Final Report of the
Joint Government/Industry Working Group
on Infectious Salmon Anaemia (ISA)
in Scotland

Published by the Scottish Executive

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EXECUTIVE SUMMARY

Chapter 1: Introduction

Infectious salmon anaemia (ISA), a viral disease of salmon which scientists agree poses no threat to human health, was first recognised in Scotland in May 1998. The disease is confined to salmon, and all of the confirmed sites to date have originated from a point source. In October 1998 a Joint Government/Industry Working Group (JWG) was established to identify the measures required to prevent or minimise the impact of further outbreaks of ISA.

The recommendations of the JWG are broadly of two types: firstly, practical measures to minimise the risk from ISA; and secondly pointers to the research needs of the industry and diagnostic services. The first encompasses both husbandry practices and area management. Many of these recommendations are valid for fish disease control generally and may be seen as helping to shape a more sustainable industry. Research needs that have been identified include aspects of disease transmission, efficacy and environmental acceptability of chemical and physical disinfection methods, waste management and laboratory techniques for detection and diagnosis. Some of this research is already in progress.

It is intended that the majority of the practical husbandry and management recommendations be implemented by incorporation into Codes of Practice. Some of the recommendations may need to be implemented through new legislation. In one instance, of ceasing the practice of using salmon waste as creel bait, it has been possible to implement the recommendation by advising local authorities of their powers under existing legislation (Animal By-Products Order 1999).

Chapter 2: Vertical Transmission and Ova Disinfection

Whilst neither intra- nor extra-ovum vertical transmission has been shown to occur, a precautionary approach is advocated. The following management recommendations are intended for inclusion in a Code of Practice. To avoid any possibility of intra-ovum vertical transmission, it is recommended that gametes should not be taken from ISA infected broodstock (2.3.1). As a precaution against extra-ovum transmission, recommendations are made for avoidance of contamination of gametes through hygiene protocols and disinfection of ova (2.3.2).

Research into the efficacy of iodophor disinfection against ISA Virus (ISAV), and further work to quantify the risk of vertical transmission, is proposed (2.3.3).

Chapter 3: Horizontal (Site-to-Site) Transmission

Section 3.1: Risks to and from freshwater farms

ISA outbreaks have been closely linked with, among other factors, horizontal transmission of infection in sea water, and therefore the recommendation is made that sea water should not be used in the production phase in hatcheries (3.1.7).

Other recommendations aimed at isolating hatcheries from the marine environment have been made for equipment, protective clothing, fish management and movements (3.1.7). The JWG considers that all of these recommendations should be incorporated into Codes of Practice.

Section 3.2: Risks associated with sea water to sea water fish movements

Numerous aspects of the movement of fish between seawater sites were considered in order to evaluate the ISA risks posed by the different management practices used in production and harvesting. The overriding conclusion was that there should be a general presumption against seawater-to-seawater movements (3.2.3.1). It is of course realised that such movements are sometimes necessary and the circumstances when different types of movement are tolerable are reviewed. As with risks associated with freshwater farms, these recommendations (3.2.3) are seen as foundations for a Code of Practice.

Section 3.3: Risks associated with trout farming

This chapter raises the questions of the risk posed to farmed marine trout by ISA and the risk of farmed marine trout harbouring the virus and subsequently infecting marine salmon. The trout referred to are brown and sea trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). As these may be covertly infected, it is recommended that the current Scottish Executive Rural Affairs Department (SERAD) policy of treating marine trout farms in the same way as salmon farms should continue (3.3.3.1). Meanwhile, programmes of surveillance and research, detailed in 3.3.3.2, should be undertaken, and in the light of the results of these studies, the risks from current trout farm management policies be re-assessed.

Section 3.4: Risks associated with wellboats

It was identified that the level of risk posed by a wellboat depends on the ability to clean and disinfect the vessel effectively, on the disease status of the area in which the boat is operating and the task being undertaken. Seven different operational scenarios are described, and the appropriate level of cleaning and disinfection is defined, drawing on the FRS Marine Laboratory Aberdeen: *Disinfection Guide with regard to the ISA Virus: Version II.*

Recommendations are made to the Scottish Executive for legislative regulation of wellboat entry into UK waters, to monitor wellboat activities, review slipways, establish standard disinfection procedures and arrange for routing of wellboats. Wellboat operators are recommended to apply the standard disinfection procedures, adapt procedures to take account of individual wellboat design and to travel closed (ie with no water exchange) when within 5 km of any fin fish farm site. The operational recommendations to wellboat users are intended for implementation by means of a Code of Practice. Compliance should be monitored by auditing the records of fish movements (3.4.5). It is also recommended that Government consider ways to support the development of a shipping infrastructure in coastal areas with significant aquaculture activity.
Section 3.4.6: Risks associated with the movement of other equipment

The risks associated with other fish farm vessels, equipment and farming practices are highlighted. As with the recommendations for fish movements, there is a general presumption against inter-site movement of vessels and equipment. It is recommended that where economics permit, equipment and protective clothing should be site specific and, failing this, movement should be minimised and the standard disinfection procedures followed. Procedures are recommended for the auditing of inter-site movement of equipment and biologically active material. In the absence of any legislative powers within the Diseases of Fish Act 1937 (as amended), it is recommended that non-farm vessels entering the area of a farm be contacted and made aware of the potential disease risk with a view to minimising contact. As with wellboat operations implementation by Code of Practice is recommended (3.4.7).

Section 3.4.8: Risks associated specifically with diving

Divers handle potentially high risk material (mortalities) and may make serial visits to sites in different areas. It is recommended that the standard disinfection procedure for diving equipment be followed, documented and audited on each occasion, and similarly, other equipment be included in a Code of Practice (3.4.8.1).

Section 3.5: Harvesting operations

The risks associated with three different categories of harvest operation are reviewed, and a range of risk reduction measures is proposed for implementation by means of a Code of Practice. These measures cover training, auditing, separation distances, containment, disinfection, risk of escapes, fish movement and the different categories of harvest operation. It is recommended that research into the design of harvest bins, enclosed holding cages at harvest stations, and the risk posed by wellboat waste-water and its treatment be conducted (3.5.4.3).

Section 3.6: Processing operations

Processing operations involve handling potentially high risk material and producing potentially infective waste and effluent. The attendant risks are identified and recommendations made to minimise them. One of these, the disinfection of processing effluent, is recommended for implementation by means of legislation. The ensiling of all processing waste as a legislative requirement is called for and is covered elsewhere in this report (3.7.6.1). The remainder of the recommendations, for containment and disinfection of high risk material are intended for inclusion in a Code of Practice (3.6.4).

Section 3.7: Disposal of mortalities and processing waste

Recommendations are made against the background of the Animal By-Products Order 1999. The recommendations call for legislation for the ensiling of all mortalities, primary and secondary processing waste, and disinfection of processing effluent. It is recommended that SERAD issue guidelines to local authorities on the enforcement of the Animal By-Products Order 1999 and end the practice of using salmon waste as creel bait. The need for infrastructure for the storage and
collection of ensiled waste is indicated, and it is recommended that Government encourage and develop the capacity to render ensiled waste in Scotland. Research into the efficacy of disinfectants against ISAV is called for (3.7.6.7).

Section 3.8: Assessment of the risk of transmission of ISA to wild fish and other farmed fish from fish farm escapes

This chapter only considers escapes in relation to ISA, leaving the details of fish containment to the Farmed Fish Escapes Working Group. It is recommended that the conclusions of the latter are taken into account and that cage security inspection is increased when ISA is suspected. Additional measures are considered necessary when ISA infected or suspect stock is being moved. Whilst the major concern of both working groups is prevention, it is recommended that particular effort is directed towards recapture of sexually mature salmon, using recapture methods proposed by the Farmed Fish Escapes Working Group.

Section 3.9: Other biological vectors of ISA

The lack of knowledge regarding the role of numerous other potential biological vectors of ISA led to a list of research proposals which are the main feature of the recommendations in this section. The threat posed by wild sea trout to unprotected freshwater farms is considered, and the research proposed here overlaps that which is made regarding risks associated with trout farming (3.3.3). Attention is drawn to some of these vectors as potential bridges of the hydrographically defined Management Areas. Other research recommendations include investigating the carrier status of other non-salmonid aquaculture species, benthic persistence of ISAV, the potential role of shellfish, marine annelids and sea lice as vectors, and the risks posed by fishing effort near cages.

Management recommendations are made for effective sea lice control, predator proofing and a further call to minimise the risk posed by escapes.

Chapter 4: Detection and Diagnosis of ISA

In addition to classical pathological techniques, this section covers areas of rapidly developing molecular genetic (RT-PCR), immunochemical (IFAT) and general immunological diagnostic methods. It is recommended that research be undertaken to optimise existing techniques and to develop and validate alternative techniques (eg ELISA) for the detection and diagnosis of ISA (4.5).
Chapter 5: Catchment Management to Avoid and Minimise the Effects of ISA

Section 5.1: Hydrographically defined Management Areas for the Scottish Aquaculture Industry

Hydrographically defined Management Areas for the Scottish aquaculture industry have their origins in earlier strategies for controlling furunculosis and sea lice. They are applicable to the whole Scottish industry, can take into account specific local conditions, and form the basis for tackling the present ISA outbreak. It is recommended that they be adopted for dealing with any water-borne disease and for a planned approach to managing the industry. Clearly they must be scrutinised on a case-by-case basis to take into account local conditions and the planned occupancy of farms, in order to avoid the siting of farms in 'fire breaks' where they might bridge adjacent areas.

Section 5.2: Fallowing and rotation

The JWG does not make specific recommendations in this section, which is a review of the rationale for fallowing, technical evidence for its effectiveness and current practice in Scotland and other countries (5.2.1-3).

Fallowing, by removing the host biomass for a period, reduces infection pressure and is routinely used in Scotland for controlling and minimising bacterial diseases such as furunculosis and as a response to the present outbreak of ISA. There are other benefits such as benthic recovery, and a fallow period is sometimes a mandatory requirement of a discharge consent issued by the Scottish Environment Protection Agency (SEPA). Site rotation allows fallow periods to be extended whilst maintaining production.

Section 5.3: Management agreements

The expansion of the salmon farming industry and limited availability of prime sites meant that new farms were established in proximity to their neighbours, resulting in shared disease risk. Management agreements evolved so that coordination of stocking, fallowing and disease control measures could be achieved, thus minimising the mutual threats to health status that neighbouring farms might otherwise represent.

It is recommended that farmers use the hydrographically defined Management Areas as the basis for determining the biological areas subject to management agreements and cooperate in tailoring their own area management agreements (AMA). An example of an AMA is provided in Box 5.1a.
IMPLEMENTATION

Introduction

The interaction of industry, Government and special interest groups in the JWG has been valuable and productive. This interaction is one which the JWG believes should be carried forward into the future in the form of a joint Government/industry working group on fish health (Aquaculture Health JWG). Amongst other things, this group will take responsibility for implementation of those recommendations of the current ISA JWG requiring:

a) legislation;

b) a Code of Practice for the prevention and control of ISA;

c) additional research needs; and

d) industry restructuring consistent with Management Areas developed on an hydrographic basis.

The implementation strategy will be achieved by development of the Code of Practice, promotion of the recommendations and monitoring progress and compliance. In time, the Aquaculture Health JWG will focus on wider health and welfare issues in aquaculture.

Legislation

The Scottish Executive is invited to respond to the JWG with proposals for legislative changes. High priority should be given to finding space within the Executive's legislative programme.

Code of Practice for the prevention and control of ISA

The Code of Practice will be written by the Aquaculture Health JWG. The Code will be promoted actively by the new Aquaculture Health JWG through the trade press, statutory authorities, the retail industry and insurance sectors. The Code should be made available to farmers and promoted at regional presentations. It is recommended that:

• the Code of Practice is incorporated into the industry quality assurance schemes;

• retailers use the Code of Practice in specifying the nature of the product they wish to sell;

• insurers use compliance with the Code of Practice in assessing risk in insurance schemes;

• compliance shall be a condition of site licence renewal and authorisation;

• the Code of Practice shall be included in AMAs between farmers;
• there shall be a copy of the Code of Practice on each farm and the owner shall ensure that a copy is available to, and understood by, all fish farm workers;

• all suppliers, training establishments, processing plants and hauliers shall make the Code of Practice available to, and understood by, all staff involved in aquaculture related activities.

Research

The Aquaculture Health JWG should prioritise the Research and Development (R&D) recommendations and should promote their uptake through organisations such as the Committee on Aquaculture Research and Development (CARD), the EU and through international collaboration.

Restructuring

The Aquaculture Health JWG should review progress with the adoption of the individual Management Areas defined in this report, and shall facilitate the establishment of Management Areas especially in difficult areas where restructuring is necessary.
PREFACE

This is the final report of a Joint Government/Industry Working Group (JWG) established to identify the measures required to prevent or minimise the impact of further outbreaks of Infectious Salmon Anaemia (ISA) in Scotland. The report is submitted to the Deputy Minister of the Rural Affairs Department of the Scottish Executive, the Scottish Salmon Growers Association (SSGA), the Shetland Salmon Farmers Association (SSFA), the Orkney Fish Farmers Association (OFFA), and other members of the Scottish aquaculture industry. The purpose of the working group was not to address the immediate areas of disease containment and control. Rather, its function has been to review current practices within the salmon farming industry in Scotland with a view to identifying those practices which might pose a risk for the transmission of ISA.

The presence of ISA was first confirmed in Scotland in May 1998. It is clear that the epizootic arose from a point source of infection and that to a greater or lesser degree all of the confirmed sites to date were connected back to the original outbreak. These transmission routes included movement of fish, contaminated materials and equipment, and the discharge of untreated effluent from factories processing salmon into coastal areas containing salmon farms. The JWG has set out to address these risks and has made a variety of recommendations for risk reduction measures to be considered by the industry and Government. These recommendations encompass calls for new legislation, strengthening the implementation of existing legislation, the development and implementation of Codes of Practice and calls for research in areas where our understanding is poor. The report is structured into chapters addressing specific risks: vertical and horizontal transmission of ISA, detection and diagnosis of ISA, practical suggestions for managing aquaculture in shared coastal zones and finally, a practical guide to disinfection procedures. It makes reference to unpublished research and surveillance carried out as part of investigations required by the EC, and to be published as an epizootic report.\(^82\)

We wish to express our gratitude to colleagues on the JWG who have contributed with such commitment and enthusiasm over the past year. The first meeting took place on 4 October 1998 and in the intervening time we have produced two interim reports addressing urgent issues. These have been included in this report.

We do not think our work has ended here. There is increasing recognition that we have to see the recommendations through to implementation and that there is a need for a group with a wider and more sustained remit to address other disease and husbandry issues affecting the industry. The wish expressed in the final recommendations of the JWG is that we can continue our work so that together industry and Government can contribute to developing a sustainable and vibrant industry to support the communities of rural Scotland.

Dr Ron Stagg, Chairman
Dr Graeme Dear, Vice Chairman
January 2000
## GLOSSARY OF ACRONYMS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AMA</td>
<td>Area Management Agreement</td>
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<tr>
<td>Bus stop deliveries</td>
<td>The practice of delivering smolts to more than one location from a single supplier in one journey by wellboat.</td>
</tr>
<tr>
<td>DAO</td>
<td>Designated Area Order — under the Diseases of Fish Act 1937 (as amended) to place movement of fish and foodstuffs under control of the official service in the case of a notifiable disease.</td>
</tr>
<tr>
<td>ELISA</td>
<td>Enzyme-linked immunosorbent assay</td>
</tr>
<tr>
<td>Embayment</td>
<td>A marine inlet or bay with no major freshwater input.</td>
</tr>
<tr>
<td>Ensiled waste</td>
<td>The maceration and preservation in formic acid of dead fish and factory offal at a pH of less than 3.9.</td>
</tr>
<tr>
<td>Extra-ovum</td>
<td>Outwith the egg.</td>
</tr>
<tr>
<td>Fallow period</td>
<td>Interval of time when no fish are stocked on a fish farm site.</td>
</tr>
<tr>
<td>Fallowing Zone</td>
<td>All farms where part or all of their occupied licensed site lies within one tidal excursion of the centre of a farm confirmed or suspected of being infected.</td>
</tr>
<tr>
<td>FITC</td>
<td>Fluorescein isothiocyanate</td>
</tr>
<tr>
<td>FRS</td>
<td>Fisheries Research Services, comprising: the Marine Laboratory Aberdeen and the Freshwater Fisheries Laboratory Pitlochry</td>
</tr>
<tr>
<td>FW</td>
<td>Fresh water</td>
</tr>
<tr>
<td>Gametes</td>
<td>Ova and sperm</td>
</tr>
<tr>
<td>Gate Order</td>
<td>Control regulation applied to the waters of a farm or a control zone under the Diseases of Fish (Control) Regulations 1994 in the event of suspicion of a List I or List II disease.</td>
</tr>
<tr>
<td>IFAT</td>
<td>Indirect fluorescent antibody test</td>
</tr>
<tr>
<td>Intra-ovum</td>
<td>Within the egg.</td>
</tr>
<tr>
<td>IOA</td>
<td>Institute of Aquaculture (University of Stirling)</td>
</tr>
<tr>
<td>IPN</td>
<td>Infectious Pancreatic Necrosis</td>
</tr>
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</table>
IPNV  Infectious Pancreatic Necrosis Virus
ISA  Infectious Salmon Anaemia
ISAV  Infectious Salmon Anaemia Virus

Infected Zone  The region enclosed by a circle, of radius equal to one tidal excursion, centred on the middle of a licensed site. Infected Zones become Fallowing Zones once a farm is officially confirmed or suspected of being infected. (In the interim reports of the JWG, Infected Zones were referred to as High Risk Zones).

JWG  Joint Government/Industry Working Group
Management Area  See Surveillance Zone
Nursery Site  A marine site from which fish are moved to another site for on-growing.
OIE  Office Internationale des Epizooties
OFFA  Orkney Fish Farmers Association
ppm  Parts per million
pp smolt  Photo period smolt

40 km Surveillance Area  The 40 km Surveillance Area is defined as a circle, of radius 40 km, centred on a sea loch containing a farm officially confirmed or suspected of being infected with ISA. (In the interim reports of the JWG, 40 km Surveillance Areas were referred to as Surveillance Areas).

RT-PCR  Reverse transcriptase polymerase chain reaction
Rotation  A falling regime with an inter-stocking period of greater than one year.

S½  A salmon smolt that is less than one year old and which goes to sea in the autumn.

S1  A salmon smolt that is approximately one year old and which goes to sea in the spring.

S1½  A salmon smolt that is approximately eighteen months old and which goes to sea in the autumn.
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>S2</td>
<td>A salmon smolt that is approximately twenty-four months old and which goes to sea in the spring.</td>
</tr>
<tr>
<td>SDP</td>
<td>Standard Disinfection Procedures</td>
</tr>
<tr>
<td>SEPA</td>
<td>Scottish Environment Protection Agency</td>
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<tr>
<td>SERAD</td>
<td>Scottish Executive Rural Affairs Department (formerly The Scottish Office Agriculture, Environment and Fisheries Department).</td>
</tr>
<tr>
<td>SFPA</td>
<td>Scottish Fisheries Protection Agency</td>
</tr>
<tr>
<td>SQS</td>
<td>Scottish Quality Salmon</td>
</tr>
<tr>
<td>SSFA</td>
<td>Shetland Salmon Farmers Association</td>
</tr>
<tr>
<td>SSGA</td>
<td>Scottish Salmon Growers Association</td>
</tr>
<tr>
<td>Surveillance Zone</td>
<td>The region enclosed by all overlapping Infected Zones. The Surveillance Zone becomes active once a single farm within it is officially confirmed or suspected of being infected. When ISA is not present within a Surveillance Zone it is referred to as a Management Area. <em>(In the interim reports of the JWG, Surveillance Zones were referred to as a High Risk Areas).</em></td>
</tr>
<tr>
<td>Tidal excursion</td>
<td>The distance a particle (of water) will move over one tidal cycle.</td>
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<tr>
<td>Vertical transmission</td>
<td>The transmission of a pathogen within the contents of the gametes, ie from parents to offspring.</td>
</tr>
<tr>
<td>WML</td>
<td>Waste Management Licence</td>
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ACKNOWLEDGEMENTS

The JWG is grateful for the cooperation of many people including:

Sarah Heath, Trevor Hastings and Gordon Rae for long hours spent editing this report, Keith Mutch and Alvan Rice for preparation of the figures and artwork, Tracy Moir, Sandra Darling and Hayley Leitch for typing and formatting the text.

The inspectorate at FRS and particularly David Fraser and Pauline Munro for drafting the Disinfection Guide which forms the basis of Chapter 6.

Thanks also go to Randolph Richards and all his staff at the Institute of Aquaculture, University of Stirling who have accommodated us for most of our meetings.

The following people provided constructive comments on our interim reports:

George M Baird, Haulage Contractor, Kinross
Dr R Bradley, Wester Ross Salmon
Mr B Davidson, Assistant Director, Association of Salmon Fishery Boards
Mr J McCallum, Commercial Director, PDG Helicopters
Mr C J Shepherd, Managing Director, BioMar Ltd
Mr A Tear, FICS, Managing Director, J & A Gardner & Co Ltd
Dr M K Thompson, Managing Director, Vetrepharm Ltd
Mr I Waddell, Fraser Aquaculture Ltd
CHAPTER 1: INTRODUCTION

1.1 Establishment of the Joint Government/Industry Working Group (JWG)

In early May 1998 the Fish Health Inspectorate at the FRS Marine Laboratory Aberdeen were notified of a suspicion of ISA in a salmon farm in Loch Nevis. This was subsequently confirmed, and was the first occurrence in Scotland of a serious viral disease reported previously only in Norwegian and Canadian salmon farms. To date the disease has spread to a total of 11 farms and has been suspected on a further 24 farms on the Scottish west coast mainland, Skye, Orkney, Shetland and the Western Isles. Currently, five farms on which the presence of ISA had been confirmed and another three where ISA was suspected, have successfully completed the necessary fallowing requirements along with the disinfection of cages, nets and equipment allowing movement restrictions on fish stocks to be removed. A further 12 farms where ISA was suspected have fallowed but not, at time of writing, completed all of the necessary requirements to allow movement restrictions to be lifted. Maps showing the status of ISA in Scotland in June and December 1999 are given in Figure 1.1a and b. The chronology of suspect and confirmed cases is shown in Figure 1.2 and shows a progressive decline in the incidence of confirmed cases with time.

ISA is a List I disease which is required to be eradicated under European legislation (Directives 91/67/EEC (as amended) and 93/53/EEC) transposed into UK law via the Fish Health Regulations 1997 and the Diseases of Fish (Control) Regulations 1994, respectively. Although this legislation provides a comprehensive package of measures for the containment and control of an outbreak of ISA, it was soon recognised by both industry and Government that there were additional management measures that would minimise a recurrence of ISA and reduce the risks of further spread. As a consequence, a JWG was established with the following terms of reference:

a) To investigate relevant technical aspects of ISA management and regulation:
   • in the light of the ISA outbreak, to identify the key risk factors associated with the transmission of the disease, particularly between salmon farms;
   • to identify the measures required to reduce risk and prevent a recurrence of ISA;
   • to review current industry practices from a fish health control and management perspective.

b) To produce interim reports, the first by the end of December 1998, and others as appropriate thereafter, containing proposals for any immediate measures which should be implemented.

c) To submit to Ministers and relevant industry associations, proposals for change and the means by which they should be implemented (voluntary Code of Practice or legislation).

d) To conclude the review and produce a final report by the end of September 1999.
e) In partnership with the UK Government, to make representation on the agreed position to the European Commission as and when appropriate.

The membership of the JWG was drawn from a variety of industry and Government sectors to represent all of the statutory bodies which might impinge on the management of ISA and all sectors of the aquaculture industry including the Scottish Salmon Growers Association (SSGA), Shetland Salmon Farmers Association (SSFA), Orkney Fish Farmers Association (OFFA), non-association members and the trout industry.
Figure 1.1a   Outbreak of ISA in Scotland - suspect and infected farms as of June 1999.
Figure 1.1b  Outbreak of ISA in Scotland - suspect farms as of December 1999.
Figure 1.2  Chronology of suspect and confirmed areas of ISA in salmon farms in Scotland 1989-1999.
1.2 Membership and Participation in the Joint Government/Industry Working Group on ISA

**Chairman:** Dr Ronald Stagg  
Head of Aquaculture and Animal Health Programme  
FRS Marine Laboratory Aberdeen

**Vice Chairman:** Dr Graeme Dear  
Production Director, Marine Harvest McConnell  
Chairman of Scottish Quality Salmon Technical Committee and Chairman of SSGA Scientific Panel

**Members:**

Mr Ralph Baillie, Managing Director, The Salmon Management Company, representing independent fish farmers

Mr Willie Baxter, Orkney Fish Farmers Association

Dr Martyn Blissitt, State Veterinary Service, Pentland House, Edinburgh

Mr Gordon Brown, SERAD, Pentland House, Edinburgh

Mr Robin Brown, Highland Fish Farmers Ltd, Chairman of SSGA Fish Health Working Group and member of Skye Salmon District Fishery Board

Mr Stuart Cannon, Director, Kames Fish Farming Ltd

Mr Andrew Grant, Health Services Manager, Marine Harvest McConnell and President of the Fish Veterinary Society

Dr Trevor Hastings, FRS Marine Laboratory Aberdeen

Mr Gibbie Johnson, G Johnson Ltd, Chairman of SSFA

Dr Alasdair McVicar, Fish Health Inspectorate, FRS Marine Laboratory Aberdeen

Mr Alan Ockendon, SSFA

Mr Gordon Rae, Research and Development Manager, SSGA

Professor Randolph Richards, University of Stirling, Institute of Aquaculture, representing trout producers

Mr John Rea, Biological Services Manager, Hydro Seafoods Ltd
Mr Andrew Rosie, SEPA, Northern Region

Mr David Sandison, General Manager, SSFA

Mr Ronald Soutar, General Manager (Production) Scotland, Hydro Sea Foods GSP Ltd

Ms Maureen Spence, Orkney Fish Farmers Association

Mr Alan Stewart, Chief Executive, Landcatch Ltd, representing smolt producers

Mr David Wyman, SERAD, Pentland House, Edinburgh

Secretariat: Mr Paul Shave, SERAD, Pentland House, Edinburgh

The following also contributed to the work of the group by attendance at various meetings as experts on specific matters or as co-authors in preparation of some of the chapters.

Dr Philip Gillibrand, FRS Marine Laboratory Aberdeen

Mr Craig Selkirk, Broodstock Manager, Marine Harvest McConnell

Dr Bill Turrell, FRS Marine Laboratory Aberdeen

Dr John Webster, Technical Affairs Manager, SSGA

1.3 Schedule of the Meetings of the Joint Government/Industry Working Group on Infectious Salmon Anaemia

2 October 1998 Drummond House, Perth

13 October 1998 Caledonian Hotel, Inverness

11 November 1998 Institute of Aquaculture, University of Stirling

25 November 1998 Murrayshall House Hotel, Scone

10 December 1998 Murrayshall House Hotel, Scone

14 January 1999 Murrayshall House Hotel, Scone

9 February 1999 Murrayshall House Hotel, Scone

13 April 1999 Institute of Aquaculture, University of Stirling

5 May 1999 Institute of Aquaculture, University of Stirling

4 June 1999 Institute of Aquaculture, University of Stirling

19 July 1999 Institute of Aquaculture, University of Stirling

20 August 1999 Institute of Aquaculture, University of Stirling

1 September 1999 Institute of Aquaculture, University of Stirling

2 December 1999 Pentland House, Edinburgh

In addition, a number of editorial subgroup meetings have taken place.
1.4 Visit to Norway

As part of the preparation for the work carried out by the JWG it was important to make use of experience elsewhere in dealing with ISA. Consequently a delegation from the JWG visited Norway between 9-11 March 1999. The delegation consisted of Gordon Brown (SERAD); Graeme Dear (SSGA); Gordon Rae (SSGA); and Ronald Stagg (FRS).
CHAPTER 2: VERTICAL TRANSMISSION AND OVA DISINFECTION

2.1 Risk Factors

There are three ways in which infected broodstock may transmit ISAV to their progeny:

a) True (intra-ovum) vertical transmission within the contents of the gametes.

b) Extra-ovum transmission on the surface of the gametes and in natural secretions and excretions from the parents, eg ovarian and seminal fluids; mucus.

c) Transmission via contamination from infected water, personnel, clothing and equipment associated with stripping broodfish and fertilising ova.

2.2 Risk Assessment

2.2.1 Quantitative evidence

There have been three unsuccessful analytical attempts to demonstrate vertical transmission in Norway and Canada. In one of these three cases the infectious state of the broodfish was unknown, although it originated from an ISA infected site. In the remaining two cases the broodfish were confirmed ISA positive fish. In one case the eggs were reared to the juvenile stage, although they were disinfected beforehand; in the other two cases an homogenate made from the eggs was inoculated into healthy parr. ISAV was not detected, nor were signs of ISA seen in any of these cases. Some Norwegian researchers suggest that ISAV is not capable of intra-ovum transmission. For intra-ovum or extra-ovum vertical transmission to be established as a genuine risk factor, ISA virus particles must be present in the ovarian fluid, on the egg surface and/or within the eggs themselves.

At present it is not possible to make a quantitative assessment of the risk of vertical transmission. Further research is required to establish the transmission route via gametes and repeat transmission experiments from eggs to juveniles.

2.2.2 Qualitative evidence

There have been no reported incidences of ISAV being vertically transmitted from parents to juveniles in Norway or Canada. Horizontal transmission experiments clearly show that juveniles in fresh water are susceptible to ISAV, typically with conspicuous pathology and associated high mortality. It is therefore unlikely such events would have been ignored or misdiagnosed had they occurred.

If the virus is not capable of transmission within the egg, then the only 'vertical' routes remaining are via the egg surface, in the ovarian fluid or in the urine and mucus of infected broodfish. One study has revealed the virus to be labile and short lived outside its host in both marine and fresh-
water environments, with significant loss of infectivity after 24-48 hours.\textsuperscript{13} It is possible that complete inactivation of the virus on the egg surface could occur in the several weeks between stripping and hatching. However more research in this area is required.

2.2.3 Ova disinfection

A wide range of disinfectants and disinfection procedures (eg hypochlorite, heat, low pH) are effective against ISAV on processing and husbandry equipment (see Chapter 6). None of these techniques are safe for use on ova. Under normal circumstances iodophor is the disinfectant of choice for salmonid ova. However, the efficacy of iodophor-based disinfectants against ISAV has not been fully investigated. Preliminary evidence indicates that certain iodophor disinfectants can provide effective disinfection following five minutes exposure in soft water (FRS Marine Laboratory Aberdeen, unpublished results). It is not clear why Norwegian and Canadian scientists have not established the effectiveness of iodophors against ISAV, but the lack of epizootic evidence of a vertical transmission risk may be a factor.

Existing protocols for the disinfection of newly stripped and eyed eggs, put in place largely as a safeguard against IPNV and \textit{Aeromonas salmonicida}, have been maintained by both Norwegian and Canadian certifying authorities. A definitive study to determine the efficacy of existing disinfection protocols against ISAV is required.

2.3 Recommendations

2.3.1 \textit{True vertical transmission has not been proven, and there is circumstantial evidence to suggest that it does not occur. As a precautionary approach it is recommended that gametes should not be used from ISAV infected broodstock populations. This is in line with the Norwegian industry, where at present, fish reared in ISAV affected regions of Norway cannot be used for breeding purposes. This is consistent with current EU control legislation (93/53/EEC).}

2.3.2 \textit{Extra-ovum vertical transmission has not been achieved in the laboratory, nor does any evidence suggest it has so far occurred in the field. Again as a precaution, and as part of good husbandry, the following steps are recommended as part of a Code of Practice:}

a) \textit{Avoidance of contamination of gametes with urine, faeces and blood during stripping.}
b) *Disinfection of pre-hardened eggs should take place as soon after fertilisation as possible, using iodophor\(^\dagger\) diluted in 0.9% isotonic saline solution to give a free iodine concentration of 100 ppm. Thorough rinsing of disinfected, fertilised eggs should be carried out using clean isotonic saline followed by fresh water.*

c) *Disinfection of eyed eggs should be carried out using iodophor solution to give a free iodine concentration of 100 ppm, prior to batch or movement to another water supply.*

d) *Transmission via contamination. Strict protocols and high standards of hygiene with respect to personnel, clothing and equipment used must be maintained during each stage of the stripping and fertilisation processes.*

2.3.3 *It is recommended that research is undertaken on:*

a) *The efficacy of a wide range of disinfectants against ISAV.*

b) *Further experimental investigation on the quantification of the risk of true vertical transmission of ISAV.*

\(^\dagger\)In line with phasing out the use of endocrine disrupting chemicals, proprietary iodophor disinfectants should be alkyl phenol ethoxylate free.
CHAPTER 3: HORIZONTAL (SITE-TO-SITE) TRANSMISSION

3.1 Risks to and from Freshwater Farms

3.1.1 Identification of ISAV risks to and from freshwater farms

To undertake an assessment of the risk of ISAV to and from freshwater farms it is necessary to:

a) consider experiences from other areas with ISA, ie the epizootiology of ISA in Norway and Canada;

b) take into account evidence for the survival and transmission of ISAV in the freshwater and marine environment;

c) evaluate the factors in Scottish freshwater farming operations which could lead to risk of ISAV being introduced or being transmitted by smolt movements.

3.1.2 Epizootiology

Norway

Clinical signs and mortality associated with ISA were first identified in a Norwegian salmon hatchery in 1984. Although at that time a form of cold water vibriosis was suspected, no bacteria were isolated consistently from affected fish. It was not until 1990 that the aetiological agent was shown to be viral and this was identified in 1994 as an enveloped RNA virus of the Orthomyxoviridae family. The earliest outbreaks only occurred in hatcheries using untreated sea water. The subsequent spread of the disease to marine farms was associated with the transfer of fish from these affected hatcheries. In 1989, a ban was introduced on the use of untreated sea water in Norwegian smolt farms and all further cases of ISA were restricted to marine farms until 1998 when an outbreak occurred in first feeding Atlantic salmon fry in a hatchery. The possibility of vertical transmission was considered improbable and it was concluded that the most plausible explanation is that ISAV entered the hatchery through a hitherto unknown route, although since the UV filters were not functioning properly at the time of the outbreak, introduction of the virus through sea water cannot be excluded.

Canada

The first reported ISA incident in Canada was diagnosed in 1997. Originally diagnosed as hemorrhagic kidney syndrome (HKS), the condition was shown to be due to ISA in 1997. All outbreaks have been confined to seawater farms. In 1999, evidence of ISAV was found, without associated clinical signs, in a broodstock population in a marine farm in Nova Scotia and subsequently in a post-smolt population transferred from that farm to another cage site. The origin of the infection is not known (R. Cusack, pers. comm.). Preliminary genetic evidence indicated major differences between the Nova Scotia and the New Brunswick isolates of ISAV, strongly
indicating that they had different origins, although the Nova Scotia variant is also very similar to the Glasvaer strain isolated in Norway.

**Horizontal Transmission**

Outbreaks of ISA have been closely associated with horizontal transfer of infection between salmon in sea water or associated with sea water. Epizootiological studies in Norway and Canada indicate that ISAV can be transmitted with live fish being moved from infected smolt farms and between infected marine sites, through water\(^7\) with a significantly increased risk near (less than 5 km) to infected farms\(^{10}\) and to facilities gutting and processing infected fish without disinfection of discharge water.\(^9,10\) Sharing of equipment or staff between sites has also been identified as an area of risk of transmission of the virus. It has been shown experimentally\(^8\) that sea lice and wild salmonids can act as carriers of ISAV and be capable of transmitting infection to new hosts, but their significance in the farm environment has not been shown.

3.1.3 Evidence of the survival and transmission of ISAV in the freshwater environment

**Experimental Evidence**

Transmission trials of ISAV to salmon parr have been conducted in Norway in 10% sea water\(^1\) and more recently in fresh water in Canada\(^{11}\) and Scotland (FRS Marine Laboratory Aberdeen, unpublished results). These studies have provided evidence that ISAV is infectious to salmon parr in fresh and brackish water by inoculation and by co-habitation, and is capable of producing pathology with high levels of mortality.

**Field Evidence**

ISA has only been found in freshwater salmon farms using untreated sea water with the single exception of a recent outbreak in Norway\(^3\) where the use of sea water was uncertain. Given the high level of infection shown in these hatcheries where up to 80% of the infected parr died showing typical clinical signs of the disease,\(^2\) it is likely that such obvious signs of ISA would have been detected in freshwater farms had it been present.

**Conclusion**

The available evidence would strongly indicate that freshwater salmon farms which avoid using untreated sea water are not at major risk from the disease.

3.1.4 Factors in Scottish freshwater farming operations which could lead to a risk of ISAV being introduced

Risk factor analyses in Norway\(^{12}\) and Canada\(^9\) have both concluded that ISA is a disease which is transmitted from infected salmonids to new hosts through sea water. Blood and mucus have been shown\(^2,7\) to be particularly effective in transmitting ISAV. Faeces and urine have also been shown to be vectors. Risk is therefore present with the transfer from infected to uninfected areas of any contaminated materials, whether animate or inanimate, which have not been subjected to adequate
cleaning and treatment to destroy infection. Considering the normal operational activities of freshwater farms, it is possible to categorise the main areas of risk to these as associated with water, farmed fish, wild fish and contaminated equipment.

**Water**

Prior to 1998, all of the documented outbreaks of ISA in freshwater farms were in those which had introduced untreated sea water to the freshwater farm. The origin of the Norwegian outbreak in 1998 is unknown. Limited use of blended sea water/fresh water has been associated with pH adjustment, temperature elevation, control of fungus on eggs and sac fry and in sea water acclimation of smolts. Where freshwater farms are located close to the sea, a risk of contamination associated with aerosols is possible, but considered to be a low risk. It is clear that sea water taken from the area of marine farms infected with ISA will pose the highest risk and should be avoided.

**Farmed Fish/Eggs**

Under normal operating conditions, the only time live fish are likely to be transferred from marine to freshwater salmon farms is associated with broodstock during conditioning and stripping. The resident freshwater stocks on the site would be placed at risk from horizontal transmission via water or contaminated equipment if ISAV was present in the broodfish. This risk could be avoided by using separate facilities for broodfish and parr/smolts or reduced by the maintenance at all times of strict sanitary conditions between these different populations within the same site. Under no circumstances should broodstock and juveniles share the same water mass, for example, the same freshwater loch.

There is no evidence for vertical transmission of ISAV and provided eggs are surface disinfected as recommended before transfer to the hatchery, the associated risk is small.

**Wild Fish and Birds**

Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) have all been shown to be capable of acting as carriers of ISAV under experimental conditions. Recent findings indicate some evidence of ISAV in freshwater fish in Scotland (sea trout, rainbow trout, salmon and eel (*Anguilla anguilla*) but this has not been associated with disease. There is therefore a possible risk that horizontal transmission through fresh water could occur if the freshwater farm is using surface water containing populations of wild or stocked fish which have been exposed to ISAV. However, as no such events have been recorded since the identification of ISA as a disease threat, the risk is considered to be very low. Risk reduction is achieved by the application of normal disease avoidance protocols on farms, the use of water from supplies not containing migrating fish and the use of intake disinfection where practicable.

Similarly, although it is extremely unlikely that ISAV can pass through the gut of birds in an infective state, there is the theoretical risk that birds migrating from infected areas could transmit infection by regurgitation of infected fish and by carrying infection on their legs and other external surfaces, for example after feeding on mortalities or unguarded dump sites. Good husbandry
practices and secure mortality disposal would reduce any risk associated with birds or other predators.

Equipment

It is evident from the epizootiology of ISA in Norway, Canada and Scotland that there is a high risk of transfer of ISAV between areas associated with the use of shared, unsterilised equipment, including the use of the same personnel on several sites. It is safe to assume that a similar level of risk would be present regarding the transfer of equipment into freshwater farms, particularly from marine farms.

Any item of equipment (from portable oxygen monitoring probes to feed lorries) which may have been recently exposed to ISAV carries a risk. However, the elimination of this risk would be difficult to achieve as it would be impractical to implement a total ban on the crossover of equipment or human resources between sites. It is therefore essential that adequate hygiene, cleaning and disinfection protocols are implemented and adhered to in such a way as to minimise the risk. This should include the waterproof clothing of husbandry personnel and visitors to the farm and a minimum requirement is that site-specific protective clothing should be provided.

A particular risk can be identified associated with the use of helicopters to transfer smolts from freshwater sites into wellboats or directly to marine cages. The smolts are transported in 600-900 litre bins, normally with two bins being used alternately, one being loaded with smolts at the freshwater site, while the other is in transit to the wellboat or marine farm. There is a high risk that during these transfers some sea water from the marine site will be introduced into the freshwater farm.

To minimise any associated disease risk, it is necessary for empty returned bins to be disinfected and rinsed before re-use. To maintain continuity of smolt transfer, additional bins may be required. Account should also be taken of the location of the disinfection point in relation to the remainder of the freshwater site. On land-based sites a 'quarantine' area should be operated around the disinfection point, but in freshwater cage sites an on-shore location in the vicinity would be necessary. A similar procedure should be conducted on road transportation equipment. Appropriate disinfection protocols are contained within the FRS Marine Laboratory Aberdeen: Disinfection Guide with regard to the ISA Virus: Version II.

3.1.5 Survival and transmission of ISAV in the marine environment

Field Evidence

With one possible exception all reported cases of ISA to date have occurred in seawater sites or freshwater sites using sea water. The risk of infection is significantly increased within 5km of an infected farm or processing plant. There have been no cases in Norway to suggest significant risk exists beyond 10km of the source of infection, although the prevailing hydrography and weather of an area are principal factors. There is further evidence to suggest that highly stressed and physically damaged fish are more susceptible to infection.
Experimental Evidence

It has been demonstrated that, under laboratory conditions, ISAV is successfully transmitted to healthy fish from infected individuals. There is evidence that virus has been able to survive and remain infective for up to 48 hours outside the host in sea water, and up to six days in infected bloodwater and offal. Infective virus particles are shed continually by the host in urine, faeces and body secretions, and the virus enters a new host predominantly through the mucus layer and gill epithelium.

Conclusion

The evidence that ISAV does transmit in sea water and is capable of producing disease would indicate that newly transferred smolts are at risk, particularly when placed in the same area as epizootics of disease.

3.1.6 Factors in Scottish smolt movement operations which could lead to risk of ISAV infection and transmission

As already identified in 3.1.4, horizontal infection through sea water and hygiene breakdown are the general areas of concern in the transmission of ISAV. The main risks associated with the smolt movement process is acclimatisation within hatcheries using sea water, wellboat transportation, sea site stocking policy and the health status and physical condition of the smolt. Current scientific knowledge would indicate that the risks from sites exclusively using freshwater are inconsequential.

Use of Sea Water in Hatcheries

The use of sea water in hatcheries for environmental control and acclimatisation of smolts is covered in 3.1.4 and it is recommended that these practices should cease (3.1.7).

Movement of Wellboats

Where seawater is not used in hatcheries, and given that all other evidence indicates that freshwater salmon farms are not at major risk from ISA, it is important to protect smolts in transit from the risk of infection via sea water. Factors which increase the risk of ISAV infection will include bus stop deliveries, proximity of passage to known infected areas or processing plants and poor standards of hygiene in the wells, superstructure, bilges, ballast tanks and wellboat pumping equipment, all of which are covered in 3.4.
Condition of the Smolt Stock

The risk of infection by ISAV is increased if the fish are under stress or have open wounds. Smolting is one of the most stressful natural events Atlantic salmon experience and if this is compounded by poor fin and body condition, the stock become less resistant to pathogens including Aeromonas spp., Vibrio spp., IPNV and ISAV. It is important, therefore, that the stock must be physiologically competent to thrive in sea water and be in good physical condition. It should be the joint responsibility of supplier and purchaser to ensure that these criteria are satisfied.

Stocking Policy

In Norway, those farms with primary ISA outbreaks were found, on average, to have smolt intake from 3.5 different hatcheries, compared with an average of 2.3 smolt suppliers to sites with no ISA. This may not only be a reflection of the different sources, but may be caused by other factors associated with multiple movements such as the mode of transport. Increasing the number of smolt suppliers may increase the risk of exposure to ISAV, and it is therefore recommended that stocking a site from multiple hatcheries is minimised.

3.1.7 Recommendations

3.1.7.1 Sea water should not be used at any stage in the production phase in fresh water.

3.1.7.2 Equipment and personnel should be site specific as far as is practicable. Where transfer of equipment between sites is unavoidable it should be cleaned and disinfected in accordance with the SDP (Chapter 6).

3.1.7.3 Protective clothing should be site specific and suitable hygiene, cleaning and disinfection protocols adopted (Chapter 6).

3.1.7.4 Helicopter buckets and road transport equipment used for fish transfer should be operated to the recommended protocols and disinfected according to the SDP (Chapter 6).

3.1.7.5 Wellboat movements should be controlled, and wellboats should be operated in accordance with the recommended Code of Practice, with high standards of hygiene (Section 3.4)

3.1.7.6 The practice of bus stop deliveries other than to an empty site or series of empty sites should cease. This does not preclude delivery to a site containing fish, as long as the vessel does not subsequently proceed to another site.
3.1.7.7 Stress on smolts should be minimised and smolts should be transferred to sea only in good physical condition and when in optimal physiological state. It should be the joint responsibility of the supplier and the purchaser to ensure that this is the case.

3.1.7.8 Broodstock and juvenile stock in fresh water should never share the same water mass.

3.1.7.9 Mortality disposal and predator control measures should be taken to reduce the risk associated with birds and other predators.

3.1.7.10 Operators should carry out a risk assessment before transferring smolts to sea water. Stocking smolts from multiple freshwater sources should be minimised.

3.1.7.11 All the foregoing recommendations should be incorporated into a Code of Practice.

3.2 Risks Associated with Seawater-to-Seawater Fish Movements

3.2.1 Identification of risks associated with seawater-to-seawater movements

The greatest risk of transmission of infection in sea water arises from movement of live fish and especially those which may be harbouring ISAV. Provided fish are not subject to a restriction as a consequence of being infected or suspected of being infected with any notifiable disease, movement of fish between farms is not subject to any regulation in Scotland. This has not been an issue in the past, because traditionally salmon have not been moved between sites from the time they arrive as smolts through to harvest. The best ISA avoidance strategy, if at all possible, is not to move live fish from a seawater-to-seawater site.

However, in the last few years seawater movements have become common. They are carried out for reasons such as harvesting, biomass consent maximisation and the formation of broodstock populations. Some movements are now considered to be essential and this chapter addresses the risks associated with seawater movements and how they can be minimised.

In considering this issue, it is useful to examine what happens in countries where ISA has already been identified. In Norway, there is a national framework prohibiting movements in sea water, but with some latitude for regional interpretation by local veterinarians. The Canadians have no legislation to control movements, although it is reported that fish are not moved from site-to-site at sea. Management programmes are in place but these are ad hoc, and attempts are being made to establish voluntary zonal management.
In Scotland, Norway and Canada farms are quarantined and statutory regulations come into force as soon as suspicion of ISA is placed on a farm.

### 3.2.2 Risk assessments and risk reduction measures

Although it is agreed that the greatest risk of spreading disease comes from the movement of live fish, some movements are deemed essential, for example, to broodstock sites, and for harvesting purposes. In other cases, the requirement for movements in sea water is less clear, particularly between nursery and growout sites.

**Movements Associated with Broodstock Sites**

There are essential movements in sea water, particularly to broodstock sites which often have to contain multi-year class stocks. Such sites are in short supply and different companies develop and manage them in different ways. Ideally, they should be situated at least 5 km or one tidal excursion, whichever is greater, from any other farm, harvesting station or processing plant.

The following are some examples of different types of broodstock management regimes and the problems associated with year class management and fallowing:

a) **Single year class with broodfish stripped in their second sea winter (SW).** Using a two SW broodfish management regime, a minimum of three sites would be required to maintain single year classes and a fallow period, if broodstock are introduced as smolts (Fig. 3.1a).

b) **Single year class with broodfish stripped in both their second and third sea winter.** Using the same management regime as in (a) a minimum of four sites would be required (Fig. 3.1b).

c) **Single year class with broodfish stripped in both their second and third sea winter, but with the input as post-grilse.** To increase disease control by having fallow periods, a system of falling without smolt input has been developed. This means that fish are moved from seawater-to-seawater site and are stocked as post-grilse. For broodfish stripped in their second and third sea winter, this would require three sites to maintain separate year classes and a fallowing regime (Fig. 3.1c).

d) **Pump ashore.** As a minimum this requires only one site with tank management and disinfection.

**Movements Associated with Harvest**

Movements to a harvest station are essential for some operators. However, it was considered that if fish are moved to a harvest station they should not return to a farm. It was also recommended that harvest stations should be situated at least 5 km or one tidal excursion, whichever is greater, from any farm or in a discrete management area. This subject is addressed in more detail in Section 3.5.
 Movements Associated with Nursery and On-Growing Sites

The term 'nursery site' is defined as a marine site from which fish are moved to another site for on-growing. This creates a problem when fish are moved from area to area with the subsequent increased risk of spread of disease. There is a need to consider two key elements: the risks to self (the operator carrying out the movement) and the risks to others (other operators sharing a management area).

The JWG also recognises that SEPA is a key definer of processes by limiting flexibility in compliance with discharge consents. However, some members of the JWG pointed out that the Scottish Quality Salmon (SQS) manual actually sets a limit to stocking densities and by implication defines the maximum biomass a site can hold.

The risks associated with seawater-to-seawater movements of fish between or within areas were assessed, and their acceptability evaluated:

a) Movements of fish from a previously fallowed area to another fallowed area(s) under the control of a single operator (Fig. 3.2a). **Acceptable.**

b) Movements of fish from a multi-year class area to a fallow area where the site from which it was proposed to move the fish has not been fallowed for some time (Fig. 3.2b). **Unacceptable.**

c) Movements of fish from more than one area into a new area (Fig. 3.2c). **Not acceptable unless for a specific agreed purpose such as broodstock establishment or harvesting.**

d) Sole operator movements of fish within a single year class management area (Fig. 3.3a). **Acceptable.**

e) Movements of fish by multiple operators which have many year classes inside one management area (Fig. 3.3b). **Movements are only acceptable where there is agreement between the operators, but are considered to increase the risk of spread of ISA within the area.**

f) Movements of fish by a sole operator and many year classes within a management area (Fig. 3.3c). **Acceptable, but are considered to increase the risk of spread of ISA within the area.**

It was agreed that the following recommendations should be incorporated into a Code of Practice. It was recognised that these recommendations would entail structural changes to the industry, and that these should be achieved over a three year period in consultation with the regulatory authorities. It was further recommended that Movement Records should be inspected by a statutory body to monitor compliance.
3.2.3 Recommendations

There should be a general presumption against seawater-to-seawater movements of live fish. Some movements however, are essential, and those exceptions are listed below:

3.2.3.1 Movements between Management Areas may be acceptable under certain circumstances:

a) Movements from one Management Area to many. Where there is a sole operator, movements of fish from one previously fallowed Management Area to another fallowed area or areas, which hold no fish are acceptable. Where there is more than one operator, a written agreement between operators is required.

b) Movements from more than one area into a single Management Area. These should only occur for broodstock or harvesting purposes as outlined below.
Figures 3.1  Management of broodstock sites.
Figures 3.2   Examples of fish movements occurring between Management Areas.

(a)  

Area A was fallow before 98 yo was introduced.

(b)  

Area B and C were fallow before fish were transferred in.

(c)  

Area D contains only a broodstock farm or a harvest station.
Figure 3.3  Examples of fish movements occurring within Management Areas.

a) Sole operator, single year class. 
   Area A was fallow prior to any smolt input. 
   Any combination of movements is acceptable.

b) Multiple operators, multi-year classes. 
   Movements allowed only by joint agreement. 
   Recommendation against the movement due to the higher risk.

c) Single operator, multi-year classes. 
   Recommendation against the movement due to the higher risk.
i) Broodstock

Live fish may be moved into a seawater broodstock farm from another seawater farm, but the broodstock farm must be situated at least 5 km or one tidal excursion (whichever is the greatest) from another farm, harvesting station or processing plant. No broodfish may then leave the site for on-growing elsewhere. Movements of live broodfish to freshwater sites are allowed.

ii) Harvesting Stations

Live fish may be moved to a harvesting station, but no live fish should leave a harvesting station. Harvesting stations should be 5 km or one tidal excursion (whichever is the greatest) from any other farm.

3.2.3.2 Movements within Management Areas may be acceptable under certain circumstances:

a) Movements within a Management Area where there is only one operator are acceptable.

b) Movements within a Management Area where there is more than one operator and a single year class may be allowed by agreement between the operators.

c) Movements within a Management Area where there is more than one operator and multi-year classes may be allowed by agreement between the operators. Such movements are considered to increase the likelihood of spread of ISA.

3.2.3.3 Movement records should be inspected by a statutory body to monitor compliance with the above recommendations.

3.3 Risks Associated with Trout Farming

3.3.1 Introduction

In some coastal areas trout and salmon are found in adjacent locations. There are also anecdotal reports of trout being farmed in Norway as an alternative production strategy on farms infected with ISA.
The Norwegian authorities no longer allow this practice because trout are considered to replicate and carry the ISA virus. The JWG therefore decided to address two issues:

a) What is the risk to marine farmed trout from ISA?

b) What is the risk of marine farmed trout carrying ISAV and subsequently infecting marine salmon?

**Brown and Sea Trout**

Experimental infection of brown trout can readily be achieved by intraperitoneal injection of ascitic material from infected salmon\(^27,29\) and by cohabitation with infected salmon.\(^29\) Clinical disease was not observed, but transitory anaemia has been reported. It has also been shown that blood from brown/sea trout infected by cohabitation with infected salmon can also induce ISA in marine salmon.\(^29\) Repeated challenge of brown trout demonstrates that they can mount a protective response that enables them to control the second infection more effectively.\(^25\) Using a stock of freshwater brown trout isolated from sea water over some 5,000 years it was demonstrated\(^26\) that ISAV could survive in brown trout for up to seven months after challenge, the detection of virus after this time being linked to the stress of sexual maturation.

Subsequent to the experimental studies, ISAV infection was found in 1999 in wild sea trout in Scotland without associated signs of disease (FRS Marine Laboratory Aberdeen, unpublished results). Other laboratory results indicate that the virus may also be present in wild brown trout in fresh water.

**Rainbow Trout**

Although early work\(^27\) reported unpublished results suggesting that challenged rainbow trout did not become carriers. It was shown that replication of virus could be seen in rainbow trout after intraperitoneal infection.\(^28\) Virus was thought to increase in blood up to day 20, followed by a decline to day 28 (as measured by response of salmon to intraperitoneal challenge with blood from infected trout). Reference was also made\(^28\) to cohabitation experiments\(^73\) which demonstrated spread of ISA by cohabitation with intraperitoneally injected rainbow trout. Laboratory results have indicated that the virus may be present in some freshwater rainbow trout farms in Scotland (FRS Marine Laboratory Aberdeen, unpublished results).

### 3.3.2 Factors to be considered in assessing risks

a) No outbreaks of clinical ISA have ever occurred in marine farmed trout.

b) Virus has never been isolated from marine farmed trout, even in the proximity of clinical ISA outbreaks in marine farmed salmon.

c) No wild marine trout have ever shown evidence of the disease signs of ISA, even in areas affected by clinical ISA in farmed salmon.
d) Experimentally, ISA can infect brown trout by cohabitation. The infection has on occasion been shown to persist for many months and viral replication occurs in the infected trout. Taken together with detection of ISAV in wild sea trout, this provides evidence that this species can act as a carrier of ISAV.

e) Even when experimental brown and rainbow trout infection is induced and viral replication occurs, no clinical disease results, therefore ISA is not a direct risk to marine trout. Risk of infection of salmon from marine farmed brown trout is a possibility. There is no evidence that rainbow trout can be infected with ISAV by cohabitation with infected salmon. Despite numerous outbreaks of ISA in farmed salmon in Norway over many years, ISAV had not been found in marine farmed trout in the field.

f) The operation of the marine farmed trout industry in the UK is currently managed with mixed year class sites and no fallowing. Small fish of up to 1.5 kilos are produced in contrast to large fish production in Norway. All available sites are in brackish water and therefore extremely limited in number.

g) Historical evidence suggests that marine farmed trout represent a negligible risk of the spread of the ISAV to marine farmed salmon, but the laboratory data and the existence of ISAV infection in wild sea trout populations are of concern.

3.3.3 Recommendations

3.3.3.1 The current policy whereby marine trout farms are treated in the same way as salmon farms should continue.

3.3.3.2 In the meantime, the following surveillance and research programmes should be undertaken:

Surveillance

This should be carried out in marine trout farms in fallowing and Infected Zones according to the following sampling protocol:

A sample size of 150 fish will be required to detect one or more infected fish if the prevalence of detectable infection is at least 2%.

Samples should be tested by IFAT, RT-PCR and viral culture according to accepted protocols for salmon. Wherever possible, moribund or poor condition fish should be sampled as, though clinical ISA is very unlikely to be present, clinically
compromised fish might be expected to be less likely to resist viral replication within their tissues.

Experimental work has indicated that trout, once infected, remain carriers for a considerable period of time (at least many months) and therefore samples, where possible, should be taken twice yearly at 6 month intervals. This would allow replication to take place in carrier fish, increase the possibility of detecting covert infections and would also decrease the chance of sampling error.

Research Programme

The possibility of transfer of ISAV from infected salmon to rainbow trout by cohabitation should be examined. The cohabiting rainbow trout should then be used in a follow-up experiment to determine whether they would transmit the disease to uninfected salmon by cohabitation.

3.3.3.3 The risk of marine farmed trout carrying ISAV and subsequently infecting marine salmon should be re-assessed when further results of the experimental and surveillance programmes are known. This assessment should be made with a view to excluding trout farms from the current regulations applied to salmon farms. At least one requirement for such a change to be considered will be that the eventual results of the field surveillance and the laboratory experiments (outlined in recommendation 3.3.3.2) are negative.

3.4 Risks Associated with Wellboats and Other Equipment

3.4.1 Introduction

It should be recognised that the biggest risk associated with the use of wellboats lies with contamination from the fish they carry rather than with the wellboat itself. As the risks associated with other fish movements (seawater-to-seawater) have been described in 3.2, this section will concentrate on those aspects of the risks associated with the actual use of wellboats rather than the cargoes they carry. It is assumed that the risk in carrying a non-fish cargo is considerably less than the risk associated with carrying live fish.

3.4.2 Wellboat uses

Wellboats are used for seven main functions:
• smolt transfer;
• inter-site fish transfers;
• bath treatments;
• transport of fish to a harvesting station;
• a work platform for grading operations;
• a work platform for net changing;
• general delivery to sites of non-fish items (for example, feed or equipment).

3.4.3 Identification of risks

Irrespective of the operation for which the boat is being used, the major risk lies in the ability to clean and disinfect the vessel effectively. It was also recognised that there are different levels of risk depending on where the boat is operating and the functions being undertaken. Eight operational scenarios that require different levels of disinfection are detailed in Table 3.1.

The highest risks arise from those areas of the boat that come into direct contact with the fish, and are the hardest to clean, for instance, pumps, intake and outlet grids.

3.4.4 Cleaning and disinfection procedure for wellboats

The cleaning and disinfection procedure for wellboats has three stages. The requirement for different stages will depend on operational circumstances as indicated in Table 3.1. The most rigorous protocols are required when leaving a Surveillance Zone for a new area, leaving a confirmed or suspicious site, and on entry into Scottish waters.

Stage 1 (daily hygiene when working with fish)

Brush/clean solids from all surfaces.
Hot-water pressure clean (with detergent) the following areas:

• deck;
• wells;
• equipment;
• protective clothing;
• pumps.
Follow the instructions given in Chapter 6.
Stage 2

Complete Stage 1 and carry out the following additional tasks:

- internally inspect and disinfect the fish pump† and remove and clean all organic material from it before the normal disinfection procedure;
- steam clean and disinfect with iodophor, the deck, well and hull above the waterline;
- complete the checklist (Appendix II);
- sign the checklist (Appendix II) with duplicates for each party, and copies to be retained at reception site for auditing.

Stage 3

Complete all of Stages 1 and 2, and carry out the following additional task:

- slip the vessel, clean and disinfect the hull below the waterline.

Table 3.1  Disinfection stages required for wellboats under different operating circumstances.

<table>
<thead>
<tr>
<th>Operational circumstance</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arriving from outwith UK waters other than from EU waters with equivalent zone status††</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Operating within a Surveillance Zone</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaving a Surveillance Zone on shuttle returns</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaving a confirmed or suspicious site for any location</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Leaving a Surveillance Zone for a new operating location</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Operating between sites on shuttle returns</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaving an existing site to start at a new site</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>General deliveries (non-fish)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NB Not all sites have equal status within a Surveillance Zone

†The design of pumps must enable routine inspection and disinfection to take place.

††As defined in Directive 91/67/EEC
3.4.5 Recommendations

3.4.5.1 Official points of entry for wellboats arriving in the UK should be established, and an appropriate competent authority, for example SERAD, should issue a certificate of entry once they are satisfied that all necessary disinfection procedures have been carried out in accordance with Stage 3 procedure defined in Table 3.1 and paragraph 3.4.4. This certificate should be available for inspection at any time whilst operating in Scottish waters. It is recommended that provision for certification be made by means of legislation and be additional to the current requirement for wellboats to carry a veterinary certificate of disinfection when leaving Norway. A list of wellboats certified on entry should be maintained by a competent statutory body such as SFPA, and a system of wellboat surveillance should be developed by the Government.

3.4.5.2 There is an inadequate infrastructure within Scotland to cope with the requirement of Stage 3 disinfection procedures (Table 3.1 and paragraph 3.4.4). It is recommended that the Government carries out a review of the slipway facilities in Scotland and the constraints on discharge of disinfectants at such locations, and facilitates the development of an adequate infrastructure.

3.4.5.3 The following recommendations should be implemented by a Code of Practice. Compliance should be monitored by audit of the wellboat movement records, the disinfection logs and the corresponding fish movement records.

a) Standard disinfection procedures (SDPs) for wellboats are required. These should be based on those described in Chapter 6. Any revised editions of the SDP should be dated, the current edition should always be used, and a copy of the current edition should be held on every farm. The SDP should contain clear protocols on the level of disinfection necessary for the different operational circumstances defined in Section 3.4.3 and Table 3.1.

b) Every wellboat operator should carry out an assessment of the design of each of their wellboats, with regard to the practicalities of efficient cleaning and disinfection. Each wellboat should have its own copy of the current edition of
the SDP including any supplements, to take account of any particular design features.
c) The practice of bus stop deliveries other than to an empty site or a final delivery destination should cease.

d) Wellboats should travel closed (ie with no water exchange) when located within 5 km of any finfish farm site.

e) Ballast water should not be discharged within 5 km or one tidal excursion (whichever is greater) of a farm site. This means that ballasting a ship and cleaning its pumps need to be part of a vessel’s passage plan, and are sequential operations.

3.4.5.4 The design of new wellboats should include provision for the inspection and disinfection of interior surfaces, including the interior of pumps, and ballast water.

3.4.5.5 The Scottish Executive should request that the harbour authorities be charged with issuing routings and preferred places for sheltering to minimise the risk of spreading infection.

3.4.6 Risks associated with the movement of other equipment

There is a potential risk that ISAV transmission into a 'clean' waterbody may occur by the virus being carried on research vessels, fishing boats and undisinfected equipment. Where adequate disinfection has not been thoroughly applied, there is the possibility of transmission of infection via residual ISAV within mucus or bound within organic material on hull surfaces or equipment. Research vessels or fishing vessels that come into serial contact with the seabed run the risk of importing ISAV into an area. Although consideration should be given to pleasure boats operating between areas, the risk of such vessels carrying ISAV is probably very low.

The hygiene procedures of site staff and visiting personnel are considered to be of great importance, although little direct evidence exists of transmission via this route.

The risk of ISAV transmission via the transfer of working vessels, equipment, staff and staff clothing may be reduced:

- where a site is not in receipt of equipment or visited by a vessel from outside its own waterbody;
- where a defined disinfection routine and auditing procedure exists;
- where staff do not transfer routinely between sites;
• where clothing is site-specific and visitors' clothing and equipment is disinfected prior to access;

• where general site hygiene is good;

• where the transfer of any biologically active material is prohibited;

• where mortality bins are site specific;

• where harvest bins are adequately disinfected.

3.4.7 Recommendations

3.4.7.1 The inter-site movement of any vessels should be kept to a minimum and where such movements are required, suitable disinfection procedures should be followed.

3.4.7.2 There is no legislative control that can be brought to bear on the movements of fishing or pleasure boats with respect to the Diseases of Fish Act 1937 (as amended). It is therefore recommended that the operators of any such vessels entering the area of a farm should be contacted and made aware of the potential risk that their action may pose with a view to minimising the contact.

3.4.7.3 Where possible it is recommended that staff and equipment should be site specific. When equipment must be purchased second-hand, or transferred from some other site, the standard disinfection procedures should be followed.

3.4.7.4 Where it is essential that equipment is transferred from one site to another, a system should be introduced whereby the receiving site is responsible for auditing and signing off equipment disinfection while it remains on the donor site. Further disinfection on arrival at the new site should also be considered.

3.4.7.5 The frequency of equipment movement should be kept to a minimum to reduce the risk of ISA transmission.

3.4.7.6 Inter-site contact of biologically active material (for example, fish health samples, decomposed fish material from mortality collection in undisinfected containers, undisinfected non
site-specific harvest tubs) should be prevented through strict hygiene protocols and auditing.

3.4.8 Risks associated specifically with diving

Marine sites commonly use divers who can be contracted to many companies operating in several distinct hydrographic areas. Divers encounter high-risk biological material on a daily basis and the elimination of ISAV transmission from their equipment and clothing should be a key concern of any farm. Essentially this is an issue of disinfection and control, but its importance is underlined by at least one officially ISA 'suspicious' site in Scotland being linked to a separate ISA infected waterbody through diving contact. To achieve the lowest risk in this area, site-specific diving suits and equipment would be required, but it is recognised that the cost of this may be prohibitive.

3.4.8.1 Recommendation

It is recommended that standard disinfection procedures\(^\text{79}\) for divers are implemented and should be audited and documented by site staff on each occasion.

3.5 Harvesting Operations

3.5.1 Introduction

Norwegian epizootiological studies\(^\text{55,56}\) have identified risk factors important in the transmission of ISA to salmon farms. In the context of harvesting and processing, the most important of these are:

- the movement of infected fish;
- proximity to other infected farms;
- proximity to salmon slaughter houses;
- the sharing of personnel and equipment between sites.

Laboratory studies on transmission\(^\text{7,21}\) have shown that blood waste, urine, faeces and skin mucus contained sufficient virus to establish infection. Blood is one of the primary routes of transmission. Blood-feeding sea lice have also been implicated as a vector.\(^\text{19}\)

It is concluded that the major risks associated with harvesting and processing operations are environmental contamination with blood, body fluids and offal, and the transport of fish (alive or dead), equipment and personnel. In this chapter, risks associated with processing and harvesting operations are considered separately.

3.5.2 Identification of risks
A range of harvesting methods is in operation, each of which poses different method-specific risks. These fall into three categories of operation: on-site harvesting, the use of a central point harvesting stations at sea and the use of a shore-based harvesting stations.

Generic risks arise from the proximity of farms to processing and harvesting stations, uplifting of fish from the donor farms, transport to the processing station and the requirement to disinfect water, equipment and blood water. The quality of management systems which may affect the capacity to maintain good hygiene, adherence to agreed protocols for disinfection and containment of disease are also important risk factors, particularly in harvesting operations at isolated locations.

Following slaughter at sea, fish are transported in harvest bins or larger containers on a raft or other vessel to the shore for onward transport or directly to a processing facility. The risks lie in spillage, loss of harvest bins at sea or cross-infection from the re-use of dirty or contaminated harvest bins. Further work is required to reduce the risk of leakage from harvest bins. Fish may also be transported in harvest bins on a lorry or in bulk containers from the place of harvest to the processing plant, which carries an additional risk of spillage.

**On-Site Harvesting**

On-site harvesting has the advantage of requiring no movement of live fish. However, there are risks associated with containment (especially of blood water) and movement of equipment between sites. There is also a high degree of weather dependency associated with on-site harvesting. If no account is taken of the effects of heavy rainfall, containment capacity may be exceeded and increase the risk of loss of blood water. During rough weather, cage structures and nets may be susceptible to damage caused by harvest rafts and equipment improperly moored alongside the farm, leading to a risk of escapes.

**Harvesting Station at Sea**

A harvesting station at sea is a slaughter facility with holding cages into which live fish are transferred from production sites. It has the advantage of creating an independent harvest population, allowing greater harvest control and short-term planning. It avoids movement of harvest equipment or personnel between sites and greatly reduces weather dependency.

The risks associated with this method involve the uplifting and movement of live fish, usually using wellboats, and the creation of a population of live fish at the station. This method has been questioned in Norway, but now appears to be acceptable. The risks arise from the introduction of fish from many sources and/or management areas to the harvesting station, usually by wellboat and carrying infection back to the farm on the return journey. Where fish are moved in transport cages, equipment failure leading to escape and potential virus transmission to other farms are additional risks. A question also remains as to whether virus levels can rise in populations with a rapid turnover. Investigation of the use of enclosed (bag) cages may indicate better containment and is an area requiring further research.

**Shore-Based Harvesting Stations**
A shore-based harvesting station operates by transferring the fish directly from a wellboat to an on-shore slaughter facility. This means there is no discharge of fish into a holding facility. The method has the advantage of a high level of containment compared to harvest at sea. If the processing plant is adjacent to a suitable pier, there is the additional benefit of not having to transport harvested fish, as harvesting and processing are combined in one facility.

The principal risks associated with this method of harvest are in the uplifting and movement of live fish and the disinfection of a large quantity of water from the wellboat. This method may also be associated with increased pre-harvest stress for fish resulting in a deterioration in quality.

3.5.3 Risk reduction measures

Training and Procedures

Staff should be given appropriate training. Highly trained and disciplined staff are essential for maintaining the required level of hygiene and adherence to protocols. Written protocols, including risk assessments, which are regularly audited will increase security and are particularly important for activities on remote sites. These should be formally audited through existing quality assurance schemes such as the SQS scheme or an equivalent. Standard disinfection procedures should be followed. The Scottish Environment Protection Agency (SEPA) must be consulted at an early stage of the harvest planning process to reach agreement on disinfection methods. There is a presumption against the use of sodium hypochlorite. Although short-term crisis usage may be permitted, long-term plans should involve alternatives.

Separation Distances

It is recommended that production units are not sited within 5 km or one tidal excursion (whichever is greater) of a harvesting station or, until effluent disinfection is implemented, of a processing plant.

Containment and Disinfection

It is a requirement under the Welfare of Animals (Slaughter or Killing) Regulations 1995 that fish must be dead or deeply unconscious when their gills are cut. Compliance also reduces blood splashing which is beneficial from a disease containment perspective. Gill cutting must take place on a facility where the blood water can be caught and disinfected. This may mean using guttering and bins particularly when slaughtering at sea. The use of covers to reduce volume variations caused by rain is required when these processes occur in the open. At the end of each day blood water bins, anaesthetic harvest bins and all other equipment require disinfection according to the standard disinfection procedures.

Risk of Escapes

Before commencing harvest at sea or transporting fish from a farm to a harvesting station, the cage net should be examined for holes or signs of weakness. This should be carried out before crowding the fish. The method of crowding the fish and removing them to the slaughter point should be
assessed for risk, and contingency arrangements made to prevent fish escaping. Examples of the types of contingency arrangements are the establishment of a 'safety net' system to catch fish escaping from the lifting method (braille bags should not be operated outside the area of containment) and a hand net to recapture fish lost at sea from the killing table.

**Uplifting and Transportation of Harvested Fish**

Risk reduction measures should be directed at preventing:

- leakage from harvest bins by using: harvest bins in good condition; double skinned harvest bins† where possible; and rubber seals and bindings;
- loss of harvest bins at sea by maintaining rafts in good repair; having contingency arrangements for poor weather conditions; ensuring harvest bins are properly loaded and secured; and using harvest bins which are buoyant and therefore recoverable;
- cross-infection by having a clear identification system in place for those harvest bins originating in Surveillance Zones (for example, the use of colour-coded harvest bins); and ensuring all harvest bins are cleaned and disinfected according to the standard disinfection procedures79 prior to re-use;
- plastic pallets should be used where possible and the use of wooden pallets phased out by treating them as 'single-use only'.

**On-Site Harvesting Stations**

Additional risks associated with on-site harvesting arise from the transfer of equipment and personnel between sites, and the vulnerability of some sites to adverse weather conditions. The following risk reduction measures are specific to this type of harvesting operation:

- equipment should be site-specific or if moved between sites must be disinfected in compliance with the standard disinfection procedures;79
- rafts made of wood or other material which are not readily disinfected should be avoided;
- contingency arrangements for deteriorating weather should be in place before commencing harvest. Rigorous procedures should be established to minimise the likelihood of damage from harvest rafts, and equipment moored alongside cages. Blood water containment equipment should be covered to prevent rain water from entering.

**Harvesting Station at Sea**

†The use of liners is beneficial, but may create a disposal problem.
Additional risks arise from the movement of live fish and the maintenance of a population of live fish on the station. Risks may be reduced by having permanent harvest equipment and containment methods, and by siting such stations in sheltered locations.

The following risk reduction measures are specific to harvesting operations at a central point harvesting station at sea:

- movement of fish to harvesting stations in another Management Area should be discussed with the Fish Health Authorities at SERAD and FRS MLA, but there should be a presumption against a harvesting station in a Management Area unless by agreement with other operators;
- use of wellboats to move fish to harvesting stations should be in accordance with the Code of Practice referred to in 3.4.5.3;
- the use of transport cages for moving fish from farm to harvesting station should be limited to transport of fish over short distances within zones. Journey routes should be through safe water, free of obstacles and strong currents, and with adequate depth;
- to avoid attracting wild fish, there should be no feeding at a harvesting station;
- to reduce the risk of viral transmission and the development of disease, fish should not be on a harvesting station for more than seven days;
- fish should never be transferred from a harvesting station back to a production site.

**Shore-Based Harvesting Stations**

The principal risks associated with this method of harvest are in the uplifting and movement of live fish and the disinfection of a large quantity of water from the wellboat. Two possible methods are suggested to deal with this water: discharge back to the wellboat delivering the fish and return to the site of origin (the farm), prior to final discharge. In this case, ideally there should be some form of disinfection treatment *en route*. Alternatively, the water may be pumped ashore with the fish, and be disinfected before discharging through the factory. Further risk analysis and cost-benefit work on these two options is required before final recommendations can be made.

### 3.5.4 Recommendations

3.5.4.1 All of the risk reduction measures referred to in 3.5.3 should be implemented by incorporation into a Code of Practice.

3.5.4.2 Written procedures, including risk assessments and contingency plans, should be audited to comply with existing quality assurance schemes such as the SQS scheme or an equivalent.
3.5.4.3 **Research should be undertaken in the following areas:**

- to improve the security of harvest bins to eliminate leakage and investigate the application of novel designs;
- to investigate the use of enclosed (bag) cages which may lead to better containment at harvesting stations;
- to carry out further cost-benefit and risk analysis on the disinfection and treatment of waste water arising from wellboats involved in the transport of fish to pump ashore harvesting stations.

3.6 **Processing Operations**

3.6.1 **Introduction**

Packing plants may be categorised as primary processors (generally based close to harvesting facilities and dealing with gutting, grading and packing for onward transport) and secondary processors (often nearer to market and dealing with a wide variety of further processing operations). In all processing facilities, areas containing contaminated fluids or solids must be identified and access restricted. All activities in these areas must be risk-assessed.

3.6.2 **Identification of risks**

*Reception and Off-Loading*

Risks include spillage in off-loading bays, either in routine tipping of harvest bins or in accidental 'catastrophic' release, for example, where a harvest bin bursts or falls. There may also be contamination of personnel (workers, visitors and/or passers-by) and contamination of vehicles which leave the site. Storage facilities, disinfection areas and waste disposal from Surveillance Zones also pose a risk of contamination.

*Effluent Management, Including Blood Water*

All effluent and blood water must be contained and passed through the standard disinfection procedures. Contamination of personnel, equipment or vehicles by blood water or wash water leads to risk of spread of ISAV. Seepage of potentially infected material to ground water or water courses must be avoided.

*Waste Solids*

Risks are associated with access by and contamination of vermin (for example, birds and rodents). The use of waste material as bait (for example, in creels) could lead to infection of new areas and/or the contamination of protective clothing.
Equipment and Vehicles Leaving the Processing Plant

There is a risk of contaminated equipment, harvest bins or pallets (particularly wooden ones) being carried on vehicles leaving the facility. Spread of ISAV could also occur through contamination of the wheels and decks of lorries, and via workers leaving with contaminated clothing.
Final Product/Carcasses

Although outwith the scope of this group, further work is required on risks associated with the eventual fate of fish placed on the market from suspect or confirmed sites.

3.6.3. Risk reduction methods

- Off-loading bays should be equipped with a waterproof apron, draining to a collection point, and should be surrounded by a bund or similar structure.

- Roofing over reception areas is recommended to avoid the problem of rainwater run-off becoming contaminated. Drainage from dirty areas must feed into a disinfection facility.

- Sprays or wheel-baths should be available to treat vehicles leaving the site.

- Full protective clothing should be provided for staff and should be retained on the premises. The availability of disposable protective clothing should be considered where possible. Laundering of clothes should be at a temperature which will inactivate ISAV (at least 55° for more than five minutes). Rubber coveralls need to be disinfected in a soak bath.

- Plastic pallets should be used whenever possible. The use of wooden pallets should be phased out. When wooden pallets have to be used, they should be for 'single use' only.

- Site boundaries must be clear and access to dirty areas restricted.

- Processing areas dealing with high-risk material must be identified and restricted. All surfaces must be waterproof and amenable to disinfection, and drainage from dirty areas must feed into a disinfection facility.

- Disinfection (6.4) of all effluent from processing facilities should be required by law.

- Ensiling of waste solids is required (3.7).

3.6.4 Recommendations

3.6.4.1 The requirement to disinfect the effluent arising from processing sites should be implemented through legislation.

3.6.4.2 The remaining risk reduction measures detailed in 3.6.3 should be put in place through a Code of Practice which should incorporate the disinfection checklist detailed in Chapter 6.
3.6.4.3 *Further work is required to address risks arising from secondary processing and the placing on the market of carcasses from suspect or confirmed sites.*

3.7 Disposal of Mortalities and Processing Waste

3.7.1 Legislation

The disposal of mortalities and processing waste is controlled by the Animal By-Products Order 1999, which implements the Animal Waste Directive 90/667/EEC. The Directive lays down rules for 'the disposal and processing of animal waste, for its placing on the market and for the prevention of pathogens in feed stuffs of animal or fish origin'.

*Animal By-Products Order 1999*

Fish are included in the definition of animals, and animal by-products are defined as:

'animal carcases, or parts of animal carcases, or products of animal origin which are not intended for human consumption'.

The Order divides animal by-products into 'high risk' or 'low risk' categories. High risk material includes:

- 'fish which show clinical signs of disease communicable to man or fish' (Article 3.1 (f));
- 'fish which are killed in the context of disease control measures (other than those slaughtered for human consumption)' (Article 3.1 (d));
- 'all animals (fish) kept for agricultural purposes which have died or been killed, but were not slaughtered for human consumption' (Article 3.1 (b)).

'Low risk' fish by-products would include, for example, fish waste from fish processed for human consumption. The Order specifically excludes from its provisions a) fish caught and discarded at sea, and b) waste from processing fish at sea, although the Order does apply to the processing and disposal of fish on land. Fish by-products (high or low risk) must be disposed of without undue delay by:

a) rendering or part rendering in approved premises;

b) incineration;

c) burning, other than in an incinerator or, in exceptional circumstances, burial.
Provision also exists for the use of fish by-products in educational, diagnostic, or research establishments and, in the case of 'low risk' material only, for petfood, pharmaceutical or technical use or for feeding to zoo, circus or fur animals.

Burial may only be used as a disposal option where the distance to a prescribed disposal outlet (approved renderer or incinerator) and the quantity of by-product involved does not justify transporting it. When large quantities of fish by-products are generated, these are likely to be sufficient to justify rendering or incineration. However, where outbreaks of epizootic disease such as ISA occur, transporting animal by-products to renderers or incinerators may cause a health risk. There may also be insufficient rendering or incineration capacity available. In these cases, the Scottish Ministers may serve a notice on the person in charge of fish by-products, requiring disposal by burning or burial, as specified in the notice. Notices would be signed by officials in SERAD. The current absence of rendering or incineration capacity for fish by-products in Scotland makes it imperative to identify burial sites which could be used if the existing disposal route to Norwegian renderers is closed.

The export of ensiled fish to Norway is an option that has been used in the case of big kills or culls. This is acceptable as part of the process leading to rendering in approved premises, albeit in Norway. The Animal By-Products Order describes six acceptable methods of rendering (Schedule 2, Part II). 'Method 6' describes how fish may be ensiled in formic acid before being heat treated. This recognises ensiling and heat treatment as a form of rendering. Composting and ensiling are not options for disposal other than as part of a scheme to employ rendering or incineration.

The Environmental Protection Act 1990

The Environmental Protection (Prescribed Processes and Substances) Regulations 1991 describes, in Schedule 1, the processes for which an authorisation is required under Section 6 of the Environmental Protection Act 1990. Section 6.9 of Schedule 1 describes the treatment and processing of animal or vegetable matter. The ensiling or rendering of dead fish and processing offal falls within this definition, and anyone proposing to operate such a process must first obtain such an authorisation from SEPA. Plants sited on agricultural premises may be exempt from this requirement provided the resulting material is not then sold. Guidance should be sought from the local SEPA office.

All waste produced by fish processing has to be disposed of properly. Waste packaging, boxes and plastic liners have to be kept, treated and disposed of in accordance with Section 34 of the Environmental Protection Act 1990. This requires that any waste being transferred from a producers' premises has to be:

- contained properly;
- carried by a Registered Waste Carrier;
- subject of a Waste Transfer Note;
- consigned to a site which has an appropriate Waste Management Licence (WML).
If the waste is not taken directly for disposal and is kept or treated in any way at another site, that site must have an appropriate WML. An example of this would be a fish processor engaging a contractor to remove waste bin liners for washing/ disinfection before transporting to a licensed waste disposal site. This activity would be classed as treatment of waste, thereby also requiring a WML. The transfer from the processor to the contractor and then from the contractor to the disposal site would both require to be covered by Waste Transfer Notes.

A duty of care applies to all parties involved in the waste production collection and disposal chain and a Code of Practice "The Duty of Care" 83 gives guidance on the steps required to ensure all parties meet their obligations.

The Control of Pollution Act 1974

Disinfectants used to treat processing waste and equipment fall within the definition of biocides making them EC List II dangerous substances. Their discharge to the water environment constitutes an offence under this Act unless it is carried out in accordance with a consent issued by SEPA. Advice and application forms can be obtained from one of the offices listed in Appendix I. Scottish Environment Protection Agency may require that any residual active ingredient is neutralised prior to discharge to protect the quality of the receiving water and this may be stipulated as a condition of the consent.

The Groundwater Regulations 1998

The discharge of spent disinfectants to land may (unless completely neutralised prior to disposal) require an authorisation issued under these regulations. Again, advice and application forms can be obtained from the local SEPA office (Appendix I).

3.7.2 Collection and disposal of mortalities from salmon farms

On all farms, populations of fish in pens should be inspected daily to check on their well-being. Moribund or dead fish should be removed and post mortem examination carried out to ascertain the cause of death. Carcasses should then be disposed of by ensiling and rendering. Should the presence of ISA be suspected at the farm, the law requires that FRS MLA must be informed without delay. Clinical signs of ISA are described in Chapter 4, and in an advisory leaflet entitled 'Infectious Salmon Anaemia' (Appendix VI). If the disease becomes clinical, mortalities from ISA can be severe and, even though a cull is planned, dead fish should be removed daily or more frequently in order to reduce the load of viral particles being released into the surrounding waters.
3.7.3 Collection of moribund and dead fish

Hand Nets

A hand net is used to remove moribund fish, runts and 'poor-doers' as they swim near the surface. In small pens the nets can be lifted and any dead fish removed. Hand nets should be stored in disinfectant when not in use (Chapter 6).

Dead Socks

Some nets are fitted with 'dead socks' where dead fish collect. They are usually serviced from the inside of the net by raising the net and either hand netting the fish out or tipping directly from the sock into a container.

Dead Basket

A round, stainless steel frame with a bag net attached to it sits on the bottom of the pen creating the low point into which dead fish roll. The basket can be lifted every day and the dead fish removed.

Air Lifts

These were designed to remove dead fish from the bottom of the net with minimal disturbance. The net bottom has a fine mesh base into which a plastic cone is sewn. The cone is attached to corrugated flexipipe which is in turn attached to a vertical solid pipe running up the outside of the pen. The air lift is attached to the solid pipe and, when compressed air is released, a powerful lift is created which sucks the fish from the pen. The cone is normally closed off with a ball during the day. Faeces and waste feed are also sucked up and experience suggests that this job should be carried out at the end of the day to minimise the effects of self pollution.

Divers

Divers are widely used to remove dead fish, and the normal procedure is for one diver to go into a pen, fill a net and have it pulled to the surface by a support team. This avoids tiring the diver and helps to avoid the effects of yo-yo dives. This method can be tiring if a large fish kill occurs. Diving teams must follow Health and Safety Executive regulations.

When teams of divers are employed on a number of farms, they must pay particular attention to the disinfection of gear between sites or use site specific equipment.

Disinfection of Equipment

Procedures for disinfection of equipment have been described.79
Containers for Dead Fish

Designated site specific bins should be used. It is strongly recommended that mortalities are ensiled immediately or at least on the day of collection. Designated bins containing ensiled material should be stored at specified collection points to await removal for disposal in an approved manner.

Storage of Mortalities

Ensiling

This method is currently favoured because ISAV particles are quickly inactivated by low pH.

The ensiling process involves the maceration and preservation in formic acid of dead fish (morts) and factory offal. It is effective in inactivating ISAV and therefore reduces the risk of spreading the disease when material is subsequently transported. It also prevents foul odour as it effectively arrests the biodegradation process, allowing the material to be stored and transported to disposal facilities from the point of origin.

The process has been widely adopted in Norway where ISA has been endemic for over 15 years. There are no down-stream processing facilities within the UK and the fish silage arising in Scotland is currently being exported to Norway to undergo a rendering process. The ensiling of fish as a preliminary step in its disposal by rendering or burial is permitted by the Animal By-Products Order 1999.

Ensiling of fish waste is recognised by the JWG as best practice in reducing the risk of spread of the disease from this material. To achieve this, the following are required:

• the ensiling vessel must be purpose-built to resist acid attack and robustly constructed to prevent leakage. It is strongly recommended that proprietary ensiling plants are used, as these have been designed specifically for the task;

• the ensiling plant should be sited in a position to minimise the risk of spillage resulting from collision with vehicles;

• fish tissues must be thoroughly macerated when loaded into the ensiling plant to permit rapid contact with the formic acid;

• the mixture should be circulated periodically to assist the dissolution of bone tissue;

• dosing with formic acid (nominally 15 litres 85% formic acid per 500 kg fish material) must be sufficient to maintain the pH of the mixture below 3.9 at all times. This means that the pH must be regularly monitored and more acid added if the pH rises above this level. Responsibility for this must be clearly assigned and should be incorporated into routine operating procedures;
• dead fish and processing offal must be ensiled immediately to maintain a high quality of silage and reduce the risk of infection due to leakage of body fluids.

Ensiling plants may be constructed at fish farm shore bases where plants tend to be small units of around 1,000 litres or at processing factories where installations tend to be medium sized, capable of retaining volumes of 5-30 m³ of ensiled liquor. There may also be bulk storage installations where quantities in excess of 400 m³ may be held awaiting export or transport for rendering by ship or tanker.

It should be noted that some fish pathogens, particularly IPNV are not affected by the ensiling process, and that the resulting material is still classified as 'high risk waste' which must be disposed of according to the Animal By-Products Order 1999. Ensiling may be used as part of the process which must be completed using incineration, rendering or burial.

Composting

This method is not approved.

i) Transport

Vehicles. Where mortalities are transported by road, for example to a common ensiling facility, spillage must be avoided by using appropriate tanks. It is a statutory requirement that any animal by-product must be collected and transported in suitable containers or vehicles in such a way as to prevent leakage. The containers or vehicles must also be adequately covered and maintained in a clean condition. Standard disinfection procedures should be followed.79

Boats. Suitable containers should be used. Disinfection of fish farm vessels and wellboats has previously been described.

3.7.4 Risks associated with mortalities

It is considered that proper ensiling of mortalities removes the risk of infection by ISAV and many other fish pathogens from the resulting material. Risks therefore come from inadequate disinfection of the hardware used to collect the dead fish from the pens and anything in contact with dead fish that is moved from site to site. A prime example of this is when divers are used and, in this case, farmers must take responsibility and assure themselves that the equipment used by visiting divers is disinfected to their satisfaction.

3.7.5 Disposal of primary and secondary processing waste

All solid primary and secondary processing waste should be ensiled prior to disposal by one of the approved methods.

• Offal. All offal should be minced and deposited in an ensiling plant for bulk storage before collection and removal in accordance with the legislation.
• **Blood water.** In the short term it is acceptable to treat blood water with sodium hypochlorite which can then be neutralized before discharge. In the long term, this method is unlikely to be acceptable and research is necessary to determine alternative acceptable methods. The possible use of chlorine dioxide, heat (pasteurisation) and ozone all merit assessment.

• **Frames and Heads.** There are anecdotal reports of frames and heads being used as bait for lobsters. This procedure is illegal under the Animal By-Products Order 1999.

### 3.7.6 Recommendations

3.7.6.1 *There should be legislation to ensure that all mortalities and processing waste are ensiled irrespective of whether the fish are from ISA infected areas. This will include solid primary and secondary processing waste.*

3.7.6.2 *Infrastructure should be developed for the storage, collection and disposal of wastes from aquaculture activities. On-farm ensilers should be as close as is practical to the point of collection of mortalities.*

3.7.6.3 *The Government should encourage the development of capacity to render ensiled waste in Scotland.*

3.7.6.4 *Liquid effluent from processing activities must be disinfected.*

3.7.6.5 *SERAD should issue guidance to local authorities indicating how the Animal By-Products Order 1999 applies to the disposal of fish by-products, in order to ensure that the existing legislation is enforced.*

3.7.6.6 *SERAD should establish a statutory basis for controlling the use of heads and frames from aquaculture products as bait.*

3.7.6.7 *Research should be undertaken to establish the efficacy of a wide range of disinfectant treatments against ISAV.*
3.8 Assessment of the Risk of Transmission of ISA to Wild Fish and Other Farmed Fish from Fish Farm Escapes

3.8.1 Introduction

Fish stocks are normally the most valuable asset on a fish farm and considerable efforts are made by the fish farming industry to limit escapes. However, escapes do occur in Scotland. Escaped fish are noted each year in fisheries for wild salmon and in some years at some locations they occur at substantial frequencies.30 The joint concerns of fish farmers, the Government and other interests have culminated in the creation of the Farmed Fish Escapes Working Group, which is currently developing a Code of Practice to limit escapes further. Through these measures, it is hoped that fewer fish will escape and consequently any risk of ISA spread through escaped fish should be reduced.

However, without pre-judging the final conclusions of the Farmed Fish Escapes Working Group, the level of containment required to achieve total security would need to be maintained at full quarantine standards, a level which is impractical in commercial farms. It is therefore an inevitable conclusion that some live fish will escape at some time from commercial fish-holding facilities.

3.8.2 Factors contributing to the level of disease risk

Several factors will contribute to the level of disease risk to wild and other farmed fish associated with fish escaping from an ISA infected fish farm:

• the likelihood of an escape event occurring on an ISA infected farm;
• the level of disease on the farm at the time of escape;
• the subsequent dispersion of escaped fish in relation to susceptible wild and farmed fish populations;
• the survival of escaped fish and the persistence of ISAV in an infectious state.

3.8.3 Risk assessment and containment measures

a) Level of Escapes

Salmon escape from fish farms at all stages of their life-cycle. In Scotland there is no official system to report escapes from farms, data from stock movement records are not sufficiently refined to calculate losses due to escapes, and deductions can only be made from observations of farmed fish in the wild. In the North Atlantic, between 20 and 40% of commercially caught salmon in the wild are cultured fish.31,32 In Norwegian coastal areas, the proportion of farmed salmon to wild salmon in commercial catches is high, between 44 and 49%,33,34 but data from Scottish waters currently suggest that the occurrence of farmed salmon there is lower.35,36
It is apparent that there is considerable variation in the numbers of fish escaping from different sites, possibly reflecting aspects of management, level of investment, exposure to weather or frequency of predator attack. It is therefore not possible to assign an overall level of risk of escapes to the whole of the Scottish salmon farming industry, but instead assessment of individual farms has to be made. On sites confirmed or suspected of being infected with ISAV, there should be an immediate and full inspection of all nets and equipment, and thereafter, twice weekly documented programme of inspection until all stocks are removed. Any nets showing significant defects should be renewed. Particular care should be taken whenever fish are being moved during net changes, grading or harvest. If brailles are being used, safety nets/sheets should be placed to channel any fish escaping either back into the cage, or into another secure area.

To avoid duplication of effort with the Farmed Fish Escapes Working Group, the JWG does not intend to make recommendations on more general measures to be taken to limit escapes of stock.

b) **Risk of Infection Posed by the Farm at the Time of Escape**

Under the Diseases of Fish (Control) Regulations 1994, when fish on a farm show clinical signs or post mortem lesions or dubious reactions in laboratory tests giving rise to reasonable suspicion of the presence of ISA, the farm is officially designated as suspected of being infected. When the presence of ISA has been confirmed in fish on a farm as a result of laboratory examination or as a result of clinical examination and a post mortem examination, the farm is officially confirmed as infected with ISA. These designations of different levels of confidence of the occurrence of ISA reflect the level of infection in the farm stocks and hence on the infectivity of any fish which may escape. In both cases, official control notices are placed on the farm with the purpose of containing infection.

The Diseases of Fish (Control) Regulations 1994 require that all fish on an 'ISA infection confirmed' farm are immediately removed from the waters of the farm. Any fish escaping from the farm prior to this being achieved should be considered to be in the high risk category of carrying ISAV at levels capable of transmitting infection to other susceptible fish. Farms which are under notice of 'official suspicion' of the presence of ISA are permitted to continue to grow the fish stocks on site. Balanced against the increased risk of some fish escaping because of their extended time on site, is the lower level of risk of significant infection in individual fish. The level of risk from such sites can not be considered to be as high as ISA confirmed sites, but may still be appreciable.

c) **Dispersion of Escaped Fish in Relation to Susceptible Wild and Farmed Fish Populations**

The behaviour of infected salmon once they have escaped will strongly determine which other wild or farmed fish are at risk.

Anecdotal information from the salmon farming industry in Scotland suggests that there is a very rapid dispersion of fish after they escape from a farm. Most scientific data on this subject have been derived from Norwegian studies. In a review of information on the dispersal, migration and spawning of escaped cultured salmon, it was noted that their distribution pattern depends on their developmental stage and the time of year they escape or are released. Smolts and post-smolts in
Norway, and probably other European countries, move in the same general direction as the prevailing water currents along the coast before moving out to the oceanic feeding areas in the North Atlantic. Although many wild salmon migrate to West Greenland waters, farmed salmon do not show the same trait, as few occur in these waters. Escaped farmed fish in Norway have been found to spend up to three weeks in the vicinity of the site of escape. Other uninfected farms in the area would therefore be at increased risk. Cultured salmon may return to fresh water within one year of release or may remain at sea for one or more years before they enter rivers to spawn. When maturing sexually, most escaped farmed fish return to the geographical area of their escape and having no home stream tend to enter large rather than small rivers. Sexually maturing salmon which have escaped are more inclined to stay in coastal areas, although some also move out to the oceanic feeding grounds.

When assessing risks to other fish populations from an escape of fish carrying ISAV, it is necessary to incorporate the above factors into the analysis on an individual case by case basis.

d) Survival of Escaped Fish and the Persistence of ISAV in an Infectious State

It has been noted that there are many factors determining the survival of farmed salmon in the wild, the most important being size and age at escape, geographical location where they escape, season, physiological status and the extent of domestication. Most of this information relates to smolt survival. The high numbers of farmed Atlantic salmon observed in oceanic waters north of the Faroe Islands and in rivers indicate that many escaped fish do survive in the wild, but this has to be considered in relation to the numbers which have escaped. This may be limited, as survivals from escape to return are usually considered to be low (A. Youngson, pers. comm.).

Pathogenic diseases are normally difficult to detect in wild fish populations, mainly because diseased fish are unlikely to survive for long periods of time in the environment. As ISAV is highly pathogenic, it can be deduced that any individual escape or fish suffering from the disease will be removed selectively from the population. Consequently, any sick fish escaping probably die rapidly and any fish carrying infection die as the disease progresses to a clinical level.

The probability of high levels of infection persisting in escaped fish populations is therefore low.

3.8.4 Conclusions

Available data do not permit quantification of the risk to wild and other farmed salmon due to salmon which have escaped from populations which are ISAV infected or are under suspicion. Large numbers of salmon were escaping from Norwegian farms in the late 1980s and early 1990s at the peak of the ISA outbreak in that country. Despite the probability that many of these fish were carrying infection at the time of their escape, the Norwegian ISA control policy then adopted was highly successful. This indicates that the long-term risk to farms from escaped fish present in farming areas is probably very low.

The risk to wild fish from their proximity to escaped fish can not be analysed because of the problems in detecting highly pathogenic disease and assessing its effect in wild salmon populations.
The risk of ISA being transferred from escaped fish to other farmed and wild populations will decrease with time elapsed after the escape because of the high mortality rate in escaped farmed fish. Escapes of sexually mature salmon present the highest risk because of their tendency to remain in inshore waters or to ascend local rivers rapidly.

3.8.5 Recommendations

3.8.5.1 Account should be taken of the conclusions of the Farmed Fish Escapes Working Group;

3.8.5.2 Cage security inspection should be implemented immediately ISA is suspected or confirmed on a site and a net inspection programme with increased frequency is followed until all fish are removed from the cages;

3.8.5.3 Additional safety measures to prevent escapes should be implemented whenever ISA infected or suspect stocks are being moved;

3.8.5.4 Particular effort should be directed at attempts to recapture escaped sexually mature salmon in line with any recapture methods proposed by the Fish Farm Escapes working group.

3.9 Other Biological Vectors of ISA

3.9.1 Introduction

This section is concerned with evaluation and review of those ISAV vectors not yet covered by other chapters in this report.

3.9.2 Wild salmonid fish

Section 3.3 of this report indicates that brown trout and rainbow trout can both be ISAV carriers. Recent surveys (FRS Marine Laboratory Aberdeen, unpublished results) suggest that there is now evidence of occurrence of ISAV in wild sea trout. It has been suggested that sea trout may well be a natural reservoir of ISA. If this is true, and sea trout are persistent ISAV carriers without clinical disease, then sea lice movements from wild sea trout to farmed salmon may be a source of primary infection. Perhaps of equal importance, sea trout or asymptomatic salmon carriers entering a freshwater system may pose a risk, particularly during spawning migrations. Infectivity of blood samples from brown trout, some seven months after initial challenge, may have been associated with persistent infection and/or maturation stress leading to higher levels of virus. In this way, sea trout might present a risk of ISAV transmission to an unprotected hatchery. In Canada, ISAV causing clinical disease has been detected in escaped farmed salmon and wild salmon entering a spawning river (F. Whoriskey, unpublished results). Potential risks to farmed stocks associated with wild salmonids are:
3.9.3 Sea lice

*Lepeophtheirus salmonis* and *Caligus elongatus* have both been demonstrated to transfer ISAV infection.\(^{19,41}\) The mobility of pre-adults and adults is well known and there may be a significant risk of transmitting ISA between sites. Scotland differs significantly from Norway in the number of available veterinary medicines licensed for sea lice control and the probable number of lice generations in any year. The overall effect of this is to give a substantially greater lice challenge to farms in Scotland. Equally, discharge consent conditions in the UK often promote the use of hydrogen peroxide, and yet peroxide has been shown to exhibit low efficacy and there are reports of resistance.\(^{78}\) The problem has been illustrated in an experiment\(^{43}\) where some 96% of the Chalimus larvae remained viable and 84% of the pre-adults and adults actually recovered after a 20 minute treatment at recommended concentrations under laboratory conditions. There is anecdotal evidence that farmers can discern when a neighbour has treated with hydrogen peroxide simply by a sudden influx of pre-adult and adult lice stages. In this context, lice must have the potential to be a major ISAV vector in Scotland. The following statement by a Norwegian researcher\(^{19}\) should be carefully considered:

"It is not satisfactory to remove 90% of the pre-adult and adult lice when a few still remain on the fish. In areas with ISA disease all the lice have to be removed from the fish and killed."

It will be critical to have maximum treatment efficiency through best practice in methodology, selection of optimal timing and to have access to consented compounds which can demonstrate maximum efficacy. In terms of ISAV infection from inter-site sea lice movement, the risk will be significantly reduced where the following apply:

- licensing authorities assist the industry through improved availability of safe, efficacious and environmentally acceptable anti-sea lice medicines;
- synchronous treatments consistent with environmental safety throughout a hydrographic area;
- full enclosure at treatment;
- weekly on-site lice inspections to select optimal timing;
- regular compound resistance testing;
- post-treatment lice inspection to verify efficacy;
- minimise the use of hydrogen peroxide or other non-effective compounds.
3.9.4 Non-salmonid fish

Norwegian researchers\textsuperscript{27} investigated the susceptibility to ISAV infection in goldsinny wrasse (\textit{Ctenolabrus rupestris}), turbot (\textit{Scophthalmus maximus}) and charr (\textit{Salvelinus alpinus}) and failed to demonstrate evidence of infection or carrier status in a laboratory challenge, but also failed to demonstrate carrier status in rainbow trout. It has been reported (A. Nylund pers. comm.) that ISAV may replicate in herring (\textit{Clupea harengus}), but transmission to salmon failed in a co-habitation experiment where the herring were found to be positive. The FRS Marine Laboratory Aberdeen has undertaken a limited survey of wild stocks in the Minch, Shetland, Mull and Lochs Nevis, Snizort and Creran for evidence of ISAV. As a result of the epizootiological study in Scotland, ISAV was detected in eel caught in fresh water and in saithe (\textit{Pollachius virens}) caught within the cages of a salmon farm during a clinical outbreak of ISA.

The other species examined by the FRS MLA to date have been found to be negative. These include; the \textit{Scyliorhinus canicula} (lesser spotted dog fish); \textit{Raja clavata} (thornback ray); \textit{Clupea harengus} (herring); \textit{Sprattus sprattus} (sprat); \textit{Ciliata mustela} (five-bearded rockling); \textit{Melanogrammus aeglefinus} (haddock); \textit{Merlangius merlangus} (whiting); \textit{Trisopterus esmarki} (Norway pout); \textit{Trisopterus minutus} (poor cod); \textit{Merluccius merluccius} (hake); \textit{Lophius piscatorius} (angler (monk)); \textit{Zeus faber} (dory (John dory)); \textit{Eutrigla gurnardus} (grey gurnard); \textit{Myxocephalus scorpius} (short-spined sea scorpion); \textit{Agonus cataphractus} (hook-nose (pogge; armed bullhead)); \textit{Trachurus trachurus} (scad (horse mackerel)); \textit{Callionymus lyra} (dragonet); \textit{Pomatoschistus microps} (common goby); \textit{Lepidorhombus whiffiagonis} (megrim); \textit{Zeugopterus punctatus} (topknot); \textit{Hippoglossoides platessoides} (long rough dab); \textit{Limanda limanda} (dab); \textit{Pleuronectes platessa} (plaice); \textit{Solea solea} (sole).

While no evidence yet exists of infection in wrasse, the use of wild caught wrasse for biological control of sea lice should be treated with caution. There may be an increased disease risk if such wrasse are caught outwith the salmon farm’s hydrographically defined area.

3.9.5 Marine environmental factors: shellfish

Bivalves have previously been found to harbour virus, for example, aquatic birnaviruses\textsuperscript{80} and so can be regarded as generally having a transmission role in the case of some pathogens. However, regarding ISA specifically, the limited experimental work conducted so far suggests that shellfish may not be considered as a high risk for ISAV transmission. It has been reported\textsuperscript{44} reported that ISAV could not be detected in the great scallop (\textit{Pecten maximus}) after exposure to known infective material. The Scottish Executive lifted restrictions on the relaying of live bivalve molluscs after laboratory trials conducted at FRS MLA failed to show evidence of transmission of ISAV from oysters or mussels to Atlantic salmon. Further research will be required to eliminate the possibility of either ISAV residency or active transmission of virus from bivalve molluscs, marine worms and a broad range of crustacea. Ultimately, this work will assist in generating a scientific basis for the duration of fallow periods.

An ISAV reservoir or transmission role in shellfish has not been demonstrated, but a mandatory fallowing period should reduce any potential risk. Further research should be undertaken to assess the risks associated with depuration or relaying.
Consideration should be given to regulating access by fishing boats to the immediate waters of all farms.

### 3.9.6 Marine birds

While there is an obvious link between aquaculture and sea birds, especially gulls and cormorants, digestive temperature and low pH probably means ingested fish material has a 'low risk' of ISAV transmission by the time of excretion. However, passive viral transfer through body contact or the dropping of infective material is possible. Also, regurgitation of partly digested food presents some risk of transmission from site to site, and from cage to cage within a site. Thus a minimisation of avian contact on the marine farm is desirable. Denying birds access to feedstuffs via adequate coverings on boat, quay or barge as well as anti-bird netting on the cage hand rails will assist in reducing risk. Careful feeding control, by reducing waste is of critical importance as is the hygiene routine employed with mortality disposal. Salmon carcasses or ensiled material should not be available for opportunistic scavenging. Critically, when culling an infected site, every measure should be considered to remove the risk of escaping biological debris being picked up by birds. Risks are thus decreased by:

- attention to measures designed to exclude birds from direct in-cage contact;
- good hygiene routines in handling mortalities;
- good feeding practice which minimises wastage.

### 3.9.7 Marine mammals

Seals and otters are often reported as having an interaction with marine farmed salmon and both are occasionally in direct contact with stock through predation. The linkage of waterbodies through seal dispersal is unknown, but must be a possibility. However, it is considered that there is a very low risk of ISAV transmission from marine mammals. They may have an indirect impact by damaging nets. Thus seal deterrent measures (net strength, acoustics, predator mesh) will have a role in lowering ISAV transmission risk especially in Surveillance Zones.

### 3.9.8 Recommendations

**3.9.8.1** Licensing authorities should assist the industry through improved availability of safe, efficacious and environmentally acceptable anti-sea lice medicines.

**3.9.8.2** Synchronous treatments should be used without prejudice to environmental safety throughout a hydrographic area.

**3.9.8.3** There should be full enclosure of sea cages during bath treatments.
3.9.8.4 Farmers should conduct weekly on-site lice inspections to select optimal timing.

3.9.8.5 Regular compound resistance testing should be carried out.

3.9.8.6 Post-treatment lice inspection should be carried out to verify efficacy of treatment.

3.9.8.7 The use of hydrogen peroxide or other non-effective compounds should be minimised.

3.9.8.8 Further surveillance should be carried out to determine the distribution of ISA in wild fish.

3.9.8.9 Further research should be carried out to establish the susceptibility to ISA of wild fish species, such as saithe and wrasse.

3.9.8.10 Further research should be carried out to determine the risk of transmission of ISAV from a crustacea, marine worms and bivalve molluscs to Atlantic salmon, including risks associated with depuration or relaying.

3.9.8.11 The risk of passive transmission of ISAV by birds should be minimised by:

• attention to measures designed to exclude birds from direct in-cage contact;

• good hygiene routines in handling mortalities;

• good feeding practice which minimises wastage.

3.9.8.12 The risk of damage to nets by seals should be minimised through the use of appropriate deterrent measures, for example, suitable net strength, acoustics and predator mesh.
CHAPTER 4: DETECTION AND DIAGNOSIS OF INFECTIOUS SALMON ANAEMIA (ISA)

4.1 Introduction

Although ISA was first described in 1984, the first isolation of the infectious agent ISAV was not reported until 1995, and diagnostic procedures are to a considerable extent still based on clinical, pathological, histopathological and haematological changes. Furthermore, the diagnostic criteria for confirming ISA are constrained by the requirements of EU legislation. This chapter will provide an overview of current diagnostic methods for ISA in the context of EU legislation, the OIE Diagnostic Manual for Aquatic Animal Diseases, advice received from the EU Community Reference Laboratory for Fish Diseases and the OIE Reference Laboratory for ISA.

4.1.1 Characteristics of the disease

Clinically, ISA appears as a systemic and lethal condition that is characterised by anaemia, ascites, congestion and enlargement of the liver and spleen, as well as peritoneal petechiae. Haemorrhages in the eyes may also be seen and hepatocellular degeneration and necrosis are consistent histopathological findings in typical outbreaks.

4.1.2 Characteristics of the virus

ISAV is an enveloped single-stranded RNA virus belonging to the Orthomyxoviridae family. The virus is pleomorphic, with a typical diameter of 100 to 140 nm and mushroom-shaped surface projections of about 10 nm. The genome consists of eight segments ranging from 1.0 to 2.3 kb with a total molecular size of approximately 14.5 kb. ISAV contains four major structural polypeptides with estimated molecular sizes of 71, 53, 43 and 24 kDa. One of the characteristics of orthomyxoviruses is their ability to bind to red blood cells. ISAV has been reported to agglutinate erythrocytes from Atlantic salmon and rainbow trout, but not the closely related brown trout. The maximum rate of virus replication in vitro (in salmon head kidney SHK-1 cells) has been observed between 10°C and 15°C. Production of infective virus was reduced by 99% at 20°C and no replication has been detected at 25°C or above.

4.2 Overview of Diagnostic Methods

The main diagnostic tools for the detection and diagnosis of ISA are as follows:

• clinical signs and macroscopic findings, including evidence of anaemia;
• isolation and identification of virus;
• evidence of the presence of virus using molecular genetic or immunochemical techniques;
• histopathology.
4.2.1 Clinical signs and macroscopic findings

The clinical signs of ISA can be variable. In classic cases the fish are lethargic, congregate in the upper water levels, gasp at the surface, go off feed and may hang motionless at the sides of the cage. Affected fish may exhibit exophthalmos, ocular haemorrhage, distended abdomen and/or skin haemorrhage.

Internal pathology may include:

- dark, pale or yellow liver;
- ascites;
- pale gills and heart;
- enlarged spleen;
- petechial haemorrhage in visceral fat;
- dark foregut.

None of the above are pathognomonic for ISA. However, the probability of ISA being present increases with increased observation of these signs and lesions.

4.2.2 Evidence of anaemia

Observation of pale gills and heart provides evidence of anaemia, and this may be demonstrated quantitatively by measurement of haematocrit. In advanced cases, haematocrit values are frequently below 10. Although anaemia is a classic feature of ISA, it is not specific to ISA and fish may exhibit anaemia for other reasons, for example, other infections or ulcerative conditions.

4.2.3 Sampling requirements and sample handling

Selection and Collection of Samples

In cases where one or more fish show clinical signs or gross pathology consistent with ISA, samples are taken in the manner described below. Fish showing typical clinical signs or gross pathology consistent with ISA are sampled preferentially. If these are in insufficient numbers, the sample may be completed using any weak or abnormally behaving fish. If weak or abnormally behaving fish are in insufficient numbers, the sample may be completed using healthy fish, to provide a statistically representative sample.

- Virus isolation — a minimum of 10 fish are sampled.
- Reverse transcriptase polymerase chain reaction (RT-PCR) — a minimum of 10 fish are sampled.
• Indirect fluorescent antibody test (IFAT) of kidney imprints — a minimum of 10 fish are sampled.

• Histology — up to 10 sick, weak or abnormally behaving fish are sampled.

Samples for virus isolation

The tissue material to be sampled is anterior kidney, spleen, heart and liver. Organ pieces are removed aseptically and transferred to tubes containing transport solution (Earles Balanced Salt Solution, EBSS, with antibiotics but no serum). Organ pieces from five fish are collected in one tube containing transport medium and represent one pooled sample.

Samples for RT-PCR

Samples of kidney tissue from five fish are placed in one tube containing RNAlater (Ambion Inc.) and represent one pooled sample.

Samples for IFAT

The tissue to be sampled is mid-kidney. A piece of kidney is removed from each fish, blotted thoroughly onto absorbent paper towel to remove excess blood and several light impressions are made in the centre of a poly-L-lysine-coated glass microscope slide. Duplicate slides are prepared for each fish sampled. Kidney imprints are air dried.

Samples for histology

Only freshly killed or moribund fish are sampled. Any external or internal lesions are sampled and in all cases the tissues to be sampled will include gills, heart, kidney, liver, spleen, pyloric caeca and intestine. Organ pieces are removed into tubes containing buffered formal saline. The volume of fixative should be at least 20 times the volume of tissue.

Preparation and shipment of samples to the laboratory

Samples for virus isolation and RT-PCR are placed in insulated containers with sufficient freeze blocks to maintain sample temperature below 8°C. Samples are not frozen and must reach the laboratory not later than 72 hours after sampling. Samples for IFAT are kept cool and transported in a sealed container with dessicant.

The above sample handling protocols are based on best practice for diagnosis of other viral diseases (for example, VHS and IHN).
4.2.4 Virological examination

Each sample (tissue pool) is homogenised, centrifuged and incubated with IPNV antiserum (to prevent growth of IPNV in the cell cultures). Salmon head kidney (SHK-1) cells are inoculated with the test material and incubated at 14°C for a period of up to six weeks with sub-cultivation. Appropriate controls are included.

Cell cultures are examined regularly for cytopathic effect (CPE), evident by cell vacuolation and subsequent detachment (Fig. 4.1). If evidence of CPE is observed at any stage, virus identification procedures are initiated immediately. The methods used for identification of ISAV are immunofluorescence (Fig. 4.2) and RT-PCR. Supplementary virus identification tests are carried out if it is considered that other viruses may be present.

It is sometimes possible to detect evidence of ISAV in cell culture in the absence of CPE using the technique of haemadsorption which utilises the affinity of orthomyxoviruses for red blood cells. Thus, SHK-1 cell cultures are now routinely screened by haemadsorption before being regarded as negative.

It is generally accepted that current virus isolation methods are slow and of uncertain sensitivity. Other cell lines have been shown to support growth of ISAV and several are currently under investigation at the FRS Marine Laboratory Aberdeen as potential alternative cell lines for virus isolation.

4.2.5 Examination of samples by RT-PCR

Each sample (tissue pool) is homogenised and the RNA is extracted. An aliquot of tissue homogenate from uninfected Atlantic salmon is processed alongside the test samples and serves as a negative control. An aliquot of the extracted RNA is subjected to a reverse-transcriptase step to produce complementary DNA. The polymerase chain reaction (PCR) is carried out using synthetic primers for ISAV and the resulting PCR product is subjected to agarose electrophoresis with standard markers and appropriate controls. A positive result is indicated by the presence of a 155bp PCR product (Fig. 4.3).

RT-PCR is a highly sensitive technique and potentially capable of detecting very small amounts of viral RNA. However, viral RNA may easily be broken down under adverse storage conditions. Also, because of the extreme sensitivity of the technique, RT-PCR needs to be carried out under rigorous hygiene conditions to avoid sample contamination. The use of suitable controls is an important component of every test and in practice a positive result in the case of any one of the negative controls would invalidate the test results for all samples examined in that batch.

4.2.6 Examination of kidney imprints by IFAT

Kidney imprints on microscope slides are fixed and incubated with a monoclonal antibody (MAb 3H6F8 to ISAV), and each imprint is then incubated with a solution containing a suitable dilution of anti-mouse fluorescein isothiocyanate (FITC) conjugate followed by a propidium iodide counterstain. Slides are examined using a microscope set up for fluorescence microscopy. Slides
are examined initially under low power and all areas of the imprint are examined. Suspect areas of the imprint are further examined at higher magnification (Fig. 4.4).
Four types of control are included with each batch of slides stained for IFAT:
If a positive result is obtained with any negative controls, the test is considered invalid for all slides in that batch. If all slides in a batch, including positive controls, are negative, the test is considered invalid for all slides in that batch.

If a slide is clearly IFAT positive, it may indicate the presence of viral infection. However, it is recognised that a small proportion (approximately 1 in 68) of imprints from uninfected fish will give a positive IFAT test (false positive), and allowance must be made for this phenomenon when interpreting IFAT results. Thus, in the absence of other evidence a single IFAT positive slide would not be considered sufficient evidence to trigger suspicion of the presence of ISA on a fish farm site.

4.2.7 Histopathology

Paraffin embedded sections are cut at 5 μm and stained using haematoxylin and eosin. Typical histological findings for ISA include multifocal haemorrhagic hepatic necrosis that may become confluent to give a ‘zonal’ appearance, leaving areas around large veins intact (Fig 4.5). This is generally considered to be a feature of advanced disease. An inflammatory response is usually absent.

There may also be local congestion and dilation of hepatic sinusoids, disruption of sinusoidal epithelium, sinusoidal congestion and formation of blood filled cavities. In the kidney there may be congestion, haemorrhage and haemorrhagic necrosis including tubular necrosis. The spleen may be congested and there may be haemorrhage and increased erythrophagocytosis.

Although the hepatic changes in ISA can be striking, especially in advanced cases of disease, findings must be interpreted with caution, as comparable though not identical liver changes have been reported in other pathological conditions, for example, cardiomyopathy syndrome (CMS).

4.2.8 Other diagnostic methods

In principle, a number of other laboratory methods could potentially be used in the detection and diagnosis of ISA. For example, research is being carried out at the FRS MLA into the development of an ELISA for detecting antibody to the virus in Atlantic salmon as an indicator of current or previous infection.

4.3 Use of Diagnostic Methods in Confirmation of ISA
EU Legislation

Council Directive 93/53/EEC defines infected fish as follows:

'infected fish': fish in which the presence of a List I or List II disease has been officially confirmed as the result of a laboratory examination or, in the case of ISA, as the result of a clinical examination and a post-mortem examination'.

OIE Diagnostic Manual for Aquatic Animal Diseases

The OIE Diagnostic Manual states that the following requirements must be fulfilled when making a diagnosis of ISA:

- typical macroscopic findings;
- typical histological findings;
- typical haematological findings.

Guidelines from EU and OIE Reference Laboratories

Advice on diagnostic criteria for confirming the presence of ISA was sought from the EU Community Reference Laboratory for Fish Diseases in Aarhus, Denmark and the OIE Reference Laboratory for ISA in Oslo, Norway.

The EU Community Reference Laboratory recommended the following criteria for confirming the presence of ISA:

- clinical signs and post-mortem examination;
- histopathology;
- viral identification (for example, using IFAT or RT-PCR).

The OIE Reference Laboratory for ISA recommended the following criteria for confirming the presence of ISA:

- macroscopic lesions;
- haematology;
- histopathology;
- virus isolation or IFAT.
Criteria Used for Confirmation of ISA

Taking into account the definition of 'infected fish' according to Directive 93/53/EEC\textsuperscript{45} and guidelines provided by the OIE Diagnostic Manual for Aquatic Animal Diseases,\textsuperscript{52} the EU Community Reference Laboratory for Fish Diseases and the OIE Reference Laboratory for ISA, confirmation of ISA requires all of the following criteria to be satisfied:

- clinical signs;
- macroscopic lesions;
- evidence of anaemia;
- histopathology;
- evidence of the presence of ISAV by virus isolation, IFAT and/or RT-PCR.

4.4 Use of Diagnostic Methods in Designating Suspicion of Infection

Council Directive 93/53/EEC\textsuperscript{45} defines fish suspected of being infected as follows:

'fish suspected of being infected: fish showing clinical signs or post-mortem lesions or dubious reactions in laboratory tests giving rise to reasonable suspicion of the presence of a List I or List II disease'.

This definition may be used directly in deciding if there are reasonable grounds to suspect the presence of ISA. Thus, a farm may be designated as being under suspicion of being infected if fish in that farm show clinical signs, macroscopic lesions or histopathological signs consistent with ISA and/or if results of laboratory tests (virus isolation, IFAT or RT-PCR) are indicative of the presence of ISAV.

4.5 Recommendation

\textit{It is recommended that research is undertaken to optimise existing techniques, and to develop and validate alternative techniques, for detection and diagnosis of ISA.}
CHAPTER 5: COASTAL CATCHMENT ZONE
MANAGEMENT TO AVOID AND MINIMISE
THE EFFECTS OF ISA

5.1 Hydrographically Defined Management Areas for the Scottish Aquaculture Industry

5.1.1 Introduction

As part of its control policy with regard to ISA the Scottish Executive has established both Surveillance Zones and Fallowing Zones around infected farms. Under OIE nomenclature these areas and zones would be referred to as a Surveillance Zone and Infected Zone respectively. The establishment of the Surveillance Zone is a requirement under Directive 93/53/EEC to ensure that farms which are at risk of becoming infected because they share the same coastal waters are subject to proper surveillance and control. The requirement for fallowing is to reduce the risk of reinfection from residual pathogens remaining in the environment following the disinfection and clearance of a farm. The current fallowing periods are: six months for confirmed infected farms and those under suspicion; a three month fallow period for uninfected farms within the Fallowing Zone; and six weeks within the Surveillance Zone. Within the Fallowing Zone fallowing of sites must be synchronous, and therefore the entire Fallowing Zone will be empty for a minimum period of three months commencing as soon as the last farm has been disinfected.

This report takes a wider view than simply addressing the 1998 ISA outbreak, and goes on to consider how the entire Scottish coastline might be subdivided into Management Areas following a logical and described approach based upon simple, yet fundamental, aspects of the oceanographic regimes found in Scottish coastal waters. Much of the discussion which follows is directed at the present situation with ISA, but equally, much of it will be applicable to any future outbreak of a water-borne disease.

5.1.2 Review of disease zone and area definition in other countries

Norway

Nine years after the first outbreak of ISA, the Norwegian authorities introduced the concept of 'Combat Zones' and 'Observational Zones', to help control the disease. In guidelines issued to Regional Veterinary Officers, it was recommended that a 'Combat Zone' should be established around a site confirmed as being ISA positive. The size of this zone should take into account:

- the presence of other neighbouring fish farming activities;
- the flow of traffic between sites in the area;
- the shared use of equipment and shore facilities;
- local topography/oceanography.
No further details of how the local topography and oceanography were used are available. The establishment of a larger 'Observational Zone' was also described by the guidelines, and its size should take into account:

- the epizootiological situation of the outbreak;
- topography/oceanography;
- possible infection contacts between sites within and outwith the 'Combat Zone'.

Other Norwegian studies\(^{55}\) have recommended minimum site-to-site distances of 5 km, and the minimum size of the 'Observational Zone' as a radius of 10 km, although local currents should also be taken into account.\(^{56}\) Both of these recommendations were based on statistical analysis of case control studies of ISA infected farms in Norway.\(^{55,56}\)

**Canada**

A Canadian scientist\(^{57}\) summarised the rationale and size of site-to-site separations with particular reference to the spread of disease between sites in order to define a basis for single area management regions. In a survey of international current practice it was found that minimum site-to-site distances were as described in Table 5.1. For each country it was concluded that these distances were unlikely to be sufficient to create a barrier to the spread of disease.

In order to recommend the division of sites in Passamaquoddy Bay into separate Management Areas, the importance of the tide in this area was recognised, and the size of the tidal excursion throughout the Bay was calculated.\(^{57}\) When examining the possible spread of disease within the Bay, it was recognised that the spread during a single tide did not reflect fully the real dispersion, and so a 45 day period was simulated and the re-distribution of water during that time was examined. Thus, the model reproduced the spread of material constantly being released from each site over many tidal cycles. This resulted in a recommendation of three single area management regions in the Bay.
Table 5.1  International site-to-site minimum distances.\textsuperscript{57}

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum site-to-site distance</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>1 km usual, 3 km if slaughter conducted</td>
<td>Not mandatory</td>
</tr>
<tr>
<td>Scotland</td>
<td>Most 1 km, 3.7 km preferred</td>
<td>Not mandatory — case by case approach</td>
</tr>
<tr>
<td>Ireland</td>
<td>1 km preferred</td>
<td>Not mandatory</td>
</tr>
<tr>
<td>Chile</td>
<td>2.4 km</td>
<td>Mandatory (although not always enforced)</td>
</tr>
<tr>
<td>Canada (BC)</td>
<td>1 km</td>
<td>Not mandatory</td>
</tr>
</tbody>
</table>

5.1.3  Scottish zone and area definitions

The concepts used in the following discussion evolved during the initial stages of the 1998 outbreak of ISA in Scotland. Their development was constrained by the following factors:

- sites were spread throughout Scottish waters, often in complex coastal sea lochs and embayments;
- at most sites no data were available, apart from those which could be extracted from Admiralty Charts and current atlases;
- no time was available for on-site surveys or complex computer modelling studies to be initiated.

In addition to these constraints, relatively little was known about mechanisms of transfer ISAV through passive dispersion.

ISA-Specific Dispersion Studies

While this report proposes Management Areas which are of relevance for the management of many environmental, disease and parasitic aspects of the fish farming industry, initially the concepts were evolved for the control of ISA. Some literature exists which describes the spread of ISAV through passive dispersion in sea water, and a short summary of this follows:

Inactivation and transmission of ISAV in sea water

- Infectivity of ISAV declines within 24 hours in sea water at 10°C. However, the virus may still be infective after 48 hours.
- Norwegian researchers\textsuperscript{41} examined several vectors which might communicate the virus from fish to fish, including sea lice, organic material and within the sea water. The study seemed
to be based on small numbers. However, since ISAV survived for at least 20 hours at 6°C, they came to the rather arbitrary conclusion that the passive spread of the virus through sea water would be 'negligible' because of the 'dilution effect'. As they give no information on shedding rates, reinfection concentrations or dilution rates at any particular site, this statement is unsupportable.

• Other Norwegian researchers studied how the virus might be shed from infected fish through natural secretions and excretions, and how these might survive in sea water. The study did not rigorously examine survival times of the virus outside of the host fish. It did show that the virus was contained within excreted skin mucus, urine and faeces from infected fish, and that these could re-infect healthy fish. The main transmission route was absorption through the skin and gills.

Distances associated with risk of infection

a) A complex case control study was conducted of 37 paired sites in Norway, considering many factors which may have affected the probability that some of these farms were ISA positive. These included such parameters as distance from neighbouring infected sites and distance from slaughterhouses. The only environmental parameter to be considered was the depth of water at the farms. When regressions of probability of infection against distance from neighbouring infected sites and from nearby slaughterhouses were examined, they showed a distinct change of slope at 5 km. There are three points to note about this study:

• the samples selected were from seven counties within Norway; vastly different oceanographic regimes could have been present at each of the sites. The arbitrary choice of distance as the independent parameter limits the usefulness of this study. The study did not take into account local hydrography nor did it express distance in terms of tidal excursion;

• in Norway, most areas experience quite weak tides (less than 1 knot). Hence the 5 km distance is most likely to be greater than one tidal excursion for the test areas;

• while the slope of the probability graphs change at 5 km, outside 5 km the probability that infection occurs does not drop to zero, but remains finite.

The authors suggest that oceanographic studies are needed to understand these results, but do not provide a physical explanation of why 5 km should be significant.

b) In a similar statistical study of infected sites the authors set a limit of 5 km to define near neighbours as 'in the authors' experience ... ISA was rarely transmitted through the sea over a distance greater than 5 km'. No evidence for this is presented, and distances are not used as a statistical parameter. They concluded that passive transmission could carry the ISAV over 5-10 km after 6-12 months, and that sites or Management Areas should be separated by at least 10 km, but these findings were not supported by the results presented.
c) One retrospective study found evidence of ISA being transmitted 5-6 km through sea water after 6-12 months.

**Zone and Area Definitions Used in Scotland**

During the 1998 ISA outbreak, a number of different areas and zones were used when attempting to manage the disease. The term 'zone' was used when describing a prescribed region around a single farm. The term 'area' was used to describe a defined region around several farms.

**Infected Zone**

**Rationale.** This is the region which receives water leaving a farm, transported by the tide alone in the absence of any other long term drift.

**Description.** The region enclosed by a circle, of radius equal to one tidal excursion, centred on the middle of a licensed site. Infected Zones become Fallowing Zones once a farm is suspected or confirmed as infected.

**Surveillance Zone**

**Rationale.** When the Infected Zones of two farms (one infected, one disease free) overlap, there is a risk that material may be transported from one farm site to the other by the tide alone. The transfer mechanism is assumed to be through water, sediment, shore deposition, or intermediate host. Once the next neighbouring farm is at risk, the farm itself must be assumed to be a possible source, and hence any neighbouring farms to that site are also at risk. This 'leap frogging' of disease is possible until a gap exists between farms which is large enough to ensure that adjacent Infected Zones do not overlap. This gap must therefore be larger than two tidal excursions.

**Description.** The region enclosed by all overlapping Infected Zones. The Surveillance Zone becomes active once a single farm within it is confirmed as infected. When no disease is present within a Surveillance Zone it is referred to as a Management Area.

**Fallowing Zone**

**Rationale.** All farms directly receiving water from a farm confirmed or suspected of being infected by the action of the tide alone must be fallowed at the same time as the infected farm.

**Description.** All farms where part or all of their occupied licensed site lies within one tidal excursion of the centre of an infected farm site.
40 km Surveillance Area

**Rationale.** Farms within a region where water may arrive from an infected farm by the action of forces other than the tide over a period of 10 days.

**Description.** On the west coast of Scotland the mean residual drift is estimated as 4 km/day. Hence the 40 km Surveillance Area is defined as all farms within a circle, centred on an infected farm, of radius 40 km.

5.1.4 Review of existing management agreements in Scotland

The aquaculture industry has already recognised the advantages of a single area management regions approach, particularly in relation to the control of sea lice in enclosed areas. Table 5.2 presents a list of all known single area management regions in Scotland.

**Table 5.2 Existing single area management regions in Scotland.**

<table>
<thead>
<tr>
<th>Area</th>
<th>Company involvement</th>
<th>Management Areas code (see Table 5.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loch Torridon</td>
<td>HFF/MHM</td>
<td>11a</td>
</tr>
<tr>
<td>Loch Carron/Kishorn</td>
<td>HFF/SC/HSFGSP</td>
<td>11c</td>
</tr>
<tr>
<td>Loch Sunart</td>
<td>MHM</td>
<td>15b</td>
</tr>
<tr>
<td>North Sound of Raasay</td>
<td>HFF/SMS/RS/OTR</td>
<td>11b</td>
</tr>
<tr>
<td>Loch Seaforth</td>
<td>MHM/Wisco/Stolt</td>
<td>5b</td>
</tr>
<tr>
<td>Arran</td>
<td>MHM</td>
<td>20</td>
</tr>
<tr>
<td>Loch Ewe</td>
<td>MHM</td>
<td>10c</td>
</tr>
<tr>
<td>Loch Greshornish</td>
<td>MHM</td>
<td>12a</td>
</tr>
<tr>
<td>West Loch Roag</td>
<td>MHM/Scaliscro/Wisco</td>
<td>6a</td>
</tr>
<tr>
<td>Sound of Mull</td>
<td>MHM/HSFGSP</td>
<td>15b</td>
</tr>
<tr>
<td>Loch Linnhe, Loch Eil, Loch Creran, Loch Leven</td>
<td>MHM/HSFGSP</td>
<td>15b</td>
</tr>
</tbody>
</table>
5.1.5 Hydrographically defined Management Areas

Underpinning Hydrographic Data

Data of tidal currents around the Scottish coast exist in several formats. Measured values of current speeds and directions through a tidal cycle are indicated at discrete locations on Admiralty Tidal Charts. More detailed tidal stream information exists in the Nautical Almanac, with current speeds around the west and north Scottish coasts shown at various stages of the tide. However, neither of these data sets are entirely suitable nor easily extracted for the purpose of estimating tidal excursions around fish farms. The data on the Admiralty Charts are sparsely located and are often based on minimal measurements. The graphical presentation of the tidal streams in the Almanac makes it difficult to extract tidal amplitudes at the location of each farm.

Hydrographic data are also available in the 'Atlas of the Seas around the British Isles'. The atlas includes a map of the maximum tidal current speed during spring tides for north-west European waters. This map was used to estimate tidal currents throughout Scottish coastal waters. Maximum current speeds vary around the coast, but some examples are shown in Table 5.3.

Table 5.3 Summary of maximum tidal currents in Scottish waters.

<table>
<thead>
<tr>
<th>Area</th>
<th>Maximum spring tide current (knots)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clyde</td>
<td>0-1</td>
</tr>
<tr>
<td>North Channel</td>
<td>3-4</td>
</tr>
<tr>
<td>South Minch</td>
<td>0-1</td>
</tr>
<tr>
<td>Kyle of Lochalsh</td>
<td>2-3</td>
</tr>
<tr>
<td>North Minch</td>
<td>0-1</td>
</tr>
<tr>
<td>Little Minch</td>
<td>1-2</td>
</tr>
<tr>
<td>Cape Wrath</td>
<td>1-2</td>
</tr>
</tbody>
</table>

Method of Management Area Definition

The maximum tidal current map was digitized, providing current speeds at a resolution of approximately 1 km x 1 km around the Scottish coast. An extract of the digitised map corresponding to the coastal waters off the Scottish west coast is shown in Figure 5.1. The maximum spring tide current was equated with the tidal amplitude, from which the tidal excursion is estimated using the equation:

\[ X_T = \frac{UT}{\pi} \]

where: 
\[ X_T = \text{tidal excursion distance (m)} \]
\[ U = \text{tidal current amplitude (m/s)} \]
\[ T = \text{tidal period} \times (12.42 \text{ hrs} \times 3,600 = 44,712 \text{ secs}) \]
\[ \pi = \text{constant} \times (3.1416) \]

The digitised map of tidal amplitudes was matched against the database containing the position of each salmon farm, and for each farm the appropriate value of the tidal current amplitude was selected and added to the database. Since most salmon farms are located in relatively sheltered waters, maximum tidal amplitudes were restricted to 1 knot. The tidal excursion for current speeds of 1.0 knots and 0.5 knots are given in Table 5.4.

**Table 5.4 Tidal excursions for current speeds.**

<table>
<thead>
<tr>
<th>Current speed</th>
<th>Tidal excursion</th>
</tr>
</thead>
<tbody>
<tr>
<td>knots</td>
<td>m/s</td>
</tr>
<tr>
<td>1.0</td>
<td>0.51</td>
</tr>
<tr>
<td>0.5</td>
<td>0.255</td>
</tr>
</tbody>
</table>

Maps of five areas of Scotland (Shetland, Western Isles, Orkney, northern mainland and southern mainland) were then produced. Each map shows the location of every salmon farm in the area, and indicates the tidal excursion around each farm. Management Areas are proposed based on the overlap between tidal excursions. In general, where the tidal excursions of adjacent farms overlap, the farms are assigned to the same Management Area. Where there is a break in the overlap, a new Management Area is created. This method minimises the likelihood of rapid spread of disease, and possibly sea lice, between Management Areas. Some subjectivity is still involved in certain cases, and this is discussed in more detail further on.

*Proposed Management Areas*

The maps of the proposed Management Areas are presented in Figure 5.2a-e. By grouping existing farms together, the proposed areas correspond to the salmon farming industry as it stands at present. Future developments may modify the areas, particularly if sites are allowed to be developed in the gaps separating existing areas or if sites are abandoned. Each Management Area is numbered. Names of the regions covered by each area are given in Table 5.5. The Management Area numbering system is designed to be flexible, to allow the introduction of new areas without unnecessary disruption to the existing system.

In Shetland, the segregation into nine Management Areas with clearly defined boundaries is fairly straightforward. In the Western Isles, there is a slight overlap between areas 5a and 5b, but it was considered to be minimal, and the two areas were partitioned. Similarly, the separations of areas 7a and 7b and 7b and 7c are based on the location of the farms being within lochs rather than directly on the coast.
Segregation into three areas in Orkney is again straightforward. On the mainland, the partition between 9b and 9c is based on the seclusion of sites within sea lochs. The other Management Areas in the northern mainland are fairly clear.

In the southern mainland, area 15b is the largest Management Area, and includes one of the Surveillance Zones associated with the ISA outbreak. The continuum of overlapping tidal excursions is apparent. Note that despite the break in central Loch Linnhe, Upper Loch Linnhe, Loch Leven and Loch Eil should all be considered part of this Management Area. No area 17 exists for reasons which are explained in 5.1.7. The sub-division of areas 18 and 19 is straightforward.

The total number of Management Areas proposed here is 46. The number of farms in each area varies from 1-56.
Figure 5.1  Map of the maximum spring tide current speeds (m s\(^{-1}\)) in the coastal waters of the west of Scotland. The values shown were digitised from MAFF\(^60\) and were used to calculate tidal excursions around the coast.
### Table 5.5 List of Management Areas by Code and Area Name/Description.

<table>
<thead>
<tr>
<th>Management Area code</th>
<th>Area name/description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Whale Firth, W Yell</td>
</tr>
<tr>
<td>1b</td>
<td>E Unst, E Yell, Fetlar</td>
</tr>
<tr>
<td>1c</td>
<td>Out Skerries</td>
</tr>
<tr>
<td>2a</td>
<td>NE Shetland mainland</td>
</tr>
<tr>
<td>2b</td>
<td>SE Shetland mainland</td>
</tr>
<tr>
<td>3a</td>
<td>SW Shetland mainland</td>
</tr>
<tr>
<td>3b</td>
<td>Gruting, Vaila, Walls</td>
</tr>
<tr>
<td>4a</td>
<td>St Magnus Bay</td>
</tr>
<tr>
<td>4b</td>
<td>NE Shetland mainland, Ronas Voe</td>
</tr>
<tr>
<td>5a</td>
<td>E Lewis</td>
</tr>
<tr>
<td>5b</td>
<td>SE Lewis, E Harris</td>
</tr>
<tr>
<td>6a</td>
<td>Loch Roag</td>
</tr>
<tr>
<td>6b</td>
<td>West Loch Tarbert, W Harris</td>
</tr>
<tr>
<td>7a</td>
<td>E North Uist</td>
</tr>
<tr>
<td>7b</td>
<td>Ronay, Benbecula, N South Uist</td>
</tr>
<tr>
<td>7c</td>
<td>E South Uist</td>
</tr>
<tr>
<td>7d</td>
<td>Barra</td>
</tr>
<tr>
<td>8a</td>
<td>Westray</td>
</tr>
<tr>
<td>8b</td>
<td>Central Orkney</td>
</tr>
<tr>
<td>8c</td>
<td>Scapa Flow</td>
</tr>
<tr>
<td>9a</td>
<td>Loch Eriboll</td>
</tr>
<tr>
<td>9b</td>
<td>Inchard, Laxford</td>
</tr>
<tr>
<td>9c</td>
<td>Badcall, Chairn Bhain, Eddrachillis</td>
</tr>
<tr>
<td>10a</td>
<td>Enard Bay</td>
</tr>
<tr>
<td>10b</td>
<td>Broom, Little Loch Broom</td>
</tr>
<tr>
<td>10c</td>
<td>Ewe</td>
</tr>
<tr>
<td>11a</td>
<td>Torridon</td>
</tr>
<tr>
<td>11b</td>
<td>Sound of Raasay, Ainort, Scalpay</td>
</tr>
<tr>
<td>11c</td>
<td>Carron, Kishorn</td>
</tr>
<tr>
<td>Management Area code</td>
<td>Area name/description</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>12a</td>
<td>Snizort</td>
</tr>
<tr>
<td>12b</td>
<td>Dunvegan</td>
</tr>
<tr>
<td>12c</td>
<td>Braehead</td>
</tr>
<tr>
<td>13a</td>
<td>Eishort, Slapin</td>
</tr>
<tr>
<td>14a</td>
<td>Alsh, Duich</td>
</tr>
<tr>
<td>14b</td>
<td>Hourn</td>
</tr>
<tr>
<td>14c</td>
<td>Nevis</td>
</tr>
<tr>
<td>15a</td>
<td>Moidart, Ailort</td>
</tr>
<tr>
<td>15b</td>
<td>Sunart, Sound of Mull, Linnhe, Firth of Lorne</td>
</tr>
<tr>
<td>16a</td>
<td>Tuath, na Keal</td>
</tr>
<tr>
<td>16b</td>
<td>Scridain</td>
</tr>
<tr>
<td>18a</td>
<td>Sound of Jura</td>
</tr>
<tr>
<td>18b</td>
<td>Gigha</td>
</tr>
<tr>
<td>19a</td>
<td>Fyne</td>
</tr>
<tr>
<td>19b</td>
<td>Kyles of Bute</td>
</tr>
<tr>
<td>19c</td>
<td>Cumbray</td>
</tr>
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<td>20</td>
<td>Arran</td>
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</tbody>
</table>
Figure 5.2a Proposed Management Areas for the aquaculture industry in the coastal waters of the Shetland Isles. Registered salmon farm sites are identified (+) and the area around each site with a radius of one tidal excursion is shaded. Labels refer to each Management Area.
Figure 5.2b  Proposed Management Areas for the aquaculture industry in the coastal waters of the Western Isles. Registered salmon farm sites are identified (+) and the area around each site with a radius of one tidal excursion is shaded. Labels refer to each Management Area.
Figure 5.2c  Proposed Management Areas for the aquaculture industry in the coastal waters of the Orkney Islands. Registered salmon farm sites are identified (+) and the area around each site with a radius of one tidal excursion is shaded. Labels refer to each Management Area.
Figure 5.2d  Proposed Management Areas for the aquaculture industry in the coastal waters of the northern mainland. Registered salmon farm sites are identified (+) and the area around each site with a radius of one tidal excursion is shaded. Labels refer to each Management Area.
Figure 5.2e  Proposed Management Areas for the aquaculture industry in the coastal waters of the southern mainland. Registered salmon farm sites are identified (+) and the area around each site with a radius of one tidal excursion is shaded. Labels refer to each Management Area.
5.1.6 Management Area separation distances

The Management Areas in Scottish waters described above have adequate 'fire breaks' or distances between neighbouring farms within adjacent Management Areas. The statistics of these 'fire breaks' are given below:

![Distribution of separation distances between neighbouring Management Areas for the salmon farming industry in Scotland.](image-url)

**Figure 5.3** Distribution of separation distances between neighbouring Management Areas for the salmon farming industry in Scotland.
5.1.7 Comparison with sea lice Management Areas

The division of the industry into Management Areas roughly follows the plan for sea lice Management Areas proposed early in 1998 by the Scottish Salmon Growers Association (SSGA). The numbering system described in the previous section is based on the SSGA plan. The SSGA areas have essentially been sub-divided into smaller areas and given the suffixes a, b, c. In Figure 5.4, the original SSGA Management Areas are superimposed on the areas described above. The numbering in Figure 5.4 denotes the SSGA areas. It is immediately apparent that the 46 Management Areas proposed here fit very well into the 20 larger areas proposed earlier by the SSGA. One significant difference is that the SSGA document defined area 17 as lying between Kerrera and Loch Sween. The northern part of this area lies within the current Surveillance Zone in the Firth of Lorne, and is therefore incorporated into area 15b. There are no farms in the southern half of SSGA area 17 (because Loch Sween itself must be assigned to area 18), and hence, area 17 becomes redundant. SSGA areas 19 and 20 match the Management Areas proposed in this report.
Figure 5.4a  Comparison between the proposed Management Areas (bounded by the solid lines) and the Management Areas established by the Scottish Salmon Growers Association (delimited by the dashed lines) in the Shetland Isles. Labels refer to the SSGA areas. The maps also show the potential effects of shellfish (♦) and registered trout (◊) farms on the transmission of disease by including tidal excursions around those farms (shaded areas) in addition to the registered salmon farms (+).
Figure 5.4b  Comparison between the proposed Management Areas (bounded by the solid lines) and the Management Areas established by the Scottish Salmon Growers Association (delimited by the dashed lines) in the Western Isles. Labels refer to the SSGA areas. The maps also show the potential effects of shellfish (❖) and registered trout (◊) farms on the transmission of disease by including tidal excursions around those farms (shaded areas) in addition to the registered salmon farms (+).
Figure 5.4c  Comparison between the proposed Management Areas (bounded by the solid lines) and the Management Areas established by the Scottish Salmon Growers Association (delimited by the dashed lines) in the Orkney Islands. Labels refer to the SSGA areas. The maps also show the potential effects of shellfish (♦) and registered trout (◊) farms on the transmission of disease by including tidal excursions around those farms (shaded areas) in addition to the registered salmon farms (+).
Figure 5.4d  Comparison between the proposed Management Areas (bounded by the solid lines) and the Management Areas established by the Scottish Salmon Growers Association (delimited by the dashed lines) in the northern mainland. Labels refer to the SSGA areas. The maps also show the potential effects of shellfish (●) and registered trout (◆) farms on the transmission of disease by including tidal excursions around those farms (shaded areas) in addition to the registered salmon farms (+)
Figure 5.4e  Comparison between the proposed Management Areas (bounded by the solid lines) and the Management Areas established by the Scottish Salmon Growers Association (delimited by the dashed lines) in the southern mainland. Labels refer to the SSGA areas. The maps also show the potential effects of shellfish (closed diamonds (◇) and registered trout (◇) farms on the transmission of disease by including tidal excursions around those farms (shaded areas) in addition to the registered salmon farms (+).
5.1.8 Other aquaculture species

It is possible that salmon diseases, such as ISA, may be transmitted via other species. The spread of disease in the salmon farming industry may therefore be exacerbated by the presence of other farmed species, in particular shellfish and trout.

Figure 5.4 shows the locations of existing shellfish and trout farms in Scottish coastal waters. The procedure for assigning a tidal excursion to each site followed the same method used for salmon farms (5.2). The tidal excursions around the shellfish and trout farms were included in the maps to examine the effect on the Management Areas proposed above.

Shellfish

Shellfish farms are denoted in the maps by closed diamonds (♦). In Shetland, the Western Isles and Orkney, the inclusion of shellfish farms makes a negligible difference to the proposed Management Areas. On the northern mainland, the farms make no difference to areas 9 and 10. However, the presence of a significant number of shellfish producers between Skye and the mainland confuse the partitioning between areas 11b-c and 14a-c. If shellfish act as a transmission route, disease transfer around this area is not likely to be prevented by the proposed Management Areas.

In the southern mainland, shellfish farms could cause the conglomerination of Management Areas 15b and 18. Therefore, there could be a disease transfer risk from Gigha to Ardnamurchan. Shellfish farms also merge the three sub-divisions of area 19 into one.

In summary, existing shellfish farms could have a potential effect on the risk of disease transfer around the Inner Sound and Sound of Sleat, from Ardnamurchan to Gigha and in the northern Clyde, that would not be eradicated by the proposed Management Areas. However, there is no evidence to date that shellfish pose a significant risk of transmission of ISA.

Trout

Trout farms are indicated on the maps by open diamonds (◊). They are much less numerous than shellfish farms and no significant changes to the Management Area overlaps are caused by existing trout farms.

5.1.9 Refinement of proposed Management Areas

The proposed Management Areas presented in this report must still be reviewed on a case by case basis in order to take into account occupancy of registered farm sites, local knowledge of tides, on-site data and specific circumstances such as enclosed bodies of water or restricted channels and sounds. The maps have been prepared with very coarse coastlines, and there has been a simple approach to tidal amplitudes as described in sub section 5.1.5. If, and before, these areas were to be adopted in any statutory or mandatory role, they should be thoroughly reviewed by a joint industry/Government working group. In the case of disputed areas, more in-depth studies, involving modelling and field measurements, should be undertaken.
5.1.10 Recommendation

The hydrographically defined Infected Zones, Surveillance Zones, Management Areas, Fallowing Zones and 40 km Surveillance Areas are based on simple yet fundamental, aspects of the oceanographic conditions found in Scottish waters. They are able to take into account specific local conditions, and can also be applied widely to the entire Scottish industry. They should be adopted as the basis for dealing with outbreaks of any water-borne disease, as well as forming the basis for a sustainable and planned approach to managing the industry in future. However, they must first be scrutinised on a case by case basis to take into account local conditions and the planned occupancy of farms.

5.2 Fallowing and Rotation

5.2.1 Rationale for fallowing

Fallowing of salmon farm sites was first introduced in Scotland in the late 1970s in order to break the cycle of disease caused by the furunculosis bacterium, *Aeromonas salmonicida*. Studies by industry scientists suggested that removal of all fish from a farm followed by disinfection of equipment eliminated the main source of infection. After a fallow period of some weeks, disease free smolts could be introduced and grown through to harvest without a recurrence of furunculosis. This practice has been in place for many years and the length of the fallow period has varied, but is now generally around 4-6 weeks. Fallowing for bacterial disease also gives some relief from sea louse infestations.

Fallowing can provide an environmental benefit by reversing the progressive accumulation of material in the local environment (sediment, water or biotic components) around active fish farms. In the context of salmon farming, this material may include nutrients (for example, from ammonia), faeces, un-eaten food, anti-foulants and the residues of veterinary medicines.

The main uses of fallowing in the salmon farming industry are therefore as a disease control measure and as a mechanism to allow the environment to recover.

Fallowing Method to Break a Cycle of Disease

This requires farming single year class sites in such a way that there is a break at the end of each production cycle. In this case the fallow period is relatively short and is up to a maximum of three months. Traditionally this fallow period would have occurred in late winter/early spring, but with the availability of S½ smolts, this period can now occur at different times of the year. Continuously stocked multi-generation sites do not provide an opportunity to fallow.
Fallowing Method to Allow the Environment to Recover

This uses ‘site rotation’ whereby a minimum of three sites are used alternately to crop fish to maintain a continuous annual harvest. The fallowing periods in this case are relatively long and can be from 3 to 24 months.

5.2.2 Technical evidence for the effectiveness of fallowing

It has become apparent that when fish farm sites first begin production, the performance and health of the stocks is usually good, but may deteriorate progressively with time as sites age or become ‘tired’. It is a generally accepted dogma that the introduction of even a short fallow period on a farm site can rejuvenate a site and return it towards 'new' status. The benefits of fallowing are based upon the following evidence.

Expert Views on Perceived Benefits

One report has described the results of interviews with experts from both the regulator and industry on the benefits of year class separation, fallowing and separation distances for farms in Canada, Norway, Ireland and Scotland. It was determined that there was a fair degree of unanimity in the belief that a fallow period was effective in breaking disease cycles and that this was largely achieved as a consequence of eliminating the host biomass for a significant period with a resultant decrease in infection pressure. In Norway there was also a belief that reducing the pathogen burden in sediment underneath cages was an important additional factor in the fallowing process.

Effects of Fallowing on Disease

Epizootiological studies have shown that in Ireland there was a reduction in mortality attributed to vibriosis and pancreas disease in farms which fallowed compared with those which did not. Total year class mortality was 19.6% in fallowed farms compared with 30.1% in farms which did not fallow. This study also showed that farms rearing only one generation of fish had lower mortality and this was attributed to a break in the cycle of disease at the end of the growing cycle. Interestingly, the study showed that the length of time during which a farm was occupied was not a significant risk factor in survival. A case control study on furunculosis and infectious pancreatic necrosis (IPN) in Norway found that new sites, less than one year old, were at greater risk than farms established for more than one year. At first sight this would appear to argue against a beneficial effect of fallowing, but the authors argued that this was caused by confounding effects such as problems in the management of new sites.

Studies conducted over a 20-month period on four marine Atlantic salmon farms in Scotland showed the beneficial effects of fallowing on infections of Lepeophtheirus salmonis on newly introduced fish. Industry scientists have published an account of the use of fallowing to control sea lice infection at two sites in Scotland. The study demonstrated that stocking a farm already containing infected fish resulted in rapid infection of new fish, whereas in the subsequent year, after a fallow period the build up of infection was much slower.
The foregoing has considered the benefits of fallowing individual farms. However, there is also strong evidence for interactions between farms sharing the same coastal waters and greater benefits arising from disease control (by treatment or fallowing) when applied in an integrated way over wider areas. Control of sea lice is markedly improved if fallowing is carried out simultaneously on all farms in the sea loch, and in Ireland similar results have also been demonstrated by the application of synchronised treatments triggered by the results of a co-ordinated sea lice monitoring programme. In Scotland studies by industry scientists have shown the benefits of strategic spring sea lice treatments and this is the basis of the sea lice strategy established by the SSGA which advocates management agreements with coordinated lice treatments. The same is likely to be true of other diseases although there is little evidence of this. However, it is known that the proximity of farms infected with furunculosis or ISA increases the risks of disease outbreaks on adjacent farms. There is much evidence for the survival of pathogens in water and sediment for considerable periods of time, for example, up to 230 days for IPN, and modelling work indicates that pathogens such as A. salmonicida can rapidly spread through sea lochs to such an extent that all other farms established in the loch would be at risk.

There is also evidence that other vectors are important in the transmission of disease between farms. Wild fish are a likely source of infection since it is known that pathogens transmit from farmed to wild fish (for example, IPNV) and that wild fish can act as a reservoir of pathogens in the environment for example, IPNV and are potential carriers, for example of ISAV. Sea lice have also been shown to have the potential to transmit disease (for example, ISA) and in one epizootiological study the frequency of lice treatments on farms with furunculosis was twice that on farms without the disease indicating a potential role of lice as a risk factor. Although it is clear that one of the major mechanisms by which fallowing breaks the cycle of disease is by reducing the biomass of the host on the farm, a significant factor in the length of the fallow period required will be survival of the infectious agent and the dispersion of other wild hosts or carriers in the environment to insignificant levels.

**Benthic Recovery**

It is well established that the sediment underneath cage sites acts as a depository for solid organic wastes (for example, faeces and uneaten food) and in some cases residues of veterinary medicines used in disease control. The determination of appropriate fallowing and rotation periods has been hindered by the lack of scientific information on the recovery rates of sediment. Recent studies of benthic communities in Scotland, and the physico-chemical properties of the sediment have shown that recovery is quicker at high energy compared to low energy sites, and is slower at higher impact sites. Generally this study showed that recovery required from 20 to 24 months, although low impact sites recover in less than six months.
5.2.3 Review of current practice

Norway

New regulations\textsuperscript{81} (December 1998) specify that all farms shall be emptied regularly and lie fallow and that fallowing will become mandatory. Generally fallowing periods are required to be long enough so that benthic recovery is possible and therefore the period will be variable depending on the site characteristics. There is a desire for all farms to have more than one site to enable rotation of sites rather than 'between production cycle' fallowing arrangements. Figures obtained in a recent fact finding visit to Norway revealed that in 1998, of some 2,500 licensed sites only some 1,500-1,770 made were in operation at that time. In the case of a disease outbreak be special fallowing arrangements may be put in place, whereby several farming operations may be emptied and lie fallow under a co-ordinated plan. In the case of ISA, a combat zone is established whereby infected farms are fallowed for six months and the whole of the zone should be fallowed for at least one month.

Ireland

Site fallowing is voluntary and strongly recommended by the authorities. Three months is the recommended period.

Chile

Fallowing is carried out by a proportion of farms and is not mandatory. A period of one month is recommended by the authorities.

Canada (British Columbia)

Fallowing is not mandatory, but is widely practised. The authorities believe that for the full benefits to be realised, a rotation system is required with farms lying empty for one whole growth cycle (12-15 months).

Scotland

Fallowing is practised widely and is recommended by the Scottish Executive on health grounds. The annual fish farm survey for 1998\textsuperscript{86} showed that of 343 salmon production sites, 118 did not fallow and the remainder fallowed for variable periods (Fig. 5.5). This pattern did not differ substantially from results for the previous four years. Most salmon freshwater smolt production sites typically fallow every year for several months as a normal part of their production cycle. Rainbow trout farms in fresh or sea water typically do not fallow as they introduce new stocks on a regular basis before existing stocks are harvested. On occasions falling can be mandatory when it is specified on statutory disease control grounds or as part of a discharge consent.
5.3 Management Agreements

The expansion of the salmon farming industry in the 1980s meant that new farms were established in proximity to their neighbours and thus shared the same health problems. In time, farmers recognised the benefits of synchronising year classes with their neighbours and the concept of 'management agreements' was developed. Eleven of these, involving 10 different companies are already in place in Scotland and their use is highly recommended for the future.

5.3.1 Movements between and within biological areas

Chapter 3 of this report addresses the risks associated with seawater-to-seawater fish movements and this should be referenced when considering movements between and within zones encompassed by management agreements.

Figure 5.5  Fallowing period for seacage sites rearing Atlantic salmon in 1997 in Scotland.
5.3.2 How to set up area management agreements

The hydrographically defined Management Areas for the Scottish aquaculture industry have been defined in 5.1 and should be used as the basis for determining the biological areas subject to any management agreement. It is recommended that farmers within these areas should co-operate in drawing up their own tailored area management agreements (AMA). It should be noted that within each area there may be opportunities to create sub-management areas and, conversely, two or more areas may wish to join under one AMA. An example of an established AMA is shown in Box 5.1 a and b.

The essential elements of an AMA are as follows:

- agreement on the participants;
- clear statements on the objectives;
- definition of the area and the farms included;
- agreement on the following specific issues:
  
  **Single Year Class Fish**

  Modern farming techniques mean that smolts can be transferred to sea water in virtually any month of the year and it is therefore important to define what is meant by a 'single year class'. Figure 5.6 shows how the various combinations of $S^{1/2}$ and $S^1$ inputs should be managed so as to ensure a fallow period within a reasonable space of time. Subsequent stocking of $S^{1/2}$ and of $S^1$s or *vice versa* is possible under these regimes.

  **Fallowing and Re-Stocking Dates**

  Dates should be agreed between all parties and should be obligatory.

  **Health Status of New Smolts**

  There should be agreement on the quality of the smolts to be stocked into a Management Area which may include: physiological status of smolts; use of vaccines; and tests for specific pathogens.

  **Good Husbandry Practices**

  These will be agreed by the participants, but will include: adherence to stocking density limits; stock inspection; daily dead fish removal; veterinary input; proper disposal of dead fish (by ensiling in the first instance); net changing regimes; general hygiene and site cleanliness.

  **Exchange of Information**
Information exchange may include: veterinary reports; mortality rates; timing and types of medicines used; and mutual inspections for assurance purposes.

5.3.3 Tailoring an area management agreement

In drawing up an AMA farmers may find that their situation does not fit easily into the template and they will require a tailored management agreement. Some examples are shown below:

• to enable synchrony, farmers may agree to grow each others’ fish;

• in the absence of notifiable diseases farmers may choose to use a shorter fallow period of 4-6 weeks;

• in a case where a farm cannot fit into the required regime, it may have to close and efforts made to mitigate the loss.
### Box 5.1a
Example of a management agreement

**MANAGEMENT AGREEMENT FOR SOUND OF MULL (SOUTH)/SPELVE (PRODUCTION AREA 2 ON ATTACHED MAP)**

1. **Participants:**
   - Marine Harvest McConnell
   - Hydro Seafood GSP

2. **Objective:** To define operating practices which will minimise the risk of disease on all farms included in the agreement

3. **Farms**

   3.1 **MHM:** Scallastle
   3.2 **HSFGSP:** Spelve, Fishnish A & B, Fiunary

4. **Terms of the agreement**

   4.1 The participants shall agree and specify fallow and restocking dates in farms as in 3 above

   4.2 All farms in 3.1 and 3.2 shall be fallowed to allow restocking with PPLs/ SOs from 1 October 1999. All farms shall be fallowed by 15 August 2001

   4.3 No farms shall be stocked outwith the specified dates nor shall any new farms commence operation without the prior agreement of the other participant

   4.4 All smolts destined for the farms shall be immunised in fresh water with an oil-based vaccine including a furunculosis component

   4.5 Farms will operate in accordance with accepted best husbandry practice. It is the intention of both parties to introduce on all farms methods for daily removal of mortalities

   4.6 Mortalities from all farms will be dealt with in such a way as to minimise the risk of transmission of infectious agents

   4.7 Participants shall abide by current codes of practice issued by the Scottish Salmon Growers Association (SSGA)

   4.8 Sea lice burdens shall be monitored to an agreed standard and control will be coordinated

   4.9 Bath treatments shall be carried out using full enclosure
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<tr>
<td>4.10</td>
<td>Lice shall be screened at an agreed frequency for sensitivity to medicines</td>
</tr>
<tr>
<td>4.11</td>
<td>There shall be regular exchange of information regarding fish health and other relevant issues at an agreed frequency</td>
</tr>
<tr>
<td>4.12</td>
<td>There shall be no discharge of harvest blood water</td>
</tr>
<tr>
<td>4.13</td>
<td>There will be freedom of inspection of farms by approved staff with a reasonable period of notice</td>
</tr>
<tr>
<td>4.14</td>
<td>The agreement shall be reviewed annually but may be amended at any time by mutual consent</td>
</tr>
<tr>
<td>4.15</td>
<td>Any of the above may be over-ridden by demands of legislation. In this event the terms of the agreement shall be reviewed immediately</td>
</tr>
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</table>

Signed for and on behalf of:

<p>| | |</p>
<table>
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<tr>
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<tbody>
<tr>
<td>Marine Harvest McConnell</td>
<td>Hydro Seafoods GSP</td>
</tr>
<tr>
<td>Graeme Dear</td>
<td>David Rackham</td>
</tr>
<tr>
<td>Production Director</td>
<td>Director, Scotland</td>
</tr>
<tr>
<td>Date:</td>
<td>Date:</td>
</tr>
</tbody>
</table>
Map reproduced courtesy of Marine Harvest McConnell and Hydro Seafoods GSP.
Figure 5.6 Fallowing strategies on salmon farms with different stocking regimes.
6.1 Introduction

This Chapter is based on the FRS Marine Laboratory Aberdeen. *Disinfection Guide with regard to the ISA Virus: Version II.* The guide should be regarded as best practice at fish farm sites and processing plants. It is intended for distribution to relevant industry personnel. The disinfection procedures described have been developed based on current scientific knowledge and practical experience.

Discharge of disinfectants to the environment is controlled under the Food and Environment Protection Act 1985 Part II Deposits in the Sea (as amended) (FEPA) and The Control of Pollution Act 1974 (COPA) as amended by the Water Act 1989 and the Environment Act 1995. Control Of Pollution Act discharge consent is issued and must be obtained for discharges made during activities such as net and cage disinfection at both cage sites and shore bases and for effluent disinfection at processing plants. A list of SEPA addresses is given in Appendix I.

Epizootiological evidence to date suggests that the risk of ISA transfer is reduced by the implementation of good sanitary practices by fish farmers and the application of effluent disinfection systems in the processing industry. Basic equipment must include footbaths and brushes, detergent and disinfectant sprays. Large vessels, such as wellboats, must carry an adequate supply of detergent and disinfectants onboard. Staff should be aware of the dangers associated with the use of chemicals and seek guidance from management on their use.

6.2 Disinfectants Effective Against ISA

Sodium hypochlorite is an effective disinfectant against ISA. In common with many methods of disinfection, the effectiveness of sodium hypochlorite is markedly reduced by organic material. The concentration required is therefore dependant on the amount of organic material present. Generally, 100-1,000 mg/l in fresh water for a minimum of 30 minutes is adequate to inactivate ISA. It is essential that all equipment is cleaned thoroughly before being disinfected. Sodium hypochlorite is commonly supplied as a solution containing 14% (wt/vol) available chlorine. To obtain a 1,000 mg/l solution, make 1 litre of sodium hypochlorite up to 140 litres with fresh water.

Other effective disinfectants include:

- iodophor (100-200 mg/l for five minutes);
- formaldehyde (0.5% for 16 hours);
- formic acid (pH less than 3.9 for 24 hours);

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\(^{†}\)In soft water
sodium hydroxide (pH greater than 12 for 7 hours);
• heat (greater than 55°C for longer than 5 minutes);
• ozone (8 mg/l/min for 4 minutes - corresponding to a Redox potential of 600-750 mV);
• UV irradiation (120 mJ/cm² recommended for processing plant effluent).

The Scottish Environment Protection Agency (SEPA) maintains a presumption against the authorisation of the discharge of chlorinated effluents regardless of source. This was set aside at the onset of the outbreak of ISA to allow fish farmers and processors to implement effective disinfection procedures rapidly. However, SEPA will be obliged to reinstate this presumption and the use of sodium hypochlorite (and other active chlorine compounds where there is a risk of the formation of organochlorine compounds) will require to be phased out. At present there are insufficient data on the efficacy of more acceptable alternatives and this requires to be addressed as a matter of some urgency.

Compounds recommended for further investigation under a range of conditions include:
• chloramine T;
• glutaraldehyde;
• iodophor;
• chlorine dioxide;
• peracetic acid.

As a first step, it is recommended that a review is carried out of existing data on their virucidal activity.

6.3 Disinfection Procedures

6.3.1 Wellboats, fish farm vessels and ancillary equipment

The following procedure is recommended for cleaning and disinfection of well-boats, fish farm vessels, helicopter buckets, killing tables and most other fish farm equipment:

Step 1 remove all gross fouling and organic matter by scraping and brushing;

Step 2 clean using a detergent solution to remove particulate matter, fats and oils, which are likely to bind to ISAV. (Hot water may give optimum performance but check detergent manufacturer’s instructions);
Step 3  

disinfect with iodophor or other suitable disinfectant.

Steps 2 and 3 may be combined as one step if a foaming detergent solution containing hypochlorite (minimum 100 mg/l hypochlorite) is used as a disinfectant.

**Note:** On wellboats, a disinfection checklist (Appendix II) must be kept with the ship’s log. The skipper is responsible for overseeing all procedures and must sign the checklist on completion. Guidelines on the disinfection requirements for wellboats in different operational circumstances are given in 3.4 of this report.

- Wellboats and fish farm vessels operating between sites of equal ISA risk status, eg two non-suspect sites within a Surveillance Zone or two sites within a 40 km Surveillance Area, are required to disinfect the surface structure and hull of the vessel, down to and including the waterline, between sites.

- Vessels which have been operating at ISA-confirmed or -suspect sites must be slipped to disinfect the hull below the waterline before operating at sites of lower ISA risk status. While travelling to a slip, the vessel must be routed to minimise contact with any fish farm site.

Anyone unsure of the disinfection requirements for a specific operation should contact FRS MLA for advice. In ISA Surveillance Zones, approval must be obtained from FRS MLA for the movement to or from a site of all items of equipment liable to transmit infection. The form given in Appendix III may be used for applications seeking approval to move equipment.

### 6.3.2 Pallets

Wooden pallets in use at ISA-confirmed or -suspect sites must not be recirculated to other sites as the absorbent nature of wood means it is difficult to ensure successful disinfection. Pallets from ISA-confirmed or -suspect sites must be labelled for future identification. Pallets returned to the distribution or holding yard from ISA-confirmed or -suspect sites, together with those which may have been contaminated in transit, must be kept in a designated ‘dirty’ area for disposal. Plastic pallets should be disinfected according to the procedures described in 6.3.1.

### 6.3.3 Nets

If nets from a site in an ISA Surveillance Zone are to be removed from the site before disinfection they must be transported in sealed containers. The nets must be immersed in sodium hypochlorite solution at a concentration of 1,000 mg/l for 6 hours, then rinsed with fresh water. The sodium hypochlorite solution must be agitated to ensure an even concentration of hypochlorite. Alternatively, the nets can be heat treated by immersion in hot water so that the entire net is subjected to a temperature of more than 55°C for at least 5 minutes. Nets may be destroyed by incineration, disposed of in an approved landfill site or buried.
If nets are very heavily fouled the sodium hypochlorite concentration should be increased to ensure the presence of at least 5 mg/l active free chlorine after 6 hours. Free chlorine concentration can be measured using commercially available kits.

**Note**

- Iodine based disinfectants are not suitable for use on nets treated with copper based compounds. Iodine will render the antifoulant process ineffective.

- Heat treatment of nylon nets above 71°C significantly affects their breaking strain.

### 6.3.4 Cages and moorings

The requirements for disinfection of cages are dependent on how the cages are to be deployed after the fish have been removed ie whether they are to be moved to another site or reused on the original site after the fallow period. The requirements are given in Table 6.1.

#### Table 6.1 Disinfection requirements for cages and moorings.

<table>
<thead>
<tr>
<th>Site type/location</th>
<th>Cages to be used on another site (Level 1 disinfection)</th>
<th>Cages to be reused at same site (Level 2 disinfection)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISA confirmed/ suspect</td>
<td>All removable items, including nets, must be disinfected by an approved method. Cages, barges etc must be scraped clean, using divers if necessary, and fully disinfected by an approved method. The cages can be moved to shore for disinfection or wrapped in a tarpaulin at sea (discharge consent required).</td>
<td>Level 1 disinfection is recommended. Otherwise, as Level 1 except no requirement to remove cages for fill disinfection. The cages may be left to fallow <em>in situ</em> for the required fallow period.</td>
</tr>
<tr>
<td>Fallowing Zone</td>
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<tr>
<td>Surveillance Zone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elsewhere</td>
<td>A fallow period is not compulsory for sites in this area, thus, site disinfection is not mandatory. However, a six week fallow period following site disinfection is recommended.</td>
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</tbody>
</table>

Sub-surface moorings can be considered as part of the seabed and as such they can be fallowed *in situ*. If moorings from a site within a designated ISA Surveillance Zone are required for use on another site, and the appropriate fallowing period has not been observed, they must be disinfected prior to transfer. Metal chains, etc must be disinfected as described in 6.3.5, while ropes must be disinfected as described in 6.3.3.
6.3.5 Divers and diving gear

ISA and other diseases can be transmitted via equipment or personnel who come into contact with infected fish during working practices. It is essential that strict hygiene procedures are followed on a daily basis. It is recommended that staff and visitors, including divers, should use the protective clothing supplied at sites within designated ISA Surveillance Zones. Divers removing dead fish from an infected site before diving on an unaffected site, without first thoroughly disinfecting their equipment, pose a serious threat of disease transmission. Fish farm companies and diving companies should consider allowing for site specific gear. Dirty and disinfected suits and associated equipment must be kept separate at all times.

Diving suits and equipment must be treated as follows:

Step 1 remove organic debris;

Step 2 immerse in fresh water containing iodophor (minimum 100 mg/l free iodine) for 20 minutes or heat treat by immersing equipment in clean fresh water so that the gear is maintained at a temperature higher than 55°C for at least 5 minutes;

Step 3 rinse thoroughly with clean fresh water.

6.3.6 Harvesting

All fish farm sites with a Designated Area Order (DAO) or other Control Regulations in place for ISA must obtain approval from the FRS MLA prior to harvesting. The form given in Appendix IV may be used for such applications. The slaughter of salmon is particularly hazardous with regard to the spread of ISA because of the risk of transmission of the disease via fish blood. Full containment of blood is recommended at all on-site slaughtering operations and is mandatory at sites within ISA Surveillance Zones. If necessary, tarpaulins should be placed underneath killing tables and any spillage collected and disinfected using sodium hypochlorite (1,000 mg/l for 30 minutes). Care must be taken to ensure that there are no escapes, and morts must be disposed of as high risk waste. Fish showing clinical signs of disease cannot be marketed for human consumption and should be disposed of as high risk waste.

Harvest bins must be leakproof, lined with polythene bags and have well fitting lids strapped on tightly. The bins must not be over filled to prevent spillage of blood in transit. Leaking bins or bins with broken straps or poorly fitting lids must not be used. All bins should be labelled for identification purposes and disinfected as described in 6.3.1 between sites. Separate bins should be used in ISA Surveillance Zones.

Vehicles used to transport harvest bins should be fitted with a drainage pipe and sump to collect any spillage. In the event of spillage the lorry bed and sump must be disinfected. Lorries must carry disinfectant and drivers must be trained in the use of the equipment and chemicals to be applied on leaving a site and in the event of spillage in transit. Contingency plans should be in place to deal with a major spillage or loss of a harvest bin in transit.
6.3.7 Processing plants and ensiling

Fish blood and viscera are particularly infectious, therefore, strict hygiene practices must be maintained during the processing of fish, and staff must be trained in observing recommended procedures. In addition, staff must be trained to recognise clinical signs of disease as diseased fish cannot be placed on the market for human consumption.

Disinfectant foot baths and brushes must be used on entering and leaving a facility. Suitable notices must be in place at entrances restricting access and at disinfection points compelling the use of foot baths. The concentration of disinfectant should be checked and logged at least once a day and maintained at an effective level. Protective clothing should be regularly cleaned and disinfected, at least at the end of each shift, and kept on site. Plant managers may find the checklist in Appendix V useful.

ISAV is inactivated by the process of ensiling. Mortalities and viscera may be ensiled by a process of blending the fish to a liquefied state, then mixed with formic acid. Full ensiling requires a minimum of 24 hours at pH less than 3.9. Logs recording pH measurements must be kept and be available for inspection by FRS MLA. Although ensiling inactivates ISAV, this process does not inactivate all fish viruses. For example, infectious pancreatic necrosis virus (IPNV) is not inactivated at low pH. Consequently, ensiled waste must still be treated as high risk waste.

All equipment associated with the delivery of harvested salmon, morts and fish waste including lorries, tubs, lids, barrels, tote bags, skips and covers must be thoroughly cleaned and disinfected as described in 6.3.1. Washing and disinfection must be carried out within a designated area, ensuring that all waste is collected and disinfected before disposal. All waste water should flow into a suitable effluent drainage system in which it can be disinfected prior to discharge. This is mandatory for plants processing fish from ISA Surveillance Zones.

All effluent and blood water associated with fish processing should be contained and passed through an approved disinfection procedure. This is mandatory for processing of fish from ISA Surveillance Zones. Approved treatments for disinfecting blood water include sodium hypochlorite, ozone and UV. All of these treatments are rendered less effective by particulate or organic material, and it is important to remove as much of this as possible, for example, by filtration.

Sodium hypochlorite must be added to ensure a residual chlorine concentration of at least 5 mg/l for more than 30 minutes. Generally, an initial concentration of 1,000 mg/l (wt/vol) sodium hypochlorite is sufficient. If the effluent treatment system includes a bacteriological digestion system, the required concentration of hypochlorite will be reduced. Sodium hypochlorite may be neutralised with sodium thiosulphate prior to discharge but care must be taken to ensure adequate mixing. Treated water must be disposed of through a SEPA-approved location.

Ozone and UV treatment are only effective if particulate matter, including red blood cells, is removed prior to disinfection. This can be achieved, for example, by a bacteriological treatment plant or a filter capable of removing particles down to 7 µm in size. The sludge must be treated as high risk waste and ensiled by mixing with formic acid to a pH of less than 3.9 for 24 hours. Ozone must be added to give a minimum of 8 mg/l/min (equivalent to a Redox potential of 600-750 mV).
If UV is to be used there must be a logging system to monitor the dose (minimum 120 mJ/cm²) and a back-up method must be in place in the event of failure of the disinfection system.

The movement of waste must be accompanied either by a waste transfer note, or consignment note if it is high risk waste (available from SEPA). The material must be disposed of at a waste management facility which is licensed to handle high risk waste.

6.3.8 Disinfection of ova

The following procedures are recommend to minimise the risk of transmission of fish pathogens from parent to progeny on egg surfaces.

a) Contamination of gametes with urine, faeces and blood should be avoided during stripping.

b) Disinfection of pre-hardened eggs should take place as soon after fertilisation as possible, using buffered iodophor† volume for volume in 0.9% isotonic saline solution to give a free iodine concentration of 100 ppm for 10 minutes. Thorough rinsing of disinfected, fertilised eggs should be carried out using clean isotonic saline followed by fresh water.

c) Disinfection of eyed eggs should be carried out using iodophor solution to give a free iodine concentration of 100 ppm, prior to hatch or movement to another water supply.

†In line with phasing out the use of endocrine disrupting chemicals, proprietary iodophor disinfectants should be alkyl phenol ethoxylate free.
APPENDIX I

SEPA contact addresses for further information —

North Region

North Region HQ, Graesser House, Fodderty Way, Dingwall, IV15 9XB
Tel: 01349 862021; Fax: 01349 863987.

Fort William Area Office, Carr's Corner, Lochybridge, Fort William, PH33 6TQ
Tel: 01397 704426; Fax: 01397 705404.

Thurso Area Office, Thurso Business Park, Thurso, Caithness, KW14 7XW
Tel: 01847 894422; Fax: 01847 893365

Western Isles Area Office, 2 James Square, James Street, Stornoway
Isle of Lewis, HS1 2QN
Tel: 01851 706477; Fax: 01851 703510.

Orkney Area Office, 58A Junction Road, Kirkwall, Orkney, KW15 1AG
Tel: 01856 871080; Fax: 01856 871090

Shetland Area Office, The Esplanade, Lerwick, ZE1 0LL
Tel: 01595 696926; Fax: 01595 696946

West Region

West Region HQ, 5 Redwood Crescent, Peel Park, East Kilbride, G74 5PP
Tel: 01355 574200; Fax: 01355 264323

Argyll and Bute Area Office, 2 Smithy Lane, Lochgilphead, Argyll, PA31 8TA
Tel: 01546 602876; Fax: 01546 602337
## APPENDIX II

### Checklist for Cleaning and Disinfection of Wellboats

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<thead>
<tr>
<th>Cleaning</th>
<th>Tick</th>
<th>Disinfection</th>
<th>Tick</th>
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</thead>
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<tr>
<td>Hull below waterline</td>
<td></td>
<td>Hull below waterline</td>
<td></td>
</tr>
<tr>
<td>Hull above waterline</td>
<td></td>
<td>Hull above waterline</td>
<td></td>
</tr>
<tr>
<td>Wells</td>
<td></td>
<td>Wells</td>
<td></td>
</tr>
<tr>
<td>Grid plates</td>
<td></td>
<td>Grid plates</td>
<td></td>
</tr>
<tr>
<td>Pumps (including vacuum pump)</td>
<td></td>
<td>Pumps (including vacuum pump)</td>
<td></td>
</tr>
<tr>
<td>Bilge pumps</td>
<td></td>
<td>Bilge pumps</td>
<td></td>
</tr>
<tr>
<td>Sea valves</td>
<td></td>
<td>Sea valves</td>
<td></td>
</tr>
<tr>
<td>Deck</td>
<td></td>
<td>Deck</td>
<td></td>
</tr>
<tr>
<td>Railings</td>
<td></td>
<td>Railings</td>
<td></td>
</tr>
<tr>
<td>Bulkhead/casings</td>
<td></td>
<td>Bulkhead/casings</td>
<td></td>
</tr>
<tr>
<td>Hatches and covers</td>
<td></td>
<td>Hatches and covers</td>
<td></td>
</tr>
<tr>
<td>Derrick</td>
<td></td>
<td>Derrick</td>
<td></td>
</tr>
<tr>
<td>Crane</td>
<td></td>
<td>Crane</td>
<td></td>
</tr>
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<td>Ladders</td>
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<tr>
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</tr>
<tr>
<td>Other equipment (specify)</td>
<td></td>
<td>Other equipment (specify)</td>
<td></td>
</tr>
<tr>
<td>Water temperature used</td>
<td></td>
<td>Disinfectant used</td>
<td></td>
</tr>
<tr>
<td>Detergent used</td>
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<td>Disinfectant</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>concentration</td>
<td></td>
</tr>
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</table>

I, .................................................................................................................. skipper of the .................................................................................................................. have overseen the Cleaning and Disinfection procedures outlined in FRS Marine Laboratory Aberdeen. *Disinfection Guide with regard to the ISA Virus: Version II.*

Signed .......................................................... (Skipper) .......................................................... (Witness)

Date .......................................................... Date ..........................................................
### APPENDIX III

**Application for Approval to Move Equipment**

This form may be copied and used when making an application for approval to move equipment to or from an ISA suspect or confirmed fish farm site. Fill in the details required and fax or post to FRS Marine Laboratory.

**To:** The Duty Inspector, FRS Marine Laboratory, PO Box 101, Victoria Road, Aberdeen, AB11 9DB

**Fax no:** 01224 295620

<table>
<thead>
<tr>
<th>Ref no:</th>
<th>Inspector:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Site name:</th>
<th>Site no: FS/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business name:</td>
<td></td>
</tr>
<tr>
<td>Contact name:</td>
<td>Tel:</td>
</tr>
<tr>
<td>Contact address:</td>
<td>Fax:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment source:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment destination:</td>
</tr>
<tr>
<td>Proposed date of movement:</td>
</tr>
<tr>
<td>Equipment to be moved:</td>
</tr>
<tr>
<td>Reason for movement:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Approved by:</th>
<th>Date:</th>
</tr>
</thead>
</table>

For Official Use only:
APPENDIX IV

Application for Approval to Harvest Fish

This form may be copied and used when making an application for approval to harvest fish from a fish farm site with a Designated Area Order (DAO) or other Control Regulations for ISA. Fill in the details required and fax or post to FRS Marine Laboratory.

To: The Duty Inspector, FRS Marine Laboratory, PO Box 101, Victoria Road, Aberdeen, AB11 9DB

Fax no: 01224 295620

<table>
<thead>
<tr>
<th>For Official Use only:</th>
<th>Inspector: .................................................................</th>
</tr>
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<tbody>
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<td>Ref no:</td>
<td></td>
</tr>
<tr>
<td>Site name:</td>
<td>Site no: FS/</td>
</tr>
<tr>
<td>Business name:</td>
<td>Tel:</td>
</tr>
<tr>
<td>Contact name:</td>
<td>Fax:</td>
</tr>
<tr>
<td>Contact address:</td>
<td></td>
</tr>
</tbody>
</table>

**Proposed start date for harvest:** .................................................................

**Proposed finish date for harvest:** .................................................................

**Number of fish to be harvested:** .................................................................

**Process plant for harvested fish:** .................................................................

**Proposed method of transport:** .................................................................

**For Official Use only:**

Approved by: .................................................................  Date: .................................................................
# APPENDIX V

## Check List for Processing Plants

<table>
<thead>
<tr>
<th>Check</th>
<th>Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notices restricting access posted at all entrances</td>
<td></td>
</tr>
<tr>
<td>Disinfectant foot baths with brushes provided at all entrances and exits with suitable notices</td>
<td></td>
</tr>
<tr>
<td>Disinfectant concentration checked and maintained at effective level</td>
<td></td>
</tr>
<tr>
<td>Vehicles entering and leaving the site pass through disinfection procedure</td>
<td></td>
</tr>
<tr>
<td>Transport of fish in sealed, clean and disinfected containers</td>
<td></td>
</tr>
<tr>
<td>On-site vehicles, forklift trucks routinely cleaned and disinfected</td>
<td></td>
</tr>
<tr>
<td>Drains connected to disinfection plant \textit{via} filters</td>
<td></td>
</tr>
<tr>
<td>Yard clean and disinfected - no blood water evident</td>
<td></td>
</tr>
<tr>
<td>Foot baths in place between discrete work areas, eg yard, factory, chill, etc</td>
<td></td>
</tr>
<tr>
<td>Protective clothing cleaned and disinfected (at least after every shift)</td>
<td></td>
</tr>
<tr>
<td>Processing equipment, utensils, etc routinely cleaned and disinfected</td>
<td></td>
</tr>
<tr>
<td>System in place to prevent wind blown effluent when emptying fish bins</td>
<td></td>
</tr>
<tr>
<td>Fish-receiving hopper/tank designed to prevent spillage of fish and effluent</td>
<td></td>
</tr>
<tr>
<td>System in place to prevent access to carcasses by predators, eg birds</td>
<td></td>
</tr>
<tr>
<td>Cleaning and disinfection system in place for empty bins</td>
<td></td>
</tr>
<tr>
<td>Bins from ISA Surveillance Zones kept separate from other bins</td>
<td></td>
</tr>
<tr>
<td>Eviscerated material pumped into ensilage system and fully contained</td>
<td></td>
</tr>
<tr>
<td>Log in place to monitor pH of silage (pH less than 3.9)</td>
<td></td>
</tr>
<tr>
<td>Log in place to monitor effluent treatment method (eg residual free chlorine in effluent greater than 5 mg/l after 30 minutes)</td>
<td></td>
</tr>
<tr>
<td>pH and free chlorine logs kept for inspection by FRS MLA</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inspected by:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td></td>
</tr>
<tr>
<td>Recommendations for improvements: Y / N</td>
<td></td>
</tr>
<tr>
<td>Specify:</td>
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</tr>
</tbody>
</table>
APPENDIX VI

INFECTIONOUS SALMON ANAEMIA (ISA)

What is Infectious salmon anaemia (ISA)?
ISA is a contagious viral disease of farmed Atlantic salmon that was first found in Scotland in the late 1980s and has since been recorded in many other countries. ISA is a notifiable disease under EU fish health legislation. The disease is only transmitted via the fish itself.

Methods of spread
- Fish-to-fish transmission is possible but not well established.
- Dissemination of infected material has been reported in contaminated feed and water.
- Infection can also occur via water lost from fish tanks.

Risk factors associated with ISA include:
- Poor water quality
- High stocking densities
- Stressful handling
- Exposure to cold water
- Exposure to sunlight
- Exposure to contaminated water

Action taken by government
- National fish health strategy to be developed.
- National control strategy to be developed.
- National surveillance strategy to be developed.
- National biosecurity strategy to be developed.

Action for salmon farmers
- Unexplained fish mortality of any cause should be reported immediately.
- All affected fish should be removed from the farm.
-Affected fish should be disposed of in an authorized manner.
- Fish health inspections should be conducted regularly.
- Fish health plans should be developed and implemented.
- Fish health advice and guidance should be sought.

Disease signs
- Severe anaemia
- Accumbent swim bladder
- Haemorrhaging in visceral organs
- Darkening of the liver
- Enlarged, dark spleen
- High levels of mortality

Disinfection
- It is imperative that all equipment is thoroughly cleaned prior to disinfection. Sodium hypochlorite is a highly effective disinfectant against the ISA virus. Other methods of disinfection include formaldehyde, formalin, acid, sodium hydroxide, heat, ozone and UV irradiation.

Contact Address for Further Information
Fish Health Inspectorate
FRS Marine Laboratory
PO Box 101
Victoria Road
Aberdeen AB9 9SB
Tel: 01224 870344
Fax: 01224 870330
web: http://frsmarine.ac.uk

ISA advisory leaflet issued by FRS MLA to industry following the outbreak of ISA in Scotland.
REFERENCES


81. Regulations relating to the establishment and operation of fish farms, and measures to prevent disease at fish farms (operating and disease prevention regulations). Laid down by the Norwegian Ministry of Fisheries and the Ministry of Agriculture on 18 December 1998 pursuant to Act No 68 of 14 June relating to the Breeding of Fish, Shellfish etc and of Act No 54 of 13 June 1997 relating to Measures of the Prevention of Fish Disease and Disease of other Aquatic Animals (Fish Disease Act).


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