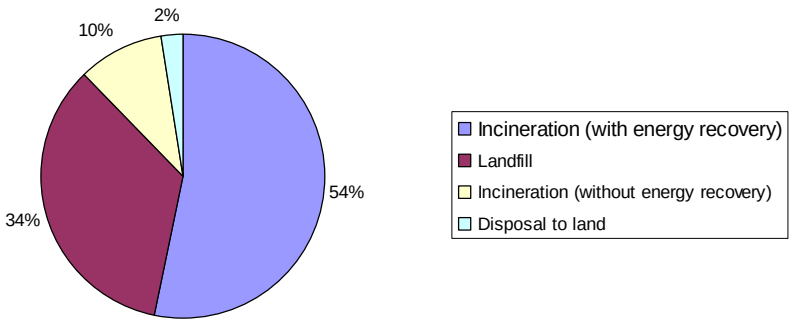


Figure 4.4 Estimated Disposal Routes of Freshwater Fish Mortalities



Note: Incineration at Widnes and Shetland includes energy recovery.

Figure 4.5 Disposal Routes for Fish Mortalities (Sea Water and Freshwater)



From Figures 4.3, 4.4. and 4.5, it can be seen that a considerable proportion of fish mortalities are being transported to England for incineration, estimated as a total of 1,630 tpa. Granox themselves confirmed that it handled approximately 2,350 tonnes of fish mortalities from Scotland in 2007, which may have included species other than salmon (Granox Ltd, 2008, *pers. comm.*).

There remains, however, a significant amount of disposal to landfill and a small amount of burial (on-site and off-site) under licence. Orkney does not have landfill capability for fish mortalities and, from survey replies and consultations, it was apparent that they are either incinerated on site or in Lerwick (Orkney Council, 2008, *pers. comm.*).

4.4 Timber

Timber was estimated to account for approximately 800 tpa of arisings (8%) across the industry. Whilst no detail was given of the types of wastes, this would include a proportion of broken pallets although, as previously described, the quantity of pallets will be in decline due to the decreasing number of pallets used in fish farming, as well as general site wastes.

Fish farmers were asked about disposal of wooden pallets in the survey, although not for quantifiable data. Most said that pallets were reused and/or recycled. Some were also sent to landfill, although there were several comments that this applied to broken ones only.

4.5 Steel

A total of 766 tpa of steel wastes were estimated by aggregating survey responses, which related entirely to sea water cages and walkways. Companies were asked how many steel walkways and cages were disposed of. The replies varied considerably, with most companies saying none, although four gave very different answers: 2 walkway modules, 4 cages, 18 cages and 24 cages. In all cases, these were reused or sent for scrap. Reuse included within the company as part of other cage units/pontoons and for 'various community projects'. Steel cages have an inherent value, whether for reuse or recycling (scrap), and would not be landfilled.

There would also be disposal of other steel wastes, including redundant plant and equipment other than cages. No company identified this in the survey, so it is considered to be low on an annual basis and would reflect the attitude of reusing materials on site where possible.

4.6 Paper and Card

Paper and cardboard was estimated at a total of 709 tpa of total sea water and freshwater wastes. This would have included packaging and office wastes. In addition, as mentioned previously, some respondents may have included paper and cardboard under 'domestic' wastes, so this figure may be higher. No respondents mentioned that paper and cardboard were being recycled in their survey responses, so it has been assumed that all paper and cardboard is being landfilled.

However, in follow up discussions at a later date, one sea water company informed us of a shore base where recycling had recently been established. This was estimated to have reduced their skip contents by a quarter. Another company (freshwater) noted that it had set up a recycling collection from their local council at one site, but that the council would not collect from their other nearby one as it fell outside its area for collection.

4.7 Domestic Wastes

No respondents mentioned that domestic wastes were being recycled during the survey, which means that in excess of 391 tpa from salmon sites is being landfilled.

4.8 Special Wastes

In general, special wastes are being disposed of via waste management companies, although batteries may be taken back by the supplier when new ones are ordered. However, for one major company, all special wastes are handled by their main supplier. Special wastes require reprocessing, and no company knew the location of reprocessing plants or the final destination of waste for disposal.

In the Western Isles and some parts of the West Coast, such as the Isle of Skye, the council provides some facilities for waste oil and filters. These are often for joint use by the fishing and aquaculture industries.

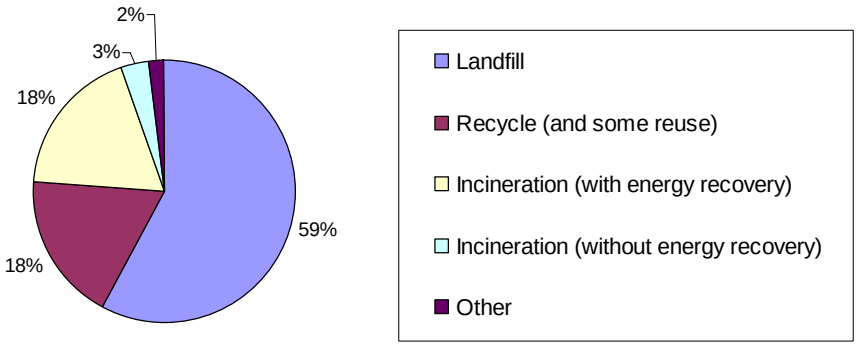
4.9 Expired Feed

One company (freshwater) mentioned expired feed as a waste stream, albeit a small amount. Whilst all companies are likely to have some amount of waste feed on occasion, this would be very low in volume due to the high costs of feed. All waste feed would be landfilled.

4.10 Summary of Disposal Routes

A summary of the major disposal routes has been made, based on an extrapolation of the information contained in this chapter. This is based on a number of assumptions and should be regarded as an estimate for general information only. It is presented in Figure 4.6 below.

Figure 4.6 Estimated Scottish Salmon Farming Waste Disposal Routes



From Figure 4.6, it can be seen that almost 60% of Scottish salmon farming wastes are estimated to be disposed of to landfill. Almost 20% is recycled (or reused) and the same again is incinerated with energy recovery. There is also a relatively small amount of incineration without energy recovery and disposal to land (on site and off site).

Chapter 5 Discussion of Key Themes

5.1 Introduction

The purpose of this chapter is to discuss the key themes identified from the project findings which were presented in Chapters 3 and 4 to identify the opportunities and barriers to more sustainable waste management practices in the Scottish salmon farming industry.

5.2 Aquaculture Wastes in the Broader Context

The total estimated arisings of controlled[11] waste in Scotland was 22.22m tpa in 2005. The estimated arisings for the five major controlled waste streams in Scotland for 2005/6 are presented in Table 5.1 below.

Table 5.1 Total Estimated Controlled Waste Arisings for Scotland, 2005.6

Waste Type	Million Tonnes	%
Household	2.89	13
Commercial and industrial	8.41	38
Construction and demolition	10.61	48
Agricultural	0.32	1
Mines and quarries	-	-
Total	**22.22**	**100**

Source: SEPA, 2007.

Note:
- Agricultural is estimated using the Environment Agency's Agricultural Waste Estimates Model.
- Data for mines and quarries is unavailable.

It can be seen that the estimated total fish farm waste of 9,270 tpa (Chapter 3) is very small compared to the total controlled waste arisings, being less than 0.05%. Aquaculture is part of the agricultural waste stream, where it represents a relatively small proportion of just under 3%.

Agricultural waste arisings are not available on a regional basis, so it is not possible to evaluate the contribution of salmon farming wastes as a proportion of each region. It would be expected that aquaculture wastes would be more prominent in Shetland, the Western Isles and the Highlands, where agriculture might be less intensive than other areas and perhaps associated with reduced waste streams. It is recommended that SEPA estimates agricultural wastes on a regional basis so that the relative importance of aquaculture wastes can be evaluated.

Although salmon farming wastes make up a small proportion of national arisings, attendees at the Inverness workshop considered that they are of importance to the industry and local community.

[11] Controlled waste is that regulated by SEPA.

5.3 Scottish Salmon Farming Waste: Drivers for Change

There are several key drivers that may influence the waste arisings and disposal routes in regard to Scottish salmon farming, including:

- Financial;
- Legislation and Government Policy; and,
- Environmental Management Systems, Health and Safety and Company Policy.

5.3.1 Financial

Whilst total waste costs can appear significant, one consultee said that they amount to only up to 1p per kilo of salmon sold. Waste disposal costs were not included in the survey due to difficulties in obtaining consistent data, since companies record costs differently in this regard. Also, waste costs will vary from company to company on a pence per kilo sold basis, due to differences in the intensity of production. Sites where waste is transported on an inter-island basis will have significantly higher costs, as will those with greater distances to disposal points. Therefore, the aforementioned value should be taken as an indication that waste handling and disposal costs as a proportion of total production costs are low rather than as a definite figure.

Few companies appear to record waste arisings and disposal routes as a key performance indicator (KPI). Similarly, not all companies separately identify waste costs and may include them in other cost accounting categories. It is recommended that all fish farmers monitor and measure wastes, from both a tonnage and financial perspective; this will help to identify baselines from which savings can be made.

Whilst some companies said that waste disposal was a relatively insignificant cost, others stated that all costs are important and waste is especially so since it is directly 'off the bottom line'. It was particularly important for companies with long transport routes and high ferry costs for wastes, which particularly relates to fish mortalities. These could increase dramatically as a consequence of a major mortality event (mortality disposal is discussed further in Section 5.4.4. and 5.4.5 below).

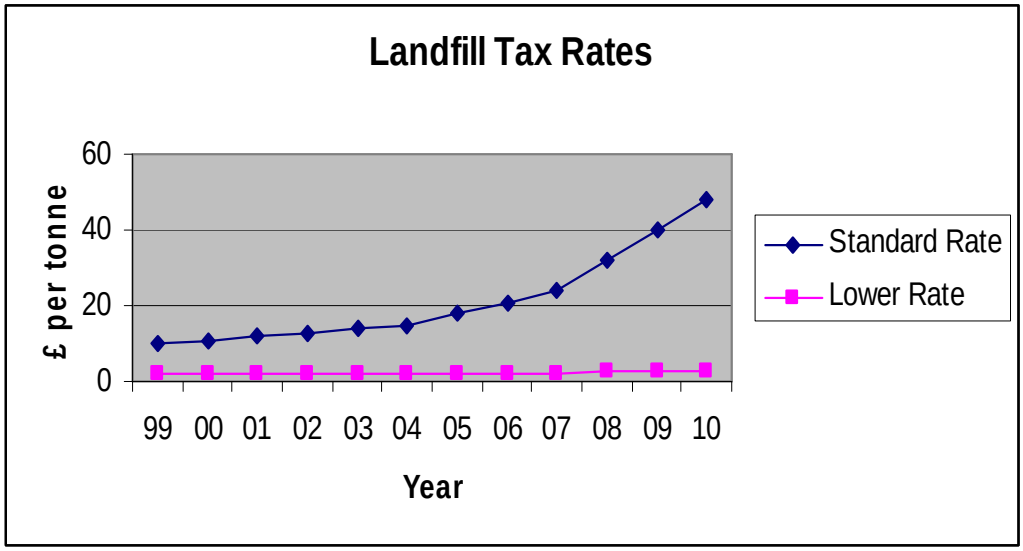
Waste costs are rising, and will continue to rise, due in part to the Government's intention to increase the Landfill Tax, brought in under The Finance Act 1996, at an above inflation rate year on year until 2010. Wastes considered to be higher risk (active wastes) are taxed at a higher 'standard rate' while lower risk (inert) wastes are taxed at the 'lower rate'. Inert wastes are defined by waste type and include naturally occurring rocks and soils, ceramics etc., and will not apply to the overwhelming majority of fish farm wastes.

The historical and projected trends in Landfill Tax have varied over time, as shown in Figure 5.1 below. From the initial rate of £7 per tonne in 1996, the tax has risen to the present £32 per tonne and is projected to rise to £48 by 2010 (Business Link, undated).

Although the increasing Landfill Tax has been described as a 'very significant increase' that will 'impact very heavily on all waste producers' by the business

advisory firm Deloitte (2007), the opinion of the Inverness workshop[12] is that such increases are not particularly significant for fish farmers as a whole.

Figure 5.1 Historic and Projected Trends in Landfill Tax



Note: the projection for the standard rate is based on current government policy and for the lower rate, based on an assumed continuation of the 2008 rate.

Source: HM Revenue and Customs, 2007.

5.3.2 Legislation and Government Policy

Looking forward, there are several policy drivers that will continue the policy focus of reducing landfilling, which are highlighted below.

- The European Union's (EU) proposed revision of the Waste Framework Directive is expected to set recycling standards and require that Member States develop waste prevention programmes (Europa, 2007).
- The Scottish Government recently published its Business Waste framework (Scottish Executive, 2007) which includes an objective of reducing business waste by at least 200,000 tonnes a year.
- The increasing interest in the concept of 'zero waste' as an aspirational objective to guide waste management policy is typified by The Scottish Government's Waste Summit in October 2007, which included consideration of 'options for moving towards a zero waste society' (Waste Summit, undated). While aimed primarily at municipal wastes, this indicates the direction that future policy may take.

The above will all have the aim of putting increased pressure on business, whether voluntary or regulatory, of reducing the amount of arisings disposed of to landfill. This is in accordance with the waste hierarchy, which is a concept designed to assist policy makers and organisations to make decisions on the most sustainable means of waste management. The waste hierarchy promotes, in order of preference:

[12] And also another workshop event in Inverness for the SSPO's sustainability project (Thistle Environmental, 2008).

prevention, reduction, reuse, recycling (including composting and anaerobic digestion), disposal with energy recovery and, finally, the least preferred option, disposal without recovery. The opportunities for Scottish salmon farmers to move up the waste hierarchy are discussed with regard to key waste streams later in this chapter.

Fish wastes are one of a number of SEPA's National Best Practice Projects. This has resulted in three reports:

1. Wastes Arising from fishing and fish relating industry in Scotland, SEPA 2003.
2. Developing a Sustainable Fish Waste Management Infrastructure, SEPA, 2004.
3. Evaluation of Fish Waste Management Techniques, Poseidon Aquaculture, 2004.

However, it does not appear that there has been significant action in regard to fish wastes in the last three to four years. This issue is discussed later in Section 5.4.4 and 5.4.5.

The disposal of fish mortalities are covered by the Animal By-Products (Scotland) Regulations 2003 (ABPR). Under the ABPR, mortalities are Category 2. The regulations specify treatment methods which, for Category 2, include incineration and heat treatment, alkaline hydrolysis and rendering for specific purposes. Composting is also included although, since rules for this have not been finalised, it is not a currently accepted form of treatment. However, there is a derogation in place which applies to certain remote areas in Scotland, including many salmon farming locations, which permits burial or on-farm burning for routine mortalities and a separate derogation for those arising from a notifiable disease.

The APBR are expected to be revised during 2008 or, more likely, 2009 following the forthcoming European review (Scottish Government, 2008, *pers. comm.*). It is also expected that the remote area derogation will be reviewed and, most likely, removed for Scottish mainland (but retained in the Western Isles, Orkney and Shetland), due to the establishment of the National Fallen Stock Scheme, although this review has not commenced and the outcome has not yet been determined (Scottish Government, 2008, *pers. comm.*).

5.3.3 Environmental Management Systems, Health and Safety, and Company Policy

The majority of Scottish salmon farmers now operate an Environmental Management System (EMS) in accordance with the international standard ISO 14001, and most significant sized companies that do not are currently implementing one. This is a recommendation of the Code of Good Practice for Scottish Finish Aquaculture (CoGP)[13]. An ISO 14001 certified EMS requires that significant environmental issues are controlled, that key impacts are monitored and that a process of continual improvement is implemented. Some farmers have chosen to focus on wastes as an area of improvement, and it is clear that in some cases EMS has been one key driver in increasing the amount of feed bags and, in the case of at least one farmer, other wastes being recycled.

[13] Recommendation being defined as an action that should be implemented other than in unique circumstances; it should remain be an aspiration.

Other than the financial perspective, discussed in Section 5.3.2 above, most if not all fish farmers consulted consider they have a responsibility to try to handle and dispose of wastes in a responsible manner. They were all keen to reduce their impact on the environment.

Whilst most fish farmers commented that the costs of fish mortality disposal in particular are high, many noted that they were also concerned about the unpleasantness of handling mortalities for staff and the health and safety issues associated with ensiling. This is an unpleasant area of work which all companies would like to improve. One company noted concern with regard to mortality events, in terms of the negative psychological impact on staff of disposing of large numbers of dead fish.

5.4 Waste Handling and Disposal

The purpose of this section is to discuss the barriers to, and opportunities for, the Scottish salmon farming sector to move towards more sustainable waste management practices. However, the amount of work already implemented in terms of waste minimisation and recycling should be recognised. This section is approached under the headings of the waste hierarchy (see Section 5.3.2).

5.4.1 Elimination of Waste

The main area where waste could be eliminated is in regard to plastic feed bags. A move towards the bulk transport of feed, by the use of blowers and associated bulk transport and storage systems, would allow farmers to move away from feed bags altogether. Not only would such a move reduce waste disposal costs, it would also reduce feed handling requirements. There has been significant movement in this regard in the Norwegian industry, but none in Scotland.

However, the potential for bulk feed delivery is low at this time. Unlike Norway, the Scottish industry is characterised by a greater range of feed products due to the more differentiated end product market demand. This requires road and sea transport capable of handling a considerable range of feed types for different sites, which is logistically challenging. Further, many Scottish sites are too small to be able to hold sufficient feed in storage hoppers for bulk delivery to be viable, although there has been a trend towards site consolidation and increased use of feed barges with greater capacity for feed storage. Farmers are also concerned that in the case of a problem with feed quality, a greater amount of feed could be affected than would be the case with the current system.

At this time, a significant move toward bulk feed delivery would require major investment by fish farmers and the supply chain, including feed manufacturers and transport companies. It would also require a change in market demand to a more homogeneous salmon product range. All considered it unlikely in the foreseeable future.

5.4.2 Reducing Waste

The industry has implemented several initiatives in this regard, with significant results. Firstly, the amount of feed consumed relative to salmon produced has reduced considerably over the years due to an increasingly efficient use of feed, as measured by the food conversion ratio (FCR). The twin drivers in this regard have

been the cost of feed, which is the main material cost for farmers, and the desire to reduce impact on the marine environment from uneaten feed. A related benefit is the reduction in waste feed bags.

Secondly, there has been an increased use of half tonne and one tonne bulk bags over the years as sea sites have become better equipped for the bulk handling of feed. This has included increased use of feed barges and mechanised handling systems (cranes and forklifts). The programme of consolidation and increased size of sea sites followed – where possible[14] – by some companies has been a factor in this regard.

The increased size of sea cages (see 4.2.3) facilitated by mechanised handling and feeding systems will reduce the amount of redundant capital generated by the industry. The larger cage volume reduces the amount of cage, net and mooring materials required to produce the same amount of salmon.

Finally, developments in pharmaceutical products and delivery systems, particularly inoculation and in-feed treatments, have reduced the amount of 'bath treatments' over recent years[15]. This has led to a corresponding reduction in the amount of plastic containers being disposed of by the industry.

At the present time, there are two initiatives which appear to be gaining momentum with regard to reducing waste:

1. An interest in increasing the one tonne feed bag to one and a quarter tonnes, which would give better efficiencies for transport as well as reduced waste; it is recommended that fish farmers engage with the feed manufacturers and transport companies to bring in this measure. .
2. An interest in increasing the longevity of nets by looking at design and material type. New stronger materials (e.g. Dyneema – a polyethylene) are now being manufactured for use in aquaculture and fishing and such nets should have a longer life and can be made from the one material making recycling easier. The cost of these nets is higher but the longer life may make the depreciated cost lower. They may also be more effective in terms of preventing escapes.

Interest in cage and net design could be a useful way of both reducing waste and producing financial savings for the industry. This could be a useful research project for a joint university/industry initiative; it is recommended that the industry considers such an approach by proactively involving universities with marine engineering capabilities. It should be noted that the SSPO, through their demonstration project, is undertaking some relevant research in this regard, which includes different net materials and systems; this is expected to report in 2010 and it is recommended that the industry take note of the findings. The industry should consider approaching the Telford Institute, established under the Northern Research Partnership, which is understood to have civil engineering expertise and an interest in aquaculture. Also, the industry should keep abreast of any developments in Norway and the EU in this regard.

[14] The size of salmon farming sites is restricted by planning and environmental legislation.

[15] However, it seems likely that bath treatments will increase as part of an overall sea lice management strategy to minimise the development of resistance to in-feed medicines.

5.4.3 Reusing Waste

Elements of the industry have already implemented a number of initiatives in this regard, including:

- The reuse of plastic containers for liquids and as cage weights;
- The reuse of plastic cages through refurbishment and upgrading;
- The reuse of plastic and steel cages, nets and other equipment (on a relatively small scale) for certain applications including marine and garden use.

Feed Bags

The reuse of feed bags is a potential opportunity for the industry to reduce waste. This, however, is problematic due to the oil residue and handling methods, which require bags to be split. In terms of reuse within the industry, there are also major concerns over biosecurity from fish farmers and the feed industry.

From preliminary discussions with one feed company, it is apparent that the proportion of feed cost to the customer from the procurement of feed bags is small. Therefore, whilst reusing feed bags would generate environmental benefits, it was considered that cost savings would not be particularly significant.

However, preliminary discussions with Bulk Bag Containers Ltd, the only sizeable Scottish bulk bag manufacturing company, suggested that reuse within the industry could be cost effective and technically feasible by limited remanufacturing of bags to address the damage caused by spiking or cutting the base of the bag, providing that biosecurity issues can be addressed. This was considered to offer cost savings to the industry. Should a bottom discharge bag be acceptable to the industry, reusable bulk bag manufacture would be a more attractive proposition. Reuse outwith the industry was considered more problematic since feed bags are based around a single or two point lift system, whilst most other demands are for a four point system.

Biosecurity concerns are a major barrier to the reuse of bags within the industry which are unlikely to be easily addressed, and could also be a concern outwith the industry. Whilst there is a biosecurity risk attached to bag reuse it is also the case that boats, personnel and equipment are moved between sites regularly with due regard to biosecurity regimes. It is recommended that a research project on biosecurity issues in relation to the potential for feed bag reuse, both within and outwith the industry, be established as a partnership between academia (or other research establishments) and the industry.

Bulk bags are used by many other industries, including consignment of aggregate, shot blast etc. In most cases, it is envisaged that bulk feed bags would require cleaning to remove residual oils and odours. Depending on the findings of the recommended research project above, an appropriate disinfection protocol might also be required. It is recommended that an industry waste working group be established to meet on periodic basis in order to review progress on such issues, and to liaise with other interested parties in this regard. The industry should promote regular contact with the National Industrial Symbiosis Programme (NISP), who has a remit to promote the use waste from one industry as an input for others.

Reusing of bags could divert a significant proportion of the currently estimated 379 tpa of sea site bags currently being recycled and landfilled. Whilst the biosecurity issues should not be underestimated, it is recommended that this issue be considered

following the above suggestion for biosecurity research in this regard. This could be pursued through a pilot study and, perhaps, with assistance through the Business Resource Efficiency and Waste Programme (BREW) programme - Envirowise should be approached in the first instance.

Redundant Plant and Equipment

Note that this topic is also considered under recycling in Section 5.4.4 below.

There is some potential for the reuse of plant and equipment in its current state without further processing, particularly cages, feed pipe and nets. Discussions with NISP indicated this particularly for the use of feed pipes in the renewable energy industry in regard to micro-hydroelectric schemes. There is also considered to be potential for the use of feed pipe within the construction industry, for drainage and, to a lesser extent, the use of cages, nets and tanks etc. for reuse on an ad hoc basis without further processing.

A barrier to such opportunities is putting waste producers in touch with potential users[16], as well as keeping the industry informed of current developments. It is recommended that:

1. A single point of contact is provided for fish farmers to obtain information on waste disposal and recycling. This may usefully take the form of a helpline, website or newsletter operated by a person/organisation with a detailed understanding of the industry and waste management practices.
2. A mechanism is developed for fish farmers and stakeholders to submit and share good practice suggestions. This might usefully include a short annual symposium on waste management issues, perhaps included as part of the programme at fish farming conferences and exhibitions. This should be introduced for an initial period of three to five years.
3. The above could be usefully informed by a round-up of waste management issues on a confidential and independent basis, thereby allowing Scottish fish farmers to learn from each other and develop a more efficient and sustainable industry.
4. Providing an updated version of the SEPA Aquaculture Waste Minimisation Guide (Thistle Environmental, 2005) at regular intervals (which might help address points 2 and 3 above).
5. Consider setting up a cross sector resource centre(s) to encourage reuse within and between industry. This might be usefully implemented by the community recycling sector and close liaison with the Community Recycling Network Scotland (CRNS) is recommended as well as the BREW programme and NISP.
6. Plant and equipment are designed to facilitate reuse (and recycling). It is recommended that a research project(s) is undertaken in this regard; interest was expressed from Boris Nets to host such a project.

A potential barrier with regard to the reuse of nets is the use of anti-foulants on a significant proportion of nets. It is recommended that a study be undertaken in to

[16] Recommendations have been made in this regard previously (Thistle Environmental, 2004, and 2005).

whether this would present a risk to the environment in regard to the reuse of nets for geotechnical and similar purposes.

5.4.4 Recycling, Composting and Anaerobic Digestion

Feed Bags

The industry has made significant progress in recycling feed bags over the past two to three years and this is likely to continue to expand. Nevertheless, there are several concerns and barriers in this regard which are discussed below.

The dependence on boat transport as the key element of the recycling infrastructure is of some concern. Should the economics of this become unfavourable in the future this could greatly impact the economics of recycling. Boat transport appears to be successful and expanding, although it is understood that boats cannot be fully occupied by feed deliveries year round due to the reduced feed volumes used in the winter months when fish are feeding less. It was also noted by one feed manufacturer that high port costs in some locations prevented the increased use of sea transport for feed. The industry and relevant organisations such as Highlands and Islands Enterprise (HIE) should liaise closely with the feed manufacturers and transport companies in this regard, and perhaps consider a study into the economics and environmental issues of sea delivery.

In areas where sea transport is not undertaken, recycling is still often unappealing from an economic perspective and costs are prohibitive for many sites and companies. As well as freshwater sites, this relates to sites and companies where sea transport is not a practical or preferred option (due to site storage facilities, restrictions on access, preference for use of 25kg bags, company policy or simply the lack of an established sea transport system). In terms of sea transport to areas outwith the West Coast, it is recommended that a study be undertaken to ascertain whether more could be done to promote sea transport for both aquaculture and other industries – this might usefully include assessment of the environmental and social benefits and impacts .

In terms of freshwater sites, and those sea sites not using sea transport, it is recommended that fish farmers and the feed companies consider how best to promote increased levels of recycling.

Redundant Plant and Equipment

There is significant recycling of plastic cages and equipment by chipping and remoulding. Nevertheless, these could be recycled through less intensive processes, which are preferable due to reduced energy demands. In some ways this may be thought of as reuse although, since some reprocessing is required, it has been included in this section. This is discussed below, before turning to chipping and reprocessing.

Cages are suitable for recycling into other marine uses, such as pontoons etc., as well as land drainage pipes, by relatively straight forward processes such as cutting, straightening and welding. In the case of steel cages the industry already utilises re-galvanising to extend cage life where this is cost-effective. Feed pipes could also be made suitable for land drain use by cutting holes in the pipe. Such uses require less energy than chipping and remoulding and should be encouraged. They may also require less preliminary cleaning than that required for chipping which is another benefit. Likewise, nets can be used for geotechnical applications following the straightforward removal of certain elements and cutting into appropriate sizes.

Given the demand for building and geotechnical products, there is considered to be no reason in theory why the majority if not all such aquaculture products could not be recycled by such relatively non-intensive processes. Discussions with consultees suggest that barriers to increased utilisation of these approaches include:

- Lack of awareness about potential routes and buyers and sellers;
- A preference by procurers for new rather than recycled products; and,
- Labour and other costs associated with these approaches.

The recommendations included earlier in regard to the reuse of redundant plant and equipment (Section 5.4.3) would also help to address the above issues.

It is also recommended that the community recycling sector could be involved in the development of mechanisms for reusing redundant plant and equipment. Support should be given to proposals in this regard and the CRNS should be involved.

Plastic Containers

Although a relatively small waste stream (albeit more significant for freshwater sites), more could be done by suppliers to recycle waste plastic containers since there appears to be a reluctance to take these back unless strongly encouraged to do so by the customer. One pharmaceutical company expressed interest in working with peer companies and farmers to reduce plastic wastes. It is recommended that fish farmers work more with their supply chain in this regard, perhaps including recycling as a condition of contract. Liaison with the operators of EurepGAP is also recommended to ensure that containers can be reused under this scheme.

Paper and Cardboard and Domestic Wastes

Together, these are estimated to make up some 12% of the waste stream and, with the exception of food wastes, are easily recyclable. However, it is apparent that recycling provision for these materials from both local authority and waste management companies is poor. From the council perspective, the remote location of most fish farming sites may render collection uneconomic and, although there might be increased emphasis on this in the future due to the need to reduce the amount of waste being landfilled, many local authorities may not consider such provision a priority.

There is also a barrier in the use of 'bring site' recycling facilities (i.e. bottle banks etc) since these are typically for household wastes and it is difficult for companies to adequately discharge their duty of care[17], including the completion of waste transfer notes. Nevertheless, it is understood that Highland Council has piloted a scheme in this regard. It is recommended that the industry, perhaps in association with other rural industries such as fish processing, agriculture, hospitality, motor vehicle servicing and retail, enters into a dialogue with the local authorities to address this issue, perhaps with guidance from the Waste Resources and Action Programme (WRAP).

The apparent failure to provide a recycling provision for rural industries, including salmon farmers, prompted discussions with one community based recycling organisation, Fyne Futures located on the Isle of Bute and serving parts of Argyll and Bute, about the feasibility of developing a service for such industries. There is

[17] With respect to the Environmental Protection (Duty of Care) Regulations 1991, as amended.

considered to be considerable potential in this regard and it is recommended that the Community Recycling Network Scotland (CRNS), local authorities and funding bodies look favourably and support any such initiatives in this regard. This could include provision of a mobile chipping service, to service the Northern and Western Isles as well as the mainland.

Fish Mortalities: Composting, Anaerobic Digestion and Oil Extraction

There is one example in the Western Isles of off-site disposal to land which, to some extent, follows a composting approach and is approved by the authorities. It is understood that replication elsewhere is unlikely due to the particular geological and geographical circumstances in this location.

Consultations confirmed that the disposal of fish mortalities continues to be a major source of concern for the industry. The current reliance on facilities outwith Scotland (Granox Ltd, Widnes) was felt to be unsustainable due to the high costs and emissions associated with transport. Nevertheless, it was appreciated that Granox did provide a disposal route which would otherwise be lacking at the current time. It should be noted that Granox are intending to increase their capacity for fish mortalities in the future (Granox Ltd, 2008, *pers. comm*.).

Although incineration (with and without energy recovery) has seen increased use in recent years, with small scale on-site plants being of particular interest at the current time, many within the industry, as well as wider stakeholders, have long considered that composting could be a practical and preferable option. More recently, there is interest in the potential for anaerobic digestion.

Neither composting nor anaerobic digestion are currently permitted under the animal by-products (ABPR) legislation[18]. Nevertheless, there is a mechanism within the legislative framework for considering new approaches and the Scottish Government is minded that a more sustainable approach would be preferable, providing that concerns over pathogen destruction can be adequately addressed (Scottish Government, 2008, *pers. comm*.). A previous trial into composting was undertaken by FRS although this was understood to be inconclusive (FRS, 2008, *pers. comm*.).

To obtain approval, a technology requires to be accepted by the EU. To do so, acceptable performance across pilot studies and commercial trials for all foreseeable operating circumstances would need to be unequivocally demonstrated.

The demise of the former Scottish Fish Waste Management Group, which included representatives of Government, FRS, HIE, SEPA, the State Veterinary Service, fish farmers and waste management organisations has resulted in there being a lack of focus for fish waste (i.e. mortality) issues. There has also been no continuation of the previous FRS work on composting, or an impetus either from the fish farming sector, their representatives or the waste management industry to further work in regard to composting and/or anaerobic digestion of fish mortalities.

However, it is understood that a new plant, located at Brechin, is just starting that is licensed to accept Category 2 fish mortalities. This is operated by Matheson Jess along with Rossyew Ltd and Scambio (Scotland) Ltd[19]. The plant will extract fish oil

[18] Animal By-Products (Scotland) Regulations 2003.
[19] We were informed that initial contact should be made to Scanbio for further information.

for use for 'technical purposes' from ensiled fish mortalities with incineration of the residue.

It is recommended that a fish waste group, with representation from Government, fish farmers and waste management organisations, be re-established as a priority. A primary focus of this group should be to assess the initial operations of the Matheson Jess plant at Brechin to establish to what it extent this meets the needs of the fish farming industry for a sustainable solution to fish mortality disposal for arisings from both routine operations and events. Depending upon the outcome of this, it is recommended that the group should facilitate the establishment of trials of composting and anaerobic digestion, with the aim of obtaining approval for appropriate and sustainable technologies suited to fish mortalities (i.e. Category 2 wastes under the ABPR) backed up with scientifically rigorous and commercially viable trials. This work should be progressed in a way that assesses multiple technologies so as to provide the greatest impetus for future development. Consideration should be given to technologies appropriate for small scale operations, which may be of benefit to remote sites as well as larger scale plants more suited to a regional or even national service, including composting and anaerobic digestion.

A newly established fish waste group and other appropriate organisations, such as SARF, HIE, SSPO, SSFA and the Scottish Government, should consider whether public funding would be appropriate. Given that the private sector does not appear to have actively pursued this area of development, some element of public and/or industry funding is considered essential. Close liaison with NISP is also recommended, since fish wastes are included under its proposed 2008 business plan.

It is noted that SEPA has confirmed that there is a possible interest in reducing the licensing burden on mobile composting facilities (SEPA, 2008, *pers. comm*.). This may assist the implementation of composting and, indeed, anaerobic digestion facilities should an appropriate technology be developed and gain approval.

It should be noted that this report did not identify all forthcoming licensed disposal routes for fish mortalities and did not review all current ones, since the emphasis was on routes currently used by Scottish salmon farmers.

5.4.5 Disposal

Disposal is at the bottom of the waste hierarchy, although disposal with recovery is very much favoured over disposal without. In some respects the waste management industry has improved the sustainability of disposal of fish mortalities with use of incineration with energy recovery. However, the long transport distance to Widnes may make overall sustainability benefits questionable, especially when, prior to this, rendering was a major disposal route – albeit using Norwegian facilities.

Fish Mortalities

There is considerable concern from many within and outwith the industry that there is insufficient capacity for handling a major mortality event in Scotland. One company pointed out that Granox Ltd was unable to handle a recent event and the alternative they put in place (landfill) was a complex, costly and unsatisfactory alternative, although another noted that they had disposed of event mortalities via this route. In Shetland, landfill is used for event situations.

An assessment of current and planned provision for the disposal of event mortalities is recommended, which should include the development of contingency planning. This should be undertaken as a priority. Funding for such an initiative should be considered by the industry, the Scottish Government and/or SARF. This should be co-ordinated by a newly established fish waste group.

The disposal of fish mortalities to landfill has continued in some parts of Scotland. It is a well used disposal route in Shetland, and is also utilised by a relatively small proportion of sites on the mainland. Although disposal of fish mortalities to landfill is not allowed under the Animal By-Products Regulations, Scotland has a temporary remote rural derogation which allows this to continue in specified locations, including many areas where fish farmers currently operate.

As highlighted in Section 5.3.2 above, the Scottish Government plans to review the rural derogation and it is expected, albeit not confirmed, that it may be removed in the mainland (but not in the Western Isles, Orkney or Shetland). Removal could have significant impacts on certain fish farmers and, whilst this would only affect a small proportion of the industry, it is the smaller companies which would be most affected. It is recommended that the fish farmers' representatives open a dialogue with the Scottish Government to represent members' interests in this regard. Whilst it is recognised that landfill is not a sustainable approach, and that there will be increasing emphasis on diverting organic materials from landfill in the future, it is recommended that the derogation should not be removed until viable and sustainable alternatives are put in place throughout Scotland. Given the environmental and political imperatives to reduce landfill use sooner rather than later, priority should be given to consideration of more sustainable alternatives as discussed in Section 5.4.4 above.

Many consider that the ABPR are not an appropriate vehicle for fish mortalities in comparison with arisings from terrestrial agriculture. It is recommended that the industry engage with the Scottish Government and the European Union in regard to the forthcoming review to consider whether a more appropriate approach can be developed for the aquaculture industry in the forthcoming review.

5.5 Synergies with Other Industries

There was some discussion at the Inverness workshop about potential synergies with the shellfish industry and other aquaculture species. It is recommended that the fish waste group include representatives from fish processing and other aquaculture organisations, including the British Trout Association and the Association of Scottish Shellfish Growers (ASSG) and capture fisheries.

It is recommended that a wider aquaculture waste working group be established, with representation from SEPA's waste minimisation clubs, the BREW programme, and other relevant sectors such as agriculture, hospitality and motor servicing. The aim should be to further sustainable waste management in rural and remote areas of Scotland.

5.6 Surveying and Reporting

As previously stated (Chapter 4.1), it is recommended that an annual waste management survey of the industry is undertaken, possibly in conjunction with the FRS Annual Production Survey, or that discussions are held with SEPA to find ways of increasing the usefulness to the industry of their three yearly business survey.

It is also recommended that a study similar to this be undertaken in regard to fish processing, feed manufacture and other upstream and downstream elements of the supply chain. This should, as above, then lead to annual or periodic surveys.

As suggested elsewhere (Thistle Environmental 2004, 2005, 2008), it is recommended that the industry reports on its environmental impacts and initiatives, either as a cross sector report or reports by individual companies. In both cases, an impartial approach should be undertaken in accordance with best practice.

Chapter 6 Conclusions and Recommendations

Ref.	Conclusions
C1	It is estimated that approximately 9,300[20] tonnes per annum (tpa) of waste arises from the Scottish salmon farming, which can be apportioned as about: • 59% from sea water routine wastes; • 30% from sea water non-routine wastes; • 11% from freshwater routine waste; and, • A negligible amount from freshwater non-routine wastes.
C2	Across Scottish salmon farming, plastics and fish mortalities were estimated to be the two most dominant waste streams at around 35% each. Timber, paper and cardboard, and steel were each estimated at about 8%, domestic wastes as 4% and special waste as 1%. Plastics included feed bags, cages, nets and feed pipes, whilst steel consisted mostly of cages and walkways.
C3	There is a marked regional differentiation to arisings. In total, wastes were significantly higher in the North West of the Scottish mainland, being some 25% greater than Shetland which was some 53% above the next two largest areas of the Western Isles and the South West. This is linked to the regional scale of the industry.
C4	Overall, about 59% of wastes are estimated to be landfilled, 18% recycled (or reused), 18% incinerated with energy recovery, 2% incinerated without energy recovery and 2% disposed of to land. The location of waste management facilities does not reflect the location of arisings. Some 95% of the incineration with energy recovery is fish mortalities at Widnes (estimated as about 1,630 tpa); although this treatment includes recovery, is may not be considered sustainable due to the large transport distance. Incineration without energy recovery refers to incineration on site in small scale plant which, although a small percentage, is becoming increasingly popular with fish farmers and has no transport 'footprint.'
C5	The potential for moving towards large scale bulk feed delivery on a large scale (by blowers), which can eliminate the need for plastic feed bags, is unlikely in the foreseeable future in Scotland.
C6	An estimated 87% of feed bags are recycled from sea sites as follows: • West Coast: at GI Waste Solutions, Alness, due to infrastructure put in place by the feed companies and transport companies for sea delivery of feed. • Shetland: The Shetland Islands Council (SIC) organises the export of feed bags to Hong Kong for recycling. One consultee thought this would change in the future due to changing legislation.

[20] Figures are presented as 'ball-park' estimates and should be treated with caution due to the assumptions used in data extrapolation.

	Most freshwater feed bags are not recycled, although these represent a much smaller waste stream than those from sea sites.
C7	The majority of plastic cages are reused or recycled. Of this, a minority are reused or recycled with minimal reprocessing. The majority are recycled via a resource intensive process of cutting, chipping, transporting and reprocessing. Many plastic cages are upgraded and refurbished for reuse by the Scottish manufacturer Fusion Marine Ltd – this was not captured by the survey. Some nets and feed pipe are also reused and/or recycled. Steel cages and walkways are usually scrapped.
C8	A recent scheme in Shetland by the Shetland Islands Council (SIC) to recycle plastic cages and pipe appears to have been unsuccessful due to under utilisation by fish farmers. There is currently no well established service for chipping cages and feed pipe at fish farms for subsequent recycling.
C9	Few suppliers of plastic containers appear to have a scheme in place to take back empties from fish farmers for reuse/recycling.
C10	Ropes are not recycled. Nor, typically, are domestic type wastes including paper and cardboard.
C11	Concerns were raised that discarded plastic wastes, especially cages, are considered an eyesore in some areas.
C12	As well as Landfill Tax, other legislative and policy measures are expected to put increasing pressure on business to reduce arisings disposed of to landfill.
C13	Few companies record waste arisings and disposal routes as a key performance indicator (KPI) and not all companies separately identify waste costs.
C14	Although fish waste is one of a number of SEPA's National Best Practice Projects, which resulted in three reports in 2003/4, there does not appear to have been any recent action or significant overall progress in providing a sustainable solution to fish mortalities in Scotland, including implementing recommendations contained within reports undertaken under the auspices of the Scottish Fish Waste Management Group. However, it is understood that a new plant is just starting up at Brechin that is licensed to accept Category 2 fish mortalities[21] which combines oil extraction with incineration which may well address, at least to a partial extent, the lack of a sustainable solution to fish mortalities in Scotland. Fish wastes are noted to be one of the priorities of the National Industrial Symbiosis Programme (NISP) for this financial year. There used to be a working group in regard to fish mortalities (the Scottish Fish Waste Management Group), with representatives of the industry, Government and other stakeholders, which has been disbanded.
C15	There is considerable concern from many within and outwith the industry that there is insufficient capacity for handling a major mortality event in Scotland.

[21] This is operated by Matheson Jess along with Rossyew Ltd and Scambio (Scotland) Ltd – who should be contacted in the first instance.

C16	There is considerable concern from many within and outwith the industry that there is no sustainable means of handling fish mortalities within Scotland.
C17	The rural derogation that permits landfill disposal of fish mortalities in much of Scotland is expected to be reviewed in the near future. It is possible that the derogation will be removed for mainland Scotland (but kept in place for the Western and Northern Isles) due to the establishment of the National Fallen Stock Scheme. This would impact upon several fish farmers for routine mortalities and the wider industry for event mortalities, possibly leading to higher costs and reliance on fewer disposal options.
C18	In general, recycling provision for domestic type wastes from both local authority and waste management companies for fish farmers is poor.
C19	Waste handling and disposal routes are changing entities and therefore this report provides a 'snapshot' in time which will be out dated in the future.

Ref.	**Recommendations: High Priority**
R1	An aquaculture waste working group should be established. This should include representation from the industry, Government, other aquaculture and cross-sectoral interests.
R2	A sub-group of the aquaculture waste working group should address fish mortalities disposal; this should be the priority of the group in the first instance; this should include assessment of the extent to which the newly developed plant at Brechin meets the needs of the industry for a sustainable disposal route.
R3	An assessment of provision for event mortalities should be undertaken which should include contingency planning. Funding should be considered by the industry, the Scottish Government and/or SARF.
R4	Depending upon the outcome of R2 above, research into alternative treatment methods for fish mortalities (routine and event) is required, with a focus on obtaining approval for one or more technologies under the Animal By-products Regulations (ABPR). Emphasis should be given to sustainable approaches suitable for use on a local / regional basis as well as nationally within Scotland, which should include consideration of composting, anaerobic digestion and rendering. Whilst the experience of a previous project by the FRS should be given due prominence, a range of public and private sector approaches should be encouraged. Given the timescale required for research and pilot studies, especially in regard to composing and anaerobic digestions will be significant, it is recommended that there should be several projects running concurrently as a contingency in case a project is unsuccessful. This should include consideration of whether assistance should be provided to renders to establish a fish mortality process. Funding should be considered by the industry, the Scottish Government and/or SARF for this research.

R5	Fish farmers' representatives should open a dialogue with the Scottish Government to represent members' interests in regard to the possible removal of the ABPR remote areas derogation that allows disposal of fish mortalities to landfill on the mainland. The derogation should not be removed until viable and sustainable alternatives are put in place throughout Scotland.

Ref.	**Recommendations: Medium Priority**
R6	The industry should engage with the Scottish Government and the European Union in regard to the forthcoming review of the Animal By-products Regulations to consider whether a more appropriate approach can be developed for the aquaculture industry.
R7	A research project into biosecurity issues in regard to the reuse of bulk bags within and outwith the industry should be undertaken to identify the feasibility of feed bag reuse from a disease risk perspective.
R8	Depending upon the results of the above (R7), a pilot study should be set up between a Scottish bulk bag manufacturer and the industry to assess the feasibility of reusing feed bags within the industry. Envirowise, the National Industrial Symbiosis Programme (NISP) and possibly other members of the Business Resource Efficiency and Waste (BREW) programme, should be approached for potential support.
R9	Although much plastic redundant plant and equipment is currently recycled, this (with the exception of cage upgrades and refurbishment) and is centred on a resource intensive process. There is potential for much to be reused (recycled) with little additional processing for uses including: • Feed pipes and plastic cages: micro-hydroelectric schemes; • Feed pipes and plastic cages: within construction (e.g. drainage); • Feed pipes and plastic cages: within marinas and harbours; and, • Nets for geotechnical purposes. This more sustainable approach should be encouraged by the industry.
R10	It is recommended that regular information on waste arisings and disposal are obtained for use by the industry and as a basis for policy decisions. This could take the form of one or a combination of the following mechanisms: • Annual or periodic survey by an independent organisation. • Annual survey combined with the existing Annual Production Survey by the Fisheries Research Services (FRS). • Enhancing the approach of the cross sectoral three yearly Scottish Environment Protection Agency (SEPA) survey to make it a more widespread and useful reflection of Scottish salmon farming. • Discussing with SEPA whether it has relevant data on fish mortalities. It is recommended that the usefulness and practicalities of such a survey and the above approaches be discussed with the farmers' representatives, the Scottish Salmon Producers Organisation (SSPO) and the Shetland Salmon

	Farmers Association (SSFA), as well as SEPA and the Scottish Government.
R11	i) A scheme should be set up to provide information for fish farmers on waste disposal and recycling – and to put waste producers in touch with potential users of their wastes. This may usefully take the form of a helpline, website or newsletter operated by a person/organisation with a detailed understanding of the industry and waste management practices. This could be operated by an independent body or an organisation such as NISP. ii) A mechanism should be developed for fish farmers and stakeholders to submit and share good practice suggestions. For example, a short annual symposium on waste management issues is recommended, perhaps included as part of the programme at fish farming conferences and exhibitions, and introduced for an initial period of three to five years. iii) This should be informed by a round-up of waste management issues on a confidential and independent basis by an independent organisation with good knowledge of the industry and waste management issues, thereby allowing Scottish fish farmers to learn from each other and develop a more efficient and sustainable industry. iv) An updated version of the SEPA Aquaculture Waste Minimisation Guide (Thistle Environmental, 2005) should be provided at regular intervals. v) The establishment of (a) cross sector resource centre(s) to encourage reuse within aquaculture and between other industries, particularly construction, should be considered. This might be usefully implemented by the community recycling sector and close liaison with the Community Recycling Network Scotland (CRNS) is recommended as well as the BREW programme and NISP.
R12	The industry, perhaps in association with other rural industries such as fish processing, capture fisheries, agriculture, hospitality, motor vehicle servicing and retail, should enter into a dialogue with the local authorities to improve the recycling service offered to fish farmers perhaps with guidance from the Waste Resources and Action Programme (WRAP).
R13	There is considerable opportunity for the community recycling sector to provide a service to the fish farming industry. The Community Recycling Network Scotland (CRNS), local authorities and funding bodies should look favourably on initiatives in this regard. This could include provision of a mobile chipping service, to service the Northern and Western Isles as well as the mainland.
R14	It is recommended that plant and equipment are designed to facilitate reuse (and recycling). A research project(s) should be undertaken in this regard; interest was expressed from Boris Net Co. Ltd to host such a project.

Ref.	**Other Recommendations**
R15	It is recommended that SEPA estimates agricultural wastes on a regional basis so that the relative importance of aquaculture wastes as a proportion of

	agricultural wastes on a regional basis can be evaluated.
R16	It is recommended that fish farmers monitor and measure wastes, from both a tonnage and financial perspective; this will help to identify where savings can be made.
R17	The possible use of larger bulk feed bags should be supported by the industry.
R18	The interest in and development of nets of increased longevity should be supported by the industry.
R19	It is recommended that a research project into enhancing net longevity should be established between the industry and academia. The industry should consider approaching the Telford Institute in this regard.
R20	The industry should take note of the SSPO's demonstration project and any relevant Norwegian and EU research in regard to net longevity.
R21	It is recommended that fish farmers work more with their supply chain in this regard, perhaps including recycling as a condition of contract. Liaison with the operators of GlobalGAP is also recommended to ensure that containers can be reused under this scheme.
R22	The industry should promote regular contact with NISP.
R23	Industry and relevant organisations such as HIE should liase closely with the feed manufacturers and transport companies in regard to the economics of feed deliveries, and consider a study on the benefits and impacts of sea transport for aquaculture and related industries.
R24	Fish farmers, feed manufacturers, suppliers and the waste management industry should consider how to increase the recycling of freshwater feed bags.
R25	It is recommended that regular information on waste arisings and disposal are obtained for use by the industry and as a basis for policy decisions. This could take the form of one or a combination of the following mechanisms: • Annual or periodic survey by an independent organisation. • Annual survey combined with the existing Annual Production Survey by the Fisheries Research Services (FRS). • Enhancing the approach of the cross sectoral three yearly Scottish Environment Protection Agency (SEPA) survey to make it a more widespread and useful reflection of Scottish salmon farming. • Discussing with SEPA whether it has relevant data on fish mortalities. It is recommended that the usefulness and practicalities of such a survey and the above approaches be discussed with the farmers' representatives, the Scottish Salmon Producers Organisation (SSPO) and the Shetland Salmon Farmers Association (SSFA), as well as SEPA and the Scottish Government.
R26	A study similar to this should be undertaken in regard to fish processing, feed manufacture and other upstream and downstream elements of the supply chain. This should, as above (R25), then lead to annual or periodic surveys.
R27	As suggested elsewhere (Thistle Environmental 2004, 2005, 2008), it is recommended that the Scottish salmon industry [and other aquaculture sectors]

	reports on its environmental impacts and initiatives, either in the form of a cross sector report or reports by individual companies. In both cases, an impartial approach should be undertaken in accordance with best practice.
R28	Should more accurate data be required, it is recommended that further research is undertaken, including waste compositional analysis, especially if information is used as a basis for policy or commercial decisions.
R29	It is recommended that cognisance be taken by the industry of the findings of a current Scottish Aquaculture Research Forum (SARF) project on the impacts of fish farming on tourism (in regard to waste storage) when the findings are available.

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Appendix 1: Questionnaire for Scottish Salmon Farms: Tank Site/Hatchery

QUESTIONNAIRE FOR SCOTTISH SALMON FARMS

Thistle Environmental Partnership has been commissioned by SARF (Scottish Aquaculture Research Forum) to do a waste survey in the Scottish aquaculture industry. We are approaching selected fish farming companies to gather information on their key waste streams.

The questions have been designed to be answered by a freshwater tank site and / or hatchery. If you have any queries with regard to filling in this form, please contact Mark Taylor (07773 429 408) or Robert Kelly (01471 822 718).

Please feel free to write notes on the form if it will help us understand your answers. Please note that there is space for additional comments at the end. We intend to consult further with you about your waste management issues to discuss any specific issues at a later date.

Please complete on hard copy or electronically.

Many thanks for your help with this exercise

1 General

Please answer all the questions below with respect to the last 12 month period for which you have data available.

1.1 Please state which 12 month period you are using: e.g. Jan – Dec 2006 or April 2006-March 2007. 12 month period covered: …….

1.2 In which local authority areas is your tank site / hatchery?.....

1.2 How many full-time staff does your site employ?.....

1.3 How many part-time staff does your site employ?.....

2 Feed bags

2.1. How much feed was used in the 12 month period? Please give the total number of bags OR total quantity of feed for the different sizes of bags shown below:

	Total no. of bags	Total tonnes of feed used
25 kg bags		
0.5 tonne bags		
1 tonne bags		
Other (specify)		

2.2 How are your waste feed bags handled on-site? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Kept Loose	
Baled	
Stuffed into other feed bags to help compress them	
Compressed by machine	
Other (specify)	
Don't know	

2.3 In the 12 month period have waste feed bags generally been kept as a separate waste stream or mixed with other wastes? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Feed bags kept separate from other wastes	
Feed bags mixed only with other waste plastic	
Feed bags mixed with other wastes including non - plastics	
Other (specify)	
Don't know	

2.4 In the 12 month period, how have your waste feed bags been transported? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

	Tick if applies	Name of Transport Company
By lorry		
Other (specify)		
Don't know		

2.5 How have your waste feed bags been disposed of in the 12 month period? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

All recycled	
Some recycled some land-filled	
All land-filled	
Other (specify)	
Don't know	

2.6 Where have your waste feed bags been disposed of in the 12 month period? Please state city or town where recycled or land-filled?.....

2.7 Which company or companies have been responsible for recycling or land-filling your waste feed bags in the 12 month period?.....

3 Waste Plastic Containers

3.1 Please detail the types (e.g. disinfectants, formic acid, degreasants etc) and approximate amounts of plastic containers (e.g. 25l) that you disposed of in the 12 month period.

Type	Size of Container	Number

3.2 How are your waste plastic containers handled on-site? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Kept Loose	
Baled	
Compressed by machine	
Other (specify)	
Don't know	

3.3 In the 12 month period have waste plastic containers generally been kept as a separate waste stream or mixed with other wastes? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Plastic containers kept separate from other wastes	
Plastic containers mixed only with other waste plastic	
Plastic containers mixed with other wastes including non - plastics	
Other (specify)	
Don't know	

3.4 In the 12 month period, how have your plastic containers been transported? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

	Tick if applies	Name of Transport Company
By lorry		
Other (specify)		
Don't know		

3.5 How have your waste plastic containers been disposed of in the 12 month period? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

All recycled	
Some recycled some land-filled	
All land-filled	
Other (specify)	
Don't know	

3.6 Where have your plastic containers been disposed of in the 12 month period? Please state city or town where recycled or land-filled?.....

3.7 Which company or companies have been responsible for recycling or land-filling your plastic containers in the 12 month period?.....

4.0 Special Wastes

4.1 How much special waste was disposed of in the 12 month period? Please complete all boxes that apply.

	Amount	Units	Specify
Oil		Litres (or specify other units)	
Oil filters		Number "	
Oily rags etc		Specify "	
Lead acid batteries		Number "	
Fluorescent tubes		Number "	
Computer monitors		Number "	
Other (specify)			
Other (specify)			

4.2 In the 12 month period, how have your special wastes been transported off the shore base? Please tick all that apply.

	Tick if applies	Name of Transport Company
By lorry		
Other (specify)		
Don't know		

4.3 Where have your special wastes been disposed of in the 12 month period? Please state city or town where recycled or land-filled?.....

4.4 Which company or companies have been responsible for disposing of your special wastes in the 12 month period?.....

5.0 Redundant Plant and Equipment

5.1 Did you have any other major items of plant and equipment that were disposed of in the 12 month period?

……
……

6.0 Fish Mortalities

6.1 How many fish mortalities were disposed of in the 12 month period? Please complete all boxes that apply. If the amount used is negligible, please just write "negligible". If necessary, please just provide an estimate.

		Tonnes (or specify other units)
Routine morts		
Major disease events		
Other events (specify)		

6.2 Are your fish mortalities treated on-site? If more than one category applies, please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Ensiled	
Incinerated	
Other (specify)	
No, they are not treated on-site	
Don't know	

6.3 In the 12 month period, how have your fish mortalities been transported? Please tick all that apply.

	Tick if applies	Name of Transport Company
By lorry		
Other (specify)		
Don't know		

6.4 Where have your fish mortalities been disposed of in the 12 month period? Please state city or town where recycled or land-filled? .....

6.5 Which company or companies have been responsible for disposing of your fish mortalities in the 12 month period?.....

7 Skipped Waste

For each main skip and / or bin used to dispose of bulk amounts of waste, please provide information below. Please print / copy more pages if you need to for this section.

Skip / Bin 1

Draw a rough sketch of the skip / bin and give the dimensions below.

How often is it collected in the winter?.....

How often is it collected in the summer?.....

Approximately how full is it when collected (estimate %)?.....

	Estimate % of waste in skip	Specify
Plastic		
Timber		
Paper / cardboard		
Other (specify)		
Other (specify)		
Other (specify)		
Other (specify)		

Skip / Bin 2

Draw a rough sketch of the skip / bin and give the dimensions below.

How often is it collected in the winter?.....

How often is it collected in the summer?.....

Approximately how full is it when collected (estimate %)?.....

	Estimate % of waste in skip	Specify
Plastic		
Timber		
Paper / cardboard		
Other (specify)		
Other (specify)		
Other (specify)		
Other (specify)		

Skip / Bin 3

Draw a rough sketch of the skip / bin and give the dimensions

How often is it collected in the winter?.....

How often is it collected in the summer?.....

Approximately how full is it when collected (estimate %)?.....

	Estimate % of waste in skip	Specify
Plastic		
Timber		
Paper / cardboard		
Other (specify)		
Other (specify)		
Other (specify)		
Other (specify)		

Skip / Bin 4

Draw a rough sketch of the skip / bin and give the dimensions

How often is it collected in the winter?.....

How often is it collected in the summer?.....

Approximately how full is it when collected (estimate %)?.....

	Estimate % of waste in skip	Specify
Plastic		
Timber		
Paper / cardboard		
Other (specify)		
Other (specify)		
Other (specify)		
Other (specify)		

8. Wooden Pallets

8.1 Do you dispose of wooden pallets? Please delete as appropriate. Yes / No

8.2 If yes, how were these disposed of? Please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the box showing any other methods.

	Tick if applies
Reused	
Recycled	
Landfilled	
Other (specify)	
Don't know	

9 Other Comments

Please provide any other comments on waste management below.

10 Classification data

(Note this information will only be used to check that our data is representative of the industry as a whole and to allow us to aggregate figures for the industry. It will not be presented in any way that would be identifiable to the company and will not be made available to any other parties.)

What was the approximate total production of smolts (000s) from your site in the 12 month period?.....

11 Contact Information

Your Name: ……..

Position: ……

Name of Site:…….

Company: ……..

Telephone: ……

THANKS VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE.

PLEASE RETURN TO:

By post: Mark Taylor, Thistle Environmental, Thistle Place, Edinburgh EH11 1JH;

Or, by email to kelly.skye@btinternet.com

NB: if sending by post, please copy before you send in case it goes astray.

Appendix 2: Questionnaire for Scottish Salmon Farms: Shore Base Level (Marine of Freshwater)

QUESTIONNAIRE FOR SCOTTISH SALMON FARMS

Thistle Environmental Partnership has been commissioned by SARF (Scottish Aquaculture Research Forum) to do a waste survey in the Scottish aquaculture industry. We are approaching selected fish farming companies to gather information on their key waste streams.

The questions have been designed to be answered at the shore base level. If you have any queries with regard to filling in this form, please contact Mark Taylor (07773 429 408) or Robert Kelly (01471 822 718).

Please feel free to write notes on the form if it will help us understand your answers. Please note that there is space for additional comments at the end. We intend to consult further with you about your waste management issues to discuss any specific issues at a later date.

Please complete on hard copy or electronically.

Many thanks for your help with this exercise

1 General

Please answer all the questions below with respect to the last 12 month period for which you have data available.

1.1 Please state which 12 month period you are using: e.g. Jan – Dec 2006 or April 2006-March 2007. 12 month period covered: …….

1.2 How many active salmon farming sites does this shore base serve?.....

1.3 In which local authority area is your shore base?.....

1.4 How many full-time staff does your shore base employ?……..

1.5 How many part-time staff does your shore base employ?.....

2 Feed bags

2.1. How much feed was used in the 12 month period? Please give the total number of bags OR total quantity of feed for the different sizes of bags shown below:

	Total no. of bags	Total tonnes of feed used
25 kg bags		
0.5 tonne bags		
1 tonne bags		
Other (specify)		

2.2 How are your waste feed bags handled on-site? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Kept Loose	
Baled	
Stuffed into other feed bags to help compress them	
Compressed by machine	
Other (specify)	
Don't know	

2.3 In the 12 month period have waste feed bags generally been kept as a separate waste stream or mixed with other wastes? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Feed bags kept separate from other wastes	
Feed bags mixed only with other waste plastic	
Feed bags mixed with other wastes including non - plastics	
Other (specify)	
Don't know	

2.4 In the 12 month period, how have your waste feed bags been transported? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

	Tick if applies	Name of Transport Company
By lorry		
By boat		
Other (specify)		
Don't know		

2.6 How have your waste feed bags been disposed of in the 12 month period? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

All recycled	
Some recycled some land-filled	
All land-filled	
Other (specify)	
Don't know	

2.6 Where have your waste feed bags been disposed of in the 12 month period? Please state city or town where recycled or land-filled?.....

2.7 Which company or companies have been responsible for recycling or land-filling your waste feed bags in the 12 month period?.....

3 Waste Plastic Containers

3.1 Please detail the types (e.g. disinfectants, formic acid, degreasants etc) and approximate amounts of plastic containers (e.g. 25l) that you disposed of in the 12 month period.

Type	Size of Container	Number

3.2 How are your waste plastic containers handled on-site? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Kept Loose	
Baled	
Compressed by machine	
Other (specify)	
Don't know	

3.3 In the 12 month period have waste plastic containers generally been kept as a separate waste stream or mixed with other wastes? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Plastic containers kept separate from other wastes	
Plastic containers mixed only with other waste plastic	
Plastic containers mixed with other wastes including non - plastics	
Other (specify)	
Don't know	

3.4 In the 12 month period, how have your plastic containers been transported? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

	Tick if applies	Name of Transport Company
By lorry		
By boat		
Other (specify)		
Don't know		

3.5 How have your waste plastic containers been disposed of in the 12 month period? If more than one category applies please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

All recycled	
Some recycled some land-filled	
All land-filled	
Other (specify)	
Don't know	

3.6 Where have your plastic containers been disposed of in the 12 month period? Please state city or town where recycled or land-filled?.....

3.7 Which company or companies have been responsible for recycling or land-filling your plastic containers in the 12 month period?.....

4.0 Special Wastes

4.1 How much special waste was disposed of in the 12 month period? Please complete all boxes that apply.

	Amount	Units	Specify
Oil		Litres (or specify other units)	
Oil filters		Number "	
Oily rags etc		Specify "	
Lead acid batteries		Number "	
Fluorescent tubes		Number "	
Computer monitors		Number "	
Other (specify)			
Other (specify)			

4.2 In the 12 month period, how have your special wastes been transported off the shore base? Please tick all that apply.

	Tick if applies	Name of Transport Company
By lorry		
By boat		
Other (specify)		
Don't know		

4.3 Where have your special wastes been disposed of in the 12 month period? Please state city or town where recycled or land-filled?.....

4.4 Which company or companies have been responsible for disposing of your special wastes in the 12 month period?.....

5.0 Redundant Plant and Equipment

5.1 How many plastic cages were disposed of in the 12 month period?
……
……

5.2 How many steel cages / walkways were disposed of in the 12 month period?
…….
……....

5.3 How many wooden cages / walkways were disposed of in the 12 month period?
……
……...

5.4 How many nets were disposed of in the 12 month period?
……
……....

5.5 Did you have any other major items of plant and equipment that were disposed of in the 12 month period (e.g. harvest bins, freshwater tanks, barges, boats, ropes, buoys etc)?
……
……

5.6 Were any of the above cages, nets or other wastes recycled / reused / scrapped? If so, please provide details below.
……
……

6.0 Fish Mortalities

6.1 How many fish mortalities were disposed of in the 12 month period? Please complete all boxes that apply. If the amount used is negligible, please just write "negligible". If necessary, please just provide an estimate.

		Tonnes (or specify other units)
Routine morts		
Major disease events		
Other events (specify)		

6.2 Are your fish mortalities treated on-site? If more than one category applies, please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the boxes showing any other methods.

Ensiled	
Incinerated	
Other (specify)	
No, they are not treated on-site	
Don't know	

6.3 In the 12 month period, how have your fish mortalities been transported? Please tick all that apply.

	Tick if applies	Name of Transport Company
By lorry		
By boat		
Other (specify)		
Don't know		

6.4 Where have your fish mortalities been disposed of in the 12 month period? Please state city or town where recycled or land-filled? .....

6.5 Which company or companies have been responsible for disposing of your fish mortalities in the 12 month period?.....

7 Skipped Waste

For each main skip and / or bin used to dispose of bulk amounts of waste, please provide information below. Please print more sheets if you need to for this section.

Skip / Bin 1

Draw a rough sketch of the skip / bin and give the dimensions below.

How often is it collected in the winter?.....

How often is it collected in the summer?.....

Approximately how full is it when collected (estimate %)?.....

	Estimate % of waste in skip	Specify
Plastic		
Timber		
Paper / cardboard		
Other (specify)		
Other (specify)		
Other (specify)		
Other (specify)		

Skip / Bin 2

Draw a rough sketch of the skip / bin and give the dimensions below.

How often is it collected in the winter?.....

How often is it collected in the summer?.....

Approximately how full is it when collected (estimate %)?.....

	Estimate % of waste in skip	Specify
Plastic		
Timber		
Paper / cardboard		
Other (specify)		
Other (specify)		
Other (specify)		
Other (specify)		

Skip / Bin 3

Draw a rough sketch of the skip / bin and give the dimensions

How often is it collected in the winter?.....

How often is it collected in the summer?.....

Approximately how full is it when collected (estimate %)?.....

	Estimate % of waste in skip	Specify
Plastic		
Timber		
Paper / cardboard		
Other (specify)		
Other (specify)		
Other (specify)		
Other (specify)		

8 Wooden Pallets

8.1 Do you dispose of wooden pallets? Please delete as appropriate. Yes / No

8.2 If yes, how were these disposed of? Please put two ticks in the box showing the most prominent method in the 12 month period and one tick in the box showing any other methods.

	Tick if applies
Reused	
Recycled	
Landfilled	
Other (specify)	
Don't know	

9 Other Comments

Please provide any other comments on waste management below.

10 Classification data

(Note this information will only be used to check that our data is representative of the industry as a whole and to allow us to aggregate figures for the industry. It will not be presented in any way that would be identifiable to the company and will not be made available to any other parties.)

In total across your company, what was your approximate total production of smolts (000s) in the 12 month period?.....

In total across your company, what was your approximate total production of salmon (tonnes) in the 12 month period?.....

11 Contact Information

Your Name: …….

Position: ……

Name of Shore Base:…….

Company: ……..

Telephone: ……

THANKS VERY MUCH FOR COMPLETING THIS QUESTIONNAIRE.

PLEASE RETURN TO:

By post: Mark Taylor, Thistle Environmental, Thistle Place, Edinburgh EH11 1JH;

Or, by email to kelly.skye@btinternet.com

NB: if sending by post, please copy before you send in case it goes astray.

Appendix 3: Notes on Estimates and Calculations

Chapter 3.0 Waste Arisings

Total Arisings

- Total arisings for sea water and freshwater routine and non-routine wastes were estimated by aggregating the results compiled below.
- The estimated totals for the industry for type of material were then estimated. In this case, plastics were taken to include all plastics within skips as well as the plastic redundant plant and equipment.

Regional Breakdown

- The FRS Annual Production Survey (FRS, 2007) provides a regional breakdown of salmon production and was used to apportion the estimates of total arisings on a regional basis.

Sea Water: Routine Wastes

Skipped Wastes: Total Tonnages

- Information from respondents about their use of skips was entered into a data base on a shore base basis.
- For companies that did not provide a size for their skip(s), an estimate was made based on their comments and information on standard skip sizes.
- An estimate was made of the total annual arisings for each shore base on skip size, the companies' estimate of how full the skips are when emptied and frequency of collection by volume (m^3 per annum).
- The estimated annual volume of skipped wastes for each shore base was divided by the production for each shore base to give an estimated volume of skipped waste (m^3 per annum) per tonne of production.
- Volume was converted into weight (tpa) by using a bulking factor. Several different factors were considered, including SEPA's 0.26 tonnes/m^3 (the figure being used for general wastes for their current waste survey (SEPA, 2008, *pers. comm.*)), and two figures from fish farmers of 0.26 tonnes/m^3 and 0.39 tonnes/m^3. Further information was sought from a waste management company and a major supplier to verify these but was not provided within the timescale of the project. Estimates were run on the basis of densities of 0.3, 0.39 and 0.45 for each shore base. These were then averaged across the number of shore bases and multiplied by the 2006 total Scottish salmon production to produce results of 2,260tpa, 2,792tpa and 3,302 tpa. It was felt that SEPA's factor may be a little low as this would not account for the disposal of redundant plant and equipment, and some companies stated that they may bring in additional skips from time to time or have additional collections, so a slightly higher figure was considered appropriate. Therefore, a total figure of 3,000tpa was decided upon, as a compromise between the medium and higher densities. Using the survey return data, this gives an estimated 0.067 tonnes of skipped waste per tonne of production.
- This estimate was made on the basis of 13 site / shore base returns.

Feed Bags

- The total number of feed bags used was calculated for each shore base based on information provided in each survey return, to give a total number of feed bags for each of 25kg, half tonne and one tonne bags.
- The following weights were then used to calculate the total weight of waste feed bag per shore base / site.

Bag Size	Empty Weight (kg)
25kg	0.12
Half tonne	1.75
One tonne	2.5

- The estimated waste feed bags per tonne of production was then calculated by dividing the total weight of waste feed per shore base/site by their production. This was then summed and divided by the number of shore bases/sites to give an average weight per tonne of production.
- The estimated feed bags per tonne of production for the industry as a whole was calculated by multiplying this by the 2006 production figure for Scottish salmon as a whole of 131,847 tonnes (FRS, 2008).
- This estimate was made on the basis of 16 site / shore base returns.

Fish Mortalities

- The fish mortality information in the survey returns was put into a database on a site / shore base basis for routine mortalities. Production data was also entered.
- The total fish mortalities was summed for each site / shore base and divided by the number of returns to give an average tonnage. Production data was also summed.
- The site / shore base average was divided by production data to give a value of routine mortalities per tonne of production. This was then multiplied by the total tonnage for Scotland for 2006 to give a total estimated tonnage of fish mortalities for the industry as a whole.
- This estimate was made on the basis of 13 sites / shore base returns.

Special Wastes

- The information provided by companies in survey returns for special wastes, including oil, oil filters, oily rags, batteries, fluorescent tubes, computer monitors and veterinary products, was put into a database on a site / shore base basis. Production data was also entered.
- The total arisings for each category were summed for each waste stream and divided by the number of returns to give average tonnages. Production data was also summed.
- Approximate estimates were made of the weight of different special wastes as follows: oil: 0.87g/l; oil filter: 0.375kg; battery: 9kg; fluorescent tube: 1.36kg; veterinary products: 1kg/l. One company estimated their oily rag arisings to be 10kg and another to be 2kg. Computer monitors were not included since this is a

non-routine waste (and there were insufficient responses made in this regard to include as a non-routine waste).

- The average for the sites was divided by the total production data to give a value of each waste stream per tonne of production. This was then multiplied by the total Scottish 2006 production to give total estimated tonnages of special wastes equipment for each category, which was then summed to give an estimated tonnage of special waste for the industry as a whole.
- This estimate was based on information from a total of 15 sites / shore base returns for waste oils and batteries, 12 for oil filters, five for fluorescent tubes, four for veterinary products and two for oily rags.

Skipped Wastes: Individual Waste Streams

- Companies were asked to estimate the proportion of wastes falling into the following categories: plastic, paper/cardboard, timber and other. For 'other,' they were asked to specify the type of waste, from which the following additional waste streams were identified: domestic, rope, steel, nets and polystyrene. Since relatively small amounts of nets and polystyrene were identified by a small number of respondents, these were included as 'other' on the pie chart.
- The estimates were summed for each waste stream and divided by the number of respondents to give an average percentage per waste stream which are the values used in the report.
- This estimate was made on the basis of 13 site / shore base returns.

Sea Water Non-routine Wastes

Event Mortalities

- These were estimated using the same approach as for routine wastes as described above on the basis of 13 site / shore base returns.

Redundant Plant and Equipment

- The information provided by companies in survey returns for redundant plant and equipment, including cages, nets and others, was put into a database on a site / shore base basis. Production data was also entered.
- The total arisings for each category from the survey returns was summed and divided by the number of returns to give average tonnages. Production data was also summed.
- Approximate estimates were made of the weight of different items of plant and equipment as follows: plastic cages: 4.2 tonnes, steel cages: 8 tonnes, nets: 1.15 tonnes, plastic feed pipe: 8.4kg/m; polystyrene floats: 20kg.
- The average for the sites was divided by the total production data to give a value for each waste stream per tonne of production. This was then multiplied by the total tonnage for Scotland for 2006 to give total estimated tonnages of redundant plant and equipment for each category for the industry as a whole.
- This estimate was based on information from a total of 14 sites / shore base returns. Note that only seven of these identified nets as a waste stream from their

site during the period of interest, only three for polystyrene floats and one for feed pipe. Nevertheless, from follow-up consultations, it is known that these are issues across the industry. Three companies also provided information on wooden cages (this category was not reported since few companies now use wooden cages).

Freshwater Routine Wastes

- Skipped wastes, fish mortalities and special wastes were estimated using the same methodology descried above for sea water. Note that a separate category was not provided for feed bags as those companies that provided returns from freshwater operations did not handle feed bags as a separate waste stream.
- This estimate was made on the basis of 5 site returns.

Freshwater Non-Routine Wastes

- Fish mortalities were estimated using the same methodology described above for sea water.
- Insufficient information was provided on returns to allow an estimate of waste nets from freshwater production. Instead, waste nets were estimated in two approaches:

1. Using an estimate of average cage size across the industry and a replacement of 20% nets per annum gave 21.6tpa if waste nets.
2. Using an estimated annual industry procurement of freshwater nets of 1,000 nets, based on discussions with the industry, with an estimated weight of 150kg, gave 15tpa.

- Therefore, an approximate figure of 20tpa was taken as a 'ball-park' estimate.

Chapter 4.0 Waste Handling and Disposal

Feed Bags: Sea Sites

- The ratio of bags used in participating companies for the three sizes was calculated to be 17:14:119 for 25 kg, half tonne and one tonne respectively. The total tonnage of waste feed bags for sea water sites (379 tpa – see Chapter 3) was then apportioned according to this ratio to give an estimated tonnage of feed bags for each of the three sizes: 43 tpa of 25 kg bags, 35 tpa of half tonne and 301 tpa one tonne.
- The tonnage allocated to each type of feed bag was then divided by the weight of feed bag (see table below) to give an estimated number of feed bags and rounded to the nearest hundred bags: 358,300 25 kg bags, 20,000 half tonne bags and 120,400 one tonne bags.

Feed Bags: Freshwater Sites

- It was estimated that a total of 5,100,000 kg of feed was used. This was based on the following assumptions: 40.8m smolts (FRS, 2007) at 100g and FCR of 1.25.
- It was considered possible that 95% of freshwater feed was delivered in 25kg bags. This would account for 4,845,000 kg of feed and, therefore, 193,800 bags. At 0.12 kg per bag, this gives a total of 23.2 tpa of bags. Assuming that the

remaining 255,000 kg of feed is in one tonne bags; this would require 255 one tonne bags which, at a weight of 2.5 kg, is 0.6 tpa. gives 1) are one tonne. Together, these give a combined total of 24 tpa.

Fish Mortalities

Disposal routes for fish mortalities were estimated on the basis of information provided by companies in sample returns along with follow-up discussions. In several cases, assumptions were made to allow estimates to be made where there was an information gap; hence, these figures should be treated with caution.

Appendix 4: List of Consultees

Angus McDonald
Aqua Systems (UK) Ltd
Biomar Ltd
Boris Net Co Ltd
Bulk Bag Containers Ltd
Comhairle nan Eilean Siar (Western Isles Council)
Dryden Aqua Ltd
EWOS Ltd
Ferguson Transport (Spean Bridge) Ltd
Fisheries Research Services (FRS)
Fjord Seafood Scotland Farming (now Lighthouse Caledonia Ltd)
Fusion Marine Ltd
Fyne Futures (previously Bute Recycling Centre)
GI Waste Solutions
Gael Force Marine
Highland Council
Highland Salmon Co Ltd
Highlands and Islands Enterprise (HIE)
Hjaltland Seafarms Ltd
Hoganess Salmon Ltd
Lakeland Marine Farm Ltd
Lakeland Unst Ltd
Landcatch Ltd
Loch Duart Ltd
Locheil Logistics Ltd
Marine Harvest (Scotland) Ltd
Migdale Smolt Ltd
National Farmers Union Scotland (NFUS)
National Industrial Symbiosis Programme (NISP)
North Uist Fisheries Ltd
Oran Group
Orkney Islands Council
Orosay Net Station

Pan Fish Scotland Ltd (now Lighthouse Caledonia Ltd)

PHARMAQ Ltd

Scanbio (Scotland) Ltd

Schering-Plough Ltd

Scottish Environment Protection Agency (SEPA)

Scottish Government

Scottish Motor Trade Association (SMTA)

Scottish Sea Farms Ltd

Shetland Aquaculture

Shetland Amenity Trust

Shetland Islands Council (SIC)

State Veterinary Service

Sunbeam Aquaculture Ltd

W & J Knox Ltd

West Minch Salmon Ltd

Wester Ross Fisheries Ltd

Appendix 5: List of Workshop Attendees

No.	Name	Organisation
1	Andrew Taylor	Scottish Government
2	Donald Fowler	Boris Nets
3	Freda Davidson	Animal Health Office
4	Graham Imrie	GI Waste Solutions
5	Hugh Richards	Wester Ross Fisheries Ltd
6	Iain Sutherland	HIE
7	Jaqueline MacMillan	Scottish Environment Protection Agency (SEPA)
8	Jennie Sandals	Loch Duart Ltd
9	Judith White	Scottish Government
10	Kate McEwan	Fish Vet Group
11	Ken Gowrie	Novartis Animal Health
12	Mark Taylor	Thistle Environmental Partnership
13	Michaela Archer	Sea Fish Industry Authority
14	Mike Bland	Fish Health Inspectorate, FRS
15	Neil Auchterlonie	SSPO
16	Nick Bradbury	Biomar
17	Nicola McRobbie	Scottish Aquaculture Research Forum (SARF)
18	Robert Kelly	Thistle Environmental Partnership
19	Shona Anderson	Lighthouse Caledonia Ltd
20	Simon Reynolds	Landcatch Ltd
21	Suzanne Henderson	Scottish Natural Heritage (SNH)